VOLUME 1

ENVIRONMENTAL

ENVIRONMENTAL CONSULTANTS

PROPOSED RESORT DEVELOPMENT AT PARADISE PARK, SMITHFIELD, WESTMORELAND

ENVIRONMENTAL IMPACT ASSESSMENT

FINAL V. 2

DOCUMENT TITLE	**Environmental Impact Assessment for the Proposed Resort Development at Paradise Park, Paradise Pen, Westmoreland** **Volume 1**
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EXECUTIVE SUMMARY

INTRODUCTION

The proposed Paradise Park development is a sustainable luxury resort on Jamaica's south coast in Westmoreland, about 3 km from Savanna-La-Mar. The 1,120-acre site includes a variety of ecosystems such as mangroves, swamps, forests, beaches, and grasslands. The project is designed to integrate with these natural habitats while offering high-end accommodations, a golf course, wellness facilities, and recreational amenities, all prioritizing sustainability and minimizing environmental impact. The project aligns with Jamaica's government policies on sustainable development and is set to be a model for sustainable tourism in the Caribbean, blending luxury with environmental preservation.

The National Environment and Planning Agency (NEPA) requires an Environmental Impact Assessment (EIA) for the proposed development. This EIA aims to evaluate the project's potential environmental impacts, ensuring sustainable development with minimal adverse effects and optimized social and economic benefits. The EIA follows a structured process, assessing impacts on resources, ecosystems, communities, and human health. The study includes scoping, baseline data collection, impact prediction, mitigation measures, public consultation, and monitoring plans. It uses a mix of primary and secondary data, including statistical and spatial analysis, to establish a baseline environment and predict future impacts. Extensive literature, data from agencies, and geographic tools like GIS have been utilized for analysis.

PROJECT DESCRIPTION AND FEATURES

Overview

The Paradise Park development is divided into five main land use programs: Resort, Hotel, Villas, Golf Course, and Service Facilities.

- **Resort**: The resort will feature 120 exclusive resort units for sale, to provide the ultimate in luxury and privacy for its guests. The resort's central hub will offer amenities such as pools, dining options, and a beach area for guests to enjoy privacy and scenic views.
- **Hotel**: A 200-key ultra-luxury hotel will serve as the development's centrepiece, offering spacious rooms, beach access, and premium amenities like food outlets and kitchens, ensuring a high-end guest experience.
- **Villas**: A luxury residential community of 100 privately owned villas each designed to offer the highest level of comfort and privacy. A variety of villa sizes and experiences will be offered each strategically positioned in unique locations throughout the property to offer distinct, immersive environments, including a limited number of overwater and mangrove villas. The villas will

provide private, tranquil living spaces with stunning views of the expansive vistas of the golf course, ocean, mangrove wetlands, and surrounding landscape.

- **Golf Course**: An 18-hole, international-standard golf course will be built, including a clubhouse, practice areas, and collaboration with local schools for youth golf initiatives. The course is designed with sustainability in mind and will be elevated to protect against sea-level rise.
- **Service Facilities**: These will include solar farms, water treatment plants, staff facilities, stables, and parking areas to support the entire resort operation.
- **Amenities**: Resort and villa guests will have access to various luxury amenities such as a wellness centre, gym, tennis courts, equestrian centre, cooking and farming schools, an art school, music recording studio, and more. Hotel guests will also enjoy amenities like a spa, gym, and tennis courts. Common amenities for all guests will include a children's club, rum bottling facility, and a basketball court.
- **Ecological Zone**: A portion of the land will remain undeveloped, reserved for ecological preservation.
- **Access and Parking**: The development will have functional roadways and boardwalks, and 581 parking spaces to serve the site's various buildings and features.
- **Coastal Features**: Key coastal elements will include rock groynes, sandy swimming areas and a dock for enhanced environmental management.

Auxiliary Project Activities

<u>Landscaping</u>

The design preserves natural elements, incorporating trees with a minimum diameter of 20 cm. Royal palm trees frame driveways, and Foxtail palms line walkways. Bougainvillea and Sea Island Ficus provide privacy along hotel walkways, while Black Olive trees offer shade in open areas. Zoysia grass sod will cover open areas, supported by a sustainable irrigation system.

<u>Water Demand and Supply</u>

The project will use a water reticulation system, supplemented by local wells and rivers, with storage tanks of 1,000,000 gallons each. A network of PVC and ductile iron pipes will distribute water to various facilities and meet fire suppression needs.

<u>Wastewater Treatment</u>

A Wastewater Treatment Plant (WWTP) will include components such as a pump station, aerated grit chamber, aerobic digester, and chlorine contact tank. The process will use an oxidation ditch and constructed wetland for treatment, ensuring high-quality effluent before discharge.

<u>Stormwater Drainage</u>

Stormwater will be managed with natural and engineered channels, including detention ponds to control runoff and discharge it to vegetated areas for sediment and quality control.

Solid Waste

The resort will implement sustainable practices like waste monitoring and recycling, aiming for a one-third reduction in single-use plastics. The solid waste strategy follows principles of prevention, reduction, reuse, recycling, recovery, and disposal.

Hazardous Waste Management

A process will ensure safe handling, disposal, and compliance with regulations regarding hazardous materials such as cleaning supplies and batteries. Staff training and partnerships with certified disposal companies will support this initiative.

Utilities and Telecommunications

Electricity will be sourced from Jamaica Public Service and supplemented with renewable energy from a solar field. Telecommunications will be provided by Flow Jamaica or Digicel.

Mechanical and Electrical Systems

- Fire Protection: The hotel, resort, villas, and golf club will have sprinkler systems, with fire hydrants in villas and accommodations.
- Plumbing Systems: The buildings will feature storm drains, potable water systems, and hot water systems with a mix of solar and gas-fired heaters. Special plumbing fixtures will be installed to meet ADA standards.
- Mechanical Systems: HVAC systems will maximize energy efficiency, provide temperature control, and ensure proper ventilation.
- Fire Alarm Systems: The hotel and commercial buildings will have a 24V addressable fire alarm system with voice communication for emergencies.
- Electrical Systems: The electrical systems will be designed in compliance with various codes, including JS 316:2018, the National Electrical Code, NFPA standards, and JPS regulations. Power will be supplied by a 24kV, 50Hz, three-phase medium voltage connection from Jamaica Public Service Co. Ltd. (JPS), supplemented by a renewable energy system consisting of a 5MW solar plant for the hotel. The development will feature underground networks, step-up transformers, and medium voltage ring main distribution systems to ensure reliable power. Backup power will be provided by synchronized LNG-fuelled generators, capable of supporting critical systems. Low voltage systems will distribute power to guest suites and common areas, with advanced surge protection and energy-efficient lighting systems.

Construction Methodology

<u>Sequence of Construction Tasks</u>

The construction tasks for the project are as follows:

- TASK 1 – Property Markings: Survey stakes are placed to identify areas for tree removal, vegetation clearance, and site grading, preparing the site for drainage, infrastructure, and building foundations.
- TASK 2 – Establishment of East Site Access Road and Initial Infrastructure: Includes temporary surface preparation, drainage work, grading of access roads, and subgrade preparation for future paving and storm drainage integration.
- TASK 3 – Surveying, Marking, and Preparing the Site for Clearing and Habitat Protection: Involves surveying the site's topography, marking trees and natural habitats for preservation, and preparing for vegetation removal.
- TASK 4 – Environmental Control and Site Layout for Mass Excavation: Installation of environmental controls such as silt fences and check dams, followed by site clearing, excavation, soil management, and stormwater control implementation.
- TASK 5 – Installation of Main Stormwater Management System: Excavation and grading to align the site for efficient water movement, installation of stormwater infrastructure, construction of detention ponds, and implementation of silt and velocity control measures.
- TASK 6 – Installation of Water Supply and Fire Suppression Systems: Excavation and installation of water piping, securing pipes, backfilling, and setting up fire suppression systems, including hydrants placed according to safety standards.
- TASK 7 – Installation of the Sanitary Sewer System Mains: Setting up gravity flow and force main piping for wastewater transportation to the on-site treatment plant.
- TASK 8 – Installation of Initial Underground Electrical Site Power Supply and Communication Transmission Conduits: Grading the site and installing underground ducts for electrical and communication systems, along with protective measures and testing for code compliance.
- TASK 9 – Building Foundations, Under Slab Utilities, and Vertical Building Structures: Completing groundwork, utility installation, foundation casting, and the erection of vertical structures.
- TASK 10 – Vertical Building Construction and Exterior Finishes: Construction of building vertical structures using concrete and CMU walls, including roof slabs, deck casting, and application of exterior finishes like stucco and glazed window walls.
- TASK 11 – Coastal Works: Coastal infrastructure and works for the development.
- TASK 12 – Building Exterior Components and Additional Waterproofing Systems: Exterior design, including durable roofing systems and waterproofing technologies for environmental protection.

- TASK 13 – Interior Fit-Out and Finishes: Installation of high-quality materials and finishes inside the buildings to ensure durability and aesthetic appeal.
- TASK 14 – MEPFP Systems Overview: Installation of Mechanical, Electrical, Plumbing, and Fire Protection systems to meet industry standards.
- TASK 15 – Exterior Improvements Work Overview: Enhancing the functionality and aesthetic appeal of the exterior infrastructure.
- TASK 16 – Mangrove Villas and Over Water Suites: Specialized construction of villas and suites over the water, completing the development with unique accommodations.

Concrete Batching Plant

The concrete batching plant will cover 80x100 meters and produce 23,000 cubic meters of concrete. Environmental measures include waste disposal at certified landfills, dust control through stockpile covering and water sprays, stormwater and roof drainage management, and concrete washout through a soakaway pit. Noise and water runoff will be controlled, and sustainable practices like rainwater harvesting will be employed. A qualified contractor will manage operations, with water consumption at 400 litres per cubic meter of concrete.

Execution Strategy

The execution strategy focuses on proactive management of materials and equipment to ensure efficient workforce operations. Early procurement and delivery planning are crucial due to the limited local resources. Before work begins, safety measures such as emergency plans, erosion control, and hazard analysis will be implemented. The site will be organized by supervisory teams, with clear accountability for each area. Collaboration between construction teams, owners, and designers will help address conflicts and ensure timely adjustments to the project.

Health, Safety, and Environment (HSE)

Safety management on the project will emphasize management commitment, employee involvement, measurement systems, and continuous safety improvement. Activity Hazard Analysis (AHA) plans will be used to identify hazards and mitigate risks, with supervisors receiving training on accident reduction techniques. Fall protection measures will be in place, including harnesses and tie-off points for workers. A Traffic Control and Logistics Plan will also be developed and updated regularly to ensure site conditions and safety awareness are maintained.

Sustainable Construction Practices

Sustainable practices will be implemented to minimize environmental impact. A mobile fuelling system will reduce fuel waste by fuelling equipment directly on-site. Efficient excavation practices will minimize unnecessary work and energy consumption. Operator training will focus on energy conservation, and a strategic waste management plan will reduce material waste, use locally sourced products, promote recycling, and utilize BIM modelling to prevent construction clashes.

Employment

The development is expected to create approximately 600 jobs in residential and hotel construction and 100 jobs in infrastructure, with a peak workforce of 1,000. The project will also generate between 2,660–3,800 indirect jobs. Local labour will be prioritized, offering significant economic benefits to the surrounding community.

Decommissioning

When construction concludes, authorities and the community will be notified about the transition to resort operations. Security will be maintained throughout decommissioning, with restricted access for essential personnel. All construction materials, temporary structures, and waste will be removed, and a comprehensive decommissioning process will be followed, including site assessment, dismantling structures, and waste segregation. Stakeholders will be kept informed throughout, and the entire process is expected to be completed within 2–3 months after construction phases conclude.

Operations

The development is committed to environmental stewardship, integrating innovative design, resource optimization, and sustainable practices to serve as a model for energy and water conservation in commercial projects.

Energy Conservation

The development incorporates several energy-saving measures, including integration with the Paradise Park Solar Power Plant to reduce reliance on carbon-based fuels by over 50% throughout its lifespan. Smart glazing systems and superior insulation enhance temperature control, while high-efficiency LED lighting with motion sensors reduces energy consumption. Advanced building management systems allow precise temperature regulation, and solar lights for exterior landscapes help cut down on electricity use, further minimizing infrastructure costs.

Water Conservation

Water-saving strategies include grey water recycling for landscape irrigation, rainwater collection to supplement drinking water supplies, and water-saving plumbing fixtures to reduce consumption. These measures collectively promote sustainable water use across the site.

Other Sustainability Initiatives

The development also emphasizes creating a culture of sustainability through staff awareness training and a shift towards digital information to reduce reliance on paper records.

Employment

Once operational, the development will provide approximately 1,000 jobs in hospitality, management, maintenance, and support services, generating an estimated 1,840 indirect and 695 induced jobs. These long-term positions will contribute to the local economy and offer stable employment opportunities in the surrounding area.

Phasing and Scheduling

It is anticipated that the project's pre-development phase will last 12 months, from March 2024 to February 2025, with construction beginning in March 2025 and concluding by February 2028, lasting 3 years. The resort and amenities are scheduled to open in March 2028. The total duration of the project will therefore be 84 months (7 years), from March 2024 to February 2031

POTENTIAL IMPACTS AND RECOMMENDED MITIGATION

Site Clearance and Construction Phase

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
Physical	***Drainage and Hydrology***	During the initial phases, potential increased risk of flooding and runoff due to vegetation removal. Once implemented, the stormwater management system will improve site hydrology	i. To minimize disruptions to the hydrological balance, the stormwater management system will be integrated in phases, with close monitoring to ensure that each phase is functioning effectively before moving on to the next. ii. The system should be designed to accommodate fluctuations in rainfall patterns and unexpected storm events. iii. To improve water flow, regular cleaning, and maintenance of stormwater infrastructure (such as swales, catch basins, and piping systems) will be carried out. This will ensure the effective capture and diversion of water to the designated detention areas. The grading of the site will be periodically assessed to confirm that water flows in the desired directions and that any pooling of water is addressed promptly. iv. Continuous monitoring and maintenance of silt fences, check dams, and sediment removal systems and other design features will be crucial. Regular inspections will ensure that these control measures are functioning properly, preventing sediment and pollutants from entering nearby water bodies and reducing the risk of erosion during construction.
	Water Quality - Freshwater	Increased levels of suspended solids, heightened turbidity and sedimentation and potential contamination	***Primary Recommended Mitigation*** i. Erosion and Sediment Control: a. During construction, the project site should include sediment control measures such as turbidity barriers/silt screens and should be erected around the entire work area to prevent the dispersion of sediments and contaminants throughout the water column. These should be placed so as to reduce/contain the resultant sediment plume during the activities. Construction activities should only continue when these barriers are fully operational, that is; placed correctly; calm to moderate sea conditions; without damage. These barriers are particularly important when operations occur near or may influence sensitive ecosystems and species such as coral reefs and seagrass beds and or filter feeding organisms and fish. It may be necessary to have multiple layers of sediment barriers around work areas b. Erosion Control Mats: Use erosion control mats and geotextiles on exposed soil to reduce erosion. c. Conduct sediment dispersal calculation rates on coral reefs and seagrass beds within 200 meters of the proposed villas and other marine works and at control stations, on a monthly basis, for comparison to background levels. Pre-construction sedimentation rates should therefore also be conducted and used as a baseline for comparison. d. All activities should be limited to the minimal working area, and as such reducing the extent of the footprint. No activities and or placement of anchors or materials should be done placed outside the approved area. ii. Stormwater Management: a. Retention Ponds: Construct retention ponds or sediment basins to capture and treat stormwater runoff before it enters water bodies. b. Drainage Systems: Design and implement efficient drainage systems to direct stormwater away from vulnerable areas and into treatment facilities. iii. Proper Storage and Handling of Hazardous Materials: a. Raw Materials: i. Designate a central area for the storage of raw materials. ii. Area should be lined in order to prevent the leakage of chemicals into the sediment. iii. Stockpile fine grained materials (sand, marl, etc.) away from drainage channels and low berms should be placed around the piles, which themselves should be covered with tarpaulin to prevent erosion. iv. Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne. b. Hazardous Substances: i. Storage of fuels and oils, and hazardous substances should be in clearly marked containers (tanks/drums etc.) indicating the type and quantity being stored. ii. Containers should be surrounded by bunds to contain the volume being stored in case of accidental spillage. iii. Equipment should be stored on impermeable hard stands surrounded by berms to contain any accidental surface runoff. iv. Vehicle refuelling facilities must be situated on impermeable surfaces served by an oil trap, run-off collection system. Sediment basins and oil water separators should be constructed to intercept storm water before it is discharged. v. Refuelling of boats should only be done at anchor out at sea if the sea conditions are calm, otherwise, all refuelling should be done when docked at land. Appropriate refuelling equipment (such as funnels) and techniques should always be used. c. Transport: i. In terms of transporting equipment, utilise the paths of the planned roadways rather than creating temporary pathways just for equipment access. ii. Raw materials such as marl and sand should be adequately covered within the trucks to prevent any escaping into the air and along the roadway. d. Spill Response Plan: i. Develop and implement a spill response plan, including spill kits and training for workers to handle and clean up spills promptly and effectively. ii. Appropriate minor spill response equipment (for containment and clean- up) will kept on site, including oil absorbent pads and disposal bags. e. Construction Equipment Maintenance:
	Water Quality - Marine	Increased levels of suspended solids, heightened turbidity and sedimentation and potential contamination	
		Increased water turbidity and sedimentation, with potential spread by natural hydrodynamics	
	Benthic Sediment	Disturbance of seabed and resuspension of sediments	

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
			i. Regular Inspections: Conduct regular inspections and maintenance of construction equipment to prevent leaks and ensure optimal functioning. ii. Designated Maintenance Areas: Perform equipment maintenance in designated areas with proper containment measures to prevent contamination of soil and water. iv. Monitoring and Compliance: a. Weekly monitoring of water quality parameters such as temperature, salinity, pH, Dissolved Oxygen, light irradiance, turbidity, and Total Suspended Solids (TSS) in and around the project area should be conducted during construction for the first 3 months of construction. Monitoring can be conducted fortnightly thereafter. b. Adaptive management, including stoppage of works during adverse weather conditions and using monitoring data to adapt and refine mitigation measures as needed to address any emerging issues promptly.
	Noise	Increase noised levels, impacting the noise climate and potentially affecting nearby residents, wildlife, and the overall soundscape	i. Scheduling and Planning: a. Restrict construction activities to regular working hours (7 am – 6 pm) to avoid disturbances during nighttime. b. Schedule particularly noisy activities during times when they will cause the least disruption, avoiding early mornings, late evenings, and weekends. c. Minimize engine idling when equipment is not in use to reduce unnecessary noise. d. Where possible, position noisy equipment and staging areas as far from sensitive receptors e. Restricting noisy activities like construction and seismic surveys during breeding and migration seasons ii. Equipment Management: a. Use equipment that has low noise emissions as stated by the manufacturers, and properly equip machinery with noise reduction devices, such as effective mufflers and silencers to reduce noise emissions. Newer models of construction equipment are typically designed to operate more quietly and should be considered. b. Ensure equipment is maintained to prevent excessive noise from worn or faulty parts. iii. Worker Protection and Training: a. Construction workers operating noise-generating equipment should be provided with appropriate hearing protection. Workers handling equipment that produces continuous noise levels of 80 dBA or more for 8 hours or longer should use earmuffs. Those exposed to prolonged noise levels between 70 - 80 dBA should wear earplugs. b. Train construction workers on the importance of noise control and encourage best practices to minimize noise generation. iv. Monitoring and Compliance: a. Conduct regular noise monitoring (monthly) at various points around the construction site to ensure compliance with noise standards. b. Adhere to the 24-hour construction noise guidelines as stated in the environmental permit (usually 70 dBA or 75 dBA). v. Community Engagement: a. Provide advance notice to neighbouring businesses about upcoming noisy activities and expected durations.
	Air Quality	Emissions as well as fugitive dust emissions, potentially affect local air quality, health, and vegetation	i. Dust Control: a. Areas, including roads, should be dampened every 4-6 hours or within reason to prevent a dust nuisance and on hotter, more windy days, this frequency should be increased. b. Raw materials that generate dust should be covered or wetted frequently to prevent them from becoming air or waterborne; this includes those being transported on trucks. c. Minimize cleared areas to those that are needed to be used. d. Ensure material stockpiles and construction debris are stored away from the roadway ii. Equipment Emissions: a. Utilize construction machinery and vehicles that meet stringent emission standards. b. Ensure equipment is regularly maintained to operate efficiently with minimal emissions. c. Implement policies to reduce unnecessary idling of construction vehicles and machinery. iii. Monitoring and Compliance: a. Implement a monthly air quality monitoring program to regularly assess the levels of particulate matter and other pollutants. b. Ensure all activities comply with local air quality regulations and standards. iv. Worker Protection: a. Provide construction workers with appropriate Personal Protective Equipment (PPE), such as masks and N95 respirators, to protect against dust and emissions. v. Community Engagement: a. Keep local business informed about construction activities and potential air quality impacts. b. Provide a contact point for concerns and complaints.
	Pollution Sources	Increased solid waste, requiring proper management to prevent contamination Removal of agriculture and farm animals will reduce nutrient inputs, improving water quality	i. Increased Solid Waste from Workers: Construction and site activities will generate additional solid waste, including packaging materials, food waste, and construction debris. Proper waste management protocols will be necessary to prevent littering and contamination of nearby water bodies. ii. Reduced Nutrient Inputs from Agriculture and Farm Animals: With the removal of agricultural activities and farm animals from the property, nutrient runoff from fertilizers and animal waste will decrease, leading to lower nitrogen and phosphorus inputs into adjacent water bodies. This change may result in improved water quality over time, reducing the risk of eutrophication in connected freshwater and marine systems.

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
Biological	***Terrestrial Habitats***	Potential habitat and alteration loss Potential habitat fragmentation	i. Efficient space utilization and the integration of green corridors within the development can significantly reduce fragmentation by maintaining permanent connections between green spaces throughout the area. This approach supports the movement of wildlife and ensures habitat connectivity, which is essential for maintaining biodiversity. ii. Establishing buffer zones around ecologically important areas, such as wetlands or forested regions, will help protect these habitats from the direct impacts of construction. These zones will reduce edge effects and provide transitional areas for species to migrate or find refuge. iii. The recommended Conservation Areas, which are currently unmanaged, will be brought under active management to limit access and activities, reduce degradation, and implement rehabilitation actions where necessary, ensuring the protection and enhancement of these critical habitats.
	Terrestrial Flora	Potential smothering from dust Potential loss of endemics, such as Morass Royal (*Roystonea princeps*) Potential loss of ecosystem services Potential Relocation of Roystonea princeps, Epiphytes Potential introduction of invasive species	i. Relocation of key species before land clearance: Specific attention should be given to species like Wittmackia negrilensis (Tank Bromeliad) and Roystonea princeps (Swamp Cabbage), which are of conservation concern. Roystonea princeps is listed as near-threatened on the IUCN Red List and should be relocated to designated green spaces within the development where possible. All bromeliads, epiphytic cacti, and orchids that will be impacted by land clearance must also be relocated prior to commencement of construction. ii. Invasive species management: During land clearance, efforts should be made to prevent the spread of invasive species, such as Haematoxylum campechianum (logwood), through improper disposal of cut material. All vegetative material and seeds from invasive species should be properly disposed of in areas that are not designated for preservation or green spaces. iii. Integrating large trees into the development design: Large trees, particularly those with a diameter at breast height (DBH) greater than 100 cm, should be considered for retention within the landscaping of the development. Special care should be taken with trees that support other flora, such as climbers, bromeliads, and orchids, as these contribute significantly to the local ecosystem. Retaining these trees will help maintain some of the ecosystem services provided by the flora in the area, such as carbon sequestration and habitat for fauna. iv. Establishing a nursery: A nursery can be set up to temporarily house relocated species and nurture native seedlings that will be out planted within the development area. This ensures that the species are reintroduced to the site in a controlled and planned manner, helping to maintain biodiversity. v. Development of a plant relocation plan: A competent botanist should be engaged to generate a relocation plan for plant species that need to be moved due to development activities. The plan should include species deemed necessary for relocation, especially those that are endemic or have special conservation designations. Ideally, seedlings or saplings should be relocated from the development footprint prior to land clearance. vi. Incorporating native species in landscaping: It is essential to use native plant species in landscaping to maintain the biodiversity that is already part of the site's habitats. This approach avoids the introduction of non-native species, which can disrupt the local ecosystem. Some of these native species are key ecological players and help support the habitat's overall function. vii. Rehabilitation of degraded areas: To work towards a Net Gain approach, degraded areas within the site that will not be developed can be rehabilitated through various activities (for example lands within Conservation Area 4). These efforts may enhance both the ecological function and resilience. viii. Designation of Conservation areas: A small section of each land use type on the property should be designated as preservation areas outside the footprint of the project. These areas will allow for the preservation of naturally occurring species and provide valuable 'green space' for both biodiversity conservation and the relocation of plant species. ix. Monitoring and adaptive management: Ongoing monitoring of the flora during and after construction is essential to assess the effectiveness of the mitigation measures. Adaptive management strategies can be implemented to modify actions based on observed impacts, ensuring that mitigation efforts remain effective over time.
	Wetlands and Mangroves	Potential loss of mangrove carbon sequestration and storage Potential loss of biodiversity and ecosystem services	RETENTION AND CONSERVATION OF EXISTING WETLANDS In lieu of mangrove loss, the proposed mitigation strategy prioritizes the conservation of areas on the property that are more than double the size of the impacted area. Over time, replanting efforts may also be incorporated as part of broader rehabilitation activities to enhance the ecological function and resilience of these conserved habitats The following measures are proposed to effectively implement the conservation of these wetland areas: i. Restrict development completely within Conservation Area 1, the "Bluff" area. This area was identified as a very sensitive section based on the hydrology and resulting influence of outflows from the area to the sea. This point should have no alterations, pollution sources or changes in forest structure. Though the plans show a boardwalk structure to the North of this area, its construction must be closely planned and monitored to maintain the current hydrological regime. ii. Development sites should be designed to prevent any negative impact on the hydrology and long-term sustainability of the conservation areas. Ensure the inclusion of culverts and other hydrological features to maintain connectivity across roadways and infrastructure that may otherwise isolate wetland sections. Temporary roadways built to facilitate construction though wetlands shall have culverts placed every 10-20 m to facilitate the areas unrestricted water movements. Studies have shown that even temporary water stagnation in mangrove forests and swamps can result in die-back and forested wetland loss. iii. Wetland soil removed to facilitate temporary roadways, shall be replaced post construction when feasible. This facilitates the area retaining a high amounts of its original soil carbon, preserves soil structure and fertility, supports microbial activity, and promotes the re-establishment of native vegetation, thereby aiding in the recovery of ecosystem functions. iv. The various Conservation Areas that are parallel to a boardwalk structure on the property, shall be demarcated using conservation marker boundaries that are in line of sight. This allows a clear boundary to keep the construction team out of these areas. v. Conservation areas adjacent to main roads, highways and other settlements and communities, shall be aesthetically fenced to maintain the forest integrity and limit external influences from affecting the forest. vi. A buffer zone around the development footprint will be maintained to reduce the direct impact on surrounding wetland areas. This buffer will help protect the integrity of the

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
			wetland ecosystem by limiting construction activities and disturbance near sensitive habitats. vii. Construction activities should be avoided in sensitive or critical areas, such as key hydrological points, important nesting sites for fauna, regions with high carbon storage, and locations that feature "signature" tree species. viii. Regular monitoring of wetland areas should be conducted throughout the construction process to assess any impacts on the environment. Adaptive management strategies will be employed to address emerging issues and ensure that mitigation measures remain effective in protecting the wetland habitats. RELOCATION AND REHABILITATION i. Prior to any construction activities a detailed Relocation Plan will be developed and submitted to the Agency for approval. This will include but not limited to identification of any significant wetland features or sensitive organisms, such as bromeliads or orchids as well as the proposed relocation measures. Identification and details of any temporary nurseries and proposed relocation sites must also be provided. ii. Where possible, there will be proposed areas to potentially increase the mangrove population and enhance the site coastline. Though the majority of any potential wetland loss shall be mitigated for by designated new conservation areas, the development shall seek to rehabilitate mangroves in suitable degraded areas. Potential rehabilitation areas have been identified within the Conservation Areas. MANGROVE CARBON SEQUESTRATION AND STORAGE As mentioned previously, a mangrove conservation area totalling 124.4 ha will remain, preserving an estimated 54,874.08 Mg C in soil carbon. However, beyond conservation, net carbon gain measures will ensure that overall carbon sequestration is increased over time. These include: • Enhancing carbon sequestration through targeted restoration in degraded areas. • Reforestation efforts in designated zones to exceed the carbon lost from impacted areas. HYDROLOGICAL DISRUPTIONS & CONNECTIVITY LOSS • Use culverts and other drainage features to maintain natural water flow to wetland areas during both construction and operation. • Ensure culverts are placed at appropriate intervals (every 10-20m in wetland areas) to facilitate unrestricted water movement. • Avoid road alignments and construction in critical hydrological zones, such as areas with seasonal outflows to the sea. • Monitor water levels and hydrological connectivity throughout construction to assess impacts and adjust mitigation strategies as needed.
	Terrestrial Fauna	Potential species loss Noise and construction activities Introduction of Invasive Species Human-wildlife conflicts Lighting and artificial habitat alteration	i. Habitat Preservation and Minimization of Disturbance: a. Where possible, areas with high biodiversity or critical habitats (such as wetlands and epiphytes) should be preserved. Efforts should be made to minimize clearing and avoid development within ecologically sensitive zones. b. Establish buffer zones around sensitive wildlife habitats to reduce the impact of construction activities. These zones will act as a barrier to protect wildlife from direct disturbances and habitat fragmentation. c. If certain species are in immediate danger due to construction activities, such as the tank bromeliad, develop a relocation plan to move them to safer, suitable habitats, ensuring that their survival is not compromised. ii. Reduction of Noise and Vibration: a. See section above. iii. Protection of Nesting and Breeding Sites: a. Before construction begins, conduct a survey to identify and locate any nesting or breeding sites within the project area. Take steps to avoid disturbing these sites, especially during breeding or nesting seasons. b. If disturbance to nesting sites is unavoidable, arrange for the careful relocation of nests or eggs to safe areas, in consultation with wildlife experts. c. Implement seasonal construction scheduling where possible to avoid disrupting critical breeding seasons for birds, amphibians, and reptiles. iv. Air and Water Quality Protection: a. See sections above. v. Control of Invasive Species: a. Prior to bringing equipment or materials onto the site, inspect and clean them to ensure they do not carry invasive species that could disrupt local ecosystems. b. Establish monitoring programs to detect and control the spread of invasive species during the construction process. If invasive species are identified, implement a management plan to remove them from the site. vi. Mitigation of Human-Wildlife Conflicts: a. Should wildlife move into the construction zone in search of food, water, or shelter, implement a response plan to avoid harm. b. Any crocodile sighting in the area at any project stage should be reported to the National Environment and Planning Agency (NEPA) immediately. c. Provide training for construction workers on how to recognize and avoid harmful interactions with wildlife, particularly dangerous species like crocodiles. vii. Minimization of Light Pollution: a. Use low-intensity, downward-facing lights during construction activities to reduce the impact of artificial lighting on nocturnal wildlife. b. Restrict lighting to essential areas and ensure that lights are turned off when not needed to avoid disrupting natural wildlife cycles.

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
			viii. Post-Construction Habitat Restoration: a. After construction is completed, prioritize the restoration of any disturbed habitats. This may include replanting native vegetation, restoring wetland areas, or reconstructing wildlife corridors to help fauna return to their natural environment. b. Continue to monitor the recovered habitats for several years to ensure that wildlife is returning, and the ecosystem is functioning as it should.
	Freshwater Habitats	Potential habitat loss and or alteration Potential habitat fragmentation Potential shifts in community composition Potential loss of ecosystem services	i. Rivers and streams must maintain their natural flow to allow species to disperse throughout freshwater habitats. ii. Reducing habitat loss would also require establishing setback regulations for rivers, streams, ponds, and wetlands to safeguard aquatic and riparian vegetation along the banks and within water bodies. iii. To preserve current species compositions, it is essential to maintain natural hydroperiods and limit the creation of temporary water bodies with short hydroperiods. iv. Avoid the use of synthetic fertilizers, pesticides, oils, surfactants, and harsh chemicals like bleach or oxidizing agents in and around water bodies. v. Waste management facilities at the resource site must be properly regulated, and waste should be treated correctly. vi. Regular monitoring of water quality is necessary, as is the use of low-noise and low-emission machinery whenever possible. vii. Implementing effective stormwater management systems is critical to prevent runoff pollution. See Primary Recommended Mitigation.
	Benthic Habitats	Potential habitat loss and or alteration Potential loss of ecosystem services	i. During construction, the project site should include sediment control measures such as turbidity barriers/silt screens and should be erected around the entire work area to prevent the dispersion of sediments and contaminants throughout the water column. These should be placed so as to reduce/contain the resultant sediment plume during the activities. Construction activities should only continue when these barriers are fully operational, that is; placed correctly; calm to moderate sea conditions; without damage. These barriers are particularly important when operations occur near or may influence sensitive ecosystems and species such as coral reefs and seagrass beds and or filter feeding organisms and fish. It may be necessary to utilize multiple/layers of barriers around marine work areas. ii. Weekly monitoring of water quality parameters such as temperature, salinity, pH, Dissolved Oxygen, light irradiance, turbidity, and Total Suspended Solids (TSS) in and around the project area should be conducted during construction for the first 3 months of construction. Monitoring can be conducted fortnightly thereafter. iii. Sediment dispersal calculation rates will be monitored at the locations identified in the EIA or in close proximity if a location falls within the footprint of construction activities. Monitoring will be conducted on a monthly basis to compare sedimentation rates against background levels. The rates established in the EIA will serve as the baseline for comparison. iv. All activities should be limited to the minimal working area, and as such reducing the extent of the footprint. No activities and or placement of anchors or materials should be done placed outside the approved area. v. Relocation of sensitive species should be done if; they are suitable for relocation (that is suitable substrate, health and over all viability), those species fall within the potential impact area; and if mobile invertebrates are in or around the potential impact area. Sensitive organisms and systems in and outside the impact area include; mobile invertebrates such as urchins, sea cucumbers, starfish, and conch. vi. Alternative mitigations should be proposed when relocation is not suitable. vii. Where possible, as little of the natural environment should be relocated or removed. Habitat fragmentation and species displacement should be temporary, with the placement of silt screens, construction materials and equipment as well as general human activity in the area. viii. Structures placed on the seafloor may cause habitat fragmentation and displace some species, however they may also serve to add ecological volume, providing substrate for organisms to settle and colonize and eventually may serve some ecosystem functions. ix. Any temporary floating structures and /or vessels should be placed in areas with less sensitive species where possible. Floating structures anchored or moored over seagrass beds or coral colonies should not be left for prolonged time periods as the resulting shading effects may cause deterioration in overall health of the seagrass bed and coral colonies.
	Seagrass	Potential seagrass species loss Potential decline or alteration in water quality Potential loss of carbon sequestration (stored and ability to sequester additional carbon) Potential decline in water quality	See Primary Recommended Mitigation. Additionally: i. Habitat management and restoration within the Sanctuary may involve activities such as identifying areas for habitat or species restoration and rehabilitation, actively removing trash and litter, controlling invasive species, and implementing erosion control measures in seagrass beds. ii. To offset the loss of blue carbon, and in collaboration with the BFBSFS, various carbon offset projects targeting blue carbon ecosystems will be carried out. These initiatives will focus on restoring and conserving seagrass beds, mangroves, and other crucial habitats. In addition, social outreach efforts will include educating and promoting sustainable fishing and aquaculture practices to reduce habitat disruption and carbon emissions. Active involvement from local communities and the sanctuary's management will ensure the adoption and long-term maintenance of these sustainable practices. iii. Community engagement and citizen science initiatives in projects in and around the sanctuary.
	Reef Communities	Potential impact to coral colonies and reef communities Potential displacement of fish and mobile invertebrates	See Primary Recommended Mitigation. Additionally, Coral nurseries, along with potential artificial reefs, should be established to support coral restoration efforts. These nurseries are designated structures or areas designed to cultivate and propagate corals for restoration purposes. They will focus on the cultivation and rehabilitation of various coral species, providing a scientifically-based method to preserve and restore impacted coral communities. Coral nurseries offer numerous benefits for the conservation and restoration of coral reef ecosystems, including the enhancement of biodiversity and ecosystem resilience:

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
		Potential introduction of artificial substrates	i. Coral Reef Restoration: Coral nurseries provide a means to propagate and grow coral fragments in controlled environments. This allows for the production of a large number of healthy coral colonies that can be used for reef restoration projects. By transplanting these nursery-grown corals onto degraded reefs, the nurseries contribute to the recovery and resilience of coral reef ecosystems. (Bayraktarov, n.d.). ii. Genetic Diversity Preservation: Coral nurseries can enhance genetic diversity in restored reefs by cultivating and propagating multiple coral genotypes. By selecting diverse parent colonies and incorporating different genotypes, nurseries can contribute to the overall genetic health and resilience of coral populations. (Consortium, 2017) iii. Climate Change Resilience: Coral nurseries can assist in developing coral populations that are better adapted to changing environmental conditions, including ocean warming and acidification. By selecting and propagating coral genotypes that exhibit higher thermal tolerance or resilience, nurseries can help create reef communities better equipped to withstand climate stressors (Van Oppen, 2015) iv. Increased Habitat Complexity: Coral nurseries and artificial reefs enhance habitat complexity by providing three-dimensional structures that support diverse marine life. Artificial reefs offer shelter and breeding grounds, while nurseries supply resilient corals that can be transplanted onto these structures, accelerating reef development. Together, they increase biodiversity, improve ecosystem resilience, and contribute to the long-term health of marine habitats.
	Fish and Invertebrate Communities	Potential displacement of fish and mobile invertebrates	See Primary Recommended Mitigation.
	Sea Turtles	Potential disorientation of sea turtles and hatchings from lighting Potential loss of nursery, breeding, and foraging grounds	i. All staff and workers should be sensitized to all sensitive ecosystems and species in the area, in particular turtles. The site should be inspected daily for any signs of turtle activity. If a nest is suspected or found, all activity nearby should stop until an expert can determine if there is a nest and how to relocate the eggs. ii. The stakeholders, proponents and the NEPA should develop clear lines of reporting and communication in the event that action needs to be taken. iii. Silt screens should be used to prevent sedimentation but should be removed promptly along with any other construction debris and material upon completion. iv. Night-time activities should be limited or avoided when possible. No lights should be pointed out to sea confusion and disorientation of turtles or any other species that maybe affected by lunar activity. v. Fixtures in direct line-of-sight from the beach should be shielded down-light only fixtures or recessed fixtures having low wattage "bug" type bulbs and non-reflective interior surfaces. vi. Fixtures mounted as low in elevation as possible through use of low-mounted wall fixtures, low bollards, and ground level fixtures. vii. Floodlights, up-lights, or spotlights for decorative and accent purposes that are directly visible from the beach, or which indirectly or cumulatively illuminate the beach shall not be used. viii. For high intensity lighting applications such as providing security and similar applications shielded low-pressure sodium vapour lamps and fixtures shall be used.
Socioeconomic / Cultural	***Employment***	At peak, expected to employ up to 1,000 people, resulting in creation of approximately 2,660 to 3,800 indirect and induced jobs	i. Prioritize sourcing potential workers from nearby communities to strengthen community relations and support local economies. JDV aims to prioritize local talent and labour for both the construction and operation of the hotel whenever feasible. ii. Ensure that project-derived benefits are accessible to people of all genders, sexual orientations, and gender identities, fostering an inclusive environment where everyone can benefit equally from employment opportunities. iii. Implement robust measures to prevent incidents of sexual and gender-based violence, including sexual harassment, exploitation, and abuse. Establish clear protocols for prompt and effective responses to any incidents of SGBV. iv. Proactively identify and prevent risks and impacts related to gender, sexual orientation, and gender identity. When avoidance is not possible, mitigate and compensate for such impacts to ensure fairness and equality. v. The project team will collaborate closely with the Westmoreland Municipal Corporation to manage and mitigate the potential issues of squatting and influx of people.
	Electricity Supply	May increase demand on the local electrical grid, leading to potential capacity issues and voltage fluctuations. Installation of a solar field will reduce grid reliance	i. Efforts should be made to carefully manage the increased demand on the grid by working closely with the local utility provider to assess capacity and ensure the infrastructure can handle the added load. If necessary, grid upgrades or temporary solutions, such as load-shedding during peak demand, can be considered. ii. For backup power systems, the use of energy-efficient, low-emission generators, such as those powered by LNG or renewable energy sources, should be prioritized to minimize fuel consumption, emissions, and noise pollution. iii. Additionally, implementing an optimized generator maintenance schedule will help ensure the systems run efficiently and reduce environmental impacts.
	Water Supply	Impact expected to be temporary, as measures to optimize water use during operation will be implemented	i. Water use should be optimized through the use of water-efficient practices, such as recycling water for dust suppression and concrete mixing where possible. ii. Alternative water sources, such as stored rainwater or groundwater, can be explored to reduce reliance on local water supplies. iii. Scheduling construction activities that require large amounts of water during off-peak times, when demand on local water resources is lower, can also help ease pressure on the infrastructure. iv. Work closely with local authorities and water suppliers to monitor water usage and ensure that any necessary permits or water access agreements are in place will help manage demand responsibly. v. Regular assessments of the local water supply capacity should be conducted to ensure that construction activities do not strain existing resources, and adjustments can be made if necessary.

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
	Wastewater	Improper disposal of wastewater at the construction campsite could harm water quality	i. Provision and maintenance of portable sanitary conveniences for the construction workers for control of sewage waste by a licenced contractor. A ratio of approximately 25 workers per chemical toilet should be used. ii. Portable toilets should be located approximately 25 metres from the high-water mark, away from the shoreline to avoid discharge into the marine environment in the event of accidental spillage.
	Solid Waste	Increased generation of solid waste and improper disposal of this waste poses risks	In addition to the waste management plan, the following may be considered: i. Waste Management Plan: a. Develop a comprehensive waste management plan outlining procedures for waste segregation, recycling, and disposal. This should be approved by the National Environment and Planning Agency (NEPA) and the National Solid Waste Management Authority (NSWMA). b. Assign responsibilities to personnel for waste management and designate waste collection points on-site. c. Employees should be educated on impacts of solid waste and best practises. d. Prioritize waste minimization by reducing packaging materials, reusing construction waste where feasible, and recycling materials such as metal, wood, and concrete. e. Encourage contractors and suppliers to use eco-friendly packaging and materials that are recyclable or biodegradable. f. Solid waste collection points and the number of staff assigned to collection and disposal should be increased with every stage of construction and changes to the number of workers present. ii. Waste Segregation and Storage: a. Skips and bins should be strategically placed within the campsite and construction site. b. The skips and bins at the construction campsite should be adequately designed and covered to prevent access by vermin and minimise odour. c. The skips and bins at both the construction campsite and construction site should be emptied regularly to prevent overfilling. d. Disposal of the contents of the skips and bins should be done at an approved disposal site. e. Establish separate bins or containers for different types of waste, including recyclables, hazardous materials, and non-recyclable waste. f. Clearly label bins and provide training to workers on proper waste sorting and segregation practices. iii. Hazardous Waste Handling: a. Identify and properly handle hazardous materials such as paints, solvents, batteries, and chemicals according to regulatory requirements. b. Store hazardous waste in designated areas with appropriate containment measures to prevent spills and leaks. iv. Monitoring and Compliances: a. Monitor waste generation, segregation, and disposal activities regularly to assess compliance with waste management objectives. b. A ticketing system will be developed between both the Permittee and the Solid Waste Contractor to ensure effective management of waste and verification of disposal at the correct site.
	Health and Safety	Potential accidental injuries and exposure to fugitive dust	To supplement the proposed Safety Management Plan, it is recommended: GENERAL i. Worker Protection: a. Provide comprehensive safety training and education programs for all construction workers, including hazard recognition, emergency response procedures, and proper use of personal protective equipment (PPE). b. If necessary, provision of lifelines, personal safety nets or safety belts and scaffolding. c. Ensure that workers wear PPE (hard hats, reflective vests, safety shoes, eye protection etc.) d. Establish Lockout -Tag Out (LOTO) procedures. e. Where unavoidable, construction workers working in dusty areas should be provided and fitted with N95 respirators. ii. Emergency Preparedness and Response Planning: a. Develop emergency response plans and procedures for handling accidents, injuries, fires, and other emergencies on-site. Designing and implementing an Emergency Response Plan (ERP) in the event of any emergency. a. Designate a qualified safety officer or supervisor responsible for emergencies and overseeing safety compliance and enforcement on-site. This person should be clearly identified to the construction workers. b. Conduct regular safety inspections, audits, and reviews to identify areas for improvement and implement corrective actions as needed. c. Site should be equipped with first aid kits and arrangement for a local nurse and/or doctor to be on call for the construction site. d. Ensure that there is an ambulance and requisite staff onsite for any eventualities. e. Make prior arrangements with staff at the closest heath facilities to accommodate any eventualities. The Savanna-la-Mar Public Hospital and the Savanna la Mar Health Centre are located 3.5 km west of the project area. Also, the Westmoreland Public Health Services fleet includes seven ambulances, most of which are based at the Savanna la Mar Public General Hospital. f. Make prior arrangements with the Savanna-la-Mar police and fire stations to accommodate any eventualities.

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
			iii. Hazardous Material Management: a. Properly store, handle, and dispose of hazardous materials and chemicals used during construction, following regulatory requirements and best practices. b. Material Safety Data Sheets (MSDS) should be stored onsite. iv. Communication and Reporting: a. Establish clear communication channels for reporting safety concerns, near misses, and incidents on-site. b. Encourage open dialogue between workers, supervisors, and management to address safety issues promptly and effectively. TRENCH EXCAVATION i. A trench 1.2m or more in depth must have a means of egress (ladders/ stairways/ramps) and should be located at 8m intervals. ii. Excavated materials must be stored 0.6m or more from the open trench (not to be measured from the crown of the spoil). iii. Spoil should be placed so that the channels rainwater and other runoff water away from the excavation. iv. Take precautions regarding tension cracks VENDING AREAS i. Provision of adequate supply of potable water. ii. Monitoring of the various "cook shops" by public health authorities and the construction management team, to ensure proper hygiene is being followed. iii. The provision of areas to adequately wash hands and utensils. iv. Support the Westmoreland Municipal Corporation to ensure an orderly layout of vending areas. MARINE i. A safety officer, who is a competent swimmer and CPR trained, should be appointed. ii. Spotters in the water will assist the heavy equipment in accurate placement of the armour units. iii. The slopes and elevations of the armour layer will be demarcated with visual aids to guide the placement of boulders and to ensure they are properly interlocked.
	Land Use	Transformation of agricultural, residential, and recreational spaces into hospitality developments, impacting traditional land uses	i. Careful planning, phasing, and zoning should be used to minimize disruption to existing spaces and activities, ensuring a smooth transition. ii. Where land conversion is necessary, efforts should focus on relocating activities to nearby available lands or creating new spaces to offset the loss. As noted, the current owner has already identified locations for relocating agricultural assets. For residents, the potential development will require arrangements for either compensation or relocation. Compensation packages should be fair and transparent and relocation assistance should include support in finding new housing and covering moving costs, ensuring the new homes meet residents' needs. Consultation will ensure residents' concerns are addressed and their preferences considered. iii. Engage with local stakeholders to ensure their needs are considered and help facilitate a smooth transition throughout the construction phase into the operation of the resort.
	Vehicular Traffic	Potential disruption to traffic	i. Improved road lighting to enhance visibility in low-light conditions. ii. Appropriate traffic warning signs informing road users of the construction site entrance and instructing them to reduce speed. iii. Flagmen should be employed to control traffic and assist construction vehicles as they enter and exit the project site, particularly for heavy vehicles. iv. Rumble strips to improve oncoming vehicle awareness. v. Schedule all major heavy vehicle traffic during off-peak hours to reduce the impact on the main road.
	Maritime Traffic	Potential increase in accident risk Potential disruption in fishing and other maritime activities	i. Maritime Traffic Management: a. Clear Navigation Routes: Establish and clearly mark safe navigation routes for local fishers and recreational boaters to avoid construction areas. b. Exclusion/ Safety Zones: Establish safety exclusion zones around construction areas to prevent unauthorized access and reduce the risk of accidents. These zones should be clearly marked with `buoys and warning signs to keep out other marine traffic and fishers from the work area and prevent potential accidents. c. Monitoring and Enforcement: Maritime patrols to monitor and enforce safety zones, ensuring compliance by all vessels operating in the area. ii. Coordination with Local Maritime Users: a. Stakeholder Engagement: Engage with Bluefields Bay Fishermen's Friendly Society (BBFFS), local fishing communities and maritime users early in the planning process to understand their needs and concerns. Provide regular updates and opportunities for feedback throughout the construction phase. b. Communication Protocols: Implement communication protocols to inform the BBFFS and maritime users of construction schedules, locations, and potential hazards through local notices to mariners and regular updates. c. Compensation and Support: Consider compensation or support measures for the BBFFS, local fishers and maritime businesses adversely affected by the construction activities. iii. Environmental Protection: a. Minimize Turbidity and Pollution: Use turbidity curtains and other measures to minimize sediment disturbance and water pollution during construction. Ensure all vessels and machinery are well-maintained to prevent leaks and spills. b. Timing Restrictions: Schedule construction activities to avoid peak fishing seasons or sensitive periods for marine wildlife to reduce disruption to local ecosystems.
	Aesthetics	Potential reduction in aesthetic appeal	i. Site Management: a. Erect temporary hoarding or fencing around the construction site to obscure unsightly machinery and activities.

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
			b. Maintain a clean construction site by regularly removing debris, waste materials, and dust. Implement dust control measures such as water spraying and covering stockpiles. c. An area of gravel should be placed on site (just before exiting onto the main road) to help remove mud/marl from truck wheels. d. A wheel wash area on site (just before exiting onto the main road) should be implemented to rid wheels of as much mud/marl as possible. e. Use directional lighting to focus light only where it is needed and minimize spillover into surrounding areas. Employ low-intensity, warm-coloured lighting to reduce glare and light pollution. ii. Minimize Visual Intrusion: a. Compact Site Layout: Organize the construction site to minimize the footprint and reduce visual intrusion. Place equipment and materials in less visible areas whenever possible. b. Camouflage and Landscaping: Use temporary landscaping or plantings to soften the visual impact of the construction site. Employ natural colours and materials to blend temporary structures with the surrounding environment.
	Cultural and Heritage	Potential disturbance and damage to the archaeological sites and artifacts	The Taino archaeological site in the wetland area east of the Deans Valley River is of significant archaeological importance and the JNHT strongly recommends preserving the Taino site for prosperity, possibly as a research site and integrating it into the overall development plan for future study and public education (Jamaica National Heritage Trust, 2023). Therefore, the following measures are recommended, which must be agreed upon with JNHT: • The Taino archaeological site should be delineated by the JNHT to ensure the developer is aware of its boundaries. • The developer must adhere to JNHT guidelines, with JNHT present on-site during any

Operational Phase

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
Physical	***Drainage***	Potentially improved drainage	i. Monitoring and Maintenance: Establish a comprehensive monitoring program to regularly assess the functionality and efficiency of the drainage system. This includes inspecting swales, open channels, and retention ponds to ensure they are free from obstructions and operating as designed. ii. Training and Awareness: Conduct training sessions for maintenance staff and relevant stakeholders on the proper upkeep of drainage infrastructure. This ensures that personnel are equipped to identify and address any potential issues promptly.
	Water Quality - Freshwater	Potential reduction in water quality Potential improvement in water quality	i. Manage Runoff and Sedimentation: In addition to implementing effective stormwater management systems, such as those proposed in the project description, establishing vegetated buffer zones along water bodies can help filter runoff before it reaches rivers or streams. ii. Proper Waste Disposal and Chemical Management: Ensure that all waste materials, including chemicals, oils, and cleaning agents, are disposed of properly and stored securely in designated areas. Regularly inspect storage areas to prevent leaks or spills. Using non-toxic, biodegradable cleaning products and avoiding harmful chemicals on hotel grounds can significantly reduce pollution risks. iii. Maintain Groundwater Protection Measures: To prevent groundwater contamination, ensure that all hazardous substances, such as fuels, oils, and lubricants, are safely stored and handled. Implement spill prevention and response procedures to minimize the risk of contamination. Consider using environmentally-friendly alternatives in hotel operations, such as green cleaning products and non-toxic pest control methods. iv. Control Chemical Use: Following the approach taken for the golf operations, reduce the use of harmful chemicals on hotel grounds, such as pesticides and fertilizers, by adopting organic landscaping practices. Implement integrated pest management techniques and use native plants to reduce the need for chemical treatments. v. Monitor Water Quality: Regular water quality monitoring can help detect and address any contamination issues early. Monitoring should include both surface and groundwater sources to track potential pollutants, such as chemicals or heavy metals, and assess the overall health of aquatic ecosystems. vi. Staff Training and Guest Awareness: Train hotel staff on best practices for waste management, chemical handling, and water conservation. Educate guests about the importance of protecting local water resources and encourage eco-friendly behaviour, such as using less water and minimizing waste.
	Water Quality - Marine	Potential reduction in water quality Potential improvement in water quality	i. Develop and enforce guidelines for fuelling and maintenance procedures to minimize the risk of fuel spills and oil leaks. Provide regular training for boat operators on best practices for spill prevention and emergency response. ii. Limit activities that disturb the seabed, such as anchoring in sensitive areas. iii. Establish a regular water quality monitoring program to track any changes in water clarity and quality, particularly in areas with high boating and water sport activity. iv. Educate boaters and water sports enthusiasts on the environmental impacts of their activities and the importance of responsible practices to protect the marine environment. v. Create designated zones for boating and water sports to minimize impact on ecologically sensitive areas, such as seagrass beds or coral reefs.
	Wave Climate	Potential reduction in wave climate	No mitigation required.
	Currents and Sediments	Reduction in potential for resuspension of settled sediments	No mitigation required.
Natural Hazards	***Earthquake and Seismicity***	Located in an area with low spectral response for accelerations	i. Building Design and Inspections: a. Ensure that all structures are designed to meet earthquake-resistant standards, including seismic bracing, flexible foundations, and materials that can absorb and dissipate seismic energy. b. Conduct regular inspections of infrastructure and buildings to identify potential vulnerabilities related to seismic activity. Routine maintenance and reinforcement should be prioritized, especially in areas that are near fault lines. ii. Emergency Preparedness Awareness and Plans: a. Develop and implement emergency response plans that include evacuation procedures, communication strategies, and protocols for dealing with post-earthquake damage. b. Educate workers and residents on earthquake preparedness, including how to respond during and after an earthquake. Regular drills and training sessions will ensure everyone is ready in case of a seismic event.
	Hurricane Waves and Surge	Reduction in wave heights in the sheltered area behind structures.	To address this significant vulnerability described, it is recommended to implement a vegetated berm with a 1 in 5 slope and a crest height of 2.3 meters above MSL at the back of the beach. This berm will help reduce the impact of storm surges on the property. Additional mitigation measures to consider include: i. Design Standards: Adhere to robust engineering standards that account for both wave-induced currents and storm surge dynamics. Implementing these standards ensures that coastal developments withstand extreme weather events while maintaining beach stability and minimizing risks to adjacent structures. ii. Monitoring and Adaptive Management: Establish a monitoring program to assess the performance of coastal structures over time. This programme should include regular assessments of wave conditions, sediment transport patterns, and the effectiveness of mitigation measures. Adaptive management strategies can then be employed to adjust designs or operations based on observed performance and evolving environmental conditions.
	Beach Stability	Potential increase in stability	The concentration of erosion around the groyne tips highlights areas requiring structural stabilisation. Using geogrids and geotextile will help mitigate seafloor instability and reduce potential scouring in these zones. No further mitigation required.

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
	Flooding	Potential reduction in flooding	Suggested mitigation measures to reduce the impact of stormwater intrusion include raising site levels in these areas by at least 0.45m, constructing a protective berm along the western boundary of the Dean Valley River in the flood-prone zone to a height of no less than 0.7m, or placing the potentially affected structures on stilted foundations, elevating them above the 0.47m flood level. To prevent damage associated with sediment loads, it is essential that the river channels area capable of managing both peak discharge from rainfall and the sediment load. Without this capacity, the channel could become overwhelmed, leading to shifts and sediment deposition that may cause damage.
Biological	***Terrestrial Habitats***	Potential rehabilitation and restoration	i. Ongoing Monitoring and Adaptive Management: A robust monitoring program may be implemented to assess the health of local ecosystems and the success of conservation efforts. Adaptive management practices should be employed to address any unforeseen impacts or to adjust strategies based on new ecological data, ensuring long-term sustainability. ii. Employee and Guest Education: Educate hotel staff and guests about the importance of protecting local biodiversity, encouraging environmentally conscious behaviour such as avoiding littering, minimizing light pollution, and respecting natural habitats.
	Wetlands and Mangroves	Potential rehabilitation and restoration Potential increase of mangrove carbon sequestration and storage	i. Conservation Area Boundaries & Monitoring Stations: a. The boundaries of the Conservation Areas, which were previously marked with visible line-of-sight markers during the construction phase, will be enhanced to promote responsible use during the operational phase. b. These markers will be numbered and act as permanent monitoring stations to track and assess any impacts from hotel operations, e.g. such as water quality, habitat stability, and overall biodiversity. Monitoring will help identify any deviations from conservation goals, ensuring swift corrective actions if necessary. c. Enhance the boundary markers with educational signs, maps, lookout points, and relevant laws and regulations, which may inform persons about the ecological importance of the wetlands and promote responsible behaviour. This should be done in accordance with the Forestry Department's Forest Reserve Jamaica's National Mangrove & Swamp Forests Management Plan. d. Conduct periodic inspections of the markers and monitoring stations to ensure they remain functional and provide the intended support for wise use and conservation management. ii. Management of Pruning and Vegetation: a. Pruning within conservation areas shall be restricted to the inner extent of these markers. b. Any mangrove pruning will only be performed by trained professionals or certified mangrove arborists, in adherence to best practices outlined by the National Environmental and Planning Agency (NEPA). Pruning will be done according to guidelines that ensure the health and integrity of the mangrove ecosystem. c. Ongoing vegetation management will focus on maintaining ecological balance without compromising the wetland's stability or biodiversity. iii. Protection from External Disturbances: a. Conservation Areas located near main roads, highways, settlements, and communities will be tastefully fenced to prevent unplanned encroachment and reduce the risk of illegal activities such as dumping or damage from accidental disturbances. This fencing will blend with the environment and serve as a clear boundary for conservation areas. iv. Relocation of Species & Ongoing Maintenance: a. Any relocated epiphytes or other species within the Conservation Areas will be carefully monitored for survival and adaptation. This may include regular watering, maintenance, and adjustments to the care plan to ensure the successful establishment of these species in their new environment. b. Regularly track the health of relocated species and implement additional measures as needed to support their viability, ensuring that these species continue to thrive and contribute to the biodiversity of the wetlands. v. Public Engagement and Compliance: a. Provide clear educational signage and informative materials on-site to help visitors understand the importance of the Conservation Areas and adhere to rules and regulations. This can include messages about respecting boundaries, minimizing disturbances to wildlife, and the legal protection of certain areas. b. Any tours or activities conducted within or near the Conservation Areas should be guided to ensure that visitors follow the designated paths, respect the ecosystem, and are educated on the best practices for preserving the wetlands. c. Work with local authorities to enforce rules regarding access to Conservation Areas, ensuring that violations, such as unauthorized entry or harm to the ecosystem, are promptly addressed. vi. Long-Term Sustainability & Management: a. Develop a management plan to ensure long-term sustainability; a draft outline for a Wetland Management Plan is provided in section 8.2.1. b. Ensure that the management plan is adaptable and flexible, allowing for updates based on changes in the wetland ecosystem. Regular reviews should be conducted to adjust the management strategy based on monitoring results and emerging threats to the conservation areas. c. Engage the surrounding communities and local stakeholders in the ongoing protection and management of the Conservation Areas. This could include joint monitoring efforts, awareness programs, and community-led conservation initiatives.
	Freshwater Habitats	Potential reduction in water quality and habitat	Recommendations made for the construction phase also apply during operation as well as those outlined for freshwater quality.
		Potential long-term shading of seagrass	Recommendations made for the construction phase also apply during operation.

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
	Seagrass and Benthic Habitats	Potential improvement in water quality Potential disturbance to marine fauna Potential introduction of artificial structures altering benthic composition	
	Sea Turtles	Potential disorientation of sea turtles and hatchings from lighting Potential deterrence to use nearby nursery, breeding, and foraging grounds	I. All staff and workers should be sensitized to the sensitive ecosystems and species in the area, in particular turtles. The beaches should be inspected daily for any signs of turtle activity. If a nest is suspected or found; a. The nest should be cordoned off and remain undisturbed until it is hatched in approximately 60 days. b. All activity nearby should stop until an expert can determine if there is a nest and how to relocate the eggs if the nest is located in a highly vulnerable area. II. Turtle-friendly lighting and light positioning (if any) should also be placed on the overwater villas. Hotel operators should also educate their guests on sea turtle conservation and the correct actions to take if a sea turtle is observed nesting on the beach. III. The Hotel should also develop a Sea Turtle Monitoring programme which would include tagging and hatchling release. This could add to their attraction offerings (turtle watching).
Socioeconomic / Cultural	***Employment***	Expected to create 1,000 direct jobs, along with 1,840 indirect and 695 induced jobs	i. Inclusive Hiring Practices: To ensure the maximum benefit to the community, it is crucial to prioritize inclusivity in hiring practices. Addressing barriers faced by individuals from diverse sexual orientations and gender identities is essential to ensuring equitable access to employment opportunities and fostering a more inclusive workforce environment. This approach will not only maximize the positive impact of job creation but also contribute to greater social equity and cohesion in Lucea. a. Anti-Discrimination Policies: Develop and enforce strict anti-discrimination policies that ensure fair hiring practices regardless of gender, sexual orientation, or gender identity. b. Diverse Recruitment Channels: Use diverse recruitment channels to reach a broad range of candidates, ensuring that job opportunities are accessible to all segments of the community. To ensure inclusive and equitable employment practices and to mitigate potential negative impacts, the above measures should be implemented. It should be noted that, despite the implementation of measures to prevent Sexual and Gender-Based Violence (SGBV), including sexual harassment, exploitation, and abuse, there remains a potential for such incidents to occur. Therefore, standard response procedures should be employed to address any incidents of SGBV swiftly and effectively. ii. Training and Development: a. Comprehensive Training Programs: Implement training programs that provide all employees with the necessary skills and knowledge, ensuring they can perform their roles effectively and progress in their careers. b. Diversity and Inclusion Training: Offer training on diversity and inclusion to all staff members to foster a supportive and respectful workplace culture. iii. Community Engagement: a. Outreach Programs: Conduct outreach programs to engage with local communities, particularly marginalized groups, to inform them about job opportunities and the inclusive hiring process. b. Feedback Mechanism: Create a feedback mechanism for employees and community members to voice concerns and suggestions regarding employment practices and inclusivity.
	Electricity Supply	With renewable energy from solar field and emergency backup generators, will reduce dependency on the grid and cut emissions by over 50%	i. Reduction of Grid Dependency a. To mitigate potential issues related to solar power generation (e.g., intermittency), energy storage solutions or backup generators should be employed to ensure consistent power supply. b. Any excess power generated by the solar field can be fed back into the grid, potentially offsetting other energy demands in the area. ii. Energy Efficiency a. The use of energy-efficient LED fixtures for both interior and exterior lighting throughout the hotel, resort, and villas will reduce power consumption and decrease the carbon footprint. Motion sensors, dimmable drivers, and daylighting controls should also be considered. b. The installation of energy management systems will help monitor and control electricity use across the properties. These systems will ensure that power is used efficiently and only, when necessary, further reducing unnecessary energy consumption. iii. Sustainable Materials and Waste Management a. Proper disposal and recycling measures will be put in place for electrical components, including old transformers, batteries, and other materials, ensuring they are disposed of in an environmentally responsible manner. All electrical waste will be handled in compliance with local regulations to prevent contamination and pollution. b. The project will utilize sustainable and low-impact materials wherever possible, including eco-friendly wiring and electrical components that are energy-efficient and non-hazardous. iv. Electromagnetic Field (EMF) Management a. Given the installation of medium-voltage power lines and transformers, the project will adhere to local and international standards for electromagnetic field (EMF) emissions, ensuring that the levels of EMF exposure around the electrical systems are within safe limits for the health of residents, workers, and visitors. b. Transformers, power lines, and electrical systems will be strategically located to minimize EMF exposure to sensitive areas such as guest rooms and recreational zones. v. Water Conservation and Management

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
			a. Energy-efficient water heating systems (such as solar water heaters or high-efficiency electric water heaters) will be used to minimize electricity demand for hot water production, reducing the overall energy load on the electrical system. b. Integrated water leak detection systems will be incorporated into the plumbing infrastructure to prevent water wastage and reduce unnecessary energy consumption for pumping water. vi. Community Engagement and Awareness a. Guests and residents will be educated on the importance of energy conservation through signage and educational materials. This will help promote energy-saving habits such as turning off lights and appliances when not in use. b. Incentives may be offered to encourage the use of renewable energy sources (e.g., solar-powered devices) or participation in energy-saving programs. vii. Climate Change Resilience a. The design and construction of the electrical systems will take into account the potential effects of climate change, such as increased frequency of storms or extreme heat events. The systems will be built to withstand extreme weather conditions, and backup power systems will be sized to handle peak loads during these events. b. The solar field not only contributes to sustainability but also provides resilience by offering an alternative power source in the event of grid failure caused by climate-related incidents.
	Water Supply	Incorporating conservation strategies will minimize impact on the public water supply	i. Supplementary Water Sources: Explore the development of local water sources, including wells and nearby rivers, to supplement the water supply. This approach will help reduce pressure on the existing public water system. ii. Monitoring and Reporting: Implement regular monitoring of water usage to assess the effectiveness of conservation measures and quickly address any emerging issues.
	Wastewater	Comprehensive wastewater treatment plant will manage and treat wastewater	No mitigation required.
	Solid Waste	Potential increase, but comprehensive waste management plan will promote sustainability	i. Storage Bins and Skips: a. Strategic Placement: Place solid waste storage bins and skips at strategic locations throughout the hotel premises to ensure easy access for both guests and staff. b. Adequate Capacity: Ensure that the bins and skips have adequate capacity to handle the expected volume of waste without overflow. c. Secure Bins and Skips: Use bins and skips designed with secure lids to prevent access by vermin and other pests, minimizing health risks and maintaining hygiene standards. ii. Monitoring and Cleanup: a. Beach Garbage Monitoring: Regularly monitor and clean the beach area to prevent littering and maintain the aesthetic appeal of the coastal environment. b. Routine Inspections: Conduct routine inspections of the hotel grounds to promptly address any waste management issues. iii. Waste Collection and Disposal: a. Private Contractor Engagement: Contracting a private contractor to collect solid waste in a timely fashion to prevent a build-up. b. Scheduled Collections: Establish and adhere to a regular waste collection schedule to ensure consistent and efficient removal of waste. c. Proper Disposal: Ensure that all collected solid waste is disposed of at approved disposal sites, complying with local regulations and environmental standards. d. Verification System: Develop a ticketing system between the hotel (Permittee) and the solid waste contractor to ensure effective management and verification of waste disposal. e. Record Keeping: Maintain records of waste collection and disposal activities to monitor compliance and identify areas for improvement. iv. Waste Sorting and Recycling: a. Facilitate Sorting: Implement a waste sorting system to separate plastics, paper, glass, organic waste, and other recyclables. Provide clearly labelled bins to encourage proper waste segregation. b. Promote Recycling: Partner with local recycling programs to ensure that sorted materials are recycled and not sent to landfills. v. Employee and Guest Education: a. Training Programs: Provide training for staff on waste sorting, handling, and disposal procedures to ensure effective implementation of the waste management plan.
	Vehicular Traffic	Potential traffic increases and slight decline in performance since corridors and intersections will generally maintain acceptable levels of service.	i. Development Entrance: a. The entrance to the development should be widened to accommodate a turning lane for vehicles approaching from the west. This lane should include 50 meters of storage and a 45-meter taper to ensure efficient and safe entry into the development. b. To facilitate safe turning from the east, a deceleration lane should be provided, extending 50 meters in length. ii. Signage: To alert drivers of the intersection and the presence of the development, appropriate signage should be installed on both approaches to the development. Signs should be placed at 50-meter and 100-meter intervals from the entrance, ensuring that drivers are adequately warned of the intersection ahead. This will help reduce abrupt manoeuvres and improve overall traffic safety in the area.
	Maritime Traffic	Potential increase in maritime activities	i. Visible Marker Buoys: Installing permanent, highly visible marker buoys around overwater rooms to clearly indicate their presence and boundaries to maritime vessels. ii. Navigation Lights: Implementing turtle-friendly lighting and strategically positioning lights on overwater structures to ensure visibility for marine vessels during nighttime operations, reducing the risk of collisions. iii. Clearance and Safety Zones: Establishing and maintaining clearances and safety zones around overwater rooms in accordance with maritime regulations to facilitate safe navigation and prevent congestion.

CATEGORY	RECEPTOR	IMPACT	RECOMMENDED MITIGATION
			iv. Monitoring and Compliance: Regular monitoring of maritime traffic patterns and compliance with navigational safety standards to assess any potential impacts and adjust mitigation strategies as necessary. v. Public Awareness and Education: Conducting outreach and education campaigns to inform maritime stakeholders about the presence of overwater rooms, their potential impacts on navigation, and the importance of adhering to safety measures.
	Recreation	Introduction of a variety of new recreational amenities	i. To mitigate the potential displacement of existing river-based activities enjoyed by local river goers, the resort should explore opportunities to incorporate or support these activities in a modified form. For example, designated areas along the river could be set aside for local residents, or the resort could offer river-based experiences like kayaking or eco-tours for both guests and the community. Engaging with local stakeholders to understand their needs and ensuring that traditional recreational activities are respected will help minimize disruptions. ii. While the development introduces new recreational amenities, such as golf, tennis, polo, and art/music facilities, it is important to ensure that local residents have access to some of these amenities. This could be achieved through discounted rates, special access hours, or partnership programs. By involving the local community in the resort's recreational offerings, the development can create a shared space for both visitors and residents, fostering positive relationships and ensuring that the development benefits the community. iii. The introduction of new recreational activities should be carefully planned to ensure they align with the region's environmental and cultural values. For instance, golf courses and polo fields should be designed with sustainable landscaping practices, using native plants, and minimizing water and chemical usage. Additionally, cultural sensitivity should be integrated into the resort's art and music programs, highlighting local traditions and talents, and ensuring that these offerings resonate with both visitors and the local community. iv. The resort can actively encourage guests to explore surrounding areas by providing information about nearby attractions, including local recreational sites, historical landmarks, and nature reserves, encouraging them to venture beyond the resort and explore the broader area. This can be done by offering guided tours, community-based excursions, or cultural experiences that highlight the unique aspects of the local community and wider Jamaican landscape. For example, guests could be invited to visit nearby villages, engage in local cultural festivals, or participate in workshops that teach traditional crafts, music, or cooking. This would allow guests to experience the authentic local lifestyle and create a sense of connection between the resort and the community. v. The resort could partner with local businesses, artisans, and cultural institutions to promote their offerings to guests. The resort could host cultural events, such as music performances, dance shows, or art exhibitions, which showcase the talent and traditions of the local community. These events could be open to both resort guests and local residents, fostering interaction and mutual appreciation.
	Tourism	Enhances region's tourism by offering high-quality accommodations and focusing on eco-tourism and sustainable practices	It is important to carefully manage the development to ensure that the unique character, ecological significance, and protected status of Bluefields Bay is preserved. The hotel should complement the existing eco-tourism initiatives and align with conservation efforts in the area. Responsible development practices will help maintain the delicate balance between tourism growth and environmental protection, ensuring that the region continues to attract visitors seeking authentic and sustainable experiences.
	Fisheries	May not directly affect fishing activities. Offers opportunities to support marine conservation initiatives such as coral nurseries and artificial reefs. May increase fish diversity	i. Collaboration with Local Fishermen and Fishery Organizations: a. The resort can work closely with the Bluefields Bay Fishermen's Friendly Society (BBFFS) and other local fishery groups to develop a shared management plan for the protection of the Bluefields Bay Fish Sanctuary and surrounding fishing areas. This collaboration should include regular consultations and joint monitoring of fishing activities to ensure the resort's operations do not interfere with fishers' livelihoods. b. As part of its commitment to environmental stewardship, the resort can participate in or fund local marine habitat restoration programs. These efforts would help improve the health of marine ecosystems and support sustainable fisheries. The resort can also consider setting up artificial reefs to enhance local fish habitats. c. The resort can support local fishers by encouraging the use of sustainable fishing techniques and adhering to fishing regulations. This can be achieved by providing fishers with access to resources, such as better equipment or training in sustainable practices, and by offering preferential contracts for sourcing local, sustainably caught seafood for the resort's restaurants. d. To minimize disruption to local fisheries, buffer zones or restricted fishing areas could be established around the resort to protect key marine habitats and ensure that local fishers continue to have access to productive fishing grounds. These zones could be agreed upon through discussions with the local fishery management bodies and stakeholders. e. A comprehensive monitoring program should be implemented to track the impact of the resort's activities on local fisheries. This includes monitoring fish populations, water quality, and habitat health, particularly in and around the Bluefields Bay Fish Sanctuary. Regular reports should be submitted to local authorities and stakeholders, ensuring transparency and prompt action in response to any negative environmental impacts. ii. Environmental Management and Pollution Control: a. The resort should implement a robust environmental management plan (EMP) that addresses potential sources of pollution, such as wastewater, solid waste, and chemical runoff. Regular monitoring of water quality near the sanctuary should be carried out to ensure compliance with environmental standards. iii. Guest Education and Awareness Programs: a. To promote awareness of the local marine environment and the importance of sustainable fishing practices, the resort can develop educational programs for guests. These could include guided tours of the Bluefields Bay Fish Sanctuary, workshops on the region's fisheries and conservation efforts, and opportunities to engage in sustainable tourism activities. This would foster respect for the local fishing community and the preservation of marine resources.

ANALYSIS OF ALTERNATIVES

The discussion and analysis of alternatives aim to explore strategies that minimize environmental impacts while achieving project goals, as required by the National Environment and Planning Agency (NEPA). Eight (8) project alternatives have been identified:

Alternative 1 - The "No-Action" Alternative

The No-Action Alternative evaluates the implications of not proceeding with the project to understand the potential environmental benefits and drawbacks of maintaining the status quo.

Alternative 2 - The Project as Proposed in the EIA

Alternative 2 represents the proposed project in the EIA, featuring a resort, hotel, villas, a golf course, and service facilities, offering ecological enhancements like shoreline protection and fish aggregation devices but with potential drawbacks like construction-related disruptions.

Alternative 3 - The Project as Proposed in the EIA with Rearrangement of 120-key Resort, 200-key Hotel and 100-key Villas and Addition of Lagoon

Alternative 3 is similar to Alternative 2 but involves rearranging the spatial layout and potentially impacting wetland habitats more than Alternative 2.

Alternative 4 - The Project as Proposed in the EIA with Beach Option 1

Alternative 4 includes a different beach layout with nourishment and groynes to enhance the beach area. The main benefit is a larger sandy beach for visitors to enjoy and reduced silt.

Alternative 5 - The Project as Proposed in the EIA with Beach Option 2

This option involves a trade-off where beach reduction is balanced by the addition of river training to reduce silt and debris in the nearshore of the main beach area. Benefits of this concept include reduced overall costs and better management of siltation at the source.

Alternative 6 - The Project as Proposed in the EIA with Beach Option 3 and Addition of Lagoon

Alternative 6 expands on beach nourishment with the addition of a lagoon. The impact on flora and fauna, as well as the potential for smothering and sedimentation of seagrass, is also higher compared to Alternative 2 (project as proposed).

Alternative 7 - The Project as Proposed in the EIA with Golf Course situated to the East

Alternative 7 relocates the golf course to the eastern wetland area, potentially affecting wetland habitats. Other potential impacts are similar to those identified in Alternative 2.

Alternative 8 - Proposed Development with 500-key Hotel and *125 Private Residences without Coastal Works*

Alternative 8 proposes a larger hotel and private residences without coastal works, preserving the marine ecosystem but potentially affecting wetland drainage.

The Preferred Alternative is Alternative 2, as it balances ecological rehabilitation, enhanced tourism, and job creation while minimizing environmental disruption, ensuring long-term success and community engagement.

ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

An Environmental Management System (EMS) is a valuable tool for helping operations managers meet environmental requirements and challenges. It allows companies to assess their performance against environmental indicators, aiding in the achievement of environmental goals. A well-structured EMS integrates environmental management into daily operations, long-term planning, and quality assurance processes. It is recommended to monitor various parameters before, during, and after project implementation (construction and operational phases) to track any negative environmental impacts and propose corrective or mitigation measures. These parameters should include, but are not limited to, key environmental factors relevant to the project:

1) Water Quality to include but not be limited to:
    a. Nitrates
    b. Phosphates
    c. BOD
    d. pH
    e. TSS
    f. Turbidity
    g. TDS
    h. Faecal Coliform
2) Noise
3) Sediment Loading
4) Coral and Seagrass
5) Traffic
6) Maritime Operations
7) Solid Waste Generation and Disposal
8) Sewage Generation, Treatment and Disposal
9) Equipment Maintenance
10) Health and Safety

Other specific Management/Monitoring Plans applicable to this project include:

- **Wetland Management Plan**: outlines actions for the conservation, restoration, and sustainable use of wetland areas, integrating conservation principles with land use. This plan aims to preserve ecological health while accommodating development and eco-tourism opportunities.
- **Benthic Management Plan**: focuses on monitoring coral reefs and seagrass beds, water quality, and sediment dispersal before, during, and after construction. Activities, including surveys and water quality monitoring, conducted by trained marine scientists and divers. Monthly roving surveys will observe coral health, seagrass conditions, and sedimentation impacts. Monitoring will be integrated into general construction monitoring, with immediate reporting of significant issues such as marine disease outbreaks to the National Environment and Planning Agency (NEPA).

CONCLUSIONS AND RECOMMENDATIONS

The proposed Paradise Park Resort Development is a major investment in the tourism industry, though it presents environmental challenges. Issues such as habitat loss, water quality, and sedimentation have been identified; however, with the implementation of effective mitigation strategies and management plans, these negative impacts will be minimized, ensuring long-term sustainability. The project is anticipated to drive economic growth, generate employment, and strengthen the local tourism sector.

Recommendations for sustainable development include strict adherence to mitigation measures, the establishment of a long-term environmental monitoring program, and adaptive management to address unforeseen impacts. Ongoing communication with local stakeholders, including the community and regulatory bodies, is crucial for success. Conservation initiatives such as mangrove restoration and artificial reef creation, along with promoting low-impact tourism practices, will further protect ecosystems. By implementing these measures, the project can balance economic development with environmental sustainability, positioning Paradise Park Resort as a model for responsible coastal tourism.

1.0 INTRODUCTION

1.1 PROJECT BACKGROUND AND CONTEXT

The proposed Paradise Park development is envisioned as a sustainable luxury resort, located on Jamaica's south coast in Westmoreland, approximately 3 km east of Savanna-La-Mar (Figure 1-1). The project area spans a total of 1,120 acres (4.5 sq. km, 453 hectares) and is predominantly flat with a rich diversity of ecosystems and natural environments, including mangroves, swamps, forested areas, beaches, rivers, and grasslands (Plate 1-2 and Plate 1-2). The development is designed to harmonize with the rich ecosystems and natural beauty, offering a high-end resort experience with luxury accommodations, a golf course, wellness facilities, and recreational amenities, all while prioritizing sustainability and minimizing environmental impact.

Plate 1-1 View of Paradise Park looking south towards the southwestern coastline, with fields in the foreground, the beach along the shore, and mangroves on the headland.

Plate 1-2 View of the eastern section of Paradise Park looking east, with fields in the foreground and various forested areas in the background.

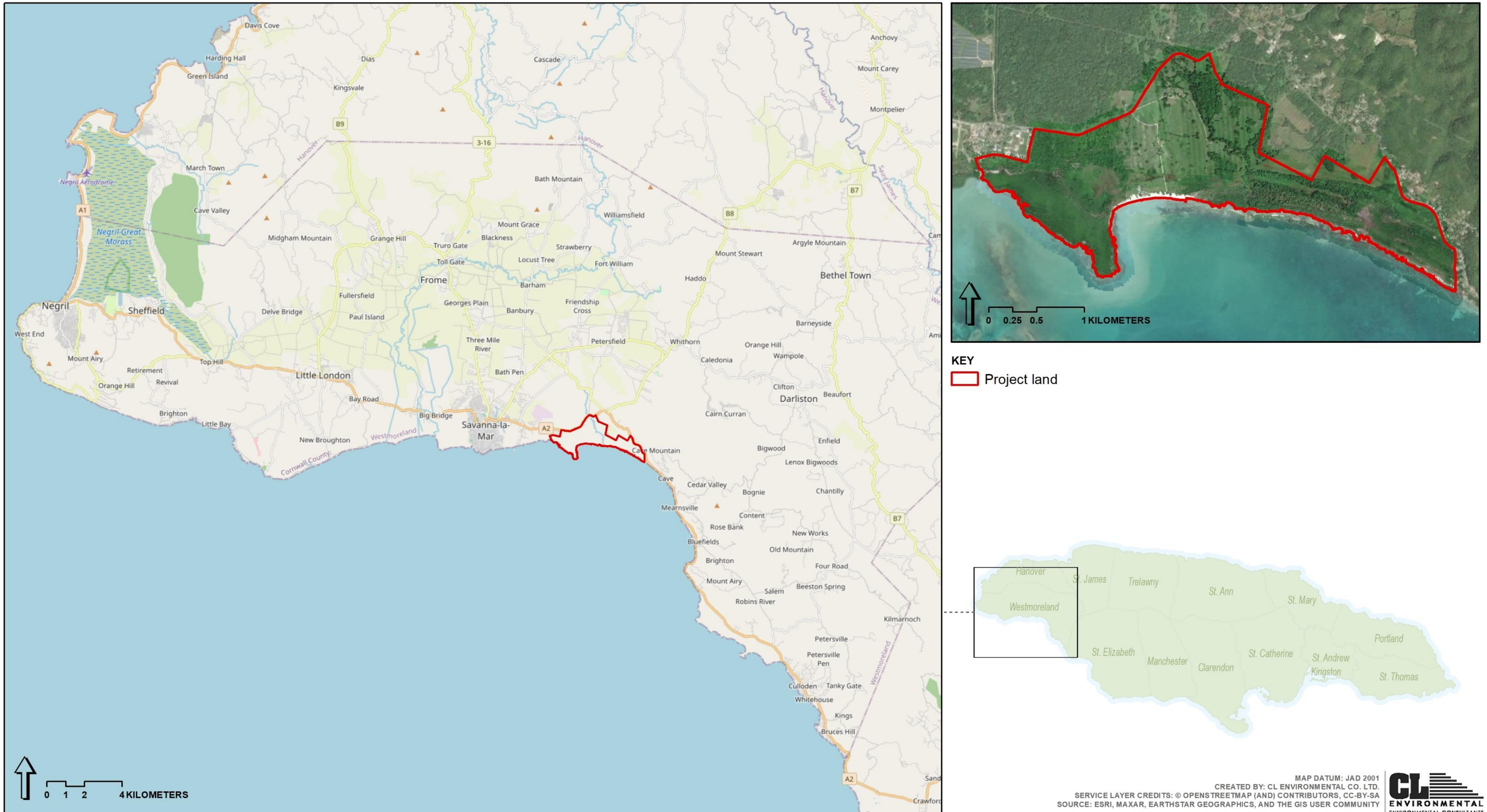


Figure 1-1 Location of the proposed Paradise Park project area, Westmoreland, Jamaica

Paradise Park is a visionary development designed to set a new benchmark for sustainable tourism and responsible land use in Jamaica. Built to the highest LEED standards, the project embodies a forward-thinking approach by integrating life-cycle materials, superior air quality, renewable energy sources, and water-saving technologies—all aimed at achieving net-zero energy goals. The site will feature a dedicated solar field to power its operations with clean, renewable energy, minimizing its environmental footprint while supporting sustainable practices.

This low-density development is a testament to a deep commitment to eco-conscious design, ensuring that it aligns harmoniously with Jamaica's rich biodiversity. The project prioritizes not only the preservation of the island's unique ecosystems but also the enhancement of the well-being of its future residents, guests, and surrounding communities. It aims to foster a balanced relationship between development and nature, contributing to the protection of local wildlife and natural habitats while creating a high-end, environmentally responsible tourism experience.

Jamaica stands at a pivotal moment in its history, with its strategic geographic location and a government dedicated to infrastructure development and economic growth. This makes the island an ideal destination for transformative investments. As Jamaica embraces this new era of opportunity, JDV and its team are uniquely positioned to lead the charge, blending international expertise with a deep appreciation for the island's heritage. The Paradise Park Resort Development is not just a hospitality project—it is a statement about the future of sustainable tourism in the Caribbean, one that balances luxury with ecological responsibility.

The project aligns with the Government of Jamaica's land use and development policies, serving as a model for sustainable tourism that prioritizes conservation, environmental education, and responsible stewardship of the land. In doing so, it aims to achieve Net Zero Energy and Carbon Neutrality, setting a new standard for sustainable design in the region. Paradise Park seeks to create an immersive hospitality experience, one that blends Jamaica's stunning natural beauty with an unwavering commitment to ecological preservation.

When completed, Paradise Park will redefine the luxury resort experience in Jamaica, offering guests a destination that integrates the island's cultural heritage and natural landscapes with innovative, sustainable practices. This groundbreaking development will not only elevate Jamaica's global standing but also ensure lasting benefits for its people and communities, marking the beginning of a new chapter in responsible tourism in the Caribbean.

1.2 SCOPE OF WORK

The Natural Resources Conservation Authority Act (NRCA) of 1991, along with subsequent legislation and regulations, mandates that individuals pursuing new developments in specific categories obtain a permit. Additionally, the National Environment and Planning Agency (NEPA) requires the completion of an Environmental Impact Assessment (EIA), with the approved Terms of Reference (TORs) for this proposed development outlined in **Error! Reference source not found.**.

The EIA process followed a structured approach to assess the potential environmental impacts of the proposed development, in line with the approved TORs. This process involved identifying, predicting, and evaluating the possible effects of the project on the environment, including natural resources, ecosystems, communities, and human health. The primary objective of the EIA is to ensure that development is conducted sustainably, minimizing adverse environmental impacts while optimizing social and economic benefits.

In accordance with the TORs, this EIA report has been prepared following the prescribed structure and includes all required information as stipulated.

1.3 STUDY APPROACH

1.3.1 Approach and Data Sources

The EIA includes several essential components, each critical to providing a thorough assessment of the project's environmental effects. These components include scoping, baseline data collection, impact prediction and assessment, mitigation and management measures, public consultation and participation, and monitoring plans. Within these broader categories, specific environmental aspects are considered, including physical, biological, natural hazard, socio-economic, and cultural/heritage factors. The methodologies used are tailored to each of these domains and are described in detail within the relevant sections of the report.

The approach integrated a comprehensive mix of methods to ensure robust analysis and reliable results. This included primary and secondary data collection and subsequent data analysis techniques such as laboratory analyses, statistical modelling, and spatial analysis. This multi-faceted approach provided a thorough understanding of the baseline environment (section 4.0) and established a strong foundation for predicting potential impacts and recommending mitigation measures (section **Error! Reference source not found.**).

For all aspects of the environment, literature review was essential to provide a comprehensive understanding of existing research and establish the foundation for the current investigation. In the case of this project, the area may be described as data-rich due to the extensive information available from academic sources, and in particular studies conducted by Missouri State University throughout Bluefields Bay and its surrounding areas. The wealth of data not only enhanced the study's context but also ensured that the findings were firmly based on a thorough understanding of previous research and the current state of knowledge in the field.

Another important element of the EIA approach involved engaging with various agencies, primarily to inform them about the ongoing EIA process and to collect relevant data. Multiple agencies were approached to request information and obtain their feedback on the project. The responses received were highly valued, and all the information shared has been incorporated into the appropriate sections.

Geographic Information Systems (GIS) played a vital role in managing, analysing, and visualizing spatial data. Geospatial data were sourced from various organizations, including the Mona GeoInformatics Institute, Social Development Commission (SDC), Forestry Department, Planning Institute of Jamaica (PIOJ), Water Resources Authority (WRA), The Nature Conservancy (TNC), and NEPA. In addition, supplementary data were obtained from the 1984 national topographic maps (metric series) and more recent sources, such as Google Maps and satellite imagery. Specifically, for this project, a 10-band image mosaic captured using the RedEdge-MX Dual Camera Imaging System mounted on a Quantum Systems Trinity F90 Plus drone in October 2023 served as the primary reference imagery. This high-resolution, image provided a comprehensive view of the entire project area including nearshore areas, enabling detailed classification of land cover types and benthic features, as well as he computation of vegetation indices.

1.3.2 Study Area

The overall study area for the EIA is defined by a 6 km radius from the project boundary, covering a total area of 193.1 km² (Figure 1-2). This complies with the Terms of Reference (TOR) requirements, which specify that the study area should extend at least 5 km from the property boundaries, while also capturing the Bluefields Bay Special Fishery Conservation Area. While the 6 km radius serves as the general study area for evaluating various physical and biological environmental receptors, the study area for the socio-economic assessment is expanded to a 10 km radius, and for the perception survey catchment area, a radius of 5 km is utilised.

1.3.3 Assumptions and Limitations

An EIA is a structured process that evaluates the potential effects of proposed project activities on the existing environment. Its primary objectives are to identify and predict significant adverse impacts and recommend measures to mitigate those impacts. However, the effectiveness of an EIA is influenced by several inherent assumptions and limitations.

Key assumptions include reliance on accurate baseline data and the ability to predict environmental impacts using established models and methodologies. These assumptions are essential for assessing current environmental conditions, such as water quality, air quality, and biodiversity, as outlined in Section 4.0 of the assessment. The existing environment described serves as the baseline from which potential impacts will be assessed. This baseline represents the conditions observed at the time of the studies and surveys. It is important to note that some of the data reflects conditions recorded prior to Hurricane Beryl (July 3–4, 2024). Additionally, large-scale events and weather patterns have influenced data collection, contributing to variations in the observed conditions.

Environmental data can vary both spatially and temporally, prompting efforts within the EIA process to gather a broad range of current and historical information to capture these variations. In situations where direct data collection is difficult, predictive models are used to estimate conditions. The assumptions underlying these models—such as their reliability and accuracy—are crucial for predicting potential impacts and formulating effective mitigation strategies.

Stakeholder engagement is a key component of the EIA process, ensuring that all relevant concerns are addressed and that diverse perspectives are incorporated. However, differences in stakeholder views about what constitutes significant environmental impacts can complicate the assessment. While it is assumed that stakeholders, including local communities, industry representatives, and regulatory bodies, provide comprehensive and representative feedback, some responses may be influenced by biases. Furthermore, the interpretation of data and the assessment of impact significance are inherently subjective, which can introduce bias into the conclusions.

Recognizing these assumptions and limitations is essential for accurately interpreting EIA results and making well-informed decisions regarding project development and environmental management. To address these challenges, ongoing monitoring and adaptive management strategies are emphasized, ensuring that the potential environmental impacts are continuously reassessed and mitigated, as necessary.

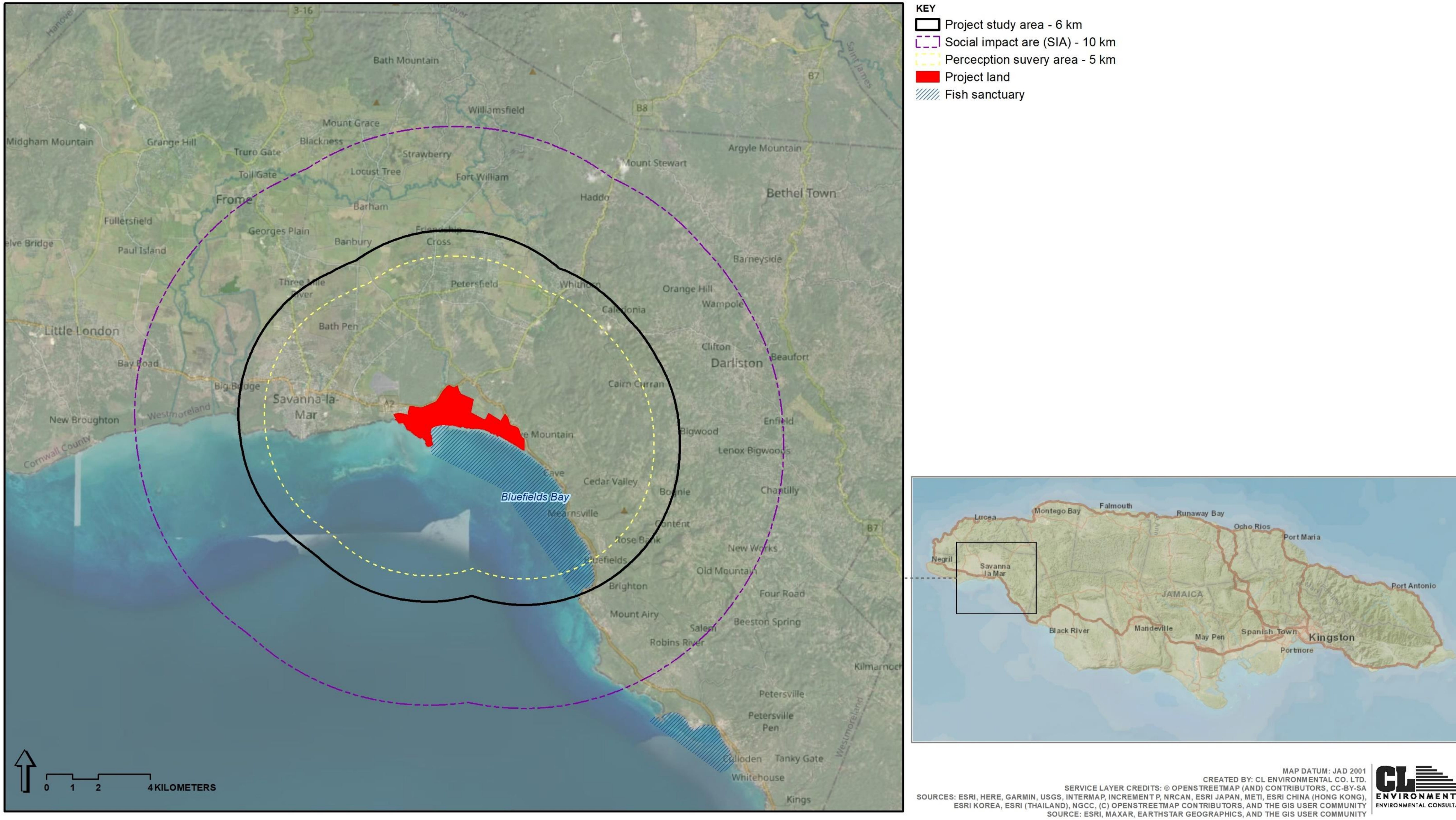


Figure 1-2 Study areas and proposed project location

1.4 ORGANIZATIONAL PROFILES

1.4.1 The Proponent

JDV Paradise Park Limited, otherwise referred to as Paradise Park Development Corporation Limited, is a real estate development and investment company dedicated to preserving Jamaica's rich heritage. By revitalizing historically significant lands and transforming them into sustainable luxury destinations, JDV fosters local economic growth and cultivates diverse, eco-conscious tourism. The team behind JDV is a collective of experienced professionals, many of whom have deep roots in Jamaica or a strong connection to its culture. United by their passion for the island, they are committed to building a future that honours Jamaica's unique character while creating lasting opportunities for its people.

Table 1-1 Contact information for the project proponent and key project consultants

Company and Role	Address	Telephone	Website and Email
JDV Paradise Park Limited *Project proponent*	Unit 1, 214 Mountain View Avenue Kingston 6 Jamaica		office@jdvdev.com
Adrian Smith + Gordon Gill Architecture LLP *Project Architectural Firm*	30 West Monroe Suite 400 Chicago, IL 60603 USA	312 920 1888	info@smithgill.com Adrian Smith + Gordon Gill Architecture
C. L. Environmental Co. Ltd. *Project Environmental Consultant*	20 Windsor Avenue Kingston 5 Jamaica	876.648.7204	info@clenvironmental.com http://www.clenvironmental.com/

On the Paradise Park project, JDV is proud to collaborate with **Adrian Smith + Gordon Gill Architecture**, one of the world's leading architectural firms renowned for their performance-based, ecologically conscious designs. Co-founder Gordon Gill, originally from Jamaica, brings unparalleled expertise and a deep personal commitment to the project. Additionally, **Olazabal Design**, the design studio of Spanish golf legend José María Olazábal, is responsible for the golf course design of the proposed project.

1.4.2 Project Environmental Consultant

C. L. Environmental Co. Ltd., established as a Limited Liability Company in Jamaica since August 2000, offers consultancy services to governmental and non-governmental agencies, both locally and internationally. Our area of expertise covers a comprehensive range of services centred on environmental management and impact assessment, spanning all project phases from pre-construction to operation. C.L. Environmental' s range of services include:

- Environmental Impact Assessments (EIAs)
- Environmental Monitoring

- Environmental Audits
- Seagrass and Coral Relocation/Replanting
- Mangrove Replanting
- Indoor Air Quality Assessments
- Noise Modelling, Measurements and Assessments
- Vibration Assessments
- Occupational Health and Safety Assessments
- Underwater Exploration (ROV)
- Unmanned Aerial Vehicle (UAV) Surveys and Remote Sensing
- Faunal and Floral Studies
- Socioeconomic Surveys, Social Impact Assessments and Stakeholder Consultations

Our multidisciplinary team comprises diverse professionals, including environmental scientists, marine ecologists, environmental engineers, waste management specialists, planners, industrial hygienists, environmental management systems specialists, environmental educators, and quality consultants.

Over the years, our team has successfully undertaken numerous environmental projects, many of which hold national significance. The range of environmental projects executed by CLE encompasses highways and road networks; hotels, residential areas, and commercial developments; power generation facilities; hospitals and health centres; and airports and port facilities. Some of our most recent and notable environmental assessments and monitoring projects include the: Proposed Phase 2 Expansion of Grand Palladium Jamaica & Lady Hamilton Resort & Spa, Lucea, Hanover; Hotel Development at Part of Richmond Estates, St. Ann; RIU Hotels (Aquarelle, Negril, Tropical Bay, Reggae, Mahoe Bay, Palace Montego Bay and Ocho Rios); Royalton (Negril, White Sands and Blue Waters); Excellence Oyster Bay, Trelawny; Karisma Hotels (Azul and Llandovery); Secrets Hotel (Wild Orchid, Breathless and St. James); Montego Bay Perimeter Road, Long Hill Bypass and West Green Avenue and Barnett Street Upgrades, St. James; Princess Hotels and Resorts, Cove, Hanover; Proposed Ian Fleming International Airport Runway Expansion, Boscobel, St. Mary; Southern Coastal Highway Improvement Project (SCHIP); Highway 2000 North South Link: Caymanas to Linstead and Moneague to Ocho Rios segments; Remediation of the American Airlines Flight 331 Accident Site at Norman Manley International Airport; and the Falmouth Cruise Pier Development in Falmouth, Trelawny, among others.

2.0 LEGISLATION AND REGULATORY CONSIDERATION

2.1 ENVIRONMENTAL IMPACT ASSESSMENT FRAMEWORK

2.1.1 Rationale and Basis

An Environmental Impact Assessment (EIA) is "a structured approach for obtaining and evaluating environmental information prior to its use in decision-making in the development process. This information consists, basically, of predictions of how the environment is expected to change if certain alternative actions are implemented and advice on how best to manage environmental changes if one alternative is selected and implemented" (Bisset, 1996).

The basis and rationale of an EIA has been summarised as follows (Wood, n.d.):

- EIA serves a broader goal beyond the mere preparation of technical reports; it aims at safeguarding and enhancing the quality of the environment.
- It involves a systematic procedure to identify and evaluate the impacts of activities on both natural and social environments. Rather than relying on a single analytical method, EIA integrates various approaches tailored to specific issues.
- While not a science in itself, EIA draws upon multiple scientific disciplines, evaluating relationships as they exist in real-world contexts.
- EIA should be considered an integral part of project planning, rather than an optional addition. Its costs should be factored into planning efforts rather than treated as an extra expense.
- Although EIA does not make decisions outright, its findings should inform policy and decision-making processes, influencing the ultimate choices made.
- EIA findings should focus on key or critical issues, elucidating their significance and estimating probabilities in a manner conducive to informing policy decisions.

2.1.2 Development Application and the EIA Process

The National Environment and Planning Agency (NEPA)[1] holds the responsibility for environmental management in Jamaica as stipulated by the Natural Resources Conservation Authority Act (NRCA) of 1991. Since the enactment of the NRCA Act, it has been reinforced by various supporting regulations that took effect in January 1997. The Environmental Permit and License System (P&L) is overseen by NEPA through its Applications Section, introduced in 1997 to ensure adherence to required standards and minimize adverse environmental impacts of all developments. Under the NRCA Act of 1991, the NRCA

[1] NEPA represents a merger of the Natural Resources Conservation Authority (NRCA), the Town Planning Department (TPD) and the Land Development and Utilization Commission (LDUC). Among the reasons for this merger was the streamlining of the planning application process in Jamaica.

possesses the authority to issue, suspend, and revoke environmental permits and licenses. Additionally, it has the power to request Environmental Impact Assessments (EIAs) for permits or activities within prescribed areas (the entire island of Jamaica) where potential adverse environmental effects are anticipated.

nepa
National Environment and Planning Agency

Environmental Impact Assessment Process

The following procedure applies where it has been determined that an environmental impact assessment (EIA) is required for an application.

1. Applicant is advised of the requirement for an EIA to be conducted and provided with a generic Terms of Reference (ToR)
2. The applicant prepares and submits draft ToR for acceptance by the NEPA
3. The NEPA (EIA Sub-committee) reviews draft ToR to determine if it is acceptable
    a. If the ToR is accepted, ToR is stamped by the NEPA as the agreed ToR and the applicant is advised to proceed with undertaking the EIA
    b. If the ToR is not accepted, the relevant comments are provided for the applicant to address (this process continues until the ToR is accepted)
4. Applicant submits draft EIA report based on the agreed ToR
5. The NEPA (EIA Sub-committee) and relevant stakeholders review the draft EIA against the agreed ToR to determine conformance
    a. If the EIA report complies with agreed ToR, NEPA accepts the EIA report, communicates same to applicant, request submission hard copies of the report and advises of the procedure for hosting of the public meeting
    b. If the draft EIA does not comply with the agreed ToR, NEPA advises the applicant of the shortcomings and requires that they be addressed (this process continues until the EIA report is accepted)
6. EIA report posted to NEPA website and hard copies placed at strategic locations to allow access and review by the public
7. EIA report circulation to relevant commenting agencies
8. The process for the public meeting commences as per the "Guidelines For Public Interface Relating To Development Applications"
9. Once public meeting is held and the required timelines have elapsed, the technical review of the application continues as per the established procedures

Source: National Environment and Planning Agency (NEPA)

Figure 2-1 Environmental Impact Assessment process

The NRCA permit process begins with the submission of an application to the Authority, which is reviewed to assess the need for an Environmental Impact Assessment (EIA) and to identify any environmental significance. If an EIA is required, the applicant is notified and provided with a generic Terms of Reference (TOR) (Figure 2-1). The applicant then drafts and submits the TOR to NEPA for approval. NEPA's EIA Sub-committee reviews the TOR and provides feedback until it is accepted. Once approved, the applicant completes the EIA and submits a draft report. NEPA, along with relevant stakeholders, reviews the report for compliance with the agreed TOR. If the report is accepted, NEPA requests hard copies and informs the applicant of the procedure for a public meeting. If the report is not accepted, the applicant is required to address the deficiencies. The EIA report is then published online and distributed to the appropriate agencies.

Public meetings are organized in accordance with the "Guidelines for Public Interface Relating to Development Applications." After the public meeting is held and the required timelines have passed, the technical review of the application proceeds according to the established procedures. The EIA is then submitted for final approval, and if it is not approved, proponents have the option to appeal the decision to the Office of the Prime Minister.

2.1.3 Project-Specific Requirements and Application Status

Starting in January 2022, communication took place with the NEPA Development Assistance Centre (DAC) with regard to the proposed development at Paradise Park. The following summarises the response received from the DAC regarding the proposed project:

1. The site is subject to the requirements, standards, and guidelines outlined in The Town and Country Planning (Westmoreland Area) Provisional Development Order 2018, (Confirmation Notification, 2021). The property is zoned as rural development and agricultural land further inland, with wetlands and mangrove areas along the coastline. It is important to note that the site does not fall within any area designated as a protected area or marine park under the Natural Resources Conservation Authority Act. However, the site has been identified in several studies as ecologically sensitive and has been recommended for future protection.
2. It is crucial that the developer agrees to maintain the conservation/coastal wetland areas as designated conservation zones in order to preserve their ecological functions. Similarly, the areas marked for conservation restoration, buffer zones, and forest and river conservation and rehabilitation must remain undeveloped, as proposed in the submitted plans.
3. The developer must agree to the imposition of a Tree Preservation Order on the remaining stand of mangroves to protect this critical ecosystem.
4. Given the location, nature, size, and scope of the proposed development, an Environmental Impact Assessment (EIA) is required for the entire site. The EIA should evaluate the additional areas of land that may be suitable for the proposed development and should include a natural resource valuation and assessment prior to the development of the property. This assessment should also consider the value of the underdeveloped wetland and the potential loss of this

wetland area as a result of the development. Furthermore, the EIA must confirm that no sensitive marine resources will be impacted by the proposed development. This will allow for the identification of appropriate mitigation measures to minimize environmental impacts.

In addition to the above comments received from the DAC, the following agencies were also contacted by the DAC for their input regarding the proposed development: Water Resources Authority, Mines and Geology Division, Jamaica National Heritage Trust, National Works Agency, Environmental Health Unit - Ministry of Health and Wellness and Westmoreland Municipal Corporation.

Applications for the proposed development were submitted to NEPA on 28 September 2023 for the following NEPA permit categories:

- Hotel: construction and operation of hotel or resort complex of 51 to 500 rooms
- Recreation and entertainment: construction and operation of golf course

Following this, the first draft TORs for the EIA was submitted to NEPA in October 2023. After a hiatus, updated drafts were submitted in August and September 2024 and the final TOR approved in November 2024 (**Error! Reference source not found.**).

2.2 NATIONAL LEGISLATION

2.2.1 Development Control and Planning

2.2.1.1 Town and Country Planning Act (TCP Act), 1957

The Town and Country Planning Act (TCP Act) of 1957 outlines the legal requirements for the organized development of land through planning and provides guidelines for the creation of Development Orders. A Development Order is a legal instrument used to direct development within its designated area, and the TCP Act applies only in regions where such orders are in place. These orders typically consist of land use zoning maps, policy statements, and standards governing land use activities. Within the framework of the TCP Act, protected areas such as Tree Preservation Areas and Conservation Areas are designated in gazetted Development Orders. Development Orders address various matters, including but not limited to: Roads, Buildings, Community Planning, Amenities, Public Services, Transportation and Communications, and Miscellaneous regulations.

The Town and Country Planning Act also institutes the Town and Country Planning Authority, which, in collaboration with the Local Planning Authorities (LPAs), also known as Municipal Corporations, oversees land use zoning and planning regulations outlined in their respective local Development Orders ((Figure 2-2). The Development Order relevant to the proposed project is **The Town and Country Planning (Westmoreland Area) Provisional Development Order 2018, (Confirmation Notification, 2021)** (Figure 2-2) and the **Westmoreland Municipal Corporation** is the local authority with jurisdiction over the proposed project, and from which planning permission will be required. Please refer to section

4.4.8.4 for a detailed description and illustration of the zoning associated with this Development Order. Resulting from consultations with NEPA at the time of project inception, it was stated that in addition to meeting the standards outlined in The Town and Country Planning (Westmoreland Area) Provisional Development Order 2018, (Confirmation Notification, 2021), the proposed development is also required to meet those outlined in the Development and Investment Manual, 2007 [Planning and Development Vol 1 Chapter 20 and 41] (Bennett, 2022). Further, it was strongly recommended by NEPA, that the preparation and development of detailed proposals be guided by the planning and environmental guidelines and standards as outlined in the Technical Information Document (TID), with the planning and environmental parameters being addressed with the assistance and guidance of the relevant professionals.

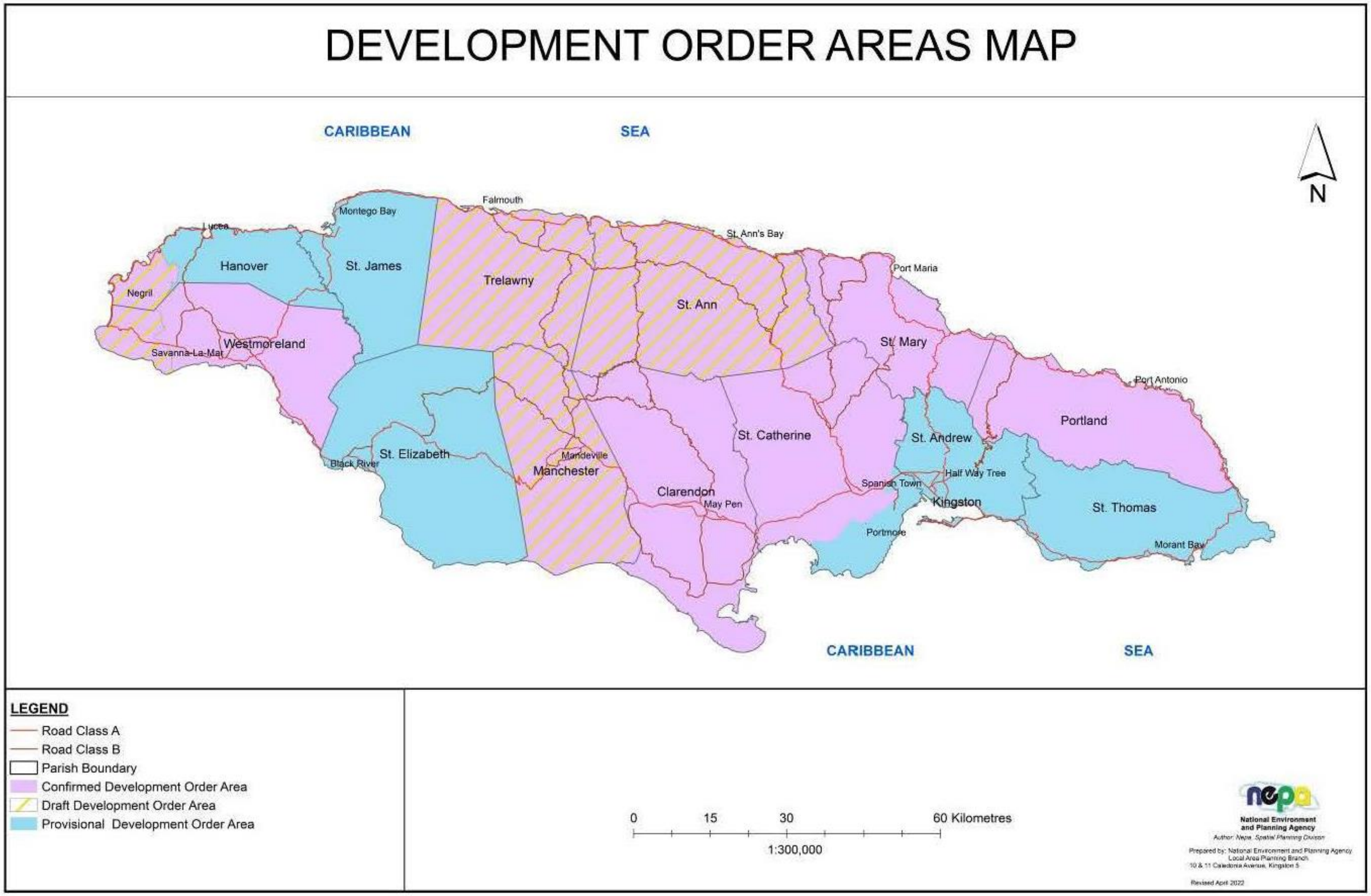
2.2.1.2 Local Governance Act 2016

This Act is a consolidation of the following Acts, which were repealed once the new legislation was enacted: The Parish Councils Act (1887), The Kingston and St. Andrew Corporation Act (1923), The Municipalities Act (2003), and The Parochial Elections (Modifications) Act (1979). This Act introduces new concepts and tenets which reflect a modern approach to local governance, and which strengthen local self-management. Local Authorities (formerly referred to as Parish Councils) are categorised as Municipal Corporations and City Municipalities or Town Municipalities.

The **Westmoreland Municipal Corporation** is the Local Authority with responsibility for development within the study area

2.2.1.3 Building Act 2016

The Building Act 2016 repeals the Kingston and St. Andrew Building Act and the Parish Councils Building Act and makes new provisions for the regulation of the building industry. It aims to facilitate the adoption and efficient application of national building standards (National Building Code of Jamaica) for ensuring safety in the built environment, enhancing amenities, and promoting sustainable development. Any person who proposes to carry out building work must apply to the relevant Local Building Authority (Westmoreland Municipal Corporation) for the appropriate building permit. A person shall not carry out any building work unless the respective building permit has been issued; where applicable, a planning permit has been issued under the Town and Country Planning Act; and the work is carried out in accordance with the building permit, the provisions of this Act, the National Building Code, or of any other regulations made under this Act.



Source: National Environment and Planning Agency

Figure 2-2 Development Order Areas in Jamaica

2.2.1.4 Beach Control Act 1956 and the Beach Control (Amendment) Act 2004

This legislation, enacted in 1956, was designed to ensure the effective management of Jamaica's coastal and marine resources through the implementation of a licensing framework. This system governs the utilization of both the foreshore and the seabed. Additionally, the Act addresses various issues such as shoreline access, fishing rights, public recreation, and the establishment of marine protected areas. Under section 5 of this Act, it constitutes an offense to encroach upon the foreshore or seabed for public or commercial purposes without the appropriate license.

The Beach Control (Licensing) Regulations of 1956 mandate a permit for any activities conducted on beaches, coastlines, or foreshores. Applications for such permits must be submitted to NEPA. Permit requirements include posting a Notice of Application on both the landward and seaward sides of the property, with the notice also served on adjoining neighbours. Members of the Natural Resources Conservation Authority or authorized officers may conduct investigations to ensure compliance with the license and may request the submission of pertinent information.

Furthermore, NEPA must be approached for a BCA (Beach Control Authority) License for the commercial or recreational use of the foreshore and seabed.

2.2.1.5 Overwater Structure Planning Guidelines, 2016

The decision to formulate planning guidelines for overwater structures was prompted by the increasing interest in developing such accommodations within Jamaica's tourism sector. This document focuses on the establishment of overwater structures and also covers the construction of navigational facilities like docks, jetties, piers, and wharfs, as well as encroachments such as groynes, all of which must comply with regulations outlined in the Beach Control Act.

This draft document also includes general guidelines aimed at providing direction for the project proponent regarding the development of overwater structures. Furthermore, it specifies that detailed and specific conditions and guidelines will be furnished on an individual basis as part of the licensing or permit process. While designed to be adaptable, these guidelines are intended to safeguard natural ecological processes and protect marine resources from any adverse impacts resulting from construction-related activities.

2.2.1.6 NRCA Guidelines for the Planning, Construction and Maintenance of Facilities for Enhancement and Protection of Shorelines

This document provides guidance on the NRCA permitting process, environmental considerations, and coastal engineering planning and design for projects aimed at safeguarding and improving shorelines. Through such guidance, the aim is to eliminate or mitigate any undesirable environmental impacts associated with these types of projects.

In the Permitting Procedures section, it is emphasized that certain activities in the coastal zone may lead to specific effects. Therefore, it is crucial for all stakeholders to understand the potential negative effects that may arise from a particular project. Project Sponsors are encouraged to engage with NRCA (NEPA) at the earliest stages of project planning to ensure effective communication and collaboration.

2.2.1.7 Office of Disaster Preparedness and Emergency Management Act 1998

This legislation founded the Office of Disaster Preparedness and Emergency Management (ODPEM), tasked with the primary responsibility of formulating and executing policies and programs to attain and uphold a suitable level of national and sectoral readiness for managing emergency situations. It is imperative for the proposed project to establish collaboration with this agency to develop the requisite emergency response plans concerning natural hazard events, such as hurricanes.

2.2.1.8 Tourist Board (Water Sports) Regulations 1985

These regulations outline the operation and conduct standards for water sports activities, which will apply to the proposed hotel development upon commencement of operation. The regulations cover three categories of water sports: SCUBA diving; parasailing & water skiing, and jet-skiing; and sunfish sailing and board sailing. They include provisions for licensing water sports operations, conducting inspections, and other relevant rules and guidelines.

2.2.2 Environmental Conservation

2.2.2.1 Relevant Plans

Protected Areas System Master Plan: Jamaica 2013 – 2017

The Protected Areas System Master Plan (PASMP) sets out guidelines for establishing and managing a comprehensive system of protected areas that supports national development by contributing to long-term ecological viability; maintaining ecological processes and systems; and protecting the country's natural and cultural heritage (National Environment and Planning Agency, n.d.). The PASMP is consistent with several national policies and plans, including the Policy for Jamaica's System of Protected Areas 1997, the National Strategy and Action Plan on Biological Diversity in Jamaica (2003) and Vision 2030 Jamaica: National Development Plan (2009). It is also a requirement under the Convention for Biological Diversity's (CBD's) Programme of Work for Protected Areas (PoWPA).

Existing protected area categories in Jamaica are listed in Table 2-1, Table 2-2 and Table 2-3 and shown on Figure 2-3. The NRCA/NEPA is responsible for areas declared/designated under the acts it administers, including the Natural Resources Conservation Authority Act, Wild Life Protection Act and Beach Control Act. As of June 20204, there were 12 protected areas declared under the NRCA Act (Figure 2-3). In addition to NRCA/NEPA, a number of other government entities (such as the Forestry Department, Fisheries Division and Jamaica National Heritage Trust), local management entities, non-governmental entities, private sector, and individuals are outlined as important role players. Responsibility for protected area management has been a shared endeavour and this collaborative approach to protected area management will continue under the PASMP (National Environment and Planning Agency, n.d.).

The project land does not fall within any area designated as a protected area or marine park under the Natural Resources Conservation Authority Act but has been identified in several studies as an ecologically sensitive site and recommended for future protection (Bennett, 2022). The landward boundary of the Bluefields Bay Fish Sanctuary (Figure 2-3) parallels the project area in the northernmost section of the bay and the proposed project coastal features fall directly within this sanctuary. Fish sanctuaries are declared through Section 18 of the Fishing Industry Act 1975, and the Bluefields Bay Fish Sanctuary is the second largest SFCA declared in Jamaica in July 2009. Please refer to section 4.4.8.3 for more information on protected areas with respect to the project.

Table 2-1 Existing categories of protected areas in Jamaica (January 2012) - protected area system categories

Source: (National Environment and Planning Agency, n.d.)

CATEGORY	RESPONSIBLE AGENCY	LAW
Protected Area	Forestry Department: Ministry of Economic Growth and Job Creation (MEGJC).	Forest Act, 1996 and Forest Regulations
	National Environment and Planning Agency (NEPA): MEGJC	NRCA Act, 1991
	NEPA: MEGJC	Beach Control Act, 1956
National Park	NEPA: MEGJC	NRCA Act, 1991
Marine Park	NEPA: MEGJC	NRCA Act, 1991
Environmental Protection Area	NEPA: MEGJC	NRCA Act, 1996
Forest Reserve	Forestry Department: MEGJC	Forest Act, 1996 and Forest Regulations
Fish Sanctuary (also previously referred to as Special Fishery Conservation Area)	Fisheries Division: Ministry of Industry, Commerce, Agriculture and Fisheries (MICAF)	Fisheries Act, 2018
National Monument	Jamaica National Heritage Trust (JNHT) Ministry of Youth and Culture (MYC)	JNHT Act, 1985
Protected National Heritage	JNHT: MYC	JNHT Act, 1985
Game Sanctuary	NEPA (NRCA): MEGJC	Wild Life Protection Act, 1945
Game Reserve	NEPA (NRCA): MEGJC	Wild Life Protection Act, 1945

Table 2-2 Existing categories of protected areas in Jamaica (as at 1 January 2012) - other designations not considered part of the system

Source: (National Environment and Planning Agency, n.d.)

CATEGORY	RESPONSIBLE AGENCY	LAW
Tree Order Preservation	Local Authority (Town and Country Planning Authority): MEGJC and Local Government Department, through Local Authorities	Town and Country Planning Act, 1958

CATEGORY	RESPONSIBLE AGENCY	LAW
Conservation Area	NEPA (Town and Country Planning Authority, Local Authorities): MEGJC	Town and Country Planning Act, 1958
Protected Watershed	NEPA (NRCA): MEGJC	Watershed Act, 1963 Protection

Table 2-3 Existing categories of protected areas in Jamaica (January 2012) - international designations

Source: (National Environment and Planning Agency, n.d.)

CATEGORY	RESPONSIBLE AGENCY	CONVENTION
Ramsar Site	NEPA (NRCA): MEGJC	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar Convention)
World Heritage Site (no existing sites, however submissions have been made)	Jamaica National Heritage Trust: MYC	World Heritage Convention

National Forest Management and Conservation Plan 2016-2026

The National Forest Management and Conservation Plan (NFMCP) 2016-2026 was created to guide Jamaica's efforts in achieving sustainable forest management and conservation, supporting the country's broader goals of social, economic, and environmental development. The plan serves as a strategic framework for managing the country's forest resources, ensuring they are used responsibly while maintaining their ecological integrity.

National Mangrove and Swamp Forest Management Plan (NMSFMP) 2023-2033

The National Mangrove and Swamp Forest Management Plan (NMSFMP) 2023-2033 has been developed to enhance coordination with stakeholders managing Jamaica's wetland resources, aligning the plan with national development goals and newly implemented laws and regulations. Key activities will focus on strengthening human resource and technological capacities, increasing research, improving data management, promoting sustainable livelihoods, and enhancing public education.

The vision for the NMSFMP is for Jamaica's forested wetlands to be nationally recognized and valued by citizens by 2033, with over 67% (10,144 ha) of existing forested wetlands conserved, restored, and sustainably used for income generation and ecosystem services. The primary goal is to achieve the conservation of at least 30% (4,430 ha) of Jamaica's forested wetlands by 2033, with a focus on both government-owned and privately owned wetlands.

Strategic objectives include reversing the degradation of forested wetlands through effective management and legislative improvements, strengthening technical and staffing capacities within key institutions like the Forestry Department and NEPA, and raising public awareness and education on the importance of these ecosystems. The plan also aims to ensure equitable economic, social, and environmental benefits from forested wetlands.

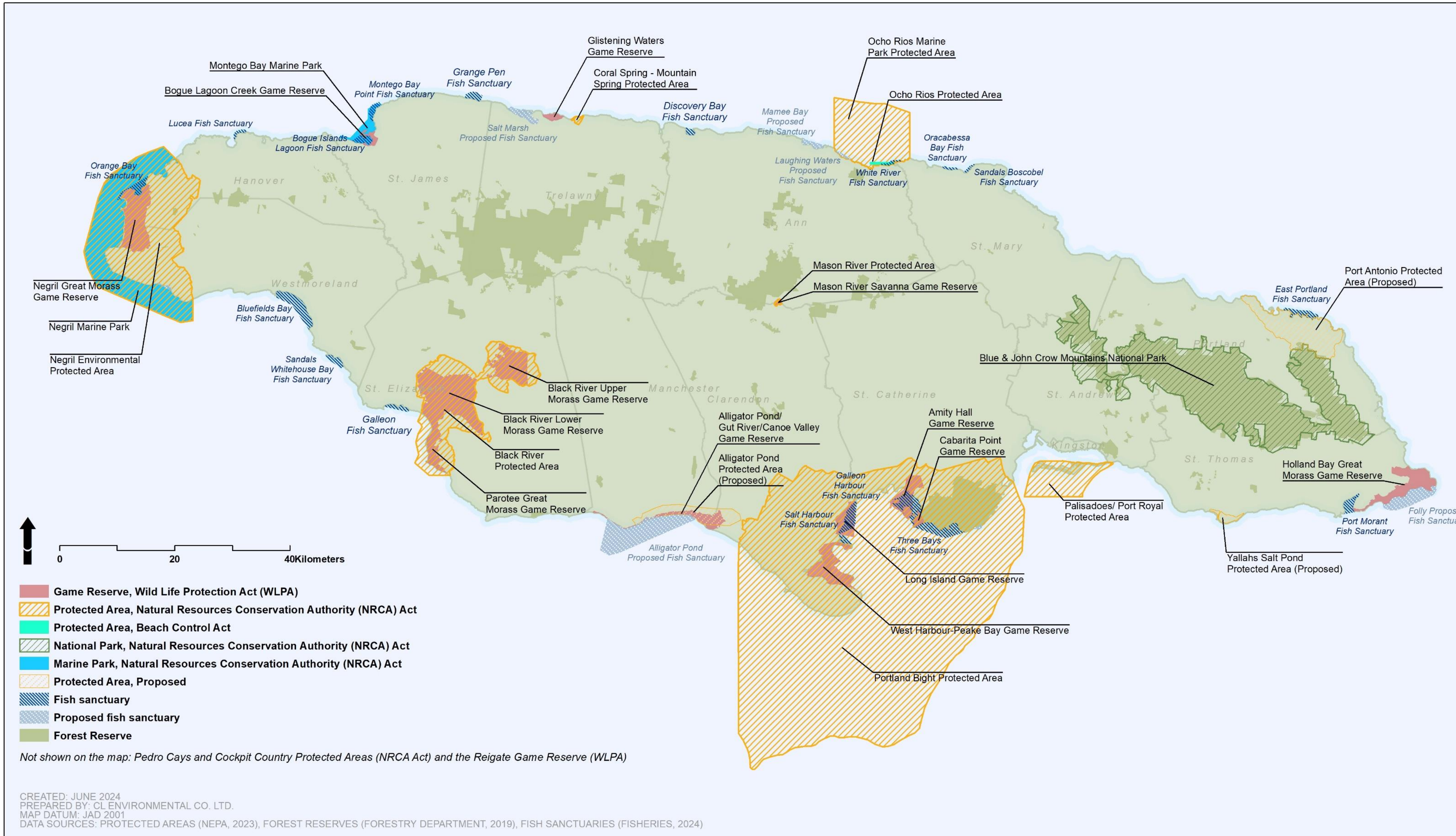


Figure 2-3 Areas protected under various Jamaican legislation including existing and proposed protected areas, national parks, marine parks, game reserves, forest reserves and fish sanctuaries

2.2.2.2 Natural Resources Conservation Authority Act 1991

The Natural Resources Conservation Authority Act (NRCA) is regarded as Jamaica's overarching environmental legislation, governing the proposed project. It establishes the Natural Resources Conservation Authority (NRCA), which is primarily tasked with ensuring sustainable development by safeguarding and managing the nation's natural resources while regulating pollution. This is primarily achieved through an environmental permit and licensing framework. The Act confers authority upon the NRCA to:

- Issue permits to the person responsible for undertaking any enterprise, construction, or development of a prescribed category in a prescribed area [Section 9][2];
- Issue licences for discharge of trade or sewage effluent or for construction or modification of any works for such discharge [Section 12 (1) (a) and (b)];
- Request information or documents as the Authority thinks fit [Section 10 (1) (a)];
- Request an environmental impact assessment containing such information as may be prescribed [Section 10 (1) (b)];
- Request information on pollution control facilities [Section 17]; and
- Revoke or suspend permits.

The Act also gave power of enforcement of a number of environmental laws to the NRCA, namely the *Beach Control Act*, *Watershed Act* and the *Wild Life Protection Act*, as well as a number of regulations and orders including:

- *The Natural Resources and Conservation (Protected Areas) Regulations, 2023*
- *The Natural Resources (Permit and Licences) Regulations 1996 and* (Amendment) Regulations *2015;*
- *Natural Resources (National Parks) Regulations 1993 and (Amendment) Regulations 2003;*
- *The Natural Resources (Marine Parks) Regulations 1992, (Amendment) Regulations 2003,* and *(Amendment) Regulations, 2015;*
- *The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order 1996* and *(Amendment) Order 2015; and*
- *The Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013.*

Natural Resources Conservation (Permit and Licences) Regulations 1996 and (Amendment) Regulations 2015

Under these regulations, a permit and licensing system was instituted to oversee the initiation of any new construction or development of a prescribed nature in Jamaica. Additionally, it manages the disposal of sewage, trade effluent, as well as poisonous or harmful substances discharged into the environment.

[2] The Prescribed Area Order designates all of Jamaica as being within the prescribed area.

Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order 1996 and (Amendment) Order 2015

The Natural Resources (Prescribed Areas) (Prohibition of Categories of Enterprise, Construction and Development) Order (1996) and the Permits & Licensing Regulations were enacted in accordance with section 9 of the NRCA Act. Section 9 designates the entire island and territorial sea as a 'prescribed area', wherein certain activities necessitate a permit, and may also require an environmental impact assessment. The significant amendment made in 2015 involved the substitution of the Categories of Enterprises, Construction, and Development (Column A), which enumerates various activities by category, for which a permit is mandated.

Natural Resources Conservation (Wastewater and Sludge) Regulations 2013

These regulations pertain to the discharge of sewage effluent and trade effluent, and outline the operations, monitoring, and reporting procedures for sewage treatment facilities. The Natural Resources Conservation (Wastewater and Sludge) Regulations 2013 were promulgated and have been in effect since 2013. Section 2.2.3.1 outlines associated water quality standards.

2.2.2.3 Wildlife Protection Act 1945 and Wildlife Protection (Amendment of Second and Third Schedules) Regulations 2016

The Wild Life Protection Act of 1945 primarily focuses on safeguarding specified faunal species and stands as the sole statute in Jamaica specifically designated for this purpose. This legislation safeguards numerous rare and endangered faunal species, with the Wild Life Protection (Amendment of Second and Third Schedules) Regulations 2016 providing substitutions for the Second and Third Schedules of the principal Act, which enumerate these species.

Under this Act, the establishment of two types of protected areas, namely Game Sanctuaries and Game Reserves, is authorized. These sanctuaries/reserves encompass parcels of land, bodies of water, or areas comprising both land and water, wherein hunting of animals (including birds), removal of eggs or nests of any bird, and the use or possession of any hunting equipment are prohibited. Additionally, all Forest Reserves are designated as Game Reserves and constitute part of Jamaica's Protected Areas System.

This Act has undergone review, particularly concerning increased fines and the expansion of protected species. Further amendments are being pursued to address various issues related to the management and conservation of natural resources, including the inclusion of flora. Prohibited activities include the removal, sale, or possession of protected animals, the use of destructive materials to harm fish, and the discharge of trade effluent or industrial waste into harbours, lagoons, estuaries, and streams. Notably, six species of sea turtles are protected under the Wild Life Protection Act.

Please refer to section 4.2.2.5 for a detailed account of the fauna found at the proposed site.

2.2.2.4 Endangered Species (Protection, Conservation and Regulation of Trade) Act 2000 and (Amendment of First, Second and Third Schedules) Order 2021

The Endangered Species (Protection, Conservation, and Regulation of Trade) Act was enacted in 2000 to formalize Jamaica's commitments under the Convention for the International Trade in Endangered Species of Wild Fauna and Flora (CITES). This legislation regulates both international and domestic trade in endangered species originating from Jamaica and encompasses provisions for the conservation and management of endangered fauna and flora.

The regulations associated with the Endangered Species (Protection, Conservation, and Regulation of Trade) Act were most recently revised in 2021. These amendments included updates to the listings of endangered species facing extinction, species at risk of extinction, or species requiring effective control. Additionally, it addresses species regulated by contracting Parties within their jurisdiction to prevent or restrict over-exploitation, necessitating cooperation among Parties to control trade in such species.

Please refer to section 4.2 for further detail of the flora and fauna found at the proposed site.

2.2.2.5 Foresty Act 1996

The Forestry Act of Jamaica, enacted on October 15, 1996, provides the legal framework for managing and conserving the country's forest resources. It designates the Forestry Department as the primary agency responsible for promoting sustainable forestry, conserving biodiversity, and regulating activities within forest reserves and protected areas. The Act mandates the Conservator of Forests to maintain an inventory of forest lands and assess their potential for various uses, including tree growth, water and soil protection, recreation, forage production, and biodiversity conservation.

The Forest Act outlines the responsibilities of the Forestry Department, the areas under its jurisdiction, and the offenses and penalties related to forest activities. Forests, whether publicly or privately owned, can be protected under the Act through classifications such as Forest Reserves, Forest Management Areas, and Protected Areas. These designations, alongside other protected areas under the Natural Resources Conservation Authority Act and Wildlife Protection Act, help safeguard forest resources. However, the multiple classifications may cause uncertainty in management goals, responsibilities, and permitted activities.

Forest Regulations 2001

The regulations under the Forests Act consist of 74 sections covering various aspects of forest management. They define the contents of forest management plans, regulate the use of forest roads, and set rules for burning fires in forest areas. They also address trespassing, timber removal, and enforcement measures, such as the seizure of timber and hunting regulations in protected areas. Provisions for community catchment areas and private forestry are included, as well as guidelines for forest estate leases and recreation activities. Additional regulations focus on timber sales, forest conservation funding, research, and licensing, ensuring sustainable forest management and protection in Jamaica.

Section 4.2.2.1 and 4.2.2.4 provides greater detail regarding forested areas at the project site.

2.2.2.6 The Forest Policy for Jamaica 2017

The Forest Policy for Jamaica (2017) outlines the government's commitment to sustainable forest management, emphasizing the importance of forests in providing ecosystem services, supporting livelihoods, and mitigating climate change. Forests are defined by the Forestry Department as "Land with tree crown cover of more than 10 percent and area of more than 0.5 hectares (ha), in closed or open formations; the trees should be able to reach a minimum height of 3 meters (m) at maturity. Young natural stands, immature forest plantations and areas temporarily unstocked due to natural or anthropogenic causes expected to revert to the above threshold are included."

The policy is structured around three overarching goals:

- Governance: Enhancing transparency, accountability, and public participation in forest management.
- Forest Ecological System Conservation: Protecting and conserving forest ecosystems to maintain biodiversity and ecological integrity.
- Socio-Economic Considerations: Promoting sustainable use of forest resources to support economic development and community well-being.

The policy also recognizes the need for increased regulation of commercial forests and forest-based industries to ensure sustainability.

2.2.2.7 The Fisheries Act 2018

The Fisheries Act of 2018 serves as the principal legislation governing fishing activities in Jamaica, replacing the previous Fishing Industry Act of 1975. This Act is designed to ensure the efficient and sustainable management and development of fisheries, aquaculture, and related endeavours in alignment with internationally recognized norms, standards, and best practices.

Under the Fisheries Act of 2018, the National Fisheries Authority (NFA) is entrusted with various responsibilities. These include the licensing of fisherfolk and fishing vessels, whether for sport, recreational, or commercial purposes. Furthermore, the Act empowers the division to establish and demarcate fish sanctuaries (also referred to as Special Fishery Conservation Areas at certain points in time), for the protection of various fisheries resources. It also outlines measures such as the establishment of closed seasons and imposes fines and penalties for illegal fishing activities or the unauthorized sale of fish.

As mentioned previously, the landward boundary of the Bluefields Bay SFCA parallels the project area in the northernmost section of the bay and the proposed project coastal features fall directly within this SFCA (Figure 2-3). Please refer to sections 4.4.7.3and 4.4.8.3 for further information.

2.2.2.8 National Policy for the Conservation of Seagrasses 1996

This policy provides guidance for the issuance of licenses or permits for various activities, including dredging, disposal of dredged material, beach development, and effluent disposal, all of which have direct or indirect impacts on seagrass communities.

Section 4.2.3.4 provides detail regarding the seagrass communities in the project area.

2.2.2.9 Mangrove and Coastal Wetlands Protection - Draft Policy and Regulations 1996

This policy provides a review of the issues affecting wetlands in Jamaica as well as the Government's role and responsibility. Five main goals are outlined which include guidelines for wetlands development, cessation of destructive activities, maintenance of natural diversity, maintenance of wetland function and values and integration of wetland functions in planning and development.

2.2.2.10 Coral Reef Protection and Preservation – Draft Policy and Regulations 1996

This document assesses the ecological and socio-economic significance of coral reefs, identifies the challenges they face, and delineates the Government's role and obligations in safeguarding them. It outlines five primary objectives, encompassing the mitigation of pollutants, curbing overharvesting of reef fish, minimizing physical damage caused by recreational activities, enhancing responsiveness to oil spills, and regulating coastal zone developments.

Section 4.2.3.5 provides greater detail regarding the occurrence of corals and reef at the project site.

2.2.2.11 Coastal Management and Beach Restoration Guidelines: Jamaica

These guidelines complement Vision 2030 Jamaica and serve as a resource for coastal stakeholders, offering guidance at the community level to ensure sustainable coastal management while considering broader environmental impacts. Various management approaches are proposed for Jamaica's coastline, influencing the suitability of site-specific interventions. The document outlines progressive steps from project inception to design and the acquisition of planning permission for coastal zone projects. Multiple design outcomes must be evaluated to ensure environmental integrity, resilience, and prevent adverse impacts on neighbouring coastal sites.

The effectiveness of the governance structure and institutional framework is emphasized, highlighting the importance of national organizations with well-defined mandates, roles, responsibilities, and capacities for the successful management of Jamaica's coastal resources.

2.2.2.12 Water Resources Act 1995

The enactment of the Water Resources Act (1995) established the Water Resources Authority (WRA), entrusted with the regulation, allocation, conservation, and management of the island's water resources. Additionally, the WRA is tasked with overseeing water quality control and providing technical support for projects, programs, or activities related to water resource development, conservation, and utilization.

According to Section 25 of the Act, prospective users must obtain planning permission, if required, under the Town and Country Planning Act. Moreover, Section 21 specifies that if the intended use of water entails effluent discharge, the applicant must apply for a license to discharge effluents from the Natural Resources Conservation Authority, or any other relevant body designated by the Minister.

2.2.2.13 The Jamaica National Heritage Trust Act 1985

The Jamaica National Heritage Trust Act established the Jamaica National Heritage Trust (JNHT) and has been in operation since 1985. The JNHT provides for protection of areas, structures, and objects of cultural significance to Jamaica by declaration of any structure as a national monument where preservation is of public interest due to historic, architectural, traditional, artistic, aesthetic, scientific or archaeological importance. This includes the floor of the sea within the territorial waters or the Exclusive Economic Zone.

Findings from an assessment of historical or archaeological sites undertaken by the JNHT for the purposes of this EIA is provided in section 4.4.8.1.

2.2.2.14 Towards an Ocean and Coastal Zone Management Policy in Jamaica 2000

Established in 1998, the Council on Ocean and Coastal Zone Management is tasked with delineating a national policy for Ocean and Coastal Zone Management. The objective of this policy document is to cultivate a framework that will "augment the role of economic sectors in the integrated management of coastal areas by fostering awareness among sectoral agencies and resource users." Acknowledging the substantial utilization and subsequent deterioration of coastal and oceanic resources in Jamaica, including coral reefs, mangroves, seagrass beds, and non-living resources such as sand, the document underscores the pressing need for concerted management efforts.

2.2.3 Public Health & Waste Management

2.2.3.1 Water Quality Standards

The NRCA has primary responsibility for control of water pollution in Jamaica. National standards for ambient marine water and freshwater are shown in Table 2-4 and Table 2-5 respectively. For drinking water, World Health Organisation (WHO) standards are utilized, and these are regulated by the National Water Commission (NWC).

Standards for industrial (trade effluent) and sewage discharge are stipulated within the Natural Resources Conservation (Wastewater and Sludge) Regulations, 2013 (Table 2-6, Table 2-7 and Table 2-8).

Table 2-4 Draft national ambient marine water quality standards for Jamaica, 2009

Source: National Environment and Planning Agency (NEPA)

Parameter	Measured as	Standard Range	Unit
Phosphate,	P*	0.001-0.003	mg/L
Nitrate,	N**	0.007-0.014	mg/L
BOD_5	O	0.0-1.16	mg/L
pH		8.00-8.40	
Total Coliform		2-256	MPN/100mL
Faecal Coliform		<2-13	MPN/100mL

*Reactive phosphorus as P
**Nitrates as Nitrogen

Table 2-5 Draft national ambient freshwater water quality standards for Jamaica, 2009

Source: National Environment and Planning Agency (NEPA)

Parameter	Measured as	Standard Range	Unit
Calcium	(Ca)	40.0-101.0	mg/L
Chloride	(Cl^-)	5.0- 20.0	mg/L
Magnesium	(Mg^{2+})	3.6- 27.0	mg/L
Nitrate	(NO_3^-)	0.1- 7.5	mg/L
Phosphate	(PO_4^{3-})	0.01 - 0.8	mg/L
Potassium	(K^+)	0.74- 5.0	mg/L
Silica	(SiO_2)	5.0- 39.0	mg/L
Sodium	(Na^+)	4.5- 12.0	mg/L
Sulfate	(SO_4^{2-})	3.0- 10.0	mg/L
Hardness	($CaCO_3$)	127.0-381.0	mg/L (as $CaCO_3$
Biochemical Oxygen Demand	(O)	0.8- 1.7	mg/L
Total Dissolved Solids		120.0-300	mg/L
pH		7.00- 8.40	
Conductivity		150.0-600	µS/cm

Table 2-6 Industrial Trade Effluent Standards

Table 3—*Trade Effluent Standards*

PARAMETER	TRADE EFFLUENT LIMIT
Ammonia/ammonium measured as NH_4	1.0 mg/L
Barium	5.0 mg/L
Beryllium	0.5 mg/L
Biological oxygen demand (BOD)	<30 mg/L
Boron	5.0 mg/L
Calcium	No standard
Chemical Oxygen Demand (COD)	<100mg/L or <0.01 kg/1000 kg product
Chloride	300 mg/L
Colour	100 TCU
Cyanide (free)	0.1 mg/L
Cyanide (Total as CN)	0.2 mg/L
Detergent	15 mg/L
Dissolved oxygen (DO)	>4mg/L
Faecal Coliform	<100 MPN/100 ml
Fluoride	3.0 mg/L
Iron	3.0 mg/L
Magnesium	No standard
Manganese	1.0 mg/L
Nitrate as NO_3	10 mg/L
Oil and Grease	10 mg/L or < 0.01 kg/1000 kg product
PH	6.5 - 8.5
Phenols	0.1 mg/L
Phosphate as PO_4	5 mg/L
Sodium	100 mg/L
Sulphate	250 mg/L
Sulphide	0.2 mg/L
Temperature	±2° of ambient
Total Coliform	<500 MPN/100 ml
Total Dissolved Solids (TDS)	1000 mg/L
Total Organic Carbon (TOC)	100 mg/L
Total Suspended Solids (TSS) (maximum monthly average)	50 mg/L
Total Suspended Solids (TSS) maximum daily average	<150mg/L

PARAMETER	TRADE EFFLUENT LIMIT
Trace Metals:	
Zinc	1.5 mg/L
Lead	0.1 mg/L
Cadmium	0.1 mg/L
Arsenic	0.5 mg/L
Chromium	1.0 mg/L
Copper	0.1 mg/L
Mercury	0.02 mg/L
Nickel	1.0 mg/L
Selenium	0.5 mg/L
Silver	0.1 mg/L
Tin	No standard
Total Heavy Metals	2.0 mg/L

Table 2-7 Sewage Effluent Standards for plants other than existing plants

Parameter	Effluent Limit
BOD_5	20 mg/L
TSS	20 mg/L
Total Nitrogen	10 mg/L
Phosphates (PO4-P)	4 mg/L
COD	100 mg/L
pH	6-9 pH
Faecal Coliform	200 MPN/100mL
Residual Chlorine	1.5 mg/L
Floatables	not visible

Table 2-8 Sewage Effluent Standards for use in Irrigation

Parameter	Effluent Limit
Oil and Grease	10 mg/L
Total Suspended Solids (TSS)	15 mg/L
Residual Chlorine	0.5 mg/L
Biochemical Oxygen Demand (BOD_5)	15 mg/L
Chemical Oxygen Demand (COD)	<100 mg/L
Faecal Coliform	12 MPN/100mL

2.2.3.2 Noise Abatement Act 1997

The Noise Abatement Act of 1997 was created in order to regulate noise caused by amplified sound and other specified equipment. This act has been said to address "some concerns but is too narrow in scope and relies on a subjective criterion" (McTavish). Given this, McTavish conducted a study to recommend wider and more objective criteria in accordance with international trends and standards but tailored to Jamaica's conditions and culture.

National guidelines (NRCA) used for noise levels are an adaptation from the Jamaica's National Noise Standards, 1999 and are shown in Table 2-9; values for commercial, industrial, and residential areas are specified.

Table 2-9 NRCA guidelines for daytime and night-time noise in various zones

ZONE	NRCA Daytime Guideline (dBA)	NRCA Night-time Guideline (dBA)
Commercial	65	60
Industrial	75	70
Residential	55	50

2.2.3.3 The Natural Resources Conservation Authority (Air Quality) Regulations 2006

Section 38 of the NRCA Act outlines regulations regarding air quality in Jamaica. These regulations establish the National Ambient Air Quality Standards (NAAQS), which are divided into two categories.

Part I of the NRCA Air Quality Regulations (2006) outlines license requirements, mandating that owners of major or significant facilities must apply for an air pollutant discharge license. Part II addresses stack emission targets, standards, and guidelines.

According to the Natural Resources Conservation Authority (Air Quality) Regulations, 2006, a "significant air quality impact", means:

(a) the increment in the predicted average concentration of sulphur dioxide (SO_2), total suspended particulates (TSP), particulate matter less than ten microns (PM_{10}) or nitrogen dioxide (NO_2) is greater than an annual average of 20 µg/m³ or a 24-hour average concentration of 80 µg/m³; or
(b) the increment in the predicted average concentration of CO is greater than 500 µg/m³ as an 8-hour average or 2000 µg/m³ as a 1-hour average.

Table 2-10 summarizes the Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations (GC).

Table 2-10 Significant Impact Concentrations and the Jamaican National Ambient Air Quality Standards (JNAAQS) and Guideline Concentrations (GC) for air quality

Pollutant	Avg. Period	Significant Impact Concentration (µg/m³)	Jamaican NAAQS or GC (µg/m³)
PM_{10}	24-hr	80	150
	Annual	20	50
TSP	24-hr	80	150
	Annual	20	60
NO_2	1-hr	N/A	400
	24-hr	80	N/A
	Annual	20	100
SO_2	1-hr	N/A	700
	24-hr	80	280
	Annual	20	60
CO	1-hr	2000	40000
	8-hr	500	10000
1,3 Butadiene	1-hr	N/A	0.04
Acetaldehyde	1-hr	N/A	1250
	24-hr	N/A	500
Acrolein	1-hr	N/A	58.75
	24-hr	N/A	23.5
Benzene	Annual	N/A	1
Benzo (a) pyrene	1-hr	N/A	0.00275
	24-hr	N/A	0.0011
Carbon Tetrachloride	1-hr	N/A	6
	24-hr	N/A	2.4
Chloroform	1-hr	N/A	1250
	24-hr	N/A	500
Ethylene Dibromide	1-hr	N/A	7.5
	24-hr	N/A	3
Formaldehyde	1-hr	N/A	162.5
	24-hr	N/A	65

Pollutant	Avg. Period	Significant Impact Concentration (µg/m³)	Jamaican NAAQS or GC (µg/m³)
Methylene Chloride	1-hr	N/A	550
	24-hr	N/A	220
Styrene	1-hr	N/A	2500
	24-hr	N/A	1000
Xylenes	1-hr	N/A	5750
	24-hr	N/A	2300
Vinyl Chloride	24-hr	N/A	1
	Annual	N/A	0.2
Arsenic	1-hr	N/A	0.75
	24-hr	N/A	0.3
Beryllium	Annual	N/A	0.0013
Cadmium	1-hr	N/A	5
	24-hr	N/A	2
Chromium	1-hr	N/A	3.75
	24-hr	N/A	1.5
Cobalt	24-hr	N/A	0.12
Copper	1-hr	N/A	125
	24-hr	N/A	50
Lead	1-month	N/A	N/A
	3-month	N/A	2
Manganese	Annual	N/A	119
Mercury	1-hr	N/A	5
	24-hr	N/A	2
Nickel	1-hr	N/A	5
	24-hr	N/A	2
Selenium	24-hr	N/A	25
	Annual	N/A	10
Zinc	24-hr	N/A	12

In 1987, U.S. Environmental Protection Agency replaced TSP with PM10 as the indicator for both the annual and 24-hour health-related standards. The reason for this is because exposure to PM10 particles may cause serious health/respiratory related issues as these particles are retained deep in the lungs. The 24-hour NEPA standards for PM10 are shown in Table 1 4. However, the 24-hour US EPA standards are used for PM2.5 and TSP:

- TSP = 150 µg/m³
- $PM_{2.5}$ = 35 µg/m³

2.2.3.4 The Clean Air Act 1964

The Clean Air Act (1964) pertains to premises housing industrial works, where the operation, as determined by an inspector, may lead to the emission of smoke, fumes, gases, or dust into the air. An inspector is authorized to access any such premises to inspect, conduct inquiries, perform tests, and collect samples of substances, smoke, fumes, gases, or dust deemed essential or appropriate for fulfilling their duties.

2.2.3.5 Public Health Act 1985

The Public Health Act is administered by the Ministry of Health through Local Boards, namely the Municipal Corporations. *The Public Health (Nuisance) Regulations 1995* aims to, control reduce or prevent air, soil, and water pollution in all forms. Under the regulations:

- No individual or organisation is allowed to emit, deposit, issue, or discharge into the environment from any source;
- Whoever is responsible for the accidental presence in the environment of any contaminant must advise the Environmental Control Division of the Ministry of Health and Environmental Control, without delay;
- Any person or organisation that conducts activities which release air contaminants such as dust and other particulates is required to institute measures to reduce or eliminate the presence of such contaminants; and
- No industrial waste should be discharged into any water body, which will result in the deterioration of the quality of the water.

2.2.3.6 Public Health Act (Air, Soil and Water Pollution) Regulations 1976

Under the ambit of this act, the Environmental Health Unit, Ministry of Health, is required to review the design and plans for sewage treatment.

2.2.3.7 The National Solid Waste Management Authority Act 2001

The National Solid Waste Management Authority Act of 2001 was enacted to regulate and oversee solid waste management. It established the National Solid Waste Management Authority (NSWMA) in April 2002, tasked with efficiently managing and overseeing the collection and disposal of solid waste in Jamaica. The primary objectives are to safeguard public health, ensure environmentally responsible handling of waste through collection, sorting, transportation, recycling, reuse, or disposal, and to promote safety standards related to waste management. Additionally, the NSWMA is responsible for raising public awareness about the importance of effective solid waste management, advising the Minister on policy matters, and executing other functions related to solid waste management. The Act mandates that solid waste be deposited only at approved or designated sites. In Western Jamaica, the designated site is located in Retirement, St. James.

2.3 REGIONAL AND INTERNATIONAL LEGISLATIVE AND REGULATORY CONSIDERATIONS

2.3.1 United Nations Convention on Biological Diversity

Signed by 150 government leaders during the 1992 Rio Earth Summit, the Convention on Biological Diversity (CBD) is dedicated to advancing sustainable development. The CBD is considered instrumental in actualizing the principles outlined in Agenda 21, recognizing that biodiversity encompasses more than just flora, fauna, and microorganisms, but also addresses human necessities such as food security, medicines, clean air and water, housing, and a pristine environment. Jamaica acceded to the CBD on April 6, 1995. The country's Green Paper Number 3/01, titled 'Towards a National Strategy and Action Plan on Biological Diversity in Jamaica', underscores Jamaica's ongoing commitment to fulfilling its obligations as a signatory to the Convention.

2.3.2 Convention on Wetlands of International Importance especially as Waterfowl Habitat, "Ramsar Convention" 1971

The Ramsar Convention is an intergovernmental treaty that focuses on maintaining ecological wetland systems and planning for sustainable use of their resources. It was adopted on 2 February 1971 in Ramsar, Iran. The mission of the Convention was adopted by the Parties in 1999 and revised in 2005 - "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world". Under Article 2.2 it is stated:

> Wetlands should be selected for the List on account of their international significance in terms of ecology, botany, zoology, limnology, or hydrology" and indicates that "in the first instance, wetlands of international importance to waterfowl at any season should be included.

Jamaica became a contracting party on 7 February 1998 and has 4 sites covering a combined total of 37,847 hectares (378.47 km^2).

2.3.3 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) primarily aims to safeguard endangered plants and animals, recognizing the transboundary nature of these species. This necessitates international collaboration to ensure that global trade in wild animal and plant species does not imperil their survival in the wild. CITES provides varying degrees of protection to over 35,000 species.

Originally drafted in 1963 during a meeting of members of the International Union for Conservation of Nature (IUCN), CITES was finalized in 1973. It was opened for signatures in 1973 and came into effect on July 1, 1975. Jamaica became a Party to CITES on June 22, 1997. In 2000, Jamaica enacted domestic legislation, the Endangered Species (Protection, Conservation and Regulation of Trade) Act, 2000, along with Regulations, to fulfil its obligations to CITES.

The Natural Resources Conservation Authority (NRCA) serves as the Management Authority for CITES in Jamaica. The Authority is responsible for processing applications for permits and certificates required for international trade in endangered species. Coordination with the local Scientific Authority is integral to the application processing procedure.

2.3.4 Cartagena Convention (Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region), 1983

Adopted in March 1983 in Cartagena, Colombia, the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, more commonly referred to as the Cartagena Convention, is the sole legally binding environmental treaty for the Wider Caribbean. The Convention came into force in October 1996 as a legal instrument for the implementation of the Caribbean Action Plan and represents a commitment by the participating countries to protect, develop and manage their common waters individually and jointly. The Convention is currently supported by three Protocols as follows:

- *The Protocol Concerning Co-operation in Combating Oil Spills in the Wider Caribbean Region* (The Oil Spills Protocol), which was adopted and entered into force at the same time as the Cartagena Convention;
- *The Protocol Concerning Specially Protected Areas and Wildlife in the Wider Caribbean Region* (The SPAW Protocol), which was adopted in two stages, the text in January 1990 and its Annexes in June 1991. The Protocol entered into force in 2000;
- *The Protocol Concerning Pollution from Land-based Sources and Activities in the Wider Caribbean Region* (LBS Protocol), which was adopted in October 1999.

2.3.5 United Nations Convention on the Law of the Sea (UNCLOS III) 1982

The United Nations Convention on the Law of the Sea (UNCLOS), also referred to as the Law of the Sea Convention and the Law of the Sea treaty, defines the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for businesses, the environment, and the management of marine natural resources. UNCLOS III supersedes the Convention on the Territorial Sea and the Contiguous Zone (entered into force on 10 September 1964), as well as the Convention on the Continental Shelf (entered into force 10 June 1964), and both agreed upon at the first United Nations Convention on the Law of the Sea (UNCLOS I). Jamaica was the fourth country to ratify the UNCLOS III of 10 December 1982 on 21st March 1983. As of August 2013, 166 countries have joined in the Convention.

2.3.6 Convention on Fishing and Conservation of the Living Resources of the High Seas 1958

This convention considers that the development of modern techniques for the exploitation of the living resources of the sea has increased man's ability to meet the need of the world's expanding population for food and has exposed some of these resources to the danger of being over-exploited. It was done at Geneva on 29 April 1958.

2.3.7 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter

This international agreement, commonly known as the London Convention, was adopted at the Inter-Governmental Conference on the Convention on the Dumping of Wastes at Sea in London, United Kingdom, in November 1972. It became effective on August 30, 1975, and has been administered by the International Maritime Organization (IMO) since 1977.

The London Convention prohibits the dumping of certain hazardous materials and mandates a special permit for the dumping of specified materials, while other wastes or matter require a general permit. In 1996, Parties to the Convention adopted the London Protocol, a supplementary agreement aimed at preventing marine pollution by dumping wastes and other matter. The Protocol, which entered into force in 2006, emphasizes a precautionary approach and introduces new regulations governing the use of the sea as a waste repository.

Article 4 of the London Protocol outlines the prohibition of dumping wastes or other matter, with exceptions listed in Annex 1 of the document.

2.3.8 International Convention on Oil Pollution Preparedness, Response and Co-operation 1990

The International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention) is an international maritime convention that sets measures for the preparation for and response to marine oil pollution incidents. The OPRC Convention was drafted within the framework of the International Maritime Organization (IMO) and entered into force in 1995. Jamaica is one of 107 parties to the convention (as of July 2013).

3.0 PROJECT DESCRIPTION

3.1 LOCATION AND BACKGROUND

3.1.1 Site Location and Characteristics

The proposed Paradise Park development is located along the south coast of Westmoreland, Jamaica, approximately 3 km east of Savanna-La-Mar, in the community of Smithfield (Figure 3-1). The project area, known as Paradise Pen, includes several land parcels: Vol. 1146 Fol. 944, Vol. 1146 Fol. 955, Vol. 1146 Fol. 946, and Vol. 1141 Fol. 494.

The total land area of Paradise Park is 1,120 acres (453 hectares), encompassing a variety of distinct ecosystems and natural environments, including mangroves, wetlands, fields, beach areas, rivers, and grasslands. The project site features a shoreline approximately 4,572 meters (about 15,000 feet) in length, with 680 meters (approximately 2,230 feet) of white sand beach.

While the project land is not within any designated protected area, it has been identified in multiple studies as an ecologically sensitive location, recommended for future protection (Bennett, 2022). The northern section of the Bluefields Bay Fish Sanctuary parallels the project site, with proposed coastal features extending into the sanctuary. Additionally, Bluefields Bay is recognized as a Habitat/Species Management Area (Category IV) under the International Union for Conservation of Nature (IUCN) Protected Areas Categories System.

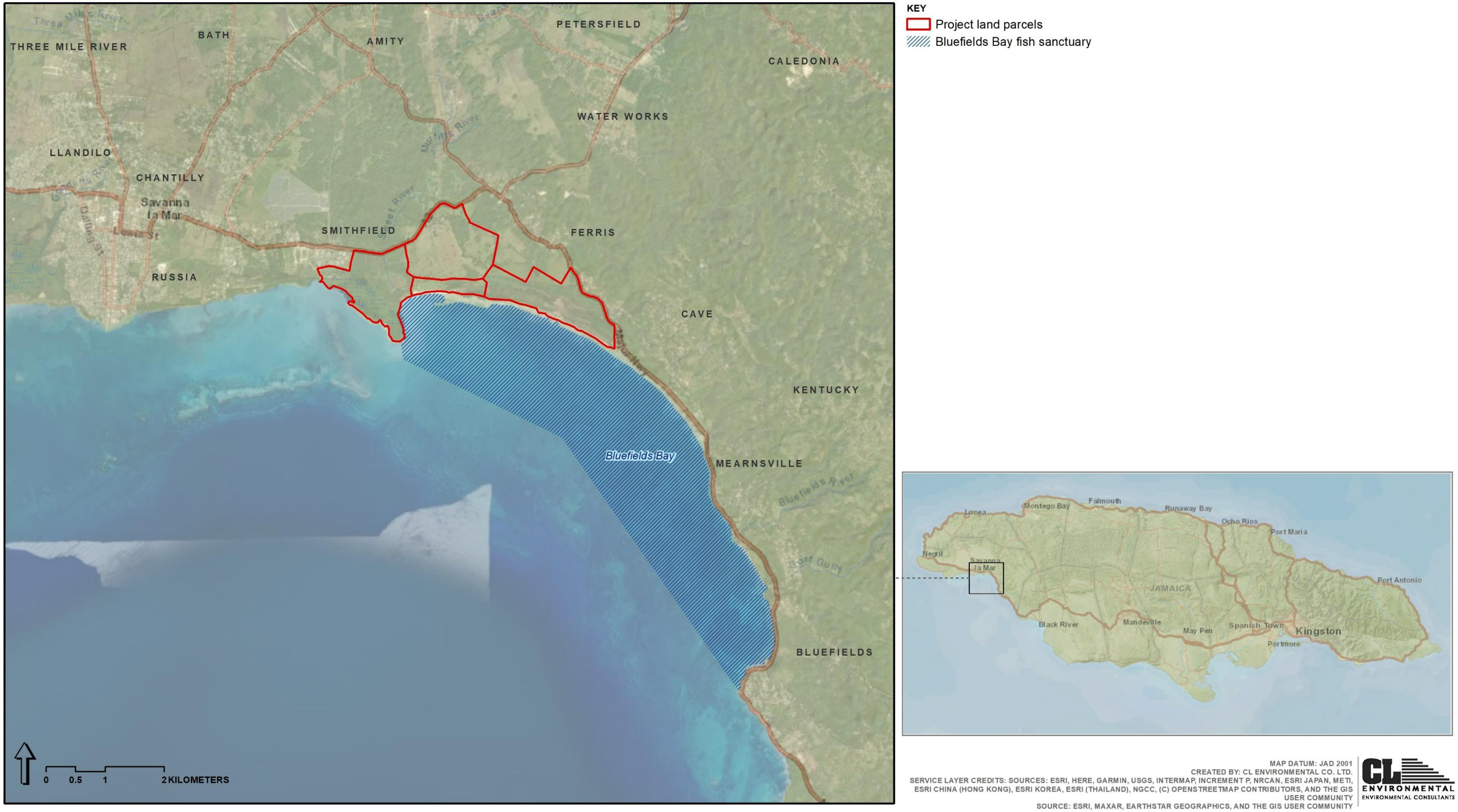


Figure 3-1 Project location and proposed resort development property boundary

3.1.2 Project Objectives and Overview

Paradise Park is envisioned as a truly unique hospitality development, set amidst the rich diversity of ecosystems and natural beauty on the south coast of Jamaica. With a strong focus on conservation, restoration, and expansion of existing natural habitats, the project aims to create a sustainable and environmentally conscious luxury resort that harmonizes with the land. The development philosophy is centred on preserving the ecological assets of the property, including its mangroves, marshlands, rivers, and palm forests, ensuring that these natural features remain central to the resort experience.

Paradise Park will strive to achieve Net Zero Energy and Carbon Neutrality, setting a new benchmark for sustainable design in the Caribbean. Through the use of cutting-edge technologies, passive design strategies, and a commitment to ecological preservation, the development will redefine luxury hospitality in Jamaica. It will offer a new, environmentally aware, and culturally rich resort experience that celebrates the island's heritage, natural landscapes, and commitment to sustainability.

The proposed development will feature a luxury resort and residential community designed to provide an exceptional experience for both guests and residents. The project will seamlessly integrate luxury accommodations, high-end amenities, and extensive recreational facilities, all while enhancing and preserving the site's natural beauty. Below is a summary of the key components and design considerations:

- **Integration with Natural Landscape**: The design of Paradise Park will be intimately connected with the surrounding environment. Key amenities such as the golf course, pools, and private villas will be carefully positioned to blend with the natural landscape, preserving the beauty and ecological integrity of the site. Strategic placement of facilities will minimize the environmental footprint, allowing guests and residents to experience the unspoiled surroundings.

- **Luxury and Exclusivity**: The development will set a new standard for both resort and residential living in the Caribbean. By combining world-class facilities with stunning natural surroundings and a forward-thinking design, the project will offer an unparalleled luxury destination. Every aspect of the development will embody luxury, offering a wide range of high-end services and facilities. From the signature spa and wellness centre to the private villas and exclusive golf course, the resort is designed to meet the highest standards of comfort, privacy, and sophistication, catering to a discerning clientele.

- **Sustainability and Self-Sufficiency**: At the heart of the development's sustainability goals is the inclusion of a solar farm connection and a focus on energy-efficient, self-sufficient operations for back-of-house services. These initiatives will help the resort minimize its environmental impact while enhancing its long-term sustainability.

- **Comprehensive Amenities**: Paradise Park will feature a wide array of amenities to ensure a holistic and enriching experience for all guests and residents. These will include leisure, dining, recreational, and wellness options, all offered in a luxurious, resort-style environment designed for relaxation and enjoyment.

3.2 PROJECT FEATURES AND DESIGN

3.2.1 Overview

The proposed resort development comprises five (5) land use programmes listed below and illustrated in Figure 3-2. Each land use type and the proposed features for each are described in subsequent subsections and summarised in Table 3-1.

1. Resort
2. Hotel
3. Villas
4. Golf
5. Service Facilities

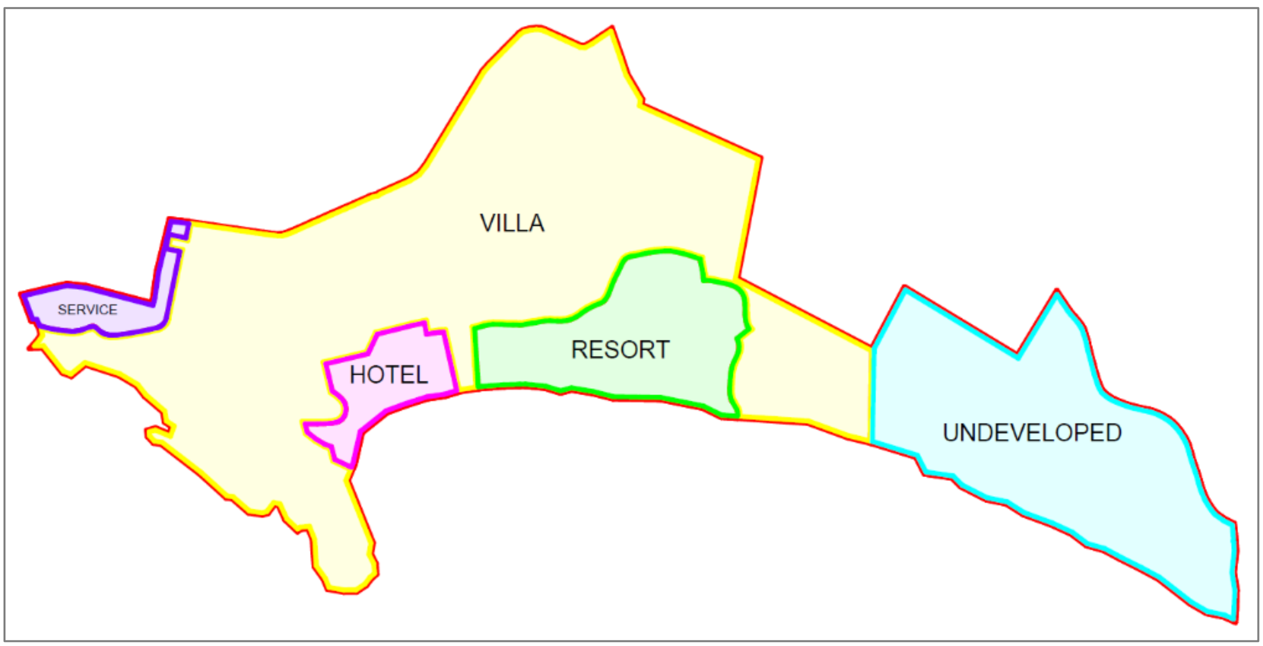


Figure 3-2 Proposed land use type delineation for the Paradise Park resort development

Table 3-1 Land use area summary for the Paradise Park resort development

	PROGRAM	KEYS/ UNITS	TOTAL BLDG FOOTPRINT (SQM)	GFA (SQM)	GFA (ACRES)
R	RESORT LANDUSE	*120*	*40273*	472,444	117
H	HOTEL LANDUSE	*200*	*35355*	180,758	45
G&V	GOLF COURSE & VILLA LANDUSE	*100*	*75594*	1,958,341	484
S	SERVICE/UTILITY LANDUSE	-	*14819*	114,962	28
U	UNDEVELOPED LANDUSE	-	-	1,731,664	428
	TOTAL AREA - PARADISE PARK			***4,458,169***	***1,102***

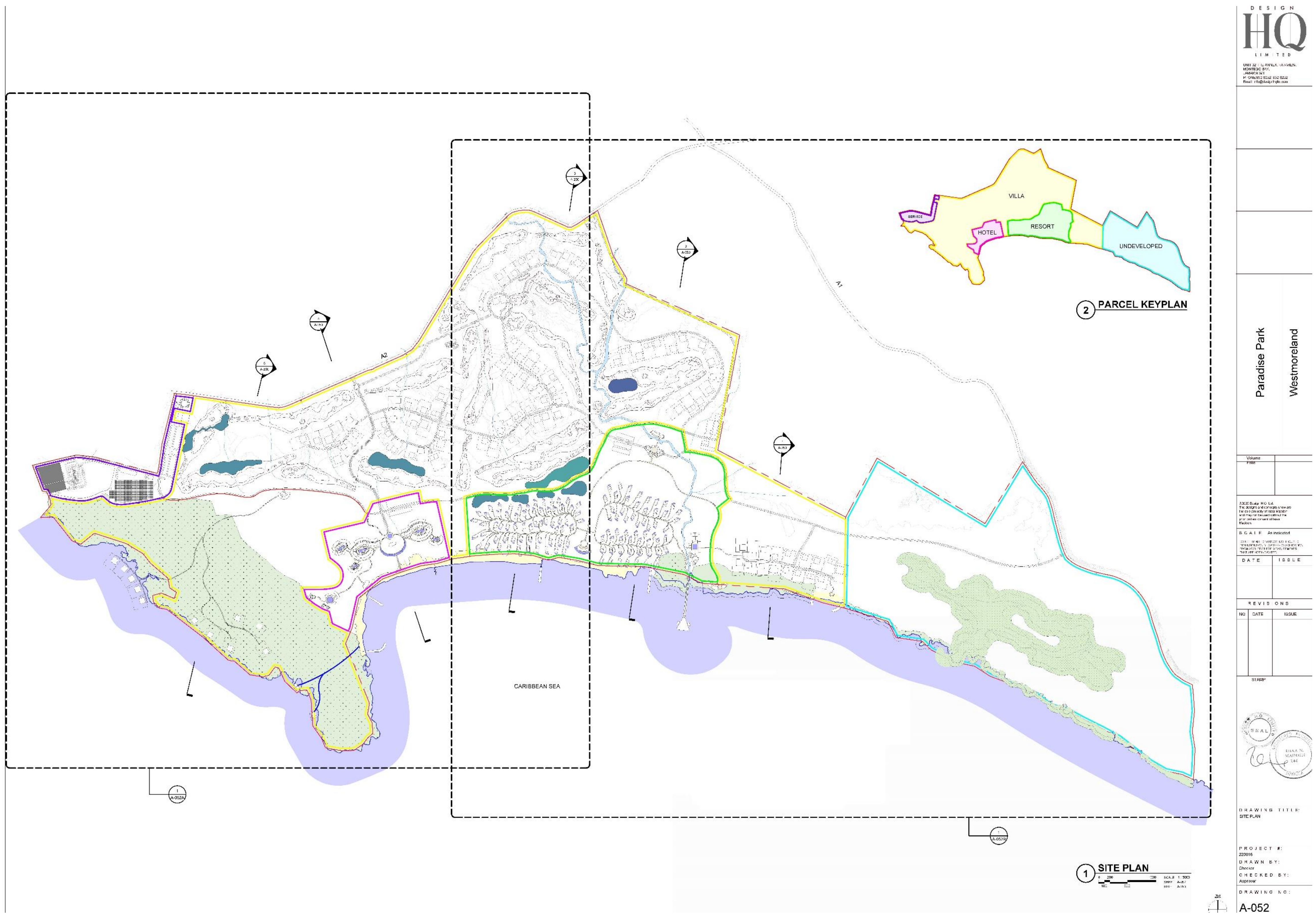


Figure 3-3 Resort master plan for the proposed development

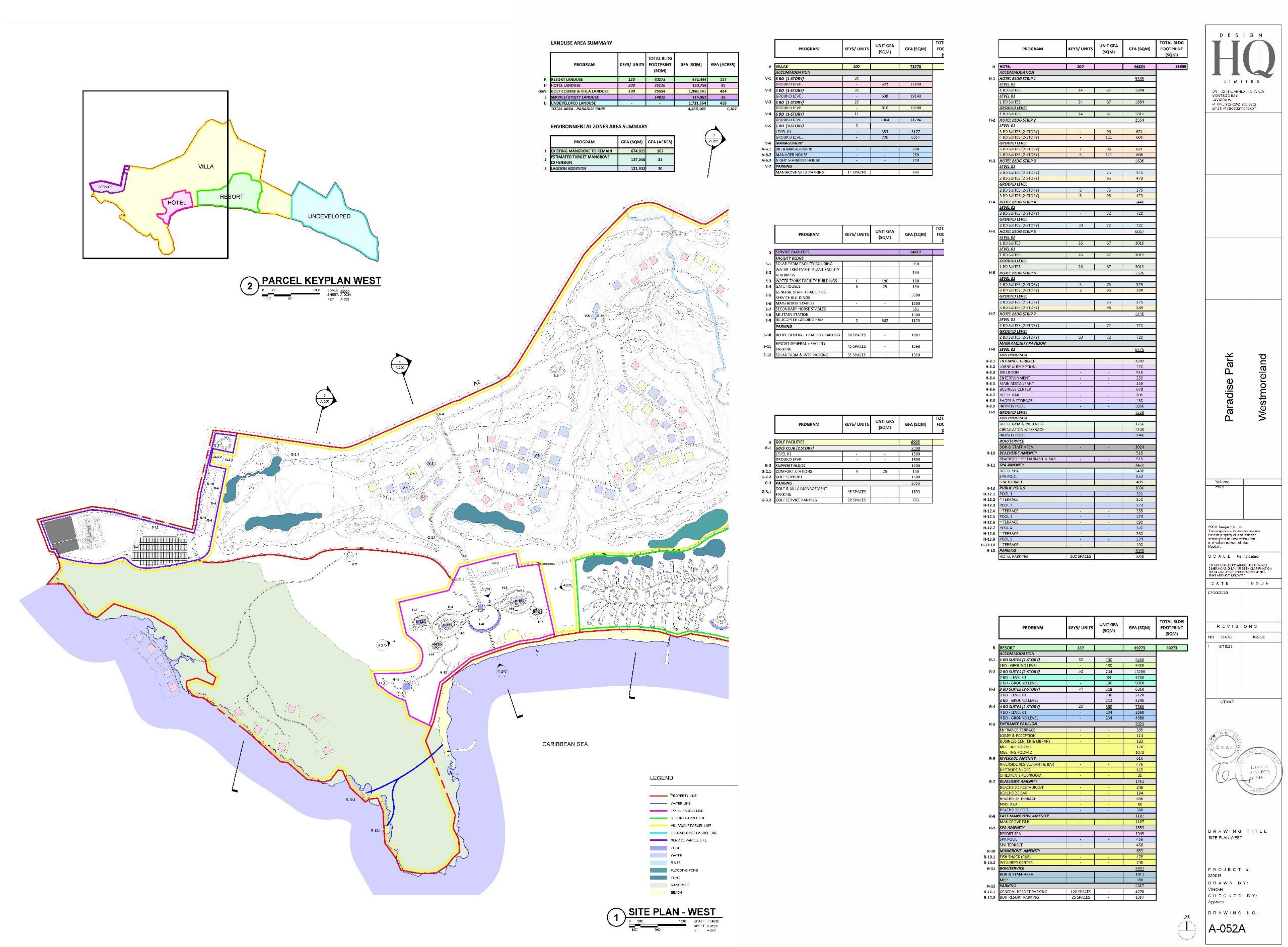


Figure 3-4 Western section of resort master plan for the proposed development

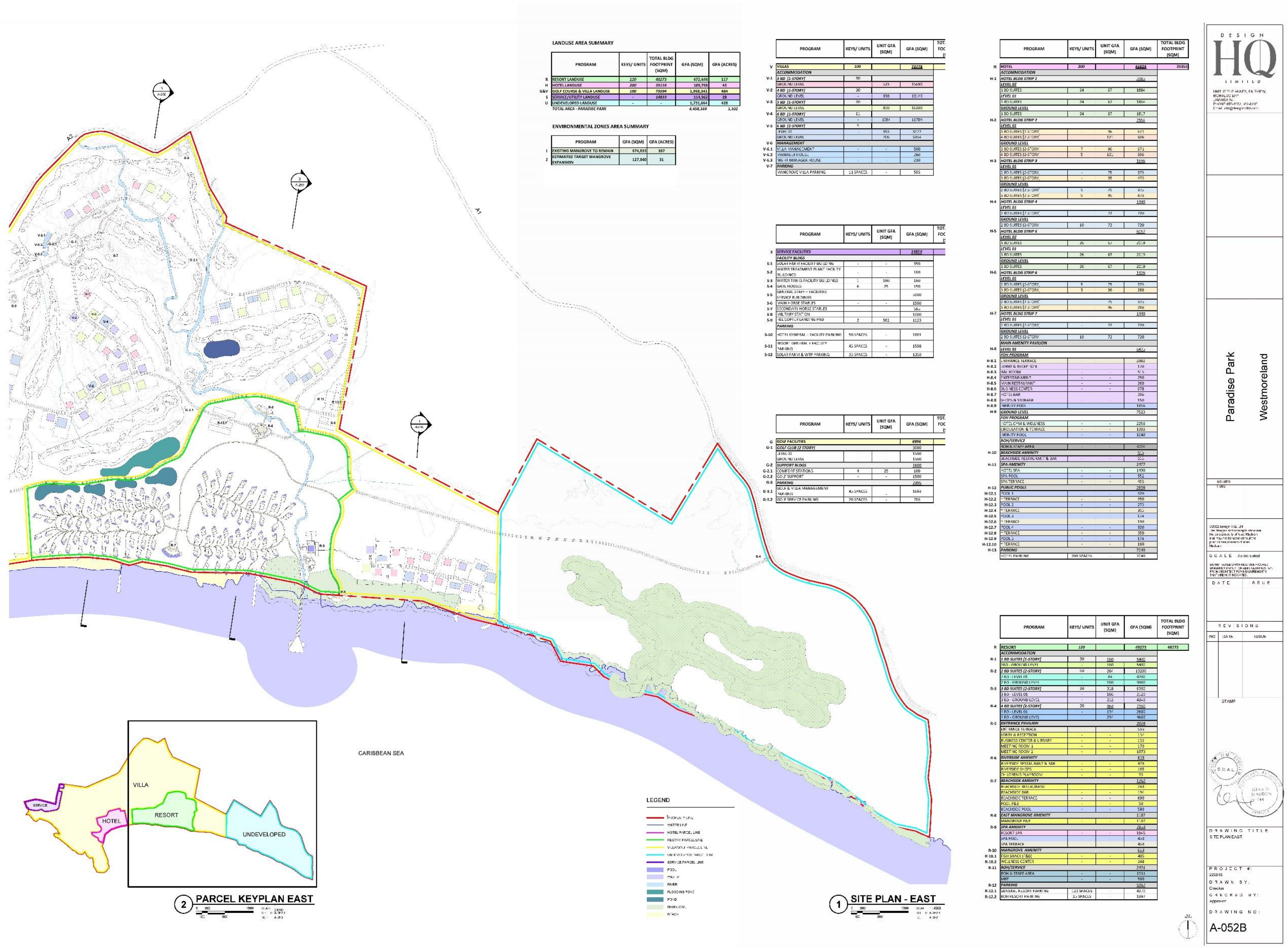


Figure 3-5 Eastern section of resort master plan for the proposed development

Figure 3-6 Illustrative site plan of the proposed development

3.2.2 Resort

The proposed Paradise Park development will feature 120 exclusive resort units for sale to provide the ultimate in luxury and privacy for its guests. These units will cater to high-net-worth individuals seeking an unparalleled, exclusive getaway experience. The resort will consist of several clusters of private villas, each with access to a shared pool and the full range of premium amenities. The resort will be anchored by a central reception and lounge area, which will serve as the main hub for visitors, providing easy access to a wealth of on-site facilities.

In addition to the central amenities, the resort will feature a designated beach area to the east of the hotel, providing guests with a private, tranquil space to enjoy the coastline. Culinary experiences will be a key part of the resort's offering, with a range of food and beverage outlets, including a main kitchen and several satellite kitchens to serve the various dining areas. For a more specialized dining experience, a small sushi restaurant will be located at the tip of land parcel Vol. 1141, Fol. 494, offering a unique, no-cooking-required experience with panoramic views.

The following are the various resort suites and amenities, the details of which are outlined in Table 3-2 and illustrated in Figure 3-7 though to Figure 3-13:

1) R-1 One Bedroom Suites (5,400 m^2)
2) R-2 Two Bedroom Suites (1,320 m^2)
3) R-3 Three Bedroom Suites (6,360 m^2)
4) R-4 Four Bedroom Suites (7,360 m^2)
5) R-5 Entrance Pavilion (2,024 m^2)
6) R-6 Riverside Amenity (616 m^2)
7) R-7 Beachside Amenity (1,762 m^2)
8) R-8 East Mangrove Amenity (1,187 m^2)
9) R-9 Spa Amenity (2,853 m^2)
10) R-10 Mangrove Amenity (653 m^2)
11) R-11 BOH/Service (2,491 m^2)
12) R-12 Parking (5,367 m^2)
13) R-13 Equestrian Amenity (2350 m^2)
14) R-14 Educational Amenity (1050 m^2)
15) R-15 Distillery Amenity (500 m^2)
16) R-16 Children's Amenity (100 m^2)
17) R-17 Water Amenity (200 m^2)
18) R-18 Sports Amenity (3734 m^2)
19) R-19 Outdoor Event Amenity (1100 m^2)

Table 3-2 Program components, keys, and unit areas for the proposed resort land use type

	PROGRAM	KEYS/ UNITS	UNIT GFA (SQM)	GFA (SQM)	TOTAL BLDG FOOTPRINT (SQM)
R	RESORT	*120*		58382	49382
	ACCOMMODATION				
R-1	***1 BD SUITES [1-STORY]***	30	180	5400	
	1BD - GROUND LEVEL	-	180	5400	
R-2	***2 BD SUITES [2-STORY]***	50	264	13200	
	2 BD - LEVEL 01	-	84	4200	
	2 BD - GROUND LEVEL	-	180	9000	
R-3	***3 BD SUITES [2-STORY]***	20	318	6360	
	3 BD - LEVEL 01	-	106	2120	
	3 BD - GROUND LEVEL	-	212	4240	
R-4	***4 BD SUITES [2-STORY]***	20	368	7360	
	4 BD - LEVEL 01	-	134	2680	
	4 BD - GROUND LEVEL	-	234	4680	
R-5	***ENTRANCE PAVILION***			2024	
	ENTRANCE TERRACE	-	-	535	
	LOBBY & RECEPTION	-	-	114	
	BUSINESS CENTER & LIBRARY	-	-	132	
	MEETING ROOM 1	-	-	170	
	MEETING ROOM 2	-	-	1073	
R-6	***RIVERSIDE AMENITY***			616	
	RIVERSIDE RESTAURANT & BAR	-	-	476	
	RIVERSIDE SHOPS	-	-	105	
	CHILDREN'S PLAYROOM	-	-	35	
R-7	***BEACHSIDE AMENITY***			1762	
	BEACHSIDE RESTAURANT	-	-	248	
	BEACHSIDE BAR	-	-	194	
	BEACHSIDE TERRACE	-	-	690	
	POOL F&B	-	-	50	
	BEACHSIDE POOL	-	-	580	
R-8	***EAST MANGROVE AMENITY***			1187	
	MANGROVE F&B	-	-	1187	
R-9	***SPA AMENITY***			2928	
	RESORT SPA	-	-	1945	
	FRAGRANCE STUDIO			75	
	SPA POOL	-	-	450	
	SPA TERRACE	-	-	458	
R-10	***MANGROVE AMENITY***			653	
	FISH SHACK (F&B)	-	-	405	
	WELLNESS CENTER	-	-	248	
R-11	***BOH/SERVICE***			2491	
	BOH & STAFF AREA	-	-	1911	
	MEP	-	-	580	
R-12	***PARKING***			5367	
	GENERAL RESORT PARKING	120 SPACES	-	4270	
	BOH RESORT PARKING	25 SPACES	-	1097	
R-13	***EQUESTRIAN AMENITY***			2350	
	EQUESTRIAN CENTER	-	-	2000	
	POLO CLUB	-	-	350	
R-14	***EDUCATIONAL AMENITY***			1050	
	FARMING SCHOOL	-	-	350	
	COOKING SCHOOL	-	-	350	
	ART SCHOOL	-	-	150	

	PROGRAM	KEYS/ UNITS	UNIT GFA (SQM)	GFA (SQM)	TOTAL BLDG FOOTPRINT (SQM)
	MUSIC SCHOOL	-	-	200	
R-15	***DISTILLERY AMENITY***			500	
	RUM DISTILLERY	-	-	500	
R-16	***CHILDREN'S AMENITY***			100	
	KID'S WORLD TOUR CENTER	-	-	100	
R-17	***WATER AMENITY***			200	
	WATER SPORTS CENTER	-	-	200	
R-18	***SPORTS AMENITY***			3734	
	TENNIS COURTS	4	264	1056	
	BASKETBALL COURTS	4	608	2432	
	PICKLEBALL COURTS	3	82	246	
R-19	***OUTDOOR EVENT AMENITY***			1100	
	RIVERSIDE	-	-	600	
	MANGROVE	-	-	500	

Plate 3-1 Aerial 3D render of proposed mangrove villas and amenities - fish shack and wellness centres (corresponding to R 10 in Table 3-2)

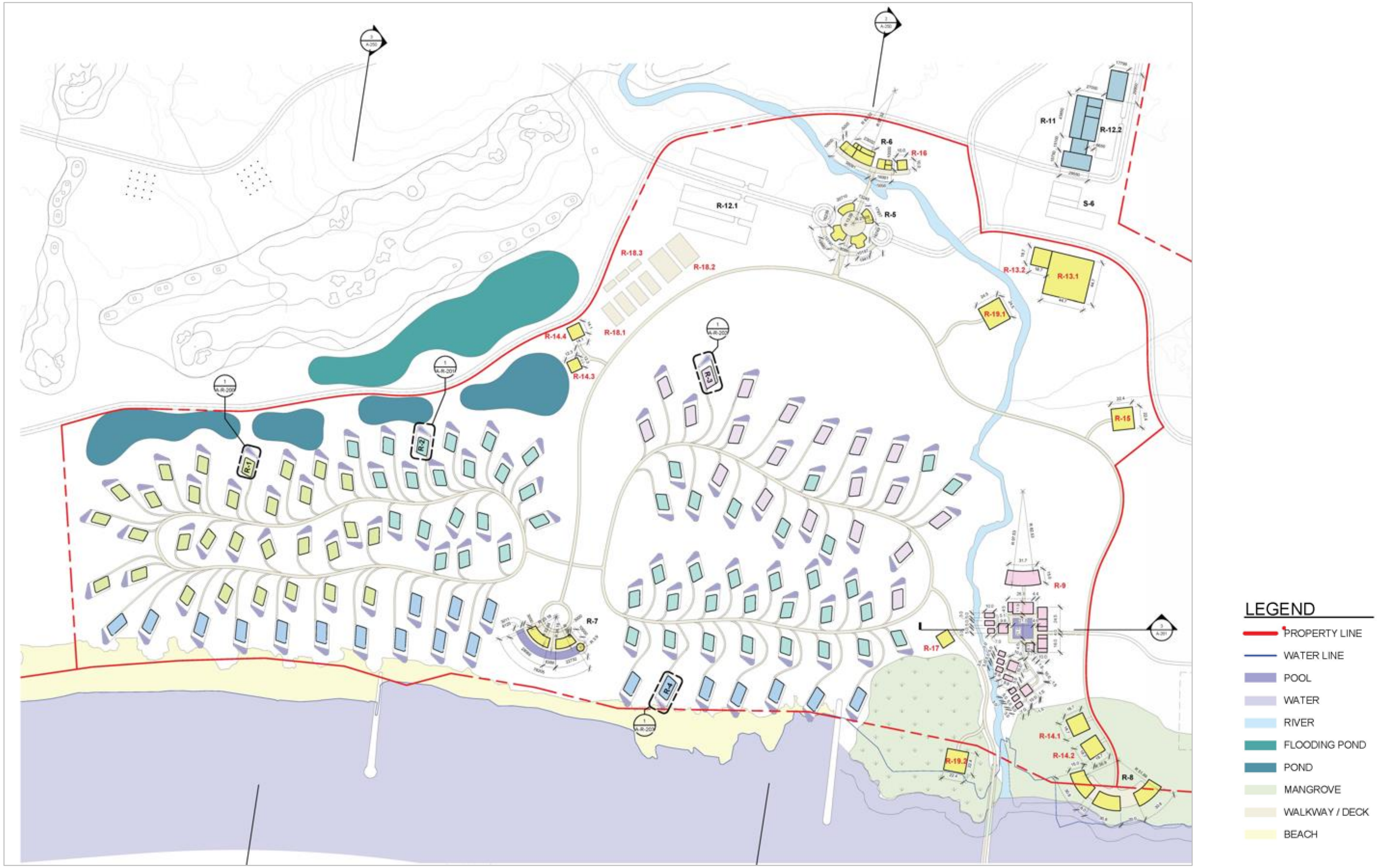


Figure 3-7 Proposed resort ground plan

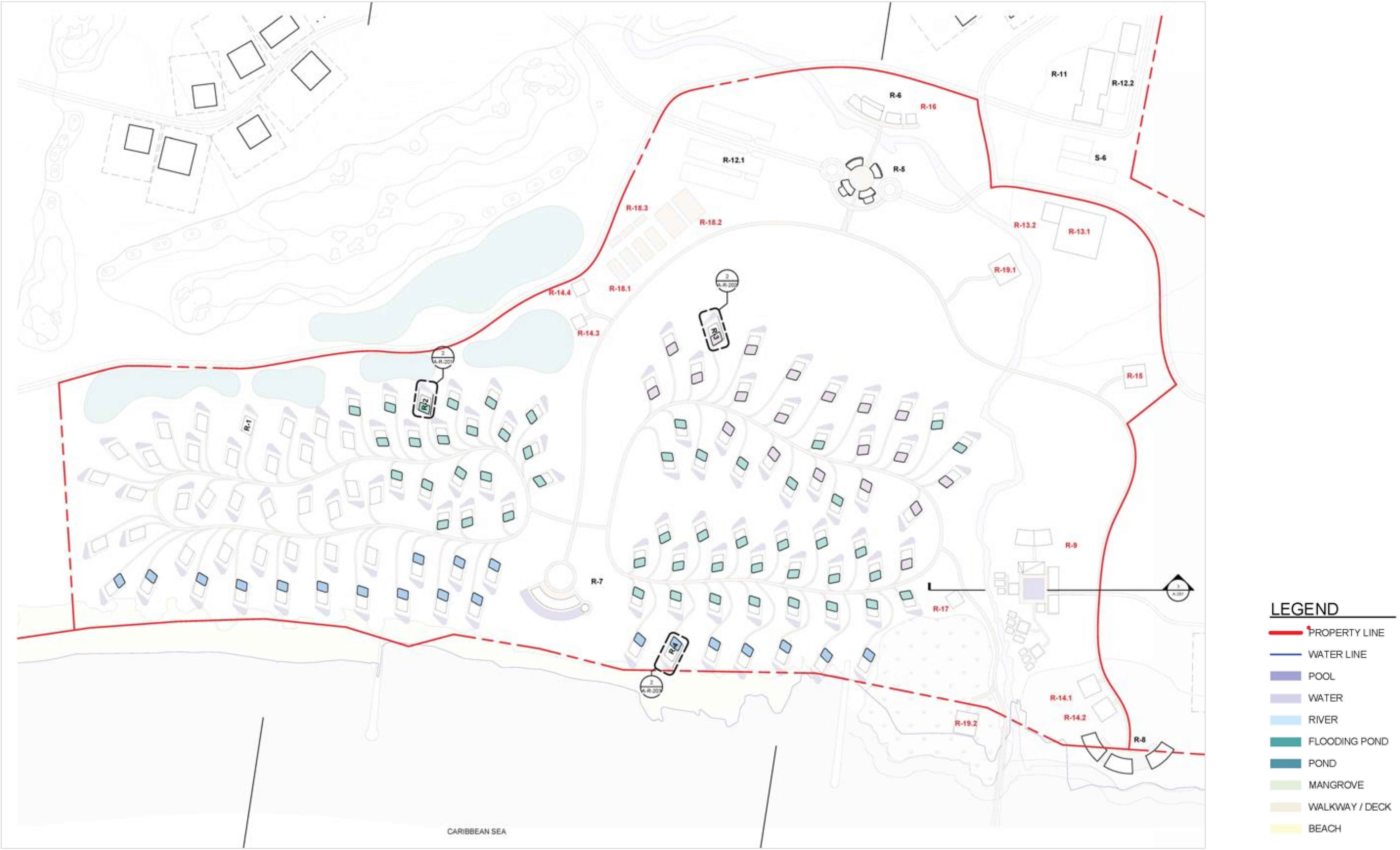
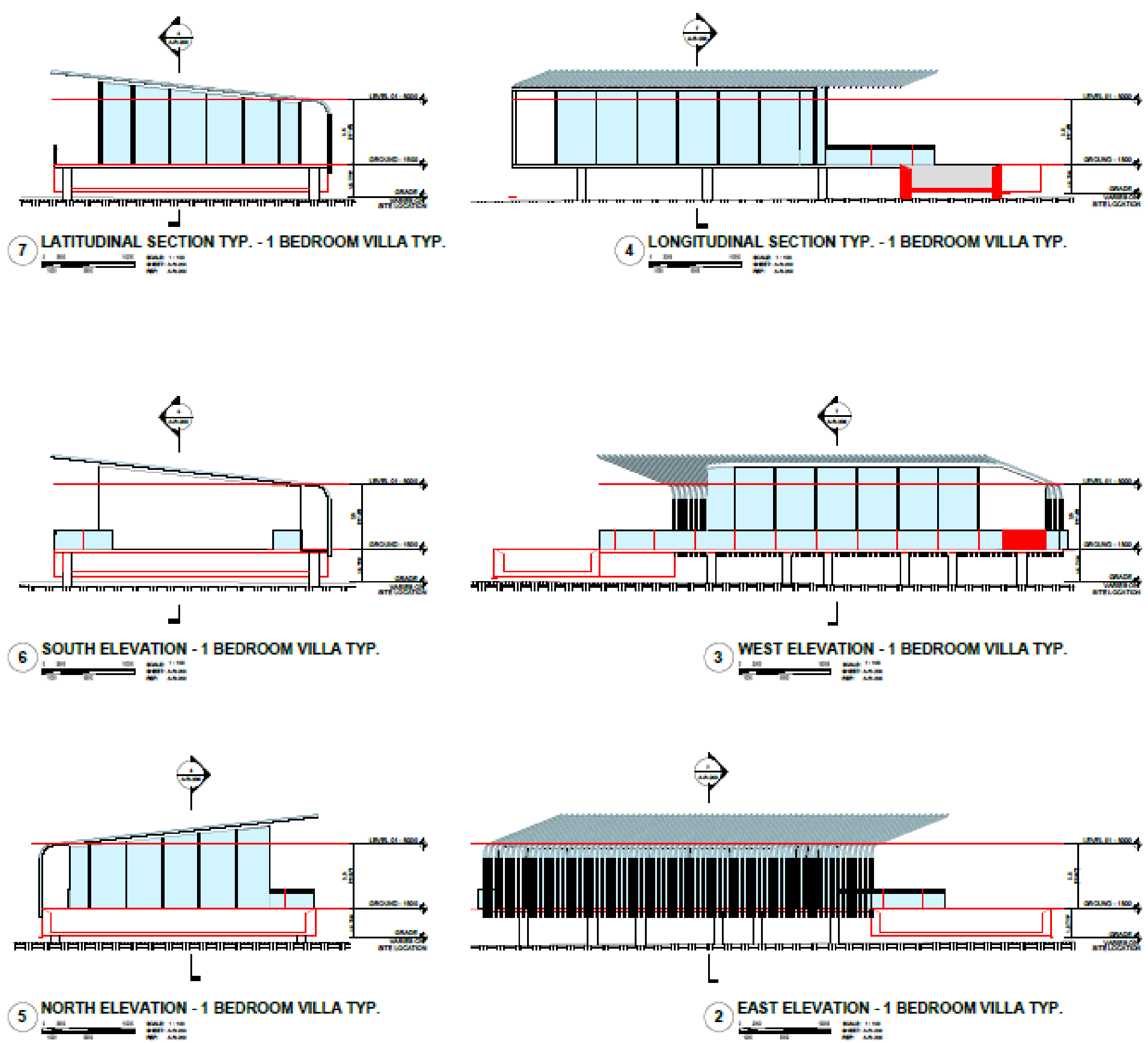


Figure 3-8 **Proposed resort level 01 plan**

Figure 3-9 Proposed resort roof plan

RESORT ACCOMMODATION

1 BD SUITES [1-STORY]	30 KEYS
NET AREA - LVL G	177 SQ M
POOL + DECK AREA	181 SQ M



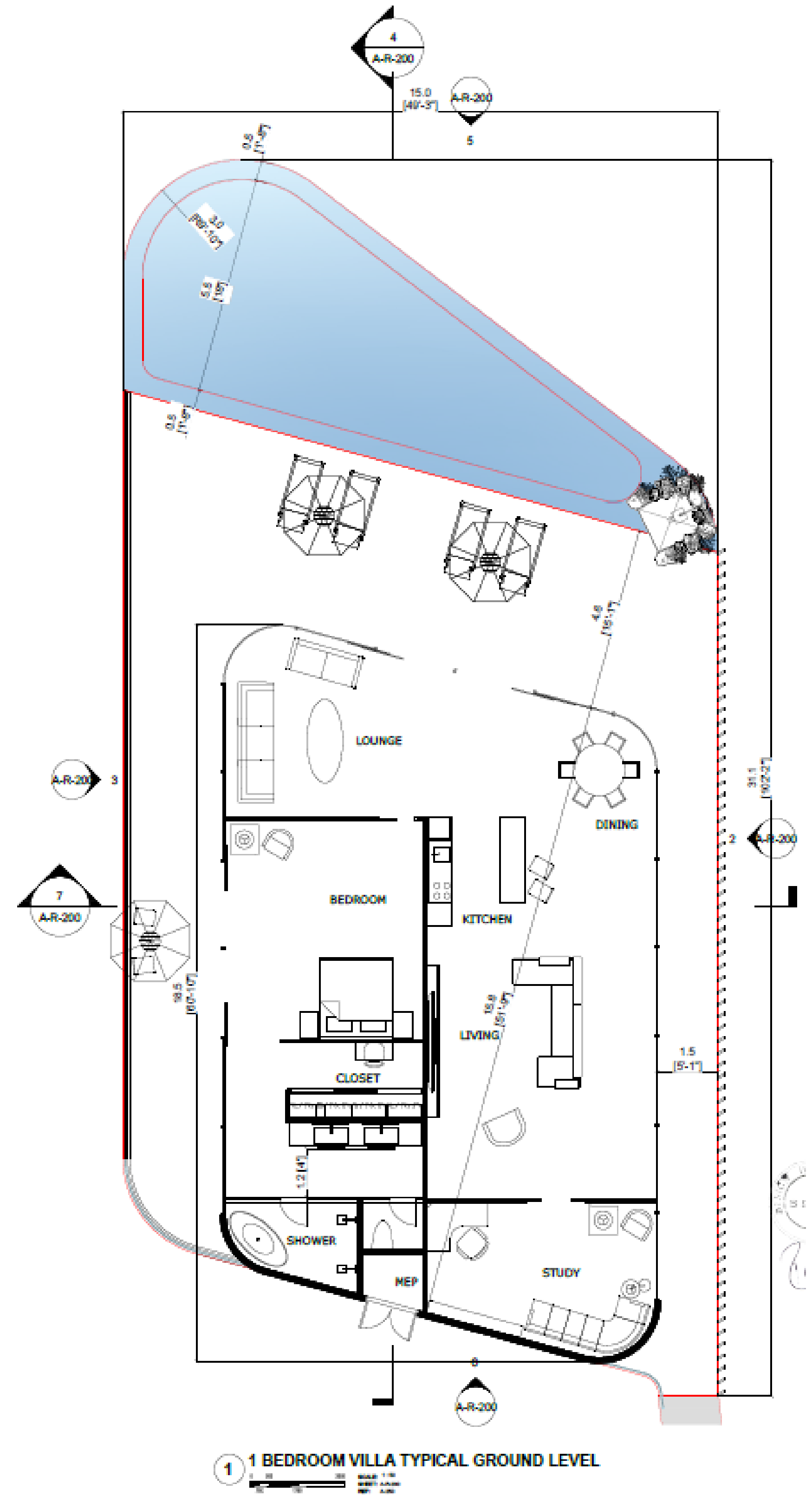


Figure 3-10 Resort 1-bedroom suite plans, elevation, and sections

RESORT ACCOMMODATION

2 BD SUITES [2-STORY]	50 KEYS
NET AREA - LVL 01	91 SQ M
NET AREA - LVL G	177 SQ M
POOL + DECK AREA	181 SQ M

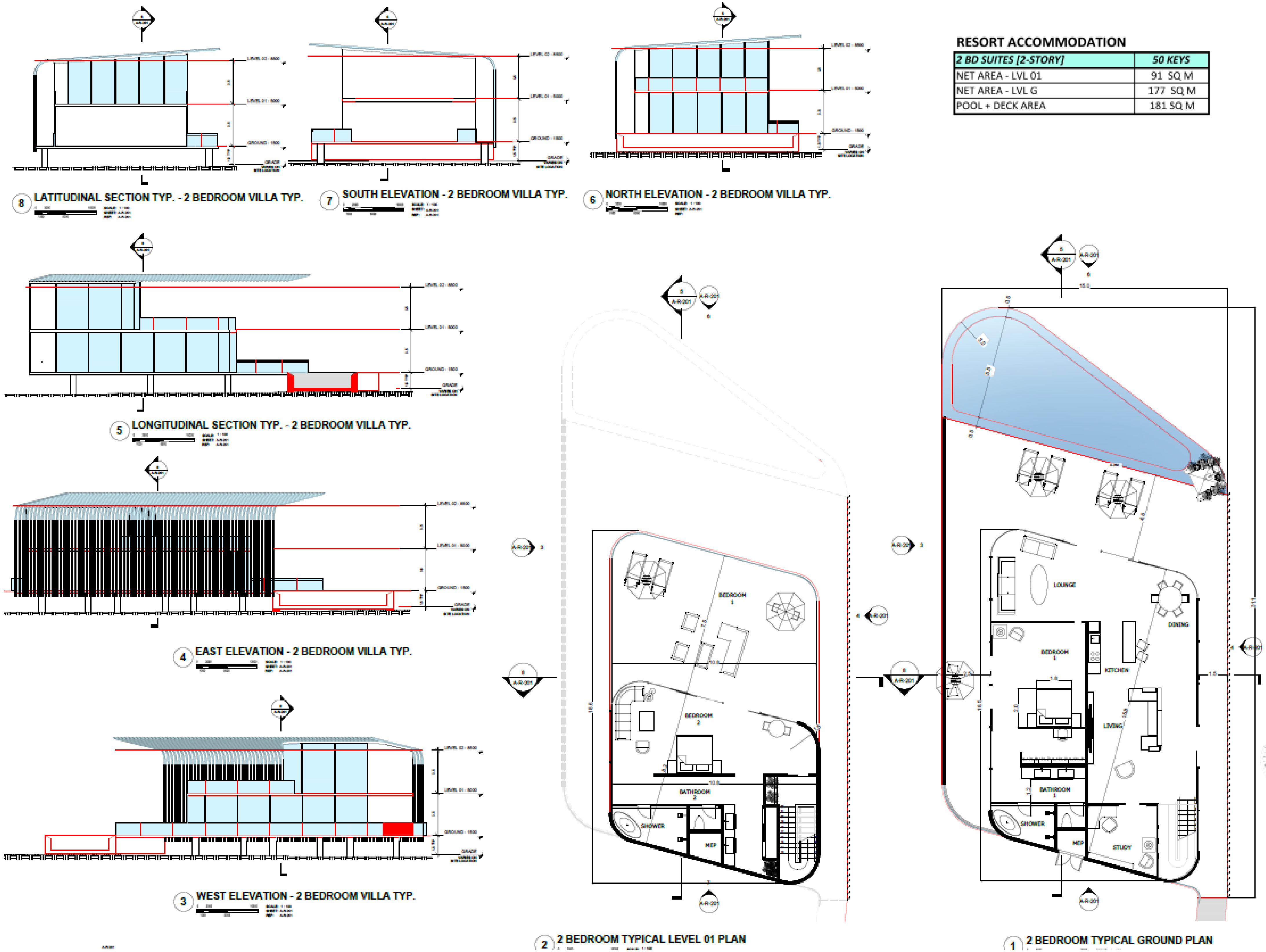
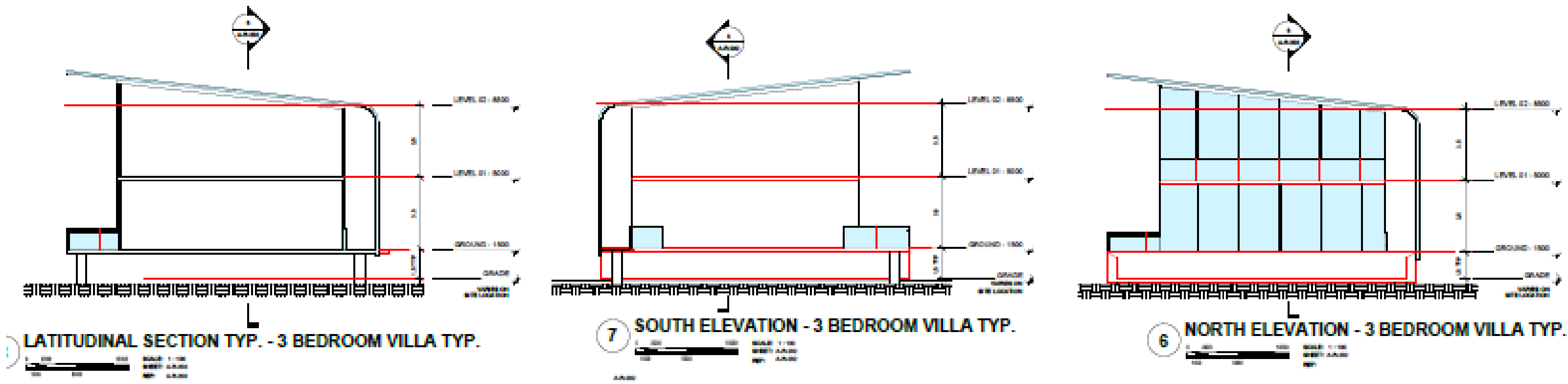
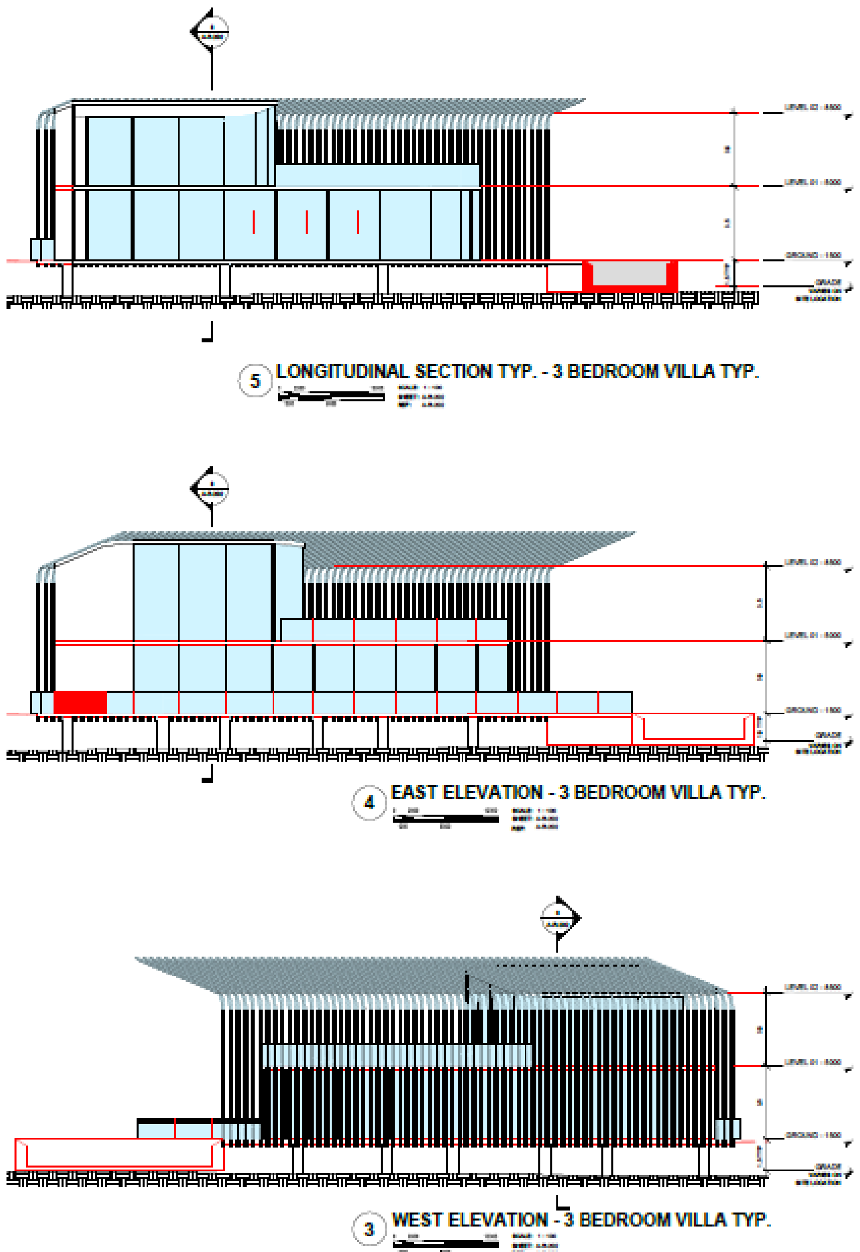


Figure 3-11 Resort 2-bedroom suite plans, elevation, and sections



RESORT ACCOMMODATION

3 BD SUITES [2-STORY]	20 KEYS
NET AREA - LVL 01	103
NET AREA - LVL G	209
POOL + DECK AREA	190



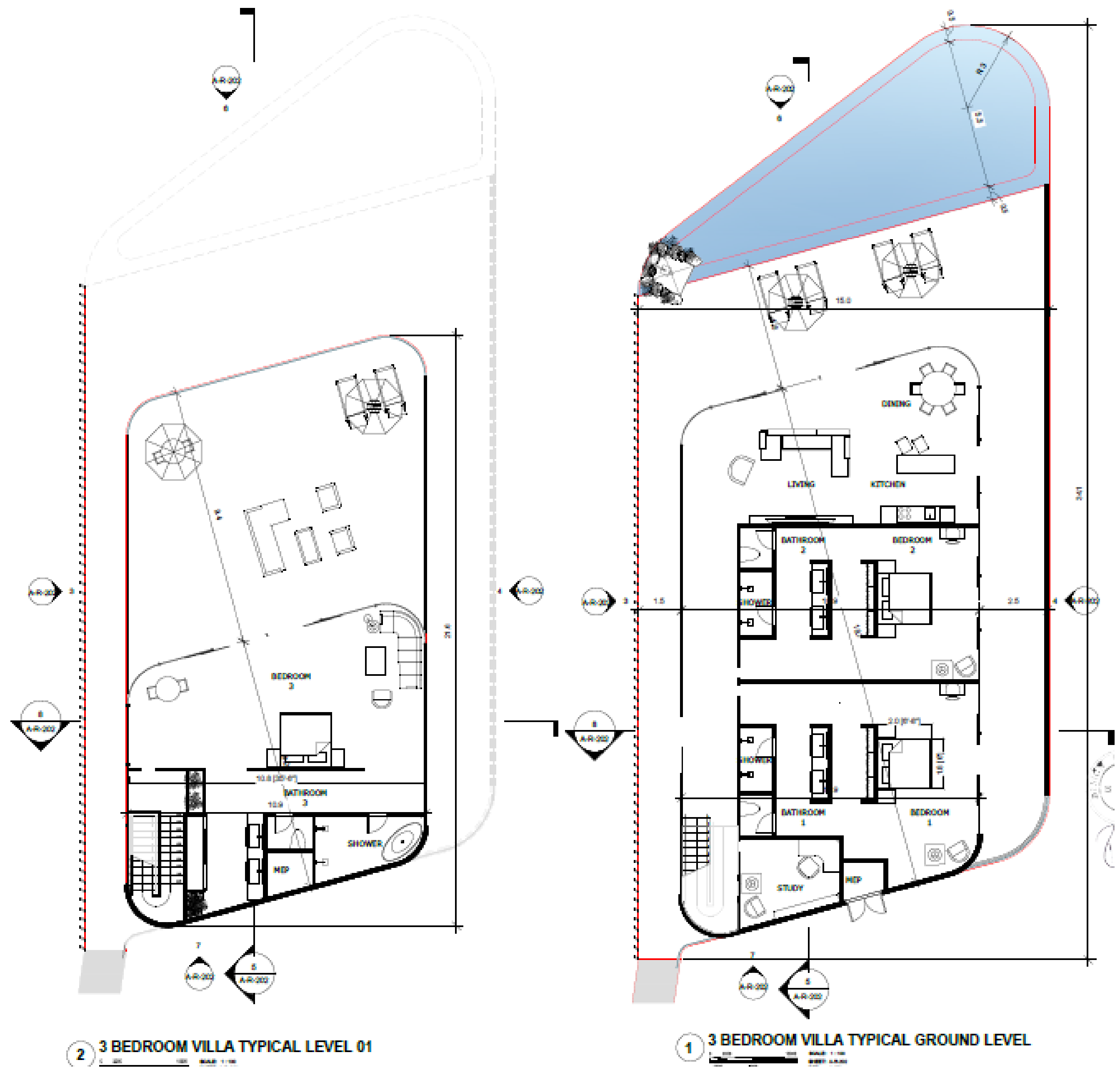
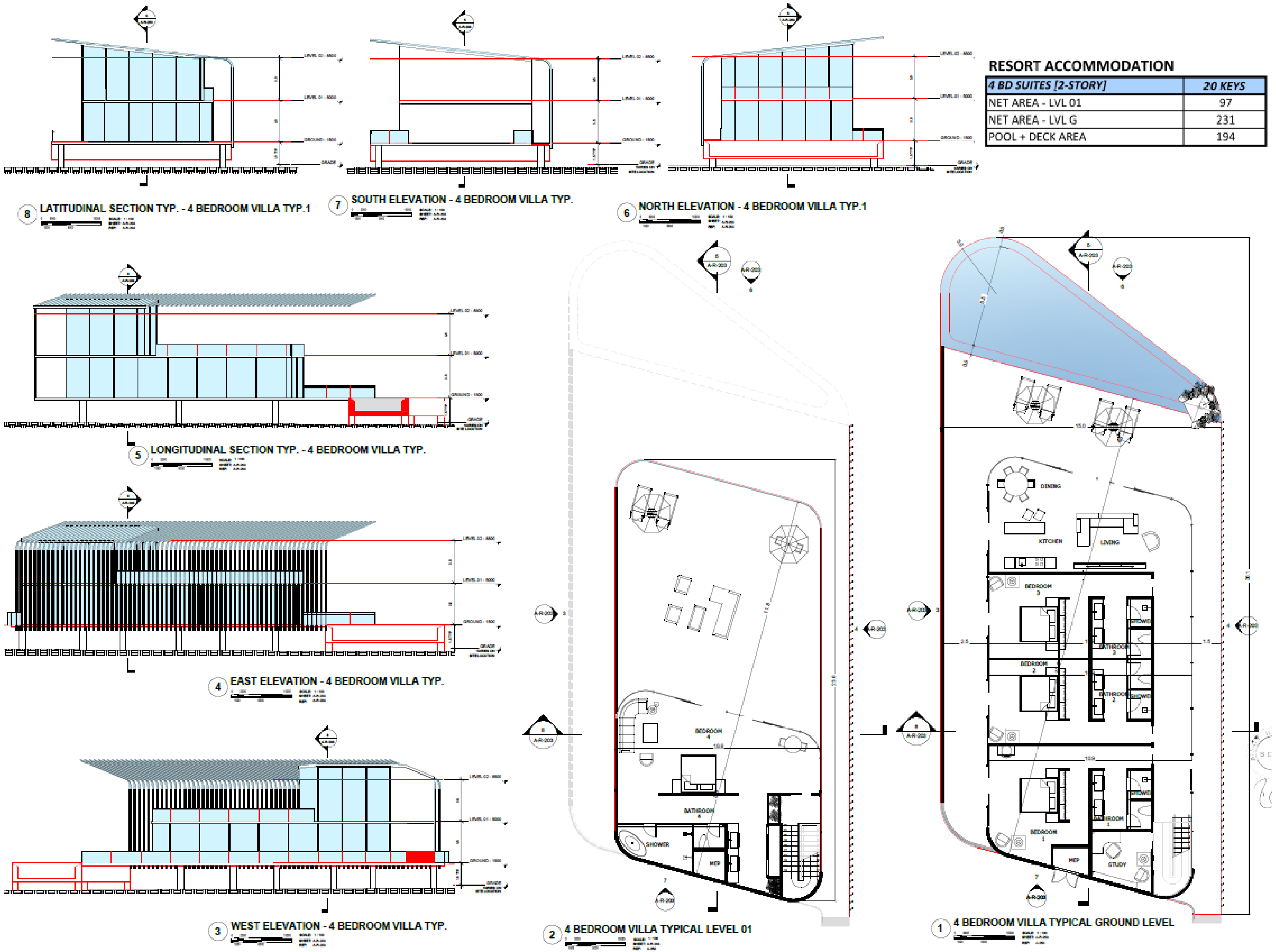


Figure 3-12 Resort 3-bedroom suite plans, elevation, and sections



RESORT ACCOMMODATION

4 BD SUITES [2-STORY]	20 KEYS
NET AREA - LVL 01	97
NET AREA - LVL G	231
POOL + DECK AREA	194

Figure 3-13 Resort 4-bedroom suite plans, elevation, and sections

3.2.3 Hotel

The centrepiece of the Paradise Park development will be an ultra-luxury 200-key hotel, designed to provide an open, airy, and elegant atmosphere through its multiple two-level strip buildings. With a total of 46,824 m^2 of interior space, the hotel will offer a variety of accommodations and services to cater to the diverse needs of its guests. The hotel's design will strategically place rooms across different sections of the site, ensuring each guest enjoys a unique experience.

