DEVELOPMENT OF KOUGA COASTAL MANANAGEMENT LINE DRAFT 1

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Abstract

The Kouga coastline, spanning iconic and socio-economically vital regions from Jeffreys Bay to Cape St Francis and the Gamtoos River mouth, faces escalating vulnerabilities driven by intense coastal erosion, severe weather events, and sea-level rise. In compliance with South Africa's National Environmental Management: Integrated Coastal Management Act (ICMA), this document outlines the framework and strategic delineation of the **Kouga Coastal Management Line (CML)**.

Annemarie Fish

Annemarie.fish@sqalproptech.com

Contents

1. Definitions

Here is a comprehensive glossary providing the exact explanations, legislative contexts, and operational definitions for each acronym, categorized by its primary functional domain within South African spatial consulting and coastal engineering.

1.1. Statutory Bodies, Organs of State, & Professional Roles

- **DFFE (Department of Forestry, Fisheries and the Environment):** The national department responsible for South Africa's environmental policy, biodiversity protection, and sustainable coastal zone management.
- **CSG (Chief Surveyor-General):** The national office responsible for regulating and maintaining all property boundaries, cadastral surveys, and approval of all land parcel divisions across South Africa.
- **NGI / CD:NGI (National Geo-spatial Information / Chief Directorate: National Geo-spatial Information):** A component of the Department of Agriculture, Land Reform and Rural Development (DALRRD) based in Mowbray, Cape Town. It serves as South Africa's national mapping agency, responsible for the national geodetic network, aerial photography, topographic data, and the primary base station networks.
- **SANHO (South African National Hydrographic Office):** An arm of the SA Navy based in Tokai, responsible for charting South African coastal waters, compiling maritime navigational charts, and calculating official tidal data.
- **MEC (Member of the Executive Council):** The provincial political head of a department (e.g., the MEC for Environmental Affairs in the Eastern Cape), who holds the statutory power to gazette provincial coastal management lines.
- **PLS (Professional Land Surveyor):** A survey professional explicitly registered under the Geomatics Profession Act to execute boundary surveys, establish property beacons, and submit legal cadastral documentation.
- **GISc (Geographic Information Science):** The scientific discipline and professional field centred on the capturing, modelling, analysing, and management of spatial datasets.
- **GIS (Geographic Information System):** The actual software, hardware, and data framework used to store, manipulate, view, and analyse geographic information.
- The **South African Geomatics Council (SAGC)** is the statutory regulatory body established by the **Geomatics Profession Act (Act 19 of 2013)**. It replaced the old South African Council for Professional and Technical Land Surveyors (PLATO).

1.2. Legislation & Regulatory Frameworks

- **SPLUMA (Spatial Planning and Land Use Management Act, Act 16 of 2013):** The national framework legislation governing all municipal land-use schemes, zoning modifications, and Spatial Development Frameworks (SDFs) across South Africa.
- **NEMA (National Environmental Management Act, Act 107 of 1998):** South Africa's foundational environmental act, outlining the duty of care, Environmental Impact Assessment (EIA) triggers, and the core principles for environmental governance.
- **ICMA / NEM:ICMA (National Environmental Management: Integrated Coastal Management Act, Act 24 of 2008):** The primary statutory act regulating the coastal zone, guaranteeing public access to the sea, and establishing rules for development near dynamic coastal environments.
- **PAIA (Promotion of Access to Information Act, Act 2 of 2000):** Legislation that enforces the constitutional right of public access to information held by the state or private entities, critical when retrieving internal municipal data or public registers.

1.3. 3. Spatial Data Standards & Geodetic Datums

- **SASDI (South African Spatial Data Infrastructure):** The institutional framework established under the SDI Act to eliminate data duplication and standardize the collection, metadata logging, and sharing of spatial datasets across all state organs.
- **SDI (Spatial Data Infrastructure):** The broad architectural mix of technology, standards, policies, and human resources required to acquire and manage geographic data across an organization or country.
- **GCS_Hartebeesthoek_1994 (Geographic Coordinate System Hartebeesthoek 1994):** South Africa's official coordinate reference system. It uses the WGS84 ellipsoid as its base and anchors all legal surveying and GIS mapping within the country to an uncorrupted geodetic reference point.
- **SANS 1878-1 (South African National Standard - Geographic Information Part 1: Metadata):** The localized national standard that governs how spatial metadata must be captured and catalogued in South Africa, ensuring absolute compatibility across state databases.
- **ISO 19115 (International Organization for Standardization - Geographic Information - Metadata):** The global standard schema for defining and structuring geographic metadata, upon which SANS 1878-1 is built.

1.4. 4. Cadastral, Property, & Boundary Management

- **CPP (Coastal Public Property):** A statutory legal zone defined by the ICMA. It primarily comprises the seashore, coastal waters, and the land submerged by them, legally owned by the citizens of South Africa and held in trust by the State; it cannot be privately owned.
- **CML (Coastal Management Line):** A legally gazetted line established under the ICMA to protect coastal property and public safety by prohibiting or restricting development within high-risk dynamic zones (e.g., areas vulnerable to erosion or storm surges).

- **CPZ (Coastal Protection Zone):** A continuous strip of land adjacent to coastal public property (typically extending 100 meters inland in urban areas and 1 kilometre in rural environments) designated to prevent ecological fragmentation and manage land-use impacts.
- **HWM (High-Water Mark):** The highest line reached by the sea during ordinary storms or regular high tides, serving as the official legal boundary dividing private property from public coastal land.
- **SG Diagram (Surveys and Mapping Diagram):** The official legal document approved by the Surveyor-General that explicitly details the exact boundary lengths, angles, coordinates, and beacons of a specific parcel of land.

1.5. 5. Hydrographic, Tidal, & Elevation Terms

- **MSL (Mean Sea Level):** The average height of the sea surface over an extended period (typically a 19-year tidal epoch), serving as the foundational reference point (0.00m) for topographical elevation tracking and land levelling across South Africa.
- **LAT (Lowest Astronomical Tide):** The lowest water level that can be predicted to occur under average meteorological conditions. It forms the standard **Chart Datum (CD)** used by the SANHO on navigation charts.
- **HAT (Highest Astronomical Tide):** The highest tidal level that can be predicted to occur under average meteorological conditions; a critical baseline indicator for identifying coastal areas vulnerable to initial sunny-day flooding.
- **LLD (Land Levelling Datum):** The national elevation reference system used by surveyors in South Africa, which is anchored directly to Mean Sea Level as measured at the primary tide gauge in Cape Town.
- **SLR (Sea-Level Rise):** The long-term progressive increase in the baseline level of the world's oceans, driven primarily by thermal expansion and melting ice sheets; a core variable in modern coastal inundation modelling.

1.6. 6. Remote Sensing, Surveying, & Technology Tools

- **GNSS (Global Navigation Satellite System):** The overarching term for satellite-based positioning arrays (including GPS, GLONASS, Galileo, and BeiDou) used to capture high-precision geographic coordinates in the field.
- **LiDAR (Light Detection and Ranging):** An active remote sensing technique that emits laser pulses from an aircraft or vehicle to calculate precise distances to the earth's surface, generating highly dense 3D point clouds.
- **SRTM DEM (Shuttle Radar Topography Mission Digital Elevation Model):** A global elevation dataset captured by NASA space shuttle radar in 2000. It offers open-source topography data at a roughly 30-meter resolution, frequently used for initial large-scale catchment calculations before high-res terrain assets are deployed.

2. Establishment of coastal management lines

2.1. Legal Framework

National Environmental Management: Integrated Coastal Management Act (Act No. 24 of 2008), commonly known as the **ICMA**, provides for the statutory mandates and procedural requirements for establishing a CML (Republic of South Africa, 2008; Law Library, 2025).

Section 25 of the ICMA: The Power to Establish CMLs

- **Provincial Mandate:** Section 25(1) empowers the provincial MEC (Member of the Executive Council) for environmental affairs, acting in alignment with provincial environmental authorities to establish or amend a CML.
- **The Purpose:** The Act explicitly states that lines must be established to:
    - Protect **coastal public property (CPP)**, private property, and public safety.
    - Protect the **coastal zone itself** (ecosystems, dunes, and sand-bypass systems).
    - Control or prohibit development in areas at risk from Sea Level Rise (SLR), storm surges, or coastal erosion

Section 15 of the ICMA: Prohibition on Shoreline Armouring

A critical piece of legislation that works in tandem with the CML is Section 15. It explicitly prohibits any person from constructing retaining walls, revetments, or seawalls to prevent coastal erosion if it impacts coastal public property, unless authorized. The CML acts as the spatial line indicating where nature must be allowed to take its course (Republic of South Africa, 2008; Law Library, 2025).

Further powers and functions relating to the Coastal Management Line includes:

An MEC must by notice in the *Gazette* establish or change coastal management lines

(a)to protect coastal public property, private property and public safety;

(b)to protect the coastal protection zone;

(c)to preserve the aesthetic values of the coastal zone; or

(d)for any other reason consistent with the objectives of this Act.

(1A) An MEC may, in regulations published in the *Gazette*, prohibit or restrict the building, erection, alteration or extension of structures that are wholly or partially seaward of a coastal management line.

(1B) When establishing coastal management lines in terms of subsection (1), the MEC must consider the location of immovable property and the ownership and zonation of vacant land.

(2) Before making or amending a notice referred to in subsection (1), or making the regulations referred to in subsection (1A), the MEC must;

(a) consult with any local municipality within whose area of jurisdiction the coastal management line is, or will be, situated; and

(b) give interested and affected parties an opportunity to make representations in accordance with Part 5 of Chapter 6.

(3) A local municipality within whose area of jurisdiction a coastal management line has been established must delineate the coastal management line on a map or maps that form part of its zoning scheme in order to enable the public to determine the position of the coastal management line in relation to existing cadastral boundaries.

(4) A coastal management line may be situated wholly or partially outside the coastal zone

(5) The Minister, after consultation with the relevant MEC, must exercise the powers and perform the functions granted to the MEC in this section, if such power relates to any part of an area that

(a) is a national protected area as defined in the Protected Areas Act;

(b) straddles a coastal boundary between two provinces; or

(c) extends up to, or straddles, the borders of the Republic.*[section 25 substituted by section 18 of Act 36 of 2014]*

Provincial policy states that the implementation of stringent Coastal Management Lines (CMLs) as required by the ICM Act, is urgently required for the Eastern Cape, as they aim to regulate development in coastal zones at risk of flooding and erosion (among other management goals) and contribute to risk and disaster reduction, for current and future development.

In short, CMLs are one of the most effective adaptation tools for ensuring coastal climate-change resilience, especially for a coast that is largely still undeveloped and can benefit significantly from proactive measures (Eastern Cape Department of Economic Development, Environmental Affairs and Tourism, 2025).

Key Legal Elements of Section 27 of the ICMA:

Section 27 grants the national Minister the authority to determine or adjust the inland boundary of Coastal Public Property (CPP) by notice in the Government Gazette which was later repealed in 2014. The critical revision as per Act 36 of 2014, included "Exclusion" Repeal: In the original 2008 text of the ICMA, Section 27 contained clauses that allowed the Minister to exclude certain areas from Coastal Public Property under specific economic or developmental conditions (such as formalizing historic harbour land). The 2014 Amendment repealed those exclusion clauses. This change was highly significant for spatial planning: it permanently closed the legal loophole that allowed parts of Coastal Public Property to be privatized or stripped of their protective public-trust status. State-owned coastal land, seashores, and the Admiralty Reserve are strictly locked as public assets.

The legal mandate of the Chief Surveyor-General (CSG) is derived primarily from the **Land Survey Act (Act No. 8 of 1997)** and the **Geomatics Profession Act (Act No. 19 of 2013)**. Its responsibilities are split across four key pillars (Republic of South Africa, 1997; Republic of South Africa, 2013; Chief Surveyor-General, n.d.).

The Chief Surveyor-General's statutory functions include cadastral oversight, examination of survey records and maintenance of cadastral information (Chief Surveyor-General, n.d.).

Regulatory Oversight & Standards Enforcement

The CSG is the ultimate statutory authority that defines *how* land surveying is conducted in South Africa.

- It creates and amends regulations detailing accuracy tolerances, survey methods, and boundary demarcation rules.
- It ensures that all work submitted by Professional Land Surveyors (PLS) complies with strict spatial and legal standards before it is made official.

Examination and Approval of Cadastral Documents

The CSG operates regional offices across the provinces, headed by regional Surveyors-General. These offices examine and formally approve:

- **SG Diagrams:** The unique legal document defining a single property's coordinates, beacons, and boundaries.
- **General Plans:** Grouped layouts representing town planning subdivisions, extensions, or large-scale developments.
- **Sectional Title Plans:** The spatial layouts governing three-dimensional property ownership (apartments, complexes).

Maintenance of the Cadastral Record System

The CSG maintains a permanent public record of every surveyed piece of land in South Africa. This includes historical records dating back centuries as well as modern digital databases.

- It maintains the **National Cadastral Spatial Database**, providing the foundational "property polygon" layers used by municipalities, GISc professionals, and utility companies across the country.

Managing Shifting Biophysical Boundaries

Under specific environmental legislation like the **Integrated Coastal Management Act (ICMA)**, the Chief Surveyor-General has the unique statutory power to approve maps that formally determine or *fix* a High-Water Mark (HWM) boundary, providing legal certainty where dynamic natural lines intersect with private land ownership.

2. Why the CSG is Critical to the Spatial Economy

The purpose of the CSG extends far beyond simply archiving maps. It serves as the ultimate bedrock for:

- **Securing Land Tenure:** By ensuring that property boundaries are mathematically precise and uniquely identifiable, the CSG prevents boundary disputes and guarantees that when a financial institution issues a mortgage or a citizen buys a home, the physical land matches the legal Title Deed.

- **Enabling Spatial Planning (SPLUMA):** Municipalities rely entirely on the base cadastral layers approved by the CSG to draft their Spatial Development Frameworks (SDFs), manage land-use schemes, and enforce zoning regulations.
- **Supporting the South African Spatial Data Infrastructure (SASDI):** The CSG is a vital base data custodian. The property layers it approves form the core framework onto which all other spatial datasets—such as environmental hazard overlays, infrastructure routing, and population density grids—are mapped.

Without the regulatory oversight of the CSG, South Africa's deeds registry system could not function, and secure land tenure would collapse.

Where Section 27 and the Chief Surveyor General intersects:

The table below outlines how administrative law and cadastral practice interact when defining these shifting coastal lines:

Feature	NEM: ICMA Section 27 (Administrative Boundary)	SG Practice Notes / Land Survey Act (Cadastral Boundary)
Primary Authority	Minister of Forestry, Fisheries and the Environment (DFFE).	Surveyor-General / Chief Surveyor-General (DRDLR).
Legal Nature	Statutory/Administrative determination of public domain.	Precise geometric registration of real property rights.
Handling Movement	Fixed via a *Gazette* notice until a subsequent administrative adjustment is published.	Dynamically shifts based on physical, natural coastal processes on the ground.
Operational Trigger	Public interest, environmental protection, or long-term hazard mitigation.	Development applications, subdivisions, or environmental authorizations (EIAs).
Resolution of Conflict	Overrides old cadastral diagrams; the SG must endorse or amend records to reflect the *Gazette*.	Recommends a fresh, site-specific physical survey if an existing diagram is outdated.

The Moving Boundary vs. The "Loss" of Private Land

Historically, under South African common law (*the doctrine of accretion and avulsion*), if the sea gradually washed away land, the private property boundary moved landward, and the owner lost that land to the State. The ICMA formalized and strengthened this via **Section 14**.

Legal Conflict

When severe erosion occurs such as the massive coastal damage seen along the St Francis Bay spit or during the **May 2026 storms in Kouga,** the physical HWM can shift significantly inland, sometimes crossing straight through a private owner's surveyed Erf, putting their home physically in the "seashore."

Landowners frequently challenge authorities on constitutional grounds under **Section 25 of the Constitution (The Property Clause)**, arguing that the automatic conversion of their private property into Coastal Public Property (CPP) due to a shifting HWM constitutes an **unconstitutional, uncompensated expropriation of land**.

Thus far, South African courts and the framework of the ICMA hold that the seashore belongs to the citizens of South Africa as a public trust. Because the shift is caused by *natural forces* rather than a proactive state acquisition, it is viewed as a natural limitation of a dynamic property boundary rather than an unconstitutional expropriation.

Because the HWM dictates where private property ends and public land begins, how the line is physically mapped is a frequent source of litigation.

Under the ICMA, the HWM is defined as the highest line reached by the sea during ordinary storms occurring during the stormiest period of the year (excluding exceptional or catastrophic events).

When the HWM moves landward and threatens to undermine a physical building, property owners often attempt to build emergency rock revetments, geotextile sandbags, or concrete seawalls to defend their assets.

