REPORT

New International Airport of Cabinda (NAIC Project) - Angola

Environmental and Social Impact Assessment - Chapter 6 - Baseline Conditions, Physical Environment

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6.0 BASELINE CONDITIONS – PHYSICAL ENVIRONMENT

This section describes the existing baseline conditions within the Project area of influence for physical components. The description combines the review results of secondary data drawn from publicly available repositories or provided by ASGC, with primary data and observations from site surveys and field observations carried out by Saioz Engenharia Ambiental.

In general, the sections in this report are divided into a first part, where more general characteristics of Angola and/or the Province of Cabinda are described for each component, and a second part, where the information for each component is narrowed down to specific characteristics of the Project area. The Area of Influence (AoI) has been previously defined in Chapter 2 of this ESIA (Project Description).

6.1 Geology

6.1.1 Regional Geology

With regard to regional geological mapping, the main source of information available for the territory is compiled by the Geological Institute of Angola (IGEO), namely through its Geological Documentation centre.

For the project region, Cabinda, there is one regional chart of geological units covering the territory, namely the Cabinda 250 k chart (Figure 1).

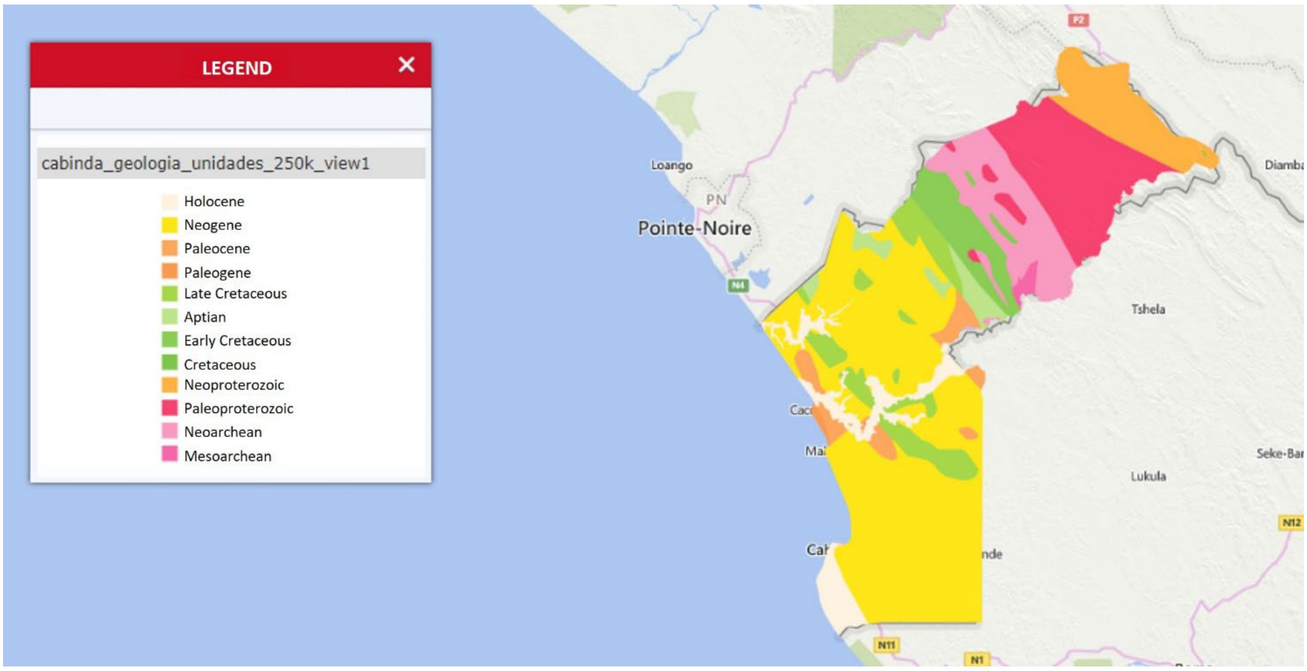


Figure 1: Regional 250 k geological chart of Cabinda – Geological units. Source: IGEO.

According to the chart, Cabinda has 11 main geological units, namely, from West to East:

- Sands, siltstones, clays and laterites (yellow) – Neogene to Quaternary;
- Malembo Formation (dark orange) – Alternation of sandstone, siltstone and claystone – Paleogene to Miocene;
- Loams, limestone intercalations, coprolitics, clays and sandstone (light orange) – Palaeocene to Eocene;
- Alluvial-Lacustrine Deposits (white) – Sandy clays, logos, clayey sands, sands – Holocene;
- Ambrizete Formation (dark green) – Sandstone, siltstone, limestone and marl intercalations – Upper Cretaceous to Paleocene;

- Red formation (light green) – Sandstone, reddish sand, interbedded claystone, siltstone and limestone – Aptian to Turonian;
- Granite porphyry (dark pink) – Paleoproterozoic;
- Shales, quartzites (light pink) – Neoarchean;
- Upper Sequence formation (medium pink) – Granite-gneisses, migmatites, shales, amphibolites, serpentinites – Mesoarchean;
- Undifferentiated Lulumba e Uonde formation (darker pink) – Rhyolites, dacites, andesites and their tuffs in the upper part, sandstone, quartzites, schists in the upper part – Paleoproterozoic to Mesoproterozoic;
- Terreiro Formation (dark orange) – Sandstone, quartzite, schist, limestone horizons in the upper part – Neoprotecozoic.

Cabinda has many geological contact lines along the limits of each geological unit, with some secondary fault lines, mainly oriented from Northwest to Southeast (Figure 2).

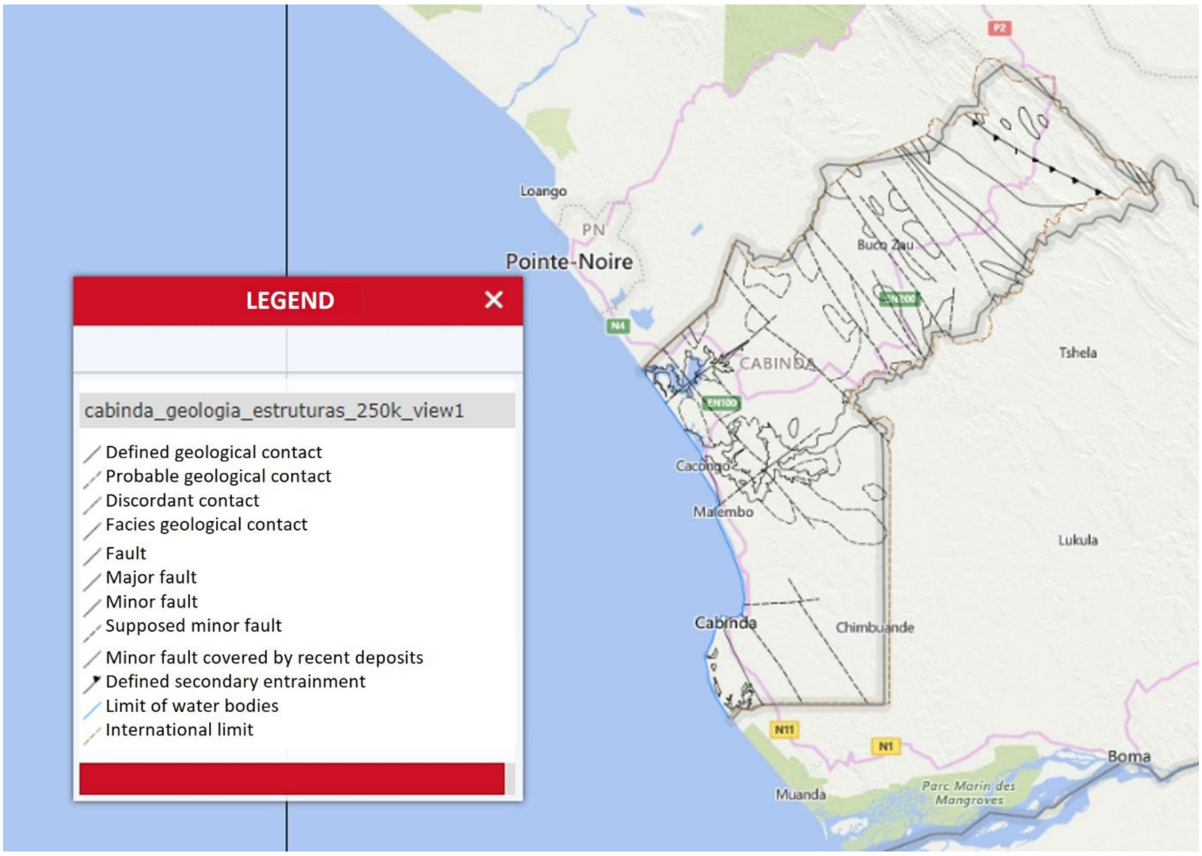


Figure 2: Regional 250 k geological chart of Cabinda – Geological structures. Source: IGEO.

Cabinda has many potential mineral resources identified, covering iron metals, non-iron metals, rare materials and earths, noble materials, non-metallic minerals, construction materials and precious stones.

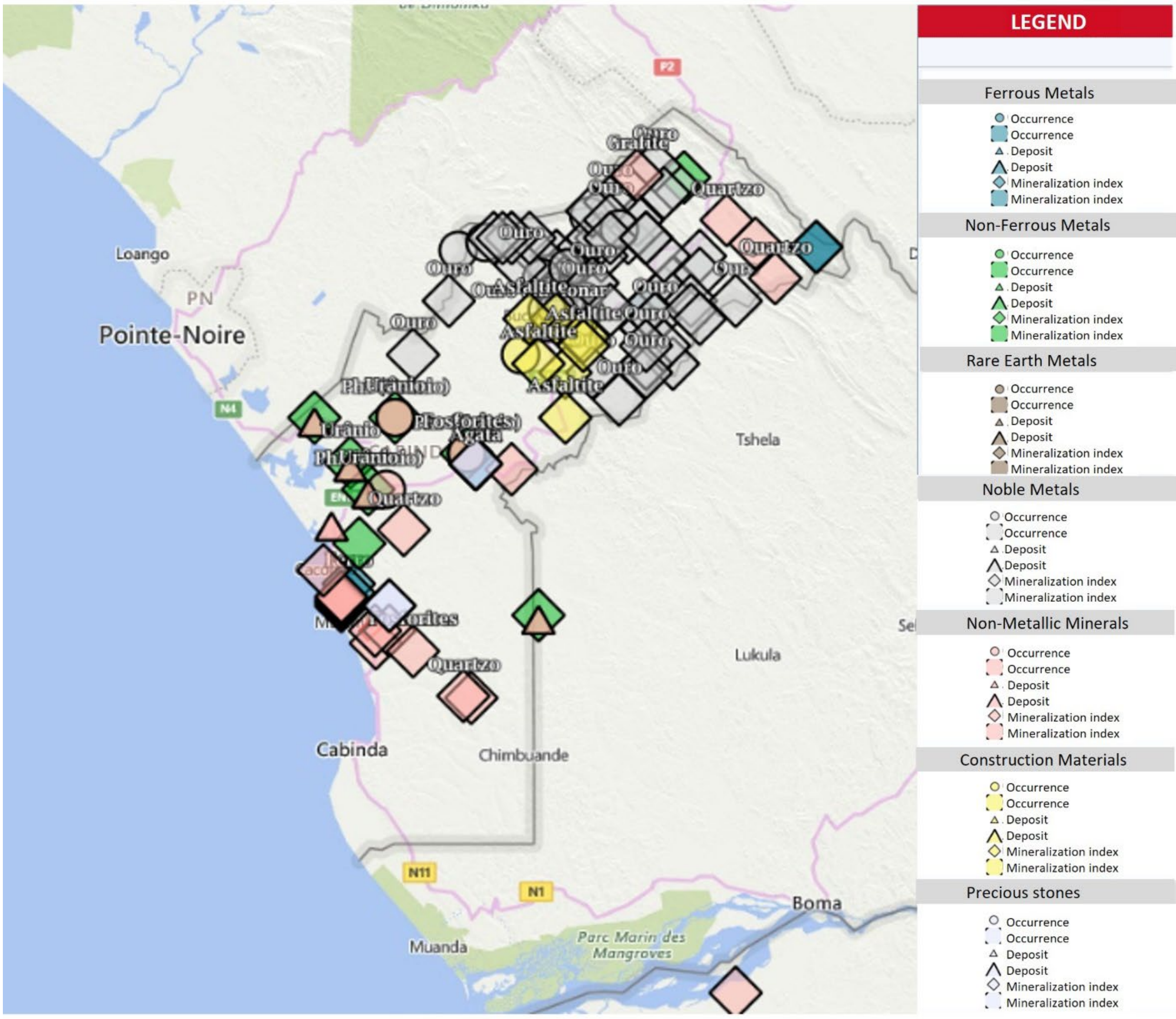


Figure 3: Mineral Resources in Cabinda. Source: IGEO.