In addition to its luxurious accommodations, the hotel will provide access to a range of premium amenities, including a spacious, designated beach area, allowing guests to enjoy the pristine coastline in privacy and comfort. The hotel will also feature a selection of food and beverage outlets, as well as a main kitchen and several satellite kitchens to support the culinary offerings. With a focus on both elegance and convenience, the hotel will serve as the focal point of the resort, offering guests a world-class stay and seamless access to all the exclusive amenities of Paradise Park.

The following are the various hotel strips and amenities, the details of which are outlined in Table 3-3 and illustrated in Figure 3-14 and Figure 3-18:

1) H-1 Hotel Building Strip 1 (5,585 m^2)
2) H-2 Hotel Building Strip 2 (2,554 m^2)
3) H-3 Hotel Building Strip 3 (1,556 m^2)
4) H-4 Hotel Building Strip 4 (1,344 m^2)
5) H-5 Hotel Building Strip 5 (6,057 m^2)
6) H-6 Hotel Building Strip 6 (1,180 m^2)
7) H-7 Hotel Building Strip 7 (1,344 m^2)
8) H-8 Main Amenity Pavilion Level 01 (6,475 m^2)
9) H-9 Main Amenity Pavilion Ground Level (7,523 m^2)
10) H-10 Beachside Amenity (515 m^2)
11) H-11 Spa Amenity (2,477 m^2)
12) H-12 Public Pools (2,696 m^2)
13) H-13 Parking (7,040 m^2)

Table 3-3 Program components, keys, and unit areas for the proposed hotel land use type

	PROGRAM	KEYS/ UNITS	UNIT GFA (SQM)	GFA (SQM)	TOTAL BLDG FOOTPRINT (SQM)
H	HOTEL	***200***		46824	35355
	ACCOMMODATION			-	
H-1	***HOTEL BLDG STRIP 1***			5585	
	LEVEL 02			-	
	1 BD SUITES	24	67	1884	
	LEVEL 01				
	1 BD SUITES	24	67	1884	
	GROUND LEVEL				
	1 BD SUITES	24	67	1817	

	PROGRAM	KEYS/ UNITS	UNIT GFA (SQM)	GFA (SQM)	TOTAL BLDG FOOTPRINT (SQM)
H-2	***HOTEL BLDG STRIP 2***			2554	
	LEVEL 01				
	3 BD SUITES [2-STORY]	-	96	671	
	4 BD SUITES [2-STORY]	-	121	606	
	GROUND LEVEL				
	3 BD SUITES [2-STORY]	7	96	671	
	4 BD SUITES [2-STORY]	5	121	606	
H-3	***HOTEL BLDG STRIP 3***			1696	
	LEVEL 01				
	2 BD SUITES [2-STORY]	-	75	375	
	3 BD SUITES [2-STORY]	-	95	473	
	GROUND LEVEL				
	2 BD SUITES [2-STORY]	5	75	375	
	3 BD SUITES [2-STORY]	5	95	473	
H-4	***HOTEL BLDG STRIP 4***			1440	
	LEVEL 01				
	2 BD SUITES [2-STORY]	-	72	720	
	GROUND LEVEL				
	2 BD SUITES [2-STORY]	10	72	720	
H-5	***HOTEL BLDG STRIP 5***			6057	
	LEVEL 02				
	1 BD SUITES	26	67	2019	
	LEVEL 01				
	1 BD SUITES	26	67	2019	
	GROUND LEVEL				
	1 BD SUITES	26	67	2019	
H-6	***HOTEL BLDG STRIP 6***			1326	
	LEVEL 01				
	2 BD SUITES [2-STORY]	5	75	375	
	3 BD SUITES [2-STORY]	3	96	288	
	GROUND LEVEL				
	2 BD SUITES [2-STORY]	-	75	375	
	3 BD SUITES [2-STORY]	-	96	288	
H-7	***HOTEL BLDG STRIP 7***			1440	
	LEVEL 01				
	2 BD SUITES [2-STORY]	-	72	720	
	GROUND LEVEL				
	2 BD SUITES [2-STORY]	10	72	720	
	MAIN AMENITY PAVILION				
H-8	***LEVEL 01***			6475	
	FOH PROGRAM				
	ENTRANCE TERRACE	-	-	2382	
	LOBBY & RECEPTION	-	-	170	
	BALLROOM	-	-	515	
	ENTERTAINMENT	-	-	250	
	MAIN RESTAURANT	-	-	268	
	BUSINESS CENTER	-	-	678	
	HOTEL BAR	-	-	206	
	SHOPS & STORAGE	-	-	150	
	INFINITY POOL	-	-	1856	
H-9	***GROUND LEVEL***			7523	
	FOH PROGRAM				

	PROGRAM	KEYS/ UNITS	UNIT GFA (SQM)	GFA (SQM)	TOTAL BLDG FOOTPRINT (SQM)
	HOTEL GYM & WELLNESS	-	-	2256	
	CIRCULATION & TERRACE	-	-	1203	
	INFINITY POOL	-	-	1040	
	BOH/SERVICE				
	BOH & STAFF AREA	-	-	3024	
H-10	***BEACHSIDE AMENITY***			515	
	BEACHSIDE RESTAURANT & BAR	-	-	515	
H-11	***SPA AMENITY***			2477	
	HOTEL SPA	-	-	1430	
	SPA POOL	-	-	552	
	SPA TERRACE	-	-	495	
H-12	***PUBLIC POOLS***			2696	
	POOL 1	-	-	320	
	~ TERRACE	-	-	350	
	POOL 2	-	-	273	
	~ TERRACE	-	-	355	
	POOL 3	-	-	174	
	~ TERRACE	-	-	190	
	POOL 4	-	-	320	
	~ TERRACE	-	-	350	
	POOL 5	-	-	174	
	~ TERRACE	-	-	190	
H-13	***PARKING***			7040	
	HOTEL PARKING	200 SPACES	-	7040	

Plate 3-2 **Aerial 3D render of proposed hotel and resort**

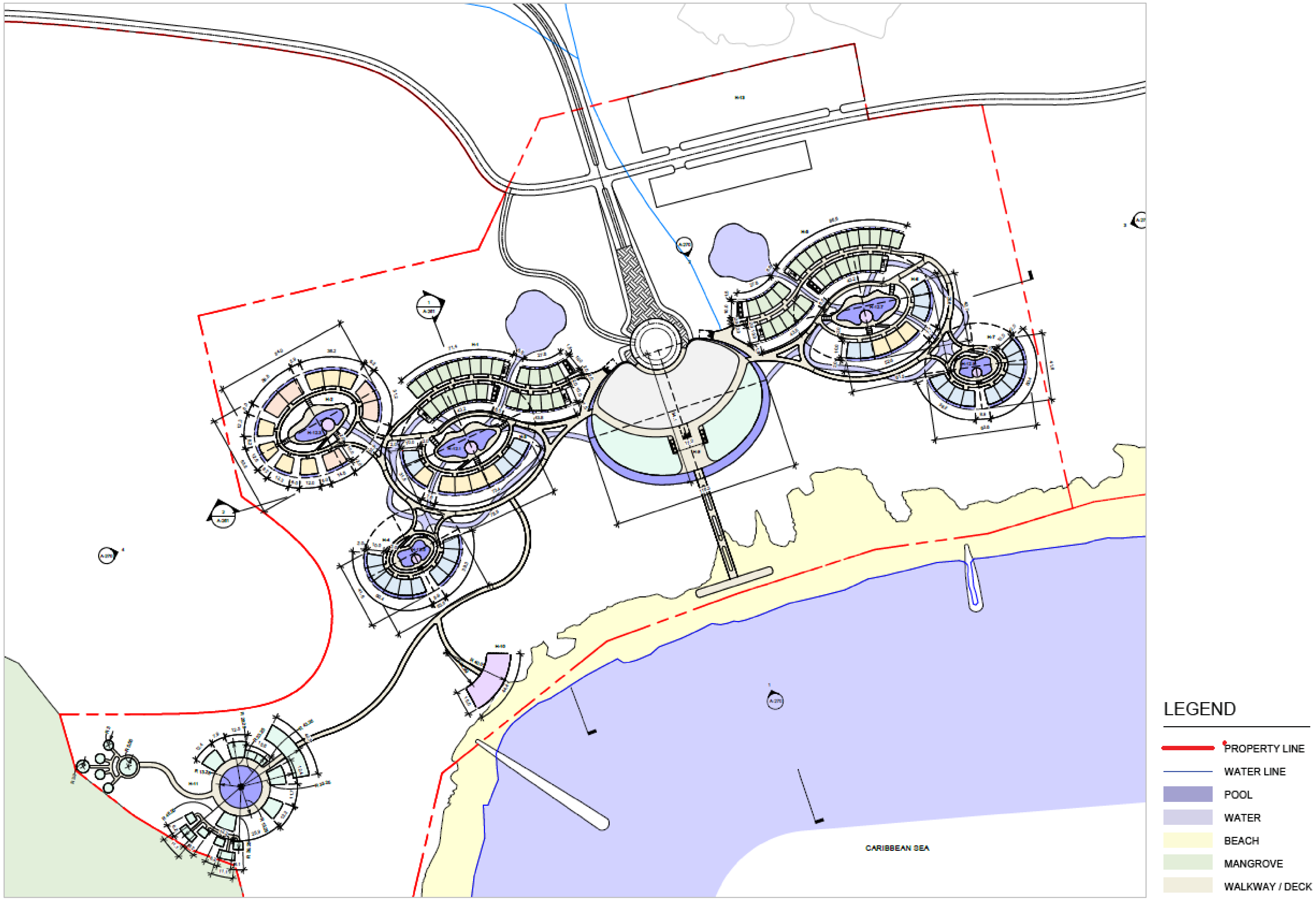


Figure 3-14 Proposed hotel ground plan

Figure 3-15 Proposed hotel level 01 plan

Figure 3-16 **Proposed hotel level 02 plan**

Figure 3-17 Proposed hotel level 02 plan

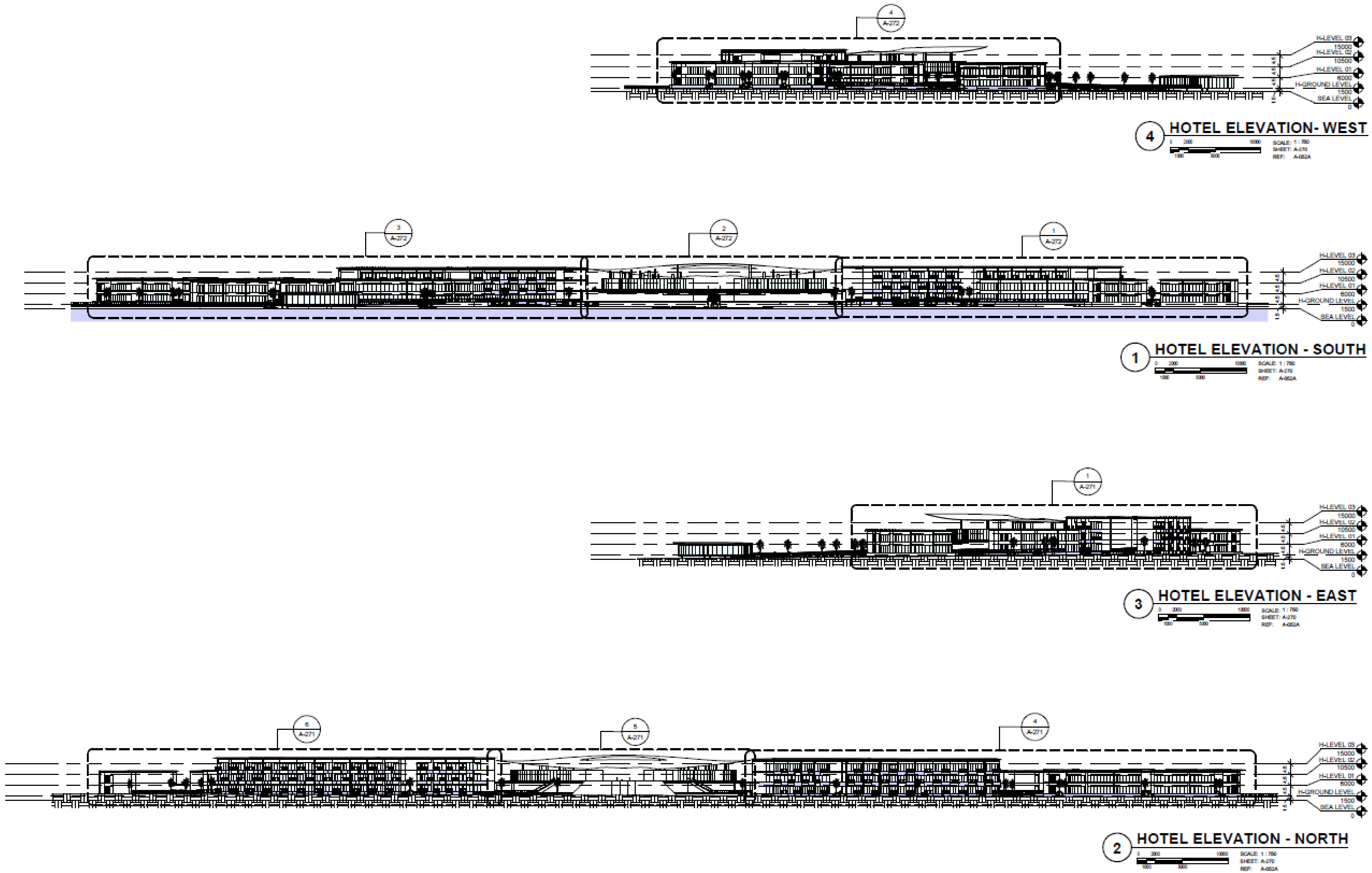


Figure 3-18 Hotel elevation

3.2.4 Villas

A key feature of the Paradise Park development will be a luxury residential community consisting of 100 privately owned villas, each designed to offer the highest level of comfort and privacy. A variety of villa sizes and experiences will be offered each strategically positioned in unique locations throughout the property to offer distinct, immersive environments, including a limited number of overwater and mangrove villas. These features will enhance the variety of views and offer a truly unique living experience for potential buyers, with expansive vistas of the golf course, ocean, mangrove wetlands, and surrounding landscape.

The villa buildings will collectively account for 73,778 m² of finished space, carefully designed to provide luxurious, private living accommodations for residents. The layout of the villas ensures that each one enjoys ample privacy and tranquillity, creating a serene environment that complements the resort's overall emphasis on exclusivity and sustainability. With their stunning views and integration into the natural surroundings, these villas will offer an unparalleled living experience in one of Jamaica's most sought-after locations.

The following are the various villas and amenities, the details of which are outlined in Table 3-4:

1) V-1 Three Bedroom Villas (15,690 m²)
2) V-2 Four Bedroom Villas (19,140 m²)
3) V-3 Five Bedroom Villas (16,200 m²)
4) V-4 Six Bedroom Villas One Story (11,704 m²)
5) V-5 Six Bedroom Villas Two Story (9,531 m²)
6) V-6 Management (1,010 m²)
7) V-7 Parking (503m²)

Table 3-4 Program components, keys, and unit areas for the proposed villa land use type

	PROGRAM	KEYS/ UNITS	UNIT GFA (SQM)	GFA (SQM)	TOTAL BLDG FOOTPRINT (SQM)
V	VILLAS	*100*		73778	70098
	ACCOMMODATION				
V-1	*3 BD [1-STORY]*	30			
	GROUND LEVEL	-	523	15690	
V-2	*4 BD [1-STORY]*	30			
	GROUND LEVEL	-	638	19140	
V-3	*5 BD [1-STORY]*	20			
	GROUND LEVEL	-	810	16200	
V-4	*6 BD [1-STORY]*	11			
	GROUND LEVEL	-	1064	11704	
V-5	*6 BD [2-STORY]*	9			
	LEVEL 01	-	353	3177	
	GROUND LEVEL	-	706	6354	
V-6	*MANAGEMENT*				
	VILLA MANAGEMENT	-	-	500	
	MANAGER HOUSE	-	-	280	

	NIGHT MANAGER HOUSE	-	-	230
V-7	*PARKING*			
	MANGROVE VILLA PARKING	11 SPACES	-	503

3.2.5 Golf

3.2.5.1 Overview

A pro tour level golf course and club house, with its own Food and Beverage facility, are situated within the villa land use to attract golfers from across the island and the world. The course integrates the existing natural environment into its hole design to have as little impact on the environment as possible. The following are the various golf features, the details of which are outlined in Table 3-5 and Figure 3-19:

1) G-1 Golf Clubhouse (3,000 m^2)
2) G-2 Support Buildings (1,600 m^2)
3) G-3 Parking (2,396 m^2)

Table 3-5 Program components, keys, and unit areas for the proposed golf land use type

	PROGRAM	KEYS/ UNITS	UNIT GFA (SQM)	GFA (SQM)	TOTAL BLDG FOOTPRINT (SQM)
G	GOLF FACILITIES			6996	5496
G-1	*GOLF CLUB [2 STORY]*			3000	
	LEVEL 01	-	-	1500	
	GROUND LEVEL	-	-	1500	
G-2	*SUPPORT BLDGS*			1600	
	COMFORT STATIONS	4	25	100	
	GOLF SUPPORT	-	-	1500	
G-3	*PARKING*			2396	
	GOLF & VILLA MANAGEMENT PARKING	45 SPACES	-	1693	
	GOLF SERVICE PARKING	20 SPACES	-	703	

The Paradise Park golf course is designed to offer an international-calibre venue that caters to golfers of all ages and skill levels, including beginners. The course will feature an 18-hole championship layout (Par 72) with a total length of 6,483 meters from the back tees, and five sets of tees ranging from 4,500 meters to accommodate various skill levels. Additionally, the facility will include generous practice areas, including a driving range, four practice greens, and three short Par 3 holes, making it an ideal venue for hosting professional competitions and youth golf programs. Collaborations with local schools and the Jamaica Golf Federation will support youth golf initiatives, fostering future talent and community engagement.

The project is fully committed to upholding sustainability policies set by both global and local standards, with a focus on creating a modern, sustainable development that prioritizes environmental protection. A construction timeline of 18-20 months, from groundbreaking to seeding or sprigging, is recommended. Recent studies suggest that all structures should be built at least 2 meters above current sea level to protect against rising sea levels in future generations. In alignment with this, the lowest point on the golf course has been designed to respect this threshold, as recommended by international hydrogeologists.

This will also provide protection for the golf area near the shoreline from the damaging effects of storm surges, which are increasing in frequency due to climate change.

SCORE CARD GOLF COURSE (meters)

HOLE	PAR	BLACK	WHITE	YELLOW	BLUE	RED	ORANGE
1	4	394	372	348	323	296	268
2	3	209	189	180	172	156	123
3	4	386	361	337	312	288	255
4	4	305	300	282	272	248	220
5	5	495	465	436	430	402	373
6	4	360	335	314	292	269	225
7	5	525	492	464	457	428	403
8	4	368	344	325	318	299	276
9	3	174	150	141	131	115	99
FRONT	36	3.216	3.008	2.827	2.707	2.501	2.242
10	4	356	331	307	297	263	235
11	3	197	182	176	154	146	123
12	4	339	334	313	305	276	252
13	3	166	153	144	133	121	103
14	4	403	380	355	331	304	255
15	5	492	466	458	433	403	371
16	4	422	397	371	343	316	283
17	5	499	468	441	434	404	377
18	4	393	368	343	319	295	258
BACK	36	3.267	3.079	2.908	2.749	2.528	2.257
TOTAL	72	6.483	6.087	5.735	5.456	5.029	4.499

LEGEND

- GOLF CART PATH
- LINE OF PLAY
- GOLF LAKE
- FILTRATION LAKE
- OVERFLOW / RETENTION LAKE
- TEE
- FAIRWAY
- ROUGH
- GREEN
- BUNKER

Figure 3-19 Proposed golf course design

3.2.5.2 Sustainability and Efficiency

Sustainability Initiatives

Meeting sustainability goals in the design of the golf course requires a comprehensive approach that incorporates multiple strategies and initiatives. Below is a prioritized list of sustainability measures being considered:

- **Maximizing Natural Features:** The design will focus on preserving and utilizing the site's existing topography, vegetation, and water features. The goal is to minimize, and where possible, eliminate any disruption to the natural landscape. Minimal grading will be undertaken, just enough to facilitate the recycling of rainwater back into the site's water storage system. A strategically placed lake system will store water and create a simple return cycle for excess water. The grading and contouring will guide surface water toward catch basins, which will be interconnected to direct runoff to a final destination. In projects near the shoreline, the use of deep wells is recommended at the lowest points to ensure any trace contaminants or silt are discharged below levels that could harm marine life.

- **Environmental Impact Assessment:** The project will carefully evaluate the environmental impact of the golf course construction, with an emphasis on minimizing disruption to existing wildlife and habitats. The lake system will serve dual purposes: capturing and reusing stormwater and excess rainwater during weather events and creating new ecosystems. This will support the development of habitats for a variety of bird species, animals, and fish, contributing to a more diverse local flora and fauna. Additionally, the engineering of the lake system will help address the silt contamination currently affecting the shoreline and bay water quality. By installing lakes at different levels throughout the valley, the suspended solids in the water can be gradually deposited, with the water eventually reaching the shoreline with significantly reduced silt content.

- **Eco-Friendly Products for Turf Management:** The golf course will make use of environmentally friendly products, ranging from organic fertilizers and natural insecticides to beneficial bacteria for controlling turfgrass fungal infections (Table 3-6). Numerous high-quality producers of sustainable golf course products exist in Mexico and Central America, many of whom are recognized internationally for their products.

Energy Efficiency Measures

The golf course maintenance industry has seen significant advancements in recent years, with a growing shift toward energy-efficient technologies. Key initiatives for energy efficiency in the Paradise Park golf project include:

- **Electric and Solar-Powered Equipment:** The industry now features electric fleets of mowers, tractors, and general maintenance machinery, many of which operate almost exclusively on solar power. While traditional gas and diesel-powered machines remain popular among greenkeepers and superintendents, these machines have become more efficient, striving to minimize their environmental impact. Once the project moves forward, detailed studies will be conducted to select a custom fleet of equipment that adheres to all environmental regulations, ensuring both efficiency and sustainability.

- **Electric and Hybrid Golf Carts:** Electric and hybrid golf carts have become standard within the golf course industry, reducing reliance on fossil fuels and offering a cleaner, more efficient alternative for course transportation. To further promote sustainability, the maintenance facility will be equipped with a photovoltaic (solar) system, enabling the sustainable charging of both the maintenance equipment fleet and the golf carts, reducing the overall carbon footprint of the operation.

Irrigation System

The irrigation system will be designed with a strong emphasis on water conservation, aiming to minimize water usage while ensuring optimal turf health. Key features include:

- **Individual Sprinkler Control:** Each sprinkler on the course will be managed by a sophisticated central control unit. This will allow the system to adjust watering based on the specific needs of different areas. For instance, sprinklers at lower points of the course will apply less water, as runoff will naturally accumulate in these areas, reducing the need for additional irrigation.

- **Integrated Pump Station and Irrigation System:** The pump station will be interconnected with the irrigation system to optimize water usage. It will ensure that the irrigation cycle is evenly distributed throughout the night, reducing energy consumption. Additionally, the coordination between the two systems will provide tight control over water application and recovery from the water source, ensuring efficiency and minimizing waste.

- **Weather-Responsive Irrigation:** The system will incorporate data from an electronic weather station, which will relay real-time information about soil moisture and humidity to the irrigation control system. This data will allow the system to adjust watering schedules based on actual conditions, significantly reducing water usage while maintaining the health of the turf.

- **Protection of Feature Trees:** Every effort will be made to protect the existing trees, which are not only key visual features but also integral to the local ecosystem. A detailed study will be undertaken to assess how each species of tree responds to irrigation water. Should any species be sensitive to irrigation water or spray, adjustments will be made to minimize or eliminate any contact with irrigation systems.

- **Drip Irrigation for Landscape Areas:** Drip irrigation will be used for flower beds and landscaped zones, as it is highly efficient in delivering water directly to the root zone. The system will be adjustable, allowing different volumes of water to be applied based on the specific needs of the landscape, ensuring that each area receives the optimal amount of water. Additionally, individual trees within the landscaped areas will be targeted by the system to ensure they receive the additional water they require.

Turf Management

The turf management strategy will focus on selecting grass varieties and practices that are well-suited to the local environment, reducing maintenance needs, and enhancing sustainability. Key initiatives include:

- **Selection of Suitable Grass Varieties:** Grass varieties will be chosen that are well-suited to the local climate and require minimal water and maintenance. For a project located near the sea, *Paspalum vaginatum* is recommended due to its high salt tolerance, making it ideal for golf course applications. This grass variety is particularly well-suited for use across greens, tees, fairways, and roughs, helping to minimize cross-contamination from other grass types and reducing the negative impact of sea spray on the turf.

- **Use of Organic Fertilizers and Soil Amendments:** Organic fertilizers and amendments will be employed to improve soil structure, enhance water retention, and ensure a steady nutrient supply. Given the project's proximity to the shoreline and groundwater, the use of organic and environmentally friendly products will be prioritized (Table 3-6). Due to the increased potential for trace contamination in these areas, every effort will be made to minimize this risk. One effective method will be the use of deep wells, particularly near the shoreline, to safely discharge any residual trace contaminants.

Table 3-6 Examples of green and blue band environmentally friendly phytosanitary products

Category	Pesticide	Description
Green Band Pesticides (Low Toxicological Profile)	**Insecticides**	
	Azadirachtin (derived from Neem)	Controls sucking and chewing insects (e.g., aphids, cutworms); used preventively and curatively on greens & fairways.
	Bacillus thuringiensis (Bt)	Controls lepidopteran larvae; biological, specific, and safe for beneficial fauna.
	Metarhizium anisopliae	Controls soil insects like blind hen (white worms).
	Spinosad	Derived from natural bacteria; effective for controlling pest insects (e.g., tracer worms) in the larval state.
	Beauveria bassiana	Biological control for sucking insects.
	Fungicides	
	Trichoderma spp	Biocontrol for fungal diseases (e.g., Pythium, Fusarium, Rhizoctonia); used preventively.
	Elemental sulphur	Controls powdery mildew (white spots) and superficial lawn diseases.
	Herbicides	
	Ammonium glufosinate	Controls broadleaf weeds (low residuality in soil); use in controlled doses.

	Pelargonic acid	Derived from plant extracts; ideal for controlling young weeds in specific areas of the golf course.
Blue Band Pesticides (Low Toxicity)	**Insecticide**	
	Imidacloprid	Systemic control for pests such as bed bugs, blind hen, Ataenius sp., weevils, etc.
	Fungicides	
	Propiconazole	Controls leaf spots, Dollar Spot, Fusarium sp.; apply in controlled doses.
	Chlorothalonil	Effective protectant for preventive and curative management of fungal diseases.
	Mancozeb	Broad-spectrum protectant for foliar diseases, especially during humid conditions.
	Herbicides	
	Sulfentrazone	Controls sedges and broadleaf weeds in greens & fairways.
	Fluazifop-P-butyl	Selective herbicide for narrow-leaf weeds (e.g., common Bermuda grass, Gaminicida grasses).

Waste Reduction and Management

Sustainability will be incorporated into waste management practices throughout the project's lifecycle:

- **Recycling and Reuse:** Grass clippings and plant material will be repurposed to return nutrients to the soil in specific areas of the course, particularly during grow-in and ongoing maintenance phases.
- **Recycling Programs:** Comprehensive recycling programs will be implemented during both the construction and operational phases of the project, ensuring that waste is minimized, and resources are reused whenever possible.
- **Minimizing Plastic Waste:** Efforts will be made to reduce or eliminate the use of single-use plastics throughout the development and operation of the golf course.

Biodiversity and Ecosystem Support

The development will prioritize the preservation and enhancement of local biodiversity and ecosystem health:

- **Diverse Plantings for Biodiversity:** A variety of plant species, including native grasses, wildflowers, and shrubs, will be incorporated around turf areas to promote local biodiversity. Landscaping decisions will consider the quality of the irrigation water and adhere to relevant local regulations. The natural flora of Jamaica will be integrated into the park’s landscaping, enhancing the beauty of the site while supporting local wildlife.
- **Creating Habitats for Wildlife:** The project will focus on creating habitats for beneficial insects, birds, and other wildlife, contributing to natural pest control and overall ecosystem health. This will include minimizing vegetation removal within the golf course footprint and surrounding areas. The construction of lakes will further enhance the ecosystem by providing new habitats

for a variety of species, boosting biodiversity, and supporting the growth of new plant and animal life.

Education and Training

Ongoing education and awareness will be central to the sustainable management of the golf course:

- **Staff Training in Sustainable Practices:** Maintenance staff will be educated and trained in sustainable golf course management practices, using the latest techniques and technologies to minimize environmental impact.
- **Raising Awareness Among Golfers:** Information about the project's sustainability initiatives will be provided to golfers, helping them understand the importance of sustainability and encouraging them to actively support and participate in these efforts.

3.2.5.3 Design Strategy

The guiding principle is to intervene as little as possible within the given land and to integrate the golf course naturally into the terrain. The preliminary designs for Paradise Park have incorporated several key considerations to ensure the project harmonizes with its natural environment:

- The design aims to avoid ecologically sensitive areas, particularly wildlife habitats. Existing natural features such as trees, water bodies, and native vegetation have been preserved and integrated into the design. As previously noted, the majestic trees around the park are central to the layout, and every effort has been made to respect and incorporate these trees into the overall design. The design approach also minimizes land alteration, preserving the site's natural contours and features to maintain the integrity of the environment (Figure 3-20).
- Native plants and trees will be incorporated into the landscaping to support local wildlife and reduce long-term maintenance. Locally sourced materials will be prioritized to reduce transportation emissions and support the local economy. For grass planting, we encourage using local sand or crushed rock as a rootzone medium. Unlike topsoil, which often contains weed seeds that can contaminate the grass, crushed rock is inert, free-draining, and ideal for all-weather play. The portion of crushed rock not suitable for rootzone can still be used to create features on the golf course, ensuring a sustainable solution without the risk of contamination.

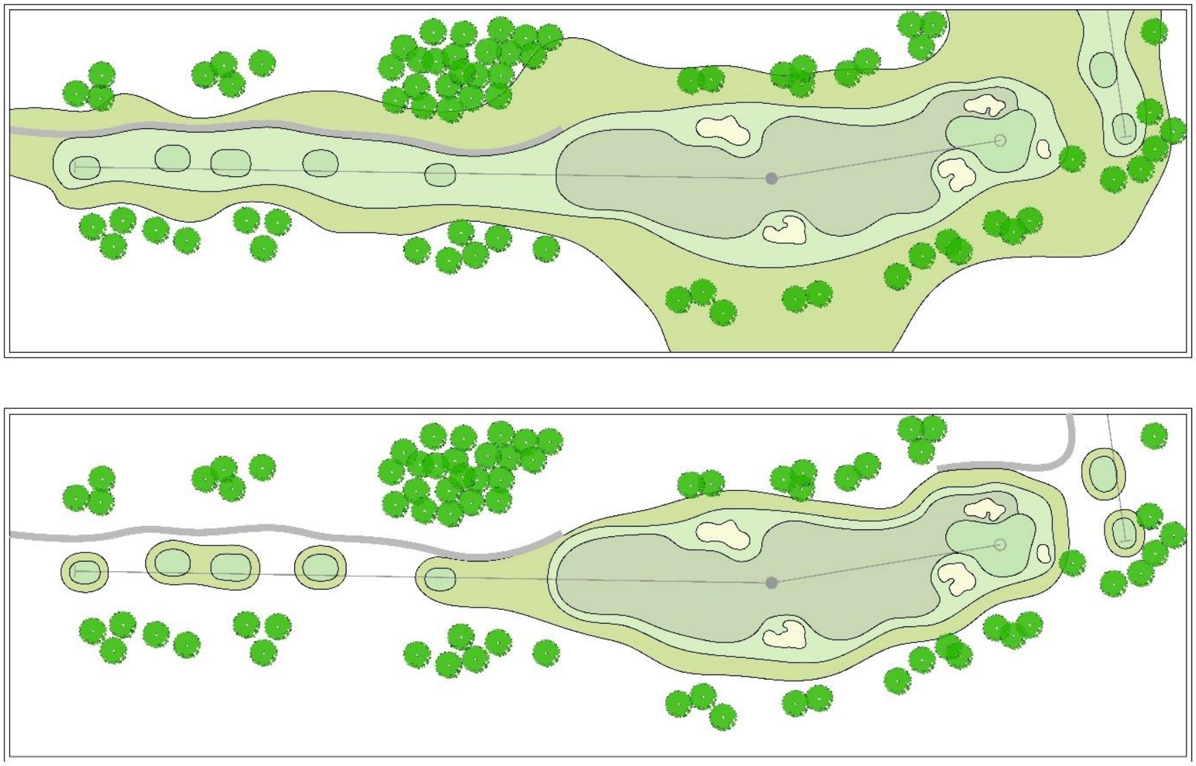


Figure 3-20 Example of extensive use of resources with large, turfed areas resulting in large earthworks area and increased irrigation needs (top) and example of reduced turfed area without compromising the playability nor golf strategy (bottom).

3.2.6 Overwater and Mangrove Villas

A total of five (5) overwater villas and six (6) mangrove villas are proposed. These will be a mixture of 3- and 4-bedroom villas with following specifications:

- The 3-bedroom units will be 34.1 M long x 15M wide. The building will rise 7 M in height for the interior space height (first floor 3.5 M and second floor 3.5 M) from the ground floor elevation and approximately 10 M in height from the water elevation to the highest point. The interior liveable space will be 523 (SQM) and the GFA 15690 (SQM).
- The 4-bedroom units will have a building foundation footprint 36.1M long x 15M wide. The building will rise 7 M in height for the interior space height (first floor 3.5M and second floor 3.5 M) from the ground floor elevation and approximately 10M in height from the water level to the highest point of the structures. The interior liveable space will be 638 (SQM) and the GFA 19140 (SQM).

The building structure will consist of cast in place concrete and weather resistant structural aluminium framing with Miami Dade Hurricane Rated Glass Wall System.

3.2.7 Service Facilities

Various service facilities are placed strategically throughout the site to optimally support the hotel, resort, villa, and golf land uses (Table 3-7):

1) S-1 Solar Farm Facility Building (350 m^2)
2) S-2 Water Treatment Plant Facility Buildings (180 m^2)
3) S-3 Water Tank Facility Building (360 m^2)
4) S-4 Gate Houses (150 m^2)
5) S-5 General Staff + Facilities – Services Buildings (5,000 m^2)
6) S-6 Main Horse Stables (1,500 m^2)
7) S-7 Secondary Horse Stables (585 m^2)
8) S-8 Military Station (1,000 m^2)
9) S-9 Helicopter Landing Pad (1,125 m^2)
10) S-10 Hotel General + Facility Parking (1,801 m^2)
11) S-11 Resort General + Facility Parking (1,598 m^2)
12) S-12 Solar Farm & Water Treatment Plant Parking (1,350 m^2)

Table 3-7 Program components, keys, and unit areas for the proposed service facilities land use type

	PROGRAM	KEYS/ UNITS	UNIT GFA (SQM)	GFA (SQM)	TOTAL BLDG FOOTPRINT (SQM)
S	**SERVICE FACILITIES**			***14819***	**14819**
	FACILITY BLDGS				
S-1	SOLAR FARM FACILITY BUILDING	-	-	350	
S-2	WATER TREATMENT PLANT FACILITY BUILDINGS	-	-	180	
S-3	WATER TANKS FACILITY BUILDINGS	1	180	180	
S-4	GATE HOUSES	6	25	150	
S-5	GENERAL STAFF + FACILITIES - SERVICE BUILDINGS	-	-	5000	
S-6	MAIN HORSE STABLES	-	-	1500	
S-7	SECONDARY HORSE STABLES	-	-	585	
S-8	MILITARY STATION	-	-	1000	
S-9	HELICOPTER LANDING PAD	2	562	1125	
	PARKING				
S-10	HOTEL GENERAL + FACILITY PARKING	50 SPACES	-	1801	
S-11	RESORT GENERAL + FACILITY PARKING	45 SPACES	-	1598	
S-12	SOLAR FARM & WTP PARKING	35 SPACES	-	1350	

3.2.8 Amenities

There will be separate amenities for the Resort, Villas, and the Hotel, as well as some shared amenities for all guests.

- **For Resort/Villa guests:**
  - Spa/Wellness Centre

  - Gym
  - Tennis Courts
  - Farming School: Guests will have the opportunity to learn how to grow vegetables, with a focus on techniques specific to Jamaica.
  - Cooking School: A hands-on culinary experience where guests can learn to prepare Jamaican dishes as well as other unique cuisines from around the world.
  - Equestrian Centre: A fully equipped equestrian facility will be built, featuring stables and outdoor riding fields.
  - Polo Club: This amenity will pay tribute to the site's history as the location of Jamaica's first Polo Club.
  - Art School: Guests can explore and learn various forms of Jamaican art, including painting and pottery.
  - Music Recording Studio: A professional studio will be available to musicians from around the world, allowing them to stay at the resort and record their music.
  - Fragrance School: Guests will be introduced to the art and science of creating perfumes and fragrances.
- **For Hotel guests:**
  - Spa/Wellness Centre
  - Gym
  - Tennis Courts
  - Pickleball Courts
- **Common Amenities for all guests:**
  - Children's Club
  - Rum Bottling Facility: Guests will have the chance to create their own personalized bottles of rum. The rum will be produced at an external distillery, stored in tanks, and bottled with custom labels.
  - Basketball Court

3.2.9 Undeveloped "Ecological Zone"

The undeveloped land use areas are reserved for ecological preservation and appreciation.

3.2.10 Access and Parking

3.2.10.1 Roadways

Defined as the areas of the public realm that are reserved for circulation and mobility. Focused on functionality, streets will include key aspects of the urban planning and design such as transportation (public and private), infrastructure, utilities, conveyance systems, landscape, and civic space. The street design will have a major role in the achievement of sustainability goals.

1. MAIN ROADS:

   a. Key aspects: Designed for primary access on to the site for the hotel and golf clubhouse. Meant to be a grand and luxurious experience through use of a wide road width, lush landscaping, and beautiful scenery.
   b. Approximate cumulative length: 1,914.2 m
   c. Approximate width: 14 m
   d. Materials: Cobblestone
   e. Landscape: Shaded trees and palms line the shoulders and medians
2. VILLA ROADS:
   a. Key aspects: Designed to branch off the main roads and act as the vehicular access roads for villa residents and resort visitors. Roads are smaller in scale to match the decreased private residential traffic, but still luxuriously spacious. The road type is also intended as a secondary, more secluded entry road onto the site for resort visitors.
   b. Approximate cumulative length: 6,931.8 m
   c. Approximate width: 10 m
   d. Materials: Gravel
   e. Landscape: Shaded trees and palms line the shoulders
3. SERVICE ROADS:
   a. Key aspects: Designed for BOH and service vehicular circulation and access. Intended to be as non-visible as possible through vegetative screening and isolated placement.
   b. Approximate cumulative length: 4,827.4 m
   c. Approximate width: 8 m
   d. Landscape: Shaded trees and palms will line the shoulders
4. MANGROVE VILLA ELEVATED BOARDWALK:
   a. Key aspects: Designed as elevated boardwalks that can accommodate both foot and golf cart traffic simultaneously for the mangrove villas. It is intended for these to be lined with mangroves.
   b. Approximate cumulative length: 1,908.4 m
   c. Approximate width: 3 m
   d. Materials: Wood boardwalk planks
5. HOTEL ELEVATED BOARDWALK:
   a. Key aspects: Designed as elevated boardwalks that allow for primarily hotel guest foot traffic but may also be used occasionally for golf cart traffic. Will be lined with suitable vegetation and constructed at a generous width to enhance the hotel's natural beauty and luxury experience.
   b. Approximate cumulative length: 1,961.6 m
   c. Approximate width: 3 m
   d. Materials: Wood boardwalk planks
   e. Landscape: Various trees, palms, and ground level plants will line the sides of the boardwalk
6. RESORT ELEVATED BOARDWALK:

a. Key aspects: Designed as elevated boardwalks that can accommodate both foot and golf cart traffic simultaneously for the resort villas. Will be heavily lined with various suitable plants to make the villas a secluded luxury experience.
b. Approximate cumulative length: 3,184.7 m
c. Approximate width: 3 m
d. Materials: Wood boardwalk planks
e. Landscape: Various trees, palms, and ground level plants will line the sides of the boardwalk

7. GOLF CART ROADS:
    a. Key aspects: Designed as one-way roads that allow for golf cart traffic around the golf course.
    b. Approximate cumulative length: 9,301.3 m
    c. Approximate width: 2 m
    d. Materials: Gravel
    e. Landscape: Various trees, palms, and ground level plants will line the sides of the path in conjunction with the golf course

3.2.10.2 Parking

A total of 581 parking spaces are supplied throughout the site to accommodate the various buildings, services, and features; these are outlined in Table 3-8. Average parking sizes are 2.4 m by 5.4 m and the parking types are as follows:

a. General Resort Parking
    i. Approximate area: 4, 270 m^2
    ii. Approximate space count: 120 spaces
b. BOH Resort Parking
    i. Approximate area: 1,097 m^2
    ii. Approximate space count: 25 spaces
c. Hotel Parking
    i. Approximate area: 7,040 m^2
    ii. Approximate space count: 200 spaces
d. Mangrove Villa Parking
    i. Approximate area: 503 m^2
    ii. Approximate space count: 11 spaces
e. Golf Villa Management Parking
    i. Approximate area: 1,693 m^2
    ii. Approximate space count: 45 spaces
f. Golf Service Parking
    i. Approximate area: 703 m^2
    ii. Approximate space count: 20 spaces

g. Hotel General + Facility Parking
    i. Approximate area: 1,801 m^2
    ii. Approximate space count: 50 spaces
h. Resort General + Facility Parking
    i. Approximate area: 1,598 m^2
    ii. Approximate space count: 45 spaces
i. Solar Farm & WTP Parking
    i. Approximate area: 1,350 m^2
    ii. Approximate space count: 35 spaces

Table 3-8 Summary of parking for the proposed land use types

	PROGRAM	KEYS/ UNITS	UNIT GFA (SQM)	GFA (SQM)
	RESORT PARKING			5367
R-12.1	GENERAL RESORT PARKING	120 SPACES	-	4270
R-12.2	BOH RESORT PARKING	25 SPACES	-	1097
	HOTEL PARKING			7040
H-13	HOTEL PARKING	200 SPACES	-	7040
	VILLA PARKING			503
V-7	MANGROVE VILLA PARKING	11 SPACES	-	503
	GOLF PARKING			2396
G-3.1	GOLF & VILLA MANAGEMENT PARKING	45 SPACES	-	1693
G-3.2	GOLF SERVICE PARKING	20 SPACES	-	703
	SERVICE FACILITIY PARKING			4749
S-10	HOTEL GENERAL + FACILITY PARKING	50 SPACES	-	1801
S-11	RESORT GENERAL + FACILITY PARKING	45 SPACES	-	1598
S-12	SOLAR FARM & WTP PARKING	35 SPACES	-	1350
	TOTAL PARKING AREA			***20,055***

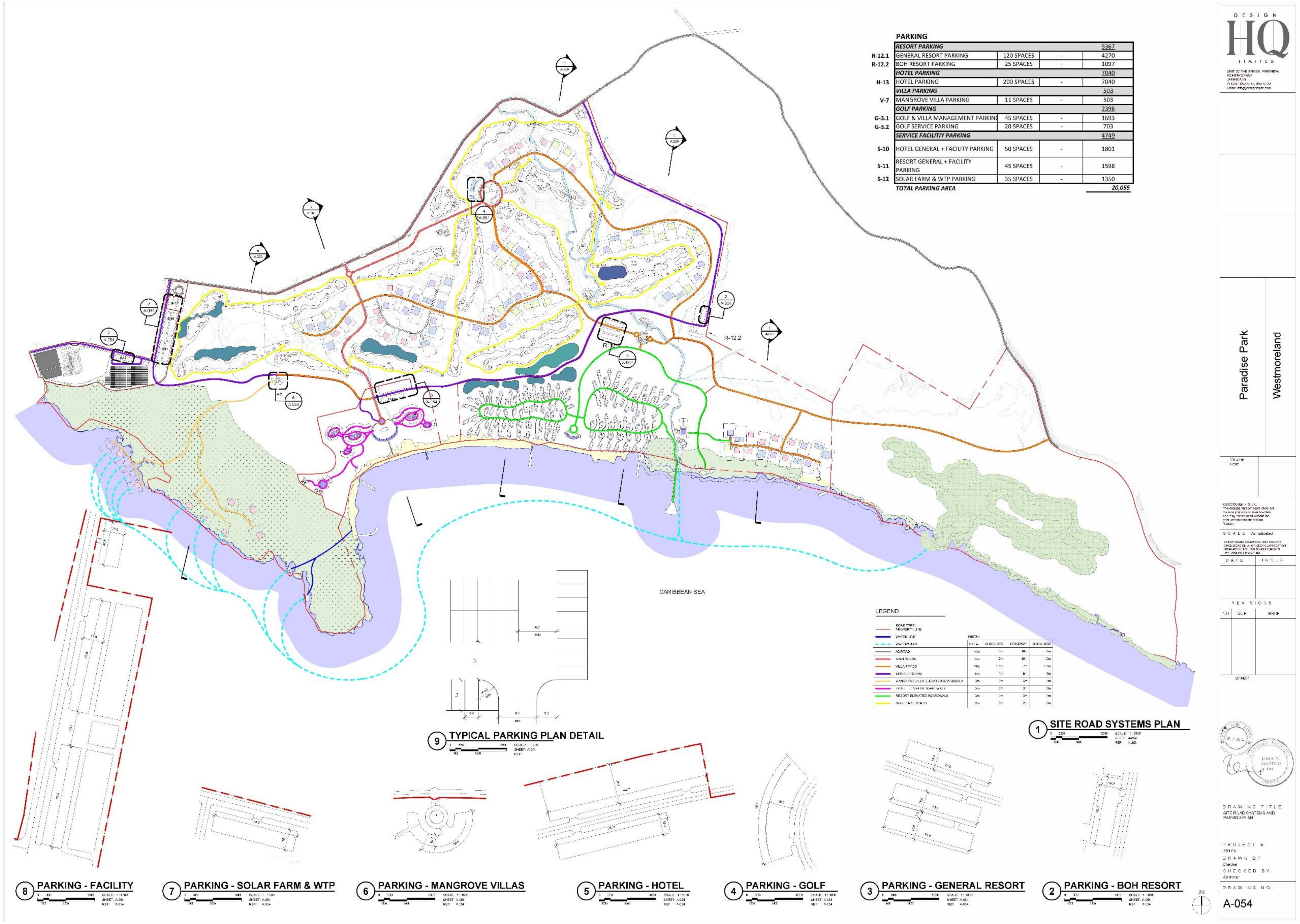


Figure 3-21 Proposed site road systems and parking plan

3.2.11 Coastal

3.2.11.1 Design Approach

The coastal design focuses on enhancing the recreational value of the beach while preserving the ecological balance of the shoreline. The new white sand beach is planned to extend approximately 900 meters (2,952 feet) in front of the land parcels Vol.1146 Fol.946 and Vol.1141 Fol.494. The drawings elucidate the strategic placement of coastal features designed to both protect and promote an enriched experience for visitors, as well as address environmental concerns.

3.2.11.2 Key Coastal Features

The following are the key coastal features and are illustrated in Figure 3-22:

1. Rock Groynes
2. Sandy Wading/Swimming Area
3. Sill
4. Sediment Sink
5. Dock and River Training Structure
6. Land Reclamation

Rock Groynes

Rock groynes are primarily designed to anchor the newly placed sand, preventing its erosion due to wave actions. Furthermore, they act as barriers, mitigating the influx of silty sediment from entering the wading zones. The construction, maintenance, and potential extension of new and existing groynes will necessitate heavy machinery, skilled labour, and access to quality rock material.

Sandy Wading/Swimming Area

The central goal is to curate an inviting offshore area, ensuring that the seafloor remains free of cohesive sediments, thus amplifying the beachgoer's experience. Silt dredging will be essential to deepen the region before filling it with sand, which will require dredging vessels and associated equipment.

Sill

Strategically positioned sills will act as a barrier to prevent silty sediment from infiltrating the sandy wading zones. This is pivotal in ensuring a pleasant experience for beachgoers. The construction will demand specialized machinery and armour stone material to ensure the sill is robust and durable.

Sediment Sink

An innovative solution to trap and hold suspended sediments, allowing them to settle out of the water column, thus maintaining the water's clarity around the wading area. Effective sediment sinks will require dredging equipment, with a preference for suction dredgers due to the silty nature of the seafloor.

Dual-Purpose Dock Structure

This dual-purpose structure will accommodate docking for small vessels and guide the river's flow away from the beach. By directing the flow further offshore, we intend to significantly reduce the reintroduction of suspended sediments into the wading zones. The construction will involve a combination of armour stone groynes for longevity and a wooden deck finish for aesthetics and functionality.

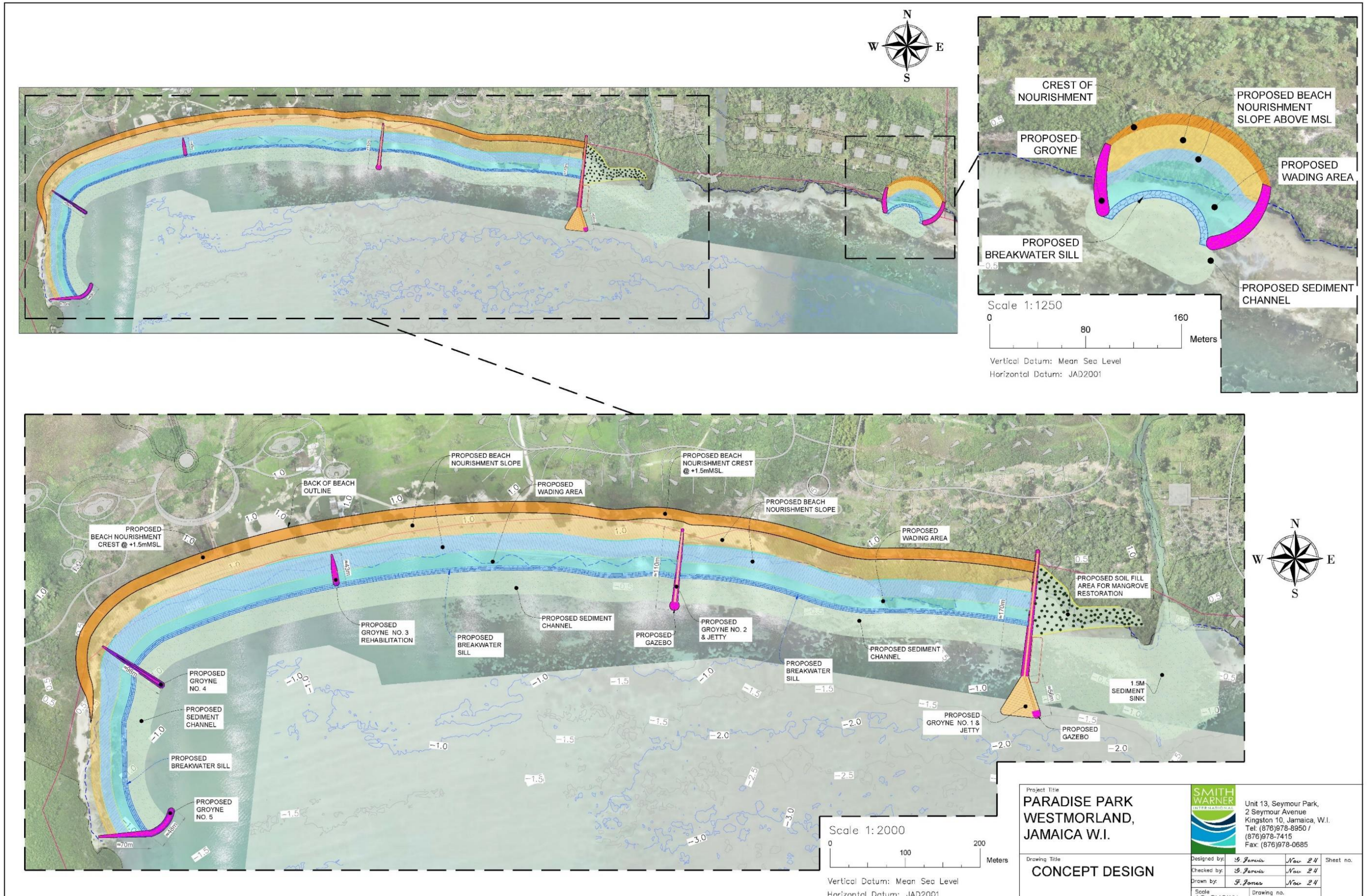


Figure 3-22 Proposed coastal features at Paradise Park resort development

3.3 AUXILIARY PROJECT ACTIVITIES

3.3.1 Landscaping

The landscaping design for the property aims to integrate the natural environment with the planned development, ensuring both aesthetic appeal and environmental sustainability. Any existing trees with a minimum diameter of 20 cm will be preserved and incorporated into the new landscaping design for the property (where possible), ensuring that the natural elements are maintained. Additionally, there will be no changes to the existing grade of the landscaped areas and the site's contours will remain undisturbed.

The landscaping plan introduces several key features that complement the existing site conditions. Royal palm trees will frame the driveways and major walkways, while Foxtail palm trees will outline the remaining hotel and resort walkways, as well as the spaces between the hotels. Bougainvillea will be planted along the exterior of the hotel buildings throughout the site.

To enhance privacy along the hotel walkways, a mix of royal palm trees and Sea Island Ficus will be used, ensuring seclusion for units adjacent to these paths. Black Olive trees will be strategically placed in large open areas to provide shade, and near the entrances to each hotel wing, they will be paired with Monstera shrubs for added visual interest.

The ground cover for open areas will consist of Zoysia grass sod, which will be used for the lawn areas across the site. A sustainable and efficient irrigation system will be implemented to support and maintain the proposed landscaping.

Figure 3-23 Plants data sheet for use in landscaping

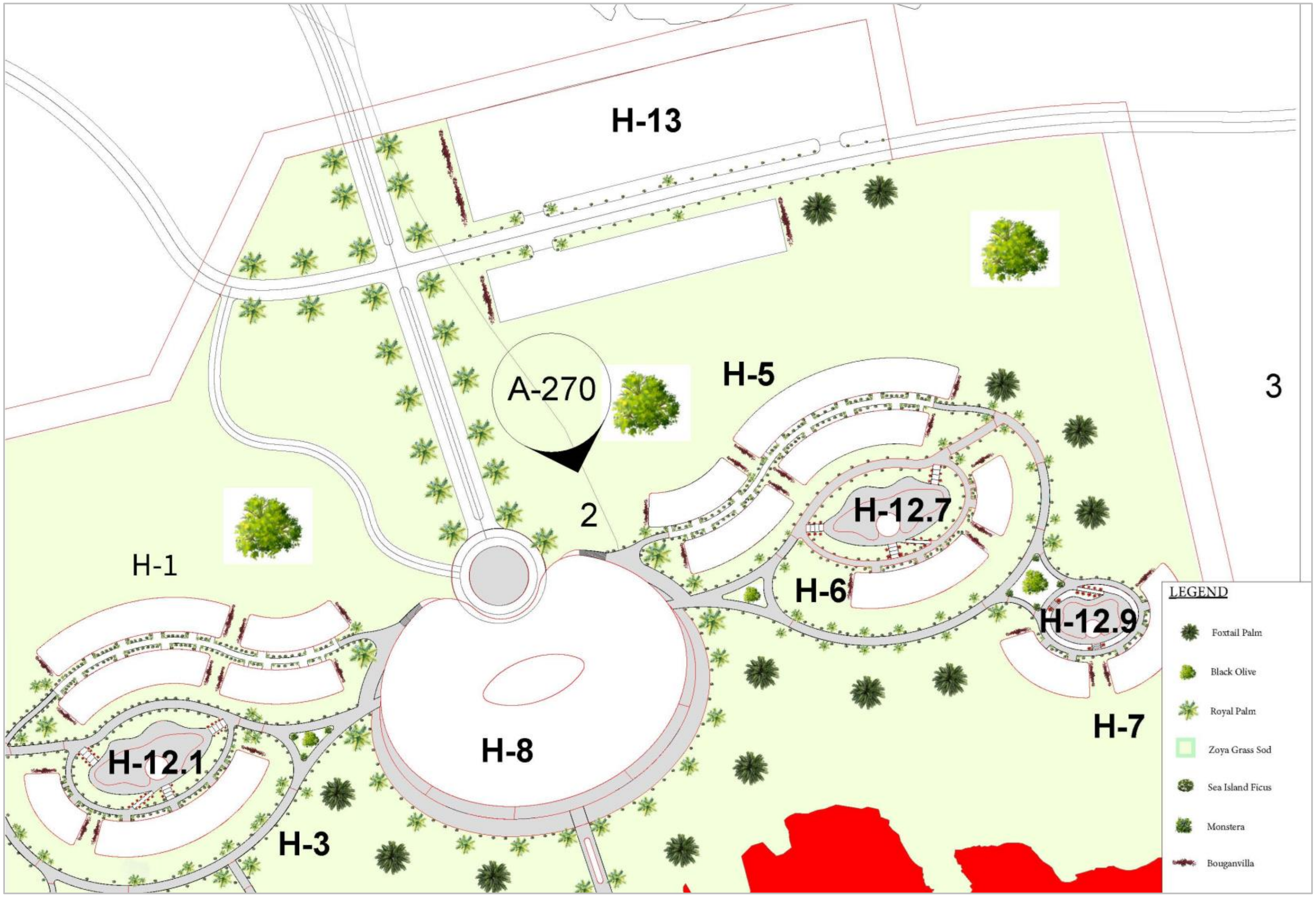


Figure 3-24 Proposed landscaping concept for the Hotel, main and east wing

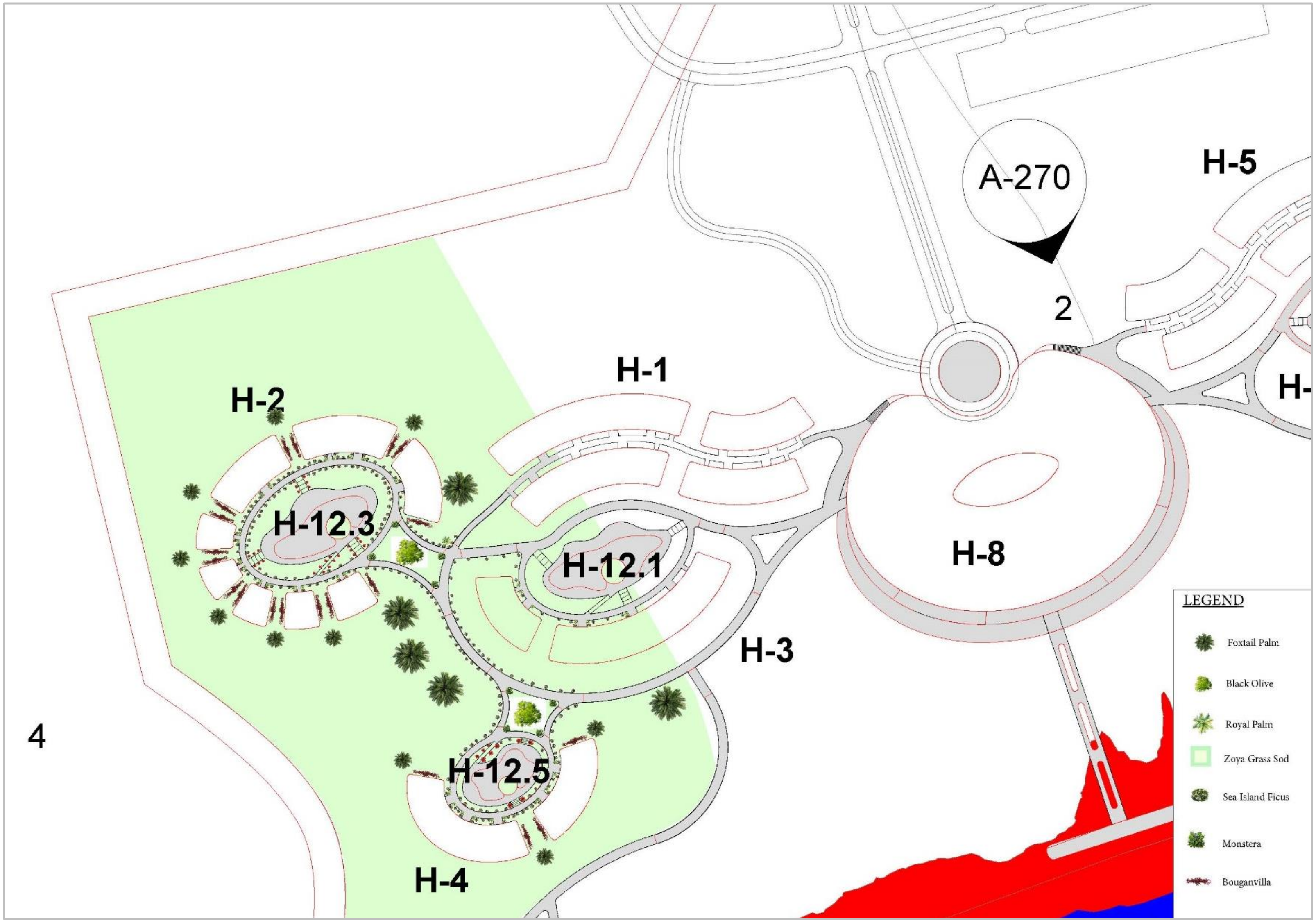


Figure 3-25 **Proposed landscaping concept for the Hotel, west wing**

Figure 3-26 **Proposed landscaping concept for the Resort**

3.3.2 Potable Water Demand and Supply

3.3.2.1 Estimation of Water Demand

Table 3-9 and Table 3-10 and Table 3-11 provide a summary of the intended programs, total occupancy, and total daily water demand. The hotel program consists of 200 units with total occupancy reaching 550 people; the daily water demand for the hotel is 330,000 litres (≈87,177 gal (US)), assuming a per capita demand of 600 litres (≈158.5 gal (US)). The resort program includes 120 units with a total occupancy of 540 people; the resort's total daily water demand is 324,000 litres (≈85,592 gal (US)), also based on a 600-liter (≈158.5 gal (US)) per capita demand. The villa program has 100 units with a total occupancy of 860 people; the daily water demand for the villa program is 516,000 litres (≈136,313 gal (US)). In summary, the hotel, resort, and villa programs collectively total 420 units, an occupancy of 1,930 people, and a combined daily water demand of 1,170,000 litres (≈309,081 gal (US)).

Table 3-9 Proposed hotel program, total occupancy, and total daily water demand

Program (Hotel)	No. of Keys/Units	Occupancy per Key/Unit	Total Occupancy per Unit Type	Water Demand per Capita (L/day)	Total Water Demand (L/day)
1 Bedroom Suites (Standard)	150	2	300.00	600	180,000.00
2 Bedroom Suites	30	4	120.00	600	72,000.00
3 Bedroom Suites	15	6	90.00	600	54,000.00
4 Bedroom Suites	5	8	40.00	600	24,000.00
	200		**550.00**		**330,000.00**

Table 3-10 Proposed resort program, total occupancy, and total daily water demand/wastewater

Program (Resort)	No. of Keys/Units	Occupancy per Key/Unit	Total Occupancy per Unit Type	Water Demand per Capita (L/day)	Total Water Demand (L/day)
1 Bedroom Suites (Standard)	30	2	60.00	600	36,000.00
2 Bedroom Suites	50	4	200.00	600	120,000.00
3 Bedroom Suites	20	6	120.00	600	72,000.00
4 Bedroom Suites (Presidential)	20	8	160.00	600	96,000.00
	120		**540.00**		**324,000.00**

Table 3-11 Proposed villa program, total occupancy, and total daily water demand/wastewater

Program (Villa)	No. of Keys/Units	Occupancy per Key/Unit	Total Occupancy per Unit Type	Water Demand per Capita (L/day)	Total Water Demand (L/day)
3 Bedroom Villas	30	6	180.00	600	108,000.00
4 Bedroom Villas	30	8	240.00	600	144,000.00
5 Bedroom Villas	20	10	200.00	600	120,000.00
6 Bedroom Villas	20	12	240.00	600	144,000.00
	100		**860.00**		**516,000.00**

3.3.2.2 Water Source and Proposed System

The project will be serviced by a water reticulation system, including two # 1,000,000 gal (US) (≈3,785.4 m^3) storage tanks (AWWA D103-19), which will be supplied with water by the National Water Commission (NWC) infrastructure and a design approach that includes the supplementation of the supply with alternate sources such as abstraction from local wells and rivers in and around the property.

Internal distribution will occur via a primarily subsurface network of PVC (AWWA-C900-16) and ductile iron pipes (AWWA-C150-14) of varying sizes, ranging from 50mm to approximately 250mm in diameter. This distribution network will supply the water demands for the residential villas, resorts, and hotels while additionally supplying sufficient water to satisfy the requirements of the project's fire suppression system, including a series of fire hydrants (AWWA-C502-18) strategically distributed across the property (Figure 3-28). The NWC infrastructure will need to be extended from 3.5km to the west, where an existing 14-inch potable main exists. Figure 3-27 shows the location of the connection and existing wells in the area with potential for source development.

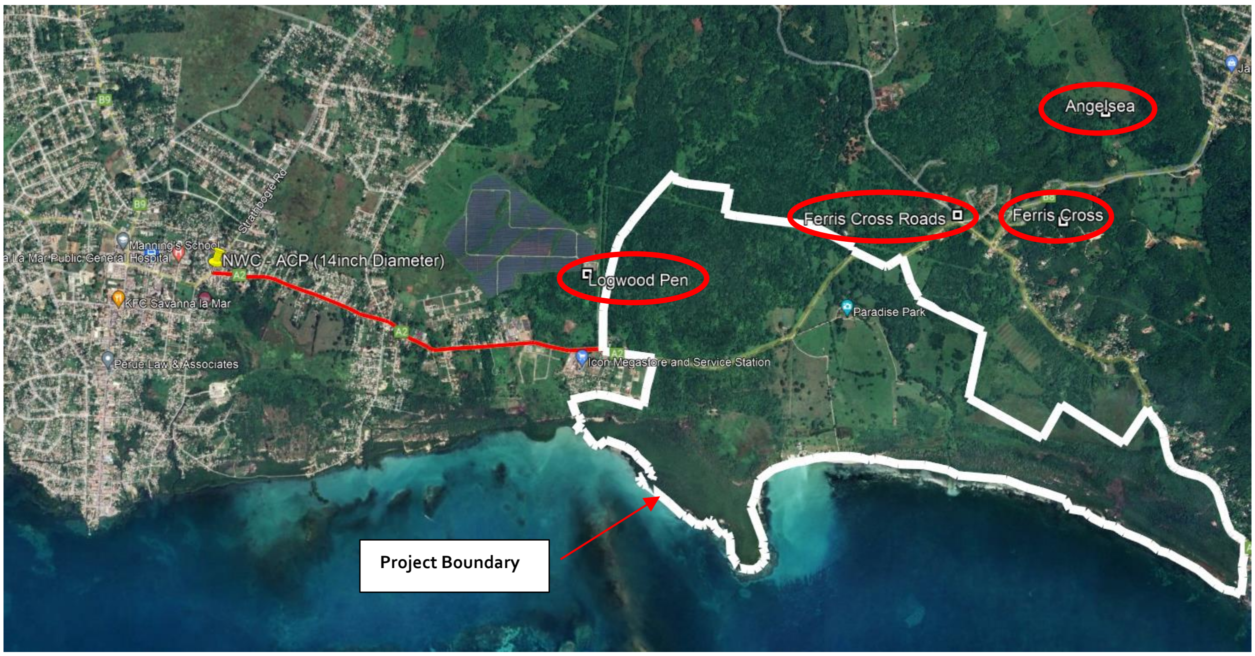


Figure 3-27 Location of the existing water resources in the area

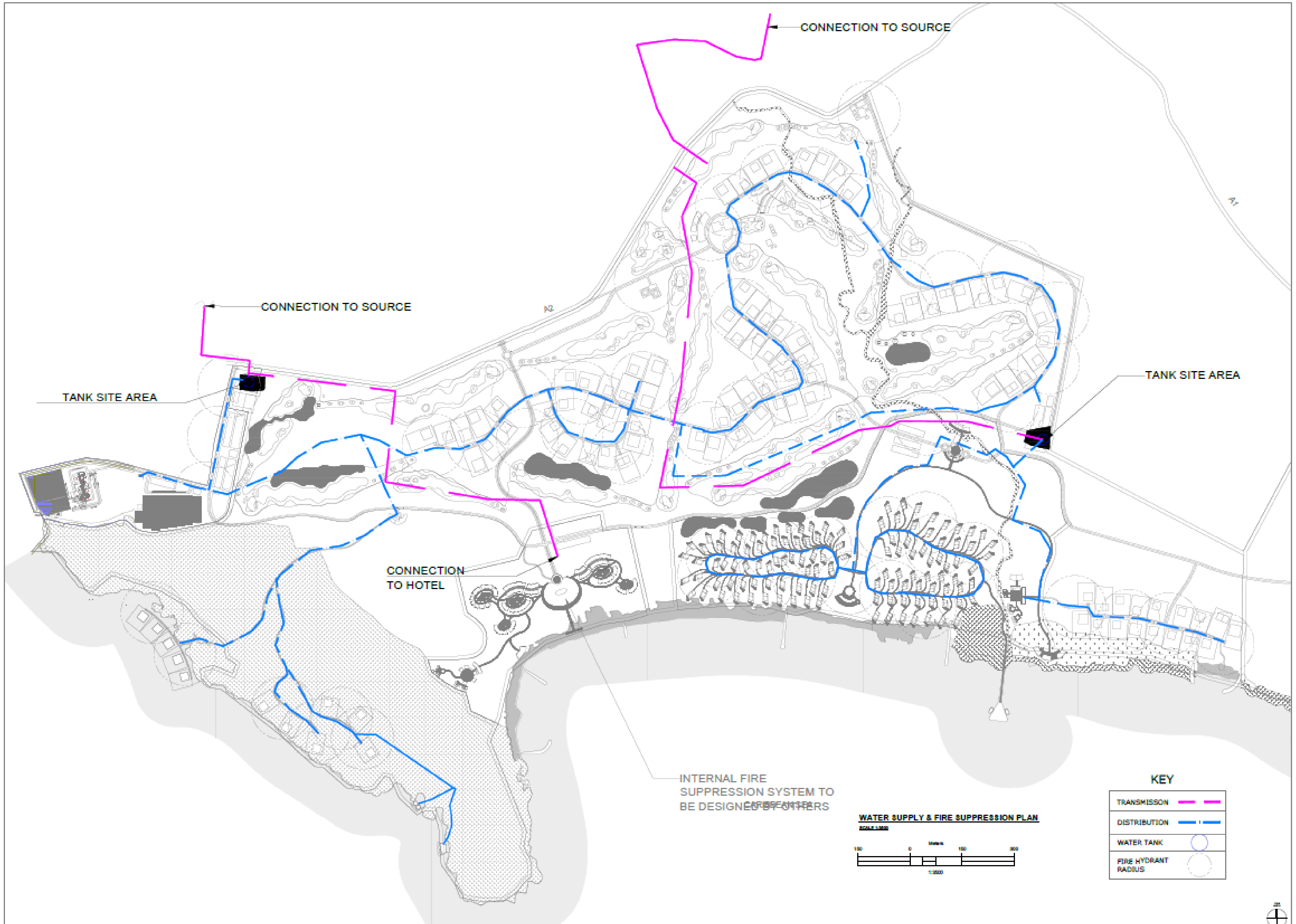


Figure 3-28 Water supply system and fire suppression plan

3.3.3 Wastewater Management and Treatment Plant

3.3.3.1 Projected Wastewater Flow Estimation

The sewer design for the proposed development is based on an average water use of 1,170,000 litres per day (≈309,081 gal (US)/day), with 90% of this water entering the building sewers, resulting in an average daily wastewater flow of 1,053,000 litres per day (12.19 L/s) (Table 3-12). Additionally, inflows and infiltration due to wet weather are anticipated to contribute 20% of the average wastewater flow, amounting to 210,600 litres per day (2.44 L/s). This brings the average wet weather wastewater flow in the ultimate sewer system to 14.63 L/s. To account for peak demand, a peak factor of 3 has been applied, resulting in an anticipated peak flow of 43.88 L/s. This design ensures the sewer system can effectively handle both normal and wet weather conditions, maintaining efficiency and capacity for the proposed development.

Table 3-12 Key design calculations for the sewer system design

Sewer Design	Quantity	Unit
Average water use for the proposed development	1,170,000	L/day
Percentage of water use that enters the building sewers	90%	
Average daily wastewater flow	1,053,000.00	L/day
	12.19	L/s
Inflows and infiltration due to wet weather as percentage of average wastewater flow	20%	
Anticipated inflows and infiltration	210,600.00	L/day
Inflow and infiltration	2.44	L/s
Average wet weather wastewater flow in the ultimate sewer	14.63	L/s
Peak factor	3	
Anticipated Peak flow	43.88	L/s

Table 3-13 Typical raw sewage strength and composition

Parameter	Design Value
Total Suspended Solids, TSS	220 mg/L
Chemical Oxygen Demand, COD	500 mg/L
Biochemical Oxygen Demand, BOD_5	250 mg/L
Total Nitrogen (as N)	40 mg/L
Total Phosphorous (as P)	8 mg/L
Total Coliform Bacteria	10^7 - 10^8 MPN/100ml

Table 3-14 Natural Resources Conservation Authority (NRCA) sewage effluent discharge requirements

Parameter	Units	Water Quality Criteria	
		Direct Discharge	Irrigation
Chemical Oxygen Demand	*mg/L*	100	<100
Biological Oxygen Demand	*mg/L*	20	15
Total Suspended Solids	*mg/L*	20	15
Total Nitrogen	*mg/L*	10	NA[1]
Phosphates – P	*mg/L*	4	NA[1]
Ph		6	NA[1]
Faecal Coliform	*MPN / 100 ml*	200	12
Residual Chlorine	*mg/L*	1.5	0.5
Oil and Grease	*mg/L*	NA[1]	10
Giardia Cyst	*# / 100 ml*	NA[1]	<1

[1] NA = *not abblicable*

3.3.3.2 Wastewater Treatment Plant (WWTP) Components

Figure 3-29 and Figure 3-30 presents the layout and a summary of the key components of the Wastewater Treatment Plant (WWTP), which include the following elements:

1. Pump station and blower pad
2. Manual Bar screen
3. Aerated grit chamber
4. Aerobic digester
5. Orbal Basin
6. Clarifiers
7. Chlorine Contact Tank
8. Sludge drying bed
9. Constructed Wetland

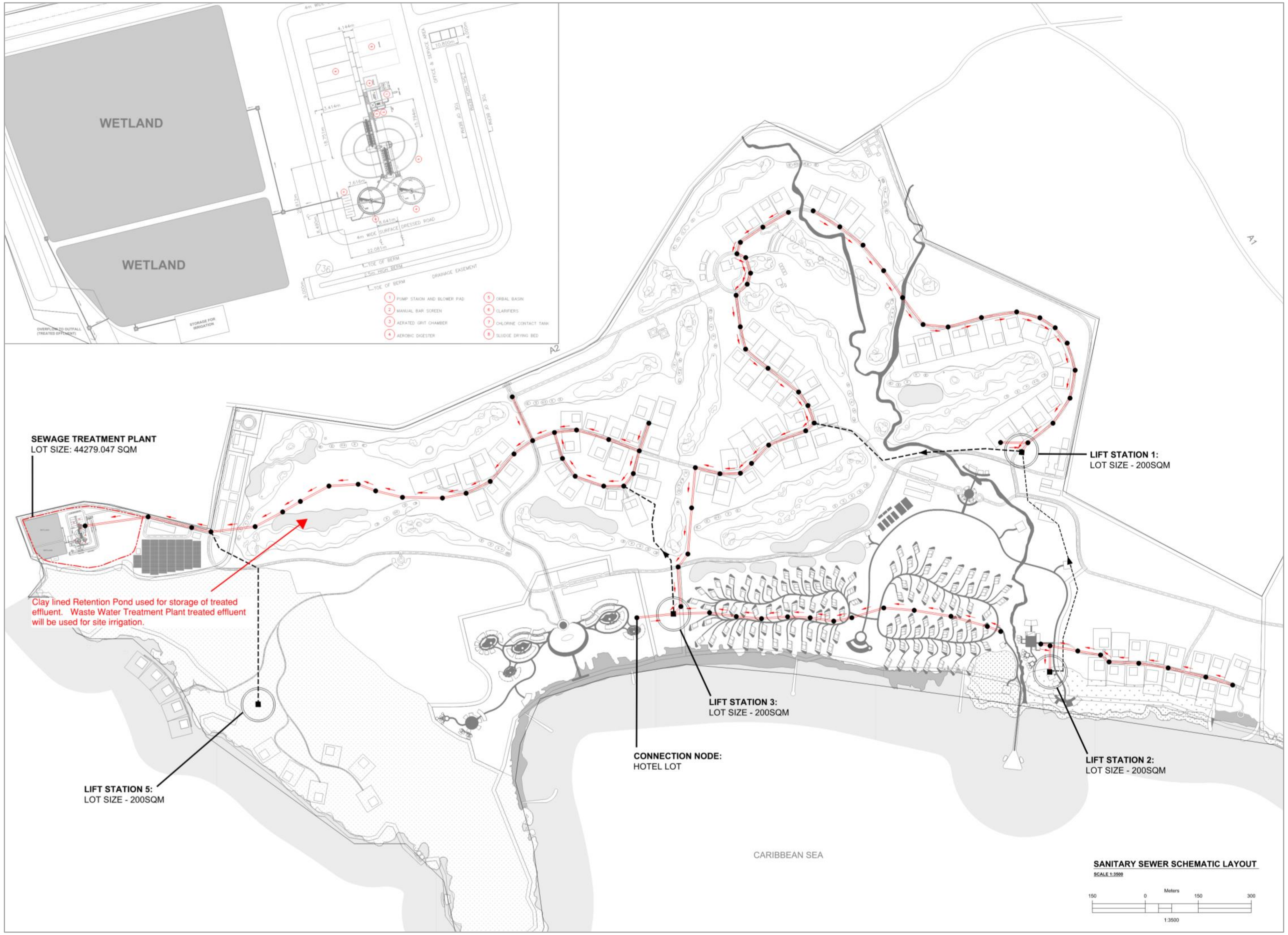


Figure 3-29 Sanitary sewer schematic layout

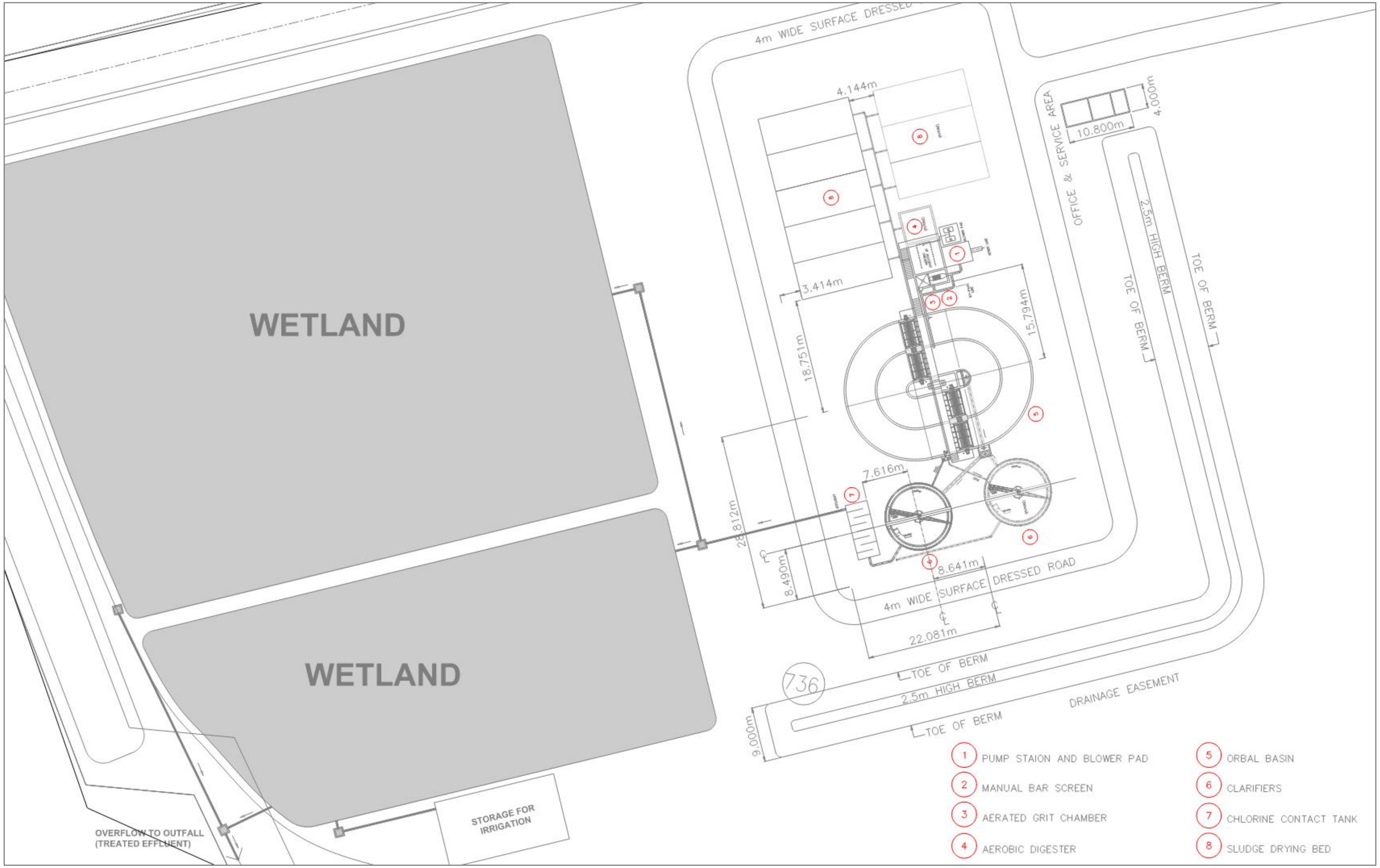


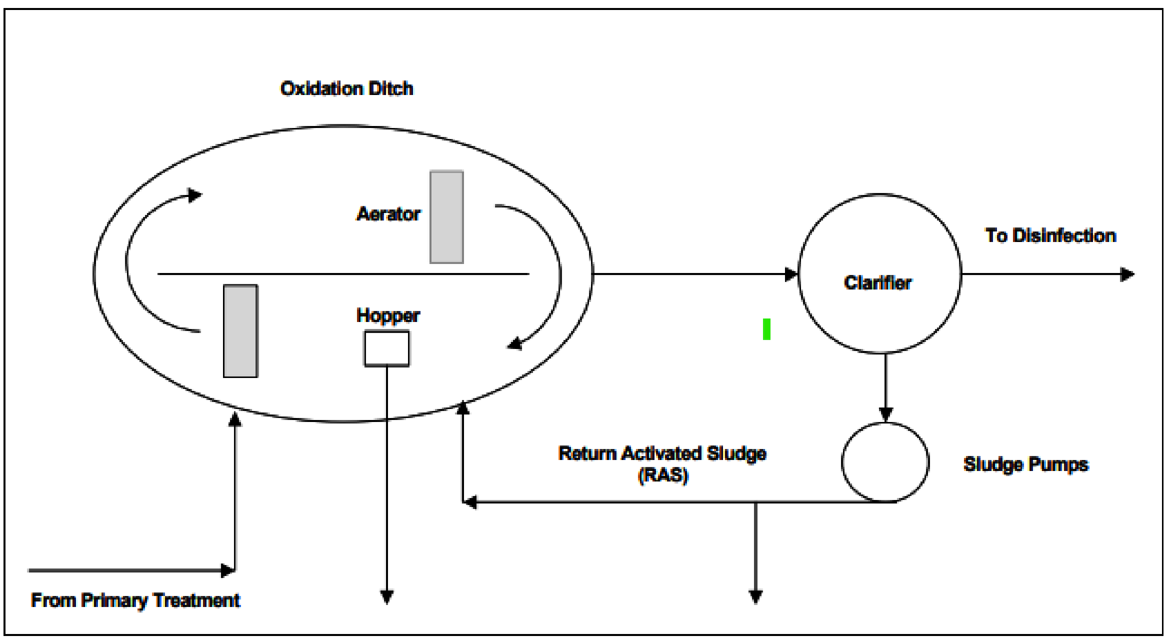
Figure 3-30 Layout of WWTP components

3.3.3.3 Treatment System and Design Criteria

Oxidation Ditch

An oxidation ditch is a variation of the activated sludge process that uses extended solids retention times (SRTs) to treat biodegradable organic matter. These treatment systems usually consist of one or more channels within a basin shaped like a ring, oval, or horseshoe, and are often referred to as "racetrack-type" reactors. Aerators, either mounted horizontally or vertically, facilitate circulation, oxygen transfer, and aeration within the ditch.

Preliminary treatments such as bar screens and grit removal are generally applied before the oxidation ditch, and while primary settling may sometimes precede the ditch, it is not commonly used in this design. Depending on effluent quality requirements, tertiary filtration may be necessary after the clarification stage, in the case of this design, a constructed wetland and chlorine contact chamber have been added to the systems process flow. Disinfection is required, and reaeration may be needed before the final discharge. Flow into the oxidation ditch is mixed with return sludge from the secondary clarifier to maintain effective aeration and treatment. A typical process flow diagram for an activated sludge plant utilizing an oxidation ditch is shown in Figure 3-31.



Source: Parsons Engineering Science, Inc., 2000.

Figure 3-31 Typical process flow diagram for an activated sludge plant utilizing an oxidation ditch

DESIGN CRITERIA

Screened wastewater enters the ditch, is aerated, and circulates at about 0.25 to 0.35 m/s (0.8 to 1.2 ft/s) to maintain the solids in suspension (Metcalf & Eddy, 1991). The RAS recycle ratio (return activated sludge) is from 75 to 150 percent, and the mixed liquor suspended solids (MLSS) concentration ranges from 1,500 to 5,000 mg/L (0.01 to 0.04 lbs/gal) (Metcalf & Eddy, 1991). The oxygen transfer efficiency of oxidation ditches ranges from 2.5 to 3.5 lb./Hp-hour (Baker Process, 1999).

The design criteria are affected by the influent wastewater parameters and the required effluent characteristics, including the decision or requirement to achieve nitrification, denitrification, and/or biological phosphorus removal. Specific design parameters for oxidation ditches include (Table 3-15):

- **Solids Retention Time (SRT):** Oxidation ditch volume is sized based on the required SRT to meet effluent quality requirements. The SRT is selected as a function of nitrification requirements and the minimum mixed liquor temperature. Design SRT values vary from 4 to 48 or more days. Typical SRTs required for nitrification range from 12 to 24 days.
- **BOD Loading:** BOD loading rates vary from less than 160,000 mg/1000 litres (10 lb./1000 ft^3) to more than 4x107 mg/1000 litres (50 lb./1000 ft^3). A BOD loading rate of 240,000 mg/1000 litres per day (15 lb./1000 ft^3 /day) is commonly used as a design loading rate. However, the BOD loading rate is not typically used to determine whether or not nitrification occurs.
- **Hydraulic Retention Time:** While rarely used as a basis for oxidation ditch design, hydraulic Retention Times (HRTs) within the oxidation ditch range from 6 to 30 hours for most municipal wastewater treatment plants

Table 3-15 Expected system performance for oxygen ditch

	Average Monthly Influent (mg/L)	Average Monthly Effluent (mg/L)	Percent Removal (%)
BOD	226	8.86	96
TSS	207	5.23	97
Total N	35.4	1.99	94

Source: City of Casa Grande, AZ, 1999.

RESIDUALS GENERATED

Primary sludge is produced if primary clarifiers precede the oxidation ditch. Sludge production for the oxidation ditch process ranges from 0.2 to 0.85 kg TSS per kg (0.2 to 0.85 lb. TSS per lb). BOD applied (Sherwood Logan and Associates, 1999). Typical sludge production is 0.65 kg TSS per kg of BOD (0.65 lb TSS per lb. of BOD). This is less than conventional activated sludge facilities because of long SRTs.

Constructed Wetland

Wetland systems are typically described based on the position of the water surface and/or the type of vegetation that grows within them. Most natural wetlands are free water surface (FWS) systems, where the water surface is exposed to the atmosphere. These include bogs (with primary vegetation of mosses), swamps (with primary vegetation of trees), and marshes (with primary vegetation of grasses and emergent macrophytes).

A subsurface flow (SF) wetland, on the other hand, is specifically designed for the treatment or polishing of wastewater and is typically constructed as a bed or channel containing appropriate media. Various materials such as coarse rock, gravel, sand, and other soils can be used as media, though gravel is the most common medium in the U.S. and Europe. The media is usually planted with the same types of emergent vegetation found in marshes, and the water surface is designed to remain below the top surface of the media.

This subsurface water level offers several advantages, including the prevention of mosquitoes and odours, and it eliminates the risk of public contact with partially treated wastewater. In contrast, the water surface in natural marshes and FWS constructed wetlands is exposed to the atmosphere, which carries the risk of mosquitoes and public access.

The water quality improvements observed in natural wetlands have been noted by scientists and engineers for many years. This led to the development of constructed wetlands as a way to replicate the water quality and habitat benefits of natural wetlands in a built ecosystem. Both physical, chemical, and biochemical reactions contribute to water quality improvement in these wetland systems. The biological reactions are primarily due to the activity of microorganisms that attach to available submerged substrate surfaces.

In FWS wetlands, these substrates include the submerged portion of the living plants, the plant litter, and the benthic soil layer. In SF wetlands, the available submerged substrates are the plant roots growing in the media and the surfaces of the media itself. Since the media surface area in a SF wetland can far exceed that in a FWS wetland, microbial reaction rates in SF wetlands can be higher for most contaminants. As a result, a SF wetland can be smaller than a FWS wetland while still meeting the same flow rate and effluent water quality goals.

DESIGN CRITERIA

The size of a subsurface flow (SF) wetland is determined by the pollutant that requires the largest land area for its removal. This is the bottom surface area of the wetland cells. For this area to be 100 percent effective, the wastewater flow must be uniformly distributed over the entire surface. This uniform distribution is achievable in constructed wetlands through careful grading of the bottom surface and the use of appropriate inlet and outlet structures.

The total treatment area should be divided into at least two cells for all but the smallest systems. Larger systems should have at least two parallel trains of cells to provide flexibility for management and maintenance.

These wetland systems are living ecosystems, and the life and death cycles of the biota produce residuals that can be measured as BOD, TSS, nitrogen, phosphorus, and faecal coliforms. As a result, regardless of the size of the wetland or the characteristics of the influent, there will always be a residual background concentration of these materials in these systems.

Typical area loading rates, characteristics and expected system performance for SF constructed wetlands are provided in Table 3-16, Table 3-17 and Table 3-18.

Table 3-16 Typical area loading rates for SF constructed wetlands

Constituent	Typical Influent Concentration mg/L	Target Effluent Concentration mg/L	Mass Loading Rate lb/ac/d*
Hydraulic Load (in./d)	3 to 12**		
BOD	30 to175	10 to 30	60 to 140
TSS	30 to150	10 to 30	40 to 150
NH_3/NH_4 as N	2 to 35	1 to 10	1 to 10
NO_3 as N	2 to 10	1 to 10	3 to 12
TN	2 to 40	1 to 10	3 to 11
TP	1 to 10	0.5 to 3	1 to 4

Note: Wetland water temperature » 20°C.

Table 3-17 Typical media characteristics for SF wetlands

Media Type	Effective Size D_{10} (mm)*	Porosity, n (%)	Hydraulic Conductivity k_s ($ft^3/ft^2/d$)*
Coarse Sand	2	28 to 32	300 to 3,000
Gravelly Sand	8	30 to 35	1,600 to 16,000
Fine Gravel	16	35 to 38	3,000 to 32,000
Medium Gravel	32	36 to 40	32,000 to 160,000
Coarse Rock	128	38 to 45	16×10^4 to 82×10^4

* mm x 0.03937 = inches
** $ft^3/ft^2/d \times 0.3047 = m^3/m^2/d$, or $\times 7.48 = gal/ft^2/d$

Source: Reed et al., 1995.

Table 3-18 Expected system performance for 14 SF wetland systems

Constituent	Mean Influent mg/L	Mean Effluent mg/L
BOD_5	28** (5-51)***	8** (1-15)***
TSS	60 (23-118)	10 (3-23)
TKN as N	15 (5-22)	9 (2-18)
NH_3/NH_4 as N	5 (1-10)	5 (2-10)
NO_3 as N	9 (1-18)	3 (0.1-13)
TN	20 (9-48)	9 (7-12)
TP	4 (2-6)	2 (0.2-3)
Fecal Coliforms (#/100ml)	270,000 (1,200-1,380,000)	57,000 (10-330,000)

* Mean detention time 3 d (range 1 to 5 d).
** Mean value.
*** Range of values.

3.3.3.4 Septage and Sludge Management

The Septage and Sludge Management Plan outlines the procedures for the handling, treatment, and disposal of septage and sludge generated by the sewage treatment plant (STP) at the proposed resort development. The proper management of these by-products is crucial for maintaining environmental integrity, ensuring regulatory compliance, and optimizing operational efficiency. The STP includes key components such as the Aerobic Digester and Sludge Drying Bed, both of which play essential roles in managing sludge. This plan establishes a comprehensive approach to ensure the safe and sustainable treatment of sludge and septage, thereby minimizing the environmental impact of the resort's wastewater treatment system.

Sludge generated at the STP can be categorized into primary sludge, secondary sludge, and waste activated sludge. Primary sludge is created by the settling of solids during the initial treatment stages, while secondary sludge results from the biological processes in the aerobic digester and orbal basin. Waste activated sludge is generated due to the excess growth of microorganisms during biological treatment. These sludges must be treated and stabilized to reduce their volume and potential environmental harm.

The treatment of sludge begins in the Aerobic Digester, where aerobic microorganisms break down organic matter and stabilize the sludge. This process helps to reduce the sludge's volume, pathogens, and odorous compounds. Regular monitoring is required to ensure that the aerobic digester operates effectively, with proper aeration levels and sufficient microbial activity. Once stabilized, the sludge will be sent to the Sludge Drying Bed for further dewatering. The drying bed allows for the evaporation of excess water, making the sludge more manageable for disposal or reuse. The bed should be inspected regularly to ensure it remains clear of obstructions and free from cracks or leaks.

After the sludge is adequately stabilized and dewatered, it can be either disposed of. If disposal is necessary, the dried sludge may be transported to a landfill or an incineration facility that meets environmental standards.

3.3.3.5 Maintenance and Operation Plan

This Operation and Maintenance (O&M) Plan outlines the procedures and guidelines for the routine operation, monitoring, and maintenance of the sewage treatment plant (STP) for the proposed resort development. The STP includes the following components:

- Pump Station and Blower Pad
- Manual Bar Screen
- Aerated Grit Chamber
- Aerobic Digester
- Orbal Basin
- Clarifiers
- Chlorine Contact Tank
- Sludge Drying Bed

This plan aims to ensure that the STP operates efficiently and in compliance with environmental and health regulations, minimizing the environmental impact of the resort's wastewater treatment.

Operations Schedule

The treatment plant will operate 24/7, but different components of the plant will require varying degrees of monitoring and maintenance based on the equipment and process requirements (Table 3-19).

Table 3-19 Proposed operational schedule

Component	Operation	Frequency	Maintenance	Frequency
Pump Station & Blower Pad	Start-up, pressure monitoring	Daily	Inspection, cleaning	Weekly
Manual Bar Screen	Check for debris, operation	Daily	Clean debris	As needed (weekly)
Aerated Grit Chamber	Check aeration, grit settling	Daily	Check aerators, clean	Monthly
Aerobic Digester	Monitor aeration, sludge levels	2-3 times/week	Check aeration system, clean	Monthly
Orbal Basin	Monitor flow, oxygenation	Daily	Clean aeration system	Monthly
Clarifiers	Check sludge levels, flow rates	Daily	Clean scraper mechanism	Monthly
Chlorine Contact Tank	Monitor chlorine levels	Daily	Inspect chlorine injection system	Monthly
Sludge Drying Bed	Monitor moisture levels	2-3 times/week	Check for clogging, clean	Monthly

Component-Specific Operational Guidelines

PUMP STATION AND BLOWER PAD

Purpose: To transport influent wastewater to the treatment units and supply air for aeration in the aerobic processes.

Routine Tasks:

- Inspect pump operation and blower efficiency daily.
- Check for any abnormal noise or vibration.
- Ensure the pumps and blowers are running at the required capacity.
- Clean and clear any obstructions in the pump or blower pads.

Maintenance:

- Lubricate pump bearings as recommended by the manufacturer.
- Replace seals and gaskets annually or when worn.
- Inspect electrical components (e.g., motor, control panels) every six months.

MANUAL BAR SCREEN

Purpose: To remove large solids from the incoming wastewater flow before it enters the treatment system.

Routine Tasks:

- Manually check the screen for debris at least once a day.
- Remove any large debris caught in the screen.

Maintenance:

- Inspect for wear or damage to the bars monthly.
- Clean the screen frame to ensure proper operation.

AERATED GRIT CHAMBER

Purpose: To remove heavier particles (grit) from the wastewater through aeration.

Routine Tasks:

- Check the aeration system for proper operation daily.
- Ensure adequate grit removal and settlement of solids.

Maintenance:

- Clean aerators monthly to prevent clogging.
- Inspect grit removal system (e.g., pump, conveyor) for damage or wear.

AEROBIC DIGESTER

Purpose: To degrade organic matter in the sludge using aerobic microorganisms.

Routine Tasks:

- Monitor sludge levels and aeration efficiency 2-3 times a week.
- Ensure the aeration system is functioning properly.

Maintenance:

- Inspect aerators and diffusers monthly.
- Check for any blockages or clogging in the aeration pipes.

- Clean the tank floor to remove accumulated sludge, as necessary.

ORBAL BASIN

Purpose: To provide secondary treatment through a rotating biological contactor (RBC) system, aiding in the removal of suspended solids and organic matter.

Routine Tasks:

- Monitor flow and oxygenation levels daily.
- Observe the condition of the RBCs, ensuring they rotate properly.

Maintenance:

- Inspect rotating arms and bearings monthly.
- Lubricate rotating components as recommended by the manufacturer.
- Clean aeration diffusers every six months.

CLARIFIERS

Purpose: To separate settled sludge (flocculants) and clarified water from the wastewater flow.

Routine Tasks:

- Monitor the sludge level and flow rate daily.
- Check for any irregularities in the settling process.

Maintenance:

- Inspect the clarifier tank and scraper mechanisms monthly.
- Ensure the sludge removal system operates efficiently.
- Clean clarifier weirs and skimmers monthly.

CHLORINE CONTACT TANK

Purpose: To disinfect the effluent before discharge into the environment.

Routine Tasks:

- Monitor chlorine dosing levels and residual chlorine daily.
- Ensure the tank is free of debris and that chlorine mixing is adequate.

Maintenance:

- Inspect chlorine injection system monthly.
- Calibrate chlorine dosing equipment quarterly.
- Check for leaks or wear in chlorine tanks and pipes.

SLUDGE DRYING BED

Purpose: To dewater the sludge and reduce its volume before disposal or further processing.

Routine Tasks:

- Check the moisture content of the sludge 2-3 times per week.
- Ensure adequate drying by turning the sludge to promote aeration.

Maintenance:

- Inspect and clean the bed surface to prevent clogging.
- Repair any cracks or damage to the bed liner.
- Remove dried sludge and dispose of it as per local regulations.

Emergency Procedures

In case of system failure or emergency, the following procedures must be followed:

1. Pump Failure: Switch to backup pumps, contact the maintenance technician, and investigate the cause of failure.
2. Power Outage: Activate backup power supply (generator). If the backup system is unavailable, initiate emergency standby measures and ensure minimal discharge into the environment.
3. Chemical Spill: Evacuate the area, inform the health and safety officer, and follow emergency spill containment protocols.
4. Equipment Malfunction: Immediately isolate the malfunctioning unit, notify the maintenance team, and take corrective action to prevent system failure.

Record Keeping and Documentation

Maintain the following records:

- Daily log sheets documenting the operational activities and any deviations or incidents.
- Maintenance log detailing routine inspections, repairs, and replacements.
- Calibration records for monitoring instruments and equipment.
- Chemical dosage and sludge handling records.

This O&M plan is designed to ensure the proper functioning of the sewage treatment plant throughout its operational life. Regular inspections, maintenance, and prompt response to issues will help minimize downtime, maintain effluent quality, and protect the environment from potential contamination.

3.3.4 Stormwater Drainage

Stormwater generated on the property will be collected and conveyed via a series of open, natural, and engineered channels and subsurface structures where necessary. Stormwater runoff from the site will be attenuated to maintain pre-construction flow rates, achieved using a series of detention ponds and planned discharge to vegetated areas as a sediment and quality control mechanism before discharge to receptors such as the river or sea.

Figure 3-32 through to Figure 3-35 illustrates the specifications of various drainage infrastructure and Figure 3-36 shows the layout of the proposed storm water drainage design.

The hydrological assessment used to inform the proposed drainage system is detailed in section 4.1.5.3.

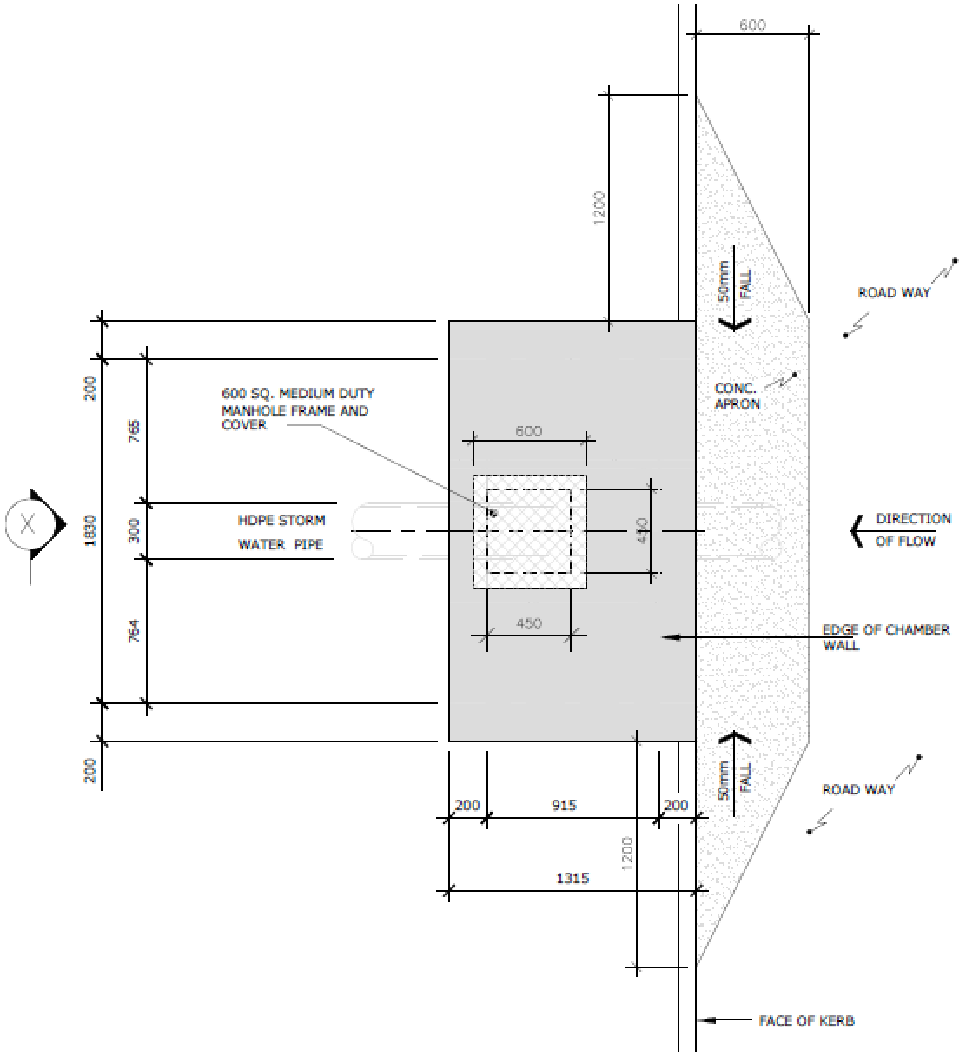


Figure 3-32 Plan of storm water inlet

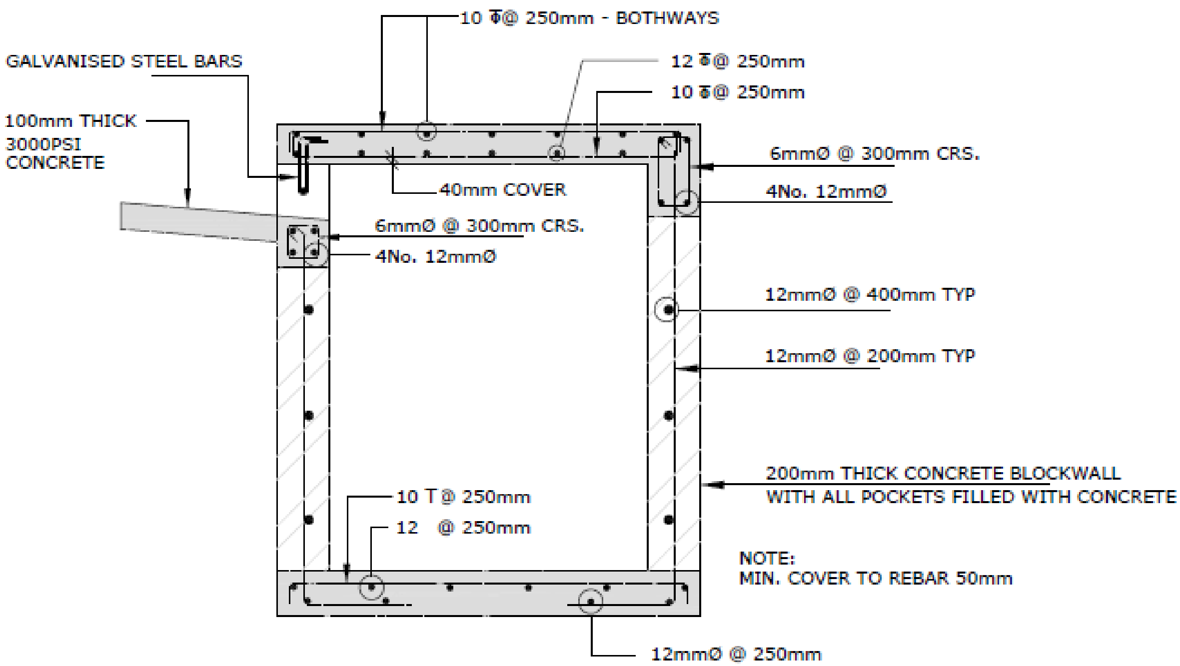


Figure 3-33 Cross-section through storm drain inlet

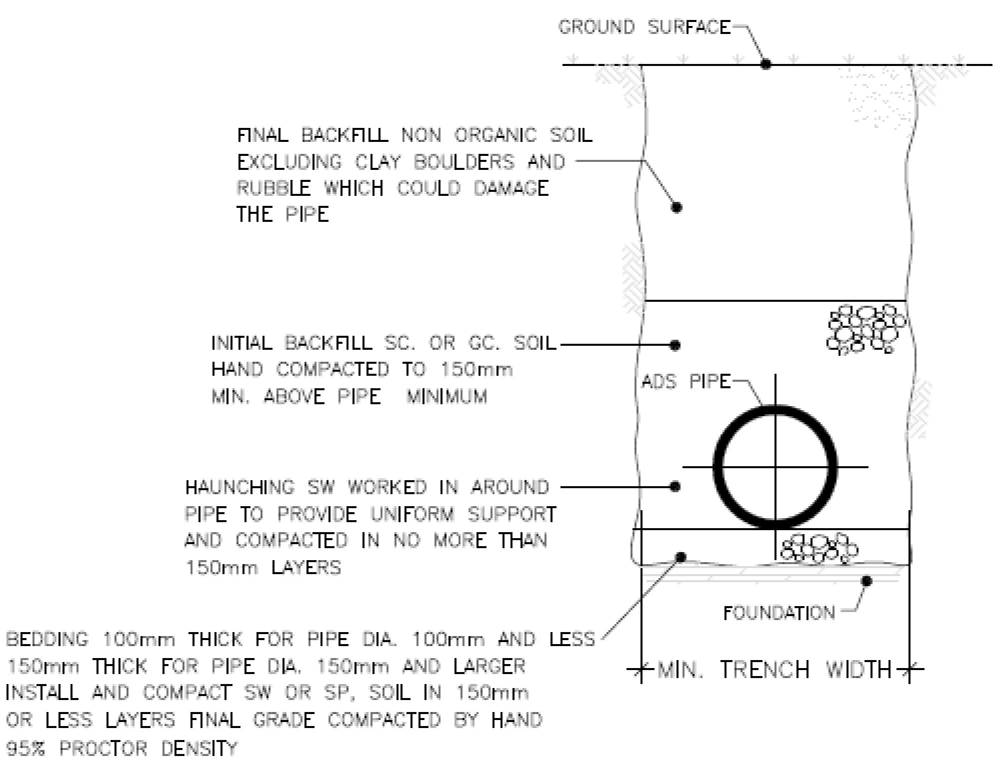


Figure 3-34 Typical trench cross-section

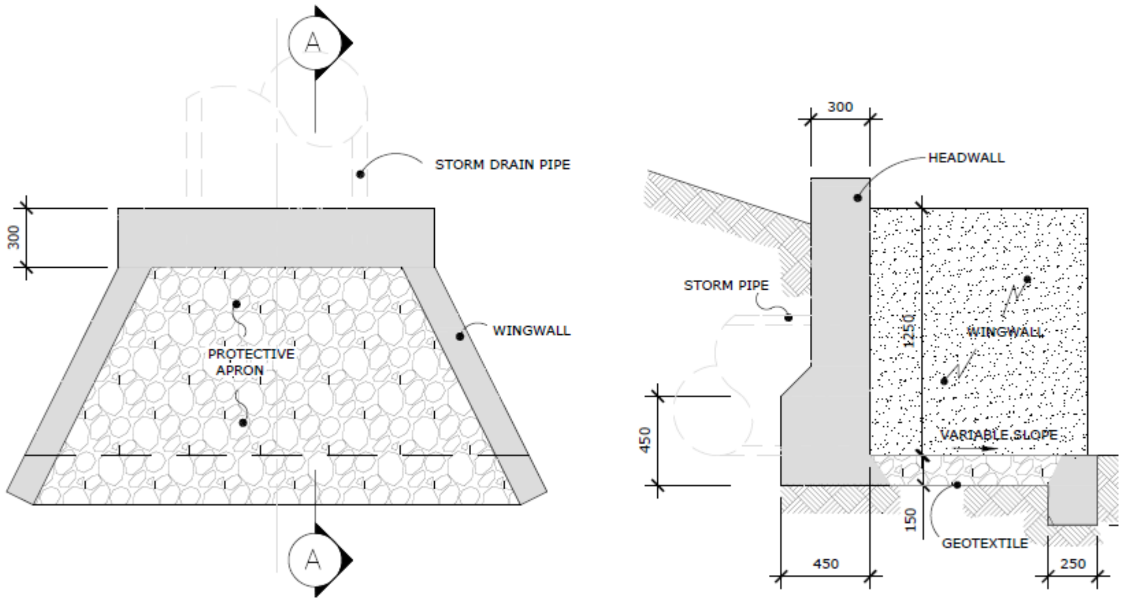


Figure 3-35 Headwall details: plan of headwall (left) and section A-A (right)

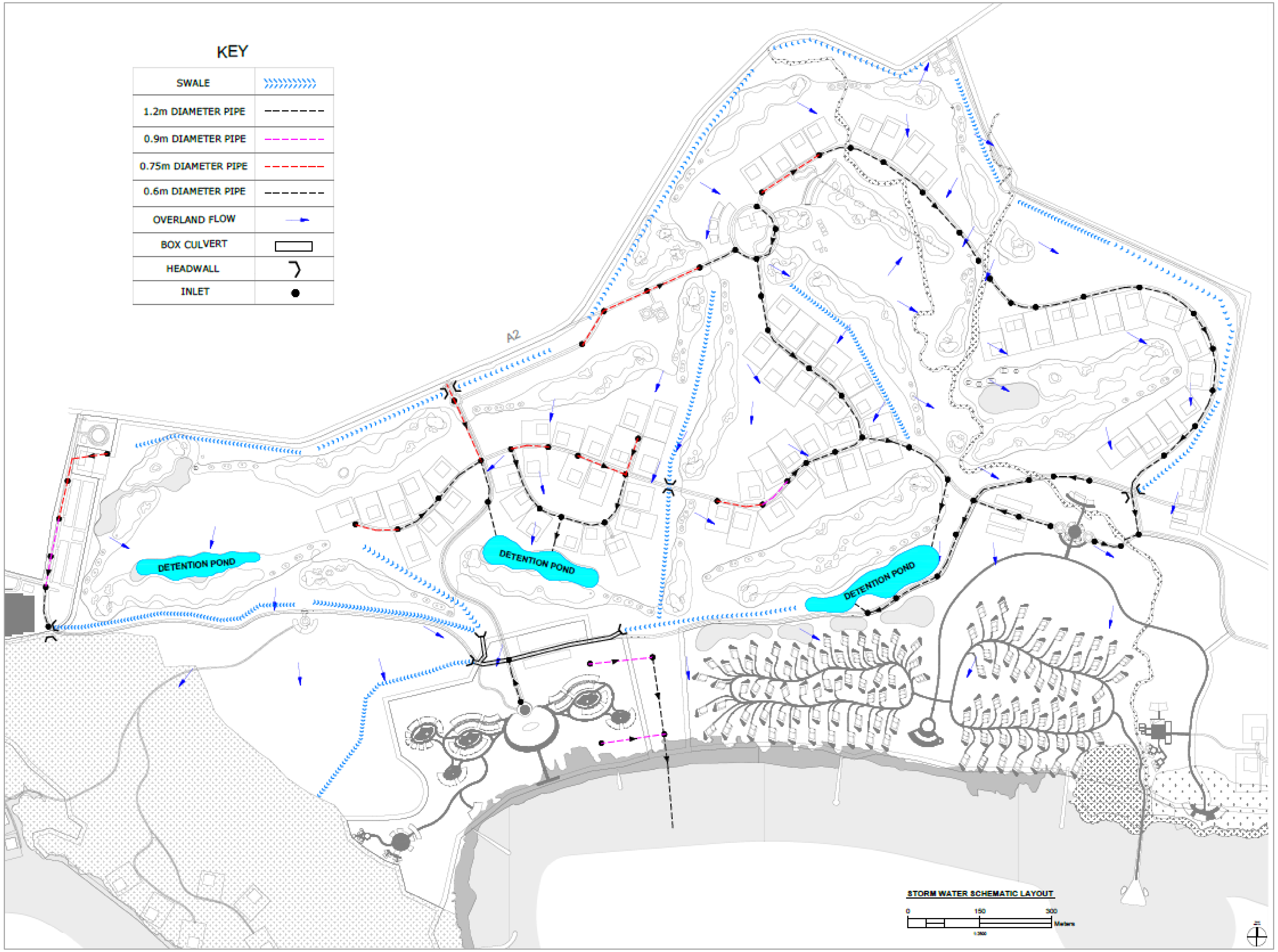


Figure 3-36 Storm water drainage design

3.3.5 Solid Waste

Hotel & Resort Operations believe in creating long-term value and making a meaningful impact on the destination and the community. They strive to embrace sustainable development through the core value of embracing environmental stewardship and empowering its people. Resort Operations will be guided by a holistic and participatory approach to maximizing impacts, while safeguarding human and physical environment. The Resort guests will enjoy energy efficient buildings, which will strive to use locally source materials and are committed to protecting the unique heritage of the local community.

Waste monitoring and recycling tracking will be implemented to achieve a 1/3 reduction in the use of single use plastic compared to other resorts. The following are the guiding principles for the Hotel to Prevent, Reduce, Reuse, Recycle, Recover and Dispose.

3.3.5.1 Objectives of Waste Management Plan

Operations will establish clear objectives essential for guiding our waste management practices.

- **Reduce Waste Generation:** Operations will implement strategies to minimize waste produced by hotel operations, promoting efficiency and sustainability. This includes working with vendor suppliers with purchasing practices that supply material that reduces excess packaging. They will use LEB bulbs that last 10 times longer than traditional products.
- **Promote Recycling:** Increase the percentage of materials recycled to divert waste from landfills and support resource conservation. We will track recycling rates and set specific targets for improvement.
- **Educate Staff and Guests:** Foster a culture of sustainability by educating employees and guests about waste management practices and the importance of reducing waste. Regular training sessions and informational materials will be distributed to enhance awareness.

3.3.5.2 Types of Waste Generated

Understanding the types of waste generated is crucial for developing effective management strategies.

1. **General Waste:** Includes non-recyclable materials such as food waste, packaging, and other disposable items. Regular assessment of waste composition to identify reduction. Food waste is the single largest waste stream in a resort and operations will include a process to having a food compost collection plan to reduce the binned waste generated by food leftovers.
2. **Recyclable Materials:** Consists of paper, cardboard, glass, metal, and certain plastics that can be processed for reuse. Operations will establish designated areas for these materials to be recycled.
3. **Hazardous Waste:** Involves materials such as cleaning chemicals and electronic waste that require special handling and disposal. Operations will maintain a clear inventory of hazardous materials and ensure safe disposal methods are in place.

3.3.5.3 Waste Segregation Procedures

Proper waste segregation is essential for efficient recycling and disposal. Clearly labelled bins for general waste, recyclables, and hazardous materials will be placed throughout the hotel to ensure easy access for staff and guests. Color-coded bins will aid in proper sorting, while containers tailored to specific areas will help streamline waste collection. Strategically placed trash chutes will centralize waste for efficient and regular pickups, while trash compaction systems will condense waste, reducing transportation requirements and supporting sustainable disposal practices.

Staff will receive thorough training on waste segregation techniques, with an emphasis on correctly separating materials. Regular refresher courses and annual training sessions will be conducted to reinforce best practices and adapt to evolving needs.

Guests will be educated about the waste segregation system through informational signage in guest rooms and common areas, encouraging their participation in recycling efforts. Additional materials, such as brochures included in welcome packets, will further inform guests about the program and its benefits.

3.3.5.4 Recycling Program

A comprehensive recycling program will be implemented to reduce landfill waste and promote sustainability. Partnerships with local recycling companies will ensure the efficient collection and processing of recyclable materials, with regular communication in place to enhance service quality and efficiency.

Regular audits will monitor recycling efforts, measure the volume of recycled materials, and pinpoint areas for improvement. Data collected from these audits will inform adjustments to the recycling strategy to achieve optimal outcomes.

Incentive programs will encourage active participation from staff and guests, offering rewards and recognition for significant contributions to recycling efforts, including milestones achieved by teams.

3.3.5.5 Hazardous Waste Management

Operations will establish a comprehensive process for the proper handling and disposal of hazardous waste, prioritizing health, and environmental safety. Regular identification and categorization of hazardous materials, such as cleaning supplies and batteries, will be conducted to ensure accurate compliance and safety measures. A detailed inventory will be maintained, and hazardous materials like mercury or lead will be identified, pre-treated, and segregated according to the requirements of certified landfill operators.

Safe disposal procedures will adhere strictly to local regulations, minimizing risks and ensuring compliance. Operations will foster partnerships with certified hazardous waste disposal companies to guarantee the responsible management of such materials.

Staff will receive thorough training in the handling and disposal of hazardous waste, with a focus on safety protocols and legal obligations. Records of these training sessions will be kept to meet regulatory requirements and support ongoing safety initiatives.

3.3.5.6 Operations Waste Reduction Strategies

Waste reduction strategies will enhance overall sustainability and operational efficiency. A key focus will be on sourcing eco-friendly and recyclable products, prioritizing suppliers who align with sustainable practices to minimize waste at the source.

Portion control measures will be introduced in food and beverage services to reduce food waste, with menu adjustments based on guest preferences to prevent overproduction. Locally sourced food products will be used to lower shipping emissions, support a sustainable local economy, and provide fresh, high-quality meals. Additionally, refillable dispensers will replace single-use cleaning product containers.

To further reduce waste, operations will transition to digital documentation wherever possible, replacing printed materials with digital contracts and forms to streamline processes and decrease paper usage.

3.3.5.7 Monitoring and Reporting

Regular monitoring and reporting play a crucial role in evaluating the success of waste management initiatives. Operations will implement a reporting system to regularly update management and stakeholders, promoting transparency and accountability. Senior management will receive monthly progress updates to ensure that implementation plans are effectively carried out.

To drive continuous improvement, audit findings will be used to develop actionable plans aimed at enhancing waste management practices. Operations will set new targets informed by historical performance data and emerging best practices in sustainability. Quarterly waste audits will be conducted to assess waste generation patterns, recycling rates, and adherence to waste management objectives. The insights from these audits will contribute to an annual sustainability report, providing a comprehensive overview of progress and areas for improvement.

3.3.5.8 Employee and Guest Engagement

Operations will actively involve both staff and guests in waste management initiatives to cultivate a culture of sustainability. To achieve this, awareness campaigns and workshops will be organized for employees, emphasizing the significance of effective waste management and sustainable practices. Guests will also be encouraged to participate through information sessions, newsletters, and strategically placed signage throughout the hotel.

To further enhance engagement, feedback forms will be made available to gather guest insights, ideas, and support for sustainability efforts. Additionally, channels such as suggestion boxes or online surveys will be established to allow both staff and guests to provide feedback on current waste management practices and propose improvements.

3.3.6 Utilities and Telecommunications

Electricity supply will be from Jamaica Public Service Company Ltd. (JPS) alongside renewable energy from the proposed solar field. Additionally, provisions for an emergency backup generator will be included. Please see section3.3.7.5, which details the proposed electrical systems for the project.

Telecommunications services will be provided by either Flow Jamaica Limited (formerly LIME Jamaica Limited) or Digicel Jamaica Limited.

3.3.7 Mechanical and Electrical Systems

3.3.7.1 Fire Protection Sprinkler System

Fire Protection System Overview

The Fire Protection systems will comply with the most recent adopted edition of the Jamaica Building Code, including the International Building Code, JS-316, International Fire Code & JS-313, and NFPA 13, 14, 20, 22, and 24. Figure 3-28 provides the layout for the water supply and fire suppression plan.

HOTEL FACILITY

The 4-story hotel facility will be equipped with complete sprinkler coverage by an automatic wet pipe fire sprinkler system, which includes electric fire pump(s) and fire water storage tank(s). Additionally, the buildings will have an automatic, class III wet standpipe system (with 1-1/2" hose and 2-1/2" hose connections) designed for use by trained in-house personnel and the Jamaica Fire Brigade.

RESORT

The administrative and service buildings within the resort (including reception buildings, restaurants, etc.) will also have complete sprinkler coverage with an automatic wet pipe fire sprinkler system, including electric fire pump(s) and fire water storage tank(s). However, the resort's guest accommodations (1 to 4-bedroom suites) are considered residential-type buildings and do not require automatic fire sprinkler systems. Firefighting capabilities for the guest suites will be provided through fire hydrants strategically located throughout the property.

VILLAS

The villas, which are residential homes, will not require fire sprinkler systems. Firefighting capabilities will be provided by fire hydrants located throughout the community.

GOLF CLUB

The 2-story golf club facility will be equipped with complete sprinkler coverage by an automatic wet pipe fire sprinkler system, including electric fire pump(s) and fire water storage tank(s). Since the highest occupied level is expected to be below 30 feet above fire department access, a standpipe system will not be necessary. The buildings will have an automatic, class II wet standpipe system (with 1-1/2" hose stations) for use by trained in-house personnel.

SERVICES BUILDINGS

At this stage, it is not anticipated that the service buildings will require fire sprinkler coverage. This assessment will be re-evaluated as the project scope for these buildings evolves.

Fire Protection Description and Specifications

An automatic wet pipe fire protection system will be installed throughout all areas of the buildings in accordance with Jamaica building codes and NFPA 13, 14, 20, 22, and 24 standards.

Sprinkler zones will be limited to a maximum of 52,000 square feet per fire area per valve. The buildings will be fire sprinkler zoned by floor, with additional sub-zoning applied to specific hazard areas as needed.

Building elevators will be equipped with an intermediate temperature upright sprinkler at the top of the shaft and a sidewall sprinkler 24 inches above the finished elevator pit floor. The water supply to these sprinklers will be monitored with a flow switch. If the elevator cab is non-combustible, sprinkler protection will not be required.

Sprinklers will be concealed and fully recessed in finished areas with ceilings. Sidewall, exposed, and extended-coverage sprinklers will be installed where appropriate. Upright sprinklers with protective baskets will be used in the gymnasium. Quick-response sprinkler heads will be installed in light-hazard areas. Unless otherwise noted, sprinklers will have a ½-inch orifice and a 165°F temperature rating. Intermediate temperature sprinklers will be installed in mechanical rooms, skylights, and other relevant areas.

Sprinkler system piping will consist of:

- Steel Pipe: ASTM A53, Schedule 40 seamless carbon steel. Schedule 10 pipe is acceptable for sizes larger than 2 inches when roll-grooved mechanical couplings are used. Fittings will be grooved mechanical fittings (ANSI A21.10 ductile iron, ASTM A47 grade malleable iron). Couplings will be made of ASTM A536 ductile iron or malleable iron, with EPDM gaskets and secure locking mechanisms for pipe and fittings.
- CPVC Pipe: Schedule 40 and 80 CPVC sprinkler pipe, conforming to ASTM F442 standards.

Sprinkler piping will be installed above ceilings and concealed within chases where applicable. Inspector's test connections and drains will be installed in remote areas of the building. Drains will terminate at the building exterior, at a splash block.

3.3.7.2 Plumbing Systems

The plumbing systems for the Paradise Park Resort shall be designed in accordance with the current edition of the Jamaica Building Code, including the International Building Code, JS-306, International Plumbing Code, and JIS-307.

Plumbing and Piping Systems

STORM DRAIN SYSTEM

For the hotel and resort, all buildings with flat roofs will be equipped with primary and secondary (emergency overflow) storm drain systems. Storm drain piping will be hubless cast iron with standard torque clamps, conforming to CISPI 301, or schedule-40 PVC for above-ground piping. Below the floor slab, storm drain piping will be hub and spigot cast iron conforming to ASTM A74 or schedule-40 PVC. The storm, waste, and vent piping will be concealed within chases and walls where possible. The storm and waste services will exit the building below the slab at multiple locations, to be coordinated with the site engineer. The secondary storm drain system will exit separately from the primary system, with discharge visible to the building maintenance staff.

For the villas, which are expected to have sloped roofs, roof gutters will be used for the conveyance of stormwater. Flat roof areas will be provided with primary and secondary roof drain systems.

DOMESTIC WATER SYSTEM

All buildings will be supplied with potable/domestic water. The domestic water supply will combine water from the local utility service provider (NWC) and a separate on-site water storage system for each facility. The hotel facility will have above-ground water storage systems distributed throughout the buildings, utilizing a multi-pump, staged pumping system controlled by variable frequency drives (VFDs). These systems will be located in the centralized Utility/Plant Room (otherwise referred to as the Energy Plant[3]) for each facility. Each villa and resort guest accommodation will have a potable/domestic water storage and pumping system.

Water for irrigation, toilet flushing, and cooling tower makeup will be supplemented by onsite condensate and rainwater harvesting systems for the hotel, resort, and golf club facilities.

Hot Water

Hot water for the hotel, resort, golf club, and service facilities will be generated from a combination of centralized gas-fired hot water heaters/boilers (located in the centralized Utility/Plant Room) and solar water heaters (roof-mounted). The hot water systems for resort guest suites and villas will use a

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[3] The Energy Plant is a centralized Utility/Plant Room for the provision of main utilities to the Hotel facility and will include equipment such as chillers, transformer substations, plate heat exchangers, generators etc. It is NOT Combined Heat and Power Plant (CHP).

combination of electric resistance and solar water heating. Hot water distribution will include 140°F piping for commercial kitchens (boosted to 180°F at the dishwasher only), and 110°F piping for the remainder of the building. Hot water will be stored at 140°F to mitigate the risk of Legionnaires' disease.

Hot water will be distributed throughout the resort, hotel, and golf club buildings using a multi-pump, staged pumping system controlled by VFDs. Hot water recirculation systems will be installed to maintain appropriate temperatures, ensuring hot water is available within 15 seconds of faucet activation. Balancing valves will be provided to ensure proper system flow.

Potable water piping (cold-water, hot-water, and domestic hot-water recirculation) will be of type L copper conforming to ASTM B88 and/or CPVC piping. Domestic hot water piping will be insulated with rigid moulded, non-combustible glass fibre insulation conforming to ASTM C335. Domestic water piping will be installed above ceilings and concealed within walls, with PVC jacketing provided on exposed piping.

Sanitary Sewer Drain System

All buildings will be equipped with sanitary sewer drain systems. The sanitary drain system for buildings, including commercial kitchens (hotel, resort, and golf club), will be supplemented with grease drain systems and underground grease traps installed exterior to the building. Sanitary drain piping will be hubless cast iron with standard torque clamps, conforming to CISPI 301, or PVC drain/waste/vent (DWV) piping for above-ground piping. Below the slab, the piping will be hub and spigot cast iron conforming to ASTM A74 or schedule-40 PVC. DWV piping will be concealed within chases and walls where possible. Storm and waste services will exit the building below the slab at multiple locations, to be coordinated with the civil/site engineer.

FUEL GAS SYSTEMS

The resort, hotel, and golf club facilities will each have independent fuel gas supply systems. Natural gas will be supplied by the local gas utility service provider and stored onsite in above-ground gas storage tanks. The meter assembly will include shut-off valves, a pressure regulator, and a meter. Fuel gas will serve the electrical generators, hot water boilers, and commercial kitchen appliances.

Natural gas piping to mechanical and other large equipment will be 2psi, reducing at the equipment with a pressure regulator. Distribution to the commercial kitchens/restaurants will include a dedicated low-pressure (7-14" w.c.) distribution main. Gas piping will be ASTM A53 schedule 40 black steel and/or copper pipe.

Plumbing Fixtures and Specialties

- All plumbing fixtures required to be accessible will comply with the Americans with Disabilities Act (ADA), Section 504, and UFAS standards.

- Water closets and urinals will be low consumption. Flush valves will be hard-wired and sensor-operated.
- Lavatories in public facilities (hotel, resort, and golf club) will feature low-flow faucets and will be sensor-operated.
- Drinking fountains will be stainless steel, wall-recessed, bi-level, ADA-compliant, vandal-resistant, and equipped with bottle fillers.
- Wall hydrants will be installed on exterior walls every 200 feet of the building perimeter. These hydrants will be lockable and backflow-protected.
- Reduced pressure backflow preventers will be installed on the domestic water connections to mechanical and kitchen equipment.
- Grease interceptors will be installed below grade at the exterior of the building to serve grease-producing fixtures in commercial kitchens.

3.3.7.3 Mechanical Systems

Mechanical systems shall be in accordance with the current adopted edition of the Jamaica Building Code (International Building Code & JS-306, International Mechanical Code & JS-312). The goals of the mechanical systems are to:

- Provide individual temperature control to all guest rooms and commercial spaces.
- Maximize energy efficiency and payback of the HVAC systems.
- Provide good ventilation of supply air (SA) and fresh air/outside air (OA).
- Install systems that minimize maintenance and the degree of difficulty of maintenance.
- Install systems that are durable and have an extended lifespan.
- Ensure temperature control and monitoring through a centralized Building Management System (BMS).

Hotel

Water air-cooled central station air conditioning units shall provide air conditioning for the hotel, golf club, and commercial buildings. The AHUs (Air Handling Units) shall be located in dedicated equipment rooms, with conditioned air distributed throughout the building via galvanized sheet metal ductwork.

HOT WATER PLANT

The hot water heating plant shall consist of multiple high-efficiency condensing, natural gas-fired boilers, with one boiler serving as a backup. The hot water pumping system will consist of an array of base-mounted, end-suction pumps, all served by variable frequency drives (VFDs). The hot water distribution mains and branches will be sized for low velocities and reduced pressure drop to reduce operating pressure and motor horsepower.

COOLING PLANT

The chiller plants will consist of multiple high-efficiency water-cooled chillers (one serving as a backup), each sized to provide partial capacity of full-load cooling requirements. Each chiller will be sized for nominal 15°F delta T (43°F supply and 58°F return temperatures) for energy efficiency.

Golf Club Resort Commercial Buildings

Water/air-cooled central station air conditioning units will provide air conditioning for the Golf Club and commercial buildings. The AHUs will be located in dedicated equipment rooms, with conditioned air distributed via galvanized sheet metal ductwork.

HOT WATER PLANT

The hot water heating plant for the golf club and commercial buildings will follow the same principles as the hotel, with high-efficiency condensing, natural gas-fired boilers, and VFD-driven base-mounted pumps. Hot water distribution will be optimized for low velocities and reduced pressure drops.

COOLING PLANT

Chiller plants will consist of multiple high-efficiency air-cooled chillers, each sized for partial capacity, and will follow the same energy-efficient specifications as the hotel. The chilled water distribution system will use a primary-secondary pumping system for redundancy, with the secondary pumps sized for 100% redundancy.

Villa and Resort Guest Accommodations

Air conditioning for the residential buildings of the Villas and Resort accommodations will be provided by variable refrigerant flow (VRF) split systems, consisting of indoor central station air handling units and an outdoor air-cooled condensing unit. Conditioned air will be distributed through microbial-coated fiberglass duct board.

HOT WATER PLANT

Hot water will be provided by electric storage water heaters or tankless instant hot water heaters.

MATERIALS AND METHODS FOR HVAC SYSTEMS

Ductwork and accessories will be made from galvanized steel or fiberglass duct board, fabricated, and installed per SMACNA standards. Hydronic piping up to 2 1/2" in size will be Type L copper or PVC/CPVC and piping larger than 3" will be ASTM A53 Schedule 40 black steel or PVC/CPVC.

3.3.7.4 Fire Alarm Systems

Hotel, Golf Club Resort Commercial Buildings

The fire alarm systems for the hotel and commercial buildings will be protected throughout with a 24V, addressable, automatic fire alarm system in compliance with code requirements and ADA regulations.

An emergency voice communication and evacuation system will be provided throughout the buildings. The systems shall be provided with fire alarm control panels to contact the local fire department.

- Manual pull stations shall be installed in the egress paths at exterior doors and at entrances to stairwells. Manual pull stations shall be provided with station guards with horn.
- Audible and visual signalling devices and smoke detector/alarms shall be installed in guest rooms, common spaces, corridors, vestibules, etc.
- Remote annunciator mounted at main entry door.
- Speaker/multi-candela strobe in all spaces. Strobe candela intensity to be selected based on classroom dimensions.
- Monitoring modules for sprinkler tampers and flows.
- Monitoring and control modules for elevator shunt-trip and recall operations.
- Control modules for fan shut-down and damper control.
- Signal to BMS system on alarm condition.
- (2) telephone cables from the fire alarm panel to the telephone demarcation board.
- Magnetic door hold-open devices at all required corridor doors, connected to the control modules to release on alarm condition.
- Smoke detector within five feet of both sides of the corridor doors with magnetic hold- opens, where required by building fire separation.
- Monitor module for Kitchen hood fire extinguishing system (Ansul System).

3.3.7.5 Electrical Systems

Hotel

APPLICABLE CODES AND STANDARDS

The electrical systems will be designed in conformance with the requirements of the following codes and regulations and all applicable local authority requirements, including the:

- JS 316: 2018 (Jamaica Standard, Jamaica Application Document for the International Code Council
- Electrical Administrative Provisions and National Electrical Code).
- National Electrical Code 2011
- The National Fire Protection Association (NFPA)
- JPS Electrical Standards for High and Medium Voltage Installations JPS ES1300

MAIN SERVICE

A medium voltage 24kV, 50Hz three-phase (3ϕ) power supply from the Jamaica Public Service Co. Ltd. grid, combined with a proposed 24kV, 50Hz three-phase (3ϕ) renewable energy system, will meet the calculated load requirements of the hotel. Renewable energy will be provided through the implementation and operation of a solar field. This solar field will involve the design and setup of multiple arrays, which will be arranged using ground-mounted solar racking methods.

Solar Field

The solar field will be located remotely from the hotel, within the Service Area, and will supply power (DC Volts) via a network of combiner boxes and underground DC cables. These cables will be routed and terminated at the supply terminals of a series of DC-AC inverters located in the main electrical room at the Service Area. This room will also house other components, including the power management system, low voltage switchboards, specific instrumentation, and weather monitoring systems, to facilitate the proposed grid tie.

The combined DC-AC inverters will convert the power to three-phase (3ϕ), 415V, 50Hz (AC Volts), which will then be supplied to the common bus of a low voltage switchboard in the aforementioned Main Electrical Room. Each inverter will be connected to the common bus through a three-phase protective device (circuit breaker) at the low voltage switchboard. This setup will allow a common set of three-phase AC feeders to leave the switchboard at the rated three-phase 415V, 50Hz, corresponding to the percentage of usable power allocated to the hotel property. These feeders will be routed from the switchboard through indoor trenches in the switchroom, as well as a network of underground manholes, ducts, and outdoor trenches. The goal is to route these feeder cables through this underground cabling system to the designated medium voltage substation on the Service Area property.

The feeder cables will then be terminated at the primary terminals of a step-up transformer (415V/24kV, 3ϕ, 50Hz). The step-up transformer will distribute medium voltage 24kV, 3ϕ, 50Hz through its secondary terminals to an overhead line infrastructure installed along the private roadway, traveling eastward from the service area to the hotel property. It is important to note that there will be a point where the overhead lines transition to underground cables to allow the power supply network to enter the hotel property.

All medium voltage feeder cables coming onto the hotel property from the Service Area substation will be terminated at the ring main distribution switchgear (medium voltage switchboard) in the main medium voltage electrical room on the hotel's property. The grid tie will occur at this connection point.

A 5MW solar plant is being proposed based on the available footprint for the installation of solar panels (approximately 7,150 panels @ 700W/panel) and the supporting building infrastructure for the solar power plant.

Utility Connection

A medium voltage 24kV, 50Hz three-phase (3ϕ) power supply from the Jamaica Public Service Co. Ltd. will be metered at a 'dead end' overhead utility pole, strategically located along the entrance roadway to the hotel. Metering will take place at this point, allowing for the transition from overhead to underground medium voltage cabling within the hotel grounds. As previously mentioned, the hotel's medium voltage distribution system will be routed via an underground network of code-compliant manholes, ducts, and trenches.

After transitioning at the JPS metering point, the underground medium voltage supply cables from JPS will be routed to the medium voltage main electrical room located on the hotel premises. These underground cables will then be terminated at the line side terminals of the designated switchgear, which forms part of the main medium voltage bus, where the grid tie occurs.

Transition points will be constructed in compliance with the Jamaica Public Service (JPS) Field Manual FM007. An excerpt from Section 4 of the manual is provided in Figure 3-37. Cable trenches for medium voltage cables shall be constructed per the JPS ES1300 installation manual in conjunction with the JPS FM007 field manual.

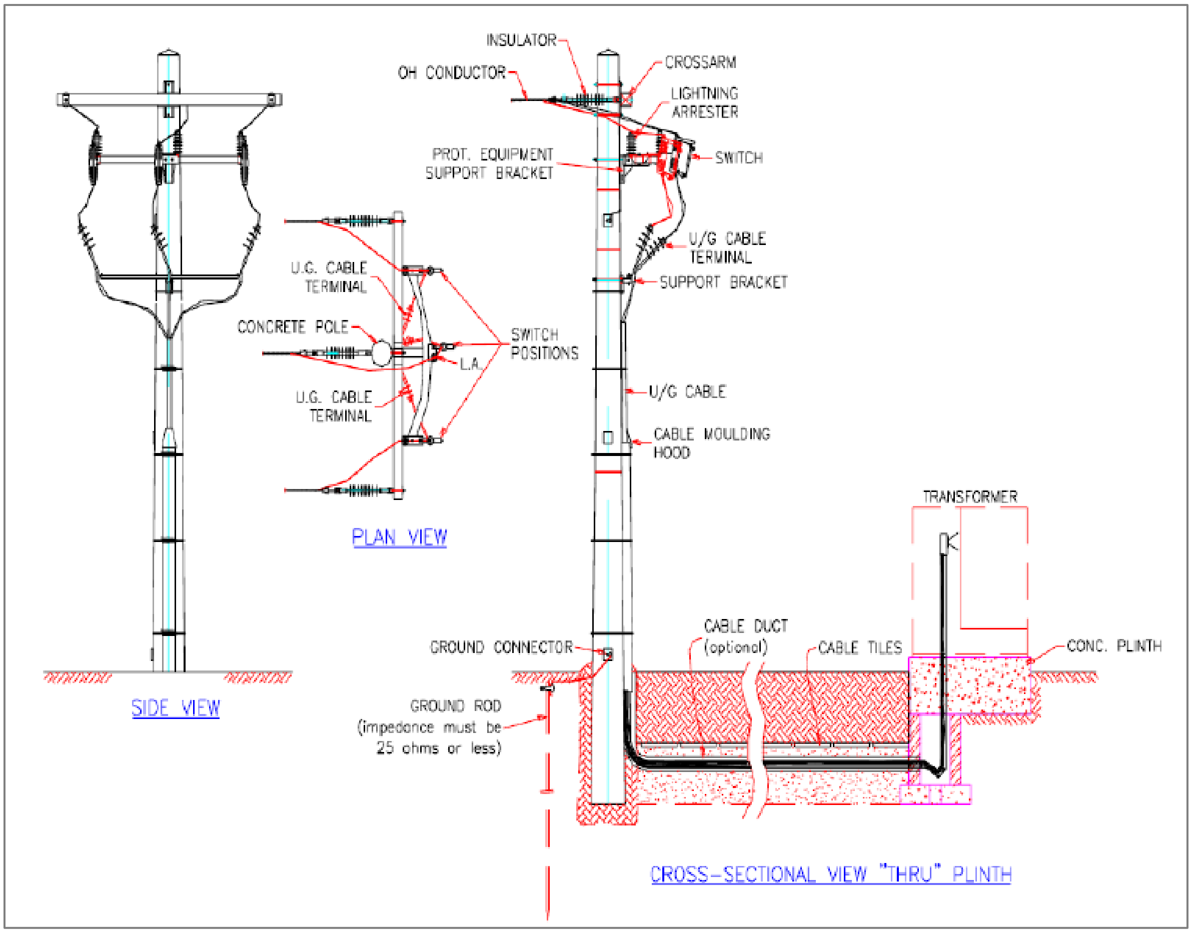


Figure 3-37 Code compliant connection methodology for transitioning of overhead 24kV, 3ϕ, medium voltage distribution to underground 24kV, 3ϕ medium voltage distribution

Standby/Emergency Systems

Standby systems will be integrated into the main service connection at the sectionalized medium voltage bus in the medium voltage Main Electrical Room. The system will consist of the following:

- Paralleled low voltage generators, synchronizers, and associated generator controls.
- A common bus low voltage switchboard to accommodate the incomers from the paralleled generators.
- Protective devices, including relays, breakers, etc.
- An enclosed substation/transformer room with a step-up transformer sized to provide the medium voltage bus with sufficient capacity to meet load consumption requirements over time.

The generators will be automatically brought online through switching mechanisms at the medium voltage bus whenever the utility power is absent due to isolation or unexpected outages. When the generators are activated due to any of these conditions, the incomer from the Solar Field supplying the medium voltage bus in the Main Electrical Room will be isolated by automatic switching mechanisms.

All standby generators will use LNG as the primary fuel source. Fuel storage tank specifications will ensure that these generators can provide emergency power to meet the hotel's real-time load requirements for up to five days or 120 hours. Designated access ways will allow fuel trucks to replenish the onsite generator fuel tanks. All storage tanks will comply with the relevant implementation and operational codes set by The National Fire Protection Association (NFPA).

The emergency generator will supply power to the following systems:

- Plumbing equipment, including motors, motor MCCs, and their associated controls.
- HVAC equipment, including chiller units, pumps, condensers, and their controls.
- Kitchen equipment and facilities, including freezers.
- Common areas, including pools, restaurants, ballrooms, gyms, etc.
- Data closets and associated cooling systems.
- Sanitary ejector pumps and controls.
- Security systems.
- Fire alarm systems.
- Building management systems.
- Offices.
- Security lighting and other lighting systems and controls.
- Irrigation systems.
- All other electrical infrastructure.

DISTRIBUTION

Medium Voltage Distribution

Two medium voltage ring main distribution networks will be designed to meet the hotel's on-site load requirements. The main electrical switchroom will serve as the protection and control point for the supply of power to these two underground medium voltage ring main distribution networks.

One network will supply power to the western end of the hotel's property, while the other will provide power to the eastern end. A single substation, located in the plant room area of building H9, will meet the power needs of that building, including equipment for the plant room, hotel restaurants, lobbies, and common areas.

This network will incorporate ring main units and medium voltage step-down 24kV/415V delta-wye three-phase 50Hz pad-mounted transformers, situated in enclosed transformer rooms on the hotel's property. These transformer rooms will be constructed in compliance with Part III, Article 450 of the National Electric Code.

The transformer rooms will be separated and secured from adjacent low voltage switchrooms. The low voltage switchrooms will be placed near the transformers to minimize the impact of long cable runs and voltage drops due to increased mV/A/m losses, especially at the low voltage high amperage distribution level.

Transformer rooms will be strategically positioned on the property to minimize visibility while maintaining the aesthetic balance of the hotel, ensuring the facility's operational and functional needs are met. All medium voltage system components on-site will undergo the necessary functionality tests before being put into service. These tests will include transformer tests (such as Turns Ratio Tests, Polarity Tests, and Winding Resistance Tests), medium voltage cable tests, and testing of associated ring main units and switchgear.

All electrical services will be routed underground to the pad-mounted transformers using schedule 40 PVC conduit. For areas crossing roadways, sidewalks, etc., concrete-encased conduit will be used (refer to section 2.2). All conductors will be made of copper.

Low Voltage Distribution

All main low voltage switchrooms on-site will receive electrical energy through cables routed from the secondary terminals of the designated power supply transformer. Switchrooms will be equipped with:

- A sectionalized main low voltage distribution switchboard with service entrance conductors from the associated transformer, terminated at the line side terminals of the Main Circuit Breaker/Main Switchgear. Incoming power will be three-phase (3ϕ), 415V, which will then be distributed to branch circuit sub-panels, HVAC equipment, pump rooms, dry-type transformers, and all other plug/lighting services.

- Fire alarm and gas monitoring systems.
- Protective relays and associated devices.
- Proper lighting and receptacle points.
- Cable distribution infrastructure, including cable trays, etc.
- A Transient Voltage Surge Suppression (TVSS) device and arc energy reduction at the main circuit breaker. The switchgear will have copper bussing with group-mounted branch circuit breakers.
- Panelboard feeders to limit voltage drops to a maximum of 3% from the main switchboard. All necessary adapters/reducers to accommodate panel lug sizes will be provided.

Downstream sub-panels rated at 415/240V, three-phase, 4-wire will serve various loads, including:

- Mechanical loads (circuits for central chiller plant pumps, cooling towers, and required controls, as outlined in the mechanical systems narrative).
- Fire protection systems (e.g., fire pumps).
- Plumbing equipment/systems (e.g., water pump motors).
- Interior and site lighting.
- Plant room mechanical loads (e.g., boilers, as outlined in the mechanical systems narrative).
- Food service equipment circuits.
- Office equipment circuits.
- Primary windings of 220V/110V, three-phase dry-type distribution transformers.

Dry-type transformers located within the building will step down the 415V three-phase distribution to a usable power supply of 220/110V or 208/120V three-phase, depending on load requirements. These transformers will support general receptacle and lighting loads and supply power to kitchen equipment, guestroom HVAC systems, data equipment, small equipment loads, fire alarm systems, telecommunications, security, and other infrastructure. All transformers will feature harmonic mitigation and must be properly bonded and grounded as per applicable electrical codes.

The secondary supply cables from these transformers will be terminated at the line side terminals of three-phase 220/110V or 208/120V panels, as well as 220/110V or 208/120V single-phase distribution panels. Areas supplied at this voltage level will include:

- Power supply to guestrooms and suites.
- Common areas (e.g., lobby, restaurants, ballroom, gym, etc.).
- Circuits supporting food service equipment.
- Circuits for plumbing equipment.
- Circuits for office equipment.
- Circuits for central chiller plant pumps and controls.

- Corridors.
- Areas requiring non-continuous and continuous lighting circuits.
- Guestroom controls, including vacancy and occupancy sensors.

All dry-type transformers will have accessible isolation means and protective devices directly connected to both primary and secondary windings. These devices will be located within six feet of the transformer. Dry-type transformers will be securely guarded in electrically safe areas, with access restricted to authorized personnel only, in accordance with applicable local electrical codes.

LIGHTING SYSTEMS

All interior lighting fixtures will utilize LED modules and drivers for energy efficiency and long lifespan. Lighting control panels will be installed in common and selected areas within buildings to promote the efficient use of lighting circuits. These areas include:

- Common areas and selected guestroom building corridors where illumination levels can be adjusted to create lighting ambiances at night, supporting energy conservation efforts.
- Parking lot and site security lighting, with operation times set via lighting control panels from 6 pm to 6 am.
- Lighting facades for all buildings, gardens/green areas, pools, walkways, and select beach areas.

Site-wide daylighting controls will be provided, including sensors, dimmable LED drivers, and control panels.

Lighting circuits will be primarily 220V, with 110V branch circuits where required. Exit signs will be self-contained, universal-mounted, LED-illuminated fixtures with low energy usage. These exit signs will be located no more than 200 feet apart and will be installed in every path of egress and above each egress doorway. Special lighted exit signs with the International Symbol of Accessibility will direct people to accessible exit doorways and meet the requirements for low-level exit signs. These signs will also feature LED lamps.

The following typical illumination levels will be observed:

- 15-20 foot-candles (fc) – Corridors, toilet rooms, storage rooms, and stairways.
- 90-110 fc – Mechanical rooms/plant rooms.
- 90-100 fc – Kitchens.
- 30-40 fc – Gym.
- 20-30 fc – Lobbies.
- 10-20 fc – Restaurant and dining areas.

The following fixtures will be provided site-wide, as applicable:

- Pendant-mounted direct/indirect LED fixtures.
- Recessed-mounted LED fixtures.
- Surface or suspended LED fixtures in support spaces.
- Industrial LED acrylic-lensed strip fixtures in mechanical spaces.
- Accent and feature lighting in areas such as corridors and the main lobby, as selected by the architect.
- Ceiling-mounted dual-technology occupancy/vacancy sensors in all rooms, including guest rooms, with wall overrides.

Occupancy/vacancy sensors will be installed in all lit areas, except in utility rooms and other spaces exempted by code. Corridor and stairwell lighting will remain on during occupied hours and be controlled by occupancy sensors during unoccupied times, in communication with the building management system through a contact closure and relay.

Gymnasium lighting will consist of high-output LED fixtures with protective cages and will be controlled via occupancy sensors.

Parking lot lighting will be provided by 20 to 25-foot poles with a 220V power supply and LED fixtures. These fixtures will be controlled by the building management system via a site lighting contactor panel.

Enhanced exterior lighting will be installed in areas monitored by cameras, as applicable. All egress doors will be adequately illuminated.

A performance stage lighting system will be provided for the Multi-Purpose Room/Stage in the general entertainment area. The system will include dimmable theatrical lighting fixtures mounted on light bars over the platform and stage. The theatrical dimmer system rack will be located at the back of the stage. Additionally, LED light fixtures will be installed for house lighting, integrated with the stage dimming rack.

LIGHTNING PROTECTION SYSTEM

A UL Master Label-compliant lightning protection system will be provided for all applicable buildings. The system will adhere to standards set by NFPA 780, LPI standard #175, and UL #96A. It will include strike termination devices, interconnecting conductors, and ground rods to ensure safety and compliance with industry standards.

DATA, TELECOMMUNICATION, AND SOUND/AUDIO

All infrastructure for data, CCTV, telecommunications, and sound/audio systems will be designed in consultation with the contracted technology consultants for these disciplines to ensure that the systems meet the hotel's specific operational and technical requirements.

Resort

APPLICABLE CODES AND STANDARDS

The electrical systems for the resort will be designed in strict compliance with the following codes and regulations, as well as all relevant local authority requirements:

- JS 316: 2018: Jamaica Standard, Jamaica Application Document for the International Code Council Electrical Administrative Provisions and National Electrical Code.
- National Electrical Code 2011: A comprehensive set of standards governing electrical installations.
- The National Fire Protection Association (NFPA): A set of codes and standards aimed at fire prevention and safety.
- JPS Electrical Standards for High and Medium Voltage Installations (JPS ES1300): Specific standards set by Jamaica Public Service for high and medium voltage installations.

MAIN SERVICE

The resort's electrical service will be supplied by an underground medium voltage (24kV, 50Hz, three-phase) power supply provided by Jamaica Public Service Co. Ltd. (JPS). This power supply will be sized to meet the calculated load requirements of the hotel.

The power will be routed from a take-off or underground transition point located along the private roadway to the north of the resort boundary. This transition point will allow the medium voltage cables to shift from an overhead line installation to an underground installation before entering the resort's premises.

The underground network will consist of medium voltage cables that will be routed using cable tiles, manholes, ducts, and trenches to ensure secure and efficient distribution.

Utility Connection

The resort's electrical consumption will be metered at the medium voltage transition point mentioned above. This meter will measure all kWh consumption by the resort, and monthly billing by Jamaica Public Service (JPS) will be based on readings taken at this location.

DISTRIBUTION

Medium Voltage Distribution

A medium voltage ring main distribution network will be designed to meet the load requirements of the resort. The medium voltage incomer from Jamaica Public Service (JPS) will be terminated at a pad-mounted medium voltage switch.

This switch, along with others located in transformer rooms and indoor substations around the property, will enable the switching, isolation, and maintenance of the medium voltage ring and all transformers connected to the ring. The switches will also provide fused protection for the primary windings of the pad-mounted transformers connected to the load side distribution terminals.

A total of four medium voltage switches and four pad-mounted transformers will be integrated into the overall medium voltage ring distribution system. This infrastructure will ensure reliable and maintainable electrical distribution across the resort.

Low Voltage Distribution

Low voltage switchboards will distribute power at a 208/120V single-phase voltage to all guest suites and common areas across the resort. These switchboards will be housed in strategically placed switchrooms to ensure effective distribution of power site-wide. The main switchrooms will be located next to the transformer rooms, while additional sub-distribution switchboards will be placed in various areas across the site. Transient Voltage Surge Suppression (TVSS) devices will be installed in all main low voltage distribution switchboards and select downstream switchboards to protect the system from transient voltage surges.

All guest suites will have a distribution panel for power distribution to appliances, air conditioning, lighting, and receptacles. Common areas (such as lobbies, gardens, walkways) will have designated circuits for general load receptacles and lighting, powered through local distribution panels connected to the main switchrooms.

In addition, the resort's electrical system will support various specialized circuits, including:

- Mechanical loads (as per the mechanical narrative)
- Fire protection systems (e.g., fire pumps)
- Plumbing equipment/systems (e.g., water pump motors)
- Site and security lighting
- Food service equipment (e.g., kitchen equipment)

Standby Generators/Emergency Power

Three parallel and synchronized 2.5 MW standby generators will supplement pre-estimated load requirements for the hotel. The **estimated** peak demand is 6.8MW.

Standby generators will be installed outdoors near each transformer room, housed in marine-coated sound attenuated enclosures. These generators will be designed to meet the load requirements of the associated pad-mounted transformer. The generators will provide three-phase, 208/120V, 50Hz power to the corresponding Low Voltage Main Distribution Board located in the switchroom adjacent to the transformer room.

An Automatic Transfer Switch (ATS) will control switching between power sources, ensuring that when utility power is unavailable, the generators will automatically take over. This automatic switching will also isolate the medium voltage incomer in the Main Electrical room.

The standby generators will use liquefied natural gas (LNG) as the primary fuel, with fuel storage tanks capable of supplying power for up to 120 hours (5 days). The generators will power critical systems including:

- Plumbing equipment (motors, MCCs, controls)
- HVAC equipment (chillers, pumps, condensers, and controls)
- Kitchen equipment (freezers, etc.)
- Common area facilities (pools, restaurants, ballrooms, gym)
- Data closets and cooling systems
- Sanitary ejector pumps
- Security systems
- Fire alarm systems
- Building management systems
- Offices
- Security and site lighting
- Irrigation systems

LIGHTING SYSTEMS

Interior lighting fixtures will utilize LED modules and drivers for efficiency and longevity. Lighting control panels will be employed in common areas and select guest areas to optimize energy use. Key areas for control include:

- Common areas and selected guest suites
- Parking lots and site security lighting, with timers set from 6 pm to 6 am
- Building facades, gardens/green areas, walkways, and select beach areas

Daylighting controls, including sensors and dimmable LED drivers, will be provided across the entire site to ensure energy efficiency.

- Lighting circuits will generally be 208V, with 120V branch circuits where needed.
- Exit signs will be self-contained, LED-illuminated, and low-energy usage. These will include the International Symbol of Accessibility and will be strategically located above egress doorways and along paths of egress.

The illumination levels for various areas are specified as follows:

- 15-20 foot-candles (fc) for corridors, toilet rooms, storage rooms, and stairways
- 90-110 fc for switchrooms
- 90-100 fc for kitchens
- 10-20 fc for restaurant and dining areas

The following fixtures will be provided throughout the resort:

- Pendant-mounted direct/indirect LED fixtures
- Recessed-mounted LED fixtures
- Surface or suspended LED fixtures in support spaces
- Accent and feature lighting in areas like corridors and the main lobby, as selected by the architect

Guestrooms will be equipped with ceiling-mounted dual technology occupancy/vacancy sensors with wall overrides. Occupancy/vacancy sensors will also be installed in all lit areas, except for utility rooms and other code-exempt spaces.

Parking lot lighting will be provided by 20-25 foot poles with 220V LED fixtures. These will be powered by a site lighting contactor panel and controlled by the building management system. Enhanced exterior lighting will be provided in areas with camera monitoring, as necessary. Egress doors will be adequately illuminated.

DATA, SOUND, AND TELECOMMUNICATIONS (RESORT)

All data, CCTV, telecommunications, and sound/audio infrastructure will be designed in consultation with the contracted technology consultants. This will ensure the resort's needs for communication and multimedia systems are met, using the latest technologies and standards.

Villas

APPLICABLE CODES AND STANDARDS

The electrical systems for the Paradise Park Villas will be designed in compliance with the following standards and regulations, along with any applicable local authority requirements:

- JS 316: 2018 (Jamaica Standard, Jamaica Application Document for the International Code Council Electrical Administrative Provisions and National Electrical Code)
- National Electrical Code (NEC) 2011
- National Fire Protection Association (NFPA)
- JPS Electrical Standards for High and Medium Voltage Installations (JPS ES1300)

MAIN SERVICE

Utility Power Distribution

The electrical supply will be sourced from pole-mounted medium voltage 24kV, 50Hz three-phase power lines from Jamaica Public Service Co. Ltd. (JPS). These power lines will be routed through the Villa community to provide effective transmission.

Pole-mounted transformers will be used to step down the 24kV supply to 220V single-phase power. The number of transformers will depend on load calculations and transformer load balancing. Low voltage lines will be routed from these transformers to the villas, ensuring efficient power distribution and community aesthetics.

Villa Utility Connection

Each villa will be individually metered and billed based on the JPS billing cycle. Metering facilities will be installed at the property boundary (within 5 feet) using concrete meter posts, weatherheads (potheads), and stations for safe and convenient access. All metering facilities will adhere to JPS Engineering Bulletin No. TSD 007/3.

Street lighting will be powered using JPS street lighting standards and installed on distribution line poles. The lights will be 58W LED fixtures, illuminating pathways, sidewalks, and roadways.

Service Entrance conductors will be routed underground through a manhole trench and duct network, terminating at the Main Distribution Panel of each villa. Load calculations for the villas will follow the National Electric Code 2020 optional method for dwelling feeder sizes, and protection devices will be selected accordingly.

Low Voltage Distribution

Each villa will be equipped with a Main Distribution Panel (MDP), which includes an automatic Main Circuit Breaker to manage the distribution of power throughout the villa. Branch circuits will be protected with appropriate protective devices. Lighting circuits will be protected by a maximum 15A breaker, while general use receptacle circuits will have a 20A protective device. Additional circuits, including those for appliances, air conditioning, water heaters, and laundry, will feature the necessary overcurrent and overvoltage protection.

To ensure uninterrupted power supply during outages, each villa will also be equipped with a standby generator and an Automatic Transfer Switch (ATS) for seamless switching to backup power. For safety, Ground Fault Circuit Interrupters (GFCI) will be installed in bathrooms, washrooms, outdoor areas, and laundries. Arc Fault Circuit Interrupters (AFCI) will be used in all relevant areas, such as:

- Kitchens
- Family rooms

- Dining rooms
- Living rooms
- Parlours
- Libraries
- Bedrooms
- Sunrooms
- Recreation rooms
- Hallways
- Laundry areas (via combination AFCI and GFCI outlets and breakers)

LIGHTING SYSTEMS

Interior lighting will utilize LED modules and drivers for energy efficiency. Each villa will have a lighting control panel to manage security lighting, facades, gardens, walkways, and outdoor lighting.

Outdoor lighting circuits will generally be 220V, with 110V branch circuits where necessary. Lighting fixtures in the villas will include:

- Pendant mounted direct/indirect LED fixtures
- Recessed mounted LED fixtures
- Surface or suspended LED fixtures in support spaces
- Twin batten LED fixtures and LED tubes in mechanical spaces
- Accent and feature lighting, as chosen by the architect, for walkways, walls, and gardens.

Enhanced exterior lighting will be provided in areas with camera monitoring.

DATA, SOUND, AND TELECOMMUNICATIONS (VILLAS)

All infrastructure related to data, CCTV, telecommunications, and sound/audio systems will be designed in collaboration with technology consultants, ensuring that the necessary technical requirements are met across the villas.

3.4 CONSTRUCTION METHODOLOGY

3.4.1 Approach

The proposed methodology ensures that all aspects of the construction process align with the project's goals, promoting efficient progress and maintaining high standards of execution. Key project execution will include the following:

- **Work Sequence**: Clear and logical sequencing of tasks to optimize workflow and minimize delays.

- **Construction Techniques**: Utilization of proven methods and practices to enhance durability, efficiency, and precision.
- **Quality Assurance**: Measures to ensure all project components meet defined standards and specifications.
- **Safety Protocols**: Implementation of stringent safety measures to protect personnel and equipment.
- **Environmental Stewardship**: Commitment to sustainable practices, minimizing environmental impact throughout the construction process.

Site access for the project will initially be provided through existing dirt roads, minimizing disruption to the natural surroundings. These roads will remain in use until new roadways are constructed, ensuring efficient logistics and access for equipment and personnel throughout the project.

The project design will also adhere to a comprehensive set of construction standards and codes to ensure structural integrity, safety, and energy efficiency. These include internationally recognized codes such as the Building, Mechanical, Fire, Plumbing, and Energy Conservation Codes (IBC 2018, IMC 2018, IFC 2018, IPC 2018, IECC 2015), as well as the National Electrical Code (2018) and NFPA Standards (30, 31, 54, 58). Additionally, the ASHRAE Standard 90-75 for energy efficiency will be followed. Local Jamaican codes and ordinances will also be strictly adhered to, ensuring full compliance with regional regulations and requirements.

A targeted Environmental and Marine Protection Strategy will be implemented to safeguard the existing landmass, water systems, and biodiversity. This strategy will address potential construction impacts on sensitive areas such as mangroves, the River, and local habitats. Best practices will be followed to protect the integrity of the coastal ecosystem, with sediment controls put in place to reduce erosion and pollution. Regular inspections will be conducted during construction activities to ensure that these environmental controls are maintained, and after each storm event, the controls will be reviewed, checked, and documented. In the event of any breaches, immediate repairs will be carried out.

3.4.2 Foundation System for Building Construction

The foundation system for the proposed building is designed to provide effective support and ensure long-term stability. The tallest structure will rise to a maximum height of 15,000 mm (3 levels); to support this, the foundations will be built using rebar-reinforced spread footings and a raft slab foundation. The system will be executed in multiple stages to ensure stability, durability, and adherence to the design specifications. Key steps will include excavation, subgrade compaction, installation and testing of under-slab utilities, backfilling, granular sub-base installation, and pouring the raft slab foundation. These stages will ensure that the foundation is structurally sound, properly prepared for the superstructure, and well-drained, minimizing any risk of settlement or moisture-related issues under the building slabs.

3.4.2.1 Excavation and Site Preparation

Objective: To prepare the foundation area by excavating to the required depth and ensuring the subgrade is stable and compacted for the foundation structure.

The foundation areas for the building will be excavated using a large excavator to a depth approximately 200 mm below the bottom of the raft slab thickness. This excavation will be closely monitored throughout the process to ensure that the depth and dimensions align with the design specifications for both the foundation and the raft slab. After excavation, the underlying soil, or subgrade, will be inspected to confirm its suitability for supporting the foundation. If any unsuitable soils—such as soft or loose materials—are discovered beneath the foundation or structural areas, they will be removed and replaced with approved structural fill. This replacement will ensure that the subgrade provides the necessary bearing capacity to support the foundation and maintain the structural integrity of the building.

3.4.2.2 Compaction of Subgrade

Objective: To ensure that the subgrade is firm and stable, a strong base for the foundation will be provided.

The subgrade will be compacted using mechanical compaction equipment, such as vibrating rollers or plate compactors, to achieve the specified density. This step is crucial to ensure that the subgrade is free from voids or loose material, which could compromise the stability of the foundation. The compaction process will be carried out in layers to ensure uniform and consistent density across the entire foundation area. Once the compaction is complete, the subgrade will undergo inspection and approval by the project engineer or geotechnical consultant before proceeding to the next phase. Any deficiencies in compaction or soil quality identified during the inspection will be addressed at this stage to ensure the foundation's long-term stability.

3.4.2.3 Installation of Under-Slab Utilities

Objective: To install the necessary utilities below the foundation slab before concrete is poured, we will ensure that all underground systems are in place.

Once the subgrade preparation is complete, excavation for the under-slab utilities will begin. This includes digging trenches for water, sewage, electrical conduit, HVAC system pipes, and other necessary utilities. The utility trenches will be excavated to the design elevation as specified in the construction plans.

After excavation, the pipes and conduits will be carefully placed in the trenches, ensuring proper alignment and slope for effective drainage and utility flow. The materials used for the underground piping will include HDPE, PVC/CPVC, SDR-35, SDR11, and PEX, while the underground conduits will be made of schedule 40 PVC with caution tape and tracer wire, or they may be concrete-protected or encased. The installation will adhere to all required standards to ensure that the utilities function properly and are protected from damage.

Once the installation is complete, the utilities will undergo thorough testing. This includes pressure tests for water lines and flow tests for drainage systems to ensure they meet the required performance standards. Any issues identified during the testing phase will be addressed and corrected before the backfilling process begins.

3.4.2.4 Backfilling and Re-Compaction

Objective: To backfill and compact the trenches once the utilities are installed and tested, ensuring a stable base for the foundation.

After the underground utilities have been installed and successfully tested, the next step will be backfilling the utility trenches. Clean, approved material, free from debris or organic matter, will be used for backfilling. The backfill will be placed in layers and compacted using mechanical compaction equipment to ensure uniformity and stability across the entire trench area.

Following the backfilling process, the entire foundation area, including the subgrade, will undergo re-compaction. This step is crucial to ensure that the ground achieves uniform bearing capacity and stability, which is essential for the proper support of the foundation slab.

3.4.2.5 Installation of Granular Sub-Base for Slab

Objective: To provide a stable, well-drained base for the foundation slab, settling and moisture accumulation under the concrete needs to be prevented.

A 200 mm thick granular sub-base, free from clay, silt, or organic material, will be installed across the entire area beneath the building slabs. This layer will typically consist of crushed stone or gravel.

The granular sub-base serves several important purposes. Firstly, it promotes drainage by allowing water to flow away from the slab, thereby preventing moisture from accumulating beneath the concrete. Additionally, it helps distribute the load of the building evenly across the subgrade, ensuring the foundation remains stable. Finally, the sub-base acts as a cushion to prevent the slab from shifting or cracking due to minor soil movements, helping to maintain the integrity of the structure over time.

3.4.2.6 Raft Slab Foundation and Concrete Pour

Objective: To complete the foundation by pouring the raft slab, which will serve as the main load-bearing structure for the building.

Once the granular sub-base has been installed and compacted, preparations for the raft slab will begin. The raft slab is designed to evenly distribute the weight of the building across the entire foundation area.

The slab will be constructed from reinforced concrete, with steel rebar arranged in a grid pattern to resist tension and provide additional strength to the structure.

After all preparations are complete, the concrete pour will take place. This process will involve the placement of formwork, reinforcement, and ensuring the slab's thickness and design meet the required specifications. The concrete will be poured into layers, with proper vibration and curing to ensure it achieves the necessary strength for long-term durability.

3.4.2.7 Final Checks and Curing

Objective: To ensure that the foundation is fully cured and meets all structural and regulatory requirements before proceeding with the superstructure construction.

Before the concrete is allowed to cure, final inspections will be conducted to ensure the foundation is properly aligned, level, and conforms to the design specifications. These inspections will verify that all elements of the slab are in place and meet the required standards for quality and accuracy.

Once the foundation is confirmed, the concrete will undergo curing to achieve optimal strength and durability. Curing methods may include covering the slab with wet burlap, plastic sheeting, or applying curing compounds to retain moisture during the curing process. The curing duration will typically last at least 7 days, or as recommended by the concrete supplier or structural engineer, depending on environmental conditions and the specific concrete mix used.

3.4.3 Site Construction Phasing Plan

The project phasing will include the construction of essential infrastructure components such as access roads, pathways, stormwater management systems, water and firewater distribution systems, and sanitary sewer force mains, along with lift stations and building structures. The following sections outline the expected sequence of work, the methods to be used, and the measures to be implemented to manage the physical environment while safeguarding its natural resources.

3.4.3.1 Property Survey and Utility Mapping Plan

Identification and Mapping of Existing Utilities

Objective: To identify all existing utilities on or near the site (including water, sewage, electricity, communication lines, etc.) in order to prevent accidental damage during construction, and to plan for protection, removal, or integration with new infrastructure.

A comprehensive survey of all existing utilities will be conducted, including both above-ground and underground systems. Based on the results, appropriate protection measures will be implemented during construction to prevent accidental damage or disruption to these utilities. In cases where relocation or rerouting of utilities is necessary to accommodate the new roadwork and infrastructure, these adjustments will be made. Additionally, buffer zones and safety barriers will be clearly marked around environmentally sensitive areas to prevent construction activities from encroaching on these spaces. High-visibility flagging, orange safety fences, or other barriers will be used to designate restricted areas. Coordination with utility service providers will also ensure that any temporary disruptions or relocations are properly managed throughout the construction process.

Setting Out of Survey Monuments

Objective: To mark key locations and reference points on the site for future construction and to ensure all work is done according to the approved layout and plans.

Once the boundaries have been defined, survey monuments, such as concrete or metal markers, will be placed at key points along the property lines and at critical reference locations for construction activities. These monuments will serve as reference points for accurately laying out the road network, stormwater infrastructure, and other essential site features. They will also be used to monitor the vertical and horizontal alignment of infrastructure throughout the construction process, ensuring precision in all aspects of the project.

Survey Layout and Stake-Out for Roadwork Network

Objective: To lay out the proposed road network accurately, ensuring proper alignment, elevation, and integration with existing infrastructure.

Based on the design plans, the centreline and boundaries of the new roads will be surveyed and staked out, covering the primary access roadways, internal roads, and pathways. To ensure proper road grading and alignment, elevation points (benchmarks) will be established for horizontal and vertical control. Specific measurements for curve radii, intersections, and sight distances will also be recorded to ensure safety and compliance with local road design standards. Additionally, cross-sectional surveys will be conducted to determine the appropriate dimensions for the roadwork, including width, shoulder, and drainage components. These dimensions will be staked on the ground to guide the construction process.

Survey Layout for Stormwater Collection Systems

Objective: To survey and stake-out the location of critical stormwater management infrastructure, including the three detention ponds, drainage basins, and piping systems.

The initial stormwater collection detention ponds will be surveyed and staked according to the design plan. These ponds are essential for controlling stormwater runoff, reducing flood risks, and ensuring proper drainage. The exact location, shape, and size of the detention ponds will be identified and marked on-site before excavation begins. To ensure proper site grading, topographic surveys will be conducted to direct water towards the designed stormwater catchments and pond locations, optimizing stormwater storage capacity.

The layout of catch basins and manholes will also be surveyed and staked. These drainage systems will be installed as part of the site grading works to collect surface water and prevent flooding or erosion runoff during heavy rains. Catch basins and manholes will be made from materials such as cast-in-place concrete, precast concrete, or ADS Nylop-12 HDPE. The elevation of each catch basin and manhole, along with the direction of flow, will be marked to ensure proper grading and water movement.

Additionally, the route for the stormwater drainage piping system will be laid out and staked to connect the detention ponds, catch basins, and other drainage elements. The stormwater piping material will consist of HDPE, ADS N-12 WT IB Pipe per AASHTO Specification, and Nyloplast PVC. The design parameters for the stormwater pipes, including diameter, material, and depth, will be incorporated into the survey and stake-out process to ensure proper installation and alignment.

Final Survey and Construction Documentation

Objective: To create accurate documentation of all surveyed features for use throughout the construction process and beyond.

Detailed survey notes, maps, and drawings will be compiled to provide a comprehensive record of all utility locations, survey monuments, roadwork, and stormwater infrastructure layouts. This documentation will serve as a vital reference throughout the construction process. All survey data will be integrated into the final construction plans, which will guide the construction team through each phase of the project, ensuring that work is carried out according to design specifications.

As the construction progresses, ongoing survey support will be provided. Additional surveys may be conducted to ensure that the work aligns with the original plans and to address any unforeseen site conditions that may arise. This proactive approach will help maintain accuracy and resolve any issues promptly, ensuring the successful execution of the project.

3.4.3.2 Sequence of Construction Tasks

TASK 1 - Property Markings

Survey stakes will be placed to clearly identify all areas that require the removal of trees, vegetation, existing structures, and any necessary site grading, including cuts and fills, to achieve the required subgrade. These marked areas will also accommodate the preparation needed for site drainage, infrastructure, and building foundations. The survey will ensure that all encumbrances are properly documented and addressed before work begins, facilitating a smooth and efficient construction process.

TASK 2 - Establishment of East Site Access Road and Initial Infrastructure

The east site access road will be the primary entry point to the project, featuring a secure checkpoint to manage construction access. This process will be carried out in several phases:

- **Temporary Surface Preparation and Silt Control**: A heavy layer of aggregate will be laid to stabilize the entry and manage dust, silt, and mud control to prevent tracking onto public streets. A vehicle tire wash will be established at the entry to further mitigate sediment transfer.
- **Site Clearing for Road and Drainage Preparation**: The site clearing will commence for the new access roadways, incorporating necessary drainage contours. The roads will be quickly surfaced with approximately 150mm of compacted design aggregate stone base for durability and stability during the construction period. Paving will be completed later, with an approximate 60mm asphalt layer applied once building construction near the area is almost complete.
- **Storm Drainage and Grading Integration**: Simultaneously, the team will grade the road-adjacent areas to facilitate stormwater flow, laying out and excavating for the storm drainage system where required.
- **Subgrade Preparation**: Roadways and parking areas will be excavated to subgrade elevations as per design specifications. The subgrade will be graded for efficient drainage, then a 150mm aggregate base will be placed and compacted to ensure stability until the final pavement layer is applied.

TASK 3 – Surveying, Marking, and Preparing the Site for Clearing and Habitat Protection

- **Topographical Survey and Protection of Natural Feature**s: The team will survey the site's topography, documenting trees, vegetation, and any habitat requiring protection, relocation, or preservation. A comprehensive marking of trees and natural habitats will guide the site clearing process, with clearly marked boundaries for preserved areas.
- **Establishment of a Temporary Nursery**: A designated area will be established for a temporary nursery, where relocated plants and trees will be stored and maintained.
- **Site Encumbrance and Vegetation Removal Preparation**: Site encumbrances such as vegetation, structures, and grade variations will be identified for clearing, making way for achieving subgrade elevations as per the project design.

TASK 4 – Environmental Control and Site Layout for Mass Excavation

- **Environmental Controls Installation**: Initial environmental controls, such as silt fencing and check dams, will be installed to prevent silt migration and protect surrounding areas and waterways.
- **Clearing, Grubbing, and Mass Excavation**: Site clearing will begin with mass excavation aligning with the planned development contours (Plate 3-3). The excavation work will be conducted by qualified operating engineers to meet design requirements with minimal erosion.
- **Soil Management and Compaction**: Large excavators will remove and load earth onto heavy-duty trucks, redistributing soil to areas needing elevation increases. The soil will be spread and compacted to achieve 95% modified compaction specifications, verified by a third-party testing agency.

- **Storm Drainage and Erosion Control Implementation:** Drainage swales and riprap stone revetments will be constructed to manage stormwater effectively, while temporary measures like check dams and erosion blankets will minimize sediment transport (Plate 3-4 and Plate 3-5).
- **Best Management Practices for Erosion Control**: Limiting exposed soil and following Best Management Practices will reduce erosion risks and sediment transport.

Plate 3-3 Mass earthwork process, including clearing the land with excavators, moving soil, and compacting the ground to ensure a stable foundation for construction.

Plate 3-4 Clearing and rough grading completed in advance of building foundations. Note silt fence (black line) installed at bottom of excavation line protecting the beach from silt /erosion.

Plate 3-5 Example of storm detention ponds with outflow drainpipes at head wall and riprap protection.

SILT FENCE PLACEMENT AND INSTALLATION

- **Location**: The silt fence will be installed around the perimeter of disturbed or excavated areas where soil erosion and sediment transport are a concern, particularly near grading, excavation, or construction activities. It will also be placed at the bottom of slopes to capture sediment before it can reach stormwater drains, roads, or adjacent properties.
- **Installation**: The installation process will involve trenching the fabric into the ground by 6 to 8 inches to prevent undercutting from water flow. Wooden or metal posts will be spaced 6 to 10 feet apart, depending on the terrain and anticipated water flow. The fabric will be securely attached to these posts using staples or ties, ensuring it is taut and free of gaps. Additionally, the smooth side of the fabric will face outward to resist wind uplift and water penetration.

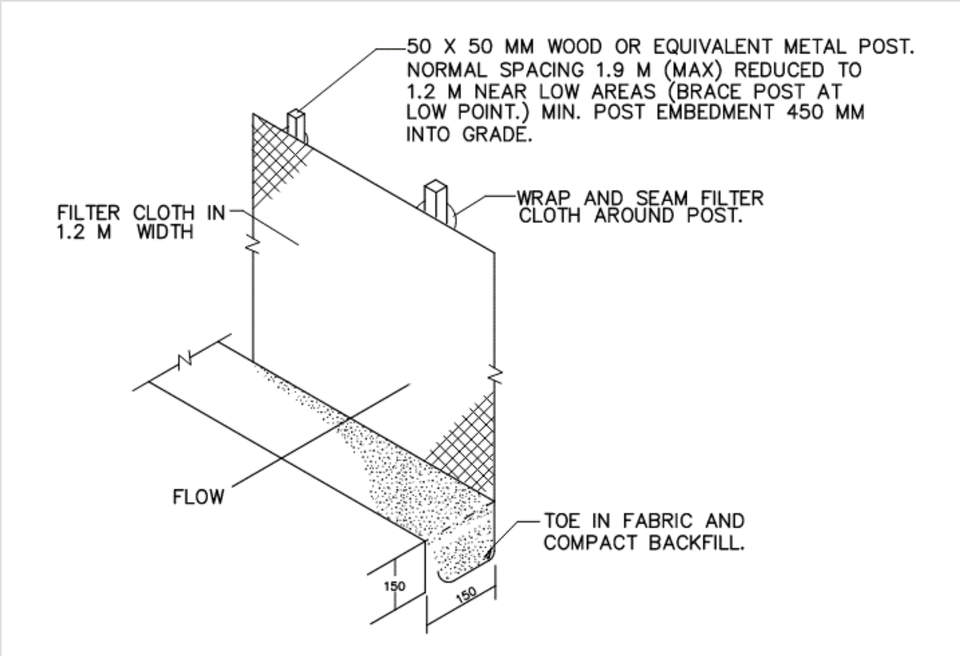


Figure 3-38 Silt fence detail (not drawn to scale)

STORMWATER CHECK DAM DETAILS

A check dam is a temporary structure built in drainage channels or swales to slow down water flow, encourage sedimentation, and control erosion. It helps capture silt and sediment runoff during excavation and other construction activities. Below is an outline of how the check dam will be designed and installed for effective stormwater runoff management:

- **Check Dam Purpose and Function:** The primary purpose of the check dam is to reduce the velocity of stormwater flow in channels or swales, allowing sediment to settle before water continues downstream. This helps to prevent soil erosion and the transport of silt and sediment to sensitive areas like waterways, adjacent properties, or storm drains. By acting as a barrier, the dam slows water flow, creating small pools behind it where sediment can settle.
- **Location:** The check dam will be placed in low-lying, open drainage channels or swales, typically found at lower elevations or along slopes of the construction site. It will be installed after excavation or grading activities. The dams will be spaced approximately 100 to 150 feet apart in gently sloping areas, with closer intervals used for steeper slopes.
- **Design and Materials:** The dam can be made from earth, gravel, rock, or a combination of these materials, depending on the soil conditions, water flow rate, and site-specific requirements. Earth berms will be compacted to create a low dam, and gravel or rock dams will use large stones or riprap. The dam will be 18 to 24 inches high and span the entire width of the channel. It will have a wider base than the top to prevent failure under heavy flow conditions. An overflow

section will direct excess water safely and will be lined with erosion-resistant materials like gravel or riprap.

- **Installation Method:** Before construction, the area will be cleared of debris, roots, and loose material. A shallow trench will be dug to ensure the dam is stable and securely anchored. If using earth materials, the soil will be compacted to form a firm barrier. For gravel or rock check dams, large stones will be placed at the base, topped with smaller stones to ensure stability. The dam will include a spillway to allow excess water to bypass the dam without causing damage, reinforced with erosion-resistant materials.
- **Maintenance and Monitoring:** The check dam will be regularly inspected, especially after heavy rainfall, to ensure it remains intact. The sediment accumulation behind the dam will be monitored, and once it reaches 1/3 to 1/2 of the dam height, the sediment will be removed and properly disposed of. Any damage, such as erosion at the base or sides, will be repaired promptly with additional materials as needed.
- **Documentation and Compliance:** The installation, maintenance, and inspection of the check dams will be documented as part of the Stormwater Pollution Prevention Plan (SWPPP) to comply with local environmental regulations. Inspection logs will be kept, and any necessary repairs, sediment removal, or modifications will be reported to ensure effective stormwater management throughout the construction process.

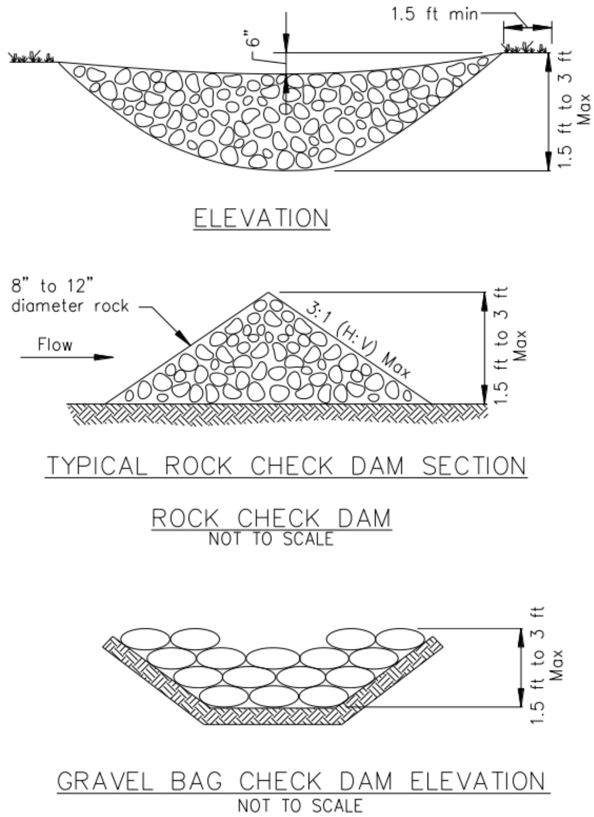


Figure 3-39 Typical rock and gravel bag check bag detail (not drawn to scale)

TASK 5 – Installation of Main Stormwater Management System

The stormwater management system is designed to manage both onsite and offsite water flow, directing it safely to the sea while minimizing environmental impact. The system will be implemented in several stages, ensuring sustainable water management throughout the construction process and beyond.

- **Excavation and Grading:** Excavation and grading will be conducted using large and medium-sized excavation and compaction equipment. The goal is to contour the site in alignment with the drainage plan, ensuring efficient water movement toward the new detention ponds and designated outflow points.
- **Installation of Stormwater Infrastructure:** Key stormwater infrastructure will be installed, including underground storm pipes, catch basins, and drainage swales. These elements will be strategically placed according to the site plan to collect and guide runoff water. Designed to handle peak flows, the system will reduce potential flooding risks and ensure water is safely channelled across the property.
- **Construction of Detention Ponds:** Three detention ponds will be constructed to manage water flow, capturing excess runoff, and allowing silt and sediment to settle before the water is

discharged to the Caribbean Sea. The ponds will be strategically located to realign existing and planned watercourses, ensuring controlled water release and mitigating soil erosion and sedimentation in marine environments.

- **Stormwater Velocity Control and Silt Management:** To regulate outflow rates, the stormwater management system will include velocity control measures within the detention ponds. These measures will facilitate sediment settling, improving water quality before it is discharged into surrounding ecosystems.
- **Phased Construction Approach for Environmental Protection:** The stormwater system will be implemented in phases, allowing for ongoing environmental protection as site conditions evolve. Temporary erosion and sediment controls, such as silt fencing and check dams, will be maintained and adjusted as each phase progresses, ensuring minimal impact on surrounding ecosystems.

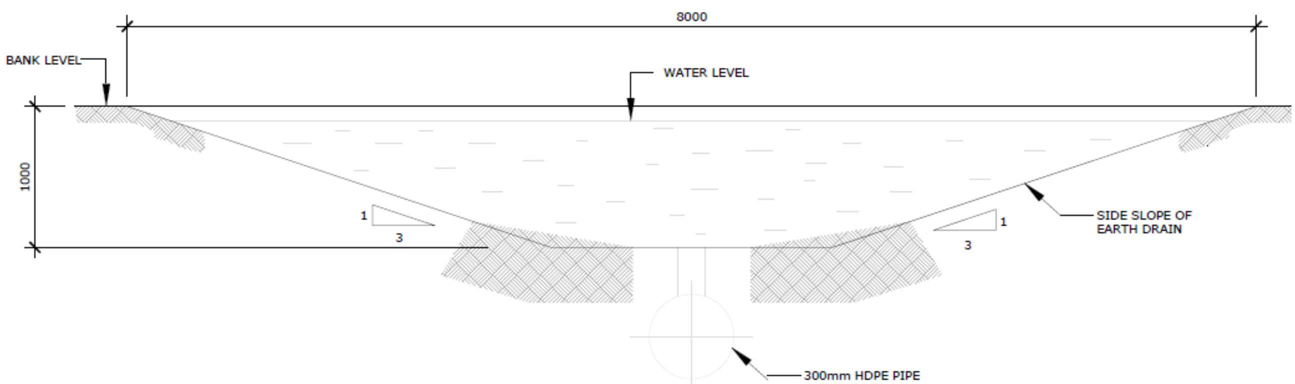


Figure 3-40 Typical section through earth swale that will be excavated with a 1 to 3 side wall earth slope

TASK 6 – Installation of the Water Supply and Fire Suppression Systems Main Piping and Hydrants

The installation of the water supply and fire suppression systems (Figure 3-28) will begin after the site earthwork is completed to the final subgrade elevations. This ensures accurate placement and depth of utility pipes. The installation process will include several key steps.

- **Excavation for Piping Installation:** Excavation for piping installation will be carried out using excavators or backhoes to dig trenches to the specified depths according to the design plans. These trenches will allow for the correct burial depth of the pipes, ensuring they are protected and meet code requirements.
- **Pipe Bedding and Laying:** A well-graded bedding material will be placed at the bottom of the trench to support and protect the pipes. The main water pipes, made from Polyvinyl Chloride (PVC DR14), will be laid on this bedding, ensuring stability and compliance with the project specifications.

- **Securing Piping and Accessories:** To secure the pipes, thrust blocks will be used at key points, preventing movement, and maintaining pressure requirements. Additional system accessories, such as backflow prevention devices and other safety equipment, will be installed to meet local codes and protect water quality.
- **Backfilling and Compaction:** After the pipes are positioned, the trench will be backfilled with tamped material in layers to ensure even compaction and reduce the risk of settlement. Special attention will be given to properly compacting the backfill to prevent future shifts or breaks in the piping.
- **Fire Suppression System Installation:** For the fire suppression system, it will be installed independently from the potable water supply and include mains and hydrants strategically placed to meet emergency access requirements. Fire hydrants will be positioned no more than 45.5 meters apart from any building, measured along the roadway centreline, and at least 13 meters away from structures to comply with fire safety standards.
- **Fire Hydrant Details and Turnaround Circulation:** The fire hydrants will be constructed with standard materials, including concrete thrust blocks, and tamped backfill, with protective bedding material. The design will also account for necessary access and turnaround space for firefighting vehicles, ensuring that emergency response can proceed effectively.

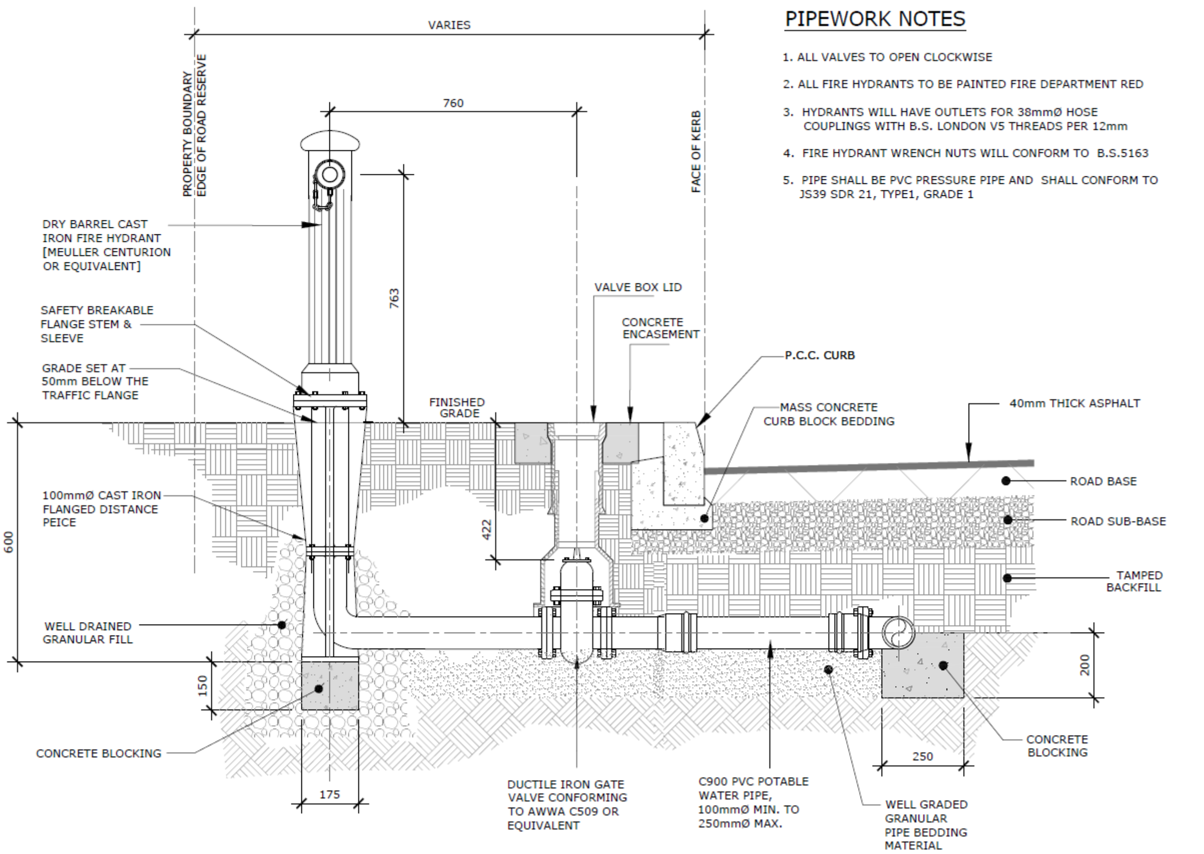


Figure 3-41 **Fire hydrant detail**

TASK 7 -Installation of the Sanitary Sewer System Mains

The installation of the sanitary sewer system (Figure 3-29) involves setting up gravity flow and force main piping, designed to efficiently collect and transport wastewater to a future on-site Wastewater Treatment Plant (WWTP). This work includes the following steps:

- **Excavation and Trenching for Sewer Lines:** Trenches for the sanitary sewer system will be dug using backhoes or excavators to the required depth, ensuring proper slopes and elevations for both gravity flow and force main pipes. This process will ensure that the pipes are installed at the correct depth for efficient wastewater flow.
- **Gravity and Force Main Piping Installation:** The gravity-flow sections of the sewer system will be installed to use natural slope for wastewater movement towards the lift stations. In areas with minimal slope, force main pipes, equipped with low-pressure pumps, will be used to pump wastewater against gravity towards the treatment facility.
- **Lift Stations and Pumping Systems:** Lift stations will be strategically placed along the system to grind solids and pump wastewater through the force mains. These stations will be designed to

handle peak flow conditions, ensuring the system remains reliable and efficient as the development progresses. Figure 3-43 shows an example of the sanitary grinder pump lift station that will be excavated deep into the ground and a concrete ballast base placed to stabilize and hold down the structure.

- **Pipe Materials and Specifications:** The sanitary sewer pipes will be made of durable materials such as PVC SDR-35 or DR-26, or HDPE, as approved by local authorities. The pipes will be carefully bedded to ensure stability and will be backfilled with compacted material to prevent shifting over time.
- **System Design for Full Development Build-Out:** The design of the sanitary sewer system will accommodate the entire build-out capacity of the development, with provisions for increased flow as the development expands. The system will be capable of handling future wastewater flow demands as the site matures.

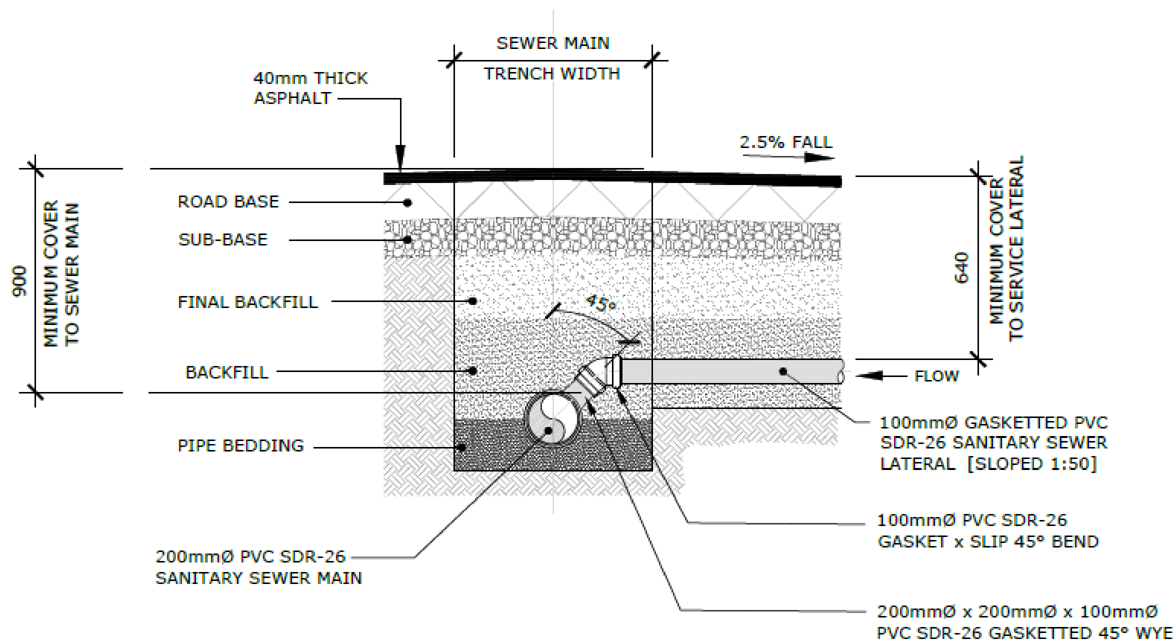


Figure 3-42 Standard sanitary sewer service connection for mains and laterals between 0.90m and 2.40m deep

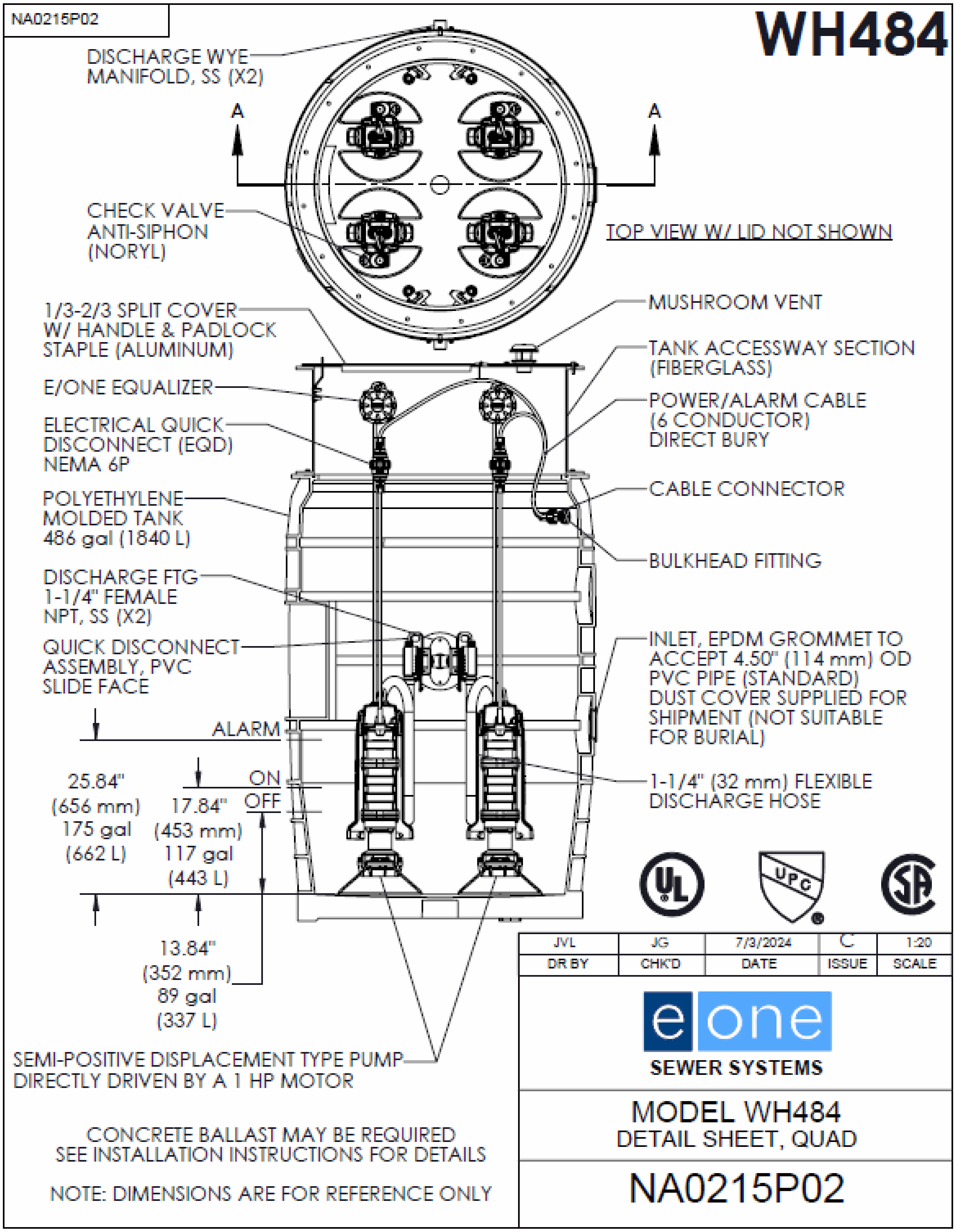


Figure 3-43 **Example of the sanitary grinder pump lift station**

TASK 8- Installation of Initial Underground Electrical Site Power Supply and Communication Transmission Conduits

- **Site Grading and Preparation:** Before installing the conduits, the site will be graded and contoured to ensure it is within ±5 to 15 cm of the final subgrade. This preparation will ensure proper alignment with other utilities, setting the stage for the smooth installation of electrical and communication systems.
- **Conduit and Duct Bank Installation:** Underground duct banks will be constructed to house the main electrical service conduits, distributing power throughout the development. Communication conduits will be installed alongside the electrical ducts, ensuring that data and communication needs are met across the entire site.
- **Placement of Utility Components:** Utility components such as pull boxes, hand holes, transformers, and other equipment will be installed according to the design plans. These components will be strategically placed to facilitate efficient access and ensure smooth integration with the future emergency generator system, which will be linked to transfer switches and breakers for backup power.
- **Code Compliance and Testing:** All materials and installation work will comply with the National Electrical Code (NEC) and local government regulations. Regular inspections and testing will be carried out during the installation process to ensure that all work meets safety and operational standards.
- **Protective Measures and Warning Tape Installation:** To protect the conduits from external impacts, concrete caps will be used in certain areas as required by design and local codes. Additionally, warning tape will be installed above all buried utility lines to mark their location, ensuring safe identification and traceability during future excavation activities.

The underground electrical and communication conduit installation will create a robust infrastructure for delivering consistent power and communication services across the site, designed to meet regulatory standards and accommodate future expansion.

TASK 9 - Building Foundations, Under Slab Utilities and Vertical Building Structures

The installation of building foundations, under-slab utilities, and initial vertical structures is a key phase in the development of the hotel. This task involves sequentially completing groundwork, utility installation, foundation casting, and vertical structural elements, as follows

- **Site Preparation and Stabilization**: After the site is excavated to the required subgrade level, surrounding areas will be graded and protected to prevent stormwater and groundwater intrusion. This stabilization ensures that the site is secure and suitable for the installation of foundations and under-slab utilities.
- **Under-Slab Utility Installation**: Before the foundation is cast, essential under-slab utilities, including floor drains, sanitary drains, conduits, and elevator pits, will be installed. These utilities

will be carefully routed and secured to ensure proper accessibility and performance once the slab is in place.

- **Foundation Design and Preparation**: The final foundation design will be completed by the Structural Engineer, based on the findings of the Geotechnical Exploration Report. For this three-level hotel, a raft slab foundation will be used, designed to evenly distribute the building's load across the site.
- **Raft Slab Construction**: The raft slab will be a 520mm thick continuous slab, reinforced with #5 bars spaced 30cm on centre, both at the top and bottom. This reinforcement will provide the necessary structural integrity to support the building.
- **Granular Base Installation and Compaction**: A granular base layer will be placed beneath the raft slab and compacted using mini roller compactors, vibratory rammers, or plate compactors. This ensures the base is stable and provides a well-compacted surface for the slab.
- **Casting of the Raft Slab**: Once the granular base is prepared, the raft slab will be cast using a concrete pump truck, cranes with concrete buckets, or direct discharge from the concrete truck. Continuous quality checks will be conducted to ensure the slab meets thickness, reinforcement, and material specifications as required for the project.

This approach provides a stable, long-lasting foundation for the hotel structure, ensuring that the site is prepared to handle the demands of the building load and integrates essential utilities below the foundation level. Once the raft slab is completed and cured, work will commence on the vertical structural elements of the building. See Figure 3-44 for building section foundation examples.

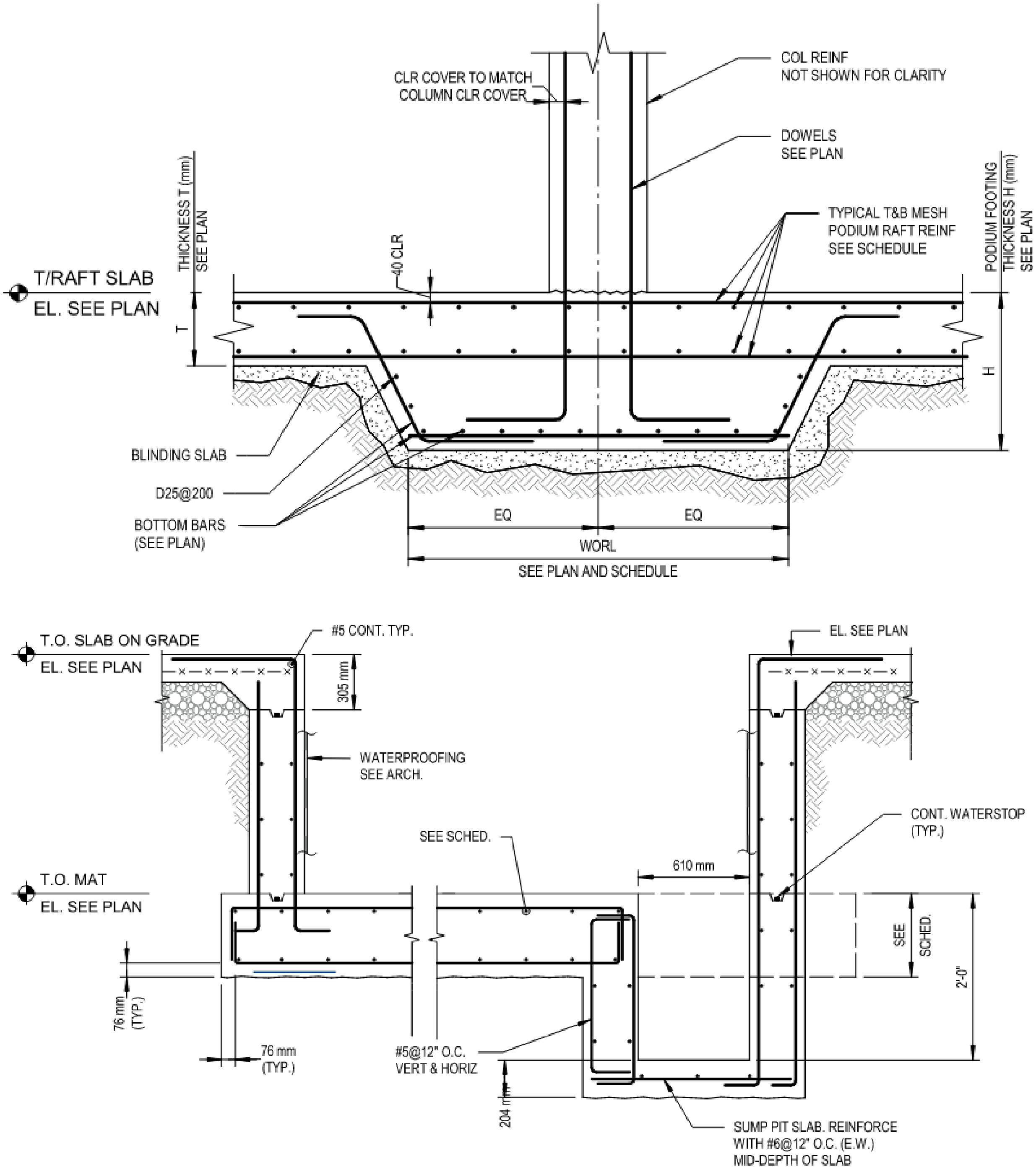


Figure 3-44 Building section foundation examples

TASK 10 - Vertical Building Construction and Exterior Finishes

The vertical construction of the hotel, villa, and resort structures will involve a combination of cast-in-place concrete, reinforced CMU walls, and cast-in-place concrete decks and roof slabs. The following is a breakdown of the process and materials:

- **Structural Elements:** The vertical construction of the hotel, villa, and resort buildings will involve a combination of cast-in-place concrete, reinforced CMU (Concrete Masonry Unit) walls, and cast-in-place concrete decks and roof slabs. Shear walls and load-bearing columns will be constructed with cast-in-place concrete, supported by footings or raft mat slabs to ensure stability and load-bearing capacity. Foundations will have a minimum bearing capacity of 390 kPa, and wall forms will be set to secure the vertical concrete with reinforcing bars in place to meet design specifications. For the villas and resort buildings, spread footings will be used for the single-level villas, with reinforced CMU walls and integral cast-in-place concrete columns for structural support. Resort buildings, typically two stories, will use similar construction practices as the hotel, with cast-in-place concrete and CMU walls, supported by raft slab foundations for enhanced stability.
- **Decks and Roof Slabs:** Raised concrete decks and roof slabs will be cast in place to provide strength, durability, and resistance to weather and load requirements. The raised deck forms will be supported by shoring frames designed to carry all vertical and lateral loads without failure.
- **Subgrade Inspection**: Before placing any foundation concrete, subgrade levels will be thoroughly inspected and approved to ensure they meet the project's bearing capacity and site conditions requirements.
- **Exterior Building Finishe**s: Exterior finishes will include a three-coat stucco system applied for weather resistance and aesthetic appeal. Tall, glazed window walls and sliding glass doors will be installed to maximize natural light and create a seamless connection between indoor and outdoor spaces. These windows will be designed and installed to meet hurricane resistance standards. Architectural wood-look elements and specialized veneers will be incorporated for exterior accents, offering a high-quality finish that complements the resort's aesthetic. Additionally, flat roofs will be constructed with EPDM (ethylene propylene diene monomer) single-ply rubber roofing membrane, installed over ridged R40 insulation, as part of the roofing and waterproofing system.

TASK 11 - Coastal Works

The construction methodology for the proposed coastal works, including rock groynes, wading/swimming area, sill, sediment sink, dock, river training structure, and land reclamation is detailed in section 3.4.5.

TASK 12 - Building Exterior Components and Additional Waterproofing Systems

The exterior design and roofing systems of the project prioritize durability, visual appeal, and protection against the elements. With the use of premium materials like stone masonry, fluid-applied membranes, PVC roofing, and cutting-edge waterproofing technologies, the building will be equipped to endure challenging environmental conditions. These measures ensure long-term resilience and contribute to the project's aesthetic value, providing both function and style for years to come.

- **Exterior Concrete and Masonry Walls Protection**
    - Portland Cement Plastering: The exterior walls will be finished with high-quality Portland cement plastering to provide a durable, weather-resistant surface, protecting the underlying structure from moisture and environmental elements.
    - Stone Masonry Veneer: A decorative stone masonry veneer will be applied to the exterior walls, enhancing the aesthetic appeal while adding an extra layer of protection against the elements.
    - Fluid-Applied Membrane Air Barrier: A fluid-applied membrane will serve as an air barrier, preventing air leakage, improving energy efficiency, and providing moisture resistance.
    - Vapor Permeable Products: These materials will allow moisture to escape from the walls while preventing water infiltration, ensuring the integrity and longevity of the structure.
- **Roofing Systems**
    - Ceramic or Composite Roofing Tiles: High-quality ceramic or composite tiles will cover the roofs, offering long-lasting protection and contributing to the building's aesthetic appeal.
    - TPO Roofing Membrane: A thermoplastic polyolefin (TPO) roofing membrane will be applied to provide an energy-efficient, weather-resistant roofing system with excellent UV and heat resistance.
- **Waterproofing Systems for Roofs and Below-Grade**
    - Self-Adhered Waterproofing: A self-adhering waterproof membrane will be used for its ease of installation and excellent waterproofing properties.
    - Hot Fluid Applied Waterproofing: This waterproofing method will be applied to large areas, creating a seamless, durable barrier against water pressure.
    - Crystalline Waterproofing: A crystalline waterproofing system will be used in areas prone to moisture penetration, providing long-term protection.
    - Pedestrian Traffic Coating: A protective coating will be applied to roof areas accessible by foot to prevent damage and wear to the membrane.
    - Polyvinyl Chloride (PVC) Roofing Membrane: A PVC roofing membrane will be used in specific areas for its strength, durability, and UV resistance.
    - Protected Hot Fluid Applied Waterproofing: For high-traffic areas, protected hot fluid-applied waterproofing will create a long-lasting waterproof barrier.