Section 15 of the ICMA explicitly prohibits anyone from constructing structures that prevent the natural movement of the HWM or impede public access along the coast, unless authorized.

Municipalities and the province regularly issue **Compliance Notices** and **Directive Orders** forcing owners to dismantle unauthorized sea defences.

Property owners challenge these directives in court by claiming an urgent "right to protect property" or alleging that the state's failure to maintain public coastal infrastructure (like public dynamic dune systems) forced their hand. This creates long drawn-out legal standoffs while the physical beach continues to erode around the disputed structures.

2.1.1. Chief Surveyor-General Advisory Note on High-Water Mark Determination

In response to recurring disputes involving coastal property owners and shifting coastal boundaries, the Chief Surveyor-General issued an Advisory Note to the Department of Forestry, Fisheries and the Environment on the practical determination of the High-Water Mark (HWM).

The advisory note clarifies that, for spatial planning and decision-making purposes, the HWM must be determined in accordance with the *Land Survey Act 8 of 1997*. This is important because the HWM has legal consequences for cadastral boundaries, coastal public property and development control.

- **Legal defensibility:** A HWM intended to withstand legal scrutiny must be located and surveyed according to the requirements of the Land Survey Act.
- **Professional responsibility:** Only a Professional Land Surveyor may lawfully locate and survey the HWM for cadastral purposes.
- **Planning relevance:** Where the position of the HWM affects development rights, environmental authorisations or coastal management decisions, the surveyed position should be treated as the authoritative basis for decision-making.

Lastly, it is recommended that any organ of state required to give planning approval based on a development application or environmental impact assessment in terms of any law, and the property in question is bounded by the High water Mark or any line parallel thereto and where the accuracy of the position of the High-water Mark may be in question and would have a material impact on the proposed development, that organ of state could request the applicant to obtain a re-determination of the position of that portion of the High-water Mark affecting the property prior to the development application being considered further. Such re-determination of the High-water Mark affecting the property would, in consultation with the Surveyor-General concerned, be surveyed by a Professional Land Surveyor whose services would be procured by the applicant.

While the high-water mark is, with a few exceptions, a cadastral boundary, it is, by definition, an ambulatory line, which means that it moves dynamically because of the causes referred to in the introduction. Due to its ambulatory nature, the position as physically surveyed is only the legal position of the high-water mark on the date of survey. This position may become outdated over time because of its natural movement, and the recorded position may not be useful for decision-making purposes

Cadastral documents (diagrams, general plans and sectional plans) approved by the Surveyors-General are the legal documents that define cadastral spatial data. These documents are freely available through the Chief Surveyor-General's website. Every diagram and general plan that describes a land parcel or land right as extending to or bounded by the high-water mark depicts the legal position of the high-water mark at the date on which it was surveyed (Chief Surveyor-General, n.d.; Williams-Wynn, 2021). The legal position of the high-water mark is lawfully surveyed by Professional Land Surveyors external to the Offices of the Surveyors-General.

The approach that needs to occur involves surveying of effect property, in consultation with the relevant Surveyor-General who shall, if deemed necessary, visit the site with the Professional Land Surveyor appointed to undertake the survey. The Professional Land Surveyor as required would lodge the completed survey with the Surveyor-General for examination and record purposes, and the Surveyor-General shall only accept the surveyed position when he or she is satisfied that the position complies with all applicable legislation and good practice (Williams-Wynn, 2012, Fisher and Whittal, 2020, pp. 505 - 574).

2.1.2. Highwater mark determination:

The Chief Directorate: National Geo-spatial Information (NGI), the national mapping component, can assist Surveyors-General in generating a reasonable approximation of the high-water mark using agreed standards, methodology and metadata, with consistent data sources that more accurately reflect current coastal conditions for spatial planning and decision-making (Chief Directorate: National Geo-spatial Information, n.d.; Williams-Wynn, 2021).

NGI have established a positional line colloquially called the "Mean Sea Level" (or MSL) as their land levelling datum). By definition (ICMA, 2008), the high-water mark cannot be below MSL. Therefore, MSL will be the lowest possible limit (most seaward position) of any high-water mark determination; A vertical datum is used for measuring the elevations of points on the Earth's surface.

In South Africa, a separate datum is used for horizontal and vertical coordinates. The vertical datum, sometimes referred to as the Land Levelling Datum, is based on mean sea-level observations at tide gauges at Cape Town, Port Elizabeth, East London and Durban at the beginning of the 1900s. Published heights of benchmarks, town survey marks and trigonometrical beacons are given as heights above the Land Levelling Datum, which is close to, but not exactly the same as, the geoid (Chief Directorate: National Geo-spatial Information, n.d.). The NGI geoid and vertical reference frame guidance was used as the vertical-datum reference for the land levelling datum discussion (Chief Directorate: National Geo-spatial Information, n.d.). Where or when available, LiDAR determination of the elevation of the mean high-water spring (HWS) as defined and determined from the tide gauge records can supersede the MSL as the most seaward position of any high-water mark determination. The South African shoreline and high-water-mark interpretation follows the cadastral and coastal-boundary discussion set out by Williams-Wynn (2021).

2.1.3. Spatial Data Requirements and its legal implications:

2.1.4. Spatial Data and Professional Capacity Requirements

The *National Guideline Towards the Establishment of Coastal Management Lines* provides an important policy framework for CML development; however, it gives limited practical guidance on the detailed spatial-data requirements and professional capacity needed to implement CML modelling at municipal scale (Department of Environmental Affairs, 2018).

- **Spatial-data requirements:** Municipal-scale CML modelling requires high-resolution, vertically consistent and legally defensible datasets, including cadastral boundaries, elevation data, bathymetry, tide levels, erosion indicators and coastal hazard layers.
- **Professional skills:** The development of reliable CML spatial products requires input from appropriately registered geomatics, GISc, coastal engineering and environmental specialists, especially where model outputs may inform planning controls or development restrictions.
- **Implementation implication:** Without clear minimum data standards and defined professional responsibilities, CML outputs may vary significantly between municipalities and may be vulnerable to technical or legal challenge.

2.1.5. Map Scale and Spatial Resolution

Map scale and spatial resolution determine whether coastal spatial data are suitable for municipal-scale CML modelling and site-level decision-making. Small-scale maps are useful for regional overview mapping, while large-scale maps and high-resolution raster data are required where outputs may affect individual properties or development controls.

- **Small-scale mapping, such as 1:50 000:** This scale covers a large geographic area but generalises detail. A line drawn at this scale may represent a broad real-world position rather than a precise boundary, and should not be treated as accurate enough for cadastral or property-specific decisions.

- **Large-scale mapping, such as 1:1 000:** This scale focuses on a smaller area, such as a single coastal erf or development site, and supports more detailed interpretation of boundaries, features and coastal-risk lines.
- **Spatial resolution:** Resolution refers to the physical size of each raster cell or pixel. For example, a 30 m SRTM DEM is suitable for broad regional analysis, while a 1 m LiDAR-derived DEM is more appropriate for modelling flood lines, storm-surge extents and coastal management lines at municipal or site level.

2.1.6. Data Accuracy, Legal Mandate and Metadata Requirements

2.1.6.1. Data Accuracy and Scale Limitations

Data accuracy refers to how closely a digital spatial coordinate, elevation value or mapped feature represents its true physical position on the surface of the Earth. A common modelling error is to place small-scale, generalised data into a high-resolution GIS environment and then treat the resulting output as more accurate than the source data allows.

For coastal monitoring and CML modelling, this means that maps produced for broad regional assessment may not always have the scale, resolution or positional accuracy required for site-specific planning, cadastral interpretation or development-control decisions.

2.1.7. Legal Mandate for Spatial Modelling

Under South African law and the statutory framework of the South African Geomatics Council (SAGC), the legal authority to create or certify a spatial data model depends on what the model defines and how its results will be used. The *Geomatics Profession Act 19 of 2013* regulates who may perform specific categories of spatial work to protect the public interest, maintain professional standards and support the integrity of the cadastral and deeds-registration systems.

2.1.8. Non-Cadastral Spatial Hazard Models

Where a spatial model functions as a predictive risk or planning overlay, it does not directly redefine title-deed boundaries. Examples include:

- modelling a Coastal Management Line using cross-shore profiles or the Bruun Rule;
- interpolating water levels using Inverse Distance Weighting;
- mapping an Estuarine Functional Zone; or
- preparing coastal hazard overlays for environmental or municipal planning purposes.

Because these outputs inform environmental controls, spatial planning policy or risk-management decisions rather than cadastral boundary definition, they do not necessarily require a Professional Land Surveyor. However, where the outputs are intended to support municipal Spatial Development Frameworks, land-use schemes or statutory decision-making, they should be prepared or certified by an appropriately registered Geomatics Professional in GISc to improve technical defensibility.

2.1.9. Spatial Data Infrastructure and Metadata Obligations

The *Spatial Data Infrastructure Act 54 of 2003* establishes requirements for spatial data collection, management and metadata publication by organs of state and public data custodians. These requirements are intended to avoid duplicated public expenditure, promote national data standards and support the National Data Capture Project Register.

- **Statutory mandate:** Section 12 of the SDI Act requires metadata to be published for spatial data products developed by, or on behalf of, an organ of state or base data custodian.
- **PAIA manual connection:** Section 12(2)(b) links spatial metadata to the public body's mandatory manual under Section 14 of the Promotion of Access to Information Act. This means that relevant spatial datasets should be discoverable through the public body's information-access framework.
- **Reference standard:** Metadata should be profiled according to SANS 1878-1, South Africa's adaptation of the ISO 19115 geographic metadata standard.

Implication for CML Modelling

For CML modelling, the practical implication is that spatial outputs must be fit for purpose, professionally defensible and supported by appropriate metadata.

3. COASTAL SPATIAL DATA MODELLING AND DELINEATION

3.1. Coastal Protection Zone Delineation

According to Section 16 of the ICMA, the coastal protection zone consists of a continuous strip of land starting from the HWM and extending inland for a default distance of either 100 m or 1 000 m, depending on land-use circumstances and sensitive coastal features (Republic of South Africa, 2008; Law Library, 2025).

- Urban Areas (100m Buffer): Any land unit situated wholly or partially within 100 meters inland from the High-Water Mark (HWM) that was zoned for residential, commercial, or industrial use when the Act came into force.
- Rural/Agricultural Areas (1km Buffer): Any land unit situated wholly or partially within 1 kilometre (1,000 meters) inland from the HWM that was zoned for agricultural, undetermined, or conservation use, or was not part of a lawfully established urban area.

The CPZ was delineated according to the following key principles:

SG Cadastral Boundaries utilized for the development of the HWM.

- Cadastral properties along the coast line which included Public Open Spaces, erven, farms, parent farms, unalienated rivers and unalienated state land.
- Dissolve and merge all features into a polygon and convert to a line features from which the outer boundary of the cadastral seawards were selected to create the HWM.
- Downloaded relevant SG diagrams along the coast line.

- The HWM line was classified into Rural and Urban to affect the 100m and 1000m buffer.

3.1.1. Urban and Rural Classification Method

The urban and rural classification was based on cadastral spatial data provided by the Surveyor-General. Farm portions were used to define rural segments, while erven and allotments were used to define urban segments. This distinction informed the application of the 100 m and 1,000 m Coastal Protection Zone buffers and was aligned with the Subdivision of Agricultural Land Act 70 of 1970 (Republic of South Africa, 1970).

No Physical Subdivision: Agricultural land cannot be subdivided into two or more physical portions.

No Undivided Shares: An owner cannot transfer an undivided share in a farm to another person (a common historical legal loophole used to bypass physical subdivision by making multiple people co-owners of a single farm).

No Long-Term Leases on Portions: You cannot lease a *portion* of agricultural land to someone else for a period exceeding 10 years (or for the lifetime of the lessee).

No Sectional Title Schemes on Farmland: You cannot establish a sectional title scheme or share-block scheme on land classified as agricultural.

The Surveyor-General's Statutory Mandate

Under **Section 4 of Act 70 of 1970**, the Surveyor-General (SG) functions as the ultimate state gatekeeper for the cadastral processing pipeline.

- **The Survey Restriction:** A Land Surveyor can physically go into the field and survey a farm split, but the SG **shall not examine or approve** the resulting draft subdivisional diagram or general plan unless the physical copy of the **Ministerial Consent Certificate** (bearing the official departmental stamp and unique conditional parameters) is physically appended to the survey records submission.

- **The Error Block:** If a land surveyor submits a farm subdivision without this certificate, the SG office will instantly reject the entire survey dataset, halting the property registration pipeline before it ever reaches the Deeds Office.

Municipal Planning Approval
After ministerial approval has been granted, the applicant must also obtain municipal approval under SPLUMA. This approval must be consistent with the applicable Spatial Development Framework and the relevant land-use management scheme.

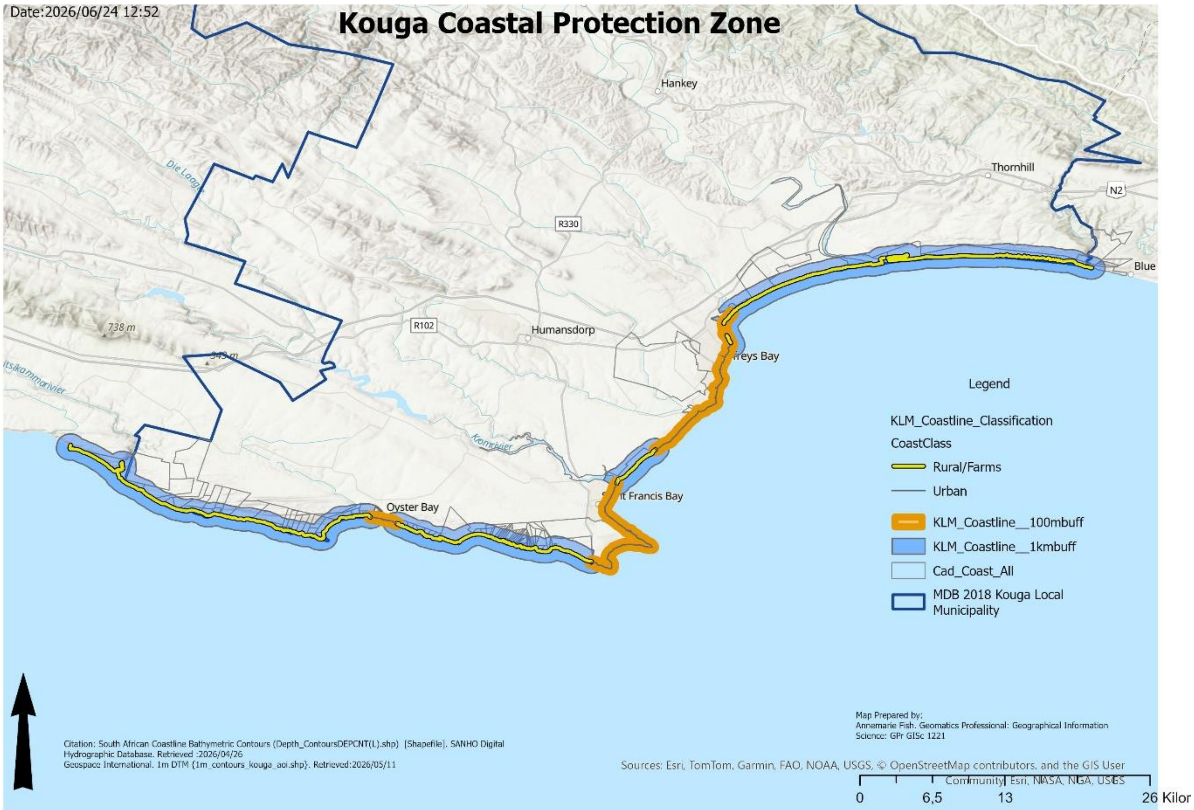


Figure 1: Modelled Coastal Protection Zone for the Kouga Coastline. Source: Annemarie Fish, Geomatics Professional: Geographical Information Science GPr GISc 1221, derived from Chief Surveyor-General (2025) cadastral data

3.2. Development of Kouga Coastal Management Line methodology

Geographical Information Systems and geoprocessing tools were utilised to develop the coastal management line spatial data products. The key software used was ArcGIS Pro and QGIS. The software solutions provide various geoprocessing tools that were applicable to the CML development.

Spatial data sources were obtained from the Surveyor-General Eastern Cape, Municipal Demarcation Board, South African National Hydrographic Office and Geospace International Pty Ltd, with bathymetric and tide-related information referenced to SANHO sources where relevant (South African National Hydrographic Office, n.d.; South African National Hydrographic Office, 2026).