6.1.2 Local Geology

Regarding local geology, the best source of available information are also charts produced by IGEO.

Assessing at a smaller scale, it can be estimated that the Project will be located entirely in the Neogene – Quaternary formation composed of sands, siltstones, clays and laterites (Figure 4).

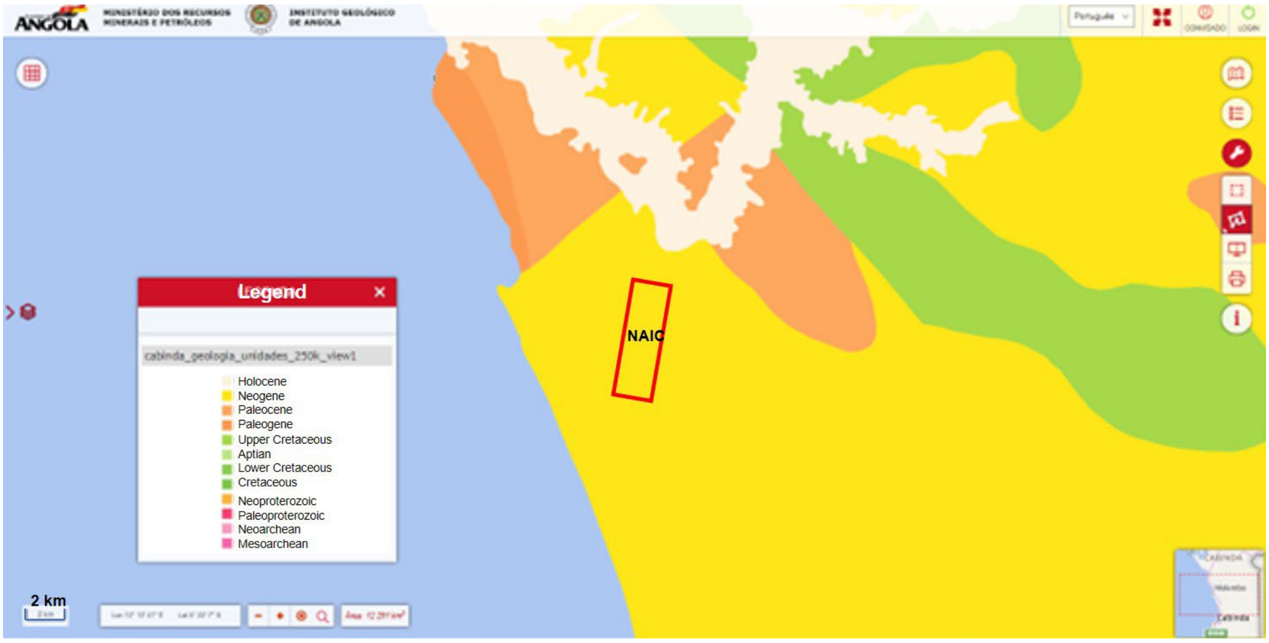


Figure 4: Project area detail (approximate location and footprint contour) - Regional 250 k geological chart of Cabinda – Geological units. Source: IGEO.

Assessing the chart of geological structures, it can be assumed that no fault line crosses the Project site, and the only structures present are associated with the limits of each geological unit (Figure 5).

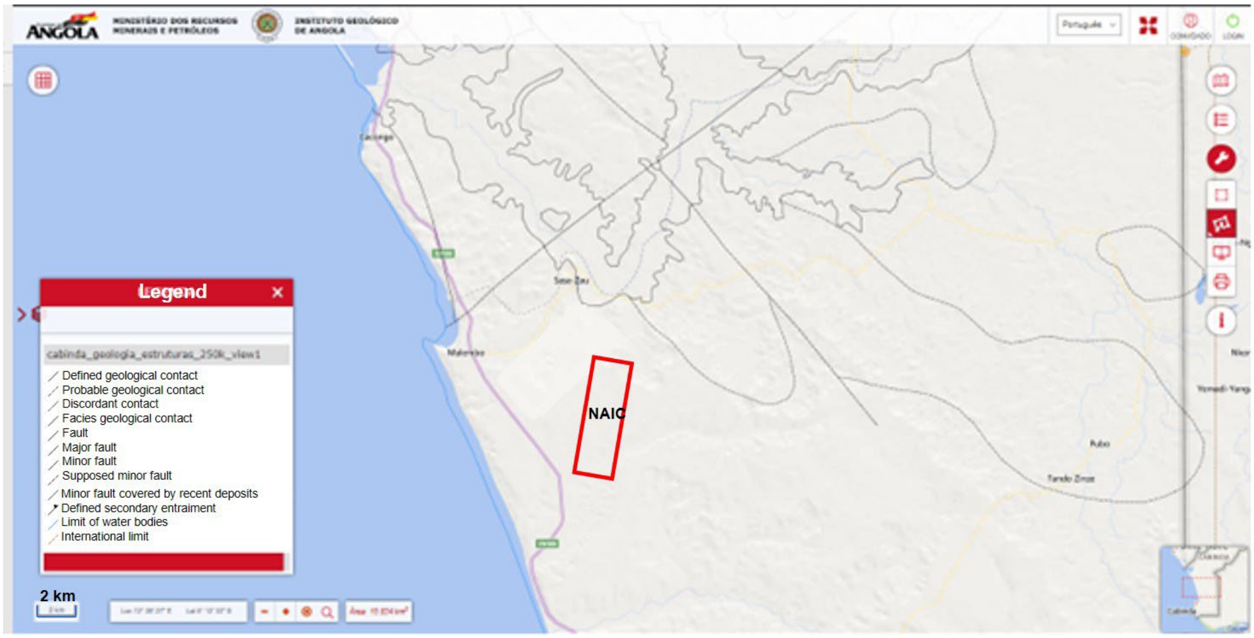


Figure 5: Project area detail (approximate location and footprint contour) - Regional 250 k geological chart of Cabinda – Geological structures. Source: IGEO.

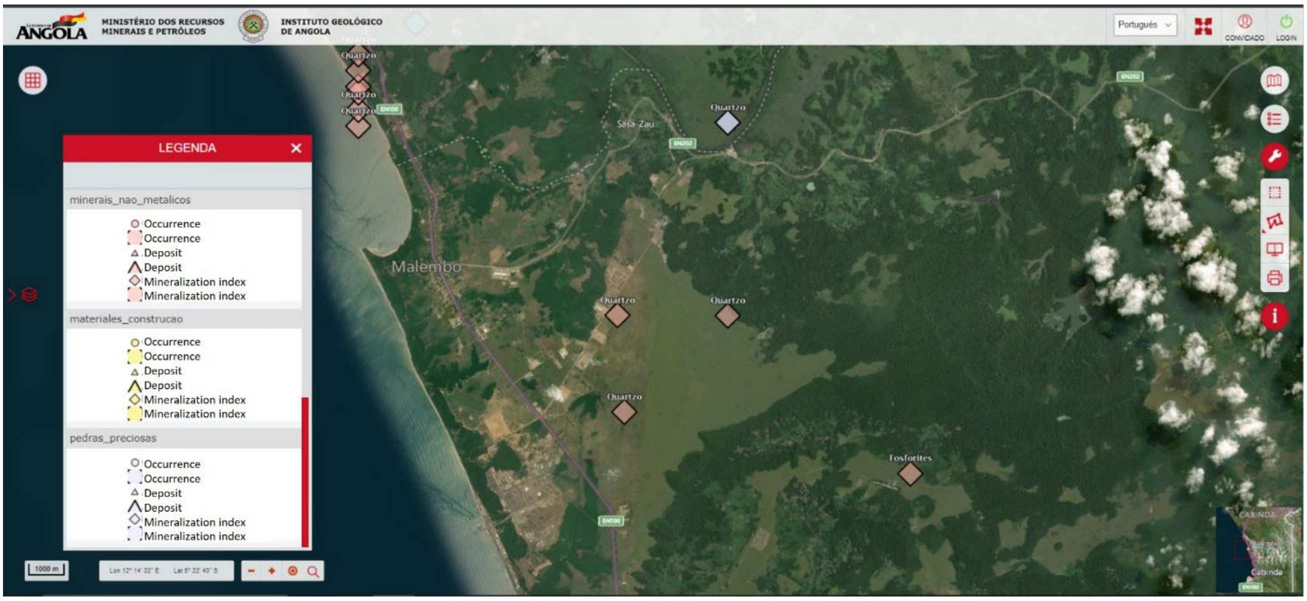


Figure 6: Project area detail (the location and format of the polygon that delimitates de Project footprint is approximate) – Mineral Resources. Source: IGEO.

When checking the geological charts for geological resources, several mineral resources appear marked in Project AoI, especially to the north of Malembo (Figure 6).

Close to the greenfield where the Project will be located, 3 possible extraction points for mineral resources are present, namely non-metallic minerals (with quartz, feldspar, kaolin and kyanite as probable mineralization index). These sites and marked as Molongo, Rio Seco and Tchinfimbo Road. All of these sites correspond to possible/probable mineralization index and none of them are active or had any extraction activity in the past.

6.1.3 Seismicity

The seismicity rate[1] of Angola is difficult to determine because of the absence of a local network capable of carrying out reasonable instrumental monitoring throughout the country and, in particular, in regions with greater seismic activity. There is also little knowledge of historical seismicity.

Nevertheless, a more in-depth study on the subject carried out by Neto (2014), led to the creation of an Angolan seismicity map with the identification of five seismic zones, by evaluating the earthquake density (Figure 7). According to the author, the map was produced by combining the information from available literature with historical events of body wave magnitude[2] Mb ≥ 3.0 and from instrumental data measurements for events of Mb ≥ 3.4. The temporal distribution of earthquakes used for the map creation is shown in Figure 8.