  - Sheet Metal and Flashing: Sheet metal will be used for flashing at joints, penetrations, and terminations to prevent water infiltration.
  - Pre-Manufactured Coping: The roof perimeter will be finished with pre-manufactured coping to ensure a neat, functional edge and additional protection.
- **Exterior Wall Systems**
  - Stone Masonry Veneer: In addition to its aesthetic value, the stone veneer will also provide added insulation and weather resistance.
  - Glass Railing System: A prefabricated glass railing system with heat-treated laminated glass will be included, combining safety with visual appeal.
  - Ornamental Metals: Decorative ornamental metal elements will be incorporated into the exterior design, enhancing the building's appearance, and contributing to its structural integrity.
  - Fiber Cement Wall Panels: Fiber cement panels, known for their durability and low maintenance, will be used to provide excellent resistance to weather and fire.
  - Joint Sealants: High-performance joint sealants will be applied around windows, doors, and other openings to ensure the building is airtight and watertight, preventing moisture infiltration.
  - Sliding Aluminium-Framed Glass Doors: Aluminium-framed sliding glass doors will provide modern functionality and aesthetic appeal, allowing seamless transitions between indoor and outdoor spaces.
  - Glazed Aluminium Systems: Pre-designed, pre-assembled aluminium storefront and window wall systems will be used for their strength, energy efficiency, and sleek design.

TASK 13 – Interior Fit Out and Finishes

The interior fit-out of the buildings will feature a selection of high-quality materials and finishes designed for durability, functionality, and aesthetic appeal. Below is a breakdown of the key interior elements:

- **Interior Walls**
  - Cold Form 20 Gauge Metal Stud Framing: Most interior walls will be constructed using cold-formed 20-gauge metal studs for a solid framework to support drywall installations. Mold-resistant 5/8" drywall will be used to protect against moisture and mould, ensuring a long-lasting finish.
  - Reinforced concrete masonry units (CMU) or Concrete Walls: For enhanced strength and fire resistance, certain high-load areas such as mechanical rooms and wet zones will feature reinforced CMU or concrete walls. These will typically be finished with drywall or metal stud furring where needed.
- **Insulation and Soundproofing**
  - Insulation for AC Spaces: To improve energy efficiency and comfort, various insulation methods will be applied in air-conditioned spaces:

    - Thermal Batts: For general thermal insulation.
    - Acoustical Insulation: To minimize sound transmission between rooms.
    - Spray Foam or Rigid Insulation: For areas requiring higher levels of thermal resistance or soundproofing.
- **Flooring**
    - Stone, Tile, or Hardwood Flooring: Durable and aesthetically appealing flooring materials, including stone, tile, and hardwood, will be used throughout the interiors. Waterproofing layers will be applied beneath all flooring to prevent moisture damage.
    - Wet Areas: In bathrooms and shower areas, stone or tile flooring will be installed to ensure water resistance and ease of maintenance.
- **Interior Doors**
    - Prefinished Doors: Interior doors will be prefinished flush wood, hollow metal, or aluminium, depending on the room's function. Matching frames will be used to create a clean, modern appearance and enhance the doors' functionality.
- **Trim Work and Millwork**
    - Architectural Woodwork and Millwork: High-quality woodwork and millwork, including baseboards, mouldings, and other trim elements, will be used throughout the building, adding aesthetic value and functionality.
    - Plastic (FRP) Panelling: In areas like bathrooms or kitchens, durable and easy-to-clean plastic (FRP) panelling will be installed to ensure long-term durability.
- **Wall Finishes**
    - Cement Plaster and High-Performance Coatings: Common areas and bedrooms will feature smooth cement plaster finishes that offer both durability and easy maintenance.
    - Acoustical Ceiling Panels: In spaces where sound control is essential, acoustic ceiling panels will be used to improve acoustics and reduce noise transmission.
    - Paint and Textured Coatings: High-quality paints and textured coatings will be applied to walls and ceilings, offering a variety of textures and colours to complement the overall design. High-performance coatings will be applied to high-traffic areas for enhanced durability.
    - Wallpaper: Selected feature walls or specific areas may incorporate wallpaper for added design flair and sophistication.
- **Specialty Finishes**
    - Toilet Accessories and Shower Enclosures: Durable, high-end toilet accessories (towel bars, soap dishes, mirrors) and custom shower doors will be installed for functionality and aesthetic appeal.
    - Specialty Kitchen and Built-In Cabinets: Custom cabinetry and built-in vanities will be installed in kitchens and bathrooms, featuring premium materials, stone or solid surface countertops, and efficient layouts.

  - Metal & Wood Lockers and Wire Mesh Partitions: In areas like locker rooms, metal and wood lockers will be provided, along with wire mesh partitions for privacy and functionality.
- **Furnishings**
  - Stone or Simulated Countertops: High-end stone countertops (e.g., granite, marble) or simulated stone materials will be used in kitchens and bathrooms, providing both a luxurious aesthetic and durability. These materials are resistant to moisture and staining, ensuring long-term performance.

TASK 14 –MEPFP Systems Overview

The Mechanical, Electrical, Plumbing, Fire Protection (MEPFP) systems for the project will be installed to meet the highest industry standards. Section 3.3.7 provides a detailed breakdown of each system, which will be integrated into the overall building design and construction, ensuring that the project meets all required safety, efficiency, and sustainability standards.

TASK 15 – Exterior Improvements Work Overview

The exterior improvements for the development will enhance both functionality and aesthetic appeal, while providing long-lasting infrastructure. The key components of the exterior work include:

- **Aggregate Base Course for Roads & Paving**
  - Roads and Paving: The roads and access routes will be constructed using an aggregate base course. This foundation will provide a stable surface for vehicular traffic and will be followed by the installation of a durable, smooth paving surface. The aggregate base ensures excellent drainage and load-bearing capabilities, supporting traffic both during and after construction.
  - Future Pavement: Once the base is compacted and stabilized, the final paving surface will be applied according to the project's design specifications. Materials for the surface paving will be chosen based on their durability, functionality, and aesthetic value.
- **Concrete and Stone Paving for Walks & Curbs**
  - Walkways: Pedestrian pathways will be constructed with high-quality concrete and/or stone paving, ensuring smooth, accessible routes for foot traffic. These materials will be selected for their durability, safety, and ability to withstand various weather conditions.
  - Curbs: Concrete curbing will be strategically placed at the perimeter of roads and walkways. The curbs will help separate vehicular traffic from pedestrians and guide water runoff away from walking areas. They will integrate seamlessly with surrounding landscaping and infrastructure.
  - Aesthetic Stonework: Where applicable, decorative stone will be incorporated into the paving to complement the design theme of the development, adding visual appeal to the walkways and public spaces.

- **Parking Accessories**
    - Parking Areas: Designated parking spaces will be installed to meet the needs of residents, visitors, and staff. The parking areas will be designed to accommodate heavy traffic and include necessary signage, markings, and barriers.
    - Parking Accessories: Additional features will include the installation of parking meters, bollards, wheel stops, and appropriate lighting to ensure safety and organization within the parking areas.
- **Fence with Gates**
    - Security Fencing: A temporary secure perimeter fence will be installed around the site to provide safety, security, and privacy. The fence will be designed to blend with the overall architectural theme of the development while creating a secure boundary for the property.
    - Gates: Entry and exit points will be fitted with gates that ensure controlled access to the property. These gates will be designed to accommodate security measures and vehicular traffic, with automated gate systems where required.
- **Landscaping**
    - Softscape: Landscaping will play a key role in the exterior design, with an emphasis on enhancing the site's natural beauty. Trees, shrubs, grass areas, and ground cover will be strategically planted to improve the visual appeal of the development while providing shaded areas for comfort. The project team will also re-plant trees and shrubs that were harvested at the start of the project and kept safe within an on-site nursery, in alignment with the landscape plan.
    - Irrigation Systems: An efficient irrigation system will be installed to ensure the landscaping remains healthy and lush. The system will be designed to minimize water usage while ensuring plants receive adequate hydration.
    - Hardscape Elements: Decorative stone features, planters, and other architectural elements will be incorporated into the landscape to create attractive and functional outdoor spaces.
- **Signature Golf Course**
    - Course Design: A signature golf course will be developed as part of the exterior amenities, utilizing the site's natural topography and strategic landscaping to create a challenging yet enjoyable course for golfers.
    - Greens and Fairways: The course will feature well-maintained greens and fairways with high-quality turf and drainage systems to ensure optimal playing conditions.
    - Course Features: The design will include water features, sand traps, and scenic vistas to enhance the golfing experience. Sustainable practices, such as water conservation and organic pest management, will be employed to minimize the environmental impact of maintaining the course.

TASK 16 - Mangrove Villas and Over Water Suites

The detailed construction approach for these villas and suites are provided in section 3.4.6.

3.4.4 Concrete Batching Plant

The Ready-Mix Plant and Contractors Offices & Storage Area will be strategically located on the site to ensure minimal impact on neighbouring properties (Figure 3-45). The batch plant will occupy an area of approximately 80 x 100 meters (Figure 3-46) and is expected to produce around 23,000 cubic meters of concrete for the development. To ensure compliance with NEPA requirements, the following environmental measures will be implemented:

- A Waste Management Plan will be put in place, ensuring proper disposal of solid waste and hazardous materials at a certified landfill with appropriate chain-of-custody documentation.
- Dust control measures, including covering stockpiles and using water sprays, will be employed to minimize fugitive dust.
- Stormwater and roof water drainage will be managed through approved design systems to ensure effective water management.
- A soakaway pit will be constructed for concrete washout, with regular cleaning and disposal of waste at a certified landfill.
- Noise limits will be adhered to, and measures will be taken to prevent water runoff from affecting nearby properties.
- Sustainable practices, such as rainwater harvesting, will be used to reduce environmental impacts.
- A ready-mix contractor with relevant experience in Jamaica will be selected to ensure high-quality operations.
- The plant will operate with an approximately 80,000-liter water tank, with a consumption rate of approximately 400 litres per cubic meter of concrete produced.
- The batch plant layout and the location of the contractor's temporary offices and storage area are shown on the site plan below.

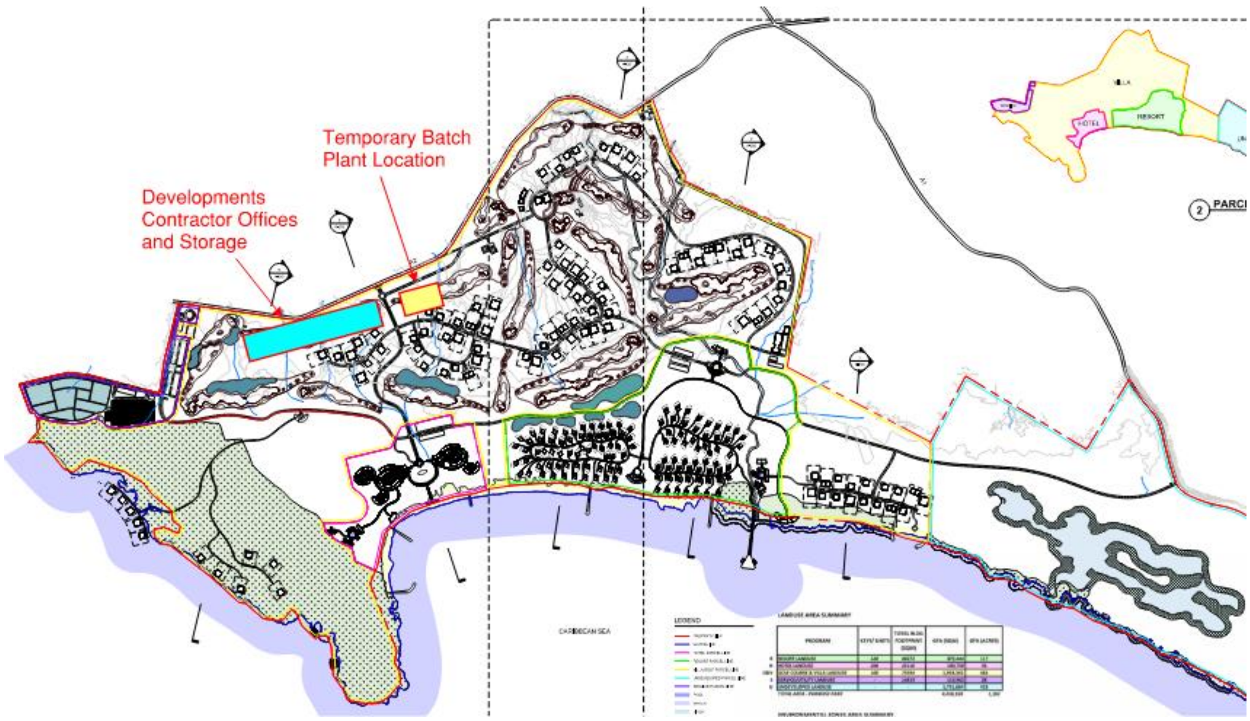


Figure 3-45 **Location of temporary batching plant and contractors temporary office and storage**

Table 3-20 Batching plant machinery description

CARACTERÍSTICAS TÉCNICAS CARACTERISTIQUES TECHNIQUES TECHNICAL SPECIFICATIONS	Unidades Unités Units	EBA-1002
Producción/Production/Production	m3/h	50
Ciclo/Cycle/Cycle	m3	1
Nº de áridos /Nº d'agrégats/Dry numbers	u	4
Disposición de áridos/disposition des agrégats/Hoppers layout		Cuadro/Carré/Square
Capacidad total acopio áridos Capacité totale approvisionnement des agrégats Storage capacity dry	m3	25
Silos de cemento/Silos de ciment/Cement silos	u	2
Capacidad acopio cemento x silo Capacité d'approvisionnement de ciment chaque silo Cement storage capacity each silo	Tn	112
Dosificador – contador agua Doseur–compteur d'eau Water meter		Sí
Diámetro tornillo sinfín Diamètre Convoyeur a vis Screw conveyor diameter	mm.	219
Nº de vías de carga Nº de voies de charge Nº charge ways	u	1
Mezcladora/Malaxeur/Mixer		Eje vertical FTR-1500 FTR-1500 d'axe vertical Vertical axle FTR-1500
Acopio de áridos/Approvisionnement d'agrégats/Dry storage		Opcional/Optionnel/Optional
Caseta de mandos/Cabine de control/Control cab		Incluida/Inclus/Provided
Instalación neumática/Installation pneumatique/Pneumatic installation		Incluida/Inclus/Provided
Cuadro eléctrico/panneau électrique/Electrical panel		Incluida/Inclus/Provided
Equipo informático/équipe informatique/Computer equipment		Incluida/Inclus/Provided
Potencia total/puissance total/Total power	Kw	84
Potencia absorbida/Puissance d'alimentation/Power input	Kw	72

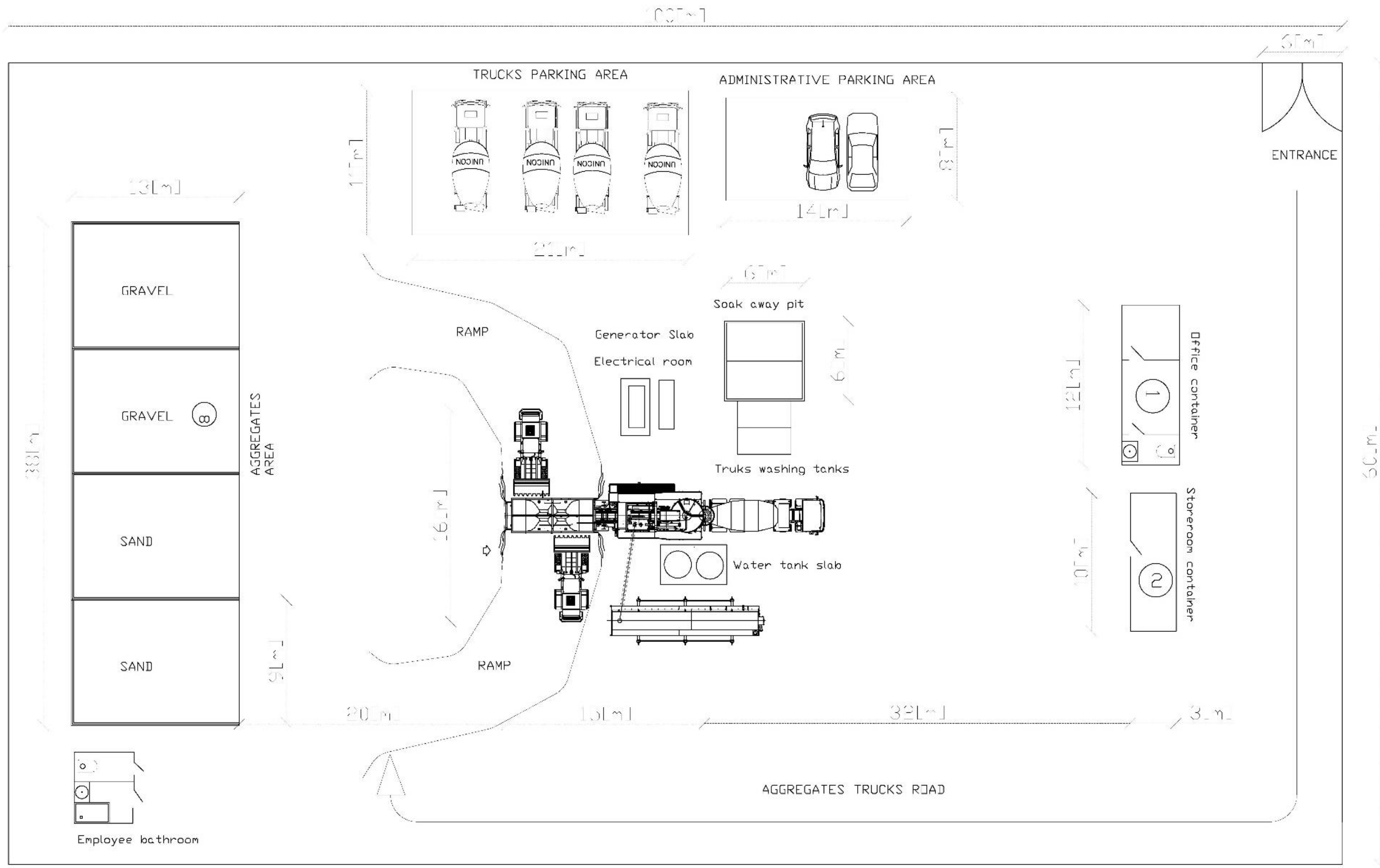


Figure 3-46 **Batching plant set up**

3.4.5 Coastal Works

The construction of the proposed costal works is planned as Task 11 (Section3.4.3.2).

3.4.5.1 Construction Equipment and Material

Heavy equipment needed throughout the construction phase will be excavators, front-end loaders, hydraulic suction dredge pumps, dump trucks and site boats. Local boulders from approved quarries will be used to construct the groyne and breakwater-sill structures. Sand used for beach nourishment will be locally manufactured and imported from the Bahamas. Geotextile and geogrid materials will be used to reinforce the seabed and control the flow of silt in the area.

3.4.5.2 Construction Methodology

The main steps in constructing the proposed coastal concept to enhance the shoreline at the Paradise Park Beach property are summarised below.

Turbidity Monitoring

Turbidity barriers will be used around all sea works to minimize the leakage of silty material to sensitive areas (Plate 3-6 and Figure 3-47). Turbidity will also be monitored daily at recommended locations by the environmentalist at each work area in the sea where construction occurs. Where turbidity measurements exceed NEPA standards due to marine construction operations, work will stop until normal conditions recover.

Plate 3-6 Example of a turbidity barrier

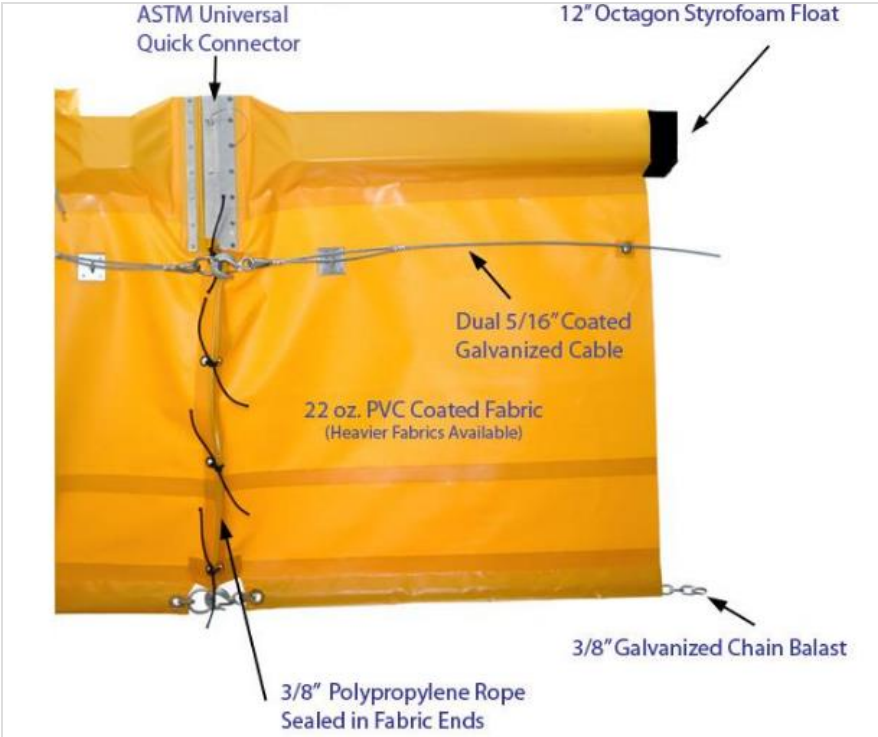


Figure 3-47 Specifications of a Mark III turbidity barrier

Oil Pollution

There is the potential for fuel leaks or spills from equipment used for the construction, excavation and/or sand nourishment during refuelling or operation. Refuelling the boat and sea-based equipment should only be done at anchor out at sea if the sea conditions are calm; otherwise, all refuelling should be done when docked on land. Appropriate refuelling equipment (such as funnels) and techniques should always be used.

Appropriate minor spill response equipment (containment and clean-up), including oil absorbent pads and disposal bags, must be kept on-site.

Construction Prep Work

This stage of construction requires the identification of an access route for carting construction materials and waste materials from the construction process to the site. The access route will be aligned with the property's existing entrance. The stockpile area will be prepared with a suitable compacted gravel-fill working surface. The stockpile area will be used for:

- Site office,
- Storage of equipment when not in use,

- Storage of imported or manufactured sand,
- Storage of boulders,
- Storage for waste material heading to landfill, and
- Drainage area of excavated material site.

Where necessary, a temporary construction pad/access road (typically 5m wide at the crest) will be built from the shoreline in a seaward direction. The access road will help with the delivery and removal of material and will serve as a work platform for the mechanical placement of stone for the proposed structures. The temporary access roads will be built in the proposed areas for modification. All features for the beach enhancement main and eastern pocket beach can be constructed directly from land with the need for temporary access pads.

Construction of Coastal Components

Boulders can be used in the works without further scale model testing or field investigations, although specific physical, chemical, and structural laboratory tests will be required for the stone material. Once an appropriate quarry is located, the required numbers and sizes of stones can be sourced and stockpiled. The quarry(ies) selected for use in boulder supply must be inspected to ensure they are certified to operate in a manner that respects the environment.

A stockpile of armour stones will be created. The size and quality of individual armour stones will be checked against a sample. The samples are armour units of the correct geometry and structural properties and must be free of fractures and impurities. These armour stones will be displayed prominently near the stockpile area at the quarry and on-site to allow for easy comparison and easy identification of stones that meet the requirements of the technical specifications. Stones smaller than the sample stone or with more imperfections will not be used in the structures.

During this stage of the construction, the boulders will be placed according to the design. For this process, an excavator will progressively place the boulders from shore. The rocks will first be placed at an elevation suitable for moving the equipment from land to the extent of the works. When returning, rock structures will be shaped and brought to the required elevation by either removing the rock layers or adding additional layers to meet design requirements. Spotters in the water will assist the heavy equipment in accurately placing the armour units. The slopes and elevations of the armour layer will be demarcated with visual aids to guide the boulders' placement and ensure they are properly interlocked.

Excavation and Grading

The second stage of work involves excavating/dredging the existing shoreline up to the back of the beach. Excavation will also be done in the nearshore to remove the silt. This will also slightly deepen the nearshore area, making it easier for adults to wade.

Dredging of Wading Area and Flushing Channel

The foreshore will be mechanically and hydraulically dredged (by excavator and suction pump). An excavator will be used to create the sediment sink channel. The channel will be sloped and excavated in accordance with the design.

Sediment Sink Dredge Spoil

The material dredged from the beach area and sediment sinks will be brought to the stockpile area with trucks and/or discharge pipes. The material will be dewatered in a settling pond constructed in the same area as the stockpile. After the dredge spoil is dewatered, suitable material will be used for the backfill, creating a berm at the back of the beach and filling for other parts of the project.

Pile Driving for Jetty

A temporary construction pad will be necessary to execute this operation regardless of the method. This pad will be made of only granular material below the sea level to minimise the introduction of silt within the area.

The construction of the jetty's superstructure will primarily involve masonry and carpentry work above sea level. Platforms and scaffolding will facilitate this construction. Debris from these operations will be brought onshore daily and disposed of appropriately.

Beach Creation

Once the appropriate slope into the water has been attained through excavation and grading, the beach will be nourished with appropriately sized sediment. The sand will then be mechanically placed on the beach to match the lines and grades of the design and finally smoothed manually by labourers.

Marine sand will be required for the beach nourishment exercise, while manufactured sand will be placed on the seafloor for the wading areas. The materials will be brought to the site from a certified/approved source. All acquired sediment will be placed on the proposed beach and shaped accordingly. The silt content should be low—ideally, less than 0.5%—and great care should be taken when spreading to minimise material loss.

Demobilization

The demobilisation phase of the project will involve:

- Removing all the debris from the nearshore
- Removing all construction pads
- Removing and carting off any excess fill material
- Removal of equipment and site facilities.

Outside of the construction activities, supporting considerations for the phase have been outlined (Table 3-21).

Table 3-21 Construction phase considerations for the project

Consideration	Action
Site security and hoarding	Given that the property is private, minimal additional signage will be needed for the coastal zone construction. However, it is recommended to place "Men at Work" and "Caution" signs along the beach for safety purposes.
Storage of materials and equipment	Materials will be stored on site in designated stockpile areas.
Beach traffic impact and safety	Little beach traffic was present before construction. As such, it is only expected that the property owners/operators will have their beach access impeded during construction.
Temporary sanitary facilities	Sanitary facilities will be included in mobile site offices.
Access and staging	The property access will be mainly from the A2 Highway for the works. Internal unnamed marl pathways will transport materials and equipment to the coastal zone. These will be removed after construction.
Solid waste management	Proper waste disposal bins will be set up near the site office. Waste will be carted away weekly or as required to an approved landfill.
Liquid waste management	Washing activities should be conducted close to the existing areas of ponding. This will allow for runoff to be contained within the property boundary and allowed to infiltrate. Settling ponds will be dismantled and material disposed at an approved landfill (locations in Figure 3-48).
Control of air, dust, water, and noise pollution	Construction will be confined to the working hours of 8 a.m. to 5 p.m. to reduce the disturbance to nearby properties. Equipment will be well maintained and checked daily for leaks or excessive exhaust. If a piece of equipment is malfunctioning, work with that equipment will be stopped and the equipment repaired.
Control/storage of fuels and other dangerous substances	Fuels/fluids and small tools will be stored in a locked equipment container to prevent tampering with or unauthorised access.

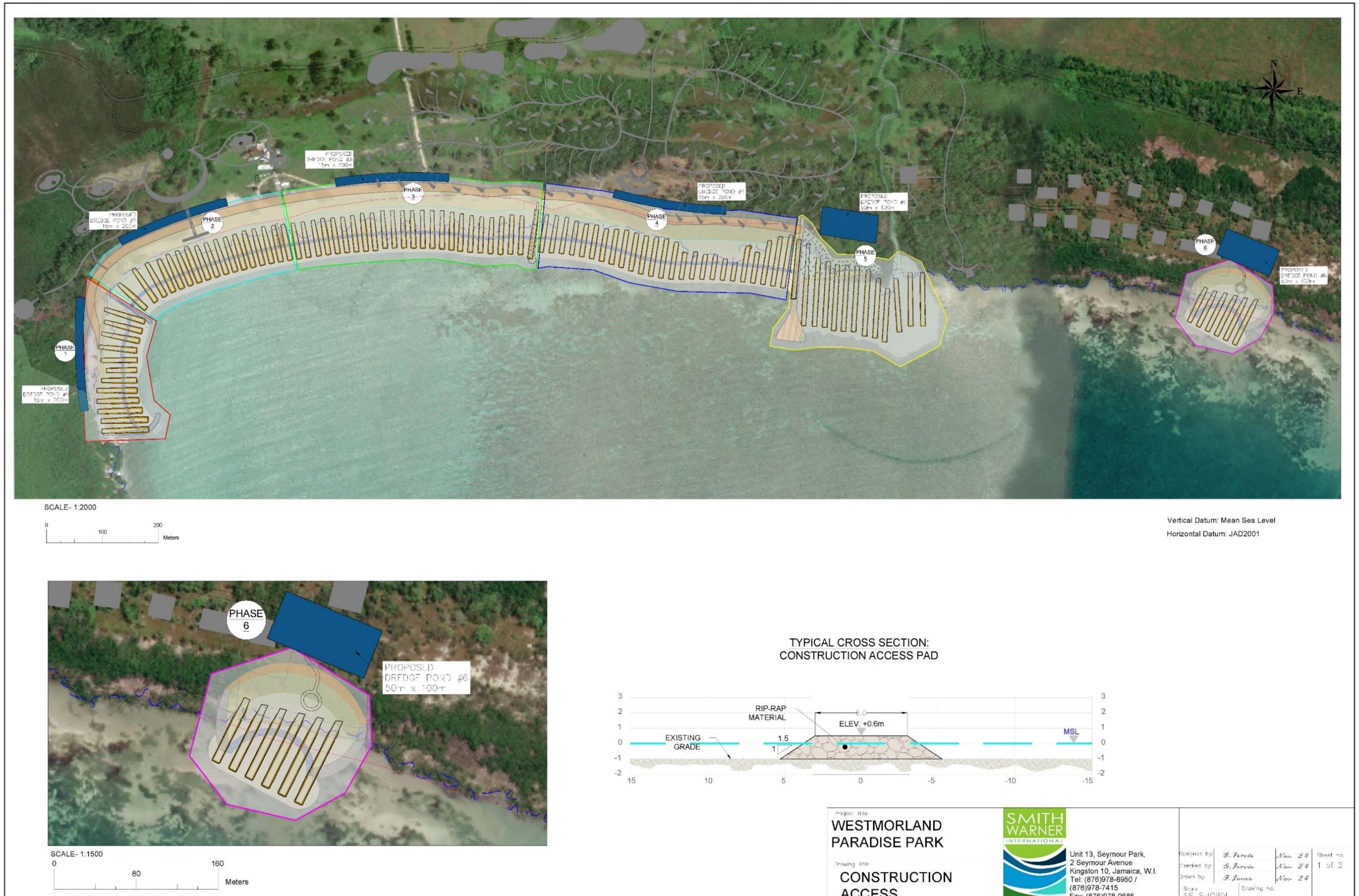


Figure 3-48 Phases, settling ponds and temporary access pad locations

3.4.6 Overwater and Mangrove Villas

The development of the Mangrove Villas and Over Water Suites is designated as Task 16 (Section3.4.3.2).

The construction work required within the sensitive mangrove area, located on the southwest side of the property (Figure 3-49), will be conducted with the utmost care to minimize the removal and disruption of mangroves. Any vegetation or natural elements that must be moved to access the buildings and construction sites will either be relocated to a safe area within the property or replaced on-site to ensure the preservation of the ecosystem.

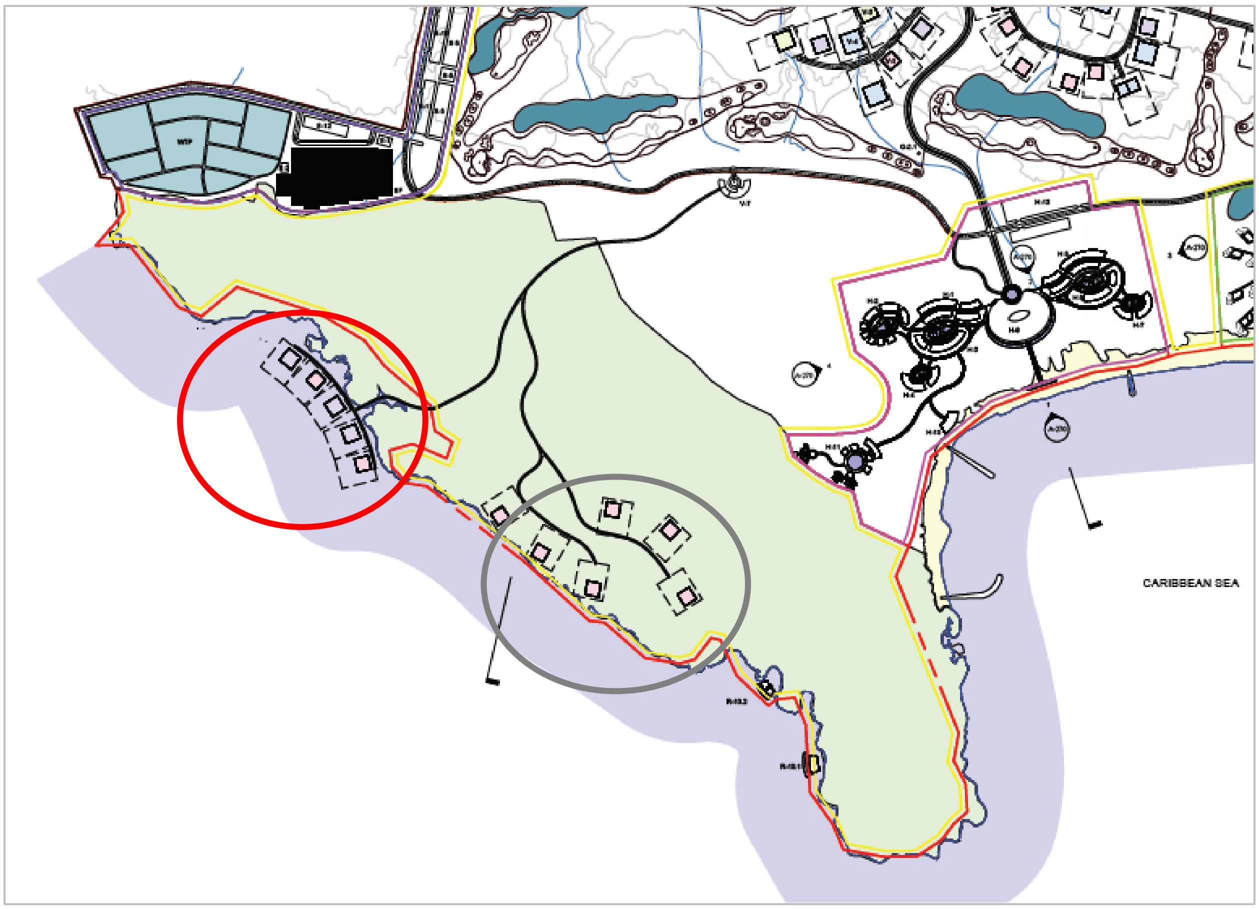


Figure 3-49 Location of proposed mangrove villas (circled in blue), overwater villas (circled in red) and construction and operation access routes (black lines)

The contractor fully acknowledges the Jamaican government's efforts in preserving and protecting the country's forested wetlands and ecosystems. We are committed to adhering to all regulatory requirements set forth by the National Environmental and Planning Agency (NEPA). Within the existing mangrove area, we anticipate disturbing approximately 2,700 m² or .68 acre of land for the construction of a 3-meter-wide access road. This road will be built using 20 to 46 centimetres of crushed river shingle base with Tensar brand geogrid and geo fabric, with strategically placed crossroad buried culverts pipes to allow water drainage across the access road and free flow towards the sea.

An additional clearing of approximately 18,060 m² or 4.46 acres will be required for the construction of six landside homes and five overwater structures within the mangrove area. These buildings will be constructed on raised pilings to allow for the maximum possible regeneration of natural habitat. The contractor will utilize floating rafts and/or temporary buildup of fill to access the overwater villa construction. The villas will be constructed on concrete piles landed into the seabed. The service utilities routing to and from the mangrove area building sites will be constructed above grade on concrete pedestals to eliminate any additional damage caused by below grade excavation near the mangroves.

Special care will be taken during construction by qualified workers to unearth and relocate any vegetation, mangroves, seagrasses, endangered species, and viable trees or shrubs to safe locations within the property. The contractor will strictly follow all NEPA standards for monitoring and reporting the removal and replanting of vegetation, ensuring the replacement of removed mangroves with seedlings to promote a net gain in mangrove coverage for the development. Measures such as silt screens, waddles, silt booms, or other silt mitigation materials and strategies will be implemented to protect adjacent wetlands or marine environments from potential contamination.

Site access will be strictly limited to the defined roadway route leading to the construction sites. All personnel involved will be informed of the sensitive nature of the surrounding environment and the importance of following the correct procedures. It is essential that any mangroves removed during construction are replaced with seedlings at other designated locations, contributing to a net ecological gain upon the completion of the project.

3.4.7 Execution Strategy

The primary strategy for executing this project will be to proactively manage the materials and equipment needed, ensuring that the workforce can operate efficiently and according to the project schedule. Given the remote location of the site, local resources are limited—almost none of the major building materials can be sourced locally. Therefore, early, and accurate procurement, along with identifying the most efficient shipping and delivery methods, will be critical to the project's success. Additionally, careful tracking of submittals and material scheduling, whether for self-performed work or subcontracted tasks, will be essential to ensuring timely project completion.

Before work starts on the project, the following controls will be in place:

- An emergency medical plan will be established.
- An emergency evacuation plan will be established.
- A severe weather/hurricane preparedness plan will be established.

- Any temporary erosion control measures that are the responsibility under the contract will be installed.
- Temporary electrical systems with GFCI protection will be implemented for project tools to ensure safety for workers.
- Activity Hazard Analysis (AHA) planning for each definable feature of work will be completed prior to that activity to identify hazards and take necessary precautions to protect workers and for the management team to provide the necessary PPE, tools, and equipment to perform the work in a safe and efficient manner.

To effectively control the flow of work, the onsite supervisory teams will be organized into specific areas or work divisions. This approach will help streamline operations and ensure clear accountability. Proper pre-task planning will be critical, with an emphasis on implementing necessary safety protocols to maintain a fast-paced, efficient workflow, ensuring the project meets its planned completion date. Additionally, close collaboration between the project construction teams, the Owner, Owner Representatives, and Designers is essential to identify and address any design conflicts or omissions. This collaboration will facilitate timely adjustments to the building documents, ensuring that any issues are resolved quickly and efficiently.

3.4.8 Health Safety and Environment (HSE)

3.4.8.1 Safety Management

The Project Team believes there are four essential, consistent characteristics of safety excellence. These include:

1. Management leadership and commitment
2. Meaningful employee involvement
3. Measurement systems
4. A safety improvement process

On this project, because of inherent risk factors associated with some of the planned activities, it is fundamental that the contractor have a personal commitment by each supervisor and the craft employee to promote and enforce safety. Appropriate PPE with high visibility clothing or vests will always be worn during work.

3.4.8.2 Construction HSE

The Contractor will be actively participating in the pre-planning process with safety. The Contractor will develop and implement Activity Hazard Analysis plans. These AHA plans will be communicated to the work force and the vision and accountability of how these plans are to be implemented will be the responsibility of each participating worker. The work force will be encouraged to actively participate in making changes to the plans to identify principal steps in the sequence of work, analyse the hazards, develop specific controls to prevent hazard by identifying the proper equipment, training, and inspections to ensure safety. These AHA's will be kept at both the workplace and on file, the AHA's will be monitored and updated as changes to the work plans occur.

Each field supervisor will be given up to date Supervisory Training in Accident Reduction Techniques (S.T.A.R.T). Our team will focus on being proactive rather than reactive to controlling hazards.

It is anticipated that the roof construction will require workers using full body harnesses with 100% tie off points for all workers until acceptable provisions are made to protect the leading edge from fall hazards (anticipated to be via scaffolding). Rope grabs and/or retractable lanyards that will be fastened to the roof structure and utilized to restrain roof workers from falls. The exterior building scaffold erection and/or scaffold modifications will require workers to be tied off to the roof structure or tied to the erected frames to protect falls from heights.

The project will assign Competent Person(s) with the appropriate qualified training and or experience for all work associated with scaffold erection, fall protection, rigging, cranes or lift operations, confined space, trenching, aerial lifts or any other activity that requires an appointment of a competent person to be present at the work site to implement and manage safety and health programs as well as ensure compliance with all applicable regulations and requirements. Training will be provided as appropriate to ensure adequate qualified individuals are available.

Several material lifts will be utilized to hoist materials on the project, and more specifically to the roof by use of boom forklifts or individual crane pics, equipment shall be specifically designed for the intended purpose and scaffolds erected and dismantled under the direct supervision of a qualified person.

3.4.8.3 Traffic Control Plan

A project Traffic Control and Logistics Plan will be developed before mobilization to the project by the Contractor and will be updated on a regular basis and used to educate and inform of existing conditions and awareness.

3.4.9 Sustainable Construction Practices

1. Mobile Fuelling Service:
    - Reduces wasted fuel by fuelling heavy equipment on the construction site at their work location without moving back to a centralized fuelling location.
2. Efficient Excavation Practices:
    - Utilizes optimized equipment and strategies to minimize unnecessary work and energy expenditure.
    - Includes precise site surveying and oversight to ensure accurate excavation.
3. Operator Training:

- Educates operators to shut off idle equipment, preventing unnecessary energy consumption.

4. Strategic Waste Management Plan During Construction:
    - Waste elimination through design. Utilize products that minimize waste stream, like prefabricated materials and modular products. Examples – modular joists and trusses, use of pre-engineered buildings to capture manufacturing efficiencies.
    - Adapt temporary construction warehousing and storage structures into the final design.
    - Reduce the site areas of disturbance or area that require additional grading or planting.
    - Detailed design simplification systems on structures and components.
    - Select environmentally friendly materials, and mould resistant materials, to avoid unnecessary removals being placed in the waste stream.
    - Perform accurate material take offs.
    - Procurement agreements with shippers to prevent excessive material packaging from arriving on site.
    - Purchase locally sourced materials as much as possible to eliminate shipping.
    - Utilize BIM modelling to eliminate waste caused by construction clashes and rework.
    - Trash dumpsters - separate recycling materials, wood, and metal from general construction trash.
    - Maintain a clean site with frequent waste collection to segregate and recycle the reuse of lumber, rebar, and pipe.
    - Utilize an efficient quality control program and consistent quality construction process to eliminate errors of rework required that create waste.

3.4.10 Employment

As the development progresses, many construction-related job opportunities will become available, with a strong emphasis on hiring local labour as these opportunities arise. Over the long term, the project is expected to generate significant employment for the local community. Specifically, the development will create approximately 600 jobs in residential and hotel construction, as well as 100 jobs in infrastructure and amenity construction. At peak it is expected that 1,000 persons will be employed. This should create approximately 2,660 – 3,800 indirect and induced jobs during the construction phase.

To the extent practicable, JDV will utilise local skills and labour for the construction and operation of the Project. These positions will provide sustained employment opportunities, contributing positively to the local economy.

3.4.11 Decommissioning

At the time of decommissioning, the following activities will be undertaken to address health, safety, and environmental considerations associated with the closure of the construction site. These measures aim to mitigate any adverse environmental impacts and ensure a smooth transition to the site's operational phase as a hotel resort.

3.4.11.1 Notifications to Authorities and Community

- **Advanced Notification:** Two weeks prior to the near completion of construction, relevant local authorities, including NEPA, NFA, National Works Agency and the Westmoreland Municipal Corporation, will be notified of the impending change in site status.
- **Final Notification:** Upon completion of construction, a formal notification will be issued to relevant authorities to confirm the transition of the site to operational status as a hotel resort.
- **Community Notification:** One week before decommissioning activities commence, notifications will be issued to the Bluefields Bay Fishermen's Friendly Society (BBFFS), property neighbours and the surrounding residential community.

3.4.11.2 Security and Access Control

- **Security Personnel:** Security staff will remain present throughout the decommissioning process, as during the construction phase. Signage at the site entrance will clearly state that the facility is "Closed" and the area is "Restricted."
- **Restricted Access:** Only authorized personnel essential for decommissioning will be granted access. Flag persons will manage heavy equipment entering or exiting the site, maintaining safety protocols established during construction.
- **Access Records:** All site access will be monitored and logged by posted security personnel.

3.4.11.3 Equipment and Material Removal

- **Construction Materials:** All equipment and materials used during construction will be removed. This includes:
    - Temporary boulders used for access roads.
    - Anchors, debris, rebar, scrap metal, and other marine-related materials from the shoreline and overwater villas construction process.
- **Temporary Structures:** Administrative office structures, portable toilets, and hand wash facilities will be removed and returned to their respective operators.
- **Stockpiles and Debris:** Any remaining stockpiled materials will either be utilized in construction or removed. Solid waste and debris will be disposed of by licensed municipal waste operators at approved disposal sites.

3.4.11.4 Detailed Decommissioning Steps

- Site Assessment and Planning:
    - Conduct a comprehensive assessment to identify all areas and structures requiring decommissioning.

- Develop a detailed decommissioning plan outlining timelines, resources, and safety measures.
- Dismantling of Structures:
    - Safely dismantle temporary structures, including batching plants, prefab areas, offices, storage units, and worker accommodations.
    - Ensure proper decommissioning and removal of all equipment.
- Waste Management:
    - Segregate waste materials for appropriate disposal or recycling.
    - Handle hazardous materials, such as batching plant chemicals, in compliance with environmental regulations.
- Site Clean-Up:
    - Remove all construction materials, tools, and equipment.
    - Address any spills, especially in batching plant areas, to prevent soil and water contamination.
- Stakeholder Communication:
    - Keep stakeholders, including local authorities, communities, and regulatory bodies, informed throughout the decommissioning process.
    - Address concerns and feedback from stakeholders promptly.
    - Maintain a Complaints Register

3.4.11.5 Timeline

The estimated timeline for completing decommissioning activities is 2–3 months after the conclusion of each construction phase. By adhering to these structured decommissioning protocols, the site will be safely cleared and prepared for its operational phase as a resort, minimizing any negative environmental or community impacts.

3.5 OPERATIONS

3.5.1 Conservation Strategies

This developments initiative demonstrates a well-rounded commitment to environmental stewardship through innovative design, resource optimization, and sustainable practices. By implementing these measures, the development is positioned to serve as a model for energy and water conservation in commercial projects.

3.5.1.1 Energy Conservation

1. Integration with Paradise Park Solar Power Plant:
    - Reduces reliance on carbon-based fuels by more than 50% over the lifetime of the development.
    - Leverages renewable energy to significantly lower the carbon footprint.

2. Smart Glazing Systems and Superior Insulation:
   - Uraft-free systems maintain temperature control efficiently.
3. LED Lighting with Auxiliary Sensors:
   - High-efficiency LED lights reduce energy consumption.
   - Motion sensors shut down lighting in unoccupied spaces, conserving electricity.
4. Advanced Building Management Systems:
   - Computerized control systems for precise temperature regulation.
   - Innovative cooling technologies reduce energy use while maintaining comfort.
5. Use of Solar lights for exterior landscape and pathways:
   - Save on nighttime electric use and the need for underground electrical cables and other infrastructure costs.

3.5.1.2 Water Conservation

1. Grey Water Recycling:
   - Treats wastewater for landscape irrigation, reducing freshwater demand.
2. Rainwater Collection:
   - Supplements drinking water supplies, promoting sustainable water use.
3. Water-Saving Plumbing Fixtures
   - Lower water consumption and sanitary volume.

3.5.1.3 Other

- Awareness training in conservation strategies in developing a culture of sustainability in the hotel and shared responsibility among staff to conserve resources.
- Reduce reliance on paper records and utilize digital information.

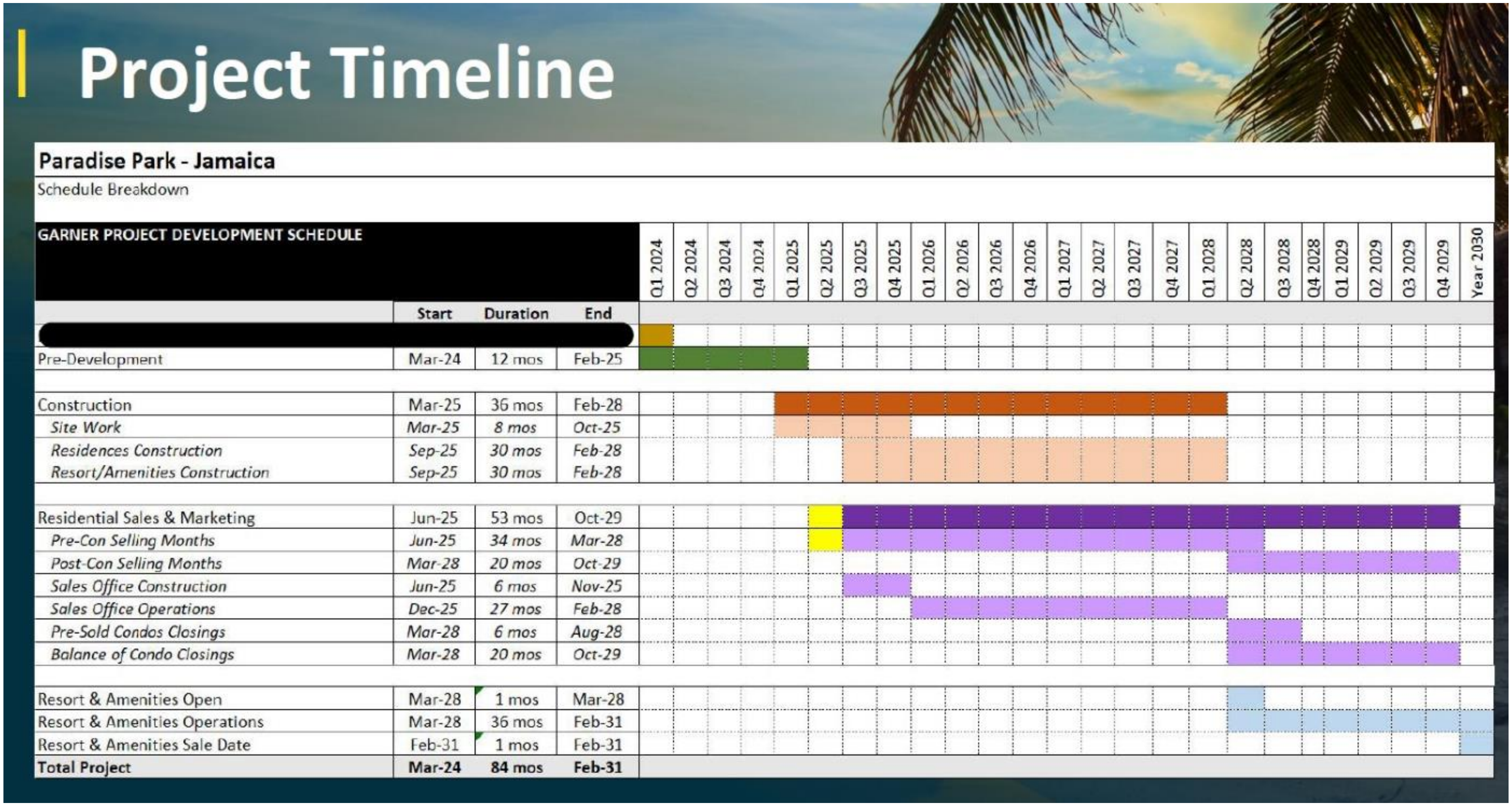
3.5.2 Employment

The operation of the development will generate significant employment opportunities for the local community. Once operational, the hotel is expected to create approximately 1,000 jobs across various roles, including hospitality, management, maintenance, and support services. This is expected to result in approximately 1,840 indirect and 695 induced jobs.

These long-term positions will provide stable employment and contribute to the growth of the local economy, fostering ongoing job opportunities for the surrounding area.

3.6 PROJECT PHASING AND SCHEDULING

It is anticipated that the project's pre-development phase will last 12 months, from March 2024 to February 2025, with construction beginning in March 2025 and concluding by February 2028, lasting 3 years (Figure 3-50). The resort and amenities are scheduled to open in March 2028. The total duration of the project will therefore be 84 months (7 years), from March 2024 to February 2031.



	Start	Duration	End
[redacted]			
Pre-Development	Mar-24	12 mos	Feb-25
Construction	Mar-25	36 mos	Feb-28
Site Work	*Mar-25*	*8 mos*	*Oct-25*
Residences Construction	*Sep-25*	*30 mos*	*Feb-28*
Resort/Amenities Construction	*Sep-25*	*30 mos*	*Feb-28*
Residential Sales & Marketing	Jun-25	53 mos	Oct-29
Pre-Con Selling Months	*Jun-25*	*34 mos*	*Mar-28*
Post-Con Selling Months	*Mar-28*	*20 mos*	*Oct-29*
Sales Office Construction	*Jun-25*	*6 mos*	*Nov-25*
Sales Office Operations	*Dec-25*	*27 mos*	*Feb-28*
Pre-Sold Condos Closings	*Mar-28*	*6 mos*	*Aug-28*
Balance of Condo Closings	*Mar-28*	*20 mos*	*Oct-29*
Resort & Amenities Open	Mar-28	1 mos	Mar-28
Resort & Amenities Operations	Mar-28	36 mos	Feb-31
Resort & Amenities Sale Date	Feb-31	1 mos	Feb-31
Total Project	**Mar-24**	**84 mos**	**Feb-31**

Figure 3-50 **Anticipated project timeline for proposed development at Paradise Park**

4.0 DESCRIPTION OF ENVIRONMENT

4.1 PHYSICAL ENVIRONMENT

4.1.1 Topography

Jamaica's topography is marked by coastal plains that surround interior mountain ranges. The topography of Paradise Pen is described as a low-lying coastal plain (Jamaica National Heritage Trust, 2023). Most of the project site is below 4 meters in elevation (Figure 4-1), with the highest areas reaching up to 13 meters in the northern part near the main road. There is a clear distinction between this elevated northern area, which generally exceeds 3 meters, and the southern coastal lowlands, which have slopes of less than 3% and do not exceed 4metres in elevation (Figure 4-2).

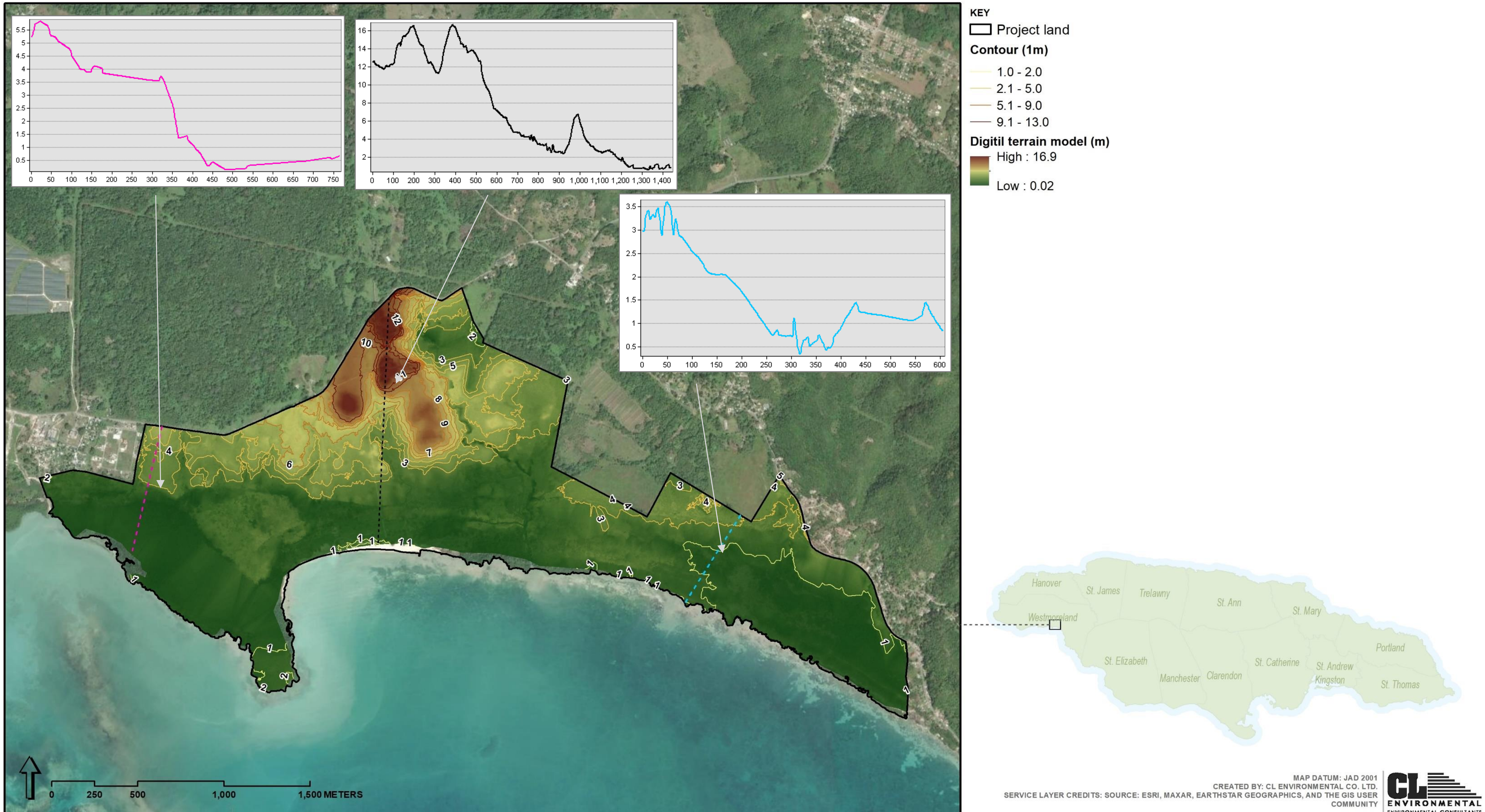


Figure 4-1 Contours, digital terrain model (DTM) and profile graphs for the proposed site

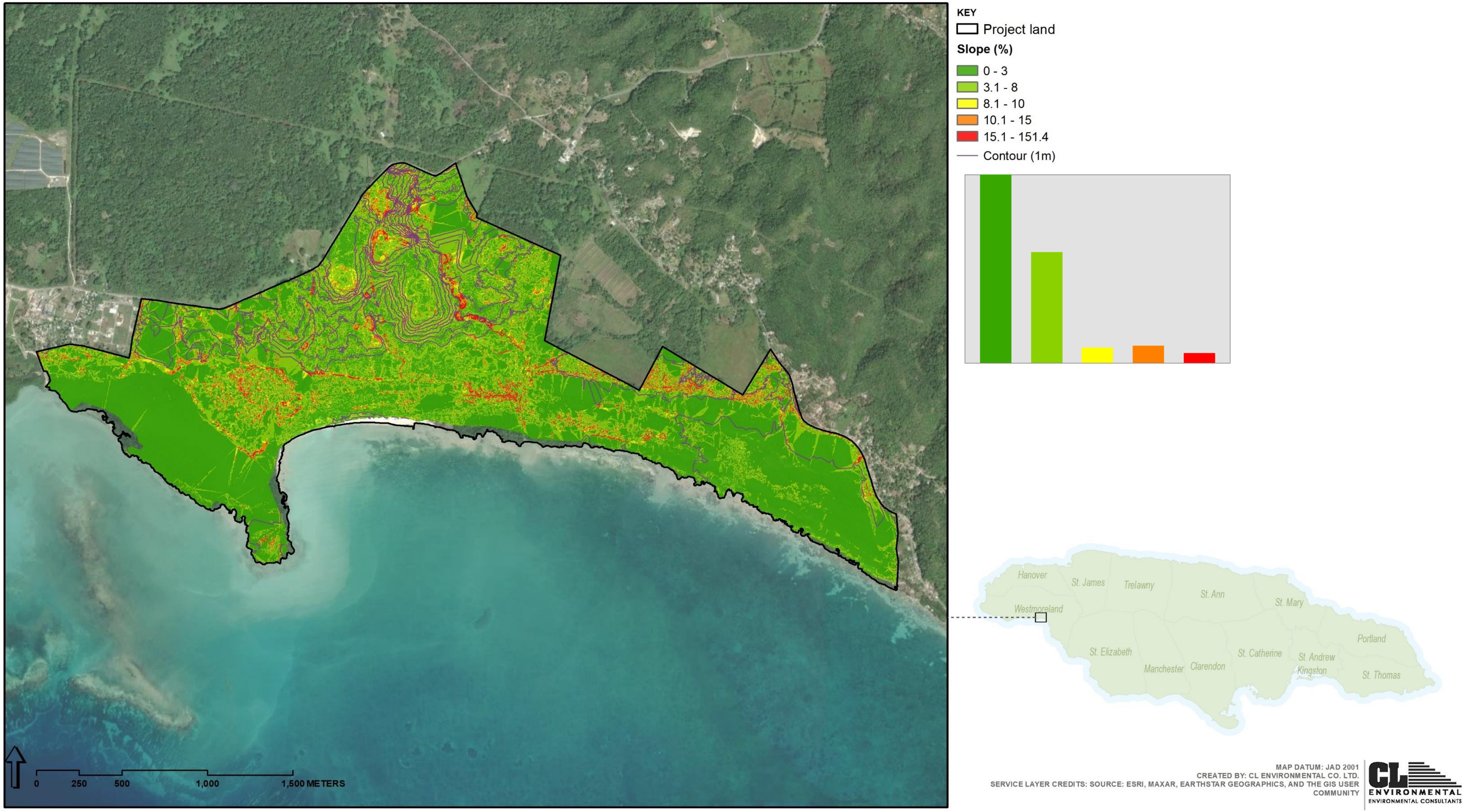


Figure 4-2 Slope and associated height histogram at the proposed project site

4.1.2 Geology and Soils

The southern region of Jamaica is predominantly composed of plains (Warner & Goodbody, 2005), with Bluefields Bay located within the southwestern coastal plain and wetland zone, a key natural coastal area of the island (Norrman, et al., 1997) (McIntyre, 2015). Inland from the bay, the geology is dominated by the Gibraltar-Bonny Gate formation, while the coastline features alluvial deposits and other surface materials (Mines and Geology Division, 1984). The surrounding area is characterized by alluvial sands, along with boulder and sand deposits (Burrowes, 2013) (McIntyre, 2015), and similarly the project site is also characterized by Alluvium and other surface deposits (Figure 4-3).

The soil types in the area are heterogeneous; on the project land, there are 12 distinct soil types, with the predominant texture being clay in the interior sections of the land, while sand is more commonly found towards the coastline (Figure 4-4, Table 4-1).

Table 4-1 Soils present within the project site boundary

NAME	TEXTURE	EROSION
Bonnygate	Stony loam	High
BS		Without Rating
Carron Hall	Clay	Moderate
Crane	Sand	Slight
Fontabelle	Clay	Slight
Foour Paths	Loam	Slight
Frontier	Clay	Slight
Knollis	Clay	Slight
MA		Without Rating
Nonsuch	Clay	Slight
Shrewsbury Ball	Clay	Slight
SW		Without Rating
Wallens	Clay	Slight

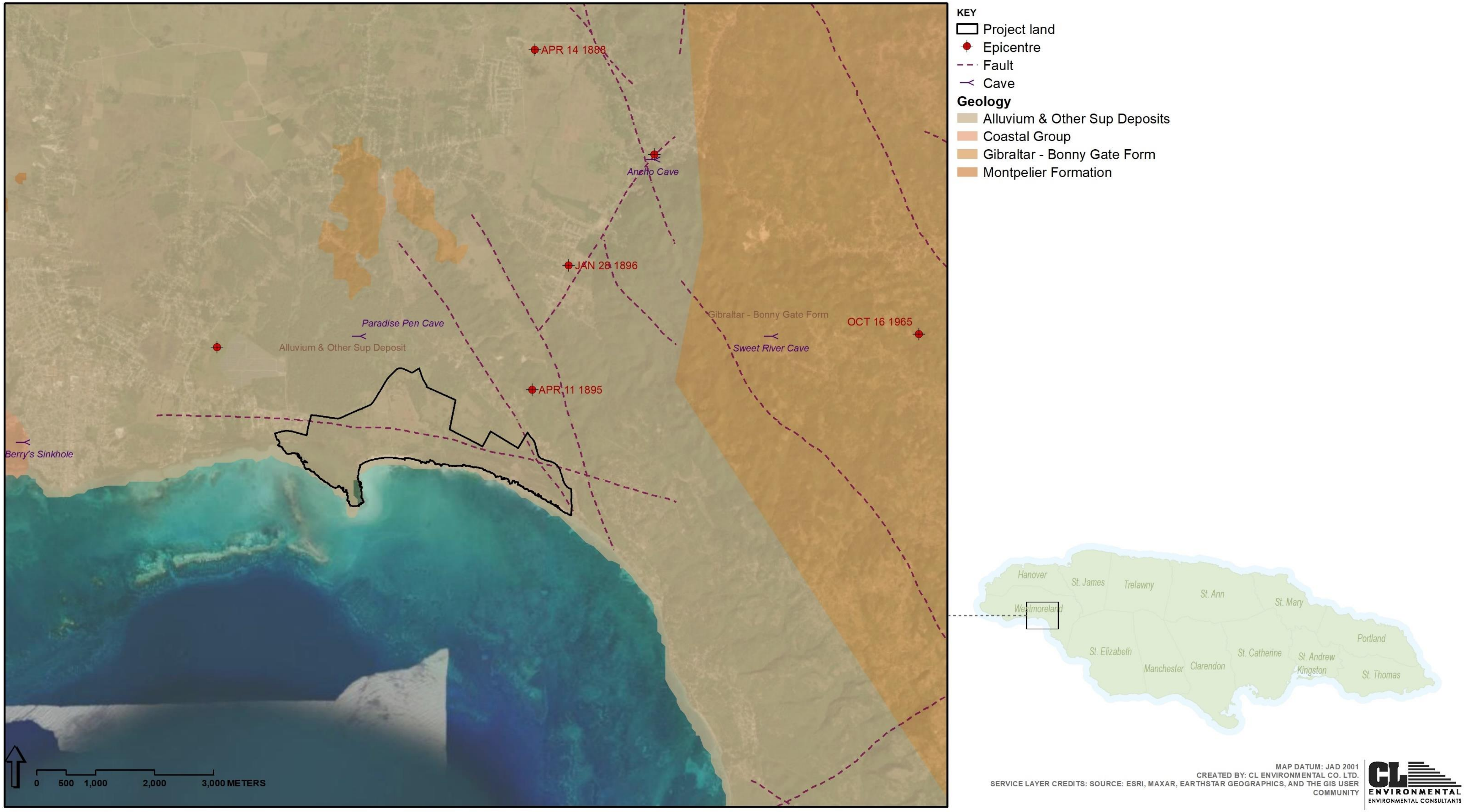


Figure 4-3 Geology in the project area

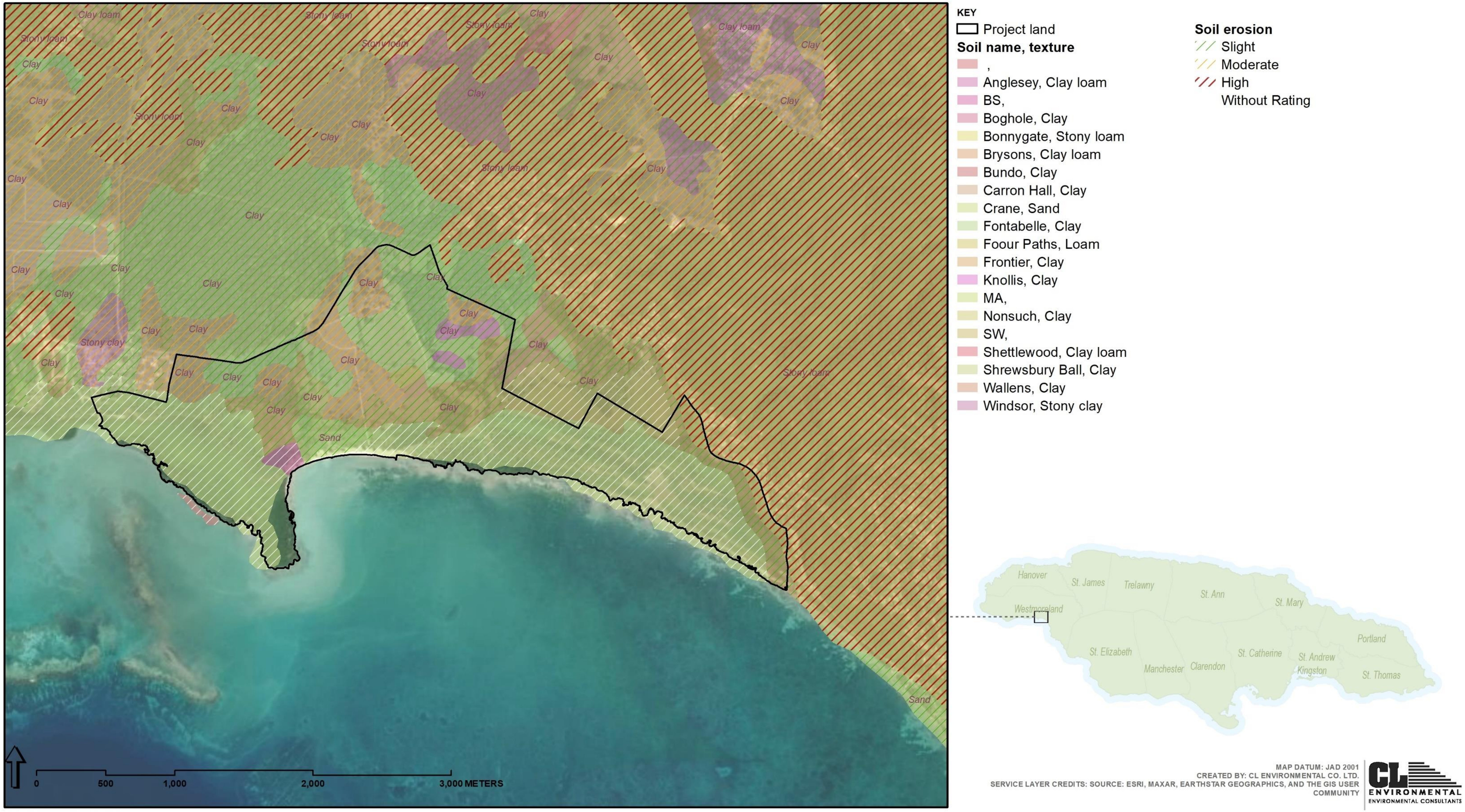


Figure 4-4 Soil type and erosion potential in the project area

4.1.3 Geomorphology and Geotechnical Considerations

Paradise Pen is located within the south-western coastal plains and wetlands of Savannah La Mar - Surinam Quarters. The coastal area is characterized by sandy bays, coastal barriers, patch, and fringing reefs (Norrman, et al., 1997). The Bluff Point headland splits the coastline of the property into two segments. The coastline east of Bluff Point is part of Bluefields Bay. The coastline to west of Bluff Point facing Savanna-La-Mar forms the western flank of the headland. Bluff Point itself is marginal (1-2m) higher than the adjacent wetlands. The coastline east of the headland begins with an 800m long white sand beach followed by a string of small bays with mangrove vegetation. The coastlines forming the flanks of the headland are straighter than the coastline west of the beach and are also covered with mangrove vegetation. The west flank has two relatively wide bays with a shallow coastline recess (250m by 70m).

The beach has been modified with the addition of two groynes. While the exact construction dates are unclear, it is known that the groynes were built after 2007. Google Earth imagery indicates that the first groyne was constructed between 2007 and 2009, and the second one, located to the east, was built sometime between 2009 and 2012. Satellite images show a net beach accretion of between 17 to 50 meters from February 2001 to September 2023. The stability of the beach, along with an analysis of erosion and accretion, is further discussed in the sections 4.1.6.5 and 4.3.3.

The property is bordered to the east and north by steep White Limestone hills, but the land itself is generally low-lying and near flat. About 87% of the property has a slope of no more than 8%, with 55% of the area featuring a slope of 3% or less (Figure 4-2). Approximately 67% of the property lies at an elevation of less than 3 meters. This 3-meter contour roughly marks the boundary between the higher northern section of the property and the coastal wetlands and mangroves to the south. The higher northern areas, which make up 33% of the property, range in elevation from 3 meters in the south to a maximum of 13 meters near the main road in the north (Figure 4-1). This elevated area is marked by numerous shallow drainage channels, most of which flow into the wetlands below, with only a few reaching the sea.

Most streams entering the property are part of the Deans Valley/Sweet River watershed, which extends deep into the White Limestone Hills to the north. The watershed system is characterized by distributary channels that branch off from the main channel. Some of these branches rejoin, creating a braided, interconnected network of channels (Figure 4-5). Many of the channels are ephemeral, flowing only after significant rainfall. Numerous channels have been filled in overtime and exhibit notable lateral shifts. Some channels are in the process of disappearing and reemerging, linking surface water and groundwater flows. While this is a common feature in karst topography, in this case, it is likely not related to solution features but rather to variations in the permeability of the alluvium.

The far eastern corner of the property receives runoff from ephemeral streams originating in the White Limestone Hills of Cave Mountain. This area was directly impacted by the June 1979 flood event, with limestone rubble transported by these minor streams being deposited along the main road and across the property (Figure 4-5). It is estimated that approximately 40,500 m² (10 acres) of the property was covered by flood deposits (O'Hara et al., 1979). However, no detailed information is available regarding the impact of the 1979 floods on the central section of the property. While catastrophic flooding was documented to the north in the Water Works area near Petersfield, which lies within the Deans Valley watershed, the extent to which the property itself was affected by these floods remains uncertain. Given the hydrological connection between the two areas, it is plausible that the property experienced some degree of impact, potentially linked to the watershed dynamics.

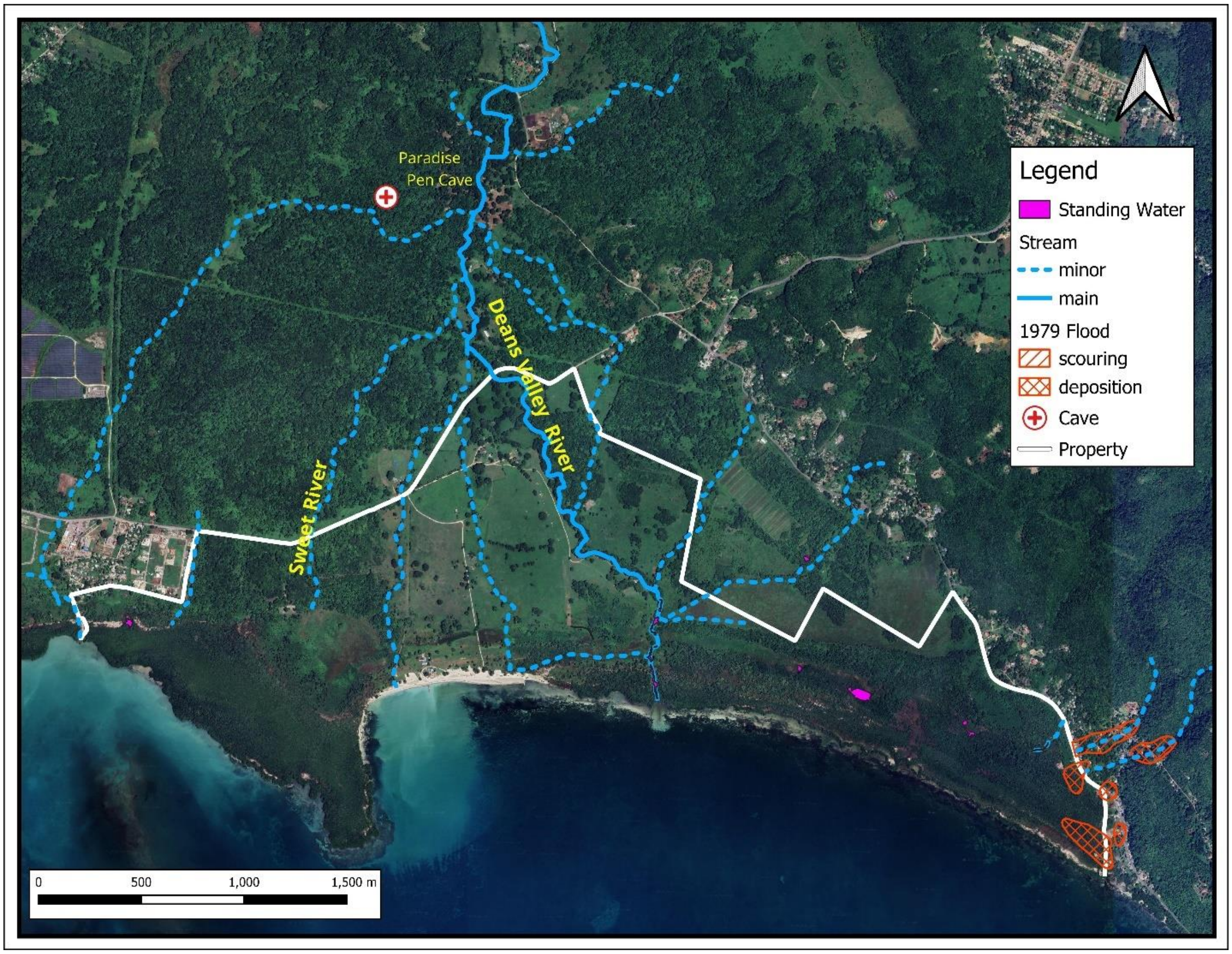


Figure 4-5 Geomorphological features, Paradise Pen

The impact of the 1979 flood rains was exacerbated by the significant bedload transported by the streams. During periods of heavy rainfall, rivers carrying large volumes of sediment tend to deposit this material in areas where the channel slope decreases. As the riverbed becomes filled with sediment, the water will often abandon the original channel and carve a new path, which was the cause of extensive damage during the 1979 floods. Many houses were destroyed as a result of this channel shifting.

4.1.4 Climate

4.1.4.1 Overview

Jamaica has a tropical marine climate influenced by the Northeasterly Trade Winds, mountain ranges, atmospheric troughs, and the warm waters of the Caribbean Sea. Rainfall across the island is seasonal and follows a bimodal distribution, with two wet seasons occurring annually from April to June and from August to November. The first wet season typically peaks in May, just before the onset of the Atlantic hurricane season in June, while the second and generally more intense wet season peaks in October (Figure 4-6). Drier periods are observed between February and March and again in July. While this pattern represents the all-island mean, spatial variations in rainfall timing and intensity are well documented. Three parishes, namely Portland, Hanover, and Westmoreland, account for approximately 30 to 40 percent of Jamaica's annual rainfall. Westmoreland, the third wettest parish, receives an estimated 9 percent of the island's total monthly rainfall on average (Figure 4-7).

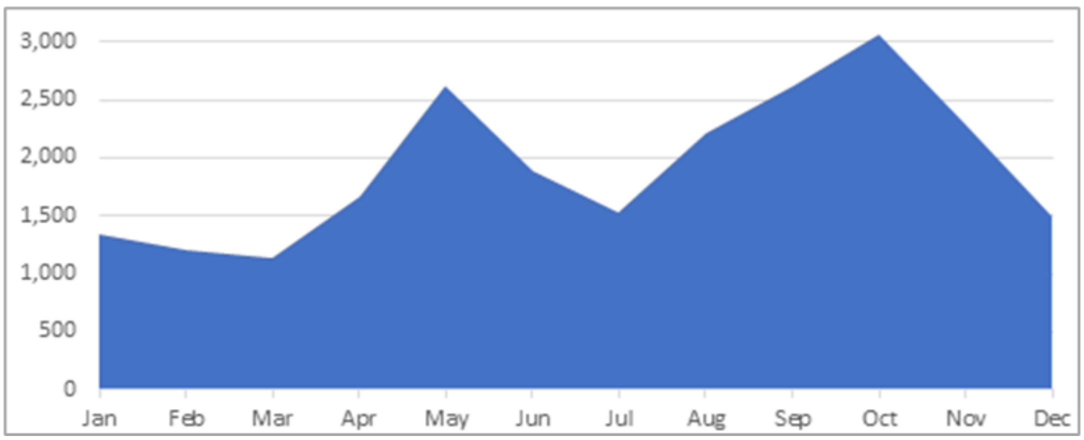


Figure 4-6 Graph showing total monthly rainfall in Jamaica

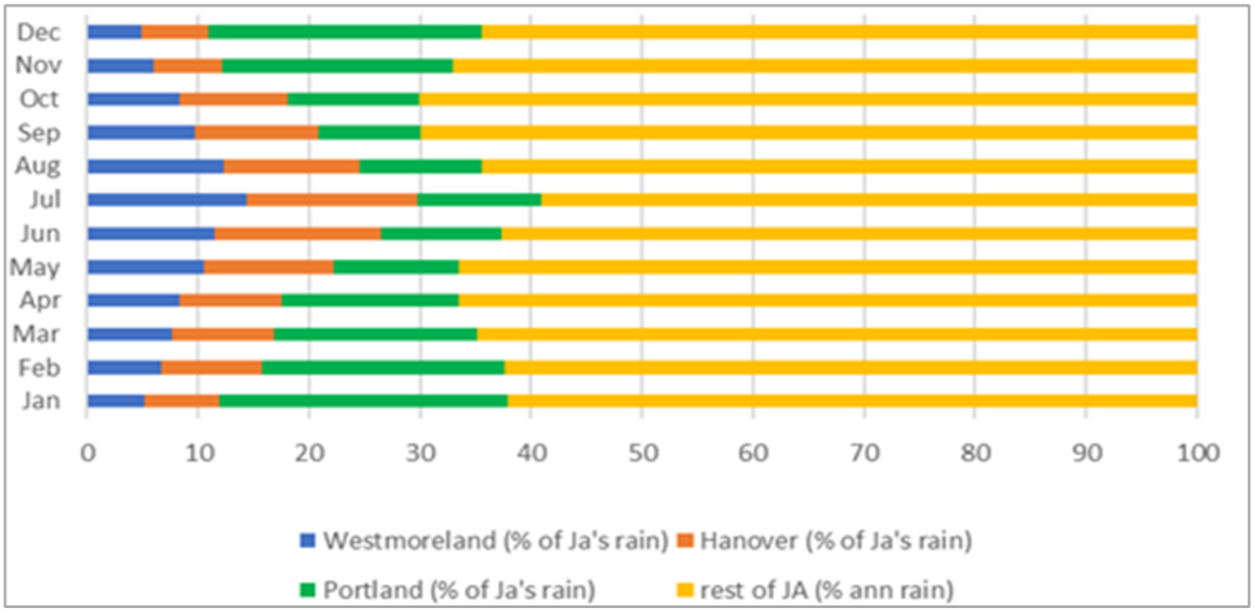


Figure 4-7 Graph showing distribution of annual rainfall across the island and among the three wettest parishes

Figure 4-8 shows Jamaica's thirty-year monthly means for temperature and precipitation. Mean surface air temperatures remain relatively stable year-round, ranging from approximately 24°C to 27°C. Mean maximum temperatures exceed 30°C, while minimum temperatures remain above 20°C. Precipitation follows a bimodal pattern, with distinct peaks in May and October, aligning with the country's two main wet seasons.

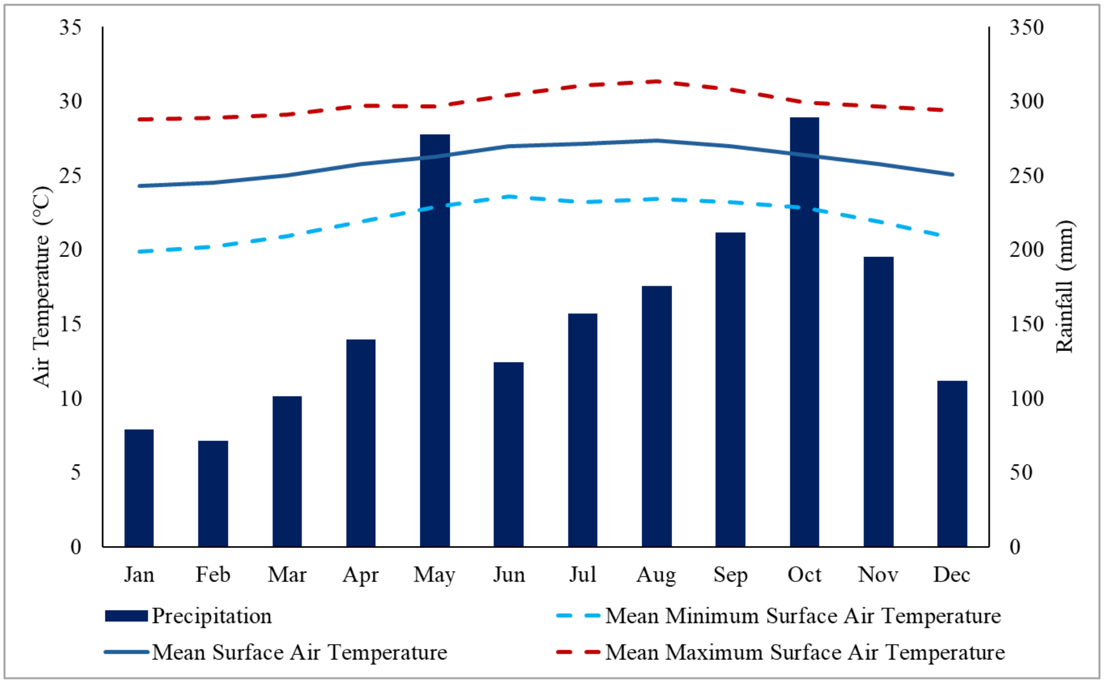


Figure 4-8 Jamaica's thirty year means for temperature and precipitation (World Bank Group 2021)

Figure 4-9 illustrates observed annual mean temperatures from 1901 to 2021. A clear warming trend is evident, with cooler-than-average conditions dominating the early part of the record and a steady increase in temperature anomalies from the 1980s onward. The most recent decades are characterized by persistent above-average temperatures, consistent with observed global climate change trends.

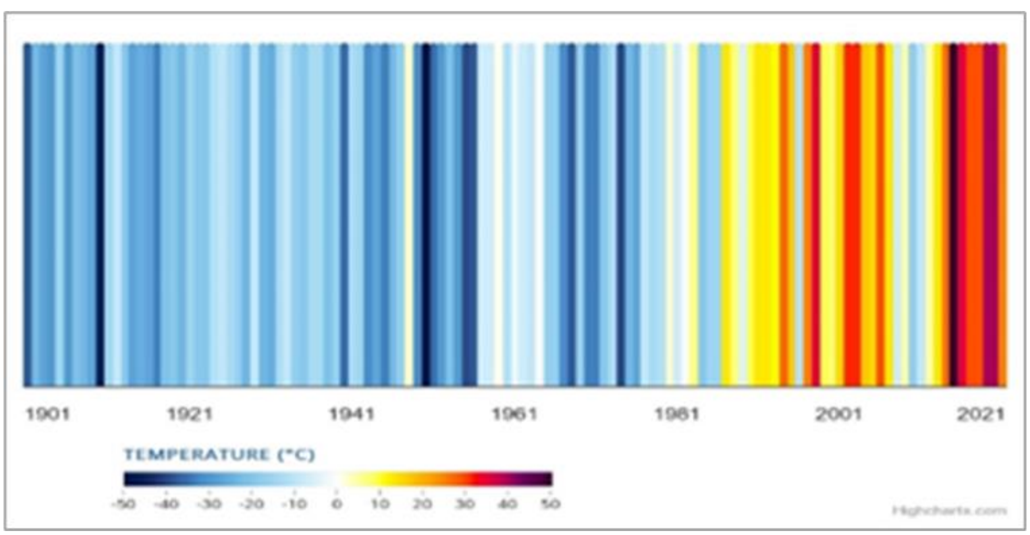


Figure 4-9 Observed annual mean temperature for Jamaica, 1901-2021 (World Bank Group 2021)

4.1.4.2 Site-Specific (2023-2024)

Temperature, relative humidity, rainfall, and wind speed and direction were recorded over 6 months (August 18th, 2023 – February 29th, 2024), on the proposed project site, using a Davis Instruments wireless Vantage Pro2 weather system with a data logger and a complete system shelter erected on a tripod. Data were collected every fifteen minutes and stored on the data logger. This information was downloaded using the WeatherLink 6.0 software.

The following were the summarized results of the assessment over the data collection period:

- Average temperature recorded was 26.3°C and ranged from a low of 15.4°C to a high of 35.7°C.
- Average relative humidity was 84.1% and ranged from a low of 42% to a high of 99%.
- Average wind speed was 1.0 m/s and ranged from a low of 0 m/s to a high of 7.2 m/s.
- Dominant wind direction was from the northwest.

August to October were slightly warmer months and had slightly higher humidities compared to the other months (Table 4-2). December, January and February had the highest wind speeds while December had the highest total rainfall (64.94 mm) (Figure 4-10 to Figure 4-13).

Table 4-2 Monthly weather station data over the assessment period

Month	Avg. Temperature (°C)	Avg. Relative Humidity (%)	Avg. Wind Speed (m/s)	Total Rainfall (mm)
Aug-23	27.6	87	0.56	0
Sep-23	27.1	88	0.31	0
Oct-23	27.4	86.7	0.34	0
Nov-23	26.5	87.4	0.42	0
Dec-23	26.0	80.9	1.79	64.94
Jan-24	25.4	80.7	1.78	1.77
Feb-24	24.4	77.7	2.06	30.7

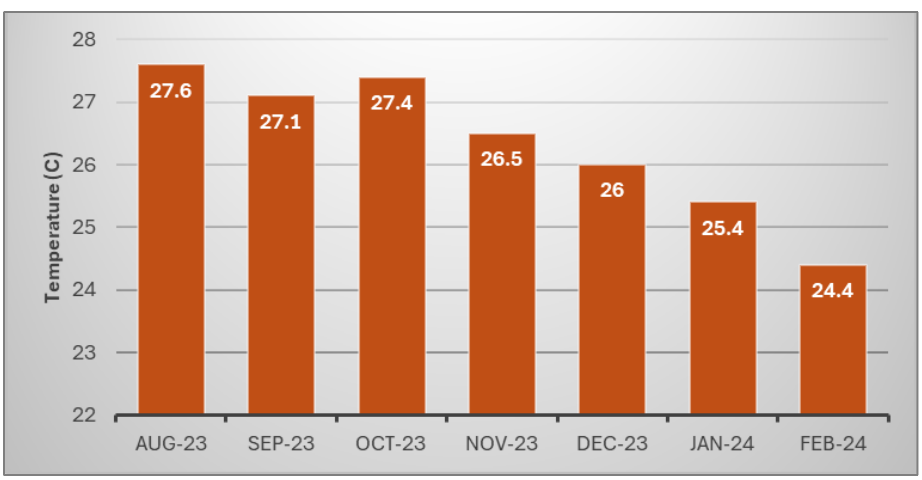


Figure 4-10 Average monthly temperature over the assessment period

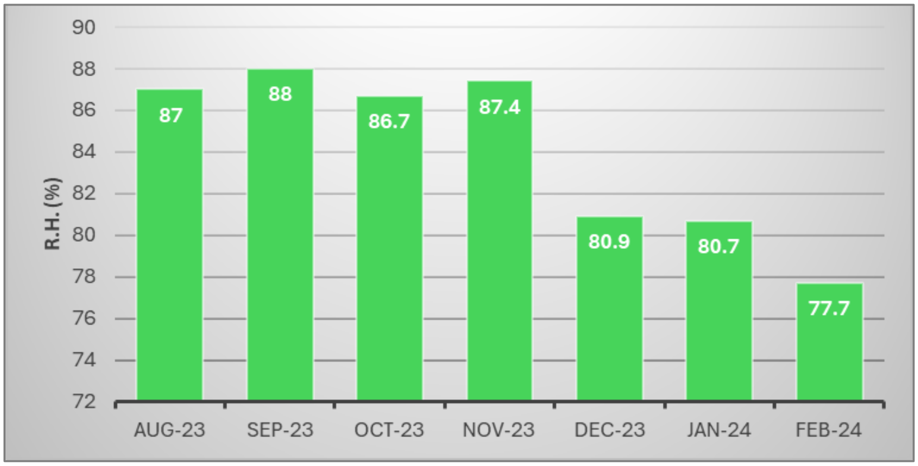


Figure 4-11 Average monthly relative humidity over the assessment period

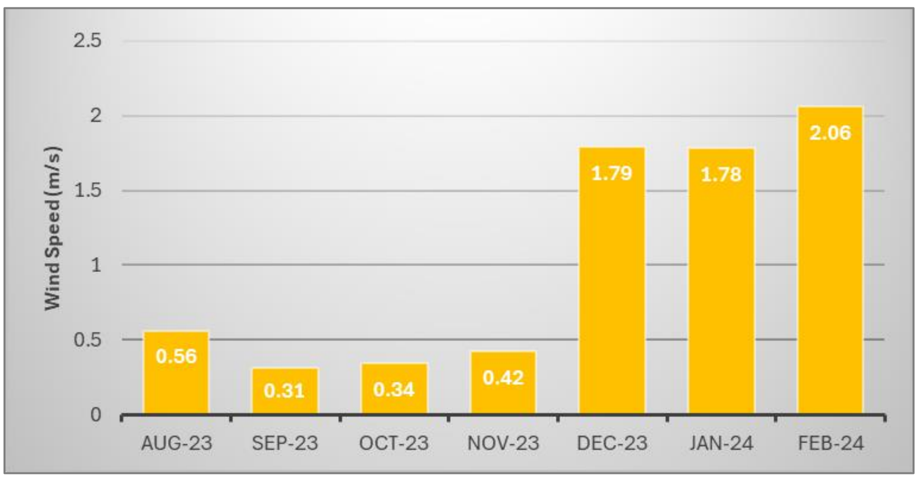


Figure 4-12 Average monthly wind speed over the assessment period

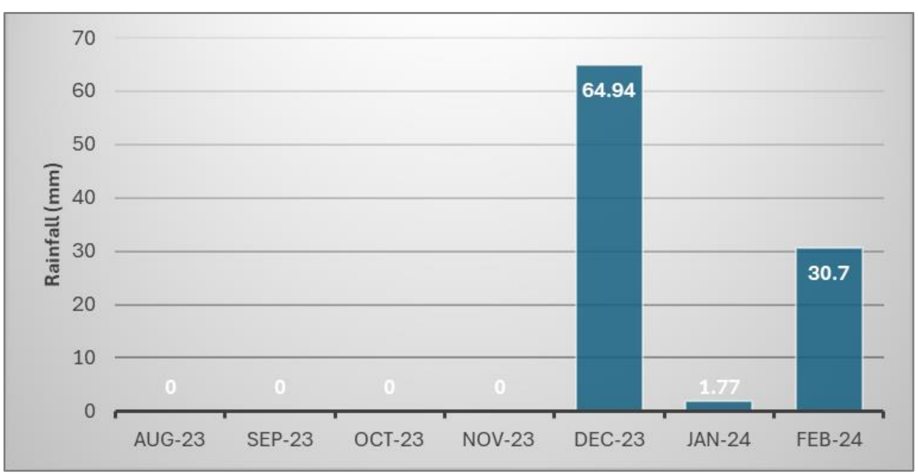


Figure 4-13 Monthly rainfall over the assessment period

Comparison with Long-Term Climate Trends

The site-specific data recorded between August 2023 and February 2024 generally align with Jamaica's long-term climatic trends, particularly in relation to the bimodal rainfall pattern and seasonally stable temperatures. However, notable deviations were observed.

While Jamaica's thirty-year mean daily surface air temperatures typically range from 24°C to 27°C, the project site recorded a comparable average of 26.3°C. However, the maximum temperature recorded at the site (35.7°C) significantly exceeds the long-term average maximum, reflecting the broader global context in which 2023 and early 2024 have been confirmed as the hottest period on record globally.

Relative humidity and temperature were highest between August and October, coinciding with the second national wet season, although no rainfall was recorded at the site during this time. This divergence may be attributed to localised rainfall variability or microclimatic effects, which are not uncommon in coastal environments. Rainfall at the site was concentrated in December and February, consistent with national reports of a shift in rainfall distribution during this period.

Wind speeds observed at the site peaked between December and February, aligning with the drier season, and were within the expected range for low-elevation coastal areas in western Jamaica.

Overall, the site-specific data reflect seasonal patterns consistent with national means but show elevated temperature extremes and atypical rainfall timing, likely influenced by the exceptional regional and global climatic conditions prevailing during the monitoring period.

4.1.4.3 Global Temperature Trends

It is important to note that the year 2023 was the warmest year since global records began in 1850 at 1.18°C above the 20th-century average of 13.9°C. This value is 0.15°C more than the previous record set in 2016. The ten (10) warmest years in the 174-year record have all occurred during the last decade (2014–2023) (Figure 4-14) (NOAA, 2024). Figure 4-14 shows yearly average temperature since 1976 compared to the 20th-century average. It has been forty-seven (47) years since Earth's temperature was colder than average. 2023 set a new warmest-year record by a wide margin (NOAA, 2024).

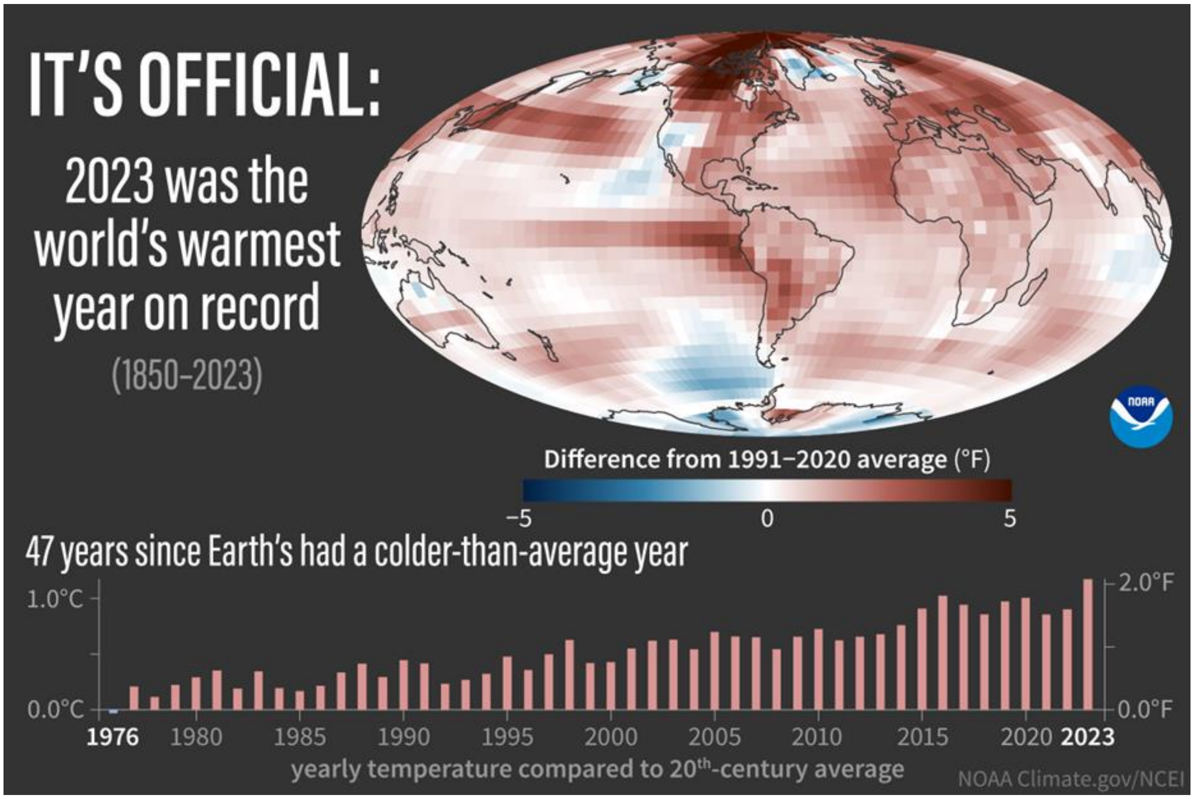


Figure 4-14 Yearly temperatures compared to 20th century average (NOAA, 2024).

4.1.5 Drainage and Hydrology

4.1.5.1 Overview and Background

Numerous rivers and streams flow from Jamaica's mountainous interior, draining into the northern and southern coastal plains, which are typically alluvial in nature. Jamaica is divided into ten hydrologic basins based on how these rivers drain large areas of the predominantly karst limestone interior. Westmoreland has several streams and a main river, the Carbarita River, which gives its name to Basin VI. There are four watershed areas within the parish, the project area falls in zone 24 based on the WRA map zonation (Figure 4-15).

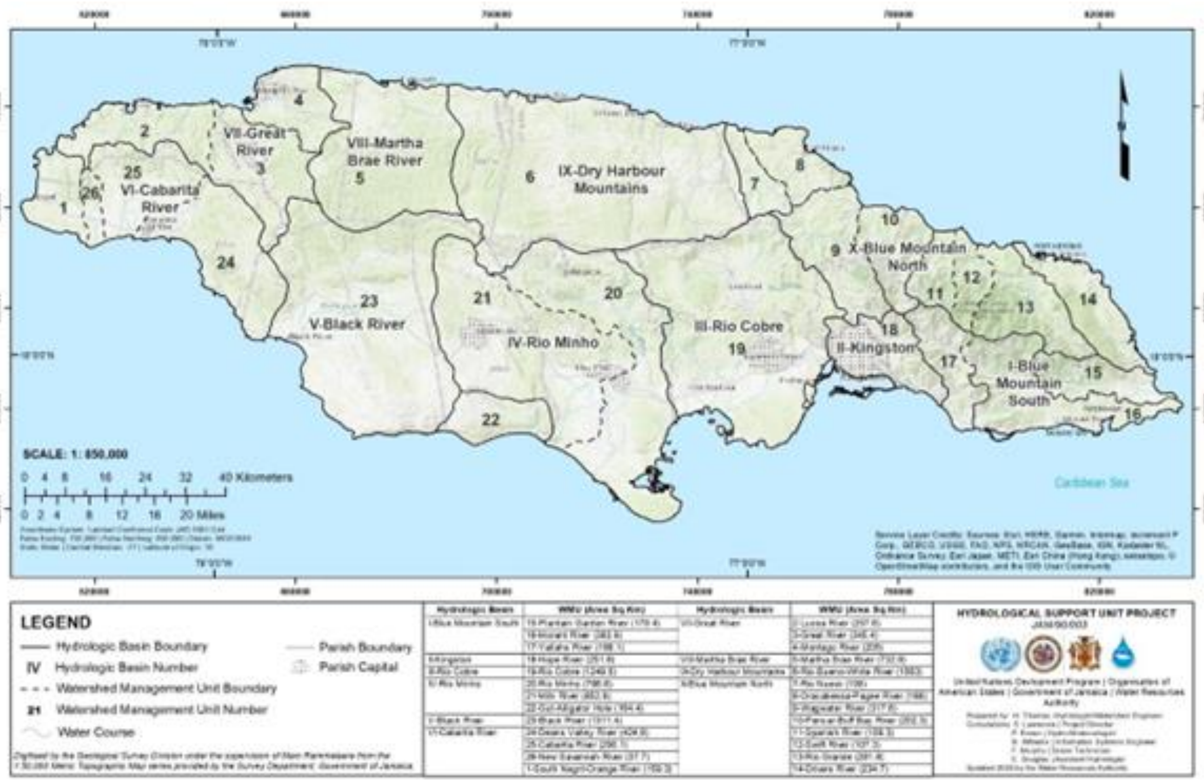


Figure 4-15 **Jamaica's hydrologic basins and Watershed Management Units of Jamaica (WRA 2020)**

Karstic limestone's porosity moves water rapidly from the surface into groundwater via springs, fractures, sinkholes, and caves. Westmoreland's watersheds show a mixture of limestone and alluvium. In the southeastern area of the parish, white chalky limestone predominates, and alluvium soils overlay this limestone in the region of the Cabarita River and its watershed. Alluvium can be sandy or clayey loam soils, when mainly clay, they encourage overland flow and stream formation due to high amounts of clay restricting percolation. Paradise and areas east of it (WMU 24) are classified as limestone aquifer. Due to the high prevalence of limestone, Jamaica's groundwater from limestone aquifers is considered 'hard' and shows high turbidity (US Army Corps 2001).

The project land is situated within the Deans Valley sub-Watershed Management Unit of the Cabarita River Hydrologic Basin and the site itself has various rivers which run from the north side of the property that empty into the Caribbean Sea (Figure 4-16). These rivers include two tributaries of the Sweet Water River and the Deans Valley River[4] (Jamaica National Heritage Trust, 2023) (Plate 4-2 and Plate 4-2). On-site, several existing culverts are located at road and river intersections (section 4.1.5.2). It should also be noted that many of the river and stream channels are ephemeral, flowing only after significant rainfall.

[4] Different literature refers to the main eastern river on the property by various names, including Murfitts River and Deans Valley River.

Plate 4-1 View looking northwest showing a lower section of Deans Valley River

Plate 4-2 View looking south showing the mouth of Deans Valley River

The study area is a dynamic and diverse ecosystem characterized by important natural drainage features, including several rivers and streams. It encompasses hydrological, ecological, biological, and cultural sub-regions that interact continuously. The watershed's topography consists of four main zones, with upland regions rising up to 500 meters above sea level and featuring hilly terrain. The coastal areas, which receive drainage from the watershed, play a crucial role in the system by linking inland and coastal ecosystems through the flow of water, sediment, chemicals, and organic matter. Key water sources, such as groundwater recharge zones and headwater streams, are particularly sensitive to changes in the watershed landscape (Ebert, 2010).

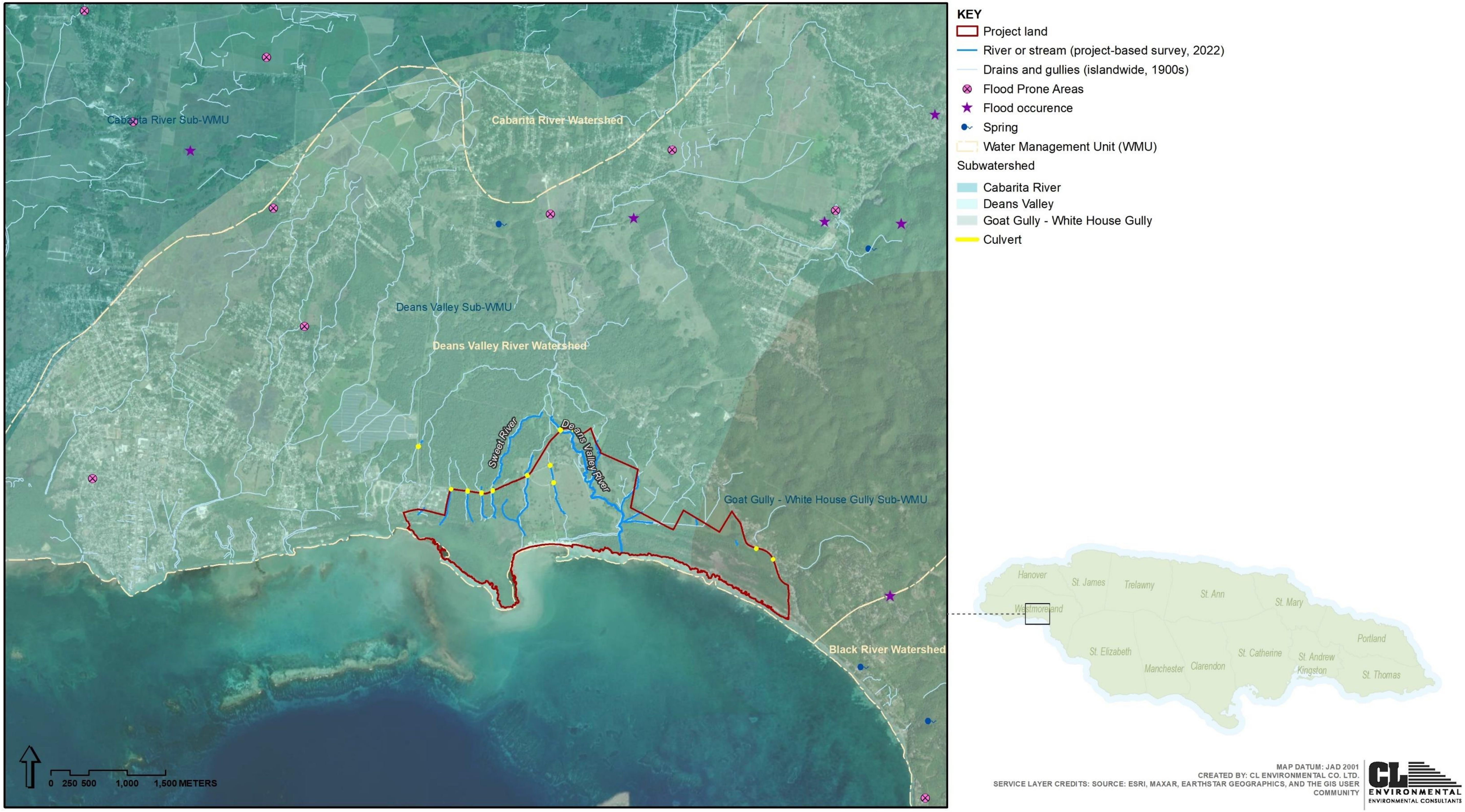
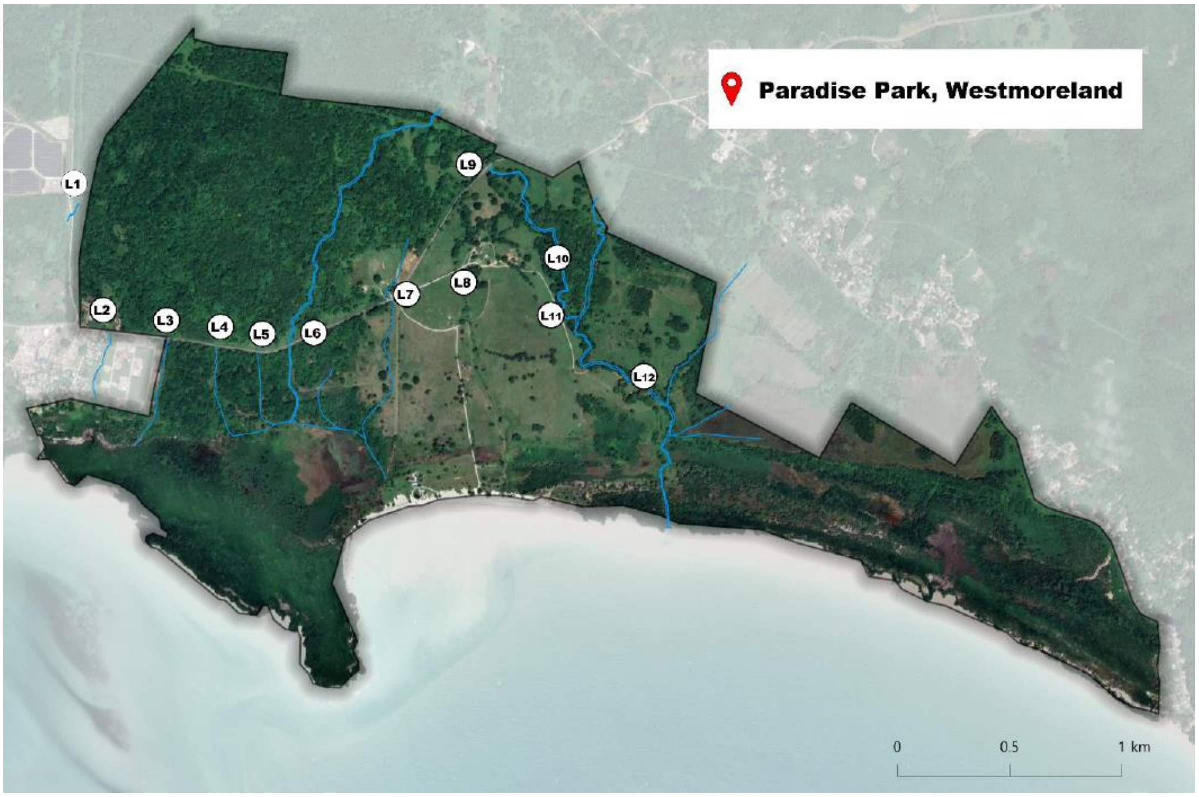


Figure 4-16 Drainage systems and hydrological features at and surrounding the project site

4.1.5.2 Culvert Crossings

Twelve existing drainage features were assessed in the field (Figure 4-17); the following provides a summary of their key characteristics (Premier Land & Water Development Ltd., 2023):

- L1: A bridge crossing east of the Paradise Park Solar Farm. The riverbed in some sections was dry, and ponding was observed. The four-barrel culvert system (1.2m each) suggested significant flows, with a discharge of approximately 1.2 m^3.
- L2: The 0.9m diameter concrete culvert was in good condition, but the flow in both upstream and downstream areas was minimal. The upstream earthen channel had a top width of 3.2m and water depth of 0.05m at the time of measurement.
- L3: A concrete drain with an estimated 0.6m diameter showed overgrowth, making it difficult to inspect.
- L4: A concrete drain with a diameter of 0.5m–0.6m was found. Similar to Point L3, it is expected to have low flows and minimal impact.
- L5: A double-barrel 0.6m concrete culvert showed no flow at the time of inspection. It was expected to function similarly to the previous culverts with low flows.
- L6: The Sweet River crossing had a collapsed culvert system, and no discharge values were obtained. The expected pipe diameter was 0.9m, with a possible double-barrel system.
- L7: A 0.4m x 0.3m irregular culvert was obstructed by debris. An upstream concrete U-drain had dimensions of 0.6m x 0.71m and was partially covered by dense vegetation, affecting flow.
- L8: A 1.6m x 0.6m box culvert was located at the entrance corridor of Paradise Park. The channel was partially blocked by debris, resulting in stranded water upstream.
- L9: The Murfitts River (Deans Valley River) crossed through a 4.5m x 2m box culvert. With a flow depth of 2m and a discharge of approximately 0.6 m^3, the Murfitts River (Deans Valley River) was found to be significantly larger than the Sweet River and the main river course through the property.
- L10 & L11: Further investigation of the Murfitts River (Deans Valley River) revealed a continuous, meandering course with high banks (2m on the left bank, 4m on the right). Some sections showed signs of erosion.
- L12: The downstream section of the Murfitts River (Deans Valley River) maintained pristine conditions, with left and right banks approximately 2m above the water surface. This area has an appealing natural aesthetic.



Source: (Premier Land & Water Development Ltd., 2023)

Figure 4-17 Culvert crossing locations assessed in the field

Source: (Premier Land & Water Development Ltd., 2023)

Plate 4-3 Deans Valley River (Murfitts River) upstream and culvert

Source: (Premier Land & Water Development Ltd., 2023)

Plate 4-4 Deans Valley River (Murfitts River) bank

Source: (Premier Land & Water Development Ltd., 2023)

Plate 4-5 Deans Valley River (Murfitts River) downstream

4.1.5.3 Hydrological Modelling and Analysis

Methodology

The methodology utilised consisted of a desktop study and field investigations (Premier Land & Water Development Ltd., 2024).

FIELD INVESTIGATION

A site visit was done on June 29, 2023, to understand the general characteristics of the site, its soil and vegetation. Keen attention was paid to the rivers and wetlands. General characteristics of the river(s) were also noted, such as width at certain area flood lines and discharge. Discharge data specific to the site was measured using a modified version of the velocity area method.

RIVER DISCHARGE DETERMINATION METHOD

River discharge is governed by river morphology and stream velocity. Discharge in a river and any open channel is given simply by the following equation:

$$Q = AV$$

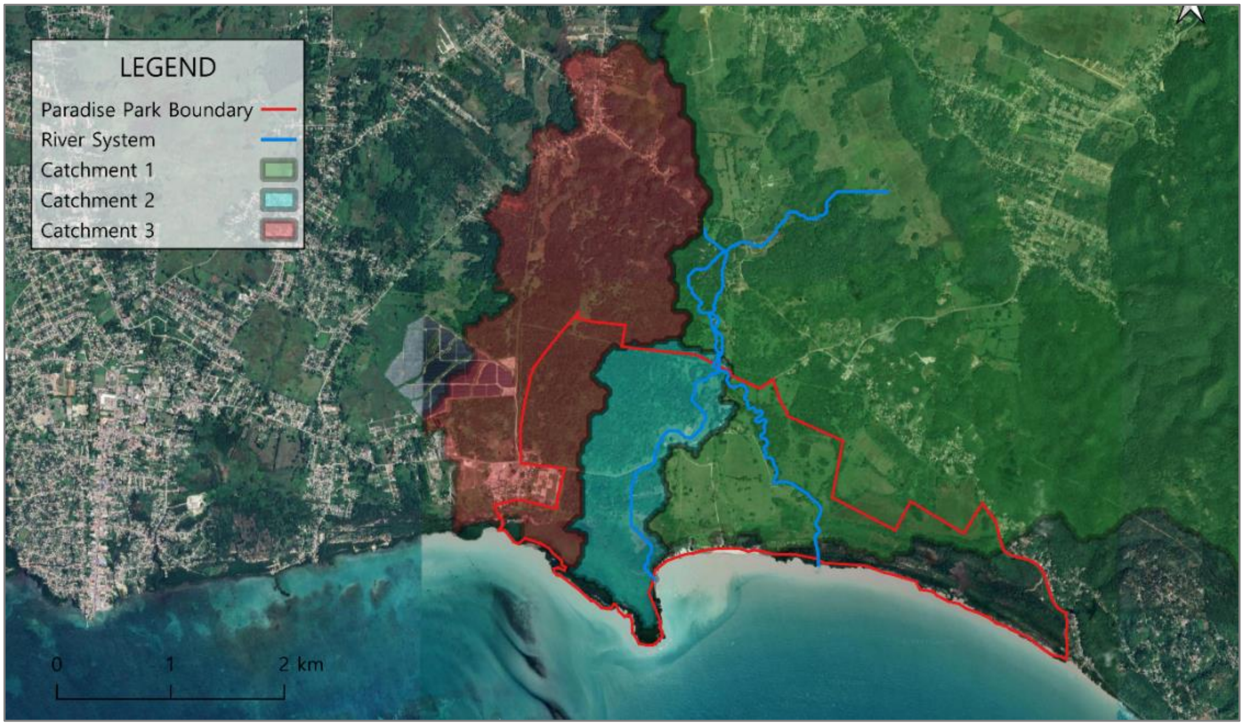
Where, *Q* is the discharge in m^3/s
A is cross-sectional area
'*V'* is mean velocity

The velocity area (current meter) method is a method of flow determination using the above equation. In this method the area is determined by sounding and the velocity is determined by a float. The Stingray 2.0, which measures level, velocity, and temperature; the Doppler flow meter, designed for pipes and conduits; and the area velocity flow meter were used for river discharge determination. The area velocity flow meter, in particular, was utilized to measure the required parameters. In principle the measurements are taken in steady state conditions. Measurements are commonly taken from left bank.

The process involved selecting a section of the river on a straight reach, positioned at least one river width away from curves and confluences, with well-defined banks. It was ensured that no backflow occurred in the selected location. The width of the cross-section was measured using a tape and was symmetrically divided into vertical sections. Velocity measurements were taken at a depth of 0.6d from the surface in each vertical section, along with depth measurements, to determine the riverbed's cross-sectional profile. The river discharge was then calculated using the average velocity and the cross-sectional area (Premier Land & Water Development Ltd., 2024).

DESKTOP STUDY

General surface water data and meteorological data close to the site was obtained from the relevant agencies (Water Resources Authority and Meteorological Service of Jamaica). GIS was used to delineate the catchment area of the river within the site (Figure 4-18); it should be noted that due to the relatively flat nature of the site, exact catchment delineations could not be obtained on a gravity flow basis (Premier Land & Water Development Ltd., 2024).



Source: (Premier Land & Water Development Ltd., 2024)

Figure 4-18 Catchment area estimations based on GIS gravity flow delineation

The HEC RAS software was used to carry out 2D modelling of the area, to determine possible flood inundation. The 10, 25, 50 and 100-year return period isohyet map was used and a precipitation model at a time interval of an hour was done. The hydrograph obtained from this model was then added to the estimated peak discharge value from the upstream Dean Valley reach (Murfitts River), where a monitoring station is located. The resulting hydrograph was used in determining the preliminary flood extent based on existing conditions, at a 100-year rainfall return period. Rivers were modelled separately (Premier Land & Water Development Ltd., 2024).

Rivers and Discharge

The site lies within Cabarita River Basin. Upstream of the site in the vicinity of Ferris Cross is a gauge station named the Dean Valley River station (Figure 4-19). The Dean Valley River diverges downstream to form the two river reaches, which both lie within the Paradise Park proposed site. The eastern river, which is referred to unofficially as the Murfitts River terminates into the sea and has a stream order value of 1 while the western Sweet River, has a value of 2 and terminates into a wetland. By this categorization, the Sweet River would be the larger of the two as it relates to discharge (Premier Land & Water Development Ltd., 2024).

Source: (Premier Land & Water Development Ltd., 2024)

Figure 4-19 Dean Valley River station

It was found from 2019-2023, that the highest discharge recorded at the Dean Valley Gauge station was 384cfs (10.87cms) (Figure 4-20). Downstream of the station the river branches into three sections. It is assumed that the discharge is divided equally to each reach. The Lower Sweet River is classified as a 2^{nd} order stream by the WRA, whilst the Murfitts River is classified as a 1st order. This means that the latter has a smaller discharge. The expected discharge to Lower Sweet River is then reduced by approximately 30% and is used as the discharge to be found in the Murfitts River. This is cross checked with the estimated volume of a section of the river, and an approximation of 2.4 cubic meter per second is assumed to be the highest flow for the reference period (Premier Land & Water Development Ltd., 2024).

1/22/2019	DM,DDM,FM	34	26.2	1.15	2.7	30.1
3/26/2019	RMC,DDM,FM	36	30.9	1.2	2.68	37.2
4/24/2019	DM,CMC,FM	36	29.58	1.05	2.65	31.1
05/2019						
6/25/2019	DM,CMC,FM	52	99.29	1.49	4.5	148
7/23/2019	CMC,FM,MS	56	85.1	1.3	4.42	110.25
08/2019						
9/27/2019	DM,MS,FM	61	155.08	1.86	5.5	288
10/25/2019	DM,CMC,FM	54	101.73	1.11	4.15	113
11/29/2019	DM,MS,FM	51	79.6	1.15	3.81	91.73
12/20/2019	MS,CMC,CT	48	74.72	1.26	3.36	94.39
1/21/2020	MS,CMC,FM	32	24.12	1.26	2.59	30.31
2/18/2020	MS,CMC,CT	26	15.94	1.41	2.35	22.55
5/23/2020	CMC,MS,FM	46	54.3	0.93	3.39	50
7/21/2020	MS,FM,CMC	55	93	0.95	4.14	89
8/25/2020	MS, DM, FM	55	130	0.98	4.87	127
9/25/2020	MS, RM, FM	52	81.32	1.5	3.79	122
11/6/2020	MS, RM, FM	50	79	1.48	3.9	117
11/24/2020	MS, DM, FM				3.48	105
1/22/2021	RM, MS, FM	42	31.44	1.3	2.7	40.1
2/23/2021	RM,DM, FM	38	29.9	1.56	2.66	46.7
3/25/2021	DM, MS, FM	30	20	0.87	2.4	17.46
5/27/2021	MS, RM, FM	50	70.08	1.52	3.7	106
10/20/2021	RM, MS, FM	63	126	1.13	4.43	142
12/3/2021	DM, MS, FM	57	99.09	1.57	4.04	155
12/21/2021	MS, RM, FM	44	51.69	1.22	4.48	63.31
1/19/2022	MS, FM, RM	42	22.36	1.27	2.82	28.42
2/25/2022	MS, RM, FM	48	32.14	0.98	2.6	31.61
4/29/2022	DDM, DM, FM	52	76.16	1.19	3.74	90.37
5/26/2022	RM, MS, FM	57	89.61	0.83	4.08	73.98
6/23/2022	DM, MS, FM	64	102.15	0.53	3.64	53.8
7/29/2022	DDM, DM, FM	51	148	2.13	4.1	318
8/26/2022	MS, RM, FM	61	185.92	2.07	5.94	384.55
10/28/2022	MS, RM, FM	50	84.16	1.56	3.94	130.92
12/23/2022	MS, FM, DDM	25	16.05	1.37	2.45	21.92

Source: (Premier Land & Water Development Ltd., 2024)

Figure 4-20 Discharge data of the last 3 years (2019-2022) of the Dean Valley River (Murfitts River)

Pre-Construction Storm Water Analysis

The site's sub-catchment characteristics and storage requirements were analysed to assess pre-construction hydrological conditions and plan for effective stormwater management. Sub-catchments were manually determined based upon flow path directions (Figure 4-21). Sub-catchment areas ranged from 24.0 ha (Catchment I) to 61.2 ha (Catchment H), with flow path lengths varying between 675 m (Catchment A) and 1,543 m (Catchment E) (Table 4-3). Slopes were generally uniform at 1–2%, resulting in similar peak times, with time to peak around 12.2 hours across all catchments. The time of concentration ranged from 24 minutes (Catchment A) to 44.8 minutes (Catchment E) (Premier Land & Water Development Ltd., 2024).

Figure 4-21 Sub catchments used in pre and post construction assessment

Table 4-3 Sub-catchment characteristics pre-construction

Source: (Premier Land & Water Development Ltd., 2024)

Sub-Catchment	Area [ha]	Flow Path [m]	Slope [~%]	Time to Peak [hrs]	Time of conc. [min]
A	40.1	675	2	12.13	24
B	33.6	1,160	2	12.23	35.7
C	25.2	695	1	12.20	33.7
D	33.1	710	2	12.17	27.3
E	37.0	1,543	2	12.33	44.8
F	31.0	727	1	12.20	30.6
G	25.1	966	2	12.20	31.0
H	61.2	1,059	2	12.20	33.2
I	24.0	1,128	2	12.27	40.3
J	26.7	738	2	12.20	30.6

4.1.6 Hydrodynamics

4.1.6.1 Coastal Characteristics

Site Description

The existing beach stretches approximately 1.2 km in length and reaches up to 50 meters wide in certain areas (Smith Warner International Limited, 2025). Two low-crested groynes are currently in place along the shoreline, helping to retain sediment over a 700-meter stretch. The central groyne, which is around 15 years old (Figure 4-22), is showing signs of failure.

Source: (Smith Warner International Limited, 2025)

Figure 4-22 Site photos showing the nearshore and features of the existing coastline

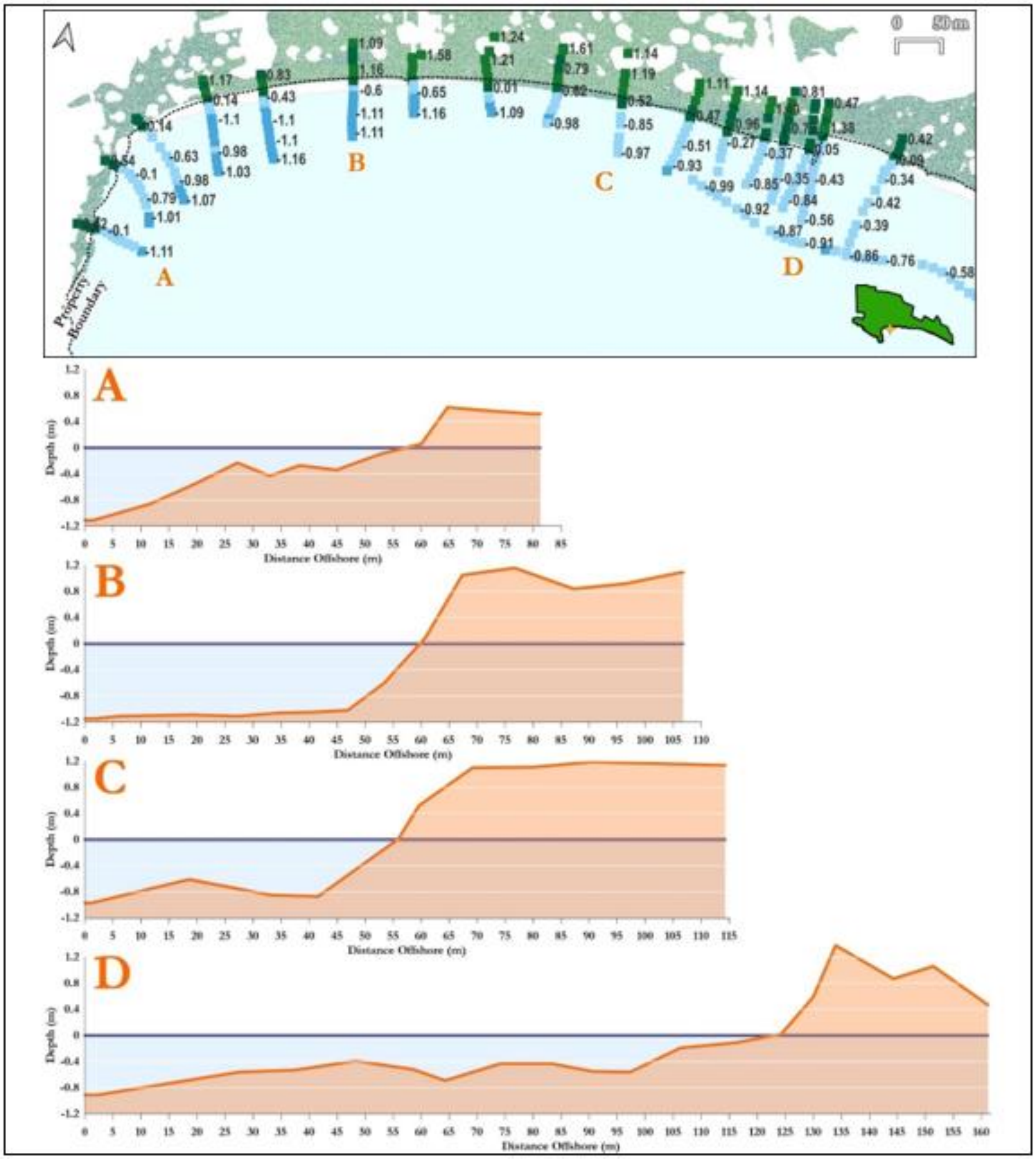
The widest section of the beach is located in the centre, where it is supported by a low-crested groyne constructed from small cobbles and stones. To the west, the beach becomes significantly narrower and has exhibited signs of erosion in recent years. Inset 2 (Figure 4-22) illustrates the central groyne, where a 40-meter section has become exposed. Over time, some of the stones in the structure have shifted, causing a reduction in the crest elevation in certain areas. Fortunately, the groyne remains anchored to the beach, helping to maintain its stability (Smith Warner International Limited, 2025).

Inset 3 of Figure 4-22 shows the mouth of Murfitts River (Deans Valley River), the largest watercourse on the property. The river serves as a source of sediment in the nearshore area, affecting the quality of the seafloor. In this vicinity, the nearshore has a silty bottom, which makes walking on it difficult for beachgoers. The river is bordered by vegetation and a mangrove area at its interface with the sea (Smith Warner International Limited, 2025).

Beach Profiles

Seventeen beach profiles were surveyed along approximately 1 km of beachfront (Figure 4-23). The length of the profiles helps indicate the steepness of the area, as the vertical ranges are similar. Profiles taken in the centre of the beach were shorter, resulting in a steeper gradient compared to those taken elsewhere. The elevation at the back of the beach near the main beach was approximately 1.2 meters, while profiles at the western end showed lower elevations of around 0.5 meters at the back of the beach (Smith Warner International Limited, 2025).

Figure 4-23 also highlights four profiles to illustrate the variation in the shallow zones. These profiles exhibit different overall shapes and beach slopes. Profile A, located on the western side, had an average nearshore slope of 1(V):30(H). Profile B was steeper, with a slope of 1(V):10(H), and featured a near-flat slope seaward of the main beach slope. Profile C, measured in the middle of the existing groynes on the site, had a gentler beach slope of approximately 1(V):14(H), compared to Profile B. Profile D, located on the eastern side of the east groyne, exhibited one of the gentlest slopes in the survey, with an average nearshore slope of 1(V):50(H) (Smith Warner International Limited, 2025).

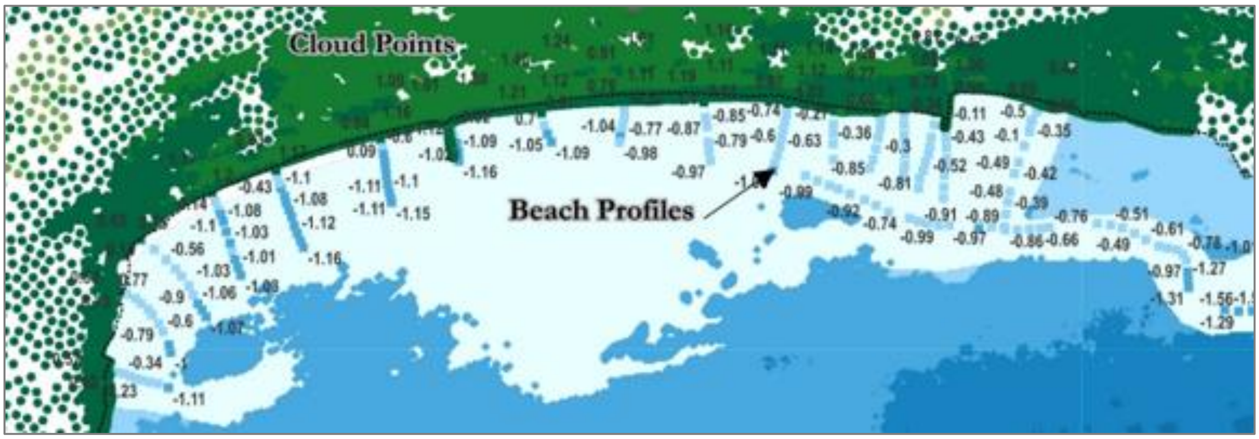


Source: Smith Warner International Limited, 2025

Figure 4-23 Beach profiles in plan (above, rotated north) with four profiles highlighted to show beach slopes (below, with an exaggerated vertical scale).

Bathymetry

Calculations based on 2022 EOMAP® bathymetry data reveal a seafloor slope of 1(V):200(H) extending 1.5 km to a depth of 7 meters. Beyond this, the slope becomes even gentler, at 1(V):900(H), extending to the 10-meter contour, approximately 3 km offshore. The absence of offshore reefs or shallow platforms suggests a potential vulnerability to wave events (Smith Warner International Limited, 2025).

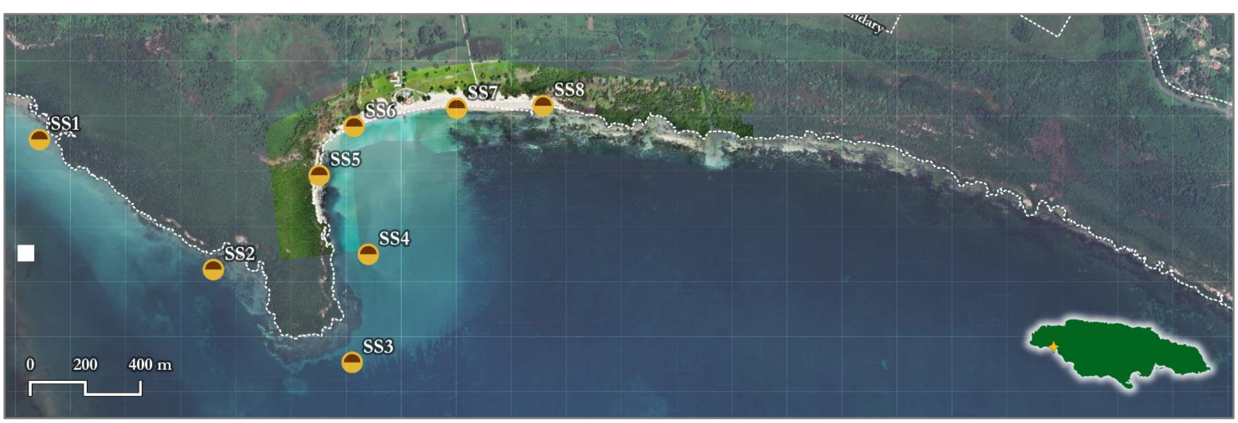


Source: (Smith Warner International Limited, 2025)

Figure 4-24 Beach profile and EOMAP® bathymetry data

Sediment Analysis

Eight sediment nearshore samples were collected from the site for sediment type classification, four of which were taken from the beach (SS5 to SS8) (Figure 4-25) (Smith Warner International Limited, 2025). Following sample collection, the samples were sent to a geotechnical laboratory, where they were visually inspected, air-dried, and subjected to standard dry sieve analysis to assess grain size distribution and classify the sand (USDA, 1979). Grain size distributions are shown in Figure 4-26, and Table 4-4 shows indicative grain diameters and classifications (BSI, 2018).



Source: (Smith Warner International Limited, 2025)

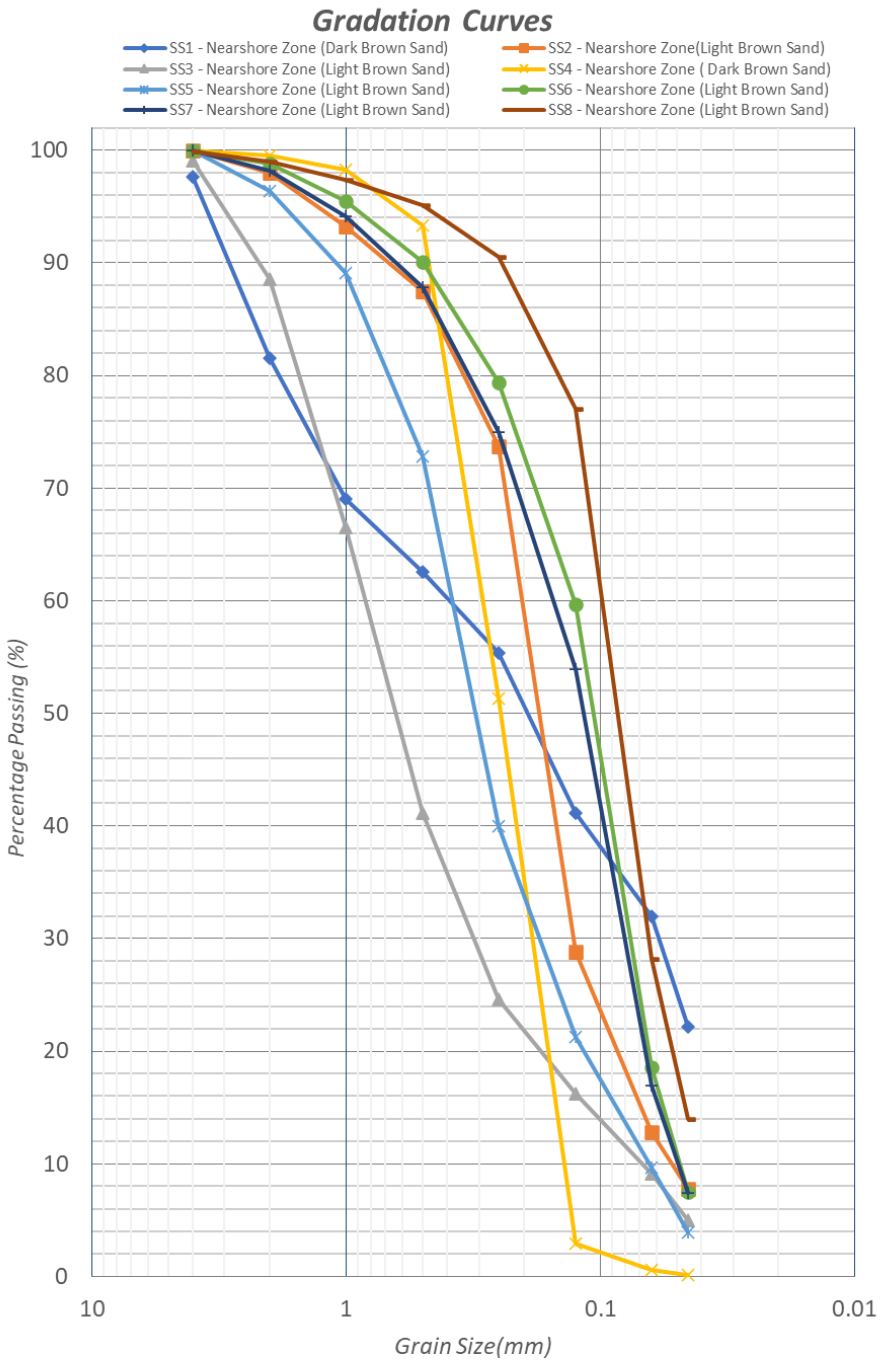
Figure 4-25 Sediment sample and borehole locations

Table 4-4 Sediment sample key diameters and sediment type percentages

Source: (Smith Warner International Limited, 2025)

Specimen	Type	Diameter (mm)				% Gravel	% Sand	% Silt	% Clay
		D_{50}	D_{60}	D_{30}	D_{10}				
SS1	*Fine Sand*	0.203	0.410	0.059	0.020	18.5	49.5	32.0	
SS2	*Fine Sand*	0.184	0.212	0.128	0.053	2.0	85.2	12.7	
SS3	*Coarse Sand*	0.675	0.872	0.332	0.071	11.4	79.5	9.1	
SS4	*Medium Sand*	0.247	0.302	0.195	0.143	0.5	98.9	0.8	
SS5	*Medium Sand*	0.326	0.402	0.183	0.065	3.6	86.7	10.3	
SS6	*Fine Sand*	0.110	0.127	0.080	0.049	1.2	80.2	18.7	
SS7	*Fine Sand*	0.119	0.162	0.085	0.050	1.8	81.4	17.0	
SS8	*Fine Sand*	0.091	0.104	0.066	0.033	1.0	71.1	28.3	

Sediment gradation curves (Figure 4-26) are valuable because their steepness indicates how well a sample is mixed, while its position on the x-axis helps determine whether the sample consists of gravel, sand, or fines. Five samples, collected from the eastern half of the beach and the nearshore area of the western coast of the property, were classified as fine sand. Two samples, taken east of the headland, were classified as medium sand. One sample, collected from the nearshore area south of the headland, was classified as coarse sand (Smith Warner International Limited, 2025).



Source: (Smith Warner International Limited, 2025)

Figure 4-26 Sediment distribution and breakdown of grain sizes

Seabed Jet Probing

Seabed jet probing is a method used to assess the properties of the seabed, typically in shallow coastal or marine environments. Probing was conducted using a high-powered jet, pump, and a 2.7-meter (10-foot) probe at eleven locations (Figure 4-27). Seawater was drawn into the pump and expelled through the probe with high pressure. The probe was then positioned vertically and used to jet down into the seafloor. The jet stream displaced the sediment, allowing the probe to move downward until it encountered resistance or reached the limit of the pipe. At the point of refusal or when the probe reached its maximum depth, the depth was recorded. This procedure was repeated three times at each location, and the average of the measurements was used to determine the final depth (Smith Warner International Limited, 2025).

The results of the probing exercise revealed that at six locations, the sediment layer extended to the full length of the probe, suggesting that these areas may have sediment layers deeper than 2.7 meters. Three probes taken near the beach shore showed sediment depths ranging from 2.4 meters to 2.5 meters, indicating that the sediment layer is somewhat thinner in these areas.

Source: (Smith Warner International Limited, 2025)

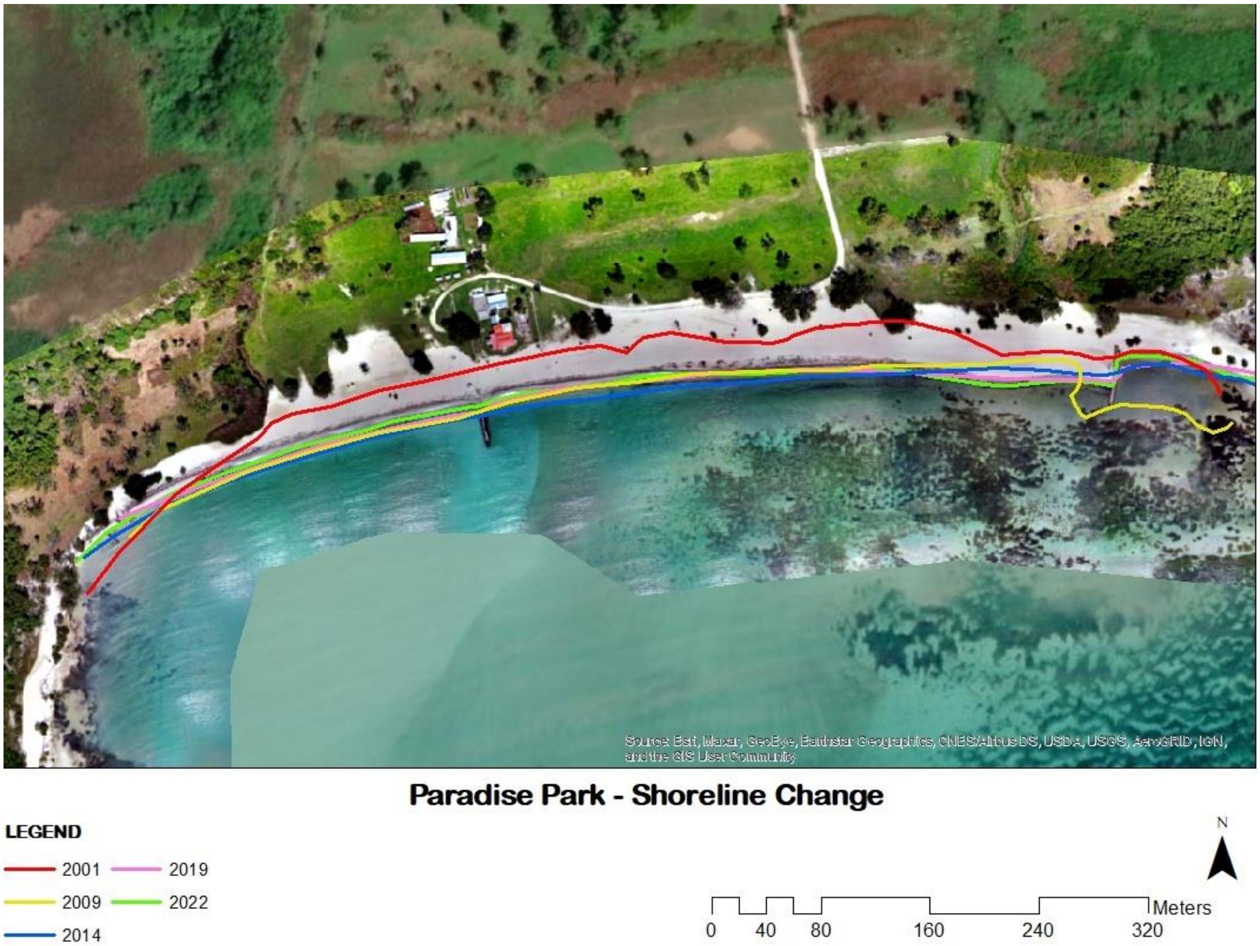
Figure 4-27 Probing locations

Historical Shoreline Comparison

Satellite images of the shoreline were obtained from Google Earth, geo-referenced and imported into ArcGIS software. For each available image, the shoreline, defined here as the high-water mark (HWM) or the 'wetted' area, was traced on the base map. The shoreline's location over time was then analysed and compared. However, this methodology has several limitations which should be mentioned, mainly related to uncertainties about the precise location of the shoreline at the time each satellite image was captured (Smith Warner International Limited, 2025):

- Seasonal Error: Many beaches experience seasonal cycles of erosion and accretion. Due to the limited availability of high-resolution satellite images for regions like the Caribbean, images cannot be chosen based on specific seasonal periods.
- Tidal Fluctuation Error: Satellite images were captured without accounting for tidal cycles, which can lead to inaccuracies in the digitized shoreline.
- Digitizing Error: Errors associated with the process of digitizing the shoreline from the images.
- Pixel Error: The pixel size in orthorectified images is 0.5 meters, meaning any variations smaller than 0.5 meters cannot be resolved.
- Rectification Error: Satellite images are corrected (or rectified) to minimize distortions caused by lens effects, Earth curvature, refraction, camera tilt, and terrain relief through remote sensing software.

Despite the potential for various errors, comparing the variations between images is still considered valuable for quantifying coastal changes in a general sense. From 2001 to 2009, the beach experienced significant accretion in width along the shoreline. Mr. Busha Clarke, a resident of the property, explained that certain storm events played a role in the beach's development during this period. According to NOAA hurricane tracks, several notable hurricanes, including Hurricane Ivan and Hurricane Dean, impacted Jamaica's south coast between 2001 and 2009. These extreme events are believed to have brought non-silty sediment from deeper waters onto the beach. Since 2009, the shoreline has remained relatively stable up to 2025. During a site visit in January 2025, Mr. Clarke confirmed that the beach had shown no signs of change. This suggests that the main beach has been replenished by high-energy hurricane events, as indicated by historical data and interviews with local residents. Since then, the shoreline has remained stable, with day-to-day conditions having minimal impact on its movement.



Source: (Smith Warner International Limited, 2025)

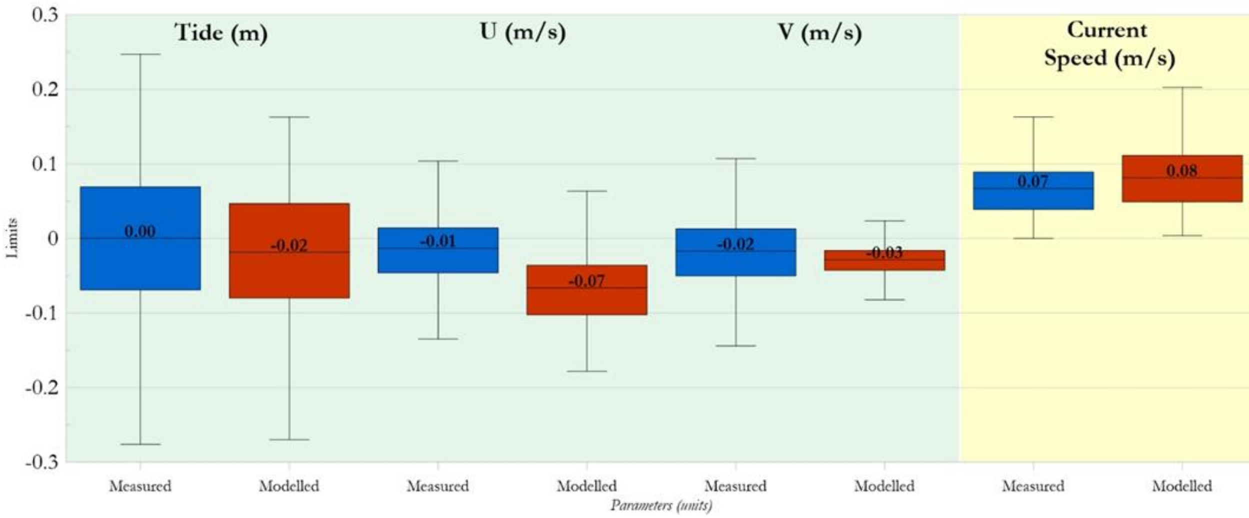
Figure 4-28 Historical shoreline change from 2001 to 2022

4.1.6.2 Coastal Conditions

Numerical Model Simulations

Numerical model simulations were used to develop an understanding of the coastal processes at the project site (Smith Warner International Limited, 2025). Numerical models help simulate various scenarios in the coastal environment and determine how the project site is impacted and/or how it would respond. First, however, how the site behaves under existing conditions must be determined to create a 'baseline' against which the project impacts can be compared.

The numerical model was calibrated using the nearshore measurements before using the numerical model to simulate the coastal processes. The current regime and waves were the main processes in the calibration exercise. For the current regime, three parameters (tide, u-component, and v-component) had a passing score, while the current speed had a marginal score (Figure 4-29).



Source: Evans & Research, 1993

Figure 4-29 Summary of the model calibration data ranges as whiskers, the 25th to 75th percentile conditions as boxes and the mean values at the centre.

The wave height, period and direction were also tested against established guidelines (Williams & Esteves, 2017). Wave height variations were well represented by the model, while the overall wave period range was captured in the model. Modelled wave directions showed more variations than the measured data, which led to a shift in the mean direction, which could lead to the model overpredicting wave action to the west of the main beach (Smith Warner International Limited, 2025).

The MIKE hydrodynamic and spectral wave-validated setup was then used for all operational modelling exercises to determine how the offshore wave climates impact the Paradise Park site.

Wave Climate

Westmoreland Paradise Park is exposed to two very different wave climates:

- the **operational** wave climate defined by day-to-day waves from the north-east Trade Winds and seasonal (winter) swell waves and,
- the **extreme** wave climate, defined by occasional hurricanes that generate much higher waves.

These wave conditions contribute to sediment movement along the coastline and are responsible for long-term morphological changes (Smith Warner International Limited, 2025).

The extreme wave climate describes waves associated with tropical storms and hurricanes, to which the Caribbean region is vulnerable each year from June to November. Dramatic and abrupt changes to the coastline can occur due to these storms. In general, coastal protection structures are designed to withstand wave attacks from these extreme storm events; for example, selecting an armour stone size that would be required for a coastal structure or determining design wave forces that may occur due to extreme waves. However, the stability of beach nourishment would not be designed for such wave conditions (Smith Warner International Limited, 2025).

The severity of the design storm event (i.e., return period) is typically chosen given the acceptable risk of damage or failure that the owner is willing to assume. A 50-year return typically represents an acceptable balance between capital investment and maintenance costs.

This section focuses on the operational wave climate, while details regarding the extreme hurricane wave climate may be found in section 4.3.2.

4.1.6.3 Operational Wave Climate

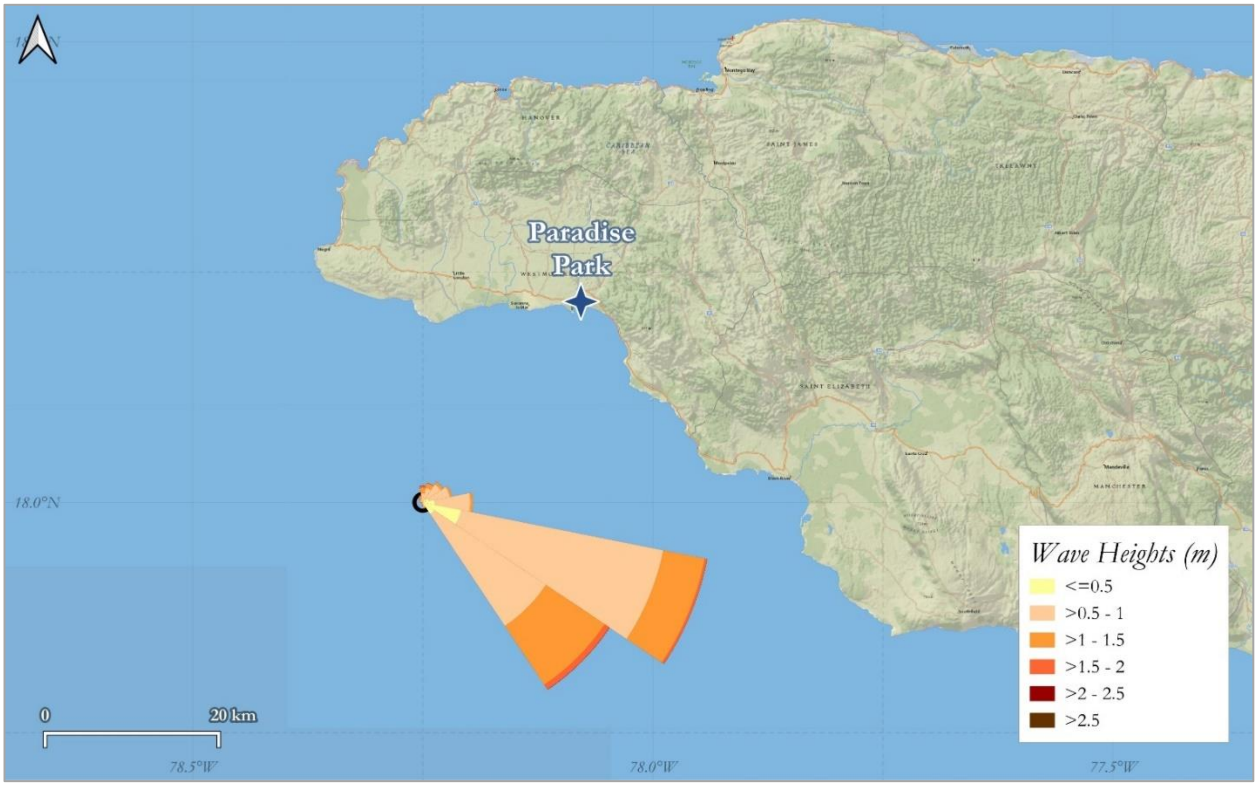
The operational wave climate at Westmoreland Paradise Park is influenced by its south-facing orientation along the coastline of Westmoreland, Jamaica. Waves approaching the area typically originate from the east-southeast (ESE) direction. The north-facing coastlines of Jamaica tend to experience more of the intense winter swells generated by North Atlantic cold fronts. However, the southward orientation of Westmoreland Paradise Park means the location is largely sheltered from those more extreme wave conditions annually. Instead, the day-to-day waves are driven by regional wind patterns and localised storms, leading to the more moderate ESE wave climate that batters the coastline throughout the year.

Although these winter swells account for a relatively small percentage of the year, it is important to note that they typically have a more significant impact on the project site's shoreline than the daily wave conditions. This is due to their higher energy, contributing to greater sediment transport and coastal morphological changes. Understanding these nuances in the operational wave climate is essential for effective coastal engineering design and management strategies (Smith Warner International Limited, 2025).

Daily Wave Climate

The deep-water operational wave climate was determined using the Reanalysis v5 (ERA5) dataset produced by the European Centre for Medium-range Weather Forecast (ECMWF). The ERA5 model reanalyses wave parameters, including significant wave height, wave period, mean wave direction, and wind speed and direction every hour from 1979 to 2023. This dataset provides over 392,256 timesteps of data at an enhanced resolution of approximately 31x31km (or ~0.25 degrees) over the Caribbean region (Smith Warner International Limited, 2025).

Model data revealed that waves offshore of Westmoreland Paradise Park predominantly come from the east, east-southeast (ESE) direction and that the wave heights from that direction range from 1-1.5m (Figure 4-30). The average wave period is 7s across the whole data set. The wave rose also shows that the higher wave heights (above 2m) are mainly from the southeast sector, which would be related to swell waves (which will be explored in the following section).



Source: (Smith Warner International Limited, 2025)

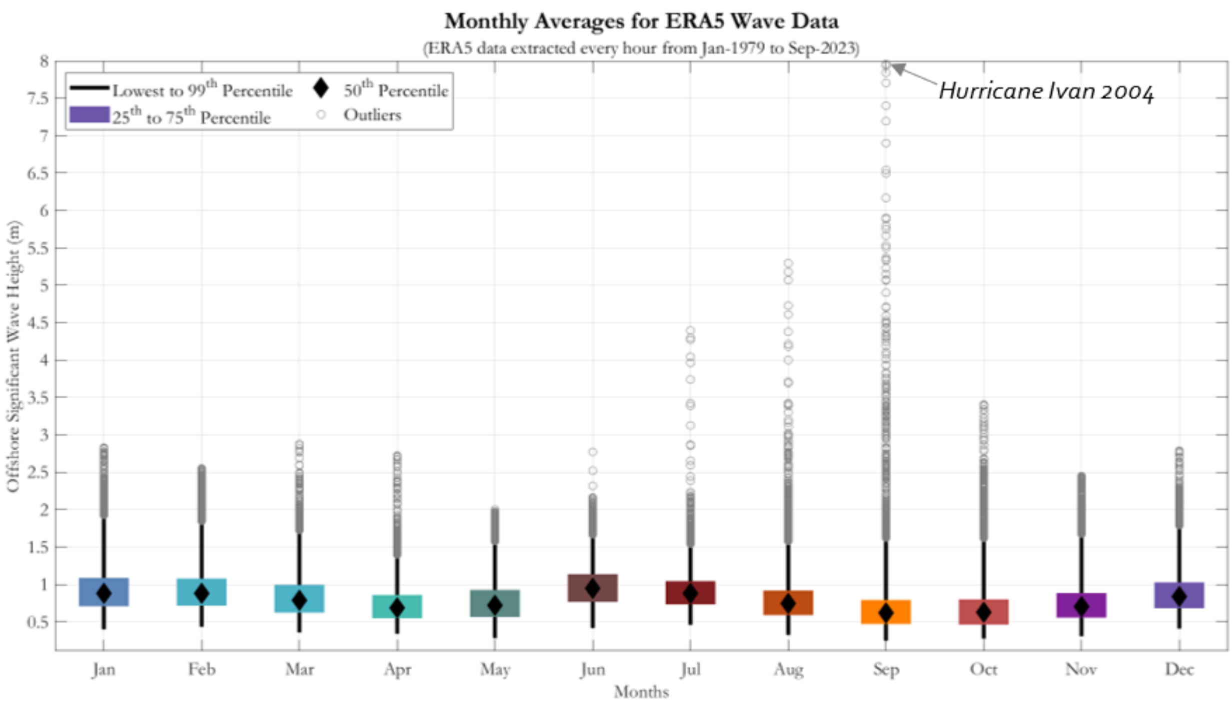
Figure 4-30 Offshore node location with wave rose showing wave heights and directions.

The wind data extracted from the selected node indicates that winds primarily come from the eastern sector. The winds were shown to come from the east 48% of the time, the east-south-east 24% of the time and the south-east 11.7% of the time (Figure 4-32). The average speed over the dataset was 6m/s, with a 99th percentile wind speed of 12m/s. Therefore, the model-extracted wind directions agree with the literature, which identifies the east Trade Winds as the predominant winds in the area. This analysis presents the wave and wind data to help the reader better understand the complexity of the operational wave climate at the project site (Smith Warner International Limited, 2025).

The 43 years of wave data was also analysed to assess the variation in offshore wave conditions across different months of the year. The candlestick diagram shows the average, 99.86th percentile waves and outliers representing the highest 1% of waves in a month. The months of August and September have the highest outliers in the dataset, which is related to the approximate peak of the hurricane season. For example, the maximum wave height over the entire duration was 7.984m in September 2004, which coincided with the passage of Hurricane Ivan (Smith Warner International Limited, 2025).

Considering only the average values (i.e., not the outliers), the summer months (May through October) have the smaller average wave heights. Conversely, the months of December to April have larger wave height averages. This difference is linked to frequent North Atlantic storms in the "winter" months.

Therefore, strong winds and energetic waves are more prevalent, increasing the average wave height. These results are intended to show the monthly variability of the wave climate and may also be used to schedule future construction activities (Smith Warner International Limited, 2025).



Source: (Smith Warner International Limited, 2025)

Figure 4-31 Monthly statistics on offshore wave data

Frequency of Wave Heights and Wave Directions (%)

Wave Directions (°) \ Wave Height (m)	[0 - 0.5]	[0.5 - 1]	[1 - 1.5]	[1.5 - 2]	[2 - 2.5]	[2.5 - 3]	[3 - 3.5]	[3.5 - 4]	[4 - 4.5]	[4.5 - 5]	[5 - 5.5]	[5.5 - 6]	[6 - 6.5]	[6.5 - 7]	[7 - 7.5]	[7.5 - 8]	[8 - 8.5]
N	0.191	1.1	0.819	0.261	0.0543	0.0038	0	0	0	0	0	0	0	0	0	0	0
NNE	0.35	1.78	0.687	0.0752	0.0076	0.001	0.0005	0.0008	0.0005	0.0003	0.0003	0.0005	0	0	0	0	0
NE	0.527	2.63	0.427	0.028	0.0015	0.0005	0	0	0.0003	0	0	0.0003	0	0	0	0	0
ENE	0.895	3.12	0.317	0.0018	0.0003	0.0003	0	0	0	0	0.0005	0	0	0	0	0	0
E	1.74	5.17	0.391	0.0102	0.0008	0	0	0	0	0.0003	0.0003	0	0	0	0	0	0
ESE	5.68	30	6.17	0.353	0.0145	0.001	0.0003	0.0003	0.0005	0.0003	0.0008	0	0	0	0	0	0
SE	2	19.5	10.3	0.847	0.0324	0.0051	0.0041	0.0005	0.001	0	0	0.0003	0	0	0	0	0
SSE	0.196	0.461	0.18	0.0321	0.0166	0.0018	0.001	0	0	0	0	0	0	0.0003	0.0003	0	0
S	0.113	0.206	0.116	0.0242	0.0099	0.0074	0.0028	0.0013	0.0023	0	0.001	0.0005	0.0005	0.0003	0.0003	0.001	0
SSW	0.0461	0.127	0.0795	0.0181	0.0087	0.0018	0.001	0.0015	0.0005	0.0013	0	0	0	0	0	0	0
SW	0.0242	0.0918	0.0614	0.0212	0.0079	0.0028	0.0028	0.001	0	0	0	0	0	0	0	0	0
WSW	0.0359	0.0829	0.0706	0.0247	0.0094	0.0008	0.0005	0	0	0	0	0	0	0	0	0	0
W	0.0403	0.105	0.0377	0.0166	0.0048	0	0.0008	0	0	0	0	0	0	0	0	0	0
WNW	0.067	0.202	0.0905	0.0362	0.0227	0	0.0008	0	0	0	0	0	0	0	0	0	0
NW	0.0617	0.327	0.17	0.079	0.0184	0.0033	0.0003	0	0	0	0	0	0	0	0	0	0
NNW	0.0964	0.47	0.333	0.141	0.0451	0.0122	0	0	0	0	0	0	0	0	0	0	0

Frequency of Wave Heights and Wave Periods (%)

Wave Period(s) \ Wave Height (m)	[0 - 0.5]	[0.5 - 1]	[1 - 1.5]	[1.5 - 2]	[2 - 2.5]	[2.5 - 3]	[3 - 3.5]	[3.5 - 4]	[4 - 4.5]	[4.5 - 5]	[5 - 5.5]	[5.5 - 6]	[6 - 6.5]	[6.5 - 7]	[7 - 7.5]	[7.5 - 8]	[8 - 8.5]
[15 - 18]	0.0013	0	0.0018	0.0008	0	0	0	0	0	0	0	0	0	0	0	0	0
[12 - 15]	0.0013	0.0082	0.0079	0.011	0.0054	0.0005	0	0	0	0	0	0	0	0	0	0	0
[9 - 12]	0.11	0.29	2.2	0.58	0.05	0.011	0.0074	0.0018	0.002	0.0015	0.002	0.001	0.0005	0.0005	0.0005	0.001	0
[6 - 9]	6.4	57	17	1.3	0.2	0.03	0.0074	0.0036	0.0031	0.0005	0.0008	0.0005	0	0	0	0	0
[3 - 6]	5.5	8.1	1.2	0.054	0.0013	0.0003	0	0	0	0	0	0	0	0	0	0	0
[0 - 3]	0.086	0.0015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Frequency of Windspeeds and Wind Directions (%)

Wind Speeds (m/s) \ Wind Directions (°)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
[26 - 28]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
[24 - 26]	0	0.0003	0	0	0	0	0	0.0015	0	0	0	0	0	0	0	0
[22 - 24]	0.0003	0.0005	0.0003	0	0	0.0005	0	0.0005	0	0	0	0	0	0	0	0
[20 - 22]	0.0003	0	0	0.0003	0.0003	0.0003	0	0.0008	0	0	0	0	0	0	0	0
[18 - 20]	0.0005	0	0.0003	0	0	0.0003	0.0013	0.0003	0.0005	0	0	0	0	0	0	0
[16 - 18]	0.0013	0	0	0.0003	0.0005	0	0.0008	0.0031	0	0	0	0.0003	0.0003	0	0.0003	0
[14 - 16]	0.0003	0	0	0	0.0003	0.001	0.0013	0.0025	0.0023	0.0015	0.0005	0	0.0003	0.0005	0	0
[12 - 14]	0.0168	0.0166	0.0028	0	0.0023	0.0138	0.0181	0.0087	0.0043	0.0015	0.0003	0	0	0	0.0005	0.001
[10 - 12]	0.134	0.172	0.041	0.0025	0.0041	0.0933	0.187	0.0357	0.0082	0.0059	0.0008	0.0005	0.001	0	0.0054	0.0161
[8 - 10]	0.335	0.48	0.245	0.0324	0.0454	0.902	1.2	0.17	0.0367	0.0161	0.0082	0.0031	0.0031	0.0122	0.0214	0.0941
[6 - 8]	0.491	1.1	1.34	0.354	0.654	3.24	2.7	0.512	0.0933	0.0278	0.0219	0.0143	0.012	0.0186	0.0691	0.224
[4 - 6]	0.724	2.43	4.66	2.79	4.24	5.16	3.06	1.21	0.28	0.0979	0.0507	0.0395	0.0438	0.088	0.186	0.335
[2 - 4]	1.85	4.85	10.4	12	9.75	6.42	4.08	2.74	1.66	1.05	0.796	0.63	0.634	0.643	0.782	0.998

Source: (Smith Warner International Limited, 2025)

Figure 4-32 Frequency of wind, wave height, wave direction and wave period for the 43 years of data

Nearshore Operational Wave Climate

The offshore wave data obtained from the ERA5 node underwent a tri-variate frequency analysis of wave height, period, and direction, commonly called "binning." This analysis categorised the wave data into 2152 distinct conditions or "events" based on wave height, peak period, and direction. Each event had a specific duration related to the number of occurrences over 43 years.

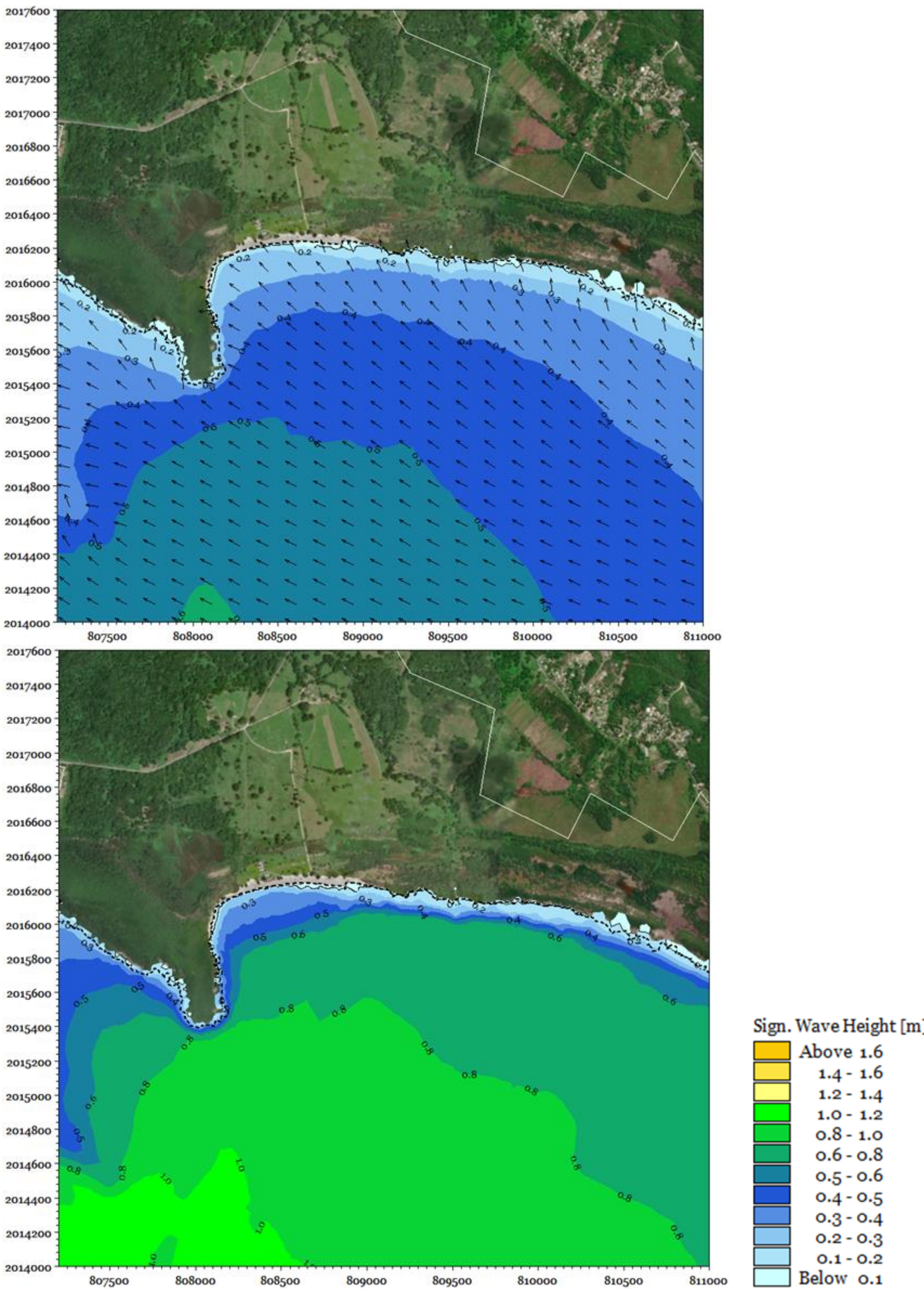
The ERA5 model is typically applied at spatial scales larger than 30km and outside the surf zone, which was not detailed enough to provide reliable nearshore wave data. Therefore, a spectral wave model called MIKE 21 SW (described in Appendix A) was utilised to develop the nearshore wave climate for the project area. This model simulated waves approaching from the west, southwest, south, southeast, and east, moving over the deep water to the nearshore bathymetry of the project area. The model was run in a semi-stationary mode with inputs of winds, wave heights, periods, and directions along the model domain's boundaries (Smith Warner International Limited, 2025).

The resulting nearshore wave climate data are displayed in Figure 4-33 as wave roses demonstrated the variation of wave heights and directions along the Westmoreland Paradise Park shoreline, wave roses were extracted at depths of around 1m to control any differences linked to wave breaking. E1 to E4, where the existing beach is, the average wave heights at these locations range from very calm to 0.35m annually. E5 to E7, where no existing beach is present, shows much higher wave heights, ranging from an annual average of 0.3 to greater than 0.5m (Smith Warner International Limited, 2025).

Source: (Smith Warner International Limited, 2025)

Figure 4-33 Nearshore wave roses along the shoreline of Paradise Park, Westmoreland

To better understand the spread of wave heights and wave directions at the Paradise Park shoreline, the mean annual average and the annual 99.86th percentile conditions were calculated and plotted and are shown in Figure 4-34. 99.86th percentile wave conditions correspond to wave conditions exceeding only 12 hours per year and may be used to describe an energetic swell condition. The main wave direction under the mean annual wave conditions was from the southeast with wave heights ranging between 0.2 to 0.4m. Under the yearly extreme wave conditions, wave heights increased from 0.3 to 0.8m just outside the headland. In general, the wave conditions along the Paradise Park shoreline are generally calm and even under extreme annual wave conditions, the conditions are still manageable (Smith Warner International Limited, 2025).



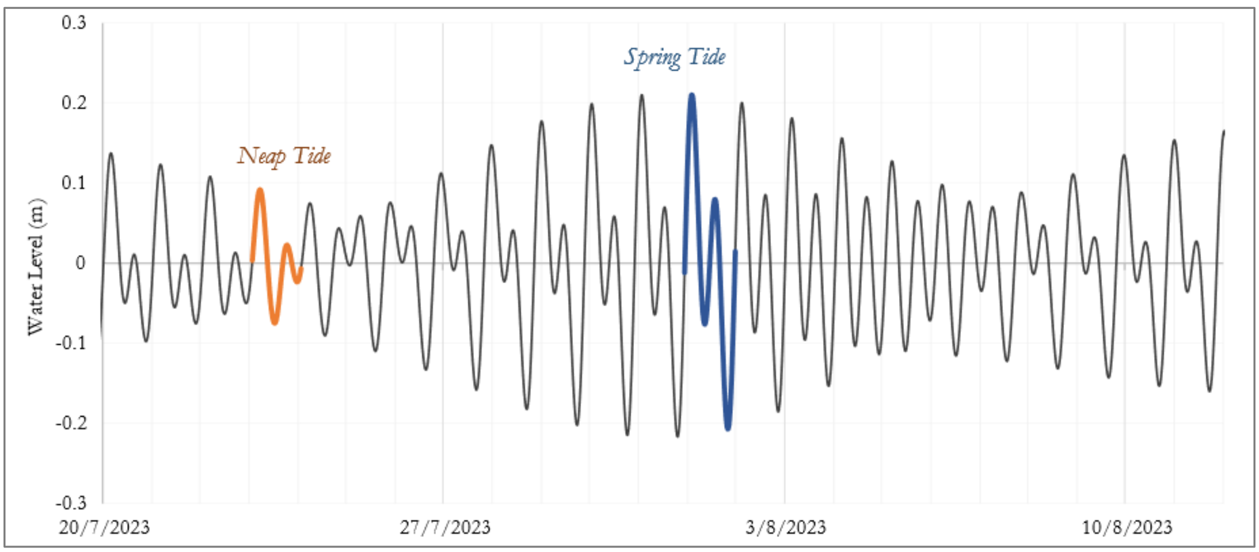
Source: (Smith Warner International Limited, 2025)

Figure 4-34 Significant wave heights along the Paradise Park, average conditions (top) and 99.86th percentile (bottom)

4.1.6.4 Operational Hydrodynamics

Global Tide Model

Global tide models are generally accepted as sufficiently accurate to describe operational hydrodynamics, including coastal circulation. Typically, these global tide models are based on harmonic analyses of measured tide gauge data or processed satellite observations. An example of a month's worth of the Denmark Technical University (DTU)[5] model-predicted tides just offshore the project site in Figure 4-35. The tidal signal has an unequal semi-diurnal pattern. This means that over a day, there are two high tides of different magnitudes and two low tides with different magnitudes. It should be noted that these model-generated tides tend to ignore thermal effects, which can vary the water level through the year by ±0.07m, and a multitude of other smaller factors that can cause "natural variability" in the tide; they are, however sufficient to form a basis for circulation and flushing analysis (Smith Warner International Limited, 2025).



Source: (Smith Warner International Limited, 2025)

Figure 4-35 Predicted tide levels near to Paradise Park in July of 2023

The following observations can be made about the tides:

- Tidal range is quite small. (approx. 0.48m);
- Typical spring high tide of 0.23m and a low tide of -0.25m;
- Typical neap high tide of 0.10m and a low tide of -0.15m;
- The tide plot also reveals a semi-diurnal signal, meaning there are two highs and lows per day, often of unequal magnitude, and

[5] The DTU10 global ocean tide model is an update of the AG95 ocean tide model with a resolution of 0.125° x 0.125° and including the 12 major tidal constituents.

- This tidal range is quite typical for the coast of Jamaica, and because of its relatively small range, tidally induced currents are negligible.

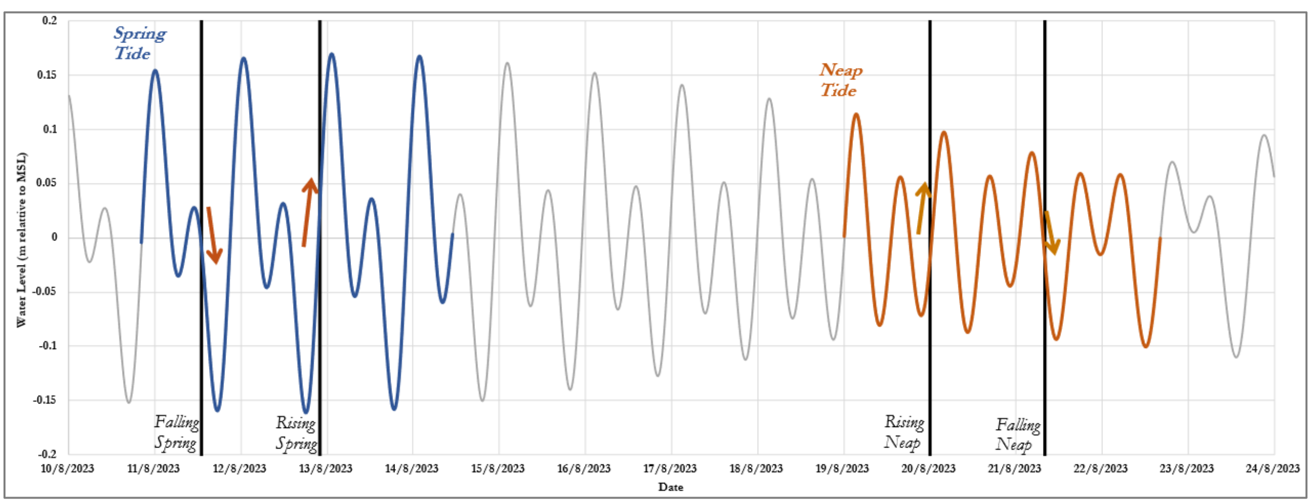
These values were similar in tidal range to the measured values described.

Water levels from the DTU global tide model were used as inputs to force the numerical models and derive daily currents around the project area.

Tidal Current Speeds and Direction with Waves

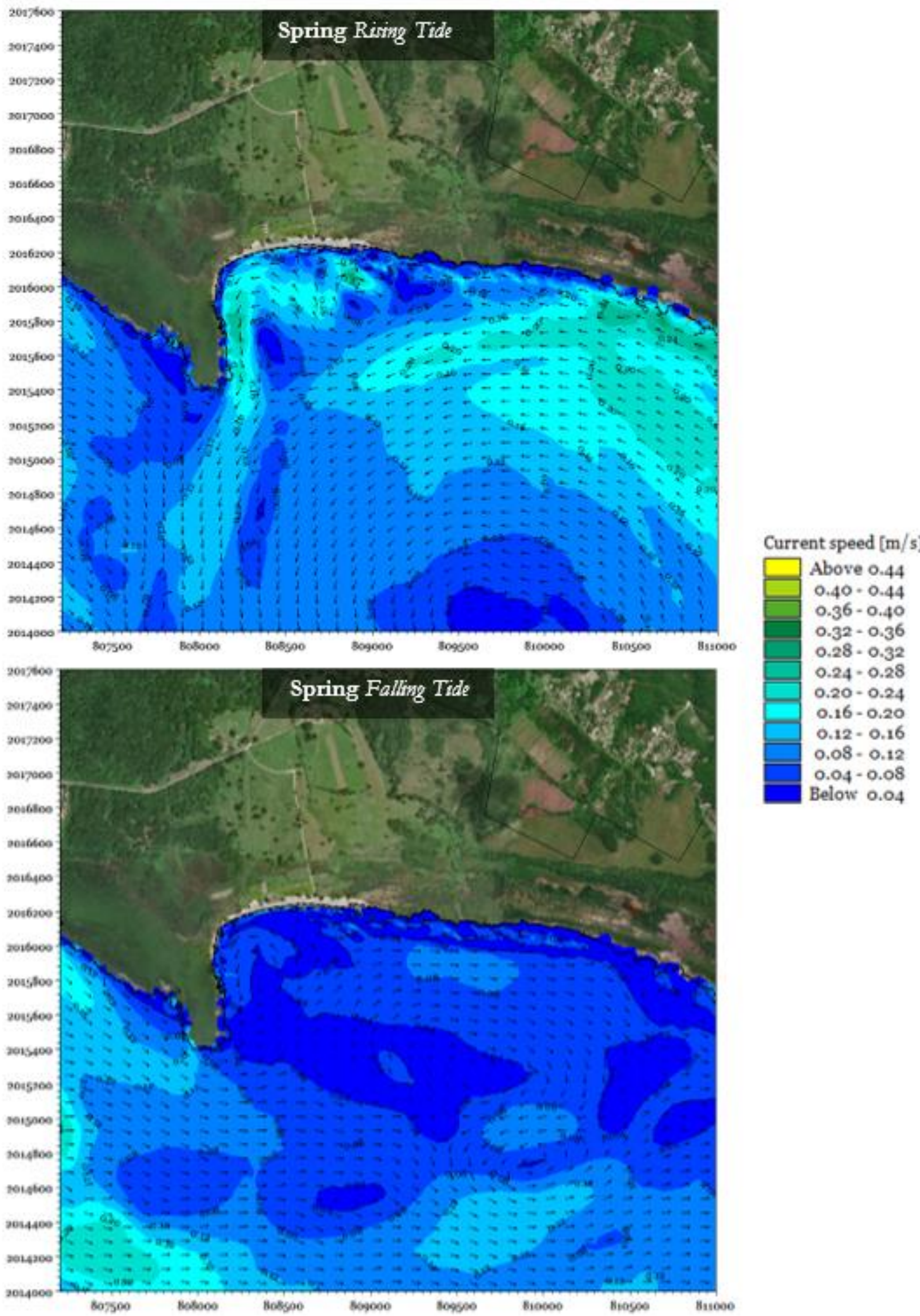
This section examines the influence waves have on the current speeds and direction along the shoreline. The mean annual wave height, which is approximately 0.5m in deeper water, was used for this simulation. The waves approached from the southeast, typical for the mean annual wave climate. What stands out is the influence of wave conditions on current directions; even when the tide is falling, the currents are still influenced by incoming waves, driving the currents towards the shore. In other words, current speeds as a result of waves are faster than just the tidally influenced current speeds (Smith Warner International Limited, 2025).

In addition to capturing differences in tidal ranges, the rising and falling phases of the tide signal were extracted to see how changing water levels affect current speeds and directions. Figure4-36 shows the instances used to show rising and falling tide currents for Paradise Park. Although the tidal currents are negligible due to the small tidal range in and around Jamaica, wind and wave-induced currents influence water circulation and add to water exchange and mixing. Rip currents are usually in the order of 0.6m/s and are generally unsafe for the average swimmer. For the nearshore along Paradise Park, the wave-induced current speeds range between 0.04 to 0.24m/s as shown in Figure 4-37 and 3-11. The nearshore areas are, therefore, safe for swimming (Smith Warner International Limited, 2025).



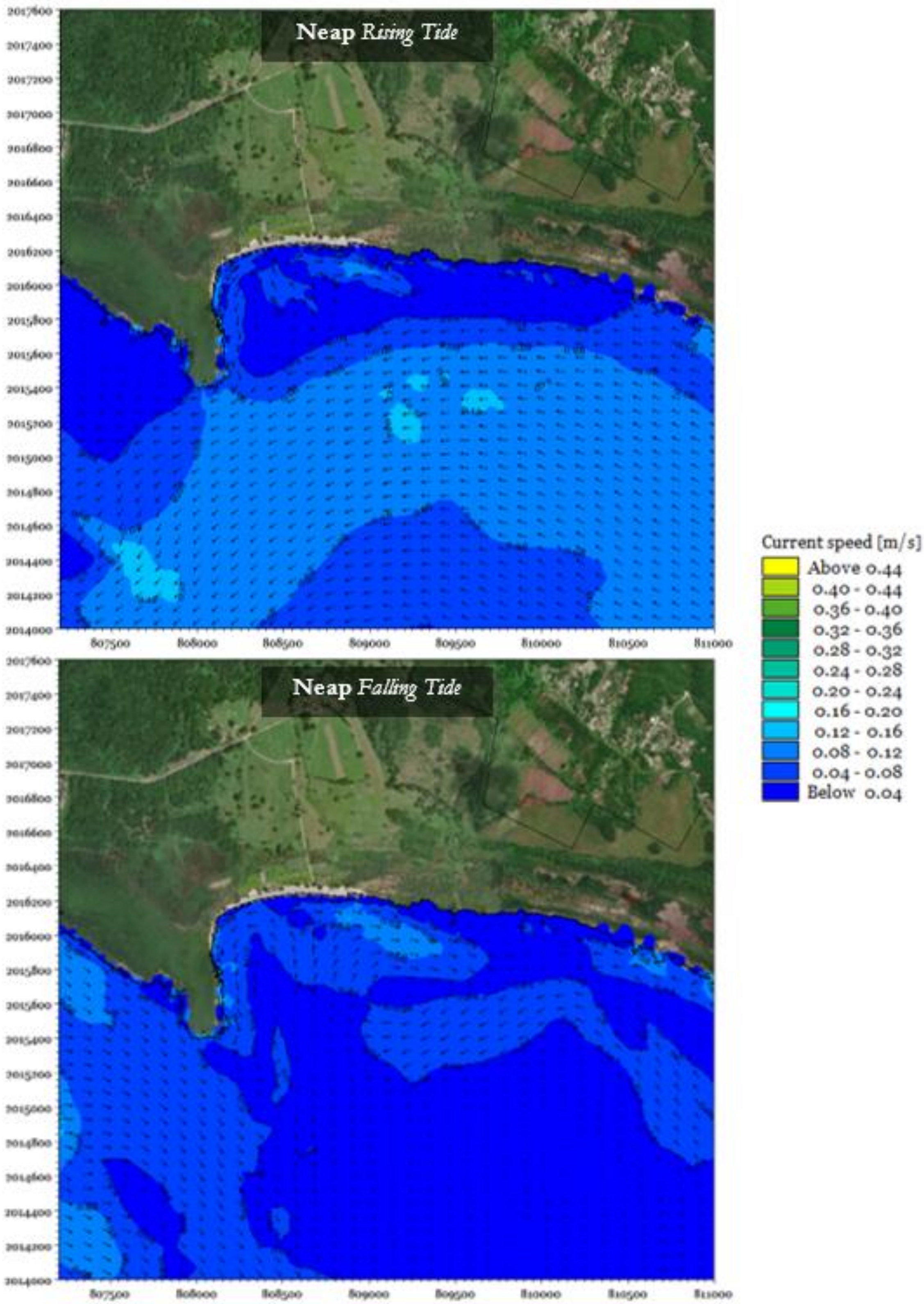
Source: (Smith Warner International Limited, 2025)

Figure4-36 Tidal signal during the simulation period with lines showing the instances used to examine the current regime (m relative to MSL)



Source: (Smith Warner International Limited, 2025)

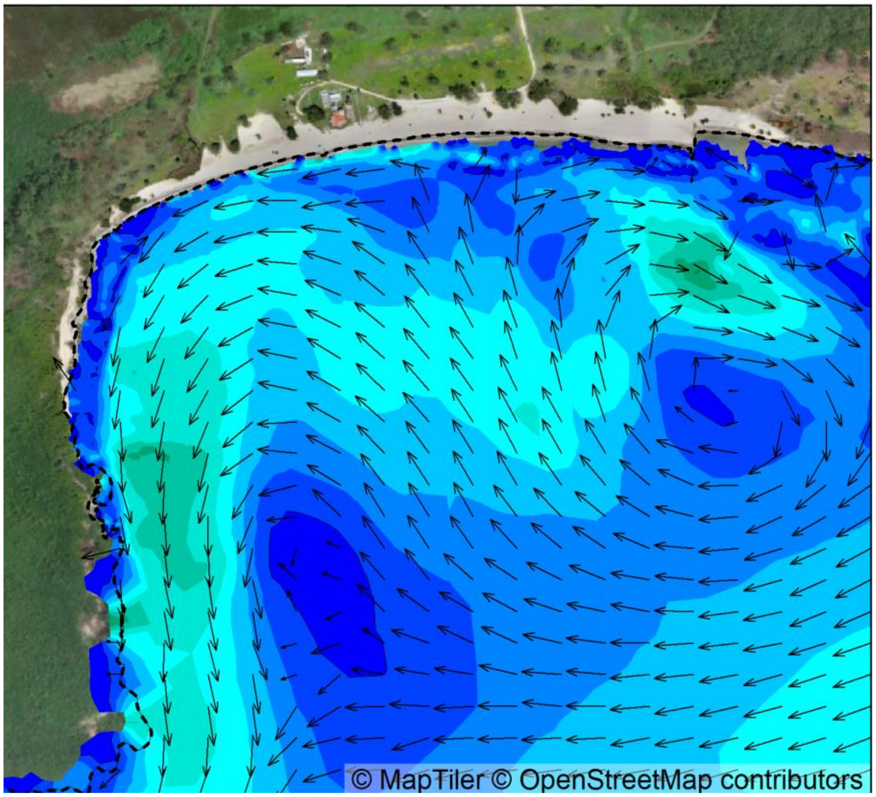
Figure 4-37 Tidal currents under spring tides in rising (top) and falling (bottom) under baseline conditions.



Source: (Smith Warner International Limited, 2025)

Figure 4-38 Tidal currents under neap tides in rising (top) and falling (bottom) under baseline conditions

One observation not shown in Figure 4-34 is the direction of the nearshore currents, which move both westward and eastward, as illustrated in Figure 4-39. This demonstrates the effectiveness of the eastern groyne in stabilizing the beach and preventing potential alongshore sediment transport to the east (Smith Warner International Limited, 2025).



Source: (Smith Warner International Limited, 2025)

Figure 4-39 Wave-induced currents under average wave conditions

4.1.6.5 Sediment Movement

Waves and currents are the most impactful drivers of sediment morphology, i.e., sediment movement in particular and changes in said sediment movement. The model validation exercise showed that the Paradise Park site's nearshore currents are well understood. Offshore wave data has also been assessed and categorised to determine that the site is very sheltered from wave action. Having developed a deeper understanding of the wave climate at the project site, the next step is understanding how and why the sediment is moving along the project shoreline. Sediment movement under existing conditions was assessed in three ways (Smith Warner International Limited, 2025):

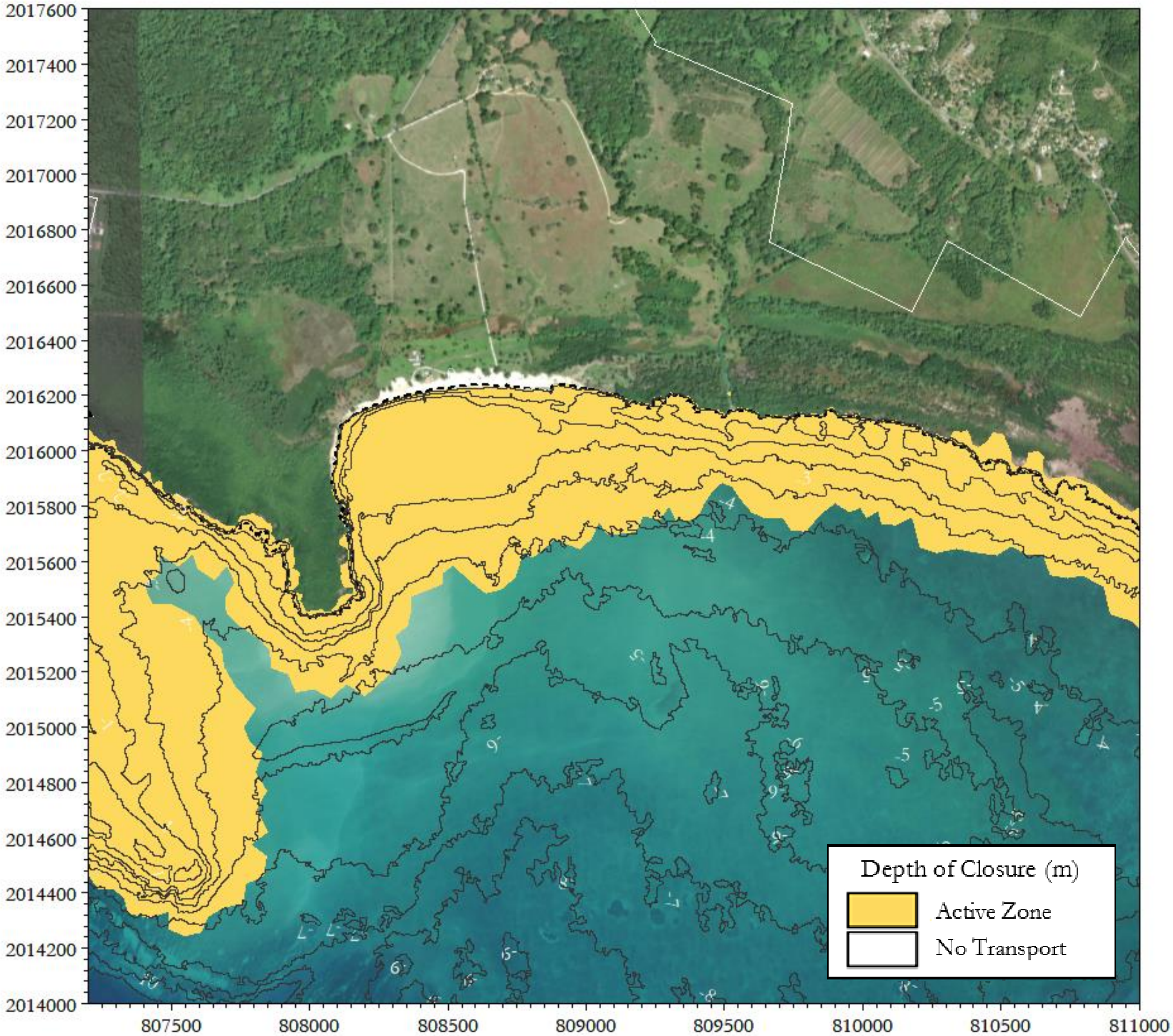
- Nearshore depths of closure were calculated to determine the zones of active transport,
- Annualised long-term transport parallel to the shoreline was described and

- Short-term (or episodic) cross-shore sediment movement was assessed to determine erosion/accretion patterns during a swell event (section 4.3.3).

Depth of Closure

The closure depth is the depth beyond which no significant longshore or cross-shore transport occurs due to littoral transport processes. Also, the depth of closure can be defined as the depth to which the zone of sediment movement is active or the depth at the seaward boundary of the littoral zone. Results showed that many areas had the potential for sediment transport (Figure 4-40); however, this area would have little transport since the substrate is mainly seagrass. Along the shoreline, there were varying widths of possible transport. To the west of the project site had an active zone width of about 250m to a depth of about 4m. To the east of the project was an active zone about 600m wide to a depth of about 4m. A very wide active sediment zone was located near the shore of the project site. The zone was an average of 700m wide, which corresponds to a depth of 4m. The wide transport zone is related to the mean annual wave condition at the property (Smith Warner International Limited, 2025).

The zone indicates that using perpendicular structures would trap considerable moving sediment. The depth of closure calculation is based on average conditions, which would inform long-term patterns. However, there is more complexity in the nearshore when an energetic event could widen the active zone. Both phenomena are explored further in the upcoming sections.



Source: (Smith Warner International Limited, 2025)

Figure 4-40 Depth of closure calculated for the Paradise Park nearshore.

Source: (Smith Warner International Limited, 2025)

Figure 4-41 Sediment agitation along Paradise Park shoreline.

Patterns of Sediment Movement

Sediment transport occurs on multiple scales that affect the stability of a beach:

- In the long term (multiple years), a dominant net transport is typical along the shoreline. Sand grains will move along the nearshore depending on the dominant drift direction. To maintain a beach, the sand flowing into a beach area and the sand flowing out should be in equilibrium. If there is an imbalance, there will either be accretion or erosion. The subsequent section explores this type of sediment transport.
- In the short term (a few days), high-energy swells can quickly erode beaches. These long-period waves churn up sediment in the water column and deposit it further offshore. Fortunately, the erosion that is seen after a swell event is typically not permanent, as the long-term patterns of sediment transport slowly move the offshore sediment back to the beach area. Section 4.3.3 details swell-induced sediment movement.

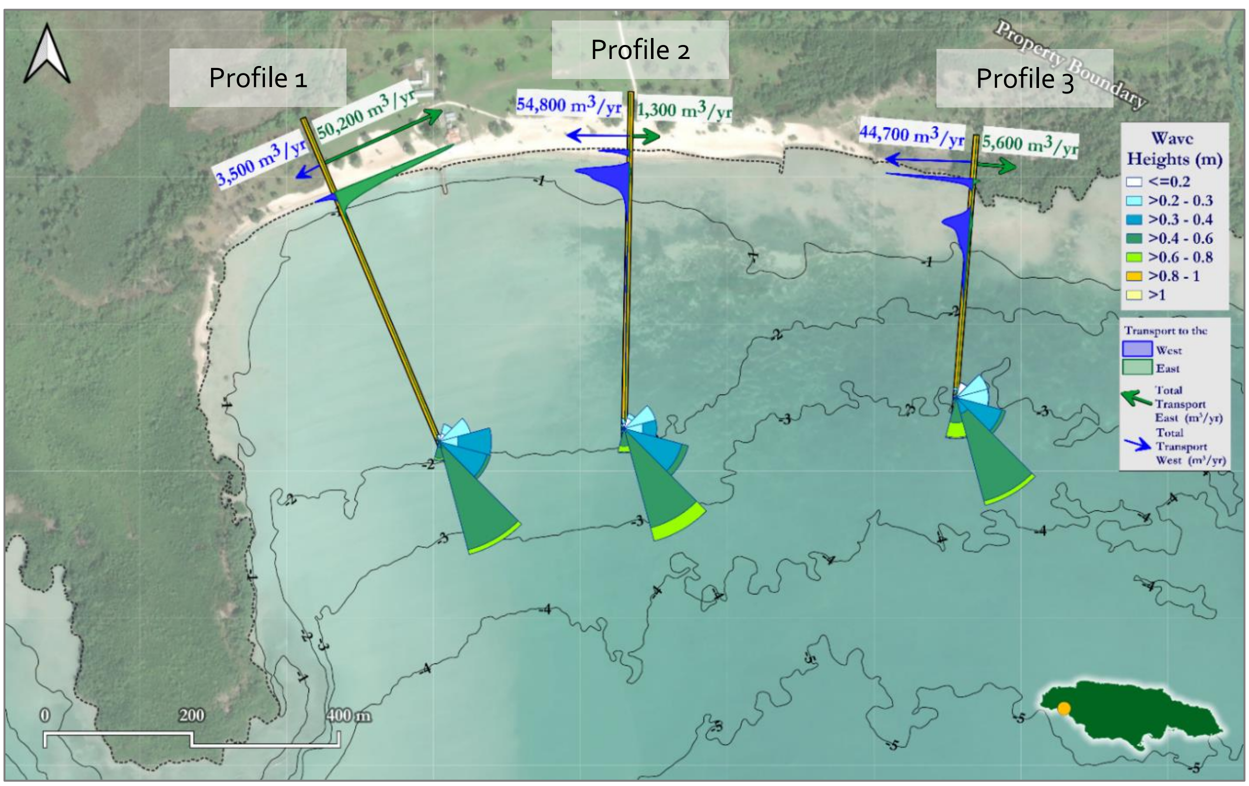
Long-Term Sediment Transport Patterns

Sediment transport along the shoreline was analysed by performing 1-dimensional sediment transport modelling for three profile lines that ran through the site. Two of these profiles extended to the 2m contour and the other to the 3m contour to capture the seafloor features (Smith Warner International Limited, 2025).

LitDrift was used to calculate the longshore sediment drift in the area. The program's inputs were annualised wave conditions at the end of the profiles, depths along the profiles, and sediment grain size properties described in the previous phase of the project. Figure 4-42 This shows the profile locations and wave conditions at the end of the profiles as the wave roses. Transport results for sediment movement are plotted along the profiles' length.

The results indicate that over a typical year, Profile 1 has about 3,500m^3 of transport to the west and 50,200m^3 to the east. Profiles 2 and 3 show more transport to the west, with 54,800m^3 and 44,700m^3 to the west and 1,300m^3 and 5,600m^3 to the east, respectively. The higher transport to the west is related to more waves approaching from the south-eastern sector. Most transport in Profile 1 happens within a 15m wide zone that starts at MSL. In Profiles 2 and 3, transport notably occurs in two sectors, approximately 10m and 25m long along both profiles. The 10m zone starts around MSL, while the 25m zone starts at the high-water mark (approximately 0.25m above MSL).

The wave roses at the end of the profiles show that most wave directions parallel to Profile 1 but are at an angle to Profiles 2 and 3, although about a quarter of the waves (20-25%) approach perpendicular to the profile. Perpendicular waves are more likely to generate movement across the profile, for instance, moving from the back of the beach to the nearshore shelf. The LitDrift program does not consider this mode of transport well in its calculations. To overcome this limitation, a perpendicular swell event was modelled to investigate how the sediment would move perpendicularly to the shore (Smith Warner International Limited, 2025).



Source: (Smith Warner International Limited, 2025)

Figure 4-42 LitDrift profile lines, wave roses at the profile ends, and sediment transport results are shown along the profiles.

4.1.6.6 Summary

The nearshore wave climate at Paradise Park shows average wave heights of 0.2–0.4 meters under normal conditions, with wave heights reaching up to 0.8 meters during extreme annual events. This indicates a generally calm wave environment along the shoreline. Longshore sediment transport modelling indicates that sediment movement is mainly driven by waves approaching from the southeast, with the majority of sediment transport occurring within a 10–25 meter zone extending from mean sea level. Additionally, the nearshore currents, driven by wave action and local hydrodynamics, move both westward and eastward along the main beach, influencing sediment transport and redistribution along the shoreline.

4.1.7 Water Quality

4.1.7.1 Background

Water Quality Assessment in Marine, Coastal, and Freshwater Systems

Water quality assessment involves the long-term evaluation of marine, coastal, freshwater, and brackish environments across both wet and dry seasons to understand seasonal variations, detect trends, and assess ecosystem health. This process is essential for identifying pollution sources, evaluating hydrological changes, and ensuring compliance with environmental standards.

In marine and coastal waters, assessments focus on temperature, salinity, pH, dissolved oxygen, and nutrient levels, along with biological indicators such as faecal coliform. Seasonal shifts can influence eutrophication, where excess nutrients lead to algal overgrowth, depleting oxygen and affecting marine life.

In freshwater and brackish systems, assessments cover rivers, gullies, wetlands, and pond-like water bodies, examining factors such as turbidity, flow rate, bacterial contamination, and nutrient fluctuations. Brackish areas, where freshwater meets seawater, require special attention due to changing salinity and tidal influence, while stagnant water bodies may experience pollution buildup and significant seasonal variation.

By conducting assessments over time, including across wet and dry seasons, this process provides critical insights into water quality trends, ecosystem resilience, and potential impacts on various habitats and species.

4.1.7.2 Methodology

Water quality sampling was carried out during seven (7) events between June 2023 and March 2025. While conditions were generally sunny and calm during sampling, rainfall had occurred prior to the sampling events in August, September, and October. The sampling seasons, days and weather conditions at the time of sampling can be viewed below in Table 4-5.

Table 4-5 Water quality seasons, sampling dates and weather conditions

Sampling Day	Season	Weather	Note
June 21, 2023	Dry	Sunny, Moderate to Calm wave climate	End of the first wet season
August 10, 2023	Dry	Fair and Sunny	Dry interlude, Start of second wet season
October 19, 2023	Wet	Fair and Sunny	Peak of second wet season
November 24, 2023	Wet	Sunny, Light wind and waves	End of the second wet season
September 27, 2024	Wet	Fair and Sunny	Within the second wet season
October 24, 2024	Wet	Fair and Sunny	Peak of second wet season
March 27, 2025	Dry	Partly Cloudy, Rough nearshore wave climate, calm offshore	Late dry season

Sampling Locations and Classification

Sampling was conducted at twenty-seven (27) stations (PP1–PP27), covering both freshwater and marine environments (Table 4-6 and Figure 4-43). The results were compared with the Draft NRCA Ambient Marine Water Quality Standards and the NRCA Ambient Freshwater Standards.

FRESHWATER STATIONS

Eleven (11) stations were classified as freshwater based on hydrological conditions and site characteristics: PP1, PP2, PP3, PP4, PP5, PP17, PP18, PP19, PP20, PP24, and PP25.

- PP24 was located along Salt River while PP1 was located along a tributary.
- PP2, PP3, PP4, and PP25 were located along the Deans Valley River.
- PP5 and PP19 were sampled from Sweet River.
- PP20 was taken from a community drain.
- PP17 and PP18 were sampled from a wetland area containing partially brackish standing water.

These stations were assessed using the NRCA Ambient Freshwater Standards.

MARINE STATIONS

Sixteen (16) stations, PP6–PP16, PP21–PP23, PP26, and PP27—were located both in and outside the BBFFS and were assessed using the NRCA Marine Water Quality Standards. Stations 26 and 27 were assessed using in-situ Hydrolab data only.

Table 4-6 Water quality sampling locations (JAD2001)

Station	Depth (m)	Freshwater/Marine/Brackish	Easting	Northing
PP 1	<0.5	Freshwater	633937.9102	674715.0552
PP 2	<0.5	Freshwater	636412.8053	674244.2886
PP 3	<0.5	Freshwater	636381.4586	674384.6809
PP 4	<0.5	Freshwater	635991.0069	674758.2146
PP 5	<0.5	Freshwater	635493.4367	674968.6295
PP 6	0.5	Marine	635307.3045	673808.0539
PP 7	2	Marine	635176.7593	673406.7946

Station	Depth (m)	Freshwater/Marine/Brackish	Easting	Northing
PP 8	3	Marine	635663.8272	673381.7273
PP 9	3	Marine	636124.068	673319.4824
PP 10	4	Marine	636520.8977	673280.9367
PP 11	2	Marine	637413.5831	673423.774
PP 12	1	Marine	637004.1282	673585.2744
PP 13	1	Marine	636592.7326	673638.6714
PP 14	0.5	Marine	636430.183	673841.7991
PP 15	0.5	Marine	636175.9276	673716.1106
PP 16	0.5	Marine	635728.705	673777.7473
PP 17	<0.5	Brackish	635159.9668	674020.4284
PP 18	<0.5	Brackish	635766.6067	673975.4392
PP 19	<0.5	Freshwater	635201.0386	674804.2959
PP 20	<0.5	Freshwater	638408.7122	673741.4181
PP 21	1	Marine	638075.3612	673178.6899
PP 22	3	Marine	637197.9787	673131.1209
PP 23	2	Marine	634116.5689	673390.1074
PP 24	<0.5	Freshwater	633782.5451	675219.7485
PP 25	<0.5	Freshwater	635622.1323	675461.9893
PP 26	3	Marine	635002.7981	673013.6099
PP 27	0.5	Marine	633926.165	673943.7885

ADDITIONAL FRESHWATER SAMPLING

In addition to the water quality assessment, further freshwater sampling was conducted as part of the freshwater ecological study to provide a more comprehensive evaluation of ecosystem conditions (Section 4.2.2.6). These results represent a single sample event from the Freshwater Habitat study, while the water quality assessment spans a seven-month period; the values presented here are averages over that timeframe and cannot be directly compared.

In-situ Parameters

Temperature, conductivity, salinity, dissolved oxygen, turbidity, Photosynthetically Active Radiation (PAR) – light irradiance, total dissolved solids (TDS) and pH were collected using a Hydrolab DataSonde-5 water quality multi probe meter (**Error! Reference source not found.**) and light extinction through the water column was calculated from PAR values recorded.

Lab Analysis

Water quality samples were collected in pre-sterilized bottles, stored on ice, and taken to Caribbean Environmental Testing and Monitoring Services Limited (CETMS Ltd.) for analysis of Total Suspended Solids (TSS), Phosphates, Nitrates and Faecal Coliform, as well as Environmental Technical & Analytical Service Ltd (ETAS) for analysis of Biological Oxygen Demand (BOD).

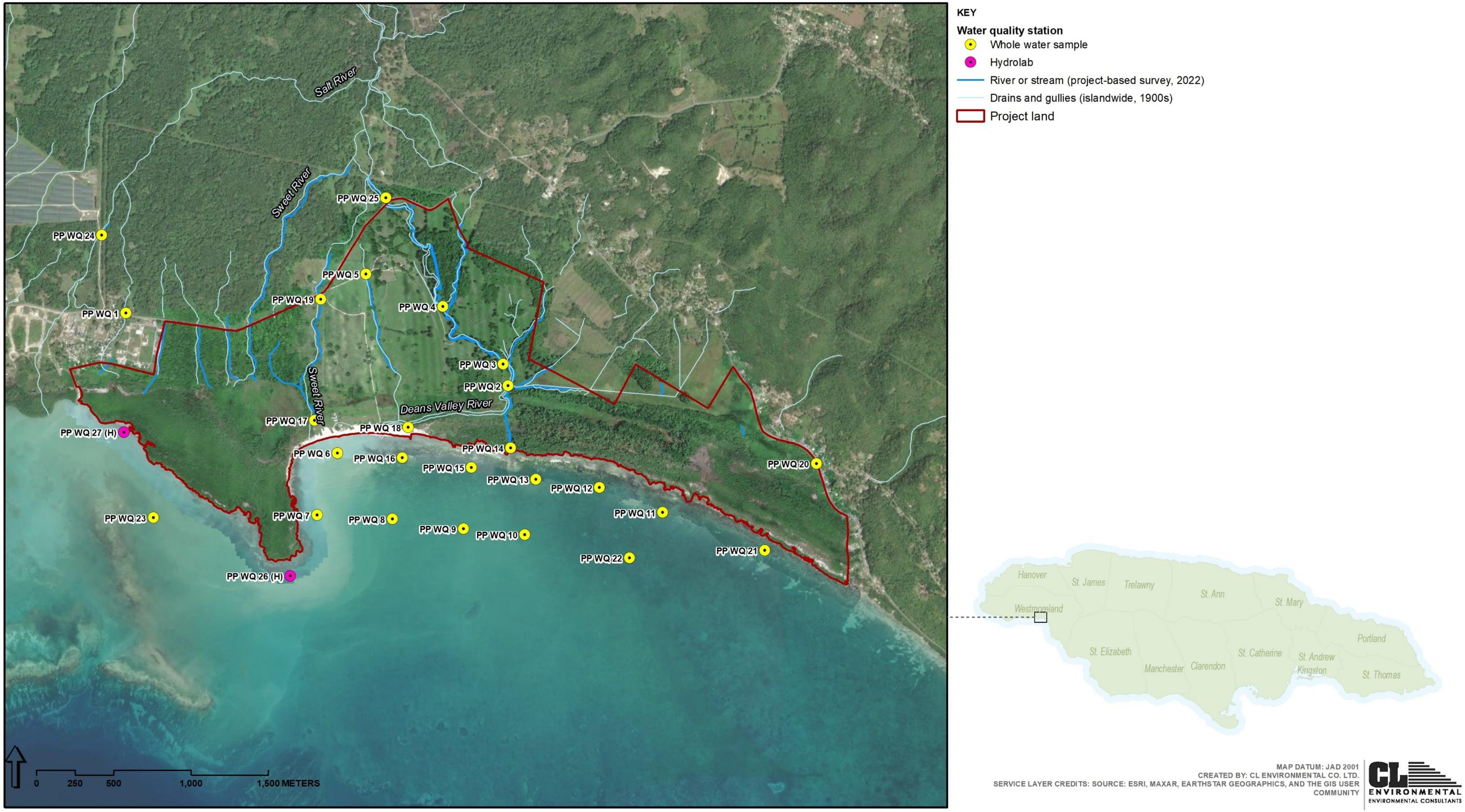


Figure 4-43 Water quality sampling stations

4.1.7.3 Results

This section presents the average water quality results collected during the entire sampling period, aimed at capturing seasonal variations; raw data is provided in **Error! Reference source not found.**.