3.2.1. Choosing the Correct Vertical Datum

Spatial data showing height, elevation and depth need to be merged for modelling of seaward related flooding and storm surges. To create seamless raster layer using Bathometry data and Digital Terrain model required vertical datum correction which was applied as follows.

In South Africa, the national vertical datum is maintained by the **Chief Directorate: National Geo-spatial Information (NGI)**, a branch of the Department of Agriculture, Land Reform and Rural Development (Chief Directorate: National Geo-spatial Information, n.d.).

The following adjustments had to be applied to any bathometry data that is provided at a Chart Datum versus land related surveys which is provided a Land Levelling Datum. NGI ran precise levelling lines across the country, implanting physical brass pegs known as **Town Benchmarks** and **Trig Beacons.**

Understanding the NGI vertical datum requires looking at two distinct but intertwined frameworks: the historical **Land Levelling Datum (LLD)** and the modern **South African Gravimetric Geoid (SAGG)** models used to compute orthometric heights via GNSS.

Engineering vs. Marine Datums in South Africa

When working on coastal or infrastructure projects, it is vital to distinguish between NGI's land levelling datum and maritime datums:

- **Terrestrial Projects:** All civil engineering, municipal GIS, stormwater infrastructure, and environmental mapping (such as SPLUMA land-use schemes or NEMA flood line assessments) must use the **NGI LLD / Gravimetric Geoid**.
- **Marine & Hydrographic Projects:** Bathymetry and nautical charts maintained by the South African Navy Hydrographic Office use **Chart Datum (CD)**, which is set at **Lowest Astronomical Tide (LAT)**.

Critical Coastal Link: Because NGI's LLD represents Mean Sea Level, it does not match Chart Datum. For instance, along much of the South African coast, Chart Datum (LAT) is roughly 0.9m to 1.1m below the NGI LLD. Mixing these up in coastal vulnerability or sea-level rise modelling can cause catastrophic errors in inundation zones.

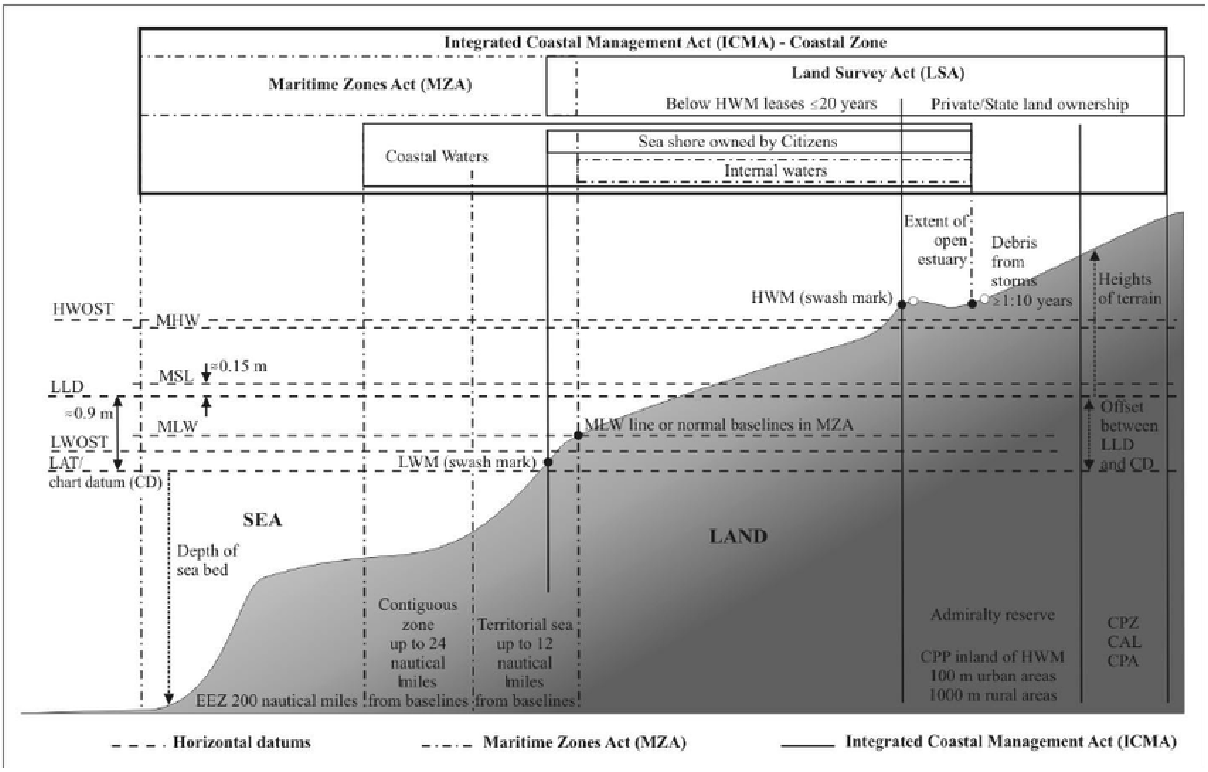


Figure 2 Coastal zones, datums, water marks, and boundary legal frameworks in the coastal zone (Whittal and Fisher (2011)

In GIS modelling for the **Kouga Coastal Management Plan**, selecting the correct bathymetry line is a matter of defining the "Seaward Boundary" and the "Depth of Closure." For Sea Level Rise (SLR) and CML delineation in South Africa, it's a general practise to use the **-15m Chart Datum (CD)** line. (Zwamborn, 1978).

3.2.2. Bathymetry and DEM Datum Alignment

To merge the bathymetry and DEM datasets for the Jeffreys Bay and St Francis area, the bathymetry must first be converted from Chart Datum (CD) to the Land Levelling Datum (MSL) used by the terrestrial DEM.

The South African Navy Hydrographic Office (SANHO) defines and publishes tide, chart datum and hydrographic information, with the nearest primary tidal reference for the study area being Gqeberha/Port Elizabeth (South African National Hydrographic Office, n.d.; Permanent Service for Mean Sea Level, n.d.).

3.2.3. Vertical Conversion Offset

Chart Datum (CD): SANHO bathymetry data is typically referenced to Lowest Astronomical Tide (LAT), the hydrographic zero used for nautical charts.

Land Levelling Datum (LLD/MSL): Terrestrial DEMs and topographic mapping use Mean Sea Level (MSL) as the vertical reference.

For data collected from 1 January 2003 onwards, Chart Datum (CD/LAT) at Gqeberha is 0.836 m below the Land Levelling Datum (MSL).

3.2.3.1. Bathymetry Adjustment Formula

Use the Raster Calculator to align the bathymetry with the terrestrial DEM:

- **If depth values are positive:** ("Bathymetry_Raster" * -1) + 0.836. For example, a 10 m depth becomes -10 + 0.836 = -9.164 m relative to MSL.
- **If depth values are already negative:** "Bathymetry_Raster" + 0.836.

3.2.4. Projection and Final Alignment Checks

Because the bathymetry is already in Lo25, it uses the South African national grid projection and is horizontally aligned with local topographic standards for the Jeffreys Bay and St Francis area.

Before merging with the DEM for HAT flood mapping, confirm that both the ellipsoid shift and the vertical datum offset have been addressed.

The projection applied to the raster datasets:

Projected Coordinate System TRANSVERSE_MERCATOR_M_HART94

Projection Transverse Mercator

Authority Custom

Linear Unit Meters (1,0)

False Easting 0,0

False Northing 0,0

Central Meridian 25,0

Scale Factor 1,0

Latitude Of Origin 0,0

Geographic Coordinate System GCS_Hartebeesthoek_1994

WKID 0

Authority

Angular Unit Degree (0,0174532925199433)

Prime Meridian Greenwich (0,0)

Datum D Hartebeesthoek 1994

Spheroid GRS 1980

Semimajor Axis	6378137,0
Semiminor Axis	6356752,314140356
Inverse Flattening	298,257222101

The bathometry data or depth contour provided by SANHO was in a vector line format. To ensure the data can be used to model storm surges the data had to undergo the following geoprocessing: Using a geoprocessing tool a point feature was generated along the depth contour at 5 m intervals to provide input to the Inverse Distance Weighting (IDW) model which is an deterministic spatial interpolation method.

Name	reproj_depthcontour_deptcntlsplit5m
Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\reproj_depthcontour_deptcntlsplit5m.shp
Sidecar files	reproj_depthcontour_deptcntlsplit5m.cpg, reproj_depthcontour_deptcntlsplit5m.shx, reproj_depthcontour_deptcntlsplit5m.dbf, reproj_depthcontour_deptcntlsplit5m.prj
Total size	159.53 MB
Last modified	Tuesday, 05 May 2026 09:11:46 (reproj_depthcontour_deptcntlsplit5m.shp)
Provider	ogr

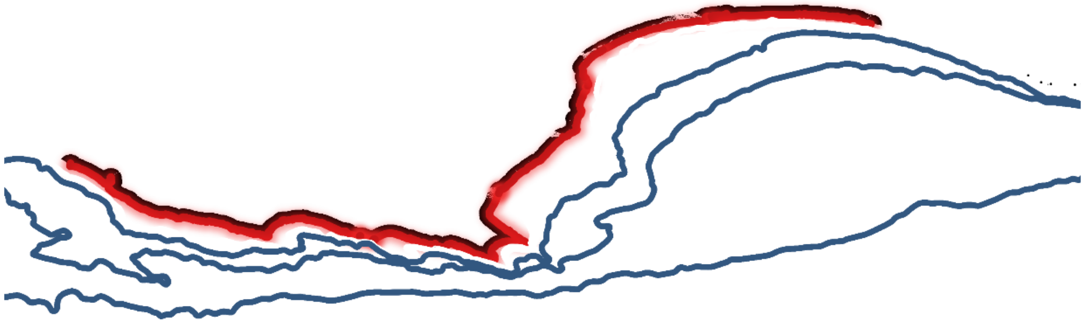


Figure 3 Depth Contours at a 5m point feature interval

The adjustments were done using the following values:

Feature	GIS Layer Source	Reference Datum	Conversion for Kouga
Land Elevation	Geospace 1m DTM	**LLD (Land Levelling)**	Keep as 0.0m
Sea Floor	SANHO Bathymetry	**CD (Chart Datum)**	Subtract -0.84m

The IDW-derived bathymetry raster was converted to negative depth values and adjusted by subtracting 0.84 m rounded from -0.836m. The raster calculation applied was: -15 m which is the chart datum – (-0.84 m).

Summary of Values for Jeffreys Bay

Feature	Value (Chart Datum)	Value (Land Datum/MSL)
HAT Level	2.14m	**1.30m**
Zero Level	0.00m	**-0.836m**

To establish an accurate vertical datum and facilitate tide-gauge interpretation, the Gqeberha (Port Elizabeth) tide-gauge station was utilized as the primary reference point (Permanent Service for Mean Sea Level, n.d.). The generated Inverse Distance Weighting (IDW) bathymetric raster was reprojected to the Lo25 coordinate reference system and resampled to a 1m* 1m cell size to match the spatial resolution of the Geospace 1m Digital Elevation Model (DEM). Using the Align Raster tool, the resampled bathymetry layer (Batho_IDW) was structurally aligned with the land-based 1m DEM. Finally, a dedicated seaward vector mask (Batho_Clip_Area.shp) was applied to clip the bathymetric dataset to the Kouga coastal boundary, producing a clean, integrated terrain model optimized for subsequent inundation calculations.

The following spatial and environmental datasets were systematically generated during the execution of this project:

Name	Batho_IDW
Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\Batho_IDW.tif
Size	453.09 MB
Last modified	Tuesday, 05 May 2026 15:19:50
Provider	Gdal

Data Type	Raster
Location	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour
Name	Batho_IDWClip.tif
Vertical Units	Meter

Name	Clip_Batho_IDWClip
Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\Clip_Batho_IDWClip.tif
Side car files	Clip_Batho_IDWClip.tif.ovr, Clip_Batho_IDWClip.tfw, Clip_Batho_IDWClip.tif.aux.xml
Total size	9.74 GB

Last modified	Friday, 08 May 2026 10:16:14 (Clip_Batho_IDWClip.tif.aux.xml)
Provider	gdal

Name	Batho_IDWClip_negative
Path	[E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\Batho_IDWClip_negative.tif](E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\Batho_IDWClip_negative.tif)
Size	9.60 GB
Last modified	Friday, 08 May 2026 14:16:16
Provider	gdal

To represent seabed elevations correctly relative to the terrestrial baseline, the clipped Inverse Distance Weighting (IDW) bathymetric model was inverted to reflect negative depth values below the land datum. This vertical adjustment was executed via a raster calculator transformation using the following expression:

Adjusted Bathometry :Clip_Batho_IDWClip * -1

To facilitate the seamless integration of the marine and terrestrial datasets, the bathymetric raster was horizontally reprojected into a uniform coordinate reference system. This transformation eliminates spatial offsets and ensures absolute pixel co-registration, enabling an accurate merge of the two elevation surfaces into a unified digital terrain model.

The following spatial and environmental datasets were systematically generated during the execution of this project:

Name	batho_idw_1m_dsm_merge

Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\batho_idw_1m_dsm_merge.tif
Side car files	batho_idw_1m_dsm_merge.tif.aux.xml, batho_idw_1m_dsm_merge.tfw, batho_idw_1m_dsm_merge.tif.ovr
Total size	10.75 GB
Last modified	Friday, 08 May 2026 16:41:16 (batho_idw_1m_dsm_merge.tif.aux.xml)
Provider	gdal

To ensure absolute vertical accuracy, the chart datum interpretation was cross-referenced and validated against official tidal publications and geodetic guidelines issued by the South African National Hydrographic Office and national tidal tables (SA Tides, n.d.; South African National Hydrographic Office, n.d.)

3.2.5. Merging Workflow for HAT Analysis

After converting the bathymetric surface to MSL, the Highest Astronomical Tide (HAT) of 2.14{m} (Chart Datum) converts to 1.30m relative to the terrestrial land datum 2.14m - 0.836m = 1.304m.

The integration workflow is executed across four key phases:

1. **Data Projection:** Confirm both datasets are standardized to the **Hartebeesthoek94 / Lo25** coordinate reference system.
2. **Datum Transformation:** Convert positive chart depths to negative values relative to MSL using the raster calculator formula: ("Bathymetry" * -1) + 0.836.
3. **Raster Fusion:** Execute a surface merge using **Mosaic To New Raster** (ArcGIS Pro) or **Merge** (QGIS).
4. **Layer Hierarchy:** Arrange input priority so that the bathymetric raster overwrites the flat water mask in the terrestrial DEM, establishing a continuous land-sea terrain model.

Level	Height (m) Relative to CD	Height (m) Relative to Land Levelling Datum
HAT (Highest Astronomical Tide)	**+2.14 m**	**+1.23 m**
MHWS (Mean High Water Springs)	**+1.85 m**	**+0.94 m**

ML (Mean Level)	**+1.04 m**	**+0.13 m**
LAT / CD (Chart Datum)0.00 m-0.84 m		**CD0.00 m LLD-0.84 m**

Data base	**E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\Kouga_Lm_CoastalManagement.gdb** **null_2m_contours_kouga_aoi_HAT**

3.2.6. Key Data Variables for Geo Processing Modelling of the CML

Tidal Level	Height (m)	Description
HAT (CHART DATUM)	**2.44m**	**The highest level reachable under average weather. (https://www.sanho.co.za/Default.htm)**
LAND LEVELING DATUM	**0.836**	**LAND LEVELLING AS PER https://www.sanho.co.za/Default.htm**
HAT FOR KOUGA AREA	**2.44 – 0.836 =**	**1.60M** **Used the 2m contour**
MHWS (Mean High Water Springs)	**1.86 metres. CD**	**LLD/MSL): MHWS is +1.03 metres.**
Storm Surge (1:10 yr)	**+0.45 m**	**Typical storm surge additive for the Eastern Cape.**
Storm Surge (1:100 yr)	**+0.75 m**	**Extreme event surge.**
Total (HAT + 1:100 Surge)	**2.89 m**	**The "extreme" high water level (excluding waves).**
Reference Datum	**Elevation for ML**	**Elevation for MSL**
Land Levelling Datum (LLD)	**+0.20 m**	**0.00 m**

3.3. The Primary Line: -15m (Depth of Closure)

Along the Western and Eastern Cape coastlines, the -15m Chart Datum (CD) contour is formally recognized as the representative regional **Depth of Closure (DoC)**. This morphological boundary defines the depth beyond which there is no significant, measurable sediment exchange between the nearshore beach system and the deeper offshore seabed. In Geographic Information System (GIS) applications—particularly when modeling Sea-Level Rise (SLR) induced shoreline retreat via the Bruun Rule or advanced profile-response models—this contour serves as the critical offshore "anchor" defining the base of the dynamic active beach profile.