The Angola region is very little seismically active, since it is located in a zone that can be considered tectonically stable. The maximum known earthquake occurred in 1914 in the Angola craton, with a magnitude of 6.0 Ms[3]. Seismic events with a magnitude of 4.5 Ms have shown a return period of about 10 years and events of magnitude 5 Ms and above occur with a return period of about 20 years. Overall, the cratonic regions that are exposed tend to experience more earthquakes compared to other regions such as sedimentary basins. Earthquakes tend to occur in Archean rocks, especially in pre-existing zones of weakness and in zones of tectonic-magmatic reactivation, associated with the installation of intrusive rocks, strongly marked by intense

[1] Number of earthquakes in a specified interval of space-time-magnitude, normalized by the length of the time interval (source: CORSSA).

[2] Body wave magnitude (Mb) is a scale that measures earthquake sizes usually used at larger distance from the epicentre. It is calculated from the body waves P, PP and S. It can be used for any earthquake at any depth (source: British Geological Survey).

[3] Surface-wave magnitude (Ms) is a scale that measures the amplitude of surface waves. It is used for observations near the earthquake epicentre where the surface wave is larger than the body wave (source: British Geological Survey).

tectonics. In general, in intraplate regions, seismic occurrences are associated with pre-existing zones of weakness.

The five seismic zones defined for Angola are situated in and along the edges of cratons and in sedimentary basins, including offshore. According to Figure 7 below, they are defined as follows (Neto F. P., 2014):

1. Angola craton (largest known event in 1914 with magnitude 6.0);
2. Cassai craton (largest observed event in 1999, with magnitude 4.5);
3. Bangwedo craton (largest observed event in 2013, with magnitude 4.8);
4. Intracratonic sedimentary basin (largest observed event in 1960 with magnitude 5.9);
5. Passive margin and Angola offshore largest observed event in 2001, with magnitude 5.3);

The Project area is situated close to zone 5, where 56 events of magnitude 3.4 or greater have been historically reported (information from 2018), combining the passive margin[4] area (9 events) and its adjacent continental margin region (47 events). This seismic activity is associated to flexural stresses from uncompensated lithospheric loads. As it can see from Figure 7, the closest seismic event to the Cabinda province was registered at a distance greater than 150 km.

According to the ThinkHazard website[5], developed by the GFDRR (Global Facility for Disaster Reduction and Recovery – World Bank), in the Cabinda province, the seismic risk is classified as very low according to currently available information, meaning that there is less than a 2% chance of a potentially damaging earthquake occurring in the area of project over the next 50 years.

[4] Passive margins are areas where continents have rifted apart to become separated by an ocean (source: Geological Survey of Norway).

[5] https://thinkhazard.org/en/report/401-angola-cabinda/EQ

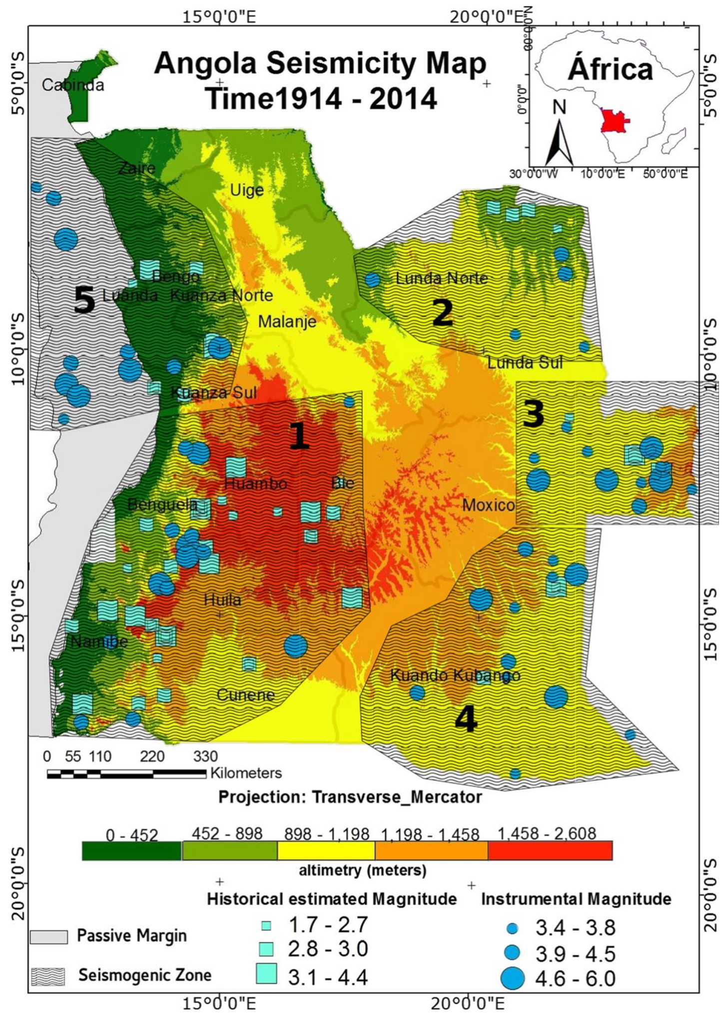


Figure 7: Angola seismicity map with seismic zones. Source: Neto, et al. (2018).

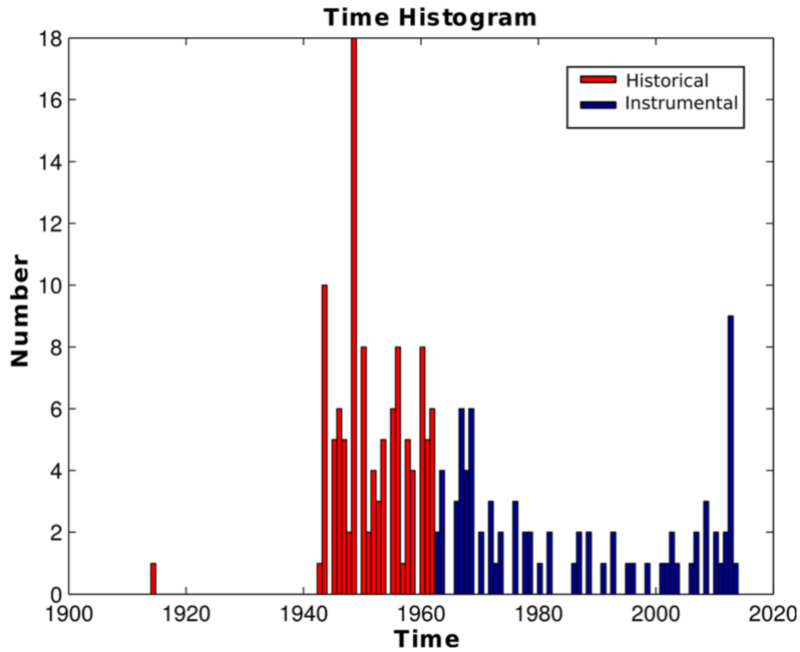


Figure 8: Temporal distribution of Angolan earthquakes. Angolan seismic studies started in the late 1940s. From 1965 until the beginning of the 2000s, seismic measurements were very scarce due to the civil war that took place in the country. Source: Neto, et al. (2018).

6.2 Geomorphology and Topography

6.2.1 Regional Geomorphology

The general topography of Angola is illustrated in Figure 9. In summary, 5% of the country's land surface is occupied with coastal plains lying below 200 m in altitude and 10 to 150 km in width. Moving towards the interior of the continent, the terrain leads to a mountainous, stepped escarpment rising to 1000 m (23%) and an extensive inland plateau varying from 1000 –1500 m (65%). Seven percent of the country is located above 1500 m, reaching its highest point at 2620 m on Monte Moco, in the Huambo region.

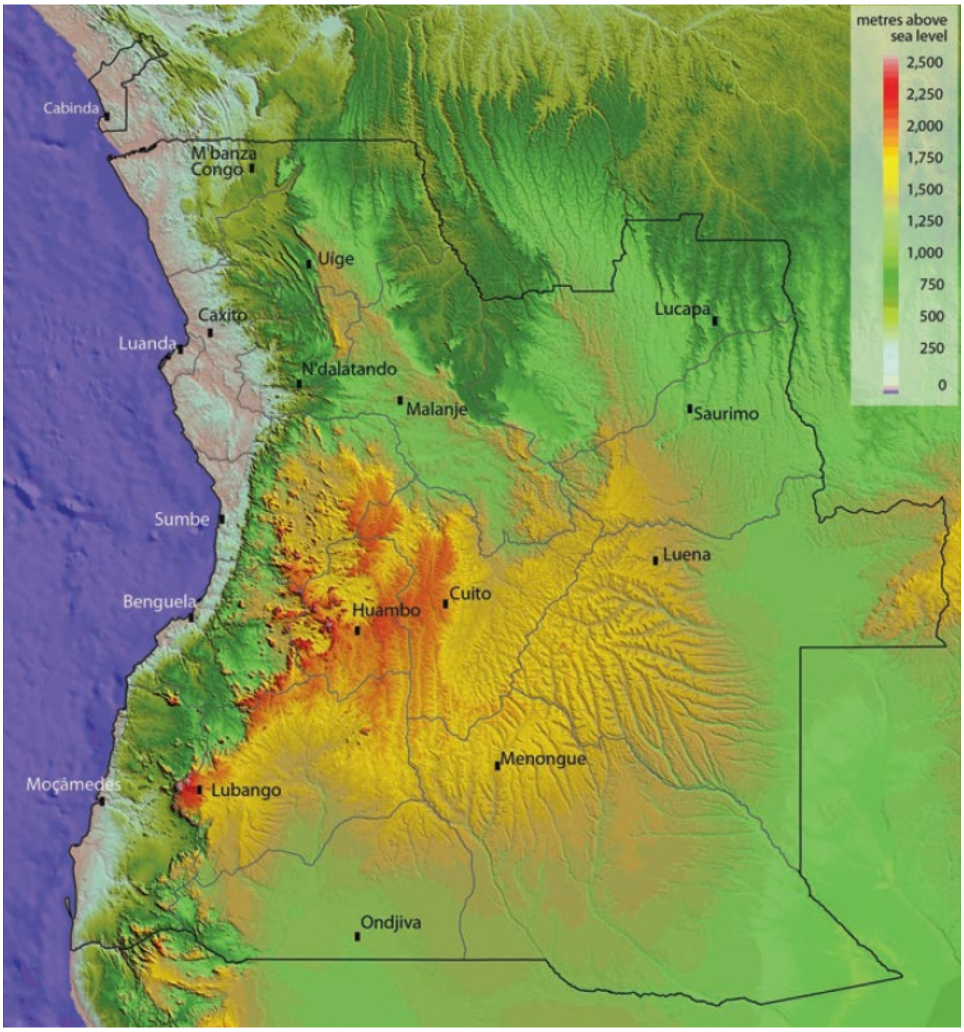


Figure 9: Topography of Angola, indicating provincial boundaries and capitals. The map reveals the coastal low-lands, western escarpments, central highlands and plateaus. Source: (Huntley, Russo, Lages, & Ferrand, 2019).

Eleven broad geomorphological units are identified in the country (Diniz, 1973 *apud* Huntley, et al., 2019):

- **Coastal Zone**: mainly a continuous platform at 10-200 m above sea level, sometimes broken by broad river valleys. Long sandbars stretch northwards from rivers such as the Cunene and Cuanza. The most part of the coast is uplifted, resulting in steep sea-cliffs of 10-100m. From the city of Lobito northwards, mudflats and mangroves occur at most river mouths. In general, the coastal belt has around 40 km width, but it varies from 10 km, in its narrowest parts, to 150 km, in the widest parts. The coastal plains are mainly composed of fossiliferous marine sediments from the geological basins of Cabinda, Cuanza, Benguela and Namibe. The northern coastal platforms are covered by deep red Pleistocene sands (*terras de musseque*) from ancient beaches. Beneath these sands, and exposed over large areas, are Cretaceous to the Miocene clays, gypsipherous marls, dolomitic limestones and sandstones. The southernmost segment of the Coastal Belt includes the mobile dunes of the Namib Desert.