Results Summary

FRESHWATER IN SITU ANALYSIS

Most in situ water quality parameters fell within expected ranges and standards, however four stations exceeded conductivity standards, and all were non-compliant for total dissolved solids. Possible influences most likely included marine water for nearshore stations (PP17 and PP18) and dissolved minerals or pollutants further inland (PP19 and PP20) (Table 4-7).

- Average water temperature values were all considered typical for tropical freshwater locations, with low readings at rivers and streams and higher readings for the stagnant water and the shallow drain (PP20).
- Conductivity, Salinity and Total Dissolved Solids (TDS) values were higher than typical for freshwater environments at most stations, with non-compliant TDS values at all stations, these elevated values may have been due to saltwater infiltration for stations closer to shore, or dissolved minerals and pollution.
- Average dissolved oxygen (D.O.) values were mostly within acceptable levels (>4 mg/l) and above the critical threshold that is considered detrimental to aquatic life (< 3 mg/l) (United States Environmental Protection Agency, 2016). However, Stations PP18 and PP19 were below <4mg/l with Station PP17 being below <3mg/l. Stations PP17 and PP18 were located in shallow brackish water, these areas were fairly stagnant with decaying flora, while Station PP19 was located in a drain which was not free flowing, and had shallow stagnant pools these locations were typical of low DO environments.
- Average pH values were considered normal for freshwater and were found to be compliant with the NRCA freshwater quality standard (7-8.4NTU).
- Water turbidity remained low for most stations but was elevated at Stations PP17, PP18 and PP20. Station PP17 and 18 were located within marshy lowland, the water there was shallow with little movement and a soft sediment bottom, these factors most likely caused increased turbidity levels. Station PP20 was located within a drain, which was stagnant, with a cloudy appearance and littered with solid waste.

Table 4-7 Average Freshwater in-situ data

Station	Temp. (°C)	Cond. (mS/cm)	Salinity (ppt)	pH	D.O. (mg/l)	Turbidity (NTU)	TDS (g/l)
PP1	27.95	0.5320	0.27	7.76	5.69	0.00	0.3384
PP2	26.54	0.4791	0.24	7.92	8.01	0.00	0.3073
PP3	26.22	0.4819	0.24	7.92	8.23	0.00	0.3373
PP4	26.96	0.4944	0.25	7.80	8.00	0.00	0.3164

Station	Temp. (°C)	Cond. (mS/cm)	Salinity (ppt)	pH	D.O. (mg/l)	Turbidity (NTU)	TDS (g/l)
PP5	27.41	0.4744	0.24	7.94	6.83	0.00	0.3039
PP17	29.87	8.6457	5.27	7.68	4.22	8.85	5.5280
PP18	27.78	0.6141	0.31	7.60	4.08	8.33	0.3941
PP19	27.75	0.6453	0.33	7.45	3.67	0.00	0.4139
PP20	31.14	0.7484	0.39	7.49	6.06	16.30	0.4784
PP24	27.51	0.4938	0.25	7.80	5.88	0.02	0.3160
PP25	26.73	0.4873	0.25	7.54	7.67	0.00	0.3121
NRCA Fresh Water Std.	-	***0.15 – 0.6***	-	***7 – 8.4***	-	-	***0.12 – 0.3***

NB. Numbers in red are non-compliant with the standard/guideline.

FRESHWATER LABORATORY ANALYSIS

Nitrate and phosphate values at all stations sampled were compliant with the NRCA freshwater standards (Table 4-8). Average faecal coliform values were high at all stations with the highest value 5,197 MPN/100ml at Station PP17, and the lowest value being 113 MPN/100ml at Station PP19. Biological oxygen demand (BOD) values were non-compliant with the NRCA standards. Higher BOD and faecal coliform values were recorded in onsite areas influenced by animals, where the presence of buffaloes, horses, cows, sheep, and goats may have contributed to these levels through direct interaction with water bodies or runoff carrying animal waste into streams and rivers during rainfall and storm events. Off-site areas were influenced by the surrounding community, with anthropogenic pollution from solid waste dumping and untreated sewage discharge.

Total suspended solids (TSS) levels at freshwater stations mirrored the turbidity values and remained low, indicating mostly clear water, with high values for brackish Stations 17, 18 and 20 which also had higher turbidity values.

Table 4-8 Average Freshwater laboratory data

Station	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	BOD (mg/l)	Faecal Coliform (MPN/100ml)
PP1	3.67	0.65	0.52	2.35	2458
PP2	5.57	1.29	0.45	3.63	743
PP3	3.86	1.11	0.30	3.59	1671
PP4	3.57	1.31	0.21	3.81	876
PP5	4.57	1.04	0.18	3.29	1124
PP17	94.29	0.67	0.60	14.06	5197
PP18	109.86	0.69	0.33	6.01	2226
PP19	21.25	2.03	0.22	2.87	113
PP20	26.60	0.98	0.27	3.64	132
PP24	9.67	0.58	0.22	4.21	2600
PP25	2.83	1.25	0.31	1.73	1930
NRCA Fresh Water Std.	-	***0.1 – 7.5***	***0.01 – 0.8***	***0.8 – 1.7***	-

NB. Numbers in red are non-compliant with the standard/guideline.

Examples of the freshwater sample locations can be observed in Plate 4-6 through to Plate 4-10.

Plate 4-6 Water Quality Station PP1

Plate 4-7 Water Quality Station PP3 (Deans Valley River)

Plate 4-8 Water Quality Station PP5 (Small water channel running through property)

Plate 4-9 Water Quality Station PP17 (Brackish)

Plate 4-10 Water Quality Station PP19 (Channel where Sweet River enters the property)

MARINEWATER IN SITU ANALYSIS

Most marine in situ water quality parameters fell within expected ranges and standards. With possible influences from nearshore runoff or possible upwellings (Table 4-9).

- Average water temperatures recorded were higher than the typical tropical marine range of 24–29°C, ranging from 26.40 to 30.55°C, with only one station, Station PP14 being below 29°C due to freshwater influences. These elevated temperatures are above the usual range for tropical marine waters, which may reflect broader climatic trends. The period sampled mostly took place during 2024, which coincided with record high temperatures (Hydrology, 2024).
- Conductivity, Salinity and Total Dissolved Solids (TDS) values were within normal ranges for tropical marine environments at all stations. However, Station PP14 had low values most likely due to freshwater outflow from the nearby river.
- Average dissolved oxygen (D.O.) values at all locations were all within acceptable levels (>4 mg/l) and above the critical threshold that may be considered detrimental to aquatic life (< 3 mg/l) (United States Environmental Protection Agency, 2016).
- Average pH values were mostly considered normal for seawater however, a few stations had low values and were found to be non-compliant with the NRCA marine water quality standard (8-8.4NTU).
- Water turbidity remained low for most marine stations but were elevated at a few stations. Station PP6 was located near shore on the south of the property, this location was most often noted to be very cloudy due to wave action. Station PP27 was located to the west of the property; this location was shallow with silty substrate which was easily re-suspended.

- Light extinction calculated ranged from 0.2254 – 1.5118. The extinction coefficient indicates the rate of loss of light with depth. Stations located in a seagrass bed further from land influences, such as PP10 and PP12 have lower extinction coefficients, indicating better light transmission due to fewer suspended particles. In contrast, areas, which experience high wave action and lack seagrass coverage, exhibited higher extinction coefficients, likely due to increased water turbulence and resuspension of sediments, for example PP6 and 7.

Table 4-9 Average in-situ water quality data

Station	Depth (M)	TEMP. °C	COND (mS/cm)	SAL (ppt)	pH	D.O. (mg/l)	Turb (NTU)	TDS (g/l)	PAR (uE/cm/s)	EC
PP6	0.5	29.76	53.44	35.37	7.99	5.18	40.29	34.20	1014	1.5118
PP7	2	29.90	53.93	35.67	8.08	5.86	26.33	33.31	629	1.1490
PP8	3	30.13	53.96	35.75	8.11	5.90	1.84	34.52	464	0.4356
PP9	3	30.21	53.82	35.65	8.10	5.81	0.97	34.43	511	0.3605
PP10	4	30.23	53.47	35.48	8.10	5.97	1.06	34.48	536	0.3260
PP11	2	30.17	53.86	35.72	8.02	4.87	0.61	34.41	741	0.2945
PP12	1	30.19	53.78	35.62	8.02	4.72	0.48	34.45	880	0.2716
PP13	1	30.49	53.41	35.40	8.04	5.35	1.04	33.99	988	0.2254
PP14	0.5	26.40	12.92	8.52	7.89	6.25	40.75	8.94	1026	0.8886
PP15	0.5	30.55	53.20	35.17	8.00	5.13	4.44	34.04	1121	0.3890
PP16	0.5	30.08	53.56	35.44	8.02	5.19	7.34	34.26	1014	0.4054
PP21	1	30.33	53.88	35.68	8.01	4.82	1.97	34.47	740	0.4488
PP22	3	30.23	54.02	35.79	8.09	5.70	0.68	34.55	628	0.3310
PP23	2	29.71	53.60	35.49	8.06	5.28	3.36	34.36	444	0.4237
PP26	3	30.02	53.96	35.75	8.07	5.04	6.82	34.53	395	0.8519
PP27	0.5	29.77	53.43	35.38	7.96	4.18	55.95	34.29	450	0.5877
NRCA Marine Water Standard		-	-	-	***8 - 8.4***	-	-	-	-	-

NB. Numbers in red are non-compliant with the standard/guideline.

MARINEWATER LABORATORY ANALYSIS

Nitrate and phosphate values at all stations sampled were non-compliant with the NRCA marine standard; however, these nutrient values are considered normal for Jamaican coastal waters and seldom vary outside of this range.

Average faecal coliform and biological oxygen demand (BOD) values were mostly non-compliant with NRCA standards across stations, however pp15 was compliant for BOD and PP8, 11 and 21 were compliant for F. coliform levels. Similar exceedances in both freshwater and marine environments suggest that freshwater inputs are a primary driver of contamination. These freshwater systems, influenced by agriculture, livestock (buffaloes, horses, cattle, sheep, and goats), human activity, and runoff, likely transport pollutants (which may including untreated sewage) and solid waste, into marine areas. While direct pollution sources may also contribute, freshwater discharge likely serves as the main conduit for contaminants reaching coastal waters.

Total suspended solids (TSS) levels at marine stations mirrored the turbidity values and remained low, indicating mostly clear water, the highest TSS value was at Station PP6 which also had the highest turbidity value.

Table 4-10 Average Marine laboratory water quality data

Station	Depth (M)	TSS (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	BOD (mg/l)	Faecal Coliform (MPN/100ml)
PP6	0.5	21.86	1.74	0.09	3.18	3086
PP7	2	12.43	1.90	0.15	2.94	20
PP8	3	4.14	2.34	0.18	3.22	8
PP9	3	3.43	1.93	0.07	3.35	37
PP10	4	3.43	1.93	0.36	2.29	29
PP11	2	3.71	2.11	0.08	2.64	13
PP12	1	3.86	1.97	0.22	2.15	270
PP13	1	4.14	1.94	0.21	2.17	106
PP14	0.5	10.00	1.16	0.33	3.33	261
PP15	0.5	2.83	2.23	0.30	1.01	206
PP16	0.5	4.29	2.21	0.23	2.32	1900
PP21	1	3.57	2.16	0.17	2.30	12
PP22	3	3.14	1.71	0.07	1.97	903
PP23	2	4.29	1.93	0.07	2.34	1047
NRCA Marine Water Std.		-	***0.007-0.014***	***0.001-0.003***	***1.16***	***<2-13***

NB. Numbers in red are non-compliant with the standard/guideline.

Freshwater Analysis

TEMPERATURE

Temperature is a measure of how warm or cold the water is at the time of sampling. Differences in temperature may influence the types of flora and fauna present in these environments. In addition, temperatures influence the amount of dissolved oxygen (D.O.) in water, as colder water holds more D.O.

Freshwater temperatures results showed a range of 25.12 °C (PP24) to 34.11 °C (PP20), the full range of results can be seen in **Error! Reference source not found.**. The average temperature across all of the stations was 27.73°C. The lowest average temperatures were found along the Deans Valley River at PP3 (26.22 °C) while the highest average temperature was at the drain PP20 (30.14 °C), (Figure 4-44).

The temperature variations observed were most likely due to differences in flow and vegetation coverage (riparian vegetation as well as the surrounding canopy). Stations PP2, PP3, Pp4 and PP25 were located along the Deans Valley River, which was the largest freshwater body on the property, this river had constant flow during Dry and Wet seasons with low temperatures. Station PP17 (brackish) was situated in a marshy lowland area, characterized by shallow, stagnant water with minimal movement, located close to the coast. This station had little vegetation both in the water and along the canopy, which was absent entirely. PP20, positioned in a concrete drain to the east of the property and with flow limited to periods of rain. The conditions observed at both stations are indicative of higher temperatures, which were recorded at these locations.

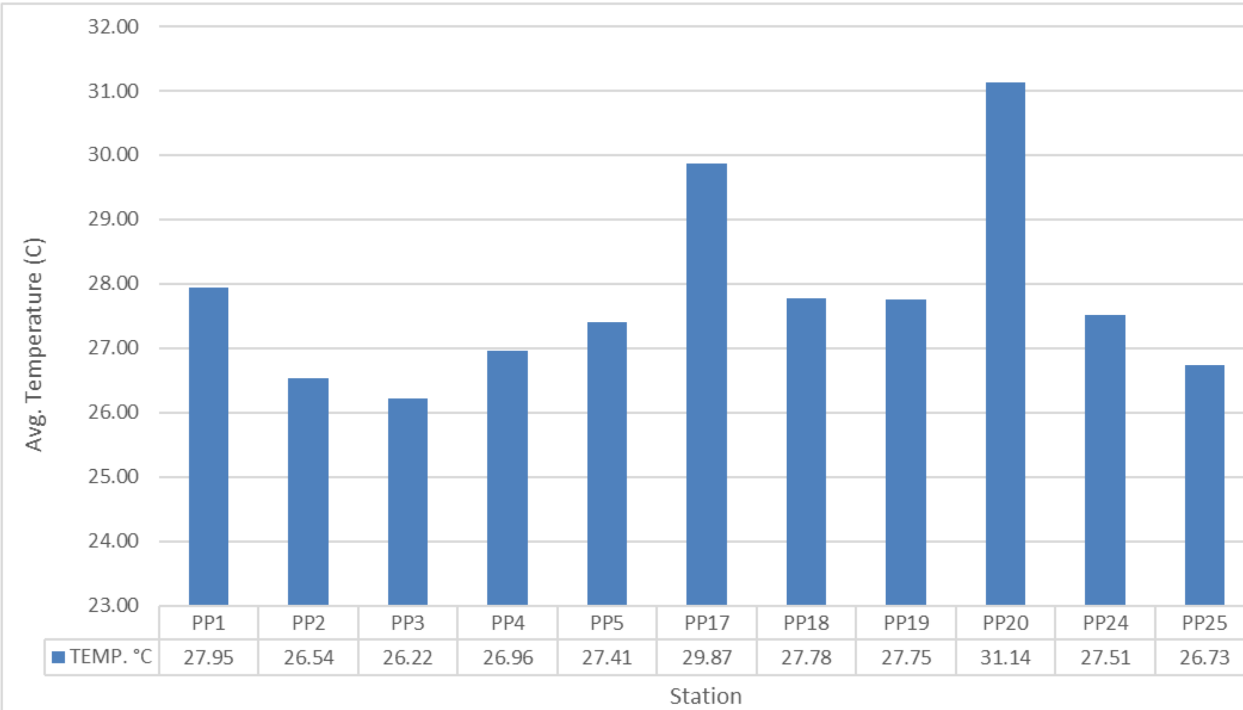


Figure 4-44 Average temperature levels at freshwater stations

Statistical Analysis – Temperature

There were significant spatial differences in temperature (ANOVA $p<0.5$), these differences showed significantly higher temperatures at Stations PP 17 and PP 20 compared to the other stations sampled. Figure 4-45 shows the mean temperature differences between the freshwater stations. Tukey's HSD test was also used to confirm these findings, showing marked differences $p<0.05$ between Stations PP17 and PP 2 to 5 and 24 and 25 and significant differences between PP 20 and all other stations besides PP17.

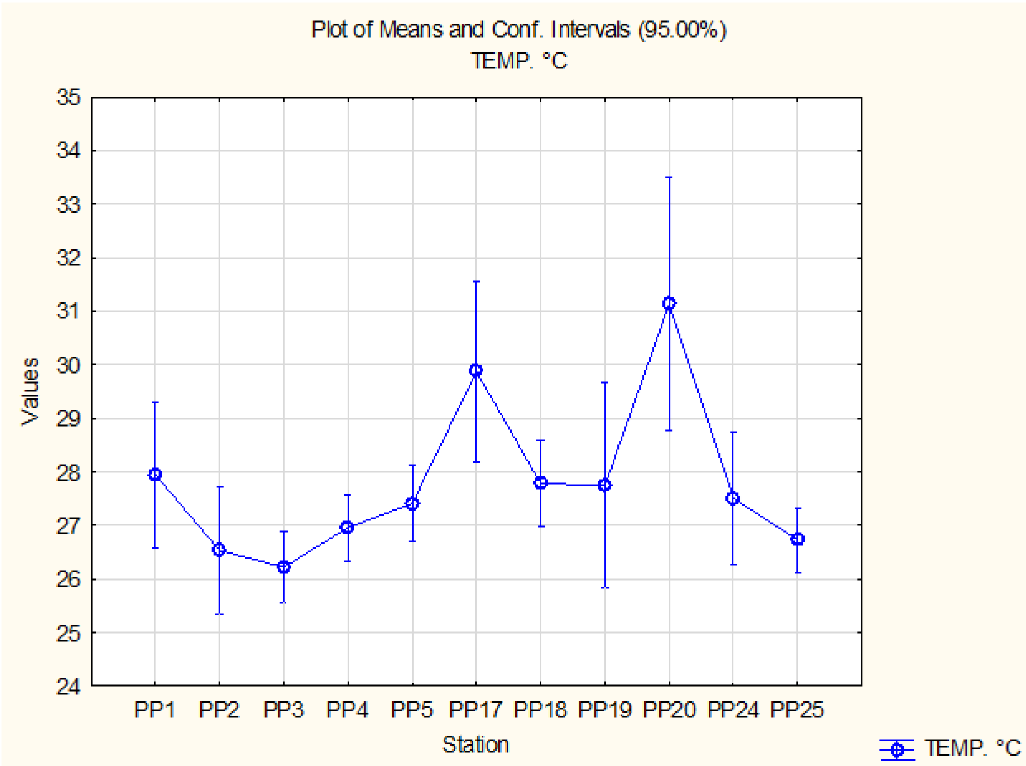


Figure 4-45 Mean temperature differences between freshwater stations

There were no significant temporal differences in temperature (ANOVA $p>0.05$). Results showed no seasonal differences throughout the year between wet and dry seasons. Temperature values peaked during October 2023 and the lowest temperatures were observed during November 2023.

SPECIFIC CONDUCTIVITY

Conductivity is a measure of the number of free ions within a given water sample and, in conjunction with salinity, is used to gauge whether the water sample is saline/marine or non-saline/fresh water. Typically, higher conductivity readings indicate a greater presence of free ions in the water sample, which is common in saline water compared to fresh water.

Freshwater conductivity results showed a range of 0.4452mS/cm (PP3,5 and 25) to 37.92ms/cm (PP17), the full range of results can be seen in **Error! Reference source not found.**. The average conductivity across all of the stations was 1.358 mS/cm. The lowest average conductivity was at Station PP5 (0.4744 mS/cm) while the highest average conductivity was at Station PP17 (8.6457 mS/cm), located within the wetland area towards the southern end of the property, beside the sea. Figure 4-46 shows the average conductivity readings measured for all eleven freshwater stations.

The conductivity variations observed were most likely due to differences in proximity to the sea and possible dissolved minerals or pollutants. Stations PP2, PP3, Pp4 and PP25 were located along the Deans

Valley River, which was the largest freshwater body on the property, this river had constant flow during Dry and Wet seasons with low conductivity values. Station PP17 was located within marshy lowland, the water there was shallow and stagnant, with little movement, its proximity to the sea may have also allowed for salt water to infiltrate increasing the conductivity readings. Station PP20 was located in a drain to the east of the property, the condition of the water in this station had shallow pools with visually polluted waters from the nearby community, some of these pollutants may have caused increased conductivity.

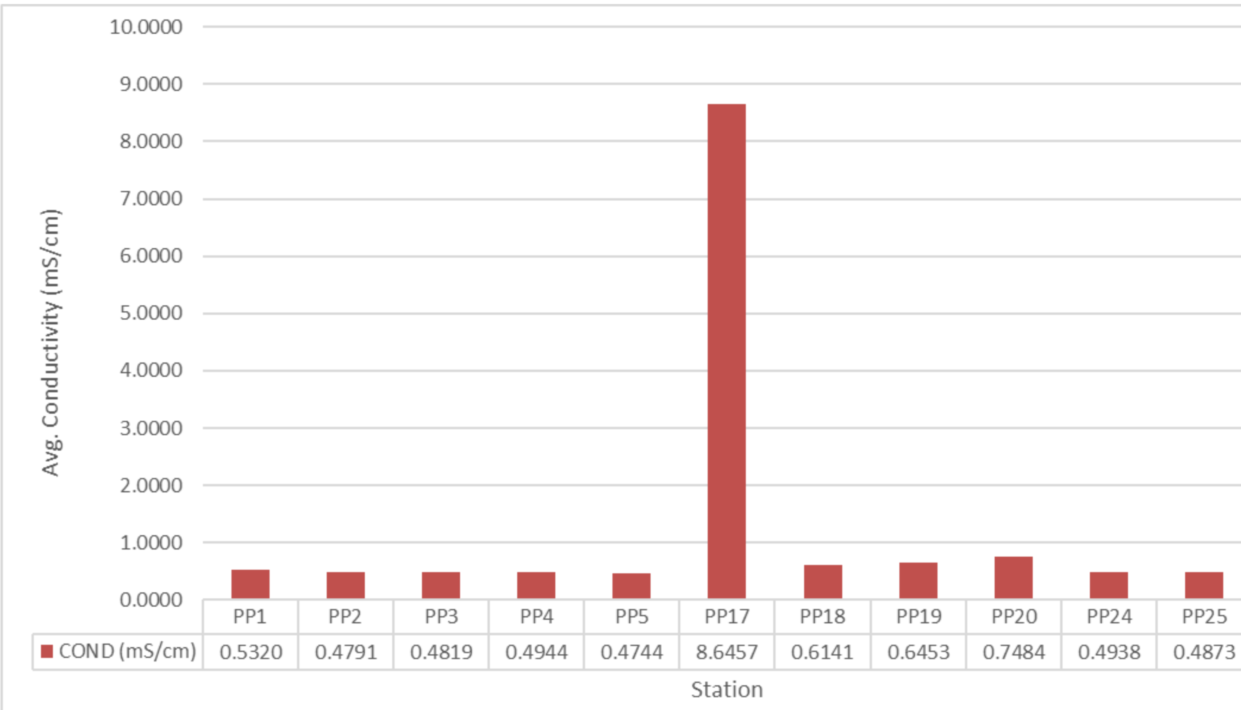


Figure 4-46 Average specific conductivity levels at freshwater stations

Statistical Analysis – Specific Conductivity

There were significant spatial differences in conductivity (ANOVA $p<0.5$), these differences showed significantly higher conductivity levels at Station PP 17 compared to the other stations sampled. Figure 4-47 shows the mean conductivity differences between the freshwater stations. Tukey's HSD test was also used to confirm these findings, showing marked differences $p<0.05$ between Stations PP17 and Stations PP2 to PP5 and PP18.

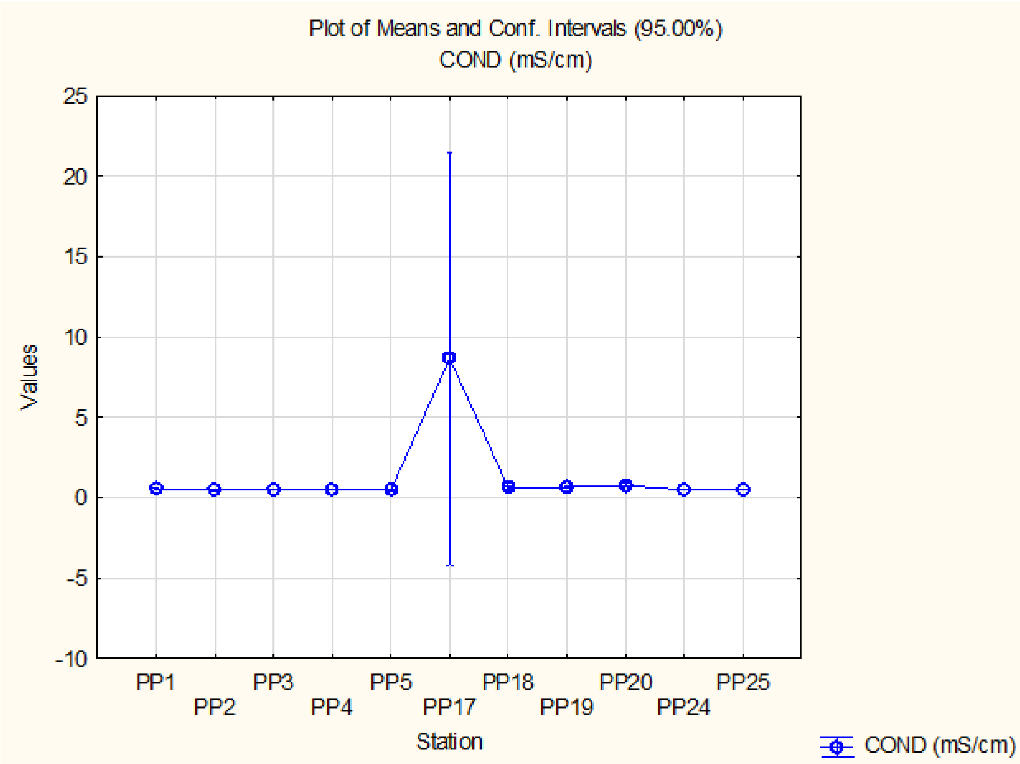


Figure 4-47 Mean conductivity differences between freshwater stations

There were no significant temporal differences in conductivity (ANOVA p>0.05). Results showed no seasonal differences throughout the year between wet and dry seasons. Conductivity values peaked during March 2025 and the lowest values were observed during October 2023.

SALINITY

Salinity is the concentration of dissolved salts in water, salinity and conductivity concentrations are directly related as the salt ions increase conductivity. Salinity values recorded (and trends noted) were similar to that of conductivity readings obtained during the monitoring exercise and support the general inferences discussed under the section on Conductivity.

Freshwater salinity results showed a range of 0.22ppt (PP5) to 24.09ppt (PP17), the full range of results can be seen in **Error! Reference source not found.**. The average salinity across all the stations was 0.78ppt. The lowest average salinity was 0.24ppt at Stations 2,3 and 5 located along Deans Valley Rivers while the highest average salinity was at Station PP17 (5.27ppt), located within the wetland area towards the southern end of the property, beside the sea.

Figure 4-48 shows the average salinity readings recorded for all eleven freshwater stations.

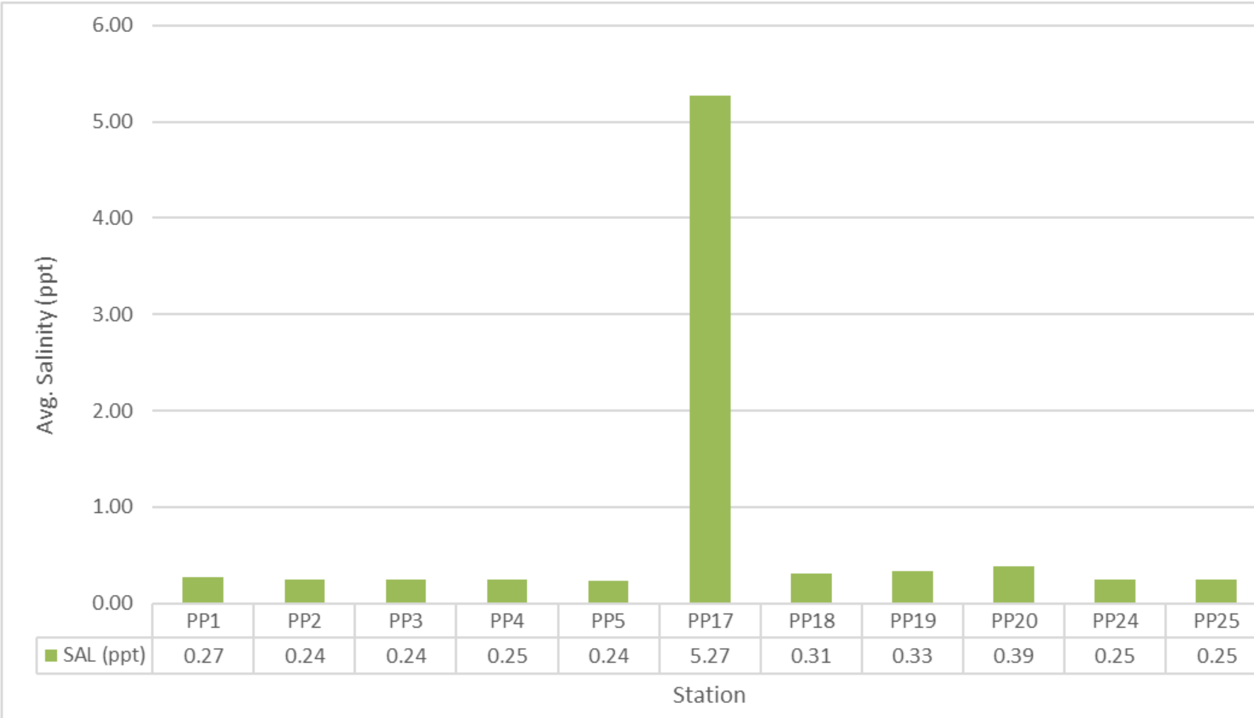


Figure 4-48 Average salinity levels at freshwater stations

Statistical Analysis – Salinity

There were no significant spatial or temporal differences in salinity (ANOVA $p>0.5$), these results showed no significant salinity difference between stations or seasons. Tukey's HSD test was also used to confirm these findings, showing no significant differences $p>0.05$. Salinity values peaked during March 2025 and the lowest values were observed during October 2023.

DISSOLVED OXYGEN (DO)

Dissolved oxygen (DO) is a measure of how much oxygen is dissolved in water, or the amount of oxygen which is available to living aquatic organisms. DO is often used as a measure to water quality, as moving water tends to have more DO than stagnant water. Additionally, bacterial respiration due to the decomposition of organic matter contribute to DO depletion.

Freshwater DO results showed a range of 0.84mg/l (PP18) to 13.48mg/l (PP17), the full range of results can be seen in **Error! Reference source not found.**. The average DO across all of the stations was 6.32mg/l. The lowest average DO level was at Station PP19 (3.67mg/l) located within a small tributary for Sweet River, while the highest average DO was at Station PP3 (8.23mg/l), located within Deans Valley River.

The variations observed in DO were most likely due to differences in flow and organic matter decomposition. Stations PP2, PP3, Pp4 and PP25 were located along the Deans Valley River, which was the largest freshwater body on the property, this river had constant flow during Dry and Wet seasons which contributed to higher DO levels. Station PP19 was located within a small tributary for Sweet River, the water there was shallow, with little movement and had no flow during the dry season, this type of environment was expected to have low DO, due to lack of movement and high organic matter.

Figure 4-49 shows the average DO values, all stations were above the minimal value (< 3 mg/l) considered detrimental to aquatic life (United States Environmental Protection Agency, 2016).

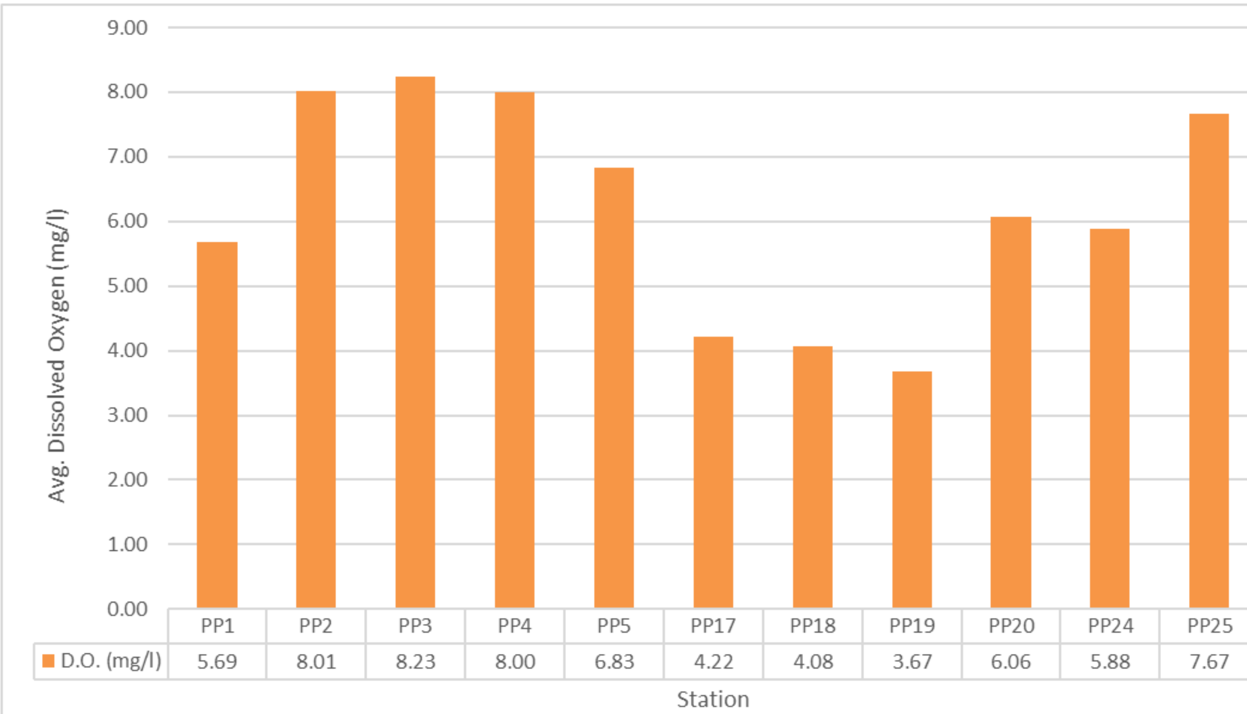


Figure 4-49 Average dissolved oxygen levels at freshwater stations

Statistical Analysis – Dissolved Oxygen

There were significant spatial differences in DO levels (ANOVA $p<0.5$), these differences showed significantly lower DO at Stations PP 17, 18 and 19 compared to the other stations sampled. Figure 4-50 shows the mean DO differences between the freshwater stations. Tukey's HSD test was also used to confirm these findings, showing marked differences $p<0.05$ between Stations PP17, 18 and 19 when compared to Stations PP2, 3, 4 and 25.

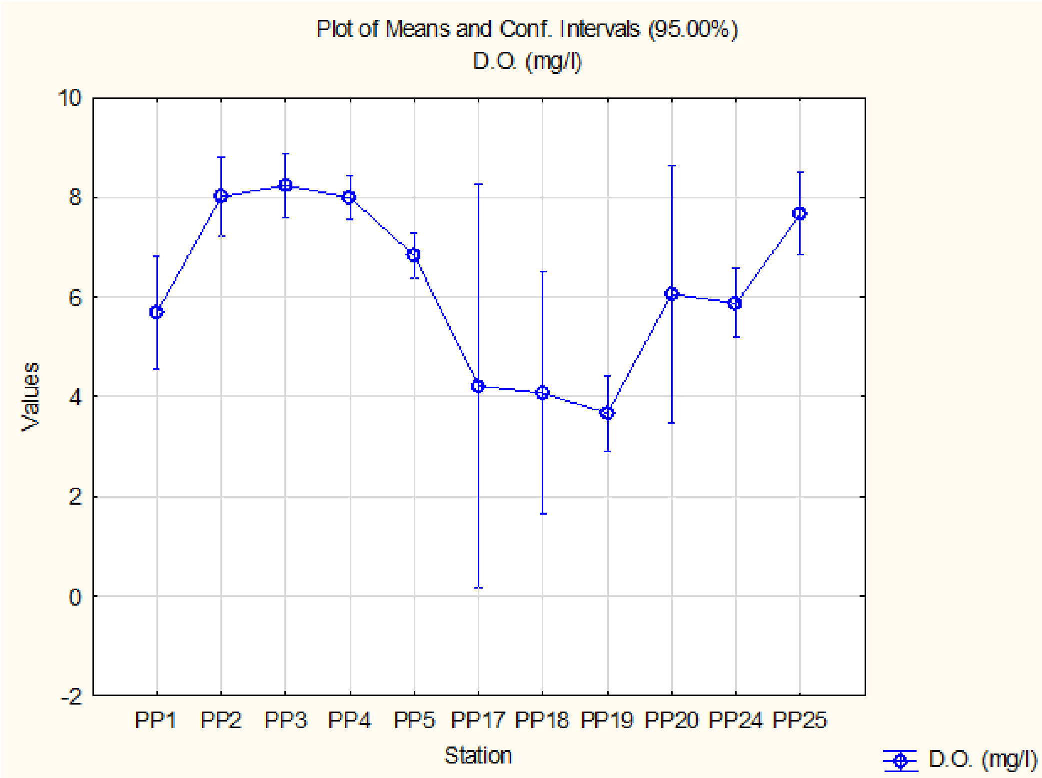


Figure 4-50 Mean DO differences between freshwater stations

There were no significant temporal differences in DO (ANOVA p>0.5), the mean DO differences between the freshwater stations was not significantly different between the wet and dry seasons. Tukey's HSD test was also used to confirm these findings, showing no significant difference p>0.05 between wet and dry seasons. DO values peaking during March 2025 and the lowest values were observed during June 2023.

PH

pH is a measure of how acidic or basic a substance is, pH in freshwater is affected by naturally occurring organic acids or by impacts from human activities. More acidic water may cause certain toxins to become more soluble, and in this in turn may negatively affect aquatic flora and fauna.

Freshwater pH results showed a range of 7.12 (PP19) to 8.26 (PP5), the full range of results can be seen in **Error! Reference source not found.**. The average pH across all of the stations was 7.74. The lowest average pH level was at Station PP19 (7.45) located on a small tributary at the entrance to the property and the highest average pH was at Station PP5 (7.94), to the northeast of the property.

Figure 4-51 shows the average pH values for the eleven freshwater stations, all stations were compliant with the NRCA freshwater quality standards (7-8.4NTU). Lower pH can be caused by freshwater runoff containing various chemicals or decomposition of organic matter, which can produce carbon dioxide (CO_2).

	PP1	PP2	PP3	PP4	PP5	PP17	PP18	PP19	PP20	PP24	PP25
pH	7.76	7.92	7.92	7.80	7.94	7.68	7.60	7.45	7.49	7.80	7.54

Figure 4-51 Average pH levels at freshwater stations

Statistical Analysis – pH

There were significant spatial differences in pH levels (ANOVA $p<0.5$), these differences showed significantly lower pH at Stations PP 19, PP20 and PP25 compared to the other stations sampled. Figure 4-52 shows the mean pH differences between the freshwater stations. Tukey's HSD test was also used to confirm these findings, showing marked differences $p<0.05$ between Stations PP19 and PP20 compared to PP2,3 and 5, and Station PP25 had significantly lower values compared to PP5.

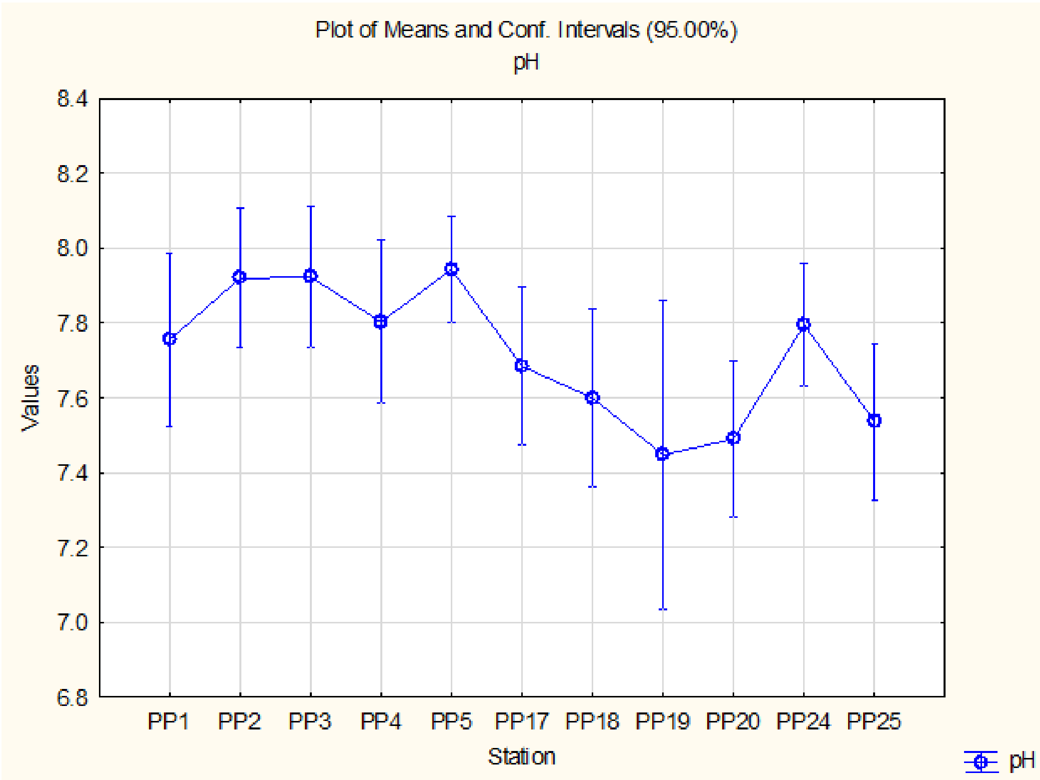


Figure 4-52 **Mean pH differences between freshwater stations**

There were no significant temporal differences in pH (ANOVA $p>0.5$), the mean pH differences between the freshwater stations was not significantly different during the wet and dry seasons. Tukey's HSD test was also used to confirm these findings, showing no marked differences $p>0.05$ between wet and dry seasons. pH values peaked during March 2024 and the lowest values were observed during August 2023.

TURBIDITY

Turbidity is a measure of water clarity, it describes the cloudiness of a liquid caused by the presence of suspended particles, such as silt, clay, algae, organic matter, and microorganisms. These particles scatter and absorb light, reducing the clarity of the water. The level of turbidity is an important indicator of water quality freshwater environments. Freshwater turbidity results showed a range of 0.00NTU (PP1-5, 17-19 and 24,25) to 41.40NTU (PP20), the full range of results can be seen in **Error! Reference source not found.**. The average turbidity across all of the stations was 2.90NTU. The lowest average turbidity level was 0.00NTU seen across multiple stations (Figure 4-53). The highest average turbidity was at Station PP20 (16.30NTU), located within the eastern community drain.

The variations observed in turbidity were most likely due to differences in flow and depth. Stations PP1 to PP5, PP19, PP24 and PP25 had very low turbidity levels, these sites mostly had flowing water, however Station PP19, when it was not flowing, had enough depth for particles to have settled. Station PP17 and 18 were located within marshy lowland, the water there was shallow with little movement and a soft sediment bottom, these factors most likely caused increased turbidity levels. Station PP20, which had the highest turbidity was located in the eastern community drain, which was not flowing during most sampling events and had shallow pools of water with soft sediment. Sediments can be easily resuspended during sampling in shallow freshwater bodies.

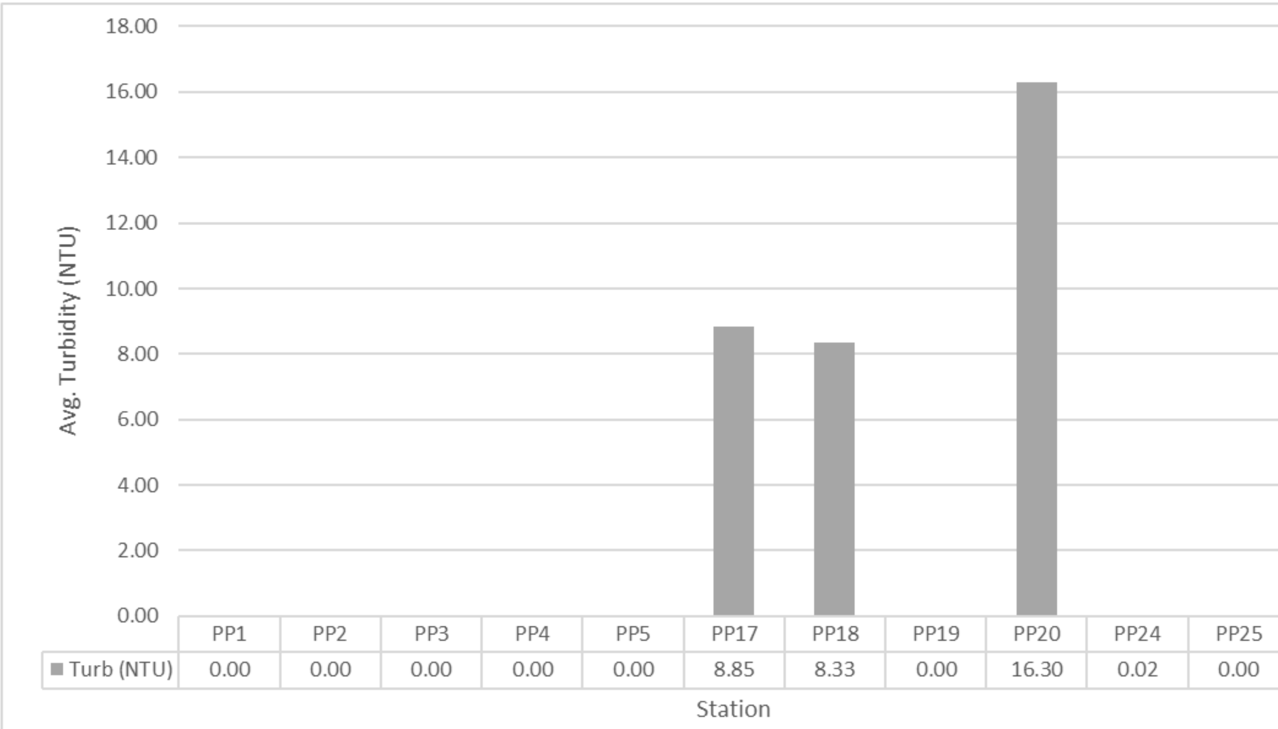


Figure 4-53 Average turbidity levels at freshwater stations

Statistical Analysis – Turbidity

There were no significant spatial or temporal differences in turbidity levels (ANOVA $p>0.5$). Tukey's HSD test was also used to confirm these findings, showing no marked differences $p<0.05$ between Stations Turbidity values peaking during October 2023 with low values (0.0NTU) observed throughout 2023, 2024 and 2025.

TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids (TDS) is a measure of dissolved combined content, organic and inorganic substances, within the water. Freshwater typically contains TDS concentrations between 50-1500 mg/l. TDS includes dissolved minerals and salts and thus is closely related to salinity and conductivity. Typical TDS reading in different types of water can be seen below in Table 4-11.

Table 4-11 Typical TDS readings in several types of water

Types of Water	Total Dissolved Solids (mg/L)
Distilled Water	0-10 mg/L

Types of Water	Total Dissolved Solids (mg/L)
Rainwater	2-20 mg/L
Tap Water	100-500 mg/L
Lakes and Rivers	50-1,500 mg/L
Ground Water	200-1,000 mg/L
Brackish Water	1,000-10,000 mg/L
Seawater	30,000-35,000 mg/L

Freshwater TDS results showed a range of 285.1mg/l (PP5) to 24,240.0mg/l (PP17), the full range of results can be seen in **Error! Reference source not found.**. The average TDS across all of the stations was 0.872mg/l. The lowest average TDS level was at Station PP5 (303.89mg/l) while the highest average TDS was at Station PP17 (5527.96mg/l), within the marshy lowland south of the property.

TDS values recorded (and trends noted) were similar to that of conductivity and salinity readings obtained during the monitoring exercise and support the general inferences discussed under those sections, in particular the inference that marine water most likely mixing at Station PP17 creating a brackish environment.

Figure 4-54 shows the average TDS values across the eleven stations.

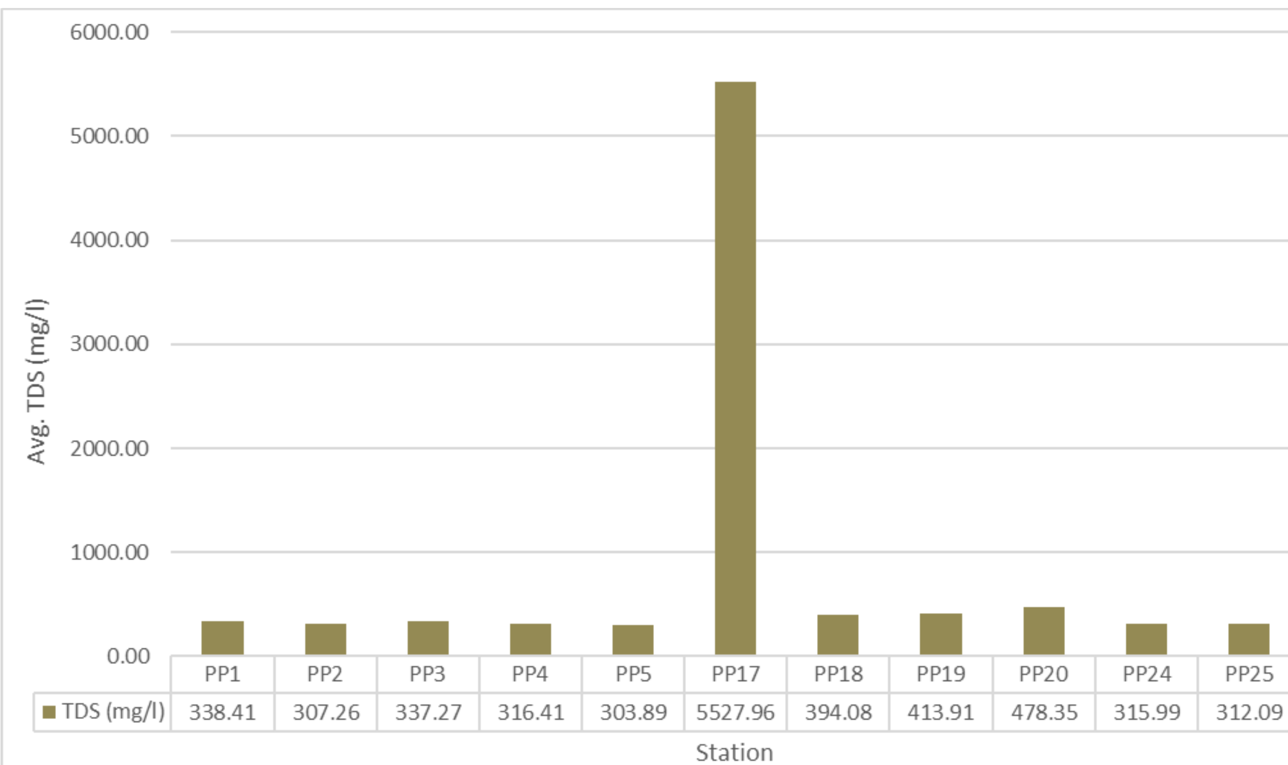


Figure 4-54 Average total dissolved solids at freshwater stations

Statistical Analysis – Total Dissolved Solids

There were significant spatial differences in TDS (ANOVA $p<0.5$), these differences showed significantly higher TDS levels at Station PP 17 compared to the other stations sampled. Figure 4-55 shows the mean TDS differences between the freshwater stations. Tukey's HSD test was also used to confirm these findings, showing marked differences $p<0.05$ between Stations PP17 and Stations PP2 to PP5 and PP18.

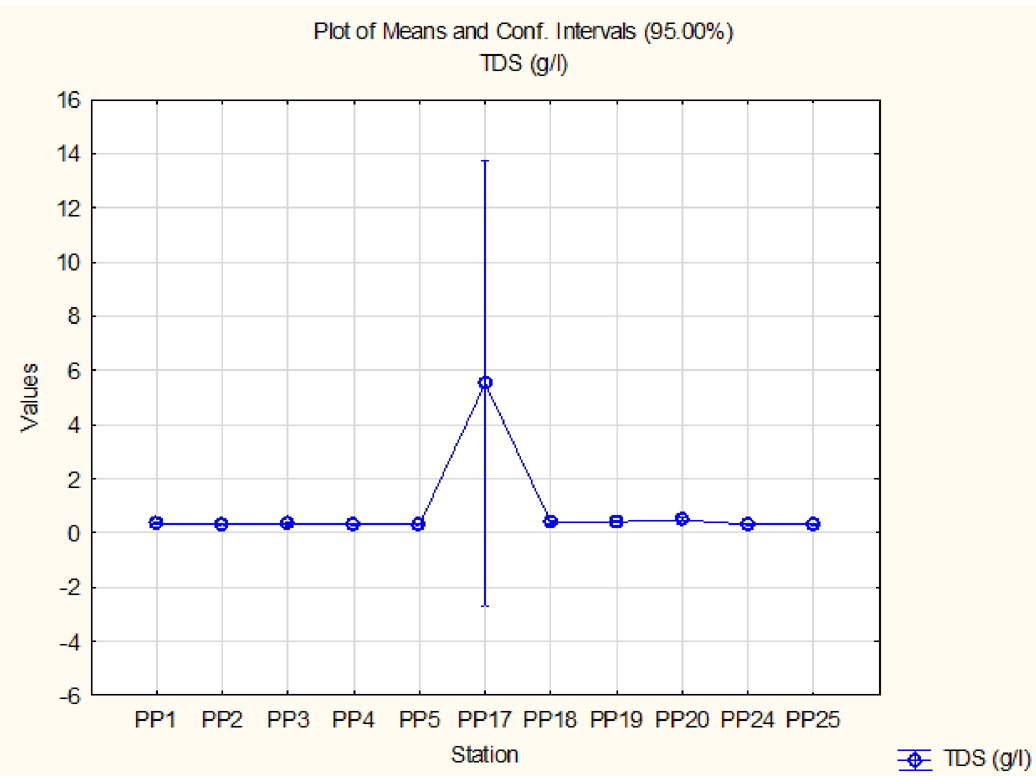


Figure 4-55 Mean TDS differences between freshwater stations

There were no significant temporal differences in TDS (ANOVA $p>0.05$). Results showed no significant seasonal changes between the dry season compared to the wet season. TDS values peaked during March 2025 and the lowest values were observed during October 2023.

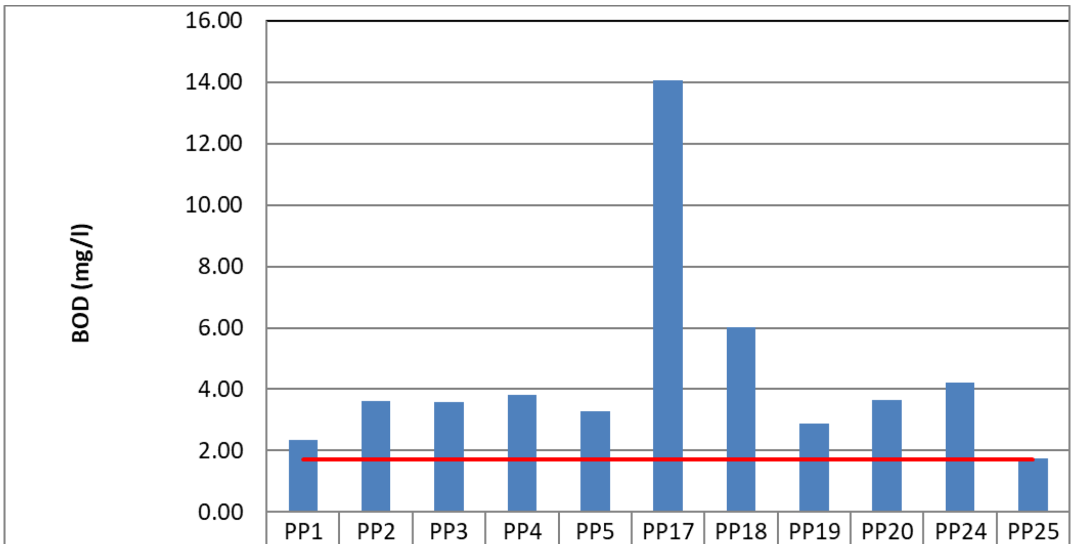
BIOLOGICAL OXYGEN DEMAND (BOD)

Biological oxygen demand (BOD) represents the amount of oxygen which is consumed by bacteria and other microorganisms while they decompose organic matter. Some common BOD sources include decomposing plants and animals, wastewater, and urban and terrestrial run off. High BOD values may indicate pollution and degraded water quality, whereas low BOD values suggest better water quality conditions conducive to supporting life and ecosystem functions.

Freshwater BOD results showed a range of 0.2mg/l (PP3) to 31.5mg/l (PP17), the full range of results can be seen in **Error! Reference source not found.**. The average BOD across all stations was 4.60mg/l. The lowest average BOD level was at Station PP25 (1.73mg/l) located above the project site at the top of Deans Valley River, while the highest average BOD was at Station PP17 (14.06mg/l), located within the marshy lowland towards the south of the project site.

The variations observed in BOD were most likely due to differences in flow and organic matter decomposition, areas with low flow and high organic matter content would have higher BOD levels. Most Stations had similar BOD levels, except for PP17 and 18, which were both located in marshland with stagnant waters which contained high organic matter. Station PP25 was located within Deans Valley River, which had a high flow rate during both Wet and Dry seasons.

Average BOD values were non-compliant for all stations with the NRCA freshwater Standard (Figure 4-56), of 1.70mg/l.



	PP1	PP2	PP3	PP4	PP5	PP17	PP18	PP19	PP20	PP24	PP25
BOD (mg/l)	2.35	3.63	3.59	3.81	3.29	14.06	6.01	2.87	3.64	4.21	1.73
NRCA Std(Upper)	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70	1.70

Figure 4-56 Average biological oxygen demand levels at freshwater stations

Statistical Analysis – Biological Oxygen Demand

There were significant spatial differences in BOD (ANOVA $p<0.5$), these differences showed significantly higher BOD levels at Station PP 17 compared to the other stations sampled. Figure 4-57 shows the mean BOD differences between the freshwater stations. Tukey's HSD test was also used to confirm these findings, showing marked differences $p<0.05$ between Stations PP17 and most other stations, excluding PP18.

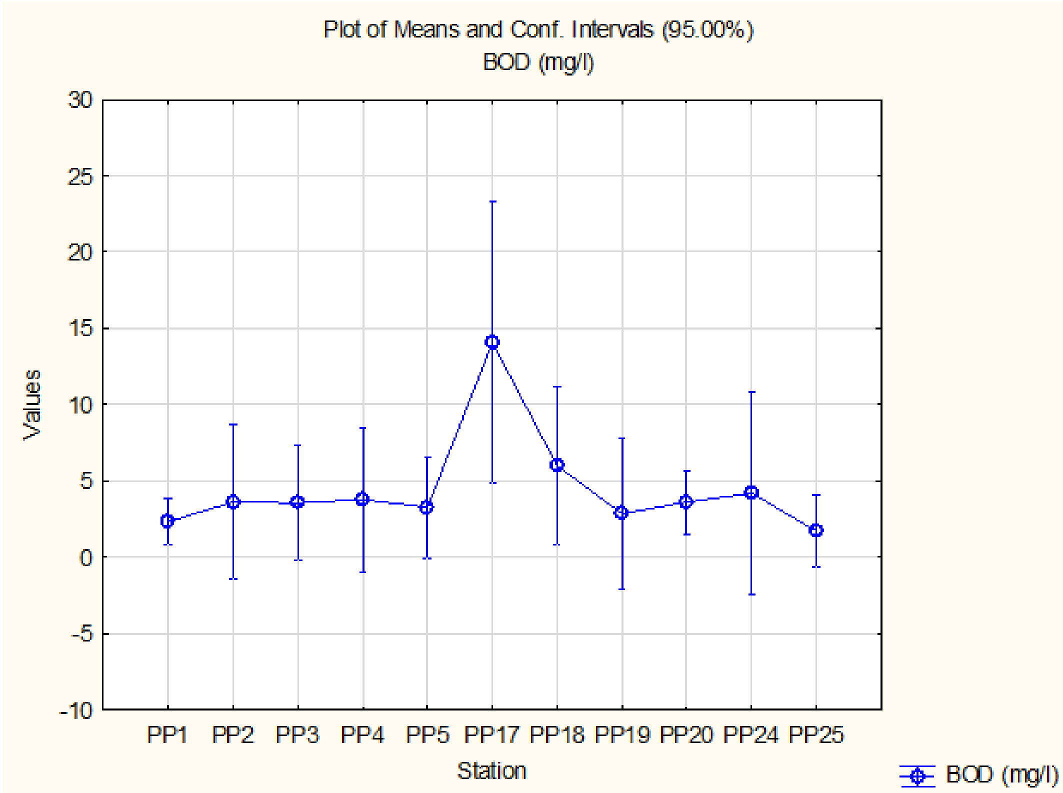


Figure 4-57 Mean BOD differences between freshwater stations

There were significant temporal differences in BOD (ANOVA $p<0.05$). Results showed a marked difference between wet and dry seasons, with significantly higher values during the dry season (Figure 4-58). BOD values peaked during March 2025 and the lowest BOD values were observed during November 2023. Higher BOD values during the dry season may be due to reduced water flow, and accumulation of organic matter, lower flow may concentrate waste material increasing BOD as microbes consume more oxygen to decompose the organic load.

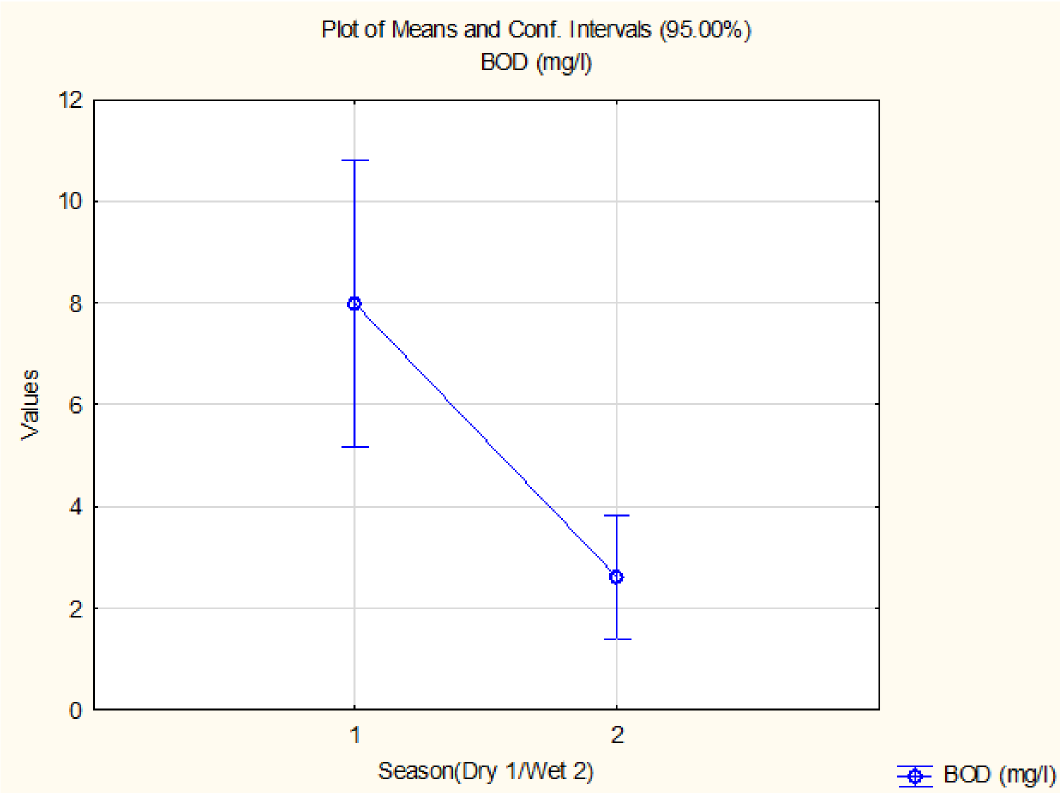


Figure 4-58 Mean freshwater BOD differences between wet and dry seasons

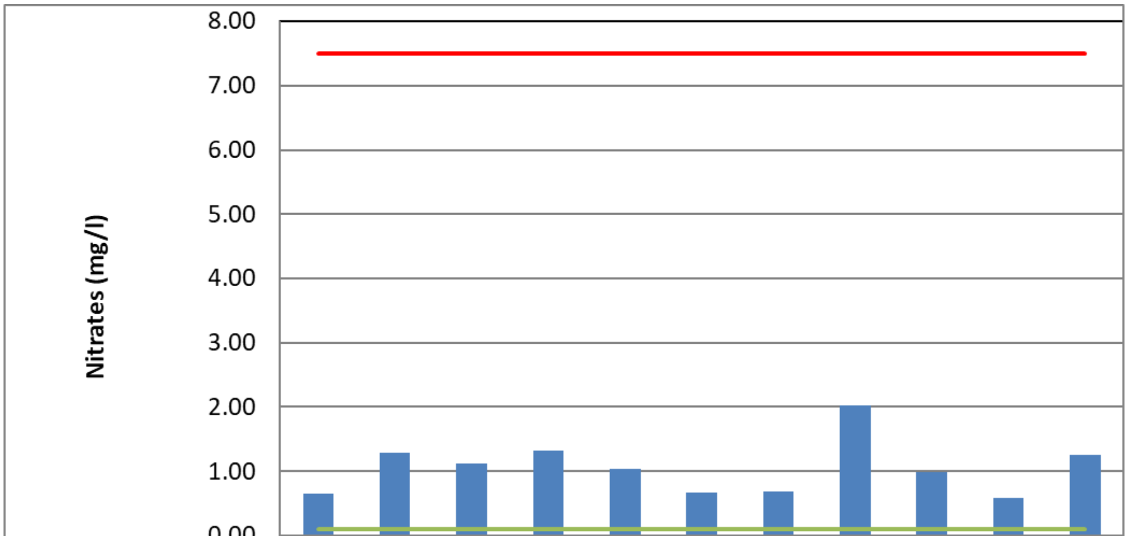
NITRATES

Nitrates are essential nutrients for plant growth, but excessive amounts in freshwater environments can lead to various environmental problems. High nitrate levels are due to water contamination from wastewater, land run-off via drains and gullies or fertilizers. Nitrogen may contribute to excess algal growth; however, research has found that reducing nitrogen inputs has little impact on algal blooms when phosphorous inputs continue (Datastream, 2021).

Freshwater nitrate results showed a range of 0.1mg/l (PP18) to 3.9mg/l (PP19), the full range of results can be seen in **Error! Reference source not found.**. The average nitrate value across all stations was 1.02mg/l. The lowest average nitrate level was at Station PP24 (0.58mg/l) located to the north west of the site on a river tributary of Salt River. The highest average nitrate value was at Station PP19 (2.03mg/l), located above the project site in Sweet River.

The variations observed in nitrates were most likely due to differences in water contamination, Station 24 was located above the property and may have had less impact form farmland or fertilizer contaminants. Station PP19 which had the highest value flowed through the property into the marshlands.

All stations were compliant (below) NEPA freshwater standards for nitrates (Figure 4-59).



	PP1	PP2	PP3	PP4	PP5	PP17	PP18	PP19	PP20	PP24	PP25
NIT (mg/l)	0.65	1.29	1.11	1.31	1.04	0.67	0.69	2.03	0.98	0.58	1.25
NRCA Std(Upper)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
NRCA Std(Lower)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Figure 4-59 Average nitrate levels at freshwater stations

Statistical Analysis – Nitrates

There were significant spatial differences in nitrates (ANOVA $p<0.5$), these differences showed significantly higher nitrate values at Station PP 19 compared to the other stations. Figure 4-60 shows the mean nitrate differences between the freshwater stations. Tukey's HSD test was also used to confirm these findings, showing marked differences $p<0.05$ between Station PP19 compared to PP1, PP17, 18 and PP24.

There were no significant temporal differences in nitrates (ANOVA $p>0.05$). Results showed no seasonal differences throughout the year between wet and dry seasons. Nitrate values peaked during November 2023 and the lowest nitrate values were observed during August 2023.

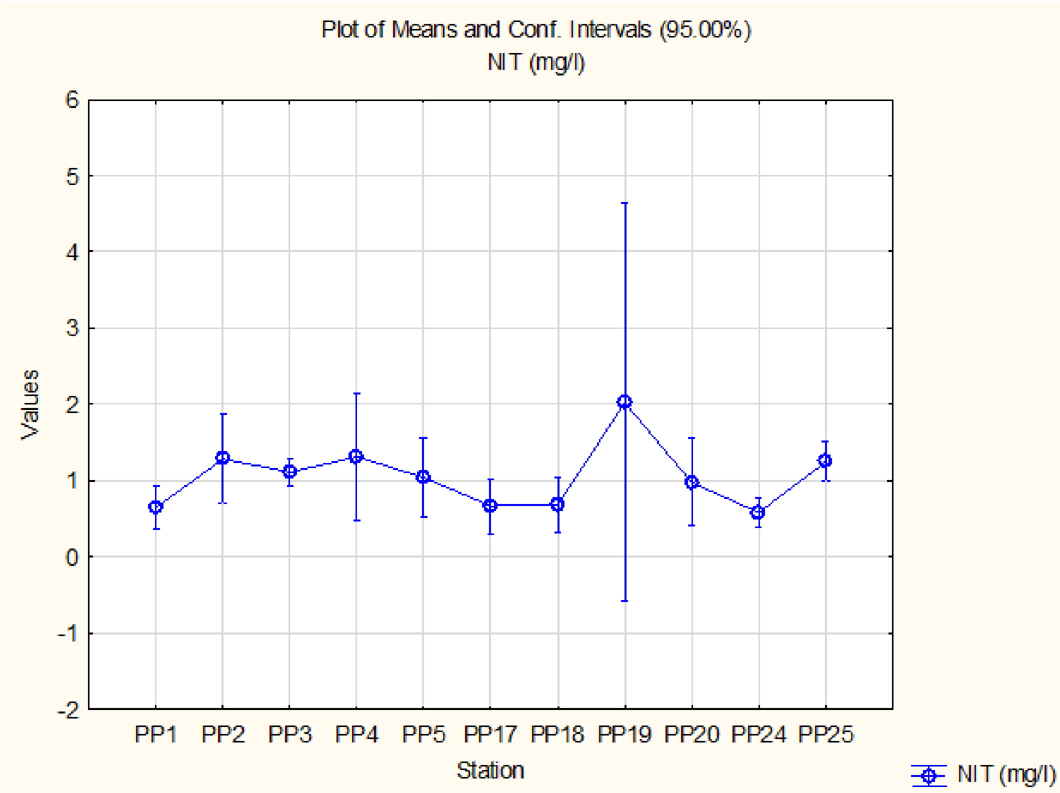


Figure 4-60 Mean nitrate differences between freshwater stations

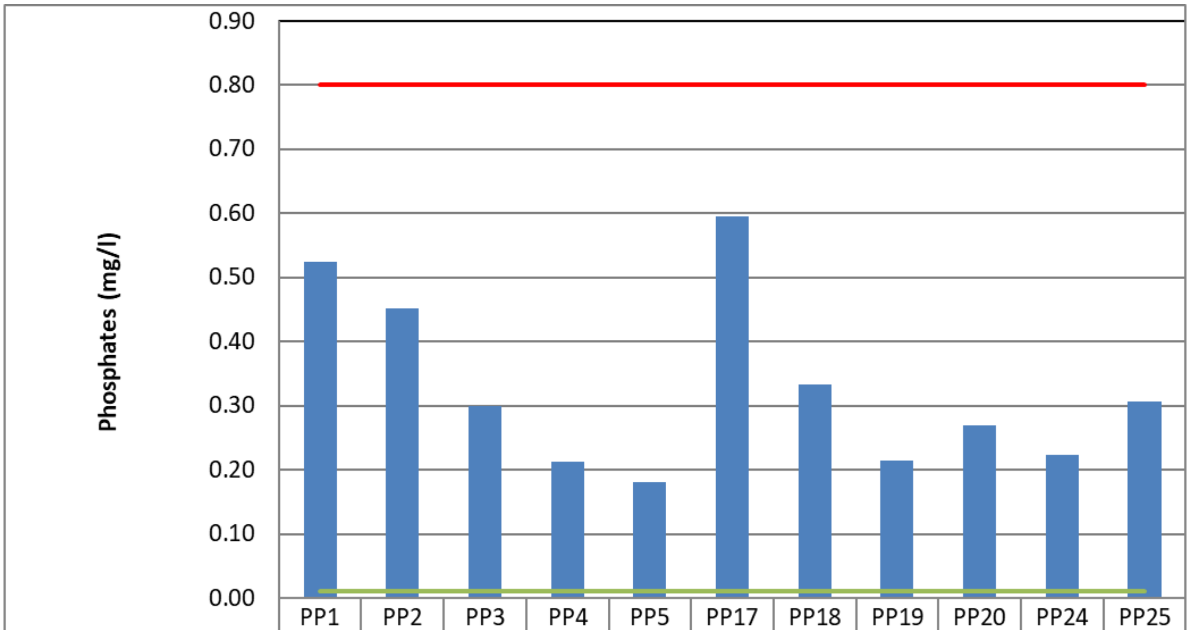
PHOSPHATES

Phosphates are essential nutrients for plant growth, but like nitrates, excessive amounts in can lead to various environmental problems. High phosphate levels are likely due to water contamination from poor agricultural practices, runoff from urban areas, or improper discharge from sewage treatment plants and decaying organic matter.

Freshwater phosphate results showed a range of 0.04mg/l (PP18) to 1.42mg/l (PP17), the full range of results can be seen in **Error! Reference source not found.**. The average phosphate value across all stations was 0.33mg/l. The lowest average phosphate level was at Station PP5 (0.18mg/l) to the northern ends of the project site and the highest average phosphate value was at Station PP17 (0.60mg/l), within the marshy lowland towards the south of the project site.

The variations observed in phosphates were most likely due to differences in water contamination and decaying organic matter. Stations PP2, PP3, Pp4 and PP25 were located along the Deans Valley River, these stations showed increasing phosphate values along the river as it flowed further into the project site. This may have been due to increased contamination from runoff in particular from manure or fertilizers. Station PP17 was located within marshy lowland, the water there was shallow with little movement, this type of environment may have had high phosphorus content, due to runoff upstream and decaying organic matter.

All stations were compliant (within) NRCA Freshwater Standards of 0.01-0.8 mg/l. (Figure 4-61).



	PP1	PP2	PP3	PP4	PP5	PP17	PP18	PP19	PP20	PP24	PP25
PHOS (mg/l)	0.52	0.45	0.30	0.21	0.18	0.60	0.33	0.22	0.27	0.22	0.31
NRCA Std(Lower)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NRCA Std(Upper)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

Figure 4-61 Average phosphate levels at freshwater stations

Statistical Analysis – Phosphates

There were no significant spatial or temporal differences in phosphates (ANOVA $p>0.5$), the mean phosphate differences between the freshwater stations were not significant. Tukey's HSD test was also used to confirm these findings, showing no marked differences $p>0.05$ between stations or seasons. Phosphate values peaked during October 2023 and the lowest values were observed during September 2024.

TOTAL SUSPENDED SOLIDS (TSS)

TSS measures the concentration of particulate matter suspended in the water column that exceed 2 microns in size. TSS values lower than 20mg/l often indicate clear water. TSS values are often related to turbidity, high TSS often indicates that the water is murky and may have suspended soil and silt in the water.

Freshwater TSS results showed a range of 0.00mg/l (PP24 and 25) to 569mg/l (PP18), the full range of results can be seen in **Error! Reference source not found.**. The average TSS value across all stations was 27.1mg/l. The lowest average TSS level was at Station PP25 (3mg/l) located above the project site along the Deans Valley River, the highest average TSS value was at Station PP18 (127mg/l), within the marshy lowland towards the south of the project site.

The variations observed in TSS were most likely due to differences in water depth and sediment composition. Stations PP1 to PP5 and PP25 were located along flowing rivers and waterways with sandy sediment and clear waters. Stations PP17 and PP18 were located within marshy lowland towards the southern end of the property, the water there was shallow with little movement and silty sediment which was easily suspended during sampling.

Most average TSS values were low (Figure 4-62) indicating clear waters, in particular within the river systems. Stations PP17, 18 and 20 were found to have the highest TSS values which coincided with their turbidity values which were also the highest observed.

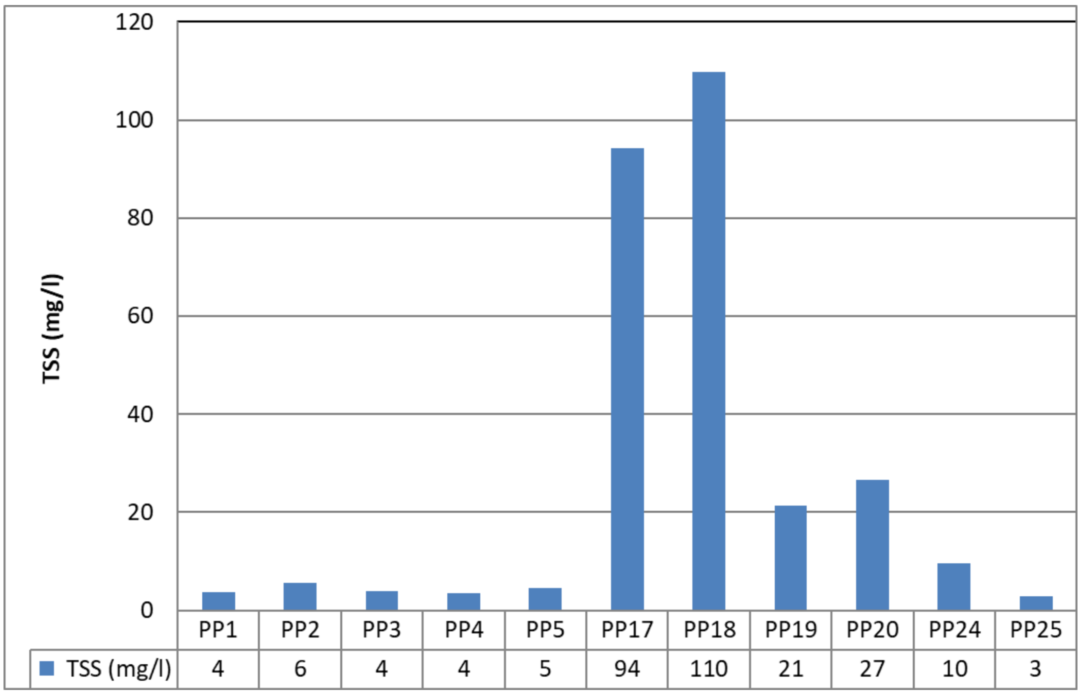


Figure 4-62 **Average total suspended solid levels at freshwater stations**

Statistical Analysis – Total Suspended Solids

There were no significant spatial or temporal differences in TSS (ANOVA $p>0.5$), the mean TSS differences between the freshwater stations were not significant. Tukey's HSD test was also used to confirm these findings, showing no marked differences $p>0.05$ between all Stations. TSS values peaked during June 2023 and the lowest values were observed during September and October 2024.

FAECAL COLIFORM

Faecal coliforms are a subgroup of bacteria that are commonly found in the intestines of warm-blooded animals, including humans, and are excreted in their faeces. High faecal coliform levels are due to water contamination from wastewater and terrestrial run off such as from animals and agriculture. Faecal coliforms can survive for extended periods in freshwater and thus may have significant effect.

Freshwater faecal coliform results showed a range of 1.1MPN/100ml (PP24) to 16,000MPN/100ml (PP17), the full range of results can be seen in **Error! Reference source not found.**. The average faecal coliform value across all stations was 1,824MPN/100ml. The lowest average faecal coliform level was at Station PP19 (113MPN/100ml) located at the northern end of the project site along Sweet River and the highest average faecal coliform value was at Station PP17 (5,197MPN/100ml), within the marshy lowland towards the south of the project site.

The variations observed in faecal coliform were most likely due to differences in water contamination, in particular from the various farm animals (buffaloes, cattle, horses, goats and sheep) on the project site. Stations PP19 and 20 had the lowest faecal coliform levels, these were located at entrance points to the property and would have been minimally affected by on site contamination. Station PP17 was located within marshy lowland towards the southern end of the property, this was a collection area for multiple water sources and drains which flowed through the project site, which may have contributed to the accumulation of faecal coliform bacteria in this location from upstream runoff and wastewater.

Faecal coliform levels exceeded NEPA freshwater standards of <11 MPN/100mL at all stations (Figure 4-63). This may suggest that the location may be experiencing pollution from multiple sources, both off and on site from animal and human wastewater.

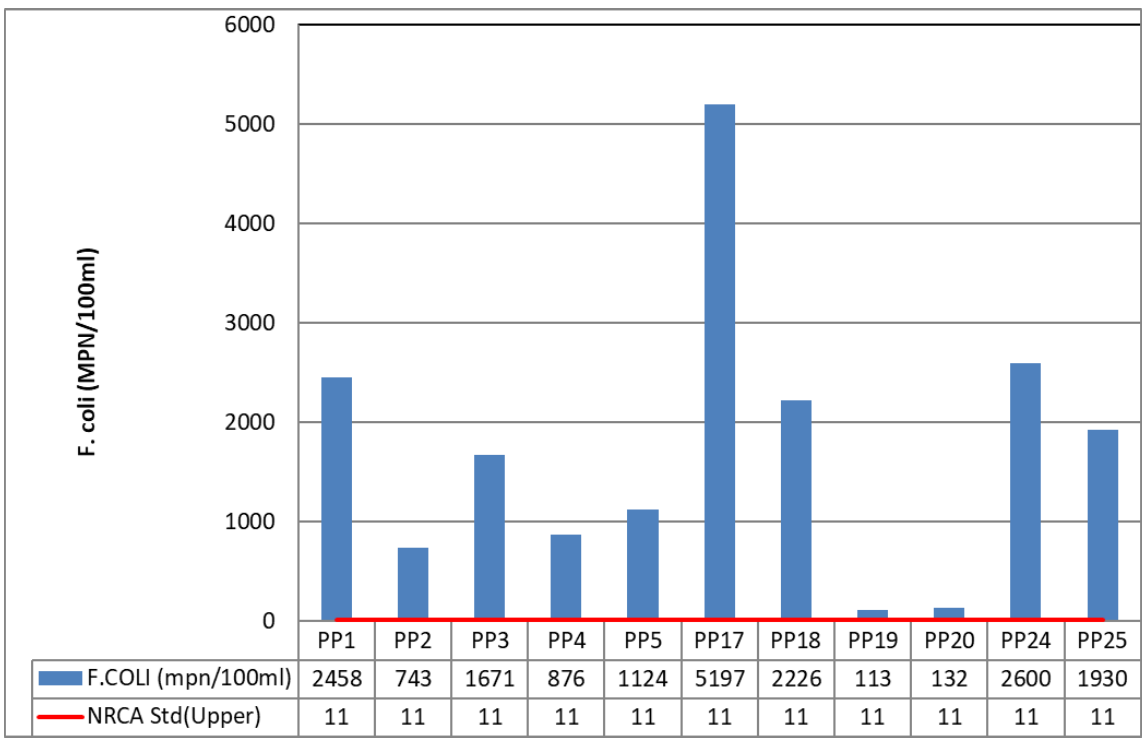


Figure 4-63 Average faecal coliform levels at freshwater stations

Statistical Analysis – Faecal Coliform

There were significant spatial differences in faecal coliform levels (ANOVA p<0.5), these differences showed significantly higher faecal coliform at Station PP17 compared to the other stations sampled. Figure 4-64 shows the mean differences between the freshwater stations. Tukey's HSD test was also used to confirm these findings, showing significantly higher values p<0.05 between Station PP17 compared to PP2, PP4, PP19 and PP20.

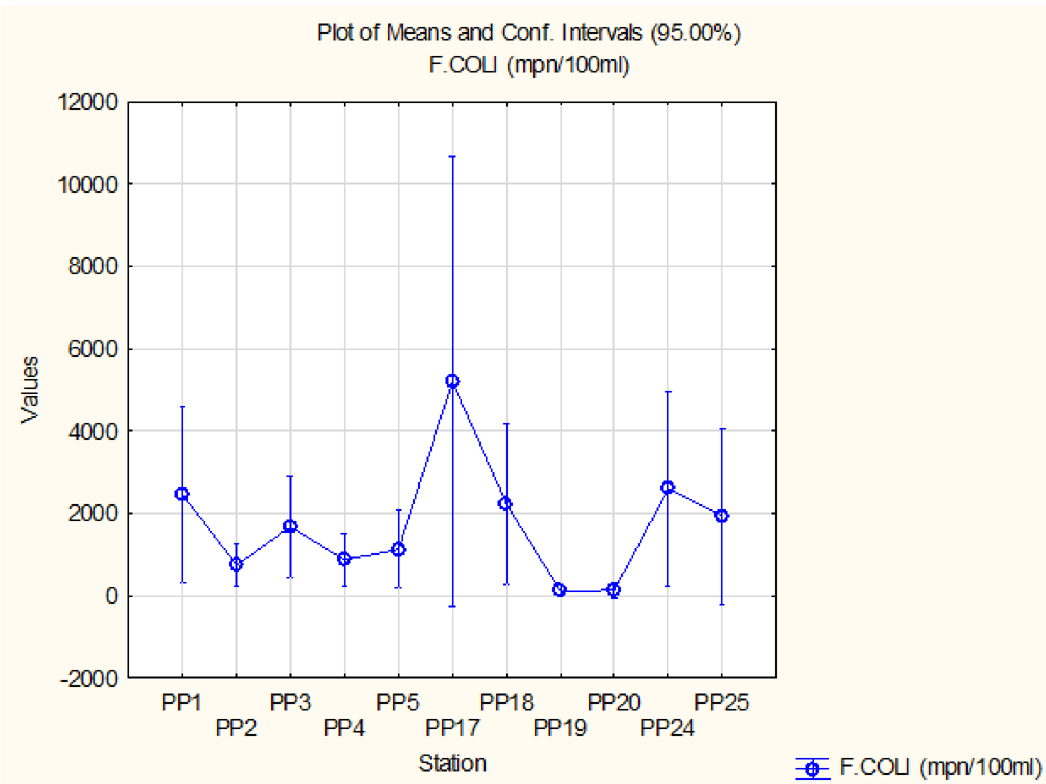


Figure 4-64 Mean faecal coliform differences between freshwater stations

There were significant temporal differences in faecal coliform (ANOVA p<0.05). The mean differences in faecal coliform levels was significant between wet and dry seasons, with higher values during the dry season (Figure 4-65). Faecal coliform values peaked during June 2023 and the lowest values were observed during September and October 2024. Higher f. coliform values during the dry season may be due to reduced water flow, and accumulation of organic matter, lower flow may concentrate waste material increasing f. coliform bacteria within water bodies, in particular when animal waste remains within these freshwater bodies.

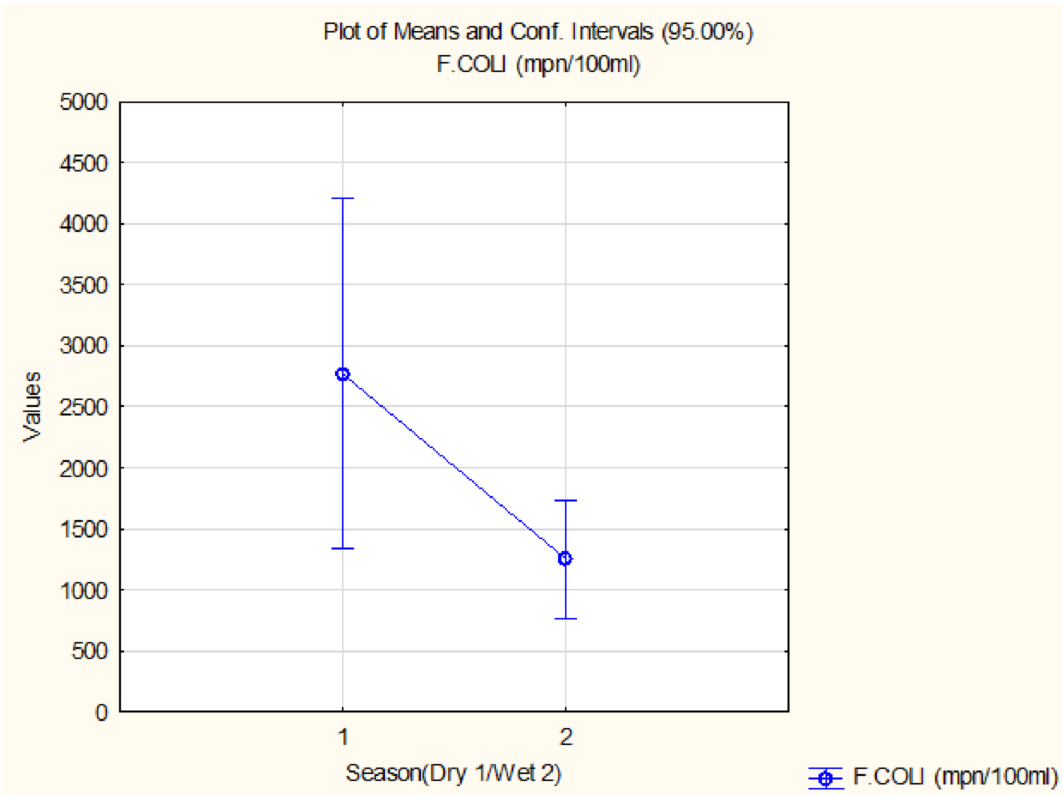


Figure 4-65 **Mean freshwater faecal coliform differences between wet and dry seasons**

STATISTICAL ANALYSIS OF FRESHWATER OUTLIERS

During sampling of the site, one freshwater station, Station PP17 stood out as a notable outlier. Its data was sufficiently distinct from the other stations, therefore it was excluded from the temporal statistical analyses. The objective behind this removal was to accurately assess seasonal variations by isolating the influence that Station PP17 had on the overall dataset.

Without Station PP17 the significant differences between seasons remained consistent, with significant temporal differences in BOD and faecal coliform (ANOVA $p<0.05$) and no significant differences between the other parameters. These significant differences showed increased values for BOD and f. coliform during the dry season compared to the wet season (Figure 4-66). Higher BOD and f. coliform values during the dry season may be due to reduced water flow, and accumulation of organic matter, lower flow may concentrate waste material increasing BOD and f. coliform bacteria within water bodies, in particular when animal waste remains within these freshwater bodies.

Temperature, conductivity, salinity, pH, DO, turbidity, TDS, TSS, Nitrate and Phosphates were not found to be significantly different (ANOVA $p>0.05$). This indicates that these parameters remained relatively stable throughout the year, showing no marked seasonal variations.

When comparing seasonal differences in the dataset both with and without Station PP17, it became evident that Station PP17 had no significant influence in the overall dataset. However, the analysis reaffirmed that BOD and f. coliform were significantly higher during the dry season regardless of the inclusion of Station PP17. This consistency lends greater confidence to the results concerning the differences in BOD and f. coliform between the two seasons.

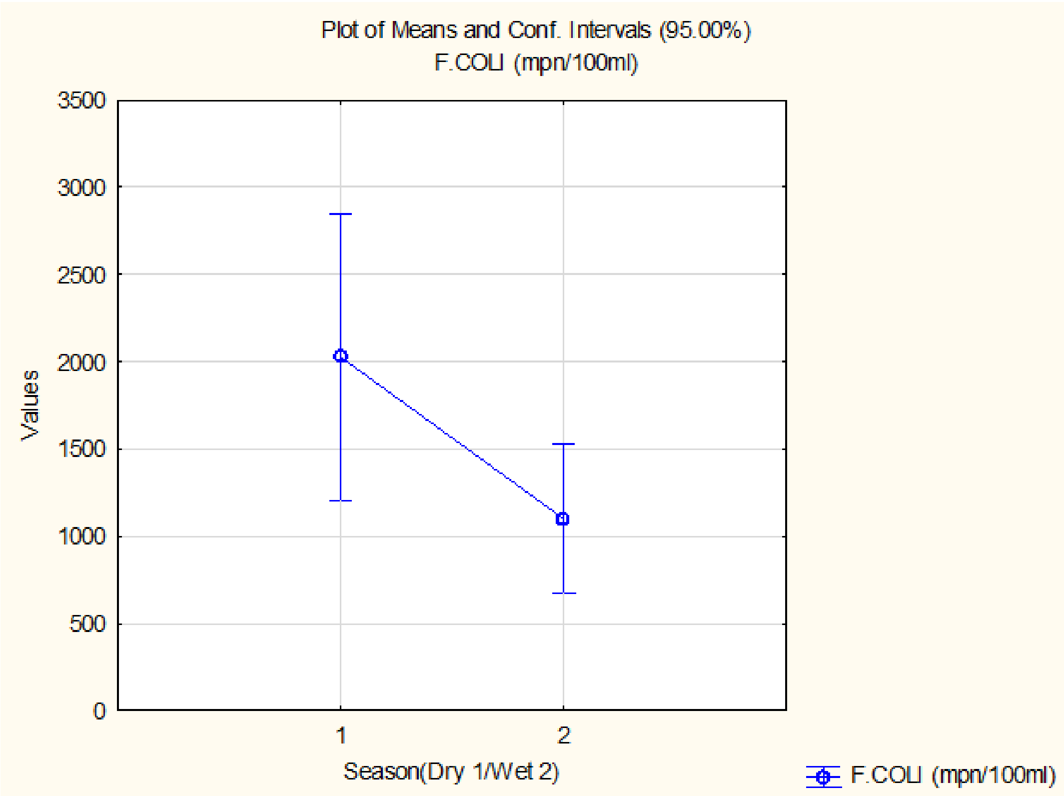


Figure 4-66 Mean freshwater Faecal Coliform differences between wet and dry seasons without Station PP17

Marine Water Analysis

WATER QUALITY AND ITS RELATIONSHIP WITH SEAGRASS

The presence of seagrass can have a significant impact on water quality parameters, and conversely, water quality influences the health and vitality of seagrass ecosystems.

Filtration and Nutrient Uptake

Seagrasses act as natural filters, trapping suspended particles and helping to clarify the water. They can absorb and assimilate nutrients, such as nitrogen and phosphorus, which are essential for their growth. This nutrient uptake reduces nutrient levels in the water, potentially mitigating issues like nutrient pollution. High nutrient concentrations in the water, often from runoff or pollution, can stimulate excessive algal growth, leading to reduced light availability for seagrasses. This can negatively impact seagrass health and coverage.

Oxygen Production and Consumption

Seagrasses contribute to oxygen production through photosynthesis, releasing oxygen into the surrounding water. This process can enhance oxygen levels and support aerobic conditions for marine life. Low dissolved oxygen levels in the water, often associated with eutrophication or excessive organic matter decomposition, can negatively affect seagrasses. Seagrasses may suffer from hypoxic conditions, leading to decline or die-off.

pH

Seagrasses influence pH levels in their surroundings through various mechanisms. Primarily, the process of photosynthesis in seagrasses involves the absorption of carbon dioxide from the water, contributing to an increase in pH by reducing the concentration of carbon dioxide and releasing oxygen. Additionally, seagrasses enhance alkalinity by increasing the concentration of carbonate ions through photosynthesis and organic carbon production, promoting a more stable pH environment. The shading effect and temperature regulation provided by seagrasses also play a role, influencing the solubility of carbon dioxide in water. Furthermore, microbial activity associated with seagrass roots and sediment decomposition can impact pH levels through the release of byproducts. Overall, the intricate interactions of seagrasses with their environment contribute to pH regulation, emphasizing their importance in maintaining the health and equilibrium of coastal ecosystems.

Although changes in dissolved oxygen appeared to affect changes in pH and vice-versa, it is in fact the result of changes in photosynthesis and respiration that results in changes to D.O. and pH. Photosynthesis increases the amount of dissolved oxygen in the water column, while respiration uses the oxygen and also produces carbon dioxide which in solution produces carbonic acid which changes the pH (Campbell, 2000).

Seagrasses are affected by changes in pH levels, which can have various implications for their growth and health. These effects include alterations in photosynthesis and respiration processes, as seagrasses may experience reduced carbon dioxide uptake and respiration efficiency under acidic conditions. The availability of carbonate ions, crucial for seagrass structure formation, can also be influenced by pH changes. Furthermore, increased acidity may favour algae growth, posing competition to seagrasses, while shifts in nutrient availability and sediment pH can affect seagrass ecosystems' overall health. Additionally, global concerns about ocean acidification exacerbate the challenges seagrasses face, particularly in regions where pH levels are naturally lower.

Sediment Stabilization

Seagrass beds stabilize sediments with their root systems, reducing sediment resuspension. This helps maintain water clarity by preventing excessive sedimentation. Excessive sedimentation from factors like runoff or plumes from the construction site can bury seagrass blades, limiting light penetration and inhibiting photosynthesis.

Biodiversity Support

Seagrass beds provide habitat and shelter for various marine species. The complex structure of seagrass meadows offers refuge for juvenile fish and invertebrates. Poor water quality, including pollutants and sedimentation, can harm the diverse community of organisms that depend on seagrass habitats, disrupting the balance within the ecosystem.

Carbon Sequestration

Seagrasses play a role in carbon sequestration by trapping and storing carbon in their biomass and sediments, contributing to climate change mitigation. Changes in water quality, such as alterations in pH or carbonate chemistry, can influence the ability of seagrasses to effectively sequester carbon.

In summary water quality, particularly in terms of nutrient levels, sedimentation, and dissolved oxygen, significantly impacts the health and persistence of seagrass ecosystems. Conversely, the presence of seagrass positively influences various water quality parameters by acting as a natural filter, stabilizing sediments, contributing to oxygen production, and supporting biodiversity.

TEMPERATURE

Recorded temperatures during the survey exceeded the typical tropical marine water range of 24°C to 29°C for the Caribbean Sea. In the cooler part of the year (December to February), the sea temperature is usually around 24°C to 26°C, while in the hotter part of the year (June to August), it typically rises to about 27°C to 29°C.

Marine water temperatures results showed a range of 25.32 °C (PP14) to 31.99 °C (PP13), the full range of results can be seen in **Error! Reference source not found.**. The average temperature across all of the stations was 29.89°C. The lowest average temperature was at Station PP14 (26.40°C) located at the mouth of Sweet River while the highest average temperature was at Station PP15 (30.55 °C), close to shore (Figure 4-67).

The temperature trends observed were mostly similar across stations, except for PP14, which was notably lower comparatively. This lower temperature was most likely due to the freshwater output from the nearby Deans Valley River, this river when sampled had an average temperature of 26.56°C. The higher temperatures may have been due to shallower waters which are more exposed to sunlight and atmospheric heat such as at Station PP13 and PP15, however these stations were also closest in proximity to PP14, which may indicate that the cooler waters form the river were not significantly influencing these stations. All stations besides PP14 had temperature values which were above 30°C.

The climate change phenomenon has led to a gradual increase in sea temperatures. Notably, 2023 was recorded as the warmest year since 1967, surpassing the previous record set in 2016 (Copernicus, 2024) while during 2024, record high temperatures were recorded (Hydrology, 2024). This highlights the importance of monitoring and mitigating the impacts of rising temperatures on marine ecosystems.

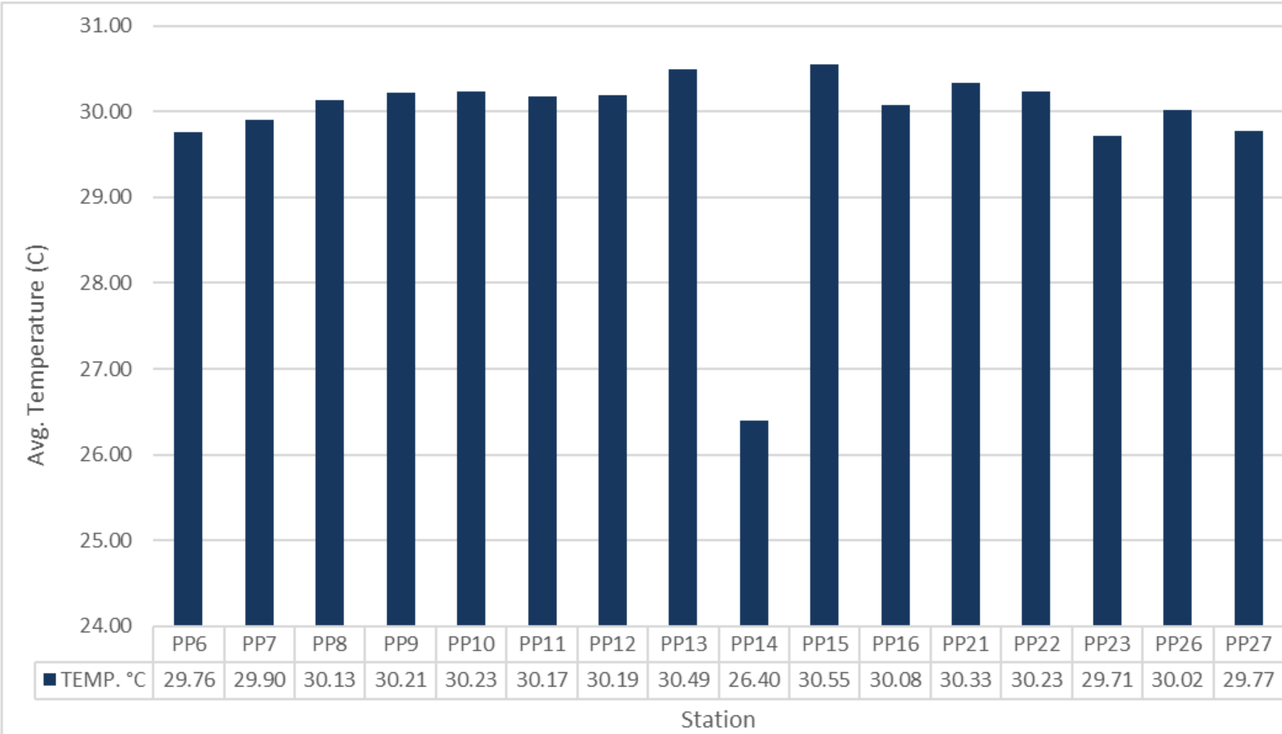


Figure 4-67 Average temperature levels at marine water stations

Statistical Analysis – Temperature

There were significant spatial differences in marine temperature levels (ANOVA $p<0.5$), these differences showed significantly lower temperatures at Station PP14 compared to the other stations sampled. Figure 4-68 shows the mean temperature differences between the marine water stations. Tukey's HSD test was also used to confirm these findings, showing significantly lower values $p<0.05$ for Station PP17 compared to all other stations.

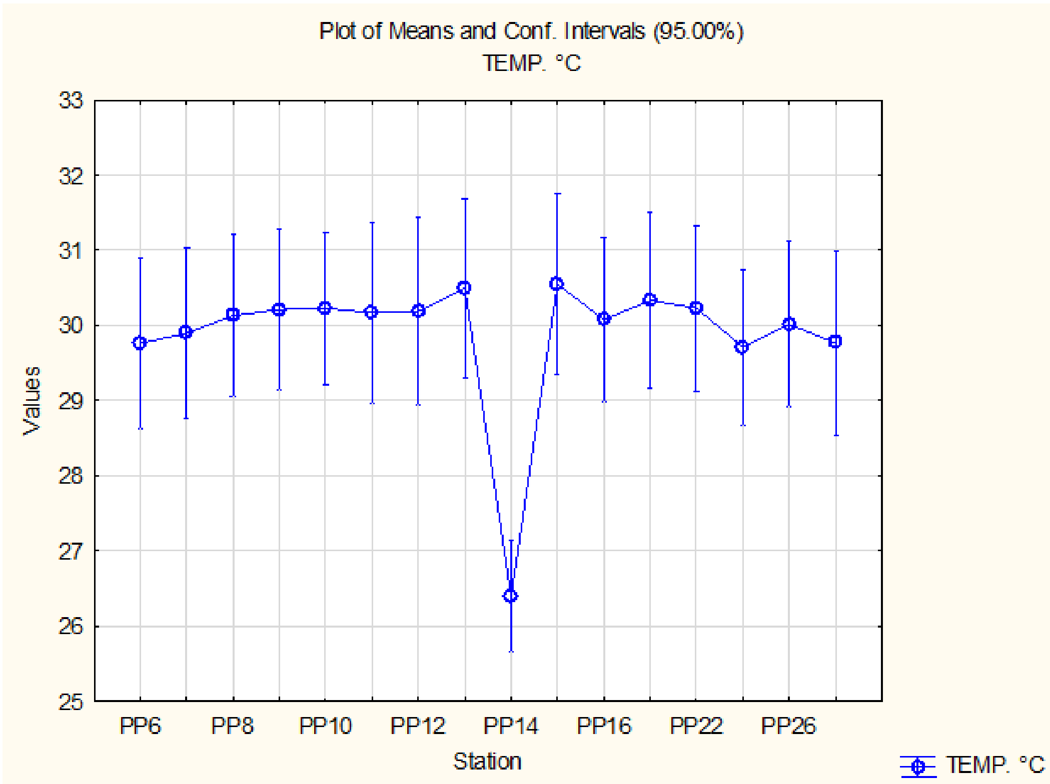


Figure 4-68 Mean temperature differences between marine water stations

There were no significant temporal differences in temperature (ANOVA $p>0.05$). The results showed no seasonal differences between wet and dry seasons. Temperature values peaked during October 2023.

SPECIFIC CONDUCTIVITY

Conductivity is a measure of the number of free ions within a given water sample and, in conjunction with salinity, is used to gauge whether the water sample is saline/marine or non-saline/fresh water. Typically, higher conductivity readings indicate a greater presence of free ions in the water sample, which is common in saline water compared to fresh water.

Marine water conductivity results showed a range of 0.4847 mS/cm (PP14) to 54.9 mS/cm (PP26), the full range of results can be seen in **Error! Reference source not found.**. The average conductivity across all of the stations was 50.71 mS/cm. The lowest average conductivity was at Station PP14 (12.92 mS/cm) located at the mouth of Deans Valley River while the highest average conductivity was at Station PP22 (54.02 mS/cm), located offshore.

The conductivity variations observed were most likely due to differences in freshwater input from the nearby river. Most stations had similar conductivity readings, however PP14 had a notable lower reading, this was most likely due to the freshwater input from the nearby Deans Valley River which would have lowered the specific conductivity in the sample are by mixing with the seawater.

Figure 4-69 shows the average conductivity readings measured for all sixteen stations.

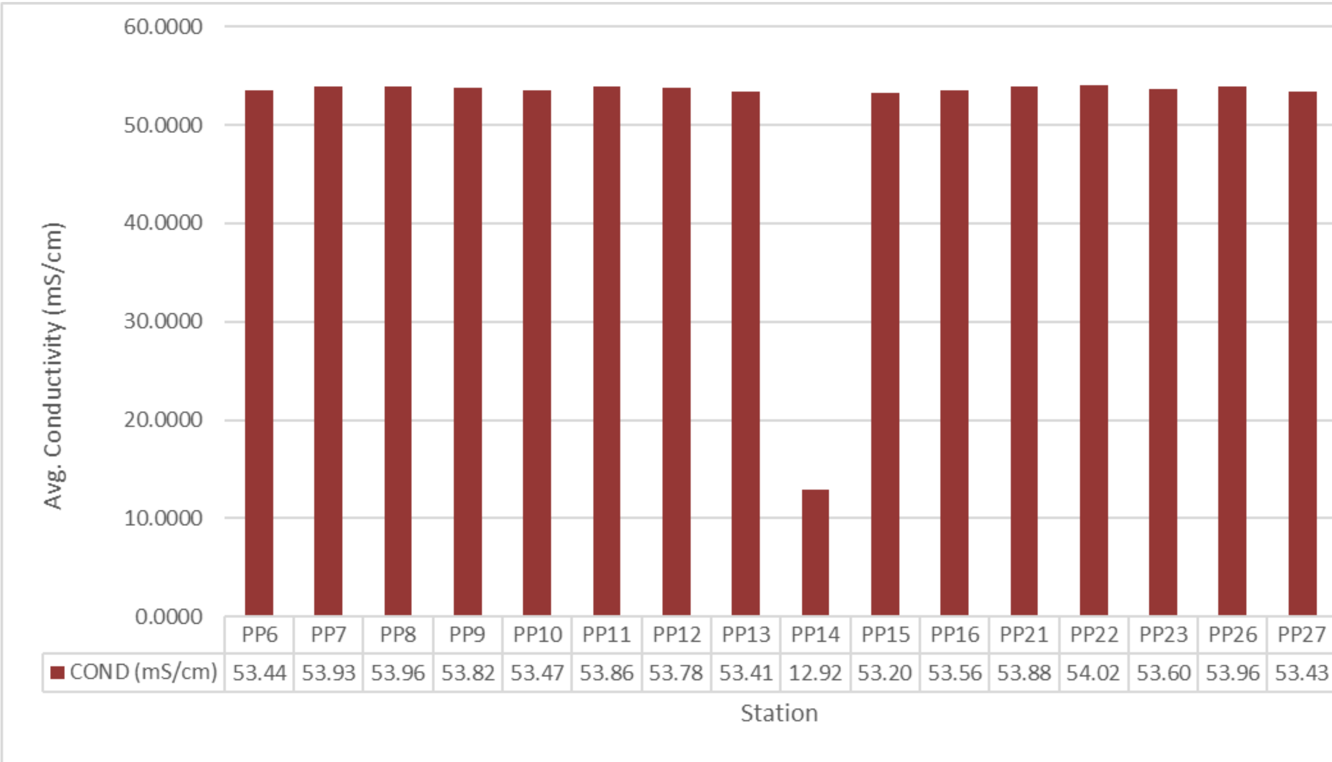


Figure 4-69 Average specific conductivity levels at marine water stations

Statistical Analysis – Specific Conductivity

There were significant spatial differences in marine conductivity levels (ANOVA $p<0.5$), these differences showed significantly lower conductivity values at Station PP14 compared to the other stations sampled. Figure 4-70 shows the mean conductivity differences between the marine water stations. Tukey's HSD test was also used to confirm these findings, showing significantly lower values $p<0.05$ for Station PP14 compared to all other stations.

There were no significant temporal differences in conductivity (ANOVA $p>0.05$). Results showed no seasonal differences throughout the year between wet and dry seasons. Conductivity values peaked during September 2024 and the lowest conductivity values were observed during October 2024.

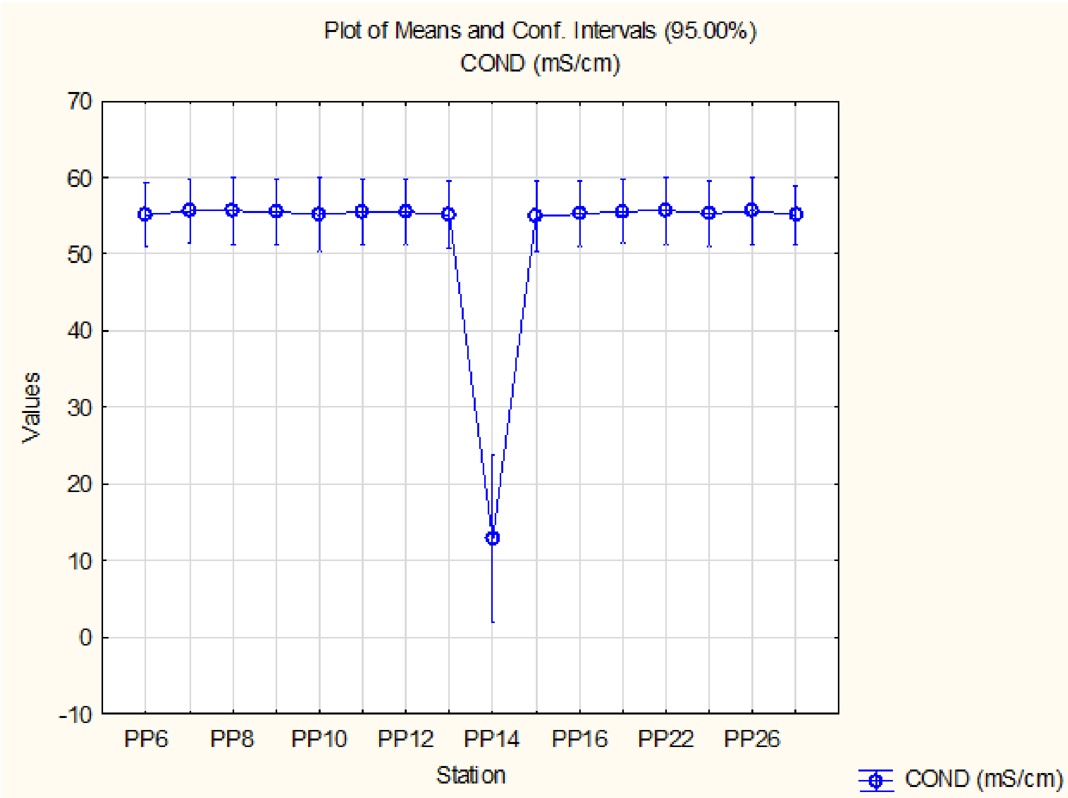


Figure 4-70 **Mean conductivity differences between marine water stations**

SALINITY

Marine water salinity values recorded (and trends noted) were similar to that of conductivity readings obtained during the monitoring exercise. This is most likely due to freshwater inflow from the nearby Sweet River and support the general inferences discussed under the section on Conductivity.

Salinity results showed a range of 0.25ppt (PP14) to 36.44ppt (PP26), the full range of results can be seen in **Error! Reference source not found.**. The average salinity across all the stations was 33.56ppt. The lowest average salinity was 8.52ppt at Station PP14 at the mouth of Deans Valley River while the highest average salinity was at Station PP22 (35.79ppt), located offshore.

Figure 4-71 shows the average salinity readings recorded for all sixteen stations.

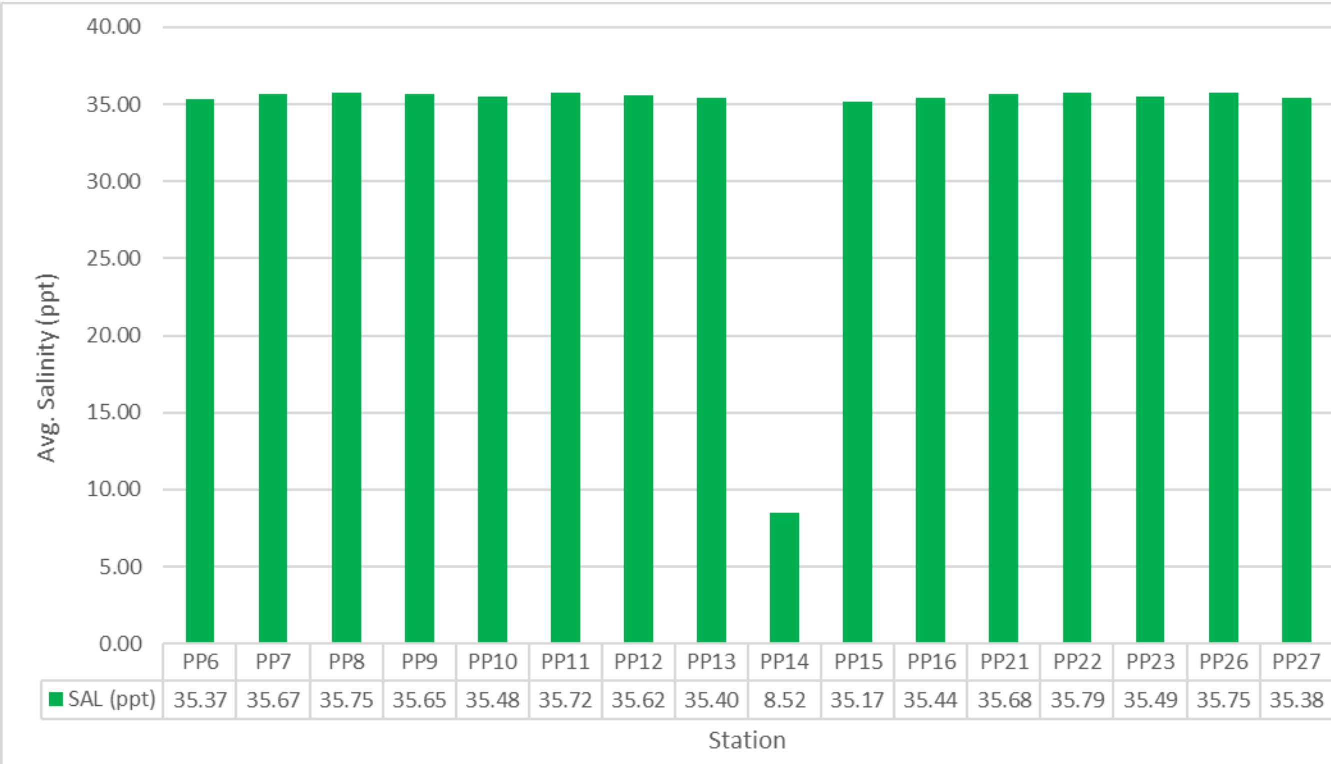


Figure 4-71 Average salinity levels at marine water stations

Statistical Analysis – Salinity

There were significant spatial differences in marine salinity levels (ANOVA $p<0.5$), these differences showed significantly lower conductivity values at Station PP14 compared to the other stations sampled. Figure 4-72 shows the mean salinity differences between the marine water stations. Tukey's HSD test was also used to confirm these findings, showing significantly lower values $p<0.05$ for Station PP14 compared to all other stations.

There were no significant temporal differences in salinity (ANOVA $p>0.05$). Results showed no seasonal differences throughout the year between wet and dry seasons. Salinity values peaked during September 2024 and the lowest salinity values were observed during October 2024.

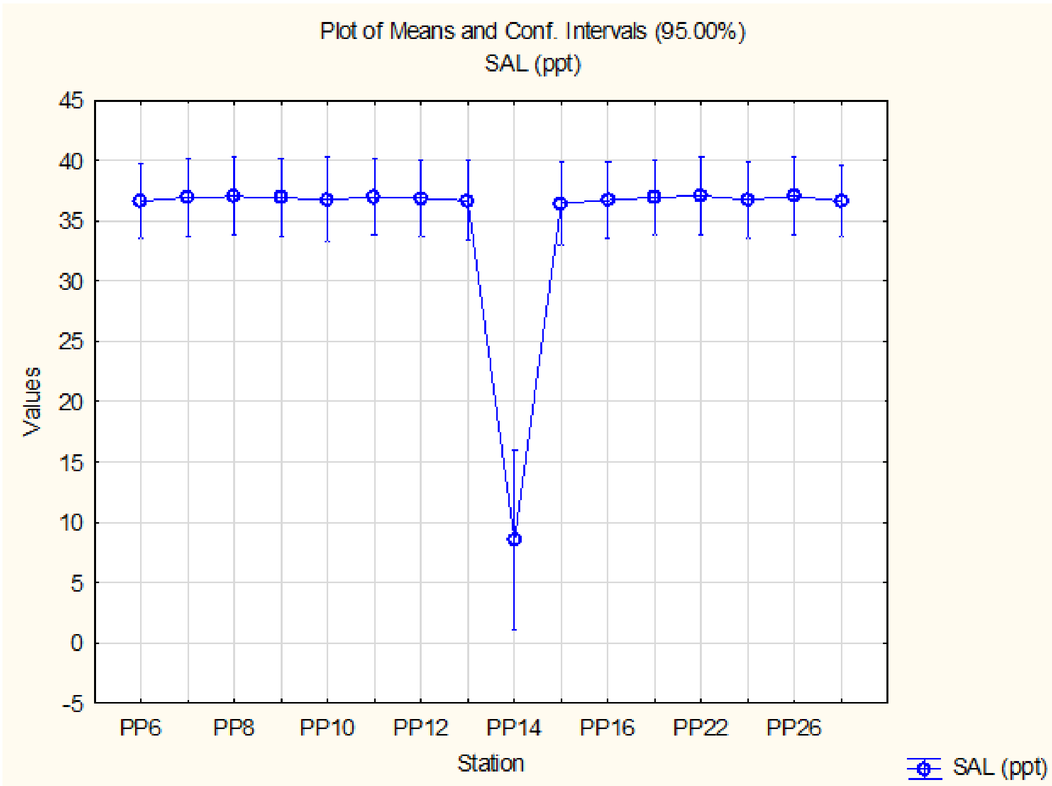


Figure 4-72 Mean salinity differences between marine water stations

DISSOLVED OXYGEN (DO)

Dissolved oxygen (DO) is a measure of how much oxygen is dissolved in water, or the amount of oxygen which is available to living aquatic organisms. DO is often used as a measure to water quality, as moving water tends to have more DO than stagnant water. Additionally bacterial respiration and organic matter decay causes the depletion of DO. Low dissolved oxygen (DO) levels can significantly impact marine communities by causing stress in marine life, leading to reduced growth, impaired reproduction, and increased disease susceptibility. They can alter species composition and reduce biodiversity, as sensitive species decline, and more tolerant or invasive species dominate. Essential habitats like seagrass beds, coral reefs, and mangroves degrade, further reducing biodiversity and ecosystem services. Low DO levels can create hypoxic "dead zones" and cause behavioural changes in marine organisms, affecting their feeding, breeding, and migration patterns.

Marine water DO results showed a range of 2.98mg/l (PP12) to 9.20mg/l (PP10), the full range of results can be seen in **Error! Reference source not found.**. The average DO across all of the stations was 5.34mg/l. The lowest average DO level was at Station PP27 (4.18mg/l) located to the west of the property, this location was shallow with muddy/silty substrate. The highest average DO was at Station PP14 (6.25mg/l), located at the mouth of Deans Valley River.

The variations observed in DO were most likely due to differences in flow and organic matter decomposition. Figure 4-73 shows the average DO values, all of which were to be above the minimal value (< 3 mg/l) considered detrimental to aquatic life (United States Environmental Protection Agency, 2016).

Station PP14 located at the mouth of Deans Valley River had the highest DO value, most likely due to the mixing of water due to the river outfall and currents, Station PP27 was located within shallow water where there was with little movement and silty/muddy substrate, this type of environment was expected to have low DO, due to lack of movement and high organic matter content.

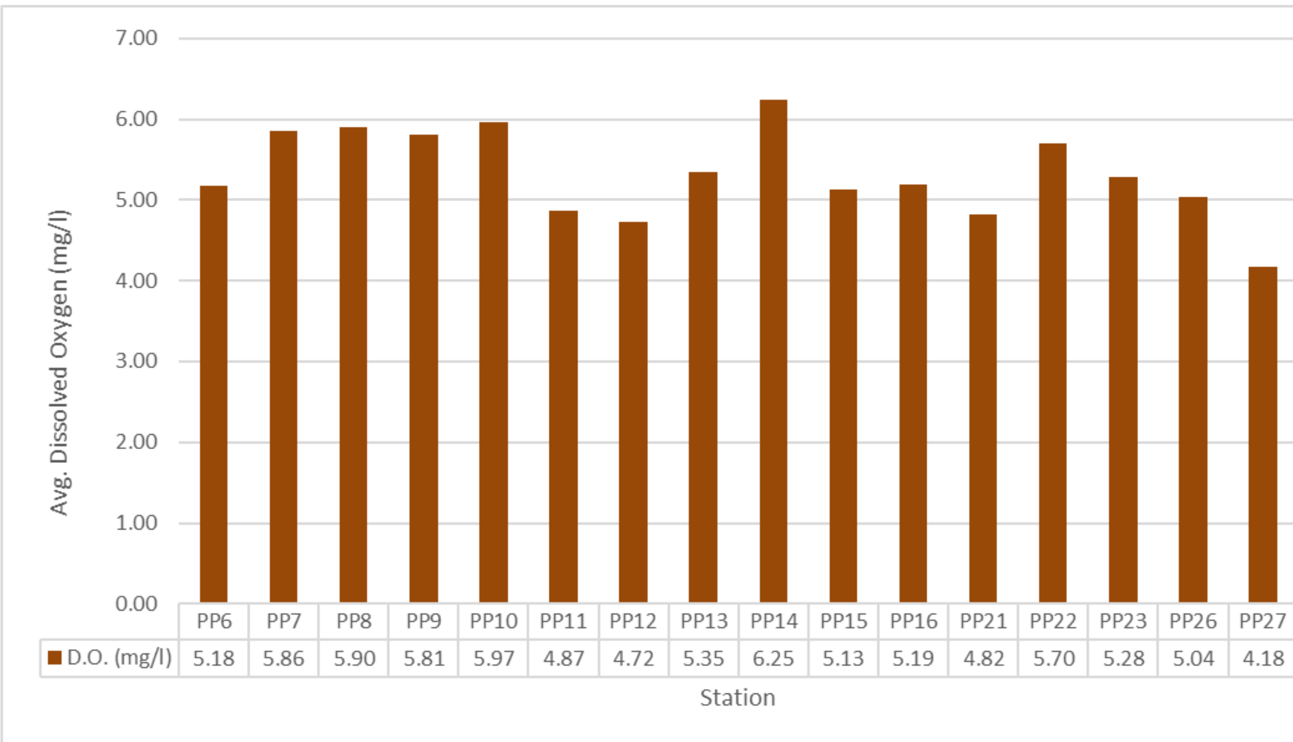


Figure 4-73 Average dissolved oxygen levels at marine water stations

Statistical Analysis – Dissolved Oxygen

There were no significant spatial differences in dissolved oxygen values (ANOVA $p>0.5$), Tukey's HSD test was also used to confirm these findings, showing no marked spatial differences $p>0.05$ between sampled Stations or between seasons.

There were significant temporal differences in dissolved oxygen values (ANOVA $p<0.5$), These significant differences showed seasonal changes, with increased dissolved oxygen levels during the wet season compared to the dry season (Figure 4-74). Highest values occurred during October 2024 with the lowest values observed during August 2023.

Higher dissolved levels during the wet season may be as a result that colder water saturates at higher DO levels. It is also known that during rainy seasons, oxygen concentrations tend to rise in most surface waters because rain saturates with oxygen as it falls.

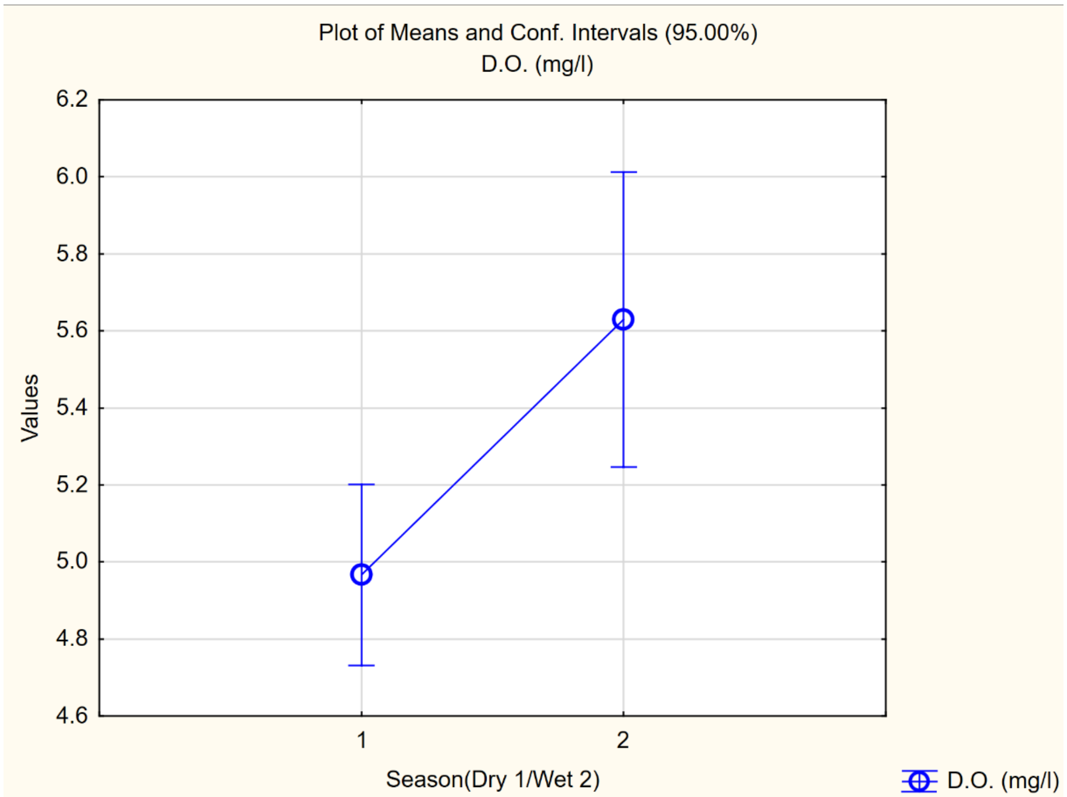


Figure 4-74 Mean marine water dissolved oxygen differences between wet and dry seasons

PH

pH is a measure of how acidic or basic a substance is, average seawater pH is around 8.1, with the NEPA marine water quality standard being 8.0-8.4.

Marine water pH results showed a range of 7.46 (PP14) to 8.37 (PP7), the full range of results can be seen in **Error! Reference source not found.**. The average pH across all of the stations was 8.03. The lowest average pH level was at Station PP14 (7.89) located at the mouth of Deans Valley River and the highest average pH was 8.11 at Station PP8 located offshore.

Figure 4-75 shows the average pH values for the sixteen stations, multiple stations were non-compliant with the NEPA marine water quality standards, with stations PP14 and PP27 having the lowest values. Lower pH can be caused by freshwater runoff containing various chemicals or decomposition of organic matter, which can produce carbon dioxide (CO_2). Stations PP7 to 10 and PP22 were located offshore, furthest from freshwater input and were noted to have the highest average pH values.

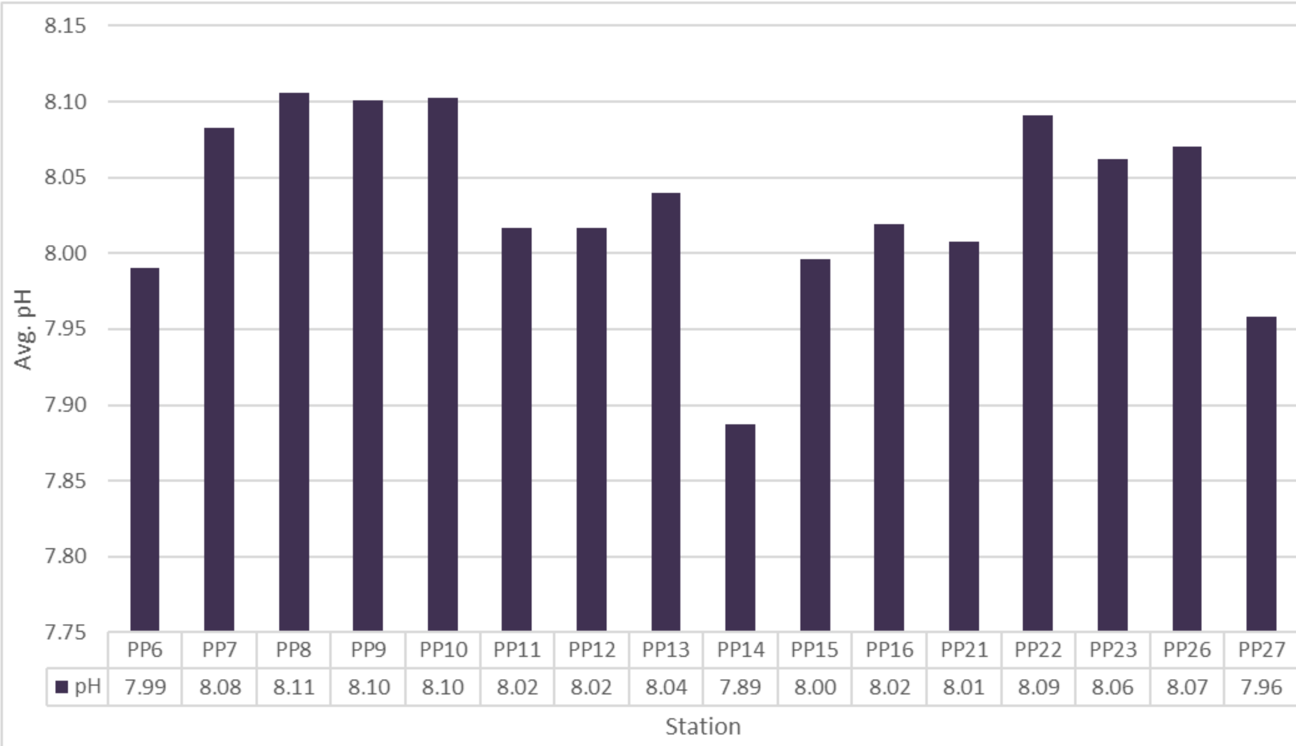


Figure 4-75 Average pH levels at marine water stations

Statistical Analysis – pH

There were no significant spatial differences in pH values (ANOVA $p>0.5$), the mean pH differences between the marine water stations were not significantly different. Tukey's HSD test was also used to confirm these findings, showing no marked differences $p>0.05$ between all Stations.

There were significant temporal differences in pH (ANOVA $p<0.05$). These significant differences showed seasonal changes, with increased pH values during the dry season compared to the wet season (Figure 4-76). Higher pH levels during the dry season may be due to less influences from freshwater inputs, during the wet season, freshwater from rivers or runoff (which tends to be more acidic) can lower pH levels. pH values peaked during October 2024 and the lowest values were observed during September 2024.

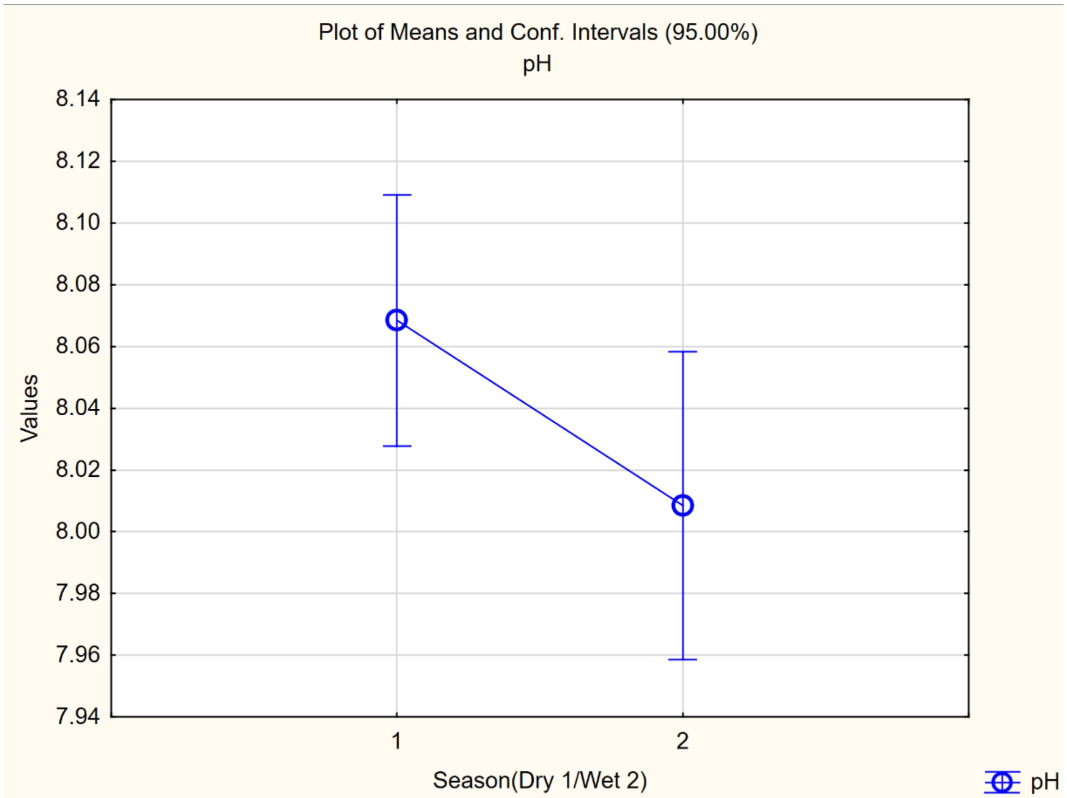


Figure 4-76 Mean marine water pH differences between wet and dry seasons

TURBIDITY

Turbidity is a measure of the cloudiness or haziness of a liquid caused by the presence of suspended particles, such as silt, clay, algae, organic matter, and microorganisms. These particles scatter and absorb light, reducing the clarity of the water. The level of turbidity is an important indicator of water quality in both freshwater and marine environments.

Marine water turbidity results showed a range of 0.00NTU (PP8-13, 15, 16, 21, 22 and 26) to 219.95NTU (PP27), the full range of results can be seen in **Error! Reference source not found.**. The average turbidity across all of the stations was 12.12NTU. The lowest average turbidity level was at Station PP12 (0.48NTU) and the highest average turbidity was at Station PP27 (55.95NTU), located to the west of the property.

Turbidity was low across most stations (Figure 4-77), however some key areas had notable turbidity values. Station PP6 and PP7 were located towards the centre of the project site, this area was noted to have poor circulation and an accumulation of suspended sediment as seen below in Plate 4-11. High turbidity at Station PP14 was most likely due to the river outflow while Station PP27 which had the highest turbidity value was shallow with a soft silty and muddy substrate, where sediments can be easily resuspended by wave action and boat activity during sampling. Figure 4-77 shows the average turbidity values for the sixteen marine stations sampled.

Plate 4-11 **Images of Marine water near PP6**

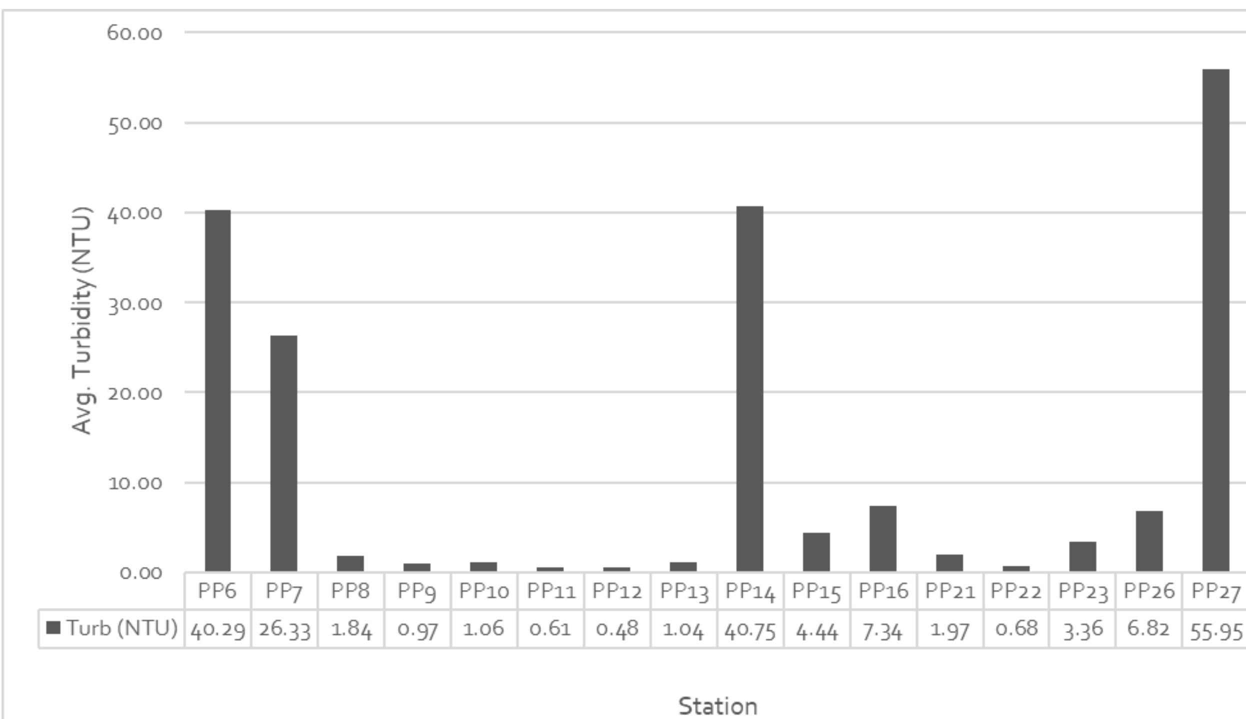


Figure 4-77 **Average turbidity levels at marine water stations**

Statistical Analysis – Turbidity

There were significant spatial differences in marine turbidity levels (ANOVA $p<0.5$), these differences showed significantly higher turbidity values at Station PP27 compared to most other stations sampled. Figure 4-78 shows the mean turbidity differences between the marine water stations. Tukey's HSD test was also used to confirm these findings, showing significantly higher values $p<0.05$ for Station PP27 compared to stations PP8 to 13 and PP15 to PP26. Stations PP6, PP7 and PP14 were not significantly different from Station 27.

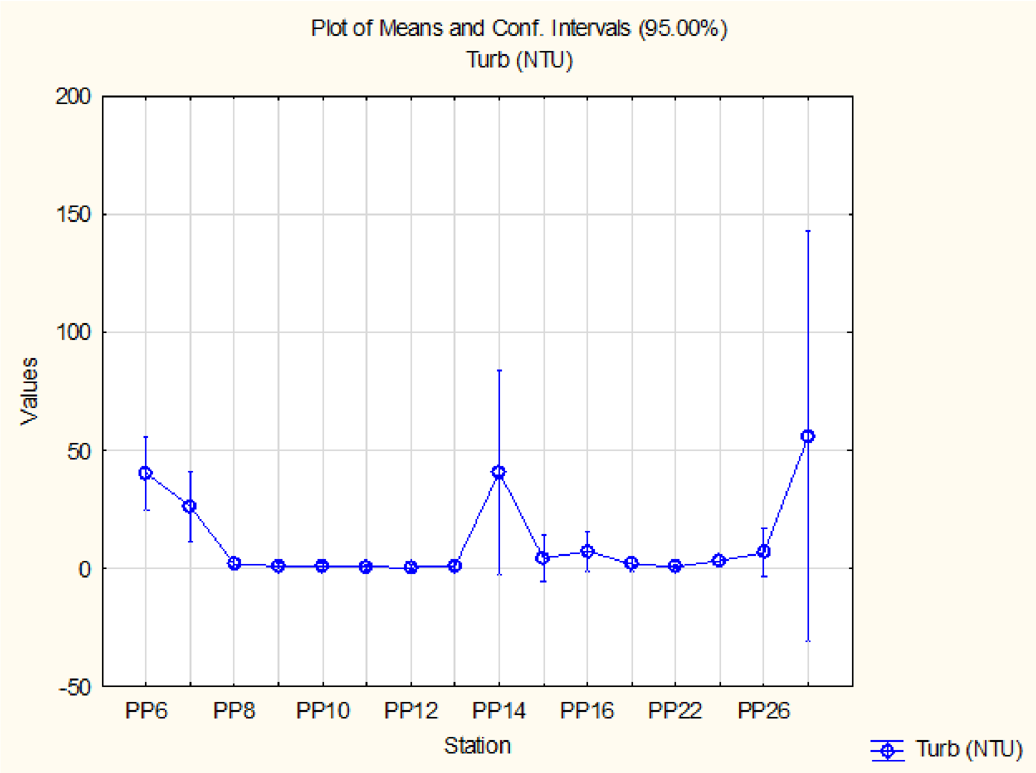


Figure 4-78 Mean turbidity differences between marine water stations

There were significant temporal differences in turbidity (ANOVA $p<0.05$). Results showed seasonal differences throughout the year between wet and dry seasons with significantly higher values during the dry season (Figure 4-79). Higher turbidity levels during the dry season, though less common may be due to several factors. The dry season in Jamaica is often accompanied by strong wind and wave action, sampling in particular during March 2025 was accompanied by a high wave climate which stirred up bottom sediments. Turbidity values peaked during June 2023 and the lowest values were observed across October and November 2023 and October 2024.

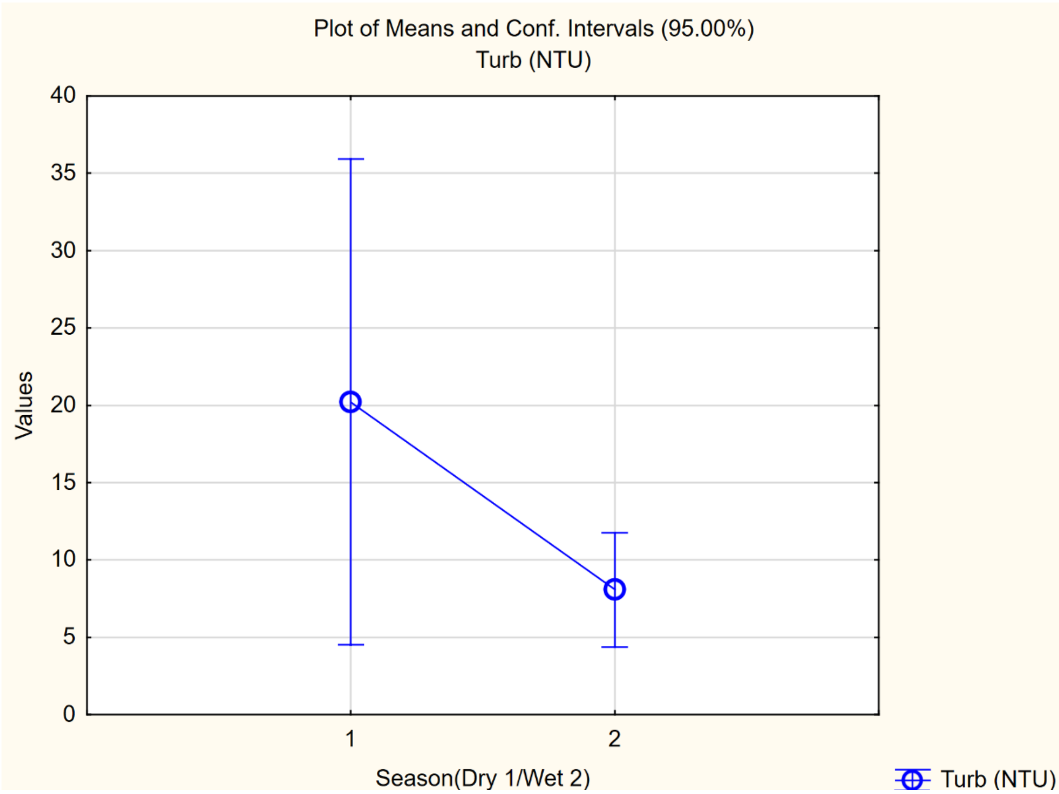


Figure 4-79 Mean marine water turbidity differences between wet and dry seasons

TOTAL DISSOLVED SOLIDS (TDS)

Total dissolved solids (TDS) is a measure of dissolved combined content, organic and inorganic substances, within the water. Seawater typically contains TDS concentrations between 30,000-35,000 mg/l. These high TDS values are due to the high concentrations of various salts and minerals in seawater (Table 4-11). TDS is closely related to salinity and conductivity.

Marine water TDS results showed a range of 305.7 mg/l (PP14) to 35,110 mg/l (PP26), the full range of results can be seen in **Error! Reference source not found.**. The average TDS across all of the stations was 32,400 mg/l. The lowest average TDS level was at Station PP14 (8,943 mg/l) located at the mouth of Deans Valley River while the highest average TDS was at Station PP22 (34,553 mg/l), located offshore.

TDS values recorded (and trends noted) were similar to that of conductivity and salinity readings obtained during the monitoring exercise and support the general inferences discussed under those sections, in particular the inference that freshwater mas most likely intermixing at Station PP14 creating a less saline environment.

All TDS values except for PP14 were found to be acceptable and within the expected range. Figure 4-80 shows the average TDS values across the sixteen stations.

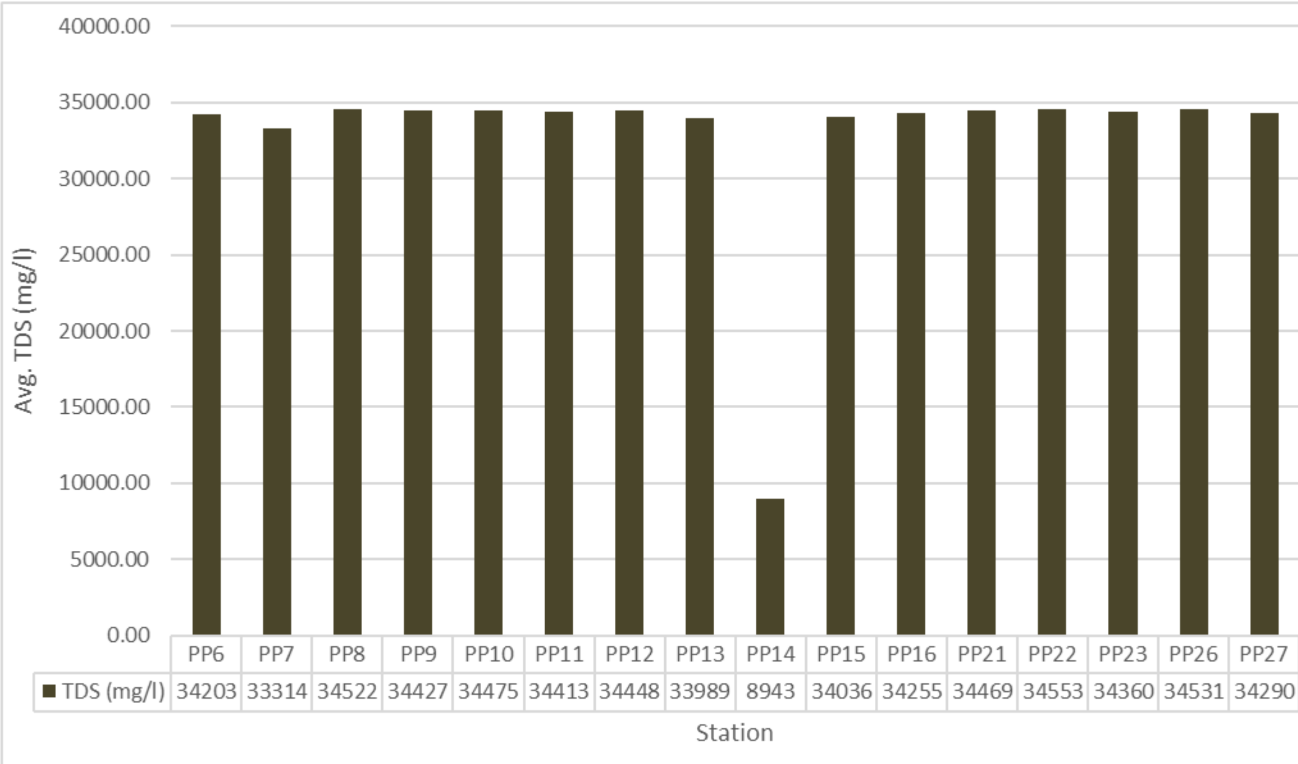


Figure 4-80 Average total dissolved solids levels at marine water stations

Statistical Analysis – Total Dissolved Solids

There were significant spatial differences in marine TDS levels (ANOVA $p<0.5$), these differences showed significantly lower TDS values at Station PP14 compared to the other stations sampled. Figure 4-81 shows the mean TDS differences between the marine water stations. Tukey's HSD test was also used to confirm these findings, showing significantly lower values $p<0.05$ for Station PP14 compared to all other stations.

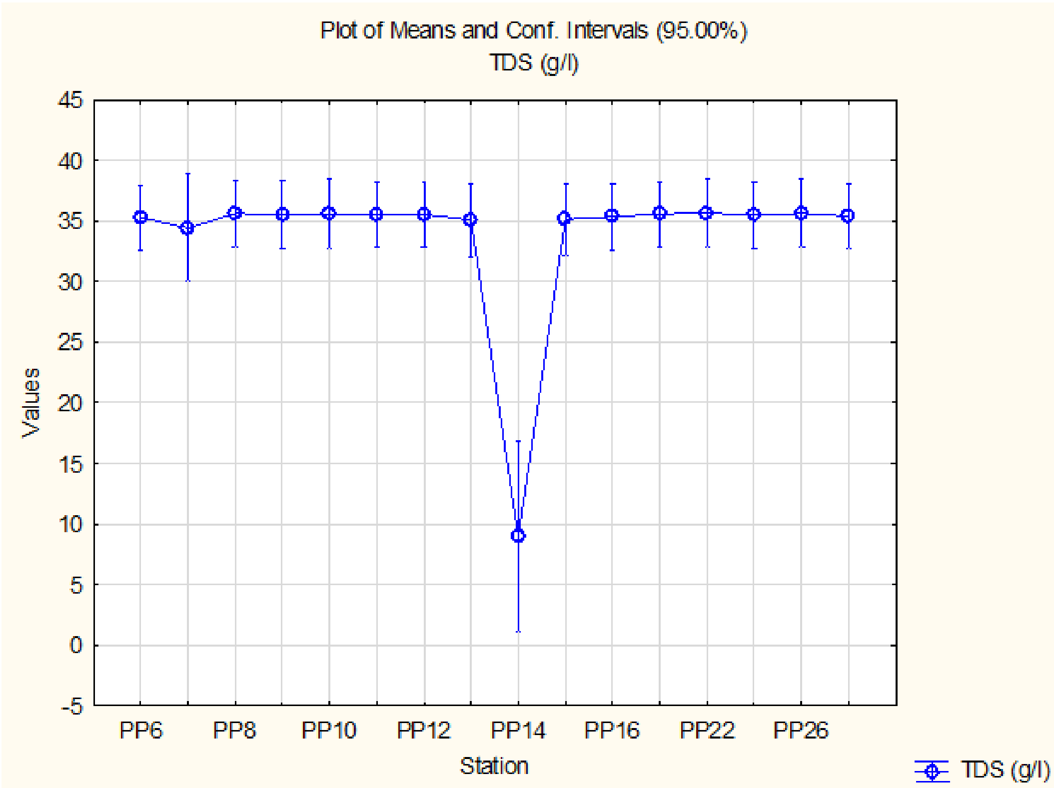


Figure 4-81 Mean TDS differences between marine water stations

There were no significant temporal differences in TDS values (ANOVA p>0.05). Results showed no seasonal differences throughout the year between wet and dry seasons. TDS values peaked during September 2024 and the lowest values were observed during October 2024.

LIGHT EXTINCTION COEFFICIENT (EC)

Photosynthetically active radiation (PAR) refers to the part of the light spectrum which typically drives photosynthesis, the differences between two PAR values at different depths of water is used to calculate the relative light extinction coefficient. Light Extinction Coefficient (EC) refers to measures of light attenuation within water or the rate of loss of light with depth. The larger the extinction coefficient the more particles (Biological or Non-Biological) are present within the water column which affect light penetration.

Light extinction coefficient results showed a range of 0.0865 (PP16) to 2.6031 (PP6), the full range of results can be seen in **Error! Reference source not found.**. The average EC across all of the stations was 0.5455. The lowest average turbidity level was at Station PP13 (0.225) offshore, and the highest average EC was at Station PP6 (1.511), located to the central coastline of the property.

Light extinction coefficient was low across most stations (Figure 4-82), with higher values at Stations PP6 7 and 14. Trends were similar to those discussed in the section on Turbidity, as both parameters are directly related. Higher suspended material within the water column would increase turbidity readings, as well as reduce light penetration, increasing EC. Higher EC values represent a greater loss of light with depth, indicating a greater presence of particles within the water column.

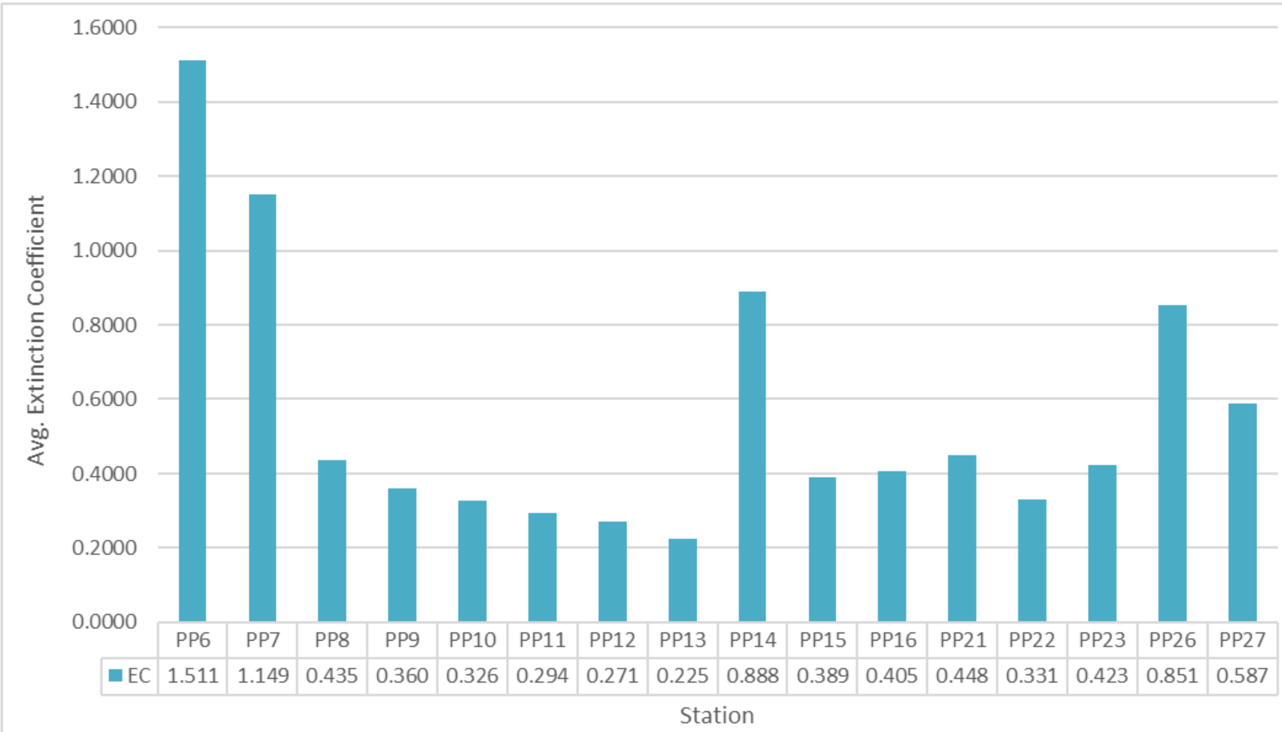


Figure 4-82 Average light extinction coefficient levels at marine water stations

Statistical Analysis – Light Extinction Coefficient

There were significant spatial differences in marine light extinction coefficient levels (ANOVA $p<0.5$), these differences showed significantly higher EC values at Station PP6 compared to most other stations sampled. Figure 4-83 shows the mean EC differences between the marine water stations. Tukey's HSD test was also used to confirm these findings, showing significantly higher values $p<0.05$ for Station PP6 compared to Stations PP10 to PP13 and PP22.

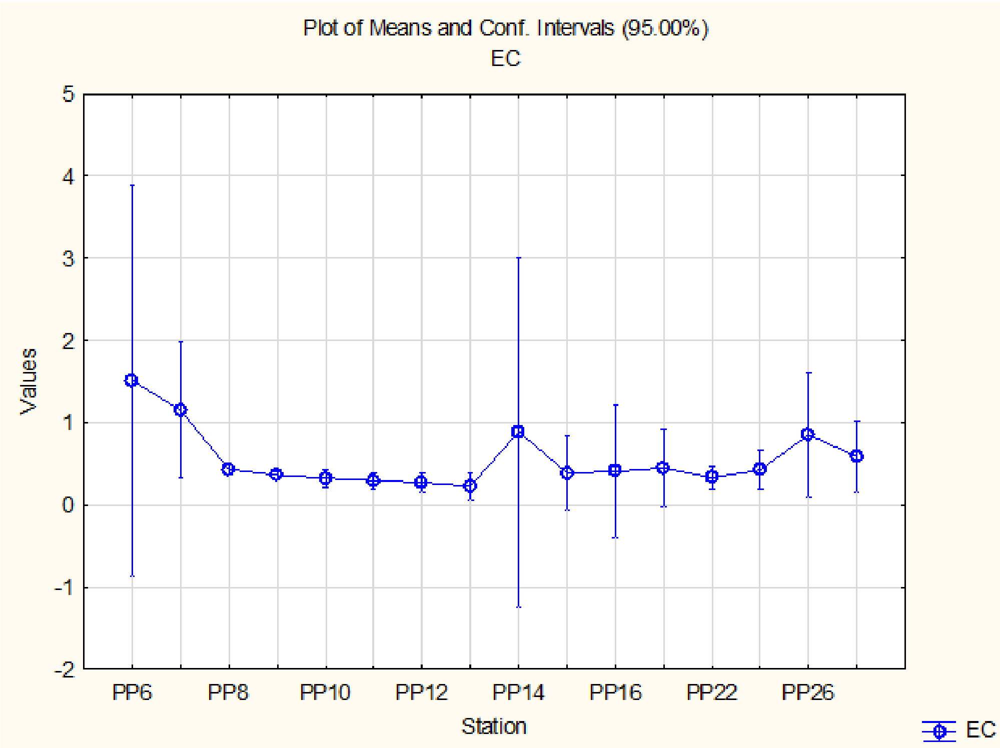


Figure 4-83 Mean EC differences between marine water stations

There were no significant temporal differences in extinction coefficient levels (ANOVA p>0.05). Results showed no seasonal differences throughout the year between wet and dry seasons. EC values peaked during September 2024 and the lowest EC values were observed during November 2023.

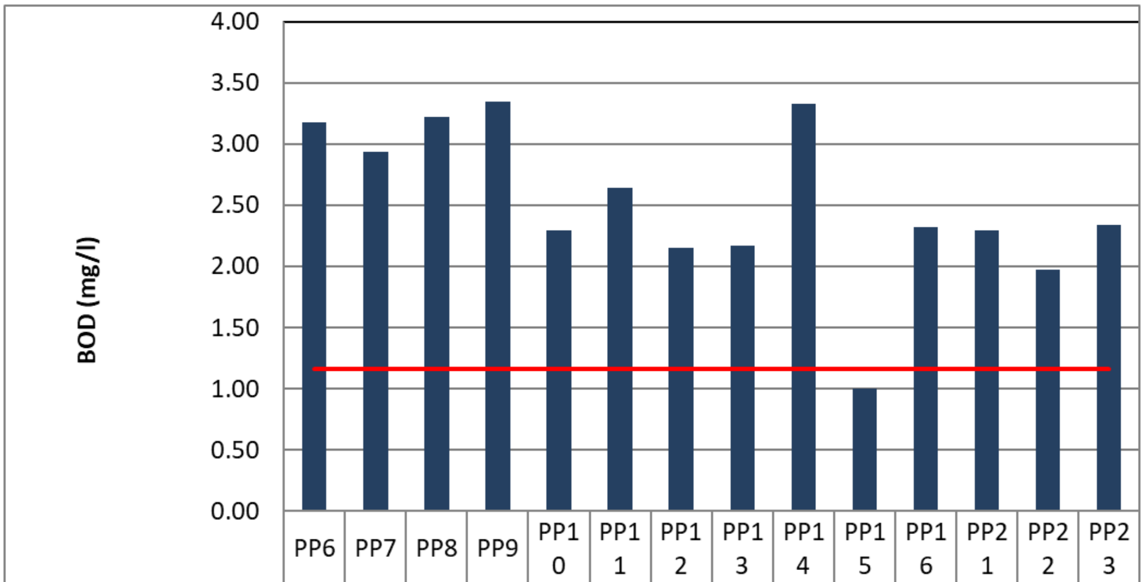
BIOLOGICAL OXYGEN DEMAND (BOD)

Biological oxygen demand (BOD) represents the amount of oxygen which is consumed by bacteria and other microorganisms while they decompose organic matter. Some common BOD sources include decomposing plants and animals, wastewater, and urban and terrestrial run off. High BOD values may indicate pollution and degraded water quality, whereas low BOD values suggest better water quality conditions conducive to supporting life and ecosystem functions.

Marine water BOD results showed a range of 0.12 mg/l (PP10) to 13.02 mg/l (PP14), the full range of results can be seen in **Error! Reference source not found.**. The average BOD across all stations was 2.53 mg/l. The lowest average BOD level was at Station PP15 (1.01 mg/l) located nearshore, while the highest average BOD was at Station PP9 (3.35 mg/l), located offshore.

Most Stations had similar BOD levels, except for a low reading for PP15, with the highest values being at PP 14 at the mouth of Deans Valley River and PP9 located offshore. BOD values were compared using a water quality model (Figure 4-85). The model showed high BOD values leaving Deans Valley River and flowing eastward along the coast, with higher values concentrated to the centre of the property, this area had poor circulation which may have contributed to slower currents and an accumulation of organic matter and debris which may have contributed to higher BOD levels.

Average BOD values were non-compliant for most marine stations sampled, which was above the NRCA Standard of 1.16mg/l (Figure 4-84). Except for Station PP15 which was compliant.



	PP6	PP7	PP8	PP9	PP10	PP11	PP12	PP13	PP14	PP15	PP16	PP21	PP22	PP23
BOD (mg/l)	3.18	2.94	3.22	3.35	2.29	2.64	2.15	2.17	3.33	1.01	2.32	2.30	1.97	2.34
NRCA Std(Upper)	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16	1.16

Figure 4-84 Average biological oxygen demand levels at marine water stations

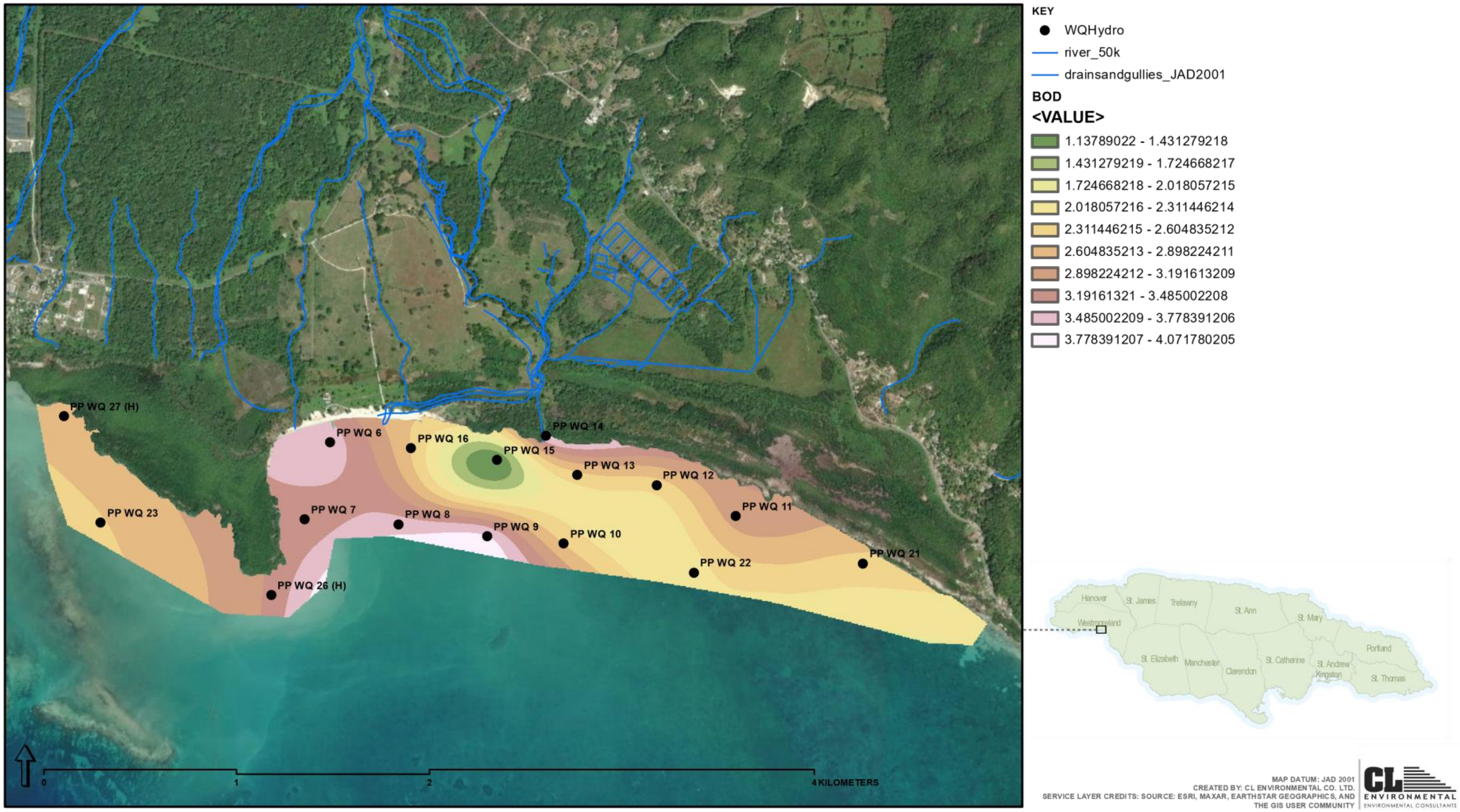


Figure 4-85 **Marine water quality model for BOD**

Statistical Analysis – Biological Oxygen Demand

There were no significant spatial differences in marine biological oxygen demand (ANOVA $p>0.5$), Tukey's HSD test was also used to confirm these findings, showing no marked spatial differences $p>0.05$ between sampled Stations.

There were significant temporal differences in marine BOD (ANOVA $p<0.05$). These significant differences showed seasonal changes throughout the year, with increased BOD during the dry season compared to the wet season. BOD values peaking during June 2023 and the lowest values were observed during September 2024. Figure 4-86 shows the significant mean BOD differences with $p<0.05$. Higher BOD values during the dry season are normally atypical, possible reasons for these results may be due to reduced freshwater input from rivers, this may lower dilution or organic matter and pollutants in the marine environment, causing increased BOD concentrations.

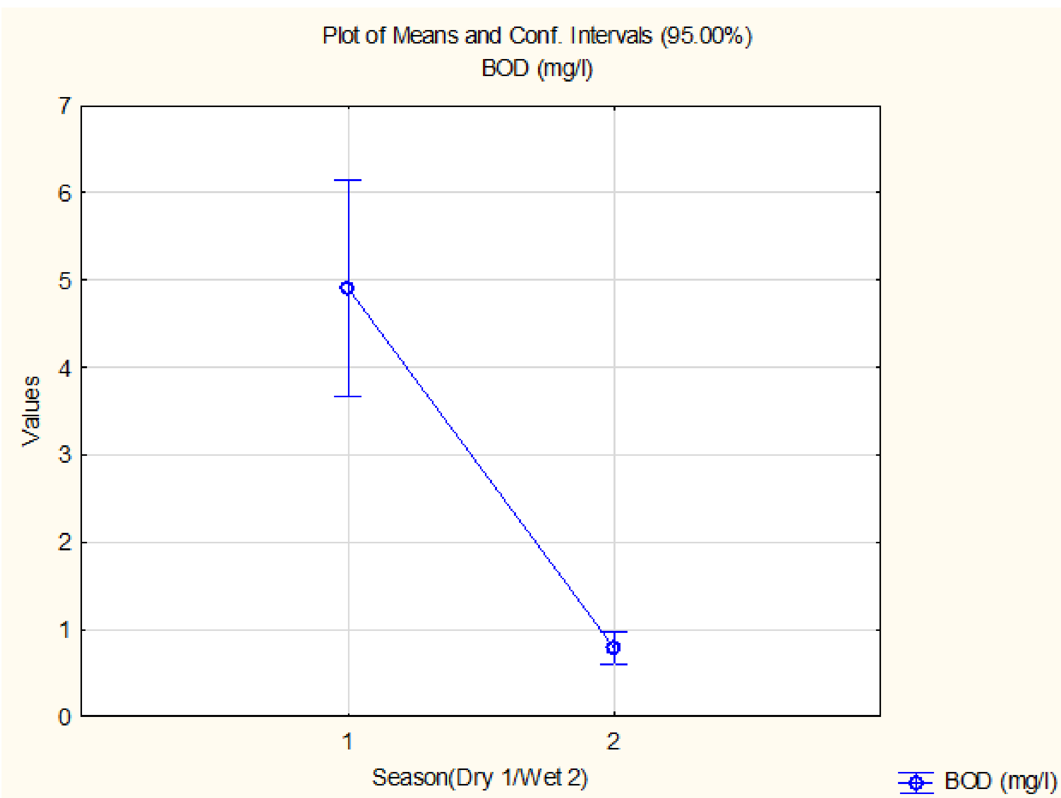


Figure 4-86 Mean marine water BOD differences between wet and dry seasons

NITRATES

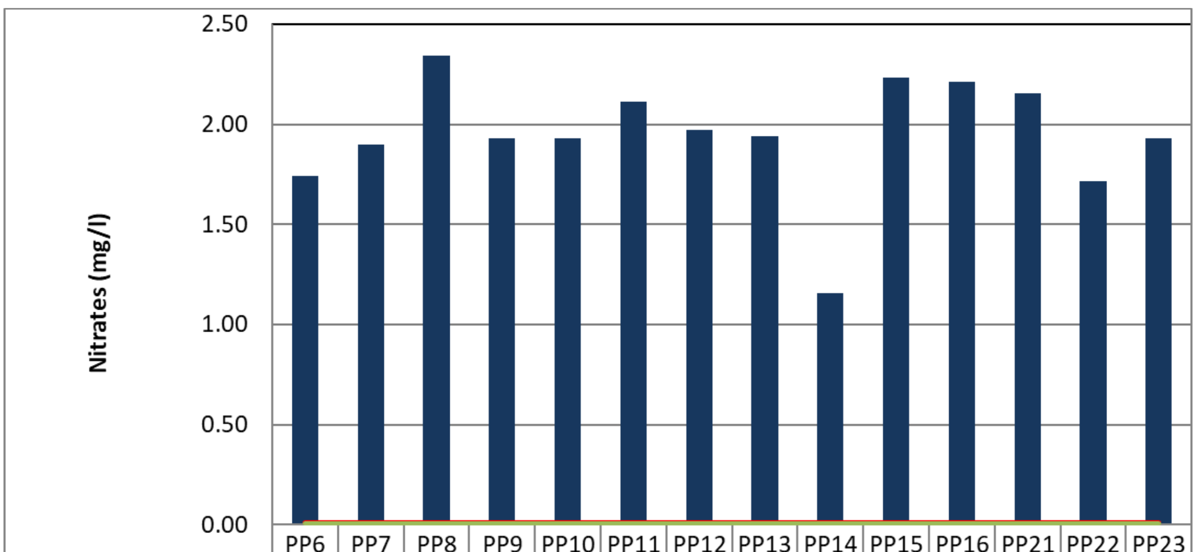
Nitrates are essential nutrients for plant growth, but excessive amounts in marine water environments can lead to various environmental problems. High nitrate levels are due to water contamination from wastewater, land run-off via drains and gullies or fertilizers and can cause increased growth of algae which can result in decreased levels of dissolved oxygen leading to eutrophication.

Marine water nitrate results showed a range of 0.4 mg/l (PP14) to 3.4 mg/l (PP16), the full range of results can be seen in **Error! Reference source not found.**. The average nitrate value across all stations was 1.95 mg/l. The lowest average nitrate level was at Station PP14 (1.16 mg/l) located in the mouth of Deans Valley River, while the highest average nitrate value was at Station PP8 (2.34mg/l), located offshore.

The variations observed in nitrates were most likely due to differences in water contamination, however Station PP8 which had the highest value was offshore and thus may not have been highly influenced by the project site. Station PP14 which had the lowest nitrate value was located at the mouth of the river and may indicate that these nutrients may have been absorbed upstream.

Jamaica's coastal waters frequently exceed standard nitrate levels due to factors such as agricultural runoff, wastewater discharge, and land-based pollution. This ongoing issue contributes to nutrient enrichment, leading to potential eutrophication and adverse impacts on marine ecosystems and water quality.

All stations were non-compliant (above) NEPA standards for nitrates (Figure 4-87).



	PP6	PP7	PP8	PP9	PP10	PP11	PP12	PP13	PP14	PP15	PP16	PP21	PP22	PP23
NIT (mg/l)	1.74	1.90	2.34	1.93	1.93	2.11	1.97	1.94	1.16	2.23	2.21	2.16	1.71	1.93
NRCA Std(Upper)	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
NRCA Std(Lower)	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007

Figure 4-87 Average nitrate levels at marine water stations

Statistical Analysis – Nitrates

There were significant spatial differences in marine nitrate levels (ANOVA $p<0.5$), these differences showed significantly lower nitrate values at Station PP14 compared to the other stations sampled. Figure 4-88 shows the mean nitrate differences between the marine water stations. Tukey's HSD test was also used to confirm these findings, showing significantly lower values $p<0.05$ for Station PP14 compared to Stations PP8, PP10 to 12, PP15 to 21and PP23.

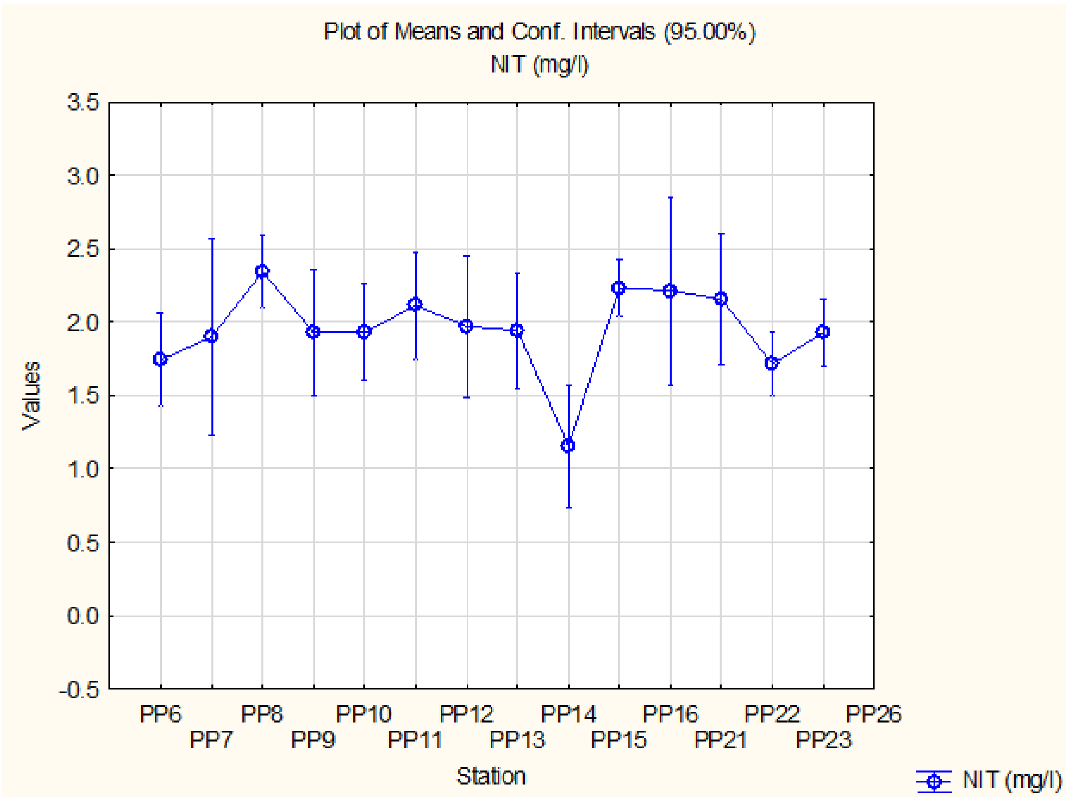


Figure 4-88 **Mean nitrate differences between marine water stations**

There were no significant temporal differences in marine nitrate levels (ANOVA $p<0.05$). There were no significant seasonal differences during the dry season compared to the wet season. Nitrate values peaked during October 2023 and the lowest values were observed during August 2023.

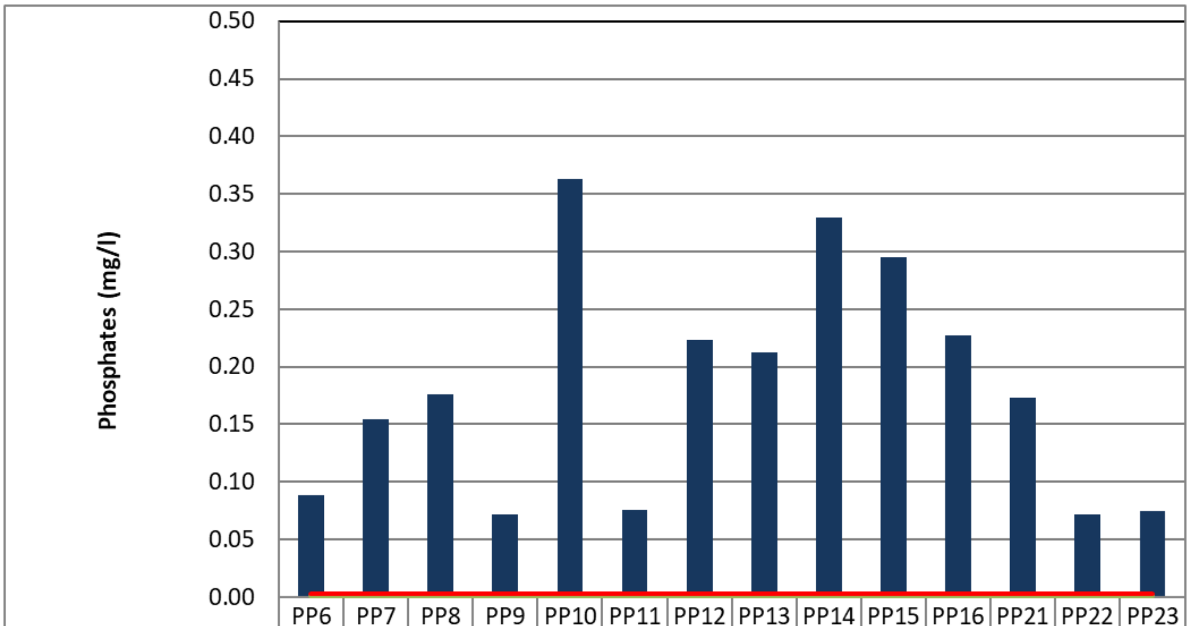
PHOSPHATES

Phosphates are essential nutrients for plant growth, but like nitrates, excessive amounts in can lead to various environmental problems. High phosphate levels are likely due to water contamination from poor agricultural practices, runoff from urban areas, or improper discharge from sewage treatment plants.

Marine water phosphate results showed a range of 0.02 mg/l (PP8, 9, 12, 13 and 22) to 2.3 mg/l (PP10), the full range of results can be seen in **Error! Reference source not found.**. The average phosphate value across all stations was 0.18 mg/l. The lowest average phosphate level was at Stations PP9 and 22 (0.07 mg/l) and the highest average phosphate value was at Station PP10 (0.36mg/l), offshore and Station PP14 (0.33 mg/l) located at the mouth of Deans Valley River.

The variations observed in phosphates were most likely due to differences in water contamination from agricultural runoff. The highest phosphate concentrations were found to be close to the Deans Valley River outflow, Stations PP14, and PP15, and Station PP10. Runoff in particular from manure or fertilizers may have been a primary contributor to the recorded phosphate readings.

All stations were non-compliant (above) NEPA Standards of 0.001-0.003 mg/l. These results are consistent for nearshore coastal waters in Jamaica. (Figure 4-89).



	PP6	PP7	PP8	PP9	PP10	PP11	PP12	PP13	PP14	PP15	PP16	PP21	PP22	PP23
PHOS (mg/l)	0.09	0.15	0.18	0.07	0.36	0.08	0.22	0.21	0.33	0.30	0.23	0.17	0.07	0.07
NRCA Std(Lower)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
NRCA Std(Upper)	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003

Figure 4-89 Average phosphate levels at marine water stations

Statistical Analysis – Phosphates

There were no significant spatial differences in phosphates (ANOVA $p>0.5$), the mean phosphate differences between the marine water stations were not significant. Tukey's HSD test was also used to confirm these findings, showing no marked differences $p>0.05$ between all Stations.

There were significant temporal differences in phosphate concentrations (ANOVA $p<0.5$) (Figure 4-90). Increased phosphate levels during the wet season are most likely due to increased land based inputs and enhanced runoff. Rainfall during the wet season may wash fertilizers, sewage and animal waste into rivers and coastal waters, the site in particular is host to a large swath of farmland. Phosphate values peaked during November 2023 and the lowest values were observed during October 2024.

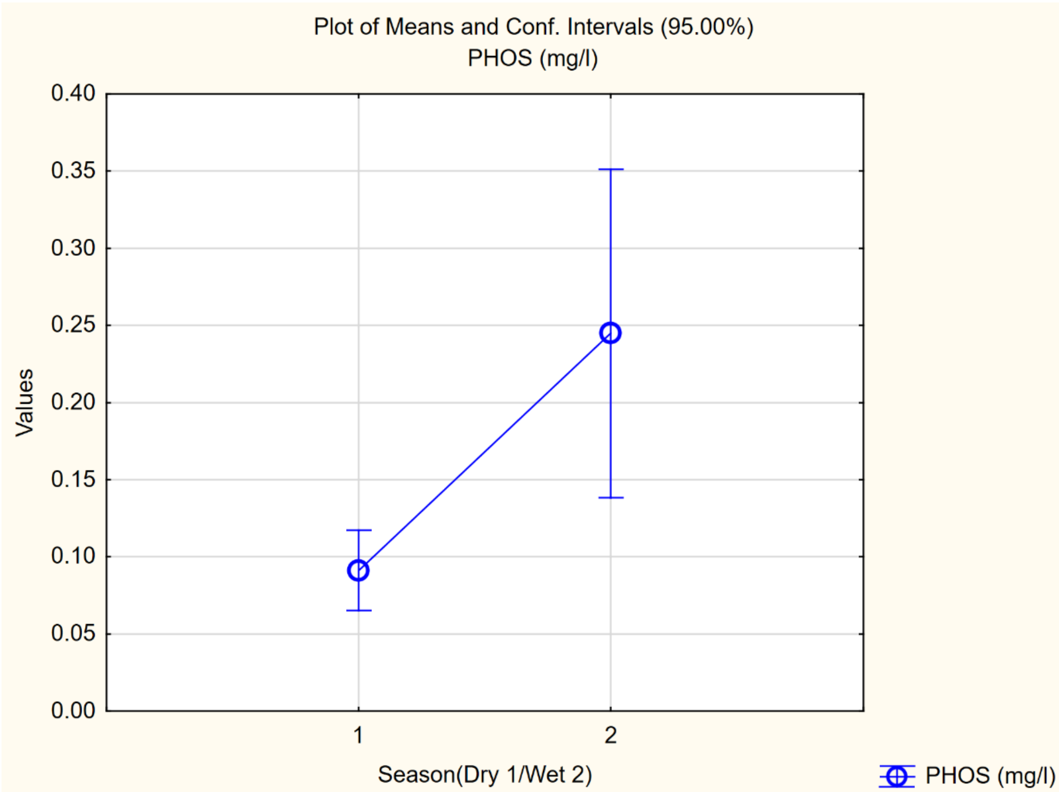


Figure 4-90 **Mean marine water phosphate concentrations, differences between wet and dry seasons**

TOTAL SUSPENDED SOLIDS (TSS)

TSS measures the concentration of particulate matter suspended in the water column that exceed 2 microns in size. TSS values lower than 20mg/l often indicate clear water.

Marine water TSS results showed a range of 0.00 mg/l (PP15, 16 and 22) to 39.0 mg/l (PP6), the full range of results can be seen in **Error! Reference source not found.**. The average TSS value across all stations was 6.11 mg/l. The lowest average TSS level was at a few stations, 3.0 mg/l and the highest average TSS value was at Station PP6 (22 mg/l), located to the central coastline of the project site.

The variations observed in TSS were most likely due to differences in suspended sediment and were closely related to turbidity values. Stations PP6 and PP7 located to the central coastline of the project site had the highest TSS values, this location was visibly turbid during most monitoring exercises. Only station PP6 had average TSS values above 20 mg/l.

Most average TSS values were low (Figure 4-91). This indicated mostly clear water through the study area at the time of sampling, which was further illustrated by similar turbidity trends.

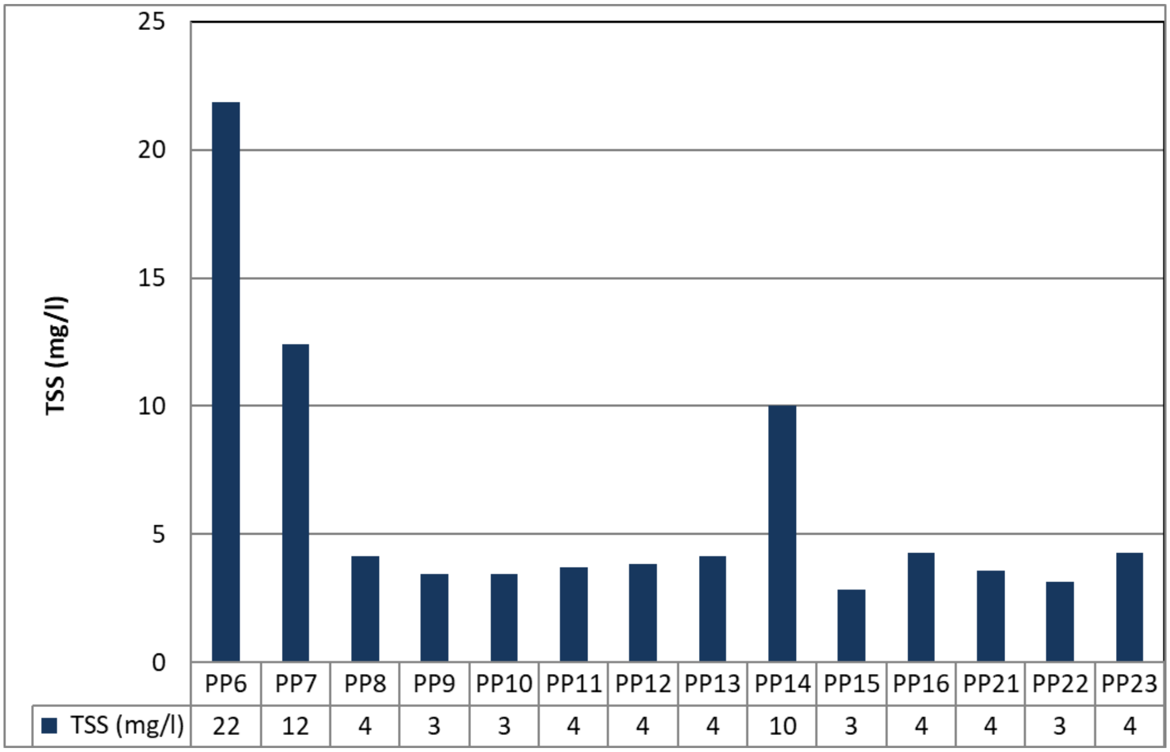


Figure 4-91 **Average total suspended solid levels at marine water stations**

Statistical Analysis – Total Suspended Solids

There were significant spatial differences in marine total suspended solid levels (ANOVA $p<0.5$), these differences showed significantly higher TSS values at Station PP6 and PP7 compared to all other stations sampled. Figure 4-92 shows the mean TSS differences between the marine water stations. Tukey's HSD test was also used to confirm these findings, showing significantly higher values $p<0.05$ for Stations PP6 and PP7 compared to all other stations sampled.

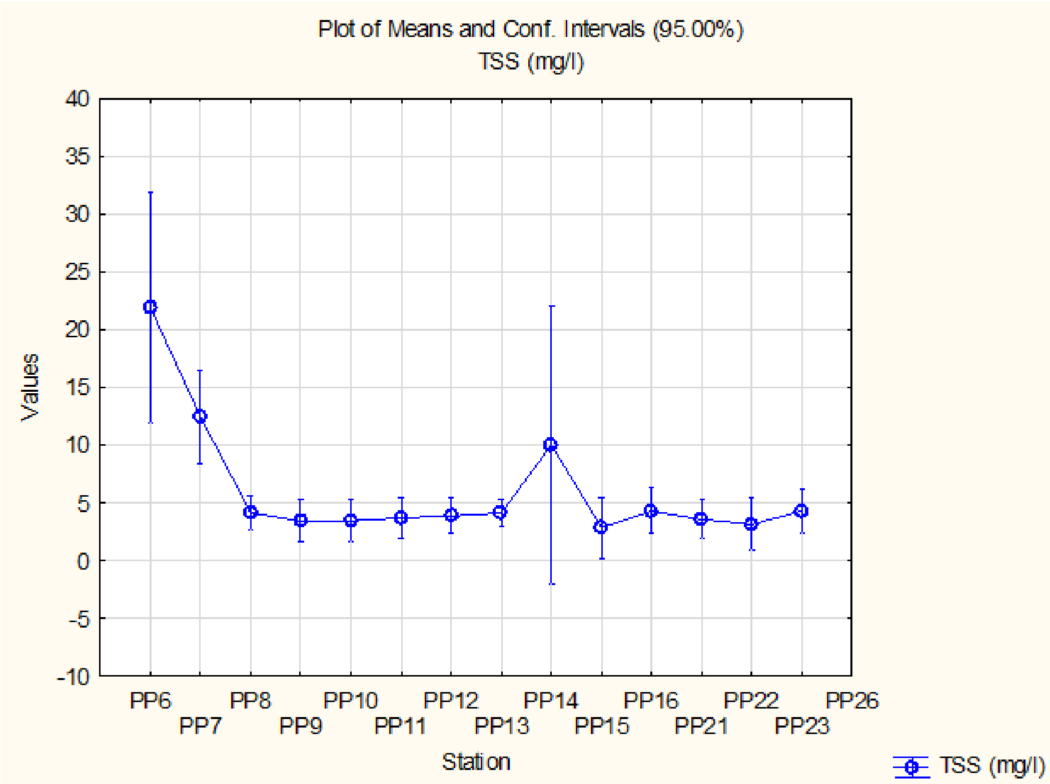


Figure 4-92 Mean TSS differences between marine water stations

There were no significant temporal differences in TSS (ANOVA $p>0.05$). Results showed no seasonal differences throughout the year between wet and dry seasons. TSS values peaked during September 2024 and March 2025 and the lowest TSS values were observed during October 2024.

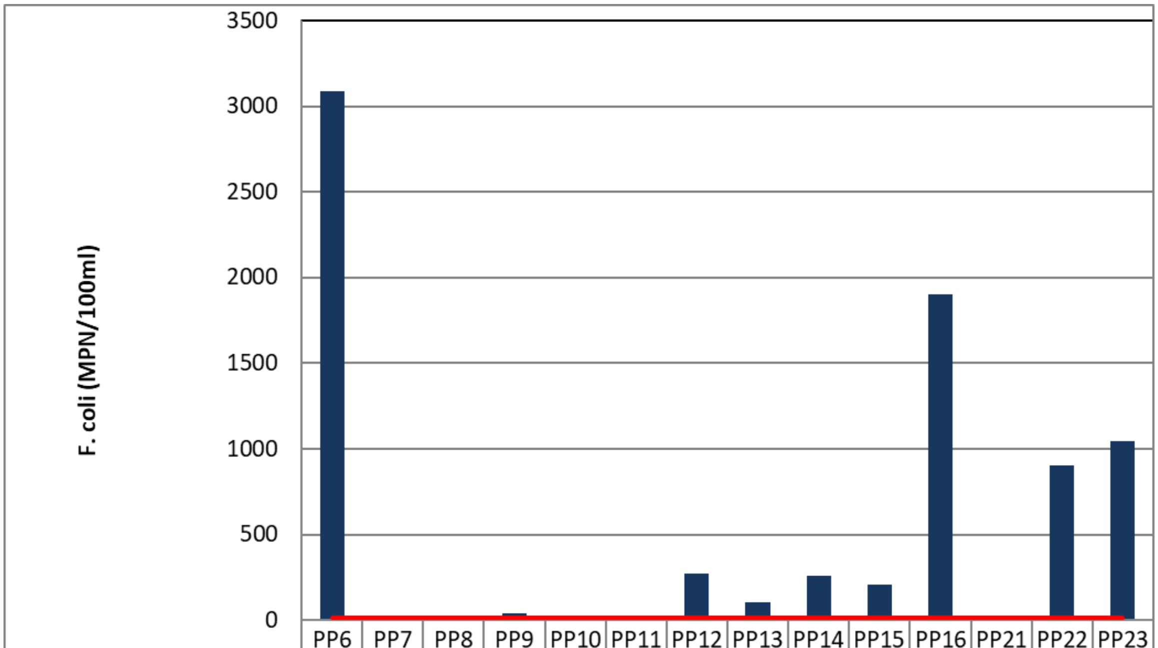
FAECAL COLIFORM

Faecal coliforms are a subgroup of bacteria that are commonly found in the intestines of warm-blooded animals, including humans, and are excreted in their faeces. High faecal coliform levels are due to water contamination from sewage, wastewater, and terrestrial run off.

Marine water faecal coliform results showed a range of 1.1 MPN/100ml (PP6-8, PP10, PP11, PP15, PP16, PP21 and PP23) to 9,200 MPN/100ml (PP6), the full range of results can be seen in **Error! Reference source not found.**. The average faecal coliform value across all stations was 567.96 MPN/100ml. The lowest average faecal coliform level was at Station PP8 (8 MPN/100ml) offshore, and the highest average faecal coliform value was at Station PP6 (3086 MPN/100ml), towards the south of the project site.

The variations observed in faecal coliform were most likely due to differences in water contamination, in particular from the various farm animals (buffaloes, cattle, horses, goats and sheep) on the project site. Stations PP7 to PP10 had low faecal coliform levels, these stations were located offsite and may have been minimally affected by on site runoff or contamination. Stations PP6 and PP16 were located close to the southern property beach, this was a collection area for multiple water sources and drains which flowed through the project site, which may have contributed to the accumulation of faecal coliform bacteria in this location from site runoff.

Faecal coliform levels exceeded NEPA marine standards of <13 MPN/100mL at all stations except for Station PP8 (Figure 4-93). This may suggest that the location may be experiencing pollution from terrestrial drainage, such as from the various marshland areas along the coastline (freshwater stations PP17 and PP18).



	PP6	PP7	PP8	PP9	PP10	PP11	PP12	PP13	PP14	PP15	PP16	PP21	PP22	PP23
F.COLI (mpn/100ml)	3086	20	8	37	29	13	270	106	261	206	1900	12	903	1047
NRCA Std(Upper)	13	13	13	13	13	13	13	13	13	13	13	13	13	13

Figure 4-93 Average faecal coliform levels at marine water stations

Statistical Analysis – Faecal Coliform

There were significant spatial differences in marine faecal coliform levels (ANOVA $p<0.5$), these differences showed significantly higher faecal coliform values at Station PP6 compared to most other stations sampled. Figure 4-94 shows the mean faecal coliform differences between the marine water stations. Tukey's HSD test was also used to confirm these findings, showing significantly higher values $p<0.05$ for Station PP6 compared to most other stations sampled, Station PP16 was found to be not significantly different from Station PP6.

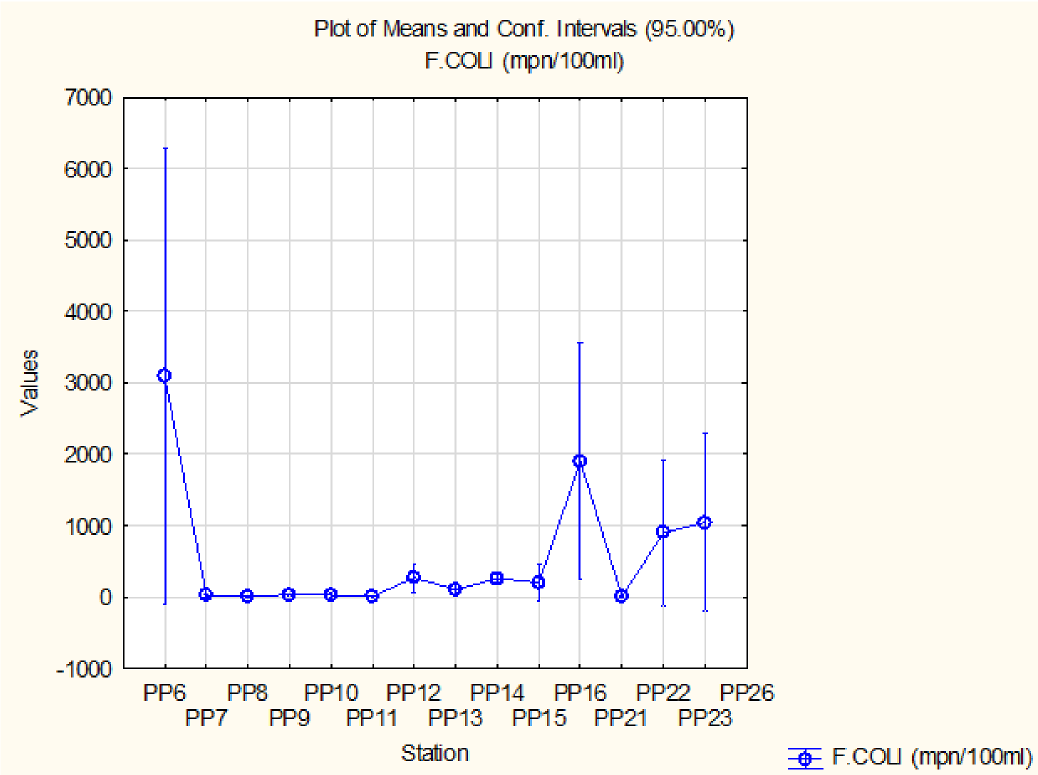


Figure 4-94 **Mean faecal coliform differences between marine water stations**

There were no significant temporal differences in marine faecal coliform values (ANOVA p<0.05). With no significant seasonal differences during the dry season compared to the wet season. Faecal coliform values peaking during June 2023 and the lowest values were observed during September 2024, October 2024 and March 2025.

STATISTICAL ANALYSIS OF MARINE WATER OUTLIERS

During sampling of the site, one marine water station, Station PP14 stood out as a notable outlier. Its data was sufficiently distinct from the other stations, therefore it was excluded from the temporal statistical analyses. The objective behind this removal was to accurately assess seasonal variations by isolating the influence that Station PP14 had on the overall dataset.

Without Station PP14, there were significant temporal differences in conductivity, salinity, DO, TDS, BOD and phosphates (ANOVA p<0.05). These significant differences showed increased values for conductivity, salinity, DO, TDS and phosphates during the wet season compared to the dry season (Figure 4-95) and significantly higher BOD values during the dry season (Figure 4-96).

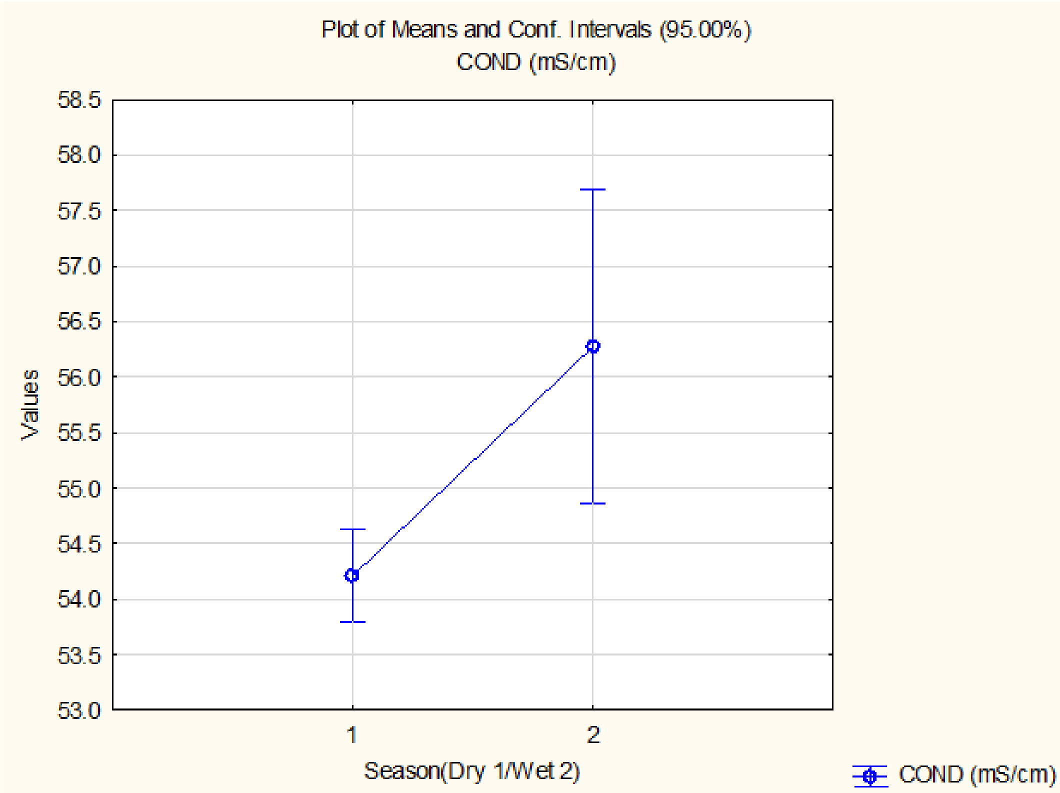


Figure 4-95 Mean marine water conductivity differences between wet and dry seasons without Station PP14

By removing Station PP14, it was observed that conductivity, salinity and TDS became significantly different for marine stations during the wet seasons. This was most likely due to the freshwater output from the nearby Deans Valley River outflow. The high volume of freshwater may have had significant effects on lowering and equalising these parameters, with the station removed, the difference between the wet and dry seasons is more clearly observed. Dissolved oxygen, BOD and phosphate values were significantly different with or without the influence of Station PP14.

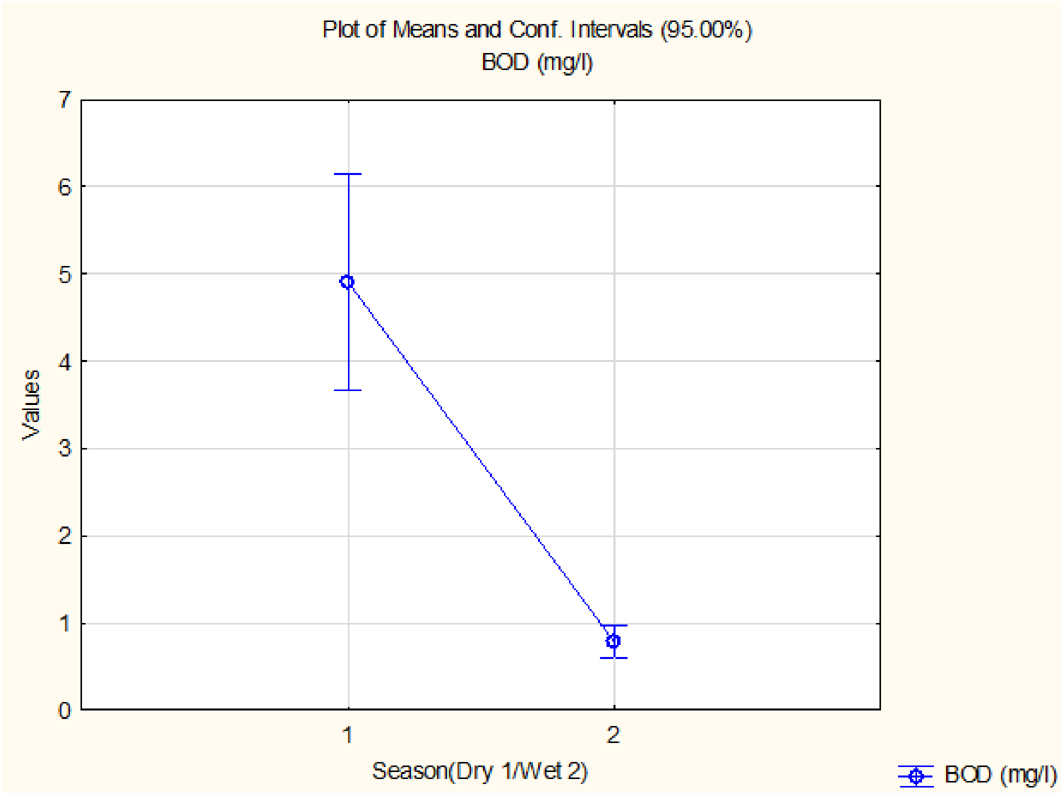


Figure 4-96 **Mean marine water BOD differences between wet and dry seasons without Station PP14**

Temperature, pH, turbidity, extinction coefficient, TSS, Nitrate, and faecal coliform values were not found to be significantly different (ANOVA $p>0.05$). This indicates that these parameters remained relatively stable throughout the year, showing no marked seasonal variations.

When comparing seasonal differences in the dataset both with and without Station PP14, it became evident that Station PP14 significantly influenced the observed seasonal variation, with significant changes to conductivity, salinity and TDS. Dissolved oxygen, BOD and phosphate remained significantly different between seasons regardless of the inclusion of data from Station PP14 (ANOVA $p < 0.05$). The analysis reaffirmed that DO and phosphates were significantly higher during the wet season, while BOD was significantly higher during the dry season, irrespective of Station PP14's data. This consistency lends greater confidence to the robustness of the findings and strengthens the conclusion that these seasonal trends are representative of broader patterns across the study area.

The statistical analysis of both freshwater and marine datasets revealed the presence of influential outliers—Station PP17 and Station PP14, respectively. Their data were sufficiently distinct from other sampling stations, prompting their exclusion from temporal statistical analyses to accurately assess seasonal variations across parameters.

In the freshwater dataset, the removal of Station PP17 confirmed significant seasonal variation BOD and faecal coliform. These significant differences showed increased values for BOD and f. coliform during the dry season compared to the wet season with or without Station PP17. Station PP17 did not significantly affect seasonal trends, as results remained consistent with or without its inclusion. This reinforces the robustness of the freshwater dataset's findings and suggests that Station PP17, while distinct, did not distort broader seasonal patterns.

Similarly, analysis of the marine dataset, excluding Station PP14, confirmed significant seasonal variation in conductivity, salinity and TDS as well as its dampening effect on seasonal variability in turbidity concentrations. Its inclusion obscured clear seasonal trends, particularly for turbidity, reinforcing the importance of critically evaluating and managing outlier influence in environmental datasets.

Collectively, these findings underscore the influence that individual outlier stations can exert on water quality assessments and the interpretation of temporal trends. Excluding these stations where appropriate enhances the clarity and reliability of observed patterns.

4.1.7.4 Discussion

Freshwater

The project area is influenced by multiple freshwater sources, including Salt River, Sweet River, Deans Valley River, and their tributaries, and PP20, a drain from a nearby community. Agricultural activity, particularly farm animals, is the primary driver of water quality conditions. Farm animals such as Buffalo, cattle, sheep, goats, and horses contribute through direct interaction and runoff. Seasonal rainfall and storm events intensify these effects, transporting animal waste, nutrients, and other pollutants into water bodies. Additionally, drains and runoff from adjacent communities and roadways introduce solid waste and contaminants, further affecting water quality and ecosystem health.

Most parameters showed significant spatial differences but limited temporal variation. Station PP17 consistently recorded elevated values for conductivity, TDS, BOD, and faecal coliform, while Station PP19 had the highest nitrate levels, and Stations PP19, PP20, and PP25 showed lower pH. DO levels were notably lower at Stations PP17, 18, and PP19.

Temporally, only BOD and faecal coliform exhibited significant seasonal differences, both being higher during the dry season. No significant seasonal changes were observed in temperature, salinity, turbidity, phosphates, TSS, conductivity, pH, DO, TDS, or nitrates. Overall, the results indicate marked spatial variability in several parameters, with station PP17 having mostly significantly higher values along with certain parameters for Stations PP18, PP19, PP20 and PP25, while temporal variations were primarily evident in significantly higher conductivity, salinity TDS, DO and pH during the dry season.

Station PP17 was a major outlier for sampled freshwater stations, with significantly higher values for conductivity, TDS, BOD, and faecal coliform. This station, located within the marshy lowlands of the site was most likely heavily influenced by its proximity to the sea causing salt water infiltration, as well as its function as a catchment area, accumulating pollutants from runoff and drainage upstream.

Significant differences in nitrate, BOD and faecal coliform concentrations were likely influenced by water contamination from both natural and anthropogenic sources. In particular, the presence of farm animals such as buffaloes and cows in the vicinity of the water bodies may have contributed to elevated nitrate and faecal coliform levels through agricultural runoff. Additionally, anthropogenic pollution from nearby settlements, inadequate wastewater management, and stormwater runoff could have further exacerbated nitrate and faecal coliform contamination.

Variations in pH and DO were likely driven by a combination of weather conditions and water levels. pH fluctuations could be attributed to variations in organic matter decomposition, runoff containing acidic or alkaline substances, and biological activity within the water. Reduced oxygen availability (DO) at some stations may also indicate poor water circulation, organic matter decomposition, or increased biological oxygen demand (BOD) due to pollutants. Station PP17 stood out as a particularly impacted site, exhibiting significantly higher values for faecal coliform while also recording lower dissolved oxygen (DO) levels compared to other stations.

Temporal analysis comparing seasonal variations revealed significant differences in multiple parameters: Results indicated that they were mostly significantly higher during the dry season. This pattern may have been driven by the availability of fresh water, lack of water could cause significant increases or decreases in water quality parameters. Formation of shallow, stagnant pools of water could concentrate pollutants and organic material. Additionally, lower water levels in the dry season may have made sediment more prone to disturbance, leading to increased turbidity and resuspension. The elevated conductivity, salinity and TDS levels during this period further suggest a buildup of salts/minerals in these stagnant conditions, potentially due to reduced flushing and reduced dilution effects compared to the wet season.

Marine Water

The project area can generally be classified as mesotrophic (moderate nutrients), however certain areas trend towards eutrophic (high nutrients), such as the southern cove of the property. The areas variability shows trends towards different trophic states. Station PP27 along with PP6, PP7 and PP16 trend towards more eutrophic conditions with high nutrient levels and poor water clarity. High nutrient levels may lead to reduced water quality and algal blooms. Other stations such as PP8, PP9, PP10 and PP22 which were located further offshore displayed trends towards more oligotrophic conditions (low nutrients), with lower nutrient levels and high-water clarity.

Significant spatial differences were observed for most parameters, especially at Station PP14, which showed lower temperature, conductivity, salinity, TDS, and nitrates. Station PP6 had the highest light extinction coefficient and faecal coliform, while PP27 showed elevated turbidity, and PP6 & PP7 had higher TSS.

Temporally, significant seasonal changes were noted for DO, pH, turbidity, BOD, and phosphates. DO and phosphates were higher during the wet season, while pH, turbidity, and BOD were elevated in the dry season. No significant seasonal trends were found in temperature, conductivity, salinity, TDS, nitrates, TSS, or faecal coliform.

Stations PP6 and PP14 were major outliers for sampled marine water stations, Station PP6 had significantly higher faecal coliform values, this location was within the site bay and was visibly milky/turbid during sampling and may have been highly influenced by high currents. Station PP14 had significantly lower values for temperature, conductivity, salinity and TDS. This station, located within the mouth of the Deans Valley River outflow, was most likely heavily influenced by the freshwater outflow, which would have significantly lowered the aforementioned parameters.

The results indicated that water quality was not homogeneous (uniform) across most measured parameters, with significant spatial variations observed among stations. The most notable station was PP14, which was located directly in front of the largest river outflow on the site, the Deans Valley River. This station exhibited significantly lower temperature, conductivity, salinity, and total dissolved solids compared to all other stations. These differences were most likely due to the substantial influence of freshwater inflow from the river, which diluted seawater characteristics and altered the local water chemistry.