Due to localized constraints, the -15m CD contour is widely adopted across South African regional coastal management and vulnerability assessments for practical and empirical reasons:

- **Data Availability and Statutory Authority:** The South African National Hydrographic Office (SANHO) provides continuous, legally verified bathymetric contour datasets nationally. Conversely, empirical site-specific cross-shore profile monitoring is highly resource-intensive and rarely available at a regional scale (SANHO, 2026).
- **Methodology:** For this spatial assessment, the -15m Depth of Closure contour was isolated and derived directly from the authoritative SANHO Digital Hydrographic Database line feature class, Depth_ContoursDEPCNT(L).shp (SANHO, 2026).

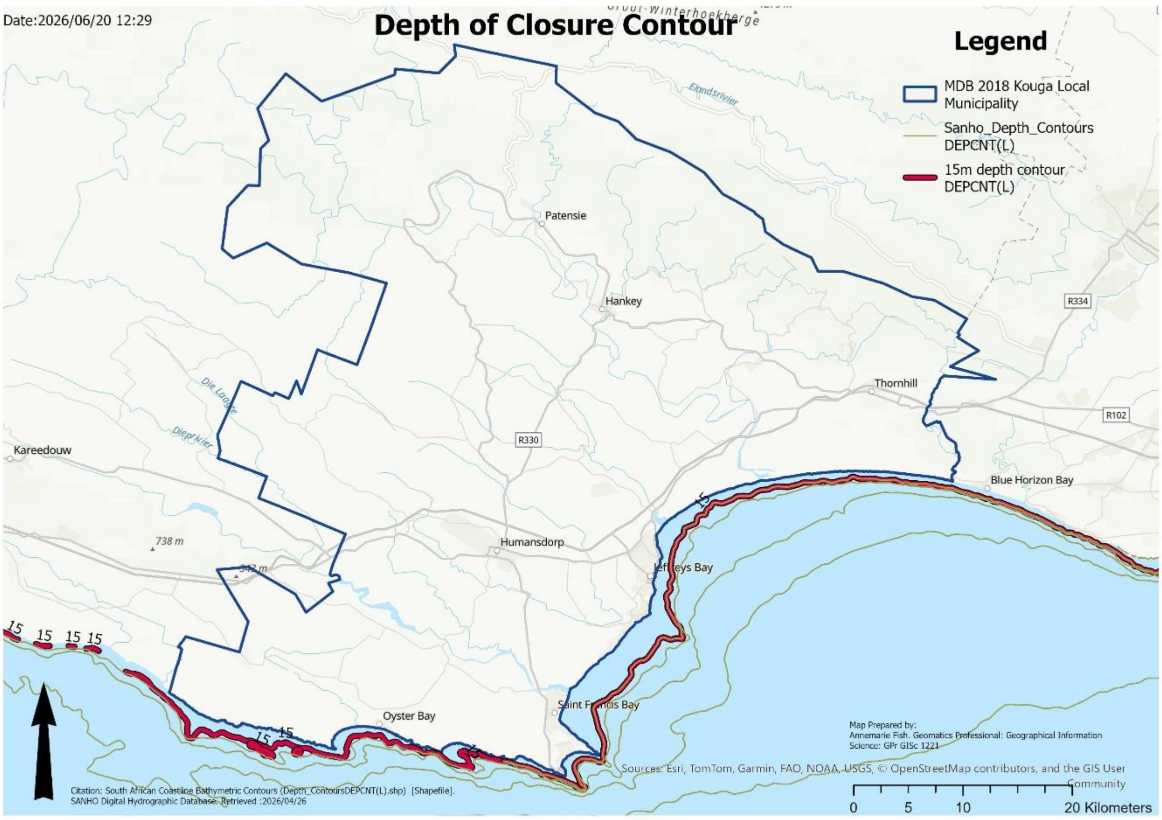


Figure 4 Depth of Closure Contour at -15m at CD

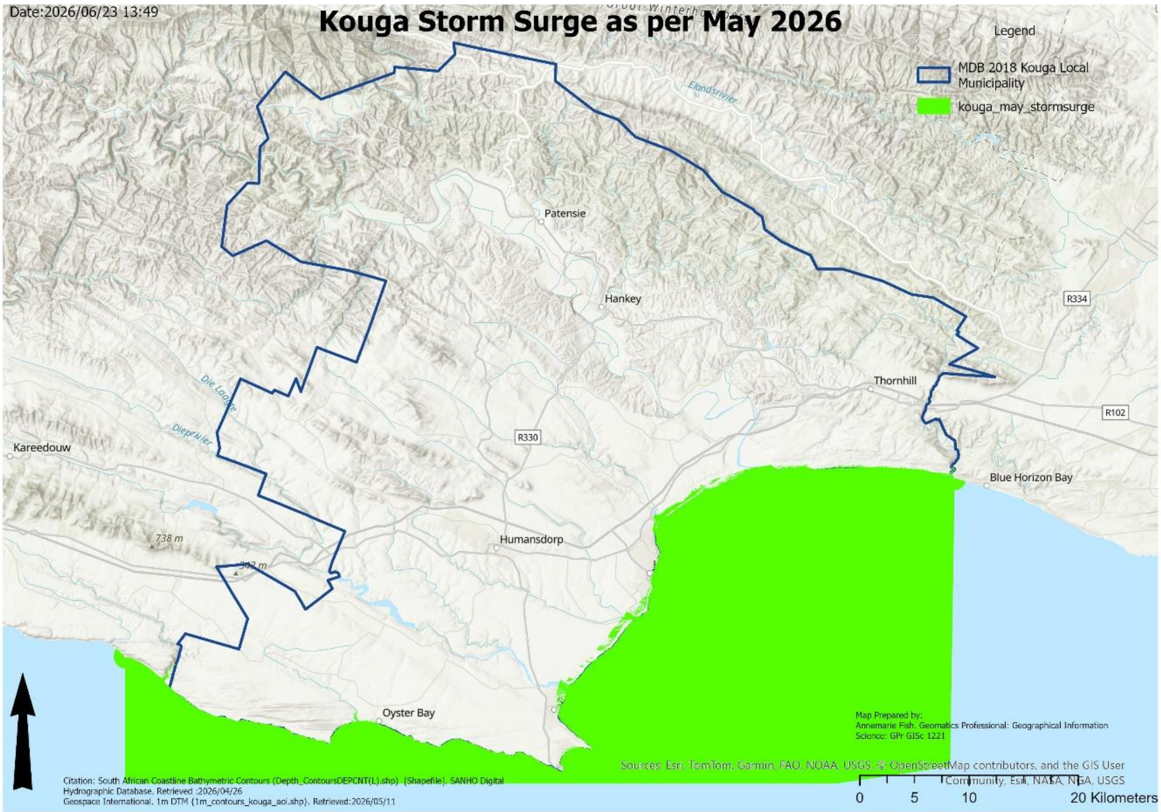
3.4. The Secondary Line: -5m to -10m (Wave Breaking Zone)

Data Availability
The required -5 m to -10 m contour interval was not available from the SANHO digital chart data. The available chart intervals were 0 m, 15 m, 20 m, 30 m, and 100 m.

Interpolated Contour Development
To address this data gap, an estimated contour was generated using Inverse Distance Weighting (IDW) interpolation. The interpolation was based on the merged bathymetry dataset and the 1 m Digital Terrain Model (DTM). The resulting estimated contour was approximately-5.84m to -10.84 m and was used in applying the vertical datum adjustment to LLD.

3.5. 1:50 Flood and Surge Parameters (May 2026)

Peak discharge at Kouga Dam during the May 2026 flood event was reported as a one-in-50-year flood event, with peak outflows reaching approximately 2 491 cubic metres per second (The Citizen, 2026). Dam Levels: The dam reached over 120% capacity during this event before starting a slow decline. Storm Surge Component: While the river flooding is the primary driver of the current "1:50" disaster, it is coinciding with a Yellow Level 2 Storm Surge forecast to push sea levels up to 0.2 m above the highest astronomical tide. Significant Wave Heights: During this 1:50-year cycle, wave heights have reached 5.0 m - 8.0m, causing extreme "wave setup" that adds to the effective inundation level in St Francis and Jeffreys Bay. The regional flood and evacuation context for the May 2026 event is supported by contemporary reporting on the Eastern Cape floods (The Citizen, 2026).



Gamtoos River Valley: Widespread flooding has submerged wedding venues, washed ferry cruise ships ashore, and led to urgent evacuation orders for low-lying communities like Gamtoos Mouth Resort and Kingsway Village. St Francis Bay: The combination of the 1:50 river flood discharge from the Kromme River and the coastal surge has put extreme pressure on the river mouth, with residents warned to stay clear of the estuary. Infrastructure damage was reported at the Seekoei Causeway in Jeffreys Bay and across local road networks, with municipal and media updates documenting repairs and storm impacts (Kouga Local Municipality, 2026; SABC News, 2026). Kouga Local Municipality's repair update was used as the municipal source for infrastructure impacts (Kouga Local Municipality, 2026). SABC News was used as a media source for reported storm-damage impacts in Kouga Municipality (SABC News, 2026).

3.6. Modelling the 1:50 Surge in QGIS

To model a 1:50-year "Combined Flood" level for this area, your total water level (TWL) in the Raster Calculator should account for:

- Astronomical High Tide: approximate 1.8m (Spring Tide reference).
- Storm Surge (Residual):+0.5- +0.8m.
- Wave Setup (1:50 estimate): +1.5m to +2.5m.

- River Backwater: In estuaries (Kromme/Gamtoos), the local water level may be 3.0 m - 5.0m above sea level due to the massive 2,49 cubic meter per second.

3.6.1. Key 2026 Storm Surge & Coastal Data (May 6-10, 2026)

- **Sea Conditions:** Wave heights of \(\pm 4.0 - 6.0\) m (very rough seas) are causing severe wave action.
- **Coastal Impact:** Waves have reached the dune line and infrastructure in vulnerable beach locations.
- **St Francis Bay:** Significant damage reported to the Two Harbours Walk, with material deposited along the lower coastal path, rendering sections dangerous. Beach erosion in the area is severe, with rock armouring exposed, according to.
- **Jeffreys Bay:** NSRI Station 37 proactively removed Pink Rescue Buoys from beach locations to prevent loss to extreme surge.
- **Kromme River/Mouth:** High floodwaters are mixing with high tides, causing significant downstream impacts, with residents asked to evacuate low-lying areas.
- **Oyster Bay:** Low-water bridges are flooded and roads were impassable due to water levels. [1, 2, 3, 4, 5, 6]

NSRI advisories were used to support the May 2026 heavy-rainfall and coastal-safety context (National Sea Rescue Institute, 2026).

Additional emergency-response context was taken from NSRI public advisories and IFRC emergency reporting (National Sea Rescue Institute, 2026; International Federation of Red Cross and Red Crescent Societies, 2026).

IFRC emergency information was used to support the regional flood-emergency context (International Federation of Red Cross and Red Crescent Societies, 2026).

3.6.2. May 2026 Storm Surge Modelling Inputs

The May 2026 storm-surge layer was developed using the following inputs:

- **Observed surge:** The residual water level was derived from tide-gauge data by comparing the predicted astronomical tide with the observed sea level.
- **Significant wave height:** Wave-height values of approximately 4.0 m to 6.0 m were incorporated to represent wave setup during the event.
- **Raster calculation:** The DEM was used to identify areas where elevation was lower than the combined observed surge and wave setup.
- May 2026 Modelling Threshold
    - The average storm-surge value used for the May 2026 scenario was approximately 1.59 m. When combined with a 5.0 m wave-height allowance, the resulting modelling threshold was approximately 6.5 m.

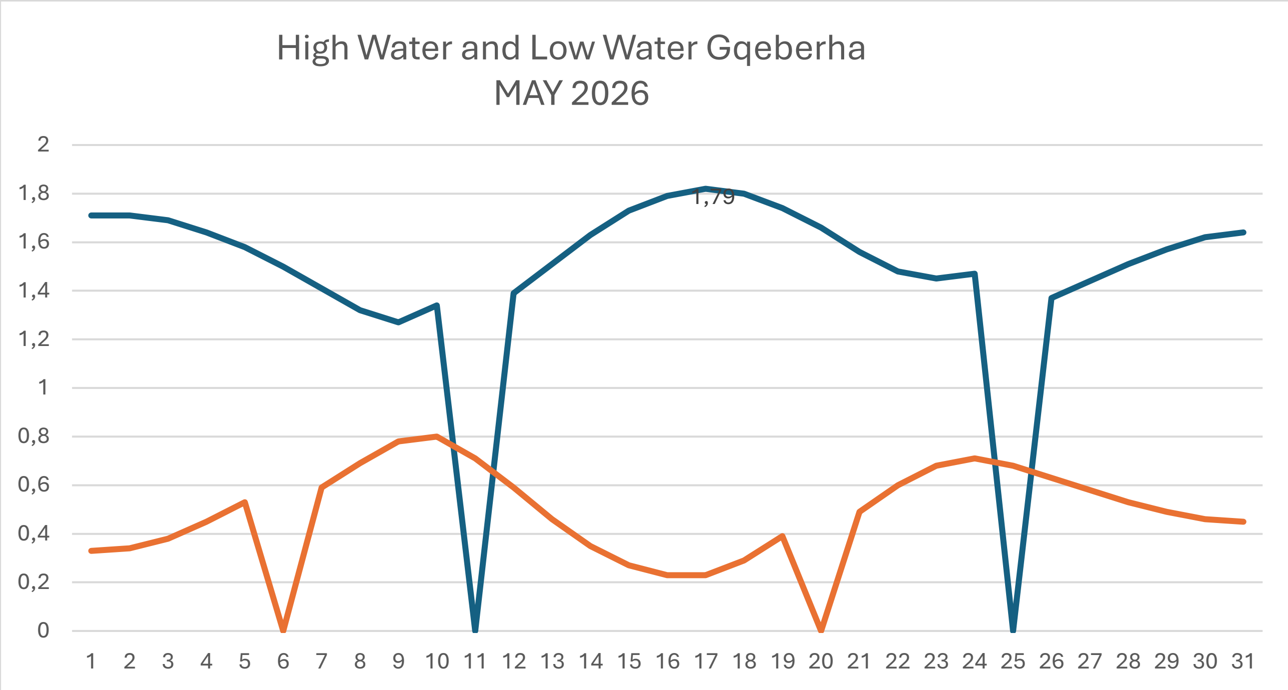


Figure 5 Tides for Gqeberha (May 2026) (South African National Hydrographic Office, n.d.).

The following spatial and environmental datasets were systematically generated during the execution of this project:

Name	**StormSurgeMay2026**
Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\StormSurgeMay2026.tif
Sidecar file	StormSurgeMay2026.tif.aux.xml
Total size	8.73 GB
Last modified	Monday, 11 May 2026 14:27:00 (StormSurgeMay2026.tif.aux.xml)
Provider	gdal

Name	**kouga_may_stormsurge**

Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\kouga_may_stormsurge.shp
Side car files	kouga_may_stormsurge.shx, kouga_may_stormsurge.prj, kouga_may_stormsurge.dbf, kouga_may_stormsurge.cpg
Total size	47.31 MB
Last modified	Monday, 11 May 2026 14:37:50 (kouga_may_stormsurge.shp)
Provider	ogr

3.6.3. Relevance of the 1.6 m Level

Within the Kouga coastal management context, the 1.6 m level is used as a practical modelling value because it represents the converted Highest Astronomical Tide (HAT) level relative to the Land Levelling Datum (LLD).