- **Escarpment Zone**: transition belt situated between the coastal plains and the interior plateaus. It varies in width and altitude. In a large part of the zone, the transition takes several steep steps between 400 and 600 m. In the south of the country, between the cities of Lubango and Moçâmedes, the escarpment is very sharp, rising at 1000 m at some points. The escarpment zone includes a very hilly country, with mountain ranges to the north and some large inselbergs to the south, the most important being the Serra de Neve, which rises 2489 m from the surrounding plains and low hills. The geology of the escarpment zone comprises crystalline rocks of the Precambrian (granites, gneisses, schists, quartzites and amphibolites).
- **Marginal Mountain Chain**: residual mountain lands, mostly at 1800-2200 m, lying at the western margin of the interior plateau. They are known as the Benguela, Huambo and Huíla Highlands, and underlain mostly by Precambrian rocks (gneiss, granites and migmatites).
- **Ancient Plateau**: extensive plateau that drops eastwards from below the Marginal Mountain Chain. It comprises undulating landscapes with wetlands and low ridges with scattered granitic inselbergs. It encompasses the headwaters of the Cunene, Cubango, Queve and Cutato rivers and drops from 1800 m in the west to 1400 m in central Angola.
- **Lower Cunene**: this unit leads imperceptibly down from 1400 m on the Ancient Plateau to the border with Namibia at 1000 m. The gentle gradient of its eastern half forms the clearly defined Cuvelai-Etosha Basin, a 160,000 km^2 transboundary wetland area shared by Angola and Namibia. To the west of the Cunene River, the landscape is more broken, with sand pockets from the Kalahari in between low rocky hills.
- **Upper Cuanza**: distinct basin formed by the upper catchments of the Cuanza River and its tributary (Luando River), at altitudes ranging from 1200 to 1500 m.
- **Malange Plateau**: a gently undulating plateau at 1000–1250 m, which falls abruptly on its northeast bank. To the west, the plateau is drained by rivers flowing into the Atlantic, with emphasis to a tributary of the Cuanza, the Lucala, which drops more than 100 m into the famous Queda de Calandula.
- **Congo Peneplain**: vast sandy peneplain (low-relief plain formed as a result of long-term erosion), drained by the northward flowing tributaries of the Cassai/Congo Basin. The gently dipping plains are mostly at 1100-800 m.
- **Cassange Basin**: wide depression, several hundred meters below the surrounding plateaus. It is delimited by abrupt escarpments to the west and a densely dendritic catchment of the Cuango River to the northeast. The geological substrate comprises limestone, sandstone and conglomerates. Within the Basin, several extensive plateaus bordered by escarpments rise above the depression.
- **Zambezi-Cubango Peneplain**: vast peneplain draining deep Kalahari sands, with slow-flowing rivers that meander across the plateau gently dipping from 1200 m at the watershed with the Congo Basin to 1000 m at the border with Namibia. Within this peneplain, the Bulozi Floodplain occupies an area of 150,000 km^2.
- **Upper Zambezi Massif**: includes the Calunda Mountains to the east of the Moxico province. The geology comprises Precambrian schists and norites, dolerites, sandstones and limestones. They rise up to 1628 m above the Zambezi peneplain. The mountains form a striking contrast to the almost featureless landscape that stretches around 800 km eastwards (from the city of Calunda to Huambo).

The 11 geomorphological units are shown below in Figure 10.

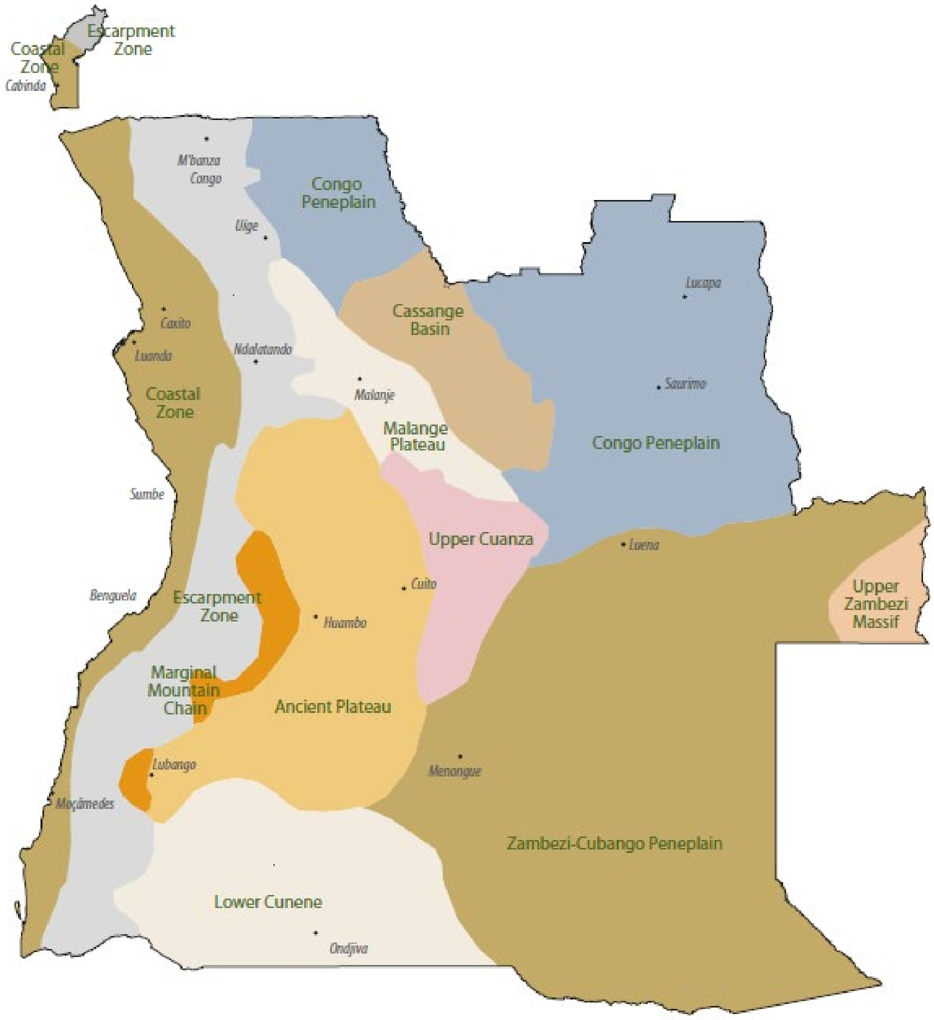


Figure 10: Main geomorphological and landscape units of Angola (Diniz, 1973 apud Huntley, et al., 2019).

6.2.2 Local Geomorphology

From a geomorphological point of view, the Project site is located in the Coastal Zone as per Figure 10 above. The low coastal region of Cabinda can be described as comprising two distinct regions (Missão de Pedologia de Angola e Moçambique, 1968):

- A Quaternary platform with many areas of depression, rising to about 100m above sea level;
- A platform at a higher altitude, up to about 200m asl, followed by a gently undulating plain at about 400m above sea level;
- The mountainous region of the interior begins at about 400m altitude, near Buco-Zau. The topography becomes particularly varied between Belize and the DRC border.

The Project is located in a flat platform, with soft slopes, at an altitude of approximately 140 m asl (Figure 11). The platform extends along the coast, covering the Malembo village, Futila and the main industrial sites along the coast.

When heading East from the Project area, a greater slope is found, that makes the transition to the Chiloango River Valley.

To the East of the project, alongside the road to Bissassanha and Sassa Zau and also in the forested area near the Project, a transition slope exists, creating a descent to the Valley below.

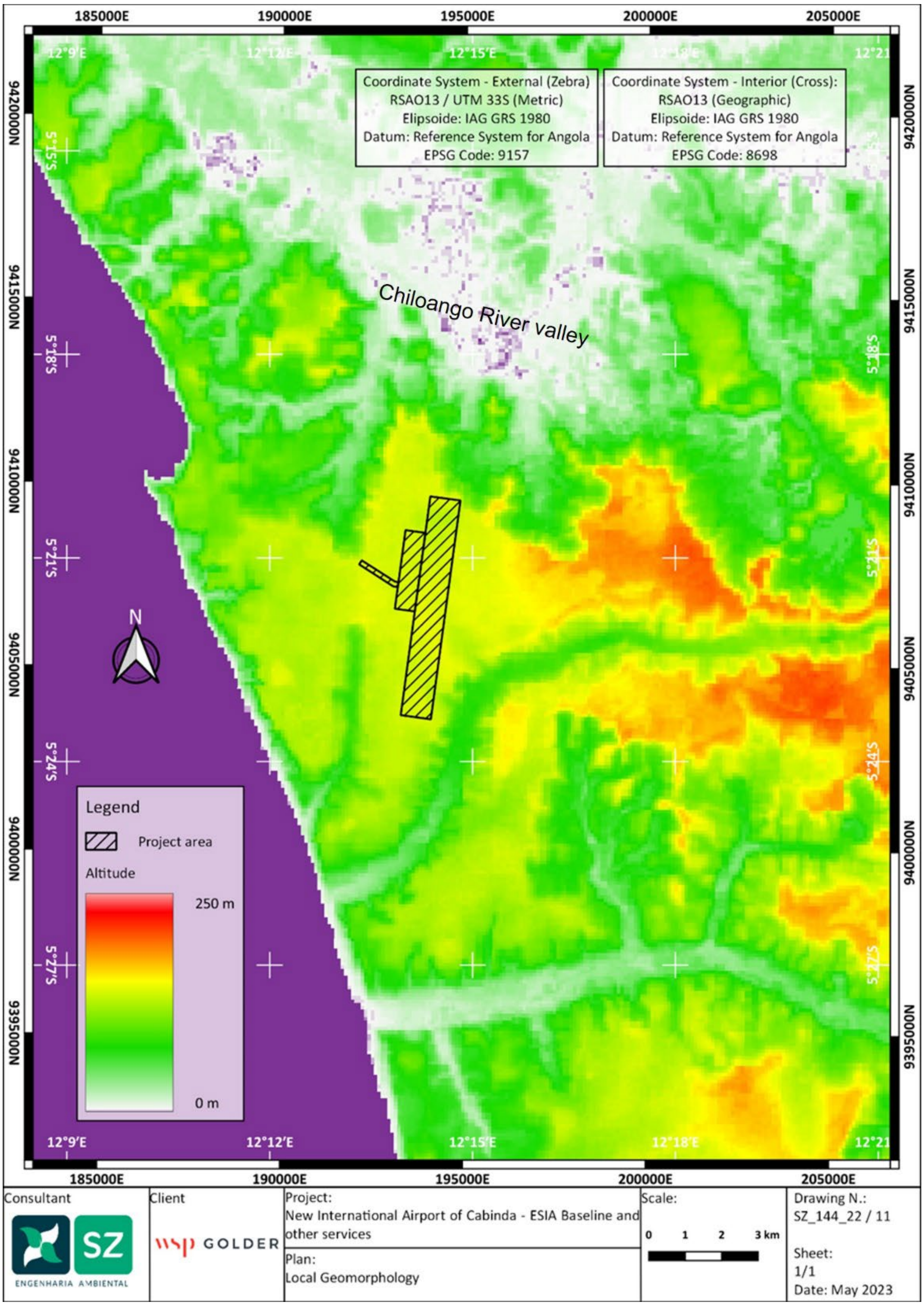


Figure 11: Local Geomorphology.