Additionally, Station PP6 displayed markedly different water quality conditions, with significantly elevated levels of faecal coliform and extinction coefficient values. These findings suggest that the bay where PP6 was located may have been a hotspot for the accumulation of anthropogenic pollutants and terrestrial runoff, with high wave currents (Figure 4-39). The presence of high faecal coliform levels indicates potential contamination from sewage or other sources of organic waste, while elevated extinction coefficient values point to increased particulate matter in the water column, likely due to sediment resuspension from wave action or runoff from nearby land-based activities.

Despite these localized variations, most other stations exhibited relatively similar water quality characteristics, suggesting that, in the absence of the influence of the Deans Valley River, the study area would have been largely homogeneous. The spatial differences observed in PP14 and PP6 highlight the importance of freshwater inputs in shaping local water quality dynamics.

4.1.7.5 Conclusion

Marine environments exhibited more pronounced spatial variability, particularly at nearshore or ecologically distinct stations, reflecting the influence of localized physical and biological conditions. In contrast, freshwater systems showed localized pollution impacts, most notably at Station PP17, which consistently recorded elevated levels of organic and microbial contamination. Seasonal variations were more evident in the marine environment for physio-chemical parameters such as pH, turbidity, and dissolved oxygen, whereas freshwater systems experienced seasonal fluctuations mainly in organic pollution indicators, particularly biological oxygen demand (BOD) and faecal coliform concentrations.

Overall, the project highlights concern for water quality parameters, with many non-compliant with NRCA standards for nutrient sources. One of the major impacts may be due to the large animal presence on the property, which may contribute to the nutrient loading of the freshwater rivers and waterways, which transport the waste into coastal waters. Continued monitoring and adaptive management are essential to address the impacts of climate change and anthropogenic activities on the terrestrial and marine environments, improving drainage in the area as well as a reduced animal presence may help to improve water quality within the study area, as well as in the immediate marine environment.

4.1.8 Sedimentology

4.1.8.1 Benthic Sediment Chemistry

Introduction

Benthic sediment chemistry involves studying the chemical composition and characteristics of sediments at the bottom of aquatic environments, like seas and rivers. This field is crucial for understanding how substances, like heavy metals and hydrocarbons, accumulate and behave in the sediments, which can affect ecological and environmental dynamics.

HEAVY METALS

High concentrations of heavy metals such as lead and mercury are key indicators of pollution, helping to identify sources and levels of contamination.

Heavy metals in marine sediments originate from both natural and anthropogenic sources, accumulating over time through riverine input, atmospheric deposition, and direct discharges. Their behaviour in sediments is influenced by serval factors including, salinity, organic matter, and redox conditions, which affect their mobility and bioavailability. Fine-grained sediments (clay, silt) adsorb and retain metals more efficiently than coarser sand due to their higher surface area and organic content. In oxygen-poor sediments, metals can become more mobile, releasing into overlying water and potentially affecting marine organisms.

Some metals, such as arsenic and lead, can be taken up by benthic organisms, entering the food web and impacting marine ecosystems. Unlike in dynamic river systems, heavy metals in marine sediments may persist for decades, making them useful indicators of historical pollution trends.

HYDROCARBONS

Hydrocarbons in marine sediments can originate from natural sources (e.g., organic decay, petroleum seeps) and human activities (e.g., fuel spills, industrial discharge, stormwater runoff). Their presence and persistence depend on sediment type, microbial degradation, and hydrodynamic conditions.

Hydrocarbons typically bind to fine sediments (clays, silts) and accumulate in low-energy environments, while high-energy areas promote dispersion and microbial breakdown.

Total Petroleum Hydrocarbons (TPH) is used to describe the number of petroleum-based hydrocarbons present in a sample. The range C8 to C40 indicates the number of carbon atoms in the hydrocarbon molecules that are being measured, from smaller, lighter hydrocarbons (C8) to larger, heavier hydrocarbons (C40).

Methodology

Ten (10) sediment samples (Table 4-12) were taken from within the project area using a sediment grab sampler or by hand on September 13th, 2023, and analysed for heavy metals (Pb - lead, As - Arsenic, Cd - Cadmium, Hg - Mercury) and Total Petroleum Hydrocarbons (C8-C40). The samples were stored on ice in a cooler and transported to Test America Pensacola Laboratory in Florida for analyses. The ten locations can be viewed in Figure 4-97.

Table 4-12 Benthic sediment sampling locations (JAD2001)

Station	Eastings	Northings
PP SS 1	633993.6354	673848.7003
PP SS 2	634613.8065	673363.6637
PP SS 3	635109.7308	673016.1998
PP SS 4	635176.7593	673406.7946
PP SS 5	635307.3045	673808.0539
PP SS 6	636175.9276	673716.1106
PP SS 7	636124.068	673319.4824
PP SS 8	636592.7326	673638.6714
PP SS 9	637413.5831	673423.7740
PP SS 10	638075.3612	673178.6899

Results

Table 4-13 presents the results of sediment sampling for key contaminants, with detailed laboratory sheets available in **Error! Reference source not found.**.

Table 4-13 Marine benthic sediment results

STATION	Arsenic (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	TPH (C8 – C40) (mg/kg)	TPH (C8-10) (mg/kg)	TPH (C10-C28) (mg/kg)	TPH (C28-C40) (mg/kg)
PP SS 1	4.2	ND	3.3	ND	ND	ND	ND	ND
PP SS 2	3.6	ND	2.9	ND	ND	ND	ND	ND
PP SS 3	3.4	ND	2.9	ND	ND	ND	ND	ND
PP SS 4	3.4	ND	2.7	ND	ND	ND	ND	ND
PP SS 5	4.0	ND	3.0	ND	ND	ND	ND	ND
PP SS 6	3.0	ND	2.9	ND	ND	ND	ND	ND
PP SS 7	2.7	ND	2.2	ND	ND	ND	ND	ND

STATION	Arsenic (mg/kg)	Cadmium (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	TPH (C8 – C40) (mg/kg)	TPH (C8-10) (mg/kg)	TPH (C10-C28) (mg/kg)	TPH (C28-C40) (mg/kg)
PP SS 8	2.6	ND	2.8	ND	ND	ND	ND	ND
PP SS 9	2.7	ND	3.0	ND	ND	ND	ND	ND
PP SS 10	3.5	ND	3.5	ND	ND	ND	ND	ND

ND- None Detected

HEAVY METALS

Arsenic and lead were detected at all ten sampling stations, while cadmium and mercury were not detected at any location. When compared to Jamaican soil baseline levels (Table 4-14), all detected heavy metal concentrations were below the national average.

Table 4-14 Metal concentrations in Jamaican soil

Metal	Avg. Concentration (mg/KG)	Range (mg/Kg)	95th Percentile (mg/KG)
Arsenic	25	1.4-203	<64.9
Cadmium	20	0.2-409	<77.6
Lead	46.5	6-897	<90
Mercury	0.2	0.04-0.83	<0.46

Source: A geochemical atlas of Jamaica, Centre for Nuclear Sciences, UWI, 1995, Canoe Press

HYDROCARBONS

No hydrocarbons were detected at any station, indicating minimal petroleum contamination within the study area. This suggests that localized sources, such as boat traffic, fuel spills, or industrial discharge, are not significant contributors to sediment quality.

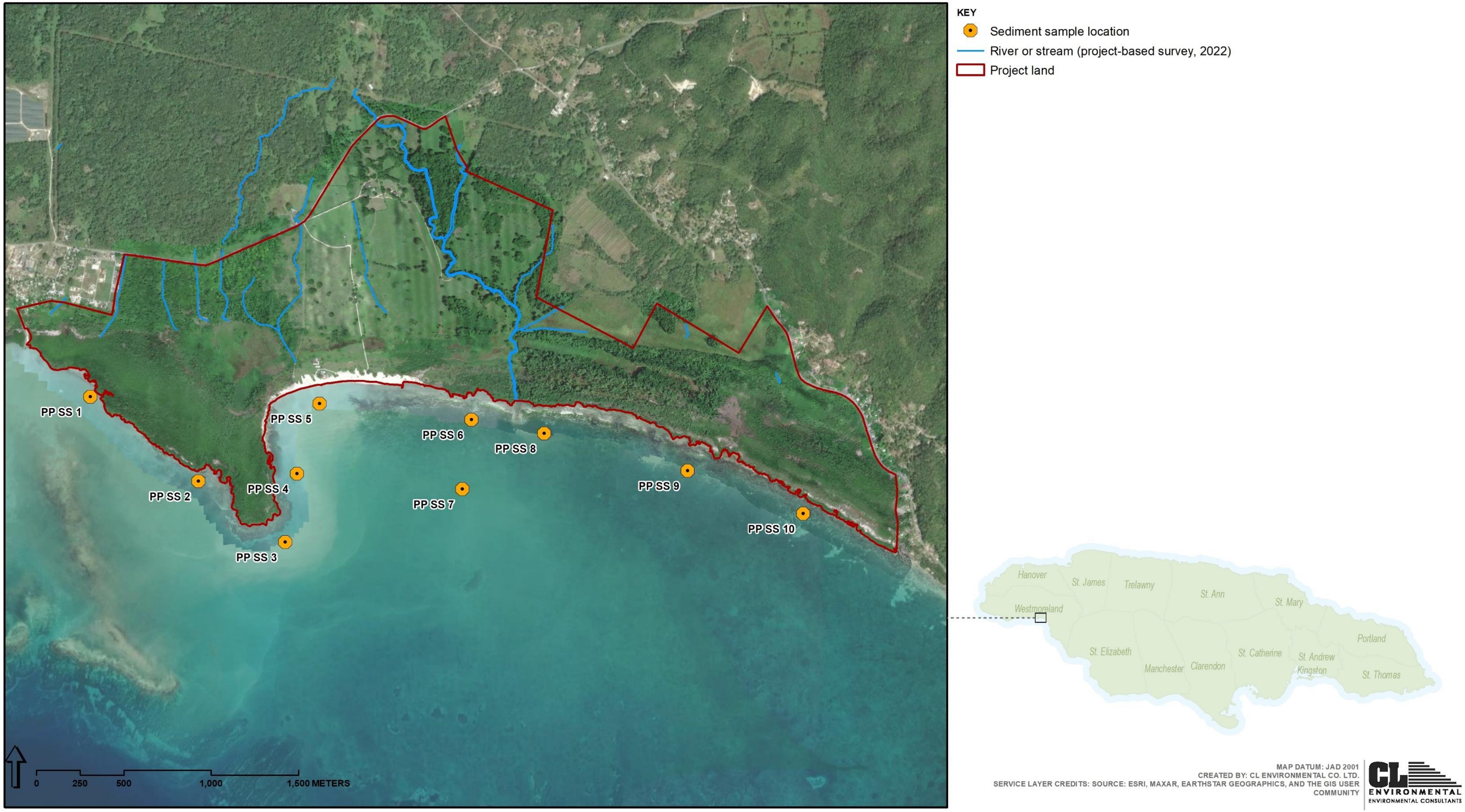


Figure 4-97 Map of sediment sample locations

4.1.8.2 Sediment Loading

Introduction

Sediment loading in benthic environments involves the deposition and accumulation of sediments on the floors of aquatic ecosystems, such as seas and rivers. This process is shaped by both natural and human activities and can significantly impact ecological and environmental conditions. Key factors in natural sediment loading include discharge from rivers, coastal erosion, and weather events, while anthropogenic factors involve pollution, construction, and land use, such as urbanisation or agriculture.

Increased sediment load can cause various issues, such as reducing water quality by decreasing clarity and light penetration, which affects photosynthesis in aquatic plants. It can alter benthic habitats by smothering organisms and carrying nutrients like nitrogen and phosphorus, contributing to eutrophication. Additionally, it can transport contaminants such as heavy metals and pesticides, posing risks to both aquatic and human health.

Methodology

Baseline sedimentation data was collected using sediment traps, approximately 21.4” (54.3 cm) long with an internal diameter of 3” (7.6 cm) (Plate 4-12). A total of eight (8) sediment traps were deployed in and around the project area (

Table 4-15 and Figure 4-98) on September 13th, 2023. They were retrieved after 36 days on October 19th, 2023., and their contents analysed to determine the rate of sedimentation ($mg/cm^2/day$) in the area.

Plate 4-12 Example of sediment trap deployed

Table 4-15 Sediment trap location coordinates (JAD2001)

Station	Eastings	Northings
PP ST 1	635855.0237	673662.249
PP ST 2	636404.8249	673692.5788
PP ST 3	636994.6166	673578.1125
PP ST 4	637192.9178	673132.4202
PP ST 5	634762.0315	673114.2479
PP ST 6	635108.0221	673022.7012
PP ST 7	634116.7919	673379.3549
PP ST 8	633954.1813	673937.6311

Sediment traps were taken to the Caribbean Environmental Testing and Monitoring Services Limited for analysis. The contents of the sediment traps were filtered through a filter paper, dried, and then weighed. The results are represented in the form of "Mass of Sediment Recovered." Using the results retrieved from the laboratory (**Error! Reference source not found.**), the sedimentation rate per day (mg/cm2/day) was calculated by dividing the mass of sediment recovered by the number of days deployed and the area of the sediment trap opening.

$$\textbf{\textit{Sedimentation Rate per day}} = \frac{\textit{Mass of Sediment Recovered}}{(\textit{\# of days deployed}) \times (\textit{area of trap opening})}$$

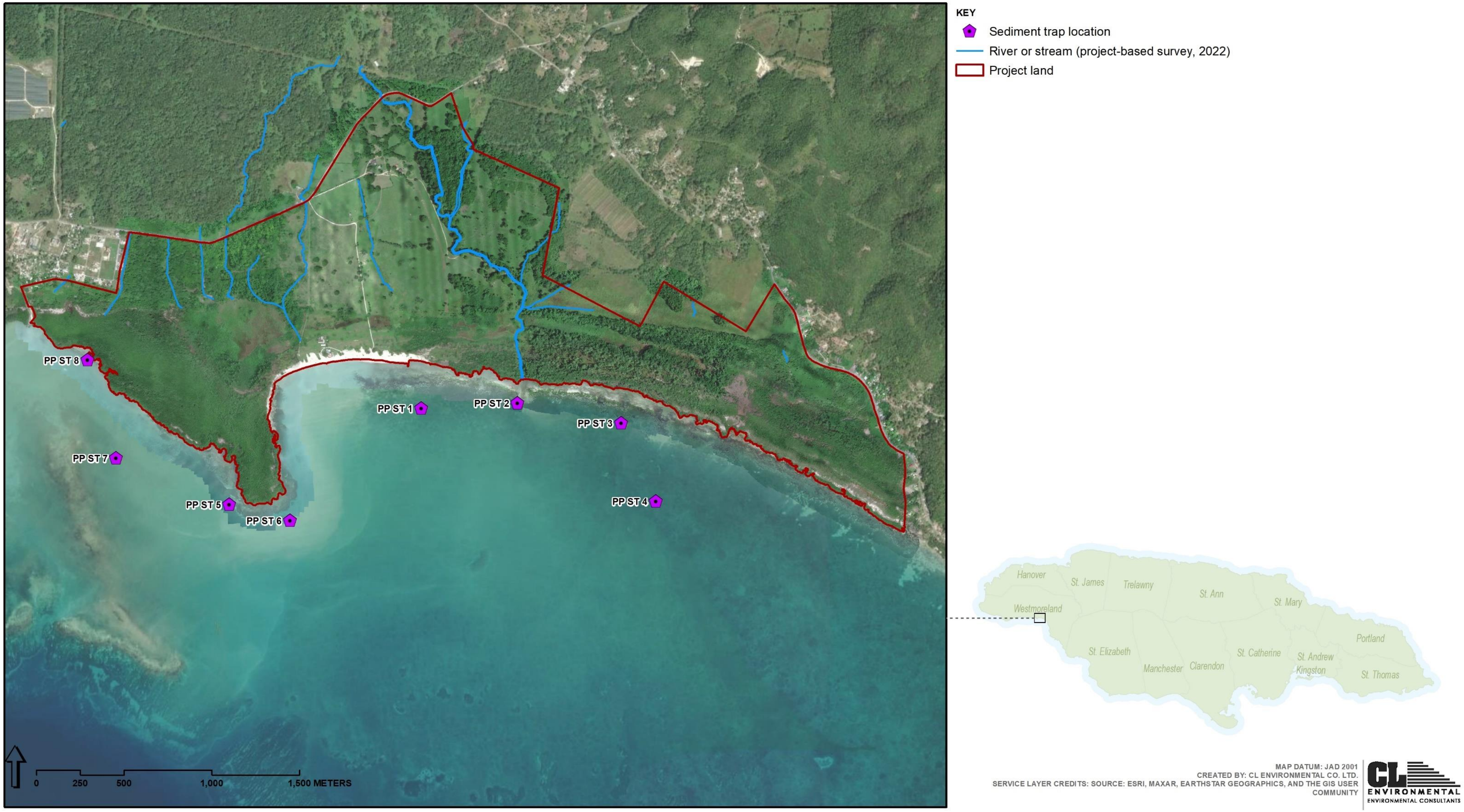


Figure 4-98 Map of sediment trap locations

Results

Sedimentation rates across the study area ranged from 0.02558 mg/cm²/day at Station ST8 to 0.58480 mg/cm²/day at Station ST3 (Table 4-16). The main driver of sediment deposition is input from rivers and streams, which introduce fine materials into nearshore waters. The extent of sediment accumulation depends on wave action, water depth, and substrate type, with calmer areas allowing for settling and more dynamic areas promoting transport and resuspension

HIGH SEDIMENTATION AREAS

- Stations ST1 and ST3 had the highest sedimentation rates. Both are in shallow, nearshore areas within the river outflow zone, where fine silts accumulate due to reduced wave energy and direct sediment input.
- Station ST6, located 10m below the surface within a cove, also showed relatively high sedimentation. The cove likely functions as a sediment trap, allowing fine particles to settle in deeper water.

VARIABLE SEDIMENTATION AREAS

- Station ST2, though nearshore and in front of the river outflow, had a lower sedimentation rate. This may be due to its sandy substrate, which resists suspension, or to wave-driven transport moving finer sediments away before settling.

LOW SEDIMENTATION AREAS

- Stations ST5, ST7, and ST8, in the western section of the site, recorded low sedimentation rates despite being in an area with muddy and silty substrates. This suggests that wave action and currents in this region keep sediments suspended or transport them away before deposition.

Sediment accumulation in the study area is primarily influenced by freshwater inputs, wave energy, and substrate type. Areas with low wave energy, such as nearshore river outflow zones and sheltered coves, experience higher sedimentation, while more exposed areas with stronger hydrodynamics show lower rates due to ongoing resuspension and transport.

Table 4-16 Sedimentation rates at each location

Sediment Trap Locations	Mass of Sediment Recovered (mg/L)	Sedimentation Rate (mg/cm²/day)
STPP1	240	**0.14620**
STPP2	64	**0.03899**
STPP3	960	**0.58480**
STPP4	180	**0.10965**
STPP5	90	**0.05482**
STPP6	170	**0.10356**
STPP7	54	**0.03289**
STPP8	42	**0.02558**

4.1.9 Noise

4.1.9.1 Background

Sound is an integral part of everyday life. It provides enjoyable experiences such as listening to music or the singing of birds, facilitates spoken communication, and serves as an alert or warning system through sounds like ringing telephones or wailing sirens. Hearing, one of the five human senses, involves the ear, where sound stimulates structures that trigger nerve signals to the brain for processing. Additionally, sound aids in quality evaluations and diagnoses, such as identifying a chattering car valve, a squeaking wheel, or a heart murmur (Brüel & Kjær, 1984).

Noise, defined as unwanted sound lacking agreeable musical quality, becomes problematic when its effects are undesirable (Agarwal, 2009). Considered a pollutant, noise can be measured and has adverse effects on humans, their environment, including land, structures, domestic animals, and natural wildlife and ecological systems (Agarwal, 2009).

Types of Noise

Noise can be categorized into three main types (Campbell, 2014):

1. Continuous/Steady Noise: Characterized by small fluctuations in its level within the observation period.
2. Intermittent Noise: Noise levels that are interrupted by periods of low sound levels, which can be regular or irregular.
3. Impulse Noise: Noise that occurs almost instantaneously with a sharp sound, such as the bang of a gun or a pile driver.

Noise Propagation in Air and Water

Noise propagation differs significantly between air and water in terms of speed, attenuation, frequency range, and environmental factors.

SPEED OF SOUND

- Air: At room temperature (20°C or 68°F), sound travels at approximately 343 meters per second (m/s).
- Water: Sound travels much faster, around 1482 m/s at 20°C, with variations due to temperature, salinity, and pressure.

ATTENUATION

- Air: Sound attenuates quickly due to air’s lower density and the presence of obstacles, with higher frequencies attenuating more rapidly.
- Water: Sound travels much farther before attenuating, especially at low frequencies, due to water’s higher density and fewer obstructions in open water.

FREQUENCY RANGE

- Air: Human hearing ranges from approximately 20 Hz to 20 kHz, with effective propagation within this range, suitable for higher-frequency sounds.
- Water: Human hearing underwater is limited and shifts in frequency sensitivity. Underwater sounds, often from marine animals or sonar, use lower frequencies (10 Hz to a few kHz) for better long-distance propagation.

ENVIRONMENTAL FACTORS

- Air: Factors like humidity, wind, temperature gradients, and obstacles (buildings, trees) significantly affect sound propagation.
- Water: Sound propagation is influenced by temperature gradients (thermoclines), salinity (haloclines), and pressure, creating layers and channels that affect sound travel, often resulting in complex propagation paths.

In summary, sound travels faster and farther in water compared to air, with less attenuation, especially at lower frequencies. The environmental conditions affecting sound propagation differ significantly between the two media, influencing how sound is transmitted and perceived.

4.1.9.2 Methodology

Noise meters were set up at eight (8) noise monitoring stations (Table 4-17, Figure 4-99) in an outdoor measuring system. A windscreen (sponge) was placed over the microphone to prevent measurement errors due to wind noise. The microphone was positioned approximately 1.5 meters above the ground, with no vertical reflecting surfaces within 3 meters (10 feet). The noise meters were calibrated pre-and post-noise assessment by using a Brüel & Kjaer Type 4231 sound calibrator (**Error! Reference source not found.**).

Noise level readings were recorded using the Brüel & Kjaer noise analysers setup at each station for 72 hours, from 12:00am Saturday June 17th, 2023, to 12:00am Tuesday June 20th, 2023. The meters were programmed to collect third octave, average sound level (Leq) over the period, Lmin (the lowest level measured during the assessment) and Lmax (the highest level measured during the assessment) every second. The octave band analysis was conducted concurrently with the noise level measurements. Since measurements were taken in the third octave, it provided thirty-three (33) octave bands from 12.5 Hz to 20 kHz (low, medium, and high frequency bands).

Noise statistics (L_{10} and L_{90}) were also calculated at each location.

Table 4-17 Noise and particulate monitoring locations (JAD2001)

Station	Eastings	Northings
PP NP 1	633774.95	675289.3444
PP NP 2	634159.5475	674485.5628
PP NP 3	635549.1295	673999.6953
PP NP 4	638651.0288	673263.8482

Station	Eastings	Northings
PP NP 5	637989.9551	674162.9204
PP NP 6	636392.3988	674375.9129
PP NP 7	635987.9668	675424.6761
PP NP 8	634074.1552	675890.8208

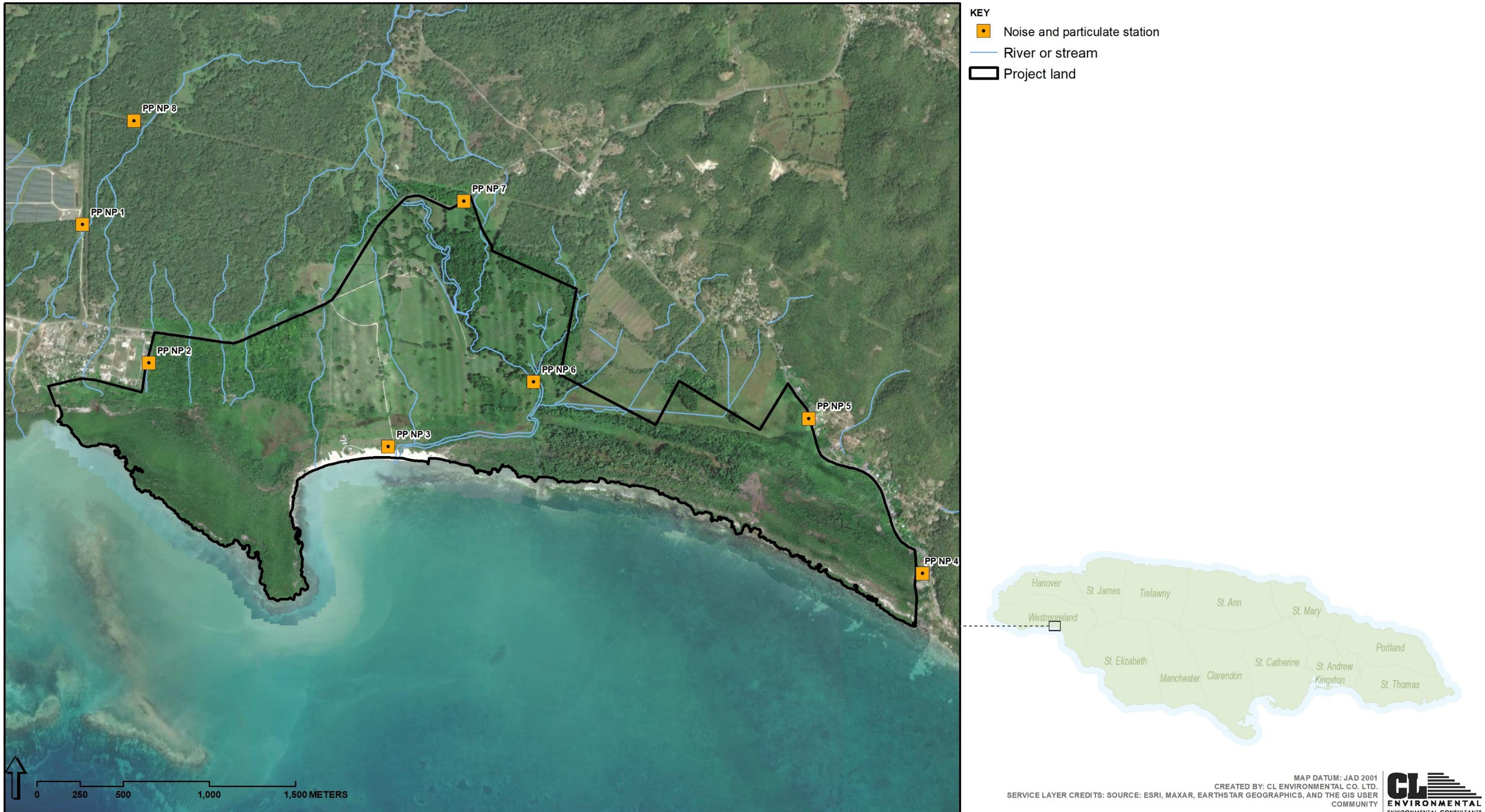


Figure 4-99 Location of noise and particulate monitoring stations

4.1.9.3 Results

Table 4-18 shows the minimum, maximum and average noise levels over the 72-hour assessment period, as well as the geometric mean centre frequencies obtained at each station.

Table 4-18 Ambient Noise data at all stations

Stn.#	Average Leq (72 hr)	Min (dBA)	Max (dBA)	Geometric Centre Frequency (Hz)	Octave Band Range (Hz)
N1	53.6	28.8	83.8	12.5	11-14
N2	52.7	28.1	80.6	12.5	11-14
N3	58.2	27.7	81.5	50	45-56
N4	61.5	32.0	89.9	4000	3565 - 4488
N5	67.7	29.0	102.6	12500	11141 - 14025
N6	50.1	37.2	77.4	12.5	11-14
N7	62.4	31.1	104.8	63	56-71
N8	58.2	27.5	78.0	12500	11141 - 14025

STATION 1

During the assessment period, noise levels at this station ranged from a low (Lmin) of 28.8 dBA to a high (Lmax) of 83.8 dBA. Average noise level for this period was 53.6 L_{Aeq}. The fluctuation in noise levels over the period is depicted in Figure 4-100.

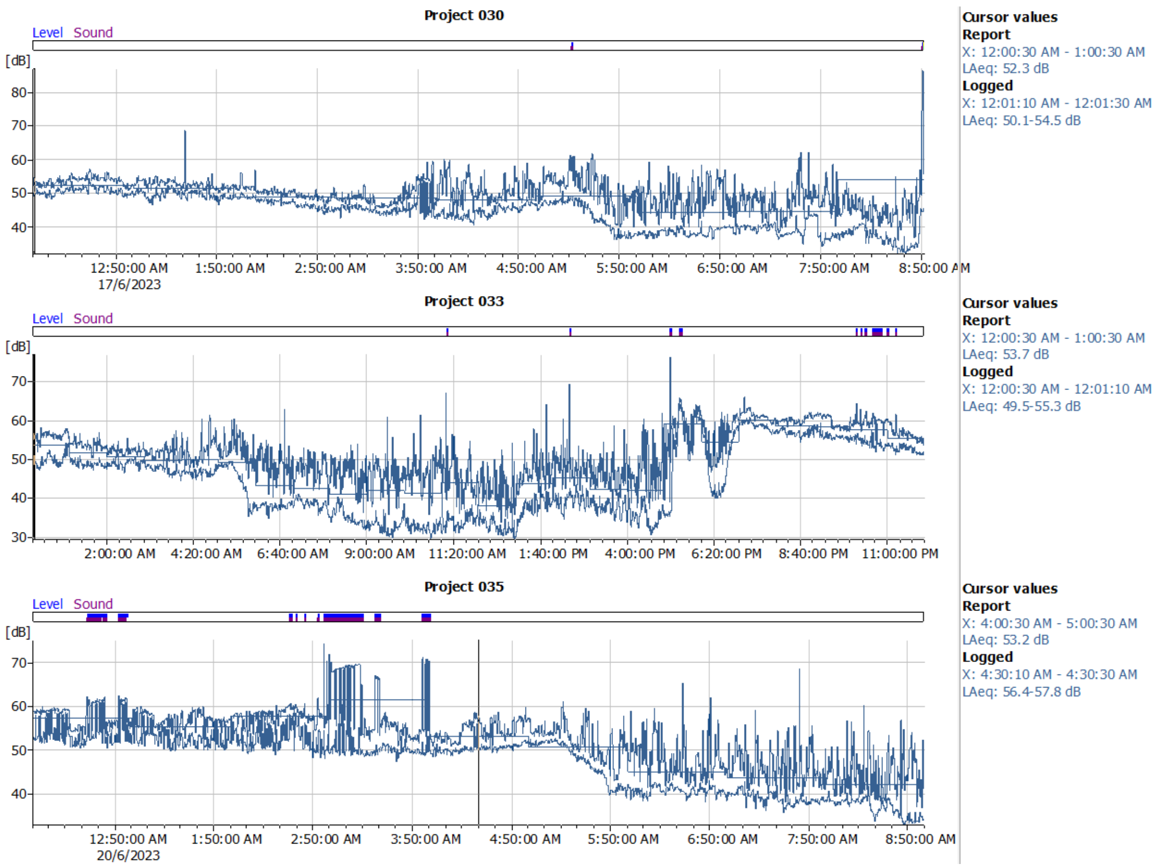


Figure 4-100 Noise fluctuation (Leq) at Station 1 (top: June 17, middle: June 18, bottom: June 19)

OCTAVE BAND ANALYSIS AT STATION 1

The noise at this station during the assessment period was in the low frequency band with a dominant geometric mean frequency of 12.5 Hz (Octave frequency range is 11-14 Hz) (Figure 4-101).

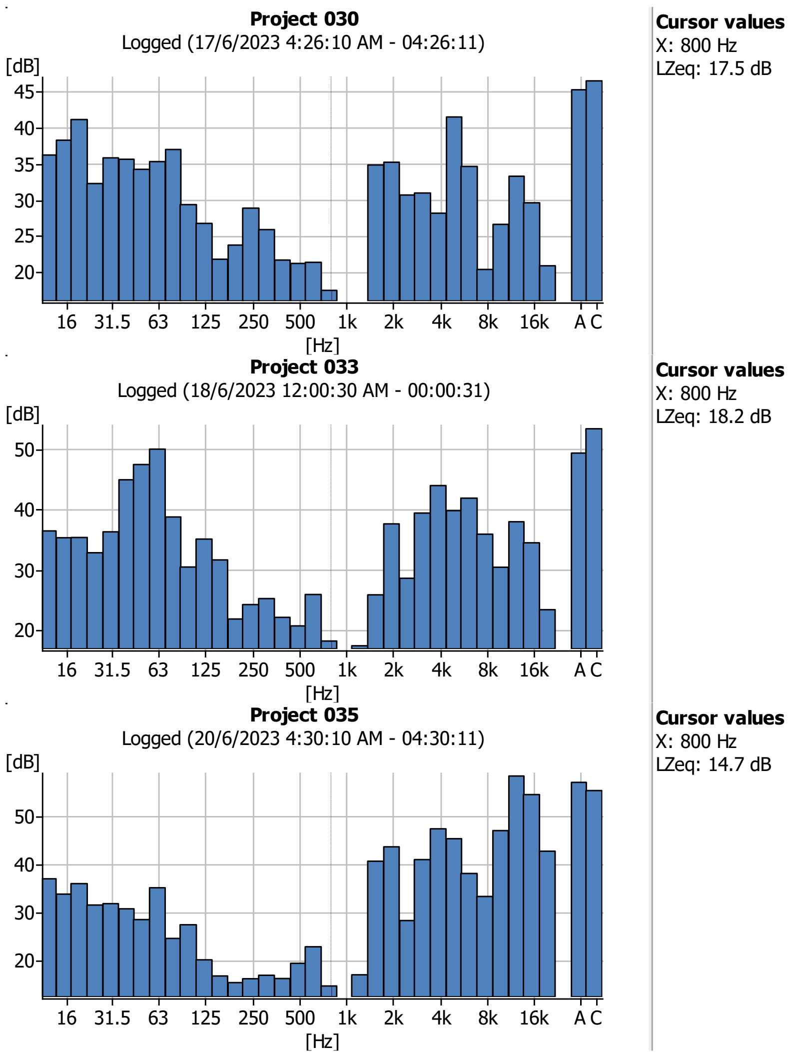


Figure 4-101 Octave band spectrum of noise at Station 1 (top: June 17, middle: June 18, bottom: June 19)

L10 AND L90

The two most common **L_n** values used are **L_{10}** and **L_{90}** and these are sometimes called the 'annoyance level' and 'background level' respectively. **L_{10}** is almost the only statistical value used for the descriptor of the higher levels, but **L_{90}**, is widely used to describe the ambient or background level. L10-L90 is often used to give a quantitative measure as to the spread or "how choppy" the sound was.

L10 is the noise level exceeded for 10% of the time of the measurement duration. This is often used to give an indication of the upper limit of fluctuating noise, such as that from road traffic. L90 is the noise level exceeded for 90% of the time of the measurement duration.

The overall L10 and L90 at this station for the time assessed were 58.9 dBA and 36.1 dBA, respectively.

STATION 2

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 28.1 dBA to a high (Lmax) of 80.6 dBA. Average noise level for this period was 52.7 L_{Aeq} (72h). The fluctuation in noise levels over the 72-hour period is depicted in Figure 4-102.

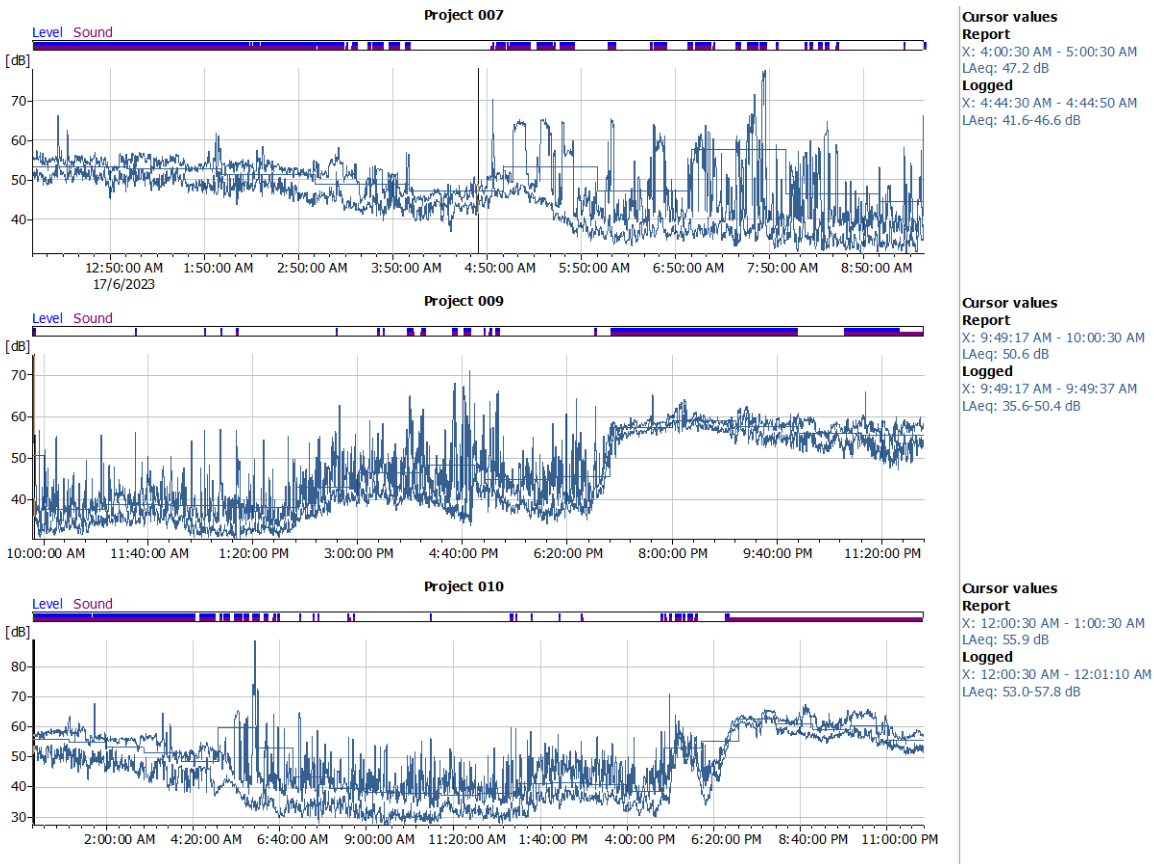


Figure 4-102 Noise fluctuation (Leq) over 72 hours at Station 2 (top: June 17, middle: June 18, bottom: June 19)

OCTAVE BAND ANALYSIS AT STATION 2

The noise at this station during the 72-hour period was in the low frequency band with a dominant geometric mean frequency of 12.5 Hz. (Octave frequency range is 11-14 Hz) (Figure 4-103).

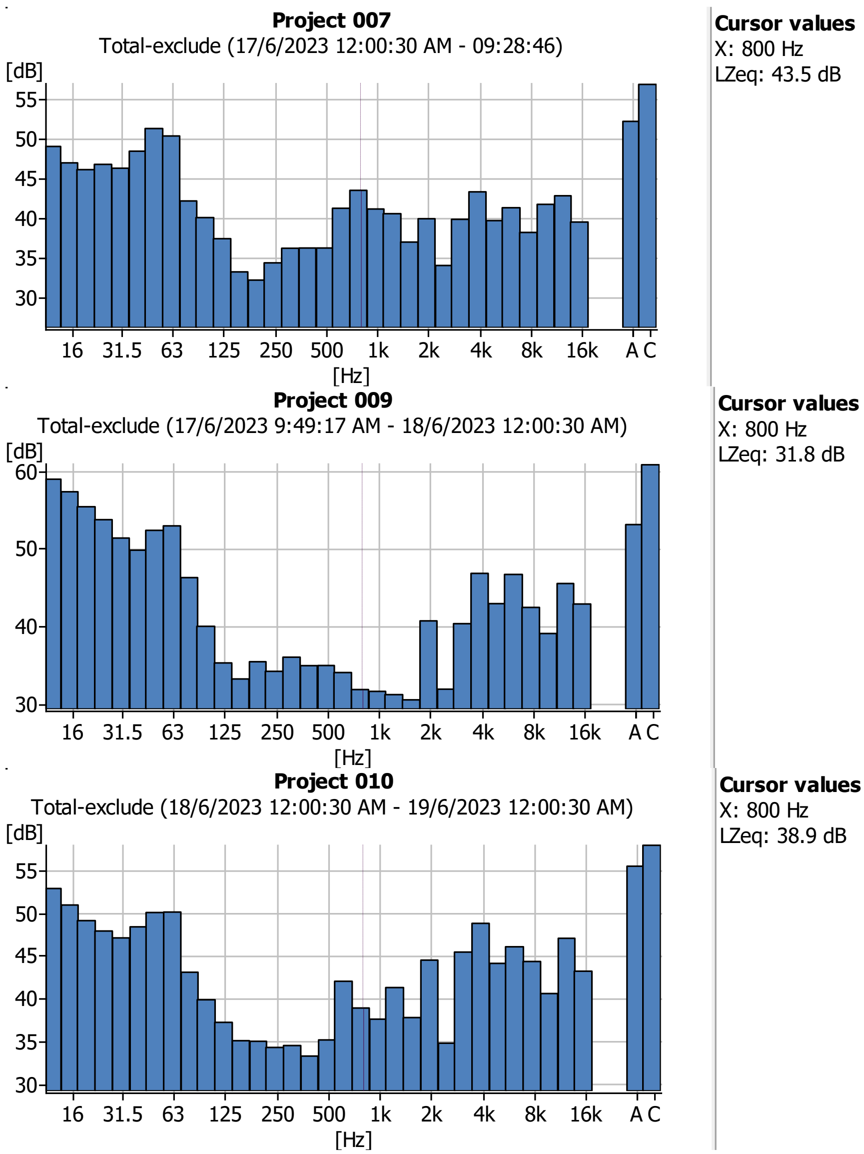


Figure 4-103 Octave band spectrum of noise at Station 2 (top: June 17, middle: June 18, bottom: June 19)

L10 AND L90

The overall L10 and L 90 at this station for the time assessed were 60.2 dBA and 33.6 dBA, respectively.

STATION 3

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 27.7 dBA to a high (Lmax) of 81.5 dBA. Average noise level for this period was 58.2 L_{Aeq} (72h). The fluctuation in noise levels over the 72-hour period is depicted in Figure 4-104.

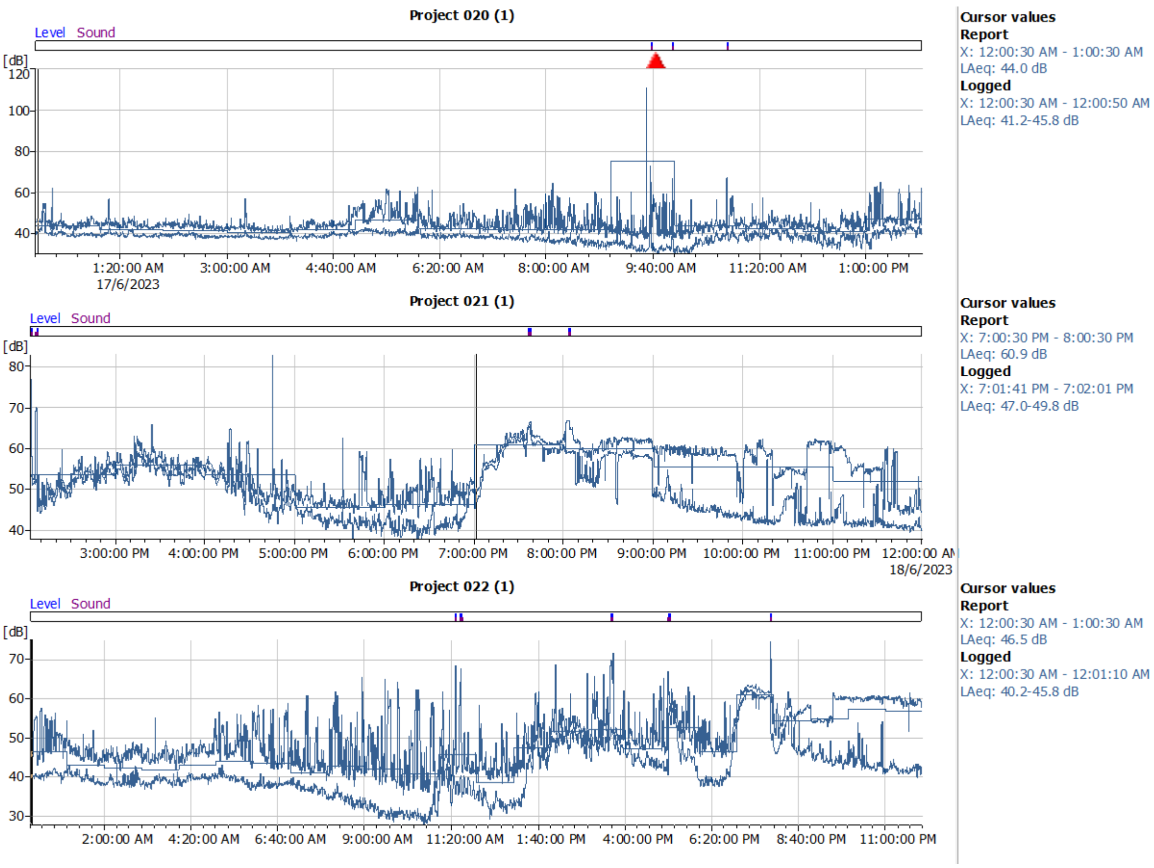


Figure 4-104 Noise fluctuation (Leq) over 72 hours at Station 3 (top: June 17, middle: June 18, bottom: June 19)

OCTAVE BAND ANALYSIS AT STATION 3

The noise at this station during the 72-hour period was in the low frequency band centred around the geometric mean frequency of 50 Hz. (Octave frequency range is 45 – 56 Hz) (Figure 4-105).

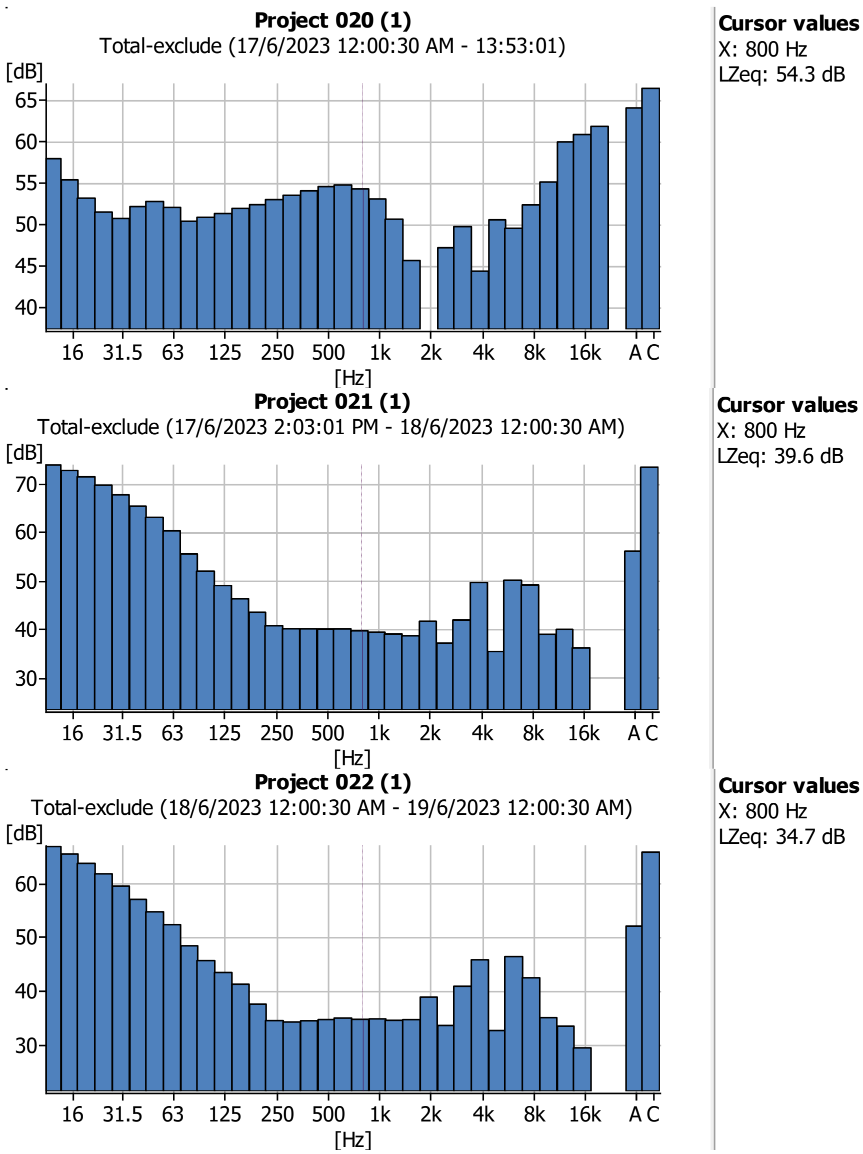


Figure 4-105 Octave band spectrum of noise at Station 3 (top: June 17, middle: June 18, bottom: June 19)

L10 AND L90

The overall L10 and L90 at this station for the time assessed were 64.1 dBA and 36.2 dBA, respectively.

STATION 4

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 32 dBA to a high (Lmax) of 89.9 dBA. Average noise level for this period was 61.5 L_{Aeq} (72h). The fluctuation in noise levels over the 72-hour period is depicted in Figure 4-106.

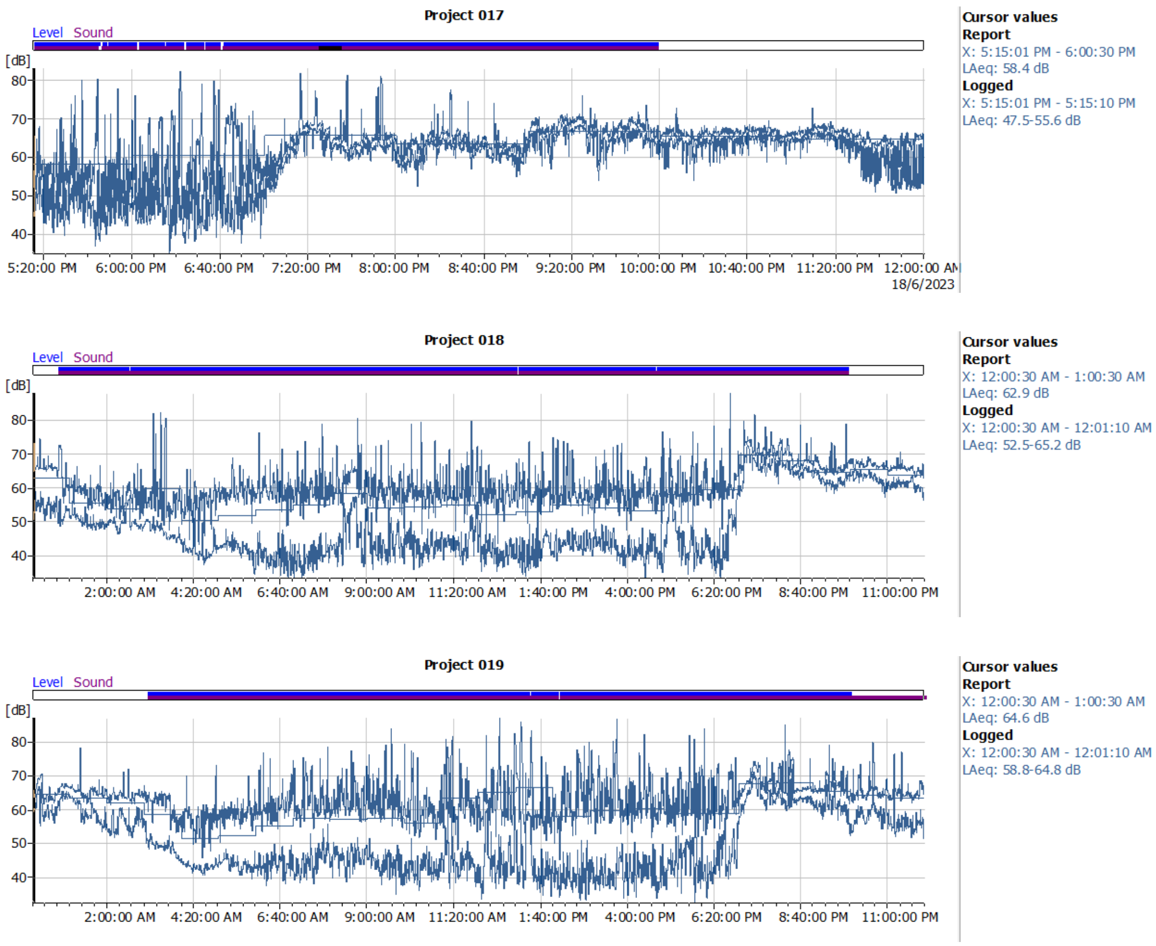


Figure 4-106 Noise fluctuation (Leq) over 72 hours at Station 4 (top: June 17, middle: June 18, bottom: June 19)

OCTAVE BAND ANALYSIS AT STATION 4

The noise at this station during the 72-hour period was in the high frequency band with a dominant geometric mean frequency of 4000 Hz. (Octave frequency range is 3565 – 4488 Hz) (Figure 4-107).

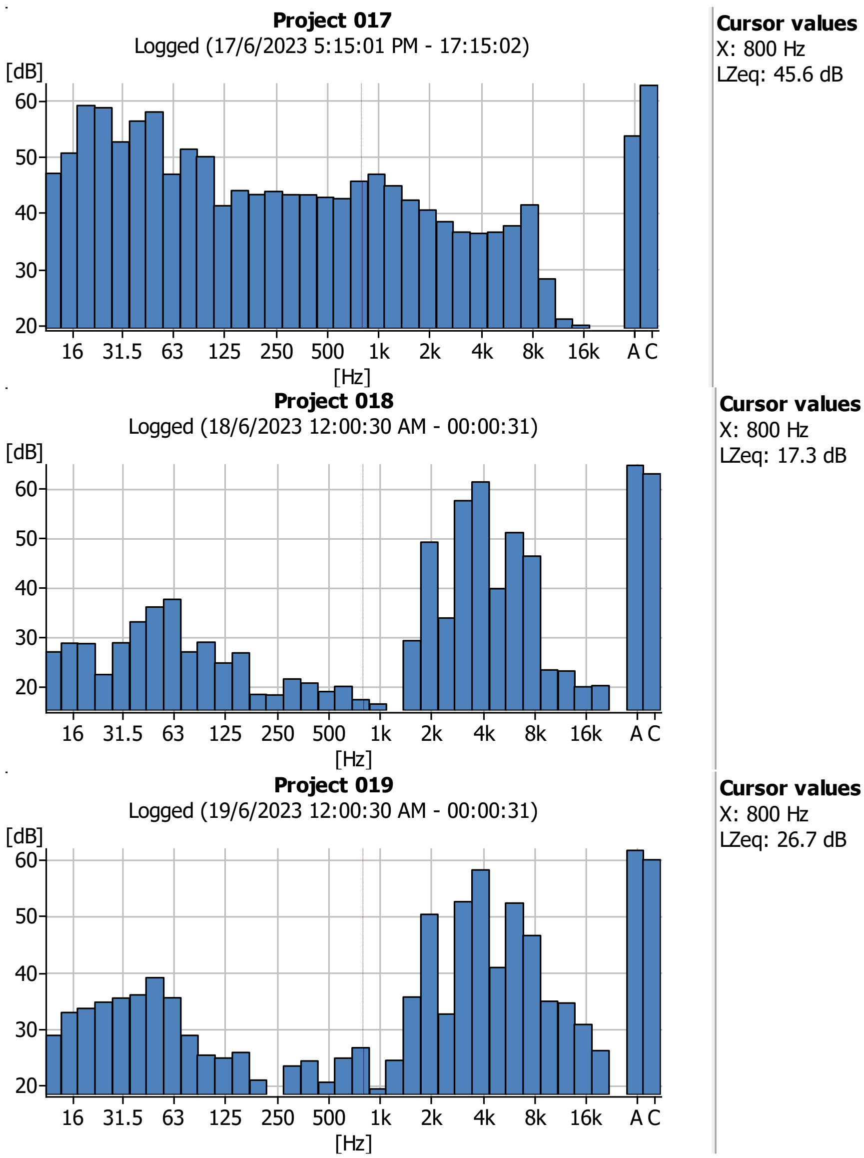


Figure 4-107 **Octave band spectrum of noise at Station 4 (top: June 17, middle: June 18, bottom: June 19)**

L10 AND L90

The overall L10 and L 90 at this station for the time assessed were 65.8 dBA and 43.3 dBA, respectively.

STATION 5

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 29.0 dBA to a high (Lmax) of 102.6 dBA. Average noise level for this period was 67.7 L_{Aeq} (72h). The fluctuation in noise levels over the 72-hour period is depicted in Figure 4-108.

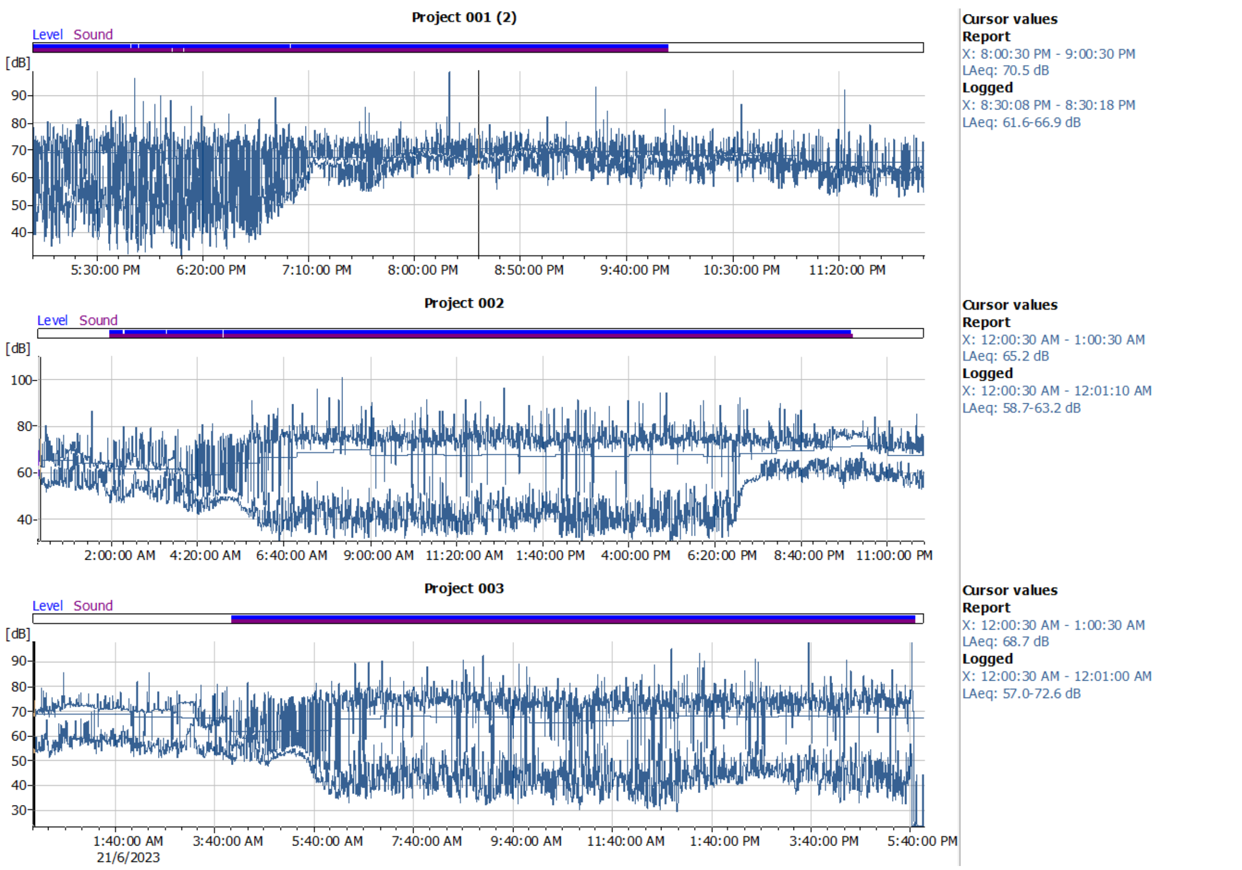


Figure 4-108 **Noise fluctuation (Leq) over 72 hours at Station 5 (top: June 17, middle: June 18, bottom: June 19)**

OCTAVE BAND ANALYSIS AT STATION 5

The noise at this station during the 72-hour period was in the high frequency band centred around the geometric mean frequency of 12500 Hz (octave frequency range is 11141 – 14025 Hz) (Figure 4-109).

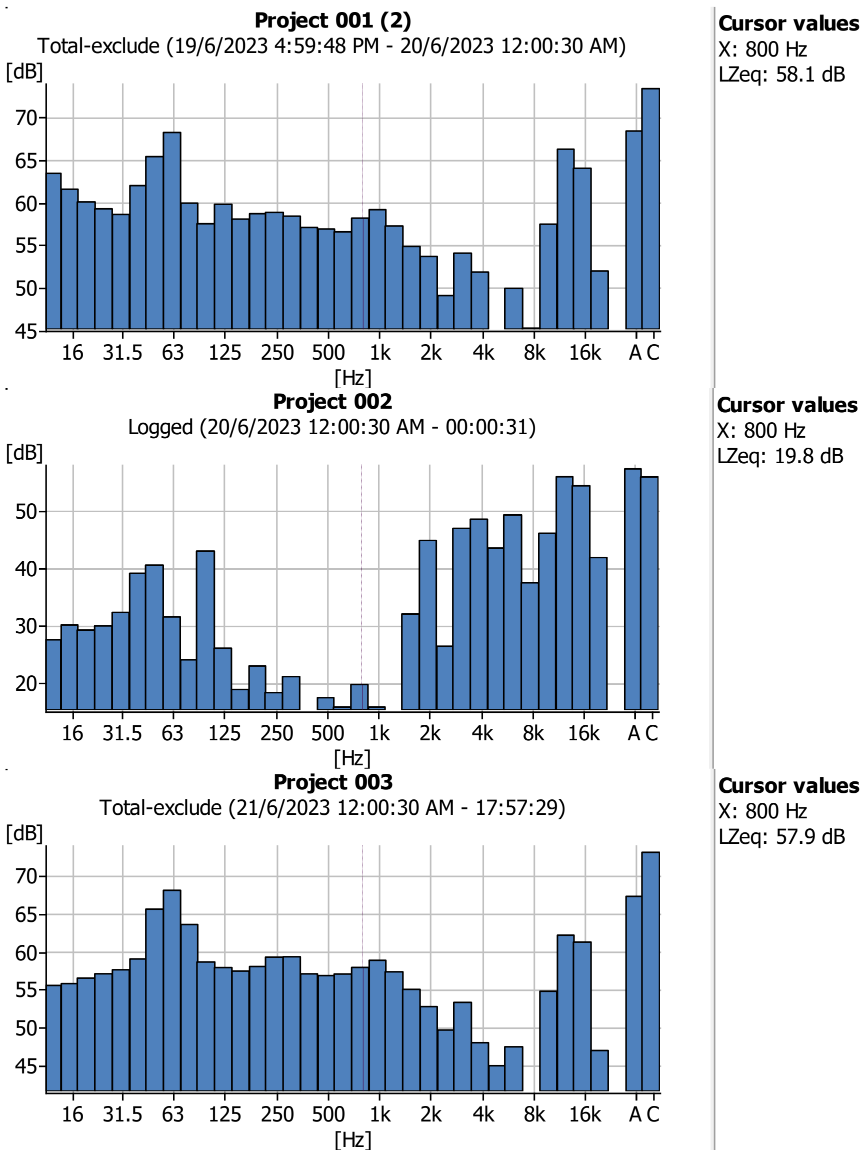


Figure 4-109 Octave band spectrum of noise at Station 5 (top: June 17, middle: June 18, bottom: June 19)

L10 AND L90

The overall L10 and L90 at this station for the time assessed were 71.2 dBA and 42.2 dBA, respectively.

STATION 6

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 37.2 dBA to a high (Lmax) of 77.4 dBA. Average noise level for this period was 50.1 L_{Aeq} (72h). The fluctuation in noise levels over the 72-hour period is depicted in Figure 4-110.

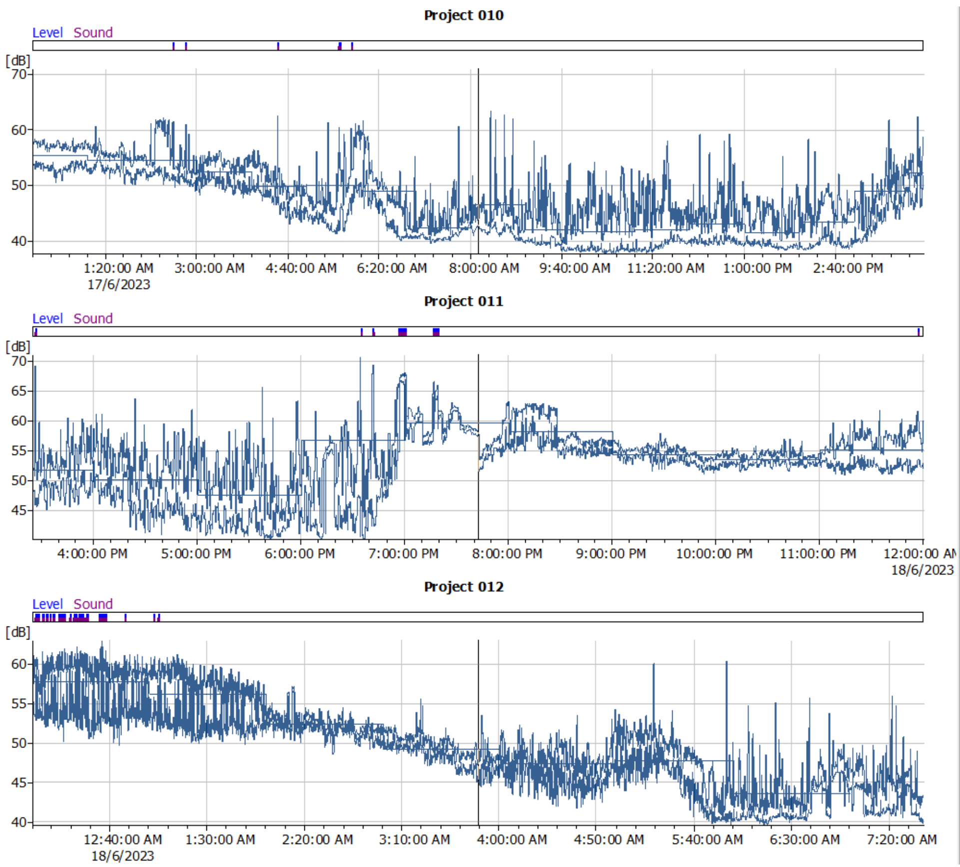


Figure 4-110 **Noise fluctuation (Leq) over 72 hours at Station 6 (top: June 17, middle: June 18, bottom: June 19)**

OCTAVE BAND ANALYSIS AT STATION 6

The noise at this station during the 72-hour period was in the low frequency band centred around the geometric mean frequency of 12.5 Hz (octave frequency range is 11-14 Hz) (Figure 4-111).

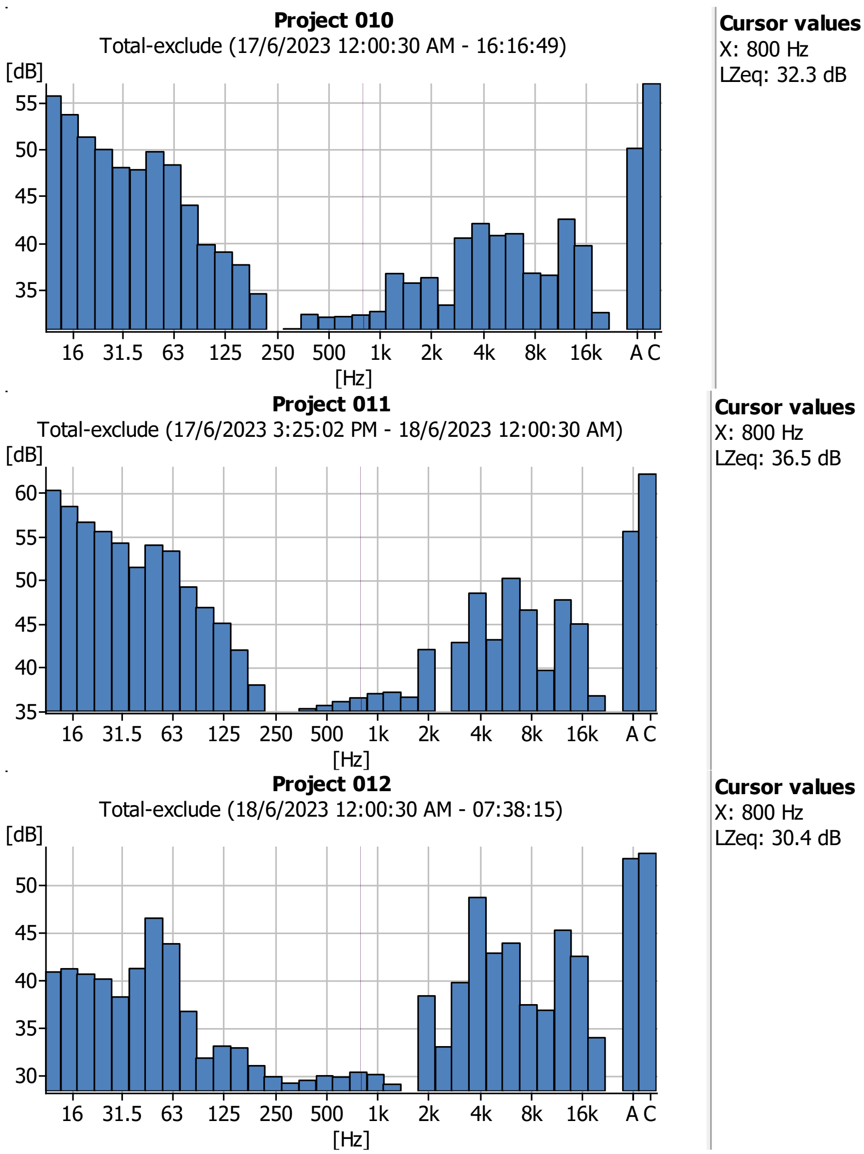


Figure 4-111 Octave band spectrum of noise at Station 6 (top: June 17, middle: June 18, bottom: June 19)

L10 AND L90

The overall L10 and L90 at this station for the time assessed were 54.6 dBA and 39.8 dBA, respectively.

STATION 7

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 31.1 dBA to a high (Lmax) of 104.8 dBA. Average noise level for this period was 62.4 L_{Aeq} (72h). The fluctuation in noise levels over the 72-hour period is depicted in Figure 4-108.

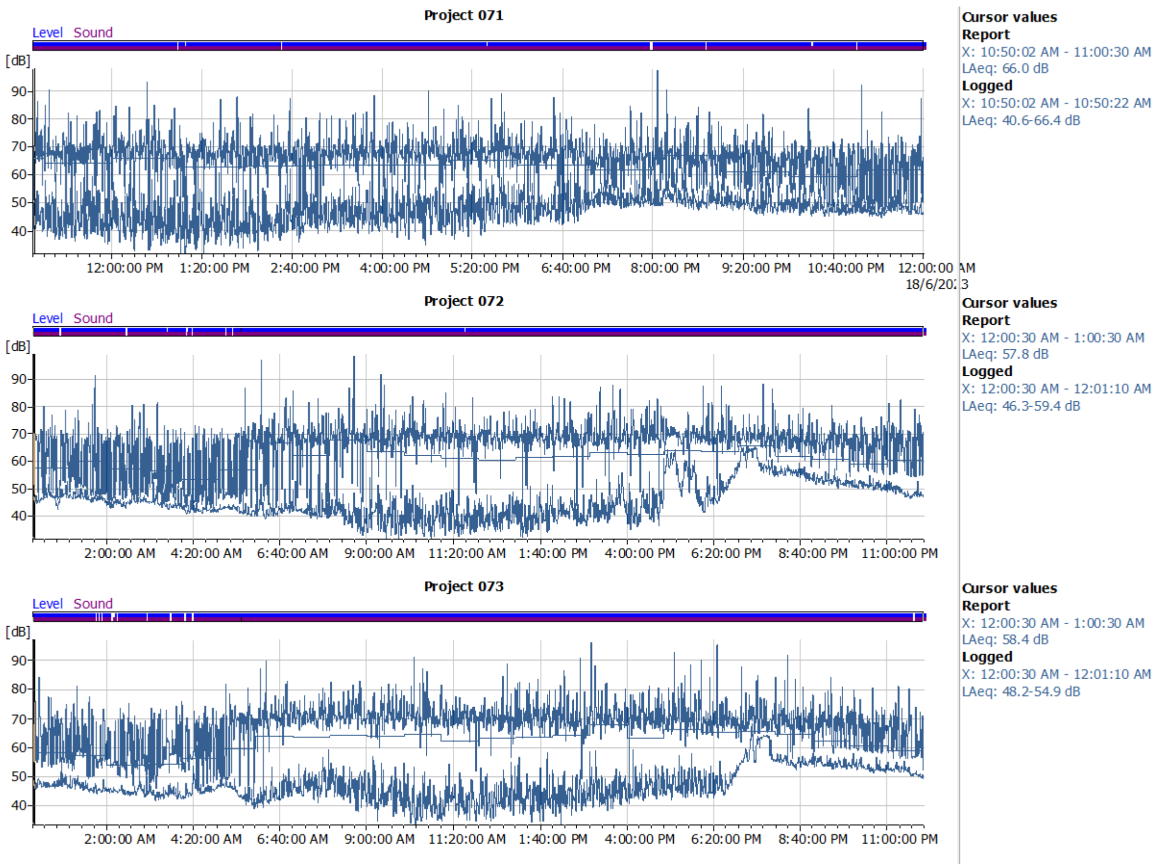


Figure 4-112 **Noise fluctuation (Leq) over 72 hours at Station 7 (top: June 17, middle: June 18, bottom: June 19)**

OCTAVE BAND ANALYSIS AT STATION 7

The noise at this station during the 72-hour period was in the low frequency band centred around the geometric mean frequency of 63 Hz (octave frequency range is 56 - 71 Hz) (Figure 4-113).

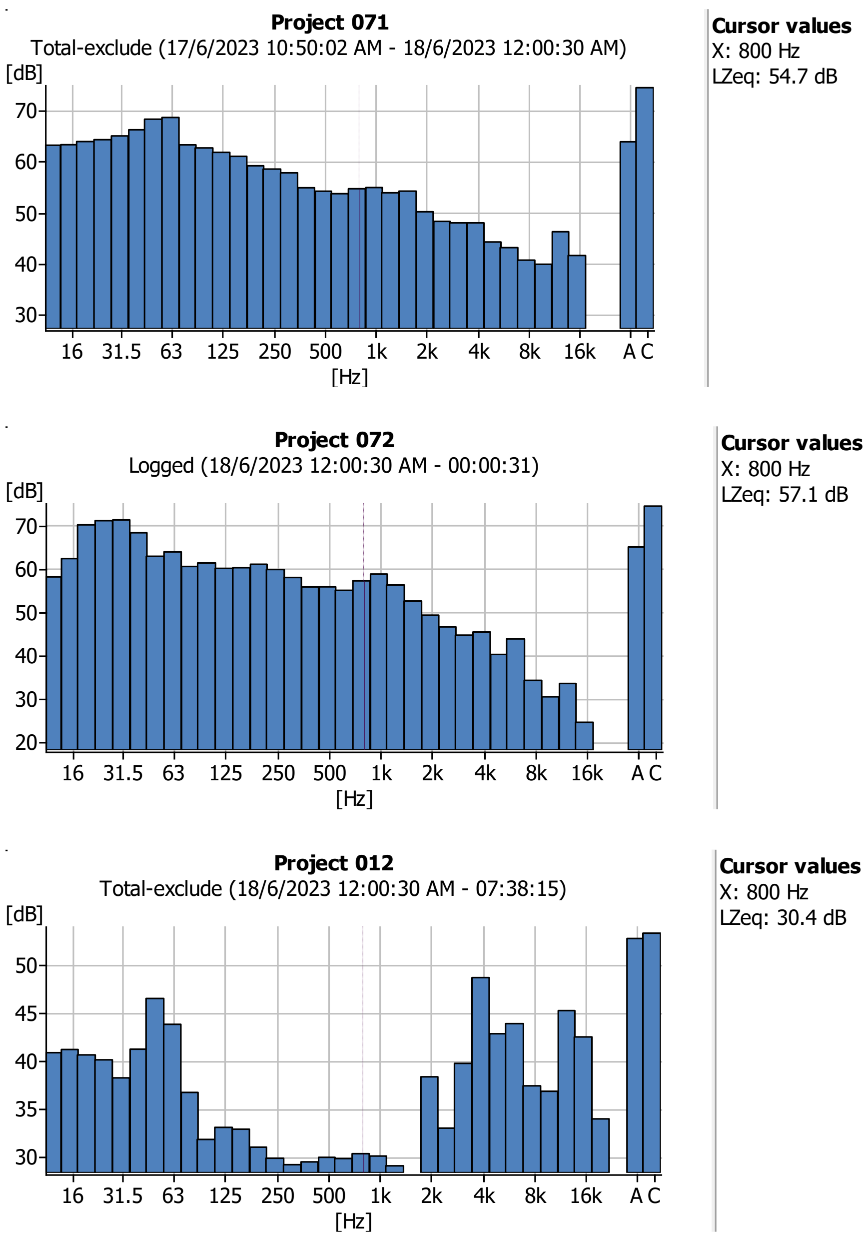


Figure 4-113 Octave band spectrum of noise at Station 7 (top: June 17, middle: June 18, bottom: June 19)

L10 AND L90

The overall L10 and L90 at this station for the time assessed were 64.9 dBA and 42.3 dBA, respectively.

STATION 8

During the 72-hour period, noise levels at this station ranged from a low (Lmin) of 27.5 dBA to a high (Lmax) of 78.0 dBA. Average noise level for this period was 58.2 L_{Aeq} (72h). The fluctuation in noise levels over the 72-hour period is depicted in Figure 4-114.

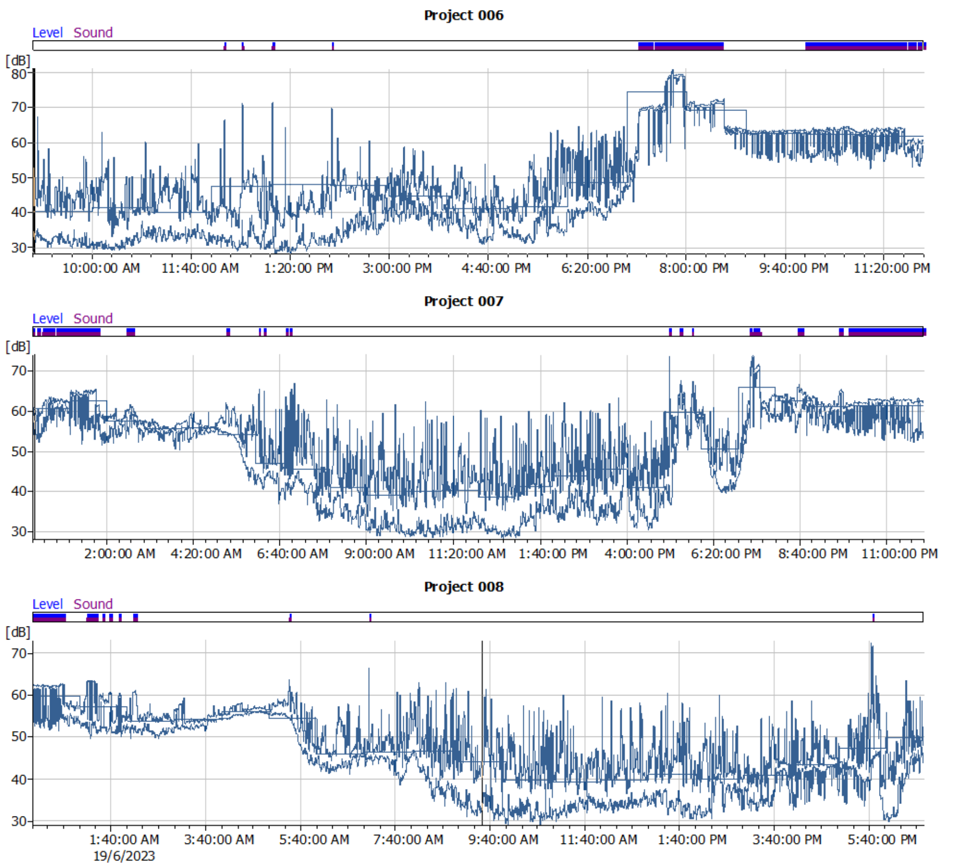


Figure 4-114 Noise fluctuation (Leq) over 72 hours at Station 5 (top: June 17, middle: June 18, bottom: June 19)

OCTAVE BAND ANALYSIS AT STATION 8

The noise at this station during the 72-hour period was in the high frequency band centred around the geometric mean frequency of 12500 Hz (octave frequency range is 11141 – 14025 Hz) (Figure 4-115).

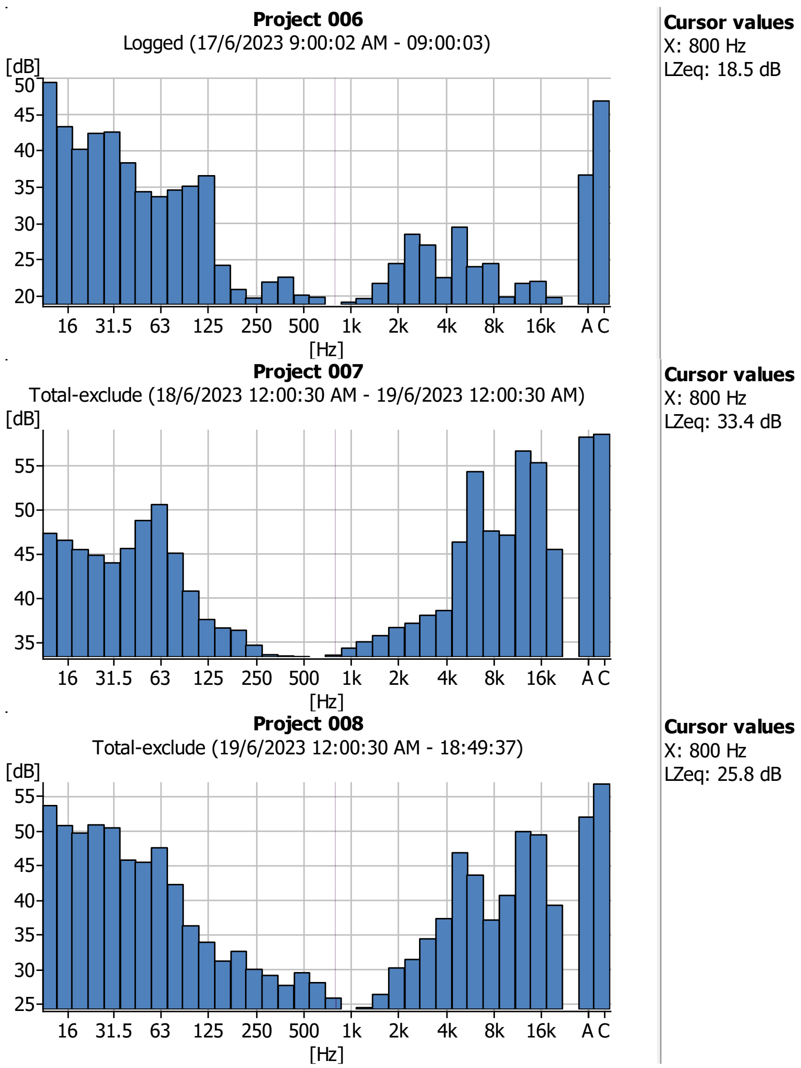


Figure 4-115 Octave band spectrum of noise at Station 8 (top: June 17, middle: June 18, bottom: June 19)

L10 AND L90

The overall L10 and L90 at this station for the time assessed were 62.4 dBA and 34.5 dBA, respectively.

Comparisons of Ambient Noise Levels with NRCA Daytime and Night-Time Guidelines

Comparison of the ambient noise levels in the study area with the Natural Resources and Conservation Agency (NRCA) Standards are shown in Table 4-19. During the daytime, noise levels at all Stations were compliant with respective NRCA daytime standards, except Station 4 (57.7 dBA) and Station 5 (68.2 dBA). During the night-time, noise levels at all Stations were compliant with respective NRCA night-time standards, except at Station 2 (52.1), Station 4 (57.5 dBA) and Station 5 (64.6 dBA).

Daytime noise sources detected which were above NRCA daytime guideline values, included: people talking, motor vehicle along road, dogs barking, crickets chirping and frogs calling

Nighttime noise sources detected which were above NRCA nighttime guideline values, included: frogs calling, crickets chirping and motor vehicles along road.

Table 4-19 Comparison of daytime and night-time noise levels at the stations with the NRCA guidelines

Stn.#	Zone	7 am. - 10 pm (dBA)	NRCA Standard (dBA)	10 pm. - 7 am (dBA)	NRCA Standard (dBA)
1	Commercial	47.5	*65*	51.2	*60*
2	Residential	47.0	*55*	52.1	*50*
3	Commercial	47.6	*65*	53.5	*60*
4	Residential	57.7	*55*	57.5	*50*
5	Residential	68.2	*55*	64.6	*50*
6	Commercial	44.3	*65*	52.2	*60*
7	Commercial	62.8	*65*	58.6	*60*
8	Commercial	47.7	*65*	57.4	*60*

NB. Numbers in red are non-compliant with the standard/guideline.

4.1.10 Particulates (Air Quality)

4.1.10.1 Definitions

Coarse particles are airborne pollutants that fall between 2.5 and 10 micrometres in diameter. Fine particle are airborne pollutants that fall below 2.5 micrometres in diameter. Sources of coarse particles include crushing or grinding operations and dust stirred up by vehicles traveling on roads. Sources of fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes.

4.1.10.2 Methodology

PM10 and PM2.5 particulate sampling exercises were conducted at the eight (8) locations (where noise monitoring was conducted) for 24 hours each over the course of nine (9) months using Airmetrics Minivol Tactical Air Samplers (Calibration Certificate in **Error! Reference source not found.**). The locations are listed in Table 4-17 and illustrated in Figure 4-99. The sampling exercises were conducted from 12:00am – 12:00am, the PM2.5 being run on days coinciding with the US EPA 3-day cycle, and the PM10 being run on days coinciding with the US EPA 6-day PM10 cycle. Sampling days spanned 17 June 2023 to 28 March 2024, taking into account both wet and dry seasons.

4.1.10.3 Results

Average PM10

The averaged results of the PM10 sampling over the 9-month sampling period is shown in Table 4-20. All locations had average particulate PM10 values compliant with the 24-hour NRCA standard of 150 µg/m^3. Detailed PM10 data can be seen in Appendix 5.

There were two (2) PM10 sampling days which occurred on days where rainfall was recorded by the on-site weather station (January 19th and 25th, 2024). On these sampling days, PM10 concentrations remained moderately low, except at Station 5 on January 19th (92.92 µg/m³) (**Error! Reference source not found.**).

Table 4-20 Average PM 10 results

STATION	AVERAGE PM10 RESULT (µg/m³)	RANGE (µg/m³)	NRCA STD. (µg/m³)
STN 1	20.15	3.33 – 60.14	150
STN 2	26.64	0.97 – 107.50	150
STN 3	22.10	1.94 – 93.33	150
STN 4	29.02	3.47 – 94.58	150
STN 5	23.98	1.11 – 92.92	150
STN 6	22.56	0.42 – 125.42	150
STN 7	23.30	1.39 – 87.08	150
STN 8	25.58	1.25 – 152.92	150

Values in red are non-compliant with NRCA standards

Average PM2.5

The averaged results of the PM2.5 sampling over the 9-month sampling period is shown in Table 4-21. All locations had average particulate PM2.5 values compliant with the 24-hour USEPA PM2.5 standard of 35µg/m³. Detailed PM2.5 data can be seen in **Error! Reference source not found.**.

There were no PM2.5 sampling days which occurred on days where rainfall was recorded by the on-site weather station

Table 4-21 Average PM 2.5 results

STATION	AVERAGE PM2.5 RESULT (µg/m³)	RANGE (µg/m³)	USEPA STD. (µg/m³)
STN 1	19.67	4.72 – 152.64	35
STN 2	24.79	2.22 – 107.50	35
STN 3	17.48	0.42 – 98.19	35
STN 4	16.82	2.92 – 38.33	35
STN 5	22.57	0.42 – 180.83	35
STN 6	14.97	0.56 – 38.61	35
STN 7	20.79	5.28 – 127.36	35
STN 8	14.34	0.97 – 39.17	35

Values in red are non-compliant with NRCA standards

4.1.11 Pollution Sources

Paradise Park is a coastal and terrestrial environment located in Westmoreland, Jamaica, with direct connectivity to Bluefields Bay Fish Sanctuary. The site includes low-lying wetlands, secondary forests and farmlands and marine ecosystems, all of which are susceptible to pollution from various sources.

Findings from the baseline surveys and analysis aid in the evaluation and identification of key pollution sources:

- Water quality results (4.1.7.3) indicate elevated nutrients, turbidity, and microbial contamination in both freshwater and marine environments. Likely key pollution sources include agricultural runoff, sewage discharge, and sediment transport from waterways. Water flow in the Paradise Park project area is influenced by a combination of culverts, drains, gullies, and natural river systems. Culverts direct water under roads and infrastructure, while drains help manage stormwater and prevent localized flooding. Gullies, formed through erosion, act as intermittent channels, carrying runoff during heavy rainfall events. In contrast, rivers provide a continuous, natural watercourse, shaping the landscape and supporting wetland ecosystems.
    - The primary hydrological pathways influencing pollution dynamics in the area include Sweet River, Deans Valley River, and their associated tributaries (Figure 4-16), which serve as conduits for sediments, nutrients, and contaminants into the marine environment. These waterways experience direct impacts from stormwater runoff, agricultural effluent, and untreated or improperly treated wastewater.
- Noise results (4.1.9.3), indicate that all but two monitoring stations met regulatory compliance levels.
- All particulate stations were compliant with NRCA and USEPA standards (4.1.10.3). However, burning of solid waste and vegetation cuttings are common practice, which may contribute to localized air quality impacts.
- Residents have also reported illegal dumping and inadequate waste collection (4.4.3.3).

The results indicate that while most parameters comply with regulatory standards, localized pollution sources persist. Runoff, sewage discharge, and waste burning contribute to air and water quality concerns, while poor solid waste management and elevated noise levels in select areas highlight ongoing environmental stressors.

Various pollution sources have been mapped (Figure 4-116).

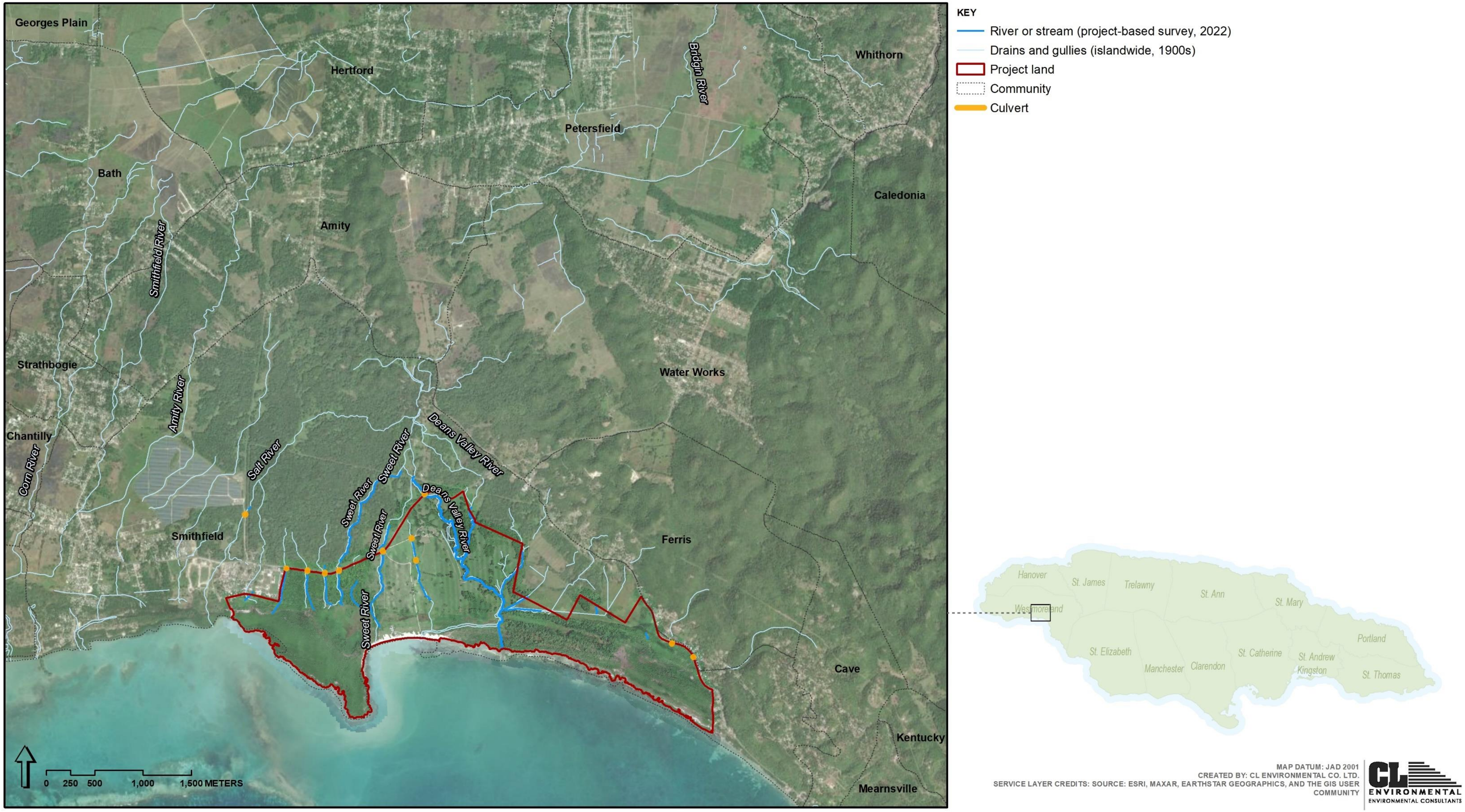


Figure 4-116 Mapped Sources of Pollution

4.1.11.1 Urban and Residential Contributions

The settlements around Paradise Park rely on septic tanks, soak-away pits, and in some cases, direct wastewater discharge. Limited sanitation infrastructure and waste collection services contribute to improper disposal of solid waste, greywater, and other pollutants (Plate 4-13 and Plate 4-14).

Plate 4-13 Insufficient and poorly maintained community trash collection area, leading to overflow and improper waste disposal.

Plate 4-14 Solid waste littering along riverbank

4.1.11.2 Hydrological Pathways

Stormwater drainage systems are either lacking or inadequate, resulting in surface runoff containing organic waste, oils, and chemicals. Road networks and impermeable urban surfaces funnel pollutants into nearby streams and wetlands. Illicit disposal of household waste, including plastics, organic refuse, and detergents, contributes to cumulative contamination of the aquatic environment.

Plate 4-15 Example of domestic activities in the river

Plate 4-16 River tributary along the main roadway

Plate 4-17 Section of Salt River runs under the roadway

4.1.11.3 Agricultural Influences

Vast pasturelands used for cattle grazing, the use of synthetic fertilizers, pesticides, and herbicides can result in high nitrate and phosphate loading, affecting water quality. Manure runoff from livestock operations introduces pathogens, ammonia, and organic matter into the waterways, increasing biological oxygen demand (BOD) and promoting eutrophication. Sediment runoff is exacerbated by soil erosion from overgrazed lands can lead to increased turbidity and siltation in marine habitats.

Examples of agricultural activities directly on property can be seen in Plate 4-18 and Plate 4-19. Agricultural activities outside the project boundaries can also have impacts to water ways and coastal environments in the project area.

Plate 4-18 Water way heavily utilized by cattle

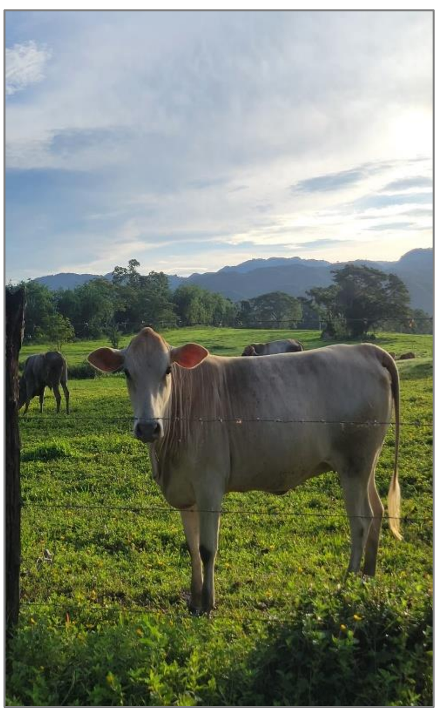


Plate 4-19 Example of cattle on the property

4.2 BIOLOGICAL ENVIRONMENT

4.2.1 Study Area and Approach

The study area is defined by a 6 km radius from the project boundary, covering a total of 194.3 km² or 19,438.52 hectares (Figure 4-117). To the west of the project site lies Savanna-la-Mar, the capital of Westmoreland, which is also the largest town and administrative centre of the parish. Smaller towns are scattered throughout the western portion of the study area, which is largely dominated by plantations and agricultural fields, with hilly terrain and forested areas exist to the east. A significant portion of the coastline is characterized by mangrove forests and sandy beaches, while the remainder features limestone bedrock, cliffs, and manmade structures such as riprap, sea walls, and boulder rubble (Carroll, 2013).

A key feature of the study area is the Bluefields Bay Fish Sanctuary, with the southern boundary of the project land adjacent to the northern section of the sanctuary. The region features a relatively shallow shelf, extending up to 20 km wide along Jamaica's south coast, with the shelf edge located about 6 km from the coastline within Bluefields Bay (McIntyre, 2015). The seafloor is primarily made up of seagrass and sand, with mud and boulder deposits found in the southern part of the bay. Offshore, the study area is part of a coastal barrier reef complex. These diverse benthic habitats are crucial for marine life, providing nurseries, feeding grounds, and shelter for various species, and are essential for the resilience and health of coastal ecosystems.

The study area is split into two components: a terrestrial (land-based) area of 123.6 km² or 12,364.45 hectares and a marine area of 70.7 km² or 7,074.07 hectares (Figure 4-118, Table 4-22). The approach to assessing the existing biological environment was designed in a twofold manner. First, to gather comprehensive primary data through field surveys in key zoned project areas. Second, a review of secondary data, including existing geospatial datasets, scientific studies, governmental reports, and previous ecological surveys, provided valuable context and insights into the characterization of habitat types and ecological conditions within the 6 km study area, particularly for regions beyond the detailed survey zones.

Table 4-22 Study area broken down into terrestrial and benthic components and survey areas

	Area (km²)	Hectares
STUDY AREA	194.3	19,438.52
Benthic/Marine	70.7	7,074.07
Detailed Survey Area	0.9	91.13
Wider Study Area (remaining)	69.8	6,982.94
Terrestrial	123.6	12,364.45
Survey Zone 1	1.4	137.29
Survey Zone 2	1.4	135.56
Survey Zone 3	0.3	34.63
Survey Zone 4	1.5	146.22
Wider Study Area (remaining)	119.1	11,910.74

The terrestrial portion of the study area was subdivided into four distinct survey zones (Figure 4-118), wherein comprehensive surveys of flora and fauna were carried out (see Section4.2.2). For the marine benthic survey, the primary survey zone focused on the nearshore area extending approximately 100 to 250 meters from the coastline. The methods used in this detailed survey area, as well as within key areas of interest through targeted roving surveys, were tailored to assess the specific benthic communities present (see Section 4.2.3).

Data collected from both the terrestrial and marine surveys, alongside existing literature, and spatial data, were integrated to create comprehensive terrestrial and benthic habitat maps. The detailed biological data gathered for both environments provided a clearer understanding of biodiversity and habitat quality within habitats. This integrated information served as the biological foundation for the impact assessment.

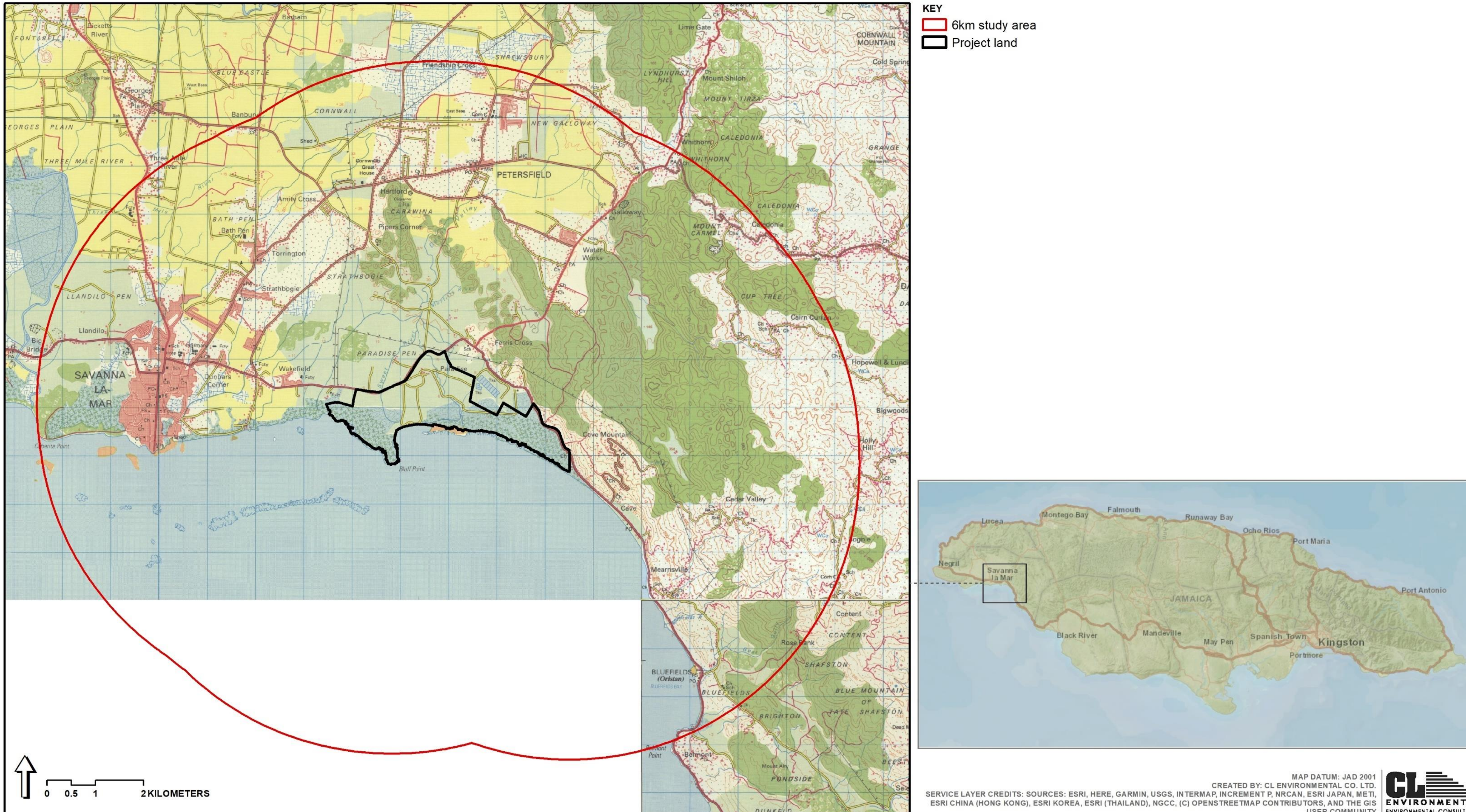


Figure 4-117 Study area and project land boundary

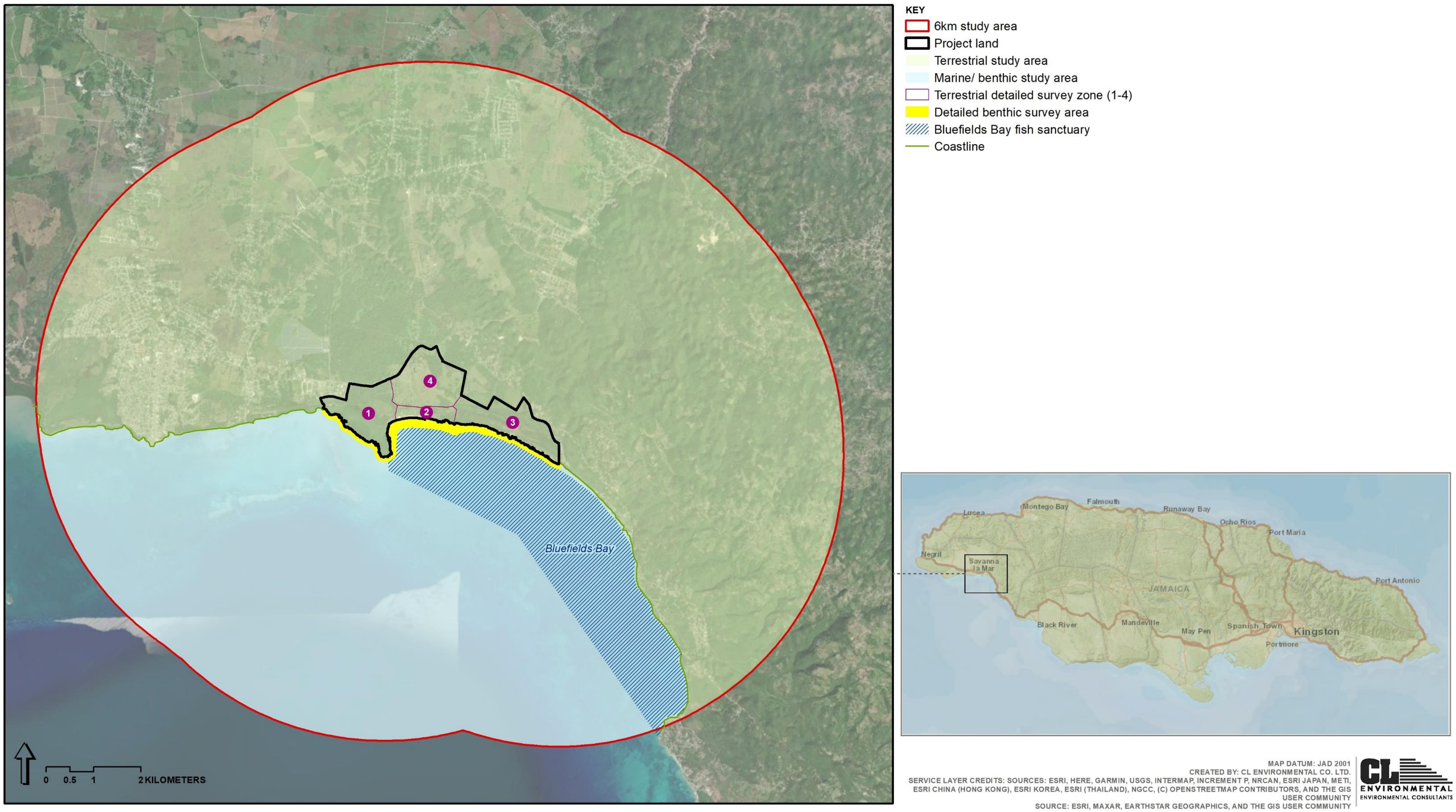


Figure 4-118 Study area and terrestrial and benthic survey zones

4.2.2 Terrestrial

4.2.2.1 Terrestrial Habitats

Mapping Approach and Classification

The project relied on the latest drone-based imagery, specifically a 10-band image mosaic captured in October 2023 using a RedEdge-MX Dual Camera Imaging System. Along with this imagery, additional data sources were assessed, including a LiDAR-derived orthomosaic, Google Earth imagery, and other drone-captured images. Through visual assessment in Geographic Information Systems (GIS), field surveys and expert judgement, the detailed survey zone area was delineated according to six (6) major terrestrial habitat groupings (Table 4-23). For the wider terrestrial study area, existing land use maps (Forestry Department, 1998) were used to assess the broader landscape and support the habitat classification process. The combination of high-resolution imagery and existing spatial data enabled a comprehensive mapping of the study area's terrestrial environments.

Description of Terrestrial Habitats

The six (6) major terrestrial habitat groupings for the project survey area are listed below, with detailed descriptions and representative images of each provided in Table 4-23:

1. Beach
2. Wetland: Mangrove Forest
3. Wetland: Herbaceous wetland
4. Wetland: Swamp forest
5. Fields
6. Secondary forest

Figure 4-119 and Plate 4-20 through to Plate 4-29 also illustrate the diverse habitats within the study area, including mangroves, swamp forests, wetlands, unique mudflats, beaches, fields, and coastal transition zones. They also highlight key ecological features, such as the endemic Royal Palm.

Table 4-23 Description of terrestrial habitat types within the project land boundary

Habitat	Definition	Example images from the project site
Beach	A coastal area characterized by loose particles such as sand, gravel, or pebbles, shaped by tidal and wave action. Beaches can be formed by erosion, deposition, or sediment transport and are often home to specialized plant and animal species adapted to the harsh conditions of saltwater and shifting sand.	 
Wetland: Mangrove Forest	Edaphic forest (areas with brackish water) composed of trees with stilt roots or pneumatophores, species-indicators such as *Rhizophora mangle* (red mangrove) and *Avicennia germinans (black mangrove)* (Forestry Department, 2003)	 

Habitat	Definition	Example images from the project site
Wetland: Herbaceous wetland	Wetland areas dominated by non-woody, herbaceous plants, such as grasses, sedges, and reeds. These wetlands are typically found in low-lying areas that experience periodic flooding or saturation with water, either seasonally or year-round. Edaphic vegetation (soil waterlogging) with herbaceous plants (Forestry Department, 2003)	 
Wetland: Swamp forest	Edaphic forest (soil waterlogging) with a single tree storey with species-indicators such as *Symphonia globulifera* (hog gum) and *Roystonea princeps* (royal palm)	

Habitat	Definition	Example images from the project site
Fields	Herbaceous crops, follow and cultivated vegetables (Forestry Department, 2003)	 
Secondary forest	Forests that have regrown after disturbance, such as logging, farming, or natural disasters. Secondary forests typically consist of younger trees and may have a different species composition compared to primary forests. Disturbed broadleaf forest with broadleaf trees at least 5 m tall and species-indicators of disturbance such as *Cecropia peltata* (trumpet tree) (Forestry Department, 2003)	 

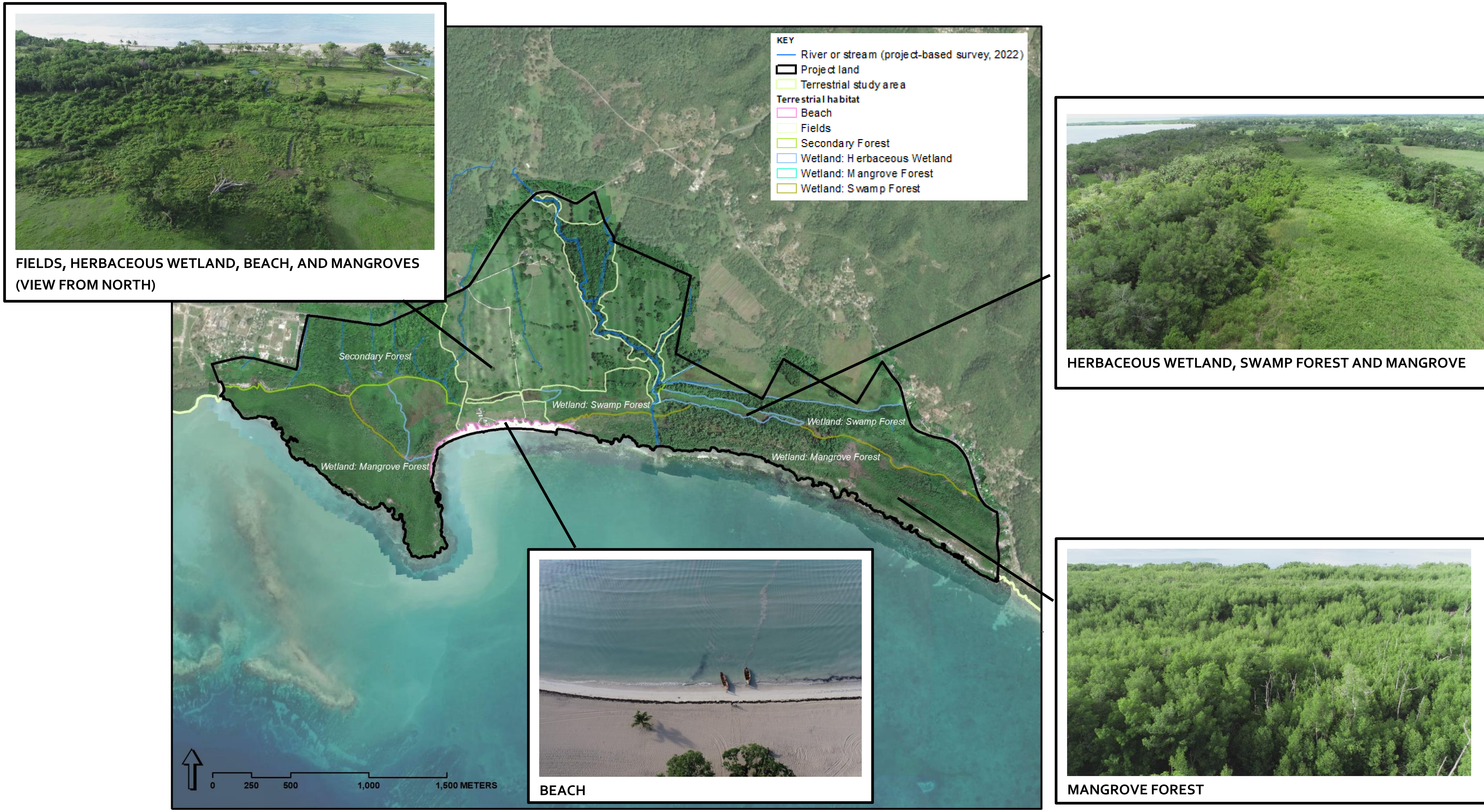


Figure 4-119 Terrestrial habitat delineation within the project boundary

Plate 4-20 ***Roystonea princeps*** **trees amidst remnant of swamp forest with mangrove forest to the right**

Plate 4-21 **Riparian and riverine area with surrounding wetlands, featuring a mix of herbaceous vegetation.**

Plate 4-22 Coastal zone showing a large beach, fields, and temporary pond areas

Plate 4-23 A mix of wetlands with Royal Palms in the swamp and mangroves along the lower area.

Plate 4-24 Mangroves in the foreground transitioning into a Royal Palm swamp.

Plate 4-25 A mix of wetlands, river, and scattered Royal Palms, with fields visible in the top right.

Plate 4-26 Wetland area

Plate 4-27 Unique mudflat habitat with scattered vegetation, transitioning into coastal wetlands.

Plate 4-28 Seagrass in the foreground leading to mangroves, transitioning into a mudflat with a strip of Royal Palms in the swamp.

Terrestrial Habitat Distribution

6KM STUDY AREA

The total terrestrial study area spans 123.64 km² (12,364.45 hectares), with a diverse range of habitats and land uses. The largest habitat category is Plantation, including tree crops, sugar cane, banana, and shrub crops (Forestry Department, 1998), which covers 2,486.02 hectares or 20% of the total area (Figure 4-117, Table 4-24). Following that, Disturbed broadleaved forest (secondary forests) occupies 2,410.42 hectares or 19% of the area. Fields (crops, fallow, and cultivated vegetables) make up 1,751.00 hectares or 14%, while Open dry forests (short shrubland/bushland and tall woodland/savanna) cover a combined total of 882.48 hectares or 7%. Urban areas, including Buildings and other infrastructures, cover 2,078.74 hectares or 17% of the total study area. The Secondary Forest and Fields category (which includes secondary forests and agricultural fields) covers 2,163.13 hectares or 17% of the total.

Wetland habitats are present in smaller portions, with Mangrove Forest covering 268.64 hectares (2%), Swamp Forest at 177.90 hectares (1%), and Herbaceous Wetland at 67.99 hectares (1%). Secondary Forest contributes 73.82 hectares (1%) of the area, and Beach habitats are minimal, occupying just 4.31 hectares (less than 1%).

Table 4-24 Terrestrial habitats and land use areas in the terrestrial study area and detailed survey zones, with colour-scaled cells from white to dark green representing the portion of each habitat class

Terrestrial habitat	DETAILED SURVEY ZONED AREA		WIDER TERRESTRIAL STUDY AREA		TOTAL TERRESTRIAL STUDY AREA	
	Area (hectares)	Percentage of detailed survey area (%)	Area (hectares)	Percentage of wider study area (%)	Area (hectares)	Percentage of study area (%)
Beach	4.31	1%			4.31	0%
Fields: Crops, fallow, cultivated vegetables	131.94	29%	1,619.06	14%	1,751.00	14%
Secondary Forest	73.82	16%			73.82	1%
Wetland: Herbaceous Wetland	39.80	9%	28.20	0%	67.99	1%
Wetland: Mangrove Forest	142.61	31%	126.03	1%	268.64	2%
Wetland: Swamp Forest	61.23	13%	116.67	1%	177.90	1%
Buildings and other infrastructures			2,078.74	17%	2,078.74	17%
Disturbed broadleaved forest (Secondary Forest)			2,410.42	20%	2,410.42	19%
Open dry forest - Short (Shrubland/Bushland)			582.02	5%	582.02	5%
Open dry forest - Tall (Woodland/Savanna)			300.46	3%	300.46	2%
Secondary Forest and Fields			2,163.13	18%	2,163.13	17%
Plantation: Tree crops, shrub crops, sugar cane, banana			2,486.02	21%	2,486.02	20%
Total	**453.71**		**11,910.74**		**12,364.45**	

SURVEY ZONES

Unlike the broader landscape dominated by fields, plantations, and disturbed forests in the wider study area, the detailed survey zone is primarily dominated by mangrove forest and fields, with significant contributions from Swamp Forest and Secondary Forest (Figure 4-120, Figure 4-122). Specifically, the detailed survey zone covers a total area of 453.71 hectares, with the largest habitat type in this zone being Wetland: Mangrove Forest, which spans 142.61 hectares, or 31% of the area. This is followed by Fields (crops, fallow, and cultivated vegetables), which cover 131.94 hectares, or 29% of the detailed survey zone. Secondary Forest accounts for 73.82 hectares, or 16%, while Wetland: Swamp Forest covers 61.23 hectares or 13%. Wetland: Herbaceous Wetland occupies 39.8 hectares or 9%, and Beach is the smallest habitat, covering just 4.31 hectares, or 1% of the zone.

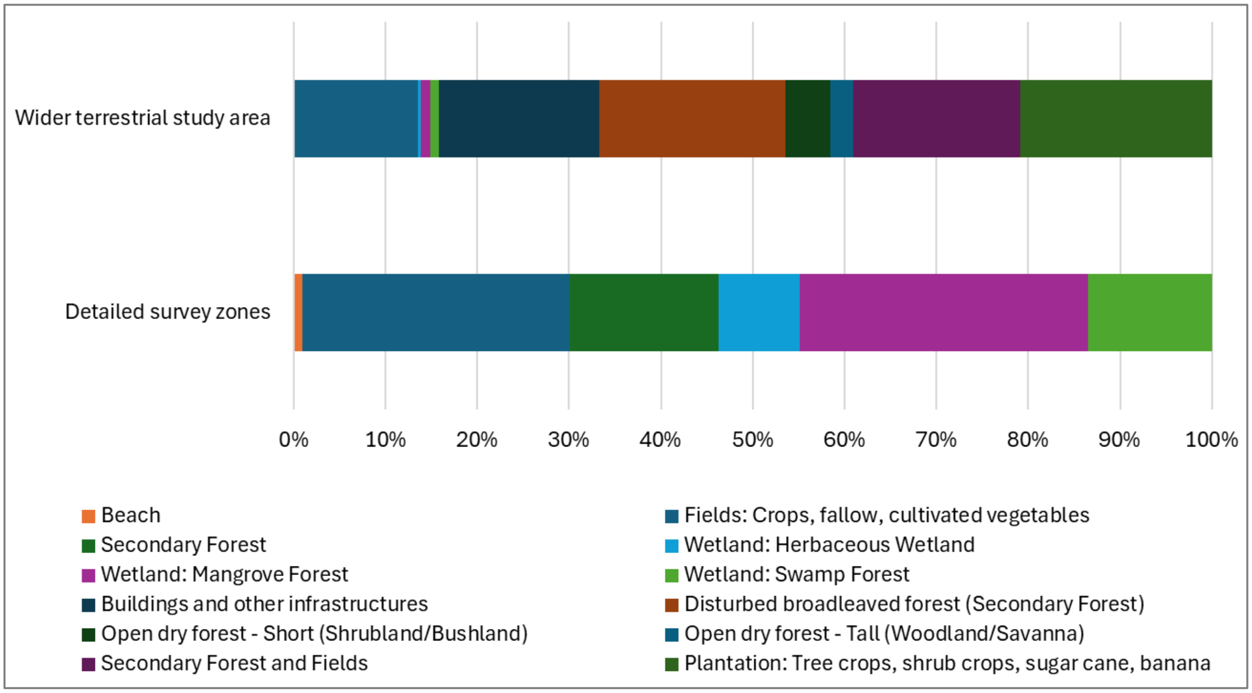
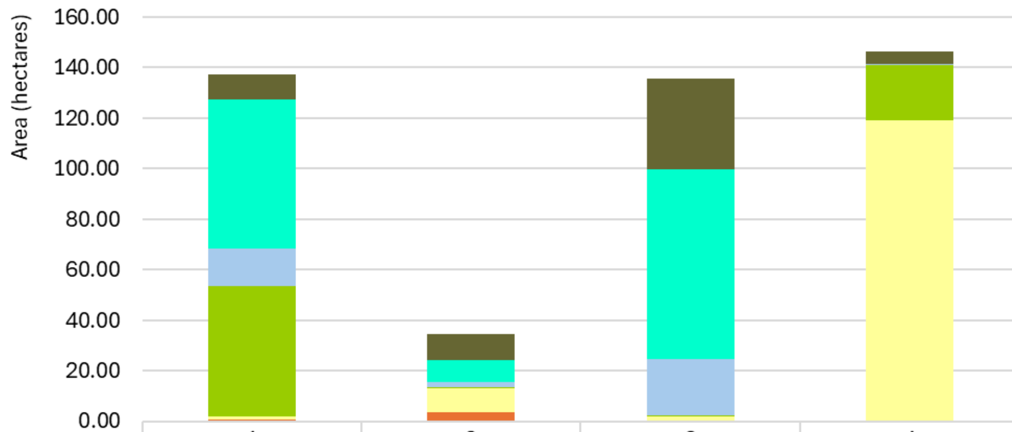


Figure 4-120 Stacked bar chart showing terrestrial habitats within the terrestrial study area and survey zones

The distribution of terrestrial habitats varies significantly across the four survey zones. Zone 1 features a balanced mix of habitats, with significant contributions from Secondary Forest (51.34 hectares) and Wetland: Mangrove Forest (58.82 hectares). Zone 2 has the smallest total coverage (34.63 hectares) and is dominated by Fields and Wetland: Mangrove Forest, with sparse representation from other habitats. Zone 3 is characterized by extensive wetlands, with Wetland: Mangrove Forest (75.12 hectares) and Wetland: Swamp Forest (35.83 hectares) being the primary contributors, while other habitats are minimally present. In contrast, Zone 4 has the largest total coverage (146.22 hectares), driven overwhelmingly by Fields (119.11 hectares), with only minor contributions from other habitats. Notably, the Beach habitat is absent in zones 3 and 4.



	1	2	3	4
Wetland: Swamp Forest	9.99	10.53	35.83	4.88
Wetland: Mangrove Forest	58.82	8.67	75.12	0.00
Wetland: Herbaceous Wetland	15.07	2.12	22.16	0.44
Secondary Forest	51.34	0.09	0.60	21.79
Fields	1.18	9.80	1.85	119.11
Beach	0.89	3.42	0.00	0.00

Figure 4-121 Terrestrial habitat area within each terrestrial zone

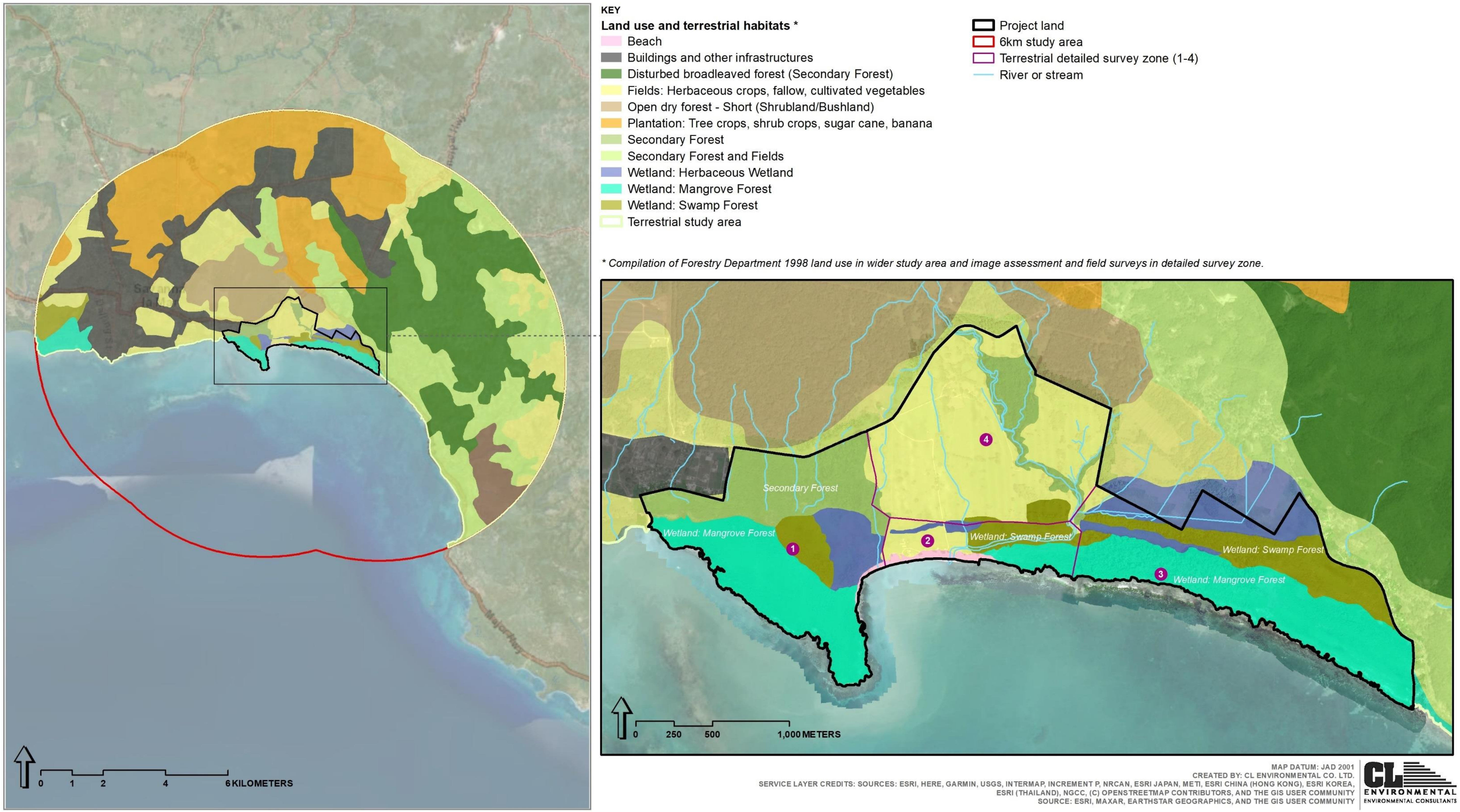


Figure 4-122 Land use and terrestrial habitats within the terrestrial study area and detailed survey zones

4.2.2.2 Vegetation Health

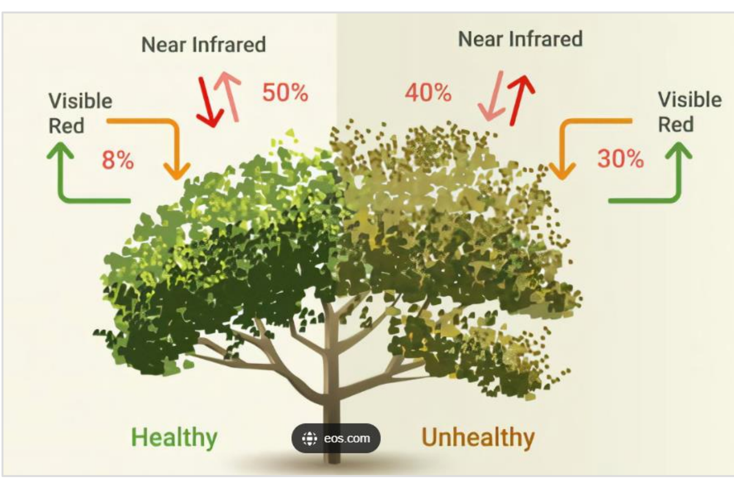
Remote sensing imagery, especially from satellites or drones, provides valuable data for calculating various indices that are crucial for monitoring and analysing environmental and ecological conditions. These indices are mathematical formulas that combine specific wavelengths of light captured in the imagery, typically from the visible, near-infrared, or thermal infrared spectrum. By analysing these indices, we can gain insights into a range of land surface characteristics, including vegetation health, soil moisture, water bodies, and urban development. The latest drone-based image mosaic captured for the project in October 2023 includes 10 spectral bands—spanning red, blue, green, RedEdge, and near-infrared (NIR)—and therefore offers the flexibility to calculate a wide range of indices.

A widely used index is the Normalized Difference Vegetation Index (NDVI), which quantifies vegetation based on differences in near-infrared (NIR) and visible red-light reflectance (Equation 4-1), and provides an indication of vegetation density, health, and land cover.

Equation 4-1 Normalized Difference Vegetation Index (NDVI)

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Chlorophyll reflects near-infrared (NIR) light (700 to 1100 nm), however absorbs visible light (400 to 700 nm) for use in photosynthesis. This means that high photosynthetic activity, commonly associated with dense healthy vegetation, will have less reflectance in the red band and higher reflectance in the near-infrared band (Figure 4-123). Resulting NDVI values range between -1 and 1. If the result yields high NDVI values, this signifies more or healthier vegetation, and vice versa with low NDVI values, less or no vegetation. NDVI may also give indications for other types of land cover and Table 4-25 provides the classification utilised in this assessment.

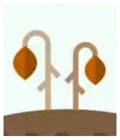
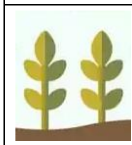
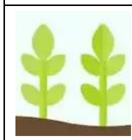
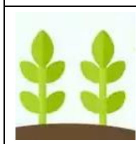


Source: NDVI FAQs: Top 23 Frequently Asked Questions About NDVI (eos.com)

Figure 4-123 Illustration of absorption and reflectance of visible red and NIR light by health and unhealthy plants

Table 4-25 Interpretation of NDVI

Source of images: NDVI FAQs: Top 23 Frequently Asked Questions About NDVI (eos.com)

NDVI	Vegetation description	Other descriptors
 **-1 - 0**	• Dead plants • Absence of vegetation	• Inorganic objects such as stones and man-made built-up areas • Clouds • Snow fields • Water bodies (slightly negative NDVI)
 **0-0.33**	• Unhealthy/ diseased plants • Very sparse vegetation cover/ early stages of cultivation/ senescing • Minimal Chlorophyll levels • Bare soil	• Water bodies (very low positive NDVI values) • Some soil types (that exhibit a near-infrared spectral reflectance somewhat larger than the red)
 **0.33-0.66**	• Moderately healthy plant • Moderate vegetation cover • Moderate Chlorophyll levels	
 **0.66-1**	• Very healthy plant • Dense vegetation cover • High Chlorophyll levels	

The NDVI was calculated for the land portion of the proposed project and the results show that the project site is primarily comprised of healthy terrestrial vegetation, with NDVI values of 0.33 and greater accounting for 98% of the project land. Roadways, trails, built infrastructure and areas of bare soil or sand with an absence of or unhealthy vegetation (~2%) are easily identifiable as shades of orange and red in Figure 4-124.

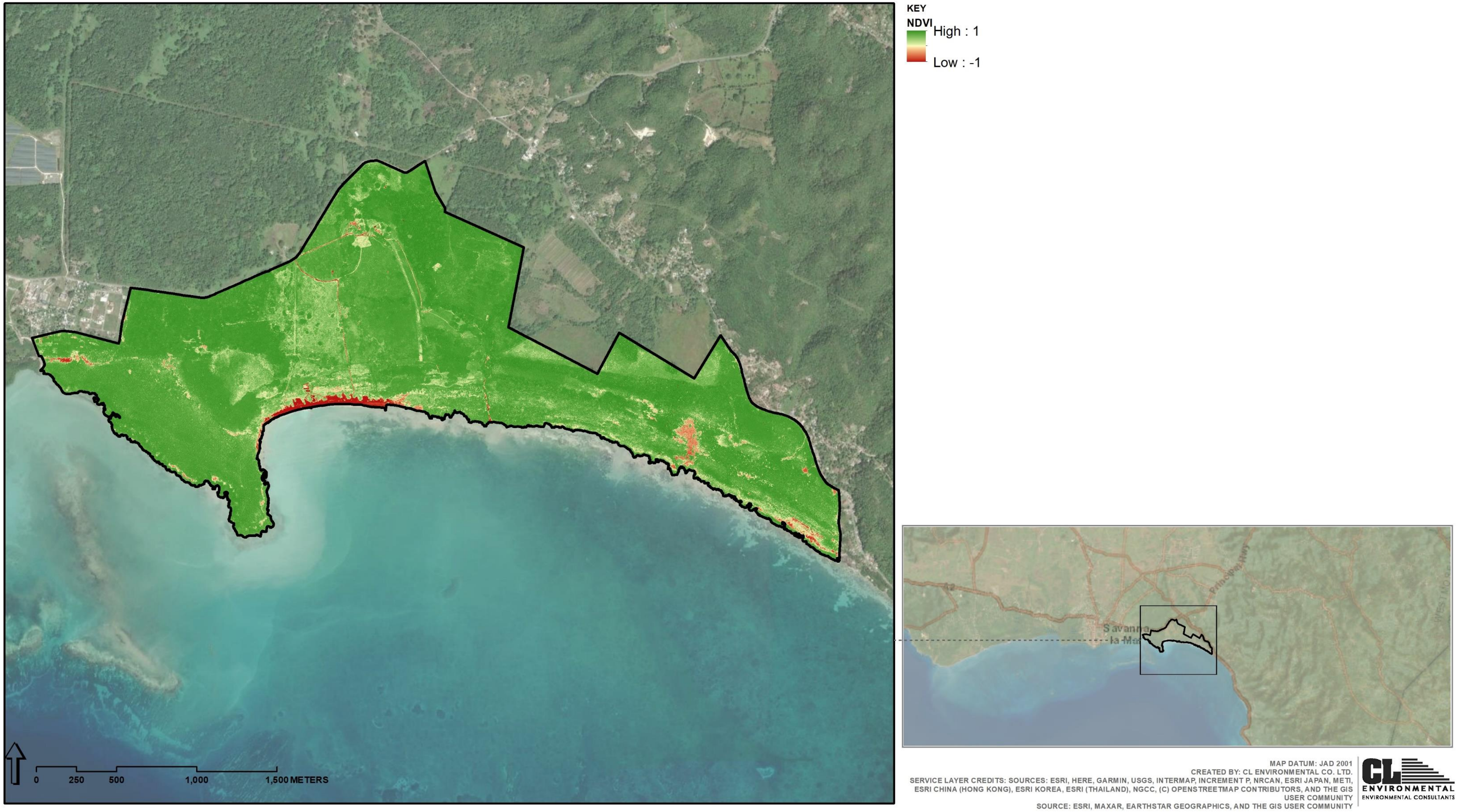


Figure 4-124 Normalized Difference Vegetation Index (NDVI) at the project site

4.2.2.3 Terrestrial Flora

Literature Review

Paradise, Westmoreland, Jamaica has had several owners from the period of when Jamaica was a British colony into the period of Jamaica's independence. Some historic owners in the 1700s and 1800s were William Dorrill, John Cope and John Wedderburn. Over the centuries the flat coastal area, which was known as Paradise Pen, Paradise Estate or just Paradise was used to farm sugarcane, ginger, cotton, raise cattle, sheep, horses, mules, and also as pasture and wharfage for logwood. The area was good for agriculture because it had alluvial soils and rivers running through the area which are utilized for irrigation. Paradise Park, which the area is presently called was also inhabited by Tainos and this is evident from artefacts found within the property in the past which confirmed their presence. The present use of the property is consistent with some uses in the past such as cattle, sheep, and horse rearing. In addition to these traditional uses the property also houses a small military station, a Gun Club, and a sports complex.

According to the forestry department the property has four broad classifications which are Herbaceous Forest, Mangrove Forest, Open dry Forest – Short (Shrubland/bushland) and Fields: Herbaceous crops, fallow, cultivated vegetables. The surveys conducted confirmed that these classifications do exist within the property but also the existence of other classifications.

It should be noted that subsequent to the survey conducted several weather systems have affected the island and the proposed development site. Hurricane Beryl a category 4 storm significantly impacted Jamaica's southwestern coast with heavy winds and rain which caused extensive damage and flooding. The habitats withing the proposed development site were impacted through flooding and loss of species including trees that were toppled by winds and or saturated soils.

Survey Methods

The assessment of the terrestrial flora was carried out by utilizing a series of walkthroughs, throughout out each of the 4 sample zones surveyed (Zones 1 to 4). This method was selected as the team of botanists were simultaneously logging large trees across the project area; it was therefore efficient to record the plant species encountered while traversing the property for the large tree survey. All plant species encountered during the walkthrough assessment were recorded: the name and perceived dominance using the DAFOR scale.

The common names of most of the species sighted were assigned in situ. In the case of unknown species, voucher specimens were collected and identified at the University of the West Indies (UWI) Herbarium. All plants were identified at the species level by examining morphological features such as leaf arrangement, leaf pattern, and pattern of branching and morphology of floral and fruiting structure in conjunction with the use of Flowering Plants of Jamaica (Adams, 1972) and preserved reference specimens of the herbarium.

An assessment of the large trees, defined as trees with diameter at breast height (DBH) >30cm, was carried on the property. For each tree encountered that fell into the category, the species along with its measured DBH and its GPS coordinate was also collected and then marked with flagging tape; a unique FID code was generated for each large tree recorded. Across the project area, large trees that were logged were labelled with pink flagging tape. In instances where the tree is endemic, orange flagging tape was used.

The team of botanists also conducted a count of bromeliads, orchids and epiphytic cacti that were observed during the flora assessment. The species, number of individuals counted, and a GPS coordinate of the individuals/cluster were recorded and marked with flagging tape.

Lastly, *Roystonea princeps* trees were mapped using two methods. Firstly, the flora team physically measured, and GPS mapped trees with DBH of 30 cm and above I the field. A general desktop mapping exercise was also undertaken of the remaining *Roystonea princeps* by utilizing aerial imagery; this did not take DBH into consideration.

Results

ZONE 1

Zone 1, as per the Forestry Land Use classification, is characterized in two classes: Fields: Herbaceous crops, fallow (agricultural land abandoned for a period of time), cultivation and Mangrove Forest. The on the ground observations were slightly different as some patches of Secondary Forest and Herbaceous Wetland, were also present in Zone 1.

Zone 1 is dominated by terrestrial influences (northern portion) and is mostly a mixture of Secondary Forest and Fields: Herbaceous crops. The south of Zone 1 is dominated by Wetland: a mix of a relatively small area of Herbaceous Wetland and vast area of Mangrove Forest.

The vegetation recorded in Zone 1 reflects the forest types observed on the ground, most of the plants encountered are classified (Adams, 1972) as being very common, commonly found in thickets and wastelands, and commonly found in secondary woodlands. Only a few species that are considered to be primarily associated with wetland ecosystems were recorded in this zone.

A total of 177 species were recorded in Zone 1, the second highest number of species across all the 4 zones assessed. The 177 species consist of 58 plant families and 152 plant genera. The most represented families in this zone are Poaceae, Fabaceae, Cyperaceae, Asteraceae and Malvaceae with 16, 15, 10, 10, and 10 species, respectively. Most of the species recorded (128) in this zone are native to Jamaica, only 3 endemic plant species (*Roystonea princeps, Wittmackia negrilensis* and *Brassavola subulifolia Lindl*) were recorded in Zone 1.

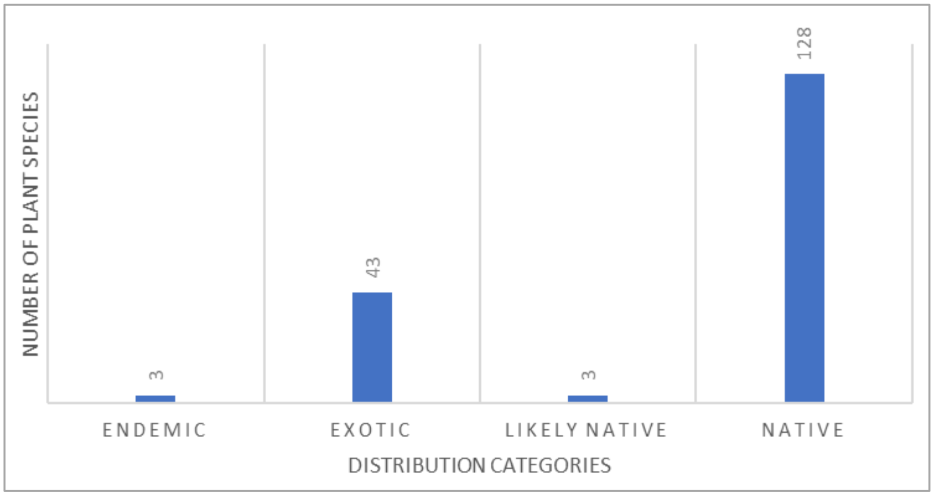


Figure 4-125 Summary chart of zone 1 plant species distribution status

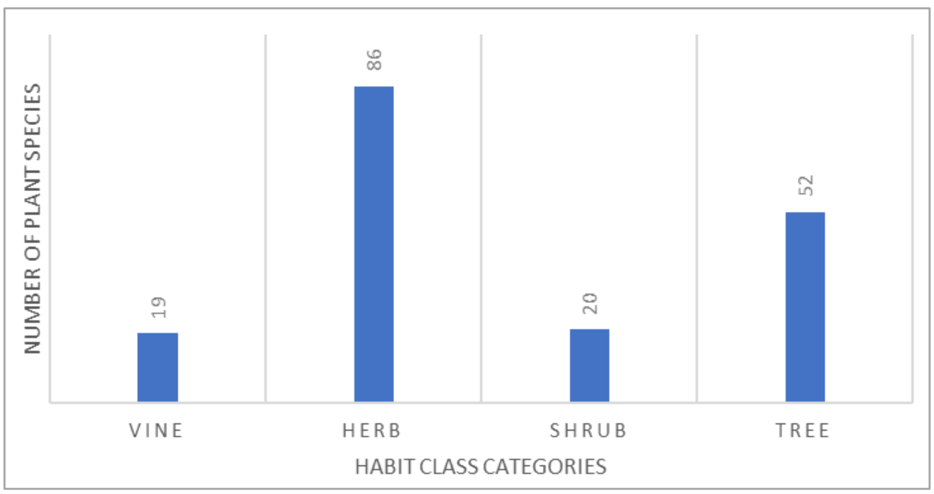


Figure 4-126 Summary chart of zone 1 plant species habit class

The majority of the plant species recorded in Zone 1 were herbs (86), followed by trees (52) the least represented Habit Classes in Zone 1 were shrubs (20) and vines (19). Commonly occurring shrubs across Zone 1 included: Duggy Gun (*Ruellia tuberosa*), Scratch Coco (*Alocasia macrorrhizos*), Jack-in-the bush (*Chromolaena odorata*). Some of the trees most frequently observed during the assessment of this zone included: Pink poui (*Tabebuia angustata*), Logwood (*Haematoxylum campechianum*), Guango (*Samanea saman*), Bastard Cedar (*Guazuma ulmifolia*).

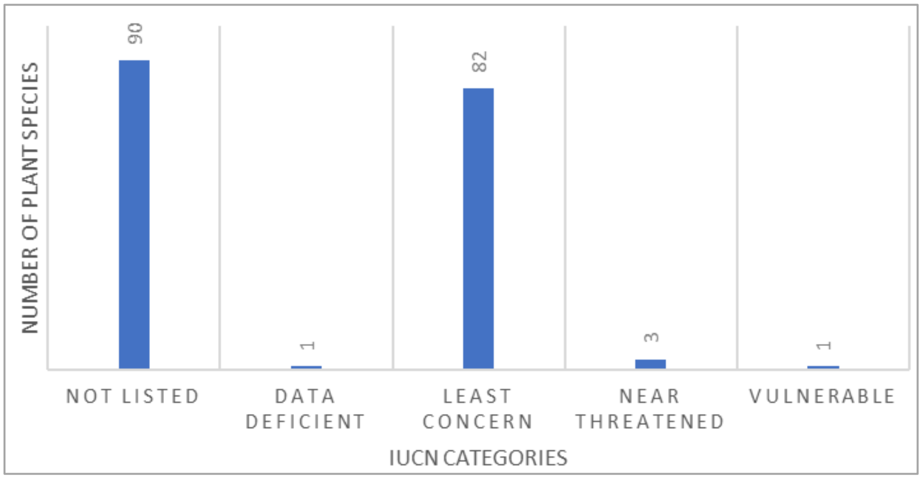


Figure 4-127 Summary chart of zone 1 plant species IUNC Red List Status

Most of the plant species recorded in Zone 1 are classified by the IUCN as Least Concerned or not listed; 4 species with special IUCN statuses were recorded in this zone: West Indian cedar (*Cedrela odorata*) that is listed as Vulnerable, and the following three species listed as Near Threarened: *Tabernaemontana laurifolia*, Morass royal (*Roystonea princeps*), *Ammannia baccifera* subsp. *baccifera.* Of the four species highlighted that fall within the categories Vulnerable or Near Threatened only one of these species is endemic to Jamaica and that is Morass royal (*Roystonea princeps*).

Anthropogenic disturbances across Zone 1 are clear, the drier areas (areas excluding Wetland) were seemingly clear cut in the past for agricultural activities; remnant irrigation infrastructure, derelict canals and terracing/furrowing of the land was observed widely across this zone. Logging of mature trees (species such as West Indian Cedar - *Cedrela odorata* and Guango - *Samanea saman*) for lumber was also observed in this area. The removal of relatively small trees/saplings for post making was also observed during the assessment of this area.

The wetland area of Zone 1 also showed signs of human influences. Selective cutting of trees was observed (however not very widespread), land clearance was seen in some instances as well, and improper garbage disposal, particularly close to the western boundary of the zone (adjacent to a small community).

Some of the plant species recorded in Zone can be used as an indicator of human disturbances, these include Trumpet Tree (*Cecropia peltata*), Breadfruit (*Artocarpus altilis*), Bastard Cedar (*Guazuma ulmifolia*) and Logwood (*Haematoxylum campechianum*).

Table 4-26 Zone 1 plant species list

Habit (V= Vine, T= Tree, and S= Shrub); DAFOR (D= Dominant, A = Abundant, F =Frequent, O= Odd and R= Rare)

	Family	Species	Common Name	Status	Habit	IUCN Category	DAFOR+C	Zone 1
1	**Acanthaceae**	*Avicennia germinans* (L.) L.	Black mangrove	Native	T	Least concern	A	F
2		*Ruellia tuberosa* L.	Duggy gun	Native	H	Not listed	F	F
3	**Aizoaceae**	*Sesuvium portulacastrum* (L.) L.	Seaside purslane, Sea-purslane	Native	H	Not listed	O	O
4	**Alismataceae**	*Sagittaria lancifolia* L.	Not documented	Native	S	Not listed	F	O
5	**Amaranthaceae**	*Achyranthes aspera* L. var. *aspera*	Devil's Horsewhip	Exotic (Naturalized)	H	Not listed	A	F
6		*Alternanthera halimifolia* (Lam.) Standl. ex Pittier	Not documented	Native	H	Not listed	O	O
7	**Anacardiaceae**	*Comocladia pinnatifolia* L.	Maiden plum	Native	T	Not listed	R	R
8		*Mangifera indica* L.	Mango	Exotic	T	Data deficient	R (C)	O
9		*Metopium brownei* (Jacq.) Urb.	Hog doctor	Native	T	Least concern	O	R
10		*Spondias dulcis* Parkinson	Jew plum	Exotic	T	Not listed	R (C)	R
11		*Spondias mombin* L.	Hog plum	Exotic	T	Least concern	R (C)	R
12	**Annonaceae**	*Annona glabra* L.	Pond apple	Native	T	Least concern	R	O
13	**Apocynaceae**	*Asclepias curassavica* L.	Redhead	Native	H	Not listed	F	R
14		*Catharanthus roseus* (L.) G. Don	Old maid, Periwinkle, Ram-goat rose	Exotic	H	Not listed	R (C)	R
15		*Echites umbellatus* Jacq. Subsp. *umbellatus*	Not documented	Native	V	Not listed	O	R
16		*Pentalinon luteum* (L.) B.F. Hansen &Wunderlin	Nightshade	Native	V	Not listed	O	O
17		*Rhabdadenia biflora* (Jacq.) Mull. Arg.	Mangrove vine	Native	V	Not listed	O	O
18		*Tabernaemontana laurifolia* L.	Not documented	Native	S	Near threatened	R	R
19	**Araceae**	*Syngonium auritum* (L.) Schott.	Five finger	Native	H	Not listed	O	O

	Family	Species	Common Name	Status	Habit	IUCN Category	DAFOR+C	Zone 1
20		*Xanthosoma sagittifolium* (L.) Schott.	Coco	Exotic	H	Not listed	O	O
21	**Arecaceae**	*Cocos nucifera* L.	Coconut	Exotic	T	Not listed	R (C)	R
22		*Roystonea princeps* (Becc.) Burret	Morass royal	Endemic	T	Near threatened	A	A
23		*Roystonea regia* (Kunth) O.F. Cook	Palm	Exotic	T	Least concern	O (C)	R
24		*Sabal maritima* (Kunth) Burret	Bull thatch	Native	T	Not listed	A	R
25	**Asteraceae**	*Acmella uliginosa* (Sw.) Cass.	Not documented	Native	H	Least concern	O	O
26		*Bidens pilosa* L. var. *pilosa*.	Spanish Needle	Native	H	Not listed	A	A
27		*Chromolaena odorata* (L.) R.M. King & H. Rob.	Jack-in-the bush	Native	S	Not listed	F	F
28		*Cyanthillium cinereum* (L.) H. Rob.	Not documented	Exotic	H	Not listed	A	A
29		*Mikania micrantha* Kunth	Guaco	Native	V	Not listed	F	F
30		*Parthenium hysterophorus L.*	Wild wormwood	Native	H	Not listed	O	O
31		*Pluchea odorata* (L.) Cass.	Wild tobacco	Native	S	Least concern	O	O
32		*Sphagneticola trilobata* (L.) Pruski	Creeping ox-eye	Exotic	H	Not listed	A	A
33		*Spilanthes urens* Jacq.	Pigeon coop	Native	H	Not listed	F	F
34		*Symphyotrichum expansum (Poepp. Ex Spreng) G.L. Nesom*	Not documented	Native	H	Not listed	F	F
35	**Bignoniaceae**	*Spathodea campanulata* P. Beauv.	African tulip tree	Exotic	T	Least concern	F	O
36		*Tabebuia angustata* Britton	Pink poui	Native	T	Not listed	A	F
37		*Tabebuia heterophylla (*DC.) Britton	White cedar	Native	T	Least concern	R	R
38	**Boraginaceae**	*Cordia collococca* L.	Clammy cherry	Native	T	Least concern	F	O
39		*Heliotropium angiospermum* Murray	Dog's tail	Native	H	Not listed	O	O
40		*Tournefortia hirsutissima* L.	Cold with	Native	S	Not listed	R	R
41		*Varronia bullata* L. subsp. humilis	Gout tea	Native	S	Least concern	O	O

	Family	Species	Common Name	Status	Habit	IUCN Category	DAFOR+C	Zone 1
42	**Bromeliaceae**	*Tillandsia compressa* Bertero ex Schult. & Schult. f.	Not documented	Native	H	Not listed	F	R
43		*Tillandsia recurvata*	Ball moss	Native	H	Not listed	A	O
44		*Tillandsia setacea* Sw.	Not documented	Native	H	Not listed	O	O
45		*Tillandsia usneoides*	Old man's beard	Native	H	Least concern	A	A
46		*Tillandsia utriculata* L.	Not documented	Native	H	Not listed	O	O
47		*Wittmackia negrilensis* Britton ex L.B. Sm.	Wild pine	Endemic	H	Not listed	F	R
48	**Burseraceae**	*Bursera simaruba* (L.) Sarg.	Red birch	Native	T	Least concern	R	R
49	**Cactaceae**	*Rhipsalis baccifera (J.S. Muell.) Stearn*	Currant cactus	Native	H	Least concern	O	R
50		*Selenicereus grandiflorus* (L.) Britton & Rose	Queen-of-the-night	Native	V	Least concern	F	F
51	**Cleomaceae**	*Arivela viscosa* (L.) Raf.	Wild caia	Exotic	H	Not listed	R	O
52		*Cleoserrata serrata* (Jacq) Iltis	Not documented	Native	H	Not listed	R	R
53	**Clusiaceae**	*Clusia rosea* Jacq.	Balsam fig	Native	T	Least concern	O	O
54	**Combretaceae**	*Bucida buceras* L.	Black olive	Native	T	Not listed	F	O
55		*Conocarpus erectus* var. *erectus*	Button mangrove	Native	T	Least concern	A	A
56		*Laguncularia racemosa* (L.) Gaertn.	White Mangrove	Native	T	Least concern	F	F
57		*Terminalia catappa* L.	Almond	Exotic (Naturalized)	T	Least concern	O	O
58	**Commelinaceae**	*Commelina diffusa* Burm. F.	Watergrass	Native	H	Least concern	O	O
59		*Tradescantia spathacea* Sw.	Moses-in-the-bulrushes	Exotic	H	Not listed	R	R
60	**Convolvulaceae**	*Ipomoea pes-carpe* (L.) R. Br.	Not documented	Native	V	Least concern	O	O
61		*Ipomoea tiliacea* (Willd.) Choisy	Wild slip	Native	V	Least concern	O	O

	Family	Species	Common Name	Status	Habit	IUCN Category	DAFOR+C	Zone 1
62	**Cucurbitaceae**	*Cucurbita pepo* L.	Pumpkin	Exotic	V	Least concern	R (C)	R
63		*Momordica charantia* L.	Wild cerasee	Exotic	V	Not listed	O	O
64	**Cyperaceae**	*Cyperus articulatus* L.	Not documented	Native	H	Least concern	F	F
65		*Cyperus involucrata* Rottb.	Not documented	Exotic	H	Not listed	F	F
66		*Cyperus ligularis* L.	Not documented	Native	H	Not listed	A	F
67		*Cyperus odoratus* L.	Not documented	Native	H	Least concern	F	F
68		*Cyperus planifolius* Rich.	Not documented	Native	S	Not listed	O	O
69		*Eleocharis elegans* (Kunth) Roem. & Schult.	Not documented	Native	H	Not listed	A	A
70		*Fimbristylis dichotoma* (L.) Vahl. subsp. *dichotoma*	Not documented	Native	H	Least concern	O	O
71		*Kyllinga brevifolia Rottb.*	not documented	Native	H	Least concern	A	O
72		*Rhynchospora nervosa* (Vahl.) Boeckeler	Star grass	Native	H	Not listed	A	F
73		*Scleria lithosperma* (L.) Sw.	Sedge	Native	H	Least concern	F	F
74	**Dioscoraceae**	*Dioscorea polygonoides* Humb. & Bonpl. ex Willd.	Renta yam	Native	V	Not listed	O	O
75	**Euphorbiaceae**	*Euphorbia hirta* L.	Milkweed	Native	H	Not listed	O	O
76		*Euphorbia hypericifolia* L.	Not documented	Likely Native	H	Not listed	R	R
77		*Euphorbia prostrata Aiton*	Milkweed	Native	H	Not listed	O	O
78		*Jatropha gossypiifolia* L. var. *gossypiifolia*	Belly-ache Bush	Native	H	Least concern	O	R
79		*Ricinus communis* L.	Castor oil plant, Oil nut	Exotic (Invasive)	S	Not listed	R	R
80		*Tragia volubilis* L.	Cowitch	Native	V	Not listed	O	O
81	**Fabaceae**	*Abrus precatorius* L.	John crow bead, Crab eyes	Exotic	V	Not listed	F	F
82		*Desmodium incanum* DC.	Not documented	Native	H	Least concern	F	F

	Family	Species	Common Name	Status	Habit	IUCN Category	DAFOR+C	Zone 1
83		*Enterolobium cyclocarpum* (Jacq.) Griseb.	Elephant Ear	Exotic	T	Least concern	O	O
84		*Gliricidia sepium* (Jacq.) Kunth	Grow stick, Quick stick, Aaron's rod	Exotic	T	Least concern	R (C)	R
85		*Haematoxylum campechianum* L.	Logwood	Exotic	T	Least concern	A	A
86		*Macroptilium lathyroides* (L.) Urb.	Not documented	Native	H	not listed	R	R
87		*Mimosa pudica* var. *pudica* L.	Shame 'o' lady	Native	H	Least concern	O	O
88		*Piscidia piscipula (*L.) Sarg.	Dogwood	Native	T	Least concern	F	A
89		*Samanea saman* (Jacq.) Merr.	Guango	Exotic	T	Least concern	A	A
90		*Senna alata* (L.) Roxb.	King of the forest	Native	S	Least concern	R	R
91		*Senna occidentalis* (L.) Link	Dandelion	Native	S	Least concern	O	R
92		*Senna siamea* (Lam.) H.S. Irwin & Barneby	Not documented	Exotic	T	Least concern	O	O
93		*Senna uniflora* (Mill.) H.S. Irwin & Barneby	Not documented	Native	H	Not listed	O	R
94		*Vachellia macracantha* (Humb. & Bonpl. Ex Willd.) Seigler & Ebinger	Park nut	Native	T	Least concern	R	R
95		*Vigna luteola* (Jacq.) Benth.	not documented	Native	V	Least concern	F	F
96	**Lamiaceae**	*Hyptis verticillata* Jacq.	John charles	Native	H	Not listed	O	O
97		*Ocimum campechianum* Mill.	Barsley	Native	H	Not listed	O	O
98		*Petitia domingensis* Jacq.	not documented	Native	T	Not listed	R	R
99	**Lauraceae**	*Nectandra hihua* (Ruiz & Pav.) Rohwer	Sweetwood	Native	T	Least concern	F	O
100	**Loganaceae**	*Spigelia anthelmia* L.	Worm grass	Native	H	Not listed	R	R
101	**Lytraceae**	*Ammannia baccifera* L. subsp. *baccifera*	Not documented	Exotic	H	Near threatened	R	R

	Family	Species	Common Name	Status	Habit	IUCN Category	DAFOR+C	Zone 1
102	**Malvaceae**	*Ceiba pentandra* (L.) Gaertn.	Silk cotton tree	Native	T	Least concern	O	O
103		*Corchorus aestuans* L.	Not documented	Native	H	Not listed	F	F
104		*Guazuma ulmifolia* Lam.	Bastard Cedar	Native	T	Least concern	F	A
105		*Hibiscus elatus* Sw.	Blue Mahoe	Native	T	Least concern	R	R
106		*Hibiscus tiliaceus* L. var. pernambucensis (Arruda) I.M. Johnst.	Seaside mahoe	Native	T	Least concern	R	R
107		*Pavonia schiedeana* Steud.	Conger watchman	Native	H	Not listed	O	O
108		*Sida acuta* Burm.	Broomweed	Native	H	Not listed	F	F
109		*Sida rhombifolia* L.	Not documented	Native	H	Not listed	O	O
110		*Thespesia populnea* (L.) Sol. ex Correa	Seaside mahoe	Native	T	Least concern	O	O
111		*Urena lobata* L.	Ballard bush, Bur Mallow	Native	H	Least concern	F	F
112	**Meliaceae**	*Cedrela odorata* L.	West Indian cedar	Native	T	Vulnerable	F	R
113	**Moraceae**	*Artocarpus altilis (*Parkinson) Fosberg	Breadfruit	Exotic	T	Not listed	R (C)	R
114		*Ficus benjamina* L.	Ficus	Exotic	T	Least concern	R	R
115		*Ficus maxima* Mill.	Fig	Native	T	Least concern	R	R
116		*Maclura tinctoria* (L.) D. Don ex Steud.	Fustic	Native	T	Least concern	R	R
117	**Musaceae**	*Musa paradisiaca* L.	Plantain	Exotic	H	Not listed	R (C)	R
118	**Myrtaceae**	*Eugenia axillaris* ((Sw.) Willd.	Black cherry	Native	T	Least concern	F	F
119		*Pimenta dioica* (L.) Merr.	Pimento; All spice	Native	T	Least concern	O	O
120		*Psidium guajava* L.	Guava	Native	S	Least concern	O	R
121		*Syzygium cumini* (L.) Skeels	Java Plum, Damson tree	Exotic	T	Least concern	R (C)	R

	Family	Species	Common Name	Status	Habit	IUCN Category	DAFOR+C	Zone 1
122	**Nephrolepidaceae**	*Nephrolepis exaltaata* (L.) Schott	Boston fern	Native	H	Least concern	O	O
123	**Nyctaginaceae**	*Bougainvillea glabra* Choisy	Bougainvillea	Exotic	S	Least concern	R (C)	R
124		*Pisonia aculeata* L.	Cockspur, Wait-a-bit	Native	T	Least concern	O	O
125	**Onagraceae**	*Ludwigia leptocarpa* (Nutt.) H. Hara subsp. *leptocarpa*	Not documented	Native	H	Least concern	F	O
126		*Ludwigia octovalvis* (Jacq.) P.H. Raven	Not documented	Native	H	Least concern	F	O
127	**Orchidaceae**	*Brassavola subulifolia Lindl.*	Not documented	Endemic	H	Not listed	A	R
128		*Oeceoclades maculata* (Lindl.) Lindl.	Monk orchid	Exotic	H	Least concern	O	F
129	**Papaveraceae**	*Argemone maxicana L.*	Yellow thistle	Native	H	Not listed	R	R
130	**Passifloraceae**	*Passiflora maliformis*L.	Sweet cup	Native	V	Not listed	O	O
131		*Passiflora suberosa* L.	Not documented	Native	V	Not listed	O	O
132	**Phyllanthaceae**	*Phyllanthus amarus* Schumach. &Thonn.	Carry-me-seed	Native	H	Not listed	O	O
133	**Phytolaccaceae**	*Petiveria alliacea* L.	Guinea hen weed, Strong man's weed	Likely Native	H	Not listed	R	R
134		*Rivina humils* L.	Dogberry, Bloodberry	Native	H	Not listed	R	R
135		*Trichostigma octandrum* (L.) H. Walter	Hoop with	Native	V	Least concern	O	O
136	**Piperaceae**	*Piper amalago* L. var. *amalago*	Jointer	Native	S	Least concern	F	F
137	**Poaceae**	*Andropogon bicornis* L.	Not documented	Native	H	Not listed	O	O
138		*Arundo donax* L. f. versicolor (Mill.) Stokes	Giant reed	Exotic	H	Least concern	A	F
139		*Axonopus compressus* (Sw.) P. Beauv.	Carpet grass	Native	H	Least concern	F	F
140		*Bothriochloa pertusa* (L.) A. Camus	Not documented	Exotic	H	Not listed	O	O
141		*Chloris barbata* Sw.	Not documented	Native	H	Not listed	O	O
142		*Chloris radiata* (L.)	Not documented	Native	H	Not listed	O	O

	Family	Species	Common Name	Status	Habit	IUCN Category	DAFOR+C	Zone 1
143		*Cynodon dactylon* (L.) Pers.var. *dactylon*	Bermuda grass	Exotic	H	Not listed	O	O
144		*Digitaria ciliaris* (Retz.) Koeler	Not documented	Exotic	H	Not listed	O	O
145		*Eleusine indica* (L.) Gaertn.	Yard grass	Exotic	H	Least concern	F	F
146		*Lasiacis divaricata* (L.) Hitchc.	Not documented	Native	H	Least concern	O	O
147		*Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs	Guinea grass	Exotic	H	Not listed	F	F
148		*Paspalum distichum* L.	Knotgrass	Native	H	Least concern	F	O
149		*Paspalum fimbriatum* Kunth	Not documented	Native	H	Not listed	O	O
150		*Paspalum paniculatum* L.	Not documented	Native	H	Not listed	O	O
151		*Phragmites australis* (Cav.) Steud.	Common reed	Exotic (Naturalized)	H	Least concern	F	O
152		*Sporobolus indicus* (L.) R. Br. var. *indicus*	West Indian rush-grass	Native	H	Not listed	O	O
153	**Polygonaceae**	*Antigonon leptopus* Hook. & Arn.	Coralita	Exotic	V	Not listed	O	O
154	**Polypodiaceae**	*Pleopeltis polypodioides* (L.) E.G. Andrews & Windham	Ressurection fern	Native	H	Not listed	F	F
155	**Pontederiaceae**	*Eichhornia crassipes* (Mart.) Solms	Water hyacinth	Exotic	H	Not listed	F	O
156	**Rhamnaceae**	*Colubrina asiatica* (L.) Brongn.	Hoop with	Exotic	T	Least concern	A	A
157	**Rhizophoraceae**	*Rhizophora mangle* L.	Red mangrove	Native	T	Least concern	D	D
158	**Rubiaceae**	*Morinda royoc* L.	Red gal; Strongback	Native	S	Least concern	R	F
159		*Psychotria pubescens* Sw.	Wild coffee	Native	S	Least concern	O	R
160		*Randia aculeata* L.	Ink berry, Box briar	Native	S	Least concern	R	R
161		*Spermacoce laevis* Lam.	Not documented	Native	H	Least concern	A	A

	Family	Species	Common Name	Status	Habit	IUCN Category	DAFOR+C	Zone 1
162	**Rutaceae**	*Zanthoxylum caribaeum* Lam.	Yellow sanders	Native	T	Least concern	R	R
163		*Zanthoxylum martinicensis* (Lam.) DC.	Prickly yellow	Native	T	Not listed	O	R
164	**Sapindaceae**	*Blighia sapida* F.D. Koenig	Ackee	Exotic	T	Least concern	R (C)	R
165		*Cupania americana* L.	Wild ackee	Native	T	Least concern	F	O
166		*Melicoccus bijugatus* Jacq.	Guinep	Exotic (Naturalized)	T	Not listed	R	R
167	**Smilacaceae**	*Smilax canellifolia* Mill.	Chainy root	Native	V	Not listed	O	O
168	**Solanaceae**	*Physalis angulata* L.	Wild gouma, Winter cherry	Native	H	Least concern	O	R
169		*Solanum erianthum* D. Don	Wild Susumber	Native	S	Least concern	O	O
170		*Solanum torvum* Sw.	Susumber, Gully bean, Turkey berry	Likely Native	S	Not listed	F	F
171	**Typhaceae**	*Typha domingensis* Pers.	Typha	Native	S	Least concern	A	O
172	**Urticaceae**	*Cecropia peltata* L.	Trumpet tree	Native	T	Least concern	F	F
173		*Pilea microphylla* (L.) Liebm. var. *microphylla*	Baby puzzle	Native	H	Not listed	R	R
174	**Verbenaceae**	*Lantana camara* L.	Wild Sage	Native	S	Not listed	O	O
175		*Priva lappulacea* (L.) Pers.	Clammy bur, Fasten-pon-coat, Velvet bur, Styptic bur	Native	H	Not listed	R	R
176		*Stachytarpheta jamaicensis* (L.) Vahl	Vervine	Native	H	Not listed	O	O
177	**Vitaceae**	*Cissus verticillata* Nicolson & C.E. Jarvis subsp. *verticillata*	Sorrel vine	Native	V	Not listed	F	O

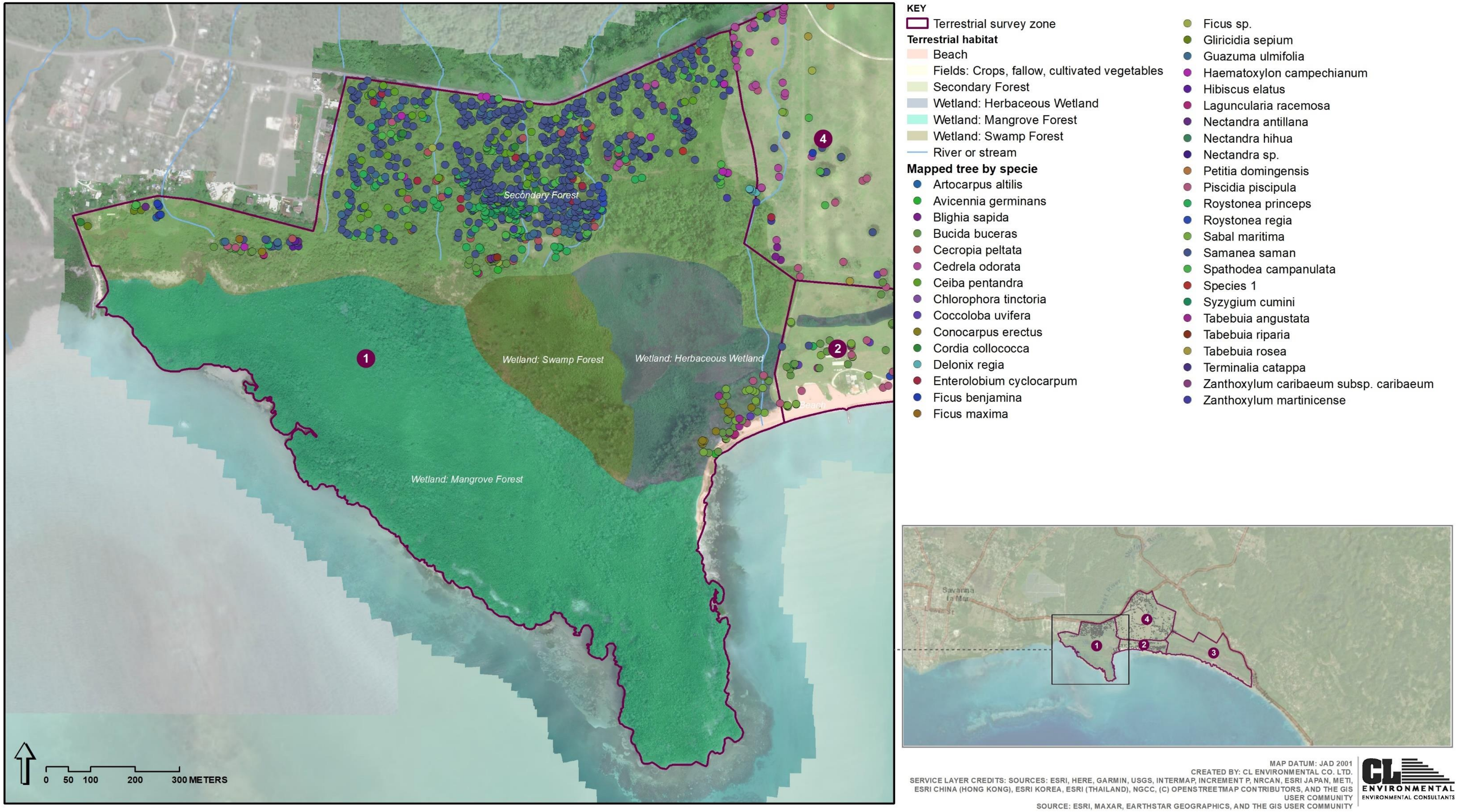


Figure 4-128 Mapped tree species within terrestrial survey Zone 1

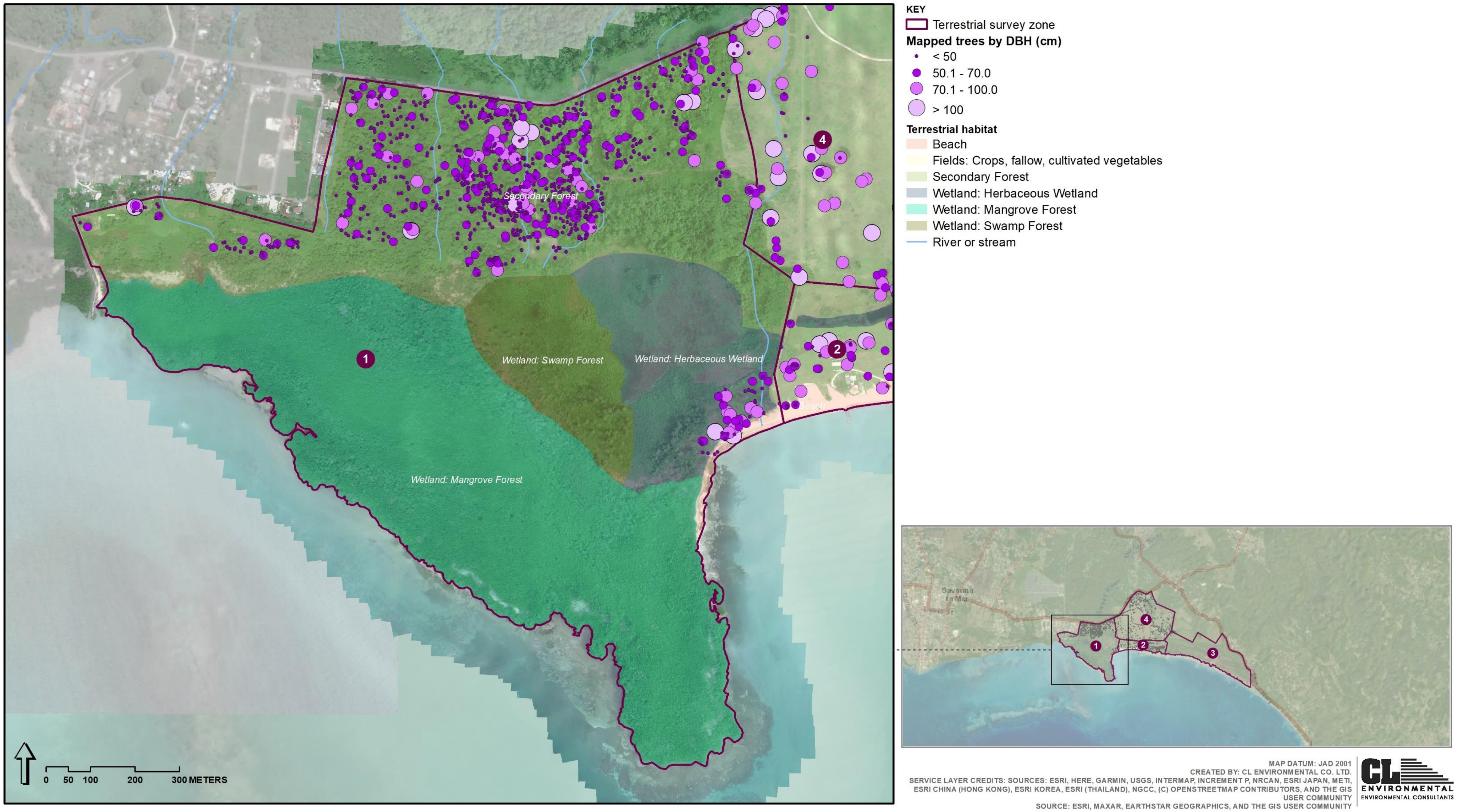


Figure 4-129 Mapped tree DBH within terrestrial survey Zone 1

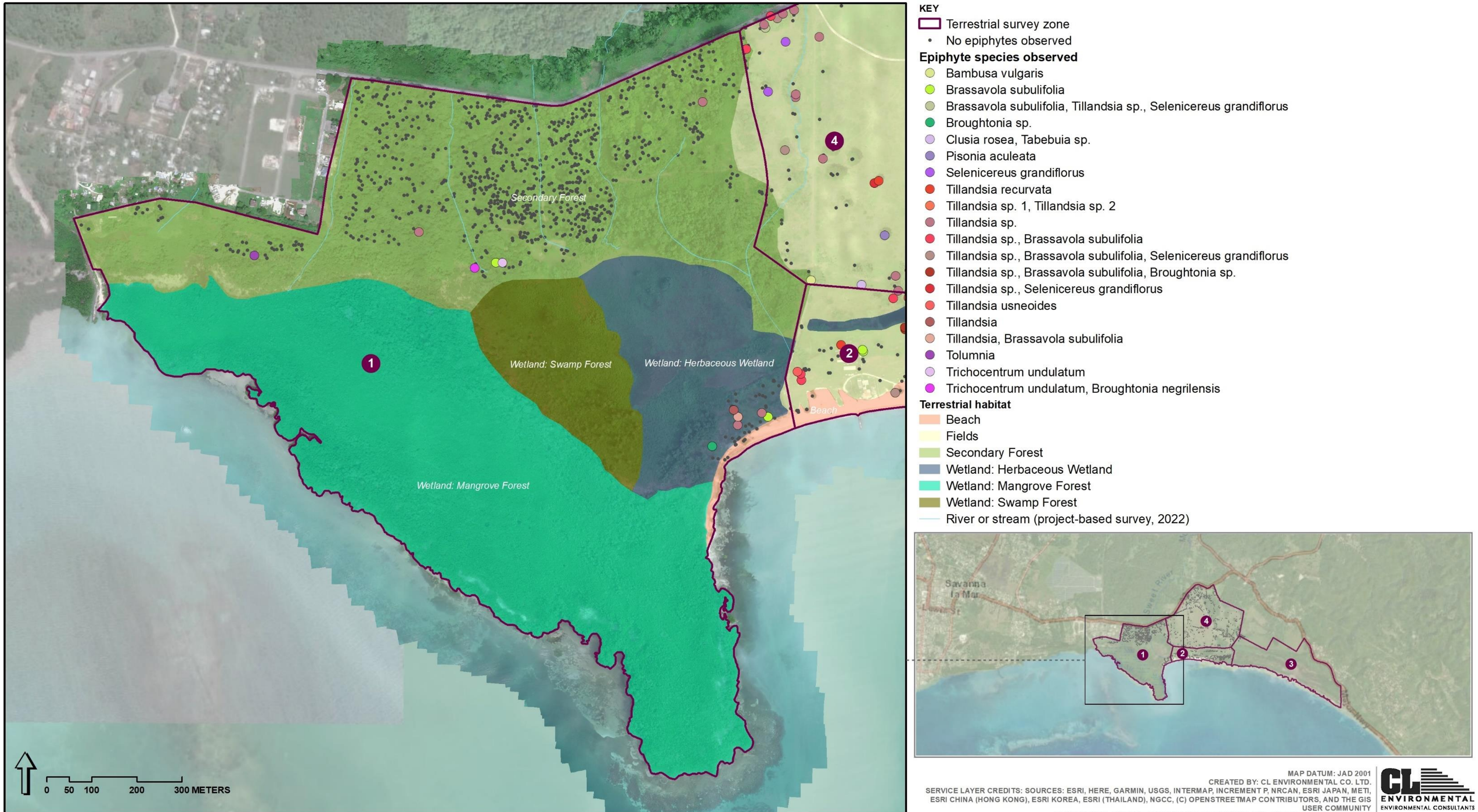


Figure 4-130 Mapped epiphytes within terrestrial survey Zone 1

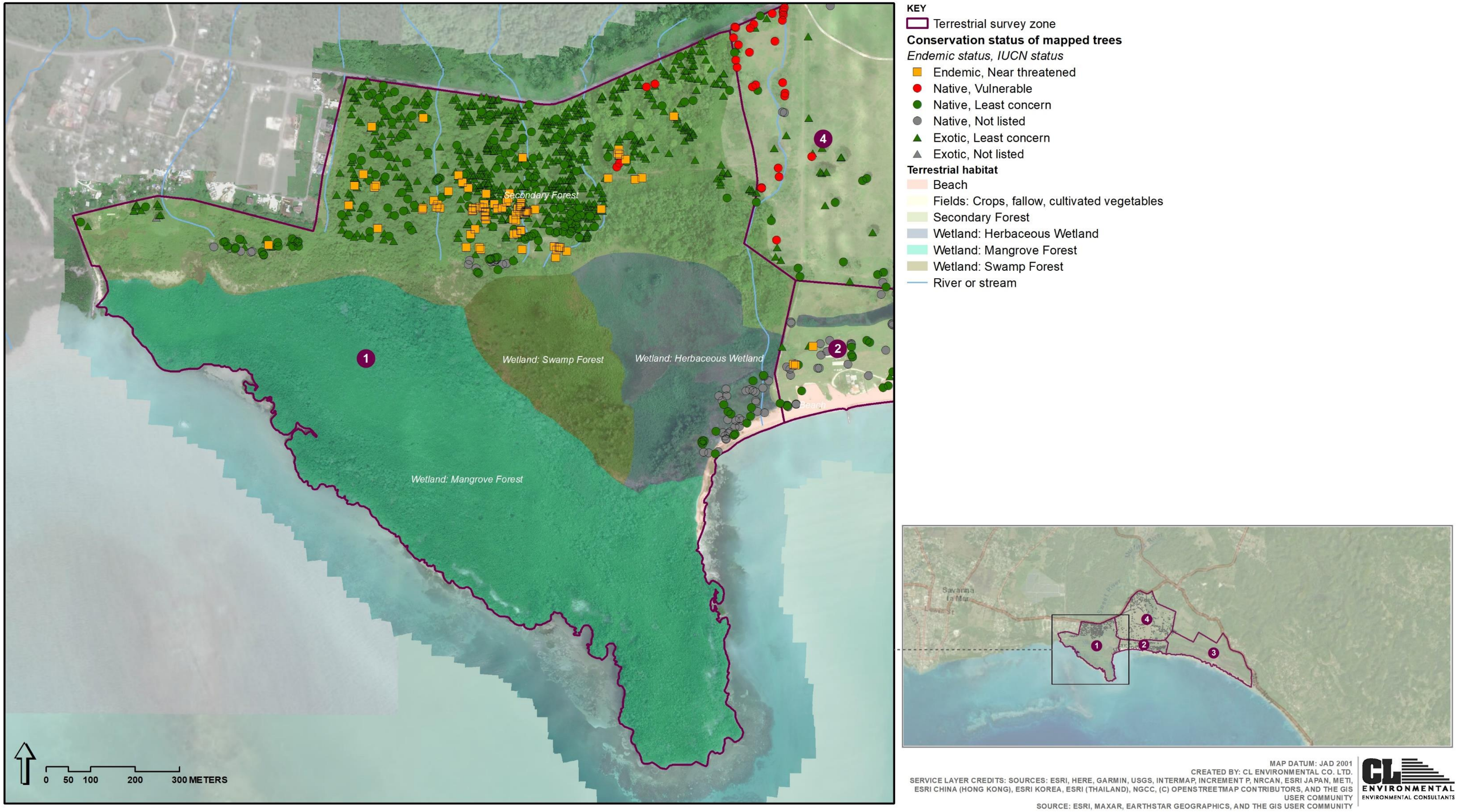


Figure 4-131 Conservation status of mapped tress within terrestrial survey Zone 1

ZONE 2

Zone 2 is classified as approximately half of the land being Fields: Herbaceous crops, follow, cultivation and the other half being Mangrove Forest. The field assessment showed that in addition to the land use types designated for the area, a small patch of Herbaceous Wetland is also present in Zone 2. This area has some terrestrial vegetation; however, it is dominated by coastal vegetation and plants that are associated with wetland ecosystems.

This area of the property has been significantly modified (most of native vegetation would have been removed a long time ago to create the vast beachfront), and much of the vegetation now present is secondary growth.

The eastern end of Zone 2 boasts a relatively small patch of Open Dry Forest and consists of species that are typical of that ecosystem type. Though none of the species encountered in this patch of Open Dry Forest, this was the only representation of this ecosystem type encountered across the study area.

A total number of 92 species of plants were recorded across Zone 2, the second lowest number of species recorded across the Zones assessed. The 92 species consist of 40 plant families and 77 plant genera. The most represented families in this zone are Cyperaceae, Fabaceae, Bromeliaceae, Malvaceae and Poaceae, Asteraceae, Arecaceae and Combretaceae with 11, 6, 6, 5 and a tie of 4,4,4 and 4 species, respectively. The vast majority of the plants recorded in this zone are native species (71), followed by exotic species (17); only 4 endemic species (*Brassavola subulifolia*, *Broughtonia sanguinea*, *Roystonea princeps*, and *Wittmackia negrilensis*) were recorded across Zone 2.

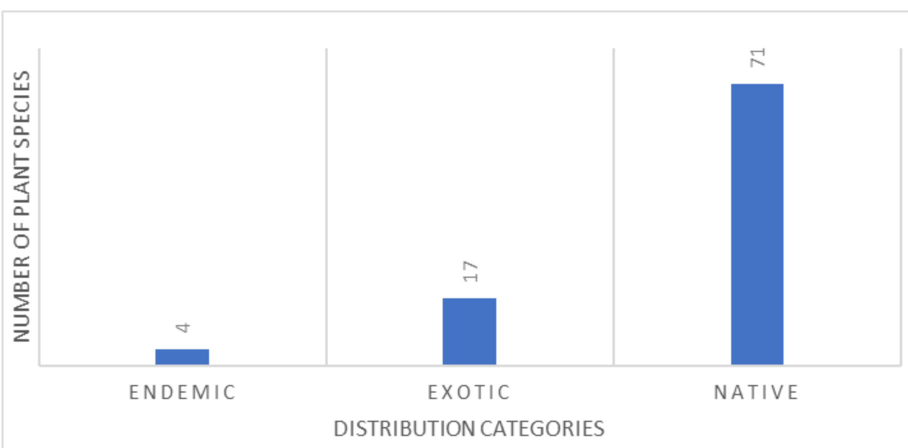


Figure 4-132 Summary chart of zone 2 plant species distribution

In terms of habit class, most of the plant species recorded herbs (42) were the most represented in Zone 2, followed by trees (19) the least represented Habit Classes in Zone 1 were vines (5) followed by shrubs (11).

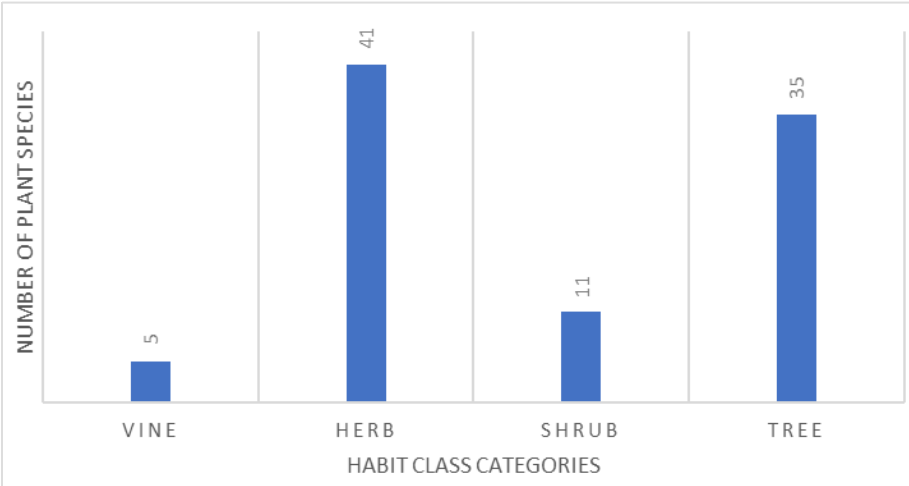


Figure 4-133 Summary chart of zone 2 plant species habit classes

Most of the plant species recorded in Zone 2 are classified by the IUCN as Least Concerned (54) or Not Listed (36); only 2 species with special IUCN statuses were recorded in this zone, both of which are classified as Near Threatened.

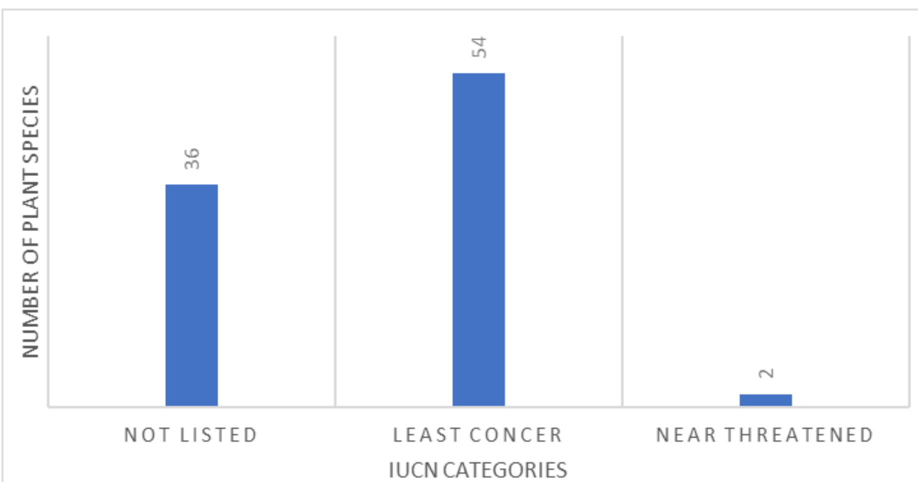


Figure 4-134 Summary chart of zone 2 plant species IUCN Red List of Threatened Species status

Table 4-27 Zone 2 plant species list

Habit (V= Vine, T= Tree, and S= Shrub); DAFOR (D= Dominant, A = Abundant, F =Frequent, O= Odd and R= Rare)

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 2
1	**Acanthaceae**	*Avicennia germinans* (L.) L.	Black mangrove	Native	T	Least concern	A	A
2		*Ruellia tuberosa* L.	Duggy gun	Native	H	Not listed	F	O
3	**Aizoaceae**	*Sesuvium portulacastrum* (L.) L.	Seaside purslane, Sea-purslane	Native	H	Not listed	O	R
4	**Alismataceae**	*Sagittaria lancifolia* L.	Not documented	Native	S	Not listed	F	F
5	**Anacardiaceae**	*Metopium brownei* (Jacq.) Urb.	Hog doctor	Native	T	Least concern	O	F
6		*Spondias mombin* L.	Hog plum	Exotic	T	Least concern	R (C)	R
7	**Annonaceae**	*Annona glabra* L.	Pond apple	Native	T	Least concern	R	R
8	**Apiaceae**	*Centella asiatica* (L.) Urb.	Not documented	Exotic	H	Least concern	O	O
9	**Apocynaceae**	*Asclepias curassavica* L.	Redhead	Native	H	Not listed	F	R
10		*Rhabdadenia biflora* (Jacq.) Mull. Arg.	Mangrove vine	Native	V	Not listed	O	F
11	**Arecaceae**	*Cocos nucifera* L.	Coconut	Exotic	T	Not listed	R (C)	R
12		*Roystonea princeps* (Becc.) Burret	Morass royal	Endemic	T	Near threatened	A	A
13		*Roystonea regia* (Kunth) O.F. Cook	Palm	Exotic	T	Least concern	O (C)	R
14		*Sabal maritima* (Kunth) Burret	Bull thatch	Native	T	Not listed	A	A
15	**Asteraceae**	*Bidens pilosa* L. var. *pilosa*.	Spanish Needle	Native	H	Not listed	A	R
16		*Pluchea odorata* (L.) Cass.	Wild tobacco	Native	S	Least concern	O	R
17		*Sphagneticola trilobata* (L.) Pruski	Creeping ox-eye	Exotic	H	Not listed	A	F
18		*Spathodea campanulata* P. Beauv.	African tulip tree	Exotic	T	Least concern	F	R
19	**Bignoniaceae**	*Tabebuia angustata* Britton	Pink poui	Native	T	Not listed	A	O
20		*Tabebuia heterophylla* (DC.) Britton	White cedar	Native	T	Least concern	R	R
21	**Boraginaceae**	*Cordia collococca* L.	Clammy cherry	Native	T	Least concern	F	R
22	**Bromeliaceae**	*Tillandsia compressa* Bertero ex Schult. & Schult. f.	Not documented	Native	H	Not listed	F	F
23		*Tillandsia recurvata*	Ball moss	Native	H	Not listed	A	A

24		*Tillandsia setacea* Sw.	Not documented	Native	H	Not listed	O	R
25		*Tillandsia usneoides*	Old man's beard	Native	H	Least concern	A	A
26		*Tillandsia utriculata* L.	Not documented	Native	H	Not listed	O	O
27		*Wittmackia negrilensis* Britton ex L.B. Sm.	Wild pine	Endemic	H	Not listed	F	F
28	**Burseraceae**	*Bursera simaruba* (L.) Sarg.	Red birch	Native	T	Least concern	R	R
29	**Cactaceae**	*Hylocereus triangularis* (L.) Britton & Rose	God Okra	Native	V	Least concern	O	O
30		*Selenicereus grandiflorus* (L.) Britton & Rose	Queen-of-the-night	Native	V	Least concern	F	O
31	**Clusiaceae**	*Clusia rosea* Jacq.	Balsam fig	Native	T	Least concern	O	R
32	**Combretaceae**	*Bucida buceras* L.	Black olive	Native	T	Not listed	F	A
33		*Conocarpus erectus* var. *erectus*	Button mangrove	Native	T	Least concern	A	F
34		*Laguncularia racemosa* (L.) Gaertn.	White Mangrove	Native	T	Least concern	F	O
35		*Terminalia catappa* L.	Almond	Exotic (Naturalized)	T	Least concern	O	F
36	**Convolvulaceae**	*Ipomoea horsfalliae Hook.*	Not documented	Exotic	V	Not listed	O	O
37		*Ipomoea pes-carpe* (L.) R. Br.	Not documented	Native	V	Least concern	O	O
38	**Cyperaceae**	*Cladium jamaicense* Crantz	Saw grass	Native	H	Not listed	A	A
39		*Cyperus articulatus* L.	Not documented	Native	H	Least concern	F	O
40		*Cyperus involucrata* Rottb.	Not documented	Exotic	H	Not listed	F	O
41		*Cyperus ligularis* L.	Not documented	Native	H	Not listed	A	A
42		*Cyperus odoratus* L.	Not documented	Native	H	Least concern	F	F
43		*Cyperus planifolius* Rich.	Not documented	Native	S	Not listed	O	O
44		*Eleocharis elegans* (Kunth) Roem. & Schult.	Not documented	Native	H	Not listed	A	A
45		*Fimbristylis dichotoma* (L.) Vahl. subsp. *dichotoma*	Not documented	Native	H	Least concern	O	O
46		*Rhynchospora nervosa* (Vahl.) Boeckeler	Star grass	Native	H	Not listed	A	F
47		*Scleria gaertneri* Raddi	Not documented	Native	H	Least concern	F	F
48		*Scleria lithosperma* (L.) Sw.	Sedge	Native	H	Least concern	F	O
49	**Euphorbiaceae**	*Dalbergia ecastaphyllum* (L.) Taub.	not documented	Native	S	Least concern	R	R

50	**Fabaceae**	*Enterolobium cyclocarpum* (Jacq.) Griseb.	Elephant Ear	Exotic	T	Least concern	O	R
51		*Haematoxylum campechianum* L.	Logwood	Exotic	T	Least concern	A	O
52		*Piscidia piscipula (*L.) Sarg.	Dogwood	Native	T	Least concern	F	A
53		*Samanea saman* (Jacq.) Merr.	Guango	Exotic	T	Least concern	A	R
54		*Senna alata* (L.) Roxb.	King of the forest	Native	S	Least concern	R	R
55		*Senna occidentalis* (L.) Link	Dandelion	Native	S	Least concern	O	R
56	**Hypoxidaceae**	*Hypoxis decumbens* L.	Star of Bethlehem	Native	H	Not listed	O	O
57	**Lytraceae**	*Ammannia baccifera* L. subsp. *baccifera*	Not documented	Exotic	H	Near threatened	R	O
58		*Cuphea parsonsia* (L.) R. Br. ex Steud.	Strongback	Native	H	Not listed	O	O
59	**Malvaceae**	*Ceiba pentandra* (L.) Gaertn.	Silk cotton tree	Native	T	Least concern	O	R
60		*Guazuma ulmifolia* Lam.	Bastard Cedar	Native	T	Least concern	F	O
61		*Hibiscus elatus* Sw.	Blue Mahoe	Native	T	Least concern	R	R
62		*Pavonia schiedeana* Steud.	Conger watchman	Native	H	Not listed	O	O
63		*Thespesia populnea* (L.) Sol. ex Correa	Seaside mahoe	Native	T	Least concern	O	O
64	**Moraceae**	*Ficus maxima* Mill.	Fig	Native	T	Least concern	R	R
65		*Maclura tinctoria* (L.) D. Don ex Steud.	Fustic	Native	T	Least concern	R	R
66	**Myrtaceae**	*Eugenia axillaris* ((Sw.) Willd.	Black cherry	Native	T	Least concern	F	R
67	**Onagraceae**	*Ludwigia leptocarpa* (Nutt.) H. Hara subsp. *leptocarpa*	Not documented	Native	H	Least concern	F	O
68		*Ludwigia octovalvis* (Jacq.) P.H. Raven	Not documented	Native	H	Least concern	F	O
69	**Orchidaceae**	*Brassavola subulifolia Lindl.*	Not documented	Endemic	H	Not listed	A	A
70		*Broughtonia sanguinea* (Sw.) R. Br.	Not documented	Endemic	H	Not listed	R	R
71	**Passifloraceae**	*Turnera ulmifolia* L.	Ram-goat dashalong	Native	S	Least concern	O	O
72	**Plantaginaceae**	*Bacopa monnieri* (L.) Pennell	Not documented	Native	H	Least concern	A	A
73	**Poaceae**	*Andropogon bicornis* L.	Not documented	Native	H	Not listed	O	R
74		*Arundo donax* L. f. versicolor (Mill.) Stokes	Giant reed	Exotic	H	Least concern	A	O

75		*Bothriochloa pertusa* (L.) A. Camus	Not documented	Exotic	H	Not listed	O	O
76		*Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs	Guinea grass	Exotic	H	Not listed	F	F
77	**Polygonaceae**	*Coccoloba uvifera* (L.) L.	Sea grape	Native	T	Least concern	F	F
78	**Polypodiaceae**	*Pleopeltis polypodioides* (L.) E.G. Andrews & Windham	Resurrection fern	Native	H	Not listed	F	O
79		*Heteranthera reniformis* Ruiz & Pav.	Not documented	Native	H	Not listed	R	R
80	**Psilotaceae**	*Psilotum nudum* (L.) P. Beauv.	Whisk fern	Native	H	Least concern	R	R
81	**Rhamnaceae**	*Colubrina asiatica* (L.) Brongn.	Hoop withe	Exotic	T	Least concern	A	O
82	**Rhizophoraceae**	*Rhizophora mangle* L.	Red mangrove	Native	T	Least concern	D	O
83	**Rubiaceae**	*Guettarda elliptica* Sw.	velvet seed	Native	S	Least concern	R	R
84		*Morinda royoc* L.	Red gal; Strongback	Native	S	Least concern	R	R
85		*Spermacoce laevis* Lam.	Not documented	Native	H	Least concern	A	F
86	**Rutaceae**	*Zanthoxylum caribaeum* Lam.	Yellow sanders	Native	T	Least concern	R	R
87		*Zanthoxylum martinicensis* (Lam.) DC.	Prickly yellow	Native	T	Not listed	O	O
88	**Typhaceae**	*Typha domingensis* Pers.	Typha	Native	S	Least concern	A	A
89	**Urticaceae**	*Cecropia peltata* L.	Trumpet tree	Native	T	Least concern	F	R
90	**Verbenaceae**	*Lippia alba* (Mill.) N.E. Br. ex Britton & P. Wilson	Cullen mint, Colic mint, Guinea mint	Native	S	Not listed	R	R
91		*Phyla nodiflora* (L.) Greene	Capeweed	Native	H	Least concern	F	F
92		*Phyla stoechadifolia* (L.) Small	Not documented	Native	H	Not listed	F	F

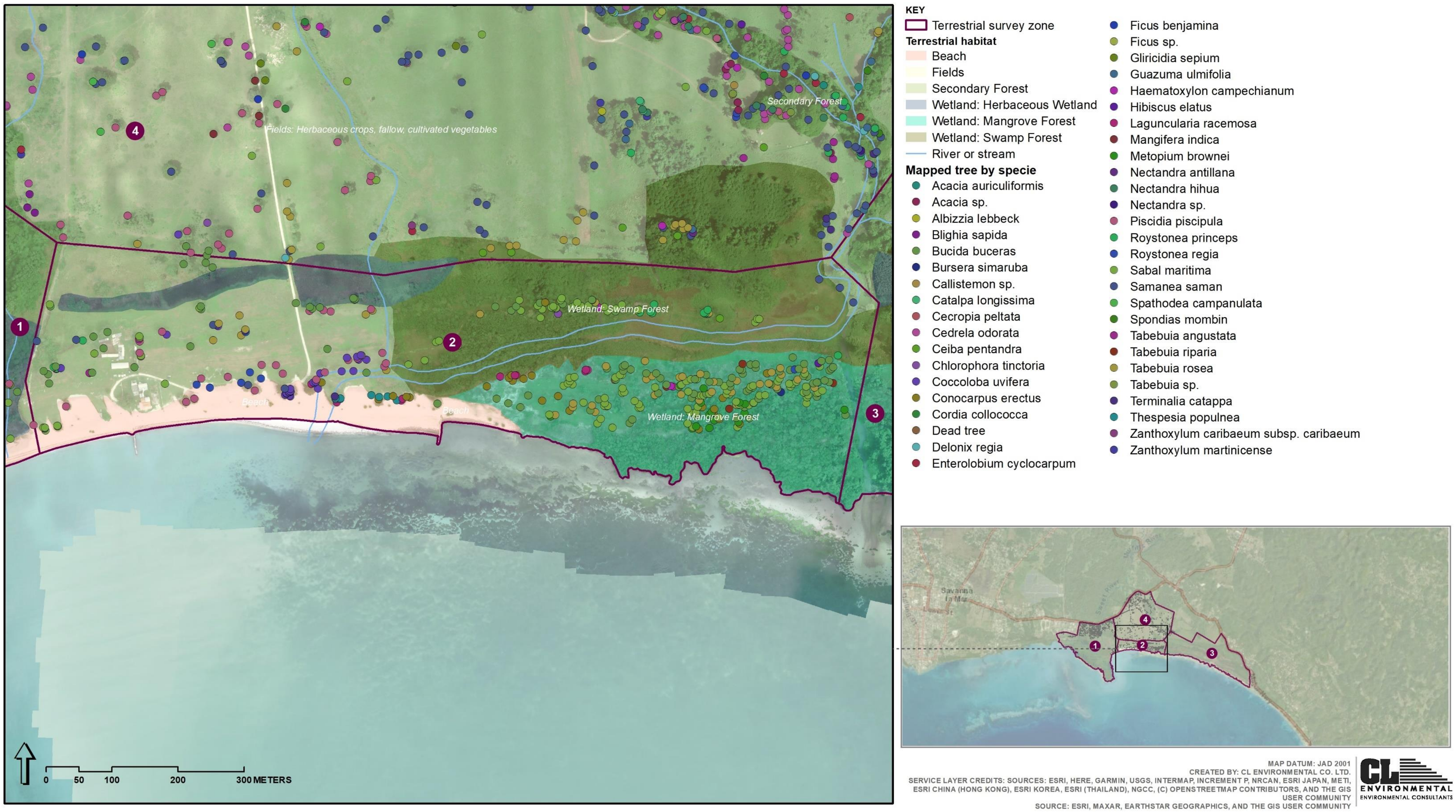


Figure 4-135 Mapped tree species within terrestrial survey Zone 2

Figure 4-136 Mapped tree DBH within terrestrial survey Zone 2

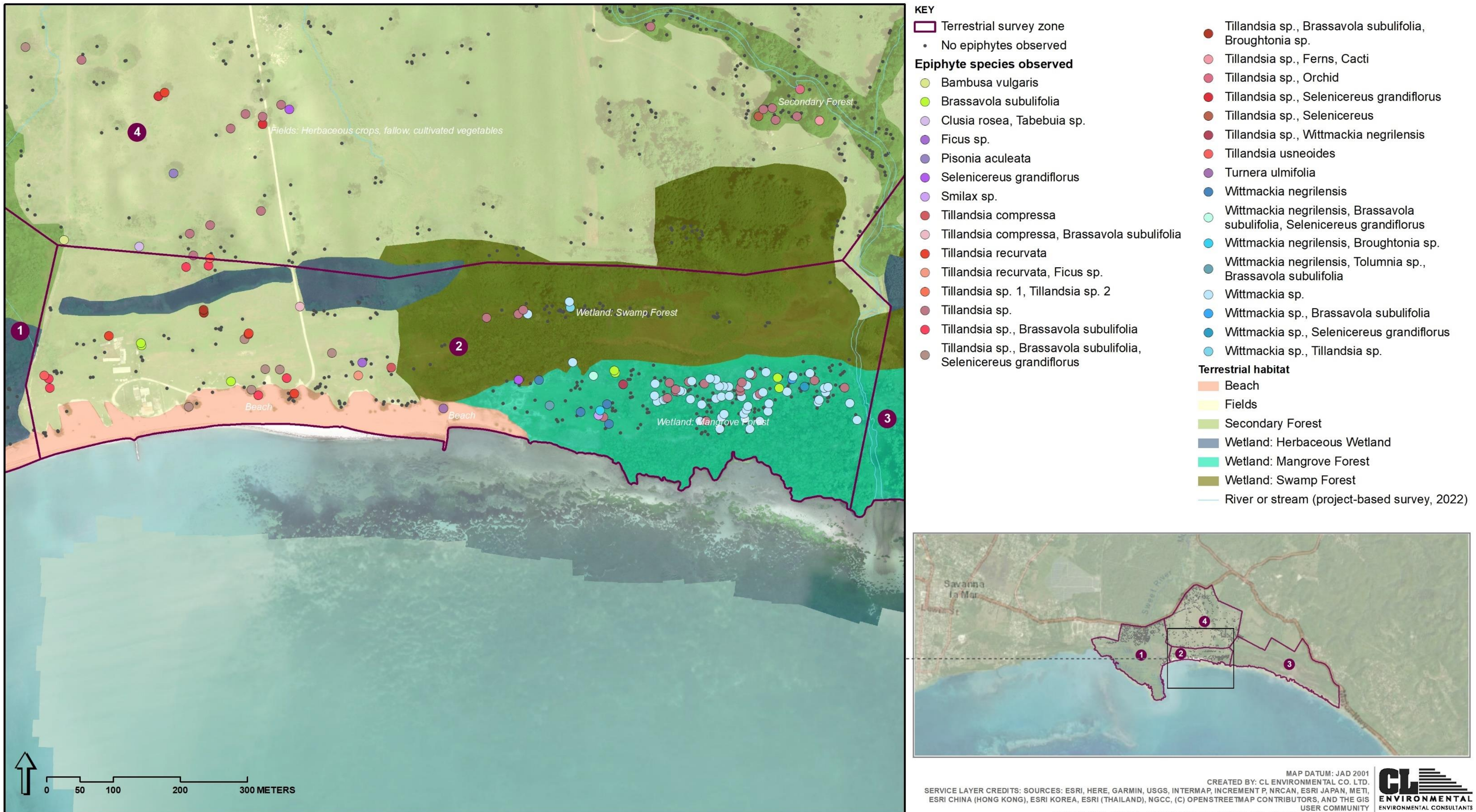


Figure 4-137 Mapped epiphytes within terrestrial survey Zone 2

Figure 4-138 Conservation status of mapped tress within terrestrial survey Zone 2

ZONE 3

This zone is characterized by the Forestry Land Use Classification as Mangrove Forest and Herbaceous Wetland, dominated by the former. The observations from the field survey correspond with the Forestry Land Use with regards to the two land use types for this zone; the only difference is that the on-ground assessment revealed that there is more land cover that is Herbaceous Wetland than suggested Forestry Land Use Classification.

The Herbaceous wetland in this zone is dominated by an understory of shrubs, vines, sedges, and grasses; Almond (*Terminalia catappa*) trees are occasionally seen in this land use type, but the dominant tree by far is the Morass Royal (*Roystonea princeps*). It should be noted that the highest density of *R. princeps* was observed in the Herbaceous Wetland of Zone 3.

The Mangrove Forest of Zone 3 is dominated by Red Mangrove (*Rhizophora mangle*); however Black Mangrove (*Avicennia germinans*) and White Mangrove (*Laguncularia racemosa*) were also observed. Several vines, epiphytes (orchids, bromeliads, and cacti) and shrubs were also observed in the Mangrove Forest of Zone 3. It should be noted that the density of *Wittmackia negrilensis* within the Mangrove Forest of Zone 3 was relatively high compared to what was observed in the other zones. This zone is being recommended to be retained for conservation purposes (no development).

A total of 77 species were observed during the floristic survey of Zone 3 which was conducted over a period of 3 weeks. The 77 species consist of 34 plant families and 70 plant genera. The most represented families in this zone are Poaceae, Bromeliaceae, Fabaceae, Asteraceae and Cyperceae with 12, 8, 5, 5, and 5 species, respectively.

Most of the plant species identified are natives (53), followed by exotic species (20); only 4 endemic plants (*Brassavola subulifolia*, *Peperomia amplexicaulis*, *Roystones princeps*, and *Wittmackia negrilensis*) were recorded in zone 3.

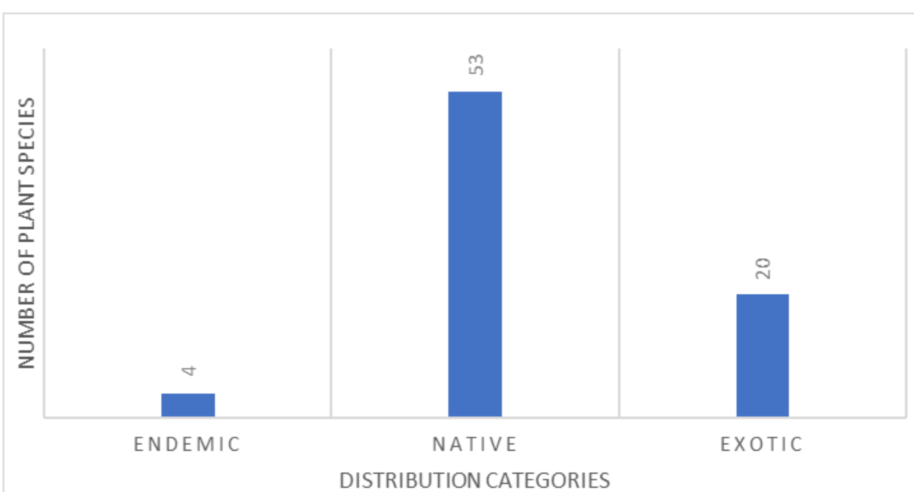


Figure 4-139 Summary chart of zone 3 plant species distribution

With regards to habit class, most of the plant species recorded in Zone 3 were herbs (50), followed by trees (19) the least represented Habit Classes in Zone 1 were shrubs (5) and vines (3).

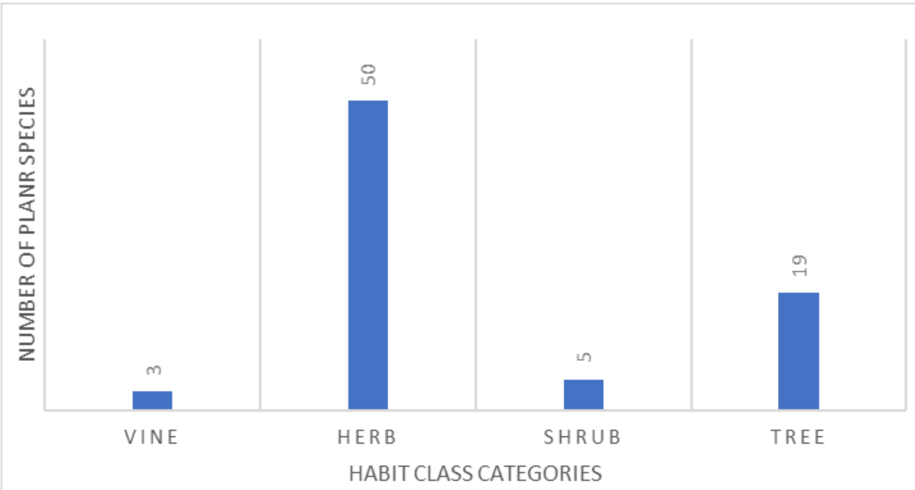


Figure 4-140 Summary chart of zone 3 plant species habit classes

Most of the plant species recorded in Zone 3 are classified by the IUCN as Not Listed (39) or Least Concerned (36); 2 species with special IUCN statuses were recorded in this zone, both of which are classified as Near Threatened.