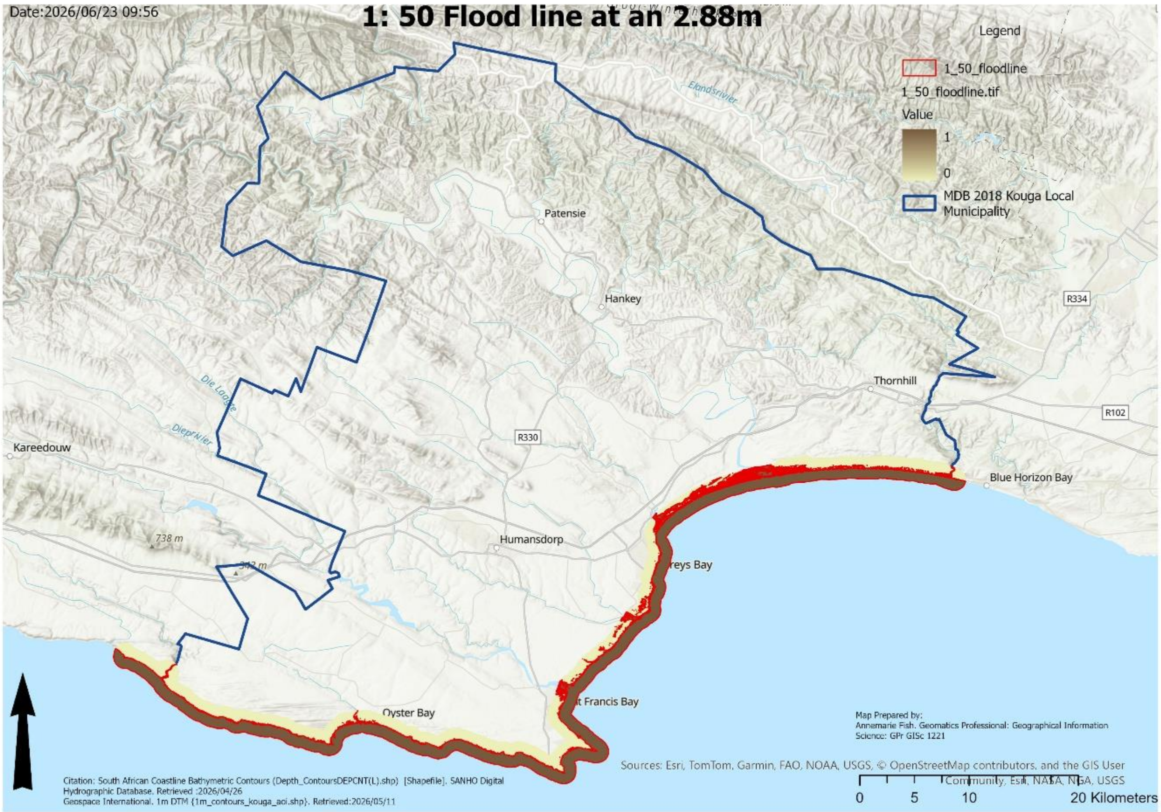
- **Vertical datum adjustment:** The value is derived by converting the HAT level from Chart Datum to LLD/MSL using the applicable regional datum offset.
- **CML modelling application:** The 1.6 m level provides the base tidal surface to which storm-surge and sea-level rise allowances can be added when modelling coastal hazard scenarios.

3.7. The 1:50 Year Total Water Level (TWL)

A 1:50 year storm surge event is not just a high tide; it is a combination of several factors. For a conservative 1:50 year model in the Kouga area (e.g., St Francis Bay), use the following calculation:

Component [1, 2]	Height (LLD/MSL)	Notes
High Tide (MHWS)	1.03 m	Your provided spring tide baseline.
Storm Surge (Residual)	0.65 m	1:50 year statistical surge for the Eastern Cape.
Wave Setup	1.20 m	Water "piling up" from \(5.0-8.0 \text{ m}\) waves.
Total Water Level (TWL)	2.88 m	The threshold for your QGIS Raster Calculator.

St Francis Today was used as a local source for observed storm impacts and coastal conditions in St Francis Bay (St Francis Today, 2026).



To validate the model's performance, localized observations of storm dynamics and subsequent beach morphology impacts were cross-referenced with documented event reporting from St Francis Today (2026). Following validation, predictive modelling for the 1:50-year coastal inundation event was executed within the QGIS environment. A raster calculator transformation was performed on the integrated digital elevation model (DEM) to isolate all contiguous low-lying areas situated at or below the calculated 1:50-year Total Water Level (TWL) threshold of 2.88m relative to the vertical baseline.

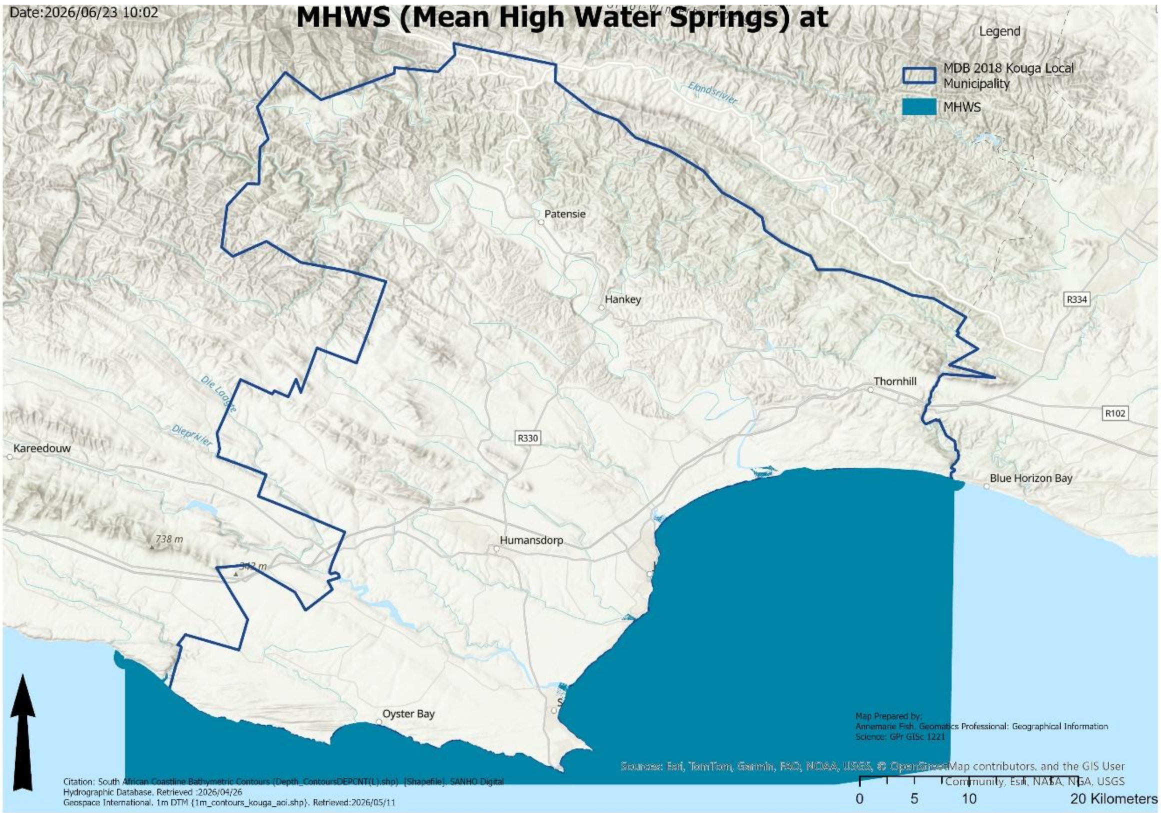
The following spatial and environmental datasets were systematically generated during the execution of this project:

Raster Name	**1_50_floodline**
Path	**E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\1_50_floodline.tif**
Size	**8.73 GB**

Last modified	**Monday, 11 May 2026 14:57:37**
Provider	**gdal**

3.7.1. Mean High Water Springs

Ensure that the Digital Elevation Model (DEM) is reprojected to a projected coordinate system, such as WGS 84 / UTM zone 35S, so that distance and area measurements are calculated in metres. Localised tidal variation, wave transformation and estuary-shoreline boundary interactions for St Francis Bay were informed by the Worley coastal modelling report, which supports use of +1.03 m LLD as a static astronomical spring high-tide benchmark (Worley Consulting, 2025).



To map the baseline tidal footprint along the coastline, areas situated at or below the Mean High Water Springs (MHWS) level of 1.03m relative to the Land Levelling Datum (LLD) were isolated. This extraction was performed in QGIS using the Raster Calculator tool (Raster > Raster Calculator). To flag all terrain cells falling within or below this tidal threshold, the following boolean expression was executed:

{"DEM"}<=1.03m

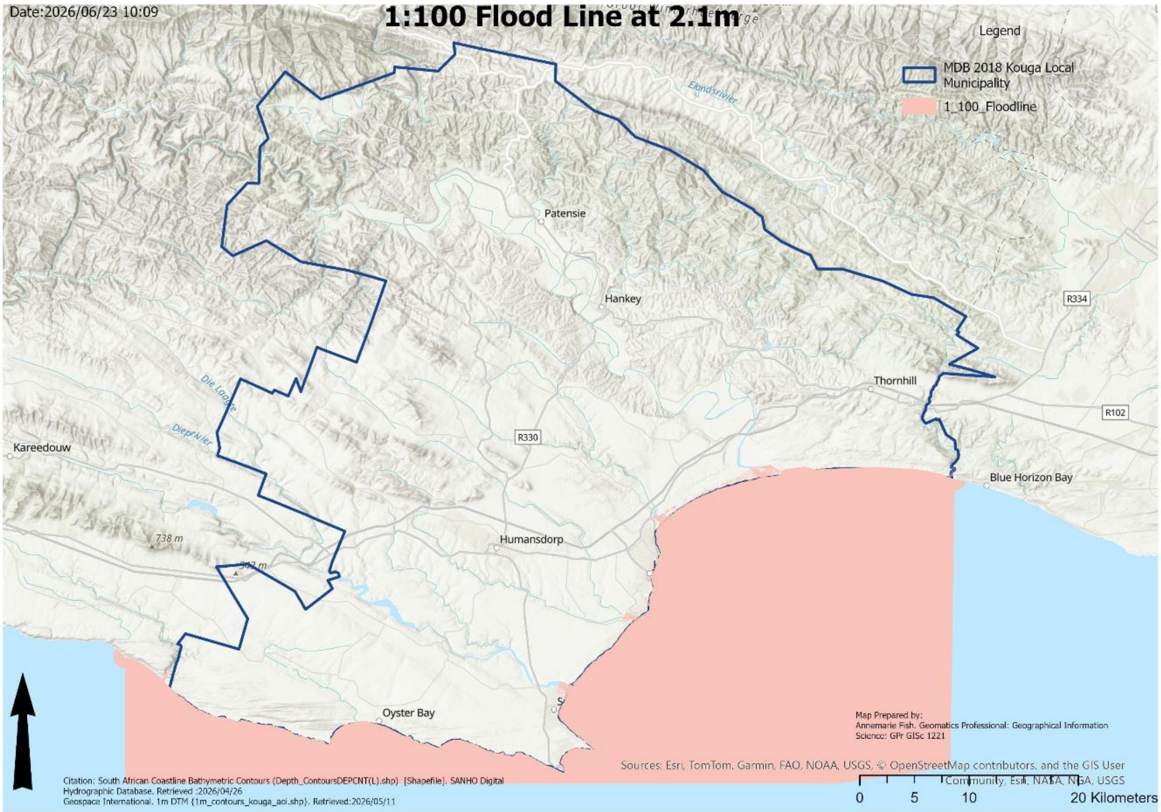
The geoprocessing workflow successfully yielded the following spatial datasets:

Name	MHWS
Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\MHWS.tif
Size	8.73 GB
Last modified	Monday, 11 May 2026 15:26:46
Provider	gdal

Name	MHWS
Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\MHWS.shp
Sidecar files	MHWS.shx, MHWS.dbf, MHWS.prj
Total size	21.41 MB
Last modified	Tuesday, 09 June 2026 09:25:37 (MHWS.shp)
Provider	ogr

3.7.2. 1:100 year floodline

Scenario Definition
The 1:100-year flood line for the Kouga coastline, including Jeffreys Bay, St Francis Bay, and Oyster Bay, was modelled at +2.1 m LLD (Land Levelling Datum). This represents a high-impact coastal flooding scenario in which the Highest Astronomical Tide (HAT) coincides with a major storm surge. The geoprocessing workflow successfully yielded the following spatial datasets:



Site-Specific Basis

For St Francis Bay, Jeffreys Bay, and Oyster Bay, the +2.1 m LLD threshold is supported by local coastal protection assessments (**Worley Consulting, 2025**).

Still-Water Level Interpretation

The assessment identifies local still-water level (SWL) thresholds for extreme coastal flooding. A 1:100-year storm surge typically adds an estimated 0.75 m to 0.80 m to the astronomical tide, reaching or exceeding the +2.1 m LLD threshold before wave setup or wave run-up are included.

1:100-Year Water-Level Components

The +2.1 m LLD threshold is substantially higher than the standard MHWS baseline of approximately +1.03 m LLD. It reflects the combined effect of astronomical tide and a major storm-surge residual.

- **Highest Astronomical Tide (HAT):** Approximately +1.3 m to +1.4 m LLD.
- **Storm-surge residual:** A 1:100-year event may add approximately +0.7 m to +0.8 m, bringing the still-water level to about +2.1 m LLD.
- **Wave setup:** Additional wave setup from 5.0 m to 8.0 m waves could raise the effective coastal hazard level further, potentially exceeding +3.5 m LLD in exposed areas.

QGIS Modelling Workflow

To map the 1:100-year floodline across the Kouga coastline, apply the +2.1 m threshold to the DEM using the Raster Calculator.

1. **Prepare the DEM:** Use a high-resolution DEM, preferably LiDAR-derived, projected to an appropriate metre-based coordinate system.
2. **Apply the threshold:** Use the Raster Calculator expression **DEM <= 2.1** to identify areas at or below the 1:100-year still-water level.
3. **Generate the floodline:** Convert the thresholded inundation area to a discrete contour or boundary line at 2.1 m for reporting and mapping.

Critical Risk Areas at +2.1 m LLD

Within the Kouga coastline, a +2.1 m LLD still-water level may affect several vulnerable coastal and estuarine areas:

- **St Francis Canals:** Canal infrastructure is generally positioned just above spring high-tide levels. At +2.1 m LLD, overtopping into adjacent properties may occur.
- **Jeffreys Bay Beachfront:** In areas already affected by erosion, the +2.1 m line may extend landward of the primary dune system.
- **Gamtoos and Kromme Estuaries:** These estuarine areas are highly sensitive to combined river flooding and elevated sea levels. A +2.1 m sea level may create a backwater effect, reducing river outflow and causing water levels in the valleys to rise above the coastal still-water threshold.

Modelling Threshold
For the 1:100-year inundation scenario, the model threshold is **DEM <= 2.1 m**.

3.7.3. Sea Level Rise Modelling

Purpose of Sea-Level Rise Modelling
Sea-level rise (SLR) modelling for Kouga Municipality, including Jeffreys Bay, St Francis Bay, and Oyster Bay, is required to assess future coastal exposure and support long-term Coastal Management Line planning. The SLR line provides a forward-looking spatial layer for identifying areas that may become increasingly vulnerable to inundation, erosion, storm surge, and estuarine backwater effects.