6.3 Climatology

6.3.1 Regional Climatology

The climatic characterization of the Project region is important for its influence on several descriptors. Local meteorological conditions, especially wind, condition the dispersion of atmospheric pollutants, thus influencing the impacts on air quality associated with a project, as well as the propagation of acoustic emissions, influencing the impacts on the sound environment descriptor. Weather conditions can also influence the hydrological cycle, namely water availability, flow regimes and soil erodibility.

The climate also conditions the type of vegetation that can be incorporated into the Project area, as a possible measure to minimize a given identified impact.

The following characterization is based mainly on the parameters: temperature, precipitation, atmospheric humidity and wind direction and speed.

National Climatic Classification

Most of the territory of Angola is characterized by having a subtropical climate, with a rainy season and a dry season (Cacimbo).

According to the Geographical Atlas of Angola for Secondary Education (first edition) (INIDE, 2008), the Angolan territory is divided into four climatic zones: modified by altitude, tropical desert, tropical dry and tropical humid (*Figure 12*). The Project area fits into the tropical humid climatic zone, that covers all of Cabinda province.

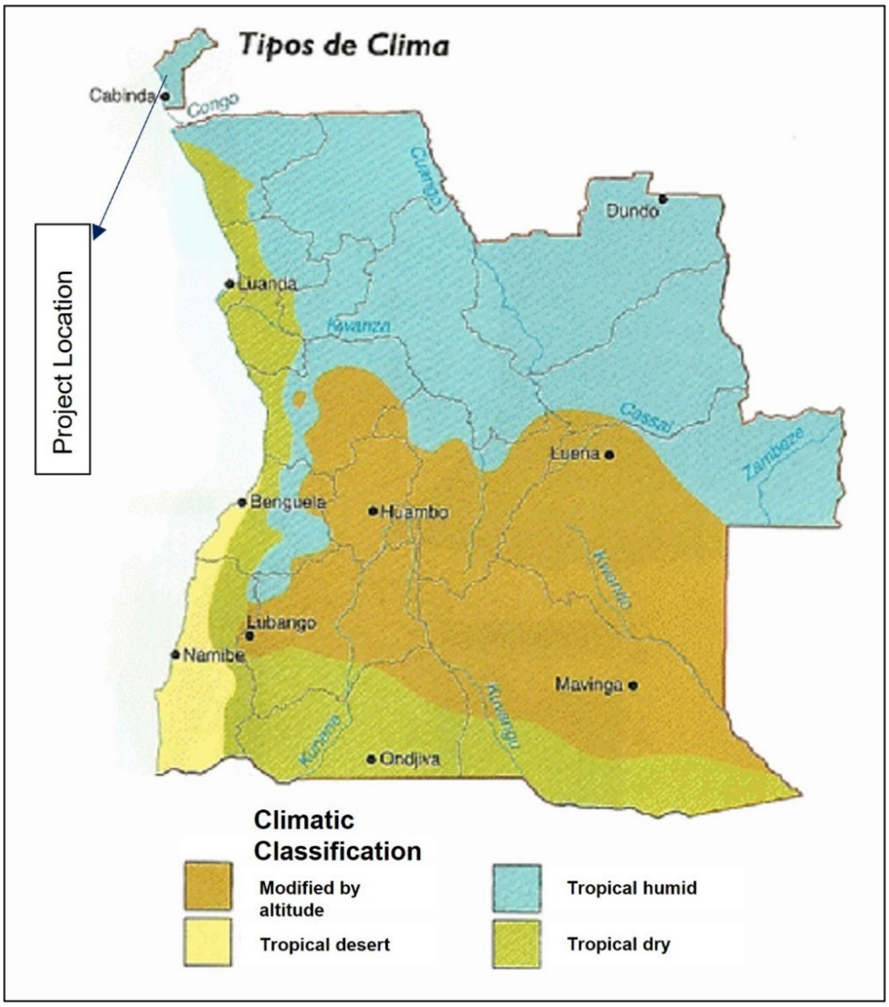


Figure 12: Climatic zones of Angola. Modified from INIDE (2008).

Among other existing climatic classifications, the analysis of the Köppen-Geiger[6] climate classification for the Angolan territory was also considered since this is an international reference widely used for climate characterization. According to this classification, the Project area is classified as a tropical savanna climate, with particularly dry winters (Aw). This is a type of transitional climate found between the equatorial climate type and the hot deserts (Figure 13).

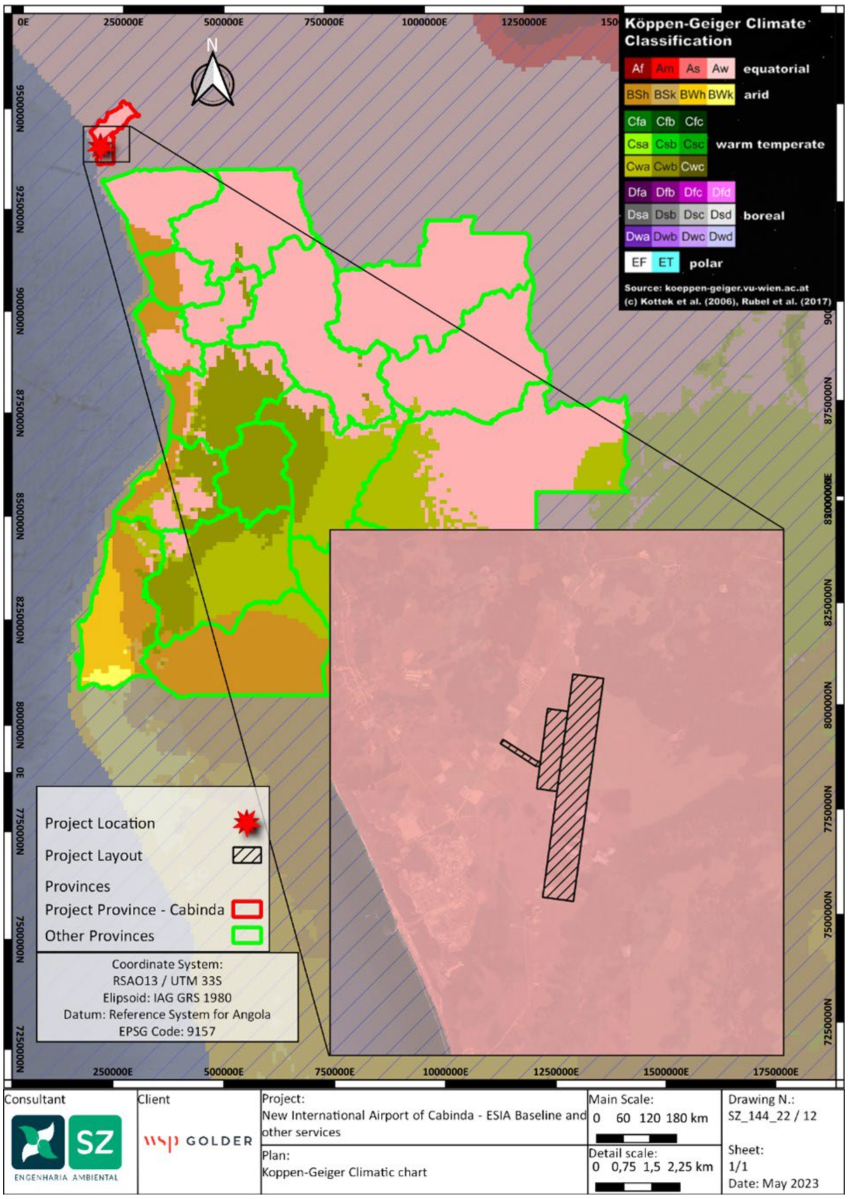


Figure 13: Köppen-Geiger Climate Chart – 2017 update.

As described in the World Bank's Climate Knowledge Portal[7], Angola's rainy season lasts from October to May and is characterized as hot and humid. The intertropical convergence zone (ITCZ) controls precipitation as it moves between the equator and the tropics, bringing precipitation to Angola as it migrates southwards from the equator in October. The rains coincide with the hottest months of the year, with temperatures ranging from 22

[6] Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006: World Map of the Köppen-Geiger climate classification updated. *Meteorol. Z.*, **15**, 259-263. DOI: 10.1127/0941-2948/2006/0130

[7] Climate Change Knowledge Portal, World Bank Group, em https://climateknowledgeportal.worldbank.org/country/angola/climate-data-historical

to 23 °C. The dry season, known as the “Cacimbo” occurs from June to September and is the coldest period of the year, with temperatures between 18 and 20 °C.

Total precipitation decreases from North to South and from East to West, with Northeast Angola receiving the highest amount of precipitation. Much of Angola's climate is linked to sea surface temperatures and variations in the cold Benguela current.

Figure 14 and *Figure 15* show the distribution of temperature and rainfall in Angola, respectively.

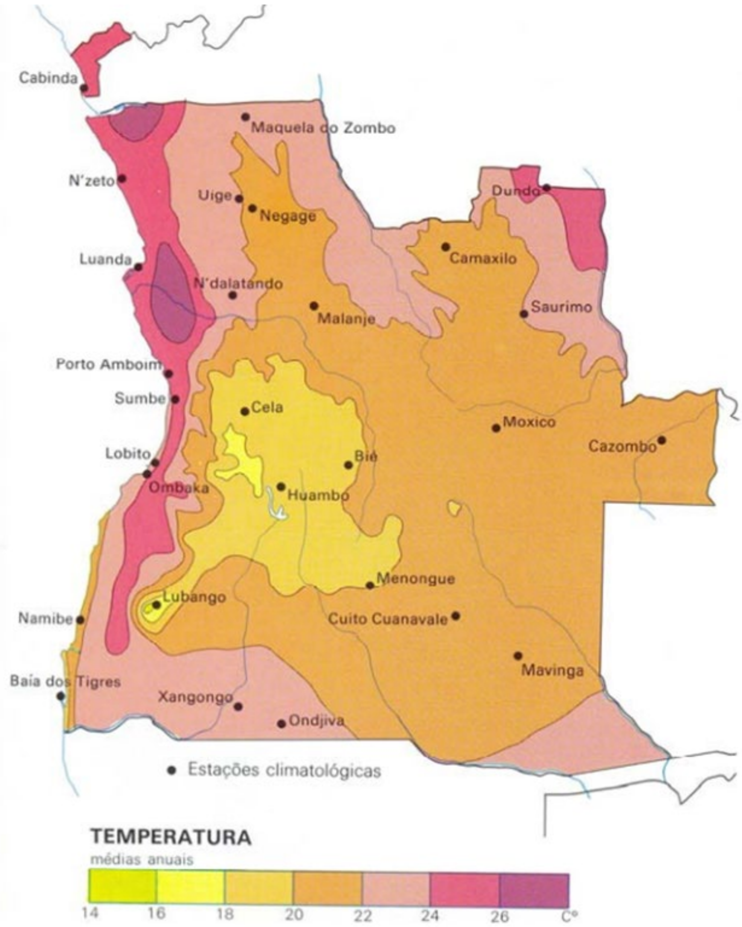


Figure 14: Temperature distribution in Angola. Source: Governo de Angola (2006).