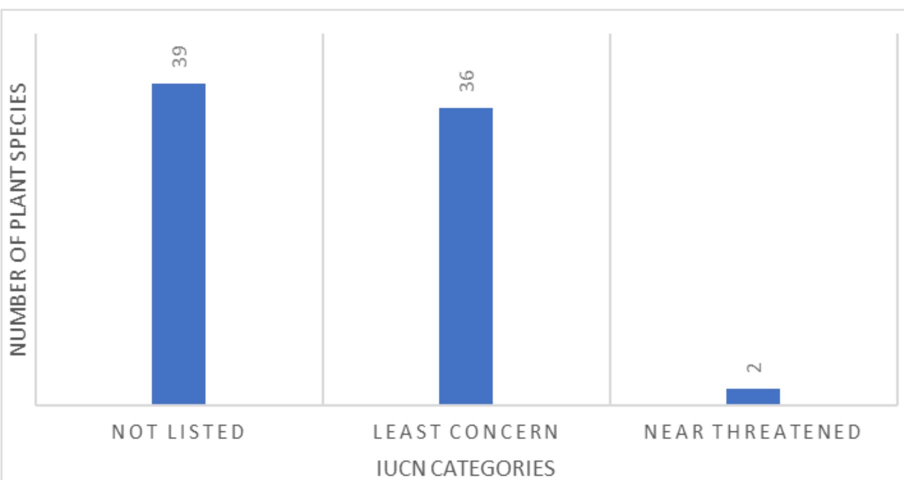


Figure 4-141 Summary chart of zone 3 plant species IUCN Red List of Threatened Species status

Table 4-28 Zone 3 plant species list

Habit (V= Vine, T= Tree, and S= Shrub); DAFOR (D= Dominant, A = Abundant, F =Frequent, O= Odd and R= Rare)

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 3
1	**Acanthaceae**	*Avicennia germinans* (L.) L.	Black mangrove	Native	T	Least concern	A	F
2		*Ruellia tuberosa* L.	Duggy gun	Native	H	Not listed	F	R
3	**Aizoaceae**	*Sesuvium portulacastrum* (L.) L.	Seaside purslane, Sea-purslane	Native	H	Not listed	O	R
4	**Alismataceae**	*Sagittaria lancifolia* L.	Not documented	Native	S	Not listed	F	R
5	**Amaranthaceae**	*Achyranthes aspera* L. var. *aspera*	Devil's Horsewhip	Exotic (Naturalized)	H	Not listed	A	O
6	**Annonaceae**	*Annona glabra* L.	Pond apple	Native	T	Least concern	R	R
7	**Apiaceae**	*Centella asiatica* (L.) Urb.	Not documented	Exotic	H	Least concern	O	O
8	**Apocynaceae**	*Echites umbellatus* Jacq. Subsp. *umbellatus*	Not documented	Native	V	Not listed	O	R
9		*Rhabdadenia biflora* (Jacq.) Mull. Arg.	Mangrove vine	Native	V	Not listed	O	F
10	**Araceae**	*Alocasia macrorrhizos* (L.) G. Don	Scratch coco	Exotic	H	Not listed	F	O
11		*Colocasia esculenta* (L.) Schott.	Dasheen	Exotic	H	Least concern	R	R
12	**Arecaceae**	*Calyptrogyne occidentalis* (Sw.) M. Gomez	Long thatch	Native	T	Not listed	R	R
13		*Roystonea princeps* (Becc.) Burret	Morass royal	Endemic	T	Near threatened	A	A
14		*Sabal maritima* (Kunth) Burret	Bull thatch	Native	T	Not listed	A	R
15	**Asteraceae**	*Parthenium hysterophorus L.*	Wild wormwood	Native	H	Not listed	O	O
16		*Pluchea odorata* (L.) Cass.	Wild tobacco	Native	S	Least concern	O	R
17		*Sphagneticola trilobata* (L.) Pruski	Creeping ox-eye	Exotic	H	Not listed	A	F
18		*Spilanthes urens* Jacq.	Pigeon coop	Native	H	Not listed	F	O
19		*Symphyotrichum expansum (Poepp. Ex Spreng) G.L. Nesom*	Not documented	Native	H	Not listed	F	O
20	**Bignoniaceae**	*Spathodea campanulata* P. Beauv.	African tulip tree	Exotic	T	Least concern	F	R
21		*Tabebuia angustata* Britton	Pink poui	Native	T	Not listed	A	R
22	**Bromeliaceae**	*Tillandsia compressa* Bertero ex Schult. & Schult. f.	Not documented	Native	H	Not listed	F	O

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 3
23		*Tillandsia bulbosa* Hook	Not documented	Native	H	Not listed	R	R
24		*Tillandsia pruinosa* Sw.	Not documented	Native	H	Not listed	R	R
25		*Tillandsia recurvata*	Ball moss	Native	H	Not listed	A	O
26		*Tillandsia setacea* Sw.	Not documented	Native	H	Not listed	O	O
27		*Tillandsia usneoides*	Old man's beard	Native	H	Least concern	A	R
28		*Tillandsia utriculata* L.	Not documented	Native	H	Not listed	O	O
29		*Wittmackia negrilensis* Britton ex L.B. Sm.	Wild pine	Endemic	H	Not listed	F	F
30	**Cactaceae**	*Selenicereus grandiflorus* (L.) Britton & Rose	Queen-of-the-night	Native	V	Least concern	F	R
31	**Chrysobalanaceae**	*Chrysobalanus icaco* L.	Coco plum	Native	T	Least concern	O	O
32	**Clusiaceae**	*Clusia rosea* Jacq.	Balsam fig	Native	T	Least concern	O	R
33		*Symphonia globulifera* L.	Boar wood, Hog Doctor	Native	T	Least concern	R	R
34	**Combretaceae**	*Bucida buceras* L.	Black olive	Native	T	Not listed	F	F
35		*Conocarpus erectus* var. *erectus*	Button mangrove	Native	T	Least concern	A	O
36		*Laguncularia racemosa* (L.) Gaertn.	White Mangrove	Native	T	Least concern	F	O
37		*Terminalia catappa* L.	Almond	Exotic (Naturalized)	T	Least concern	O	R
38	**Cyperaceae**	*Cyperus ligularis* L.	Not documented	Native	H	Not listed	A	A
39		*Cyperus odoratus* L.	Not documented	Native	H	Least concern	F	A
40		*Kyllinga brevifolia Rottb.*	not documented	Native	H	Least concern	A	O
41		*Rhynchospora nervosa* (Vahl.) Boeckeler	Star grass	Native	H	Not listed	A	A
42		*Scleria gaertneri* Raddi	Not documented	Native	H	Least concern	F	O
43	**Euphorbiaceae**	*Euphorbia hirta* L.	Milkweed	Native	H	Not listed	O	O
44	**Fabaceae**	*Desmodium incanum* DC.	Not documented	Native	H	Least concern	F	F
45		*Haematoxylum campechianum* L.	Logwood	Exotic	T	Least concern	A	F
46		*Macroptilium lathyroides* (L.) Urb.	Not documented	Native	H	not listed	R	R
47		*Piscidia piscipula (*L.) Sarg.	Dogwood	Native	T	Least concern	F	O
48		*Samanea saman* (Jacq.) Merr.	Guango	Exotic	T	Least concern	A	O
49	**Hydrocharitaceae**	*Egeria densa* Planch.	Not documented	Exotic	H	Not listed	F	O

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 3
50		*Elodea canadensis* Michx.	Canadian pondweed	Exotic	H	Least concern	F	O
51	**Hypoxidaceae**	*Hypoxis decumbens* L.	Star of Bethlehem	Native	H	Not listed	O	O
52	**Lytraceae**	*Ammannia baccifera* L. subsp. *baccifera*	Not documented	Exotic	H	Near threatened	R	R
53	**Malvaceae**	*Thespesia populnea* (L.) Sol. ex Correa	Seaside mahoe	Native	T	Least concern	O	O
54	**Nephrolepidaceae**	*Nephrolepis exaltaata* (L.) Schott	Boston fern	Native	H	Least concern	O	O
55	**Orchidaceae**	*Brassavola subulifolia Lindl.*	Not documented	Endemic	H	Not listed	A	O
56	**Phytolaccaceae**	*Rivina humils* L.	Dogberry, Bloodberry	Native	H	Not listed	R	R
57	**Piperaceae**	*Peperomia amplexicaulis* (Sw.) Dietr.	Jackie's saddle	Endemic	H	not listed	R	R
58		*Piper amalago* L. var. *amalago*	Jointer	Native	S	Least concern	F	O
59	**Plantaginaceae**	*Bacopa monnieri* (L.) Pennell	Not documented	Native	H	Least concern	A	R
60	**Poaceae**	*Arundo donax* L. f. versicolor (Mill.) Stokes	Giant reed	Exotic	H	Least concern	A	A
61		*Axonopus compressus* (Sw.) P. Beauv.	Carpet grass	Native	H	Least concern	F	O
62		*Chloris barbata* Sw.	Not documented	Native	H	Not listed	O	O
63		*Cynodon dactylon* (L.) Pers.var. *dactylon*	Bermuda grass	Exotic	H	Not listed	O	O
64		*Digitaria ciliaris* (Retz.) Koeler	Not documented	Exotic	H	Not listed	O	O
65		*Eleusine indica* (L.) Gaertn.	Yard grass	Exotic	H	Least concern	F	F
66		*Lasiacis divaricata* (L.) Hitchc.	Not documented	Native	H	Least concern	O	O
67		*Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs	Guinea grass	Exotic	H	Not listed	F	O
68		*Paspalum distichum* L.	knotgrass	Native	H	Least concern	F	O
69		*Paspalum fimbriatum* Kunth	Not documented	Native	H	Not listed	O	O
70		*Phragmites australis* (Cav.) Steud.	Common reed	Exotic (Naturalized)	H	Least concern	F	O
71		*Themeda arguens* (L.) Hack	Piano grass	Exotic	H	Not listed	O	R

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 3
72	**Polypodiaceae**	*Pleopeltis polypodioides* (L.) E.G. Andrews & Windham	Ressurection fern	Native	H	Not listed	F	F
73	**Psilotaceae**	*Psilotum nudum* (L.) P. Beauv.	Whisk fern	Native	H	Least concern	R	R
74	**Rhizophoraceae**	*Rhizophora mangle* L.	Red mangrove	Native	T	Least concern	D	D
75	**Rubiaceae**	*Morinda citrifolia* L.	Hog apple, Noni	Exotic	S	Not listed	R	R
76		*Spermacoce laevis* Lam.	Not documented	Native	H	Least concern	A	O
77	**Typhaceae**	*Typha domingensis* Pers.	Typha	Native	S	Least concern	A	F

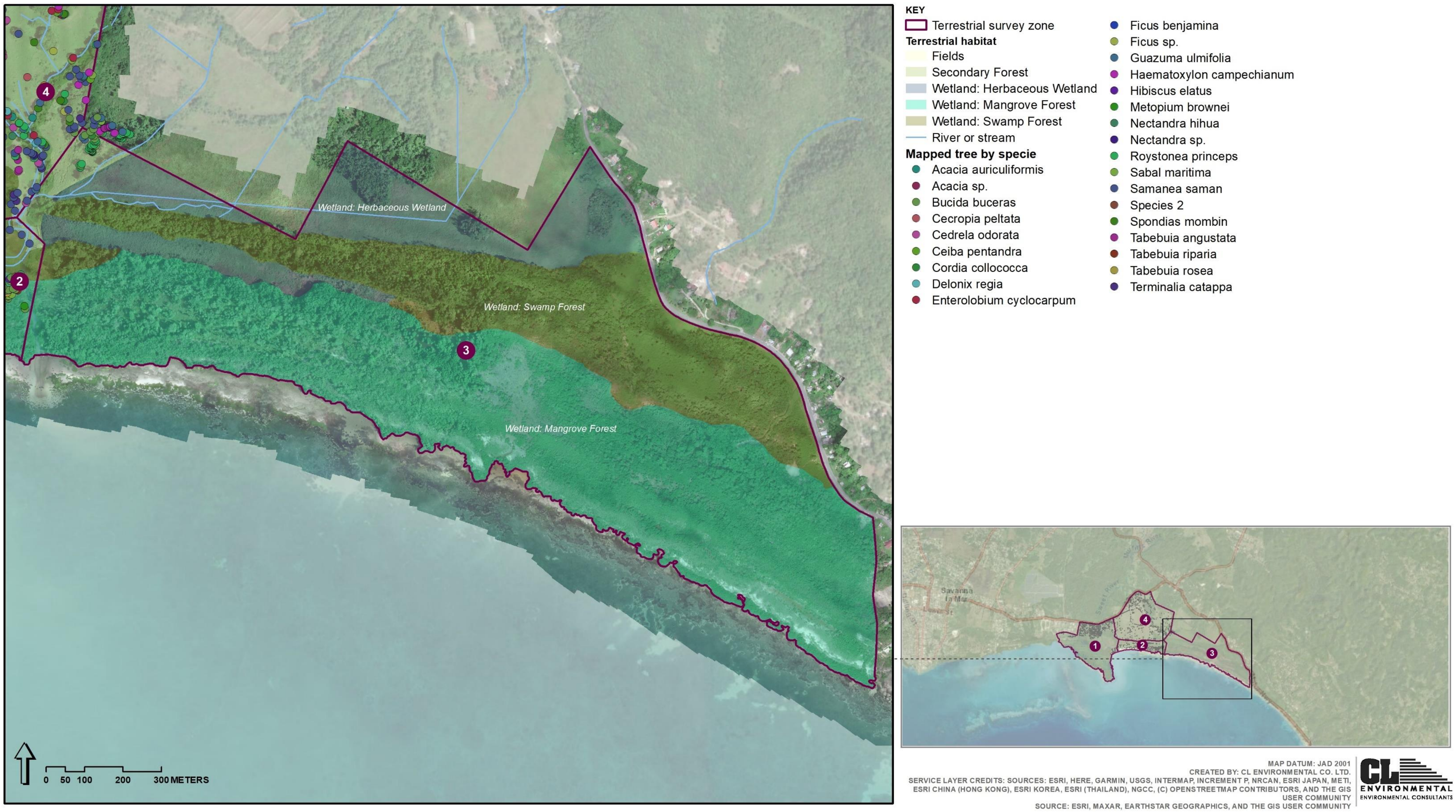


Figure 4-142 Mapped tree species within terrestrial survey Zone 3

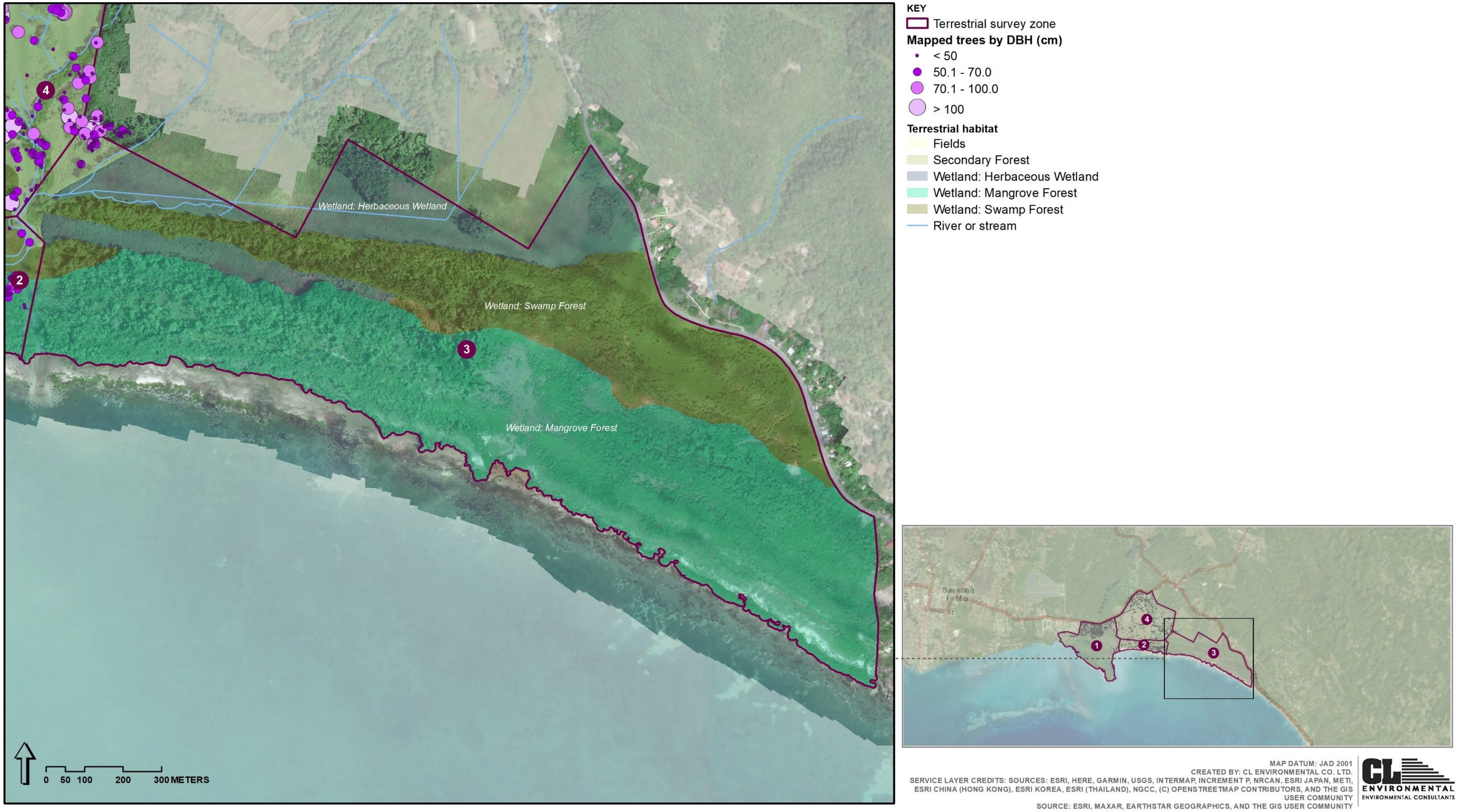


Figure 4-143 Mapped tree DBH within terrestrial survey Zone 3

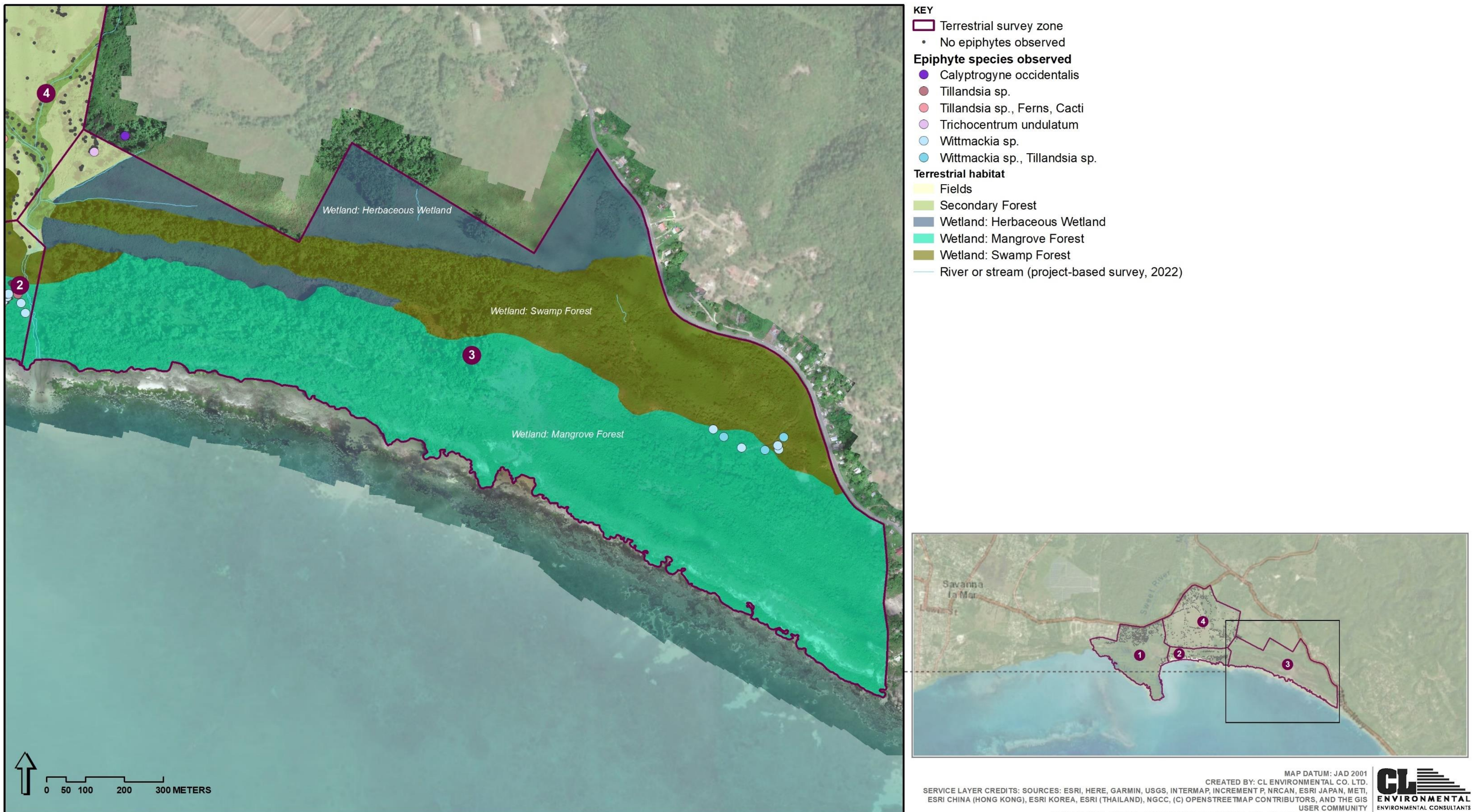


Figure 4-144 Mapped epiphytes within terrestrial survey Zone 3

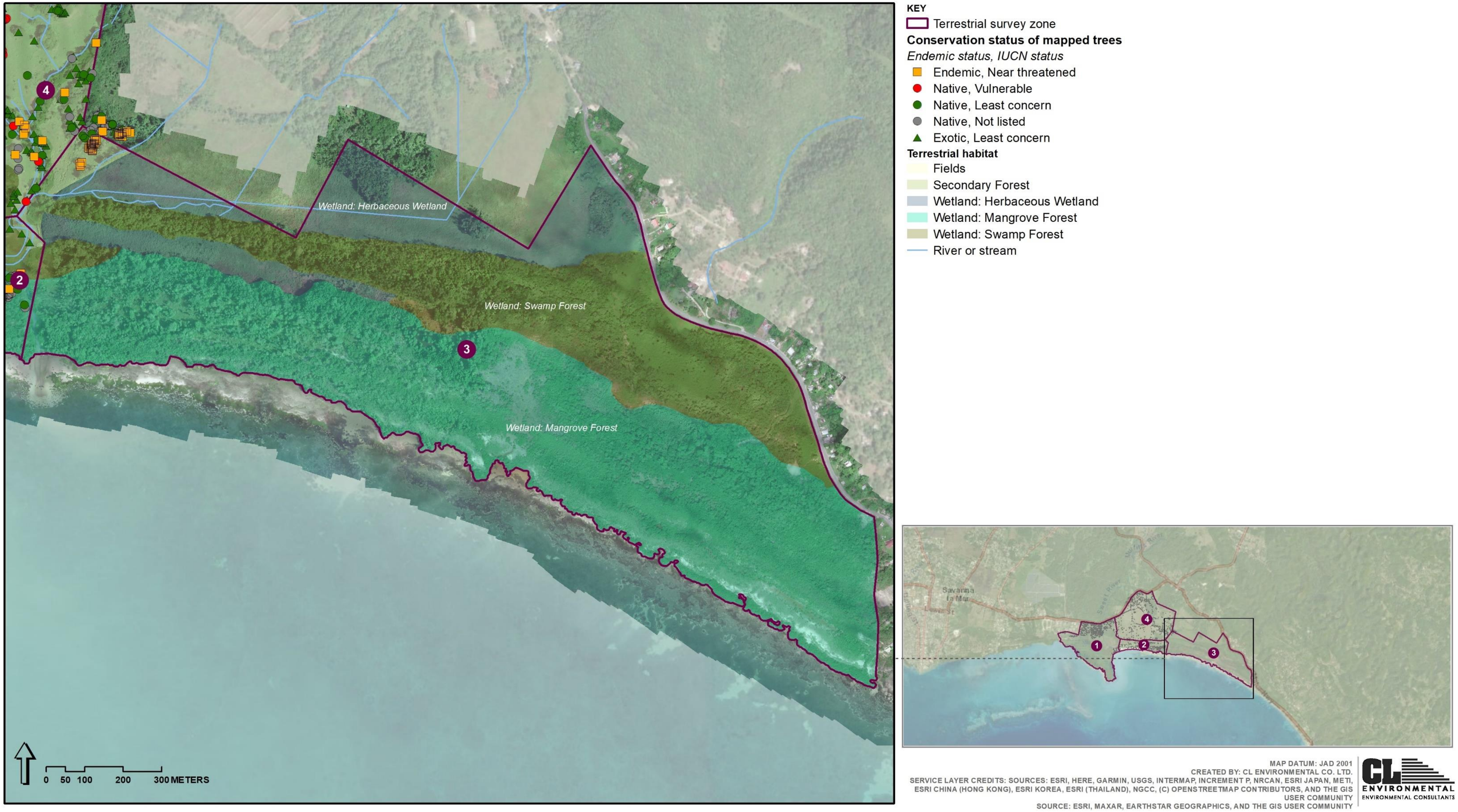


Figure 4-145 Conservation status of mapped tress within terrestrial survey Zone 3

ZONE 4

The Forestry Land Use classification characterized Zone 4 in two classes: Fields: Herbaceous crops, follow, cultivation and Herbaceous Wetland. The on the ground observations were slightly different as some patches of Secondary Forest were also observed (the Northeastern section of Zone 4) within this Zone. Fields: Herbaceous crops, fallow, cultivation was the most dominant land use type in Zone 4, however a small band of Herbaceous Wetland is present towards the southern boundary of that zone.

The vegetation recorded in Zone 4 reflects the forest types observed on the ground, most of the plants encountered are classified (Adams, 1972) as being very common, commonly found in thickets and wastelands, and commonly found in secondary woodlands. Only a few species that are primarily associated with wetland ecosystems were recorded in this zone.

A total of 210 species were observed during the floristic survey of Zone 4, the highest number of species recorded across the zones that were assessed. The 210 species consist of 63 plant families and 180 plant genera. The dominant families in this zone are Fabaceae, Poaceae, Malvaceae, Asteraceae and Cyperaceae and Euphorbiaceae with 24, 18, 9, 8, and a tie of 7 and 7 species, respectively. Most of the species recorded (130) in this zone are native to Jamaica, 71 species are exotic; only 5 endemic plant species (Brassavola *subulifolia*, *Broughtonia sanguinea*, *Oryctranthus occidentalis*, *Roystones princeps*, and *Wittmackia negrilensis*) were recorded in Zone 4.

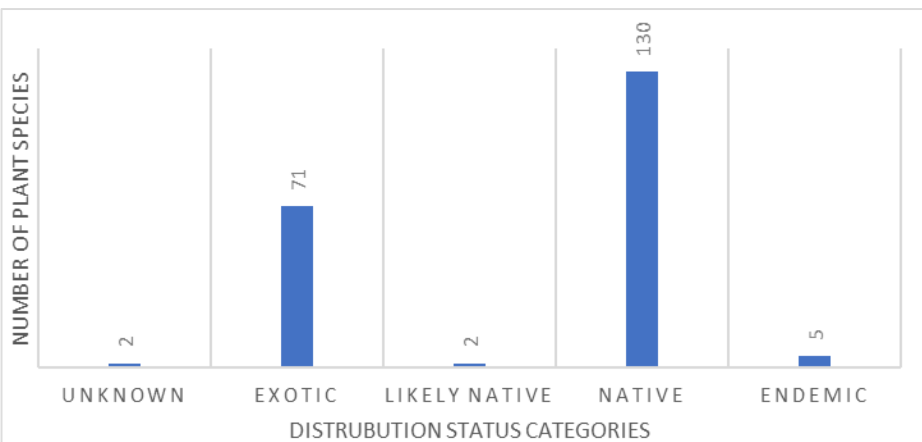


Figure 4-146 Summary chart of zone 4 plant species distribution

The majority of the plant species recorded in Zone 4 were herbs (97), followed by trees (63) the least represented Habit Classes in Zone 1 were shrubs (31) and vines (19).

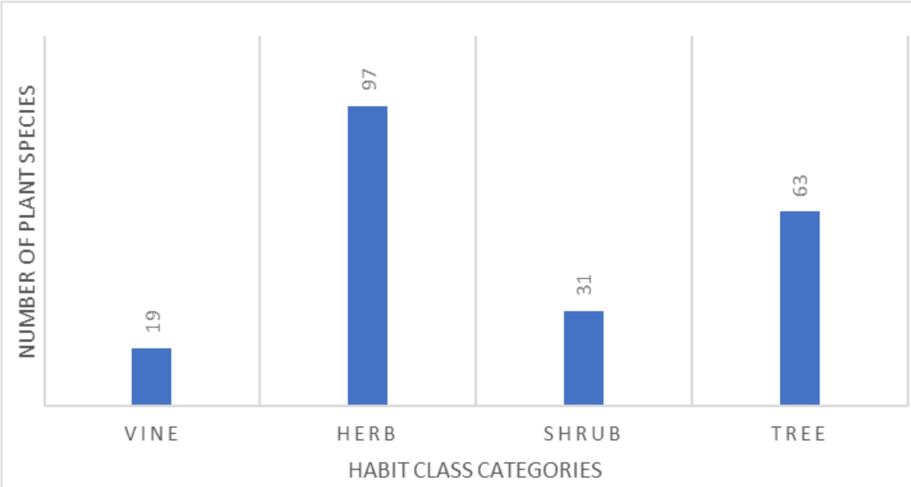


Figure 4-147 Summary chart of zone 4 plant species habit class

Most of the plant species recorded in Zone 4 are classified by the IUCN as Not Listed (102) or Least Concerned (95); 7 species with special IUCN statuses were recorded in this zone. Three (3) species are classified as Vulnerable and Endangered by the IUCN respectively, and 1 plant species in this zone is considered Near Threatened.

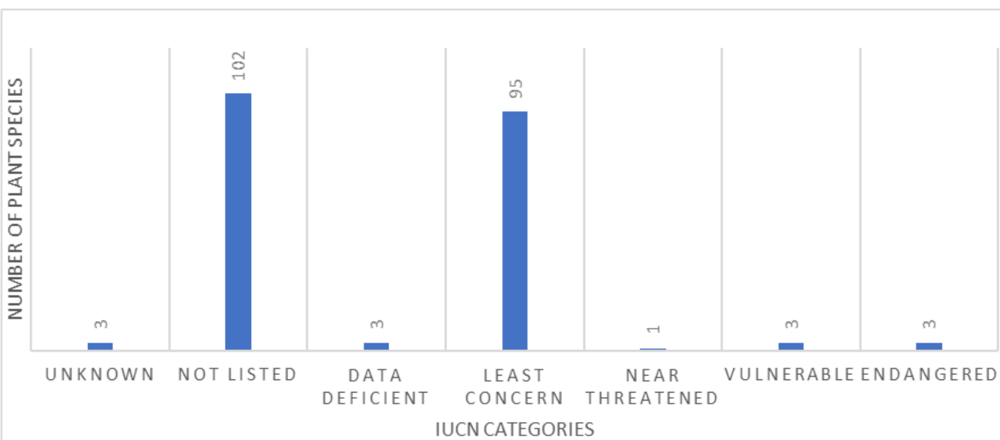


Figure 4-148 Summary chart of zone 4 plant species IUCN Red List of Threatened Species status

Anthropogenic disturbances across Zone 4 were very apparent. The zone has been subject to human activities for several years. Several pieces of infrastructure (such as buildings and roads) are scattered across this area. Evidence of past agricultural activities (slaughterhouse/dairy cow milking parlor) and current animal husbandry (cows, goats, sheep, horses, and donkeys) were seen throughout the area classified as Fields: Herbaceous crops, follow, cultivation. Some evidence of past crop production was also seen; it should be noted that no current largescale crop agriculture was observed within this zone.

The Secondary Forest within Zone 4 showed clear signs of heavy human disturbances, clearances for agriculture were frequently seen in this area, selective logging of trees for lumber and fencepost production were also seen.

The small band of Herbaceous Wetland of Zone 4 was relatively undisturbed; not much human activity was detected in this area, probably due to it being partially inundated and difficult to traverse (tall grasses and sedges)

Table 4-29 Zone 4 plant species list

Habit (V= Vine, T= Tree, and S= Shrub); DAFOR (D= Dominant, A = Abundant, F =Frequent, O= Odd and R= Rare)

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
1	**Acanthaceae**	*Megaskepasma erythrochlamys* Lindau	Brazilian red cloak	Exotic	S	Not listed	R (C)	R
2		*Ruellia tuberosa* L.	Duggy gun	Native	H	Not listed	F	A
3	**Amaranthaceae**	*Achyranthes aspera* L. var. *aspera*	Devil's Horsewhip	Exotic (Naturalized)	H	Not listed	A	A
4		*Alternanthera halimifolia* (Lam.) Standl. ex Pittier	Not documented	Native	H	Not listed	O	O
5	**Anacardaceae**	*Mangifera indica* L.	Mango	Exotic	T	Data deficient	R (C)	F
6		*Metopium brownei* (Jacq.) Urb.	Hog doctor	Native	T	Least concern	O	R
7		*Spondias dulcis* Parkinson	Jew plum	Exotic	T	Not listed	R (C)	R
8		*Spondias mombin* L.	Hog plum	Exotic	T	Least concern	R (C)	O
9	**Annonaceae**	*Annona glabra* L.	Pond apple	Native	T	Least concern	R	R
10	**Apiaceae**	*Centella asiatica* (L.) Urb.	Not documented	Exotic	H	Least concern	O	R
11	**Apocynaceae**	*Asclepias curassavica* L.	Redhead	Native	H	Not listed	F	F
12		*Calotropis procera* (Aiton) W.T. Aiton	Dumb cotton, French cotton	Exotic	S	Not listed	R	R
13		*Echites umbellatus* Jacq. Subsp. *umbellatus*	Not documented	Native	V	Not listed	O	O
14		*Pentalinon luteum* (L.) B.F. Hansen &Wunderlin	Nightshade	Native	V	Not listed	O	O
15	**Araceae**	*Alocasia macrorrhizos* (L.) G. Don	Scratch coco	Exotic	H	Not listed	F	F
16		*Colocasia esculenta* (L.) Schott.	Dasheen	Exotic	H	Least concern	R	R
17		*Dieffenbachia seguine* 9Jacq.) Schott	Dumb cane	Native	H	Not listed	O	O

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
18		*Epipremnum pinnatum* (L.) Engl. "*aureum*" Nicolson	Pothos	Exotic	V	Not listed	R	R
19		*Syngonium auritum (*L.) Schott.	Five finger	Native	H	Not listed	O	O
20		*Xanthosoma sagittifolium* (L.) Schott.	Coco	Exotic	H	Not listed	O	O
21	**Araucariaceae**	*Araucaria heterophylla* (Salisb.) Franco	Norfolk Pine	Exotic	T	Vulnerable	R (C)	R
22	**Arecaceae**	*Roystonea princeps* (Becc.) Burret	Morass royal	Endemic	T	Near threatened	A	O
23		*Roystonea regia* (Kunth) O.F. Cook	Palm	Exotic	T	Least concern	O (C)	O
24		*Sabal maritima* (Kunth) Burret	Bull thatch	Native	T	Not listed	A	O
25		*Washingtonia robusta* (H. Wendl.) Parish	Mexican fan palm	Exotic	T	Least concern	R (C)	R
26	**Asparagaceae**	*Dracaena angustifolia* (Medik.) Roxb.	Dracaena	Exotic	H	Not listed	R (C)	R
27		*Dracaena fragrans* (L.) Ker Gawl	Dracaena	Exotic	H	Least concern	R (C)	R
28	**Asteraceae**	*Acmella uliginosa* (Sw.) Cass.	Not documented	Native	H	Least concern	O	R
29		*Bidens pilosa* L. var. *pilosa*.	Spanish Needle	Native	H	Not listed	A	A
30		*Chromolaena odorata* (L.) R.M. King & H. Rob.	Jacj-in-the bush	Native	S	Not listed	F	F
31		*Cyanthillium cinereum* (L.) H. Rob.	Not documented	Exotic	H	Not listed	A	D
32		*Mikania micrantha* Kunth	Guaco	Native	V	Not listed	F	A
33		*Sphagneticola trilobata* (L.) Pruski	Creeping ox-eye	Exotic	H	Not listed	A	D
34		*Spilanthes urens* Jacq.	Pigeon coop	Native	H	Not listed	F	F
35		*Symphyotrichum expansum (Poepp. Ex Spreng) G.L. Nesom*	Not documented	Native	H	Not listed	F	O
36	**Bignoniaceae**	*Crescentia cujete* L.	Calabash; Packy	Native	T	Least concern	R	R

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
37		*Handroanthus serratifolius* (Vahl) S.O. Grose	Yellow Poui	Exotic	T	Endangered	R (C)	R
38		*Spathodea campanulata* P. Beauv.	African tulip tree	Exotic	T	Least concern	F	F
39		*Tabebuia angustata* Britton	Pink poui	Native	T	Not listed	A	A
40		*Tabebuia heterophylla (*DC.) Britton	White cedar	Native	T	Least concern	R	R
41	**Boraginaceae**	*Cordia collococca* L.	Clammy cherry	Native	T	Least concern	F	F
42		*Cordia gerascanthus* L.	Spanish Elm	Native	T	Least concern	O	O
43		*Heliotropium angiospermum* Murray	Dog's tail	Native	H	Not listed	O	O
44		*Tournefortia hirsutissima* L.	Cold withe	Native	S	Not listed	R	R
45		*Varronia bullata* L. subsp. humilis	Gout tea	Native	S	Least concern	O	O
46	**Bromeliaceae**	*Tillandsia compressa* Bertero ex Schult. & Schult. f.	Not documented	Native	H	Not listed	F	F
47		*Tillandsia recurvata*	Ball moss	Native	H	Not listed	A	A
48		*Tillandsia setacea* Sw.	Not documented	Native	H	Not listed	O	O
49		*Tillandsia usneoides*	Old man's beard	Native	H	Least concern	A	O
50		*Tillandsia utriculata* L.	Not documented	Native	H	Not listed	O	O
51		*Wittmackia negrilensis* Britton ex L.B. Sm.	Wild pine	Endemic	H	Not listed	F	O
52	**Burseraceae**	*Bursera simaruba* (L.) Sarg.	Red birch	Native	T	Least concern	R	R
53	**Cannaceae**	*Canna indica* L.	Canna lily, Indian shot	Native	H	Not listed	R	R
54	**Cactaceae**	*Hylocereus triangularis* (L.) Britton & Rose	God Okra	Native	V	Least concern	O	O
55		*Rhipsalis baccifera (J.S. Muell.) Stearn*	Currant cactus	Native	H	Least concern	O	O

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
56		*Selenicereus grandiflorus* (L.) Britton & Rose	Queen-of-the-night	Native	V	Least concern	F	F
57	**Casuarinaceae**	*Casuarina equisetifolia* L.	Casuarina, Willow	Exotic	T	Least concern	R (C)	R
58	**Cleomaceae**	*Arivela viscosa* (L.) Raf.	Wild caia	Exotic	H	Not listed	R	R
59		*Cleoserrata serrata* (Jacq) Iltis	Not documented	Native	H	Not listed	R	R
60	**Clusiaceae**	*Clusia rosea* Jacq.	Balsam fig	Native	T	Least concern	O	O
61	**Combretaceae**	*Bucida buceras* L.	Black olive	Native	T	Not listed	F	O
62		*Conocarpus erectus* var. *erectus*	Button mangrove	Native	T	Least concern	A	R
63		*Terminalia catappa* L.	Almond	Exotic (Naturalized)	T	Least concern	O	F
64	**Convolvulaceae**	*Ipomoea tiliacea* (Willd.) Choisy	Wild slip	Native	V	Least concern	O	O
65		*Momordica charantia* L.	Wild cerasee	Exotic	V	Not listed	O	F
66	**Cycadaceae**	*Cycas circinalis* L.	Cycad	Exotic	S	Least concern	R (C)	R
67	**Cyperacea**	*Cyperus involucrata* Rottb.	Not documented	Exotic	H	Not listed	F	F
68		*Cyperus ligularis* L.	Not documented	Native	H	Not listed	A	F
69		*Cyperus odoratus* L.	Not documented	Native	H	Least concern	F	A
70		*Fimbristylis dichotoma* (L.) Vahl. subsp. *dichotoma*	Not documented	Native	H	Least concern	O	R
71		*Kyllinga brevifolia Rottb.*	not documented	Native	H	Least concern	A	A
72		*Rhynchospora nervosa* (Vahl.) Boeckeler	Star grass	Native	H	Not listed	A	D
73		*Scleria gaertneri* Raddi	Not documented	Native	H	Least concern	F	O
74	**Euphorbiaceae**	*Acalypha amentacea* Roxb. subsp. *wilkesiana*	Acalypha	Exotic	S	Not listed	R (C)	R

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
75		*Dalbergia ecastaphyllum* (L.) Taub.	not documented	Native	S	Least concern	R	R
76		*Euphorbia heterophylla* L.	Not documented	Native	H	Not listed	R	R
77		*Euphorbia prostrata Aiton*	Milkweed	Native	H	Not listed	O	O
78		*Jatropha gossypiifolia* L. var. *gossypiifolia*	Belly-ache Bush	Native	H	Least concern	O	O
79		*Ricinus communis* L.	Castor oil plant, Oil nut	Exotic (Invasive)	S	Not listed	R	R
80		*Tragia volubilis* L.	Cowitch	Native	V	Not listed	O	O
81	**Fabaceae**	*Abrus precatorius* L.	John crow bead, Crab eyes	Exotic	V	Not listed	F	F
82		*Acacia auriculiformis* A. Cunn. ex Benth.	Not documented	Exotic	T	Least concern	R (C)	R
83		*Albizzia lebbeck* (L.) Benth.	Woman's tongue	Exotic	T	Least concern	O	O
84		*Alysicarpus vaginalis* (L.) DC.	Medina	Exotic	H	Not listed	F	F
85		*Andira inermis* (W. Wright) DC.	Cabbage bark tree	Native	T	Least concern	R	R
86		*Bauhinia purpurea* L.	Poor man's orchid	Exotic	T	Least concern	R (C)	R
87		*Caesalpinia pulcherrima* (L.) *Sw.*	Pride of Barbados	Exotic	T	Least concern	R (C)	R
88		*Cassia grandis* L.	Not documented	Exotic	T	Least concern	R (C)	R
89		*Cassia fistula* L.	Golden shower	Exotic	T	Least concern	R (C)	R
90		*Centrosema virginianum* (L.) Benth	Not documented	Native	V	Not listed	O	O
91		*Delonix regia* (Bojer ex Hook.) Raf.	Poinciana, Flamboyant	Exotic	T	Least concern	O	O
92		*Desmodium incanum* DC.	Not documented	Native	H	Least concern	F	A

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
93		*Enterolobium cyclocarpum* (Jacq.) Griseb.	Elephant Ear	Exotic	T	Least concern	O	F
94		*Gliricidia sepium* (Jacq.) Kunth	Grow stick, Quick stick, Aaron's rod	Exotic	T	Least concern	R (C)	O
95		*Haematoxylum campechianum* L.	Logwood	Exotic	T	Least concern	A	A
96		*Macroptilium lathyroides* (L.) Urb.	Not documented	Native	H	not listed	R	R
97		*Mimosa pudica* var. *pudica* L.	Shame 'o' lady	Native	H	Least concern	O	O
98		*Piscidia piscipula (*L.) Sarg.	Dogwood	Native	T	Least concern	F	D
99		*Samanea saman* (Jacq.) Merr.	Guango	Exotic	T	Least concern	A	D
100		*Senna alata* (L.) Roxb.	King of the forest	Native	S	Least concern	R	R
101		*Senna occidentalis* (L.) Link	Dandelion	Native	S	Least concern	O	O
102		*Senna siamea* (Lam.) H.S. Irwin & Barneby	Not documented	Exotic	T	Least concern	O	O
103		*Senna uniflora* (Mill.) H.S. Irwin & Barneby	Not documented	Native	H	Not listed	O	O
104		*Vachellia macracantha* (Humb. & Bonpl. Ex Willd.) Seigler & Ebinger	Park nut	Native	T	Least concern	R	R
105	**Hydrocharitaceae**	*Egeria densa* Planch.	Not documented	Exotic	H	Not listed	F	F
106		*Elodea canadensis* Michx.	Canadian pondweed	Exotic	H	Least concern	F	F
107	**Hypoxidaceae**	*Hypoxis decumbens* L.	Star of Bethlehem	Native	H	Not listed	O	O
108	**Lamiaceae**	*Hyptis capitata* Jacq.	Ironwort	Native	H	Not listed	O	O
109		*Hyptis verticillata* Jacq.	John charles	Native	H	Not listed	O	O
110		*Ocimum campechianum* Mill.	Barsley	Native	H	Not listed	O	O
111		*Petitia domingensis* Jacq.	not documented	Native	T	Not listed	R	R

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
112		*Tectona grandis* L.	Teak	Exotic	T	Endangered	R (C)	R
113	**Lauraceae**	*Nectandra hihua* (Ruiz & Pav.) Rohwer	Sweetwood	Native	T	Least concern	F	F
114	**Loranthaceae**	*Oryctranthus occidentalis* (L.) Eichler	Scorn the earth	Endemic	S	Not listed	O	O
115	**Malpighiaceae**	*Malpighia glabra* L.	Wild cherry	Native	S	Least concern	O	O
116	**Malvaceae**	*Ceiba pentandra* (L.) Gaertn.	Silk cotton tree	Native	T	Least concern	O	F
117		*Guazuma ulmifolia* Lam.	Bastard Cedar	Native	T	Least concern	F	D
118		*Hibiscus elatus* Sw.	Blue Mahoe	Native	T	Least concern	R	O
119		*Hibiscus rosa-sinensis* L.	Hibiscus, Sheo black	Exotic	S	Not listed	R (C)	R
120		*Malachra alceifolia* Jacq.	Wild okra	Native	H	Not listed	R	R
121		*Pavonia schiedeana* Steud.	Conger watchman	Native	H	Not listed	O	O
122		*Sida acuta* Burm.	Broomweed	Native	H	Not listed	F	O
123		*Sida rhombifolia* L.	Not documented	Native	H	Not listed	O	A
124		*Urena lobata* L.	Ballard bush, Bur Mallow	Native	H	Least concern	F	A
125	**Meliaceae**	*Cedrela odorata* L.	West Indian cedar	Native	T	Vulnerable	F	F
126	**Moraceae**	*Artocarpus altilis* (Parkinson) Fosberg	Breadfruit	Exotic	T	Not listed	R (C)	O
127		*Ficus benjamina* L.	Ficus	Exotic	T	Least concern	R	O
128		*Ficus maxima* Mill.	Fig	Native	T	Least concern	R	R
129		*Maclura tinctoria* (L.) D. Don ex Steud.	Fustic	Native	T	Least concern	R	R
130	**Musaceae**	*Musa paradisiaca* L.	Plantain	Exotic	H	Not listed	R (C)	R
131	**Myrtaceae**	*Callistemon* sp.	Bottlebrush	Exotic	S	Unknown	R (C)	R
132		*Eugenia axillaris* ((Sw.) Willd.	Black cherry	Native	T	Least concern	F	O

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
133		*Pimenta dioica* (L.) Merr.	Pimento; All spice	Native	T	Least concern	O	F
134		*Psidium guajava* L.	Guava	Native	S	Least concern	O	O
135	**Nephrolepidaceae**	*Nephrolepis exaltaata* (L.) Schott	Boston fern	Native	H	Least concern	O	O
136	**Nyctaginaceae**	*Bougainvillea glabra* Choisy	Bougainvillea	Exotic	S	Least concern	R (C)	R
137		*Pisonia aculeata* L.	Cockspur, Wait-a-bit	Native	T	Least concern	O	F
138	**Onagraceae**	*Ludwigia leptocarpa* (Nutt.) H. Hara subsp. *leptocarpa*	Not documented	Native	H	Least concern	F	F
139		*Ludwigia octovalvis* (Jacq.) P.H. Raven	Not documented	Native	H	Least concern	F	F
140	**Orchidaceae**	*Brassavola subulifolia Lindl.*	Not documented	Endemic	H	Not listed	A	A
141		*Broughtonia sanguinea* (Sw.) R. Br.	Not documented	Endemic	H	Not listed	R	R
142		*Dendrobium* sp.	Orchid	Unknown	H	Unknown	R	R
143		*Epidendrum* sp.	Orchid	Unknown	H	Unknown	R	R
144		*Oeceoclades maculata* (Lindl.) Lindl.	Monk orchid	Exotic	H	Least concern	O	O
145	**Pandanaceae**	*Pandanus dubius* Spreng.	Screw pine	Exotic	S	Least concern	R (C)	R
146	**Papaveraceae**	*Argemone maxicana L.*	Yellow thistle	Native	H	Not listed	R	O
147	**Passifloraceae**	*Passiflora maliformis*L.	Sweet cup	Native	V	Not listed	O	O
148		*Passiflora suberosa* L.	Not documented	Native	V	Not listed	O	O
149		*Turnera ulmifolia* L.	Ram-goat dashalong	Native	S	Least concern	O	O
150	**Phyllanthaceae**	*Phyllanthus amarus* Schumach. &Thonn.	Carry-me-seed	Native	H	Not listed	O	O
151	**Phytolaccaceae**	*Petiveria alliacea* L.	Guinea hen weed, Strong man's weed	Likely Native	H	Not listed	R	O
152		*Rivina humils* L.	Dogberry, Bloodberry	Native	H	Not listed	R	R

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
153		*Trichostigma octandrum* (L.) H. Walter	Hoop withe	Native	V	Least concern	O	R
154	**Piperaceae**	*Piper amalago* L. var. *amalago*	Jointer	Native	S	Least concern	F	F
155		*Piper hispidum* Sw.	Jamaican pepper	Native	S	Least concern	R	R
156	**Poaceae**	*Axonopus compressus* (Sw.) P. Beauv.	Carpet grass	Native	H	Least concern	F	F
157		*Bambusa multiplex* (Lour.) Raeusch. ex Schult. & Schult.	Hedge bamboo	Exotic	S	Not listed	R (C)	R
158		*Bambusa vulgaris* Schrad. ex H.L. Wendl.	Common Bamboo	Exotic	T	Not listed	R	R
159		*Chloris barbata* Sw.	Not documented	Native	H	Not listed	O	O
160		*Chloris radiata* (L.)	Not documented	Native	H	Not listed	O	O
161		*Cynodon dactylon* (L.) Pers.var. *dactylon*	Bermuda grass	Exotic	H	Not listed	O	O
162		*Digitaria ciliaris* (Retz.) Koeler	Not documented	Exotic	H	Not listed	O	O
163		*Eleusine indica* (L.) Gaertn.	Yard grass	Exotic	H	Least concern	F	F
164		*Lasiacis divaricata* (L.) Hitchc.	Not documented	Native	H	Least concern	O	O
165		*Megathyrsus maximus* (Jacq.) B.K. Simon & S.W.L. Jacobs	Guinea grass	Exotic	H	Not listed	F	F
166		*Oplismenus hirtellus* (L.) P. Beauv. Subsp. setarius (Lam.) Mez ex Ekman	Not documented	Native	H	Not listed	R	R
167		*Paspalum distichum* L.	knotgrass	Native	H	Least concern	F	F
168		*Paspalum fimbriatum* Kunth	Not documented	Native	H	Not listed	O	O
169		*Paspalum paniculatum* L.	Not documented	Native	H	Not listed	O	O
170		*Phragmites australis* (Cav.) Steud.	Common reed	Exotic (Naturalized)	H	Least concern	F	F

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
171		*Sporobolus indicus* (L.) R. Br. var. *indicus*	West Indian rush-grass	Native	H	Not listed	O	O
172		*Themeda arguens* (L.) Hack	Piano grass	Exotic	H	Not listed	O	O
173		*Zoysia tenuifolia* Thiele	Zoysia	Exotic	H	Not listed	A	A
174	**Polygonaceae**	*Antigonon leptopus* Hook. & Arn.	Coralita	Exotic	V	Not listed	O	O
175		*Coccoloba uvifera* (L.) L.	Sea grape	Native	T	Least concern	F	O
176	**Polypodiaceae**	*Pleopeltis polypodioides* (L.) E.G. Andrews & Windham	Ressurection fern	Native	H	Not listed	F	O
177	**Pontederiaceae**	*Eichhornia crassipes* (Mart.) Solms	Water hyacinth	Exotic	H	Not listed	F	F
178		*Heteranthera reniformis* Ruiz & Pav.	Not documented	Native	H	Not listed	R	R
179	**Psilotaceae**	*Psilotum nudum* (L.) P. Beauv.	Whisk fern	Native	H	Least concern	R	R
180	**Rubiaceae**	*Morinda citrifolia* L.	Hog apple, Noni	Exotic	S	Not listed	R	R
181		*Morinda royoc* L.	Red gal; Strongback	Native	S	Least concern	R	R
182		*Psychotria pubescens* Sw.	Wild coffee	Native	S	Least concern	O	O
183		*Spermacoce laevis* Lam.	Not documented	Native	H	Least concern	A	A
184	**Rutaceae**	*Glycosmis parviflora* (Sims) Little	Not documented	Exotic	S	Least concern	O	O
185		*Zanthoxylum caribaeum* Lam.	Yellow sanders	Native	T	Least concern	R	R
186		*Zanthoxylum martinicensis* (Lam.) DC.	Prickly yellow	Native	T	Not listed	O	O
187	**Salicaceae**	*Casearia aculeata* Jacq.	Cockspur	Native	T	Least concern	O	O
188	**Sapindaceae**	*Blighia sapida* F.D. Koenig	Ackee	Exotic	T	Least concern	R (C)	O
189		*Cardiospermum grandiflorum* Sw.	Not documented	Native	V	Not listed	R	R

	Family	Taxonomy Treatment	Common Name	Status	Habit	IUCN Status	DAFOR + C Ranking	Block 4
190		*Cupania americana* L.	Wild ackee	Native	T	Least concern	F	F
191		*Melicoccus bijugatus* Jacq.	Guinep	Exotic (Naturalized)	T	Not listed	R	R
192	**Simarubaceae**	*Picrasma excelsa* (Sw.) Planch.	Bitterwood, Jamaican quassia	Exotic	T	Vulnerable	R	R
193	**Smilacaceae**	*Smilax canellifolia* Mill.	Chainy root	Native	V	Not listed	O	O
194	**Solanaceae**	*Capsicum frutescens* L.	Bird pepper	Native	H	Least concern	R	R
195		*Physalis angulata* L.	Wild gouma, Winter cherry	Native	H	Least concern	O	O
196		*Solanum erianthum* D. Don	Wild Susumber	Native	S	Least concern	O	O
197		*Solanum torvum* Sw.	Susumber, Gully bean, Turkey berry	Likely Native	S	Not listed	F	F
198	**Typhaceae**	*Typha domingensis* Pers.	Typha	Native	S	Least concern	A	A
199	**Urticaceae**	*Cecropia peltata* L.	Trumpet tree	Native	T	Least concern	F	O
200		*Pilea microphylla* (L.) Liebm. var. *microphylla*	Baby puzzle	Native	H	Not listed	R	R
201	**Verbenaceae**	*Lantana camara* L.	Wild Sage	Native	S	Not listed	O	F
202		*Lippia alba* (Mill.) N.E. Br. ex Britton & P. Wilson	Cullen mint, Colic mint, Guinea mint	Native	S	Not listed	R	R
203		*Phyla stoechadifolia* (L.) Small	Not documented	Native	H	Not listed	F	F
204		*Priva lappulacea* (L.) Pers.	Clammy bur, Fasten-pon-coat, Velvet bur, Styptic bur	Native	H	Not listed	R	R
205		*Stachytarpheta jamaicensis* (L.) Vahl	Vervine	Native	H	Not listed	O	O
206	**Vitaceae**	*Cissus verticillata* Nicolson & C.E. Jarvis subsp. *verticillata*	Sorrel vine	Native	V	Not listed	F	F
207		*Vitis tiliifolia* Humb. & Bonpl. ex Roem. & Schult.	Wild grape, Water withe	Native	V	Not listed	R	R

	Family	**Taxonomy Treatment**	**Common Name**	**Status**	**Habit**	**IUCN Status**	**DAFOR + C Ranking**	**Block 4**
208	**Zingiberaceae**	*Hedychium coronarium* J. Koenig	White ginger lily	Exotic (Invasive)	H	Data deficient	R	R
209		*Zingiber zerumbet* (L.) J.E. Sm.	Not documented	Exotic	H	Data deficient	R (C)	R
210	**Zygophyllaceae**	*Guaiacum officinale* L.	Lignum vitae	Native	T	Endangered	R (C)	R

Figure 4-149 Mapped tree species within terrestrial survey Zone 4

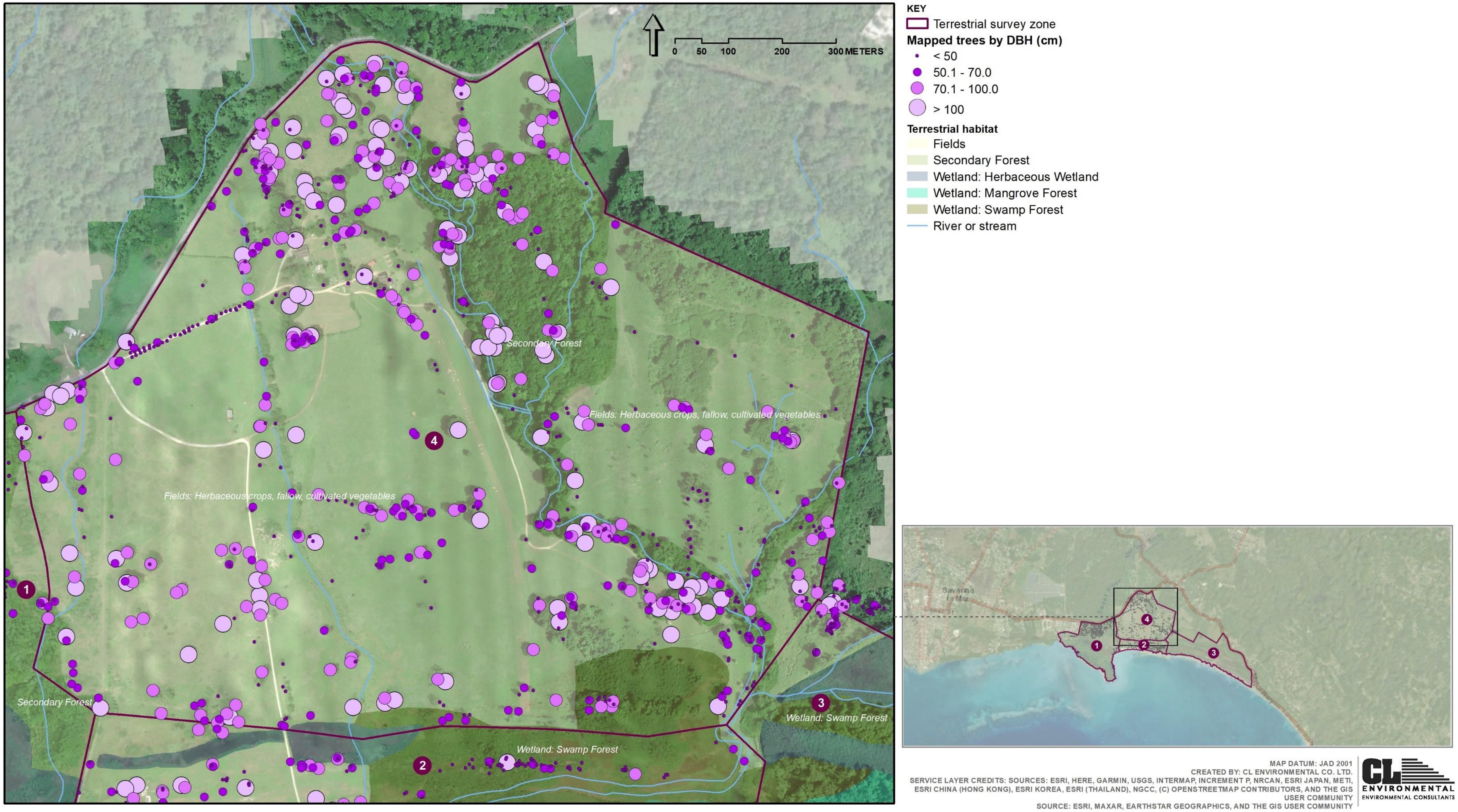


Figure 4-150 Mapped tree DBH within terrestrial survey Zone 4

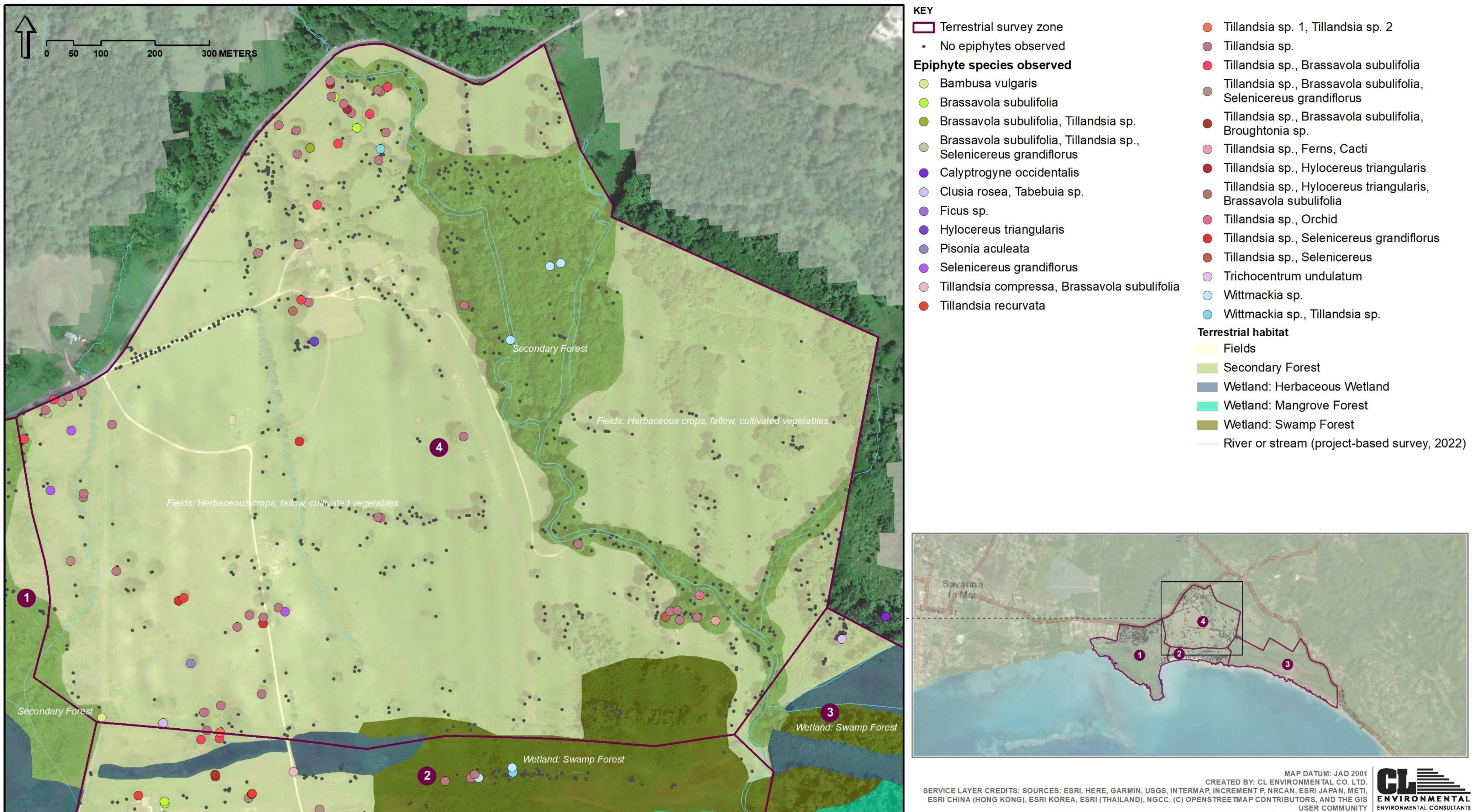


Figure 4-151 Mapped epiphytes within terrestrial survey Zone 4

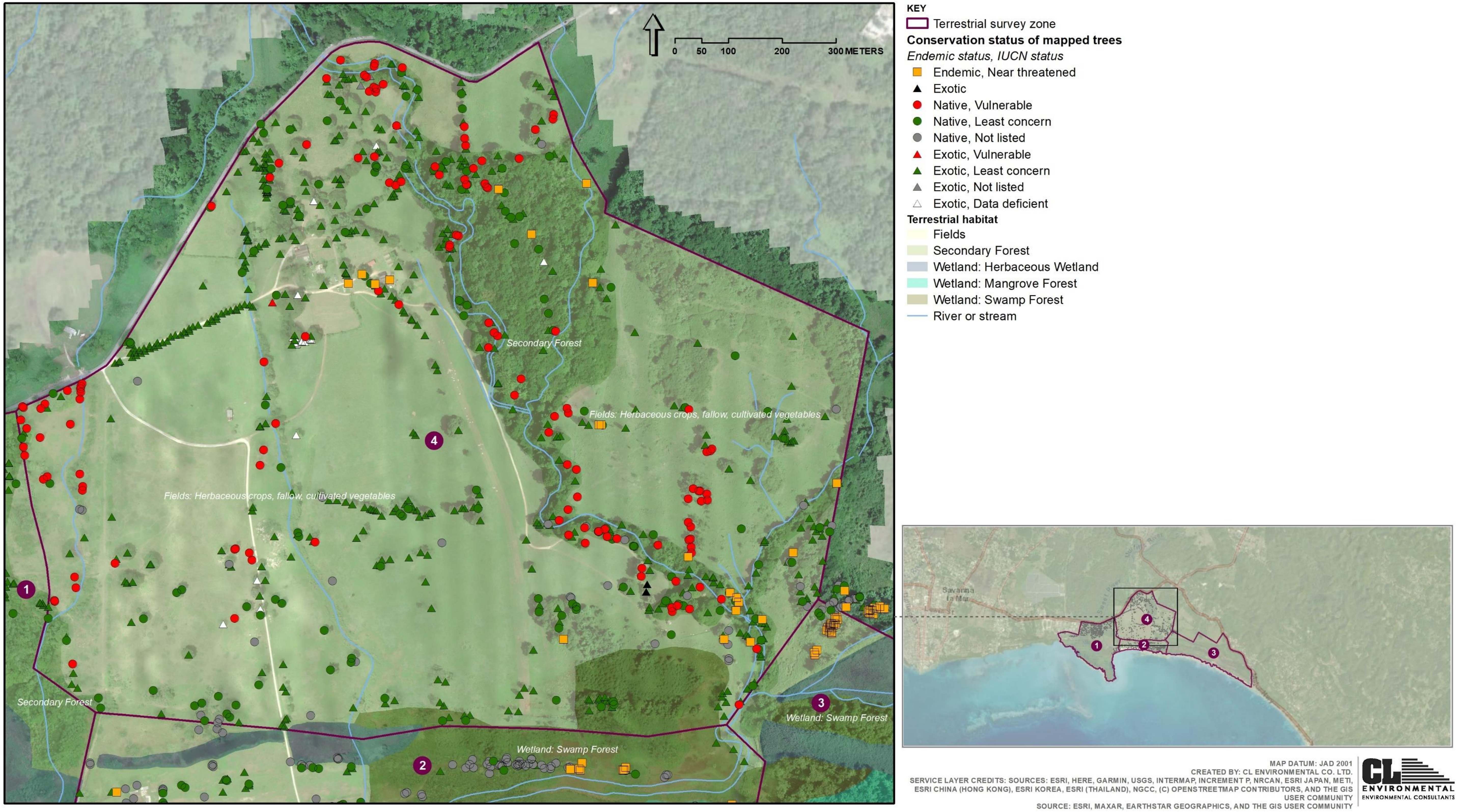


Figure 4-152 Conservation status of mapped tress within terrestrial survey Zone 4

SUMMARY OF RESULTS

Table 4-30 summarizes the results from the floristic survey conducted within the proposed development site and the four demarcated zones within the site. Overall, a total of 211 plant species were observed of which only six (*Brassavola subulifolia*, *Broughtonia sanguinea*, *Oryctranthus occidentalis*, *Peperomia amplexicaulis*, *Roystones princeps*, and *Wittmackia negrilensis*) were identified as being endemic to the island of Jamaica. None of the endemic species observed are restricted to this particular area and are not considered rare.

Table 4-30 Summary of terrestrial flora habits, species, and conservation status by zone

Zone	Habitat Classification	Species	Conservation status
1	• Fields: Herbaceous crops, fallow, cultivation • Secondary Forest • Mangrove Forest • Herbaceous Wetland • Swamp Forest	• 177 Species in total • 3 Endemic species	• 4 IUCN species (1 Vulnerable and 3 Near Threatened)
2	• Fields: Herbaceous crops, fallow, cultivation • Mangrove Forest • Herbaceous Wetland • Swamp Forest • Dry Open Forest	• 92 species in total • 4 endemic species	• 2 species classified as Near Threatened
3	• Mangrove Forest • Herbaceous Wetland • Swamp Forest	• 77 species in total • 4 endemic species	• 2 Near threatened species
4	• Fields: Herbaceous crops, fallow, cultivation • Herbaceous Wetland	• 210 species in total • 5 endemic species	• 7 species of note 3 Endangered, 3 Vulnerable and 1 Near threatened

On observation, the general site seemed to have undergone several iterations of anthropogenic and natural impacts which have shaped the flora of the site and in extension the overall ecology. Within the general site there are pockets of habitats such as Mangroves, Herbaceous Wetlands and Swamp Forests which are important habitats and wetland type which were in good ecological condition. The Swamp forests in particular have been on the decline for decades with only a few areas left in Jamaica. A high concentration/density of *Roystonea princeps* trees are consistent with areas designated as Swamp forests (Figure 4-153, Plate 4-29).

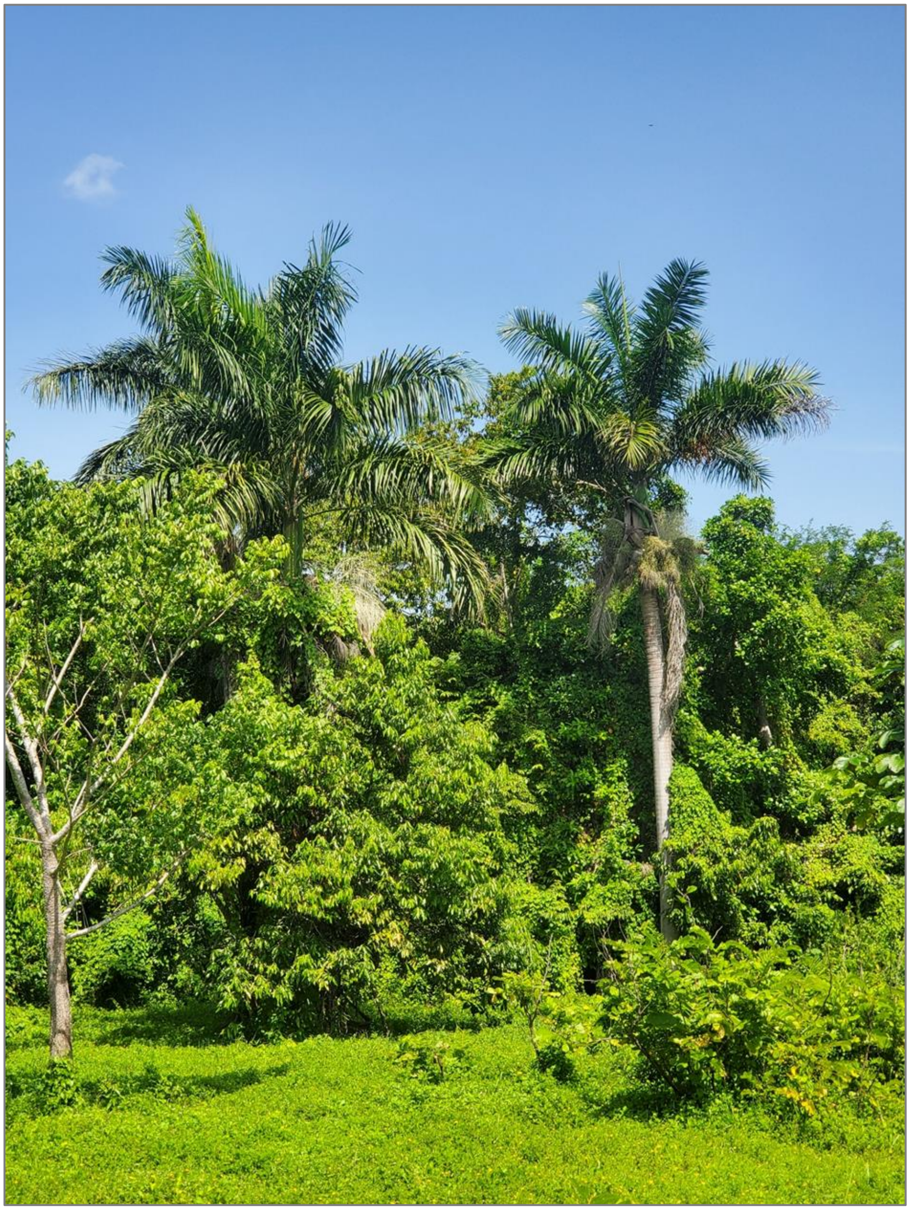


Plate 4-29 Remnant/disturbed swamp forest with Roystonea palms

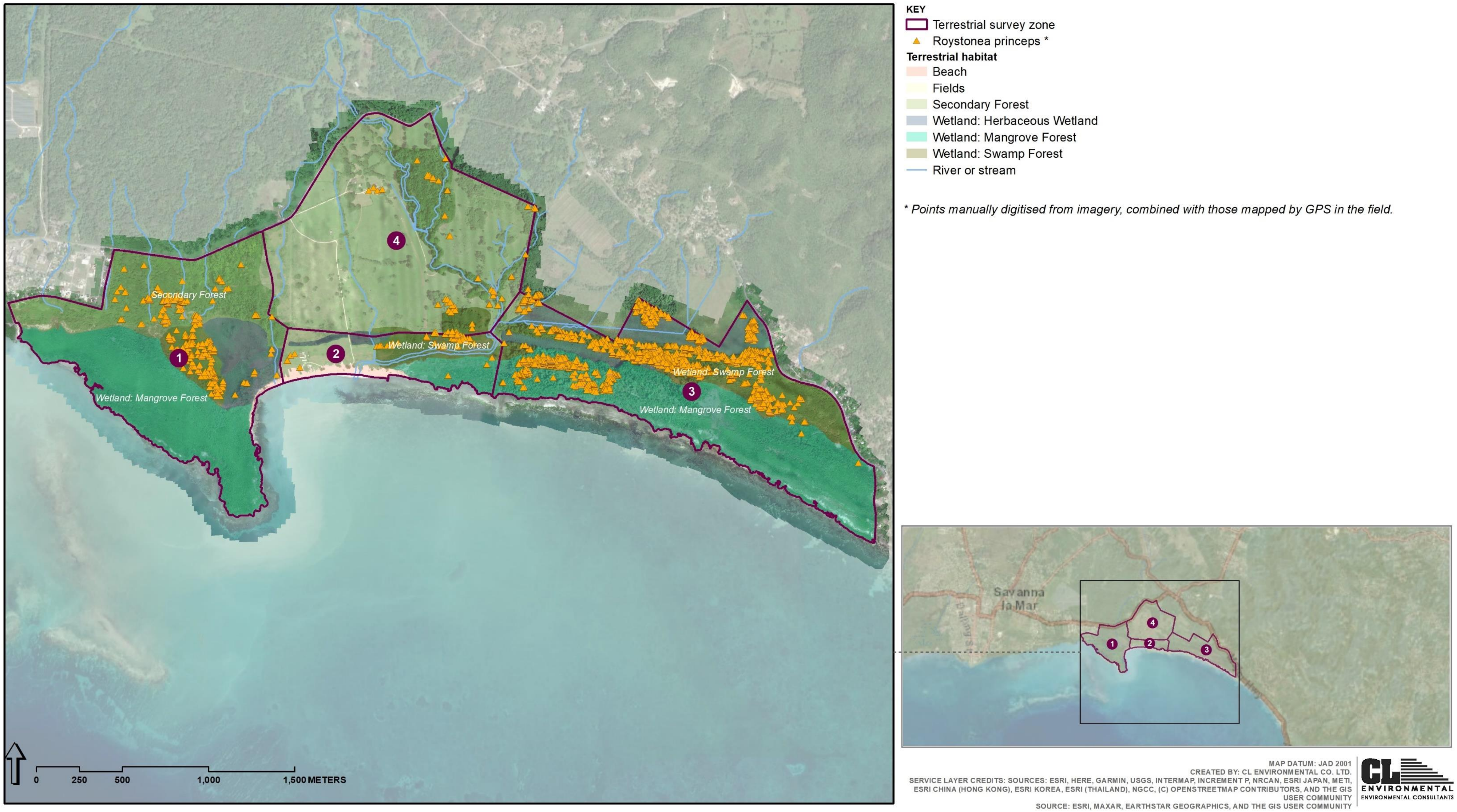


Figure 4-153 *Roystonea princeps* trees mapped in field and digitised from imagery.

4.2.2.4 Wetlands and Mangrove

Literature Review

Forested wetlands are areas with moist or inundated conditions, like mangrove forest (mangroves, mangal) and swamp forests. Mangroves are angiosperms found in the intertidal zone and adjacent communities of tropical and sub-tropical (31 °N and 38°S) coastlines (Gill and Tomlinson 1969; Tomlinson 1986) and may extend into warm temperate areas with minimal frost. A defining characteristic of mangroves is to adapt to saline, anoxic habitats (as seen in Trench, 2021) and have specialized roots to cope with occasional tidal energy and associated water movement.

Tomlinson (1986) noted over 50 mangrove species were belonging to 16 different families globally. Since the 1980s, the presence/occurrence of mangroves has increased, given that Hogarth (2015) identified about 70 taxonomically diverse, tree, shrub, and fern species (28 and 20 families, and nine orders, respectively).

Mangrove forests are revered globally for over 200 documented uses are well described (Tomlinson 1986; Kathiresan Kandasamy, and Bingham 2001; Hogarth 2017). These functions were grouped into regulating, supporting, provisioning, and cultural benefits by Webber et al. (2016) and listed below:

- Regulating: 1. Climate regulation; 2. Shoreline stabilization; 3. Water filtration and pollution regulation. 4. Coastal Protection and Resilience.
- Supporting: 1. Habitat for various biota, including juvenile fish that are important both as essential components of coral reef and other ecosystems and are important commercial species; 2. Carbon sequestration; 3. Spawning ground for numerous marine species.
- Provisioning: 1. Fisheries production 2. Aquaculture production 3. Pharmaceutical generation 4. Charcoal and lumber resources 5. Honey 6. Tannins 7. Salt.
- Cultural benefits: 1. Recreation and tourism; 2. Educational opportunities 3. Aesthetic and cultural values.

A 2016 World Bank study highlighted the role of mangroves in lowering erosion in several countries e.g. Philippines, Rwanda, Colombia, Costa Rica etc; indicating that wave height can be reduced by 13% to 66% over a 100-meter-wide mangrove belt and by 50% to 100% over a 500-meter-wide mangrove belt.

Emphasis on mangrove functionality and importance (Lee et al. 2014) has grown significantly in recent decades, with forests being increasingly celebrated globally for some of their vital roles in sustainable fisheries, shoreline protection (Uddin et al. 2013; Barbier 1993; World Bank 2019), bioremediation of wastes (Reef, Feller, and Lovelock, 2010; Alongi 2008), importance in carbon export/sequestration (Duke et al. 2007; Donato et al. 2011) and use as offsets to global emissions and tradable carbon credits (Trench, 2021).

The importance of mangroves and swamp forests is recognized through several legislations and policies which exist to offer more protection to these sensitive wetland ecosystems. As seen in the Forestry Département's National Mangrove and Swamp Forest Management Plan 2023-2033 (NMSFMP), "the country has approximately 5828 ha of mangrove and swamp forests with gazetted protection through various Acts including the NRCA Protected Areas, Forestry and the JNHT Acts".

The NMSFMP was developed with "ambitions of conserving an additional 4340 ha of GOJ-owned wetlands and 1300 ha of privately owned wetlands, with the restoration of at least 1000 ha of currently degraded mangroves and/or swamps". The vision statement for the NMSFMP is "By 2033, Jamaica's forested wetlands will be nationally recognized and valued by the Jamaican citizens, with over 67% (10,144 ha) of existing forested wetlands are conserved and/or restored and being sustainably used for income generation and green spaces, maintaining ecosystem services and delivering benefits essential for all people".

The proposed project site was captured as a swamp and mangrove forest in the NMSFMP Island wide surveys, as seen in Figure 4-155 below.

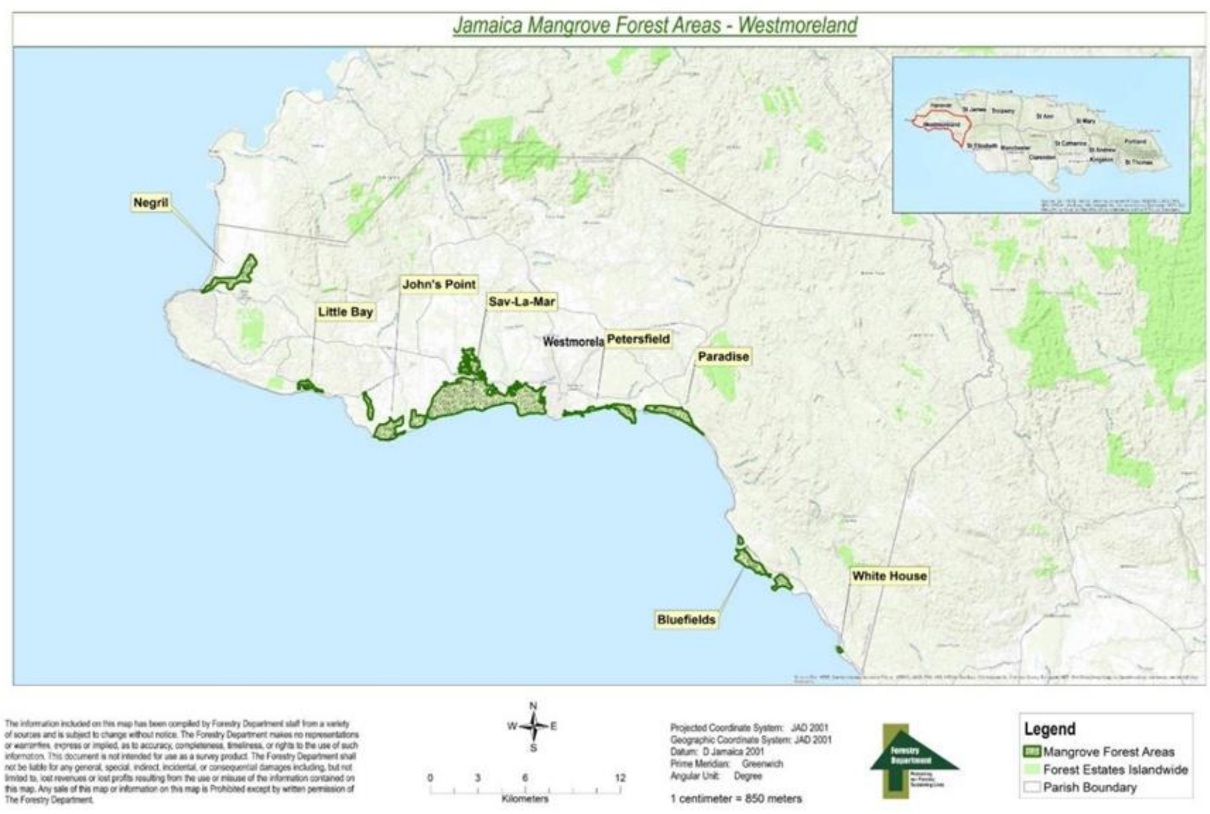


Figure 4-154 Map of forested wetlands found in Westmoreland parish, showing "Paradise" forested wetlands- as seen in NMSFMP 2023-2033

The proposed development site has been identified as part of a forested wetland system in the national inventory of wetlands and the National Mangrove and Swamp Forest Management Plan (NMSFMP), which was conducted between 2021 and 2023 (Forestry Department, 2022) . While the report categorizes the property into distinct zones, the NMSFMP documentation refers to the "Paradise" site as consisting of two separate areas: East (149.1 ha) and West (117 ha). It is important to note that these areas represent the broader connected wetland systems, which extend beyond the current study site and the proposed development area (Figure 4-155).

Figure 4-155 Paradise East and Cave Forested Wetlands (top) and Paradise West to Petersfield Forested Wetlands (bottom) (Forest Department 2021)

Forested wetlands are characterized by woody trees that thrive in areas with permanent or seasonal moisture or inundation, which can occur in saline, freshwater, or brackish (mixed) environments. In Jamaica, the two most common types of forested wetlands are swamp forests and mangrove forests. Swamp forests are dominated by water-tolerant, woody trees that are continually or seasonally flooded by riverine water sources, and these trees are specifically adapted to freshwater conditions (Forestry Department, 2023). Mangrove forests, on the other hand, are primarily composed of woody angiosperms (flowering plants) found in the intertidal zones and adjacent coastal areas of tropical and subtropical regions. Mangroves have unique adaptations that allow them to withstand prolonged exposure to tidal seawater, including mechanisms for salinity exclusion and excretion, as well as specialized roots with spongy, aerenchyma tissue that helps them cope with saltwater inundation (Gill and Tomlinson, 1969; Hogarth, 2015).

Survey Methods

VEGETATION ASSESSMENT

A roving ecological survey was conducted for a significant portion of the forested area at Paradise Park, Westmoreland, between August 26 and September 10, 2023. Throughout the study area vegetation data was collected from a total of twenty-two (22) quadrats, each measuring 10m X 10m (100 m^2), as seen in Figure 4-156.

Data collected in the quadrats included:

- Non- mangrove species present
- Number and types (species) of mangrove flora
- Height of mangrove tree species(m)-from a maximum of 10 individuals
- Diameter at breast height of mangrove tree species(cm)- from a maximum of 10 individuals
- Seedling Density (per m^2) for each mangrove species
- Water salinity (part per thousand-ppt)

Figure 4-156 **Map showing Quadrat locations and water level logger deployment locations**

VISIBLE HYDROLOGY ASSESSMENT

Standing water depth within each quadrat was measured at the centre of the quadrat. To assess and understand the visible hydrology of the site, Hobo U-20 water level loggers were deployed at three locations for a minimum of seven days; collecting hourly water pressure readings which were then converted to depth in centimetres. Hydrological features (culverts, creeks, flow points) were also observed during the roving surveys of the property. Water salinity was also collected throughout these surveys to generate a salinity map.

MANGROVE SOIL CARBON AND LEAF PRODUCTIVITY ASSESSMENT

Field Collection

Soil carbon storage assessment was conducted on August 26, 2023. Four (4) sediment cores were randomly taken from mangrove areas in zones 1-3 at the study site; listed below in Table 4-31GPS coordinates were taken at the core extraction points.

Table 4-31 **Geo- reference data for soil cores collected.**

Core Name	Location
C1	18.207373, -78.087676
C2	18.210779, -78.087426
C3	18.212871, -78.074830
C4	18.213326, -78.078881

A 1.7 m rebar was used at each location to determine the maximum depth of soil within each area. Cores were collected using a 5 cm diameter semi-cylindrical Russian peat corer with extensions (see Plate 2-1 below). Each core was further subdivided into 0-15 cm, 15-30 cm, 30-50cm and 50-100 cm subsections as per highly aggregated sampling scheme described by Howard et al. (2014). Each subsection was packed in sampling bags, preserved in a cooler and stored at 4°C in a refrigerator until processed.

Plate 4-30 Mangrove soil core sample

Laboratory Analysis

The wet weight of all samples was determined and then placed in an oven at 60°C for 48-72 hours until a constant dry mass was achieved. The samples were re-weighed and combust at 550°C for 5 hours in a muffle furnace. After cooling, the samples were re-weighed. The volume, bulk density, % Loss on ignition and soil carbon stock were calculated as seen below:

- Volume; where r is the radius of diameter and h is the length of sample (cm)
- Dry Bulk density (g cm^3):
- %Loss on ignition:
- %C org: %LOI *0.58
- Carbon density: Dry bulk density * (%C org/100)
- Carbon stock: Carbon density * depth interval
- Total core carbon: Sum of subsamples per core (g/cm^3) * 1Mg/1,000,000g *(100,000,000 cm^2/1 hectare)

- Project site carbon: Average of all cores * project area size

Leaf litter traps were set in duplicates at 6 locations, on Day 1 and 2 of the survey and collected on September 2.

Results

Figure 4-157 below shows the locations of all quadrats used to collect mangrove forest information. Based on the extent of mangrove forest surveyed on the property, data was only collected from zones 1, 2 and 3. Sections 4-6 did not display any mangrove vegetation.

The quadrats fell into 3 zones based on the properties division.

- Zone 1: Q 1-5 and 14-18
- Zone 2: Q6 and Q8-10
- Zone 3: Q7, Q12-13 and Q19-22

Figure 4-157 Location of all quadrats used to collect mangrove forest data.

Figure 4-158 Map of wetland leaf productivity and soil core sample sites

ZONE 1

Zone 1 is characterized as an estuarine mangrove forest. Quadrats 1-5 and 14-18 were sampled from this zone (Table 4-32). The quadrats sampled within this zone had tree heights ranging from 6-11m, with the exception of Q 17. Q17 is seemingly recovering from a natural mortality event and boasted trees with heights less than 4m tall. Seedling density was rather low in all quadrats (less than 20 seedlings per m^2), which is expected considering the high tree densities (15 and above) of most areas sampled.

Table 4-32 Mangrove Species found in Zone 1 (Q1-5 and Q14-18).

Location	Salinity (ppt)	Mangrove Species	Tree Density	Mean Height (m)	Mean DBH (cm)	Seedling Density (per m^2)
Q1	20	*R. mangle*	16	10.3	17.35	1
Q2	7	*R. mangle*	21	6.19	8.11	-
		L. racemosa	2	7.5	14	-
Q3	0	*R. mangle*	24	7.31	9.5	
Q4	0	*R. mangle*	34	9.85	10.4	12
Q5	0	*C. erectus*	4	11.5	29.5	
Q14	32	*R. mangle*	13	9.49	20.5	2
Q15	35	*R. mangle*	19	9.3	12.8	4
Q16	35	*R. mangle*	34	9	13.3	9

Location	Salinity (ppt)	Mangrove Species	Tree Density	Mean Height (m)	Mean DBH (cm)	Seedling Density (per m²)
Q17	35	*R. mangle*	11	3.13	0.1	9
		L. racemosa	3	2.73	<0.1	12
Q18	35	*R. mangle*	24	10.58	15.65	6

Zone 1 was dominated by *Rhizophora mangle* and lesser amounts of *Laguncularia racemosa* in the sample plots. As seen in Table 4-32 below, the salinity at Q2 is indicative of an estuarine area with mixed salinity while quadrats 3-5 were riverine in nature. Q5 vegetation indicates a freshwater transition zone with non-mangrove species like *Typha*, *Dalbergia* sp.

In terms of fauna, zone 1 had a high occurrence of puffer fish, *Aratus* sp (mangrove tree crabs), mangrove snails and coffee snails.

Plate 4-31 Survey team collecting data in Q1.

ZONE 2

Zone 2 is currently the most developed area of the site, and this had less mangrove forest trees and mangrove trees of lower stature. The quadrats sampled in this zone had the shortest trees and lower trees densities comparatively. Tree heights ranged from 3 to 11m maximum heights, which was seen in the semi-mangrove species *Conocarpus erectus* (buttonwood).

Though the mangrove sections showed an estuarine character, this zone has many sections that may be characterized as a transitional mangrove forest. Zone 2 was dominated by white mangroves, but other wetland/ecotone species could be seen at the mangrove boundary in most areas. Seedling densities were very low except for Q10 which boasted over 300 seedlings per $m^{2.}$

Table 4-33 Mangrove Species found in Zone 2 (Q6 and Q8-10).

Location	Salinity (ppt)	Mangrove Species	Density	Mean Height (m)	Mean DBH (cm)	Seedling Density (per m²)
Q6	0	*R. mangle*	7	8.57	13.67	1
		L. racemosa	1	9	114	1
Q8	10	*R. mangle*	2	5.95	10.5	-
		C. erectus	13	3.96	3.88	5
		L. racemosa	20	2.46	15.13	8
Q9	0	*L. racemosa*	-	-	-	8
Q10	0	*L. racemosa*	5	6.9	6.8	300+
		C. erectus	2	11	78.5	

Plate 4-32 Mangrove vegetation observed at Q6.

ZONE 3

Zone 3 is the Eastern-most section of the property and boasted the most robust mangrove trees. *Rhizophora mangle* (red mangrove trees) reached heights over 20m in one quadrat, in an area that was seemingly the most pristine of the entire property sampled. Table 4-34 shows the summary of sites in Zone 3 and Plate 4-33 shows the forest structure at one of the sites, Q-20.

Table 4-34 Mangrove species found in Zone 3 (Q7, Q12,13 and Q19-22).

Location	Mangrove species	Salinity (ppt)	Density	Avg. height (m)	Avg. DBH (cm)	Seedling Density (per m²)
Q7	*L.racemosa*	0	2	8	32.5	
Q12	*R. mangle*	0	14	12.63	19.8	20
Q13	*R. mangle*	0	8	23.88	30.13	63
Q19	*L.racemosa*	35	11	7.37	6.4	0
	R. mangle	35	16	6.4	6.9	0
Q20	*R. mangle*	35	19	6.9	7.7	0
	L.racemosa	35	11	10.1	8.5	0
Q21	*R. mangle*	8	17	8.92	13.8	0
Q22	*R. mangle*	30	19	5.98	7.05	24
	A. germinans	30	1	8.5	30	0

Plate 4-33 Mangrove Forest structure at Q20.

Figure 4-159 shows the mean height for the mangrove trees on the entire property, occurring in the various zones. Most sample locations displayed mangrove trees 10m or below, with the exception of the T11-T13 locations, found in zone 3.

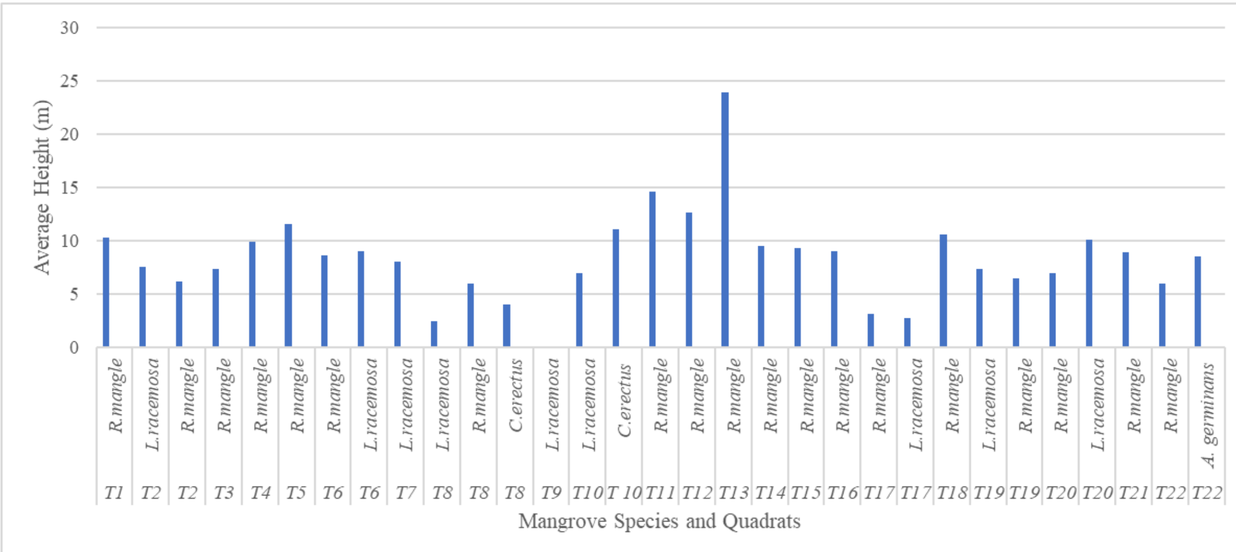


Figure 4-159 Mean height of mangrove species in various zones.

SOIL CARBON

Mangroves within this site grows on peat and sand substrates with maximum depths ranging from 1.1 m at C2 to 1.4 m at C1 and C3 (Table 4-35). Mangrove peat was observed in the 0-50cm depth ranges in Core 1 and Core 3 while the 50-100cm consist of a mixture of peat and sandy soil. Core 3 and 4 contained more sandy soil in the 1 m core.

Table 4-35 Maximum soil core depth within site.

Core name	Maximum soil depth (m)
C1	1.4
C2	1.1
C3	1.4
C4	1.3

Bulk density per subsample ranged from 0.09 to 0.67 gcm^{-3} with an average of 0.33 gcm^{-3} at the site. These values are consistent with bulk densities of tropical wetlands (Adame et al. 2013; Kauffman et al. 2014).

Soil carbon stocks for the 1 m core are shown in Figure 4-160 ranging from a low of 380.46 in C3 to a high of 502.93 in C4 with an overall average of 441.11 ±27.57 Mg C ha^{-1} for the site.

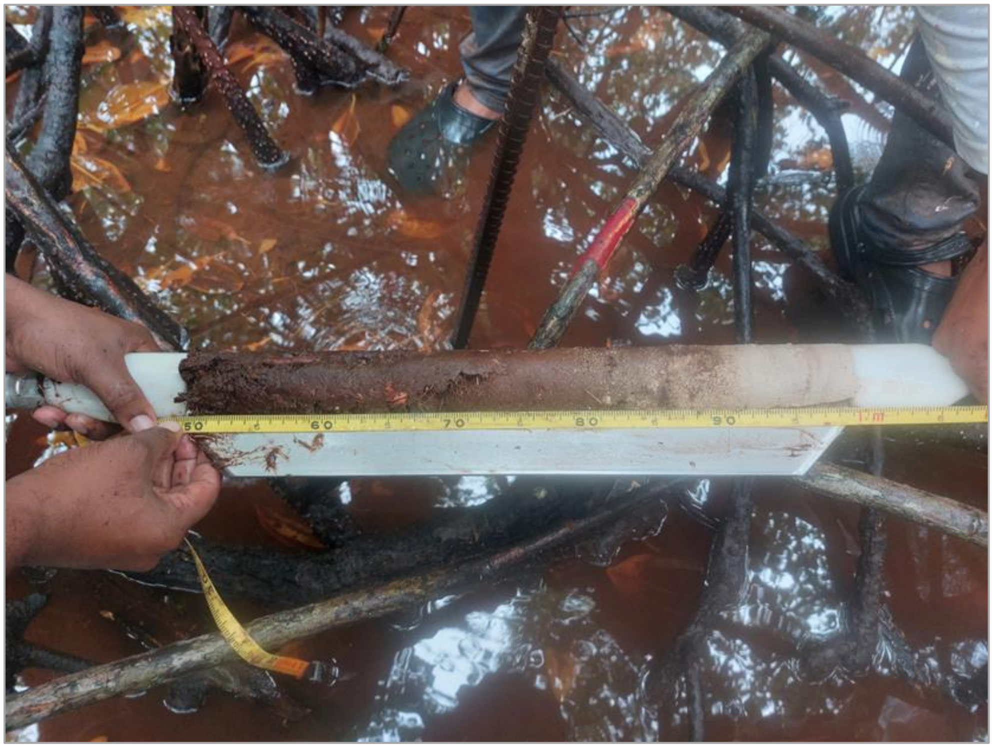


Plate 4-34 **Soil core collected 50m-100m (C1).**

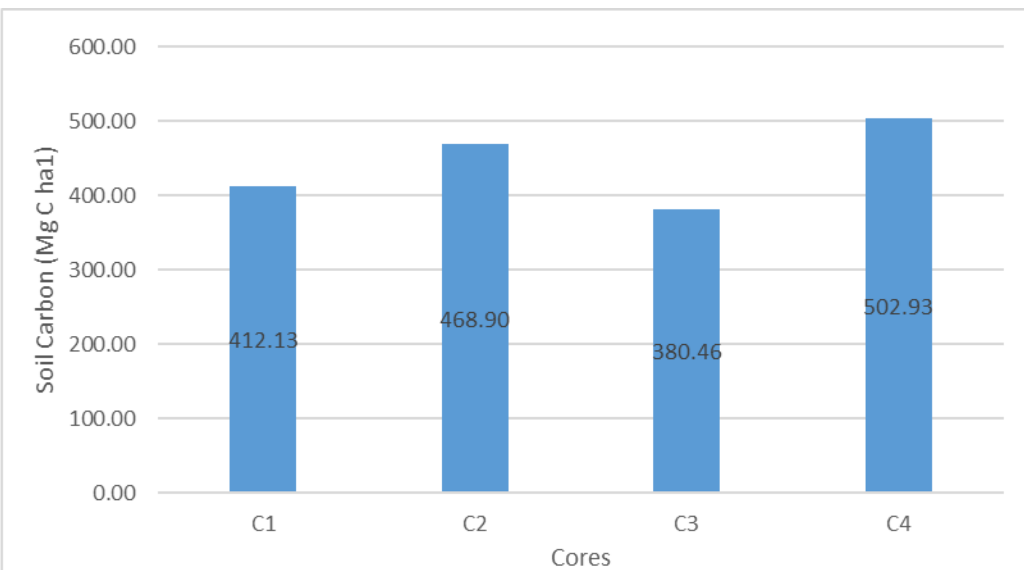


Figure 4-160 **Soil Carbon results from four core sites at study site**

Using the average carbon stock and total mangrove forest wetlands area coverage for the Paradise wetlands of 266 hectares (as stated by the Forestry Department), the total peat carbon storage within the site was estimated as 117,335.26 Mg C.

Table 4-36 Soil depth, bulk density, and the soil carbon stocks of mangroves at the site.

Core name	Sample depth	Soil Dry bulk density (g/cm^3)	Carbon Stock ($Mg\ C\ ha^{-1}$)	Total carbon per core ($Mg\ C\ ha^{-1}$)	Average site carbon stock	Site size (ha)	Total project carbon stock
C1	0-15	0.09	55.83	412.13	441.11	266	**117,335.26 Mg C**
C1	15-30	0.13	83.89				
C1	30-50	0.11	84.90				
C1	50-100	0.32	187.51				
C2	0-15	0.24	42.30	468.90			
C2	15-30	0.37	61.91				
C2	30-50	0.39	77.10				
C2	50-100	0.67	287.59				
C3	0-15	0.13	51.10	380.46			
C3	15-30	0.20	77.33				
C3	30-50	0.33	105.22				
C3	50-100	0.61	146.81				
C4	0-15	0.34	38.40	502.93			
C4	15-30	0.34	53.76				
C4	30-50	0.31	171.15				
C4	50-100	0.64	239.62				

VISIBLE HYDROLOGY RELATED TO WETLANDS AND MANGROVE FOREST STRUCTURE

Three water level loggers that were deployed in the various sections of the property revealed that the entire forest is tidally influenced with near identical tidal rhythm. Figure 4-161 and Figure 4-162 below shows the plot results for water level loggers 1 and 2, deployed about 1.5 km apart. Despite the distance and differences in water pressure peaks (indicating water depth), the water peaks and lows were matching in most instances. For example, both showed the highest water level on Sept 3 and the lowest on Sept 9th. Logger 2 did show lower mean water temperature however, indicating a more sustained flow of riverine water.

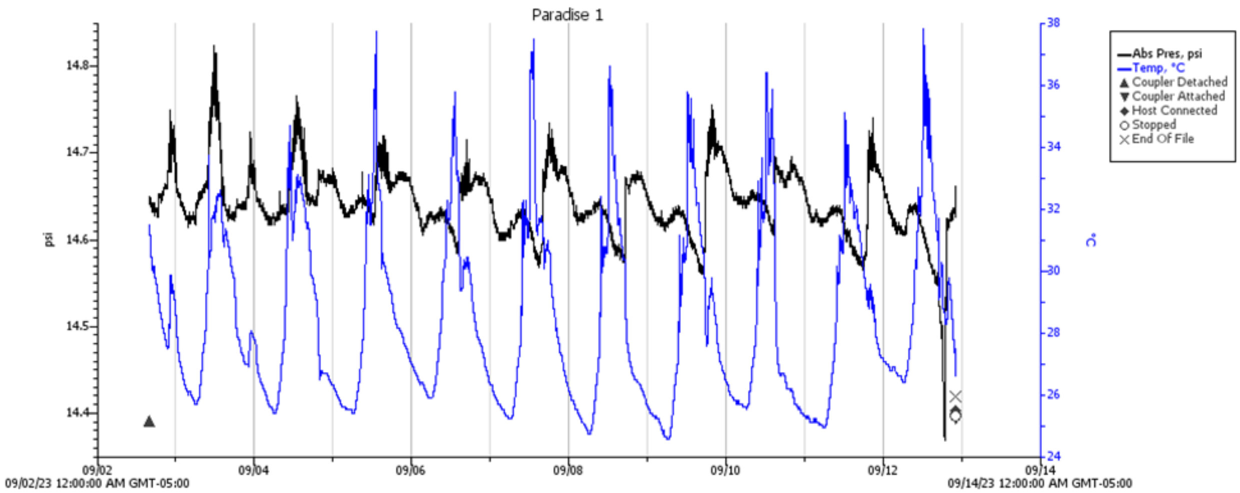


Figure 4-161 Hobo U-20 water level logger graph for logger #1 placed to the West

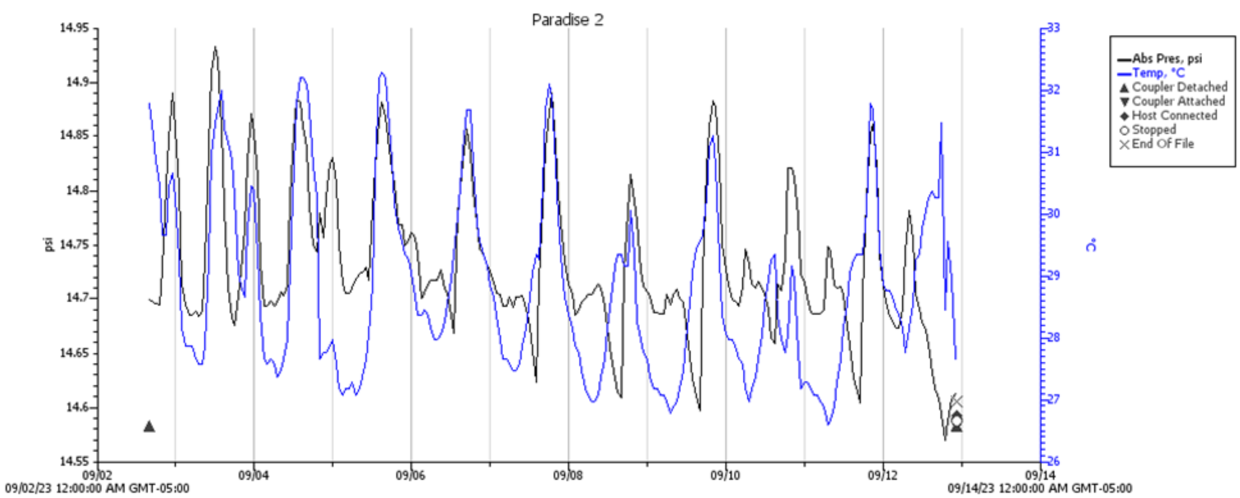


Figure 4-162 Hobo U-20 water level logger graph for logger #2 placed in the central area

Figure 4-163 highlights the great variability of the salinities of the estuarine mangrove forests found in zones 1-3. Quadrats sampled in zone 3 were influenced predominantly by seawater, except quadrat 21 where there was evident mixing of fresh and seawater as the salinity was 8ppt.

Q2 with a salinity of 7ppt and lower water temperatures in zone 1 was likely influenced by the observed outflow point in that area. The visible hydrology walk-through by the team supports this data as the team observed active outflows in the Q2 area on one occasion. As indicated in the visible hydrology map below (Figure 4-164), the entire Eastern edge of Zone 1 is a key hydrological feature of the property. Water originating from the waterways on the open fields eventually meander to the herbaceous wetlands and through the mangrove forest into the sea close to the Bluff Point.

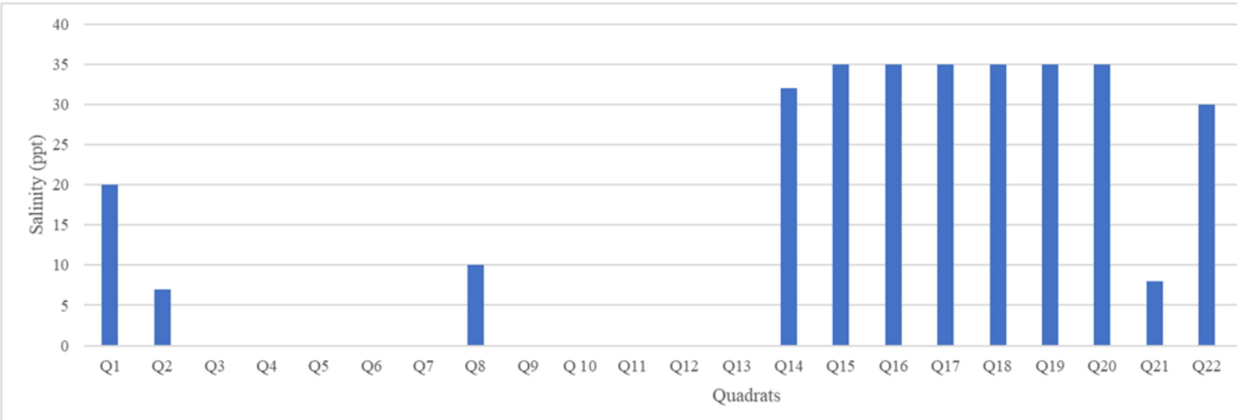


Figure 4-163 Range in salinity across the mangrove forest sample quadrats.

Figure 4-164 Visible hydrology observations for the Western property.

Figure 4-165 Observed visible hydrology for the Eastern wetlands of the property.

The Eastern wetlands (zone 3) showed more defined outflow points via streams and a storm drain near the cave community. The Cave storm drain does not empty directly into the sea however, but meanders through the mangrove forest and may have slow release via tidal movement. This fresh water originated from the herbaceous wetlands between the highway and the mangroves. The transition zone between these herbaceous plants and pure mangrove stands is indicated by forested wetlands. The mangrove zone is indicative of the highest tidal reaches, where mangrove plants out-compete these other species.

Support for this theory is shown in observing the salinity of the Easternmost water level loggers, where a salinity of 20ppt was recorded. Despite no obvious river, the water was mixed almost 50% of salt and fresh water. This is likely the result of the storm drain's waters reaching this area while tidal waters enter from the South and mix the fresh waters almost evenly in this location.

MANGROVE PROP ROOTS

The mangrove prop roots that were observed during marine benthic surveys were devoid of invertebrates and encrusting organisms. This is expected as the outflows of freshwater into the marine areas may limit the occurrence of marine organisms. Mangrove prop roots in saline environments may be normally colonized with bivalves, worms, ascidians etc. However, the proposed study site is dominated by fresh water and thus the encrusting community is absent. As seen in the figures below, only a few species of macro-algae were observed on these roots.

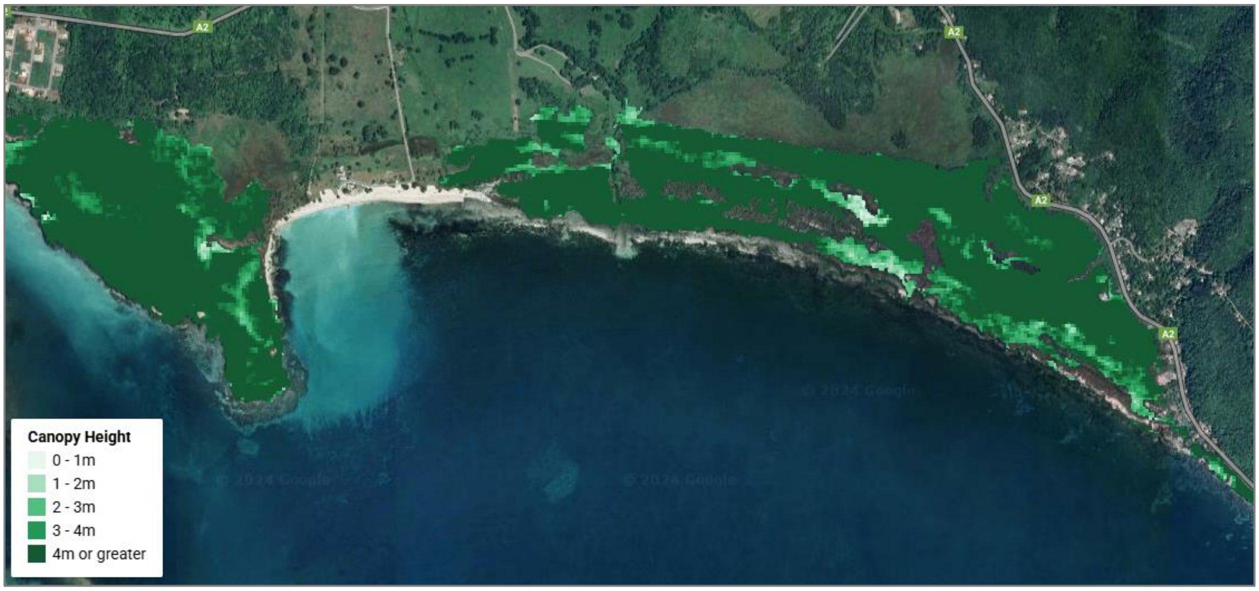
Plate 4-35 Mangrove prop roots either bare or colonized by algae

Plate 4-36 Mangrove prop roots either bare or colonized by algae

Mangrove Change Analysis

The Nature Conservancy's Blue Carbon Explorer tool was utilized to assess canopy height data and monitor changes in mangrove forests over time within the study area. This tool plays a crucial role in prioritizing the restoration and conservation of mangroves and seagrasses in the Caribbean by evaluating their capacity to store carbon[6]. It must be noted that efforts are currently underway to refine mangrove maps using field data and local knowledge, ensuring a more accurate representation of these vital ecosystems. Comparisons with field surveys conducted within the project area reveal that the region classified as mangroves is a mix of wetland types, including mangroves, swamp forests, and herbaceous wetlands (Figure 4-122). The TNC data remains a valuable resource, providing canopy height and temporal analysis, which is crucial for this project.

Within the project area, canopy heights are typically over 4m, with some areas showing heights below this (Figure 4-166).



Source: (The Nature Conservancy, 2024)

Figure 4-166 TDX canopy height

Field observations and visual historical image analysis revealed the temporal presence of mudflats in the project area. This finding is supported by significant changes in mangrove biomass between 2017 and 2024 in the eastern wetlands (The Nature Conservancy, 2024), highlighted in yellow in Figure 4-167. In 2017, the area defined as mudflats, with low biomass, was expansive, but by 2023, it had shrunk as mangroves grew (Table 4-37). The observed changes are likely driven by hydrological inputs, in contrast to the small area of significant biomass loss near the main road to the east, which is likely caused by anthropogenic factors. Overall, the wetland and mudflat habitats in the project area exhibit notable temporal changes as demonstrated by biomass variations over the years (Figure 4-168), and these changes must be considered in any restorative or ecological restoration programmes.

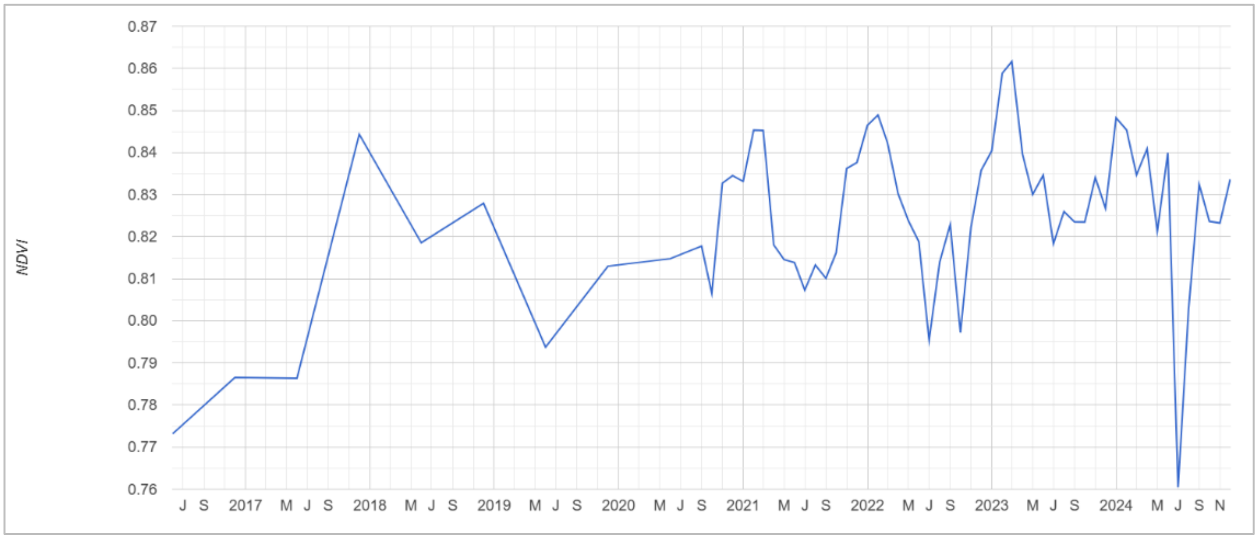
[6] https://BlueCarbon.tnc.org

Source: (The Nature Conservancy, 2024)

Figure 4-167 NDVI change in mangrove biomass between 2017 and 2024.

Table 4-37 Google Earth imagery of eastern wetlands in project area, showing changes in mangrove biomass and temporal nature of the mudflat habitat (circled in yellow).

 **2017**	 **2020**
 **2022**	 **2023**



Source: (The Nature Conservancy, 2024)

Figure 4-168 NDVI time series for mangrove biomass between 2017 and 2024

4.2.2.5 Fauna

Literature Review

The Paradise property has been influenced by agricultural practices since the 17th century, where crops and animals such as horses, cows, goats, and chickens are farmed. These practices have influenced the fauna which is present on the property. There is little information available on the fauna groups on the property, hence it was important to acquire baseline information on the fauna. In the parish of Westmoreland 173 species of birds have been reported on the Ebird app consisting of terrestrial, wetland and coastal birds which could be in the project area (Fink, et al., 2018). Several of those species could occur on the property.

Survey and Analytical Methods

Faunal assessments were carried out zone in four zones, within which various methodologies were used across the following terrestrial habitat types: Secondary Forest, Wetland, Beach, and Fields (including herbaceous crops, fallow land, and cultivated vegetables (Figure 4-169). These assessments covered different faunal groups including birds, invertebrates and herpetofauna. The DAFOR scale was applied to rank the relative abundance of species within each habitat area in the study (Table 4-38).

Table 4-38 DAFOR scale used to categorise the fauna

	Total number of species observed during the survey
Dominant	≥ 20
Abundant	15 – 19
Frequent	10 – 14)
Occasional	5- 9
Rare	< 4

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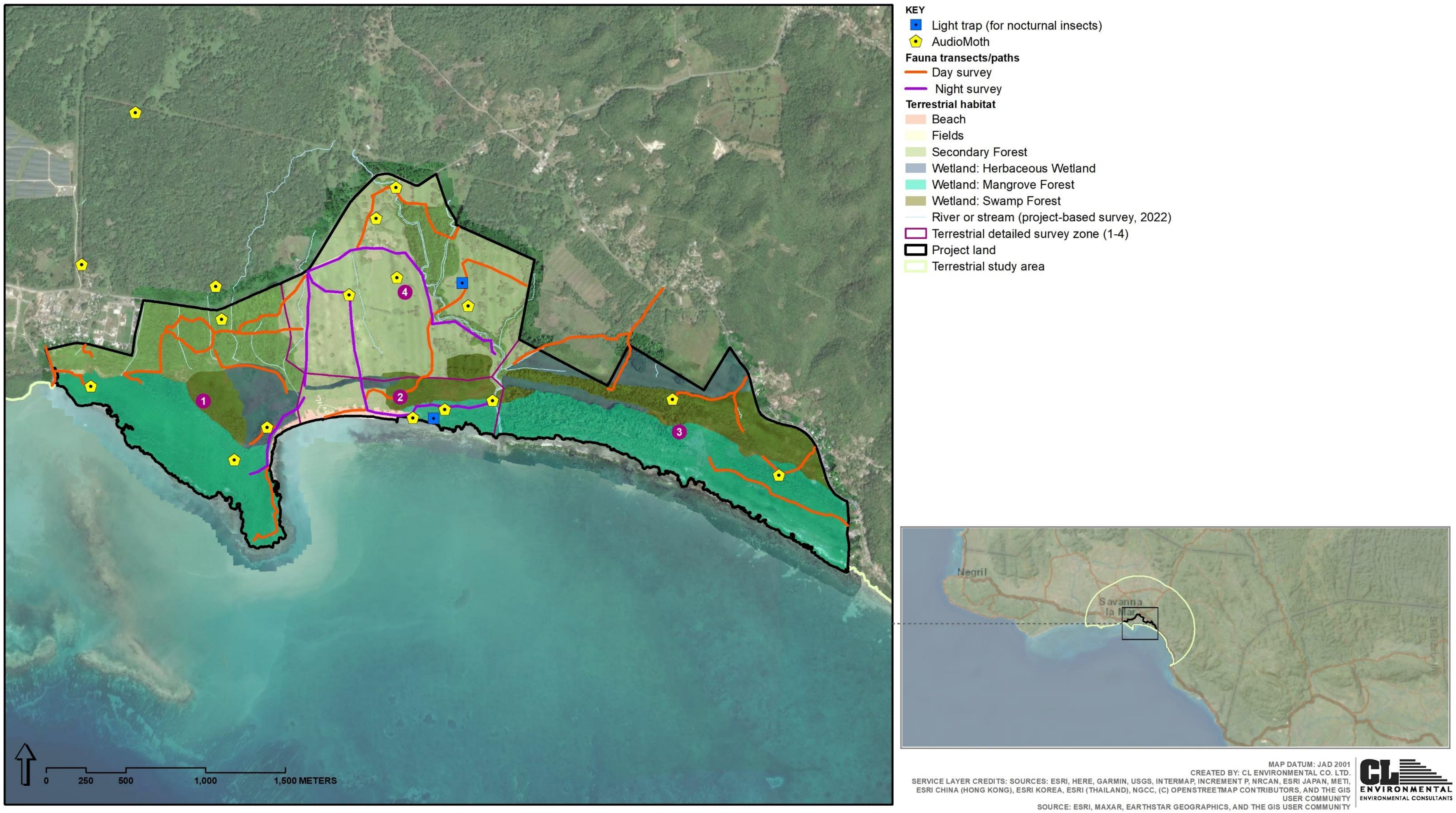


Figure 4-169 Fauna survey locations and transects

Bird Assessment

METHOD

The avian study was conducted in the vegetation zones in the project area using the methods listed below. The field study was conducted in 2023 for 5 days and 2 nights. At the same time, the acoustic study was conducted over 2 weeks.

The Line Transect method was the main method selected for the bird survey, as there were several roads/trails throughout the project area. The method entailed walking steadily along the specified path for a given distance (>100m) while recording all bird species seen or heard (Bibby et al., 2000). This method was conducted both during the day and at night. The birds observed for the first time while conducting other fauna surveys were added to the list. People in the project area were informally interviewed about the birds they observed on the property.

A modified point survey was conducted at the waterbodies (river, ponds, and coast) on the property. The method entails standing at a vantage point and noting all the birds observed at the site for 8 minutes.

Five Audio Moth devices were deployed for the nocturnal bird survey. The devices were active from 17:30 to 06:30. The audio files were processed using the Kaleidoscope Pro software from Wildlife Acoustics and the process audio file ID by experts.

Reference material used in species identification (pictures and calls) includes Merlin App (Cornell University, 2021), Ebird (Fink, et al., 2018), Birds of Jamaica (Downer & Sutton, 1990) and Bird of the West Indies (Raffaele, et al., 1998).

RESULTS AND DISCUSSION

A total of 97 bird species were observed across the property: 15 residents (endemic), 5 introduced, 25 migrants and 52 residents (non-endemic) (Table 4-39). Of note, 330 bird species have been reported in Jamaica (Lepage, 2024). The number of bird species varied across habitat types; 53 Secondary Forest, 66 wetland, 17 and 54 Fields, herbaceous crops, follow and cultivated vegetables.

Table 4-39 Bird species recorded in the study area.

Abbreviations: Range (Re- Resident, Mi- Migrant, En- Endemic, In- Introduce), IUCN status (LC- Least concern, NT- Near Threatened) and DAFOR (D-Dominant, A- Abundant, F- Frequent, O-Odd, R- Rare).

#	Common Name	Scientific Name	Range	IUCN	Secondary Forest	Wetland	Beach	Fields
1	American Kestrel	*Falco sparverius*	*Re*	LC	R	R		R
2	American Redstart	*Setophaga ruticilla*	*Mi*	LC	O	R		R
3	Antillean Nighthawk	*Chordeiles gundlachii*	*Mi*	LC		R		**R**
4	Antillean Palm-Swift	*Tachornis phoenicobia*	*Re*	LC	R	F	D	**A**
5	Bananaquit	*Coereba flaveola*	*Re*	LC	O	R		O

#	Common Name	Scientific Name	Range	IUCN	Secondary Forest	Wetland	Beach	Fields
6	Barn Owl	*Tyto alba*	*Re*	LC				R
7	Belted Kingfisher	*Megaceryle alcyon*	*Re*	LC			R	
8	Black-and-white Warbler	*Mniotilta varia*	*Mi*	LC	R	R		
9	Black-bellied Plover	*Pluvialis squatarola*	*Mi*	LC			O	
10	Black-crowned Night-Heron	*Nycticorax nycticorax*	*Re*	LC		R	R	
11	Black-faced Grassquit	*Melanospiza bicolor*	*Re*	LC	O	R		O
12	Black-necked Stilt	*Himantopus mexicanus*	*Re*	LC		O	R	
13	Black-throated Blue Warbler	*Setophaga caerulescens*	*Mi*	LC	R	R		R
14	Black-whiskered Vireo	*Vireo altiloquus*	*Mi*	LC	F	R		R
15	Blue-winged Teal	*Spatula discors*	*Mi*	LC		O		
16	Brown Pelican	*Pelecanus occidentalis*	*Re*	LC		R	R	
17	Cape May Warbler	*Setophaga tigrina*	*Mi*	LC	O	R		
18	Caribbean Dove	*Leptotila jamaicensis*	*Re*	LC	R			
19	Cave Swallow	*Petrochelidon fulva*	*Re*	LC				O
20	Common Gallinule	*Gallinula galeata*	*Re*	LC		R		
21	Common Ground Dove	*Columbina passerina*	*Re*	LC	O	R		O
22	Common Yellowthroat	*Geothlypis trichas*	*Mi*	LC		R		
23	European Starling	*Sturnus vulgaris*	*In*	LC	O			D
24	Glossy Ibis	*Plegadis falcinellus*	*Re*	LC		O		R
25	Gray Kingbird	*Tyrannus dominicensis*	*Mi*	LC	R	O	R	O
26	Great Blue Heron	*Ardea herodias*	*Re*	LC		R		R
27	Great Egret	*Ardea alba*	*Re*	LC		R	R	R
28	Greater Antillean Bullfinch	*Melopyrrha violacea*	*Re*	LC	R			
29	Greater Antillean Elaenia	*Elaenia fallax*	*Re*	LC	R			R
30	Greater Antillean Grackle	*Quiscalus niger*	*Re*	LC	O	R		O
31	Green Heron	*Butorides virescens*	*Re*	LC		R		R

#	Common Name	Scientific Name	Range	IUCN	Secondary Forest	Wetland	Beach	Fields
32	Green-rumped Parrotlet	*Forpus passerinus*	*In*	LC	O	R		
33	Indian peafowl	*Pavo cristatus*	*In*	LC				R
34	Jamaican Becard	*Pachyramphus niger*	*En*	LC	R			
35	Jamaican Crow	*Corvus jamaicensis*	*En*	NT	R			
36	Jamaican Euphonia	*Euphonia jamaica*	*En*	LC	O	R		R
37	Jamaican Lizard-Cuckoo	*Coccyzus vetula*	*En*	LC	R			
38	Jamaican Mango	*Anthracothorax mango*	*En*	LC	R	R		R
39	Jamaican Oriole	*Icterus leucopteryx*	*Re*	LC	O	R		R
40	Jamaican Parakeet	*Eupsittula nana*	*En*	NT	O	O		O
41	Jamaican Pewee	*Contopus pallidus*	*En*	LC	R			R
42	Jamaican Tody	*Todus todus*	*En*	LC	R	R		
43	Jamaican Vireo	*Vireo modestus*	*En*	LC	R	R		R
44	Jamaican Woodpecker	*Melanerpes radiolatus*	*En*	LC	R	R		R
45	Killdeer	*Charadrius vociferus*	*Re*	LC		O	R	R
46	Laughing Gull	*Leucophaeus atricilla*	*Re*	LC			O	
47	Least Bittern	*Botaurus exilis*	*Re*	LC		R		
48	Lesser Yellowlegs	*Tringa flavipes*	*Mi*	LC		R	R	
49	Little Blue Heron	*Egretta caerulea*	*Re*	LC		R	R	
50	Loggerhead Kingbird	*Tyrannus caudifasciatus*	*Re*	LC	O	R		R
51	Louisiana Waterthrush	*Parkesia motacilla*	*Mi*	LC		R		
52	Magnificent Frigatebird	*Fregata magnificens*	*Re*	LC		R	R	
53	Mangrove Cuckoo	*Coccyzus minor*	*Re*	LC		R		
54	Mourning Dove	*Zenaida macroura*	*Re*	LC				O
55	Northern Jacana	*Jacana spinosa*	*Re*	LC		R		
56	Northern Mockingbird	*Mimus polyglottos*	*Re*	LC	O	R		O
57	Northern Parula	*Setophaga americana*	*Mi*	LC	R	R		R
58	Northern Potoo	*Nyctibius jamaicensis*	*Re*	LC		R		R
59	Northern Waterthrush	*Parkesia noveboracensis*	*Mi*	LC	R	O		

#	Common Name	Scientific Name	Range	IUCN	Secondary Forest	Wetland	Beach	Fields
60	Osprey	*Pandion haliaetus*	*Re*	LC		R	R	
61	Ovenbird	*Seiurus aurocapilla*	*Mi*	LC	R			
62	Palm Warbler	*Setophaga palmarum*	*Mi*	LC	R			R
63	Prairie Warbler	*Setophaga discolor*	*Mi*	LC	O	O		R
64	Red Streamertail Hummingbird	*Trochilus polytmus*	*En*	LC	R	R		R
65	Red-tailed Hawk	*Buteo jamaicensis*	*Re*	LC	R			R
66	Rock Pigeon	*Columba livia*	*Re*	LC				O
67	Royal Tern	*Thalasseus maximus*	*Re*	LC			O	
68	Ruddy Turnstone	*Arenaria interpres*	*Mi*	LC			F	
69	Rufous-tailed Flycatcher	*Myiarchus validus*	*En*	LC	R			R
70	Sad Flycatcher	*Myiarchus barbirostris*	*En*	LC	R			R
71	Sanderling	*Calidris alba*	*Mi*	LC		R	R	
72	Sandwich Tern	*Thalasseus sandvicensis*	*Re*	LC			R	
73	Shiny Cowbird	*Molothrus bonariensis*	*In*	LC		R		D
74	Smooth-billed Ani	*Crotophaga ani*	*Re*	LC	O	R		O
75	Snowy Egret	*Egretta thula*	*Re*	LC		R	R	
76	Spotted Sandpiper	*Actitis macularius*	*Mi*	LC		R	R	
77	Stolid Flycatcher	*Myiarchus stolidus*	*Re*	LC	R			
78	Swallow species							R
79	Tricolored Heron	*Egretta tricolor*	*Mi*	LC		R		
80	Tricolored Munia	*Lonchura malacca*	*In*	LC				O
81	Turkey Vulture	*Cathartes aura*	*Re*	LC	O	O	O	O
82	Vervain Hummingbird	*Mellisuga minima*	*Re*	LC	O	R		R
83	Western cattle Egret	*Ardea ibis*	*Re*	LC	F	O		O
84	White Ibis	*Eudocimus albus*	*Re*	LC		R		
85	White-chinned Thrush	*Turdus aurantius*	*En*	LC	O	R		R
86	White-collared Swift	*Streptoprocne zonaris*	*Re*	LC				O
87	White-crowned Pigeon	*Patagioenas leucocephala*	*Re*	NT	O	O		R

#	Common Name	Scientific Name	Range	IUCN	Secondary Forest	Wetland	Beach	Fields
88	White-winged Dove	*Zenaida asiatica*	*Re*	LC	O	R		O
89	Willet	*Anarhynchus wilsonia*	*Mi*	LC			R	
90	Wilson's Plover	*Charadrius wilsonia*	*Mi*	LC			O	
91	Yellow Warbler	*Setophaga petechia*	*Re*	LC	R	O		R
92	Yellow-bellied Sapsucker	*Sphyrapicus varius*	*Mi*	LC	R			
93	Yellow-crowned Night-Heron	*Nyctanassa violacea*	*Re*	LC		R	R	
94	Yellow-faced Grassquit	*Tiaris olivaceus*	*Re*	LC	O	O		F
95	Yellow-shouldered Grassquit	*Loxipasser anoxanthus*	*En*	LC	R			R
96	Yellow-throated Warbler	*Setophaga dominica*	*Mi*	LC	R	O		
97	Zenaida Dove	*Zenaida aurita*	*Re*	LC	O	R		O

Fifteen of Jamaica's 30 species of endemic birds were observed in the project area. All endemics observed on the property can live in degraded habitats. Of note, Jamaican Becard, Jamaican Pewee and Rufous-tailed Flycatcher, which can be viewed as forest-dependent species, were observed on the property. Regarding endemic birds nesting on the property, a few Jamaican parakeets were nesting on a few termite mounds (Figure 4-170).

Figure 4-170 Jamaica Parakeet nesting on an active termite mound on the property.

Twenty-five migrants, including summer and winter, were observed on the property. The three summer migrants observed were the Black-whiskered Vireo, the Great Antillean Nighthawk, and the Gray Kingbird. The other migrants were warblers and waterbirds (coastal, mangroves and riverine). The property has vast wetlands, and it is expected that several wetlands birds (egrets, herons, shorebirds, ducks, and other birds) could use the wetlands but were not observed in the study. For example, only one duck species, Blue-wing teal, was observed in the study, and other migrant ducks could use the area but were not detected in the study. There were also signs of the migrant Yellow billed sapsucker, but they were not seen in the study (Figure 4-171).

Figure 4-171 The holes on the tree signify the presence of the Migrant Yellow Bill Sapsucker.

Five introduced species were observed on the property. Large flocks (several hundred) of shiny cowbirds were observed in the habitat type Fields: herbaceous crops, follow and cultivated vegetables. The shiny cowbirds were seen in the trees and on the ground in the cow pastures.

Two of the 3 common nocturnal birds in Jamaica, the Northern Potoo and the Barn owl, were observed during the night survey and from the acoustic study. The endemic brown owl was not observed/detected in the study; however, it could be present in the study area.

Bird shooting occurs yearly for 6 weeks on the property, mainly in the open fields, pastureland, and sections of the wetlands. There is no game reserve on the property.

Conservation Status

Only 3 bird species classified as near-threatened species were observed across the study area: Jamaican Crow (*Corvus jamaicensis*), White-crowned Pigeon (*Patagioenas leucocephala)* and Jamaican Parakeet (*Eupsittula nana*).

There are bird-sensitive habitats in the study area, such as mangroves, mudflats, and riverine habitats. Special care must be put in place to protect these habitats. The Antillean Palm Swift is listed as Least Concerned by the IUCN. However, they were only seen nesting in a few palm trees on the coast. These trees should be protected in the proposed development (Figure 4-172).

Figure 4-172 Antillean Palm-Swift nesting on the old palm leaves in the coastal section of the property

Invertebrates

METHODOLOGY

Day Surveys

An invertebrate survey was conducted during the day in the project area. This assessment consisted of a series of walkthroughs within the different habitat types throughout the project area. Various possible hiding places were carefully searched or examined; these included tree trunks, leaves, dry wood, and sticks. A sweep net was also used to collect insects from the foliage, and insects in flight were recorded.

Night Survey

Nocturnal insects were sampled using light traps. The insects were collected and taken to the laboratory for identification.

Reference Material

Most of the arthropods encountered in the field were identified on the spot; however, arthropods that could not be identified in the field were identified using insect keys (Triplehorn, et al., 2005), iNaturalist App and collections at the University of the West Indies if necessary.

BUTTERFLIES

A total of 30 species of butterflies from 11 families were observed across the sample area (Table 4-40). There was 1 endemic butterfly, Jamaican Mestra (*Mestra dorcas*) and 4 endemic subspecies, Julia (*Dryas iulia delilah*), Jamaican tropical leafwing (*Anaea troglodyta portia*), Jamaican satyr (*Calisto zangis*) and Zebra Longeing (*Heliconius charithonia simulator*), were recorded during the assessment. Overall, a low number of butterflies were observed in the study.

In terms of the number of species of lepidopteran found in the different habitat types: 20 species in Secondary forests, 27 species in Wetlands, 3 Beaches and 22 species in the Fields: herbaceous crops, followed and cultivated vegetables.

Plate 4-37 Tropical checkered skipper

Conservation Status

No butterfly of special conservation status was found during the assessment.

Table 4-40 The butterflies observed during the study. Abbreviations in the table: Range (Re- Resident, En-Endemic, IN- introduce, Un-Unknown) and DAFOR (D-Dominant, A- Abundant, F- Frequent, O-Odd, R-Rare).

#	Family	Scientific name	Common name	Range	Secondary Forest	Wetland	Beach	Fields
1	Crambidae	*Snouth Moth1*	Snouth Moths	Un		R		
2	Crambidae	*Snouth Moth2*	Snouth Moths	Un		R		
3	Geometridae	*Geometrid sp*		Un		R		
4	Hesperiidae	*Astraptes jaira*	Jamaican Flasher	Na	R	R1		R
5	Hesperiidae	*Burnsius oileus*	Tropical checkered skipper	Na	R	R		
6	Hesperiidae	*Cymaenes tripunctus*	Three-spotted Skipper	Na	R	O		R
7	Lycaenidae	*Leptotes cassius*	Cassius Blue	Na		R		
8	Noctuidae	*Noctuidae sp1*		Na		R		
9	Noctuidae	*Noctuidae sp2*	Tribe Leucaniini	Na		O		
10	Nymphalidae	*Anaea troglodyta portia*	Jamaican tropical leafwing	En subs.	O	R	R	O
11	Nymphalidae	*Anartia jatrophae*	White Peacock	Na	O			A
12	Nymphalidae	*Dione vanillae*	The Tropical Silverspot	Na	R	O		
13	Nymphalidae	*Dryas iulia delilah*	Julia	En subs.	R	O	R	O
13	Nymphalidae	*Euptoieta hegesia*	Mexican Fritillary	Na	R	O		R
14	Nymphalidae	*Heliconius charithonia simulator*	Zebra Longeing	En subs.	R	O		O
15	Nymphalidae	*Historis odius*	Orion Ceropian	Na		R		O
16	Nymphalidae	*Junonia evarete*	Tropical Buckeye	Na	R			R
17	Nymphalidae	*Junonia zonalis*	West Indian Buckeye	Na	R	F	R	O
18	Nymphalidae	*Mestra dorcas*	Jamaican mestra	En		O		R
19	Nymphalidae	*Phyciodes frisia frisia*	The Cuban Crescent-Spot	Na		O		
20	Papilionidae	*Heraclides andraemon*	Andraemon Swallowtail	Na	R			R
21	Pieridae	*Anteos maerula*	yellow angled-sulphur	Na		O		R

#	Family	Scientific name	Common name	Range	Secondary Forest	Wetland	Beach	Fields
22	Pieridae	*Ascia monuste*	Great Southern White; Antillean Great White	Na	O	R		O
23	Pieridae	*Phoebis argante*	Giant Sulphur	Na	O	F		R
24	Pieridae	*Phoebis sennae*	Cloudless Sulphur	Na	O	R		O
25	Pieridae	*Pyrisitia lisa*	Little yellow	Na	O	R		O
26	Psychidae	*Bog worm*	Bog worm Moth	Na	O			O
27	Satyrinae	*Calisto zangis*	Jamaican satyr	En subs.	R	R		R
28		*Micro Lepidoptera 1*	Micro Lepidoptera 1			R		
29		*Micro Lepidoptera 2*	Micro Lepidoptera 2			R		
30		*Micro Lepidoptera 3*	Micro Lepidoptera 3			R		

OTHER ARTHROPODS

Thirty-three species of arthropods were observed during the study (Table 4-41). Of the 33, there were no species of special conservation status. The introduced New Guinea flatworm was observed on the property during the assessment (Plate 4-38).

Table 4-41 Arthropods (non-lepidopterans) observed during the study.

Key: Status (Na = Native, Uk =Unknown and In = Introduce) and DAFOR (D = Dominant, A = Abundant, F = Frequent, O = Odd and R = Rare)

#	Order	Family	Scientific names	Common names	Status	Secondary Forest	Wetland	Beach	Fields
1	Araneae	Araneidae	*Argiope sp.*	Orbweavers	Na	R	**O**		R
2	Araneae	Araneidae	*Gasteracantha cancriformis*	Black Crab spider	Na	R			R
3	Araneae	Araneidae	*Trichonephila clavipes*	Banana spiders	Na	O	**R**		
4	Araneae	Selenopidae	*Selenops sp.*	Crab spider	Na	R	**R**		O
5	Coleoptera	Scarabaeidae	*Scarab 1*		Na	R			
6	Coleoptera	Scarabaeidae	*Scarab 2*		Na	R			
7	Diptera	Dolichopodidae	*Condylostylus sp*	Green Fly	Na	R	R	R	O
8	Diptera	Muscidae	*Musca domestica*	housefly	Na	R	O		O
9	Diptera	Muscidae	*Musca sp*		Na	O			R
10	Hemiptera	Cicadellidae	*Draeculacephala sp*	Sharpshooter LeaftHoppers	Na	R			
11	Hemiptera	Pyrrhocoridae	*Dysdercus andreae*	Cotton Stainer Bugs	Na	O			
12	Hempitera	Libellulidae	*Erythemis vesiculosa*	Great Pondhawk	Na	**O**	O		
13	Hempitera	Pentatomidae	*Nezara viridula*	Stink bug	Na	**R**	O	R	**R**

#	Order	Family	Scientific names	Common names	Status	Secondary Forest	Wetland	Beach	Fields
14	Hempitera	Pentatomidae	*Edessa meditabunda*	Stink bug	Na	**R**			
15	Hompotera	Cicadidae	*Odopoea sp.*	Cicada	Na	O	R	R	O
16	Hymenoptera	Apidae	*Apis mellifera*		Na	O	F		R
17	Hymenoptera	Formicidae	*Pheidole sp.*	Black ants	Na	O	O		O
18	Hymenoptera	Formicidae	*Camponotus*	Sugar Ants	Na				O
19	Hymenoptera	Formicidae	*Camponotus hannani*	Red Ants	Na	O			
20	Hymenoptera	Sphecidae	*Prionyx thomae*		Na		R		
21	Hymenoptera	Vespidae	*Polistes crinitus*		Na	R	R		O
22	Hymenoptera	Vespidae	*Polistes major*		Na	O	R		R
23	Hymenoptera	Xylocopinae	*Xylocopa mordax*		Na				R
24	Isopetera	Termitidae	*Nasutitermes costalis*	Termites	Na	F	O		F
25	Ixodida	Ixodidae	*Rhipicephalus microplus*	Cattle tick	Na	R			R
26	Odonata	Libellulidae	*Orthemis sp*	Green Dragonfly	Na	**O**	O		**O**
27	Odonata	Libellulidae	*Orthemis macrostigma*	Red Dragonfly	Na	**A**	O		**R**
28	Odonata	Libellulidae	*Orthemis sp*	Antillean Skimmer	Na	**O**	R		
29	Odonata	Libellulidae	*Erythemis vesiculosa*	Great Pondhawk	Na	**O**			**O**
30	Orthoptera	Acrididae	*Orphuella sp.*		Na				**O**
31	Orthoptera	Gryllidae		Cricket	Uk	**O**	R		
32	Spirobolida	Rhinocricidae	*Anadenobolus monilicornis*	Yellow-banded millipede	Na		O		
33	Tricladida	Geoplanidae	*Platydemus manokwari*	New Guinea flatworm	In	O			O

Plate 4-38 Invasive New Guinea worm (*Platydemus manokwari*)

Plate 4-39 Hermit Crab

Bats

METHODOLOGY

A total of 10 AudioMoth® acoustic recorders were deployed at random sample sites throughout the project area (Figure 4-169). The AudioMoth detectors were configured to start recording from 18:30 to 06:00 for 1 night. The sample rate was 384 kHz, and the gain was set at medium. The sleep duration was 5 seconds, and the recording duration was for 5 seconds.

The devices were deployed at least 3 m above the ground, primarily on trees and buildings where possible. The Kaleidoscope Pro® software was used to process and ID the bat calls from all acoustic devices. Please note that the software can only auto-ID 10 of Jamaica's 21 species of bats. The other species were identified using a call library from Windsor Research Centre and internet resources.

Plate 4-40 An AudioMoth device deployed in the field

RESULT AND DISCUSSION

A total of 11 species of bats were observed across the study area, all native to Jamaica (Table 4-42). A total of 8 of the 11 species observed are insectivores, 1 nectarivore, 1 frugivore and 1 Piscivore. Obligate cave dwellers constituted 5 of the species observed; 4 species occur in caves and man-made structures, and 1 in caves, crevices, and Tree hollows. No caves were found on the property, and the cave obligates foraging on the property roost in nearby caves.

Conservation Status

None of the species recorded during the assessment has a special conservation status designation by the IUCN; all bats observed are classified as least concerned by the IUCN. No caves or any other bat roost, including tree roost, was observed on the property.

Table 4-42 Number of bat species detected in the study area.

#	Scientific name	Common name	Diet	Roost	Secondary Forest	Wetland	Beach	Fields
1	*Artibeus jamaicensis*	Jamaican Fruit Bat	Frugivore	Cave, man-made structure, foliage	X			X

#	Scientific name	Common name	Diet	Roost	Secondary Forest	Wetland	Beach	Fields
2	*Eumops glaucinus*	Wagner's Bonneted Bat	Insectivore	Cave, man-made structures	X	X	X	X
3	*Molossus molssus*	Pallas' Mastiff Bat	Insectivore	Cave, man-made structures	X	X		X
4	*Monophyllus redmani*	Leach's Single Leaf Bat	Nectarivore	Obligate cave	X	X		
5	*Moormops blainvillei*	Antillean Ghost-faced Bat	Insectivore	Obligate cave	X	X		X
6	*Noctilio leporinus*	Fishing Bat	Piscivore	Cave, crevice, Tree hollow		X	X	X
7	*Nyctinomops macrotus*	Big Free-tailed Bat	Insectivore	Cave, crevices	X	X		X
8	*Pteronotus macleayii*	MacLeay's 9Mustached Bat	Insectivore	Obligate cave	X	X	X	X
9	*Pteronotus parnellii*	Parnell's Mustached Bat	Insectivore	Obligate cave	X	X	X	X
10	*Pteronotus quadridens*	Sooty Mustached Bat	Insectivore	Obligate cave	X	X		X
11	*Tadarida brasiliensis*	Free-tailed Bat	Insectivore	Caves, man-made structures	X	X	X	X

Herpetofauna

METHODOLOGY

The herpetofauna (amphibian and reptile) assessments were conducted across the different habitat types within the project area. This assessment included searching trees (under bark, on trunk and canopy), stone piles, abandoned structures, bromeliads (Plate 4-41), small water bodies and other debris. All specimens seen were identified and assigned a DAFOR ranking, and pictures were taken of the specimens if possible. We also collected some specimens for closer examination, where they were placed in glass bottles or catchment containers and returned to the habitat. The reference material includes electronic databases CaribHerp and iNaturalists. We also use the book Amphibians and Reptiles of the West Indies (Schwartz & Henderson, Robert, 1991).


Plate 4-41 Tank bromeliads found in different habitat types searched for the presence of herpetofauna

RESULTS AND DISCUSSION

During the assessment, 13 species of Amphibians and reptiles were observed across all sample areas: 7 reptiles and 5 amphibians. For the herpetofauna, 7 are endemic (Jamaican Forest Frog (*Eleutherodactylus gossei*), Jamaican laughing frog (*Osteopilus ocellatus*), Jamaican Green Treefrog (*Osteopilus wilderi*), Jamaican Giant Anole (*Anolis garmani*), Jamaican Brown Anole (*Anolis lineatopus*), Jamaican Opal-bellied Anole (*Anolis opalinus*) and Jamaican Forest Lizard (*Celestus crusculus)*, 3 are introduced, and 3 are native species. 7 endemic species are reptiles, and the other 3 are amphibians (Table 4-43).

Crocodiles were only sighted at two places during the assessment: a beach at the mouth of the river and a section of the river. We were told by fishers and other people on the property that crocodiles are encountered on the beach and areas in the river throughout the property. We did not find any crocodile nesting sites on the property.

The Jamaican slider was only seen once in one section of the river; however, the fishers told us that they encountered the turtles occasionally.

Table 4-43 Herpetofauna identified in the study area.

Abbreviations: Range (Re- Resident, En-Endemic, IN- introduce, Un-Unknown) and DAFOR (D-Dominant, A- Abundant, F-Frequent, O-Odd, R- Rare).

Class	Family	Scientific Name	Common Name	Range	IUCN	Woodland	Wetland	Beach	Fields
Amphibia	Eleutherodactylidae	*Eleutherodactylus gossei*	Jamaican Forest Frog	En	VU	O			R
Amphibia	Eleutherodactylidae	*Eleutherodactylus johnstonei*	Lesser Antillean Frog	In	LC	O	R		A

Class	Family	Scientific Name	Common Name	Range	IUCN	Woodland	Wetland	Beach	Fields
Amphibia	Eleutherodactylidae	*Eleutherodactylus planirostris*	Cuban Flat-headed Frog	In	LC	R	R		O
Amphibia	Hylidae	*Osteopilus ocellatus*	Jamaican laughing frog	En	NT	R	O		O
Amphibia	Hylidae	*Osteopilus wilderi*	Jamaican Green Treefrog	En	VU	O	R		R
Reptilia	Dactyloidae	*Anolis garmani*	Jamaican Giant Anole	En	LC	O	R		O
Reptilia	Dactyloidae	*Anolis lineatopus*	Jamaican Brown Anole	En	LC	F	O		O
Reptilia	Dactyloidae	*Anolis opalinus*	Jamaican Opal-bellied Anole	En	LC	O	O		R
Reptilia	Dactyloidae	*Anolis sagrei*	Brown Anole	In	LC	R	R		O
Reptilia	Diploglossidae	*Celestus crusculus*	Jamaican Forest Lizard	En	LC	R			R
Reptilia	Emydidae	*Trachemys terrapen*	Jamaican Slider	Na	VU		R		
Reptilia	Sphaerodactylidae	*Sphaerodactylus argus*	West Caribbean Ocellated Geckolet	Na	LC	R			O
Reptilia	Crocodylidae	Crocodylus acutus	American crocodile	Na	VU		R	R	

Conservation Status

Three amphibians and 2 reptiles from the study have special conservation status: the vulnerable Jamaican Green treefrog (*Osteopilus wilderi*), American Crocodile *(Crocodylus acutus*), Jamaican Forest Frog (*Eleutherodactylus gossei*), and Jamaican Slider (*Trachemys terrapen*); Jamaican laughing frog (Osteopilus ocellatus) is listed as Near-threatened by the IUCN.

Other Species

The main activity in the project area for several years has been agriculture. The livestock such as cattle, horses, goats, and sheep were encountered mainly in the habitat type Fields: herbaceous crops, fallow and cultivated vegetables (Table 4-44).

Table 4-44 The other fauna species observed during the assessment.

#	Order	Family	Scientific name	Common Name	Range	Secondary Forest	Wetland	Beach	Fields
1	Carnivora	Herpestidae	*Herpestes auropunctatus*	Indian Mongoose	Int	R	R		O
2	Carnivora	Felidae	*Felis catus*	Cats	Int	R	R		
3	Artiodactyla	Bovinae	*Bos taurus*	Cow	Int	O			D
4	Perissodactyla	Equidae	*Equus ferus caballus*	Horse	Int				O
5	Artiodactyla	Bovidae	*Bubalus bubalis*	Water Bufalo	Int	O	O		O
6	Goats								
7	Dogs								
8	Donkey								
9	Mule								
10	Chickens								

There are also water buffalo that roam the property (Plate 4-42). The buffalo are seen in the river and mud holes located in the wetlands and pastures on the property. It is unclear if they have created some mudholes that have become ponds. The buffalo are hunted on the property.


Plate 4-42 Water buffalo observed on the property

4.2.2.6 Freshwater Habitats

Survey Methods

The proposed development area was viewed using Google Earth. Streams flowing through the property and any other water bodies were noted and GPS locations obtained for possible access points. On the ground reconnaissance was then conducted to ground-truth these points.

A survey of the water bodies within the property was conducted by physically accessing (on foot) at different points. These water bodies included the Sweet River, which flows through the Paradise Park property and has several branches, as well as Deans Valley River. Reference points outside the Paradise Park property were also chosen. Overall, fourteen (14) sites were chosen for physical and chemical assessment (Table 4-45 and Figure 4-173), with eleven (11) of those chosen for quantitative biological assessment. No freshwater sites were in the easternmost zone, Zone 3.

Table 4-45 Freshwater habitat sample site locations in JAD2001

Site Code	Site Name	X	Y	Zone
Stream A	Sweet River on JPS Substation Rd.	633780.527082	675230.400658	5
Stream B	Stream flowing through property	633936.9984	674721.349105	5
Stream C	Sweet River at Main Road Bridge	636675.410589	675403.450471	5
Stream D	Grassy Pond off Main Rd.	633550.83811	674796.912176	6
Stream E	Sweet River at Water Park	635576.656629	676349.818819	
Stream F	Deans Valley River at JDF Thatch Hut	636218.216892	674488.890225	4
Stream G	Sweet River East near JDF Gate	635506.527001	674948.315319	4
Stream H	Sweet River Southeast End	635701.716433	674123.310782	2
Stream I	Sweet River East P-Park Mid-Point	635548.916079	674757.124098	4
Stream J	Sweet River West End	635159.836989	673984.654974	1
Stream K	Typha Marsh West	635207.123969	674120.820169	2
Pond A	Freshwater Pond	634254.099093	675865.95807	5
Pool A	Coastal Mangrove Marsh East End	635886.656533	673995.543217	2
Pool B	Coastal Grassy Marsh East End	635848.655528	673972.852468	2

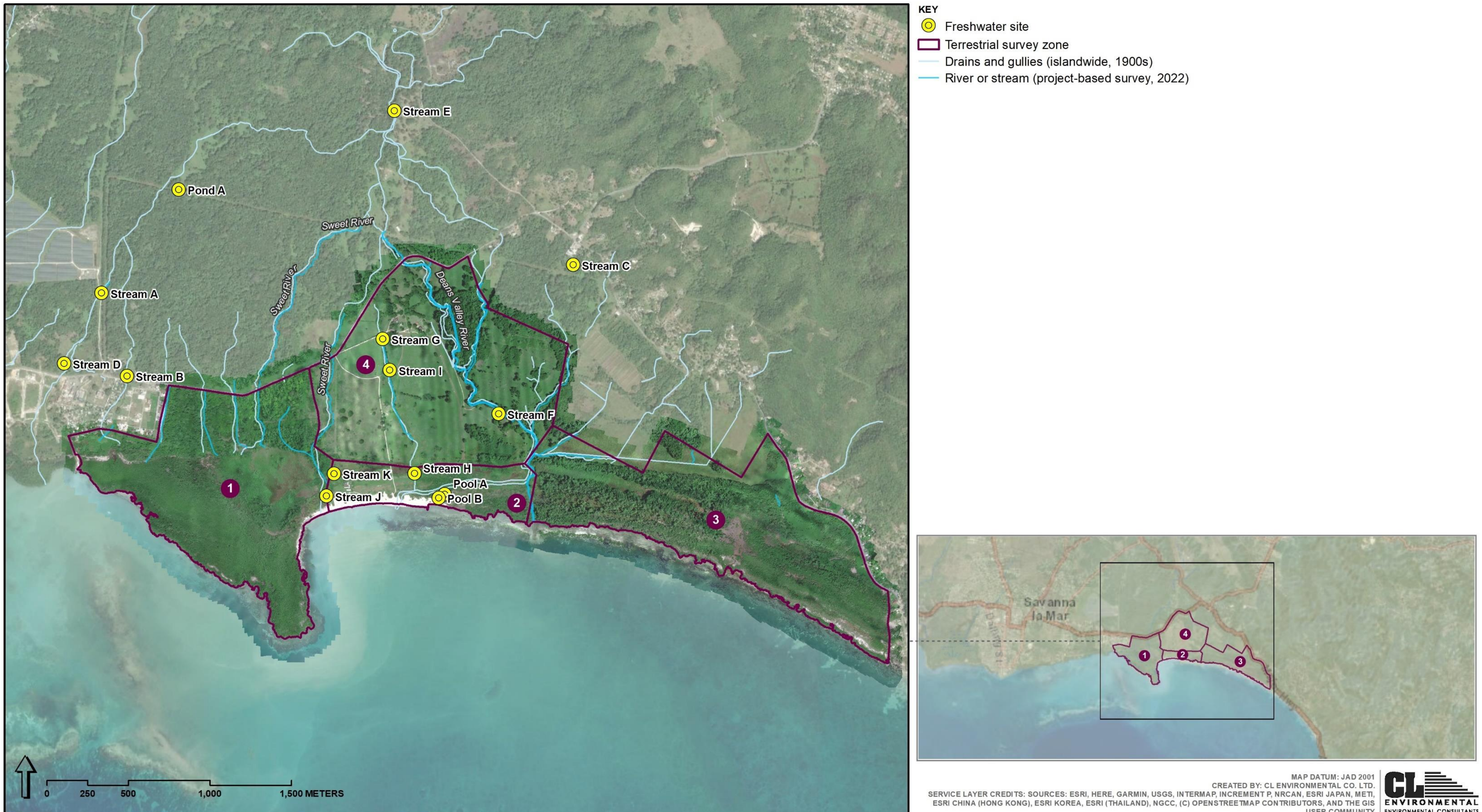


Figure 4-173 Freshwater sample sites

Plate 4-43 Selection of sample sites in Paradise Park

At each sample point the characteristics of the water body were noted; this included width and depth of the stream where possible, whether there was noticeable flow, and the presence and type of riverine vegetation (seen in the river/water body). Where there was noticeable flow, and the depth or vegetation in the river allowed, a flow meter was used to record the flow rate of the water. Physicochemical parameters (Table 4-46) were then measured using a Hanna Instruments Multiparameter Water Quality Meter (HI98194) and a Hydrolab Surveyor (Series 5).

Table 4-46 Freshwater physicochemical parameters.

Physicochemical parameters for freshwater systems	
pH	TDS- Total Dissolved Solids (ppt)
Conductivity (µS/cm)	Turbidity (NTU)
Temperature (°C)	Salinity (ppt)
Flow rate (m/s)	Dissolved Oxygen (mg /L)

Ambient water quality samples were collected from 10 sites on September 7, 2023, for analysis by the ESL Quality & Environmental Health Laboratory. The following parameters were used for all sites: Dissolved Oxygen (DR method), Nitrates (H-8039 method), Orthophosphates (H-8048 method) and Biological Oxygen Demand (BOD; H-8043 method).

The benthic invertebrates community was also sampled at each of the 11 sites using semi-quantitative sampling techniques. Sampling was adapted from the Protocol Manual from the Ontario Benthic Biomonitoring Network (Jones et al. 2007). Bankside vegetation and shallow pools were sampled by kick net sweeps, and riffles and submerged rocks were sampled by kick-sampling and hand collection. A minimum of 100 individuals were collected from each site and preserved in 70% alcohol for later identification and enumeration. Fish specimens were photographed on-site for later identification. In the laboratory, the first 100 invertebrates in each sample were randomly selected and classified to the lowest taxonomic level possible with the aid of a Wolfe stereoscopic microscope and taxonomic keys (Hyslop 2002; Thorp and Covich 1991). Each taxon was classified into a functional feeding group (FFG) according to (Ramírez and Gutiérrez-Fonseca 2014). Taxonomic richness and diversity were calculated for each site, and the richness and percent abundance of mayflies (Ephemeroptera) and caddisflies (Trichoptera) were calculated for each site.

CALCULATIONS

Alpha and Gamma Diversity – Simpson's Index

The Simpson's Index was used as a measure of alpha and gamma biodiversity for each site and for the entire section of the river, respectively. The formula for the Simpson's Index is as follows:

p - the proportional abundance of a taxon at a site

Values for Simpson's Index range from 0 (very low diversity) to 1 (very high diversity).

ET Richness and Percent ET

The ET parameters measure the representation of environmentally sensitive specimens in the orders Ephemeroptera and Trichoptera. It is calculated using the following formulae:

ET Richness = Number of Taxa in Ephemeroptera and Trichoptera

This can also be expressed as a proportion of all the taxa within the sample.

A high percentage of these environmentally sensitive organisms indicates high water quality and high dissolved oxygen content. A low percentage may indicate substantial levels of pollution.

Results

PHYSICAL AND CHEMICAL PARAMETERS

Table 2 below gives the physical and chemical data for the sample sites assessed in Paradise Park. The means of all parameters for the freshwater sites fell within the ranges of the NEPA's guidelines, with most being closer to the lower limits of the ranges. The freshwater sites can therefore be described as healthy with little to no human disturbance (NEPA 2009). Notably, dissolved oxygen was high, and conductivity, BOD, nitrates, and phosphates were low across sites. The pH, BOD, nitrates, and phosphates were higher than the standard for the saline environments of Stream J and Zone 2 – Saline (Table 4-47). The habitats within this zone represented shallow water bodies with large amounts of organic matter and decomposition of plant and animal material, explaining the high values.

Table 4-47 Physical and Chemical Parameters of Sample Sites in Paradise Park

Sites marked with an asterisk were brackish and saline, and thus were excluded from the freshwater mean

Zone/Site	pH	Conductivity (µS/cm)	TDS	Salinity	Water Temperature (°C)	BOD (mg/L)	Nitrates (mg/L)	Phosphates (mg/L)	DO (mg/L)
Zone 0	7.3	438.5	219.5	0.2	25.4	0.8	1.4	0.2	7.39
Zone 1	7.5	384	192	0.2	28.5	0.9	0.6	0.13	6.63
Zone 2 - Freshwater	7.6	466.5	236	0.2	37	-	-	-	-
Zone 2 - Saline	8.8	2108	1056	1.1	38.7	2.7	0.3	0.05	7.76
Zone 4	8	435.25	217.5	0.2	26.5	0.8	1	0.155	8.81
Zone 5	7.77	469.1	237.9	0.27	27.2	1.05	0.85	0.275	7.46
Zone 6	7.8	445.5	223	0.2	26.5	0.7	0.8	0.22	8.24
Stream A	7.6	472.7	239.7	0.3	27.3	0.7	0.8	0.38	7.06
Stream B	7.9	456.8	231.8	0.2	26.9	-	-	-	-
Stream C	7.8	477.8	242.3	0.3	27.4	1.4	0.9	0.17	7.85
Stream D	7.8	445.5	223	0.2	26.5	0.7	0.8	0.22	8.24
Stream E	7.3	438.5	219.5	0.2	25.4	0.8	1.4	0.2	7.39
Stream F	8.0	437.5	219	0.2	26.1	0.8	1.2	0.2	8.87

Zone/Site	pH	Conductivity (µS/cm)	TDS	Salinity	Water Temperature (°C)	BOD (mg/L)	Nitrates (mg/L)	Phosphates (mg/L)	DO (mg/L)
Stream G	8.0	433	216	0.2	26.9	0.8	0.8	0.11	8.75
Stream H	7.5	384	192	0.2	28.5	0.9	0.6	0.13	6.63
Stream I	8.0	432	216	0.2	27.4	-	-	-	-
Stream J*	7.7	2166	1083	1.1	30.8	7.9	0.4	0.04	6.82
Stream K	7.4	641	321	0.3	30.9	0.35	0.2	0.68	7.66
Pond A	7.6	472.7	239.7	0.3	27.3	-	-	-	-
Pool A	7.6	466.5	236	0.2	37	-	-	-	-
Pool B*	8.8	2108	1056	1.1	38.7	2.7	0.3	0.05	7.76
Mean	**7.71**	**463.2**	**233**	**0.23**	**28.13**	**0.81**	**0.84**	**0.26**	**7.81**

SUMMARY OF BIOLOGICAL COMMUNITIES

A total of 42 invertebrate taxa were collected from the sample sites in Paradise Park, one of which is endemic to Jamaica (*Helicopsyche* sp.) (Table 4-48), and one endemic to the Neotropics (*Phylloicus farri*). Four fish species were recorded in the area: *Oreochromis mossambicus*, *Limia melanogaster*, *Gobiomorus dormitator* and *Dormitator maculatus*. Limia melanogaster is listed as "Near Threatened" on the IUCN Red List, indicating the importance of the Paradise Park area to the species. Among the threats to its population are residential and commercial development, dam and water use modification, roads and railroads, and pollution (Lyons 2021).

Insects were the most represented fauna, with 64% of all taxa collected and 51.9% of all individuals collected being insects. This was followed by snails which represented 24% of taxonomic richness and 37.2% of abundance. At the opposite end, the single flatworm and roundworm species each represented only 2% of taxonomic richness and less than 1% of abundance. The most abundant species across all sites were the mayfly Baetidae A (20%), the caddisfly *Helicopsyche* sp. (8.9%) and the red-rimmed melania *Melanoides tuberculata* (8.8%). The invertebrate community is dominated by clean water taxa such as the mayflies and caddisflies. The taxonomic richness of the area is high, and the community represents that of undisturbed areas. The invasive snails *Tarebia granifera* and *Melanoides tuberculata* represented only 15.7% of the abundance of the invertebrate community. The conservation statuses of most invertebrates are unknown due to data deficiency in assessment. However, *Anax junius*, *Orthemis ferruginea, Perithemis domitia, Tramea abdominalis*, *Tarebia granifera* and *Melanoides tuberculata* are all listed as Least Concern on the IUCN Red List.

Table 4-48 List of faunal species found at the sample sites

Asterisks represent endemic species.

Number	Class	Species	Common Name	FFG
1	Annelida	Roundworm	Worm	NA
2	Crustacea	Grapsidae A	Crab	Shredder
3		*Macrobrachium* sp.	Shrimp	Shredder

Number	Class	Species	Common Name	FFG
4		*Potimirim* sp.	Shrimp	Shredder
5	Gastropoda	Ampullaridae	Snail	Scraper
6		Hydrobiidae	Snail	Scraper
7		*Melanoides tuberculata*	Red-rimmed Melania (Snail)	Scraper
8		Neritidae A	Snail	Scraper
9		Neritidae B	Snail	Scraper
10		*Physella jamaicensis*	Snail	Scraper
11		Physidae	Snail	Scraper
12		Planorbidae	Snail	Scraper
13		*Tarebia granifera*	Quilted Melania (Snail)	Scraper
14		Thiaridae A	Snail	Scraper
15	Insecta	*Anax junius*	Dragonfly	Predator
16		*Atrichopogon* sp.	Biting Midge	Scraper
17		Baetidae A	Mayfly	Collector-Gatherer
18		*Belastoma* sp.	Giant Water Bug	Predator
19		*Buenoa* sp.	Backswimmer	Predator
20		Caenidae B	Mayfly	Collector-Gatherer
21		Chironomidae A	Bloodworm	Collector-Gatherer
22		Chironomidae B	Bloodworm	Collector-Gatherer
23		Culicidae A	Mosquito	Filterer
24		*Enallagma* sp.	Damselfly	Predator
25		*Enochrus* sp.	Water Beetle	Collector-Gatherer
26		*Haliplus* sp.	Water Beetle	Shredder
27		*Helicopsyche* sp.*	Caddisfly	Collector-Gatherer
28		*Hydrocanthus* sp.	Diving Beetle	Predator
29		Hydropsychidae	Caddisfly	Collector-Gatherer
30		*Laccophilus fasciatus rufus*	Diving Beetle	Predator
31		Leptophlebidae A	Mayfly	Collector-Gatherer
32		*Nectopsyche* sp.	Caddisfly	Collector-Gatherer
33		*Orthemis ferruginea*	Dragonfly	Predator
34		*Perithemis domitia*	Slough Amberwing Dragonfly	Predator
35		*Phylloicus farri**	Caddisfly	Collector-Gatherer
36		Psychodidae	Drain Fly	Collector-Gatherer
37		Sciomyzidae	Marsh Fly	Predator
38		Stratiomyidae	Soldier Fly	Collector-Gatherer
39		*Tramea abdominalis*	Vermilion Saddlebag Dragonfly	Predator
40		*Trichocorixa reticulata*	Water Boatman	Piercer
41		*Tropisternus lateralis*	Water Beetle	Predator
42	Platyhelminthes	*Girardia* sp.	Flatworm	Predator

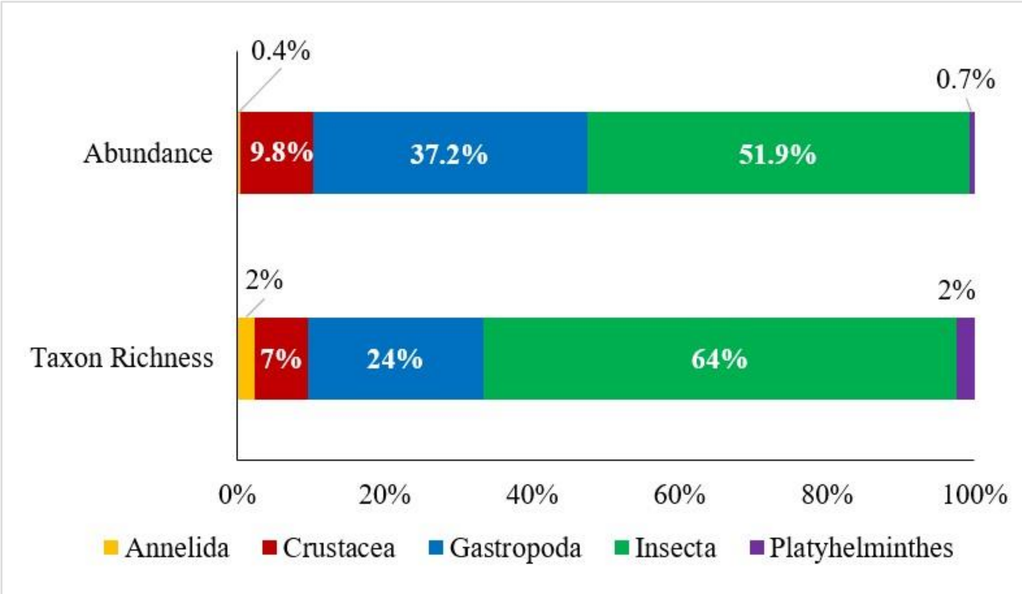


Figure 4-174 **Taxonomic Richness and Abundance of Invertebrates from Paradise Park**

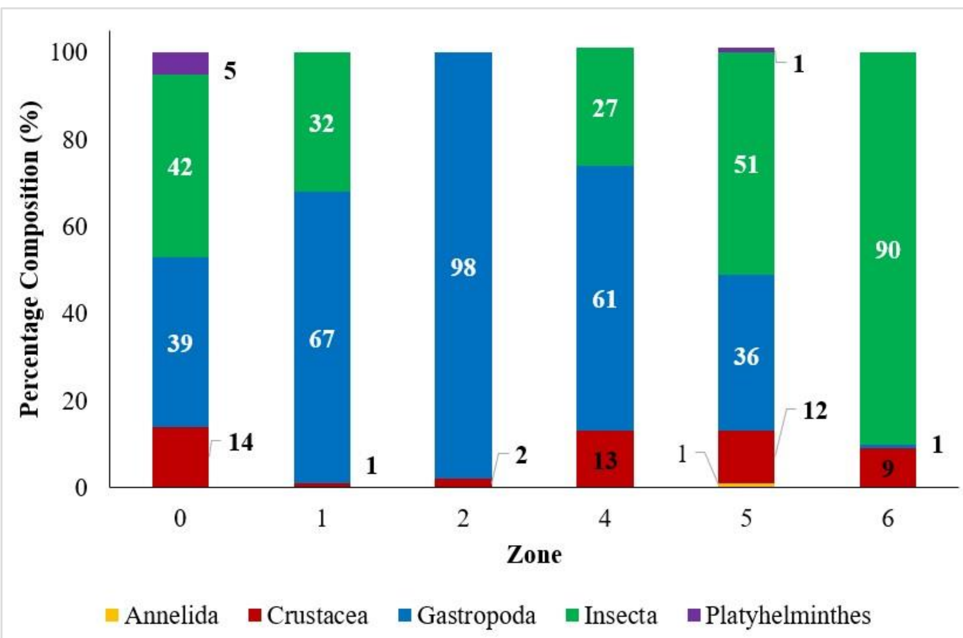


Figure 4-175 **Composition of Invertebrate Class per Zone in Paradise Park**

DIVERSITY AND ET RATIO

Gamma-diversity across all zones sample sites was very high at a value of 0.91. Mean richness and alpha-diversity per zone were 14.2 and 0.65, respectively. Zones 2 and 6 were the least taxonomically rich, with only five species each, while Zone 5 was the most taxonomically rich (29 species). The high richness of Zone 5 was due to the greater number of sample sites in the Zone. Zone 0 was the next most speciose, with a total of 18 species. Zone 6 was the least diverse (0.2), while Zone 0 was the most diverse (0.88). The low diversity of Zone 6 was due to the high abundance of mayflies in samples. The large difference between gamma-diversity and mean alpha-diversity indicates the importance of different habitats in supporting the array of invertebrates collected. Alpha-diversity represented 71.4% of total diversity, while the variety of habitats in the area represented 28.6% of total diversity.

The mean ET ratio of the zones was 32.4%, ranging from 0% in the pools of Zone 2, to 89% in Zone 6. The mean ET ration of the sample sites was 31%, ranging from Pools A and B, to 89% in Stream D. The pools lacked sensitive taxa due to the instability of the environment. They represented temporary aquatic habitats which occasionally dry, and experience high temperature and salinity conditions. Zone 6/Stream D was dominated by the mayfly Baetidae A, whose high abundance indicates very high-water quality.

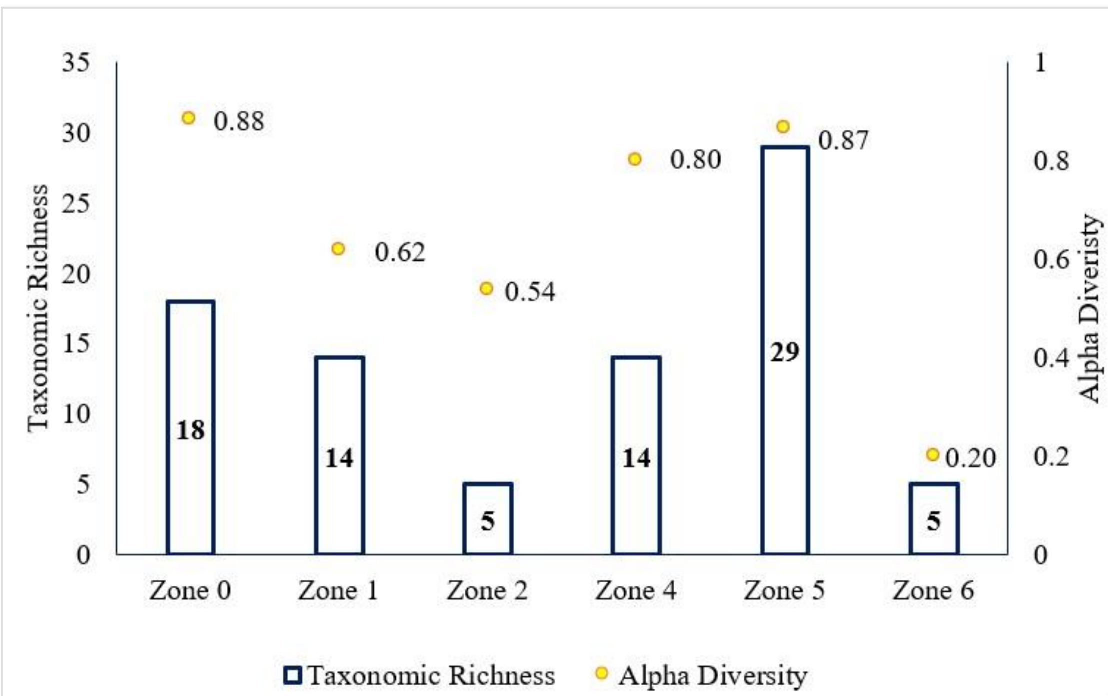


Figure 4-176 Taxonomic Richness and Alpha Diversity among Zones of Paradise Park

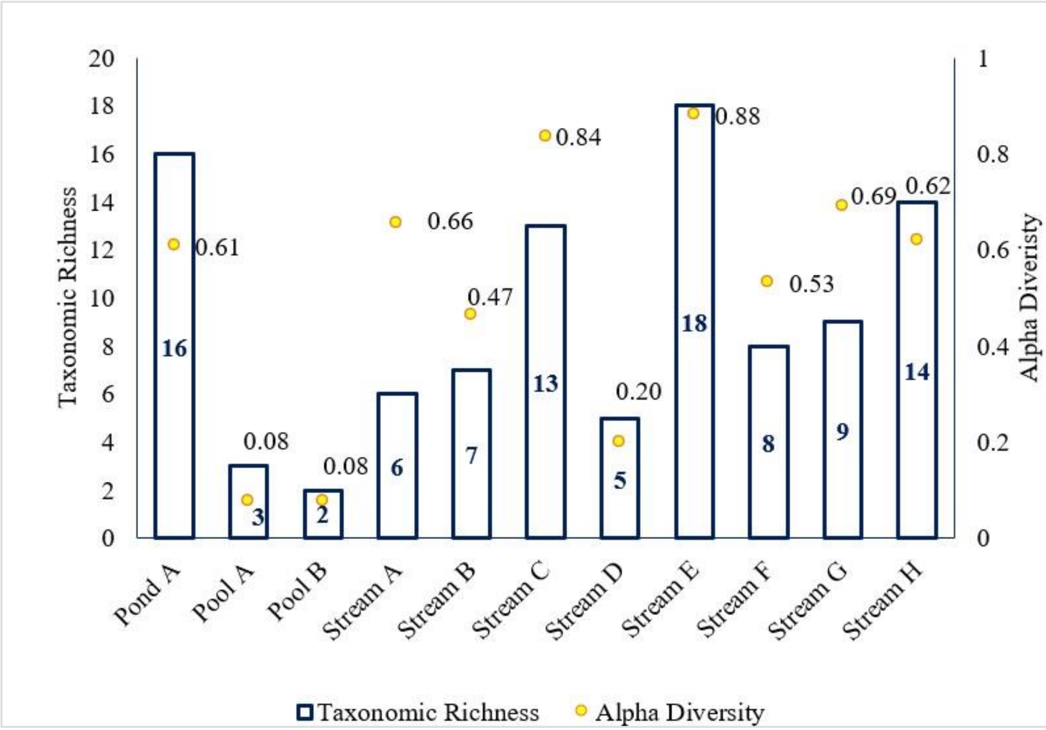


Figure 4-177 Taxonomic Richness and Alpha Diversity among Sample Sites of Paradise Park

FUNCTIONAL FEEDING GROUPS

The scraper and collector-gatherer feeding groups were dominant across all zones. The collector-gatherer was most represented in Zone 6 due to the dominance of the mayfly Baetidae A. Scrapers represented 67% and 60% of Zones 1 and 4, respectively. Piercers and filterers were the least represented across the zones, found only in Zone 1 (1% each). The abundance of scraper indicates the significant growth of algae and periphyton on the substrate of the river. The high abundance of collector-gatherers indicates the high availability of organic matter in the water bodies. The high representation of the piercer group in Zone 2 is due to the high density of plant material in the saline habitats (Figure 4-178).

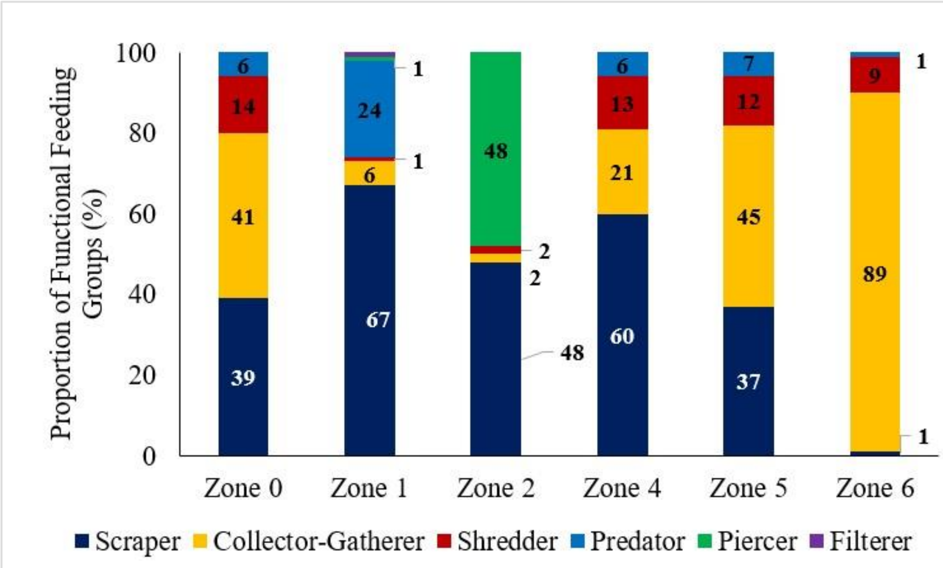


Figure 4-178 Functional Feeding Groups among Zones in Paradise Park

SUMMARY OF RESULTS

The freshwater habitats of the area are healthy, and moderately rich and diverse individually, but very rich and diverse collectively. Physical and chemical conditions indicate high water quality with minimal disturbance, high in dissolved oxygen and low in nutrient content. The various habitats support different species in different permanent, temporary lotic and lentic habitats in the Paradise Park. Clean water species such as Baetidae A and *Helipsyche* sp. dominate the invertebrate fauna, further supporting the limited influence of pollution and disturbance on the area. These freshwater species are sensitive to disturbance and development must limit altering environmental conditions and limit disturbance of natural habitats as much as possible. The data collected represent the freshwater community before the passage of Hurricane Beryl which impacted Jamaica as a category 4 hurricane in early July 2024. Hurricane Beryl likely caused temporary displacement and loss of some species within the area, but due to the high diversity across different sites, was likely restored to its former status within months. Storms are common to the region annually and many of these species can seek safe refuge amid such storms. The loss of diverse habitats risks reducing the resistance and resilience capabilities of the freshwater invertebrates.

4.2.3 Marine and Benthic Communities

4.2.3.1 Marine Benthic Habitat Classification

Mapping Approach and Data Sources

Geographic Information Systems (GIS) and remote sensing technologies were extensively utilized to map benthic features and habitat patterns within the detailed survey zone. The October 2023 drone-based 10-band image mosaic and a LiDAR-derived orthomosaic were the main inputs for image classification. After performing object-based segmentation and pixel-based unsupervised classification, the classified images were further refined through contextual editing based on ground-truthing data collected from field surveys. This process ensured accurate representation of various benthic assemblages and seagrass species where possible. The combination of high-resolution aerial imagery and precise GPS mapping enabled the effective classification of the detailed survey areas and significantly improved the accuracy and utility of the overall habitat map.

For the wider benthic study area, existing available data were utilised, including a Submerged Aquatic Vegetation (SAV) probability map for the Bluefields Bay Fish Sanctuary (McIntyre, 2015)[7] and the TNC Habitat Map (Schill, et al., 2021)[8]. Spatial data from these sources were merged to create a spatial layout of benthic communities within the wider study area. Additionally, fieldwork contributed accurate location data for coral features and verification of seagrass presence within Bluefields Bay.

Marine Benthic Habitat Distribution

The total area mapped across all benthic habitats (70.74 km² or 7,074.07 hectares) reveals a predominance of seagrass (especially Thalassia), algae, and sand/silt/mud, with hardbottom and reefs representing smaller but significant components (Table 4-49, Figure 4-181). Specifically, the largest area of the study area is covered by Seagrass habitats, particularly Thalassia (2,695.42 hectares or 38.10%), followed by Hardbottom Dense Algae (851.08 hectares or 12.03%) and Hardbottom Sparse Algae (584.96 hectares or 8.27%) (Figure 4-179). Sand/silt/mud areas also occupy a significant portion of the total area, covering 668.23 hectares or 9.45%, and other notable habitats include Coral/Algae (664.21 hectares or 9.39%) and Spur and Groove Reef (179.25 hectares or 2.53%). Other reef-related habitats, such as Patch Reef, Back Reef, Fore Reef, and Reef Crest, are represented at very low proportions (< 1% of the total area).

[7] Macro-acoustic data was modelled to create a probability map for submerged aquatic vegetation (SAV) for Bluefields Bay. To classify the map into meaningful SAV presence and absence categories, a 50% probability threshold was applied. Specifically, areas where the vegetation occurrence probabilities were greater than 50% were considered "vegetated."

[8] Using 4m resolution imagery derived from the PlanetScope (PS) Dove Classic SmallSat constellation, Schill et al. (2021) employed a comprehensive object-oriented ruleset utilizing Dove-derived bathymetry and surface/bottom reflectance data to generate an automated thirteen-class benthic habitat classification extending to 30 m water depth, which yielded a confidence interval of 78%–82%. The TNC atlas is intended to map coral reef distributions and characteristics on a regional (e.g., 100 km) to ocean-basin scale (e.g., 1000 km).

Table 4-49 Benthic habitats and seagrass specie distribution areas in the benthic survey area and detailed survey zones, with colour-scaled cells from white to dark green representing the portion of each class

Benthic Habitat	Seagrass Specie	DETAILED SURVEY AREA		WIDER BENTHIC STUDY AREA		TOTAL BENTHIC STUDY AREA	
		Area (ha)	Percentage of detailed survey area (%)	Area (ha)	Percentage of wider study area (%)	Area (ha)	Percentage of study area (%)
Back Reef				25.72	0.37%	25.72	0.36%
Patch Reef				10.16	0.15%	10.16	0.14%
Coral/Algae				664.21	9.51%	664.21	9.39%
Fore Reef				54.79	0.78%	54.79	0.77%
Fringing Reef		1.89	2.07%			1.89	0.03%
Hardbottom Dense Algae				851.08	12.19%	851.08	12.03%
Hardbottom Sparse Algae				584.96	8.38%	584.96	8.27%
Not classified (Unknown/land)		2.39	2.62%	1283.33	18.38%	1285.72	18.18%
Reef Crest				6.86	0.10%	6.86	0.10%
Sand/silt/mud		37.46	41.11%	630.76	9.03%	668.23	9.45%
Halodule	Halodule	18.27	20.04%			18.27	0.26%
Syringodium	Syringodium	0.28	0.31%			0.28	0.00%
Syringodium and Halodule	Syringodium and Halodule	0.04	0.04%			0.04	0.00%
Thalassia	Thalassia	3.61	3.96%	2691.82	38.55%	2695.42	38.10%
Thalassia and Halodule	Thalassia and Halodule	10.57	11.60%			10.57	0.15%
Thalassia and Syringodium	Thalassia and Syringodium	16.48	18.08%			16.48	0.23%
Thalassia, Syringodium and Halodule	Thalassia, Syringodium and Halodule	0.15	0.16%			0.15	0.00%
Spur and Groove Reef				179.25	2.57%	179.25	2.53%
Total		**91.13**		**6982.94**		**7074.07**	

The detailed survey area for seagrass and other benthic habitats covers a total of 0.91 km² or 91.13 hectares. Within this area, the most significant habitat type is Sand/silt/mud, which comprises 41.11% (37.46 hectares) of the survey zone (Table 4-49, Figure 4-181). Seagrass species are also prominent, with Halodule covering 18.27 hectares (20.04%), mixed Thalassia and Syringodium seagrass beds 16.48 hectares (18.08%) and mixed Thalassia and Halodule beds together occupying 10.57 hectares (11.60%). Other mono-specific and mixed seagrass beds and benthic features in the detailed survey area are minimal in size (<5 hectares), but the presence of a fringing reef around the headland must be noted, and accounts for 1.89 hectares (2.07%).

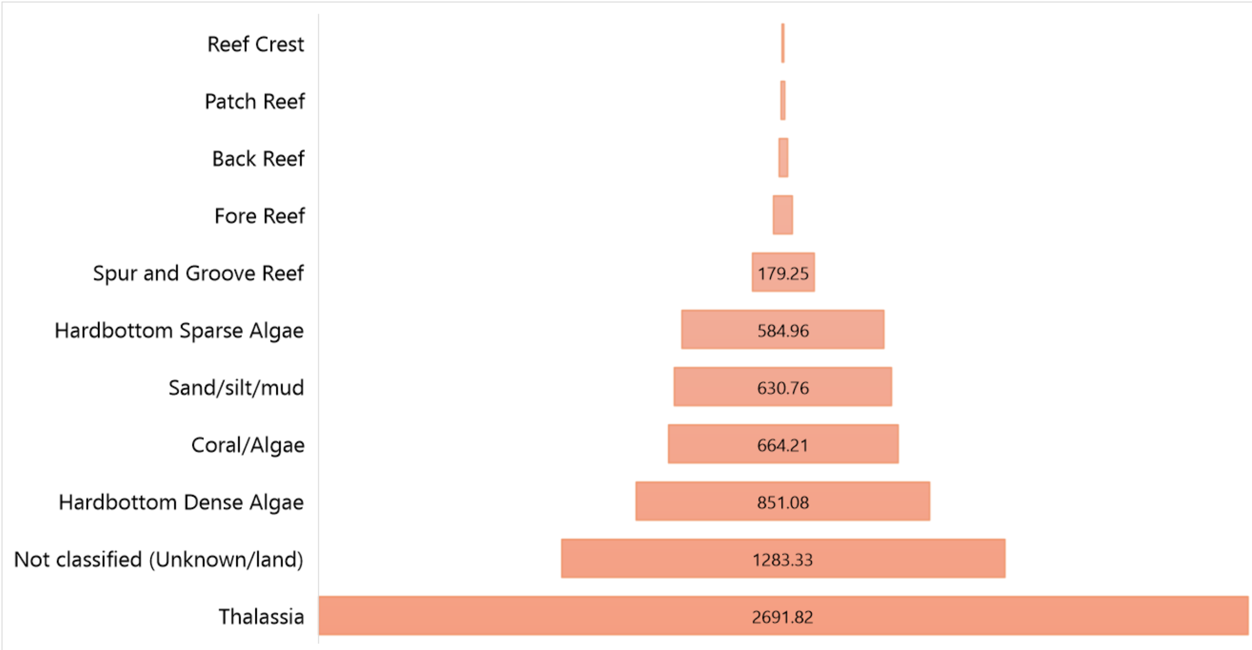


Figure 4-179 **Chart showing benthic habitats and seagrass specie distribution in the wider benthic survey**

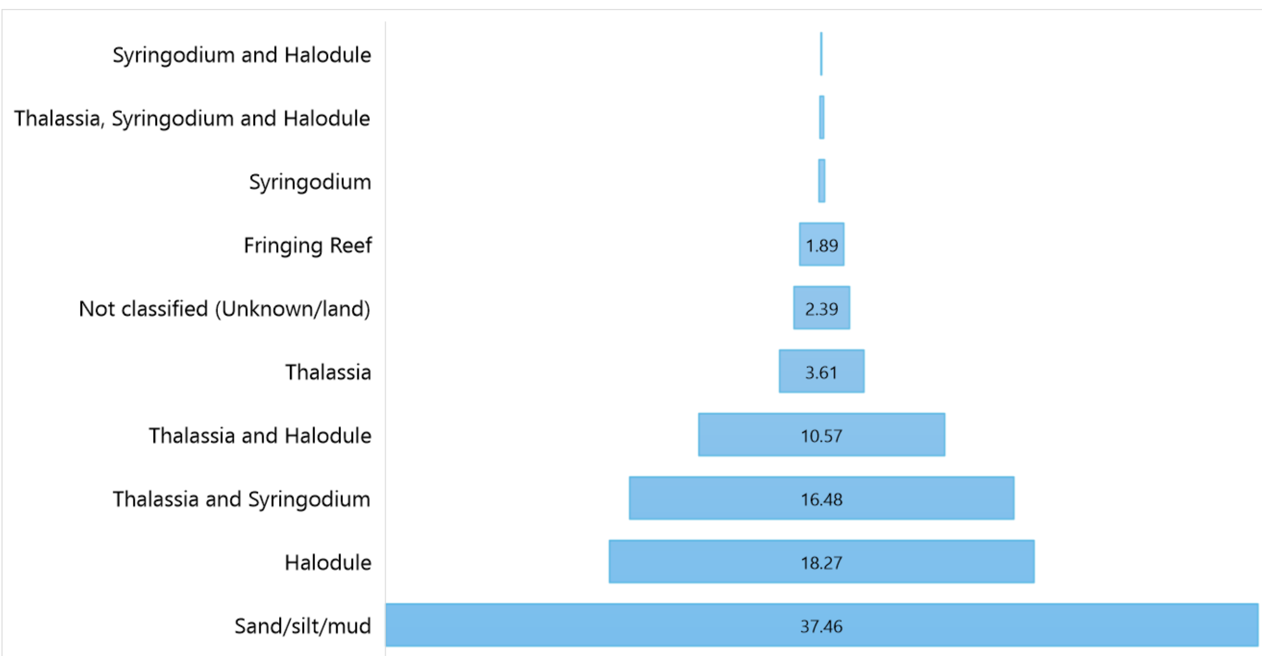


Figure 4-180 **Chart showing benthic habitats and seagrass specie distribution in the detailed survey zones**

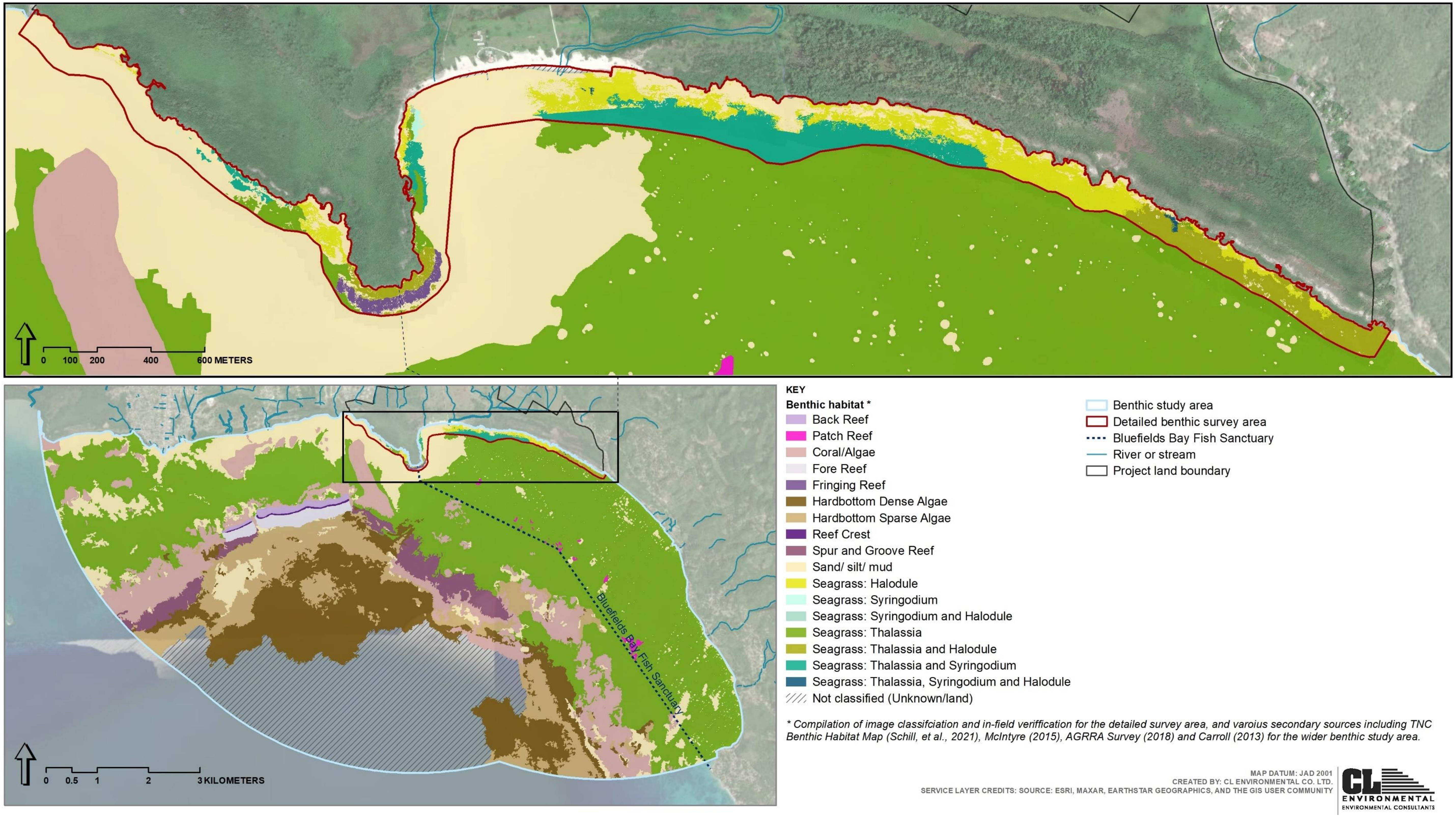


Figure 4-181 Benthic habitats within the benthic study area and detailed survey zone

4.2.3.2 Literature Review

Most of the study site falls within the Bluefields Bay Special Fishery Conservation Area (BBFS), established in 2009, in Westmoreland, Jamaica. As one of Jamaica's 20 Special Fishery Conservation Areas/Fish Sanctuary, BBFS is recognized for its ecological significance, particularly its diverse benthic habitats, including seagrass beds, coral reefs, and sandy substrates. This sanctuary spans 13.82 km², making it the second largest in Jamaica (McIntyre, 2015).

The area has been previously described by (Carroll, 2013)and (McIntyre, 2015), with both studies highlighting the dominance of submerged aquatic vegetation (SAV) within the sanctuary. Carroll's study emphasized the prevalence of seagrass beds, which constituted 82% of the benthic habitat, while McIntyre's benthic mapping confirmed similar findings. However, there are notable differences in their observations regarding coral reefs. While (Carroll, 2013) identified smaller coral patches within the sanctuary, McIntyre (2015) highlighted that most of the major reef areas are located outside the sanctuary's boundaries.

Atlantic and Gulf Rapid Reef Assessments (AGRRA) were conducted to establish baseline conditions and track changes in coral and fish populations. These surveys highlighted a decline in fish biomass and coral cover, attributed to historical overfishing and climate -induced stressors, such as coral bleaching events (AGRRA, 2018). Similarly, the management plan for BBFS emphasizes habitat monitoring and enforcement of no-fishing zones to foster ecological resilience and replenish fish stocks (NEPA, 2013).

Previously identified threats to the sanctuary also include sedimentation from upland activities, overfishing, and the construction of coastal structures.

There are four (4) documented species of seagrass found within Jamaica, namely, *Thalassia testudinum* (Turtle grass), *Syringodium filiforme* (Manatee grass), *Halodule wrightii* (Shoal Grass) and *Ruppia maritima* (widgeon grass) (Thorhaug, Miller, Jupp, & Booker, 1985). Of these species, *Thalassia testudinum*, *Syringodium filiforme* and *Halodule wrightii* are the three main documented and widely studied species within Jamaica. The presence *Halophila decipiens* has also been noted around the island according to personal communication with the National Environmental Protection Agency (NEPA) resulting in a total of five (5) species of seagrasses island wide. Of these species, *T. testudinum* is the most dominant and has the largest growth form. These species can be found in most marine areas island wide (De Kluijver, Gijswijt, De Leon, & Da Cunda, 2016); (McKenzie & Hq, 2008). Seagrass meadows are noted for being nursery grounds, with many juveniles and small fish living among seagrass blades before migrating to adjacent reefs. This proves important to the interconnectivity of ecosystems and assists in the sustenance of industries such as tourism and fisheries, the latter of which is a main economic activity in surrounding towns. Seagrass meadows also dissipate wave energy and stabilize sediment, therefore reducing coastal erosion and turbidity.

Though small in proportional coverage, coral reefs offer vast benefits. Reefs are home to a wide array of organisms, occupying various niches in the physical space. Like seagrass meadows, reefs also assist in coastline protection, with reefs reducing wave energy by as much as 86% (Ferrario et al. 2014).

Marine ecosystems face several threats to biodiversity, including climate change, coastal development, pollution, and invasive species. Nearby reefs (Belmont and Whitehouse) were both ranked "poor" by NEPA when last surveyed as a part of the national assessment exercise in 2019.

Recent Large-Scale Events

Recent large-scale events have significantly impacted marine ecosystems in the Caribbean and beyond:

1. **2023 Mass Coral Bleaching Event**: High sea temperatures in 2023, driven by climate change and El Niño, caused widespread coral bleaching across the Caribbean, leading to significant coral mortality and habitat degradation. Forecasts indicate elevated sea temperatures may continue into 2024, threatening further bleaching events. (NEPA, 2024). As of April 2024, the forecast for 2024 indicates another year of elevated sea temperatures, raising concerns for a recurring coral bleaching event. With consecutive years of warmer-than-average ocean temperatures, coral reefs across the Caribbean and other regions are at heightened risk of experiencing widespread bleaching once again.
2. **2022 Diadema Die-Off**: A mass mortality event in 2022 affected *Diadema antillarum* sea urchins, crucial for controlling algae on coral reefs. Their loss led to increased algal growth and reduced coral recruitment, weakening reef resilience.
3. **SCTLD Outbreak**: Stony Coral Tissue Loss Disease (SCTLD) has caused extensive coral mortality, particularly affecting pillar corals in the Caribbean, reducing habitat complexity and threatening reef ecosystems.
4. **Invasive Species:** Invasive species like lionfish and green mussels are disrupting Jamaica's marine ecosystems by outcompeting native species and altering habitats. Potential invasive species, such as *Unomia stolonifera* and *Halophila stipulacea*, pose additional risks by outcompeting native species and changing ecosystem dynamics.

Marine Heatwave

According to the European Earth observation agency Copernicus, February 2023 to January 2024 were the hottest on record. The global average temperature for this period was 0.64°C above the 1991-2020 average and 1.52°C above the 1850-1900 pre-industrial average. The survey was conducted during a period of elevated global temperatures, which resulted in a Marine Heat Wave (MHW).

From (Mohamed, et al., 2023) 'Global mean sea surface temperature (SST) has increased in recent decades due to anthropogenic-induced climate change (IPCC, 2021). One of the most certain consequences of this climate change are extremely warm ocean temperatures, known as marine heatwaves (MHWs) (Hobday et al., 2016). MHW have destructive impacts on marine ecosystems, biodiversity, and fisheries.

MHW pose a significant threat to benthic communities, disrupting the delicate balance of these ecosystems. Elevated sea temperatures, exacerbated by climate change, can lead to coral bleaching events, where corals expel their symbiotic algae, resulting in loss of colour and potential mortality. Heat stress also affects other benthic organisms such as seagrasses, which may experience reduced growth rates and increased vulnerability to disease. As temperatures rise, the metabolic rates of benthic organisms can increase, leading to higher energy demands and potential stress. These changes can have cascading effects throughout the ecosystem, impacting biodiversity, trophic interactions, and ecosystem services.

Heat stress is a primary driver of coral bleaching, a phenomenon where corals expel their symbiotic algae in response to prolonged exposure to elevated temperatures. Without their algae, corals lose their colour and primary source of nutrition, becoming more susceptible to disease and mortality. While some corals may recover from bleaching events if conditions return to normal quickly, prolonged, or repeated heat stress can lead to widespread coral mortality and degradation of reef ecosystems. Additionally, heat stress can impact coral reproduction, with elevated temperatures disrupting spawning events and reducing the success of larval settlement. Overall, the increasing frequency and severity of heat stress events pose a grave threat to coral communities, highlighting the urgent need for conservation efforts and climate change mitigation measures to safeguard these invaluable marine habitats.

As outlined in (Lillian R. Aoki, 2021), increasing ocean temperatures, and increasing frequency and severity of heat waves, threaten seagrass meadows and their sediment blue C. To date, no study has directly measured the impact of seagrass declines from high temperatures on sediment C stocks. Long-term record of sediment C stocks from a 7-km^2, restored eelgrass (Zostera marina) meadow showed that seagrass dieback following a single marine heat wave (MHW) led to significant losses of sediment C. Patterns of sediment C loss and re-accumulation lagged patterns of seagrass recovery. Sediment C losses were concentrated within the central area of the meadow, where sites experienced extreme shoot density declines of 90% during the MHW and net losses of 20% of sediment Cover the following three years. However, this effect was not uniformed.

Effects of MHW on seagrasses may include the following: -

- Increased Stress and Mortality: Elevated temperatures can cause thermal stress to seagrasses, leading to physiological changes and potentially resulting in mortality. Seagrasses have specific temperature tolerance ranges, and when these are exceeded, they may experience heat-induced damage.
- Reduced Photosynthesis: High temperatures can negatively impact the process of photosynthesis in seagrasses. Excessive heat can reduce the efficiency of photosynthetic reactions, limiting the production of carbohydrates essential for seagrass growth and maintenance.

- Altered Growth Rates: Prolonged exposure to elevated temperatures can lead to changes in the growth rates of seagrasses. This can manifest as reduced shoot density, slower vertical growth, and alterations in the overall structure of the seagrass bed.
- Increased Vulnerability to Diseases: Elevated temperatures can weaken seagrasses, making them more susceptible to diseases and pathogens. Stress-induced by high temperatures may compromise the defence mechanisms of seagrasses, leading to increased vulnerability to infections.
- Changes in Reproductive Patterns: Seagrasses often rely on specific temperature cues for reproductive processes. Elevated temperatures can disrupt reproductive patterns, affecting seed germination, seedling establishment, and the overall reproductive success of seagrasses.
- Altered Biotic Interactions: High temperatures can disrupt the balance of biotic interactions within seagrass ecosystems. For example, temperature-induced changes in the abundance or behaviour of herbivores and grazers can affect seagrass consumption rates and lead to altered community dynamics.
- Shifts in Species Composition: Seagrass communities may experience shifts in species composition as some species prove more resilient to elevated temperatures than others. This can lead to changes in the overall biodiversity and ecological structure of the seagrass bed.
- Impact on Associated Fauna: Elevated temperatures in seagrass beds can affect the abundance and distribution of associated fauna, including fish, invertebrates, and epiphytic organisms. Changes in temperature can influence the availability of food resources and shelter, impacting the entire ecosystem.

4.2.3.3 Survey Methods

Surveys were conducted between 2023 and 2024 to assess the benthic conditions within the study area. A variety of methods were employed to capture changes over time and provide a detailed overview of various marine resources; these are detailed in subsequent sections.

GPS Mapping and Ground-Truthing

The extent of the seagrass beds, coral assemblages and other distinct benthic features within the detailed survey area were mapped as points, lines and polygons using Trimble Geo 7x Global Positioning System (GPS) and Trimble TDC650 Global Navigation Satellite System handheld receiver (GNSS) for precise location data.

Survey target points were identified using satellite imagery for both general ground truthing as well as detailed data collection (Figure 4-183).

Transect Lines

Belt transects were conducted in the detailed survey (Figure 4-182). Each transect was used to determine seagrass species, diversity, and distribution. Each line was 100m long where possible, in the vent that 100m was not possible, the transect lines were divided into two, shorter lines. Along each transect line, a

1x1 m2 quadrat was placed at intervals of 10m. The percentage cover of each species in the quadrat was then estimated. This was also done for algae if necessary. Twenty (20) random blade lengths (canopy height) were measured in Thalassia dominated beds and shoot density counted in 8 random 5x5cm squares.

Roving Survey

Roving surveys were conducted within the detailed project survey area as well outside (Figure 4-182), including areas of interest such as, surrounding reef/coral communities.

Seagrass Target Points

Seagrass data collected included species, percentage cover and sediment composition and sediment depth.

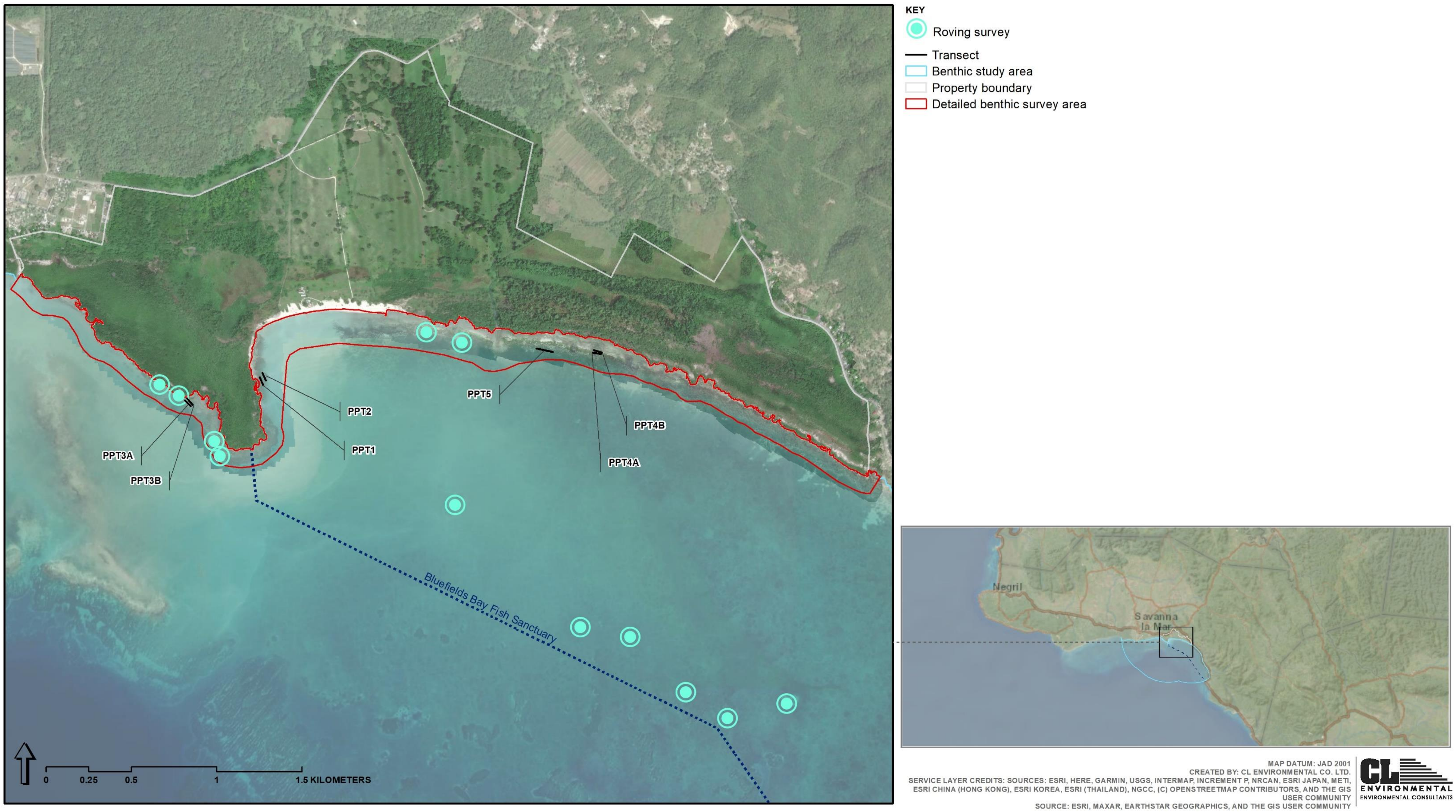


Figure 4-182 **Transects** and roving survey locations within the benthic survey area

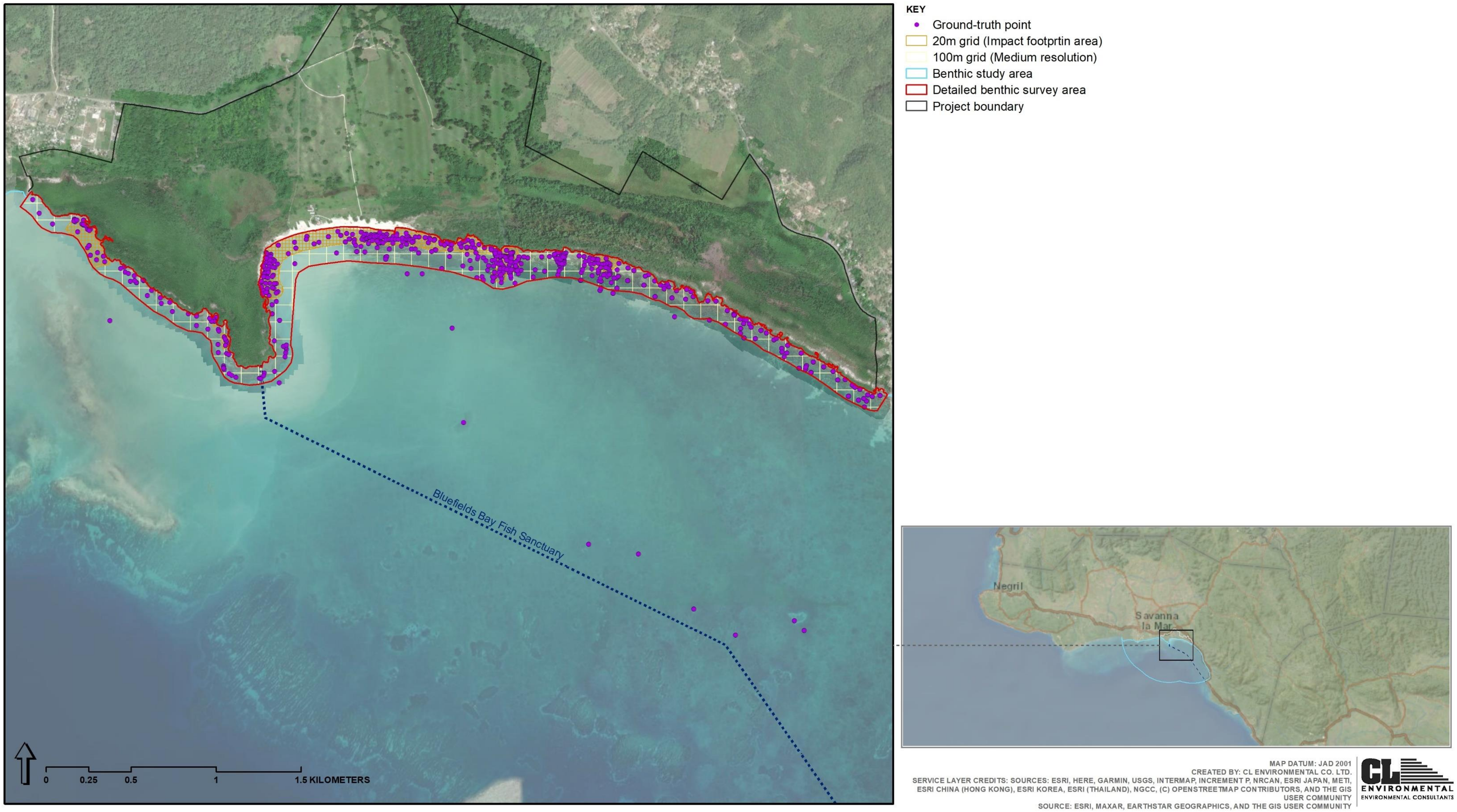


Figure 4-183 Ground-truthing points within benthic study area

Seagrass Carbon Sequestration

Within the project area a total of 11 seagrass cores were extracted (Table 4-50). At each site, diving was utilized to extract core data using a PVC corer and sledgehammer. The core was then capped and removed, and the removed core and contents (vegetative and soil plug) were then carried to the surface and stored for later processing. This process was repeated for each sample taken.