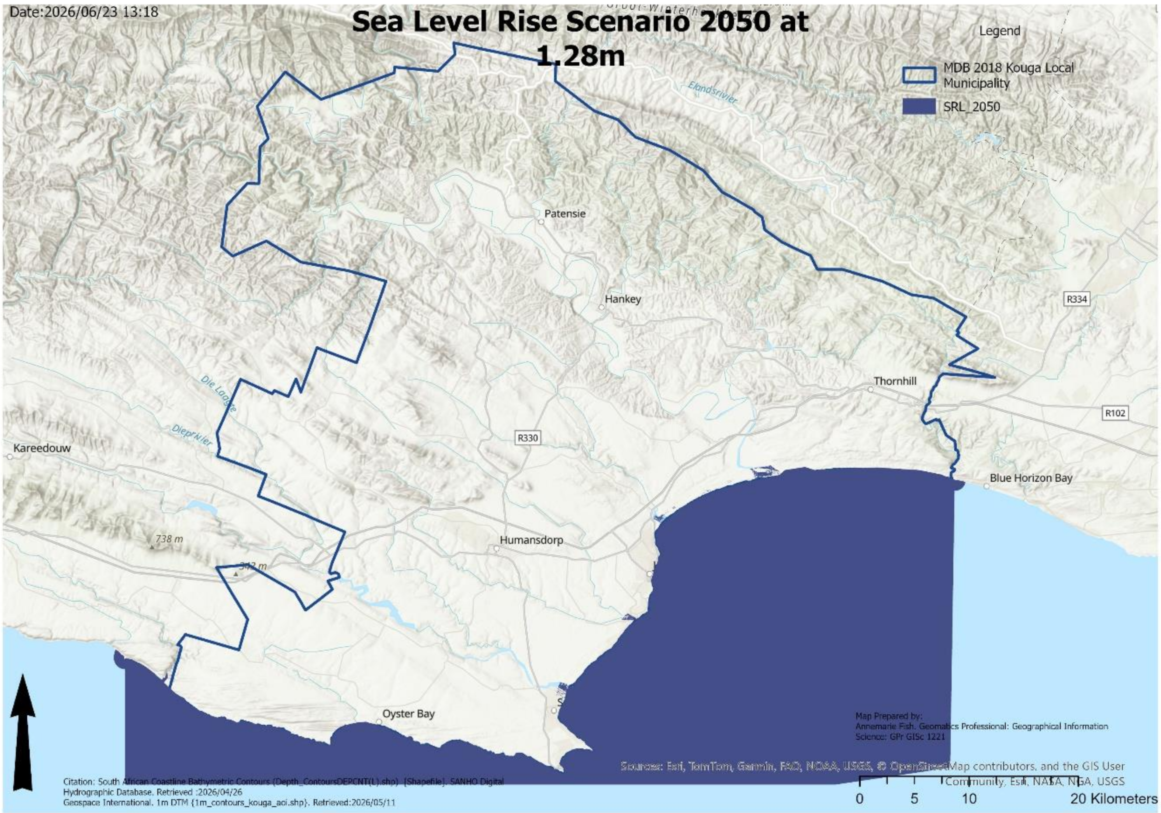
Key Projections for the Kouga Region

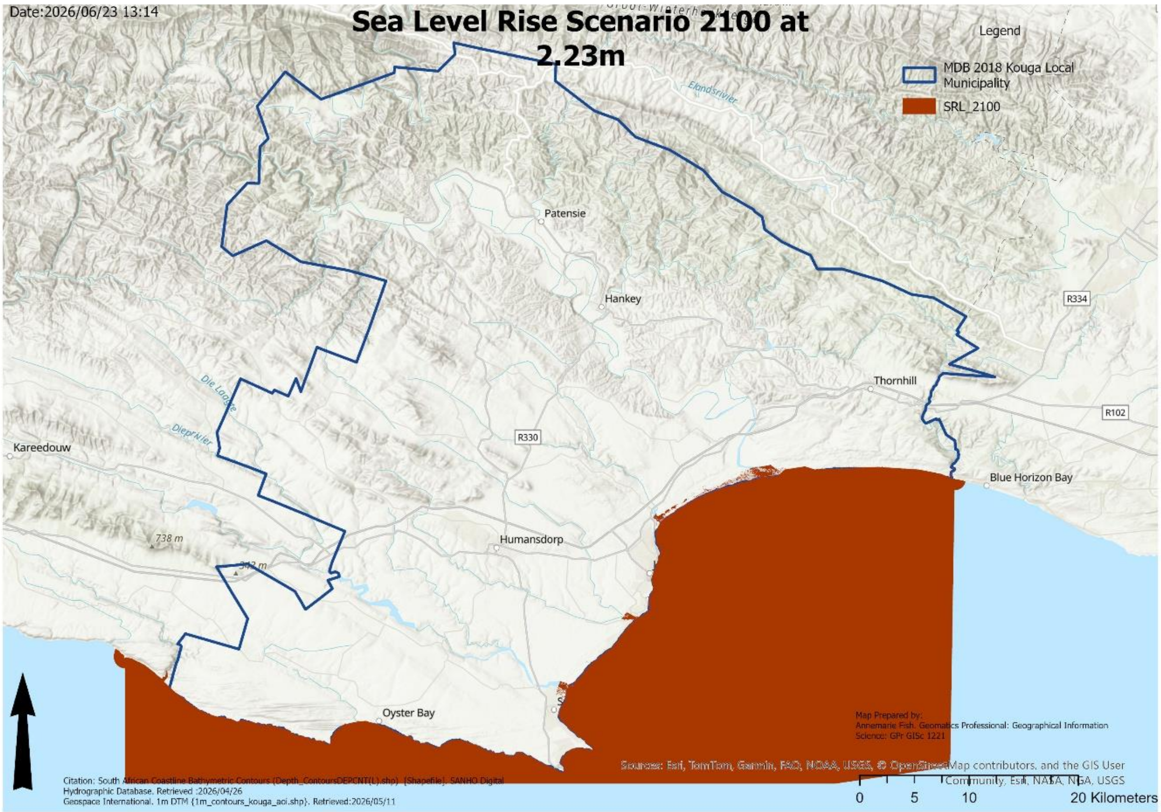
Future modelling scenarios should be developed using locally adjusted sea-level rise projections relative to the 2005 baseline.

Estuary Considerations: Kromme and Gamtoos
In river-mouth and estuarine areas, a 1:50-year event may produce water levels higher than the open-coast total water level of 2.88 m. This is due to the combined effect of elevated sea levels, storm surge, wave setup, and high river discharge, such as the 2,491 m^3/s outflow recorded at Kouga Dam. In these areas, flood levels may reach approximately 4.0 m to 6.0 m above MSL, particularly where backwater effects restrict river outflow.

Scenario Component	Threshold (LLD/MSL)Total	Modelling Height m

MHWS	1.03	1.03
2100 Sea Level Rise	MHWS +1.2 conservative	2.23
Extreme Sea Water Level :1:100 Surge + 2100 SLR	HAT 1.3 + Surge0.8 + SLR 1.2m	3.3
2050 SLR projection0.2 m to 0.3 m	MHWS + 0.25	1.28





UN-SPIDER guidance was used for the storm-surge modelling workflow and the application of digital elevation data to coastal flood modelling (United Nations Office for Outer Space Affairs, UN-SPIDER, n.d.).

3.8. Storm Surge Modelling

The SPEAR storm-surge modelling workflow was used as an applied implementation reference for geoprocessing coastal hazard layers (GitHub, n.d.; United Nations Office for Outer Space Affairs, UN-SPIDER, n.d.).

To model storm surges in Kouga, the SPEAR storm-surge model workflow was applied in line with the UN-SPIDER Knowledge Portal guidance. The workflow supports coastal hazard and risk analysis where high-quality hydrodynamic data are limited or costly to obtain (United Nations Office for Outer Space Affairs, UN-SPIDER, n.d.; GitHub, n.d.).

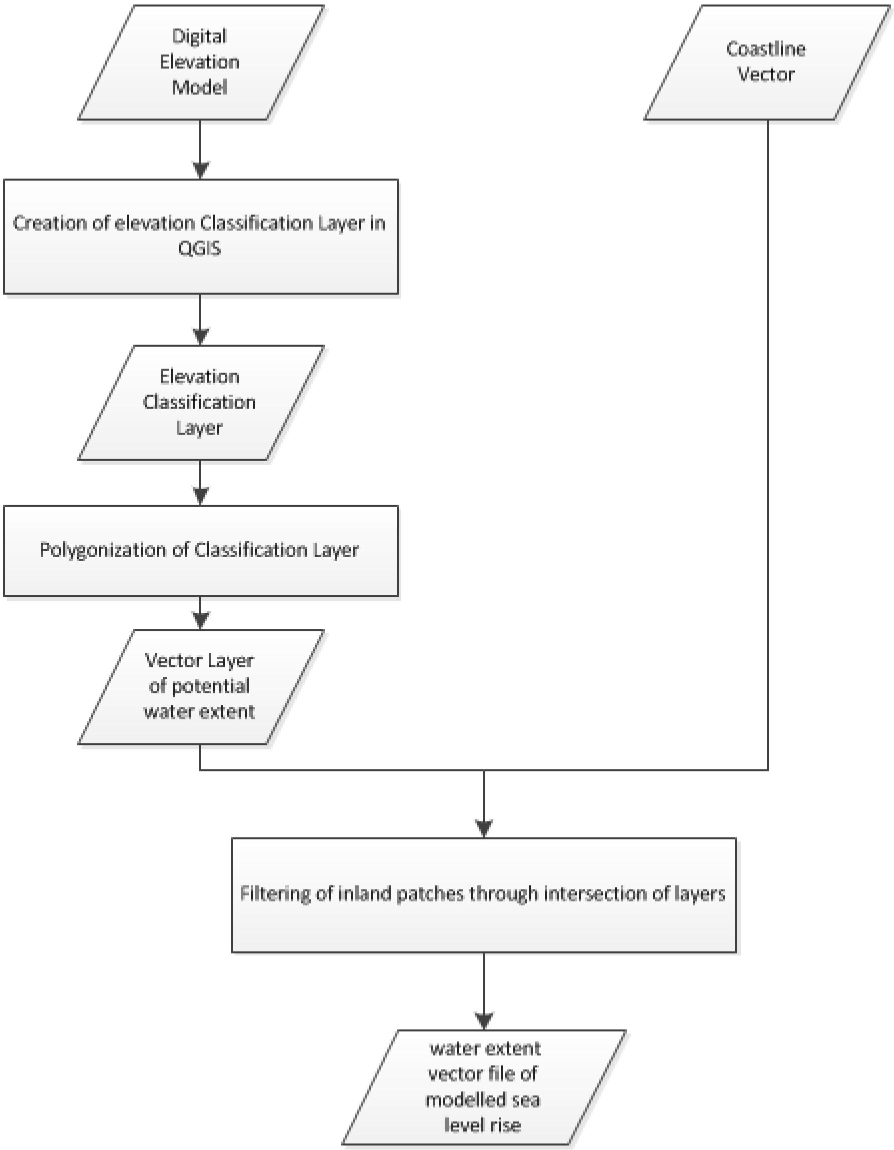
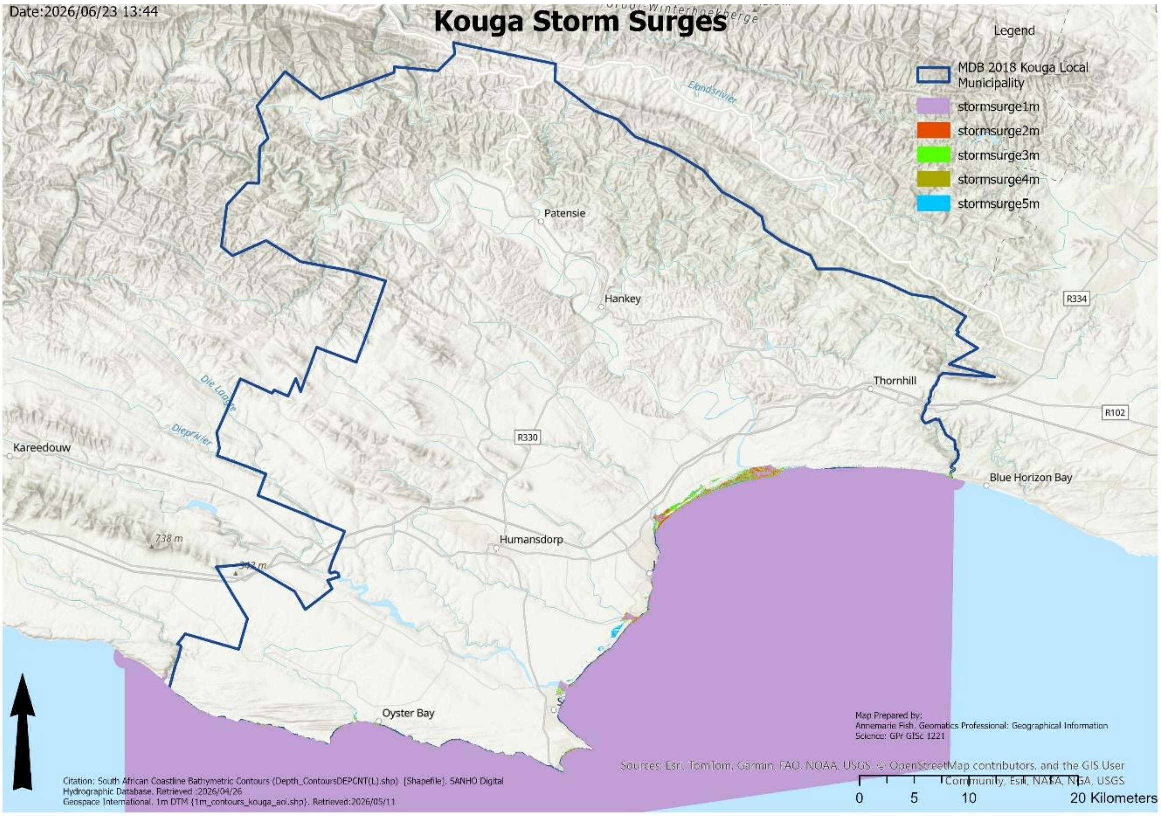


Figure 6 UN SPIDER Storm surge model

Detailed storm-surge modelling guidance was taken from the UN-SPIDER recommended-practice documentation (United Nations Office for Outer Space Affairs, UN-SPIDER, n.d.).

Model Inputs and Intervals
The storm-surge model was implemented using the 1 m DEM and the High-Water Mark (HWM) derived from cadastral data. Surge scenarios were modelled at 1 m, 2 m, 3 m, 4 m, and 5 m intervals.



The below spatial data sets were created using the Spears Modelling Method:

Name	stormsurge5m
Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\stormsurge5m.shp
Sidecar files	stormsurge5m.cpg, stormsurge5m.shx, stormsurge5m.prj, stormsurge5m.dbf
Total size	9.40 MB
Last modified	Wednesday, 13 May 2026 14:08:46 (stormsurge5m.shp)
Provider	ogr

3.8.1. Kouga Coastal Management Line

Based on the national methodology established by the Department of Forestry, Fisheries and the Environment (DFFE), your baseline calculation of 2.35m successfully isolates the combined dynamic water level for a 1:100-year storm event under current conditions.

To ensure the Kouga Coastal Management Line (CML) aligns rigorously with the full DFFE risk-modelling framework, there are a few additional factors, spatial variations, and future allowances to account for in your final raster calculations.

Figure 7 CML at a 1:3000 scale in Cape St Francis

The map delineates the draft Coastal Management Line (CML) in relation to erf, farm, and public place boundaries. Measures were taken to safeguard properties along the Cape St. Francis coast by leveraging public open space (Erf 2007, Sea Vista, SG Diagram No. 7865/89); however, under current sea-level parameters, certain private properties remain affected by the CML alignment.