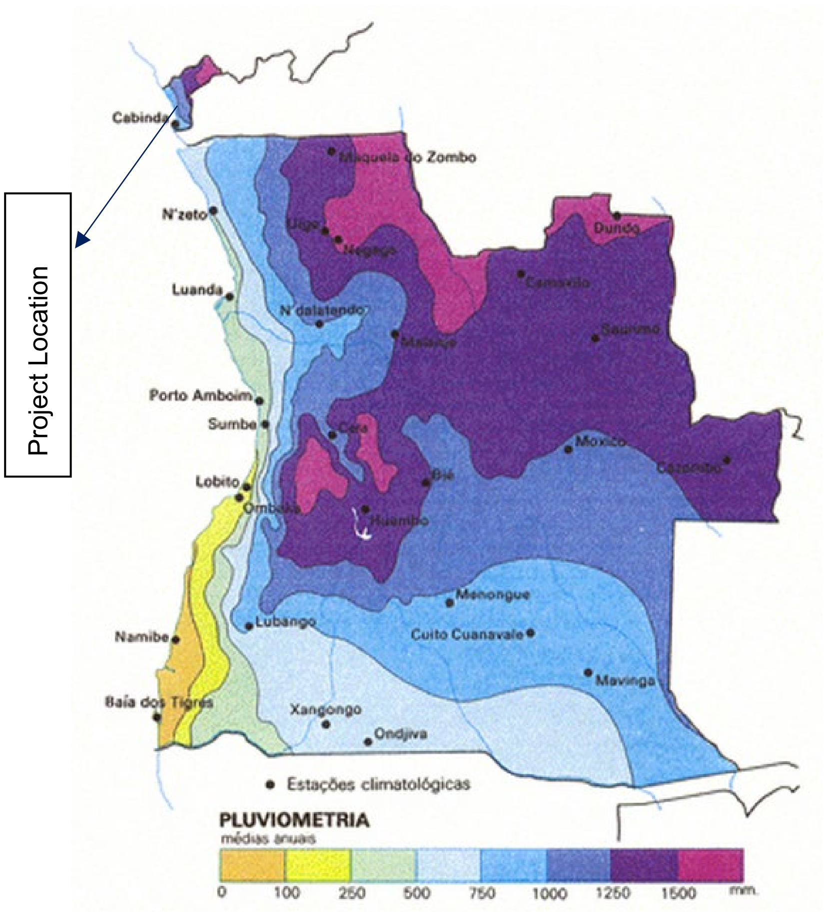


Figure 15: Representative map of pluviometry in Angola. Source: INIDE (2008).

Observed Climatic Trends

In terms of temperature, there has been a progressive increase since 1960, with the temperature increase rate being more pronounced in winter (June to August) and less expressive in summer (December to February). The frequency of "hot" days and nights per year has increased significantly between 1960 and 2003, with the greatest increase being recorded in the months of September to November. Conversely, the frequency of "cold" days and nights has reduced between 1960 and 2003, with the greatest rate of reduction in the months of March to May.

In terms of precipitation, the average annual precipitation has decreased at a rate of 2 mm/month for each decade, with the greatest reduction recorded in precipitation from March to May, with a rate of 5 mm/month per decade. In the second half of the 20th century, the southern part of the African continent has seen a reduction in summer precipitation, which has advanced from Namibia, through Angola to the Congo. This progressive downward trend in precipitation is associated with an increase in sea temperatures in the tropical zone of the Indian Ocean.

There is no clear precipitation trend in the central highlands' region. However, in the highlands of Huíla and in the central-south transition zone, there are indications of a reduction in precipitation and an increase in its variability.

In terms of specific national meteorological data, namely temperature, humidity, and precipitation data for the territory, INAMET[8] has only some official data available on its website, namely climatological precipitation normals, developed based on data from 1981 to 2010, but only for the periods from September to April.

There are alternatively multiple sources of meteorological information available internationally, typically based on extrapolation climate modelling. One of these examples is the data made available by FAO, used in the Geographical Atlas of the Ministry of Education.

It should be noted, however, that the existing national data results from extrapolations and spatial modelling and is often based on very long historical series. As described above, the climate is undergoing progressive change, as a result of climate change, limiting the applicability of old historical data series, which end up not adequately representing the current climate.

Thus, more important than a general meteorological characterization of the country, for the purposes of the Project, it is considered relevant to have a specific perspective of the meteorology in the Project region, in this case, in Cabinda area.

For this purpose, a survey of meteorological stations was carried out with recent data from the Project area, which could be assessed for data on local climate. This will be described in the next section.

6.3.2 Local Climatology

In terms of local data in the Cabinda area, climate data is available only from the existing airport weather station (*Table 1*). The airport regularly uploads station data, via TAF or METAR encoding, to various traffic control services and specialty portals. There are different files available with these data, one of which is held by the National Center for Environmental Information (CEI), of the National Oceanic and Atmospheric Administration (NOAA) of the United States of America[9]. From this data, a period of 10-year history of data (2012 to 2023) has been selected for analysis.

Table 1: General information regarding the weather station in the existing Cabinda airport.

Station	Data Period Available	Equipment	Location	Altitude
Cabinda Airport	02 Mar 2012 - Current	-	Latitude: -5.596992 Longitude: 12.188353	20,11 m

The weather station in the existing Cabinda airport only provides data related to wind and temperature, with no history data from precipitation. As such, for precipitation, it was considered historical data available from Pointe-Noire airport station, provided by Meteoblue portal. This station is relatively close to Cabinda (70 km north of the Project area) and represents similar climatic conditions (close to the coastline), thus providing data than can be considered valid for representing the Cabinda conditions.

The location of the two weather stations in relation to the Project site is shown in *Figure 16*.

[8] INAMET – National Institute of Meteorology and Geophysics.

[9] Accessible in https://www.ncei.noaa.gov/

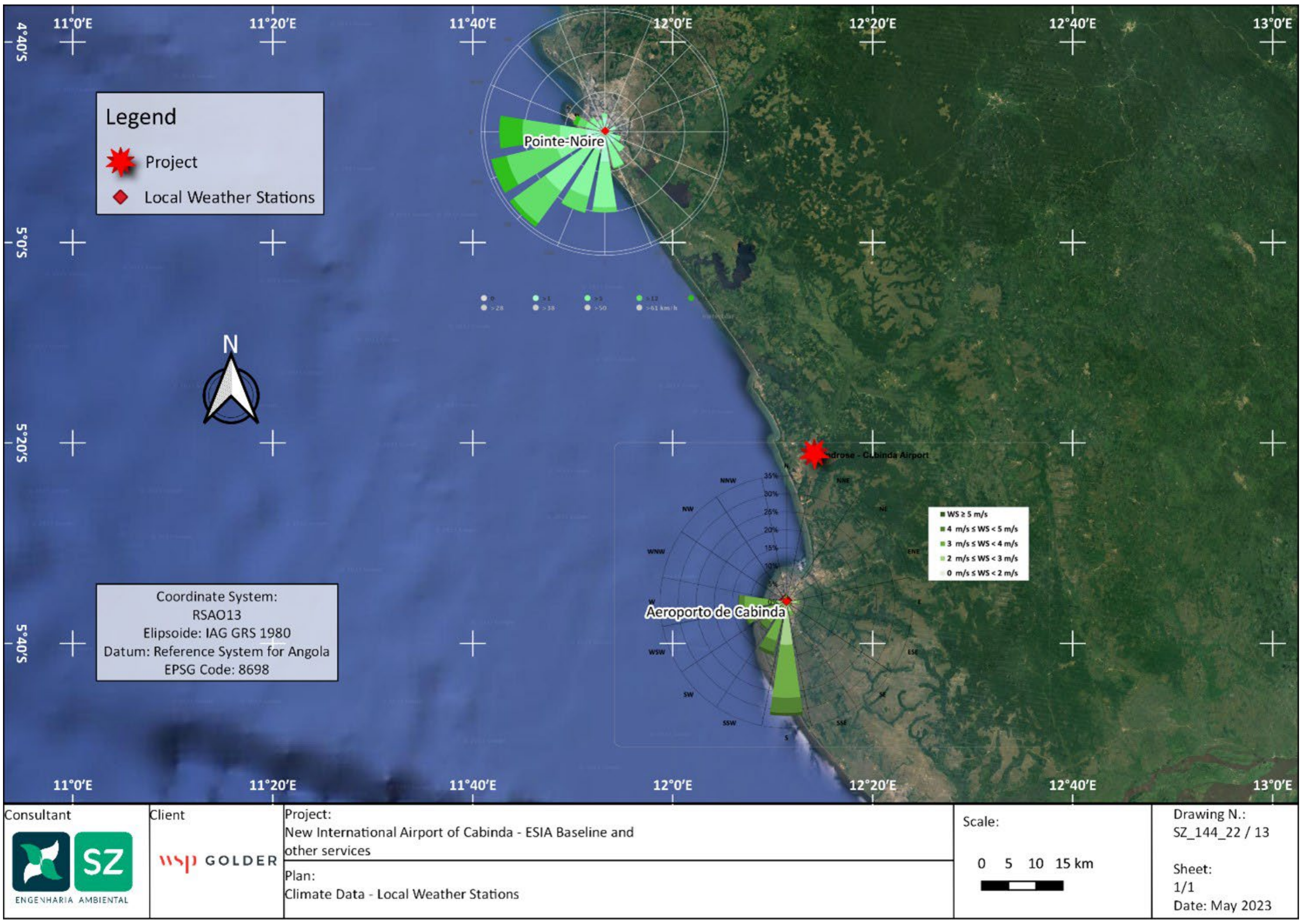


Figure 16: Considered local weather stations.

For the purposes of comparing and validating the data obtained at these two stations, a survey of historical and normalized data was carried out for each of the registered parameters. Results will be presented in the next sections.

INAMET makes available, through the Meteorological Information Service on a world scale of the World Meteorological Organization[10], normal temperature data based on the monthly average, in the period 1961-1990 (normal 1961-1990). However, this data is from the Luanda area, limiting its use for data comparison and validation.

Regarding comparison values for precipitation data, the "Climatological Monitoring" data found on the INAMET website were also considered. In this section of the INAMET portal, monthly rainfall monitoring data for 8 months of history are presented. However, the monitoring data made available on INAMET correspond to information from the CHIRPS v2.0 - Climate Hazards Group InfraRed Precipitation with Station data[11], developed to support FEWS-NET - Early Warning Systems Network against Hunger of the United States Agency for International Development (USAID). Historical data from this estimation and monitoring system is available by FEWS-NET with data since 1981. For the purposes of this characterization, the most recent monthly data were considered, that is, from January 2021 to April 2023.

[10] World Weather Information Service (WWIS), in https://wwis.ipma.pt/

[11] Funk, C., Peterson, P., Landsfeld, M. *et al.* The climate hazards infrared precipitation with stations—a new environmental record for monitoring extremes. *Sci Data* **2,** 150066 (2015). https://doi.org/10.1038/sdata.2015.66

Based on the hourly data, monthly average values were obtained for the temperature and precipitation parameters, which were compared with the normalized references indicated above, presented in the following subchapters.

6.3.2.1 Temperature

Figure 17 show the average temperature values obtained at the Cabinda Airport station and their comparison with normalized data for the period 1961-1990 provided by INAMET (for the Luanda area only).