Table 4-50 Coordinates of core extraction points (JAD 2001)

Zone	ID	Eastings	Northings
West Peninsula	PPC1	633950.9458	673949.5366
	PPC2A	634306.2996	673621.4478
	PPC2B	634264.573	673609.8498
	PPC3	634616.8826	673417.1616
East Peninsula	PPC4	635073.8393	673268.9144
	PPC5	635047.5691	673539.9797
	PPC6	635053.1153	673777.7492
East Coastline	PPPC7	636020.5588	673804.2406
	PPC8	636225.3424	673741.1086
	PPC10	637046.1538	673679.5094
	PPC11	637730.3038	673354.2976

In the laboratory, each seagrass blade from the sample was individually measured for length and width, and the wet weight was recorded along with attached epiphytes. Notable epiphytes were identified and removed using a 10% hydrochloric acid solution. After epiphyte removal, the blades were wiped clean, reweighed, and the weight of the epiphytes was noted. The entire root biomass was then extracted, weighed, and recorded. Samples were packaged, dried for 72 hours at 60 degrees Celsius, and dry weights for both roots and seagrass were recorded.

The collected soil was divided into two replicates, placed in labelled aluminium containers, and weighed for wet weight. After drying for 72 hours at 60 degrees Celsius, the soil samples were allowed to cool, weighed for dry weight, and then subjected to a muffle furnace at 450 degrees Celsius for five hours. The samples were removed, ash-free dry weights were recorded, and the resulting data were analysed.

Seagrass Productivity

At each location, four 0.027m^2 quadrats fitted with flagging tape were randomly anchored within the seagrass meadow (Table 4-51). The seagrass blades enclosed within each quadrat were properly fixed to ensure that none of the blades were folded underneath the quadrat boundary. A hole punch was then used to make a hole as close to the base of the blade as possible. This was done for at least 10 blades in each quadrat, samples were then left for two weeks after which they were reaped by removing the entire shoot from the quadrats and stored for later processing.

Table 4-51 Coordinates of productivity quadrats (JAD 2001)

ID	Eastings	Northings
PPC1	634619.6794	673416.6507
PPC2	635060.3711	673288.4404
PPC3	635040.6092	673537.9789
PPC4	635052.9912	673776.7303
PPC5	636023.7161	673802.9957
PPC6	636227.246	673742.1686
PPC7	636758.7996	673692.5334

In the lab, samples were carefully examined to identify holes made in seagrass blades. Blades were then cut along the cross section of each hole, and the upper section discarded. The remaining blade was then placed in 10% hydrochloric acid solution for twenty (20) minutes. After epiphyte removal, blades were wiped clean, reweighed, and the weight of the epiphytes noted. Samples were packaged, dried for 72 hours at 60 degrees Celsius, and dry weights recorded. Productivity data was obtained by transposing the weighted results into the formula:

Dry weight(g) x 0.027258 x 1/14

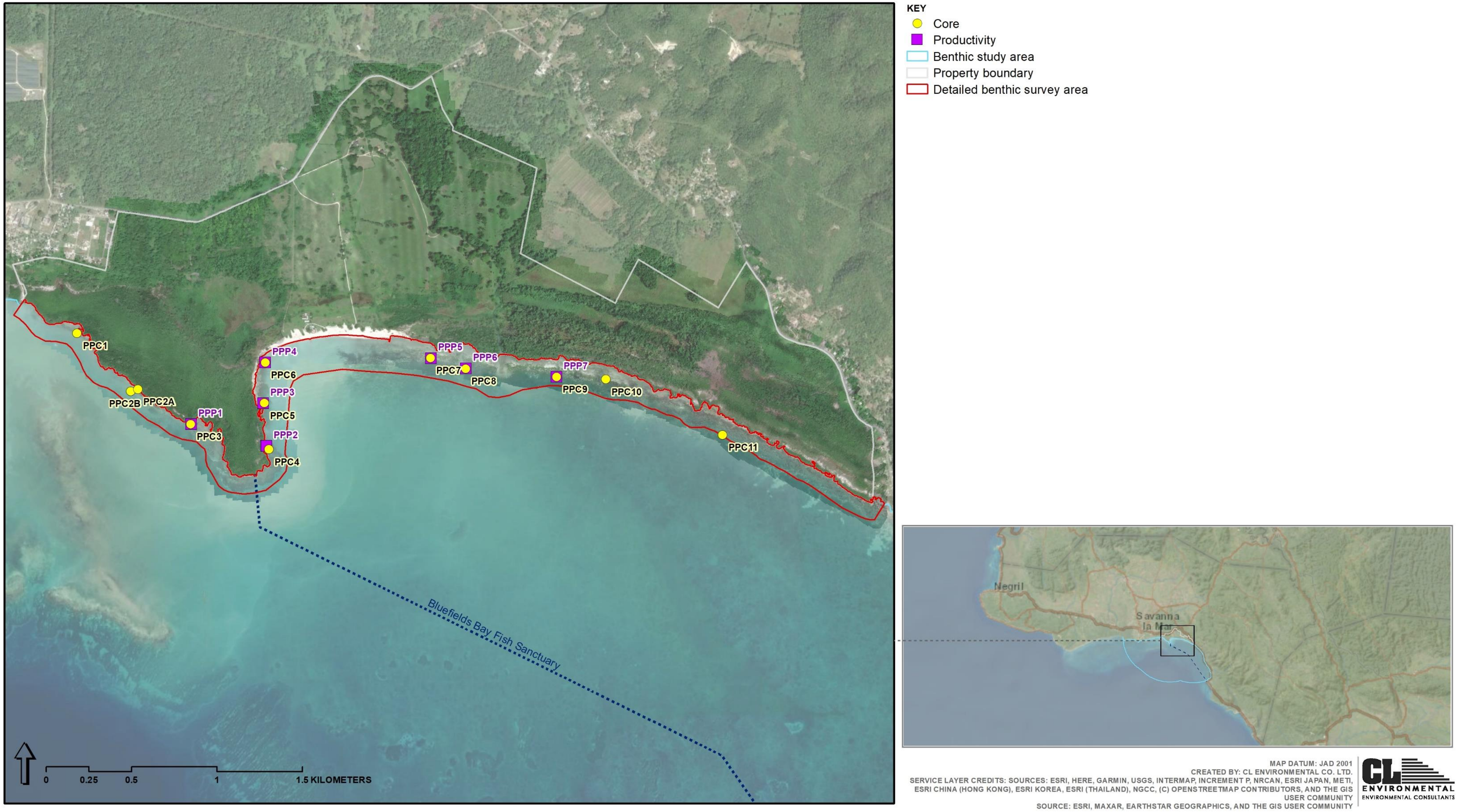


Figure 4-184 **Location of seagrass cores and productivity quadrats** within the benthic study area

Coral Communities

General observations on health and abundance were assessed during roving survey. A photo inventory and species list were compiled. Coral colonies within the detailed survey area were marked using a Trimble TDC650 Global Navigation Satellite System handheld receiver (GNSS) where possible. These surveys were done between 2023 and 2024 during a marine heatwave period. Severe coral bleaching was observed in 2023 at Thatch reef. This area was then resurveyed in 2024 to assess the impacts of bleaching on that coral community. Bleaching was still being observed in the survey area in 2024, but on a much smaller scale

Fish Surveys

SEAGRASS FISH ASSESSMENTS

The fish assessment was conducted primarily within the boundaries of the Bluefields Bay Fish Sanctuary, focusing on various habitats that support the local fishery. The sanctuary encompasses a range of ecosystems, including seagrass beds, mangroves, soft-bottom sediments, and some patch reefs. However, it is important to note that the majority of the reef areas, which also contribute to fishery productivity, lie outside the sanctuary's boundaries.

Numerous juvenile sharks and rays were observed foraging and feeding in the nearshore habitats, underscoring the importance of these areas as nursery grounds.

To evaluate the fish communities within the study area, the belt transect technique was utilized, deploying eight 50-meter transect lines parallel to the shoreline (Figure 4-182). Lines were run parallel to each other within similar depth ranges and separated by at least 5m. Swimming along the transect, all fish within a 5m wide belt and overlying water column were recorded. For each individual, the total length was estimated using a graduated T-bar and assigned to one of the following size classes: 0 - <5cm; - 10 cm; 11 - 20 cm; 21 - 30 cm; 31 - 40 cm; FishBase (http://www.fishbase.org) was used to determine the diet of each species before assigning them to one of three broad categories – Herbivore, Carnivore, and Omnivore.

CORAL REEF FISH ASSESSMENTS

To describe the fish composition on nearby reefs, the Roving Diver Technique was utilized. Within the reef system, a thirty-minute roving survey was conducted. During this survey, every observed species was identified and recorded, assigning each species an abundance rank based on the number of individuals observed: Single (1), Few (2-10), Many (11-100), and Abundant (more than 100).

Sea Turtles

Camera traps were deployed along sections of the beach which may be a potential nesting or activity areas for sea turtles. Camera traps were placed at intervals along the beach, ensuring coverage of areas likely to experience turtle activity. Proximity to environmental features such as vegetation lines and high-tide marks guided placement. Camera traps were set up on June 21, 2023 (for continuous monitoring when possible), downloaded periodically and reviewed until May 27, 2024.

Cameras were mounted on trees approximately 50 cm above ground level to capture clear, undistorted images of turtles. Each camera was angled to maximize the field of view while minimizing glare from the sand or water.

Camera settings were Motion-activated cameras with infrared flash were used to allow for nighttime monitoring without disturbing the turtles. The sensitivity was adjusted to detect subtle movements while best reducing false triggers from wind-blown vegetation or waves, however false triggers were still to be expected depending on proximity and size of moving objects.

Cameras were set to capture a sequence of still images (e.g., 3–5 photos per trigger) or short videos (10–20 seconds) for each activation. This ensured sufficient data to confirm turtle presence and activity patterns. Camera trap locations can be seen below in Figure 4-185.

The survey area, including the beach and surrounding vegetation, were inspected for signs of turtle activity. This involved visually examining the shoreline for tracks, nests, or signs of recent turtle landings, as well as searching the adjacent vegetation for potential nesting sites or disturbances indicative of turtle presence.

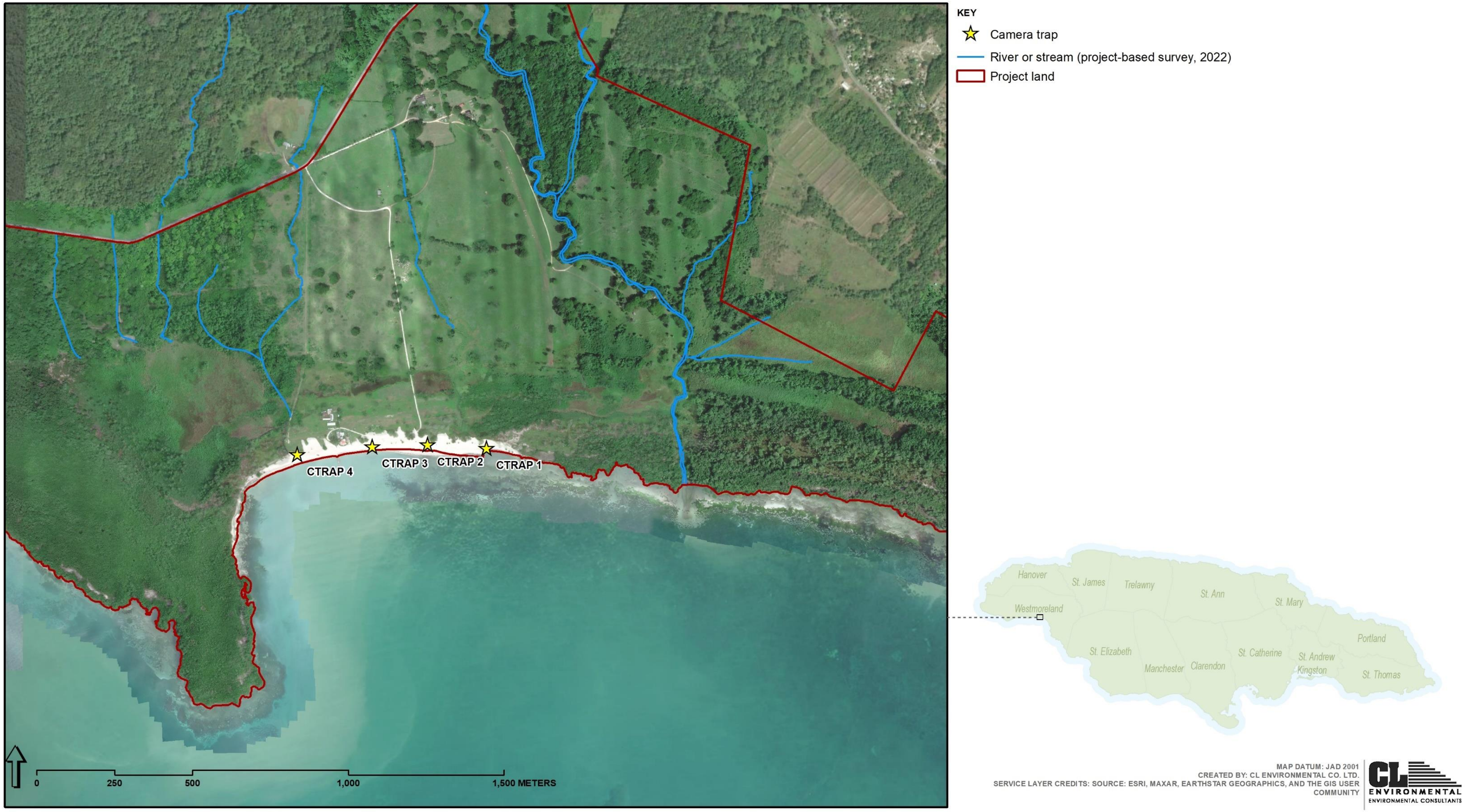


Figure 4-185 Map of camera trap locations

4.2.3.4 Seagrass

The study area includes seagrass beds both within and outside of the boundaries of the Bluefields Bay Fish Sanctuary, encompassing a range of seagrass habitats shaped by diverse environmental conditions (4.2.3.1). Nearshore areas are predominantly shallow, sheltered, and influenced by substantial silt deposition, poor visibility, and freshwater inputs. *Halodule wrightii* is the dominant species in these nearshore zones, which exhibit significant spatial and temporal variability.

The wider area is dominated by extensive *Thalassia testudinum* beds, forming a major component of the benthic habitat. Some sections of the study area including large section of the near and mid-shore areas are dominated by a muddy, silty substrate. These soft, silty areas in general have poor visibility and are devoid of vegetation.

To facilitate analysis, the study area was divided into three zones: West Peninsula, East Peninsula, and East Coastline (Figure 4-186). This zonation allowed for a more detailed characterization of the parameters collected within each area. The aerial images (Plate 4-44 - Plate 4-48)provide examples of the varied nearshore seagrass distribution, highlighting the patchy arrangement of different species across the survey area. Generally, Halodule wrightii, a primary colonizing and fast-growing species, is observed in softer, less stable sediments where conditions may be less suitable for long-term seagrass establishment. Thalassia testudinum, a climax species, tends to occur in more stable areas with deeper, well-established sediments, forming denser, more persistent beds. Syringodium filiforme is typically found in transitional zones, where conditions support a mix of both early colonizers and more established species. These observations illustrate trends in species composition, though local variability is influenced by sediment stability, water depth, and habitat conditions.

Plate 4-44 **Nearshore area with a mix of various seagrass species and algae**

Plate 4-45 **Example of a silty area dominated by *Halodule***

Plate 4-46 Example of a patchy distribution of seagrass

Plate 4-47 Example of a complicated nearshore seagrass bed

Plate 4-48 Example of a complicated nearshore seagrass bed

Examples of the dominate seagrass species are given in Plate 4-49 - Plate 4-52. *Halodule wrightii* is the dominant species in the nearshore areas, occurring in very shallow, soft, and silty conditions, generally with poor visibility. Some beds can be partially exposed at low tide, with blades occasionally tangled or covered in algae. *Thalassia testudinum*, the more dominant species throughout the wider BBFFS, forms extensive, dense beds.

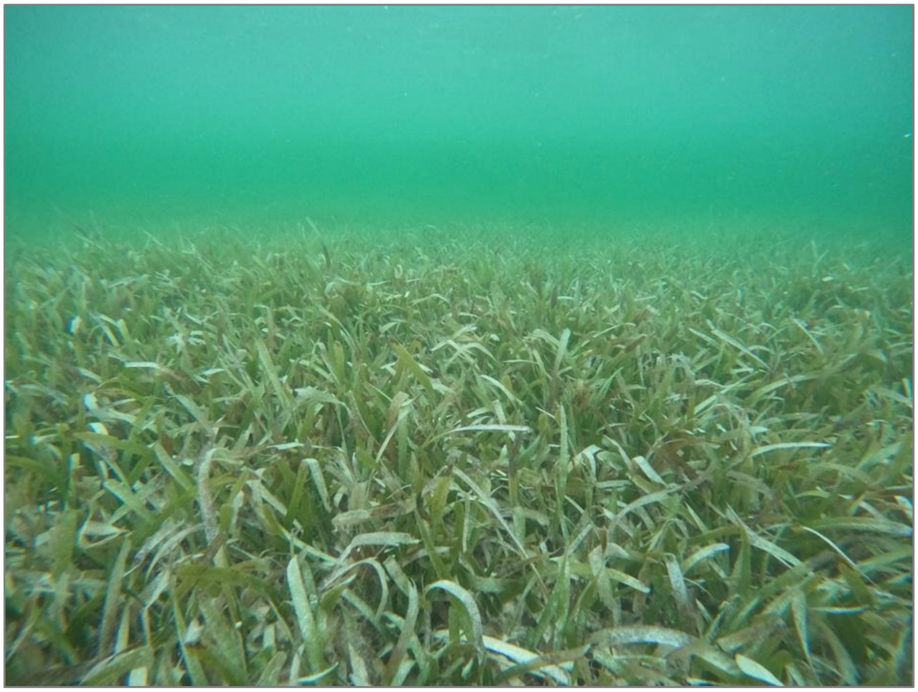


Plate 4-49 **Section of the extensive *Thalassia* bed**

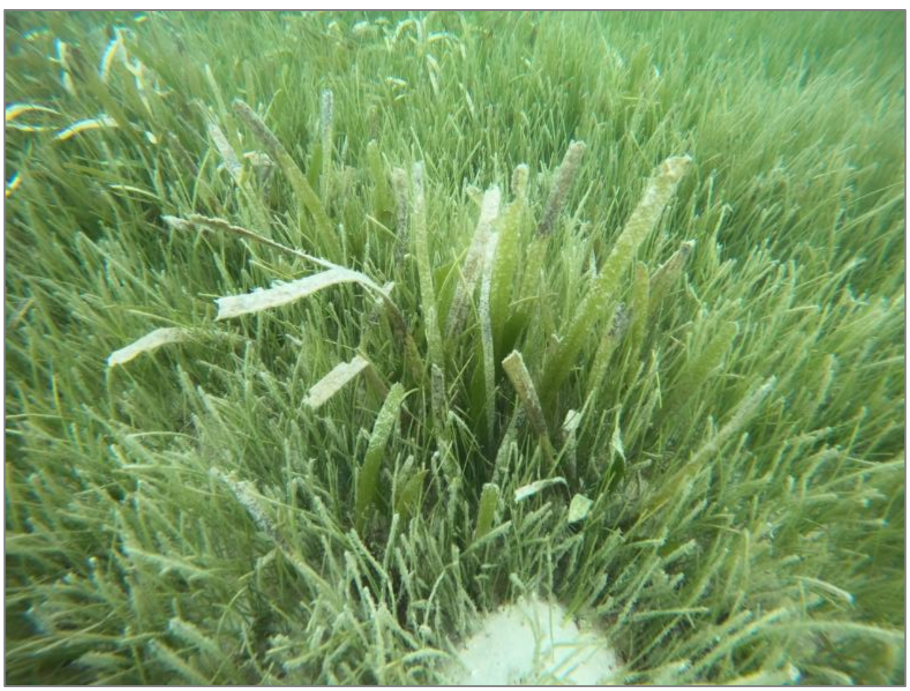


Plate 4-50 **Example of a mixed seagrass bed**

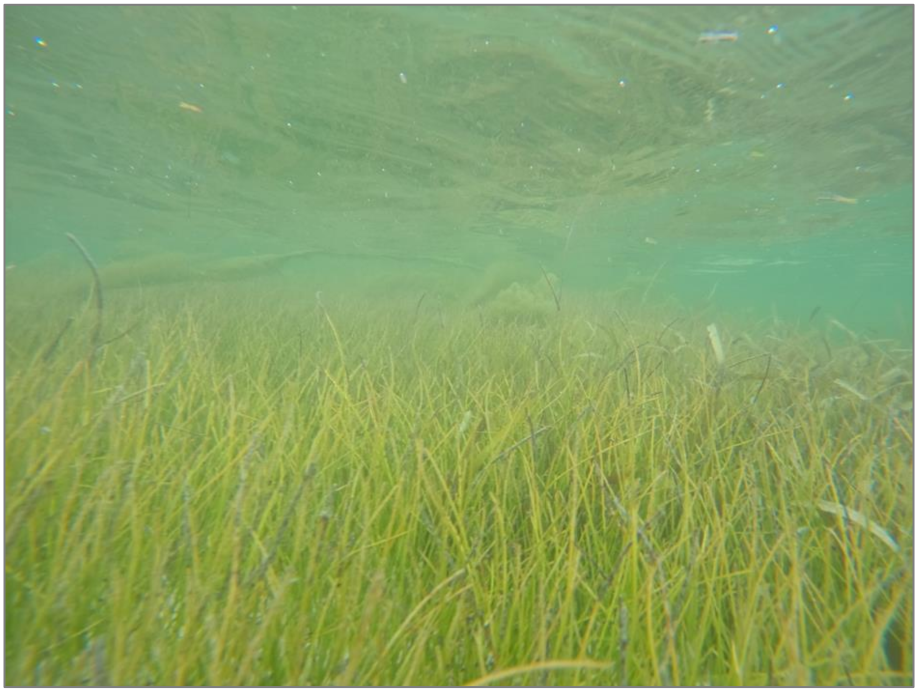


Plate 4-51 **Dense *Halodule* bed**

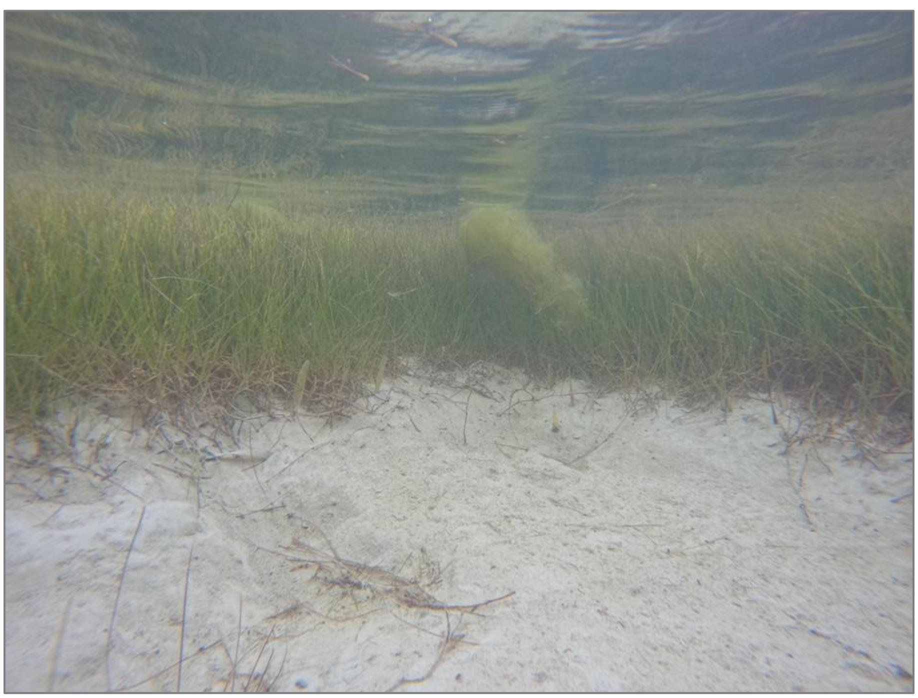


Plate 4-52 **Section of Halodule bed partially exposed and with some sections cover by thick free-floating algae**

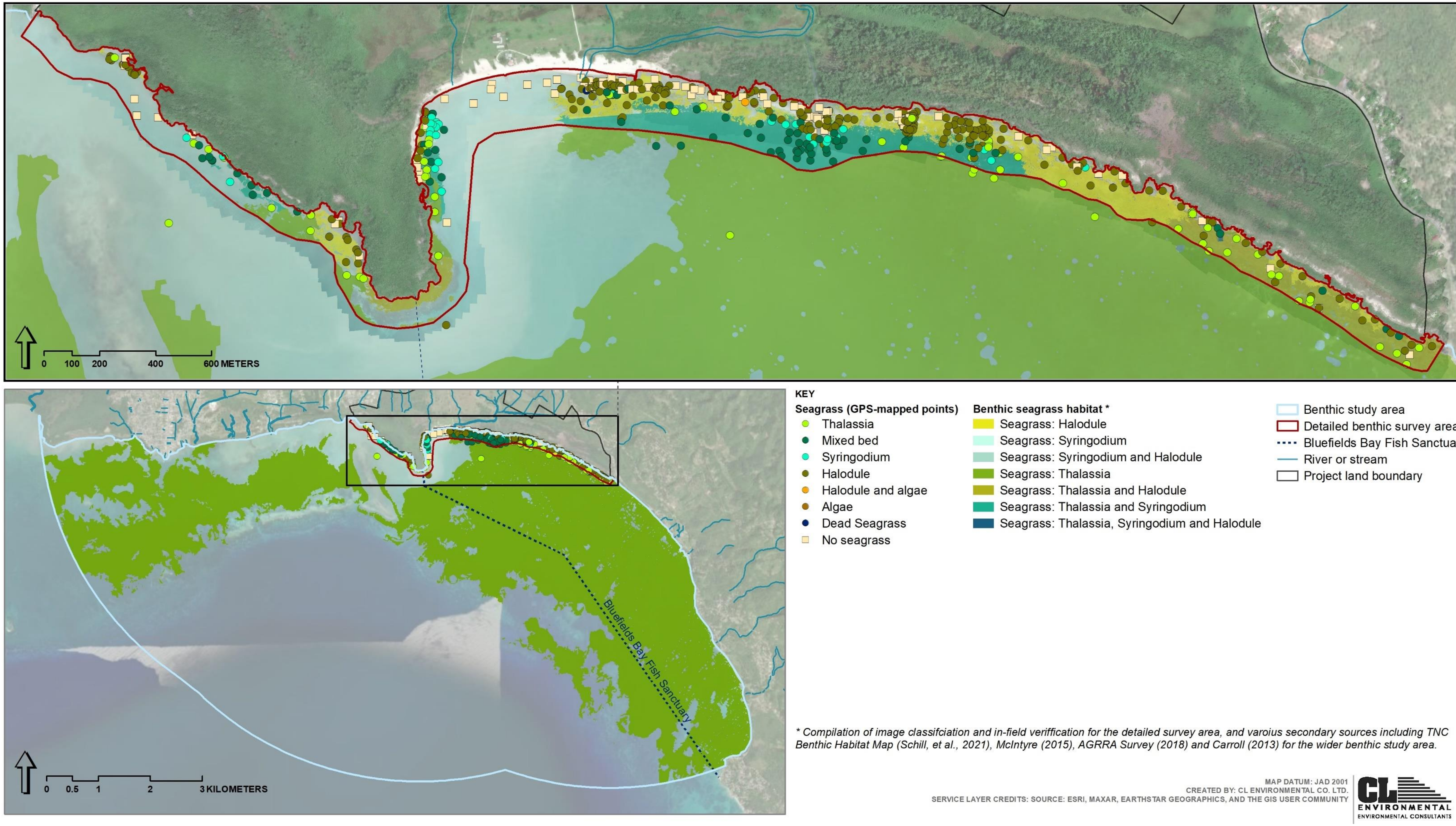


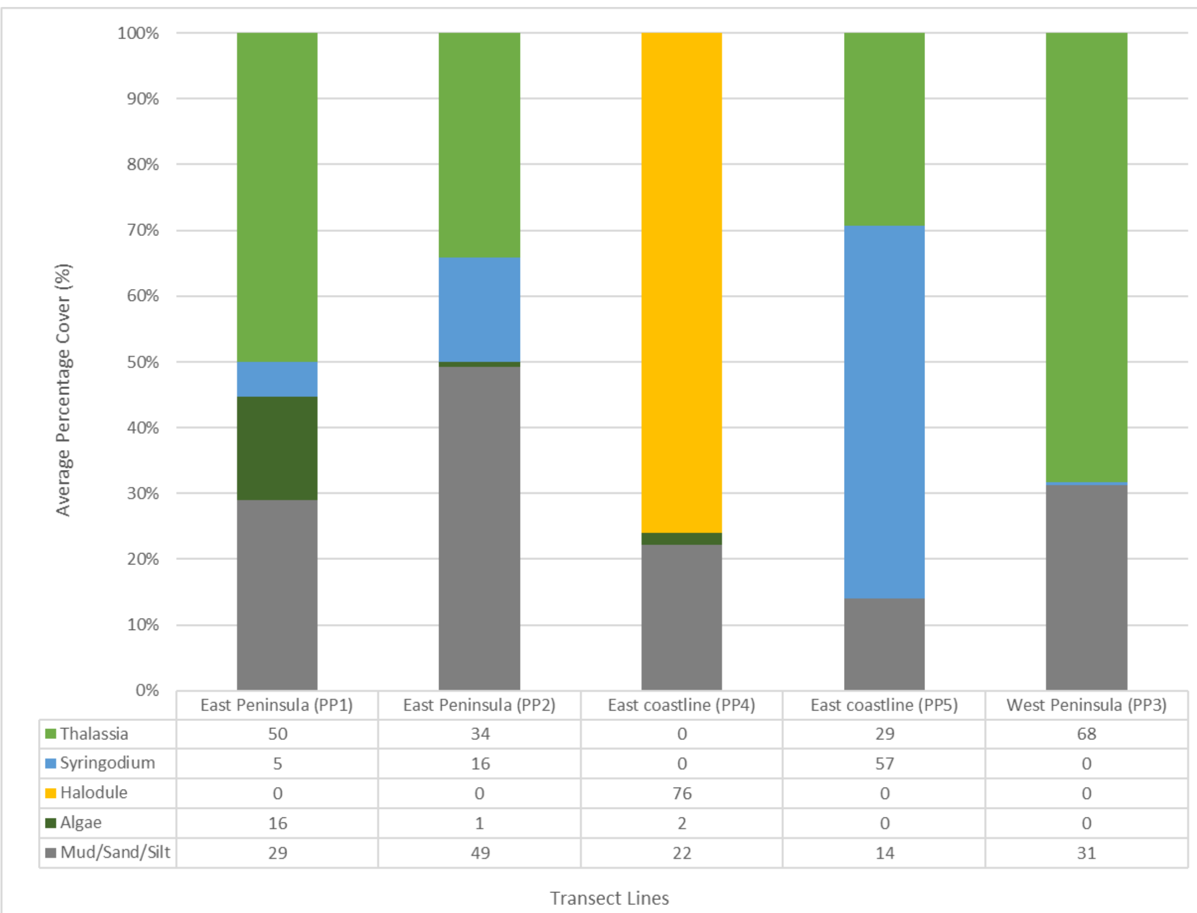
Figure 4-186 Mapped seagrass points and habitat extents

Bed Health Metrics

The seagrass bed assessment in the study area focused on species-specific health metrics. For *Thalassia testudinum*, percent cover, shoot density and blade length were measured, while for other species, *Halodule wrightii* and *Syringodium filiforme*, percent cover was used as the primary metric. *Thalassia* was identified as the dominant species across the study area, while *Halodule* was found to dominate nearshore areas with silty substrates and very poor viability, an observation not previously described for this area. Sections of the survey area had all three species coexisting, highlighting the ecological diversity and complexity of the seagrass beds.

PERCENTAGE COVER

Figure 4-187 illustrates spatial variation in benthic composition across the study area, with differences influenced by transect locations and environmental conditions. Some sections are dominated by *Thalassia testudinum*, while others are characterized by *Halodule wrightii*, particularly in silty nearshore areas. *Syringodium filiforme* is present but occurs in smaller patches across the study area. Bare substrate, composed primarily of mud and silt, is also a common feature, reflecting the influence of sediment-heavy conditions throughout the region. These variations highlight the dynamic nature of the benthic habitats within the study area.



	East Peninsula (PP1)	East Peninsula (PP2)	East coastline (PP4)	East coastline (PP5)	West Peninsula (PP3)
Thalassia	50	34	0	29	68
Syringodium	5	16	0	57	0
Halodule	0	0	76	0	0
Algae	16	1	2	0	0
Mud/Sand/Silt	29	49	22	14	31

Figure 4-187 Average percent seagrass cover by specie

SHOOT DENSITY

Figure 4-188 shows the average shoot density of minimal spatial variation across the study area. The highest density was observed at the West Peninsula (PP3) with 383.96 shoots per sq.m, located outside the sanctuary near a healthy mangrove system that may provide nutrient-rich runoff. Within the sanctuary, the East Peninsula transects (PP1 and PP2) had densities of 213.54 and 267.46 shoots per sq m, respectively, while the East Coastline (PP5) exhibited the lowest density at 125.61 shoots per sq m. These relatively small differences suggest that shoot density is generally consistent across the area, though proximity to mangroves and distance from the shoreline may slightly influence local variations. Variations in seagrass species composition were influenced by transect location. Halodule was more common in nearshore areas, while Thalassia dominated further offshore. This pattern was consistent across the study area.

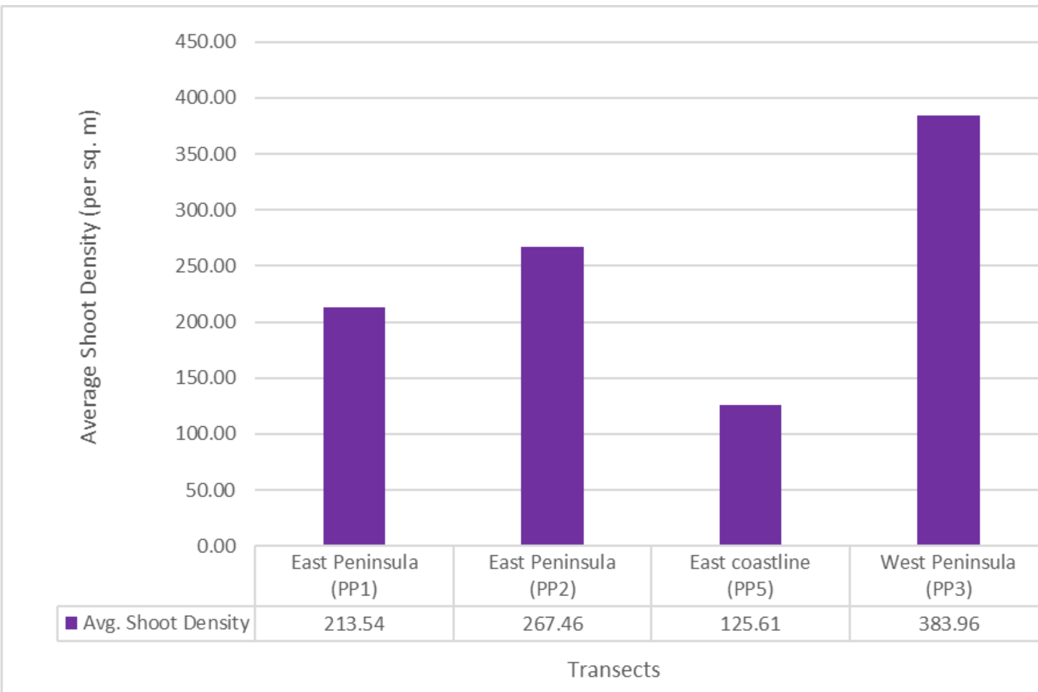


Figure 4-188 Average Shoot Density for Thalassia across the study area

LEAF BLADE LENGTH

Figure 4-189 average leaf blade length of seagrass across the surveyed transects showed minor variations, with the longest blades recorded at the West Peninsula (PP3) at 34.05 cm. This transect lies outside the sanctuary and is adjacent to a healthy mangrove system, which likely influences seagrass growth through nutrient-rich drainage from the mangroves. In contrast, the East Peninsula transects (PP1 and PP2) within the sanctuary had average blade lengths of 24.19 cm and 26.74 cm, while the East Coastline (PP5) exhibited the shortest blades at 21.14 cm. These observations suggest that the proximity to mangroves may enhance seagrass blade length. The location of each transects, particularly their distance from the shoreline, may also influence blade length.

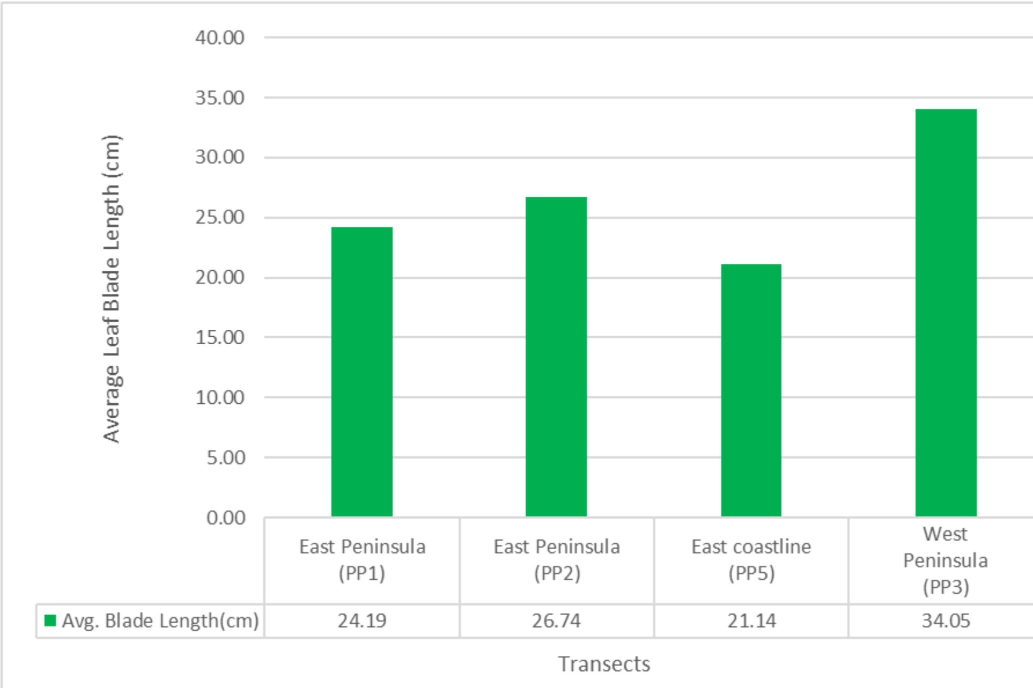


Figure 4-189 Average Leaf blade length for Thalassia across the study area

Carbon Sequestration and Storage

Sites were differentiated into three distinct areas to further describe parameters collected. Zones included West Peninsula, East Peninsula and East Coastline (Table 4-52). Across the dataset, total carbon storage within the vegetative component (roots and shoots) derived from core analysis of the seagrasses present was 2.372 MgC while total soil carbon values amounted to 391.365 MgC. Per zone values can be seen in the section below.

Table 4-52 Site groupings and zone allocation for core samples taken at Paradise Park

ZONE	SITE
West peninsula	PPC 1
	PPC 2A
	PPC 2B
	PPC 3
East peninsula	PPC 4
	PPC 5
	PPC 6
East coastline	PPC 7
	PPC 8
	PPC 10
	PPC 11

VEGETATIVE COMPONENT

Among zones, the area with the highest blade density was located within the west peninsula at which sixty-seven (67) blades were retrieved. This was followed by the east coastline and east peninsula where 40 and 28 blades were retrieved respectively (Figure 4-190). Notably, site PPC 3 located along the west peninsula had the highest blade retrieval numbers of all sampled locations with a total of fifty-four 54 blades (Figure 4-191).

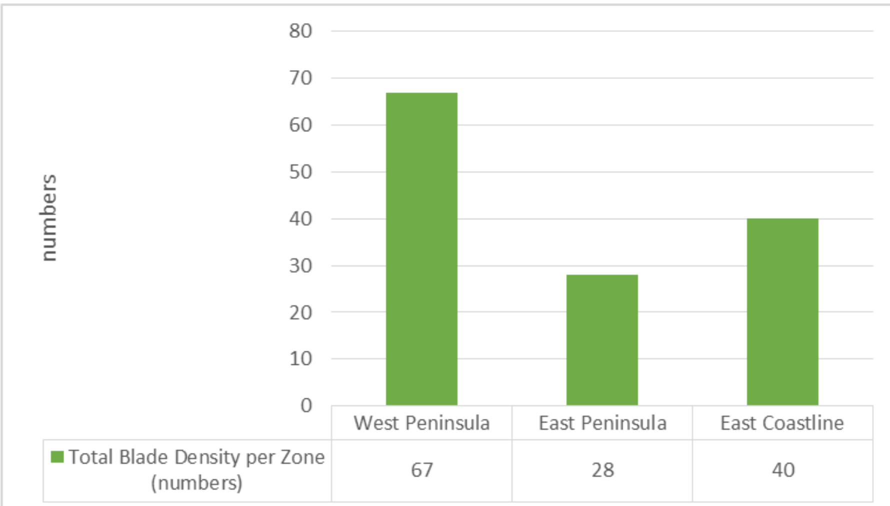


Figure 4-190 Total blade density per zone (numbers) of samples taken at Paradise Park.

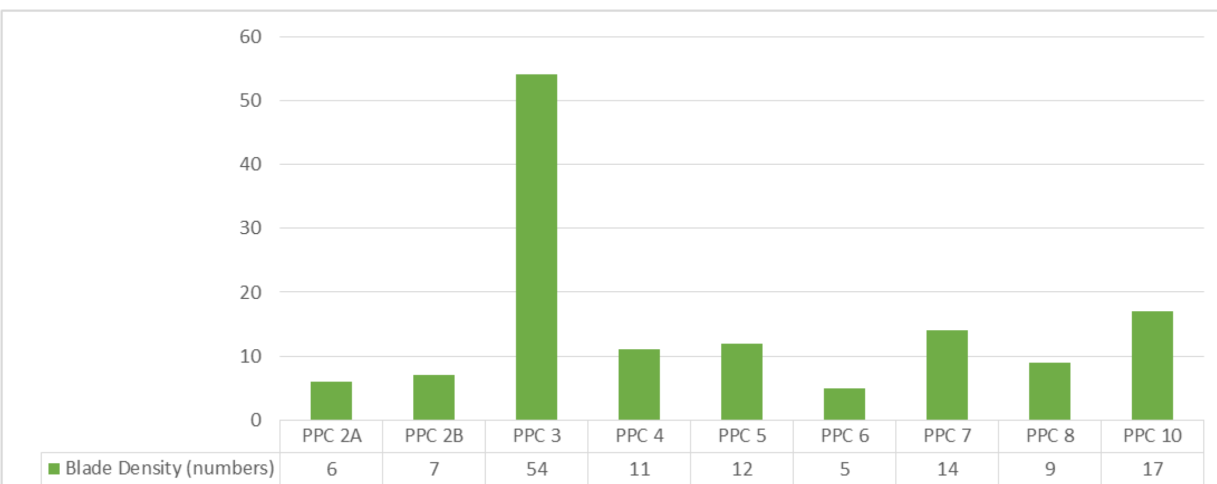


Figure 4-191 Blade density (numbers) per site of samples taken at Paradise Park.

Among zones, the east peninsula was seen to have the highest mean blade length with a value of 24.23cm. This was followed by the west peninsula and east coastline which recorded an average of 19.31cm and 18.88cm respectively (Figure 4-192). Between zones, PPC 2A was seen to have highest mean blade length (39.77cm) followed by PPC 6 (38.90cm). Sites with the lowest blade densities included PPC 3 (15.41cm) and PPC 7 (12.80cm) respectively (Figure 4-193).

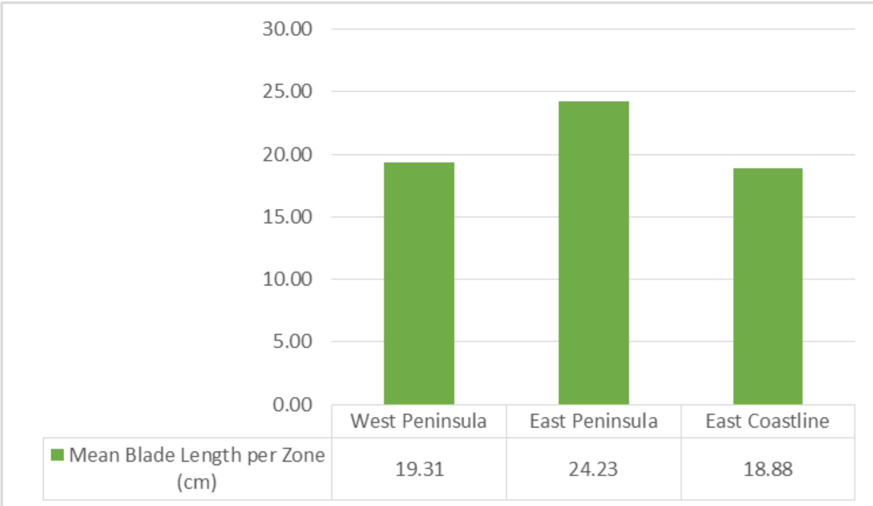


Figure 4-192 **Mean blade length (cm) per zone of samples taken at Paradise Park.**

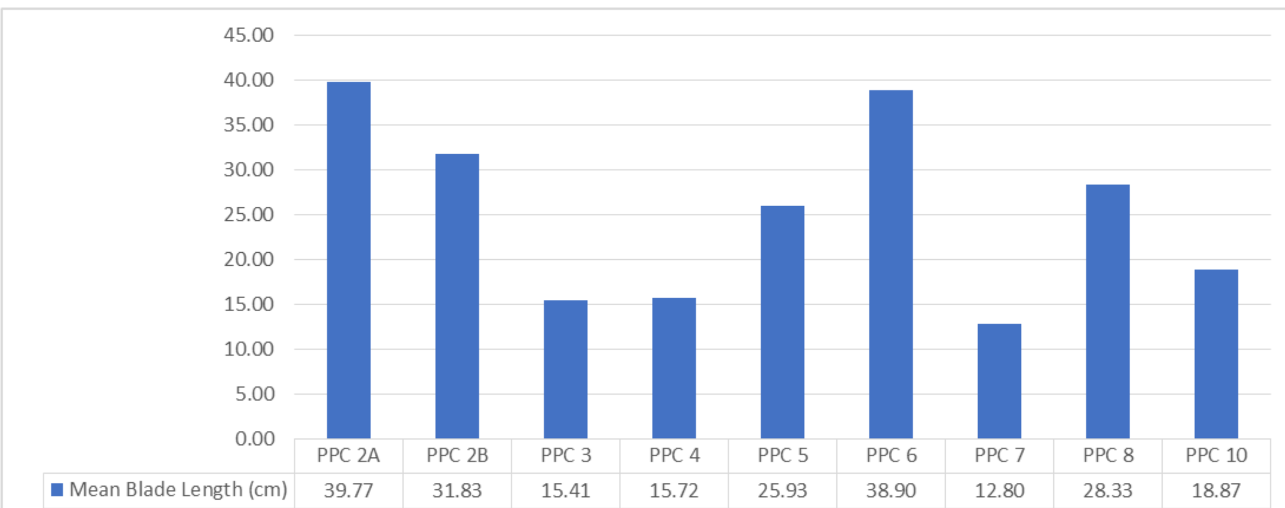


Figure 4-193 **Mean blade length (cm) per site of samples taken at Paradise Park.**

Shoot carbon biomass within the shoot component across datasets indicated a gradual decrease in values along the coastline (Figure 4-194). According to analysis conducted on samples for each zone the highest carbon value within the shoot component of the seagrasses collected was seen within the west peninsula with a total of 0.21960 megagrams of carbon while the east coastline recorded a total shoot carbon value of 0.0.19896 megagrams of carbon. Within the west peninsula dataset, shoot carbon was highest at PPC 3 with a total of 0.096 MgC, the highest of all sites which were sampled at Paradise Park (Figure 4-195).

Shoot carbon values along the east peninsula dataset indicated a total value of 0.2099MgC with highest values' being collected at PPC 4. Along the east coastline, shoot carbon was highest at PPC 10 with a total of 0.0800 megagrams of carbon. The lowest shoot carbon value across the dataset was recorded at PPC 5 with a total of 0.043MgC.

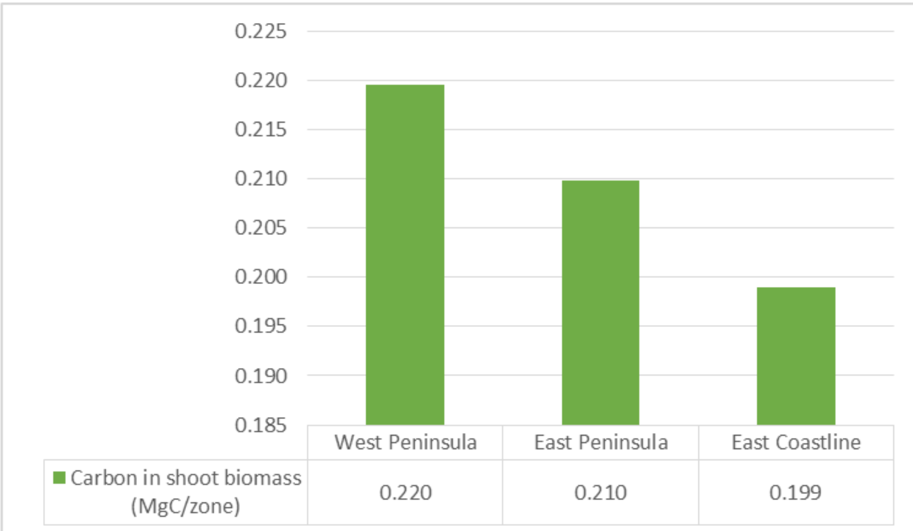


Figure 4-194 Carbon in shoot biomass (MgC) per zone of samples taken at Paradise Park.

Figure 4-195 Carbon in shoot biomass (MgC) per site of samples taken at Paradise Park.

Within the root and rhizome matrix, carbon values were seen to gradually increase along the coastline (Figure 4-196). Values were seen to be highest along the east coastline with a total of 0.6375 MgC followed by the east peninsula (0.5814 MgC) and lastly the west peninsula (0.5241 MgC).

Along the eastern peninsula, root carbon was highest at PPC 5 and lowest at PPC 6 while along the east coastline, carbon values were highest PPC 10 and lowest at PPC 7 (Figure 4-197).

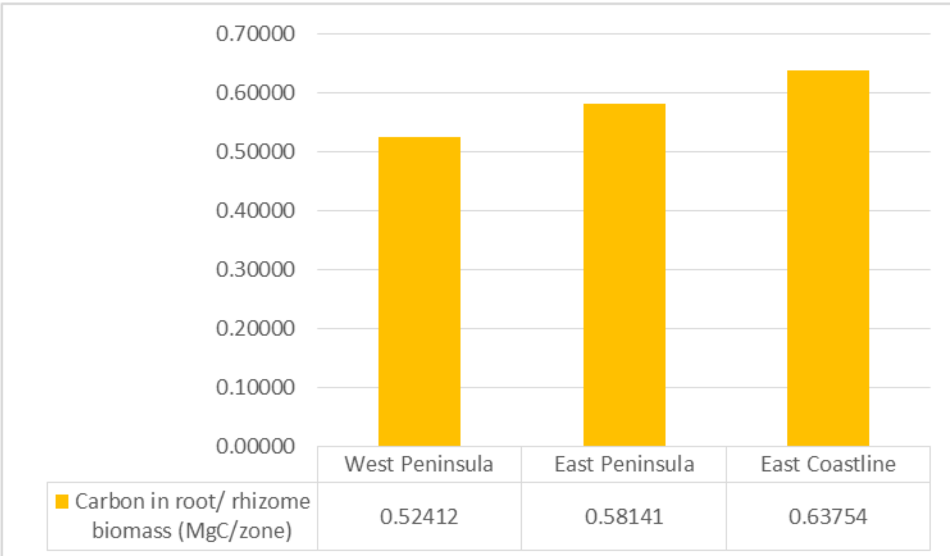


Figure 4-196 Carbon in root/rhizome biomass (MgC) per zone of samples taken at Paradise Park.

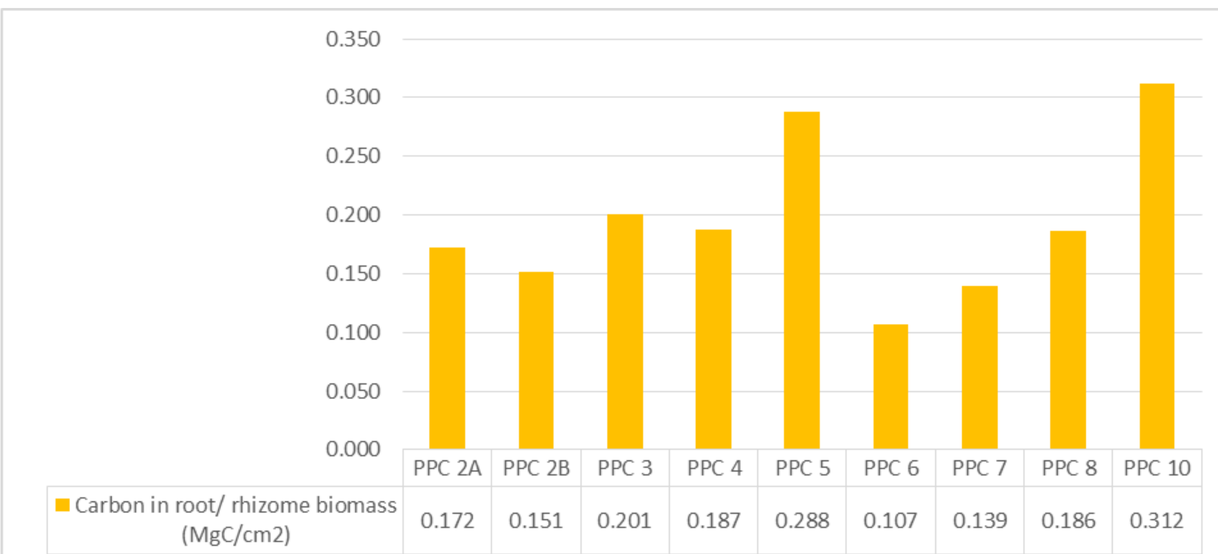
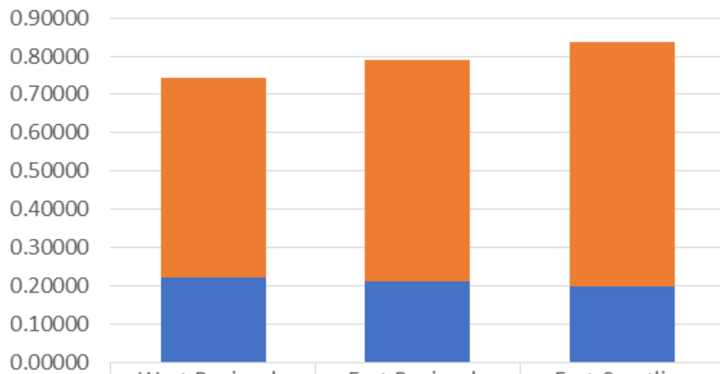


Figure 4-197 Carbon in root/rhizome biomass (MgC/cm^2) per site of samples taken at Paradise Park.

Across the dataset, total carbon values within the vegetative component amounted to 2.372 MgC. These results indicated a gradual increase in vegetative carbon storage along the coastline. Per zone total vegetative carbon indicated 0.744 MgC being located along the west peninsula, 0.791MgC along the east peninsula and 0.836 MgC along the east coastline (Figure 4-198).

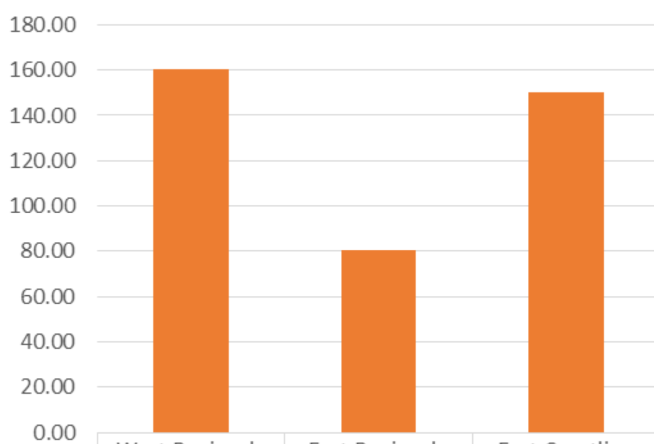


	West Peninsula	East Peninsula	East Coastline
Carbon in root/ rhizome biomass (MgC/zone)	0.52412	0.58141	0.63754
Carbon in shoot biomass (MgC/zone)	0.21960	0.20989	0.19896

Figure 4-198 Carbon within the vegetative component (MgC) per zone of samples taken at Paradise Park.

SOIL COMPONENT

Total values for sampled soil carbon content indicated highest values along the west peninsula with a total value of 160.28 MgC. Following this was the east coastline which yielded a total of150.40 MgC and the east peninsula which indicated a total of 80.68MgC (Figure 4-199). Of these zones, site PPC 1 located along the west peninsula yielded 101.MgC, with the lowest value being found at PPC 2A (16.10 MgC). Along the east coastline, the highest carbon value was seen at PPC 10 with a total value of 85.69 MgC while the lowest values were seen at PC8 (12.15 MgC) (Figure 4-200). Across the entire data set, a total soil carbon content of 391.365 MgC was found among the sampled sites.



	West Peninsula	East Peninsula	East Coastline
Total Soil Carbon Content per zone (MgC)	160.28	80.68	150.40

Figure 4-199 Total soil carbon (MgC) per zone of samples taken at Paradise Park.

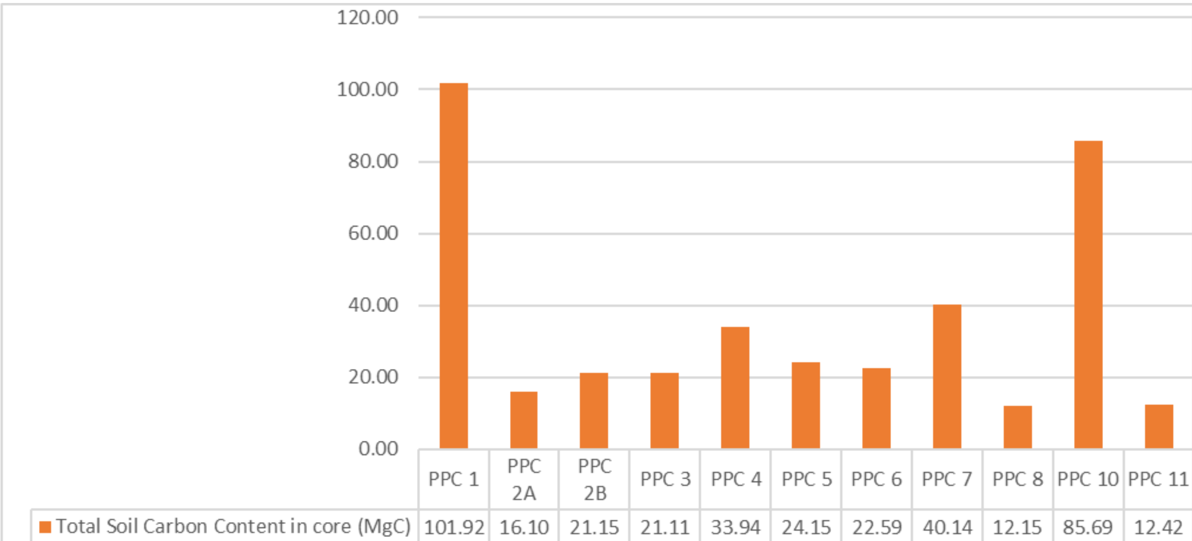


Figure 4-200 **Total soil carbon content (MgC) per site of samples taken at Paradise Park.**

Seagrass Productivity

Within the project area, a total of 6 sets of seagrass productivity samples were retrieved. Three located in Zone 1 and three located in Zone 3. Of these sites, PPC2 located in Zone 1 was seen to reflect the highest rate of productivity as it gained 0.074g/m² over a two-week period. PPC3, PPC5 and PPC7 had the lowest rate of productivity of 0.041g/m² over this period (Figure 4-201).

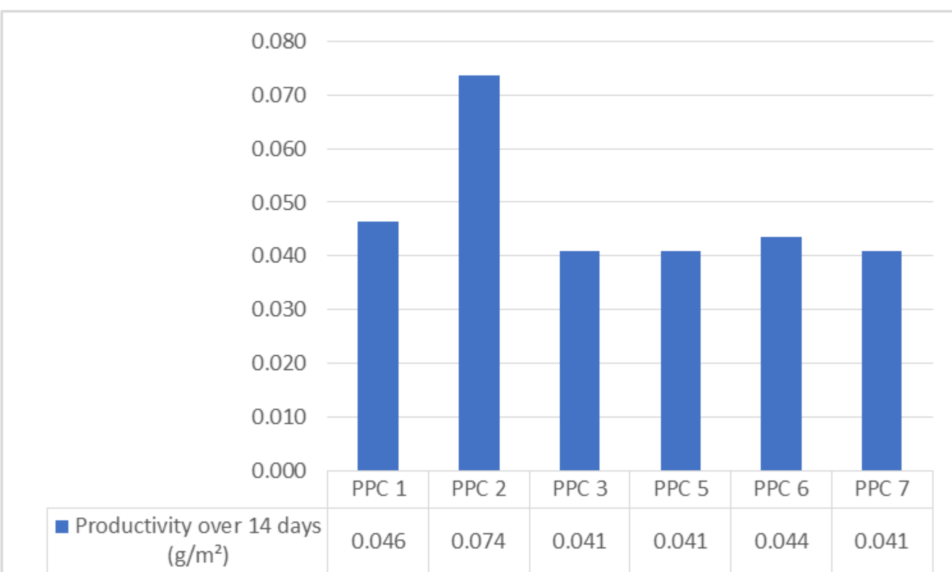


Figure 4-201 **Rates of productivity (g/m²) of samples taken at Paradise Park over a fourteen (14) day period.**

Summary of Results

In summary, seagrass carbon analysis within the vegetative component indicated a gradual increase within the root and rhizome matrix as zones progressed eastward while shoot carbon was seen to gradually decrease. Soil carbon analysis indicated high values exceeding 150MgC within both the west peninsula and east coastline while a decrease was seen along the east peninsula which possessed a total value of 80.68 MgC. Increased soil carbon storage was typically found in muddy soils with high organic carbon content while areas characterised by sandy soils had much lower carbon capabilities.

Across the dataset, total carbon storage within the vegetative component (roots and shoots) derived from core analysis of the seagrasses present was **2.372 MgC** within the sampled area with an estimated value of **709.3.9 MgC** within the project area. Total soil carbon values within the sampled area amounted to **391.365 MgC** with an estimated value of **95771.3 MgC** within the project area**.**

Overall, the Thalassia beds showed minimal spatial variation across the survey area for leaf blade length, shoot density, and percentage cover. The highest values for all metrics were consistently observed at the West Peninsula (PP3), likely influenced by nutrient inputs from nearby mangroves. While slight differences were noted, the beds within the sanctuary displayed generally consistent health, suggesting stable environmental conditions and the importance of surrounding ecosystems in supporting seagrass vitality. Seagrass productivity values varied between 0.041 g/m^{2-14} at PPC3, PPC5 and PPC7 and 0.074 g/m^{2-14} at PPC2. Soil carbon values were highest along the west peninsula (160.28 MgC) and east coastline (150.40 MgC) and lowest along the east peninsula (80.68 MgC).

Soft-bottom sediments (mud, sand, and silt) were consistently present across all transects, with the highest coverage at East Peninsula (PP2) at 49%. These sediments serve as the primary substrate for Halodule colonization and play a critical role in supporting seagrass growth, particularly in areas where other seagrass species, such as Thalassia, are less dominant.

4.2.3.5 Reef Communities

Previous studies in the broader area focused on reef environments outside the bounds of the detailed survey area. Most reef areas are found outside the boundaries of the protected area. The majority of the habitats within the study area consisted of seagrass beds and soft silty areas, which featured some invertebrates but little to no coral colonies.

(AGRRA Lang, 2016) Island-wide, coral cover and benthic conditions varied significantly, with protected areas generally showing higher live coral cover and reduced macroalgal encroachment compared to unprotected reefs. Across Jamaica, the average live coral cover inside protected areas was approximately 28.5%, while reefs outside these zones exhibited reduced cover (19.5%). Macroalgal cover was notably higher in unprotected areas, averaging 20.5%, while calcareous macroalgae were more prominent within protected areas, reflecting better herbivory control.

In Bluefields Bay, live coral cover followed similar trends, with sanctuary reefs showing higher cover (~28.5%) compared to unprotected reefs (~19.5%). Notably, Bluefields Bay reefs exhibited significant morphological diversity, including fringing reefs, patch reefs, and coral fields. Macroalgae were particularly prominent outside the BBSFA, with fleshy macroalgal cover reaching 20.5%, while calcareous macroalgae were more prevalent inside the sanctuary (12% coverage). These patterns suggest that the BBSFA's spatial management efforts are positively influencing reef health by reducing macroalgal growth and supporting coral resilience (NEPA, 2024).

During the study period, a severe Marine Heatwave (MHW) had a profound impact on much of the benthic community, particularly affecting both hard and soft corals. By 2024, all *Acropora, branching Porites sp and Millepora* colonies along with several coral species/individuals had perished. While some coral show signs of recovery from the bleaching event, additional extreme weather events including the passage of severe storms, including Hurricane Beryl have impacted the study area. Sections of this reef were also noted to have large areas covered by zooxanthellae.

The coral community was limited to areas with hard substate such as the fringing reef and multiple patch reef communities. The typical seagrass corals were absent in the seagrass survey areas. This is likely due to the soft and silty substrate in the survey area, with little area suitable for coral recruitment.

2023 Coral Survey - Thatch Reef

Thatch reef is the only fringing reef which extends beyond the boundaries on the protected area. The reef was considered unique, characterised by very large coral colonies, in particular massive *Acropora palmata*, *prolifera* and a *cervicornis* thicket. The visibility in this area is generally poor, likely as a result of sediment form the surrounding mangroves and wetland. During the 2023 survey a mass bleaching event was impacting benthic community. A mass coral bleaching event was taking place along with the bleaching of several other benthic species. These included anemones, Palythoa and seafans. Examples of the bleaching are given in Plate 4-53 - Plate 4-62.

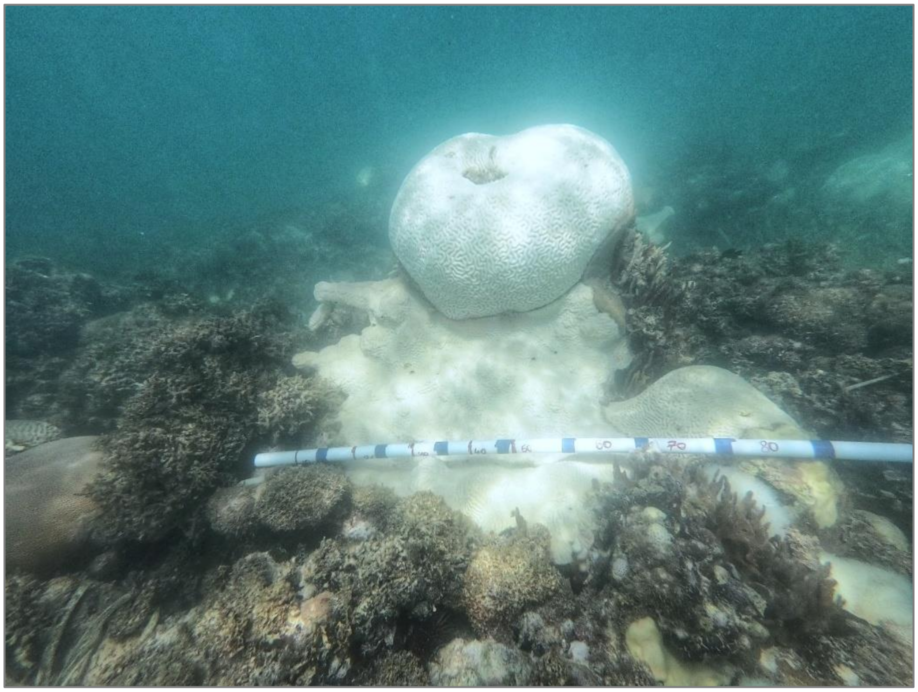


Plate 4-53 Bleaching Pseudodiploria- clivosa and strigose

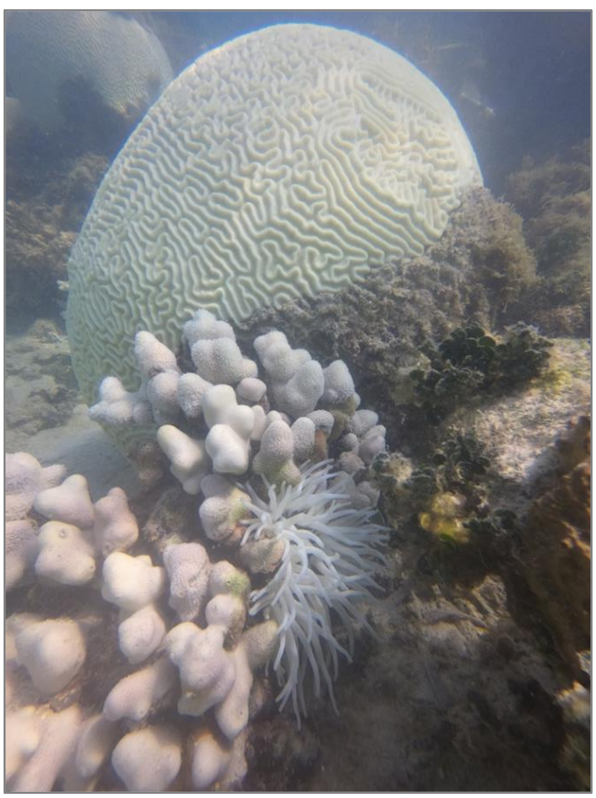


Plate 4-54 Example of bleaching seen in multiple species (corals and urchins)

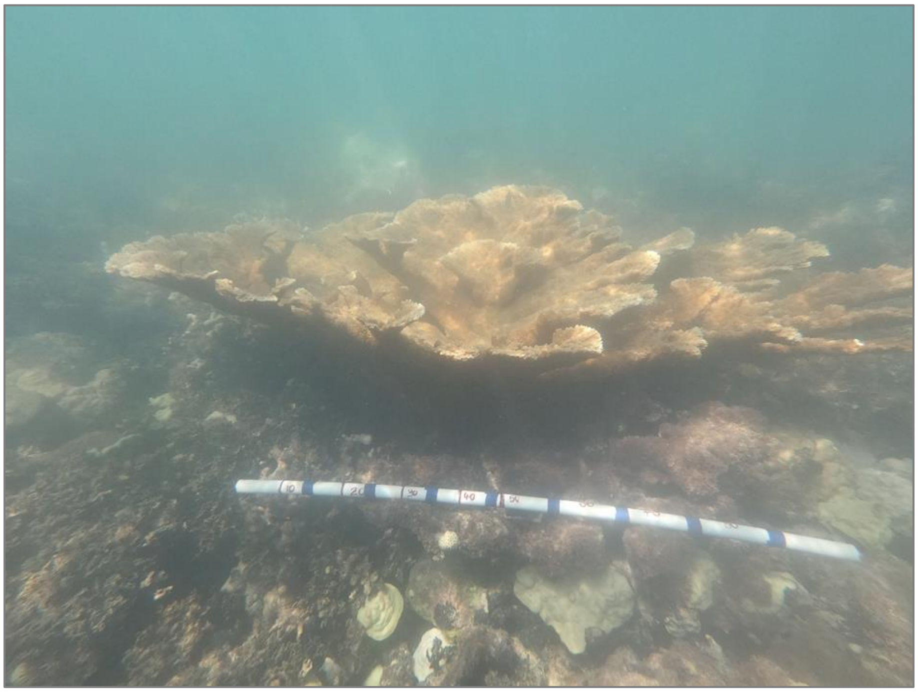


Plate 4-55 *Acropora* **showing early signs of bleaching**

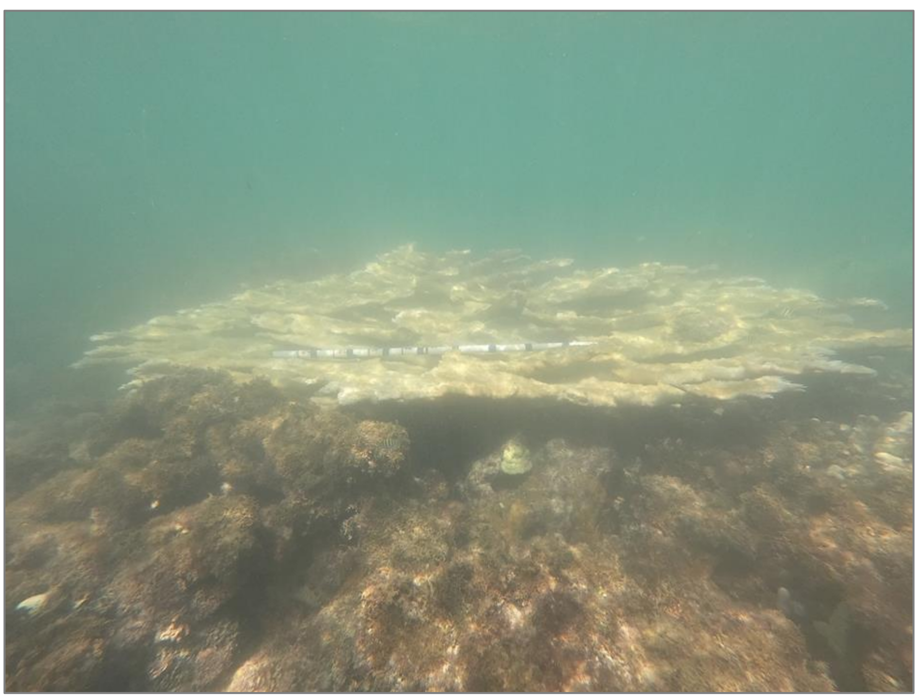


Plate 4-56 **Completely bleached** ***Acopora***

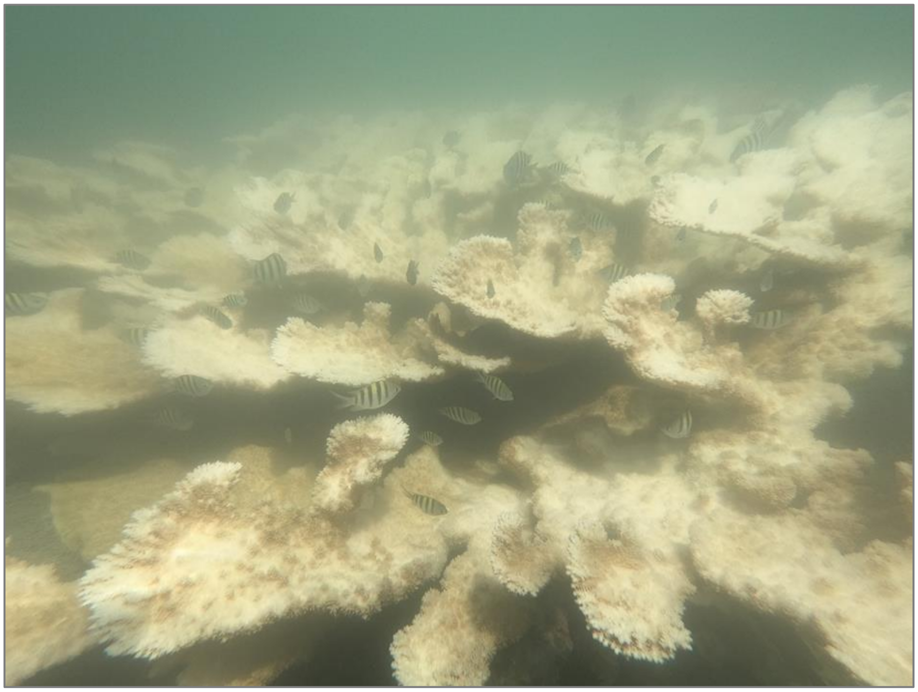


Plate 4-57 Acropora almost completely bleached

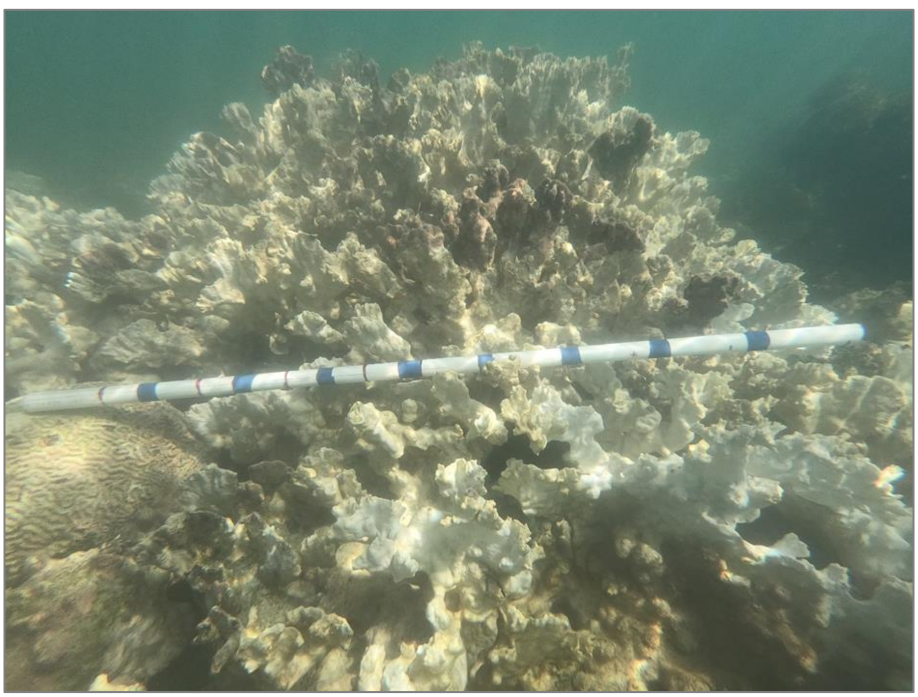


Plate 4-58 Bleached *Millipora*

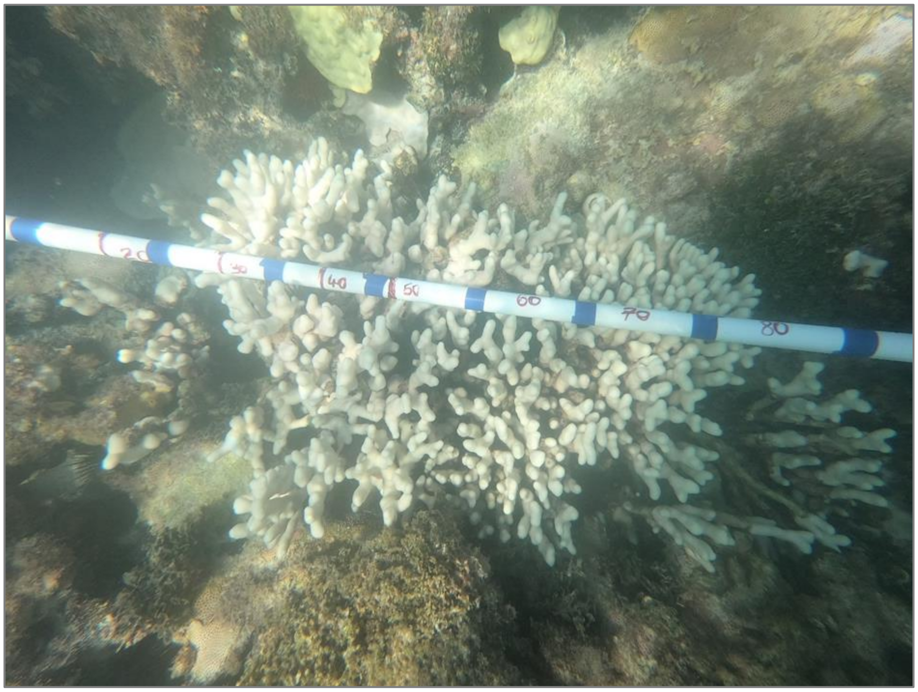


Plate 4-59 Bleached *Porites*

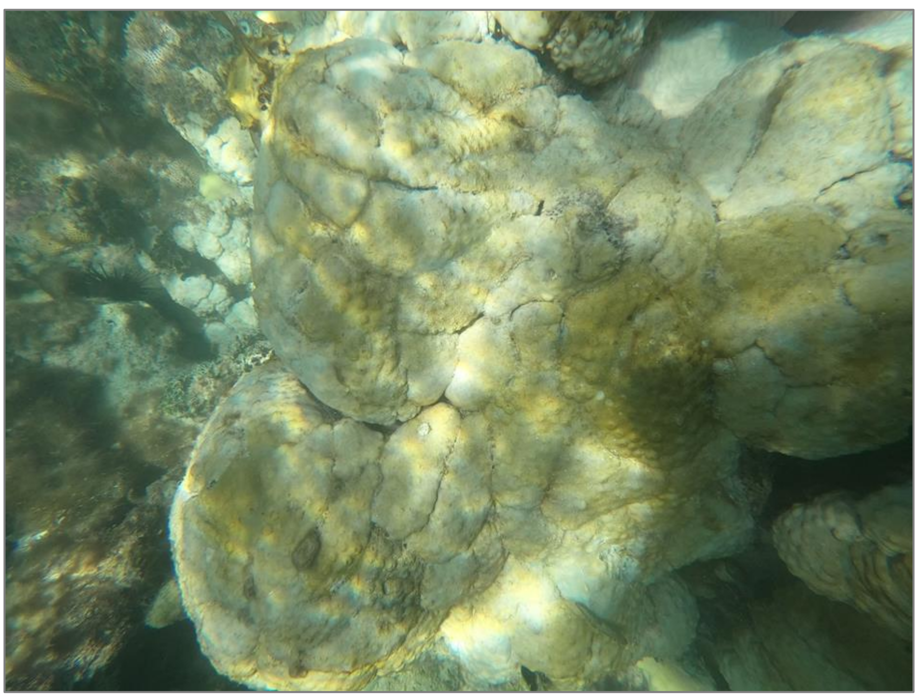


Plate 4-60 Bleached *Palythoa*

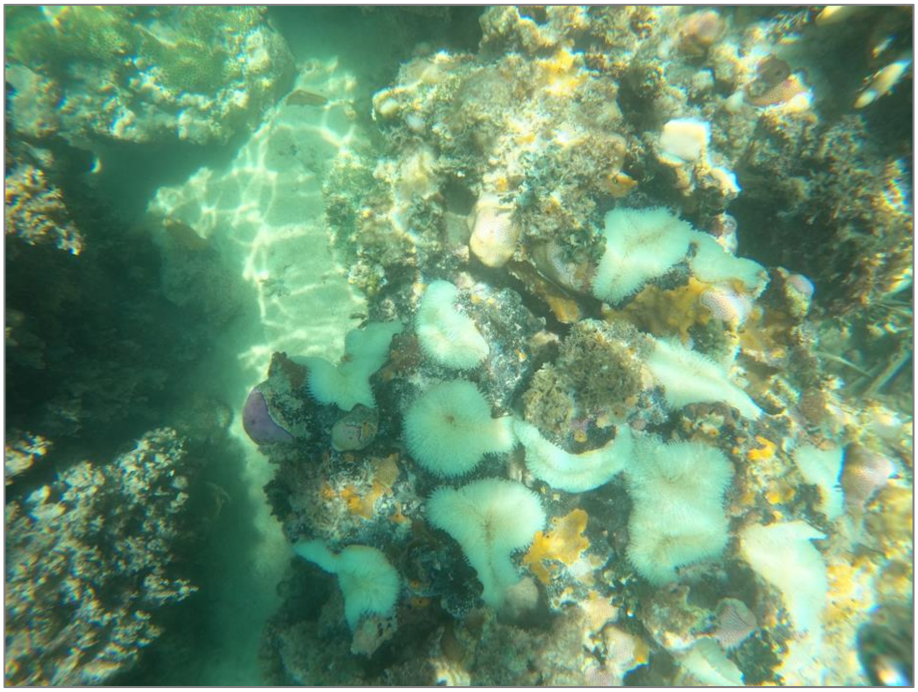


Plate 4-61 Bleached anemones

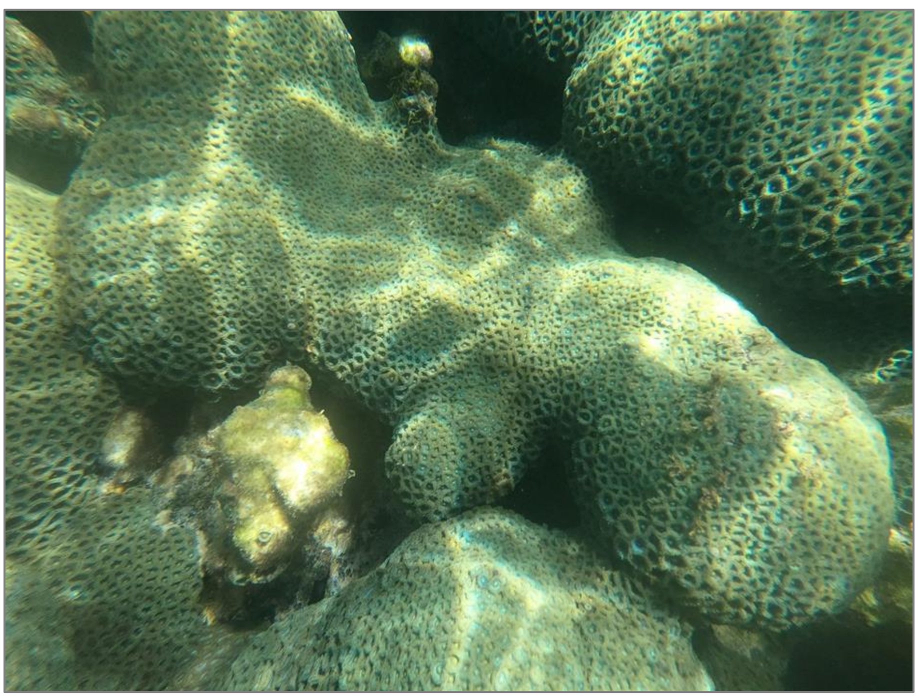


Plate 4-62 Zooxanthellae forming large mat over section of Thatch reef

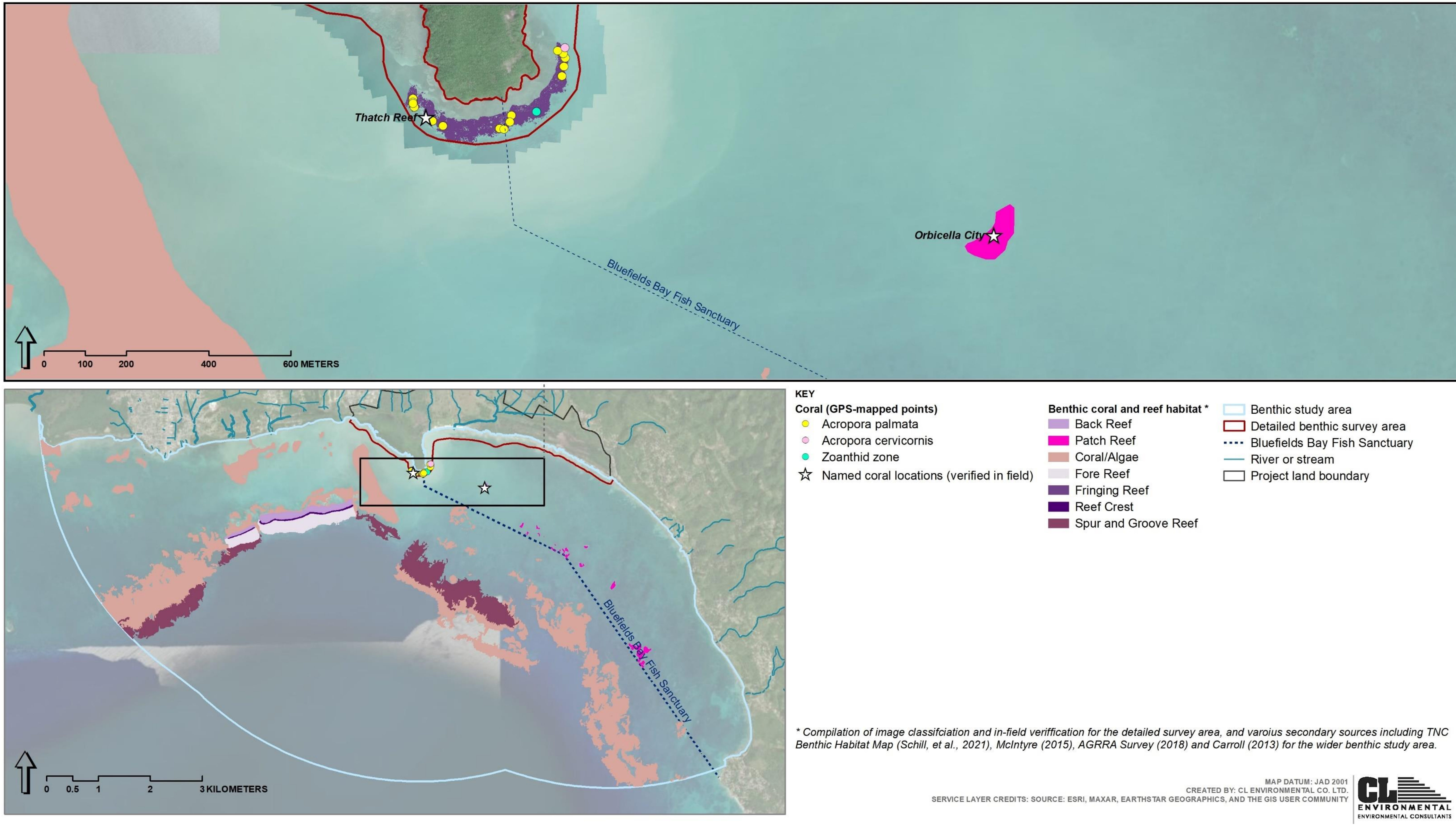


Figure 4-202 Mapped coral and reef habitats

2024 Reef Assessment

Additional surveys were undertaken in 20024; these areas were located some distance from the main study area (Figure 4-202). The survey also included a resurvey of Thatch reef. Other surveyed reef areas consisted of moderate to low-relief patch reefs. Notably, a site referred to as "Orbicella City" was unique, distinguished by its exceptionally large colonies of *Orbicella spp*., setting it apart from all other surveyed locations. Sea temperatures remained high, 32° c on average. These prolonged and elevated temperatures continue to stress the marine environment.

THATCH REEF RESURVEY

A resurvey of the fringing reef within the project area was conducted. The site, characterized by high turbidity and very poor visibility, revealed significant changes in coral communities. All colonies of *Acropora spp*., *Porites porites, and Millepora spp*. had perished. However, massive coral species such as Siderastrea spp. and Pseudodiploria spp. exhibited varying degrees of recovery. Some colonies appeared to regain their colour with minimal tissue loss or mortality, while others showed signs of stress. Although no notable increase in coral disease was observed during the survey, the risk of disease outbreaks remains high. The reef also appears to have undergone a large shift in macroalgae coverage.

Evidence of storm damage was observed, with some overturned coral colonies; however, the impact appeared to be moderate. A species list of hard corals, soft corals, Zoanthids and macroalgae can be found in Table 4-53.

Table 4-53 Species list – Hard coral, Soft coral, Macroalgae

Hard Coral	
Common Name	***Scientific Name***
Staghorn Coral	*Acropora cervicornis*
Elkhorn Coral	*Acropora palmata*
Lettuce Coral	*Agaricia spp.*
Giant Brain Coral	*Colpophyllia natans*
Flower Cup Coral	*Eusmilia fastigiata*
Fire coral	*Millipora*
Great Star Coral	*Montastraea cavernosa*
Giant cup coral	*Mussa angulosa*
Lobed Star Coral	*Orbicella annularis*
Mountainous Star Coral	*Orbicella faveolata*
Boulder Star Coral	*Orbicella franskii*
Mustard Hill Coral	*Porites astreoides*
Thin Finger Coral	*Porites divaricata*
Finger Coral	*Porites porites*
Knobby Brain Coral	*Pseudodiploria clivosa*
Lesser Starlet Coral	*Siderastrea radians*
Massive Starlet Coral	*Siderastrea siderea*
Blushing Star Coral	*Stephanocoenia intersepta*
SOFT CORAL	
Corky Sea Finger	*Briareum asbestinum*

Encrusting Gorgonian	*Erythropodium caribaeorum*
Common Sea Fan	*Gorgonia ventalina*
Bent Sea Rod	*Plexaura flexuosa*
Black Sea Rod	*Plexaura homomalla*
Porous Sea Rod	*Pseudoplexaura porosa*
ZOOANTHID	
Mat Zooanthid	*Zoanthus pulchellus*
White Encrusting Zooanthid	*Palythoa caribaeorum*
White Mermaid's Wine Glass	*Acetabularia crenulata*
Y-Twig Alga	*Amphiroa rigida*
Green Feather Alga	*Caulerpa*
Fuzzy Finger Algae	*Dasycladus vermicularis*
Y Branched and Strap Algae	*Dictyota sp.*
Cotton ball algae	*Enteromorpha*
Tubular Thicket Algae	*Galaxura sp.*
Coral Algae	*Halimeda*
Flat-Top Bristle Brush	*Penicillus pyriformis*
Reef Cement	*Porolithon pachydermum*
Pinecone Alga	*Rhipocephalus phoenix*
Coralline algae	*Rhodophyta*
Sargassum	*Sargassum spp.*
Leafy Flat Blade Alga	*Stypopodium zonale*
Manatee Grass	*Syringodium filiforme*
Mermaid's Fans	*Udotea sp.*
Small sea pearls	*Valonia spp.*
Sea Pearl	*Ventricaria ventricosa*
Cyno bacteria	
Turf Algae	

Plate 4-63 **All coral colonies dead and overgrown with algae**

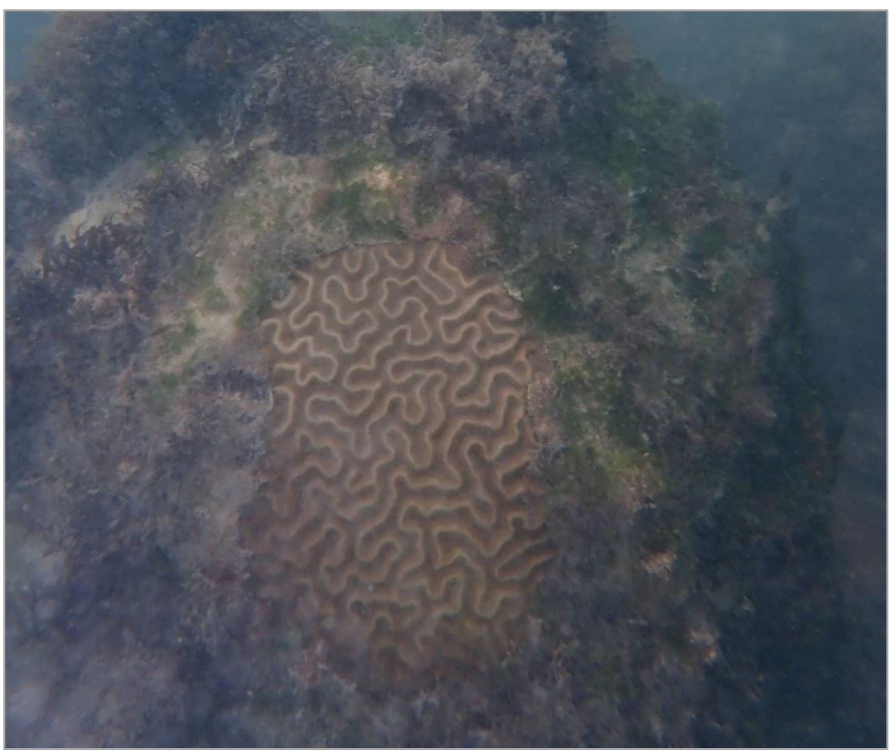


Plate 4-64 **Surviving but stressed *Pseudodiploria***

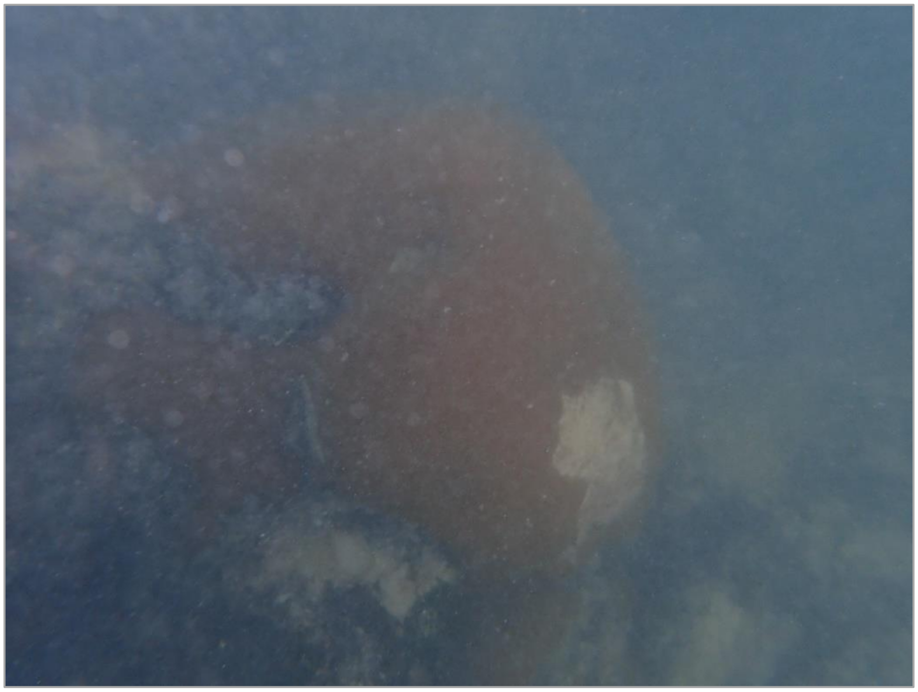


Plate 4-65 Surviving *Siderastrea* colony

PATCH REEF AREAS

The patch reefs within the study were generally small, low-relief structures surrounded by expansive seagrass beds. These reefs host a limited to moderate coral community and are instead dominated by macroalgae and sponges. This expansive sponge community includes aggressive species such as *Cliona* and *Chondrilla*, both know to outcompete and over corals and other benthic species. Visibility across the sites was generally moderate to poor. The reefs showed signs of both stress and recovery, with coral disease incidences remaining low. Similar to Thatch reef, no living colonies *of Millepora, Porites porites*, or *Agaricia* were observed, highlighting the vulnerability of these species in the region.

Plate 4-66 ***Mussa angulosa***

Plate 4-67 **Example of an aggressive sponge overgrowing a coral colony**

Plate 4-68 Montastrea cavernosa

Plate 4-69 Sick and dying coral being overgrown by algae and sponges

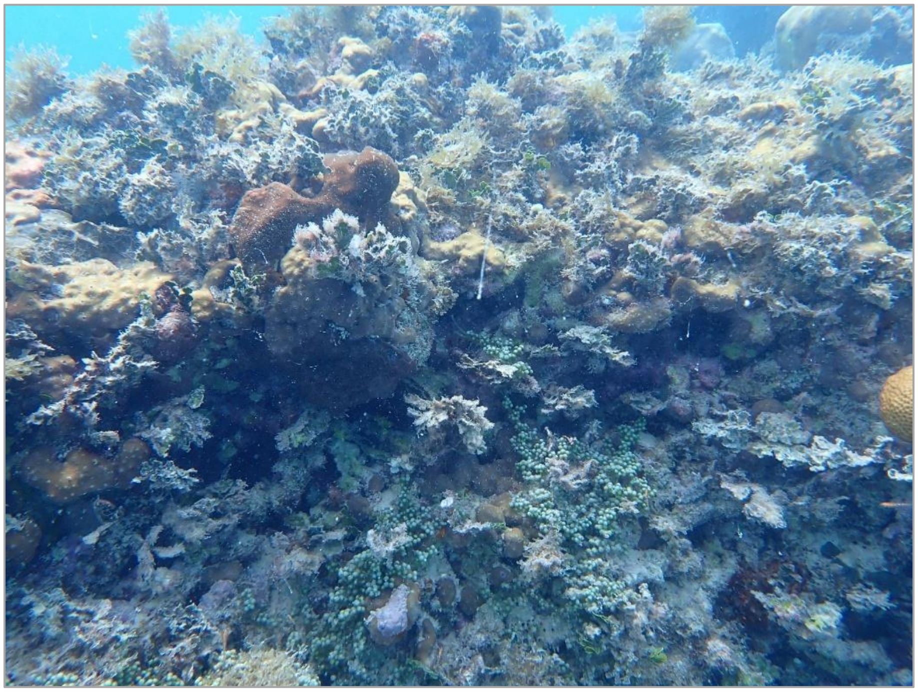


Plate 4-70 Section of the reef dominated by macroalgae and sponges

ORBICELLA CITY

Orbicella City stands out as a unique reef within the study area, characterized by exceptionally large and abundant massive colonies of Orbicella spp. Unlike other reefs in the region, this site is notable for its remarkable coral size and density, making it a significant area for conservation and protection. While signs of stress and bleaching were observed, these were relatively limited compared to other surveyed reefs. Visibility at the site was poor, consistent with conditions across the broader study area. Examples of these massive colonies and varying health conditions can be seen in Plate 4-71 - Plate 4-77.

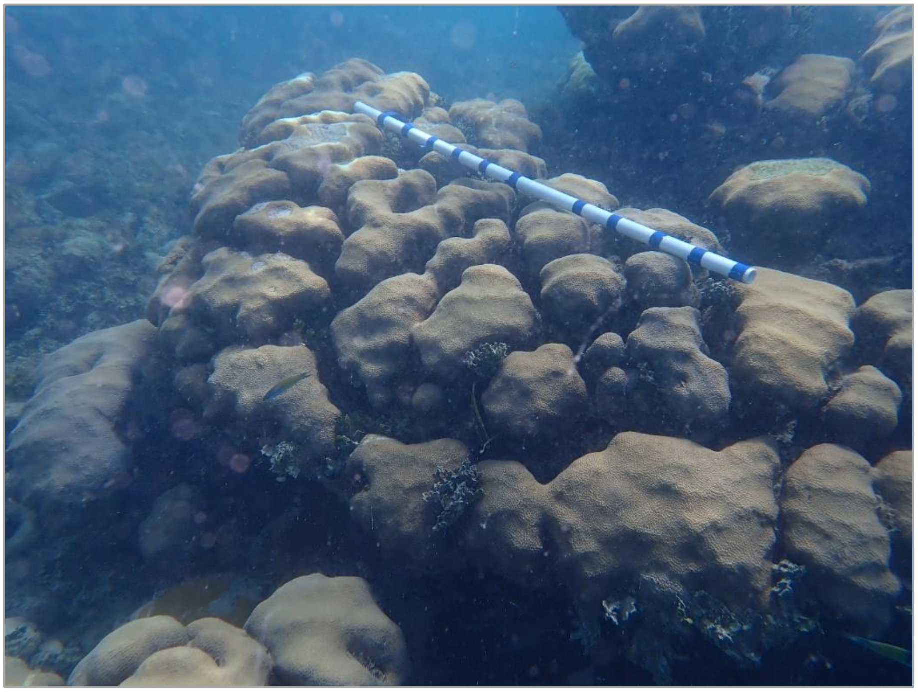


Plate 4-71 ***Orbicella annularis***

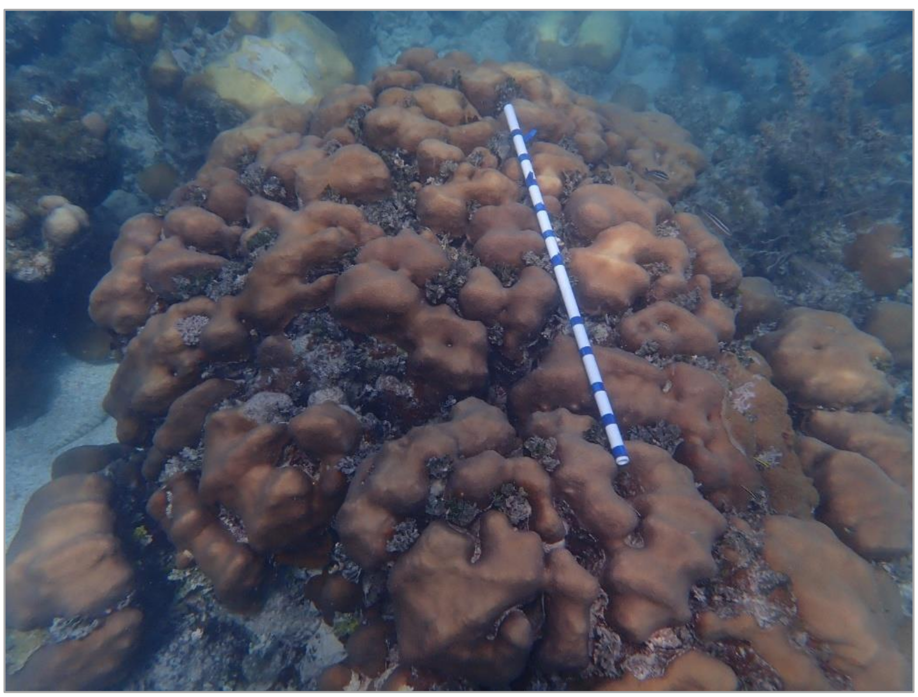


Plate 4-72 Orbicella annularis

Plate 4-73 Orbicella annularis

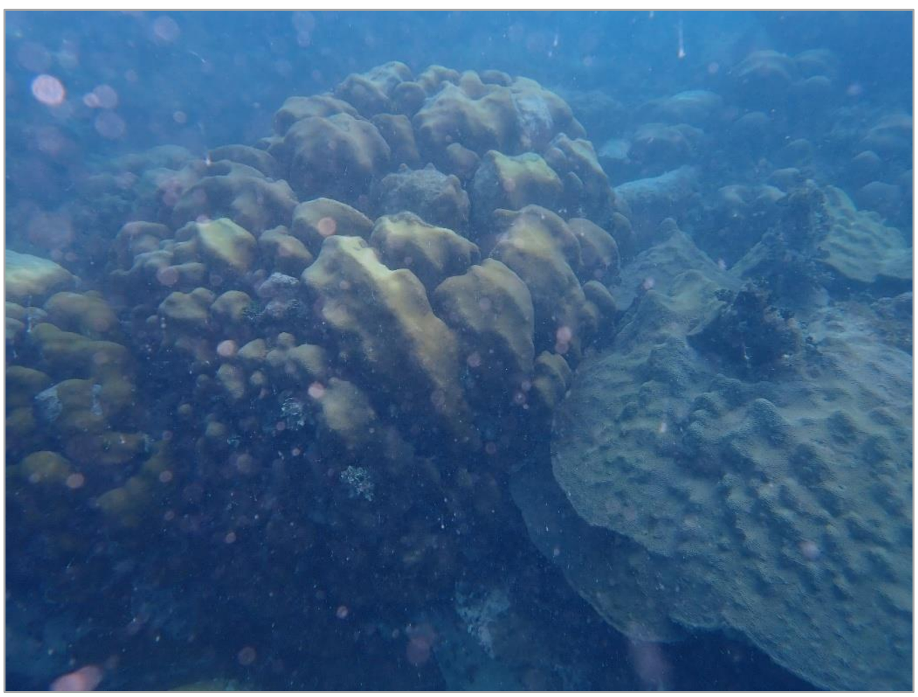


Plate 4-74 Orbicella annularis and flaveolata

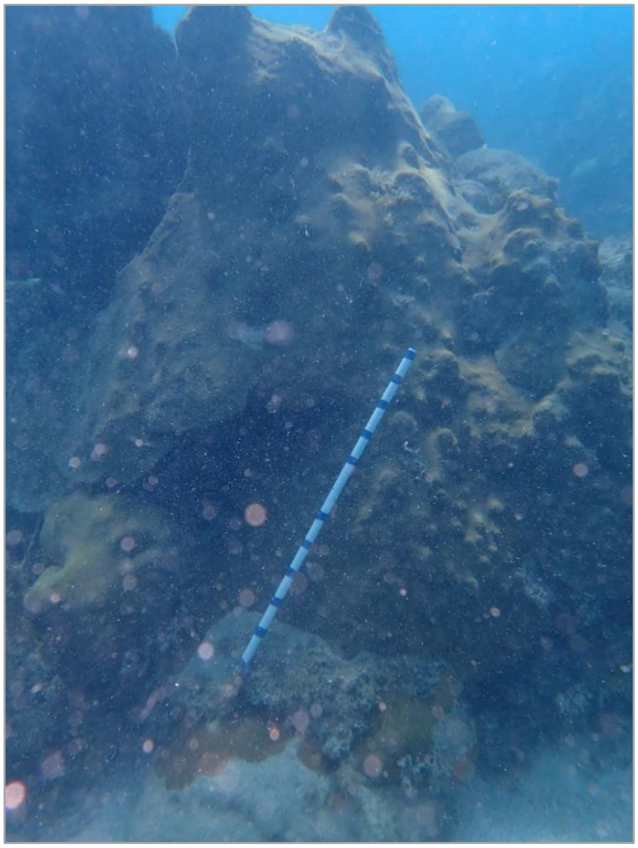


Plate 4-75 Orbicella franksii

Plate 4-76 Orbicella annularis recovering from bleaching

Plate 4-77 Orbicella annularis with recent mortality and bleaching stress

INVERTEBRATES

A general species list and inventory was generated from both transect lines and roving surveys over the study period. A detailed species list is given in Table 4-54 and photo inventory in Plate 4-78 - Plate 4-91.

Table 4-54 Invertebrate species list

ECHINODERM	
Common Name	**Scientific Name**
Common Comet Star	*Linckia guildingii*
Conical Spined Sea Star	*Echinaster sentus*
Cushion Sea Star	*Oreaster reticulatus*
Blunt-Spined Brittle Star	*Ophiocoma echinata*
Brittle Star	*Ophioderma sp*
Long-Spined Urchin	*Diadema antillarum*
Rock Boring	*Echinometra*
Variegated Urchin	*Lytechinus variegatus*
West Indian Sea Egg	*Tripnuestes ventricosus*
Slate-Pencil Urchin	*Eucidaris tribuloides*
Three-Rowed Sea Cucumber	*Isostichopus badionotus*
Donkey Dung Sea Cucumber	*Holothuria Mexicana*
Jewel Urchin	*Lytechinus williamsi*
MOLLUSKS	
Common Name	*Scientific Name*

Queen Conch	*Strombus gigas*
Flamingo Tongue	*Cyphoma gibbosum*
Lettuce Sea Slug	*Elysia crispata*
SEGMENTED WORMS	
Bearded Fireworm	*Hermodice carunculata*
Magnificent Feather Duster	*Sabellastarte magnifica*
Christmas Tree Worm	*Spirobranchus giganteus*
ANEMONE	
Giant Anemone	*Condylactis gigantea*
Sun Anemone	*Stichodactyla helianthus*
Elegant Anemone	*Actinoporus elegans*
Beaded Anemone	*Epicystis crucifer*

Plate 4-78 Bleached anemones

Plate 4-79 Sea cucumber

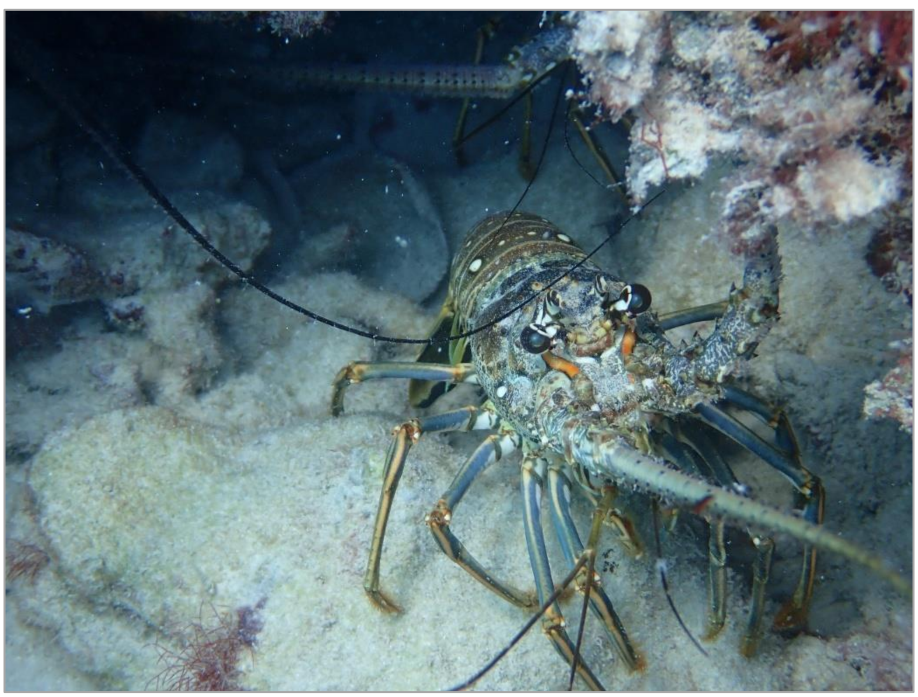


Plate 4-80 Spiny lobster

Plate 4-81 Christmas tree worms

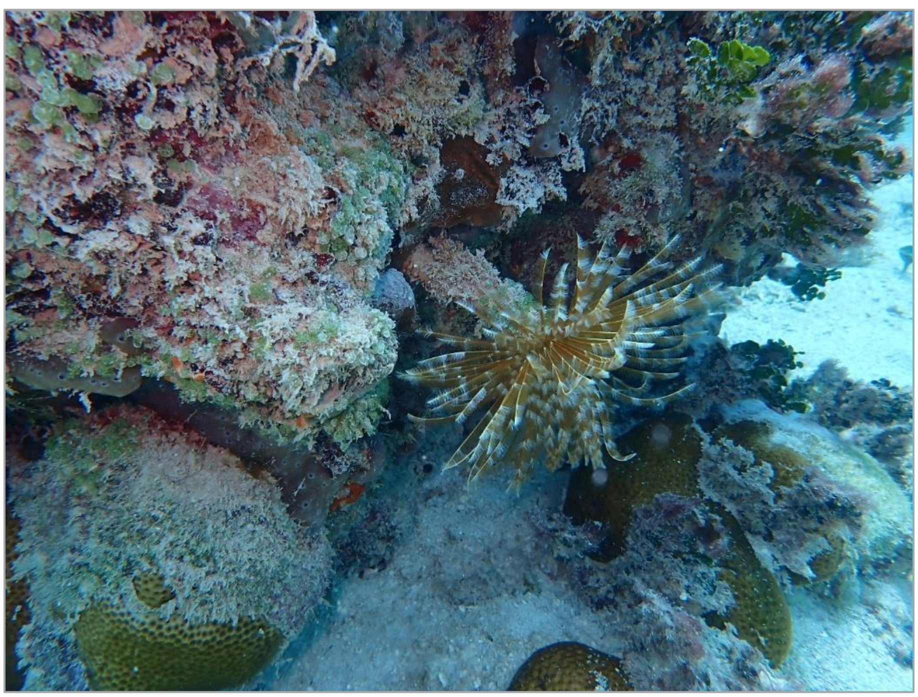


Plate 4-82 Feather duster worm

SPONGES

The patch reef survey areas appeared to have an unusually high sponge density and abundance. This includes aggressive sponges such as *Cliona* and *Chondrilla*. A detailed species list is given in Table 4-55 and photo inventory in Plate 4-83 - Plate 4-91.

Table 4-55 Sponge species list

Sponges	
Common Name	**Scientific Name**
Brown Tube Sponge	*Agelas conifera*
Branching Tube Sponge	*Aiolochroia crassa*
Brown variable Sponge	*Anthosigmella varians*
Yellow Tube Sponge	*Aplysina fistularis*
Branching Vase Sponge	*Callyspongia*
Chicken Liver Sponge	*Chondrilla nucula*
Red Boring Sponge	*Cliona delitrix*
Brown Bowl Sponge	*Cribrochalina vasclum*
Brown Encrusting Octopus Sponge	*Ectyoplasia ferox*
Black Ball Sponge	*Ircina strobilina*
Green Finger Sponge	*Lotrochata birotulata*
Orange Icing Sponge	*Mycale laevis*
Rope Sponge	*Niphates erecta*
Pitted Sponge	*Verongula rigida*

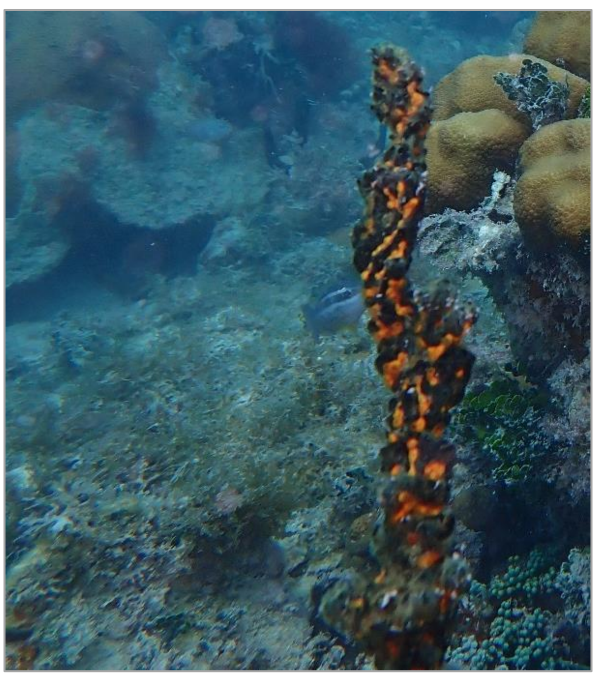


Plate 4-83 Green Finger Sponge

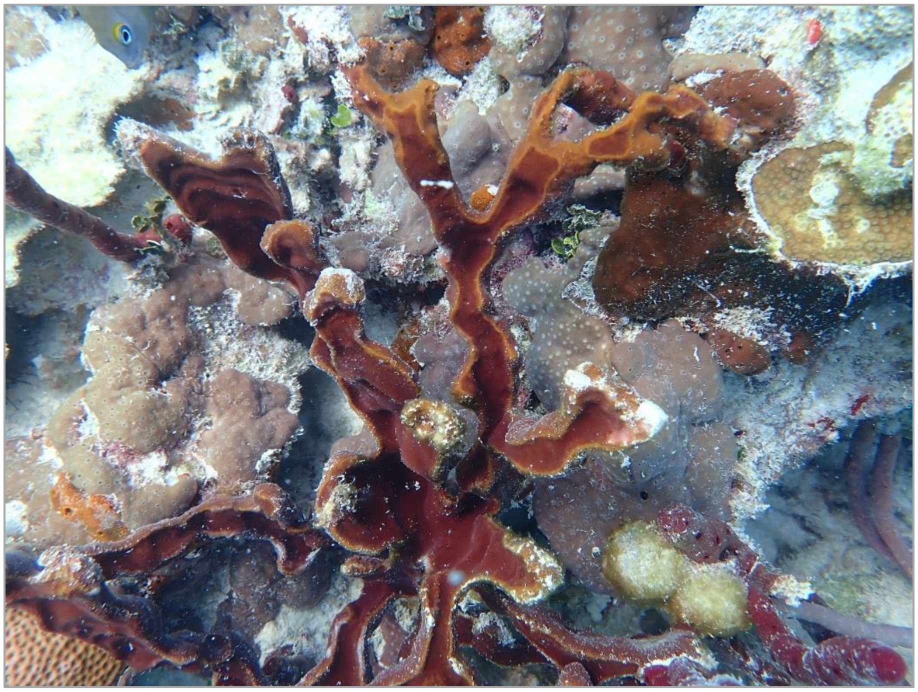


Plate 4-84 Branching Sponge

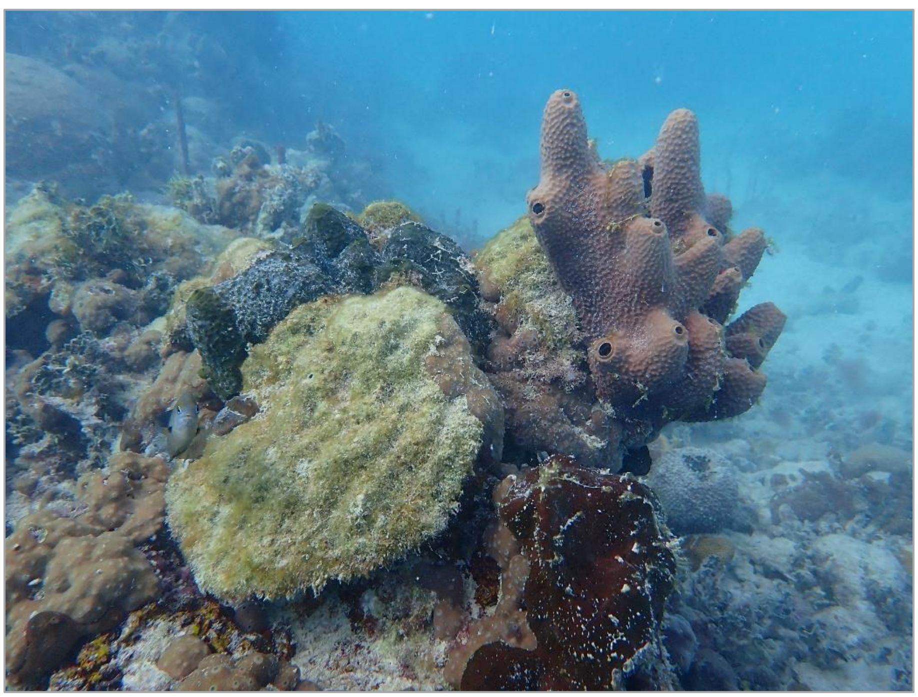


Plate 4-85 Tube Sponge

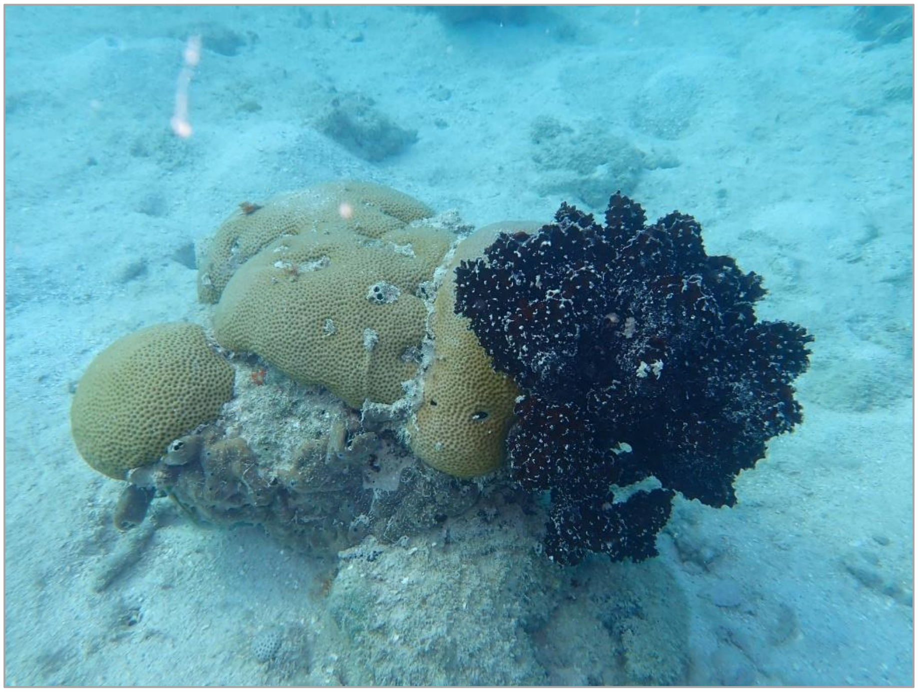


Plate 4-86 Pitted sponge

Plate 4-87 Chicken liver sponge

Plate 4-88 **Orange icing sponge and chicken liver sponge**

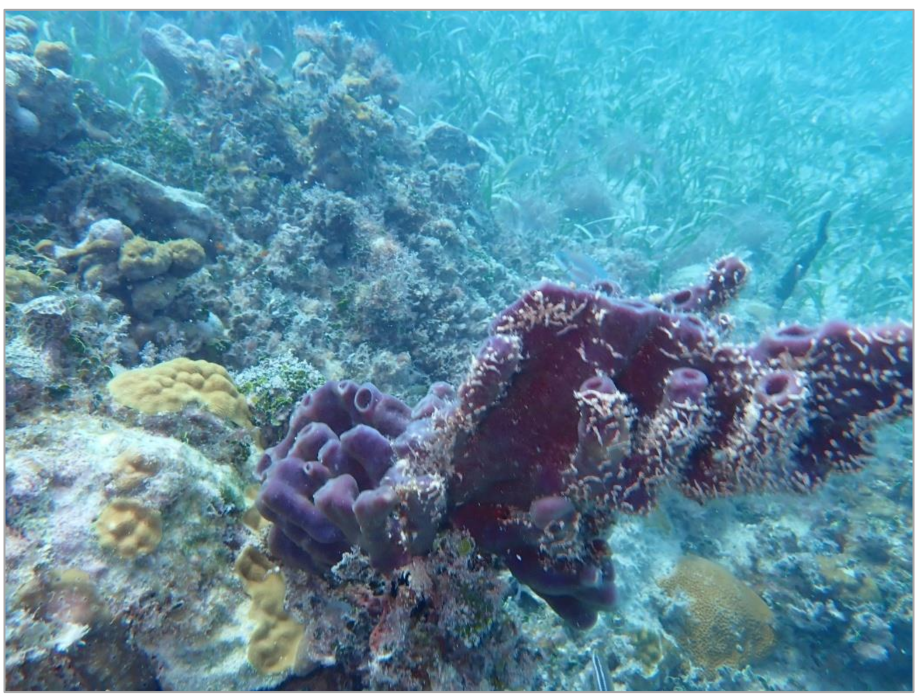


Plate 4-89 **Branching Tube Sponge**

Plate 4-90 **Rope sponge**

Plate 4-91 **Brown Encrusting Octopus Sponge**

4.2.3.6 Fish Communities

Previous studies have shown that fish communities within sanctuary show higher densities and abundance than those outside the sanctuary. 2016 AGRRA studies found that Island-wide, herbivorous fish such as parrotfish and grunts were key contributors to reef ecosystem health, with average densities recorded at 73 individuals per 100 m^2. However, their biomass was low (793 g per 100 m^2), indicating that most individuals were small, likely juveniles. This pattern reflects challenges with overfishing across Jamaica's reefs, particularly outside protected areas, where fishing pressure remains high (AGRRA Lang, 2016).

Surveys within BBSFA supported relatively high fish densities, particularly of herbivorous species like parrotfish, essential for controlling macroalgal growth. Despite their density, the small size of these fish suggests ongoing recruitment challenges. Outside the sanctuary, fish densities were significantly lower, further emphasizing the impact of protection on fish populations. The bay's artisanal fishing activities, including the use of fish pots, contribute to pressure on fish populations, particularly on commercially valuable species such as snappers and grunts.

According to the (Day, 2015) BFFS demonstrated significantly higher fish biomass inside the sanctuary compared to adjacent fished areas. Over five survey rounds (2013–2015), the mean biomass inside the sanctuary consistently surpassed that outside, demonstrating the sanctuary's effectiveness. Herbivorous species such as Acanthuridae and Scaridae dominated biomass inside the sanctuary, while commercially important species including Lutjanidae (snappers) and Haemulidae (grunts) were prominent. Species richness was comparable, with 29 species recorded inside and 32 outside the sanctuary. Herbivorous species, including Acanthuridae and Scaridae, accounted for the majority of biomass within the sanctuary, while commercially valuable species such as Lutjanidae (snappers) and Haemulidae (grunts) were also abundant. Species richness was comparable, with 29 species recorded inside the sanctuary and 32 outside.

Monitoring reports from 2022 indicate that compliance with no-fishing regulations within the sanctuary remains high, with rates ranging from 95% to 98%. Patrol efforts, supported by the Marine Police and BBFFS, have effectively reduced breaches in 2022 sanctuary reports (Bluefields Bay Fishermen's Friendly Society, 2022).

Fisheries production data for Bluefields Bay reveal its importance to Jamaica's artisanal fishing sector, with coastal pelagics and reef-associated species forming the bulk of landings. Environmental pressures, including sedimentation and climate impacts, influence fish populations and habitat health (Authority, 2023).

Seagrass Fisheries

DESCRIPTION OF SEAGRASS FISHERIES HABITAT

Nearshore habitats surveyed were mostly seagrass beds of 1 m to 1.5 m and dominated by *Thalassia testudinum*. Some areas were also mixed beds with *Halodule* and *Syringodium*. A full description of these beds is provided in 1.1.3.4. The most observed activity within the study area was fishing, with fishers and fish pots set adjacent to the boundaries of the BBFFS. Several nurse sharks and stingrays were also frequently observed feeding and roaming in nearshore areas during the survey period The minimum temperature recorded by dive computers during surveys was 32°C. Plate 4-92 shows juvenile fish in seagrass beds.

Plate 4-92 Juvenile fish in seagrass bed

SEAGRASS RESULTS

For the presentation of results, Transect 2 (T2) was treated as a replicate of Transect 1 (T1) due to their close proximity and the similarity in habitat characteristics. Consequently, the findings will focus on four distinct transects: T1, T3, T4, and T5 which were then divided into three distinct zones: Western Peninsula, Eastern Peninsula, and Eastern Coastline.

Fish Diversity

A total of 18 species within 10 families were identified across the three sites (Table 4-56Fish species per site). Although variations between the zones were minimal, the eastern peninsula exhibited the lowest species richness, with only 9 out of the 18 recorded species observed in this region. The most frequent species across the zones were Silversides/Anchovies, Schoolmaster Snapper (*Lutjanus apodus*), Striped

Parrotfish (*Scarus iseri*), and Yellowfin Mojarra (*Gerres cinereus*). Additional species observed within the beds while in transit between transect locations included several nurse sharks, yellow stingrays, and bottlenose dolphins.

Table 4-56 Fish species per site

Species	IUCN Status	Western Peninsula	Eastern Peninsula	Eastern Coastline
Ablenness hians	Least Concern		X	
Dasyatis americana	Near Threatened			X
Eucinostomus gula	Least Concern		X	X
Gerres cinereus	Least Concern		X	X
Haemulon flavolineatum	Least Concern	X		X
Halichoeres bivittatus	Least Concern	X		
Halichoeres poeyi	Least Concern	X		
Harengula humeralis	Least Concern		X	
Lutjanus apodus	Least Concern	X	X	X
Lutjanus griseus	Least Concern	X		X
Lutjanus synagris	Near Threatened			X
Ocyurus chrysurus	Data Deficient			X
Scarus iseri	Least Concern	X	X	X
Sparisoma atomarium	Least Concern	X		
Sparisoma aurofrenatum	Least Concern	X		
Sphoeroides testudineus	Least Concern	X	X	
Sphyaena barracuda	Least Concern		X	
Silversides/Anchovies		X	X	X
Species Richness		10	9	10

Table 4-57 Species richness per transect line

	T1	T3	T4	T5
A	8	8	5	5
B	9	4	4	7
Avg. #/Site	**8.5**	**6**	**4.5**	**6**

The most abundant family observed was Clupeidae, represented by sought after species such as Red-ear Sardine, commonly known as pinchers (*Harengula humeralis*) and members of silversides and anchovies Figure 4-203. These species, of which 630 individuals were recorded, are used as bait fish, and support the artisanal fisheries. The second most abundant family was Scaridae (Parrotfish) and Lutjanidae (Snapper), with 156 and 129 individuals, respectively.

The highest number of fish recorded were along Eastern Peninsula, while the Eastern Coastline had the lowest (Figure 4-204).

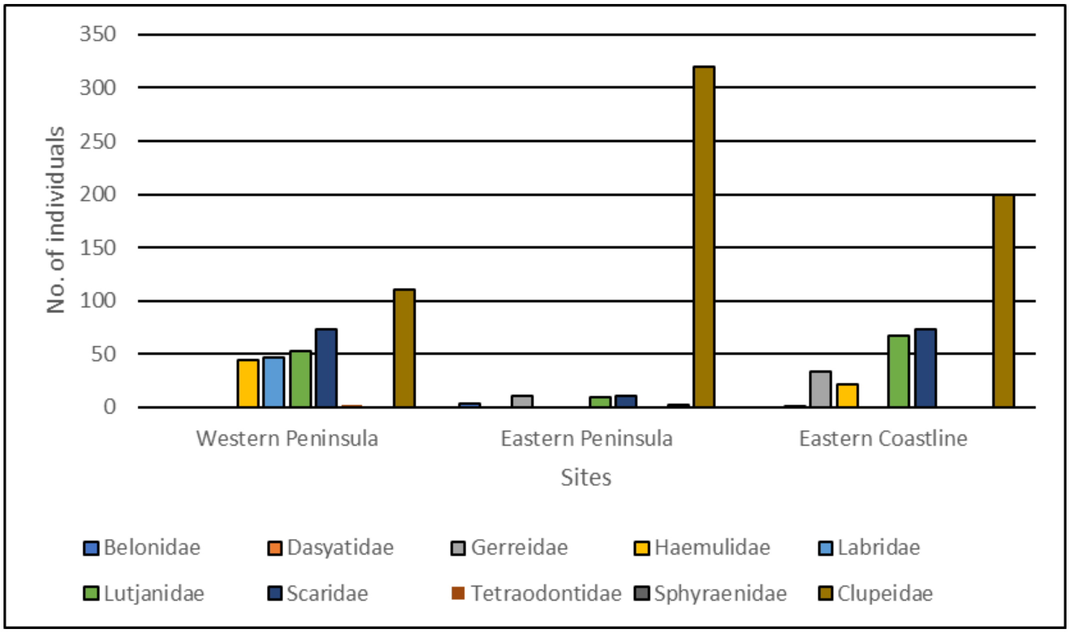


Figure 4-203 Abundance per family across transects

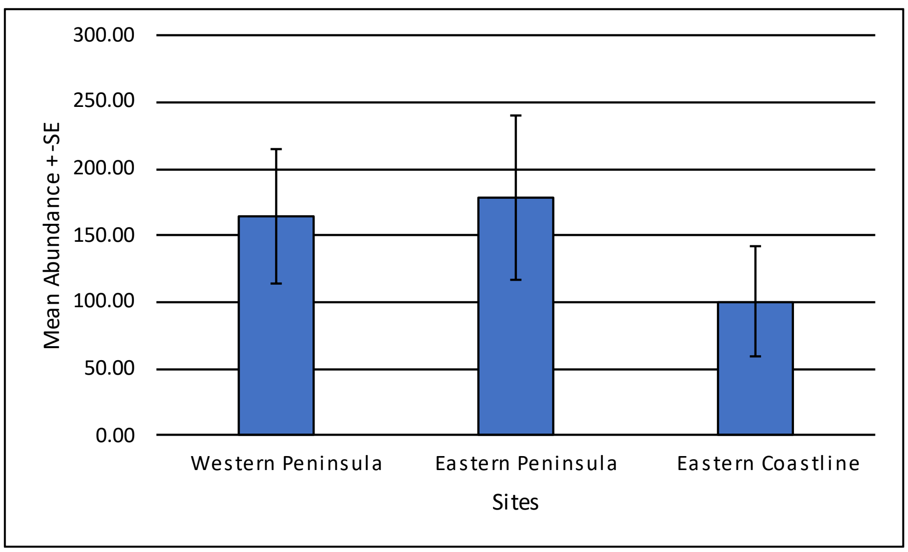


Figure 4-204 Mean abundance of fish per site

Feeding Groups

Most of the fishes observed during the surveys were carnivores, with herbivores contributing considerably low values (Figure 4-205). The most abundant carnivores were Snappers (*Lutjanus spp.*), Grunts (*Haemulon flavolineatum*), and Yellowfin Mojarra (*Gerres cinereus*). Herbivores observed belonged to the Parrotfish Family, with the most abundant fish being the Striped Parrotfish (*Scarus iseri*).

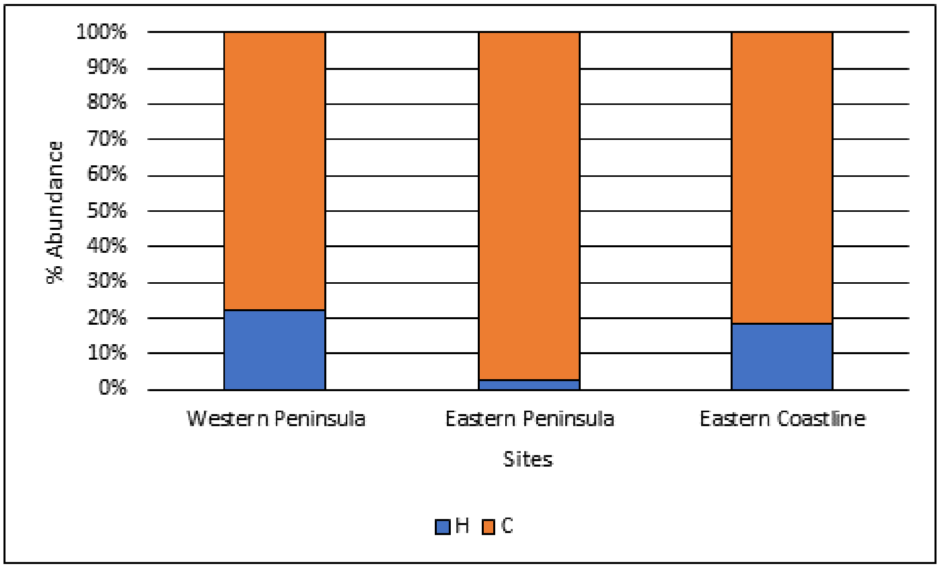


Figure 4-205 **Percentage abundance of fish per site based on feeding group**

Fish Density

The average density along transects ranged from 30.40 to 71.20 individuals /100m². Overall, the Eastern Peninsula was the densest with 71.20 individuals /100m² (Table 4-58).

Table 4-58 **Fish density per site**

	Western Peninsula	Eastern Peninsula	Eastern Coastline
Avg. Density (#/100m²)/ Site	65.80	71.20	40.10

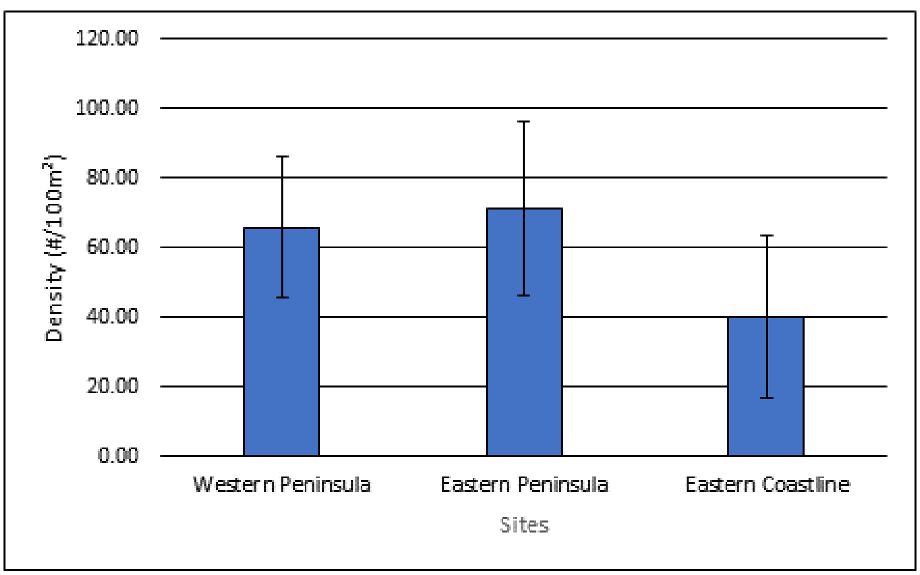


Figure 4-206 **Average density of individuals (#/100m²) per site**

Fish Size

Most fish were 20 cm and less in total length, with a significant portion being in the 0-5 and 6-10 cm size classes (Figure 4-207). Based on the families observed, most of these fishes would be within the juvenile stage of their life cycle. The largest individuals were Flat Needlefish (*Ablenness hians*), Southern Stingray (*Dasyatis americana*), and Great Barracuda (*Sphyaena barracuda*).

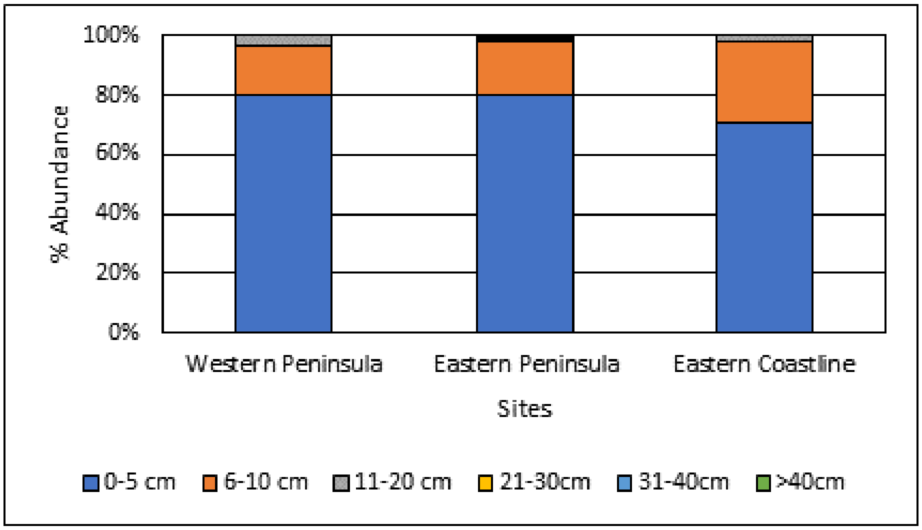


Figure 4-207 Mean abundance of fish size per site

Coral Fisheries

DESCRIPTION OF CORAL FISHERIES HABITAT

Associated reefs were fringing reefs and patch reefs in 1 to 3.5m of water and, in some locations, as close as 10m to the shoreline. Several species of corals were observed, including large colonies of *Acropora prolifera*, *Acropora palmata*, *Porites astreoides*, *Porites furcata*, *Pseudodiploria strigosa*, *Pseudodiploria clivosa* and *Siderastrea spp.* The substratum providing growth areas for these colonies was mostly dead coral. The reefs had a significant coverage of turf algae and macroalgae, most notable being *Dictyota* and *Sargassum*. These various species and growth forms provide interstitial spaces for fish occupancy, with more fish observed in more rugose areas.

The minimum temperature recorded by dive computers during surveys was 32°C. Extended periods of such warm sea surface temperatures resulted in observations of paling and bleached colonies.

RESULTS

A total of 20 species were observed during the roving surveys. The most observed individuals were members of the Damselfish family, namely dusky and sergeant major. Most species were categorized under IUCN as of "Least Concern" though one, Red Lionfish, is a notable invasive species to Jamaica (Table 4-59).

Table 4-59 Species list and abundance of reef fish

Common Name	Scientific Name	IUCN Status	Abundance
Sergeant Major	*Abudefduf saxatilis*	Least Concern	A
Doctorfish	*Acanthurus chirurgus*	Least Concern	F
Blue Tang	*Acanthurus coeruleus*	Least Concern	S
Porkfish	*Anisotremus virginicus*	Least Concern	S
French Grunt	*Haemulon flavolineatum*	Least Concern	M
Slippery Dick	*Halichoeres bivittatus*	Least Concern	M
Schoolmaster Snapper	*Lutjanus apodus*	Least Concern	F
Gray Snapper	*Lutjanus griseus*	Least Concern	S
Yellowtail Damselfish	*Microspathodon chrysurus*	Least Concern	F
Caribbean Spiny Lobster	*Panulirus argus*	Data Deficient	F
Red Lionfish	*Pterois volitans*	Least Concern	F
Striped Parrotfish	*Scarus iseri*	Least Concern	M
Redband Parrotfish	*Sparisoma aurofrenatum*	Least Concern	M
Yellowtail Parrotfish	*Sparisoma rubripinne*	Least Concern	F
Stoplight Parrotfish	*Sparisoma viride*	Least Concern	S
Dusky Damselfish	*Stegastes adustus*	Least Concern	A
Longfin Damselfish	*Stegastes diencaeus*	Least Concern	A
Threespot Damselfish	*Stegastes planifrons*	Least Concern	F
Cocoa Damselfish	*Stegastes variabilis*	Least Concern	F
Bluehead Wrasse	*Thalassoma bifasciatum*	Least Concern	A
No. of species = 20			

denotes Invasive Species

2024 ASSESSMENTS

Across the reef, a total of 54 species were identified (Table 4-60). French Grunt (*Haemulon flavolineatum*), Schoolmaster Snapper (*Lutjanus apodus*), Striped Parrotfish (*Scarus iseri*), and Redband Parrotfish (*Sparisoma aurofrenatum*) were the most dominant species. In contrast, many species such as Spanish Hogfish (*Bodianus rufus*), various Butterflyfish (*Chaetodon spp.*), and Hamlets (*Hypoplectrus spp.*) were observed in smaller numbers and classified as Rare (R) or Occasional (O).

Fish size classes exhibited considerable variation, with most fish averaging between 5-20 cm. Larger fish species such as, Moray Eels (*Gymnothorax spp.*) and the Great Barracuda (*Sphyraena barracuda*), exceeded 40 cm in length. Based on the size classes and colouration of individuals, this indicated a mixture of juveniles and adults. Invasive lionfish (Plate 4-93) were seen in patch reef areas.

Plate 4-93 Lionfish

Table 4-60 Species found throughout reefs with average size class and abundance per species

Common Name	Scientific Name	Average Size Class (cm)	DAFOR
Sergeant Major	*Abudefduf saxatilis*	5-10	O
Blue Tang	*Acanthurus coeruleus*	5-10	A
Spanish Hogfish	*Bodianus rufus*	11- 20	R
Sharpnose Pufferfish	*Canthigaster rostrata*	0 - 5	O
Bar Jack	*Caranx ruber*	11-20	O
Graysby	*Cephalopholis cruentata*	11 - 20	O
Four-Eyed Butterflyfish	*Chaetodon capistratus*	5-10	O
Spotfin Butterflyfish	*Chaetodon ocellatus*	5-10	R
Banded Butterflyfish	*Chaetodon striatus*	5-10	R
Web burrfish	*Chilomycterus antillarum*	11-20	R
Masked/Glass Goby	*Coryphopterus personatus/hyalinus*	0 - 5	F
Balloonfish	*Diodon holocanthus*	11-20	R
Goby	*Elacatinus spp.*	0- 5	R
Red Hind	*Epinephelus guttatus*	11-20	R
Spotted Moray	*Gymnothorax moringa*	>40	R
Purplemouth Moray	*Gymnothorax vicinus*	>40	R
Ceasar Grunt	*Haemulon carbonarium*	11-20	R
French Grunt	*Haemulon flavolineatum*	11-20	D
White Grunt	*Haemulon plumierii*	11-20	A
Slippery Dick	*Halichoeres bivittatus*	5-10	F
Yellowhead Wrasse	*Halichoeres garnoti*	11-20	O
Queen Angel	*Holacanthus ciliaris*	11-20	O
Squirrelfish	*Holocentrus adscensionis*	5 - 10	F
Longspine Squirrelfish	*Holocentrus rufus*	11-20	O
Indigo Hamlet	*Hypoplectrus indigo*	5-10	F

Common Name	Scientific Name	Average Size Class (cm)	DAFOR
Black Hamlet	*Hypoplectrus nigricans*	5-10	R
Barred Hamlet	*Hypoplectrus puelia*	5-10	O
Butter Hamlet	*Hypoplectrus unicolor*	5-10	R
Hogfish	*Lachnolaimus maximus*	5-10	R
Smooth trunkfish	*Lactophrys triqueter*	11- 20	R
Schoolmaster snapper	*Lutjanus apodus*	11- 20	D
Yellowtail Damselfish	*Microspathodon chrysurus*	5-10	R
Yellow Goatfish	*Mulloidichthys martinicus*	11-20	O
Yellowtail Snapper	*Ocyurus chrysurus*	11-20	F
French Angelfish	*Pomacanthus paru*	5 - 10	O
Lionfish	*Pterois volitans*	5-10	O
Striped Parrotfish	*Scarus iseri*	11-20	D
Princess Parrotfish	*Scarus taeniopterus*	5-10	F
Harlequin Bass	*Serranus tigrinus*	0-5	O
Redband Parrotfish	*Sparisoma aurofrenatum*	5 - 10	D
Redtail Parrotfish	*Sparisoma chrysopterum*	11 - 20	F
Yellowtail Parrotfish	*Sparisoma rubripinne*	11- 20	O
Stoplight Parrotfish	*Sparisoma viride*	5-10	F
Great Barracuda	*Sphyraena barracuda*	>40	R
Dusky Damselfish	*Stegastes adustus*	5-10	O
Longfin Damselfish	*Stegastes diencaeus*	5-10	O
Beaugregory	*Stegastes leucostictus*	0-5	R
Bicolor Damselfish	*Stegastes partitus*	0-5	R
Three Spot Damsel	*Stegastes planifrons*	5-10	A
Cocoa Damselfish	*Stegastes variabilis*	0-5	R
Sand Diver	*Synodus intermedius*	21- 30	R
Bluestriped Lizardfish	*Synodus saurus*	11 - 20	R
Bluehead wrasse	*Thalassoma bifasciatum*	11- 20	A
Yellow Stingray	*Urolophus jamaicensis*	21-30	R
Total Species		**54**	

Orbicella City

One of the reefs surveyed was labelled *Orbicella* City and stood out distinctly from the other surveyed locations due to its notable structural complexity and high vertical relief. This physical structure, characterized by crevices, lobes, and interstitial spaces, offered several areas for various marine organisms to occupy, with 24/54 species being represented here.

The coral community at this site was dominated by the *Orbicella* complex, particularly *Orbicella faveolata* and *Orbicella annularis*, which were prevalent throughout the area. Additional species such as *Pseudodiploria strigosa*, *Colpophyllia natans*, and *Siderastrea siderea* were also observed, adding to the coral diversity, and further emphasizing the ecological significance of the site. The dominance of *Orbicella* corals indicates a relatively mature reef, as these species have been identified as reef-building species, often forming the backbone of structurally complex Caribbean reefs.

Fish populations at Orbicella City were particularly distinct, with many species observed in large schools, with some species having several schools containing dozens of individuals. Key representatives included Striped Parrotfish (*Scarus iseri*) and Stoplight Parrotfish (*Sparisoma viride*), both of which play critical roles as herbivores in controlling algal growth on the reef. Other highly abundant fish included Grunts (Caesar, French, and White Grunts), Schoolmaster Snapper (Lutjanus apodus), and Bluehead Wrasse (Thalassoma bifasciatum). The average size class of the fish observed at Orbicella City was 11–20 cm, with a mix of juveniles and adults noted across species.

Transition from Seagrass Habitat to Coral Habitat

- Similar species observed: A total of 18 species were noted along transect lines laid within the seagrass beds. Of these 18, 8 were represented in adjacent reefs surveyed in 2023 and 2024. Though a small number, the commonality of species could be attributed to the ecological connectivity of the two habitats. Juveniles of several reef species utilize adjacent seagrass beds and shallow bays as nursery areas due to services provided such as shelter and source of food. Such species include Slippery Dick (*H. bivittatus*) and Gray Snapper (*L. griseus*), eventually migrating to nearby reefs as they grow. Additionally, some species may forage or move between habitats based on their feeding behaviours and activity patterns.
- Size class of species observed: Along the transect lines laid in the seagrass beds, most fish were 20 cm and less in total length, with a significant portion being in the 0-5 and 6-10 cm size classes. Based on the families observed, most of these fishes would be within the juvenile stage of their life cycle. In comparison, most of the fish observed in the reefs were between 11-20 cm indicating larger sized individuals and a mixture of juveniles and adults. The difference in size can be attributed to fish migrating from seagrass meadows to coral reefs as they grow, along with reefs providing more 3D area for larger fish to occupy.

4.2.3.7 Sea Turtles

The project area falls within the BBFFS, but it is not known for t turtle nesting activity. Long-term monitoring by the Bluefields Bay Fish Sanctuary has documented nesting at other nearby beaches, such as Farm, Belmont, and Culloden. Monitoring reports from the Bluefields Bay Fishermen's Friendly Society (BBFFS) between 2018 and 2022 are summarized below (Bluefields Bay Fishermen's Friendly Society, 2018) (Bluefields Bay Fishermen's Friendly Society, 2019) (Bluefields Bay Fishermen's Friendly Society, 2021) (Bluefields Bay Fishermen's Friendly Society, 2022) (Bluefields Bay Fishermen's Friendly Society, 2022) (Bluefields Bay Fishermen's Friendly Society, 2022) (Bluefields Bay Fishermen's Friendly Society, 2022) (Bluefields Bay Fishermen's Friendly Society, 2022) (Bluefields Bay Fishermen's Friendly Society, 2022).

BBFFS has conducted extensive monitoring of sea turtle nesting activity across several key beaches, including Farm, Belmont, Culloden, Black's Bay, and Sandals. Over the years, the number of nests recorded has varied, with Farm consistently showing the highest nesting activity. In 2018, 14 nests were recorded, and in 2019, 12 nests were documented across monitored beaches. The 2021 and 2022 monitoring reports recorded continued activity, though specific numbers were not consistently provided. A total of 47 turtle nests recorded in 2022.

Environmental threats, including high tides and erosion, coupled with anthropogenic pressures such as poaching and predation by mongoose, remain significant challenges. However, increased public awareness, community engagement, and the use of mitigation measures such as mongoose traps have reduced predation and poaching incidents.

While the Paradise Park beach area is not a part of the regular monitoring, nor has nesting been documented in the area, its role likely extends beyond nesting, contributing to a larger foraging area for sea turtles in the general region.

The study did not identify any turtle activity along the beach or nearby vegetation areas.

Camera traps recorded various animal activity, including livestock, domestic animals, and birds, (Plate 4-94 - Plate 4-96)but no turtles were observed, either during the day or at night. Other images captured included environmental movement such as wind-blown debris and human activity.

Frequent human activity, as well as the presence of domestic animals (dogs, cats) and livestock, could deter turtles from coming ashore.

Plate 4-94 Cat observed at camera trap 1 during the night

Plate 4-95 Horses observed at camera trap 3 during the night

Plate 4-96 Vulture observed at camera trap 4 during the day

4.3 NATURAL HAZARDS

4.3.1 Earthquake and Seismicity

4.3.1.1 Historical Seismic Activity and Faults

Seismic events pose significant risks as natural hazards, ranging from minor tremors to catastrophic occurrences with potentially devastating impacts. The severity of these events varies based on their magnitude, often resulting in damage to infrastructure and loss of life. Despite advances in monitoring technology, earthquakes remain inherently unpredictable.

Jamaica is located at the junction of the Caribbean tectonic plate and the Gonâve micro-plate, an area characterized by fault zones such as the Walton and Enriquillo Fault Zones to the west and east of the island, respectively. These, along with the Jamaican Fault system, contribute to notable seismic activity. Additional fault zones like the Duanvale and Montpelier-New-Market Faults further influence Jamaica's seismic landscape, with orientations running east-west and north-northwest to south-southeast (C. DeMets, 2007).

Jamaica has experienced significant earthquakes in its history, including the 1692 Port Royal quake, the 1907 Kingston earthquake, the 1957 March 1st tremor, and the 1993 January 13th event, all of which caused considerable damage. More recently, between 2011 and 2020, over 1,000 earthquakes were recorded with local epicentres, of which about 94 were felt. While none of these events were catastrophic, they underscore the ongoing and significant seismic activity in Jamaica.

The closest recorded earthquake epicentre to the site was 1 km to the northwest in 1895 (Figure 4-3). Additionally, two faults traverse the site: one with a west-east orientation and another with a northwest-southeast orientation in the eastern part of the site.

4.3.1.2 Spectral Acceleration

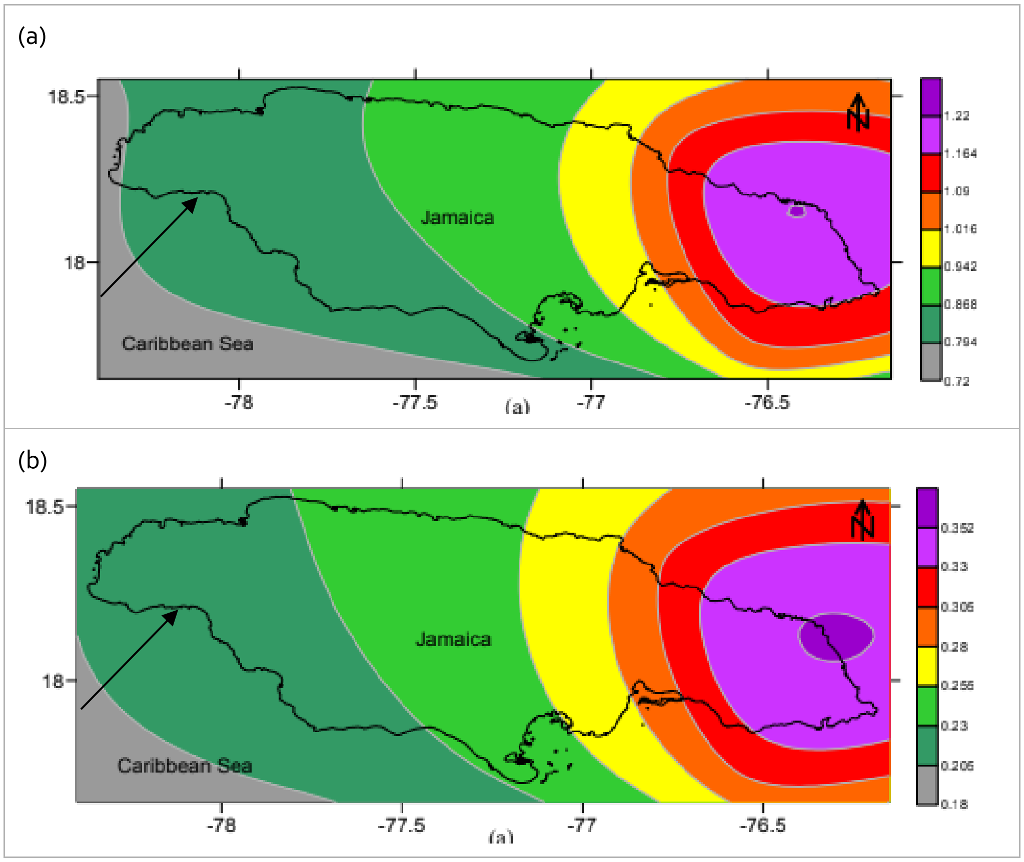
The Spectral Acceleration (SA) is the primary seismic hazard intensity parameter employed in modern building codes. It represents the maximum acceleration experienced during sustained shaking caused by an earthquake, measured at a specific oscillatory period similar to that of a building's natural vibration. This acceleration measure varies depending on the location, indicating that the intensity of ground shaking also varies across different regions. Evaluating short and long-period spectral accelerations across diverse regions provides valuable insight into the levels of seismic activity, revealing potential differences in ground motion severity among various areas. Short-period spectral accelerations, typically observed at 0.2 seconds, reflect seismic effects on low-rise structures (several floors tall). In contrast, long-period spectral accelerations, observed at 1.0 second, represent the oscillations experienced by taller structures (exceeding 7 floors).

To assess seismic hazard levels in the project area, spectral accelerations were derived from seismic hazard maps recommended in the International Building Code (IBC) adopted for Jamaica (Table 4-61).

The Paradise Park site is situated in an area characterized by relatively low spectral response for both short-period and long-period accelerations.

Table 4-61 Site Spectral Response map for 0.2s short period (a) and 1.0s long period (b), with project site indicated by arrow

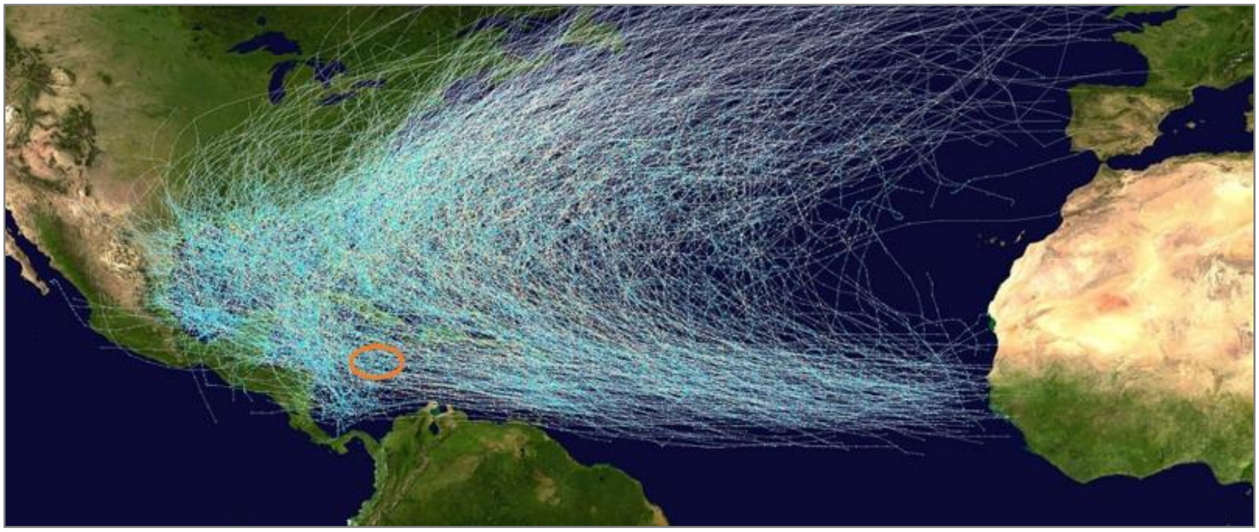
Source: Probabilistic Seismic Hazard Assessment for Jamaica Sep. 2013



4.3.2 Hurricanes

4.3.2.1 Background

The Caribbean region is vulnerable to tropical storms and hurricanes yearly from June to November. These storms can cause dramatic and abrupt changes to the coastline. Jamaica lies in 'Hurricane Alley'—an area of water in the Atlantic Ocean where hurricanes typically form because of the warmer sea surface temperatures. Figure 4-208 shows typical paths of hurricanes in the North Atlantic basin, which tend to form between latitudes 5°N and 25°N off the west coast of Africa and then track across the Atlantic Ocean. Those formed at the lower latitudes are usually pushed on a westerly track by the northeast trade winds, whereas those of the higher latitudes track more to the north and north-west (Smith Warner International Limited, 2025).



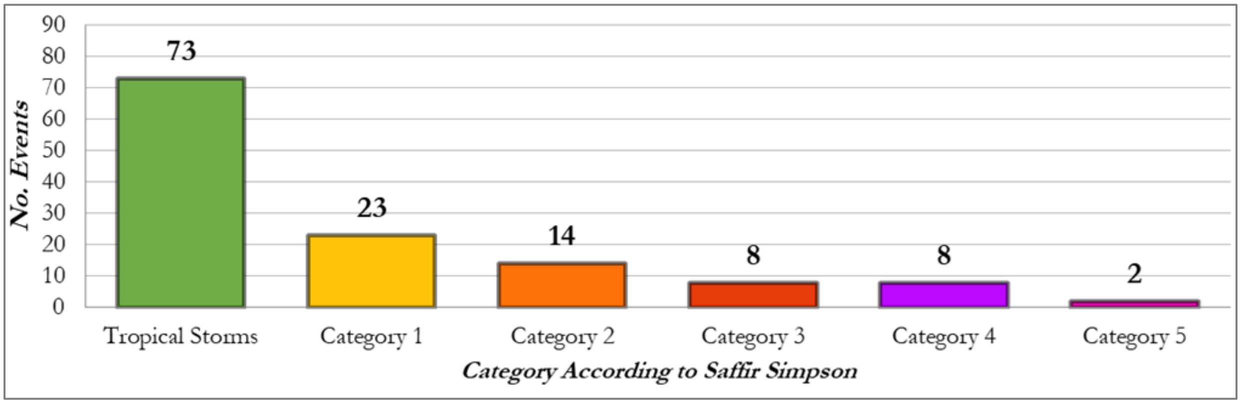
Source: (Smith Warner International Limited, 2025)

Figure 4-208 Atlantic hurricane tracks since 1851, the sweeping shape of which is commonly called 'Hurricane Alley' (an orange oval highlights Jamaica's location)

4.3.2.2 Historical Hurricane Activity

For the Atlantic Ocean, detailed information on tropical cyclones, including all hurricanes, has been collected by the US National Oceanic and Atmospheric Administration (NOAA), specifically at the National Hurricane Centre (NHC). This database of storm tracks and other parameters was the primary source of information describing the individual storms. Historical hurricane information from the NOAA's National Hurricane Centre (NHC) database was reviewed (for storms occurring between 1851 and 2022). All hurricanes passing within a 300km radius of the project site were extracted from the database. The results show that since 1851, 128 tropical storms and hurricanes have passed within this radius from the southeast coast of Jamaica.

The total number of storms can be broken down according to the categories described by the Saffir-Simpson scale as shown in Figure 4-209. The graph shows that the study area was more frequently hit by tropical storms (73) and was only affected by strong hurricanes (Category 3 and higher) infrequently (18 storms out of 128) (Smith Warner International Limited, 2025).

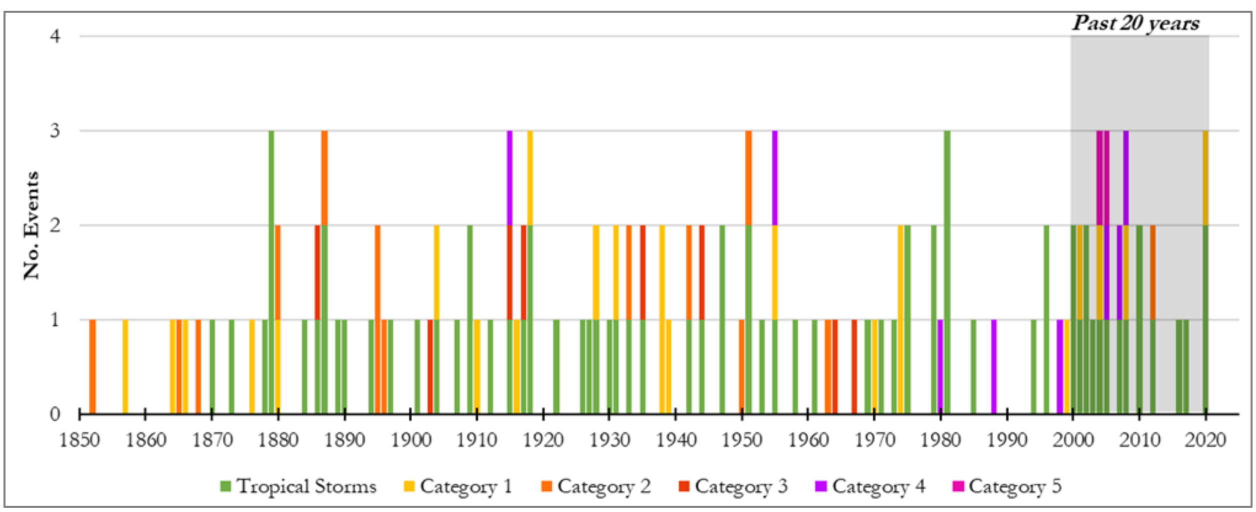


Source: (Smith Warner International Limited, 2025)

Figure 4-209 Storm distribution, according to Saffir Simpson classification, since 1851 showing storms that have passed within a 300km radius of the project site.

Figure 4-210 shows that several years pass without a hurricane, but it also indicates that more than one storm can hit the island in any given year. A particularly active year was 2020 which had 1 hurricane and 2 tropical storms passing. Since 2020, hurricanes have been infrequent with mainly tropical storms passing within the region near to Jamaica (Smith Warner International Limited, 2025).

The most recent hurricane to affect Westmoreland Paradise was Hurricane Sandy (2020) which had an unusual angle of approach. Hurricane Poloma (2008) was the strongest storm to affect the south coast as a category 4. The 2000 to the 2010 decade had the most storms while the 1850 to 1870 decade had the lowest count of storms. Jamaica was directly hit by Hurricane Charlie in 1951, Hurricane Gilbert in 1988 and Hurricane Sandy in 2012. These events impacted most of the island. Note, that within the record period one hurricane made landfall at Paradise Park (Smith Warner International Limited, 2025).



Source: (Smith Warner International Limited, 2025)

Figure 4-210 Storm distribution by year since 1851 showing storms that have passed within a 300km radius of the project site.

4.3.2.3 Hurricane Simulations

Hindcasting Hurricane Waves and Surge Levels

Extreme waves occur infrequently, and decades or centuries of data must be explored to describe the statistics adequately. The parameters of deep-water waves were calculated for each tropical cyclone using parametric models (Cooper, 1988; Young and Burchell, 1996). The resulting wave conditions were segmented into directional sectors and fit to a statistical function describing their exceedance probability. The best-fit statistical distribution determined the wave parameter values for two return periods (50-year and 100-year) (Smith Warner International Limited, 2025).

The deep-water wave parameters corresponding to the various return periods were computed for five directional sectors of incidence. Table 4-62 This chart shows the wave heights, wind speeds, and periods for the directional sectors investigated. The highest waves come from the eastern sector, with wave heights of 11.9m for the 50-year storm and 13.6m for the 100-year storm. The hurricane waves coming from the east had the largest wave heights and longest wave periods, as well as the highest winds (Smith Warner International Limited, 2025).

Table 4-62 Wave Parameters (significant wave height and peak period) and wind conditions were used for 50 and 100-year return period simulations.

Source: (Smith Warner International Limited, 2025)

Direction	Parameters		50 Year Storm	100 Year Storm
West	Wind Speed	WS (m/s)	30.3	34.9
	Wave Height	H_s (m)	6.6	7.8
	Wave Period	T_p (s)	11.2	12.1
South-West	Wind Speed	WS (m/s)	28.6	32.9
	Wave Height	H_s (m)	6.8	7.9
	Wave Period	T_p (s)	11	12.1
South	Wind Speed	WS (m/s)	26.4	29.3
	Wave Height	H_s (m)	7.8	9.1
	Wave Period	T_p (s)	12.0	13.3
South-East	Wind Speed	WS (m/s)	**33.4**	**36.9**
	Wave Height	H_s (m)	9.9	11.1
	Wave Period	T_p (s)	14.0	15.0
East	Wind Speed	WS (m/s)	35.1	38.5
	Wave Height	H_s (m)	**11.9**	**13.6**
	Wave Period	T_p (s)	**15.7**	**17.0**

To compute the total static storm surge level in deep water, global sea level rise (GSLR) for the projected year and the highest astronomical tide were added to the IBR values. The results for the 50-year and 100-year surface level values are listed in Table 4-63.

Table 4-63 IBR and design deep water surface level (m) for return periods of 50 and 100 years

Source: (Smith Warner International Limited, 2025)

Water Level Component	Value		Notes
	50yr	100yr	
Inverse Barometric Pressure Rise, IBR (m)	0.40	0.49	Determined through statistical hindcasting
Highest Astronomical Tide, HAT (m)	0.23		Determined through historical analysis
Sea Level Rise Component (m)	0.43		
Rate of Sea Level Rise (mm/yr)	*9.5*		*RCP8.5 Scenario value from IPCC, 2022*
SLR Horizon (years)	*50yr*		*How long structure is to last (not related to the design storm)*
Total design deep water surface level (m)	**1.06**	**1.15**	**The sum of IBR, HAT and SLR**

Nearshore Wave Transformation of Hurricane Waves

Previously described hurricane conditions were transformed to the nearshore regions and up to the Westmoreland Paradise Park site using MIKE21. Conditions for the extreme wave climate as listed in Table 4-62. The deep-water surface levels were applied to the model's boundary and transformed to the nearshore from the five main directional sectors: west, southwest, south, southeast, and east. Wind fields (magnitude and direction) were applied as a constant over the entire model domain. Wind directions in a hurricane change rapidly; therefore, the worst-case scenario for wind direction was used: winds approaching from the same dominant direction as waves (Smith Warner International Limited, 2025).

The coupling of hydrodynamics and waves in the numerical model is an important aspect of storm surge computations, particularly in areas such as the Caribbean, where wave set-up is a significant component of the total storm surge. As large waves approach shallow water or a reef and break, the water level increases, causing localised currents. These currents and changing water levels affect the waves, allowing them to travel farther inland. The coupling of the waves and currents in MIKE21 allows these factors to be properly simulated. The model was set to run using the conditions for the extreme wave climate listed above, and the maximum condition for each computational element was calculated.

Typical hurricane statistics for the 50-year and 100-year storms were run to provide a complete analysis. The design storm also incorporated a 50-year sea-level rise horizon. Therefore, these results give an idea of the water levels and wave heights that could occur under a designed storm 50 years from the present day (Smith Warner International Limited, 2025).

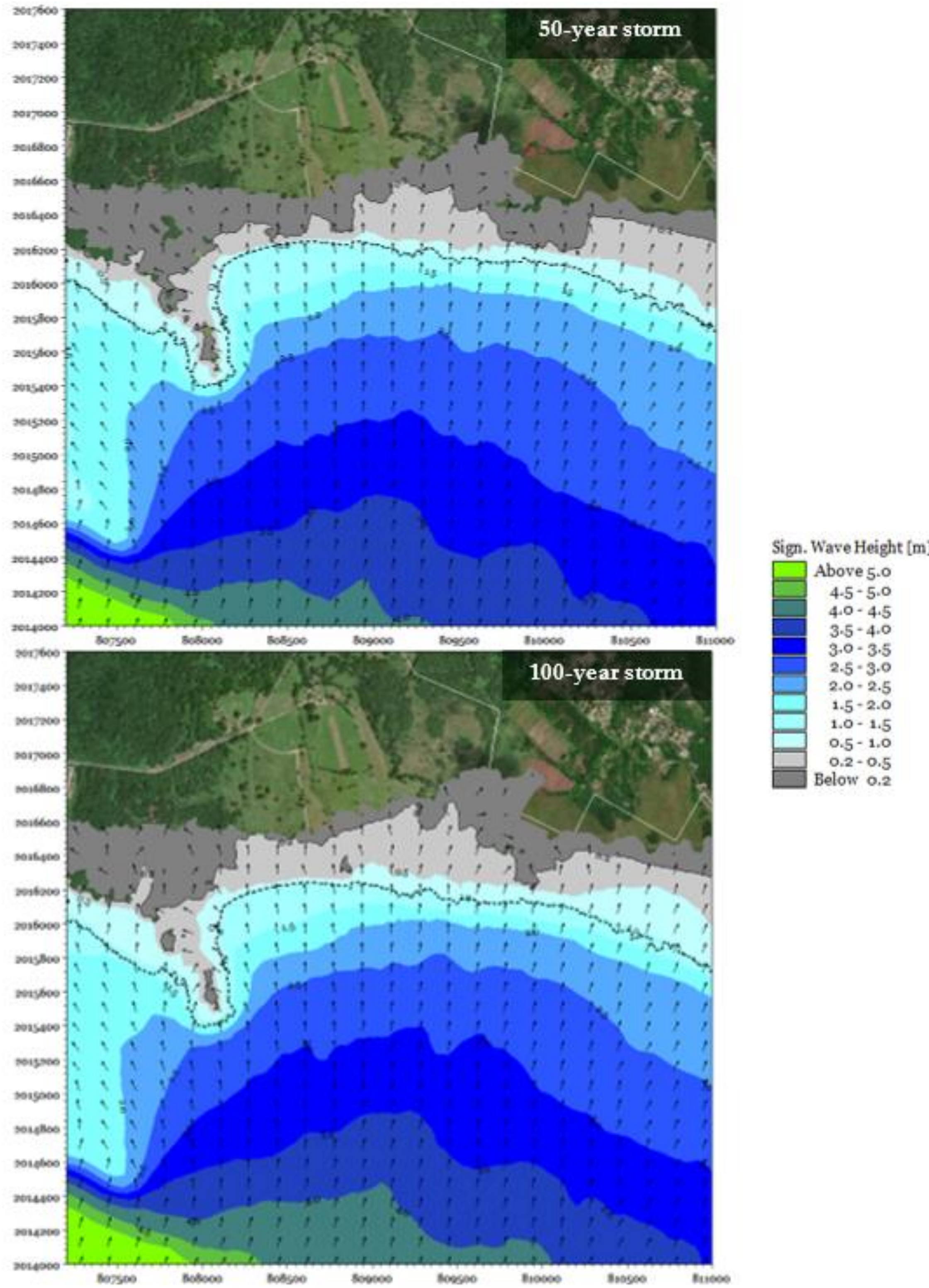
A summary of the hurricane simulation results at the shoreline is shown in Table 4-64 for the Paradise Park shoreline. Results show that water level conditions were consistent along the length of the beach.

Table 4-64 Summary of hurricane results for all scenarios tested

Source: (Smith Warner International Limited, 2025)

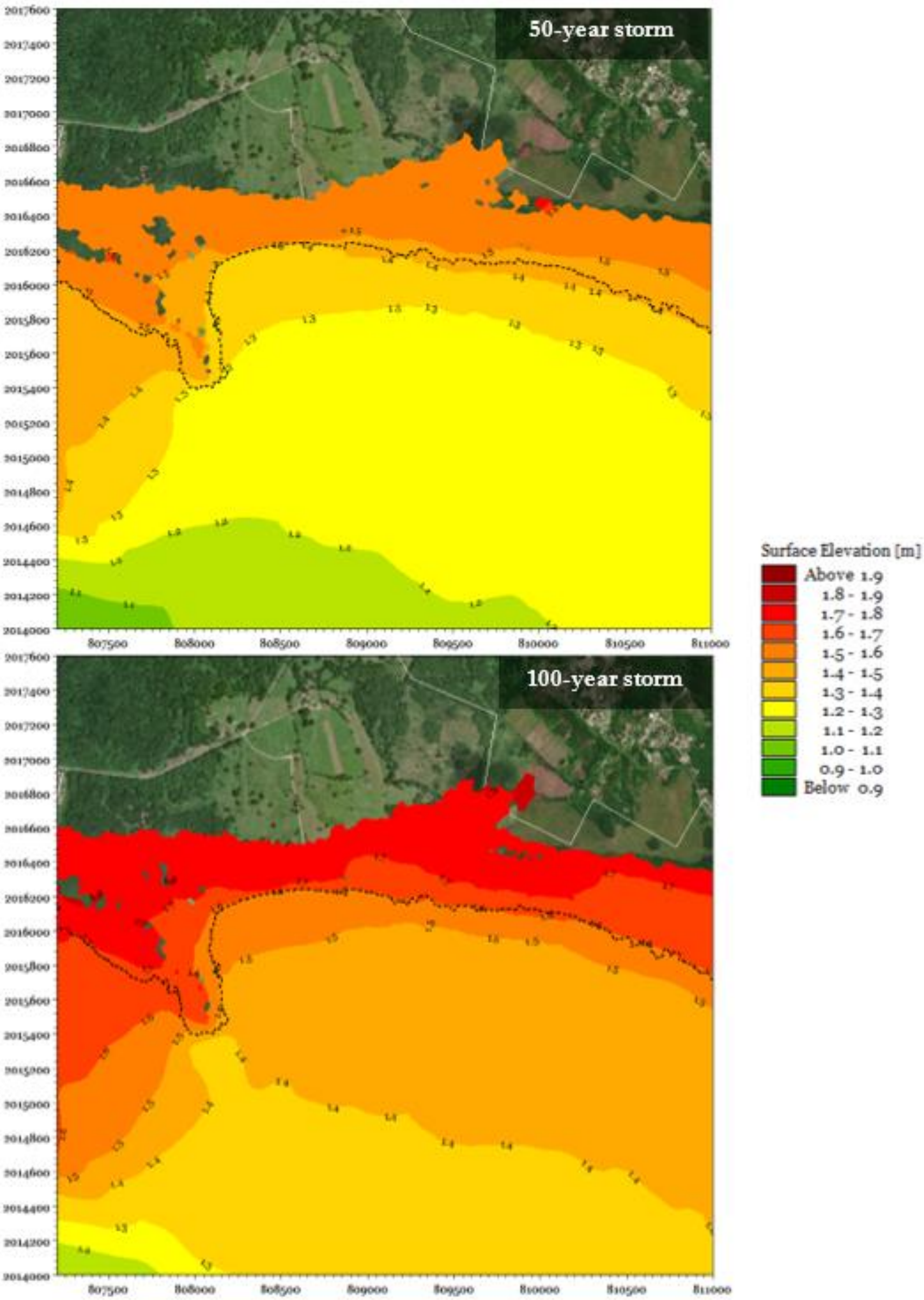
Parameter		Storm Parameters	
		50-Year SLR Horizon	
		50 Year Horizon	100 Year Horizon
Beach Shoreline	Wave Height at Shoreline (m)	1.0-1.5	1.2-1.5
	Max Static Surge Level (m +MSL)	1.5-1.6	1.7-1.9
	Inundation Depth at Shoreline (m)	1.0	1.0

Area plots have also been compiled for the parameters listed above. Maximum wave heights for the 50-year storm and 100-year storm with a 50-year design horizon (at year 2070) have been plotted in Figure 4-211. The maximum static surge levels for the same conditions are shown in Figure 4-212. Finally, the inundation levels related to the surge are shown in Figure 4-213 (Smith Warner International Limited, 2025).



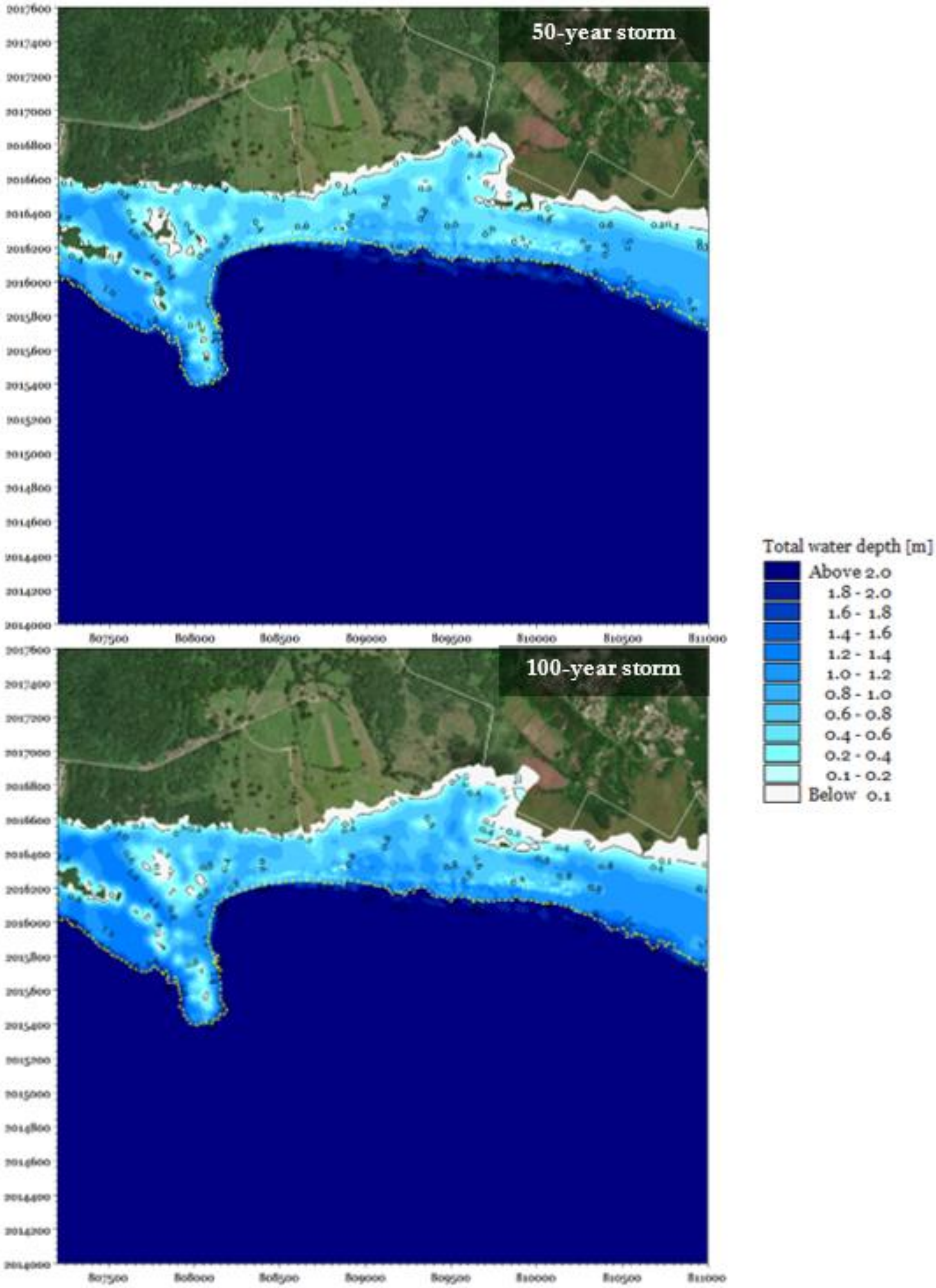
Source: (Smith Warner International Limited, 2025)

Figure 4-211 Hurricane wave heights at Paradise Park during the 50-year storm (top) and 100-year storm (bottom) over a 50-year sea level horizon



Source: (Smith Warner International Limited, 2025)

Figure 4-212 Hurricane water levels at Paradise Park during the 50-year storm (top) and 100-year storm (bottom) over a 50-year sea level horizon



Source: (Smith Warner International Limited, 2025)

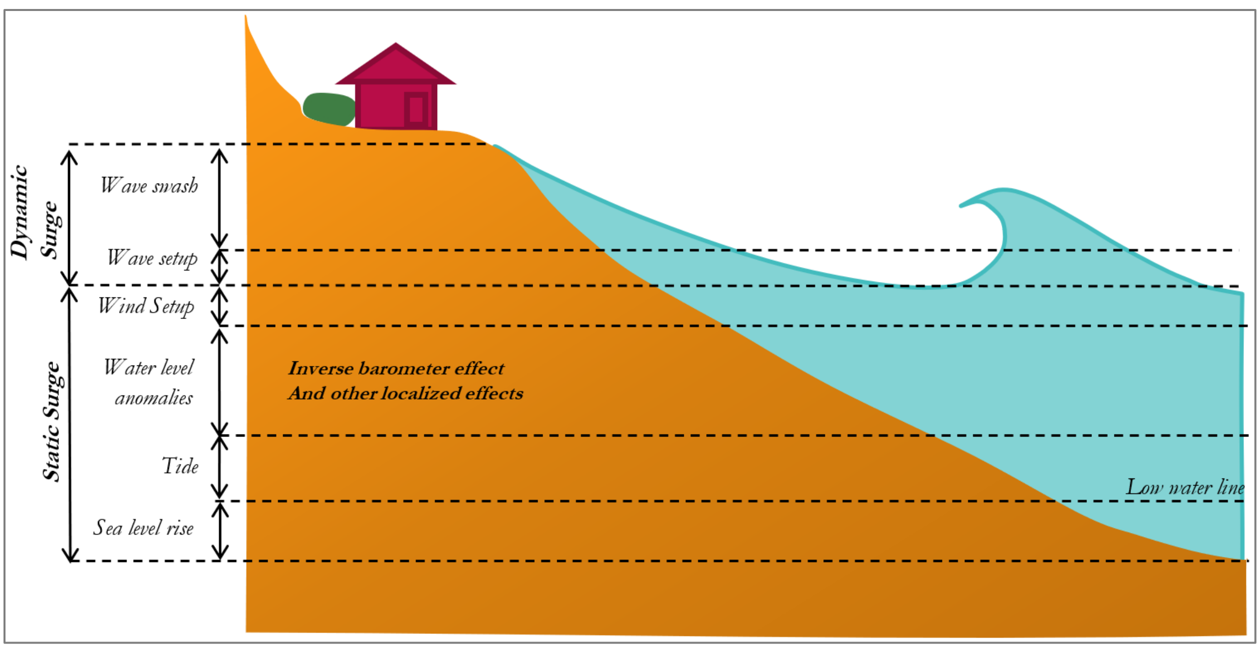
Figure 4-213 Hurricane water depths at Paradise Park during the 50-year storm (top) and 100-year storm (bottom) over a 50-year sea level horizon

Dynamic Storm Surge Inundation

Elevated water levels that accompany hurricanes, create flooding, and damage coastal infrastructure are known as storm surges. A storm surge can be thought of simply as the increase in water level in the coastal zone resulting from the passage of a storm.

Storm surge can be divided into (i) static and (ii) dynamic components. For exposed shorelines, the static components of storm surge include inverse barometric pressure rise and wind set-up. Dynamic storm surge is a result of wave set-up and wave run-up. Elevated water levels due to the static surge can remain constant for hours during a storm, whereas water levels in the wave run-up zone will fluctuate as waves "run-up" the beach profile and onto the land (Smith Warner International Limited, 2025).

A higher run-up can occur if the beach profile is smooth and impermeable. Conversely, the run-up would be reduced if a rough armour stone slope or a highly vegetated surface is encountered. Because of the localised variability of wave run-up and its dynamic component, storm surge computations do not commonly include wave run-up. However, it is calculated and used in the design of coastal structures. Figure 4-214 shows a diagram of the static and dynamic components of storm surge (Smith Warner International Limited, 2025).

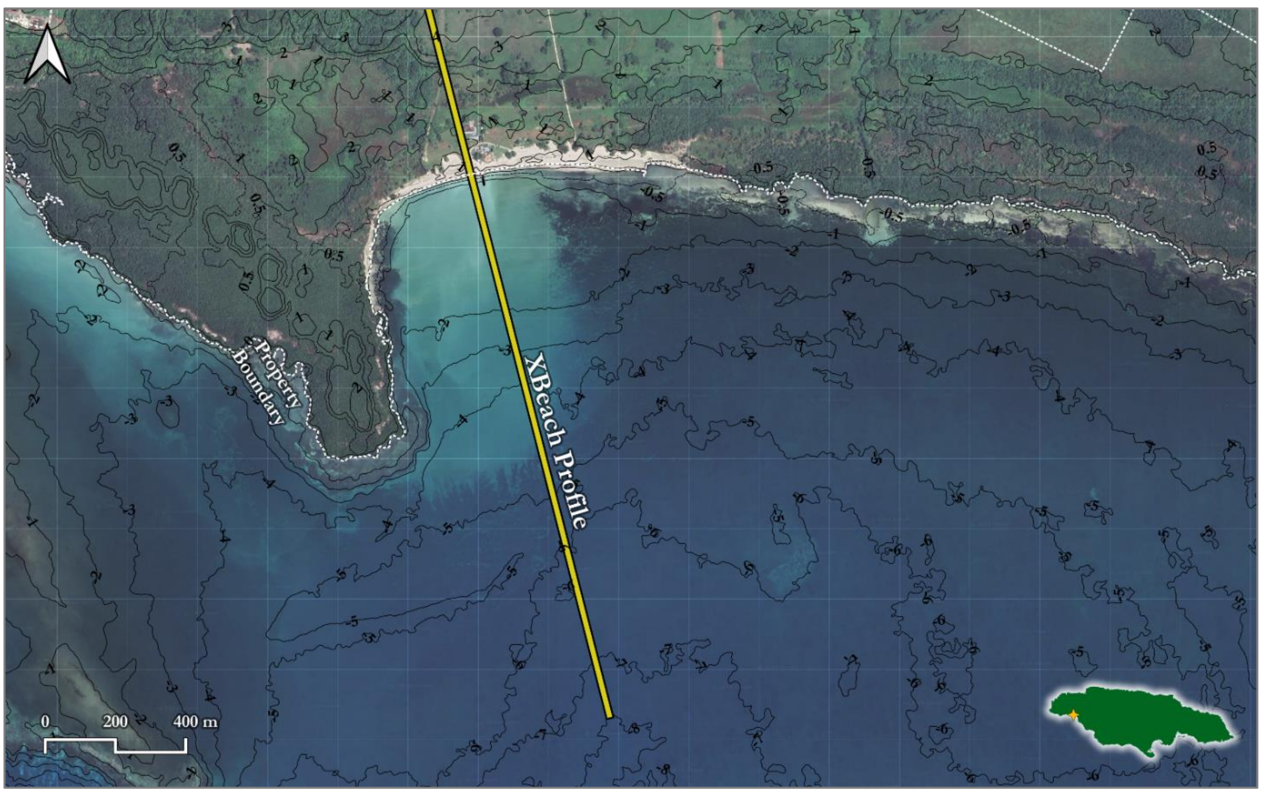


Source: (Smith Warner International Limited, 2025)

Figure 4-214 Components of storm surge (adapted from (Vitousek et al., 2017))

Paradise Park has gentle beach slopes, ranging between 1(V):40(H) and 1(V):230(H). Slopes on beaches are often associated with greater wave run-up because waves lose less energy due to the gradual incline, allowing them to travel further up the beach. This can enhance the wave run-up phenomenon, where the waves move up the shore after breaking. This topography and wave interaction requires a model that adequately resolves the water surface in shallow depths. The XBeach model calculated final inundation levels and possible scour in the project area.

XBeach (Roelvink, 2009) was applied in a one-dimensional format to simulate the storm-induced water level changes for the design events detailed in the prior sections. One profile was taken within the boundaries of the site (Figure 4-215), which would be used to predict levels for the entire property. The profile was extracted using a simple routine in GIS software that merged the topographic data, beach profiles, bathymetric tracks and EOMAP satellite-derived bathymetry. The data was interpolated to provide a one-dimensional profile that extends perpendicularly from the shoreline (and runs parallel to the bathymetry contours) to about the 8m depth contour along the project site and input to the XBeach model. The profile does not consider the buildings along the property and, as such, may be considered as a worst-case scenario (Smith Warner International Limited, 2025).

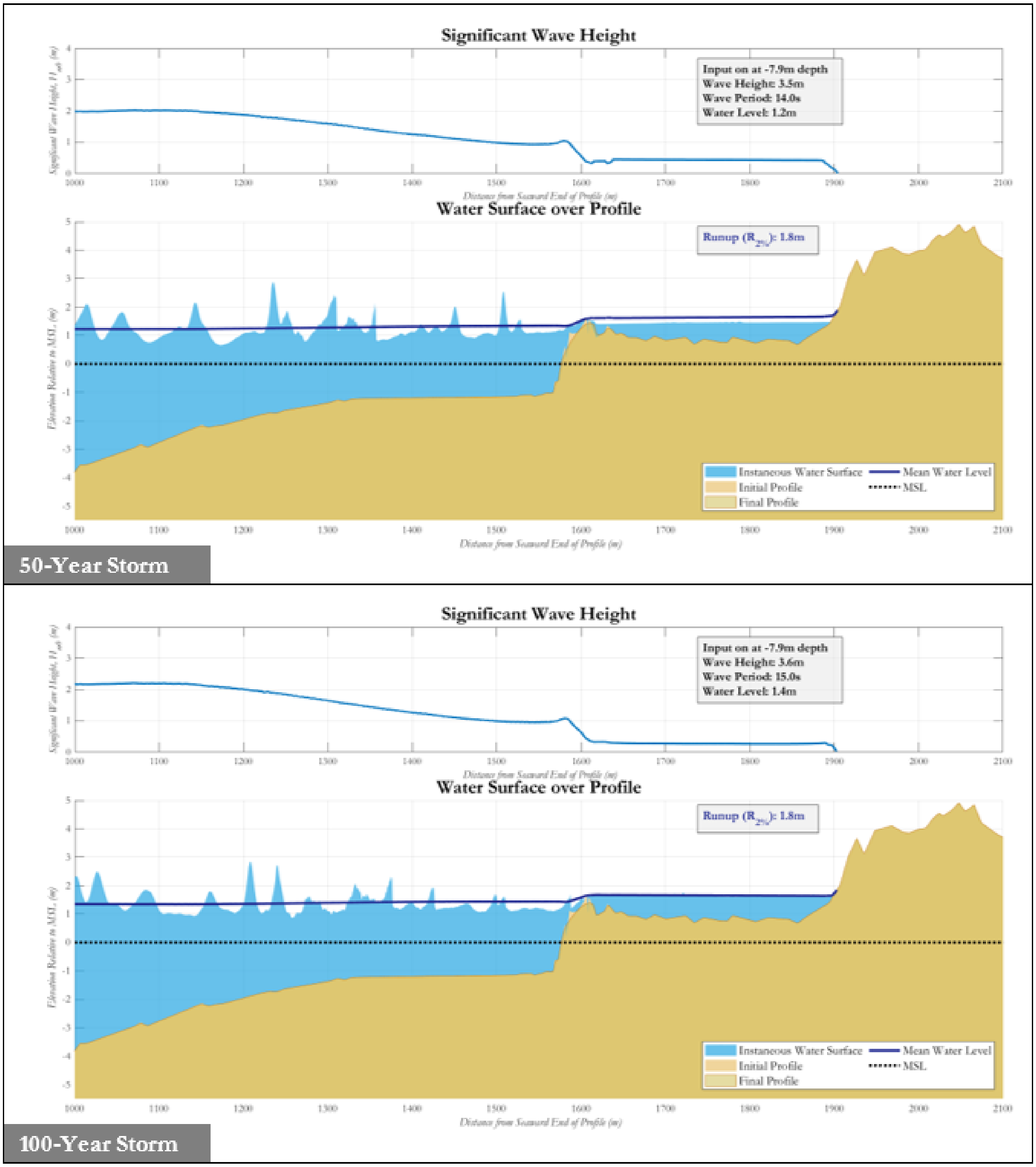


Source: (Smith Warner International Limited, 2025)

Figure 4-215 XBeach profiles assessed wave run-up on the Paradise Park, Westmoreland property.

Wind and wave parameters were extracted from the MIKE 21 hurricane models at the seaward ends of each profile. These parameters were then formatted and used as input for the model. XBeach uses a non-hydrostatic formulation for the water surface, making it suitable for modelling beach erosion, scarping and wave slam. The model also utilised the sediment characteristics to indicate sediment movement and scour. In this case, scour is defined as the maximum elevation difference between the profile before and after the hurricane.

Nearshore and on-land results for the 50-year storm and 100-year storm are shown in Figure 4-216. The 50- and 100-year storms' inundation reached a runup level of 1.8m above MSL, which corresponds to an inundation extent of 300m from the shoreline (Smith Warner International Limited, 2025).



Source: (Smith Warner International Limited, 2025)

Figure 4-216 XBeach profile results for the 50-year storm and 100-year storm

4.3.3 Beach Stability

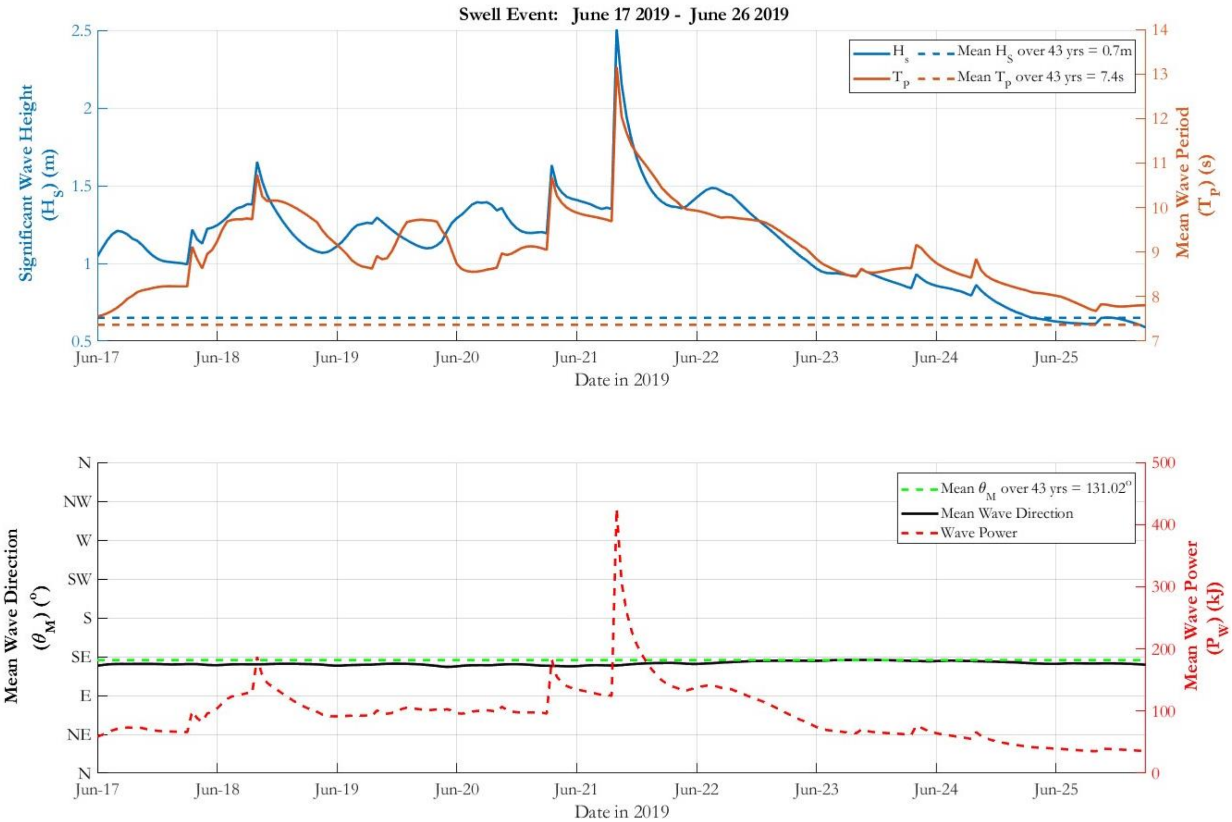
4.3.3.1 Cross-shore Sediment Transport (Swell Event)

As mentioned previously in section 4.1.6.5, high-energy swells can quickly erode beaches in the short term (a few days). Fortunately, the erosion that is seen after a swell event is typically not permanent, as the long-term patterns of sediment transport slowly move the offshore sediment back to the beach area.

Cross-shore sediment transport is the displacement of sediment perpendicular to the shore (onshore or offshore), usually into a berm (onshore) or into an offshore bar (offshore). This form of transport is likely less dominant than longshore drift, considering offshore waves are at an angle to the shore (not perpendicular). However, it is important to investigate possible episodic erosion patterns during high-energy events. A south-easterly swell event was modelled to assess cross-shore movement.

The north coast of Jamaica and the wider Caribbean are subject to swell waves from November to April. Swell waves originate from storms in the northern Atlantic Ocean and propagate towards the Caribbean Sea. Swells approach from a direction that is not typical and have long wave periods, which generate significant erosion. The Paradise Park property shoreline is parallel to the typical swell direction (ESE) and would likely experience cross-shore transport during these events (Smith Warner International Limited, 2025).

An energetic wave event was simulated to assess the impacts associated with swells. This process began by filtering the ERA5 database to produce a list of swell events. The results showed that one of the top events occurred from the 17th to the 26th of June in 2019. This event had wave heights between 0.6m and 2.5m offshore, peak wave periods of about 13s and approached from the southeast for most of the event. The time series of the event has been graphed in Figure 4-217.These wave conditions were run across the model domain, including the bathymetric information offshore of the Westmoreland parish. The model included hydrodynamic (water surface), waves and sediment transport modules. The results of the simulation at the peak timestep are shown in Figure 4-218 (currents),Figure 4-219 (waves), and Figure 4-220 (bed level change) (Smith Warner International Limited, 2025).

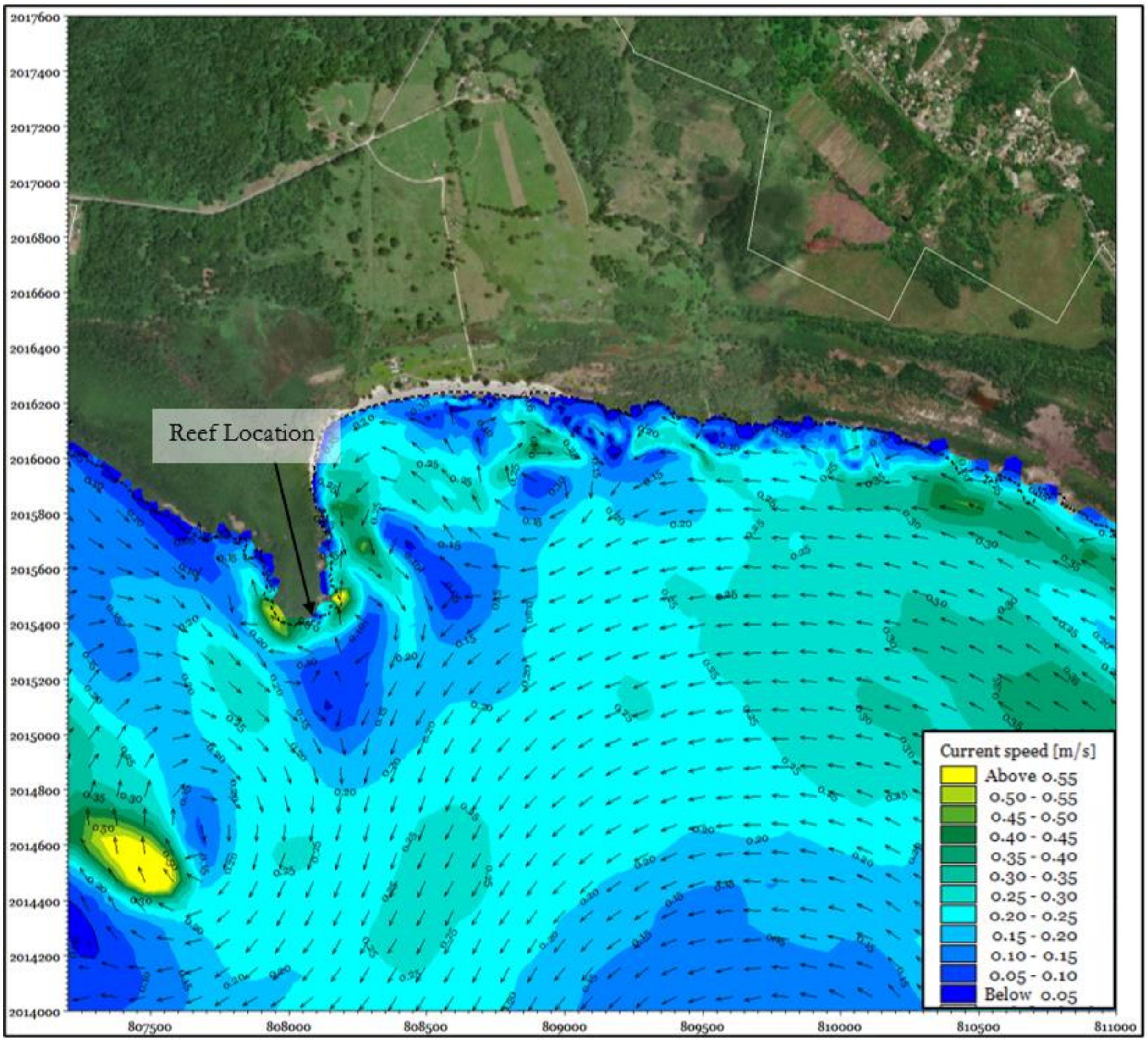


Source: (Smith Warner International Limited, 2025)

Figure 4-217 Swell event of June 17 to 26, 2019 wave conditions.

Generally, current speeds were highest at the reef face, which suggests that they were generated by breaking waves. Currents were above 0.55m/s along the reef face. Current speeds surrounding the headline to the east of the site were also high. This area also had current speeds above 0.55m/s. At the western end, the current speeds were below 0.5m/s in the pockets along the shoreline and increased to about 0.4m/s between the shoreline and the 4m depth limit (Smith Warner International Limited, 2025).

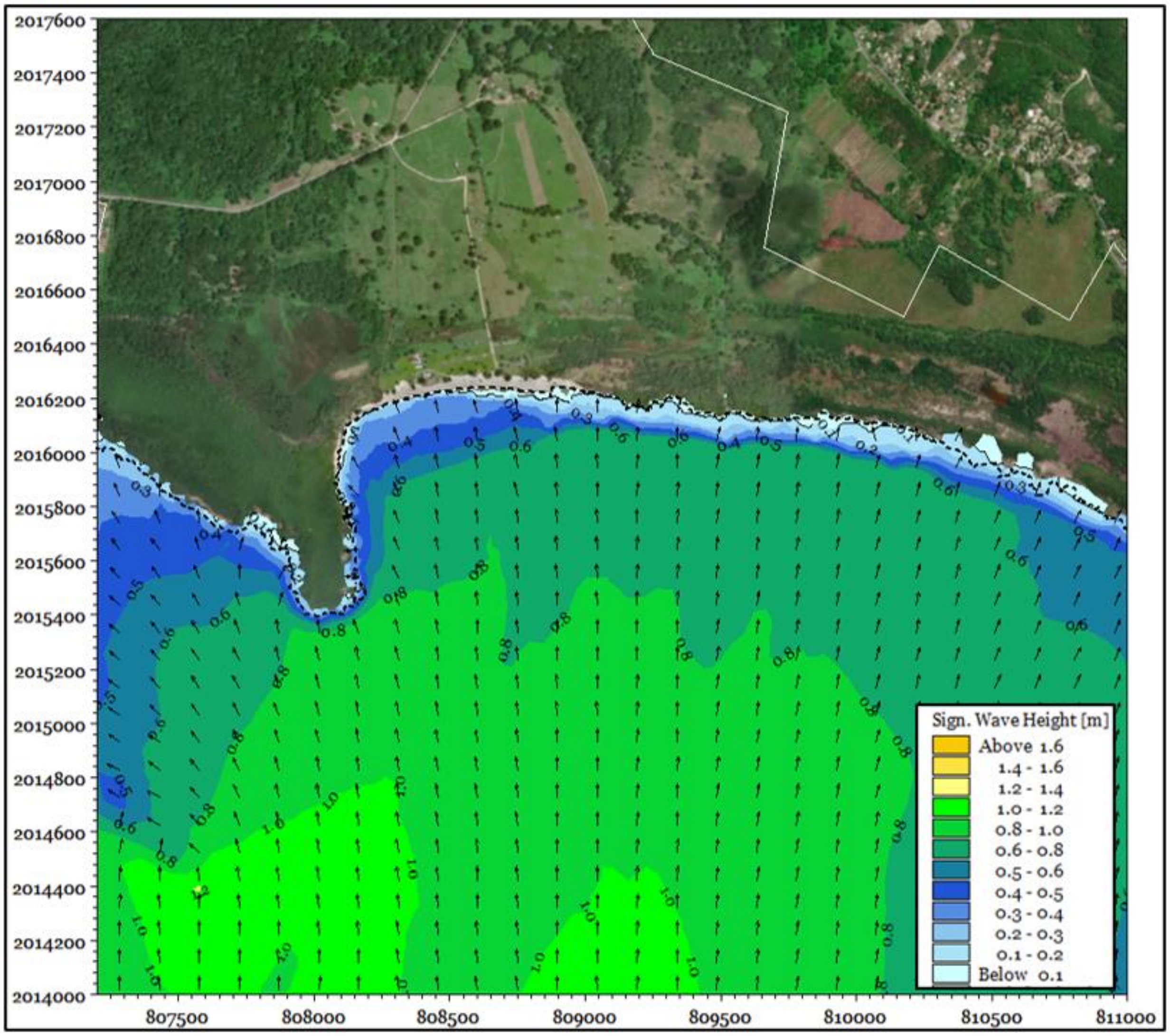
Current directions were from east to west but circulated the reef. The presence of the headland pushed currents towards the south, changing the dominant direction to the southwest in the lee of the headland. The overall current direction pattern is similar to the average currents associated with waves breaking. This is expected as a swell event would be more governed by wave induced currents and less by tidal influences (Smith Warner International Limited, 2025).



Source: (Smith Warner International Limited, 2025)

Figure 4-218 Current speeds during the peak timestep of the swell event

Wave heights at the peak of the swell simulation are shown in Figure 4-219. As shown, offshore waves outside of the reef were between 0.8m and 1.2m at the peak of simulation, but after interacting with the reef, it decreased to 0.4m. Wave heights were about 0.2m at the shoreline of the property. The predominant offshore wave direction was from the south of the site, with some slight changes due to the curvature of the shoreline. After interaction with the reef and headland on the western end, the waves refracted, changed direction, and approached from the southeast. On the eastern end, waves approached from the southwest (Smith Warner International Limited, 2025).



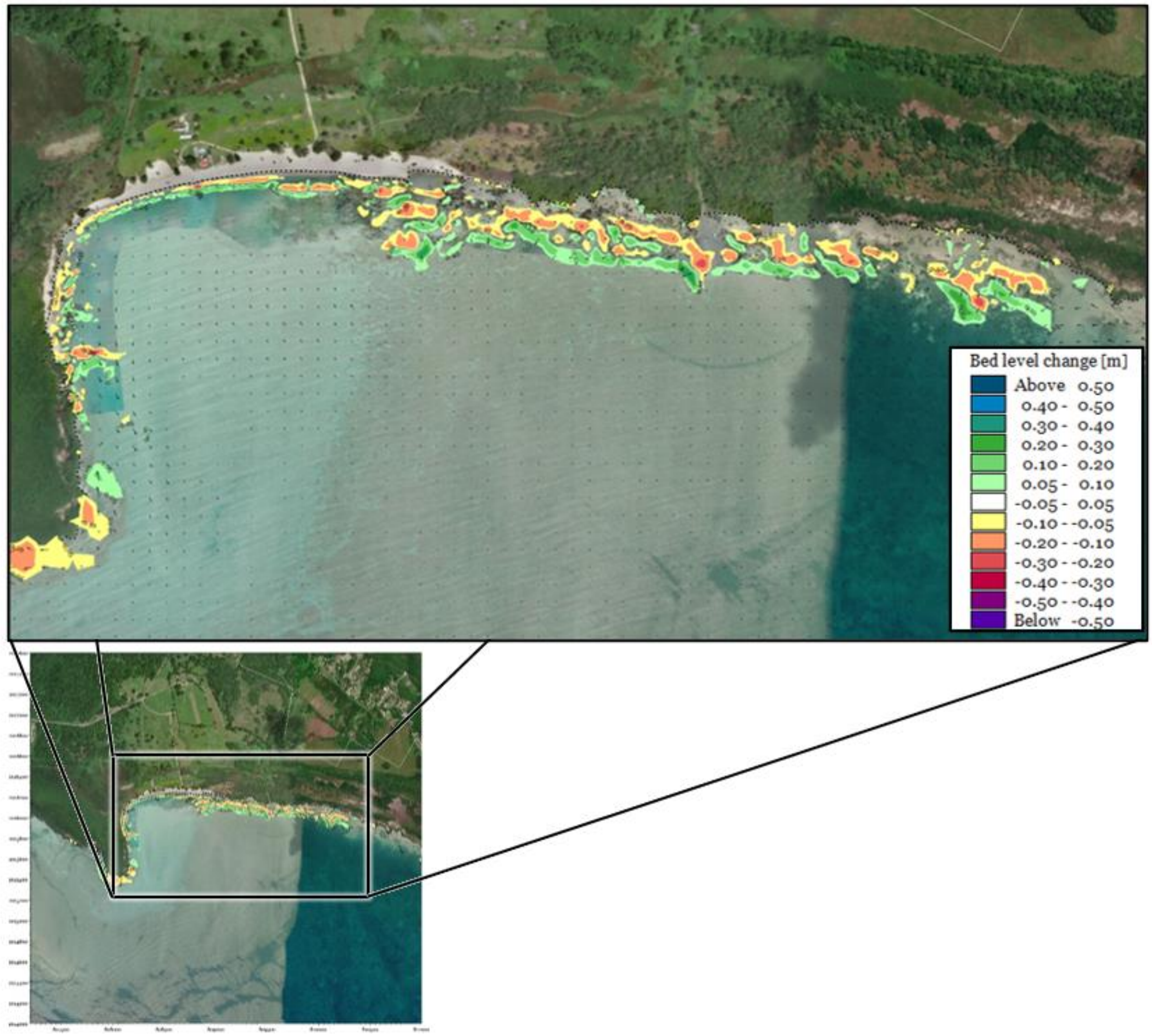
Source: (Smith Warner International Limited, 2025)

Figure 4-219 Wave heights during the peak timestep of the swell event

Figure 4-220 shows the resulting bed level change at the end of the swell event. Under existing conditions, the model predicted bed level changes between +0.1 and -0.2 m in accretion and erosion along the main beach area. The swell event results mainly showed a cross-shore movement in sediment transport due to the direction of the wave approach. The sediment movement during the swell event occurs within water depths less than 1.5m (Smith Warner International Limited, 2025).