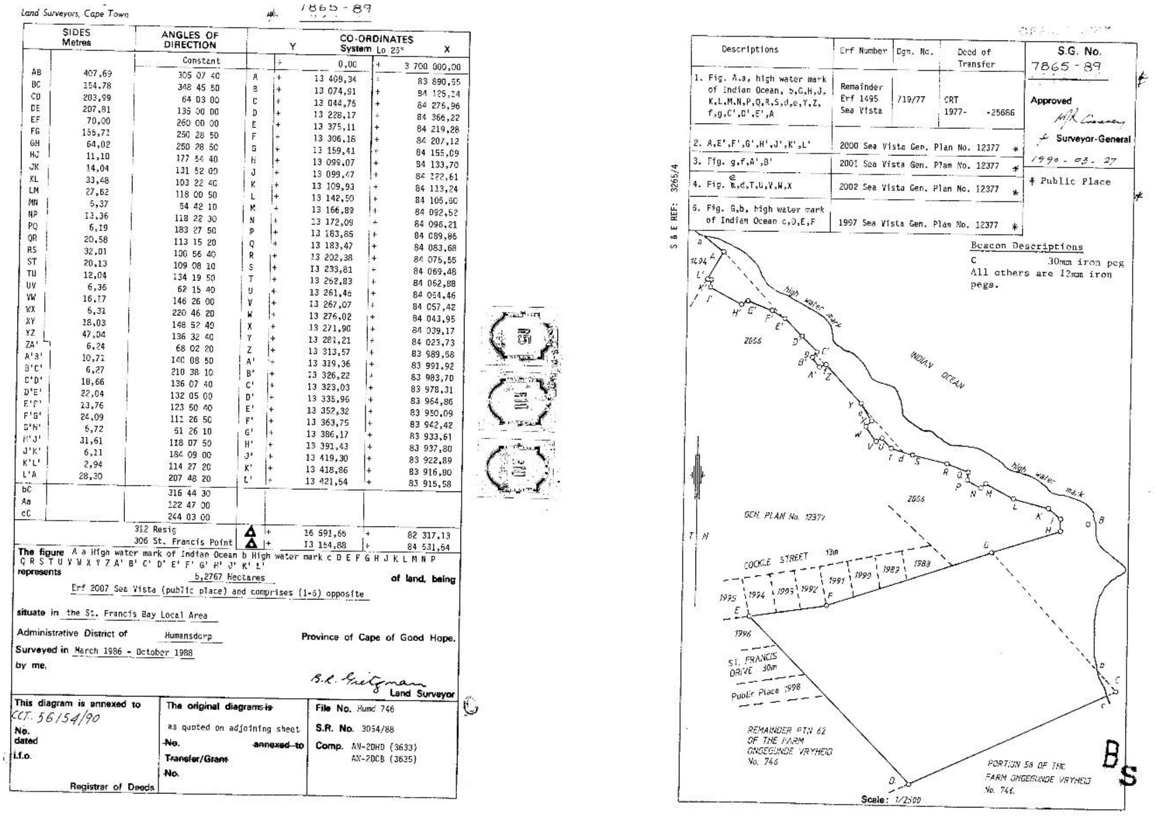


Figure 8 SG Diagram of Erf 2007, Sea Vista

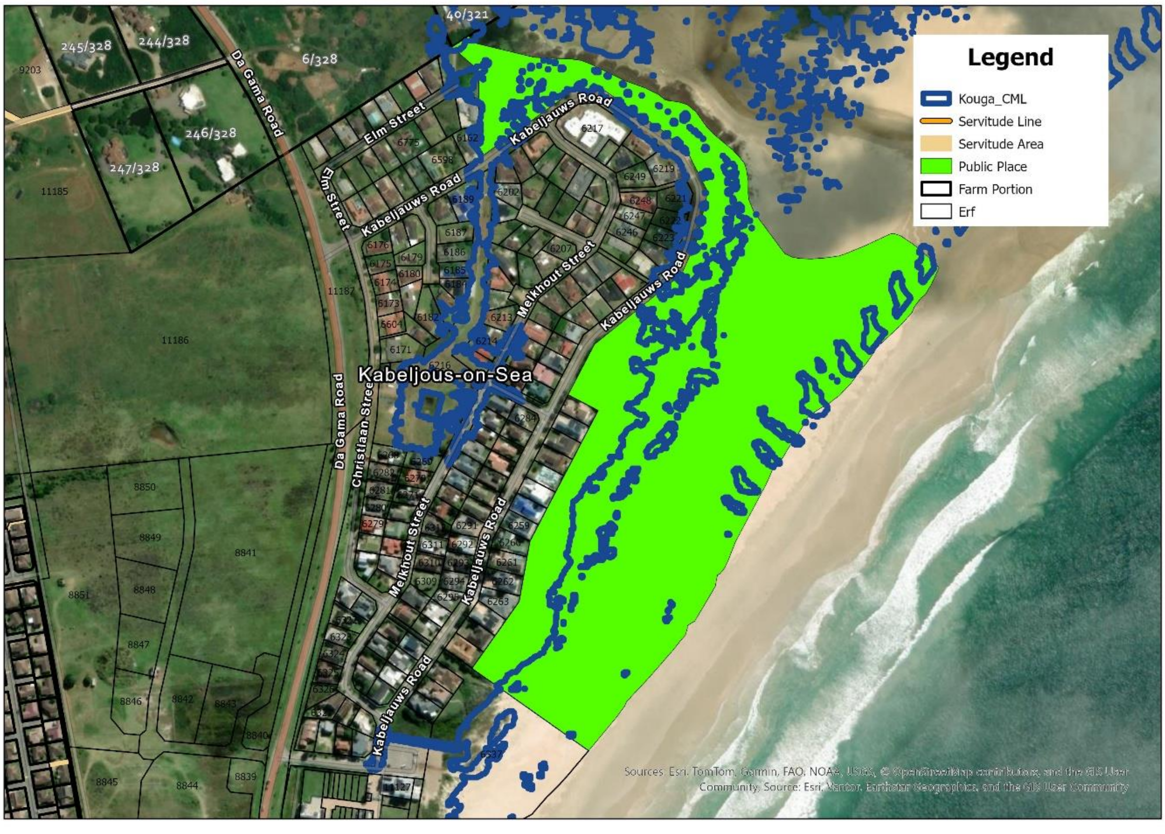
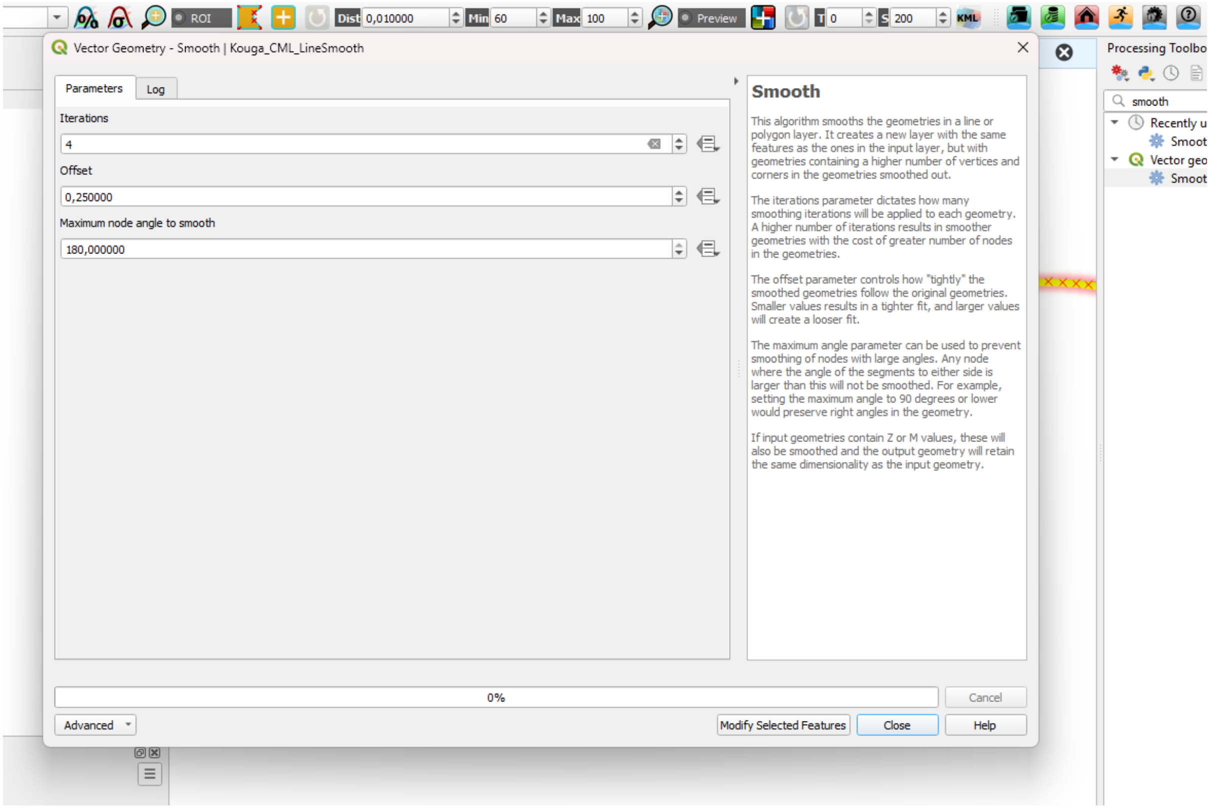


Figure 9 CML at a 1:4500 scale at the Kabeljous River Mouth

Areas adjacent to river mouths present elevated risk profiles within the CML model, which indicates potential flooding and hazard exposure for surrounding properties and transport routes, such as the Kabeljous River mouth and abutting erven.

The raw dataset derived from the 1x1m DEM raster needed to be edited to ensure that an continuous line appears. The method used was to select features and to identify the main continuous line and delete lines to inland and seaward from the continuous CML. Further smoothing was applied by using the vector geometry geoprocessing tool at 4x interactions at 0,75 offset and maximum angle of smooth at 180 degrees.



The dataset created from the 1x1m DEM is as per below table:

Name	**Kouga_CML**
Path	[E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\Kouga_CML.shp]()
Sidecar files	Kouga_CML.prj, Kouga_CML.shx, Kouga_CML.dbf
Total size	25.36 MB
Last modified	Tuesday, 09 June 2026 12:11:18 (Kouga_CML.shp)

Provider	ogr

The dataset created after cleaning and smoothing of the line is a table below:

Data Type	**File Geodatabase Feature Class**
Database	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_Management Plan\Kouga_Lm_CoastalManagement\Kouga_Lm_CoastalManagement.gdb
Name	Kouga_CML_V2
Alias	Kouga_CML_V2
Feature Type	Simple
Geometry Type	Line
Coordinates have Z value	No
Coordinates have M value	No
Object ID	32 Bit
Attachments	No Attachments
Feature Binning	Disabled
Compression	Uncompressed
COGO Enabled	No
Split Model	Update/Insert
Vertical Units	Meter
Minimum Client Version	1.0 / 10.0

Figure 10 Kouga CML Version 2 (Clean/Smoothed)

3.8.2. CML Sea Level Rise Buffer

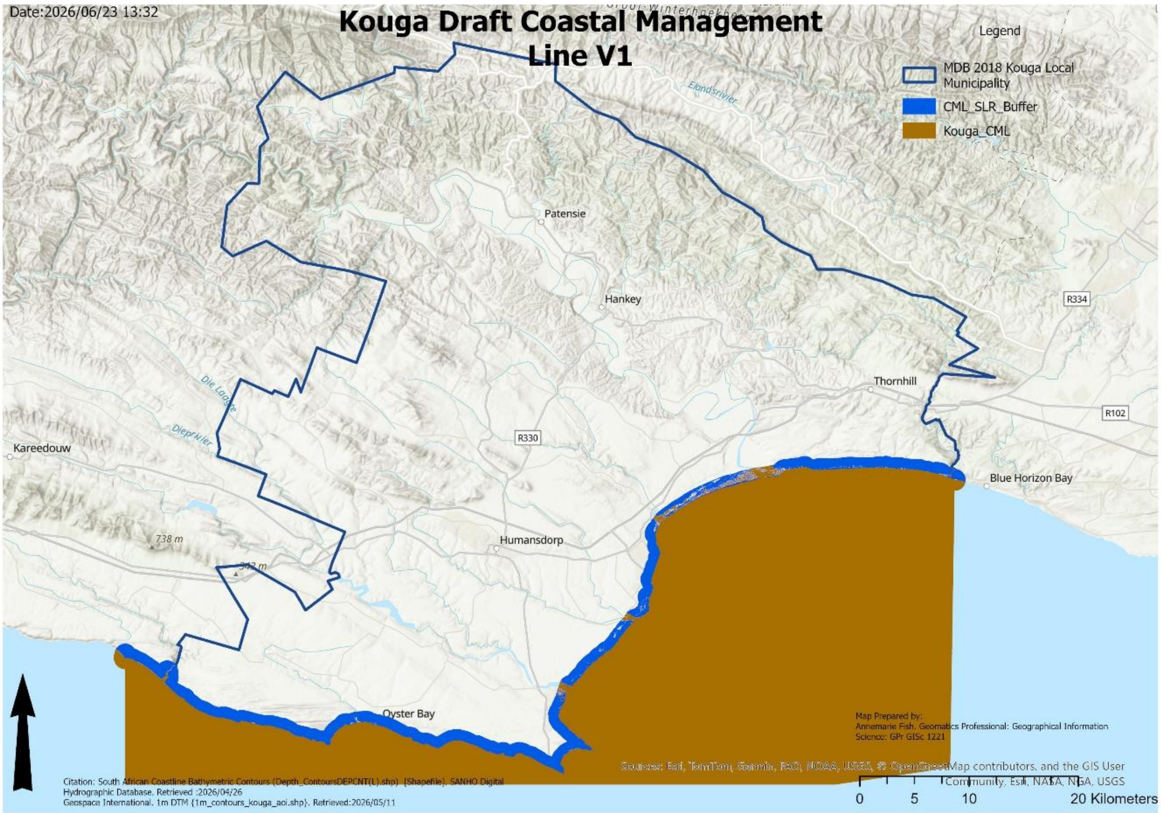
To project the high-risk hazard boundary over a 100-year planning horizon, a long-term sea-level rise (SLR) buffer of +1.0 m was added to the baseline extreme water level calculation, in accordance with national coastal vulnerability assessment standards and provincial CML modelling protocols (Department of Environmental Affairs, 2018; Western Cape Department of Environmental Affairs and Development Planning, 2014).

The combined modelling threshold of 3.35 m represents a cumulative hazard vulnerability ceiling 1.60\ m HAT + 0.75m Storm Surge} + 1.0 m SLR. This elevation profile satisfies the risk overlay procedures recommended for local government planning horizons by the national Department of Forestry, Fisheries and the Environment (DFFE, 2019), adapting standardized extreme-event parameters formulated for the South African coastline (Western Cape DEA&DP, 2014; Lück-Vogel, 2019).

The geoprocessing results of the CML SLR buffer as per below table:

Name	**CML_SLR_Buffer**
Path	E:\Documents\Annies_Stuff\PRIVATEWORK\CES\Kouga_LM_Coastal_ManagementPlan\Kouga_Lm_CoastalManagement\SpatialData\Hydrography\Kouga_15m depth contour\CML_SLR_Buffer.tif
Size	8.73 GB

Last modified	Tuesday, 09 June 2026 13:04:44
Provider	gdal



3.8.3. CML Safety Buffer

When developing a Coastal Management Line (CML), the Safety Buffer is a dedicated, additional horizontal setback added to the modelled extreme water line. While the extreme water line handles the immediate, vertical wave runup and storm surge forces, the Safety Buffer is specifically designed to provide a physical cushion against long-term, chronic shoreline erosion and localized coastal instability.

In sandy areas like the Kouga Local Municipality (encompassing highly dynamic coastal segments like the St Francis Bay spit and the Jeffreys Bay beachfront, this buffer typically ranges from 10 meters to 30 meters.

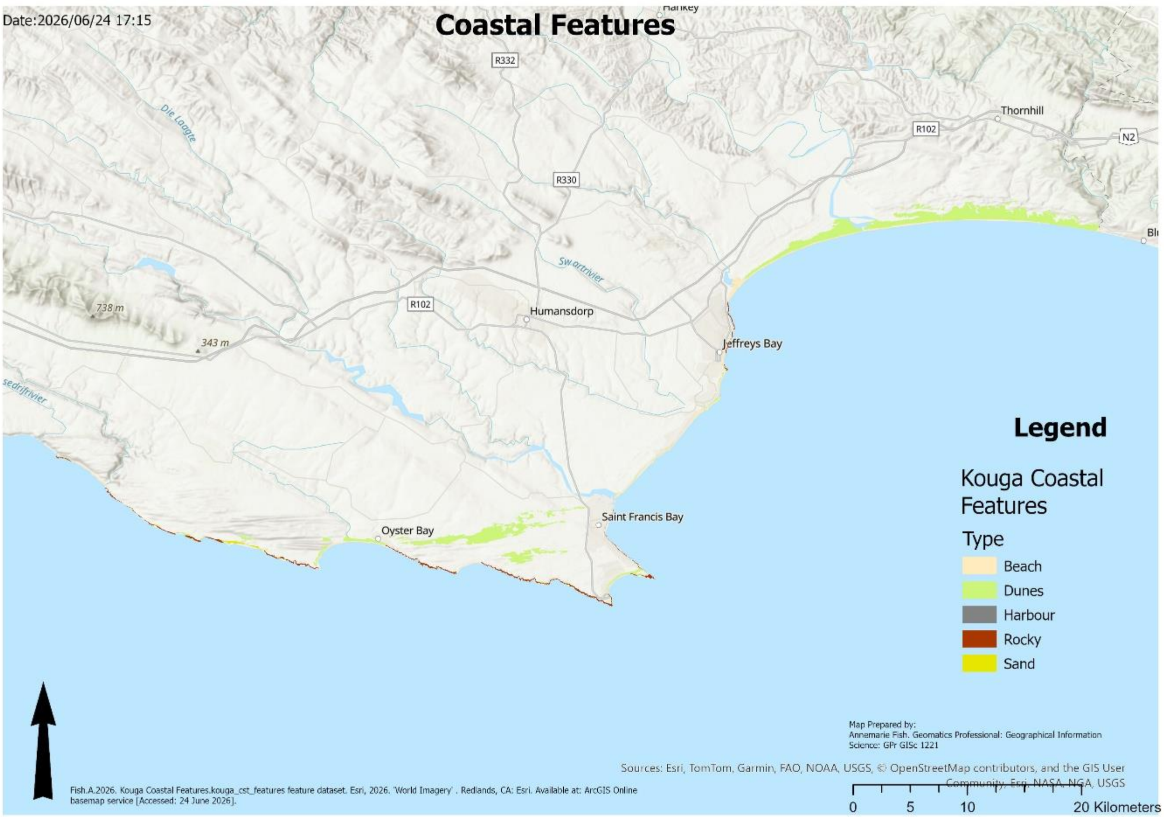
The 10m Buffer: Typically reserved for semi-stable or recovering sandy systems with low erosion rates 0.1m/yr, providing a 100-year safety window. The 30m Buffer: Applied to high-energy, chronic erosion hotspots where the beach is actively shrinking at a faster rate (e.g., 0.3 m/yr or more), ensuring houses built today remain safe from the migrating high-water mark for decades to come

Why a Sandy Coastline Requires a Fixed Safety Buffer

Unlike rocky headlands, sandy coastlines are highly dynamic and morphologically unstable. They are governed by continuous sediment transport balances. A safety buffer of 10m to 30m is injected into the to account for several distinct physical phenomena:

- **Cyclical Dune Slumping:** During an extreme event (like the **May 2026 storm surges**), heavy wave action scours the base of the frontal dune system. This creates an unstable, vertical sand cliff. Over the days following the storm, this cliff naturally collapses or "slumps" landward as the sand seeks its natural angle of repose. The safety buffer ensures that a building sitting behind the initial storm-wash line doesn't collapse during this secondary structural adjustment.