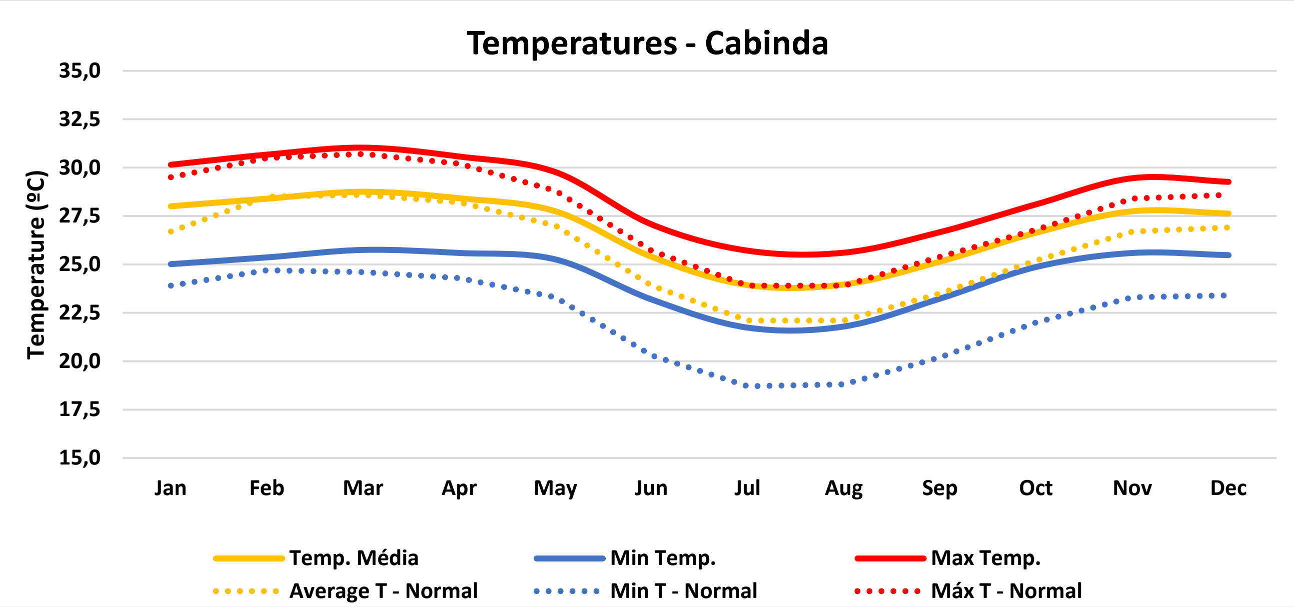


Figure 17: Monthly Temperature Data – Cabinda Airport.

Analyzing the data obtained from the meteorological station considered and the respective values of the normals, it appears that the observation data have the expected behaviour, with the lowest temperatures in the months of July/August, with values of 25-27 °C of daily maximum temperatures and 21 to 23 °C of daily minimum temperatures, and with the highest temperatures in February to April, with values of 30-32 °C of maximum daily temperatures and 25-26 °C of minimum daily temperatures. It should be noted that the temperatures registered are similar to the normal with the exception of the coldest months (June to September), where the values are higher than the normal, for minimum, average and maximum temperatures.

This difference can be related to the different locations, since the normals produced by INAMET are for the Luanda area.

6.3.2.2 Precipitation

As mentioned before, the Cabinda Airport weather station does not have publicly available data regarding precipitation. Therefore, it is considered the historical observation data from the Pointe-Noire meteorological station, available on the MeteoBlue website and with data latest CHIRPS-V2.0 precipitation data.

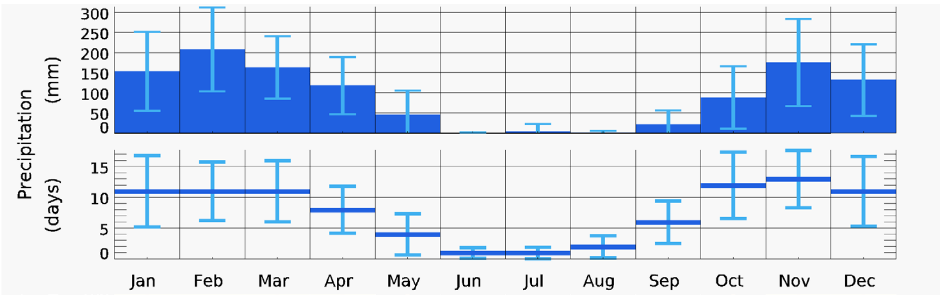
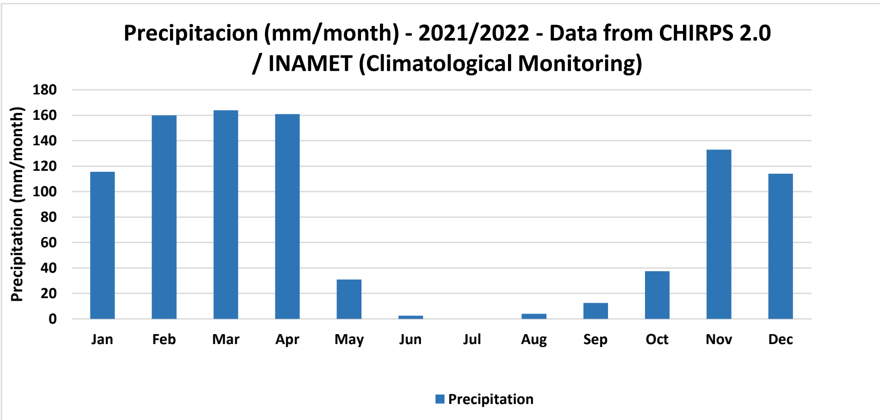
In this case, specific precipitation data for the Project area, produced by the CHIRPS-V2.0 modelling since January 2021, were measured, obtaining the results in *Table 2*.

The comparison between both data is shown in *Table 3*.

Table 2: Average monthly precipitation Data – CHIRPS V2.0 – Project Area (mm/Month).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	131	206	164	183	38	3	0	5	10	17	105	91
2022	32	89	160	76	24	2	0	3	15	58	161	137
2023	184	185	168	224	-	-	-	-	-	-	-	-
Average	116	160	164	161	31	3	0	4	13	38	133	114

Table 3: Local Precipitation Data (mm of total precipitation per month).

Reference Historical Observation data - Point Noire Station	
Precipitation data from the Climatological monitoring from INAMET / CHIRPS 2.0	

The comparison between the two sources of data shows very similar results, with a period of reduced or no precipitation between May and September, and a wet period between October and April.

For reference only, Figure 18 shows the available data on precipitation for the month of April 2023 (most recent available) in the Project area, with 224 mm of precipitation.

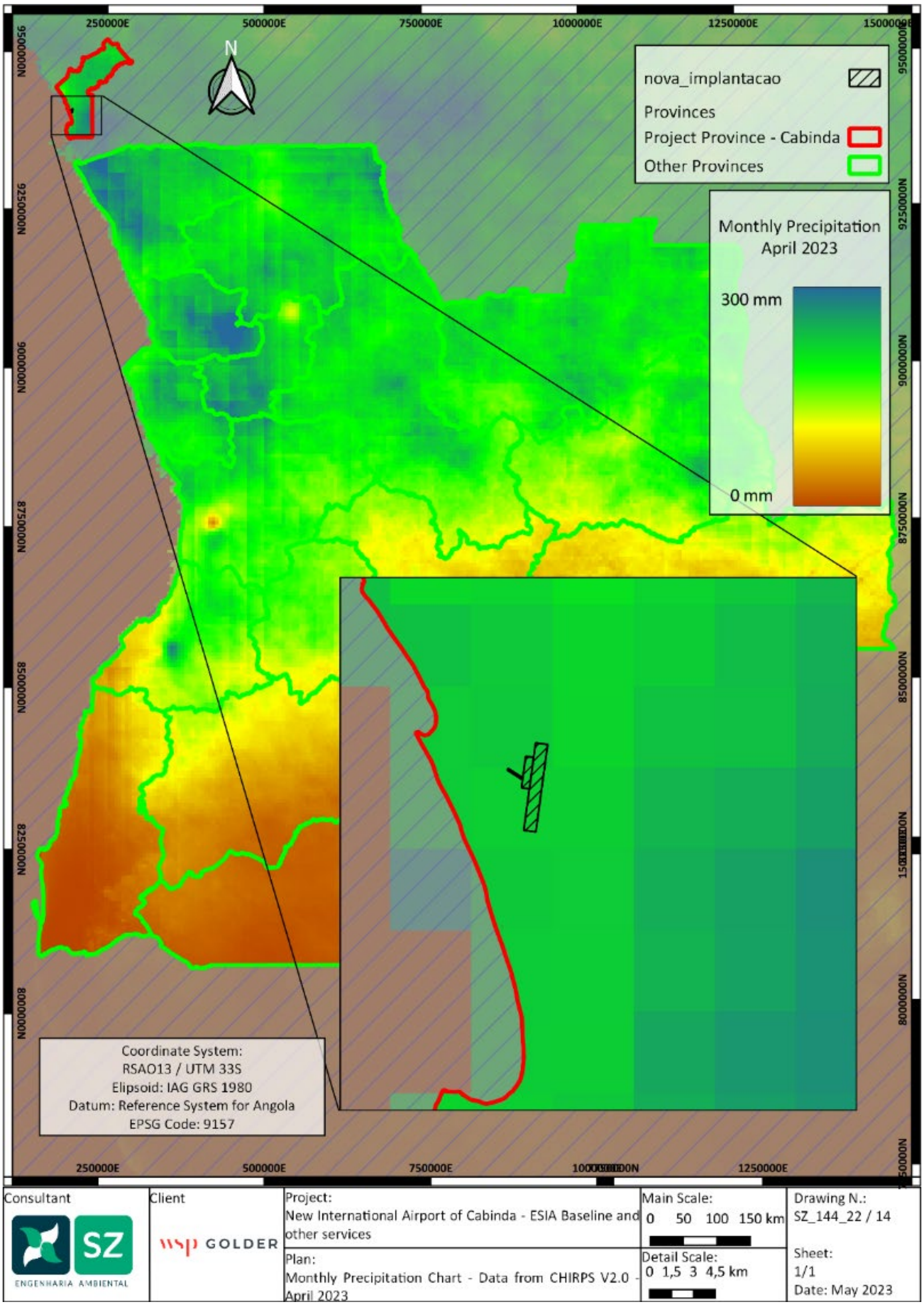


Figure 18: Precipitation Data – April 2023.

6.3.2.3 Wind

Regarding wind data, the average daily wind direction and speed in the existing airport station was assessed and a wind rose representative of the data obtained was developed, identifying the percentage of hours that were recorded in each direction and class of wind (*Figure 19*). These data were compared with the wind rose obtained from historical observation data from the Pointe-Noire station available on the MeteoBlue portal (*Figure 20*).