4.3.3.2 Implications from the Swell Event

Bed level, wave and current results show an overall cross-shore movement of sediment, which results in sediment erosion during swell events. Outside of these events, lower wave heights reintroduce sediment. Therefore, there is no permanent sediment loss, and the shoreline will be stable over the long term (Smith Warner International Limited, 2025).



Source: (Smith Warner International Limited, 2025)

Figure 4-220 Bed level change after the swell event simulation

4.3.4 Climate Change

Coastal regions are especially vulnerable due to their proximity to the sea and exposure to wind and water forces. With climate change, rising sea levels and more extreme weather events are expected to increase the risks from these hazards (Smith Warner International Limited, 2025). Three key parameters must be assessed:

- Planning Time Horizon: The period for which the plan is being developed.
- Extreme Event Return Period: The severity and likelihood of natural hazards, often analysed through statistical risk.

- Climate Change Scenario: Emission pathways that outline potential impacts, typically represented by RCP or SSP models.

Among these, the planning time horizon is most crucial. When addressing extreme events like coastal flooding, a statistical approach is commonly used, but uncertainty, compounded by climate change, makes this more challenging. Climate change scenarios, especially global sea level rise, vary significantly, and an overly optimistic or pessimistic outlook can have serious consequences. Relying on a scenario with rapid emission reductions might expose people and assets to higher risks if actual emissions exceed expectations. On the other hand, a more pessimistic view could lead to unnecessarily high costs, making it appear overly cautious in the short term (Smith Warner International Limited, 2025).

Figure 4-221 from IPCC (2019) Special Report on the Ocean and Cryosphere depicts how Historical Centennial Events (HCE's, 100-year return period events) are predicted to transition to annual events (1-year events). The data near to Jamaica appears to suggest this transition will occur in approximately 2045-2055 for both the RCP 2.6 and RCP 8.5 emission scenario (Smith Warner International Limited, 2025).

In addition to increasing return periods of storms, risk must be explored when planning. The latest IPCC report, AR6 Synthesis Report (IPCC, 2022) guides the selection of appropriate scenarios for coastal flooding and erosion risk. Figure 4-221 New research has revealed that between AR5 and AR6, the risk/impacts for various "Reasons for Concern" have increased for the same level of global warming. Put another way, moderate to high risks/impacts are now predicted to occur at even lower global warming levels. Looking at extreme weather events, the newer science (2022 vs. 2014) has revealed that high risks will occur at 1.50C warming, whereas in AR5, this was above 2°C. Figure 4-222 depicts projected global mean sea level rise until the end of the century and makes the point that jurisdictions that have the potential, desire, and/or capacity to respond will have a potentially lower risk profile.

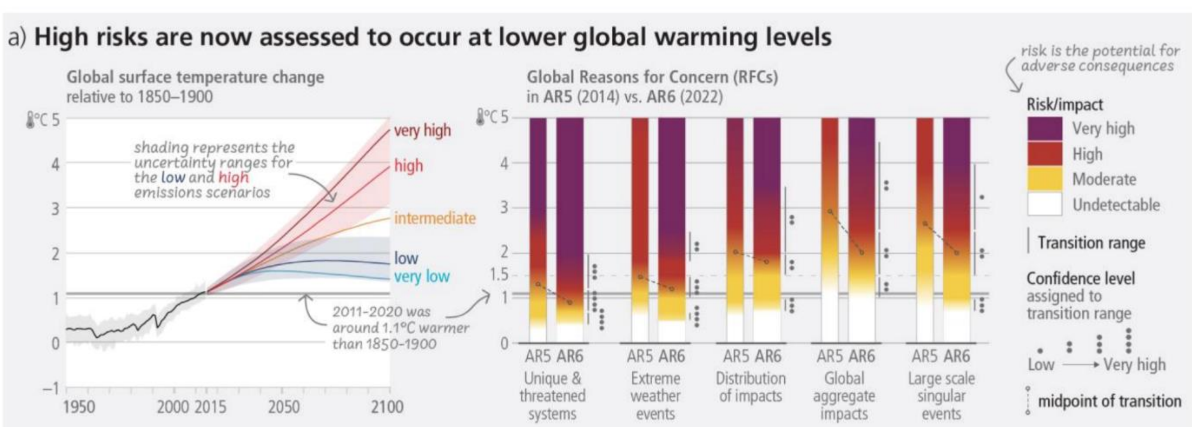


Figure 4-221 Increase in risk from IPCC's AR5 to AR6 reports for given global surface temperature change scenarios.

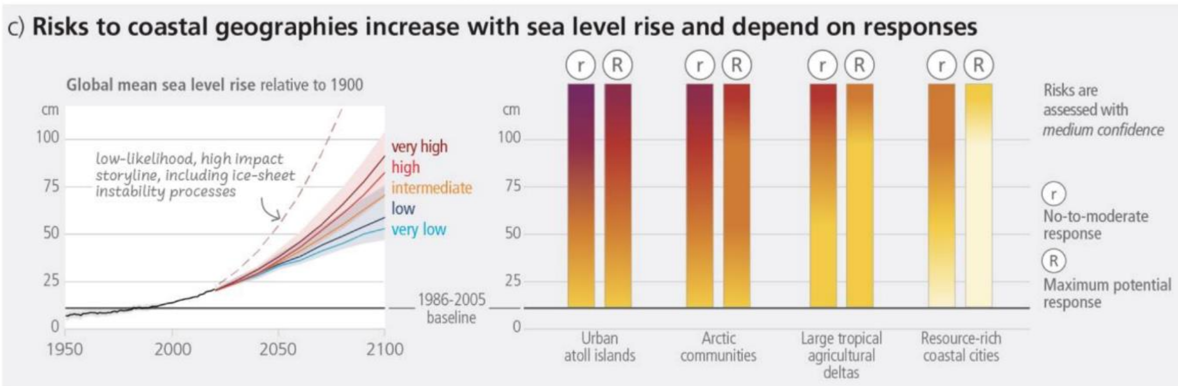


Figure 4-222 **Risk profiles of jurisdictions based on response to sea level rise threat.**

A comparison of the temperature and mean sea level rise between 1950 and 2100 shows a rather disturbing correlation – even if a low emission pathway occurs and global temperatures decrease in the latter half of this century, mean sea levels continue to increase and will continue well into the next century and beyond.

By the end of this century, the mean sea level is predicted to be at least 0.5m higher than its present value for all climate change scenarios. The intermediate climate change scenario has a median level that rises to 0.75m above present in 2100 and then above 1.0m by 2150. The steadily rising sea level, which appears to lag behind the rise in temperature, suggests that a precautionary approach for sea level rise is appropriate. A long-term planning horizon should ideally consider a 1m rise in sea level by 2100 (or 0.5m by 2070 for the medium term). Suppose the rate of sea level rise is not as rapid as the latest scientific literature suggests. In that case, that buffer will be available for the future, as sea levels will continue to rise, possibly for centuries (Smith Warner International Limited, 2025).

4.3.5 Flooding

4.3.5.1 Flood-Prone Areas and Historical Flood Records

As illustrated earlier in Figure 4-16 (section 4.1.5.1), island-wide flooding records show that flooding is generally not a significant concern at the proposed site. This aligns with findings from the perception survey (section **Error! Reference source not found.**), where 67.2% of respondents stated that the site was not affected by flooding, 26.9% were unsure, and 5.9% confirmed flooding. It should be noted however that these observations may be based on the fact that any observable inundation appears to happen in the low-lying wetlands and near the coastline, where little to no development exists.

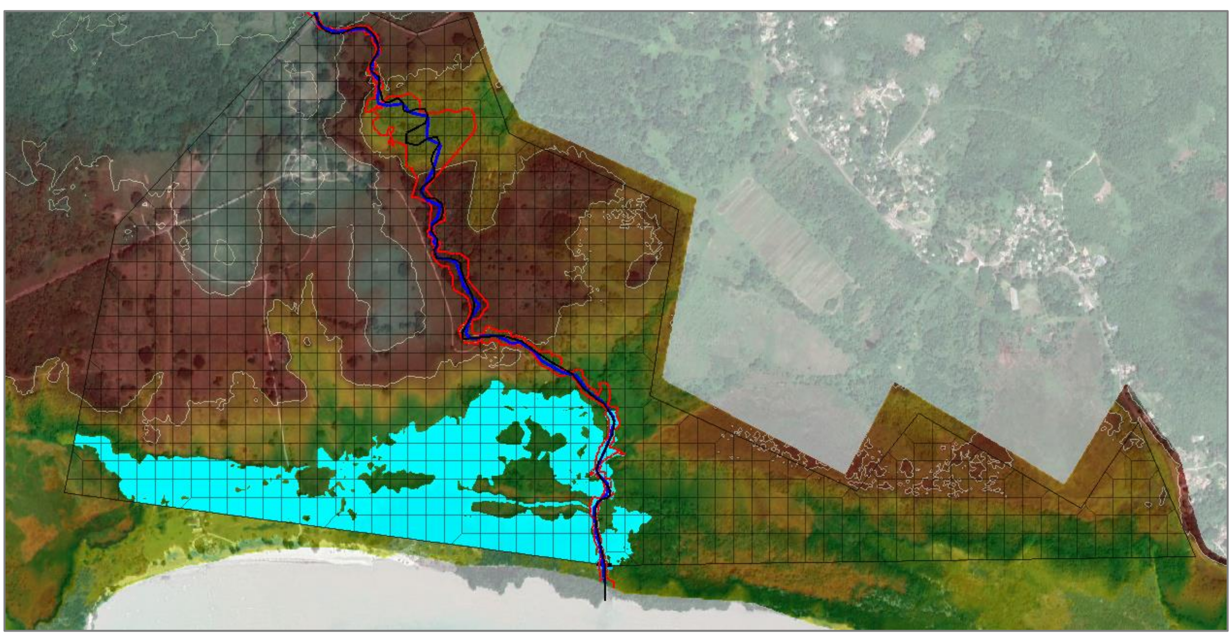
The June 1979 flood event (described previously in section 4.1.3), covered approximately 40,500 m² (10 acres) of land with flood deposits on the eastern side of the property (O'Hara et al., 1979). However, there is limited information regarding the impact of the 1979 floods on the central section of the property. While catastrophic flooding was documented to the north in the Water Works area near Petersfield, within the Deans Valley watershed, the full extent of the impact on the property itself remains uncertain.

Given the hydrological connection between the two areas, it is likely that the property experienced some level of flooding, potentially influenced by watershed dynamics. The severity of the 1979 floods was worsened by the large volume of sediment carried by the streams, causing the water to abandon its original channel and carve a new path, which contributed to extensive damage.

In the broader 5km perception survey area, 77.8% of respondents indicated that their community was not affected by flooding, 1.3% were unsure, and 20.9% reported frequent flooding. Among those who experienced flooding, the majority noted that it occurred during heavy rainfall and identified blocked or inadequate drainage systems as a contributing factor. Areas most affected by flooding included parts of Savanna-la-mar, Petersfield, Hertford, Hatfield, Paradise, Cave Main Road, and others.

4.3.5.2 Flood Discharge Projections and Inundation

As discussed previously section 4.1.5.2, the site is located within the Cabarita River Basin, where the Dean Valley River branches downstream within the proposed Paradise Park site. The estimated discharge was doubled to simulate a flood event, and it was found that the highest flood depth was approximately 0.8 meters. Only the coastal areas are expected to flood in such an event. If the event lasts for 3 days, the extent of flooding increases, but not exponentially. If the discharge triples, the lower portion of the flow area becomes flooded, with some bank areas reaching depths of up to 2.3 meters (Figure 4-223) (Premier Land & Water Development Ltd., 2024).



Source: (Premier Land & Water Development Ltd., 2024)

Figure 4-223 HEC RAS flood inundation due with no contributions from surface run-off

The flood inundation estimates were done using measured and assumed discharge readings along with rainfall data obtained. The inputs used are outlined in Table 4-65.

Table 4-65 HEC-RAS input variables

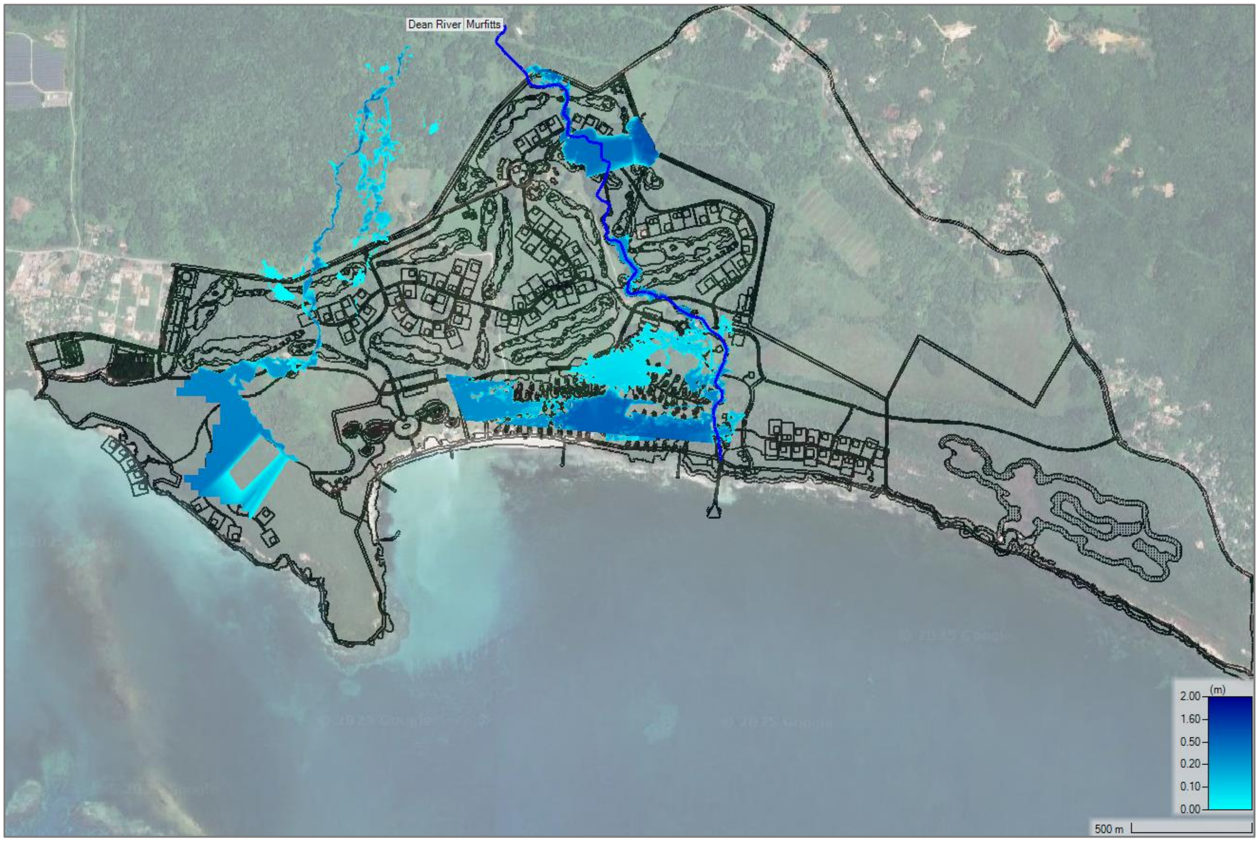
Source: (Premier Land & Water Development Ltd., 2024)

Inputs	***Values***
Manning's Number	0.10
Inlet Slope (Murfitts River)	0.04
Outlet slope (Murfitts River)	0.04
Inlet Slope (Sweet River)	0.4
Outlet slope (Sweet River)	0.04
Inlet Boundary Condition	Flow Hydrograph (Routed)
Outlet Boundary Condition	Normal Depth

Jamaica Extreme Rainfall Isohyet Maps were used (**Error! Reference source not found.**), provided by the National Works Agency's Guidelines for Preparing Hydrologic and Hydraulic Design Reports for Drainage Systems of Proposed Developments. Upstream discharge data was obtained from the Water Resources Authority.

Two models were created in order to determine the flood extent from the100-year rainfall event. Firstly, given that storm discharge data for the specified area was not available at the time; a precipitation model was created to ascertain the contribution of runoff in the area to discharge in a 100-year event. This model provided hydrographs at the outlet of both the Sweet and Murfitts River, solely based on precipitation. Mean discharge from the period 2005-2022, measured at station upstream of the focus area; was coupled with this precipitation-based hydrograph to create a storm hydrograph for the specified return period, which is used in model 2 to determine the flood extents. Model 2 used the aforementioned event-based hydrographs to determine the extent of the flood. The model was run for 3-hour hydrographs in a dry model with an initial condition time of 6 hours (Premier Land & Water Development Ltd., 2024).

The findings indicated that the highest flood depth reached approximately 1.6 meters. Wetland areas and depressions along the river reach were identified as the locations most likely to flood. Specifically, the flood inundation model indicates that there are areas adjacent to the Dean Valley River which experiences inundation levels between 0.1m to approximately 0.47m in the particularly low-lying areas (Figure 4-224).



Source: (Premier Land & Water Development Ltd., 2024)

Figure 4-224 Flood inundation map for the 1–100-year storm event at Paradise Park in the existing condition.

4.3.6 Karstic Hazards

Paradise Pen Cave is located approximately 1 km to the north of the property (Figure 4-3); this represents the only known surface expression of karst in the vicinity. Given the lack of additional information about this site, it is reasonable to conclude that it is a minor feature. The property is underlain by an alluvial cover composed primarily of clays and clayey sandy silts, which overlay soluble limestone deposits made up of fine-grained, soft to moderately hard planktonic micrite. These geological conditions provide the necessary criteria for the formation of Mantle Karst. One of the primary hazards associated with Mantle Karst development is the potential formation of cover-collapse sinkholes, which can occur suddenly and without warning. Given that no such incidents have been reported in the area and the known karst features are relatively small, the risk of large cover-collapse sinkholes developing is expected to be low.

4.4 SOCIOECONOMIC AND CULTURAL/HERITAGE

4.4.1 Approach

4.4.1.1 Study Area and Communities

To evaluate the social aspects of the proposed project, a Social Impact Area (SIA) was defined. The SIA is characterized as the anticipated spatial range of the proposed project's impact on neighbouring communities. For the scope of this study, the delineation of the SIA is based on a ten (10) kilometre buffer around the proposed project area, which equates to approximately 289 km^2 of land in the parish of Westmoreland.

The project area is in the community of Smithfield[9] (Social Development Commission, 2017), and this community, in addition to 51 other communities are either wholly or partially located in the 10km SIA (Figure 4-225). Smithfield, formerly known as Wakefield, is a coastal suburban community located about 8 km from the parish capital, Savanna-La-Mar, in Westmoreland. It is one of the thirty-two communities that make up the Savanna-La-Mar Development Area and to the west, it borders the Savanna-La-Mar Business District. To the north, it is adjacent to the communities of Chantilly and Strathbogie and to the east, the community is bordered by Ferris. Within the immediate community of Smithfield, there are several districts, including Phoenix Park, Matches Lane, Wharf Road, Back Hatfield, Emmerville, Saverent, and Paradise (including Coolie Town) (Social Development Commission, 2010).

Table 4-66 Communities located within the SIA, sorted from largest to smallest in area of coverage within the SIA

Community name	Parish	Land area within the SIA (km^2)
Water Works	Westmoreland	20.85
Smithfield	Westmoreland	17.81
Caledonia	Westmoreland	17.56
Frome	Westmoreland	17.20
Content	Westmoreland	16.87
Bluefields	Westmoreland	16.47
Big Bridge	Westmoreland	16.26
Darliston	Westmoreland	14.13
Hertford	Westmoreland	11.54
Strawberry	Westmoreland	10.41
Petersfield	Westmoreland	10.21
Fort Williams	Westmoreland	8.77
Haddo	Westmoreland	8.65
Dillion Bigwoods	Westmoreland	8.42
Three Mile River	Westmoreland	7.95
Georges Plain	Westmoreland	6.60
Roaring River	Westmoreland	5.99

[9] It's important to note that there are differences in community delineations between the Social Development Commission (SDC) and the Planning Institute of Jamaica (PIOJ) GIS datasets. The information provided here is based on the SDC community data (Social Development Commission, 2017), while the poverty community data was created by the PIOJ.

Community name	Parish	Land area within the SIA (km²)
Bath	Westmoreland	5.88
Amity	Westmoreland	5.88
Kentucky	Westmoreland	5.48
Mearnsville	Westmoreland	4.66
Ferris	Westmoreland	4.42
Beeston Spring	Westmoreland	4.21
New Works	Westmoreland	4.15
Little London	Westmoreland	4.09
Red Hills	Westmoreland	3.97
Cairn Curran	Westmoreland	3.79
Lenox Bigwoods	Westmoreland	3.65
Whithorn	Westmoreland	2.31
Savannah-la-mar Business Dist.	Westmoreland	2.06
Llandilo	Westmoreland	1.98
Cave	Westmoreland	1.97
Enfield	Westmoreland	1.88
Gooden's River	Westmoreland	1.77
Strathbogie	Westmoreland	1.60
Chantilly	Westmoreland	1.46
Mackfield	Westmoreland	1.24
Paul Island	Westmoreland	0.97
Russia	Westmoreland	0.90
Burnt Savannah	Westmoreland	0.79
Shoalin Grotto	Westmoreland	0.78
Williamsfield	Westmoreland	0.53
Beaufort	Westmoreland	0.47
New Roads	Westmoreland	0.38
12th Street	Westmoreland	0.35
Cornwall Mountian	Westmoreland	0.34
Barneyside	Westmoreland	0.30
Mount Stewart	Westmoreland	0.30
New Market Oval	Westmoreland	0.20
Harmony Town	Westmoreland	0.13
Seaton Crescent	Westmoreland	0.10
Grange	Westmoreland	0.10
Total		**289**

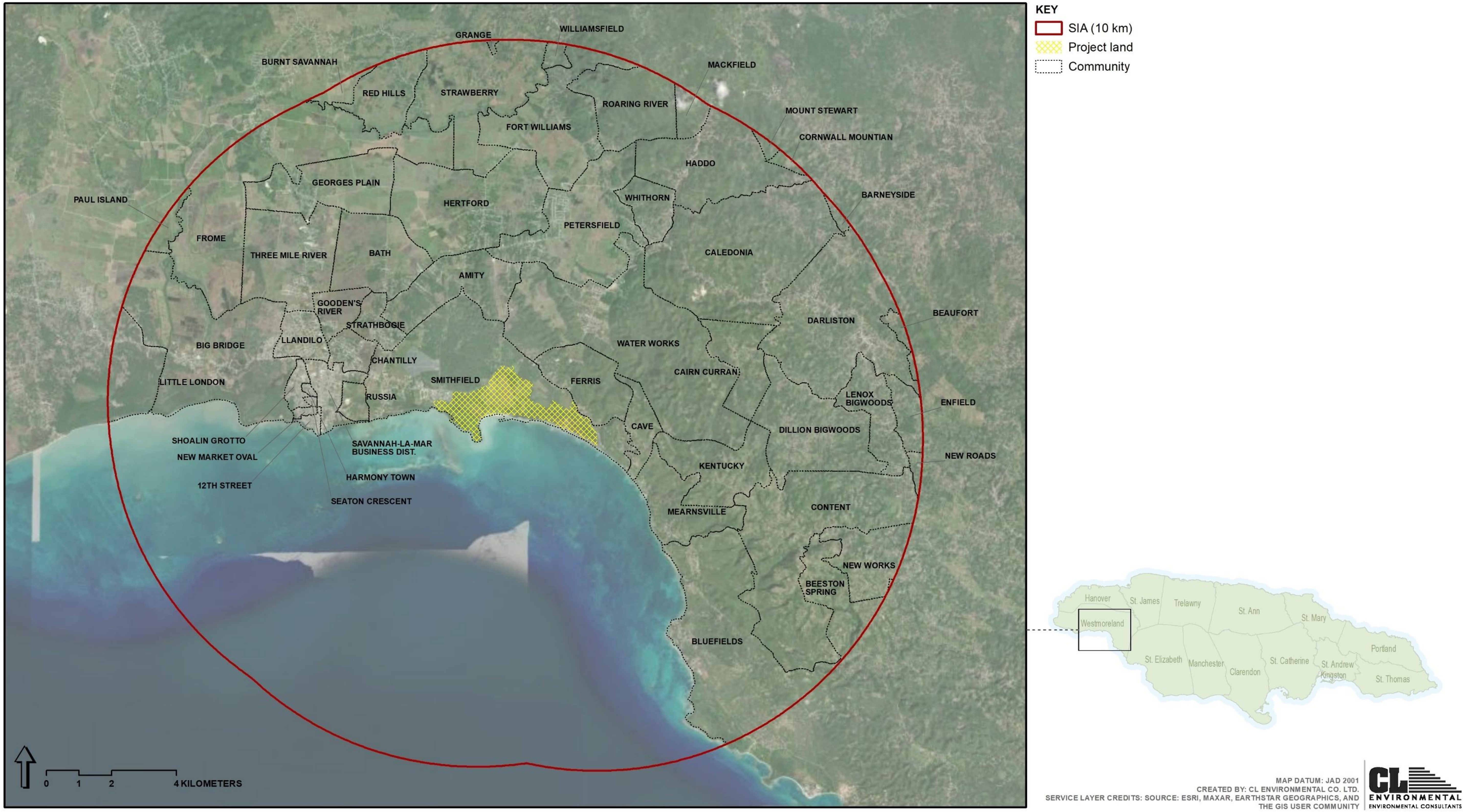


Figure 4-225 Communities within the Social Impact Area (SIA) for the proposed project

4.4.1.2 Data Sources and Computations

Population data for the Social Impact Area (SIA) were retrieved from the Statistical Institute of Jamaica (STATIN) 2011 Population Census database. The data were organized by enumeration district (ED) and analysed in relation to the percentage coverage of each ED within the SIA, utilizing Geographic Information Systems (GIS) methodologies. The subsequent computations involved:

- ***Population growth***: **[$P_n = P_o (1 + r)^t$]**
  Where P_o is the population at the beginning of a period, t is the period of time in years, r is the annual rate of increase, and P_n is the population at the end of the period (United Nations, 1952).
- ***Dependency ratio***: **[child population + aged population /working population X 100]**

  Where the child population is between ages 0-14, the aged population is 65 & over, and the working population is between ages 15-64 years. This ratio is useful for understanding the economic burden being borne by the working population.
- ***Male sex ratio:*** [**male population / female population X 100]**

  This in effect denotes the number of males there are to every 100 females and is useful for determining the predominant gender in a particular area.
- ***Domestic water consumption***

  Based on the assumption that water usage is 227.12 litres/capita/day and sewage generation at 80% of water consumption. Water consumption for workers in Jamaica is calculated at 19 litres/capita/day and sewage generation at 100% water consumption.
- ***Domestic garbage generation***
  Calculated at 4.11 kg/household/day (National Solid Waste Management Authority).

Additional socio-economic data was gathered from the SDC community profile for Smithfield (Soical Development Commission, 2010), the perception surveys conducted specifically for the project (Section **Error! Reference source not found.**) and other organizational sources referenced throughout.

4.4.2 Population and Demographics

4.4.2.1 Population Density and Growth

In 2011, the total population within the Study Impact Area (SIA) was approximately 68,706 individuals. With the SIA covering an area of about 68,706 km², the population density was calculated at 238 persons per km². This density is higher than that of the parish of Westmoreland, but lower than the national average for Jamaica (Table 4-67). It is important to note that population density within the SIA is not uniformly distributed, with some areas, such as in Savanna-la-Mar, Petersfield, Three Mile River and George's Plain experiencing significantly higher concentrations of residents than others (Figure 4-226).

Table 4-67 Comparison of ED population densities for the year 2011

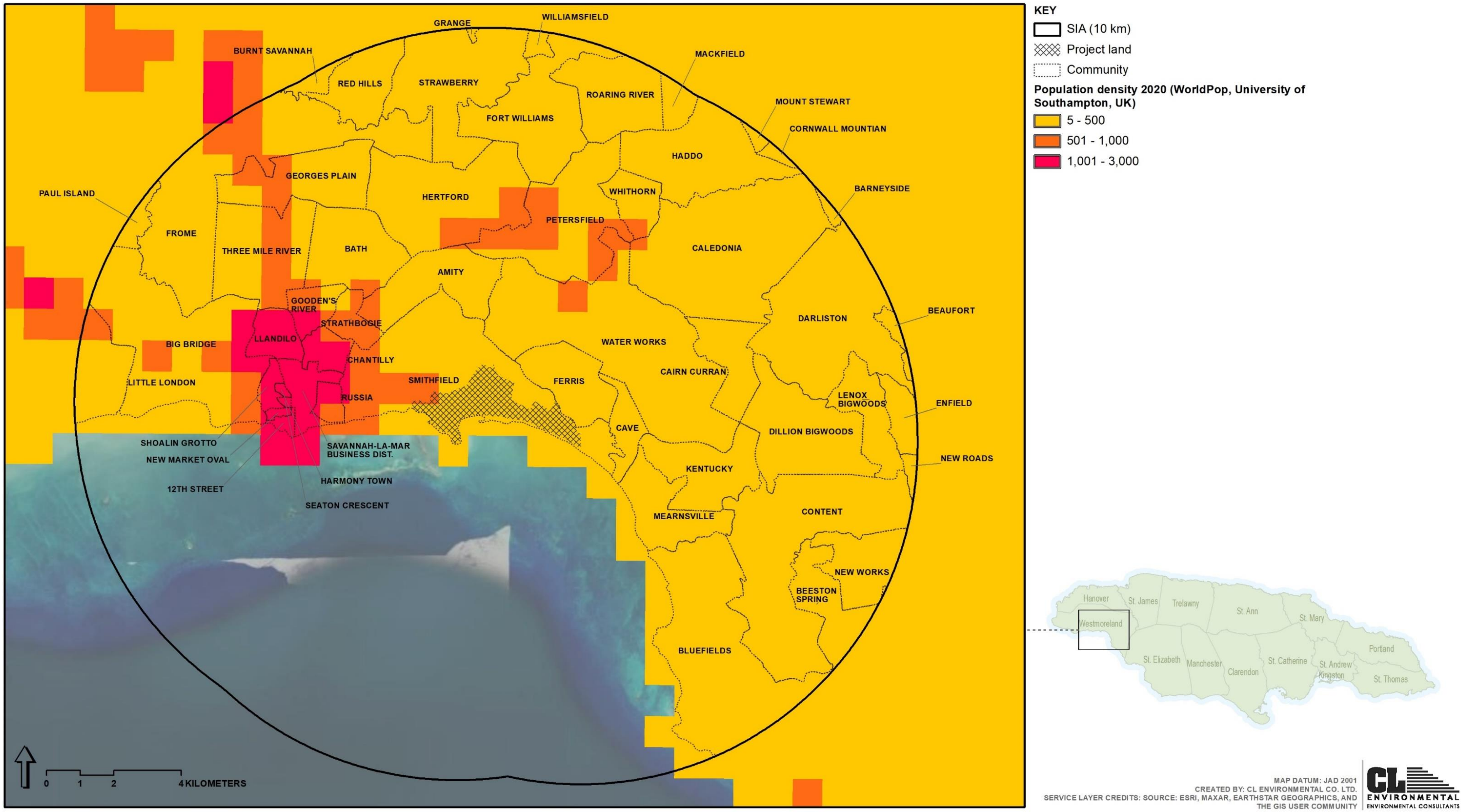
Source: STATIN Population Census 2011

Category	Jamaica	Westmoreland	SIA
Total ED area (km2)	10,991	786	289
ED Population	2,697,983	144,103	68,706
ED Population density	245	183	238

Population density has profound effects on social structures and dynamics. Areas with higher population densities often face greater pressure on social services, housing, infrastructure, and employment opportunities. Uneven distribution can have important social implications, such as access to resources and services and community cohesion and social inequality. For example, the districts of Back Hatfield and Wharf Road are the most densely populated areas in the Smithfield community, largely due to the growth of an informal settlement in the interior of Back Hatfield, commonly referred to as Gaza. This part of the community exhibits the typical characteristics of an unplanned settlement, including poor infrastructure such as marl tracks and pathways, substandard street lighting, inadequate water supply, and poorly maintained light poles. In contrast, the districts of Phoenix Park and Emmerville are more sparsely populated, primarily because they are established formal housing developments. These areas are home to middle and upper-class residents, including young entrepreneurs, retirees, and returning residents. The homes in these districts are also often rented by young professionals, contributing to the area's relatively quieter, more upscale character (Social Development Commission, 2010).

The population of the SIA in 2001 was around 65,048 individuals, with a growth rate of 0.55% annually between 2001 and 2011, indicating a modest increase in population. This slow growth suggests that, while the area may not be experiencing rapid urbanization, there may still be underlying shifts in migration patterns, social mobility, and economic opportunities, particularly in response to changing employment or educational prospects. Based on this growth rate, the population within the SIA is estimated to have reached approximately 73,772 persons by 2024. Looking ahead, if the current growth trend continues, the population is projected to rise to about 84,586 persons over the next 25 years.

The migration patterns in Smithfield community show that the majority of household heads (71.2%) were born in Westmoreland, and a smaller portion of residents migrated from other parishes. Additionally, most household heads (94.6%) have lived in Westmoreland for over ten years, and 57.7% have always lived in Smithfield itself, indicating a high level of long-term residency and local stability (Social Development Commission, 2010). Similar treads were observed for the perception survey group (Section **Error! Reference source not found.**), of which 84.1% have resided their community for more than fifteen years.



Data source: WorldPop, University of Southampton, UK (Jamaica - Population Density - Humanitarian Data Exchange)

Figure 4-226 Population density in 2020 within the SIA

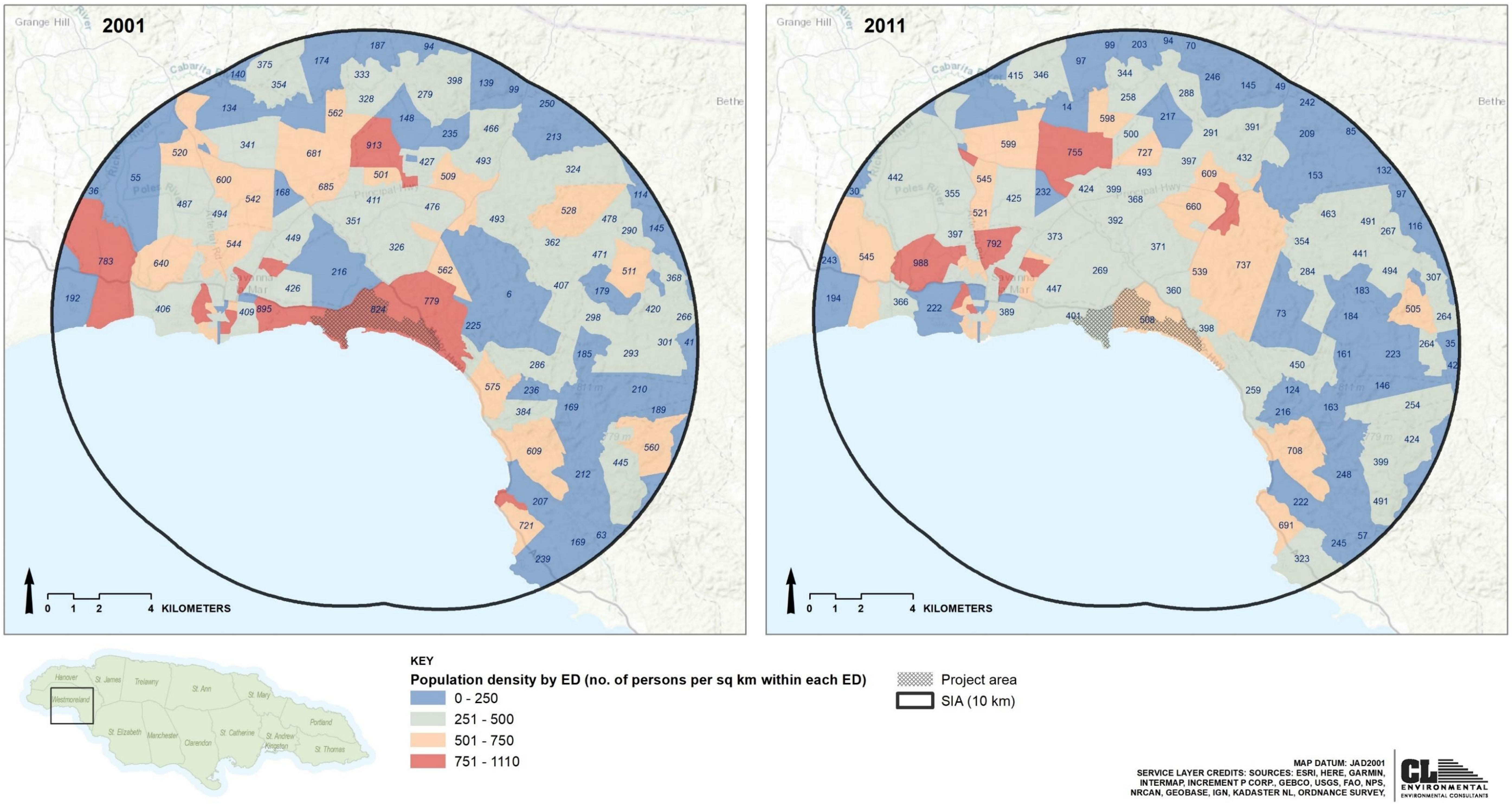
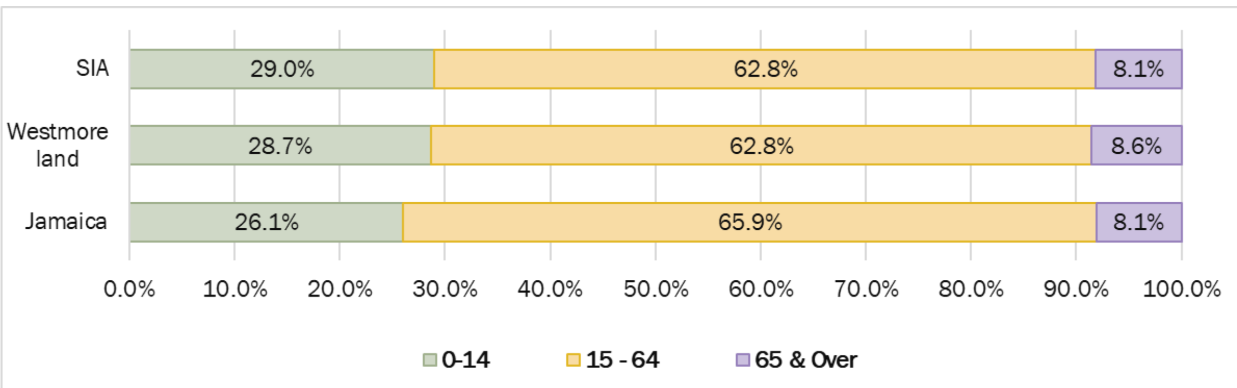


Figure 4-227 SIA 2001 and 2011 population represented by enumeration districts [10]

[10] It is important to note that direct comparisons between maps are not possible, as the boundaries of Enumeration Districts (EDs) change with each census. These boundary adjustments can affect the spatial distribution of data, making it difficult to directly compare population numbers across different years. As a result, while trends and general patterns can be observed, the specific ED areas covered in each census may differ.

4.4.2.2 Age and Gender Distribution

The age distribution within the SIA in 2011 shows a relatively similar demographic profile when compared to both the parish of Westmoreland and Jamaica as a whole (Figure 4-228). The proportion of the population aged 0-14 years in the SIA was 29.0%, which is slightly higher than the national average of 26.1% for Jamaica and the 28.7% in Westmoreland. This age group represents children and adolescents, and a higher percentage (29.0%) suggests that the SIA has a relatively young population. Similarly, the Social Development Commission (2010) reported that Smithfield has a relatively youthful population, with 43.6% of household members being 24 years old or younger. This can signal a future demand for education-related services, including schools, daycare facilities, and youth programs. The presence of a large youth population may also indicate the need for investments in recreational spaces, healthcare services targeted at children, and family support programs. This could also suggest potential for future workforce growth as these children age into working adults.



Source: STATIN Population Census 2011

Figure 4-228 Age categories as percentage of the population for the year 2011

The working-age population (15-64 years), typically considered to be the core of the labour force, made up 62.8% of the SIA population, which is consistent with the figure for Westmoreland but slightly lower than the national average of 65.9%. A large working-age population indicates a community with a potentially strong labour force, which is essential for economic productivity and growth.

The elderly population, defined as individuals aged 65 and older, makes up 8.1% of the SIA's population, which is in line with the national average, Westmoreland's rate of 8.6% and that reported for Smithfield, 7.6% (Social Development Commission, 2010). This group may not seem large, but as life expectancy increases, this demographic is expected to grow over time. An aging population raises the demand for specialized healthcare services, senior housing, and community programs focused on older adults, such as retirement facilities or social support n

In 2011, the Child Dependency Ratio for the SIA was 461.8, higher than both Westmoreland (456.9) and Jamaica (395.4) (Table 4-68). The Societal Dependency Ratio in the SIA was 591.4, similar to

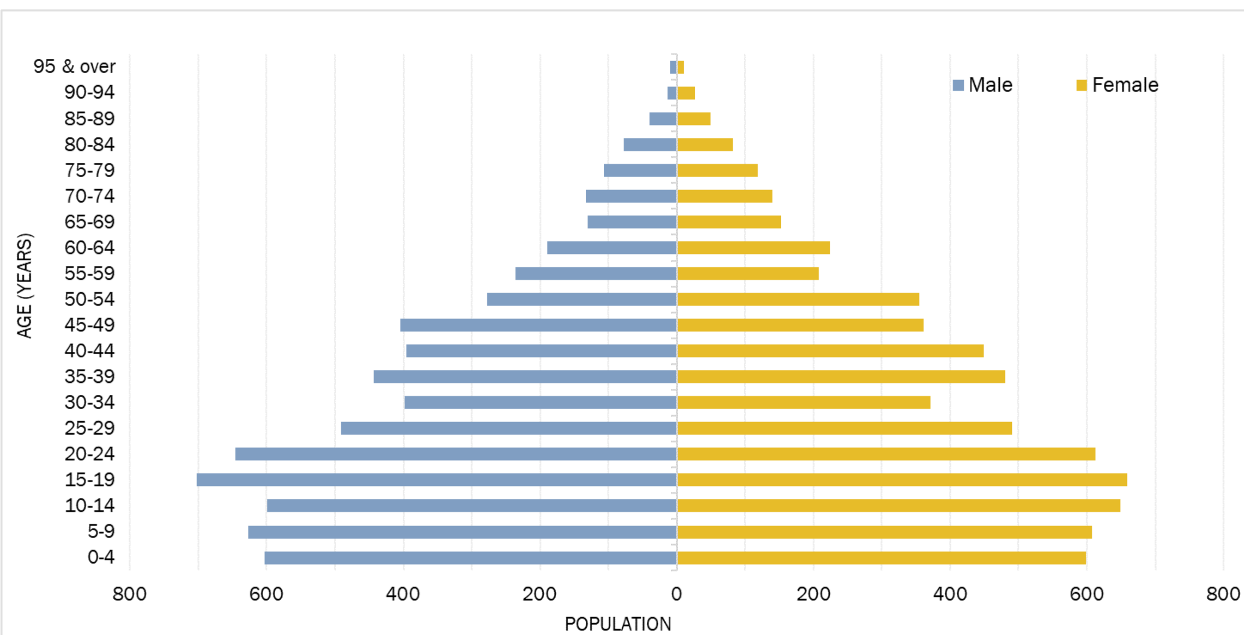
Westmoreland (593.3) and higher than the national average for Jamaica (517.8). The Old Age Dependency Ratio in the SIA was 129.6, lower than Westmoreland (136.4) but higher than Jamaica's average (122.4). In Smithfield, the age dependency ratio is approximately 48 dependent individuals for every 100 working-age persons (Social Development Commission, 2010). Overall, the dependency ratios in the study area suggest that there is significant pressure on the working-age population to support both children and elderly individuals. These demographic trends highlight the need for careful planning in terms of social services, economic strategies, and infrastructure development to meet the needs of these dependent groups in the future.

Table 4-68 Comparison of dependency ratios for the year 2011

Source: STATIN Population Census 2011

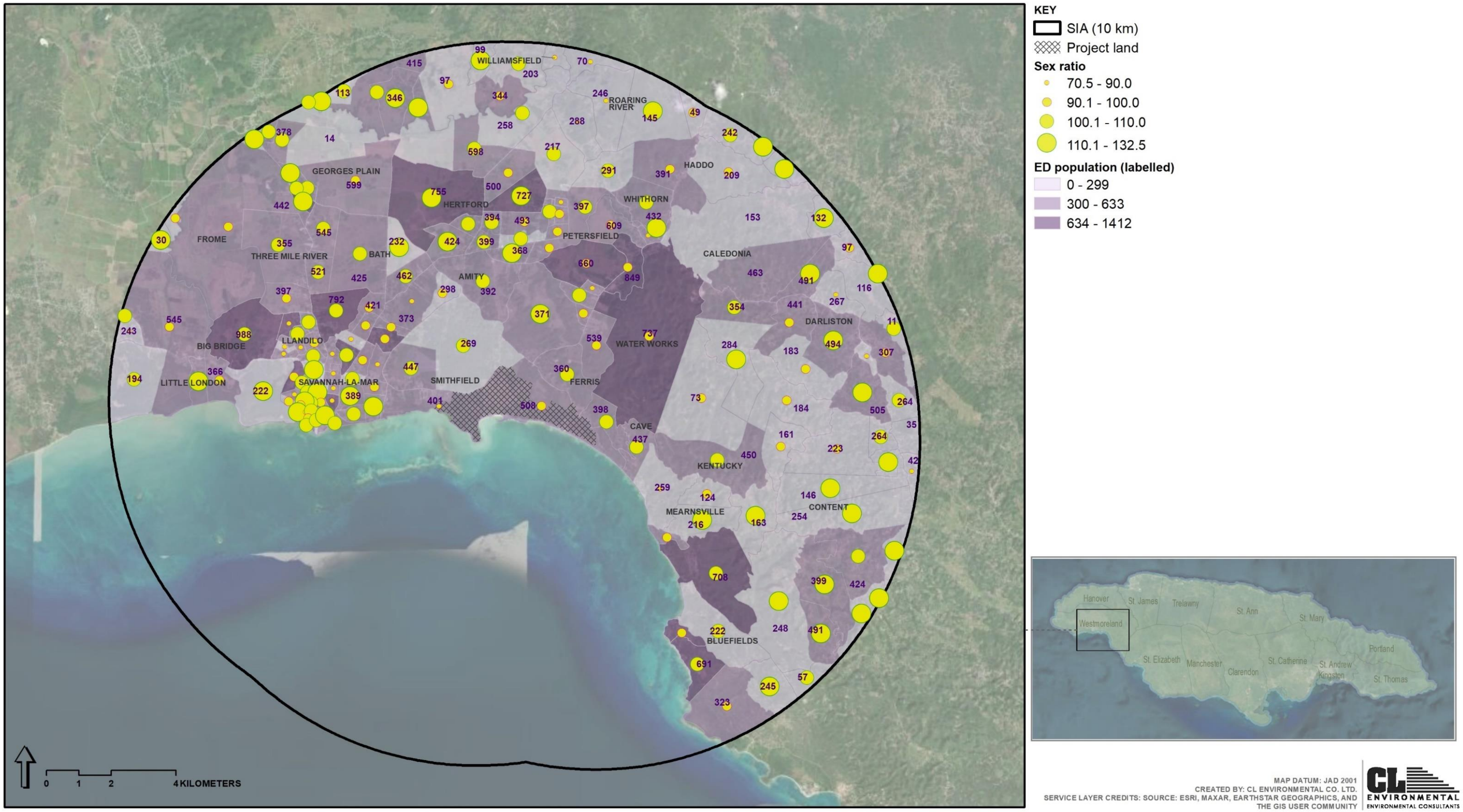
	Child Dependency	Societal Dependency	Old Age Dependency
Jamaica	395.4	517.8	122.4
Westmoreland	456.9	593.3	136.4
SIA	461.8	591.4	129.6

In 2011, the Sex Ratio in the Study Impact Area (SIA) was 101.8, indicating slightly more males than females. This can vary across different areas within the SIA (Figure 4-230), as well as depending on age (Figure 4-229). For example, in the age group 0-4, there were 3,219 males compared to 3,115 females, while in the 5-9 age range, the number of females (3,503) exceeded males (3,438). Interestingly, for age groups 20-24, 25-29, and beyond, the male population tends to outnumber the female population, suggesting a male-dominated demographic in the younger to middle adult years.



Source data: STATIN Population Census 2011

Figure 4-229 Population pyramid in 2011 for the SIA



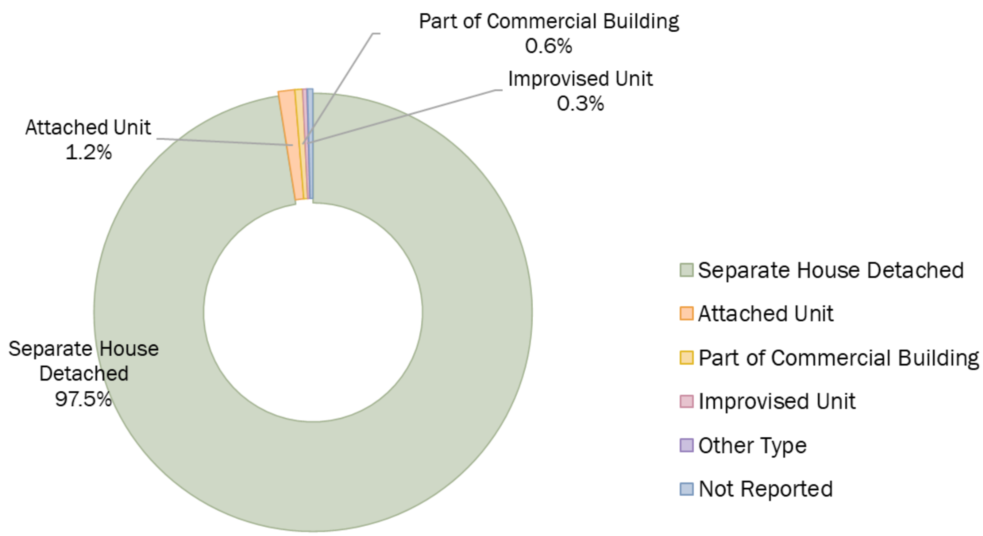
Source data: STATIN Population Census 2011

Figure 4-230 Sex ratio by ED within the SIA

4.4.3 Housing and Utilities

4.4.3.1 Housing Types and Size

In 2011, the total number of housing units within the SIA was 21,059 [11]. The percentages illustrated in Figure 4-231 indicate that while the SIA has a large proportion of traditional detached housing, there are also small pockets of alternative or improvised housing arrangements, which may be reflective of economic conditions, land availability, or specific social needs in the area. Specifically, of the housing units in the SIA, the majority were separate, detached houses, approximately 97% of the total housing stock; this trend is similar in Westmoreland. The SIA also had 257 attached units, 65 improvised units, and 119 units within commercial buildings, with small proportions of non-standard housing types. Additionally, 8 units were categorized under "other types," and 83 units were not reported.



Source: STATIN Population Census 2011

Figure 4-231 Percentage of housing units by type within the SIA

The total number of households in the SIA in 2011 was 22,635, and at the time of the study, the number of households in the SIA was estimated to be 24,303; projections indicate that the number of households in the area will increase to 27,866 over the next 25 years. This increase reflects growth in the population and housing demand, suggesting a need for expanded infrastructure and services. The number of dwellings in the SIA in 2011 was 23,236, a figure that is slightly higher than the number of housing units, indicating that some households may occupy multiple units.

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[11] For the purposes of this study, the definitions of housing unit, dwelling, and household are based on those provided by the population census conducted by the Statistical Institute of Jamaica (STATIN). A housing unit refers to a building or buildings used for living purposes at the time of the census. A dwelling, on the other hand, is any building or independent part of a building where a person or group of people lived during the census. Key features of a dwelling include "separateness and independence," meaning occupiers must have their own separate entrance to the street, without passing through another household's living quarters.

When considering population density, the average number of persons per household in the SIA was 3.0, which is comparable to the parish and national values (Table 4-69).

Table 4-69 Comparison of national, regional and SIA housing ratios for 2011

Source: STATIN Population Census 2001

	Jamaica	Westmoreland	SIA
Dwelling/Housing Unit	1.2	1.1	1.1
Household/Dwelling	1.0	1.0	1.0
Average Household Size	3.1	2.9	3.0

4.4.3.2 Tenure

Land tenure arrangements in Smithfield reveal that 24.3% of households own land, while an equal percentage (24.3%) are capturing land. Additionally, 22.5% of households lease the land they live on, and 17.1% are renting. A small percentage (0.9%) have ownership pending. 8.1% of households live on family-owned land, and 1.7% did not know their land status. Additionally, most households own the building they live in, with 10.8% renting and 2.7% living rent-free (Social Development Commission, 2010).

From the perception survey (Section **Error! Reference source not found.**), approximately 70.7% of respondents reported owning the house they lived in, 8.3% rented their homes, 0.5% lived in government-owned housing, 0.3% indicated informal ownership, and 20.2% resided in family-owned homes. In terms of land ownership, about 31.2% of respondents owned the land on which their home was situated, 16.0% leased the land, 5.2% lived on government-owned land, 4.4% squatted on the land, and 35.4% built their homes on family-owned land.

4.4.3.3 Living Conditions and Facilities

Housing Material and Condition

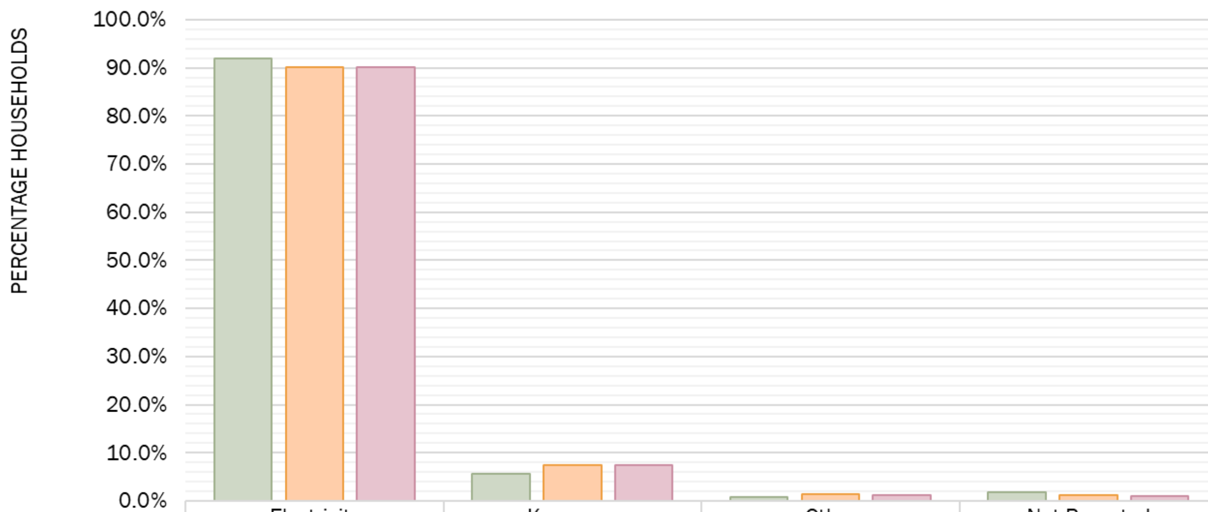
In Smithfield, approximately 55% of houses are built with board, 27% with block, and 16% with a combination of block and board (Soical Development Commission, 2010). From the perception survey (Section **Error! Reference source not found.**), regarding the type of wall construction, 42.8% of interviewees reported their homes had concrete and block walls, 39.3% had wood/board walls, and 17.3% had a combination of both concrete/blocks and wood/board. These findings differ from the national trend, where 66.6% of homes use block and concrete for the outer walls (Jamaica Survey of Living Conditions, 2007).

In terms of overall condition, about 40% of the houses in Smithfield are considered to be in fair condition, 31.3% in good condition, and 15.9% in poor condition. Only 9.4% of homes are deemed to be in very good condition, while 3.8% are in very poor condition (Social Development Commission, 2010).

Lighting

Analysis of data across different scales, including the SIA, parish, and national levels, reveals that electricity is the primary energy source among the population (Figure 4-232). Nationally, this service is primarily provided by the Jamaica Public Service Company Ltd.

Approximately 92% of households in Jamaica, 90% in Westmoreland and in the SIA and 97.4% from the perception survey reported using electricity for lighting and other household needs. This high percentage reflects the widespread availability of electricity across these regions, with only a small portion of households relying on alternative sources. However, a notable proportion of households across the SIA, still relied on kerosene as an energy source (Figure 4-233). In the SIA, 7.5% of households used kerosene, which is slightly higher than 7.4% in Westmoreland and 5.5% in Jamaica overall. The continued use of kerosene indicates challenges related to electricity access, affordability, or infrastructure in certain areas, despite the high electricity coverage.

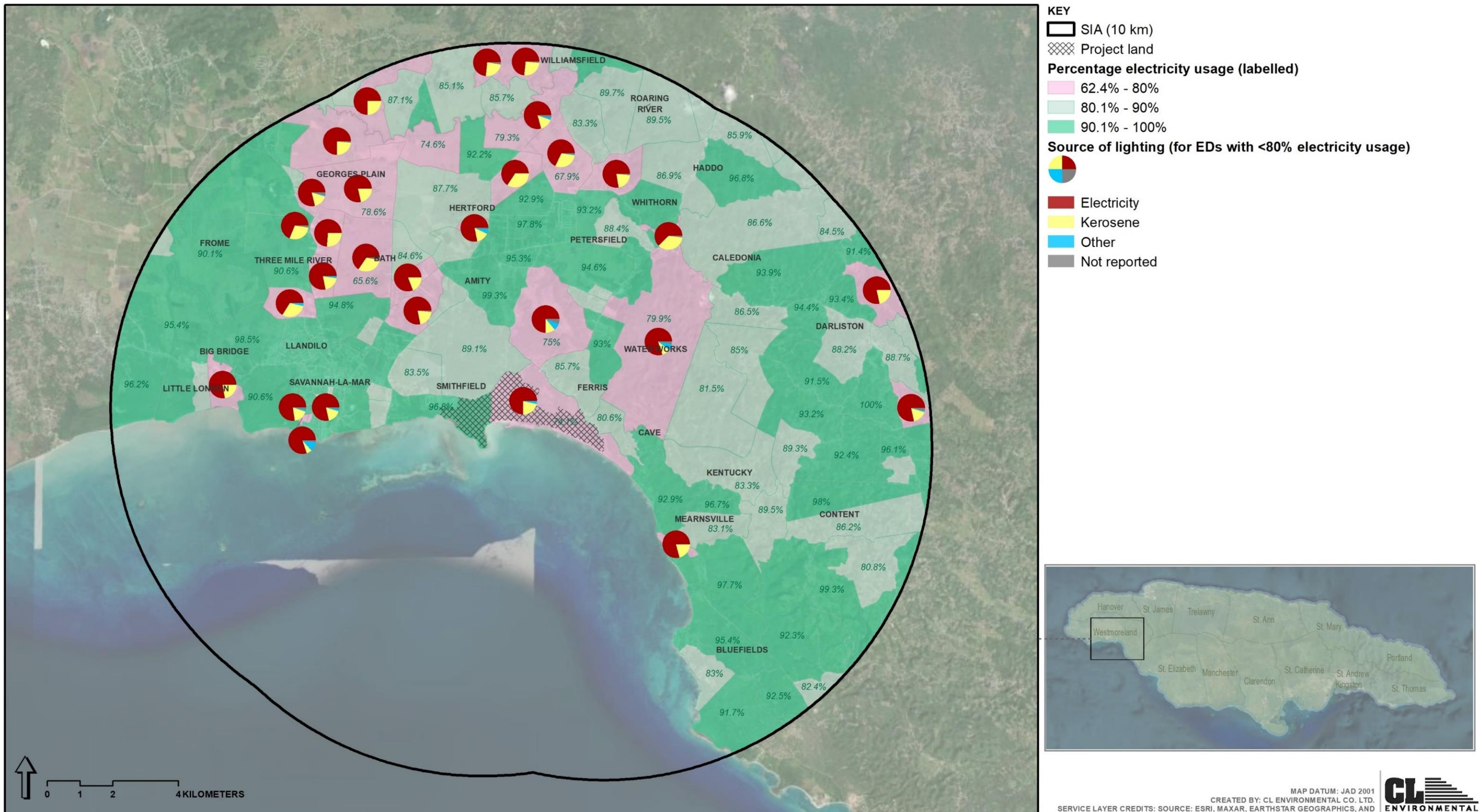


	Electricity	Kerosene	Other	Not Reported
Jamaica	91.9%	5.5%	0.8%	1.8%
Westmoreland	90.0%	7.4%	1.4%	1.2%
SIA	90.2%	7.5%	1.2%	1.1%

Source: STATIN Population Census 2011

Figure 4-232 Percentage SIA households by source of lighting

From the perception survey (Section **Error! Reference source not found.**), among those who used electricity for lighting (97.4%), respondents were asked about issues with the electricity supply. About 92.8% reported no problems, while 7.2% experienced supply issues. The problems reported included irregular supply/outages and anecdotal accounts indicated that some outages were caused by attempts to illegally tap into the electricity supply.



Source: STATIN Population Census 2011

Figure 4-233 Percentage electricity usage for the year 2011 within the SIA

Domestic Water Supply and Demand

The National Water Commission (NWC) serves as the public agency tasked with providing Jamaica's domestic water supply. Similar to the trends observed at the parish and national levels, the majority of households within the SIA (70.9%) and perception survey community cohort (94.3%) receive their domestic water supply from the NWC through piped infrastructure (Table 4-70). This is also consistent with the community of Smithfield, where most households obtain their water supply from a public piped system, either into the yard (68.5%) or directly into the dwelling (41.4%) (Social Development Commission, 2010). When asked about problems with the domestic water supply during the public perception survey, some reported issues with their water supply, but the majority stated that they had no problems. For those who experienced issues, irregular water supply, low water pressure, complete water outages, and water turbidity were cited.

Table 4-70 Percentage of households by water supply for the year 2011

Source: STATIN Population Census 2011

	Category	Jamaica	Westmoreland	SIA
Public Source	Piped in Dwelling	49.7%	39.5%	39.6%
	Piped in Yard	16.5%	23.7%	24.2%
	Stand Pipe	7.1%	5.6%	6.0%
	Catchment	2.2%	1.1%	1.0%
Private Source	Into Dwelling	6.4%	5.5%	5.6%
	Catchment	9.8%	15.4%	17.6%
Other	Spring/ River	3.0%	2.4%	2.2%
	Trucked Water/Water Truck	2.1%	2.8%	0.2%
	Other	1.8%	3.1%	2.7%
	Not Reported	1.3%	0.9%	0.8%

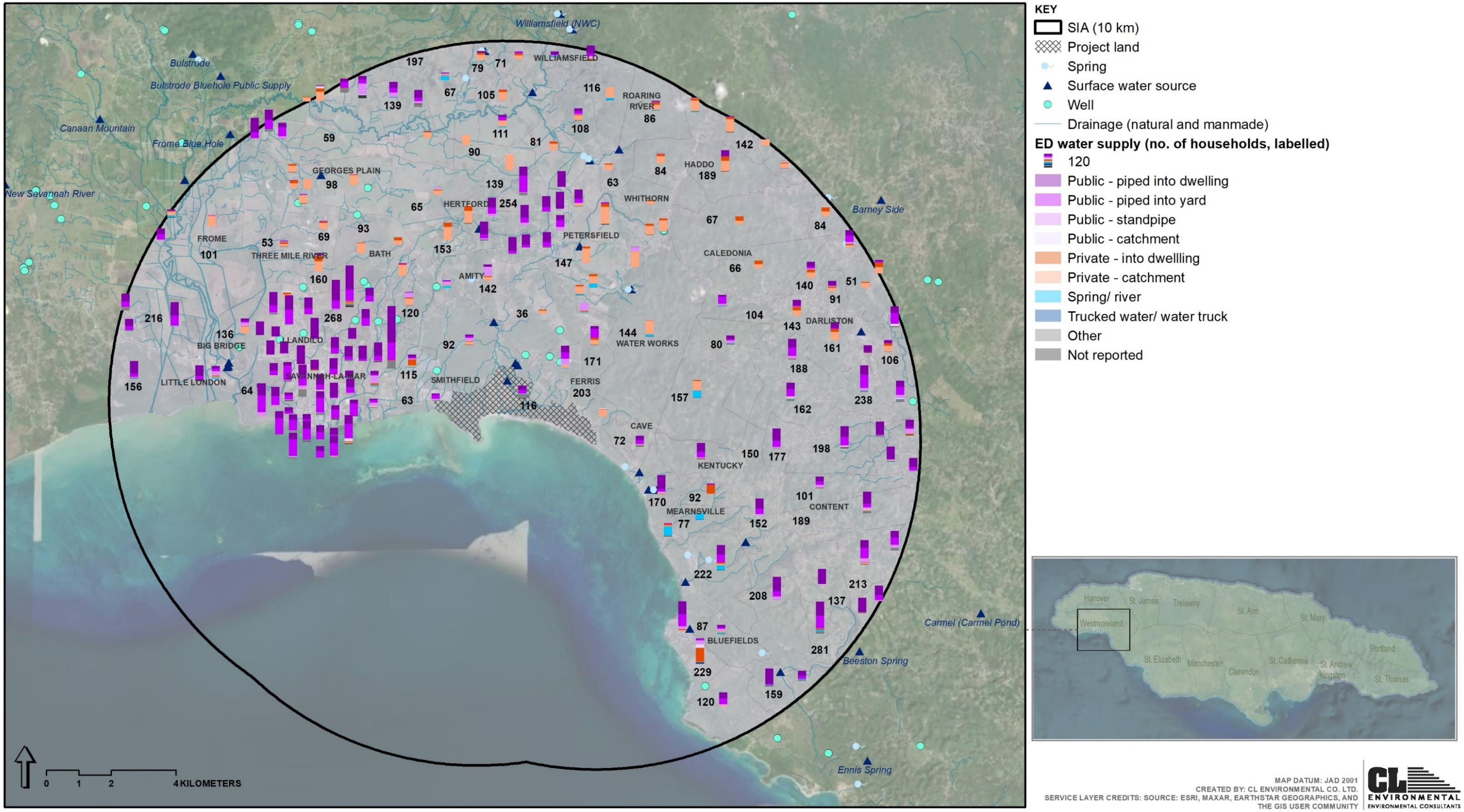
When considering private sources, households in the SIA and Westmoreland show relatively similar patterns. About 5.6% of households in the SIA obtain water through a private source directly into their dwelling. Additionally, catchment systems, such as rainwater harvesting, are more prevalent in the SIA, with 17.6% of households using this method, compared to 15.4% in Westmoreland and 9.8% in Jamaica, indicating a higher reliance on local water collection methods. Interestingly, there are distinct areas within the SIA, such as Georges Plain, Roaring River, Caledonia, Haddo, and Petersfield, where households primarily rely on private water sources (Figure 4-234). Other less common sources include springs and rivers, used by 2.2% of households; the possible water sources within the SIA are listed in Table 4-71. These statistics reveal that while many households in the SIA have access to public water sources, reliance on private sources, including rainwater catchment, is notably higher than in other areas, reflecting a mix of modern and traditional water access methods.

Table 4-71 Point water sources within the SIA

Name	Hydro basin	Watershed	Owner
Bluefields	Cabarita River	Deans Valley River	N.W.C
Cabarita River Nr 2	Cabarita River	Cabarita River	
Cabarita River at Frome	Cabarita River	Cabarita River	
Cabarita River	Cabarita River	Cabarita River	
Carawina Spring	Cabarita River	Deans Valley River	N.W.C
Cave	Cabarita River	Deans Valley River	N.W.C
Darliston (not in use anymore)	Cabarita River	Deans Valley River	N.W.C
Deans Valley (n1)	Cabarita River	Deans Valley River	
Deans Valley River at Paradise	Cabarita River	Deans Valley River	
Dutch Canal Nr2	Cabarita River	Cabarita River	
Ferris Blue Hole/South Coast Study	Cabarita River	Deans Valley River	
Friendship	Cabarita River	Cabarita River	N.W.C
Goat Gully at Bluefields	Cabarita River	Deans Valley River	
Ricketts River	Cabarita River	Cabarita River	
Roaring River 1	Cabarita River	Deans Valley River	
Roaring River at Petersfield	Cabarita River	Cabarita River	N.W.C
Roaring River BH	Cabarita River	Cabarita River	N.W.C
Robins River	Cabarita River	Deans Valley River	N.W.C
Sawmill River at Cave	Cabarita River	Deans Valley River	
Watercress Spring	Cabarita River	Deans Valley River	
Waterwheel River	Cabarita River	Deans Valley River	
Deans Valley (n2)	Cabarita River	Deans Valley River	N.W.C
Goat Gully Spring, Bluefields	Cabarita River		N.W.C

WATER DEMAND

In 2011, the daily water demand was calculated to be approximately 15,604,587 litres (or 4,122,296 gallons). Using population growth rates mentioned earlier, at the time of the study, this demand had risen to 16,754,987 litres per day (or 4,426,200 gallons). Looking ahead, if current trends continue, the water demand in the SIA is projected to further increase to 19,211,065 litres per day (or 5,075,027 gallons) in the next 25 years. This anticipated increase highlights the need for sustainable water management strategies to accommodate future growth and ensure adequate water supply for the region.



Source: STATIN Population Census 2011

Figure 4-234 Source of water supply by ED and water sources within the SIA

Wastewater Generation and Facilities

From the perception survey (Section **Error! Reference source not found.**), regarding the type of toilet facility, approximately 85.7% of respondents reported having water closets, while 11.9% used pit latrines. Just over 2% (2.1%) indicated that they had both a water closet and a pit latrine, and 0.3% stated that they had no toilet facility.

In Smithfield, the most common types of toilet facilities are Sewer/WC not linked to a sewer (37.8%), pit latrines (37.8%), and Sewer/WC linked to a sewer (22.5%). This reflects the mixed socio-economic status of the community. The use of pit latrines in Smithfield is slightly higher than the national average, where 34.6% of households in Jamaica use pit latrines, according to the Jamaica Survey of Living Conditions (2007) (Social Development Commission, 2010).

WASTEWATER GENERATION

At the time of the study, the wastewater generation in the SIA was estimated at 13,403,989 litres per day (or 3,540,960 gallons per day). Over the next 25 years, wastewater generation is projected to increase to 15,368,852 litres per day (or 4,060,022 gallons per day). This rising demand for wastewater treatment underlines the importance of developing sustainable infrastructure to manage the growing volumes of wastewater and mitigate environmental impacts.

Solid Waste Generation and Disposal

The National Solid Waste Management Authority (NSWMA) oversees the collection of domestic solid waste within the study area. Garbage is collected once a week in residential zones. This service is offered at no cost to residents, with expenses partially subsidized by property taxes within the area.

A significant proportion (73.9%) of household heads in Smithfield utilize pickup truck services for garbage disposal. Additionally, 47.7% of residents burn their waste, 3.6% dispose of it in the sea, river, pond, or gully, and 0.9% dump it in an open site (Social Development Commission, 2010). Similarly, most perception survey respondents reported using the public garbage truck as their primary method of disposal, while a smaller portion indicated that burning was their preferred method. It was noted that in some communities, garbage was not collected from individual homes but was instead taken to the main road for later collection. When asked about issues with garbage disposal, the majority of participants indicated no problems; however, a significant portion of respondents who reported issues highlighted irregular collection as the main problem. Some also mentioned illegal dumping and the fact that garbage trucks did not always enter certain communities to collect waste.

SOLID WASTE GENERATION

It is estimated that at the time of this study (2024), approximately 93,029 kg (or 93.03 tonnes) of solid waste was being generated within the study area on a daily basis. Over the next twenty-five years, based on calculated growth rates, this amount is expected to increase to 114,529 kg (or 114.53 tonnes) per day, emphasizing the need for improved waste management and recycling strategies to accommodate future growth while minimizing environmental impact.

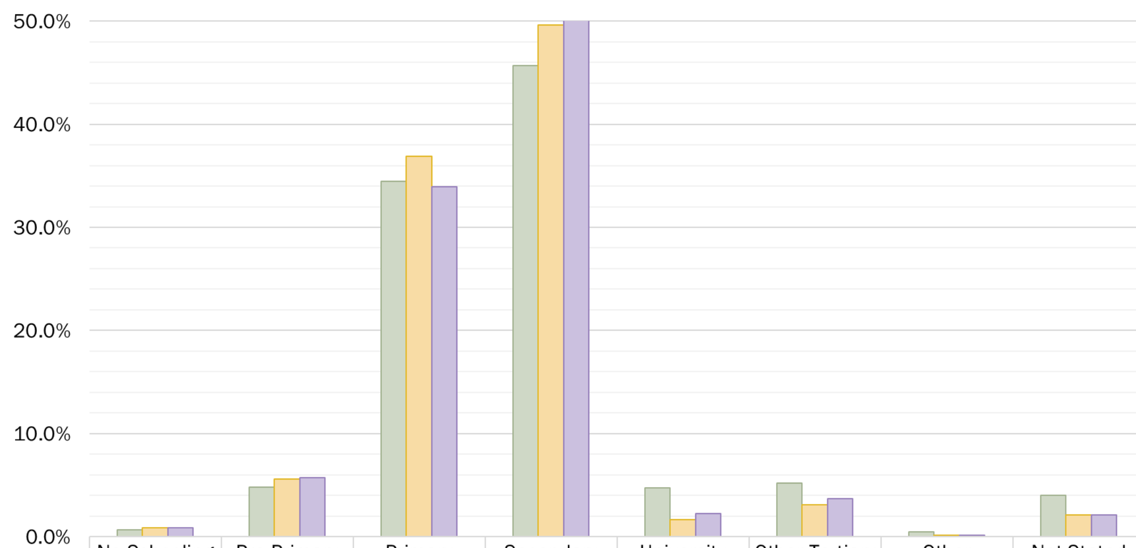
4.4.4 Livelihood and Socioeconomic Status

4.4.4.1 Education

Attainment and Qualifications

According to STATIN 2011 data, the proportion of individuals with primary education was relatively high, with 33.9% in the SIA. Secondary education had the largest representation, accounting for 51.4% in the SIA; notably, the western EDs within the SIA had higher percentages of up to 68% secondary attainment, when compared to the southeastern EDs (Figure 4-2360).

Regarding tertiary education, 4.7% of Jamaicans had university-level education, compared to 1.7% in Westmoreland and 2.2% in the SIA. The proportion of individuals with other forms of tertiary education was 5.2% in Jamaica, 3.1% in Westmoreland, and 3.7% in the SIA (Figure 4-235). The findings from both the SDC Smithfield community and perception surveys underscored the prominence of secondary education, with around 54% of household heads in Smithfield (Social Development Commission, 2010) and 62% of perception survey respondents reporting that secondary school was their highest level of education.



	No Schooling	Pre Primary	Primary	Secondary	University	Other Tertiary	Other	Not Stated
Jamaica	0.7%	4.8%	34.4%	45.7%	4.7%	5.2%	0.5%	4.0%
Westmoreland	0.9%	5.6%	36.9%	49.7%	1.7%	3.1%	0.1%	2.1%
SIA	0.8%	5.7%	33.9%	51.4%	2.2%	3.7%	0.2%	2.1%

Source: STATIN Population Census 2011

Figure 4-235 SIA population 3 years old and over by highest level of educational attainment as a percentage for the year 2011

Approximately 70% of household heads in Smithfield had no formal academic qualifications. Among those with known qualifications, 6.3% had completed at least one general subject, 5.4% had received vocational training, and 4.5% held a degree, postgraduate degree, or professional qualifications. The survey findings indicate that just over 50% of household members in Smithfield had no academic qualifications. Among those with identifiable qualifications, the majority had completed at least one CXC General, GCE 'O', or AEB subject. The data also showed gender-based trends: most females had between 3 to 4 general subjects, while most males had either 1 to 2 subjects or 5 or more. Notably, there were no males with vocational training or females with basic subjects or degree/postgraduate/professional qualifications (Soical Development Commission, 2010).

Table 4-72 Highest examination passed in Smithfield community

Source: Social Development Commission (2010)

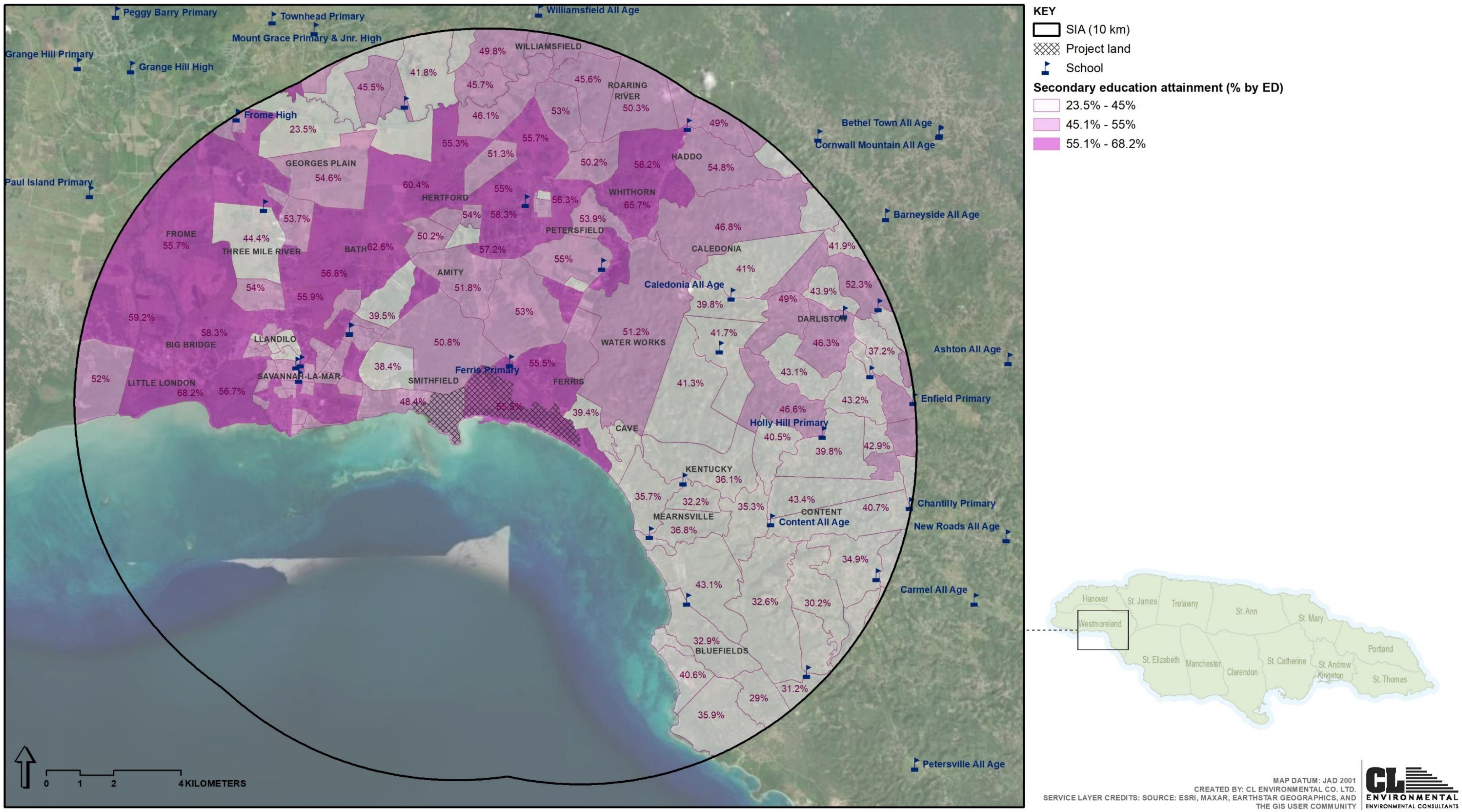
Qualifications	%Male	%Female	%Total
No academic qualifications	57.4	44.3	50.4
CXC basic, JSC, JHSC, JSCE, SSC, JC or 3rd JLCL	3.3	0.0	1.5
CXC General, GCE 'O', AEB 1-2 subjects	6.6	1.4	3.8
CXC General, GCE 'O', AEB 3-4 subjects	3.3	8.6	6.1
CXC General, GCE 'O', AEB 5+ subjects	6.6	4.3	5.3
Vocational, (Certificate)	0.0	1.4	0.8
Associate Degree/Diploma/Other Certificate	1.6	0.0	0.8
Degree/Post graduate Degree/Professional Qualification	1.6	2.9	2.3
Not Stated	19.6	37.1	29.0
Total	100.0	100.0	100.0

Educational Institutions

Twenty-six schools are located within the demarcated SIA (Figure 4-236):

1. Beaufort Primary
2. Bluefields All Age
3. Cairn Curran All Age
4. Caledonia All Age
5. Chantilly Primary
6. Coke's View Primary
7. Content All Age
8. Darliston Primary
9. Enfield Primary
10. Ferris Primary
11. Friendship Primary
12. Frome High
13. Georges Plain Primary
14. Haddo Primary
15. Holly Hill Primary
16. Kentucky Primary & Jnr. High
17. Mannings High
18. Maud McLeod High
19. Mearnsville All Age
20. New Works All Age
21. Petersfield High
22. Salem Primary & Jnr. High
23. Savanna-la-mar Primary
24. Savanna-la-mar High
25. Unity Primary
26. Jericho All Age School

In addition to those listed above, there are other educational institutions located within Smithfield community, namely Wise and Professional Studies which offers continuing educational classes, Elite Preparatory offers Early Childhood and Primary level education, Bright Stars Academy (an early childhood institution) and Back Hatfield Early Childhood Institution (Social Development Commission, 2010).



Source: Schools (Social Development Commission, 2018) and Google Maps

Figure 4-236 Secondary education attainment by ED and schools within the SIA

4.4.4.2 Employment and Occupations

At the time of the SDC survey, approximately 63% of household heads in Smithfield were employed, with 73.6% of male household heads and 53.4% of female household heads reporting employment. Overall, 54.5% of employed household members were male, while 45.5% were female (Social Development Commission, 2010).

Regarding unemployment, 60% of unemployed household members were female and 40% were male. The largest group of unemployed individuals (29.5%) were aged 65 and older, with 19% of them female and 10.5% male. The next largest group consisted of those aged 20-24 years (15.2%), with 8.6% male and 6.7% female, followed by those aged 14-19 years (13.3%), with 7.6% male and 5.7% female. The overall youth (ages 14-24) unemployment rate in the community was 28.5%, with males accounting for 16.2% and females 12.4% (Social Development Commission, 2010). Further analysis revealed that 14.4% of household heads were unemployed due to retirement, 9.9% cited a lack of skills or qualifications as the primary barrier to employment, and 6.3% were unemployed due to illness (Social Development Commission, 2010).

For the wider 5km perception survey area, of the individuals interviewed who provided a response, 57.6% reported being self-employed, 24.0% were in full-time employment, and 4.7% were employed part-time. Nearly 4% (3.9%) indicated they were unemployed, while approximately 9% (9.3%) were retired. Less than 1% (0.5%) selected "other" but did not provide further details.

4.4.4.3 Occupations and Skills

The majority of employed household members worked in service, shop, and market sales (26%), followed by those in elementary occupations (22%). A smaller proportion (14.2%) were employed in professional roles, with a similar percentage working in skilled trades, including craft and related fields. There were no males employed as clerks or in agriculture and fishery, and no females employed in technical or associate professions. However, most employed females worked in elementary occupations (35.6%) and in service, shop, and market sales (28.8%). A notable proportion of employed males were also in service, shop, and market sales, with a similar percentage in craft and related trades (Social Development Commission, 2010).

Although the specific training areas for nearly 50% of household members were not identified, among those with identifiable skills, 10.2% had training in construction and cabinet making, 8% in commercial and sales, and 7.1% in professional and technical fields. A significant portion of the male population with identifiable skills was trained in construction and cabinet making, while many females were trained in secretarial/office work (8.6%), hospitality (7.8%), and professional and technical skills (6.9%) (Social Development Commission, 2010).

Table 4-73 Areas in which household heads in Smithfield were trained.

Source: Social Development Commission (2010)

Skills	%Percent
Beauty care and services	6.2
Secretarial and office clerks	4.5
Hospitality skills	12.1
Art and craft	3.0
Construction and cabinet making skills	24.2
Machine and appliance	16.7
Computing and information technology	3.0
Apparel and sewn product skills	7.7
Commercial and sales skills	3.0
Professional and technical skills	10.6
Agriculture/farming	4.5
Skills not stated	4.5
Total	100.0

4.4.4.4 Income and Socioeconomic Status

Household Income

Of those interviewed during the perception survey, just over 9% indicated they had no weekly income, while 5.9% reported earning less than the current minimum wage of $15,000 per week. About 5.2% of respondents stated their weekly income was exactly $15,000, 3.6% earned between $15,001 and $18,000, and 7.8% reported a weekly income between $18,001 and $20,000. Approximately 24.5% of interviewees indicated earning more than $20,000 per week.

Although around 32% of household heads did not answer the salary question for the SDC Smithfield community survey, among those who did, most reported earning between $10,000 and $19,000 monthly. Other earnings included 6.3% earning $30,000-$39,999, and 5.4% earning $20,000-$29,999. Approximately 31% of employed household heads received additional financial support from remittances, while 16.2% received state assistance. Conversely, 53.2% reported no additional sources of income.

Table 4-74 Monthly salary range of household heads in Smithfield community

Source: Social Development Commission (2010)

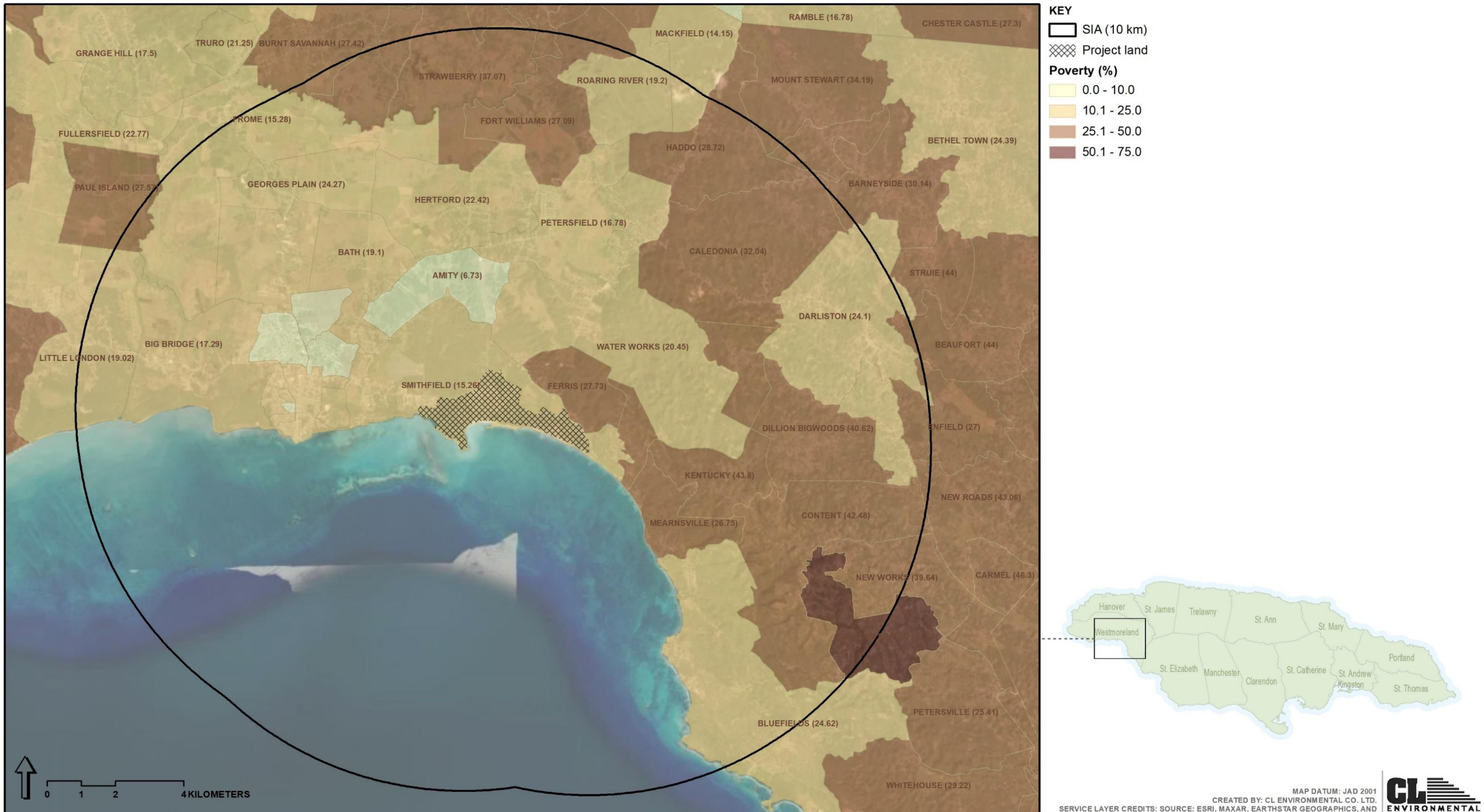
Salary Range	% Percent
Less than $3,700	0.9
$6,000 - $9,999	4.5
$10,000 - $19,999	11.7
$20,000 - $29,999	5.4
$30,000 - $39,999	6.3
$40,000 - $79,999	4.5
$80,000 - $129,999	0.9
$130,000 - $249,999	1.8
$250,000 and Over	0.9

Salary Range	**% Percent**
Not Applicable	31.5
No Response	31.5
Total	**100.0**

Poverty Levels

Within the SIA, poverty levels vary significantly, ranging from 6% to 52% of individuals living in poverty[12]. The highest poverty rates are concentrated in the community of Beeston Spring, located in the southeastern part of the SIA, while the lowest poverty levels are found in Savanna-la-Mar. This disparity highlights the spatial inequality in poverty distribution across the area, suggesting that socio-economic conditions and access to resources vary widely between communities (Figure 4-237).

[12] The Poverty GIS dataset, developed by the Planning Institute of Jamaica (PIOJ) in collaboration with STATIN, the Social Development Commission (SDC), and the University of Technology, identifies areas of poverty by community. It uses indicators from the Jamaica Survey of Living Conditions (JSLC) 2002, which were most predictive of household per capita consumption levels. By comparing variables from both the JSLC 2002 and the 2001 Population Census, compatible data was applied to estimate consumption levels across the island. Households with consumption below the regional poverty line were classified as being in poverty, and the percentage of individuals in poverty within each community was used to rank the 829 communities.



Data source: PIOJ (with contributions from STATIN, SDC and the University of Technology

Figure 4-237 Proportion of persons in poverty in each community within the SIA

4.4.5 Services and Infrastructure

4.4.5.1 Emergency Services and Issues

Healthcare

HOSPITALS, HEALTH CENTRES AND OTHER FACILITIES

In Savanna la Mar, health services are provided through both public and private healthcare facilities. The public sector consists of three health centres within the Savanna la Mar Health District - Savanna la Mar Health Centre, Petersfield Health Centre, and Williamsfield Health Centre[13] - supported by the Type B Savanna la Mar Public General Hospital.

The Savanna-la-Mar Public Hospital is the nearest hospital to the proposed development, located 3.5 km west of the project area. It operates 24-hour services, seven days a week, and provides the following departments: Accident & Emergency, Internal Medicine, Paediatrics, General Surgery, Orthopaedics, and Obstetrics & Gynaecology. These services are supported by an Operating Theatre, Laboratory, Radiology, and Pharmacy, among others. Mental health services are also offered at the Savanna la Mar Public General Hospital, where the Community Mental Health Team holds clinics and also provides routine visits in the community, along with emergency crisis responses. The hospital has outgrown its current bed capacity and is scheduled for significant expansion to accommodate the growing demand for services (Western Regional Health Authority, 2023).

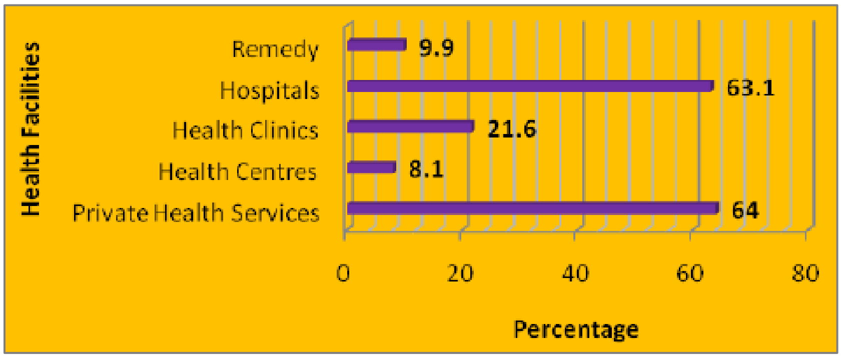
The Savanna la Mar Health Centre is adjacent to the Hospital and is the closest health centre to the proposed site. It is a Type IV facility, offering the highest level of care and the widest range of services in the parish. It is designated as a Type IV because the administrative block is located adjacent to it. This health centre serves as the headquarters for the health district and the parish health centre, accepting referrals from within the Savanna la Mar Health District and assisting with demands from other health districts in the parish. The Savanna la Mar Health Centre serves a population of over 65,000. When it was first built in 1984, the facility served 19,559 people, but this number has increased significantly over the years, partly due to the development of several housing schemes in the district. Under the Primary Care Reform initiative, further infrastructure upgrades are planned, as the current physical facility has outgrown the population it serves and the services it provides (Western Regional Health Authority, 2023).

The Type 2 Petersfield Health Centre and the Type 1 Williamsfield Health Centre also assist in the Savanna la Mar Health District, serving approximately 12,000-15,000 and 4,000 people, respectively (Primary Care Survey, June 2023). More severe cases should ideally be referred from these facilities to the Savanna la Mar Health Centre (Western Regional Health Authority, 2023).

Residents in the area generally rely on the services of the Savanna-La-Mar Public General Hospital (63.1% of the Smithfield SDC community survey and 40.3% of perception survey respondents) and the Savanna-La-Mar Health Centre, which are located about 3 kilometres away. Additionally, 64% of Smithfield

[13] Williamsfield Health Centre is not within the SIA.

respondents and 55.3% of the perception survey respondents reported using private health facilities (Social Development Commission, 2010).



Source: Social Development Commission (2010)

Figure 4-238 Main health facilities used by households in Smithfield community

Residents in Smithfield reported that they face several obstacles in accessing health services (Soical Development Commission, 2010). The most common challenge reported by approximately 55% of respondents was the long waiting times at healthcare facilities. Another 9% of individuals cited financial constraints as a barrier to accessing necessary care, while 1.8% pointed to poor transportation services, and 0.9% felt that the distance to the facilities was an issue. On a more positive note, 40.5% of respondents indicated that they faced no significant obstacles in obtaining healthcare services.

Healthcare services in the SIA and parish of Westmoreland fall under the jurisdiction of the Western Regional Health Authority (WRHA), specifically through its Westmoreland Health Services division. In addition to those health centres within the Savanna la Mar Health District mentioned previously, there are four other health centres located within the SIA offering essential healthcare services to different communities and varying in terms of the level and range of services they provide (Figure 4-239). Type 1 Health Centres in the SIA, namely Bluefields, Georges Plain, and New Works, primarily focus on offering family planning and child health services. These centres cater to the basic healthcare needs of families and children, providing essential support for maternal and child health, but with a more limited scope compared to higher-level centres (South East Regional Health Authority, n.d.). Type 3 Health Centres, such as Darliston, provide all the services available at Type 2 centres, but with additional daily services. These centres are staffed by resident Medical Officers, Family Nurse Practitioners, and Dental Surgeons, who offer daily curative and dental services. Type 3 centres also host specialist clinics, including mental health and nutrition, and provide daily dressings and pharmacy services, making them a vital healthcare resource for more comprehensive medical needs in the area.

Table 4-75 Health centres located within the SIA

Name	Type	Parish	Address
Bluefields	1	Westmoreland	Bluefields P.O.
Darliston	3	Westmoreland	Darliston P.O.

Name	Type	Parish	Address
Georges Plain	1	Westmoreland	Georges Plain P.A.
New Works	1	Westmoreland	New Works P.A.
Petersfield	2	Westmoreland	Petersfield P.O.
Savanna-la-mar	4	Westmoreland	Savanna-la-mar P.O.

Private health services in the district are offered by the Royale Medical Hospital, Clinics, and Imaging Centre (within 2.5 km of the development), and several general practitioners who operate private medical centres, some of which offer imaging, blood collection, and pharmacy services. Two private medical centres in Savanna la Mar—Dr. Reddy Medical Centre and the Urgent Care Centre—offer 24-hour services. Additionally, numerous private pharmacies operate both in the town centre and in suburban areas. Home visits are provided by both the public health team and private practitioners. Several private laboratories also operate in Savanna la Mar, with sample collection sites available in some private practices.

The Omega Medical Hospital (private health facility) in Negril is situated 40 km away, while the Black River Type C Hospital in St. Elizabeth is 47 km away. The Cornwall Regional Hospital (Type A facility) in Montego Bay is located 50.4 km from the Paradise Development.

AMBULANCE

The Westmoreland Public Health Services fleet includes seven ambulances, most of which are based at the Savanna la Mar Public General Hospital. Although the fleet is aging, it recently received two new ambulances, which have improved the overall operational efficiency. Emergency Medical Services (EMS) operates one ambulance from the Negril Fire Department, which responds to emergency situations. The EMS team is working to replace an ambulance assigned to the Savanna la Mar Fire Department, which was damaged in an accident earlier this year. Private ambulance services are also available to supplement the hospital fleet as needed (Western Regional Health Authority, 2023).

PREVALENT SICKNESSES AND HEALTH ISSUES

In 2022, the highest number of visits to the health centres within the Savanna la Mar Health District was for curative services (47%), with the most common diagnoses related to non-communicable diseases (NCDs) (Western Regional Health Authority, 2023). Among cardiovascular diseases, hypertension was the leading cause of visits, followed by the combined conditions of diabetes mellitus and hypertension. The least frequent visits were for oral health services (4%).

At the Savanna la Mar Public General Hospital, the leading causes of death were cardiovascular diseases, such as hypertension, coronary heart disease, and cerebrovascular accidents (stroke), as well as respiratory diseases, including respiratory failure and COVID-19 pneumonia. Other causes of mortality included communicable diseases, road traffic accidents, and violence-related injuries, all of which contribute to the hospital's patient load (Western Regional Health Authority, 2023).

Health issues are also prevalent in Smithfield, with 37.8% of households reporting that at least one member has a long-standing health problem (Figure 2.12). Among the household heads with health issues, the most common conditions were hypertension (14.4%), arthritis (9%), and diabetes (8.1%) (see Table 2.16). Similarly, many family members also suffered from health problems, with 6.3% experiencing hypertension, and 2.7% each dealing with asthma and arthritis. These statistics suggest a need for better management and treatment of chronic conditions within the community (Social Development Commission, 2010).

In terms of disabilities, approximately 30% of households in Smithfield had members living with some form of disability (Figure 2.13). The most common disabilities included sight-related issues (23.4%), with smaller percentages of individuals facing hearing challenges, physical disabilities, or learning difficulties (see Table 2.18). These findings highlight the need for targeted support and resources for individuals with disabilities in the community (Social Development Commission, 2010)

Fire Response

Management and Team

The Jamaica Fire Brigade is responsible for protecting life and property from fire and other disasters across the island, including its territorial seas. For operational management, the brigade is divided into four areas: Area 1, Area 2, Area 3, and Area 4. The Westmoreland Division, along with the St. James, St. Elizabeth, and Hanover Divisions, is part of Area 4 (Westmoreland Division, Jamaica Fire Brigade Divisional Headquarters, 2023) (**Error! Reference source not found.**).

The Westmoreland Division has a staff of over 128 firefighters, including teams specializing in operational suppression, emergency medical services (EMS), and fire prevention and investigation. The Operational/Suppression teams are responsible for responding to fires and emergencies, while the Fire Prevention and Investigation team is made up of firefighters trained as inspectors and investigators. These personnel review building plans, inspect buildings for fire and structural safety, conduct fire and life safety education in schools, communities, hospitals, and other organizations, and investigate the causes of fires. The Emergency Medical Services (EMS) team consists of firefighters trained as Emergency Medical Technicians (EMTs), who provide pre-hospital care at incidents, stabilize victims, and transport them to medical facilities (Westmoreland Division, Jamaica Fire Brigade Divisional Headquarters, 2023).

Fire Stations and Response

Fire and emergency responses in the Paradise Park project area are provided by two fire stations in Westmoreland: Savanna-la-Mar and Negril. The closest fire station to the proposed site is in Savanna-la-Mar, located approximately 4 km west of the development area. Both the Savanna-la-Mar and Negril fire stations are equipped with first-response units, including pumper/fire engines, and the Savanna-la-Mar station also has ambulances and a water tanker (Westmoreland Division, Jamaica Fire Brigade Divisional Headquarters, 2023).

Incident Responses (2020 - 2023)

Between January 2020 and July 2023, the Westmoreland Division of the Jamaica Fire Brigade responded to 70 incidents in the Smithfield, Paradise Pen, and Ferris areas. These incidents included:

- 42 structural fires
- 39 bush/rubbish fires
- 18 motor vehicle accidents
- 3 special service calls (non-emergency)

Police Stations and Safety Concerns

PUBLIC SAFETY

According to data from the Divisional Intelligence Unit of the Jamaica Constabulary Force, Westmoreland, the districts of Wharf Road and Back Hatfield are classified as "high crime-prone areas." Annual comparative statistics for 2008 to 2009 show a 57% increase in major crimes committed within the community. These major crimes include robbery, rape, carnal abuse, shooting, break-ins, and murder (Social Development Commission, 2010). According to the Police, robbery is the most prevalent type of crime committed in Smithfield and in most cases the culprits live within the general vicinity of the community.

Survey data from Smithfield indicates that approximately 20% of household members have been victims of crime at some point in their lives, with 95.5% of these incidents occurring within the community. When asked about their sense of safety, 43.2% of respondents reported feeling safe in Smithfield, while 23.2% felt unsafe, and 20.7% stated they felt very safe (Social Development Commission, 2010)

Public safety concerns in Smithfield are primarily centred around inadequate street lighting, the absence of streetlights, and the presence of gangs and gang-related activities. Nearly half (49.5%) of residents identified inadequate street lighting as a major safety issue, while 15.3% cited the absence of streetlights altogether. Gang activities, including gang warfare, were also a significant concern for 9% of the community. Other issues contributing to safety concerns include overgrown lots (8.1%) and the improper disposal of solid waste (1.8%). However, 24.3% of respondents indicated that they did not perceive any public safety issues in the community. These statistics reflect a mixture of infrastructural challenges and social concerns that affect the overall sense of safety within Smithfield (Social Development Commission, 2010)..

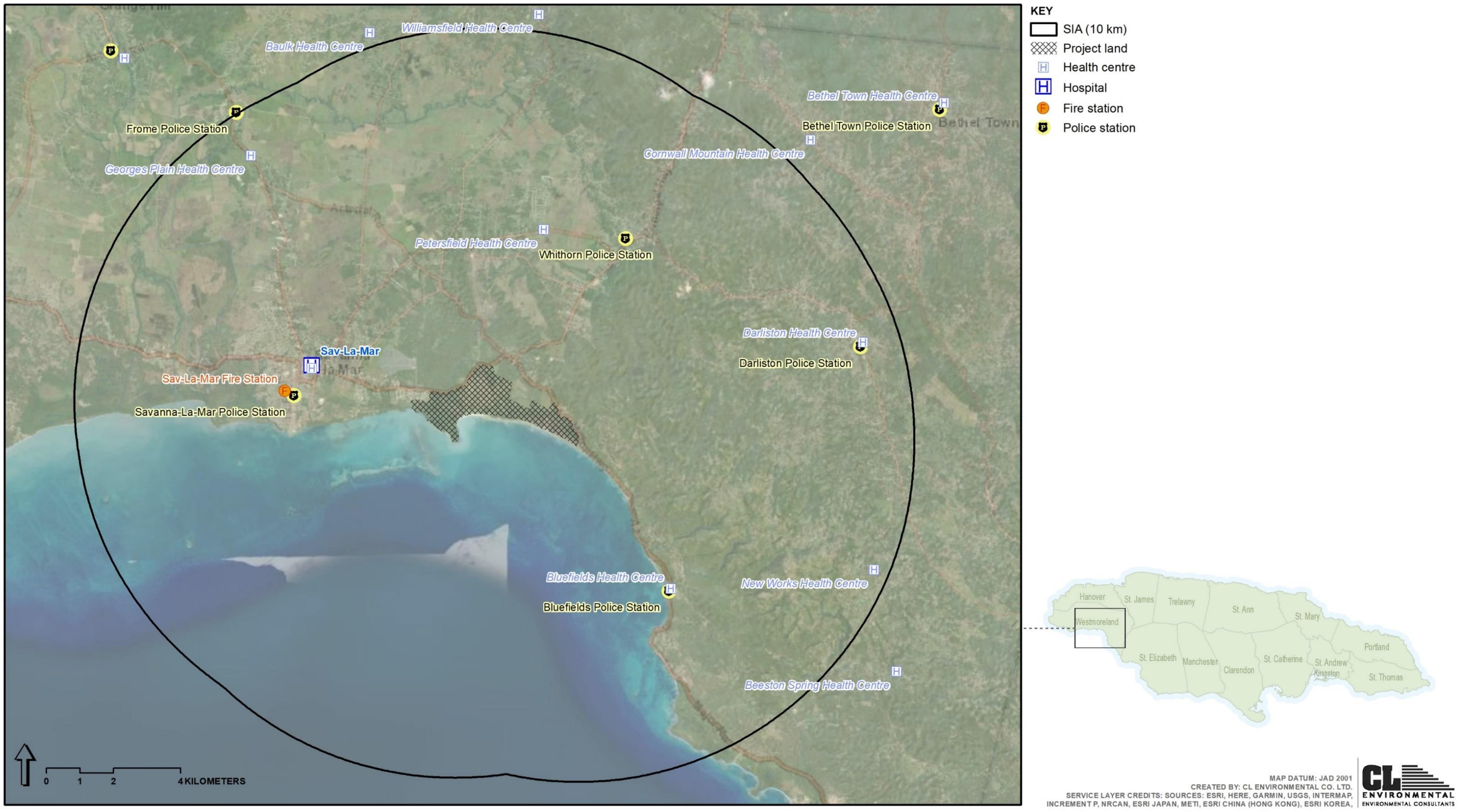
INFRASTRUCTURE

Savana-la-Mar police station is situated about 4km west of the project site; in addition to this station, three others are located within the SIA in Darliston, Bluefields and Whithorn.

Smithfield lacks a dedicated police station or post, relying instead on the nearby Savanna-la-Mar Police Station. The station serves a broad area, including several neighbouring communities, such as Big Bridge, Llandilio, Gratto, and others, in addition to Smithfield. As of May 2009, the Savanna-la-Mar Police

Station employed 125 officers, including members of the Island Special Constabulary Force and District Constables, and operated 10 service vehicles. The station's infrastructure is in good condition, and it plays a critical role in serving not just Smithfield but several surrounding areas, including providing support to other police stations in the parish, such as Little London, Withorn, and Frome. Despite these resources, Smithfield does not have the same level of direct security presence that would be provided by a local station or post. The absence of on-site police facilities is an ongoing challenge for ensuring quick and effective responses to public safety issues within the community.

Given the lack of a police presence in Smithfield, the local community is encouraged to play a more active role in policing and organizing for safety. The police have acknowledged the need for more strategic interventions, particularly with the increasing reports of crime during late evenings and early mornings. As a result, there is a call for greater collaboration between the community and law enforcement to improve public safety and reduce the impact of crime on residents' everyday lives.



Data

sources: MGI, Social Development Commission (SDC) (2023)

Figure 4-239 **Emergency, health and postal services located in the SIA**

4.4.5.2 Transportation Network and Traffic

Road Network and Accessibility

The primary access to the property is a single entrance located on the existing Savanna-la-mar main road (A2 highway), approximately 2.5 km from the town of Savanna-la-mar. The A2 highway, part of the primary road network that encircles the island, runs parallel to the northwestern and eastern boundaries of the project land. The proposed alignment for the Southcoast Highway Improvement Project (SCHIP) also follows the existing A2 highway along the eastern boundary of the project area (Figure 4-240).

The road network surrounding the site includes the following roads, both with a speed limit of 50 km/h:

- **Savanna-La-Mar Main Road**: The A2 highway is a 2-lane road without shoulders, connecting the town of Sav-La-Mar to the district of Bluefields to the east.
- **Ferris Cross to Mackfield**: The B8 is a 2-lane secondary road linking the Sav-La-Mar Main Road in the south to Whithorn, with further connections to Montego Bay on the north coast.

Traffic Volumes and Performance

CORRIDORS

Sav-La-Mar Main Road

The daily average traffic volume on the Sav-La-Mar Main Road in the vicinity of the site is 7,657 vehicles. During the morning peak period, the traffic volume reaches 566 vehicles, and in the evening peak, it decreases to 361 vehicles. The road operates at Level of Service (LOS) B during the morning peak with an average travel speed of 89 km/h and with percent time following at 42%. In the evening peak, it maintains LOS B, with an average travel speed of 88 km/h and 28% time following.

Ferris Cross to Mackfield Corridor

The daily average traffic volume on the Ferris Cross to Mackfield corridor is 5,009 vehicles. During the morning peak period, the traffic volume reaches 1,798 vehicles. This corridor operates at LOS B during the morning peak, with 43% time following and an average travel speed of 88 km/h. In the evening peak, the traffic volume is 453 vehicles, and the corridor continues to perform at LOS B.

INTERSECTIONS

Ferris Cross

During the morning peak period, the signalized intersection at Ferris Cross (Sav-La-Mar Main Road/Ferris Cross to Mackfield) currently operates at Level of Service (LOS) B, with an intersection delay of 10.6 seconds. In the evening peak, the intersection continues to perform at LOS B, with delays of 10.9 seconds per vehicle.

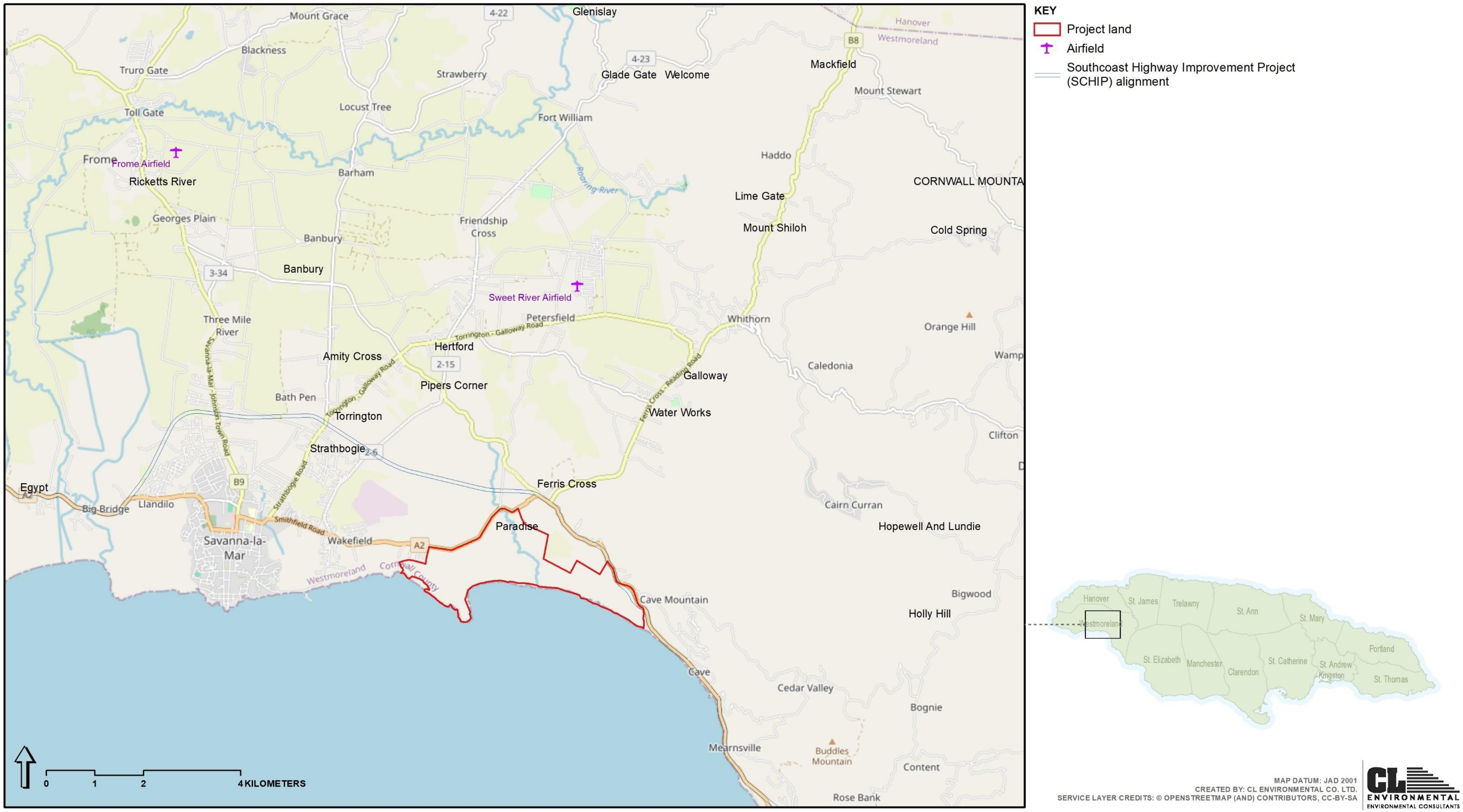


Figure 4-240 Road network in the study area

Modes of Transportation

The most commonly used modes of transportation among household members in Smithfield are licensed taxis (82.9%), robot taxis (50.5%), and private motor cars (20.7%). Public transportation in the area is generally reliable, with both licensed and robot taxis frequently traveling the route. Additionally, residents have access to other public transport options passing through the main road, including routes from Withorn, Darliston, and Whitehouse. (Social Development Commission, 2010).

Table 4-76 Types of transportation used by household members, Smithfield community

Source: Social Development Commission (2010)

Transportation	**% Percent**
Bus	1.8
Truck	0.9
Robot Taxi	50.5
Motorcycle	0.9
Licensed Taxi	82.9
Bicycle	18.9
Motor Car	20.7
None	0.9
*Note: This question allowed for multiple responses.	

4.4.5.3 Communication

The study area receives landline services from Flow Jamaica Limited (formerly LIME Jamaica Limited). Wireless (mobile) communication is offered by Digicel Jamaica Limited and Flow, while internet connectivity is facilitated through Flow's network. The vast majority (97.3%) of households in Smithfield have access to telephone service. Among these, the data shows that 80.6% rely exclusively on cellular phones, 18.5% use a combination of cellular phones and landlines, and 0.9% only have a landline. Despite the deregulation of the communications market, only 7.2% of households in Smithfield have internet access (Social Development Commission, 2010).

From the perception survey, the majority of respondents reported using mobile telephone service, while a smaller proportion indicated that they used both mobile and fixed-line services. A few respondents stated that they did not use any type of telephone service, and a small number mentioned using only a fixed-line telephone service. A significant portion of respondents were unaware of fixed-line service in the community, while others stated that fixed-line service was not available. However, nearly one-third of participants confirmed that fixed-line telephone service was present in their community.

Four post offices exist within SIA, specifically in Cave, Darliston, Petersfield and Savanna-La-Mar (Figure 4-239). Additionally, it should be noted that the Paradise Postal Agency, which ceased operations in June 2007 due to insufficient revenue and the non-renewal of the property lease, is still recognized by some residents as part of their mailing address. Mail for these residents is now collected at the Savanna-La-Mar Post Office.

4.4.5.4 Social Amenities and Services

During the perception survey (Section **Error! Reference source not found.**), the majority of respondents reported that recreational spaces were not available in their community, with a smaller proportion confirmed their presence. The spaces identified included school fields, community centres, and informal greenspaces. Most respondents who confirmed the existence of a recreational facility stated that it was accessible to people of all ages and those with special needs, while some reported limited accessibility. The majority described the facilities as being in good condition, while others noted issues with maintenance or expressed uncertainty about their upkeep.

The facilities and services available in Smithfield community include a range of institutions in varying conditions (Table 4-77.). In addition to the healthcare, emergency and educational facilities mentioned previously, for religious services, churches such as Sons & Daughters of Destiny Ministry International, Emmerville Seventh Day Adventist, and others are visited by Smithfield residents and have conditions ranging from fair to good. The cemeteries in the area, including St. George's Cemetery, Tate Cemetery, and West Palm Memorial Gardens, are located 4.5 km from Savanna-La-Mar, and are in fair to very good condition.

In terms of recreational and community services, the Paradise Cricket Ground and Paradise Park are in good condition, while playfields such as Back Hatfield Playfield, Grace Playfield, and Wharf Road Playfield are in fair to poor condition. The Back Hatfield Community Centre is in very poor, dilapidated condition. The Savanna-La-Mar Market, 6 km away, is in fair condition.

Legal facilities include the Westmoreland Resident Magistrate Court and Westmoreland Family Court, both located in Savanna-La-Mar, and both in good condition. The Savanna-La-Mar Parish Library, 4 km away, is also in good condition.

Table 4-77 Social services present within the Smithfield community by type, number, accessibility, and condition

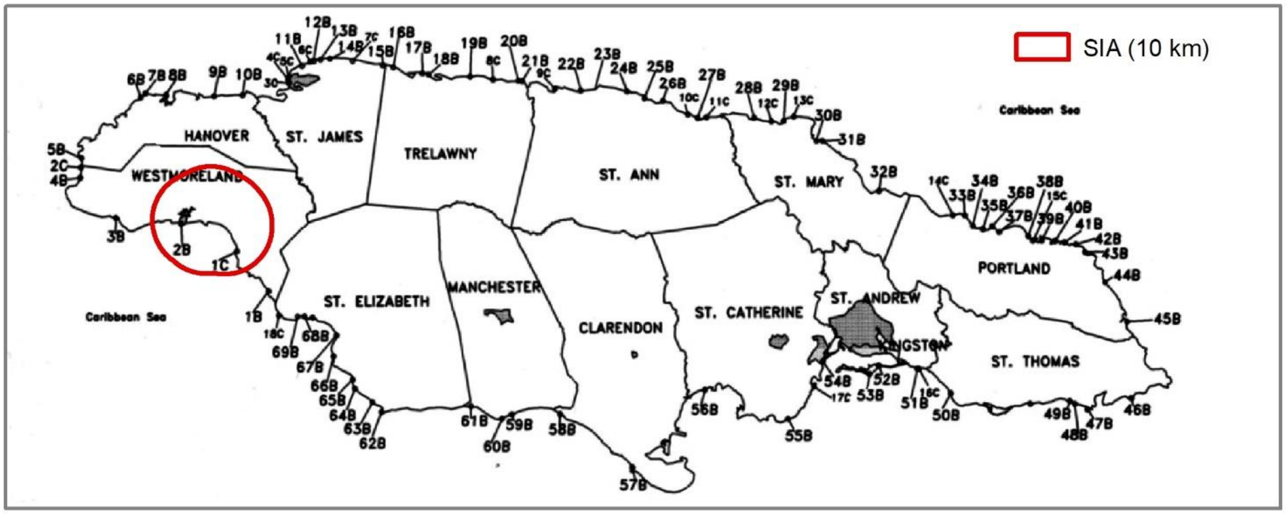
Source: Social Development Commission (2010)

Types	Name of Facility/Nearest Facility	Number	Location (District)/Proximity to nearest facility	Condition of facility
Hospitals	Savanna-La-Mar Public General Hospital Royale Medical Centre	None	3 km 3.5 km	Fair Good
Health Centres	Savanna-La-Mar Health Centre	None	3 km	Good
Health Clinics	Savanna-La-Mar Public Health Clinic	None	3 km	Good
Schools	Back Hatfield Early Childhood Institution Elite Preparatory School Bright Stars Academy Wise and Professional Studies	4	Back Hatfield Smithfield Main Road Wharf Road Smithfield Main Road	Good Good Good Good

Types	**Name of Facility/Nearest Facility**	**Number**	**Location (District)/Proximity to nearest facility**	**Condition of facility**
Churches	Sons & Daughters of Destiny Ministry International Emmerville Seventh Day Adventist Wharf Road Revivalist S.D.A Church of God Reformed I.N.C Back Hatfield Wesleyan Holiness		Smithfield Main Road Emmerville Wharf Road Back Hatfield Back Hatfield	Fair Fair Fair Fair Good
Post Office/Agency				
Police Station	Savanna-La-Mar Police Station		4.5km	Good
Fire Station	Savanna-La-Mar Fire Department		5km	Fair
Fire Trucks Available (In working Order)		1		
Community Centre	Back Hatfield Community Centre		Back Hatfield	Very Poor (dilapidated)
Sports Complex	Paradise Cricket Ground	1	Paradise	Good
Cemeteries	St. George's Cemetery Tate Cemetery West Palm Memorial Gardens-Honeygan's	4.5 km 4.5 km 4.5 km	Savanna-La-Mar Savanna-La-Mar Savanna-La-Mar	Fair Fair Very Good
Markets	Savanna-La-Mar Market	6 km	Savanna-La-Mar	Fair
Financial Institutions	None			
Recreational Sites	Paradise Park	1		Good
Playfields	Back Hatfield Playfield Grace Playfield Wharf Road Playfield		Back Hatfield Paradise Wharf Road	Fair Fair Poor
Heritage/Tourist Sites	Paradise Park		Paradise	Good
Parks	Paradise Park		Paradise	Good
Court Houses	Westmoreland Resident Magistrate Court Westmoreland Family Court		Savanna-La-Mar Savanna-La-Mar	Good Good
Libraries	Savanna-La-Mar Parish Library	4 km	Savanna-La-Mar	Good

**The Paradise Postal Agency (P.A) that has been out of operation since June 2007 due to the lack of revenue and the owner of the property did not renew the lease arrangement. Nevertheless, some residents still retain the Postal Agency as a part of their mailing address. Mails are collected at the Savanna-La-Mar Post Office.*

Attractions within the SIA include the various historical landmarks (section 4.4.9.3), the Peter Tosh Memorial and public bathing beaches, namely at Fort and Bluefields (2B and 1C respectively, Figure 4-241). Bluefields Beach Park is managed by the Urban Development Corporation (UDC) with sanitary facilities (bathrooms and changing rooms), parking and food services available for visitors.



Source: (Natural Resources Conservation Authority, 2000)

Figure 4-241 Public bathing beaches in Jamaica, with those located within the project SIA circled in red

Financial services in Smithfield are limited, as the community lacks local financial institutions. Most residents rely on services from commercial banks (68.5%) and credit unions (26.1%), which are located in the nearby parish capital, Savanna-La-Mar.

Social safety net programs also play a role in supporting Smithfield households, with 12.6% of household members benefiting from such programs. The PATH program is the most widely accessed, followed by the National Health Fund (NHF) and JaDEP. Despite the availability of these programs, residents report various challenges in accessing them, including slow response times, poor customer service, and difficulty meeting program requirements. However, more than half of respondents reported no challenges with the PATH program.

4.4.5.5 Resources and Needs

The household survey conducted by the SDC in 2010 revealed several key challenges in Smithfield, with high levels of unemployment and low literacy and numeracy being the primary concerns. Adult unemployment, especially among those aged 25 and older, and youth unemployment (ages 14-24) are significant issues in the community. The lack of educational qualifications and skills prevents many from accessing formal employment opportunities, contributing to high unemployment rates. Furthermore, there are challenges related to illiteracy and low numeracy, as a large portion of the population lacks essential academic qualifications, hindering personal and community development. Many individuals are employed in low-skill, elementary jobs, underscoring the need for skills development and training. This gap in education is a barrier to accessing better employment and improving community conditions. (Soical Development Commission, 2010).

The lack of training and employment opportunities, coupled with limited access to essential services, adds to the community's difficulties. Smithfield often feels disconnected from available resources, leading to a sense of neglect and isolation. This contributes to cycles of poverty and crime, as residents struggle to find stable work and access basic services such as healthcare, garbage collection, and transportation.

Abandoned and vandalized buildings are another visible issue in Smithfield, negatively affecting the community's environment and creating opportunities for criminal activity. Many of these buildings are owned by individuals who have migrated abroad, leading to neglect and deterioration.

4.4.6 Community Dynamics

Community dynamics in the Bluefields Bay area are exemplary, with a strong sense of collective action, mutual support, and effective organizations driving both environmental sustainability and socio-economic progress. Organizations like the Bluefields People Community Association (BPCA) and the Bluefields Bay Fishermen's Friendly Society (BBFFS) work together, sharing resources and knowledge to address key challenges, promote sustainable development, and enhance the quality of life, ultimately playing a pivotal role in fostering positive change.

4.4.6.1 Bluefields People Community Association (BPCA)

The Bluefields People Community Association (BPCA) was founded to promote sustainable social and economic development within the Bluefields community. Its vision is to transform Bluefields into the "bed-and-breakfast capital of the world," leveraging hospitality as a key driver of local growth. The BPCA focuses on four core areas: education, food, employment, and environmental protection, which serve as the foundation for their efforts to enhance the community's quality of life. Recognized internationally, the association receives support from global donors who contribute resources such as classroom fans, solar panels, batteries, and water tanks, helping the community reduce its reliance on the power grid (Bluefields People Community Association, n.d.).

4.4.6.2 Bluefields Bay Fishermen's Friendly Society (BBFFS)

The Bluefields Bay Fishermen's Friendly Society (BBFFS) has strong roots in the Bluefields Bay area, which has faced significant environmental challenges in recent decades. Destructive fishing methods, habitat degradation, and events such as the 1979 flood have severely impacted the bay's ecosystem, leading to a decline in fish populations. In response, the local fishing community began organizing in the 1970s, though early efforts were hindered by mismanagement. A key turning point occurred after Hurricane Ivan, when BPCA and Reliable Adventures Jamaica raised funds to support fishers who lost equipment. This success laid the foundation for the formation of BBFFS, a cooperative focused on marine preservation, sustainable fishing practices, and supporting the livelihoods of local fishers (Bluefields Bay Fishermen's Friendly Society, n.d.).

BBFFS is dedicated to educating its members about sustainable fishing, improving the quality of life for fishers, and conserving the natural resources of Bluefields Bay. The organization runs several initiatives, such as the Cold Storage Project, Fisher’s & Farmer’s Gear Store, and community housing programs, all aimed at creating a more sustainable and prosperous future for the community.

4.4.7 Economic Activities

4.4.7.1 Overview

According to the 2011 Population Census by STATIN, the most common industry groups in the parish of Westmoreland for males aged 14 and over were Agriculture, Forestry, Fishing, Mining, and Quarrying; Construction, Wholesale and Retail, and Repair of Motor Vehicles and Personal and Household Goods; and Hotels and Restaurants. For females in the same age group, the leading industries were Construction, Wholesale and Retail, and Repair of Motor Vehicles and Personal and Household Goods; Hotels and Restaurants; and Education, Health, and Social Work.

The Smithfield community has a diverse range of economic activities, with farming being the most dominant sector. In addition to agriculture, other key economic pursuits in the area include small-scale shopkeeping, food processing, fishing, and a variety of small to medium-sized businesses. Coastal communities around the bay also rely on artisan fishing as a vital source of income, with the bay itself serving as one of the country's primary fishing grounds (Garffer, 1992) (ECOST Project, 2007).

Local enterprises, such as the Grace Food Processing Plant, Busha’s Tyre Shop, and D.L Auto Care Centre, are key contributors to the local economy, despite facing challenges due to the global economic downturn. These businesses have been impacted by reduced consumer spending, the closure of certain operations, and difficulties in attracting customers due to transportation costs. Small-scale businesses, including shopkeepers and bar operators, also face difficulties, with some closing early due to sporadic crime incidents. However, medium-sized businesses generally remain unaffected by these challenges (Soical Development Commission, 2010).

4.4.7.2 Farming

Approximately 43.2% of households in the Smithfield community engage in farming, with the most common activities including the cultivation of ground provisions, green banana, and sugar cane. Smaller contributions come from the production of cash crops and fruits. A large majority of the farm produce (91.7%) is used for home consumption, with only a small portion (8.3%) sold in the local market. Most farming activities take place within the Smithfield community, with 89.6% of the land used for farming located locally (Soical Development Commission, 2010).

Table 4-78 Main farming activities in Smithfield

Source: Social Development Commission (2010)

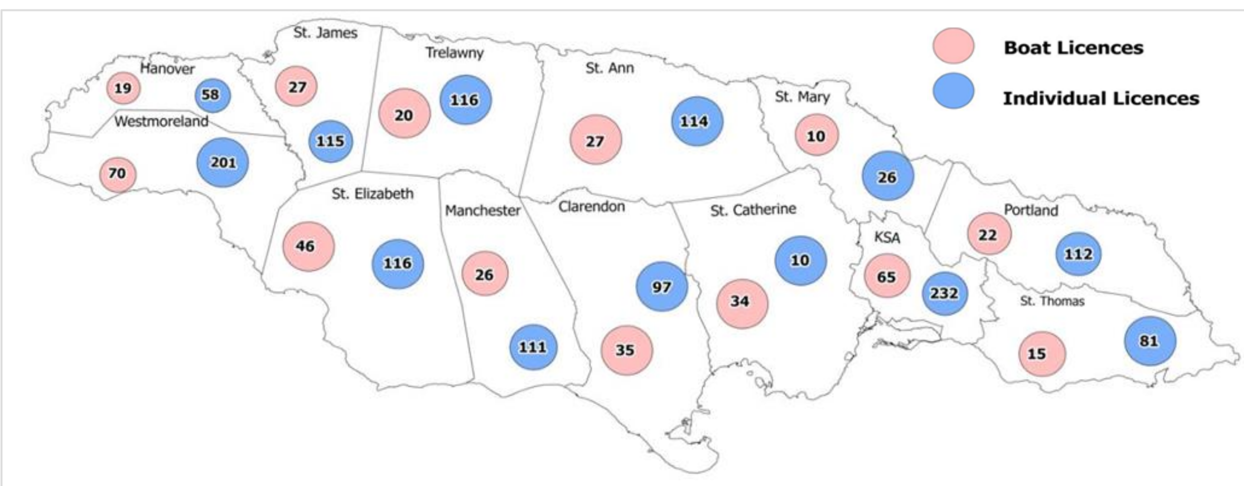
Farming Activity	% Percent
Ground Provision	29.7
Sugar Cane	13.5
Poultry Rearing	2.7
Cash Crop	13.5
Green Banana	36.9
Fruits	17.1
Note: This question allowed for multiple responses	

The high level of farming activity in the area underscores its importance to the local economy and food security. With such a strong reliance on farming, it is essential to recognize the challenges that farmers face. In Bluefields Bay area, climate change considerations highlight their vulnerability, as many struggle with weak social networks, lack of land ownership, limited access to extension services and irrigation, and difficulties obtaining seeds and planting materials. These challenges, combined with frequent crop failures, make farmers highly dependent on their farms for food, further intensifying their susceptibility to climate-related impacts and economic instability (Fath, 2014).

4.4.7.3 Fisheries

Fishing Beaches and Licensing

The parish of Westmoreland is a significant area for the fishing industry in Jamaica, representing the second-largest share of registered fishers and the largest number of boat licenses being issued between October – December 2023 (Figure 4-242).



Source: (National Fisheries Authority, 2023)

Figure 4-242 Number of individual fisher and vessel licences issued by parish in Q3 2023/24

Although St. Mary's, Smithfield, St. Anne, Cave, and Belmont are the closest gazetted fishing beaches to the project area (6F through to 10F respectively in Figure 4-243), it is important to note those within the broader parish of Westmoreland (National Fisheries Authority, 2023), because even though the fisherfolk area based in the area, they travel as far as Negril and Whitehouse (Section**Error! Reference source not found.**):

- Scott's Cove
- Whitehouse
- Braughton
- Auchendown
- Mount Edgecomb
- Market Beach
- Belmont
- Cave
- St. Anne
- Smithsfield
- St. Mary
- Hope Wharf
- Salmon Pot
- Little Bay
- Revival
- Orange Hill
- Ironshore
- Negril

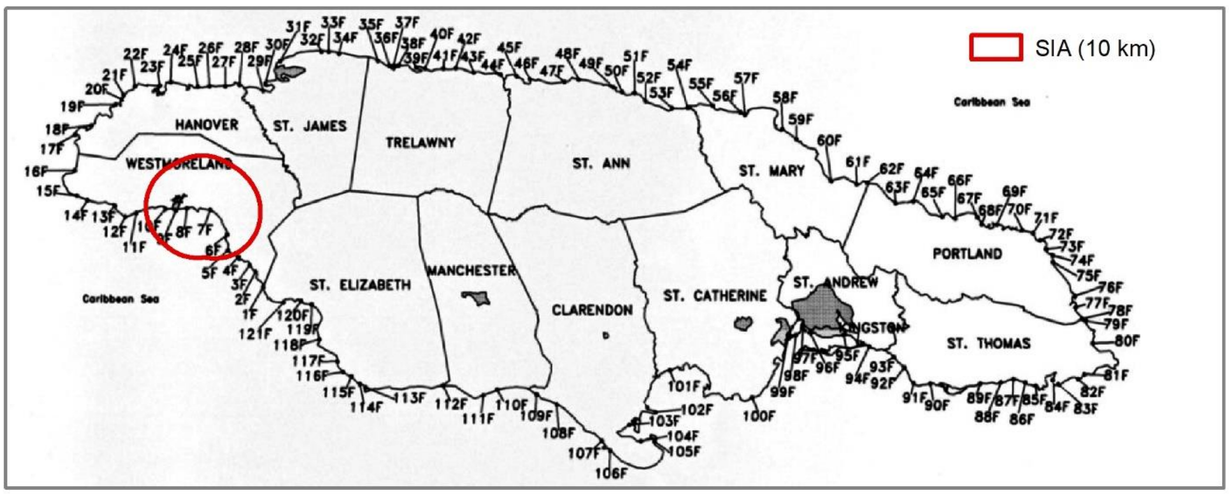


Figure 4-243 Fishing beaches within the SIA

There are varying numbers of registered fishers and vessels across different beaches in Westmoreland (Table 4-79). For those closest to the project area, Belmont has 43 registered fishers and 10 vessels, while Cave has 7 fishers and 4 vessels. St. Anne, with 26 fishers and 9 vessels, and Smithfield, which also has 22 fishers and 10 vessels, further contribute to the area's fishing activity. St. Mary's stands out with 58 fishers and 22 vessels, indicating its significant role in the local fishing economy. These communities, with their varying numbers of fishers and vessels, play an essential role in sustaining the fishing industry in the region.

Table 4-79 Registered fishers and vessels by location, Westmoreland, those within the SIA in bold red

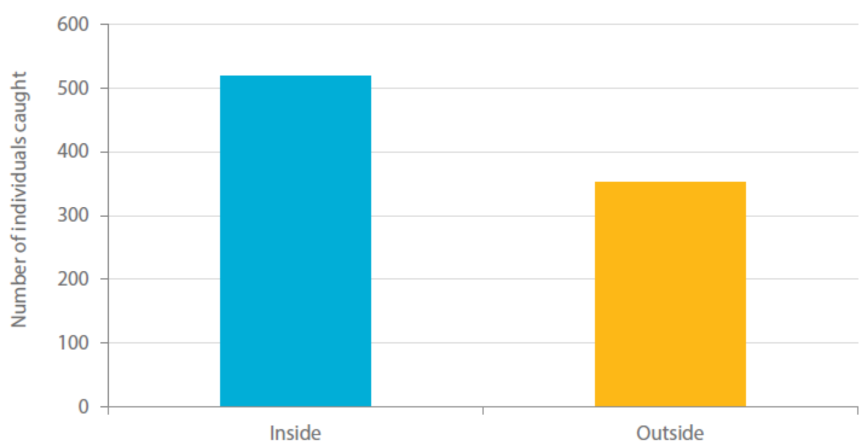
Source: National Fisheries Authority

Fishing Beach	Number of fishers	Number of vessels
SCOTTS COVE	43	17
WHITEHOUSE	270	47
BRAUGHTON	3	

Fishing Beach	Number of fishers	Number of vessels
AUCHENDOWN (CULLODEN)	7	
MOUNT EDGECOMB	43	
MARKET BEACH	6	9
BELMONT	**43**	**10**
CAVE	**7**	**4**
ST. ANNE	**26**	**9**
SMITHFIELD	**22**	**10**
ST. MARY'S	**58**	**22**
HOPE WHARF	25	9
SALMON POINT	12	4
LITTLE BAY	38	15
RIVIVAL		
ORANGE HILL		
IRONSHORE		
NEGRIL	149	37

Fish Catch

Through the C-FISH Partnership Initiative, fishing activities in Bluefields Bay conducted between 2013 and 2015 revealed that, of the total 870 individuals captured across five rounds of fishing, they belonged to 23 fish families and 37 species (Day, et al., 2015). The fish captured included not only fish but also lobsters, crabs, and conch, while starfish, sea urchins, and stingrays were excluded from the counts. The catches were distributed between the sanctuary and non-sanctuary areas, with approximately 518 individuals caught inside the sanctuary and 352 outside (Figure 4-244). A diverse range of species was captured in both areas, with the most dominant families being Crabs, Carangidae (Jacks), Acanthuridae (Surgeonfish), Palinuridae (Spiny lobsters), and Ephippidae (Spadefishes). The diversity of species in both areas was relatively similar, with a diversity index close to 0.88 for the sanctuary and 0.87 for the non-sanctuary areas (Day, et al., 2015).

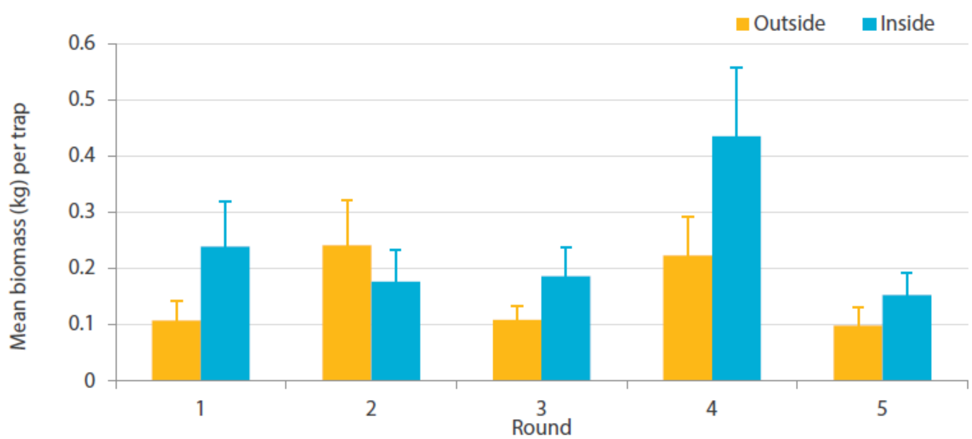


Source: (Day, et al., 2015)

Figure 4-244 Total number of individuals caught inside and outside the Bluefield's Bay fish sanctuary over the five rounds from January 2013-March 2015

In terms of biomass, a total of 139 kg of fish was caught across all rounds. Of this, 52 kg were caught outside the sanctuary, while 87 kg were caught within the sanctuary (Figure 4-245). The mean biomass per trap was higher inside the sanctuary during some rounds. Herbivorous species, such as Surgeonfish and Parrotfish, were also captured, with more herbivores caught inside the sanctuary than outside (Day, et al., 2015).

Commercial species such as Yellow Jack, French Grunt, and Lane Snapper were important in both areas, with a total of 141 commercial species caught inside the sanctuary and 90 caught outside. The biomass of commercial species varied between rounds, with higher mean biomass observed in some rounds inside the sanctuary. Spiny lobsters, an important species, were captured both inside and outside the sanctuary, with a total of 93 lobsters, including 75 caught inside and 18 outside. The abundance and biomass of lobsters were generally higher inside the sanctuary (Day, et al., 2015).



Source: (Day, et al., 2015)

Figure 4-245 Mean biomass of fish caught per trap per round inside and outside the Bluefield's Bay fish sanctuary over the five rounds from January 2013-March 2015

Bluefields Bay Fish Sanctuary

The Bluefields Bay fishing community demonstrated overwhelming support for the creation of a fish sanctuary, with surveys in 2005 and 2007 showing near-unanimous backing. In 2005, 99% of fishers supported the sanctuary, and by 2007, this support had grown to 100%, including fishers from surrounding areas. This strong community backing led the Ministry of Agriculture & Fisheries (MOAF) to designate Bluefields Bay as one of Jamaica's five priority fish sanctuaries in 2007. The sanctuary was officially declared in 2009 after extensive community consultations and boundary finalization. To ensure its success, the MOAF and the Bluefields Bay Fishermen's Friendly Society (BBFFS) formalized their partnership through a Memorandum of Agreement (MOA) in 2010, outlining joint responsibilities for managing and funding the sanctuary (Bluefields Bay Fishermen's Friendly Society, 2013).

The governance of the Bluefields Bay Fish Sanctuary is community-driven, with a collaborative approach between the government and local wardens (Thorpe, 2015). The local management entity, Bluefields Bay Fishermen's Friendly Society (BBFFS), has made significant strides in conservation and operational efforts despite persistent challenges. The sanctuary has successfully maintained 24-hour surveillance on both land and at sea, except during extreme weather conditions. BBFFS has partnered with the National Fisheries Authority (NFA) to help local fishers remain compliant by ensuring they obtain necessary fishing licenses and to ensure compliance with regulations, such as closed seasons for lobster and conch. The BBFFS also organized trash collection efforts and conducted educational workshops on proper waste disposal, with a completion target for these projects set for June 2023. The Sea Turtle Protection Program, another ongoing initiative, successfully monitored 47 nests and released 2,512 hatchlings in 2022, alongside outreach activities to raise awareness in local schools. (Bluefields Bay Special Fishery Conservation Area (Fish Sanctuary), 2022).

Despite these achievements, several challenges persist. Improper waste disposal remains a concern, though BBFFS has implemented annual cleanups and continues to maintain the cleanliness of Belmont Fishing Beach and its surroundings. The BBFFS also faces financial and staffing challenges that threaten the long-term stability of the sanctuary.

4.4.7.4 Tourism

The South Coast of Jamaica offers a unique and diverse tourism experience, distinct from the more developed North Coast resorts. This area is known for its natural beauty, relaxed atmosphere, and cultural richness. It is less commercialized, providing a more authentic Jamaican experience, with a focus on eco-tourism, nature-based activities, and heritage tourism. Amongst the highlights of the south coast is Bluefields Bay, known for its beautiful beaches, marine life, and the Bluefields Bay Fish Sanctuary, which provides a mix of conservation efforts and sustainable tourism practices. It is certainly well-positioned to capitalize on the growing global trend for nature-based tourism, with engaged stakeholders working toward responsible development (Missouri State University, 2011).

Accommodations

The Bluefields Bay area offers a limited selection of accommodations, catering to small to medium-sized groups. Horizon Cottages, rated as a two-star facility, provides basic amenities like a private beach, security wall, and recreational activities such as sea kayaking and snorkelling. Bluefields Bay Villas stands out as a high-end property, with a four- to five-star rating, offering luxury features like a private bayfront, swimming pool, tennis court, and spa services. The Bluefields Bay Resort, also rated two stars, offers a range of amenities including private huts, a bar, restaurant, and event spaces, ideal for gatherings and weddings. Sunset Cottages, a locally owned facility, provides six private rooms and additional amenities like a bayside view and courtyard gazebo, though it lacks a website. The main issue is the considerable gap in service quality between Bluefields Bay Villas and the other accommodations, which creates a stark contrast between luxury and more basic options (Clegg, 2015).

International and Regional Trends

In 2021, global tourism saw a mild 4% increase in international arrivals, with 421 million tourists compared to 403 million in 2020, though this was still 72% below pre-pandemic levels. The pandemic's impact caused a significant decline in international tourism, with 1.049 billion fewer tourists traveling compared to 2019. Despite the decrease, international tourism receipts rose to an estimated US$700–800 billion, and tourism's direct contribution to global GDP increased to US$1.9 trillion. While regions like Europe, the Americas, and Africa saw growth, Asia, and the Pacific, along with the Middle East, experienced declines in tourist arrivals (Jamaica Tourist Board, 2022).

The Caribbean Tourism Organization (CTO) reported an estimated 19 million visitors to the Caribbean in 2021, a 68.9% increase over 2020, driven by rising travel confidence, high demand, and the easing of border restrictions. The rebound was especially strong in the US market, while Europe saw modest growth and Canada struggled. The cruise industry, however, faced continued disruptions, with cruise arrivals to the region dropping by 54.6%, totalling around 3.9 million. This decline was due to reduced cruise capacities, restrictions on unvaccinated passengers, and the closure of several regional ports, with only Bermuda showing an increase in cruise visits (Jamaica Tourist Board, 2022).

Arrivals to Jamaica

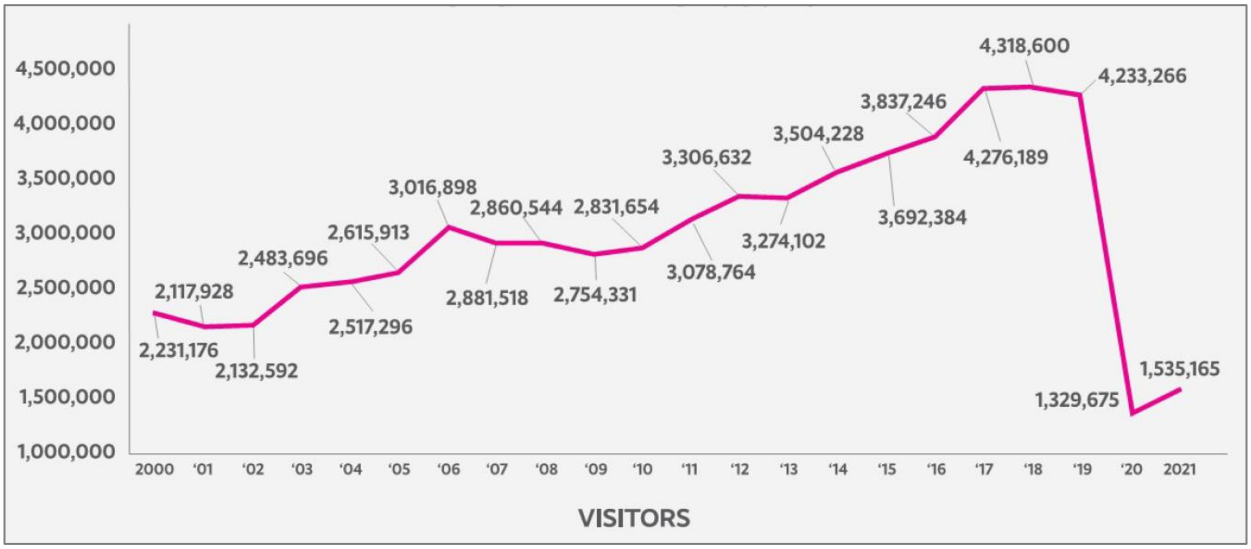
Jamaica saw a total of 1,535,165 visitor arrivals in 2021, representing a 15.5% increase from the previous year. This marked a growth of 205,490 more visitors compared to 2020, with notable increases in the second, third, and fourth quarters. Stopover arrivals accounted for 1,464,399 visitors, a 66.3% rise from the previous year, while cruise passenger arrivals decreased by 84.2%. The majority of stopover arrivals (71.9%) were for leisure, recreation, and holidays, with the remaining visitors coming for business or personal reasons (Jamaica Tourist Board, 2022).

Table 4-80 Destination performance 2021

Source: (Jamaica Tourist Board, 2022)

TOTAL VISITORS	2020	2021	% CHANGE
Stopover Arrivals	880,404	1,464,399	66.3%
Cruise Passenger Arrivals	449,271	70,766	-84.2%
Total Visitors	1,329,675	1,535,165	15.5%
Stopover Arrival Earnings US$M	1,211	2,088	72.5%
Cruise Passenger Earnings US$M	45	7	-84.4%
Gross Foreign Exchange Earnings US$M	**1,291**	**2,095**	**66.8%**

The average length of stay for foreign nationals in 2021 was 9.1 nights, slightly down from 9.4 nights in 2020 but still longer than pre-pandemic stays. American visitors stayed an average of 7.8 nights, while Canadian visitors stayed 15.9 nights, and those from the United Kingdom and Continental Europe stayed longer, averaging 18.6 and 17.1 nights, respectively. Visitors from the Caribbean stayed the longest, with an average stay of 24.6 nights. These longer stays were influenced by COVID-19 protocols, which affected travel behaviour (Jamaica Tourist Board, 2022).



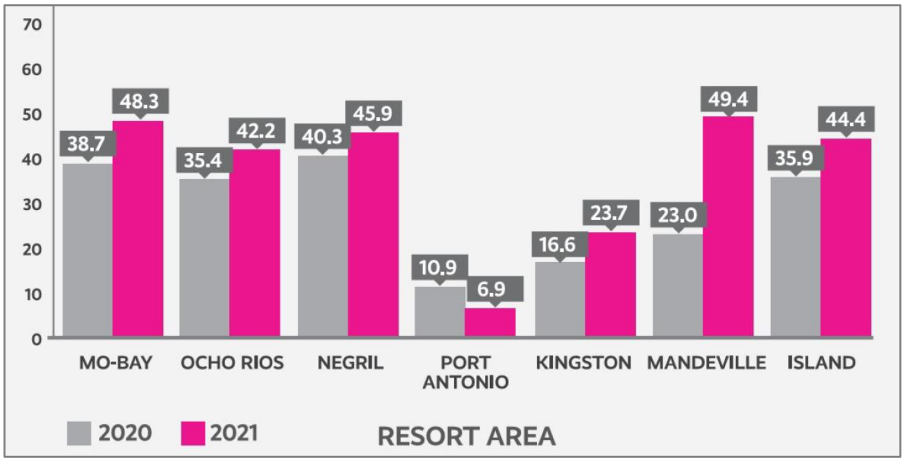
Source: (Jamaica Tourist Board, 2022)

Figure 4-246 Visitor arrivals 2000-2001

Hotel Room Occupancy

In 2021, Jamaica's hotel sector saw a remarkable recovery in room occupancy, with the national hotel room occupancy rate increasing by 8.6 percentage points to 44.4%, compared to 35.9% in 2020. The island also experienced a significant boost in the number of rooms available, rising by 34.2%, and a notable 65.9% increase in room nights sold. These positive trends were reflected across multiple resort regions, including Montego Bay, Ocho Rios, Negril, and Kingston & St. Andrew. The all-inclusive hotel sector notably achieved an occupancy rate of 49.3%, up from 40.6% in 2020. Despite challenges in areas like Port Antonio, the overall recovery was strong (Jamaica Tourist Board, 2022).

Focusing specifically on the South Coast region, the area experienced impressive growth in 2021. The average hotel room occupancy rate surged by 26.4 percentage points, from 23.0% in 2020 to 49.4% in 2021. This increase was coupled with a 32.2% rise in room capacity, growing from 515 rooms in 2020 to 681 rooms in 2021. Room nights sold jumped significantly by 182.9%, from 43,380 in 2020 to 122,752 in 2021. Additionally, the number of stopovers intending to stay in the Mandeville/South Coast region rose by an outstanding 207.8%, from 11,465 in 2020 to 35,288 in 2021, showcasing a strong recovery and demand for accommodations in this area (Jamaica Tourist Board, 2022).



Source: (Jamaica Tourist Board, 2022)

Figure 4-247 Hotel room occupancy (%) by resort area 2020 and 2021

Visitor Expenditure

In 2021, Jamaica's total visitor expenditure reached approximately US$2.1 billion, a 62.3% increase from 2020. Foreign nationals were the biggest spenders, contributing US$2.014 billion. Cruise passengers spent US$0.007 billion, while non-resident Jamaicans spent US$0.074 billion. On average, foreign nationals spent US$147.42 per person per night, while cruise passengers spent US$101.00 per person (Jamaica Tourist Board, 2022).

Employment

In 2021, the number of persons employed in Jamaica's accommodation sub-sector saw a significant decline due to the impact of the COVID-19 pandemic. At the height of the pandemic, about 90% of accommodation staff were laid off. By the end of 2021, 30% of tourism workers were rehired full-time, and 10-20% on a part-time basis. This resulted in a reduction of employment from 51,226 in 2019 to 38,647 in 2021, a decrease of 24.6% (Jamaica Tourist Board, 2022).

Table 4-81 Employment in the accommodation sector by resort area 2017-2021

RESORT AREAS	2017	2018	2019	2020	2021
Montego Bay	21,126	22,081	22,367	10,796	13,611
Ocho Rios	10,240	11,181	11,714	7,928	9,995
Negril	11,874	12,027	11,784	6,365	8,024
Kingston	2,082	2,063	2,342	2,775	3,498
Port Antonio	1,520	1,475	1,425	856	1,079
Southcoast	1,597	1,589	1,594	1,935	2,439
Total	**48,439**	**50,416**	**51,226**	**30,655**	**38,646**

The main resort areas—Montego Bay, Ocho Rios, and Negril—accounted for 81.8% of total employment in the accommodation sector. Montego Bay had the highest share with 13,611 jobs (35.2%), followed by Ocho Rios with 9,995 jobs (25.9%) and Negril with 8,024 jobs (20.8%). The remaining 18.2% of accommodation jobs were in Kingston, Port Antonio, and the South Coast (Jamaica Tourist Board, 2022).

The average number of employees per room in 2021 was 1.23 (Jamaica Tourist Board, 2022).

4.4.8 Land Use and Zoning

4.4.8.1 Historical Land Use

Smithfield

The community of Smithfield, once known as Wakefield, has a rich history of commerce, marked by its involvement in both production and export. This history includes the operation of a sugarcane plantation, logwood production and export, as well as cattle rearing and dairy farming (Soical Development Commission, 2010). A logwood plantation once thrived in the Paradise district, with its shipping point located in the Wharf Road area. While the original buildings have been demolished, remnants such as stone foundations and railway tracks still provide evidence of the significant activities that took place. The area was originally part of the Paradise Estate, which housed cattle and enslaved individuals and dates back to the 18th century.

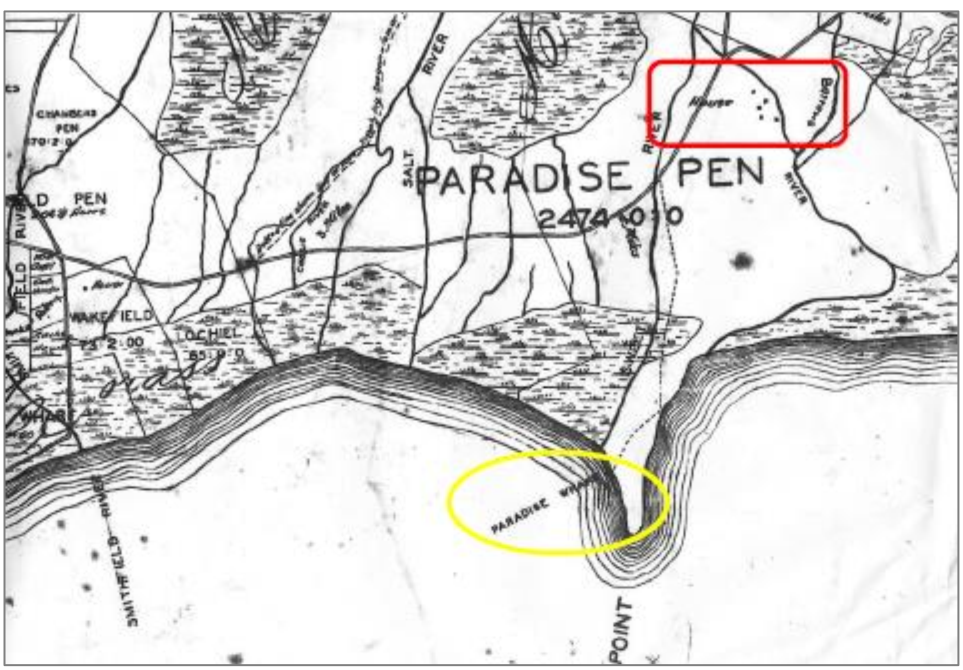
Paradise Park

Paradise Park, historically known as Paradise Pen, was initially occupied by the Tainos, Jamaica's indigenous population. Archaeological studies have uncovered numerous Taino artifacts, particularly pottery, indicating the presence of two distinct Taino sites: an Ostonian site (650-850 AD) and a Meillacan site (950-1500 AD). Excavations by Professor William Keegan in the late 1990s and early 2000s further defined these sites (Jamaica National Heritage Trust, 2023).

The name "Paradise" first appears on a 1755 map of Jamaica, where it is shown alongside a house. The Craskell and Simpson map of 1763 highlights the Sweet River and two waterwheels on the property. Early maps show the area as "Morass," with neighbouring settlements like Bluefields and Savanna-la-Mar. By 1803, records indicate that John Wedderburn owned Paradise, and an 1804 map shows his property, including rivers, morass, and two houses. An 1802 visit by General and Lady Nugent noted the "good house" and "lovely situation." By the 1890 Thomas Harrison cadastral map, the area was known as "Paradise Pen," indicating a shift in land use to cattle rearing, with an identified slave village and wharf. In 1817, Jacob Chambers owned the wharf with 13 slaves and 4 stock (Jamaica National Heritage Trust, 2023).

Source: (Jamaica National Heritage Trust, 2023)

Figure 4-248 Map made by Mr. Sheffield and others from the year 1730- 1749 and published in 1755 showing Paradise



Source: (Jamaica National Heritage Trust, 2023)

Figure 4-249 Thomas Harrison map highlighting Paradise Pen and Paradise Wharf, House, and slave village

Ownership of Paradise changed multiple times throughout history. Initially owned by William Dorrill in 1754, it passed to his children and later to John Cope, who sold the 1,650-acre property in 1774 to John Sommerville and John Cunningham for £10,500. Paradise was involved in sugar and rum production from 1778 to 1796 but shifted to growing ginger, cotton, and livestock under John Wedderburn's management from 1798 onward. In 1799, the estate included 164 enslaved persons and livestock. By 1823, the estate had 125 enslaved persons and 815 stock, though these numbers declined in the 1830s. By 1832, the estate was under the control of Joseph Stone Williams as attorney to the estate's trustees (Jamaica National Heritage Trust, 2023).

In the early 20th century, Paradise was a 2,499-acre property used for cattle and wood supply. By 1920, it spanned 3,000 acres and continued its use for livestock, remaining under the ownership of S. M. Haughton James. In 1952, the Clarke family acquired the property, which they used as a country club and resort, featuring a 9-hole golf course (Figure 4-250). The Clarke family also operated a dyewood factory on the property during the 1950s (Jamaica National Heritage Trust, 2023) and a "Jungle" attraction (Figure 4-251).

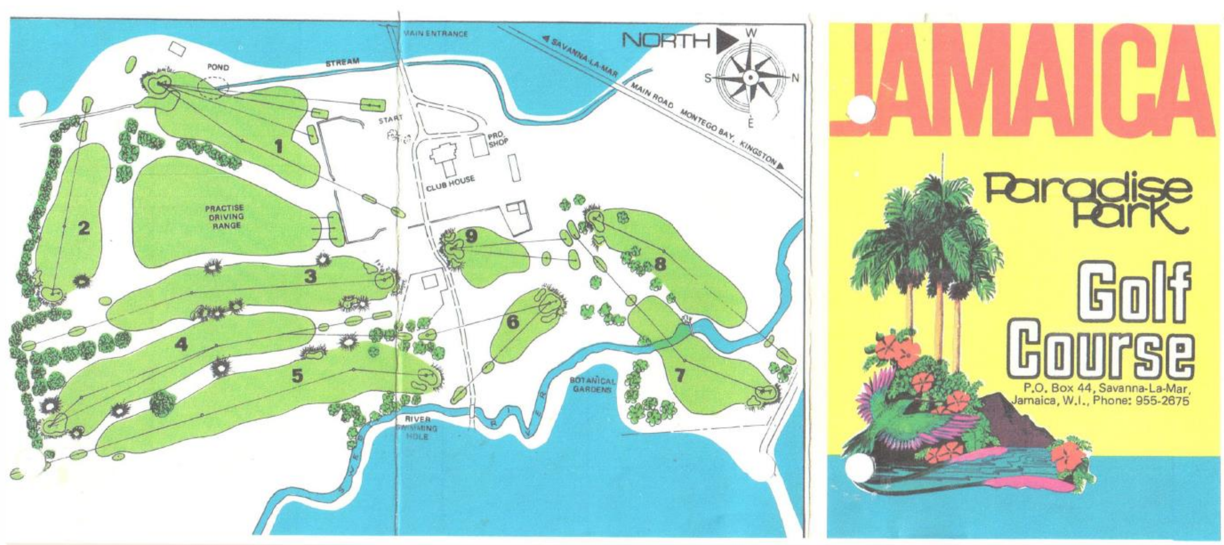


Figure 4-250 **Brochure for Paradise Park Golf Course**

Figure 4-251 **Brochure for Paradise Park Jungle attraction**

4.4.8.2 Current Land Cover and Use Patterns

SIA

Land cover within the SIA consists of disturbed broadleaved forest, secondary forest and fields primarily to the north and northeast of the project; plantations, fields, swamp forest and buildings to the north and west; and an enclosed area of short open dry forest (shrubland/bushland) to the immediate north (Figure 4-252). The vast area of buildings and infrastructure represents Savanna-la-Mar, the capital of Westmoreland, along with the nearby surrounding residential areas. The close proximity of Savanna-la-Mar to the proposed site, along with major towns like Petersfield and Darlington, and smaller coastal towns such as Belmont, Bluefields, Mearnsville, and Cave, has led to a mix of urban land and building uses within the largely rural area; this includes residential, commercial, transport, and service-oriented uses (Figure 4-253). Previous sections have examined various services and infrastructure supporting community needs, economic activities, recreation, and tourism. These factors highlight the diverse land use and building activities within the SIA, illustrating the range of functions and purposes that shape the area.

Smithfield Community

The land use distribution in Smithfield reveals a variety of activities across different sectors. The largest portion of land, 35%, is utilized for informal residential purposes, reflecting the prevalence of informal housing in the community. Formal residential areas account for 25% of the land, indicating a significant amount of designated residential space. Agricultural activities occupy 8% of the land, while commercial uses take up 5%, suggesting a modest presence of business and trade. Social spaces, including green areas and institutional buildings, comprise 20% of the land, highlighting the importance of communal spaces in the community. Industrial use is minimal, with just 1% of land allocated for this purpose. Additionally, 6% of the land is designated for mixed uses, combining both residential and commercial activities. (Social Development Commission, 2010).

Table 4-82 Land use activities in Smithfield

Source: (Soical Development Commission, 2010)

Activities	Percentage of land space utilized
Agricultural	8.0
Commercial	5.0
Social (green spaces, institutions) *	20.0
Industrial	1.0
Formal (*Residential*)	25.0
Informal (*Residential*)	35.0
Mixed Uses (Residential & Commercial Uses)	6.0

** Paradise Park, which is now primarily used for recreational purposes and a miniscule percentage of farming, is approximately 1,000 acres. It is noteworthy that this facility is privately owned.*

Paradise Park

Within the project boundary, the land is predominantly covered by fields and secondary forest. Along the coastline, areas of mangrove forest are visible, with herbaceous wetlands extending further inland to the east (Forestry Deprtment, 2023) (Figure 4-253). The southern part of the property features a white sand beach, which gradually gives way to increasingly cleared fields and pastureland (Plate 4-99).

Plate 4-97 View of southern beach looking west

Plate 4-98 **View of transition from pasture/fields to beach areas with goats grazing**

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-99 **Aerial view of pasture lands**

Surface drainage features exist, with a major river system, the Sweet River traversing the property in multiple sections. Specifically, the Paradise Estate has four rivers which run from the north side of the property that empties into the Caribbean Sea, including two tributaries of the Sweet Water River and the Deans Valley River (Plate 4-112). Buildings and building pad foundations are also found within the project boundary, along with various services and transport infrastructure; however, buildings are not the primary type of land cover.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-100 Aerial view of the Dean's Valley River emptying into the Caribbean Sea

The current land use in Paradise Park is diverse, blending agricultural, recreational, residential, commercial, and military activities. The area is primarily used for cattle rearing, with large pasturelands dedicated to dairy farming under the management of Paradise Park Limited. These pasturelands are divided into several enclosures for the grazing of cattle, horses, goats, and sheep. A concrete calf pen houses several stalls with metal gates, along with a metal feeding tank and a small concrete watering trough (Jamaica National Heritage Trust, 2023). Fish breeding and shrimping activities are conducted on the property as well. Several large fiberglass tanks are used for the commercial breeding of freshwater fish, while a small catchment area along a tributary of the Deans Valley River is used for shrimp harvesting (Jamaica National Heritage Trust, 2023).

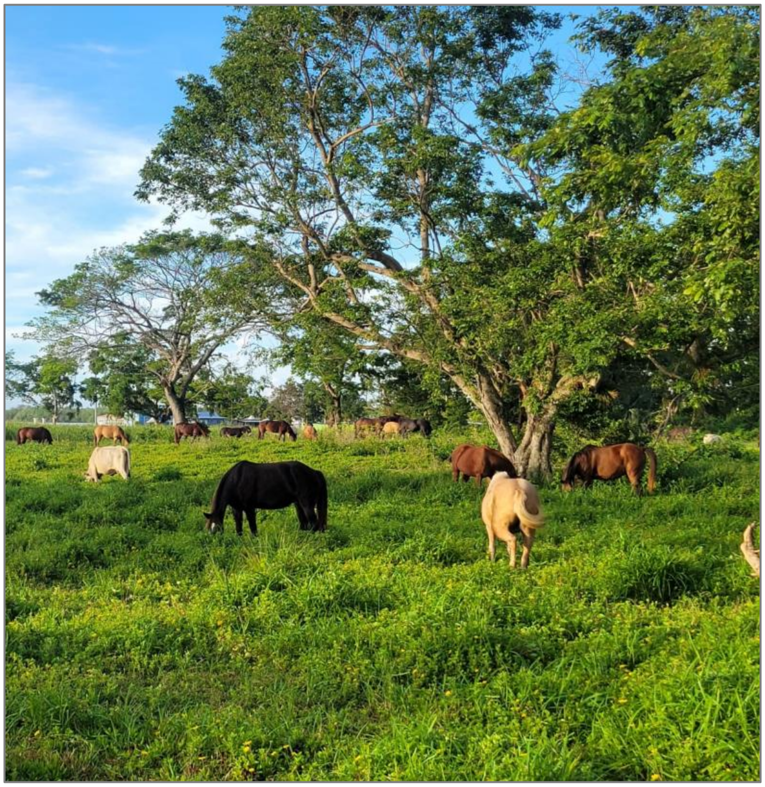
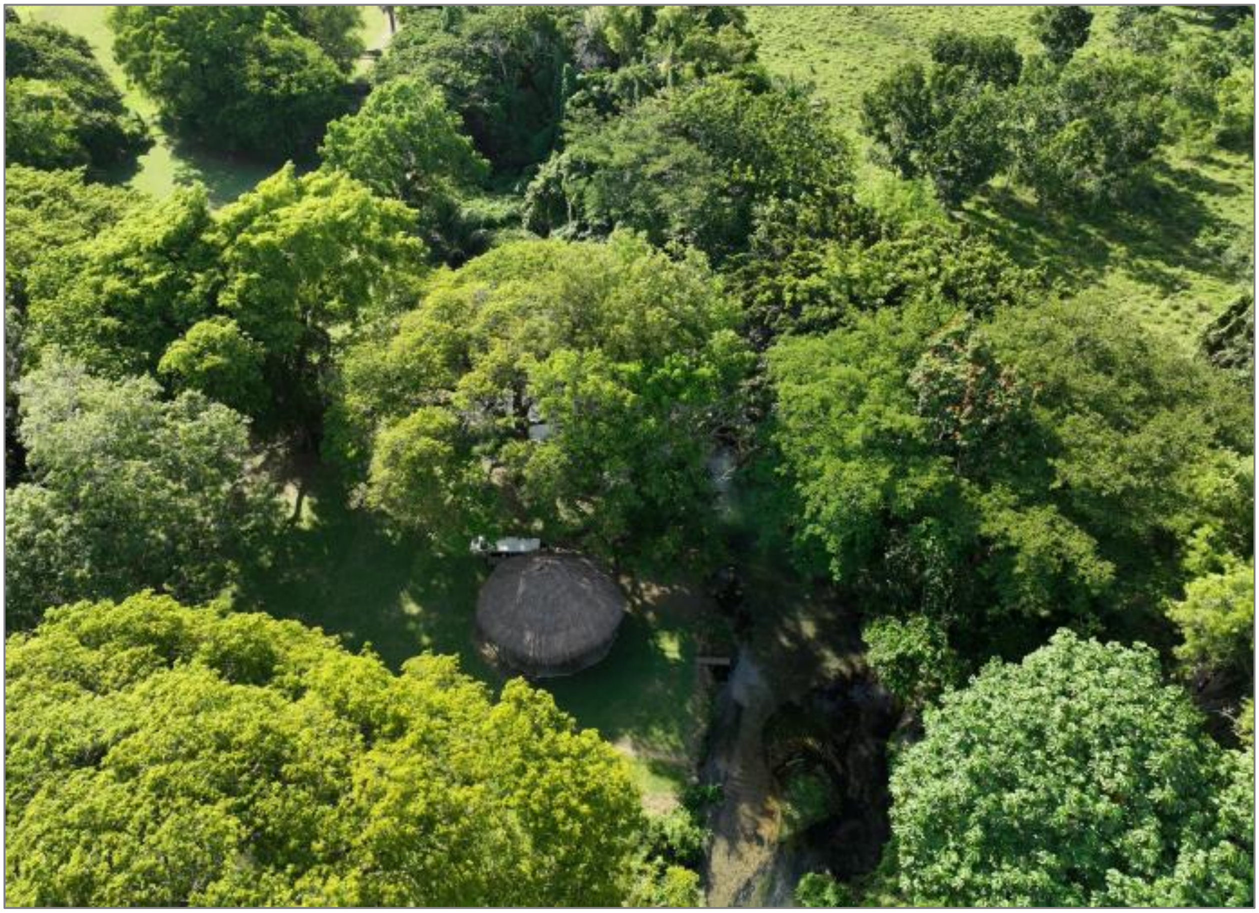


Plate 4-101 Horses and cows grazing in open field/pasture

The project area also hosts a recreational park area located along the river. This park is used for family trips, church outings, and weddings, according to Paradise Park Limited. Visitors can enjoy swimming in the river, and the park features a manicured lawn, ideal for picnics, as well as a large wooden gazebo for events (Jamaica National Heritage Trust, 2023).



Source: (Jamaica National Heritage Trust, 2023)

Plate 4-102 Aerial view of the park area at Paradise Park

An abandoned school building was once used as a preparatory school in the 1990s but is now left to deteriorate. The surrounding area is used for grazing, further adding to the agricultural use of the land (Jamaica National Heritage Trust, 2023). These activities are all managed within the framework of Paradise Park Limited, which also operates a golf course, horseback riding, and a tourist park area, reflecting the site's evolving use for leisure and tourism (Jamaica National Heritage Trust, 2023).

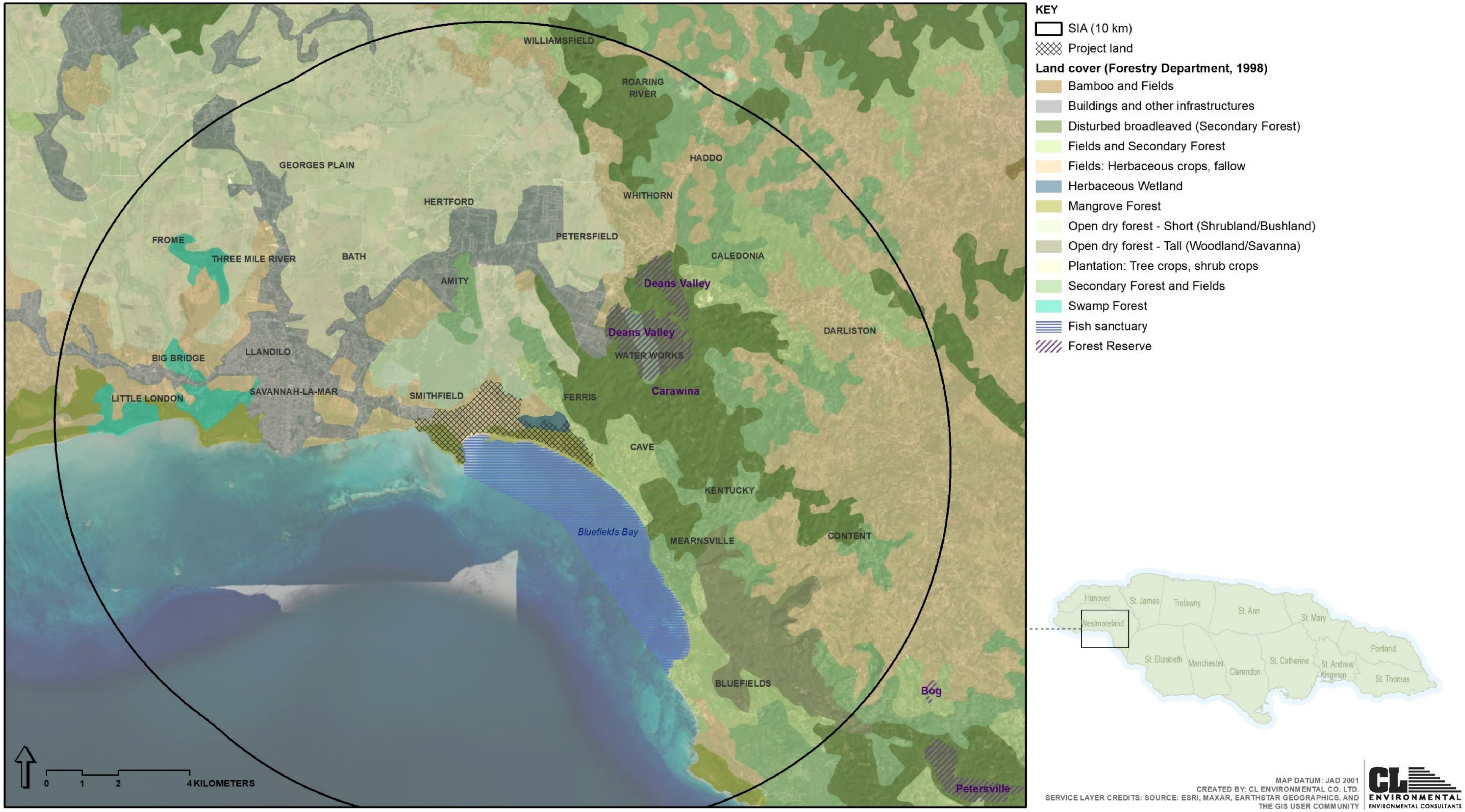
Plate 4-103 Horses grazing in open field/pasture in proximity to abandoned school building

The southern section of the property, featuring a white sand beach and coastal vegetation, also contains a blue two-storey house that was once the residence of the property's owners and remains part of the Paradise Park estate. Behind the house, three additional structures are present: a detached garage and two ancillary housing units. The property also supports poultry farming, with elongated enclosures housing chickens, quails, and pheasants.

Th project area reflects both the historical significance of the estate and its current use for agriculture and military activities. The Paradise Park Great House, now in ruins, stands as a reminder of the estate's former grandeur. Behind the ruins is a large building, which was once used for various purposes but now serves as the office for Paradise Park Limited. To the southeast of the great house lies the Overseer's House, a historic structure currently utilized by the Jamaica Defence Force (JDF) for training purposes, accompanied by three large army tents.

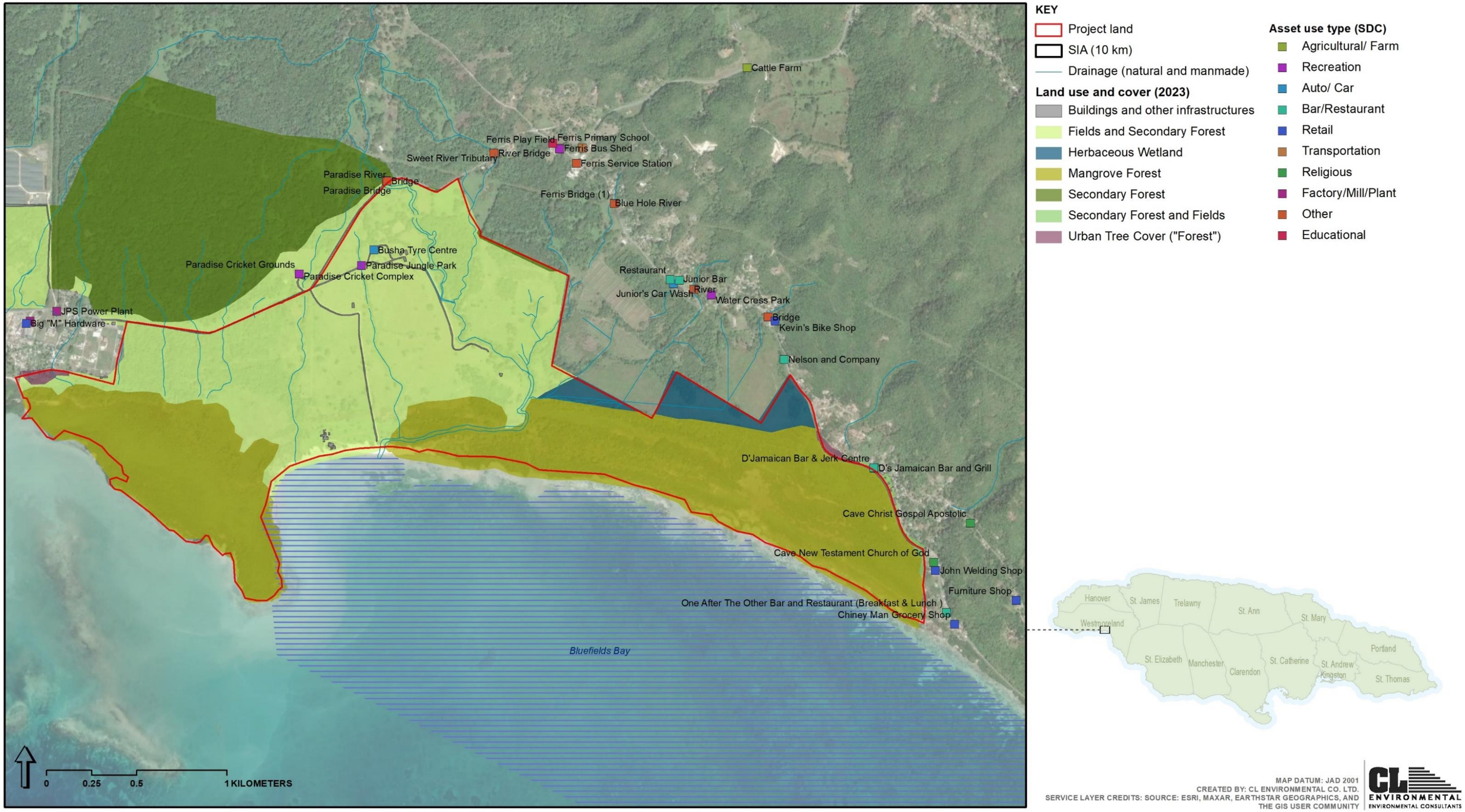
A Taino archaeological site is located towards the eastern section of the site, with evidence of Taino pottery and artefacts scattered across the surface. The area's rich archaeological potential is evident, with crabhole investigations revealing pieces of earthenware, stones, and shell fragments, indicating the cultural significance of this zone to the Taino people. The surrounding land is primarily undeveloped, with the natural coastal landscape largely intact (Jamaica National Heritage Trust, 2023).

In summary, the land use at Paradise Park combines historical agricultural practices, including cattle farming and timber harvesting, with ongoing modern activities such as dairy farming, poultry farming, and tourism, including a park area for recreational activities. Archaeological sites and historical buildings also highlight the rich cultural heritage of the area.



Data sources: Land use (Forestry Department), protected areas (NEPA, MGI and Fisheries), building use (Social Development Commission (SDC), 2023)

Figure 4-252 Land use/cover and protected areas within the SIA



Data sources: Land use and cover (Forestry Department, 2023), protected areas (NEPA, MGI and Fisheries), building use (Social Development Commission (SDC), 2023)

Figure 4-253 Land use, building use and protected areas at and surrounding the project site

Table 4-83 Google Earth images of project site (red boundary) and surrounding area between January 2001 and September2023

 **January 2001**	 **June 2007**	 **July 2009**
 **January 2014**	 **November 2019**	 **October 2023**

4.4.8.3 Protected Areas and Conservation Status

Protected areas examined here include all areas of land or water protected by various laws in Jamaica, as well as international agreements, that fall within or in proximity to the project area; these include fish sanctuaries (formerly referred to as Special Fishery Conservation Areas (SFCAs)), protected areas (declared and proposed), national parks, forest reserves, marine parks, game reserves and national heritage and monuments.

The project site does not fall within any area designated as a protected area or marine park under the Natural Resources Conservation Authority Act but has been identified in several studies as an ecologically sensitive site and recommended for future protection (Bennett, 2022). The site falls within a coastal area located to the west of the Black River Complex identified in Jamaica's National Ecological Gap Assessment Report (NEGAR) 2009, as being important for meeting specific terrestrial conservation goals for the preservation of dry and a wet alluvium forest, mesic alluvium forest, wetland and various frog species (Bennett, 2022). Bluefields Bay is also identified as a Habitat/Species Management Area (Category IV) under the International Union for Conservation of Nature (IUCN) Protected Areas Categories System.

Of important mention is the Bluefields Bay Fish Sanctuary, the landward boundary of which parallels the project area in the northernmost section of the bay (Figure 4-252). Additionally, the extent of wetland within the project boundary, regardless of whether it falls within a designated protected area, must be acknowledged.

Bluefields Bay Fish Sanctuary

Fish sanctuaries in Jamaica are designated marine areas protected by law to conserve and restore fish populations, coral reefs, and other marine life. The Bluefields Bay Fish Sanctuary, covering an area of 13.82 km^2, is the second largest sanctuary declared in the country. The landward boundary has a general northwest to southeast orientation, extending 13.82 km along the coastline between the settlement of Paradise to the north and Belmont Point at its southernmost extent, with a seaward extent less than 2 km from the shore.

The Bluefields Bay Fish Sanctuary was declared in July 2009 in response to significant threats from overfishing and destructive fishing practices (Bluefields Bay Fishermen’s Friendly Society (BBFFS), n.d.)and with strong support from the local fishing community, as evidenced by surveys conducted in 2005 and 2007 (Bluefields Bay Fishermen’s Friendly Society, 2013). In these surveys, fishers from various areas, including Cave, Farm, Belmont, and others, overwhelmingly supported the creation of a fish sanctuary, with 99% approval in 2005 and 100% approval in 2007. This widespread backing led the Ministry of Agriculture & Fisheries (MOAF) to prioritize Bluefields Bay as one of the five new fish sanctuaries in Jamaica (Bluefields Bay Fishermen’s Friendly Society, 2013).

It is managed by the Bluefields Bay Fishermen's Friendly Society (BBFFS) with the support of various governmental and community stakeholders. It operates under the Fishing Industry Act of 1976 and is supported by trained Game Wardens. Enforcement is carried out with the help of the Jamaican Defence Force and Jamaica Constabulary Force. The sanctuary's funding comes from both government support and private grants, enabling efforts like educational outreach, artificial reef construction, and wildlife surveys aimed at restoring the bay's ecosystem and reversing the effects of overfishing.

The sanctuary has seen positive results, including improvements in fish catches, the regeneration of marine life, and continued support from the local community. Further efforts, such as additional funding, research, and equipment, have strengthened enforcement and the sustainability of the sanctuary, with fishers suggesting an expansion of the sanctuary's boundaries in 2012 to enhance marine protection (Bluefields Bay Fishermen's Friendly Society, 2013).

Wetlands and Mangroves

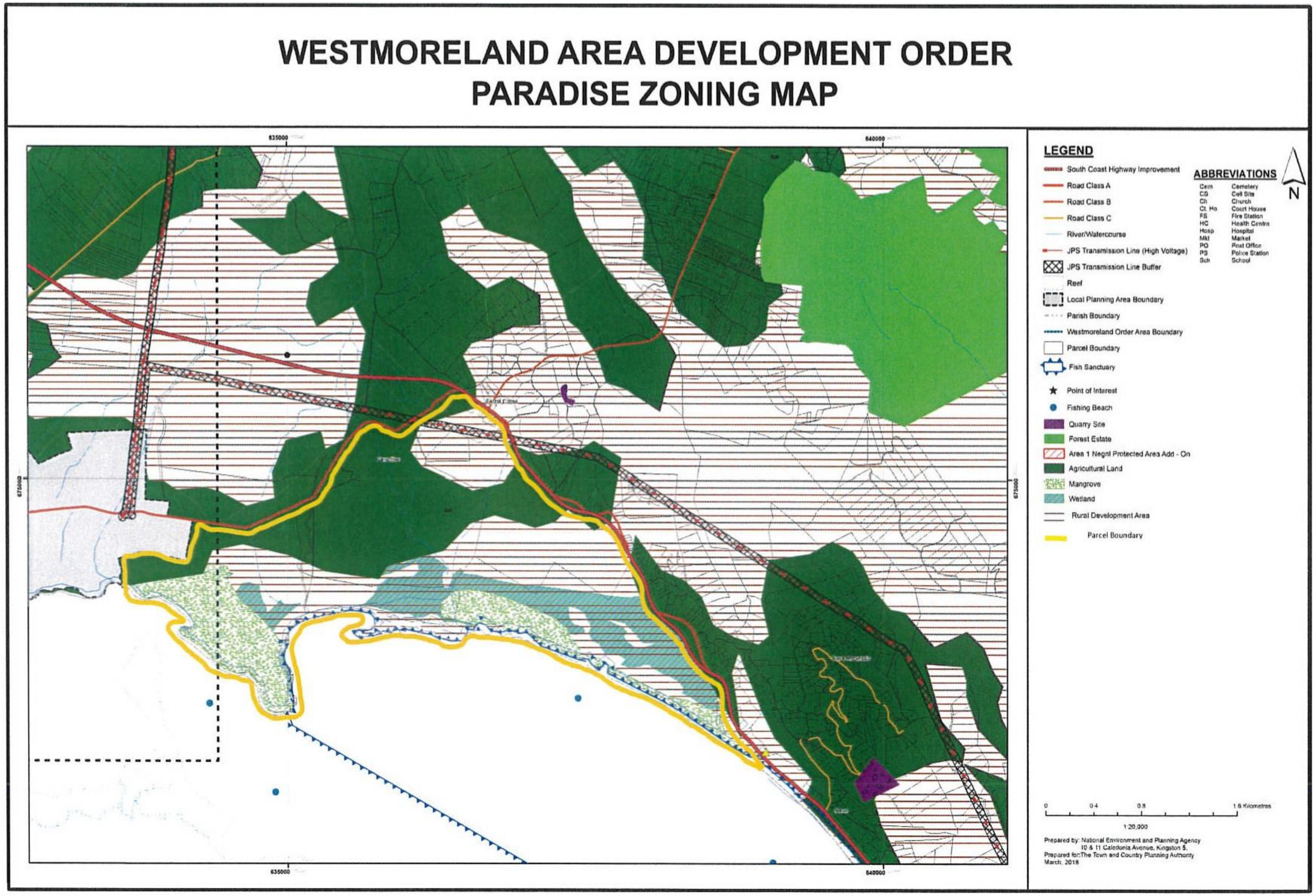
Mangroves in Jamaica are protected through various laws and national policies. The Wildlife Protection Act (1945) safeguards species within mangrove ecosystems and NEPA oversees the conservation of mangroves, enforcing regulations on wetland protection. The National Mangrove and Swamp Forest Management Plan (NMSFMP) 2023-2033 provides a strategic approach to conserve and restore these ecosystems.

4.4.8.4 Zoning

The project site falls within the boundaries of The Town and Country Planning (Westmoreland Area) Provisional Development Order 2018, (Confirmation Notification, 2021), and is subject to the requirements, standards, and guidelines of the Order. The site is zoned as rural development and agricultural lands further inland, and wetlands and mangrove territory along the coast (Bennett, 2022) (Figure 4-254). As seen in Figure 4-255, the proposed project area falls within the Bluefield/Whitehouse Stand-alone Priority Conservation Area. The western edge of the project area extends into a small section of the Savanna-La-Mar Local Planning Area Land Use Proposal; a zone proposed for residential purposes falls within the project boundary.

NEPA has stated that it is imperative that the developer agrees that the area zoned for conservation/coastal wetland must remain as conservation to maintain its ecological functions. Likewise, as proposed in the plans submitted, the areas so identified for conservation restoration expansion, buffer and forest and river conservation and rehab zones are to remain undeveloped. Further, the developer agrees to the placement of Tree Preservation Order on the remaining stand of mangroves (Bennett, 2022).

POLICY SPT03 should also be taken into consideration, which has earmarked the Paradise Pen area for a future tourism development (Bennett, 2022).



Source: (Bennett, 2022)

Figure 4-254 Paradise Zoning Map, The Town and Country Planning (Westmoreland Area) Provisional Development Order 2018, (Confirmation Notification, 2021)

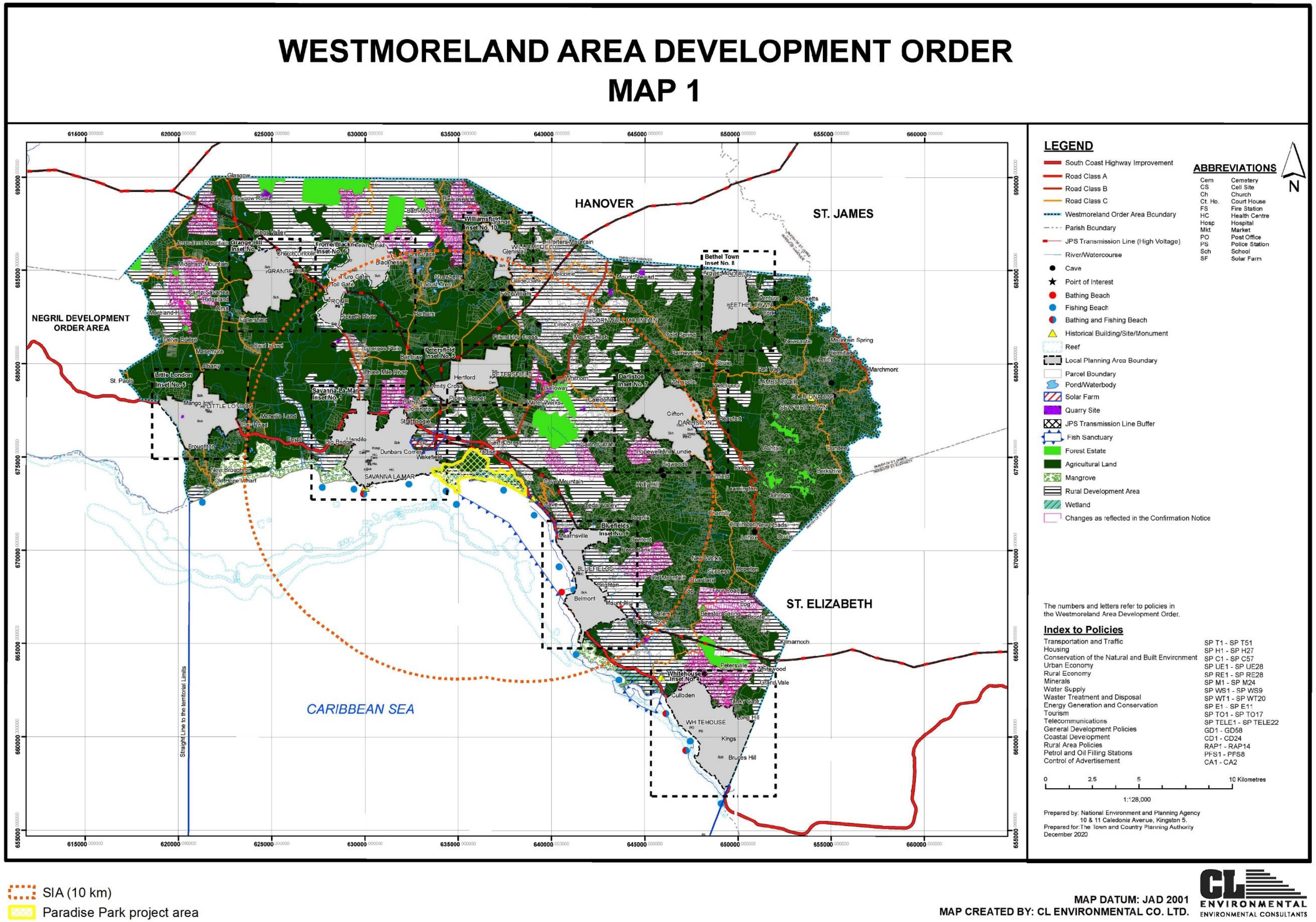


Figure 4-255 The Town and Country Planning (Westmoreland Area) Provisional Development Order 2018, (Confirmation Notification, 2021) in relation to the project area and SIA

4.4.9 Cultural/Heritage

4.4.9.1 Literature Review

Several significant archaeological reports have been conducted at Paradise Park, revealing its rich historical significance spanning Indigenous, colonial, and post-colonial eras. The *Southeast Westmoreland and Western St. Elizabeth Plan: Cultural Heritage Report* (Buncha Consultants, May 1991) identified two Taino sites within Paradise Park and uncovered tombs of the Dorrill family, the 18th-century estate owners, dating back to 1674. The report also documented a late 18th-century plantation house, a bookkeeper's house, barns, a 19th-century warehouse, and a logwood factory, shedding light on the site's colonial agricultural activities.

The *Paradise Park Amerindian (Arawak Indian) Site* (Roderick Ebanks, 1991) further explored the pre-Columbian history of the site. Discovered during a UDC survey in 1990, this site (W11) covers approximately 41.4 hectares, with test excavations revealing 2,893 artifacts associated with the Ostionoid "Redware" culture. A heritage park was proposed to interpret these findings to the public.

A study on *Changes in Invertebrate Taxa at Two Pre-Columbian Sites in Southwestern Jamaica* (Keegan, Portell, Slapinsky, 2002) documented shifts in mollusc species over time, reflecting cultural and environmental changes. The Ostionan site (Wes-15a) dated to the 9th century AD, with molluscs from high salinity seagrass habitats, while the later Meillacan site (Wes-15b) from the 15th century featured molluscs from mangrove-associated, low-salinity environments.

The most recent work, *Archaeology in Paradise (Park), Jamaica* (Keegan, 2022), continued to investigate the two pre-Columbian sites. Excavations between 1998 and 2004 revealed substantial finds at both the Paradise (Wes-15a) and Sweetwater (Wes-15b) sites. The Paradise site, dated to AD 673-1428, yielded pottery, marine shells, chert, and sea turtle bones, while the Sweetwater site (cal AD 1400 to post-contact) had pottery from the White Marl phase and a shift in mollusc usage, with clams and mud conchs dominating. This study provided a unique opportunity to compare material culture from the Little River and White Marl cultures in similar environmental settings.

4.4.9.2 Archaeological Assessment

Approach

The Jamaica National Heritage Trust (JNHT) completed an Archaeological Impact Assessment of Paradise Park, Westmoreland. The assessment involved a desk-based review, which included researching relevant historical documents such as maps, plans, estate accounts, correspondence, titles, and deeds. Additionally, published, and unpublished narratives, studies, and data sets related to the study area, surrounding regions, and associated projects were examined. Satellite images and aerial photographs were also analysed to enhance understanding of the area's historical and archaeological context (Jamaica National Heritage Trust, 2023).

A site survey was also conducted from July 23 to July 28, 2023, which included an archaeological field walk and windshield survey in the land parcels, referred to as Zones, within the project area (Figure 4-256). Artefact samples were collected and analysed, and cultural heritage contexts were interpreted. Significant cultural assets that could potentially be affected by the proposed development were recorded during the survey (Jamaica National Heritage Trust, 2023).

Figure 4-256 JNHT survey zones

Archaeological Research

In 1990, an environmental survey of the Paradise Park property led to the discovery of two Pre-Columbian archaeological sites. In 1991, Roderick Ebanks, who had previously identified the Taino archaeological site at Paradise Park, excavated five units near the old unimproved road and shores. In 1998, Bill Keegan, an American archaeologist, continued Ebanks' work and carried out further excavations from October 8-12, 1998. The goal was to define the boundaries of the archaeological materials, and 76 small test units were dug at 20-meter intervals along a 1.5-kilometer stretch of the site.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-104 Archaeologist along with students sieving artefacts at Paradise Park in 1998

Keegan identified two Taino sites in close proximity: the first, called Sweetwater, is located about 900 meters east of the Sweetwater River and extends for 220 meters. Excavations covered 71 square meters, revealing mostly undecorated Montego Bay-style pottery, abundant molluscs, especially clamshells, and small animal remains, primarily fish. Unique finds included a pottery foot, a green stone wedge, and a conch ornament. The second site, Paradise Park, was found after a 240-meter gap and is located on dunes above a swampy grove of Royal Palms. This site, which was occupied during a period of low sea level, was classified as a 'redware' site due to the presence of red-painted pottery. A transect extending 100 meters to the east revealed distributed cultural materials. Radiocarbon dating indicated a range from AD 673 to 1428. Excavations revealed pottery, fire-cracked limestone, mollusc shells (especially queen conch and olive shells), and chert and flint flakes. Notable finds included an agate-like ear spool and a stone pendant, possibly representing the Taino dog god (Jamaica National Heritage Trust, 2023).

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-105 Red painted Taino pottery found on the Paradise site

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-106 Mixed collection of pottery from the Paradise site

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-107 Stone pendant, possibly the dog God of Taino mythology

In February and March of 2002, Keegan and his team, alongside the Jamaica National Heritage Trust, conducted further excavations at both sites. The focus was to gather additional samples from midden deposits and look for evidence of structures. At the Paradise site, excavations uncovered a significant amount of flaked stones from the midden deposit. At Sweetwater, decorated ceramics in the Montego Bay style were found, and a centre post hole was discovered, although no further evidence of structures was found. Animal remains found during the excavations included small fish, birds, and hutia bones, indicating the types of animals consumed by the Tainos. A fishhook was also discovered, providing evidence of Taino fishing techniques. These investigations demonstrated that the material cultures of the two sites were distinctly different despite being in a similar environmental setting (Jamaica National Heritage Trust, 2023).

Site Assessment

ZONE 3

Zone 3 refers to the land parcel identified as Volume 1141, Folio 494. This area is densely vegetated, with coastal wetland features to the southwest, including a white sand beach and an expansive Black Mangrove Forest that extends inland. The coastline also features fan palms, sea grapes, palm, almond, coconut, and red mangrove trees. Moving north-east into the hinterland, modern cultural clearings are evident, with large areas showing signs of soil furrows, indicating previous farming activity. Shotgun shells and rice baits, placed in a northerly to southerly direction likely aligned with bird flight patterns, suggest bird shooting was another use of the land. Fishing activity was also noted in the area.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-108 Rice bait piles on the ground in cultural clearings

The northern section of the zone is a dense, secondary, disturbed forest pasture, with visible Trumpet, Ackee, Guinep, Pepper Elder, and young Cotton trees. Clusters of Ackee trees, potentially indicating historical use by enslaved Afro-Jamaicans on the estate, were observed. Animal faecal matter on the ground further suggests the land is used for grazing. Unlike the fine white sand and pale grey alluvium along the coast, the rest of the zone consists of dark sandy loam soil.

Due to dense grass and vegetation, artefacts were rarely found in this area. However, a few items indicating historical use were identified, including the base of an olive-green glass bottle dating from 1780-1830, and a horseshoe, which likely represents a modern feature associated with equine husbandry and horseback riding activities near the beach.

ZONE 4

Zone 4 corresponds to the land parcel identified as Volume 1146, Folio 944. It is bordered by the main road from Ferris Cross to Santa Cruz to the south, Zone 3 to the west and is contiguous with Zone 5 to its immediate south. The zone is predominantly flat, low-lying coastal plains, mostly covered in rolling pastures, with sections of dense secondary forests. Several streams traverse the area, and to the east, the Deans Valley River flows into the sea.

Upon entering the zone from the main road at the western end, a traditional Jamaican vernacular guard house made of nog and Spanish walling is visible. The dilapidated structure features a hip roof with a secondary gable roofing style covered with shingles, a small veranda with wooden fretwork and jalousie windows. Four large cut stone columns and an iron gate inscribed with 'Paradise Park' mark the entrance. The driveway, lined with large palm trees, leads to the northwestern quadrant of Zone 4, which contains features associated with an 18th-century sugar plantation.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-109 Historical guard house to the right of the entrance way to Paradise Park

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-110 Historical entrance way to the estate constructed from cut stone and iron

The Paradise Park Great House

The Paradise Park Great House, once grand, now sits in ruins. Facing south towards the sea, it was originally a single-storey wooden structure built on a cut stone foundation with a triple hip and pitch roof. The house was surrounded by a low-cut stone perimeter wall with columns. When the Clarke family acquired the property in 1952, modifications were made to turn the great house into a country club, including the addition of a swimming pool and new rooms. However, the house fell into disrepair and was partially demolished in the early 2000s.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-111 Old Photograph of the Paradise Park Great House

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-112 Current photograph of the ruins of the Paradise Park Great House

Cut Stone Building

Behind the ruins of the great house stands a large single-storey cut stone building with a double gabled and pitched roof and wooden columns at the front. The building, which was once used as a kitchen, buttery, storeroom, and servant quarters, is now the office of Paradise Park Limited. It operates a farm with cattle, sheep, and goats, along with a golf course, horseback riding facilities, and a park for tourists. A garage at the back of the building is used for vehicle maintenance on the estate, which includes vans, trucks, tractors, lawnmowers, and other large equipment.

The Overseer's House

Southeast of the great house ruins is the overseer’s house, a Jamaican vernacular structure with shiplap wood and a wraparound veranda with wooden rails. It has a double gable and pitch roof with glass sash windows and wooden louvres. The house is elevated on stone pillars with a cellar for storage. The front features an arched cut stone step with wooden rails leading to double French wooden doors. Several outbuildings are located behind the house, some in disrepair while others are still in use. The overseer’s house is currently used by the Jamaica Defence Force as a military post for training. A modern wooden structure with a gable roof, located immediately north of the overseer’s house, is also used by the JDF, along with three large army tents.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-113 Wooden outbuildings and JDF tents (foreground) and the Overseer's House (background)

Historic Grave

North of the cut stone building used as the garage and office for Paradise Park Limited is a historic grave. The tomb is made of cut stone and lime mortar, with later concrete rendering. It is oriented east to west with a marble headstone inscribed with the epitaph, "In the memory of James Wedderburn… who departed this life on the 17th of July 1797. Aged 45… This Tomb was erected by John Wedderburn."

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-114 James Wedderburn's tomb

Historic Cattle Pen

Near the 18th-century plantation complex, remnants of a historic cattle pen constructed from cut stone and brick fragments are visible. The walls are filled with lime mortar and stand about 4 feet high. Some walls have collapsed, and the pen is overgrown with trees and bushes. Spanish-era tile fragments incorporated into the pen walls suggest that it may have been used during the Spanish occupation of the land. The tiles were placed at consistent distances, possibly for decorative purposes.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-115 Section of cut stone wall with Spanish-era tile inclusion

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-116 Aerial view of the cut stone wall with Spanish tile inclusions

Possible Settlement Site (Slave Village)

Along a dirt road running east to the river, artefacts including wrought iron nails, iron objects, ceramics, and olive-green wine bottle sherds were found on the surface, indicating the possible presence of historical structures. This site may have been where the enslaved population lived, as the artefacts were found behind the great house and within view of the overseer's house.


Source: (Jamaica National Heritage Trust, 2023)

Plate 4-117 Metal component of a hoe head (left) and iron nail (right)

Harvesting of Lumber

Remains of a circular sawmill were observed in the overgrown bushes. This sawmill, used to cut round logs into rectangular timbers, was surrounded by several pieces of lumber.

Cattle Rearing

The historical use of the land for cattle rearing continues today with Paradise Park Limited operating a dairy cattle farm. The vast pasturelands surrounding the great house are divided into various enclosures for cattle.

Fish Breeding/Shrimping

Several large fiberglass tanks were spotted on the property, used for the commercial breeding of freshwater fish. A small catchment area at the end of a tributary of the river was also noticed, with two wicker shrimp baskets, indicating shrimp harvesting activities.

Abandoned School Building

In the centre of the zone is a single-storey building that served as a preparatory school in the 1990s. Constructed with concrete blocks and a zinc hip roof, it features wooden louvred windows and three main entrances with wooden French doors. The building is now abandoned and falling into disrepair, surrounded by land used for grazing cows.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-118 Old school building

ZONE 5

Zone 5 is the land parcel identified as Volume 1146, Folio 945. It is bordered to the north by Zone 4, to the west by Zone 3, to the south by the Caribbean Sea, and to the east by the Deans Valley River, which flows into the sea. The land is part of a low-lying coastal plain, featuring a 2,230-foot stretch of white sand beach. The eastern section of the zone is characterized by mixed wetland vegetation, including marshes and mangroves, as well as secondary coastal woodlands with sea grape (Coccoloba uyifera), seaside mahoe (Hibiscus tiliaceus), and buttonwood trees (Conocarpus erectus). There is also an untouched palm forest, and overgrown wild cane is found in the eastern part of the proposed development area.

A blue, two-storey house located on the beachfront was previously the residence of the current owners of Paradise Park. The modern structure features a hip roof with glass French windows on the original single-storey section, while the later two-storey addition has a hip roof, wooden shingle exterior walls, and glass sash windows. A low-cut stone perimeter wall surrounds the eastern side of the house, and two cannons mounted on wooden stands are positioned at the front, facing the sea.

To the rear of the house are three additional structures: a detached garage and two ancillary housing units. The property also supports poultry farming, with elongated enclosures that house chickens, quails, and pheasants. Notably, no artefact assemblages were observed on the surface of the land in Zone 5.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-119 Side profile of the beach property with historical cannons facing the sea

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-120 Elongated enclosure that houses chickens, quails and pheasants

ZONE 6

Zone 6 is the land parcel identified as Volume 1146, Folio 946, and represents the easternmost portion of the proposed development area. It is bordered to the west by the Dean's Valley River, which separates it from the southeastern quadrant of Zone 4 and Zone 5. To the east, the zone is bounded by the A2 road, which runs from Smithfield Bridge to Scott's Cove Road.

The zone is primarily characterized by a low-lying coastal plain. Near the sea, a series of curved vegetated former beach ridges align with the current coastline. The land includes mangrove swamps, dense coastal tropical forests with large trees, and stands of royal palms (Roystonea princeps).

A Taino site is located to the east of the banks of the Dean's Valley River. Based on the surface scatter of Taino artefacts, the cultural materials extend approximately 85 meters eastward. Despite the thick foliage and dense vegetation, numerous Taino pottery sherds were observed on the surface. The soil in the area was sandy loam, and interestingly, at every crabhole investigated, pieces of Taino earthenware were found. Crabs, acting as natural archaeologists, excavate below the earth and bring pottery shards, stones, and shell fragments to the surface, revealing the rich distribution of Taino material culture in the area.

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-121 Artefact assemblage showing Taino pottery near each other

Source: (Jamaica National Heritage Trust, 2023)

Plate 4-122 L-R: Pottery fragment next to crab hole; Rim sherd found on ground surface with coarse, yellow paste; Pottery sherd with grey paste on ground surface; and Pottery fragment with red paste and incised applique nubbin

4.4.9.3 SIA

According to the Jamaica National Heritage Trust website *(http://www.jnht.com/westmoreland.php)*, there are six (6) national heritage sites found within approximately 5 km of the proposed project site. These are described below.

Savanna-La-Mar Baptist Church (located approx. 3.6 km west of the proposed project area) **–** The Baptist Church in Savanna-la-mar was erected in 1835. It was destroyed by fire on the 23rd of November 1839 and rebuilt in 1840. The Church is very simple in architectural form with a rectangular floor plan. The facade is symmetrical with an arrangement of four-pointed arch window openings in the form of a crucifix. Two strategically placed projecting porches provide shelter for the entrances. There is an arrangement of five large, pointed arch windows on each side of the building. The roof is of a steep gable-ended construction (Plate 4-123).

Source: http://www.jnht.com/site_savanna_la_mar_baptist.php

Plate 4-123 Savanna-La-Mar Baptist Church

Savanna-La-Mar Courthouse (located approx. 3.5 km west of the proposed project area) **–** The Savanna-la-mar Court House was built in 1925. It is located on Great George Street, one of the major streets in the town. It is in Norman Square. The governor had donated the land called Norman Square. The square which has several other public buildings is protected by Jamaican Law. This Act is known as the Norman Square Act of 1891. This piece of legislation ensured that the expressions of Norman Square shall be deemed to include all piece or parcel of land in the town of Savanna-la-mar around the Court House. It is this piece of legislation which makes the parish's Court House so significant. It is one of the two public squares in the island to be so protected by legislation. The other is that of Mandeville in Manchester (Plate 4-124).

Source: [*http://www.jnht.com/site_savanna_la_mar_court_house.php*](http://www.jnht.com/site_savanna_la_mar_court_house.php)

Plate 4-124 Savanna-La-Mar Courthouse

Savanna-La-Mar Fort (located approx**.** 3.7 km west southwest of the proposed project area) **–** The fort at Savanna-la-mar in the parish of Westmoreland seems to have no name and is simply called the Fort. It can be seen at the end of Great George Street. It was constructed in the middle of the 18th Century at a cost of £16,000 which was funded by the parish owners. Situated partly on land and mostly in the sea, a large section of the wall in the water has crumbled. Entrance to the fort is gained through an arch in a thick stone wall which leads up to a concrete building which now houses a restaurant. The fort was built originally to protect the town but was never completed. It had mounted 18 to 20 guns and could only have promised security against pirates (Plate 4-125).

Source: [*http://www.jnht.com/site_savanna_la_mar_fort.php*](http://www.jnht.com/site_savanna_la_mar_fort.php)

Plate 4-125 Fort Montego

Manning's High School (located approx**.** 3.7 km west northwest of the proposed project area) **–** The history of the Manning's School dates back to a quarter of a century before the actual setting up of the school when in 1711, Thomas Manning, a Westmoreland planter, bequeathed a gift of land for the setting up of a free school in the parish of Westmoreland. The legal formalities which facilitated the effecting of his will were formalised in 1738 when the Jamaica Assembly made this possible by the passing of an Act, Eleventh George II chapter 9, after which the Free School was formally established.

It is interesting to note that the school was established on the present site near Savanna-la-mar instead of on the lands left by Manning at Burnt Savannah Pen at the northern end of the George's Plain. In 1780, a hurricane did extensive damage to the school and the Board petitioned the House of Assembly for help to effect repairs.

As the years progressed, the 20th Century led to the reorganization of the School into a Modern Grammar School. The oldest existing part of the school which was built in the early 20th Century is known as the Thomas Manning Building, named in honour of the school's founder. It is the most outstanding building on the entire School property and is currently used as library and classrooms.

The Thomas Manning Building is a delightful structure which is constructed from timber and the rest on a masonry plinth. Typical of the Georgian architecture, the building is perfectly symmetrical in elevation. However, for its function in the tropics, the Architect has added several features. On all sides the building has been fitted with deep verandas to add shade. The vented steep gable roof expels hot air, and a cupola with fixed jalousies provide relief for any warm air trapped in the roof. The features combined have created a perfect example of colonial architecture (Plate 4-126).

Source: http://www.jnht.com/site_mannings_high_school.php

Plate 4-126 Manning's High School

Cast Iron Fountain (located approx**.** 3.5 km west of the proposed project area) **–** Located near to the Courthouse in Savanna-La-Mar, Westmoreland, is a Corinthian fluted Cast iron Fountain. This beautiful and unique Fountain was presented to the town of Savanna-La-Mar in 1887 by E. J. Sadler, a planter from Westmoreland. Rising from the base of the Fountain are eight iron columns which give the structure an octagonal appearance. On each of the eight columns is an arch, and over each arch is a plaque with a pelican motif. Inscribed on the pelican motif is the admonition to keep the pavement dry (Plate 4-127).

Source: http://www.jnht.com/site_cast_iron_fountain.php

Plate 4-127 Cast Iron Fountain

Chebuctoo Great House (located just east of the proposed project area) **–** Chebuctoo is situated near the small village of Cave on a pimento plantation. The Great House derives its North American Indian name from the former name of Halifax in Nova Scotia with which Jamaica had considerable trade in the 18th century, especially in salted fish. The Great House possesses characteristic Georgian features: decorated with cut stone quoins and keystones over some of the window apertures, the house is two storied with a gabled shingled roof. Two small porches placed one above the other face the sea, supported by three slender wooden posts on the upper storey, but were replaced on the lower floor by concrete pillars when the building was damaged by the earthquake of 1957.

Indeed, the very construction of the house began with disaster: in 1780 there was a terrible hurricane which devastated Jamaica, and eight families decided to build houses which were hurricane-proof. An architect from England was hired for that specific purpose and Chebuctoo was one of the new homes.

According to information found in the Jamaica Almanacs, Chebuctoo was owned by Frances Jones in 1811 who retained the property well into the 1830s. Prior to Frances however, Chebuctoo was said to have been owned by one Franny Jones who was reputed to have been a stern and cruel mistress in her dealings with the enslaved Africans. During her ownership, it was said that floggings and other severe punishments were the order of the day on the estate. She is buried in a vault at some little distance from the Great House.

Chebuctoo Great House was declared a national monument by the Jamaica National Heritage Trust on December 25, 2008 (Plate 4-128).


Source: http://www.jnht.com/site_chebuctoo_great_house.php

Plate 4-128 Chebuctoo Great House

Please see **V O L U M E 2** *for the following EIA sections:*

5.0 PUBLIC PARTICIPATION

6.0 IDENTIFICATION AND ASSESSMENT OF POTENTIAL IMPACTS AND RECOMMENDED MITIGATION MEASURES

7.0 IDENTIFICATION AND ANALYSIS OF ALTERNATIVES

8.0 ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

9.0 CONCLUSION AND RECOMMENDATIONS

10.0 REFERENCES

11.0 APPENDICES