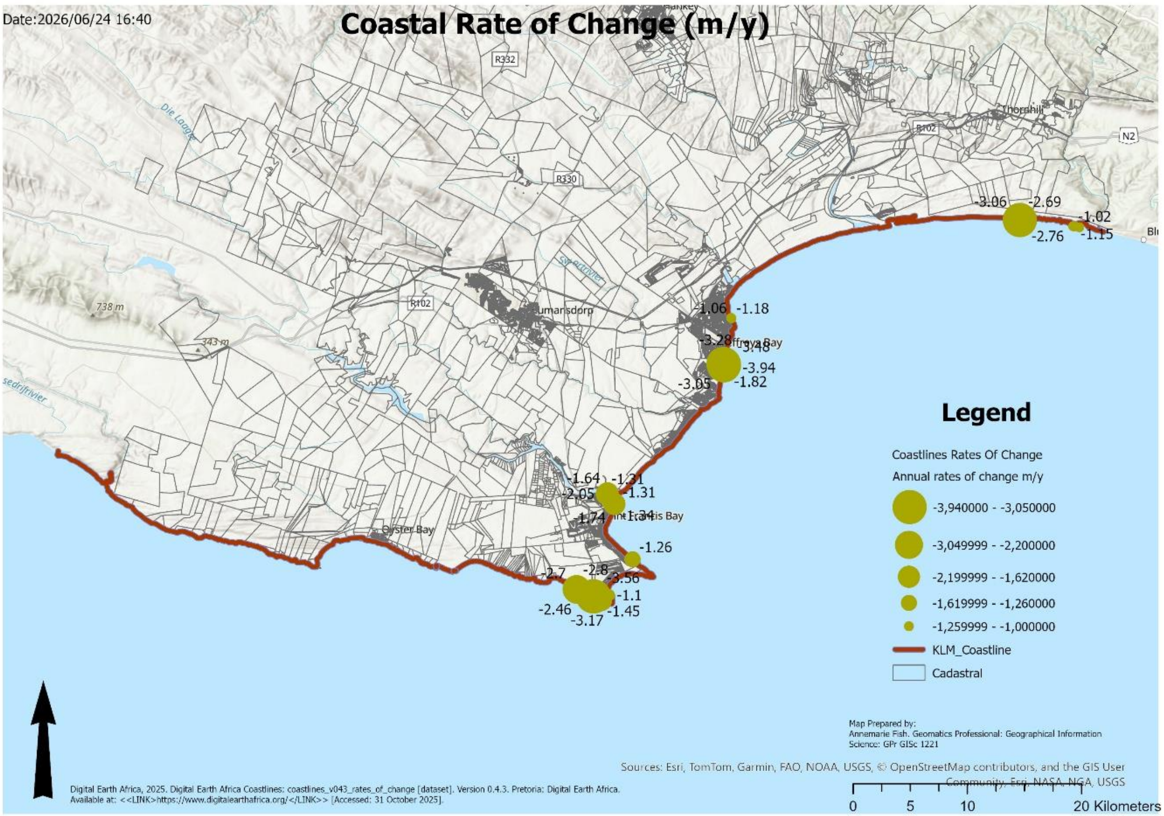
Coastal feature digitisation: Coastal feature vector boundary polygons were created through manual heads-up digitisation at a fixed scale of 1:2,000. Esri World Imagery was used as the spatial base layer for identifying and tracing the relevant coastal features (Esri, 2026).



Historical Erosion Rates (The Multi-Decade Horizon): Digital Earth Africa Coastlines monitoring provides shoreline-change attributes, including annual rates of change calculated by linearly regressing annual shoreline distances against time. Negative values indicate retreat and positive values indicate growth, with the dataset monitored from 2000 to the current period (Digital Earth Africa, n.d.; Bishop-Taylor et al., 2019; Bishop-Taylor et al., 2021).

Erosion Category	Average Annual Rate	50-Year Total Retreat	Recommended Safety Buffer	Total Points
Low / Semi-Stable	Less than 0.1 m per year (less than 10 cm per year)	0 m to 5 m	10 m	2885
Moderate	0.1 m to 0.2 m per year (10 cm to 20 cm per year)	5 m to 10 m	**15 m to 20 m**	625
High / Severe Hotspot	0.3 m per year or more (30 cm per year or more)	15 m or more	**30 m**	391

Historical erosion-rate summary: The shoreline-change dataset includes 3,797 monitoring points spaced at approximately 36 m intervals.

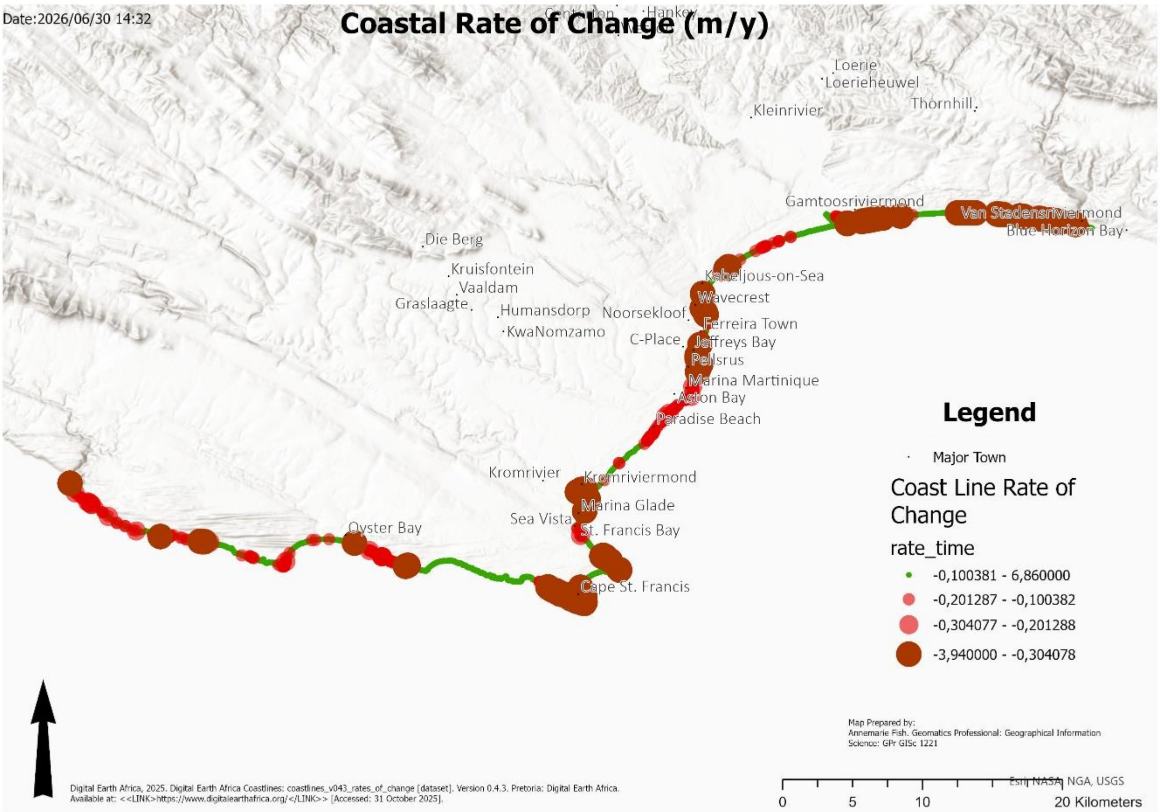


- **The "Bruun Rule" Shoreline Retreat:** As we looked at with sea-level rise buffers, an increase in offshore water heights forces sandy profiles to shift landward and upward. A horizontal safety buffer provides the physical room required for the beach profile to naturally retreat without immediately undermining private foundations.

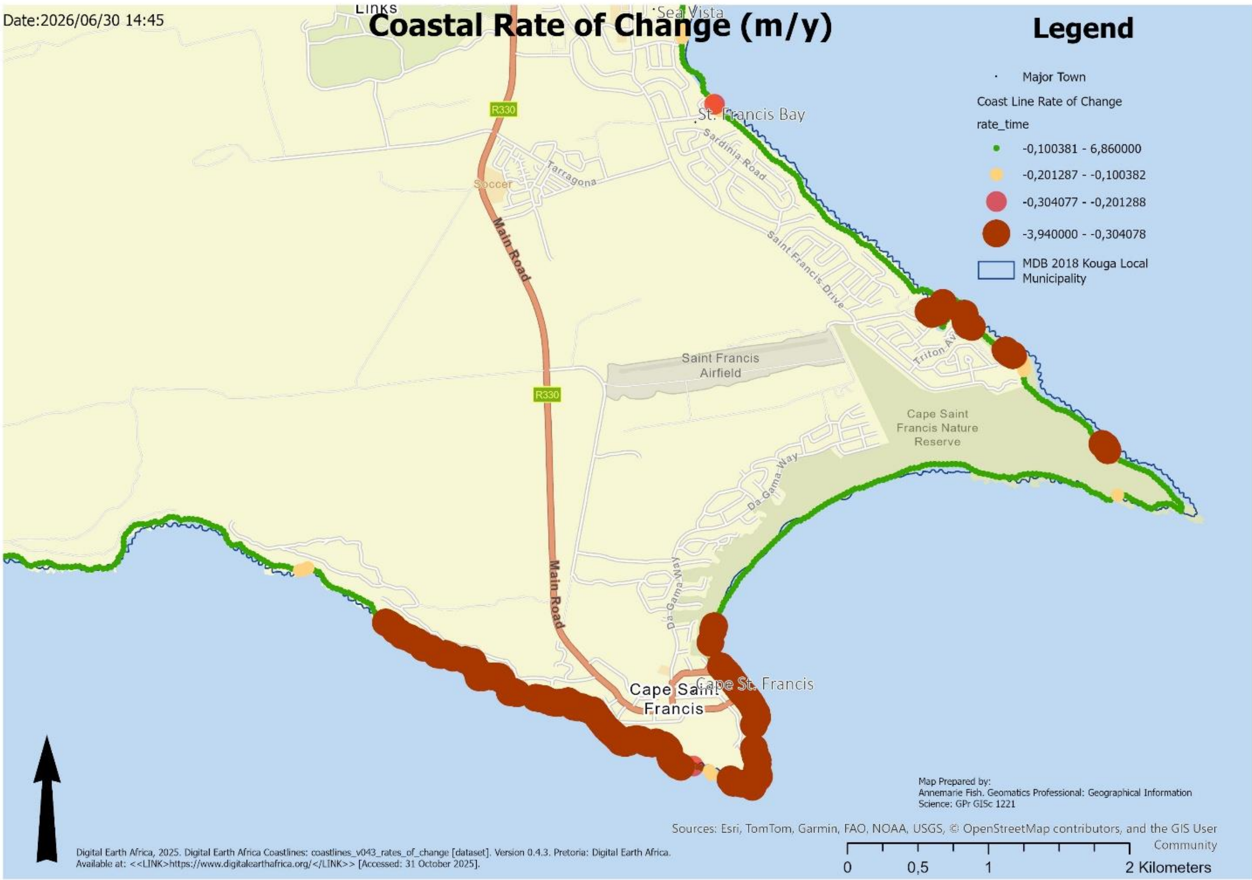
Attribute	
rate_time	Annual rates of change are calculated by linearly regressing annual shoreline distances against time, excluding outliers. Negative values indicate retreat and positive values indicate growth (Digital Earth Africa, n.d.; Bishop-Taylor et al., 2021)
sig_time	Significance is represented by the p-value of the linear relationship between annual shoreline distances and time. Small values, such as $p < 0.01$, may indicate consistent coastal change through time (Digital Earth Africa, n.d.).
se_time	Standard error (in metres) of the linear relationship between annual shoreline distances and time. This can be used to generate confidence intervals around the rate of change given by rate_time (e.g. 95% confidence interval = se_time * 1.96).
outl_time	Individual annual shoreline are noisy estimators of coastline position that can be influenced by environmental conditions (e.g. clouds, breaking waves, sea spray) or modelling issues (e.g. poor tidal modelling results or limited clear satellite observations). To obtain reliable rates of change, outlier shorelines are excluded using a robust Median Absolute Deviation outlier detection algorithm, and recorded in this column.
sce	Shoreline Change Envelope (SCE). A measure of the maximum change or variability across all annual shorelines, calculated by computing the maximum distance between any two annual shoreline (excluding outliers). This statistic excludes sub-annual shoreline variability.
nsm	Net Shoreline Movement (NSM). The distance between the oldest (2000) and most recent annual shoreline (excluding outliers). Negative values indicate the coastline retreated between the oldest and most recent shoreline; positive values indicate growth. This statistic does not reflect sub-annual shoreline variability, so will underestimate the full extent of variability at any given location.
max_year, min_year	The year that annual shorelines were at their maximum (i.e. located furthest towards the ocean) and their minimum (i.e. located furthest inland) respectively (excluding outliers). This statistic excludes sub-annual shoreline variability.
outl_time	Individual annual shoreline are noisy estimators of coastline position that can be influenced by environmental conditions (e.g. clouds, breaking waves, sea spray) or modelling issues (e.g. poor tidal modelling results or

Attribute	
	limited clear satellite observations). To obtain reliable rates of change, outlier shorelines are excluded using a robust Median Absolute Deviation outlier detection algorithm, and recorded in this column.

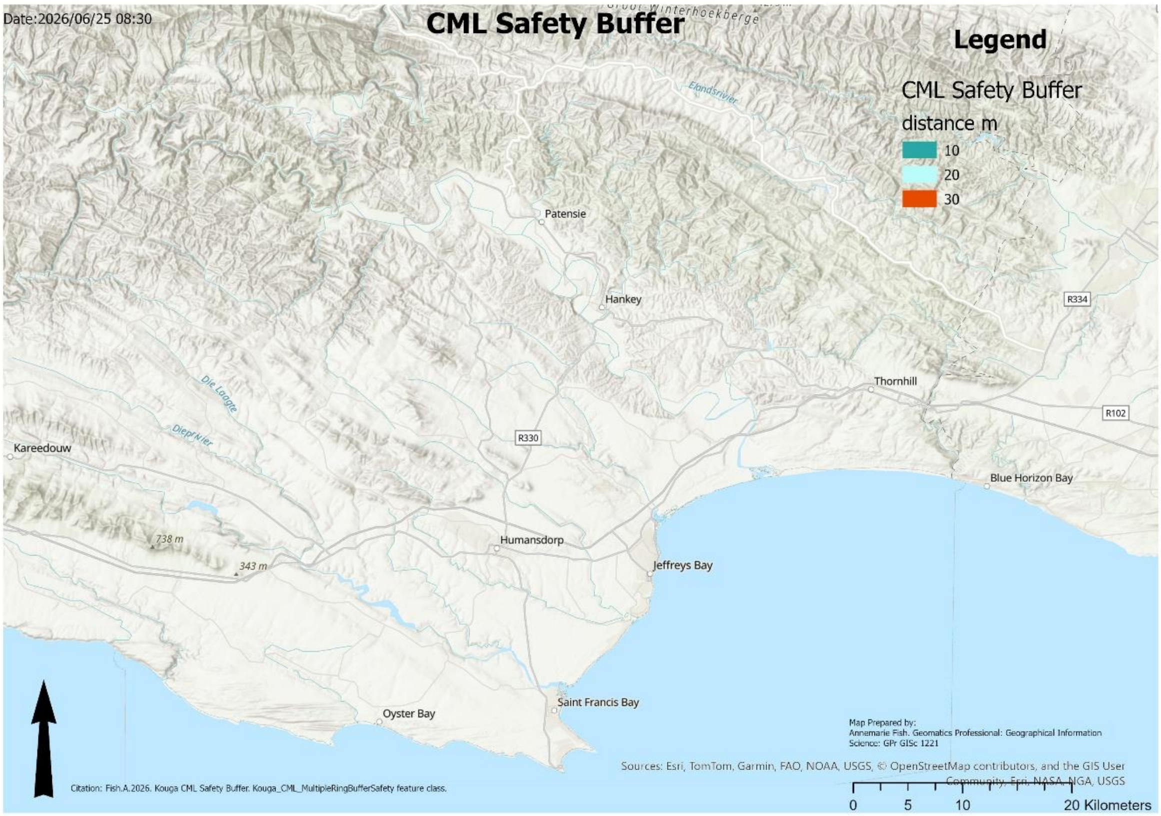
The rate of change along the coast line grouped in severity similar to the erosion category table.



Cape St Francis shows multiple sites of change ranging between -0.1m to above -0.3m which is mostly along rocky seashores.



Using a multi-distance buffering approach creates clear, discrete risk zones landward of your baseline 3.35m inundation line. This is a standard spatial planning technique used to translate a raw physical hazard level into actionable municipal setback zones, particularly for managing dynamic dune systems, coastal erosion hazards, and structural development restrictions along the Kouga coastline.



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