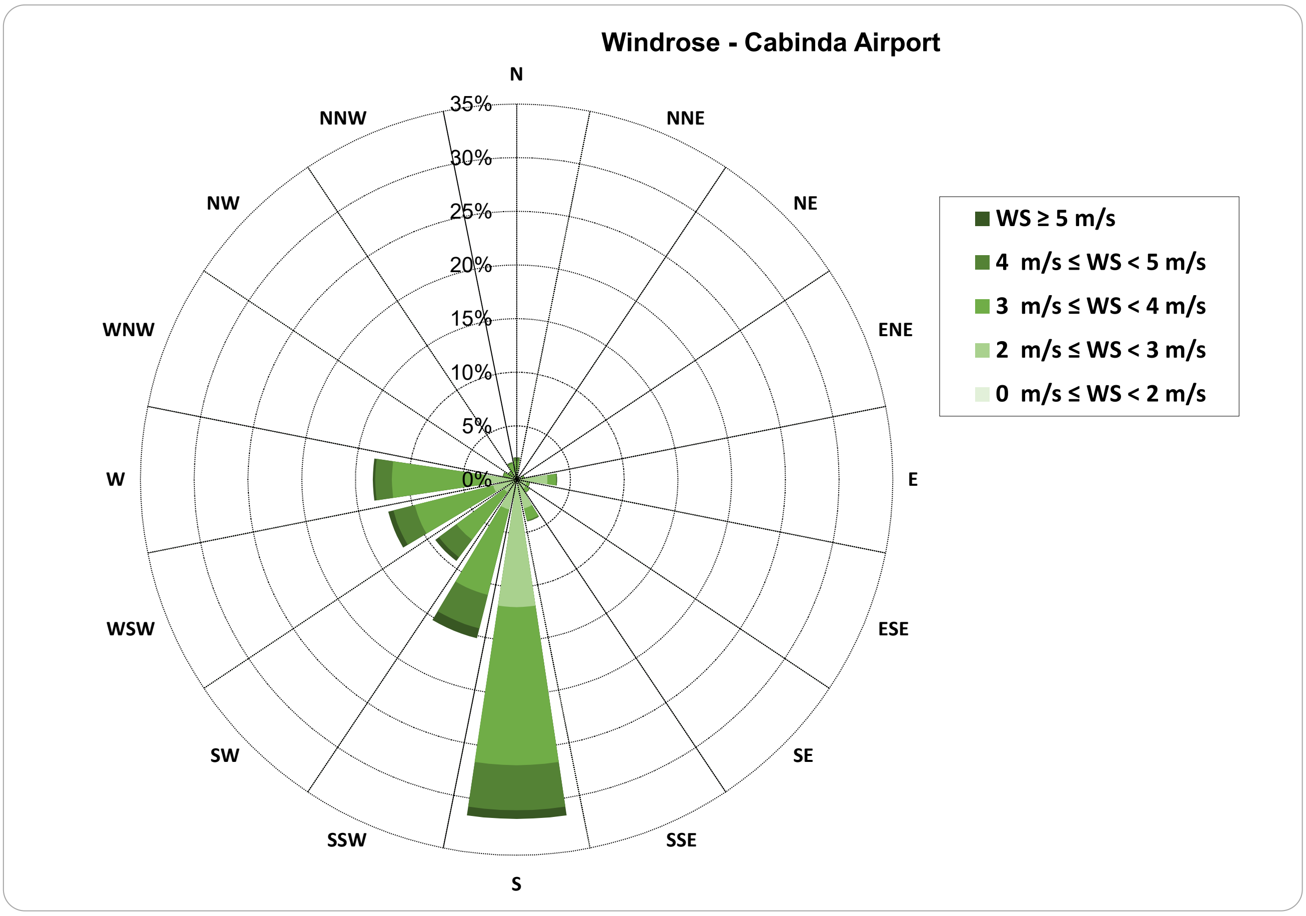


Figure 19: Windrose - Cabinda Airport.

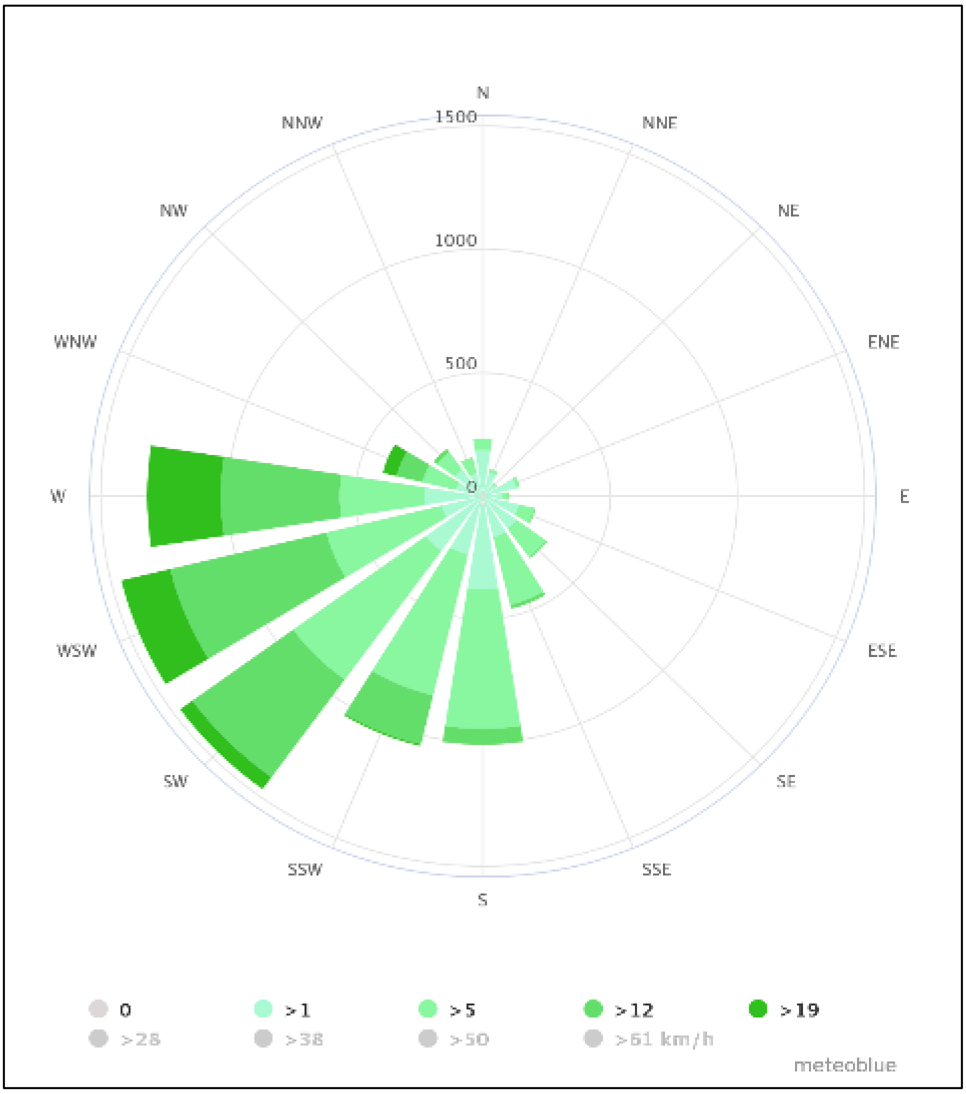


Figure 20: Wind Rose – Observation Historical Data – Pointe-Noire weather station (MeteoBlue).

Analyzing the data obtained, the Cabinda airport station has slightly different data, comparing to Pointe-Noire reference, namely from the wind directions. The Cabinda airport data suggests a predominant wind coming from the south, with some wind days coming from the West or Southwest. The Pointe-Noire station historical data suggests a broader spectrum of wind directions, with predominance of winds coming from the west to southwest quadrants.

With regard to wind speeds, the stations present similar data, with winds going from 2 m/s to 5 m/s of speed, with some days with stronger or calmer winds.

In terms of wind speeds, it is then assumed that the Project area will be affected by light to moderate winds, with predominant average speeds between 2 m/s and 3 m/s.

6.4 Soil and Land Use

6.4.1 Regional Pedology

The soils in Angola are influenced by typical soil formation factors such as geology, topography and climate, as well as secondary factors such as the length of the rainy season and annual precipitation. According to the soil map of Angola (*Figure 21*), the most abundant soils in Angolan territory are psammitic soils (also named arenosols according to the Food and Agriculture Organization of the United Nations – FAO), which occupy an area of 716 000 km^2, corresponding to 57,5% of the country (Figure 21). The remaining 42,5% of the area is occupied by soils: ferralitic and paraferralitic (also named ferralsols), tropical aridic, lithosols, hydromorphic, alluvial, clay, fersialitic (or cambisols), calcareous, calsialitic and oxisialitic.

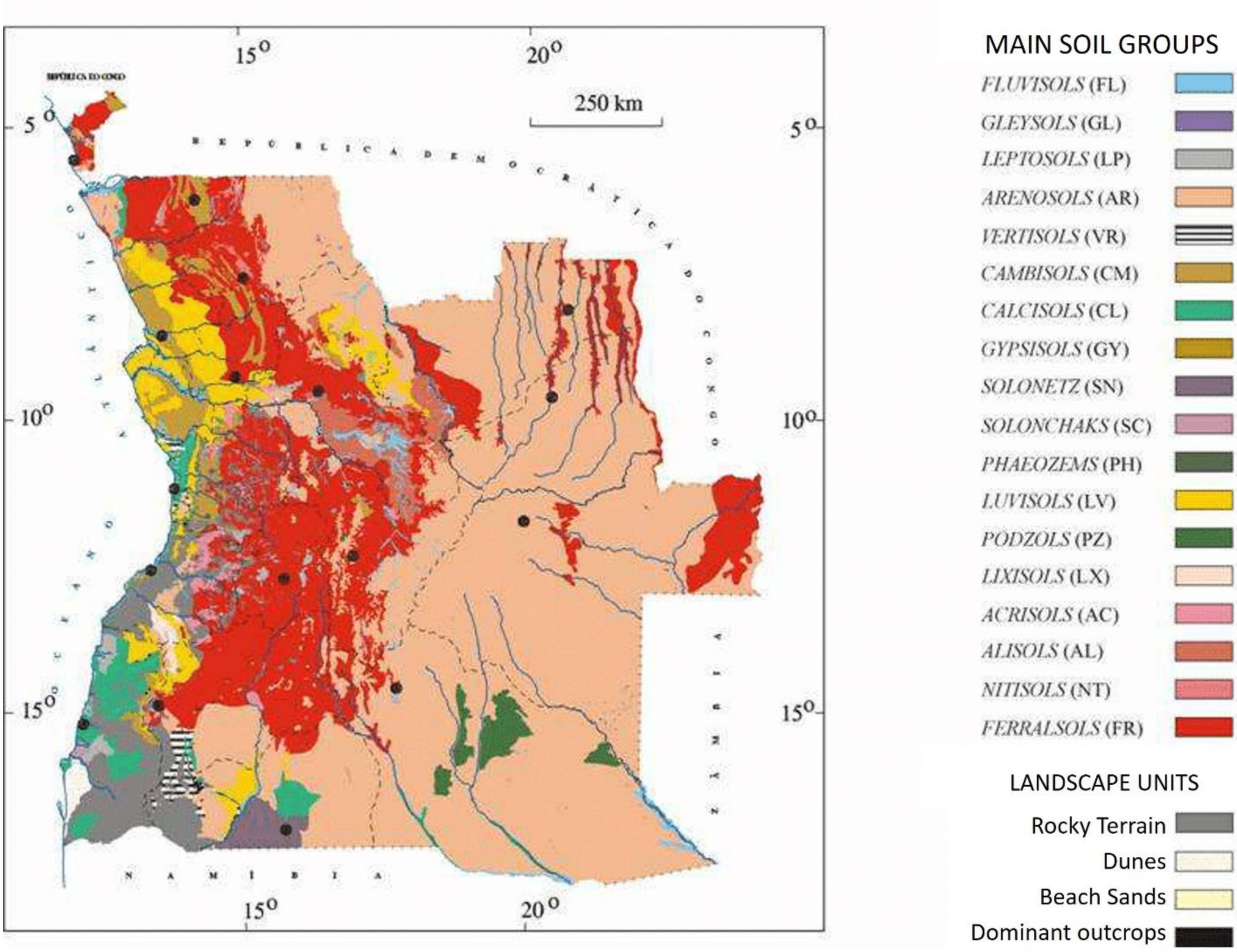


Figure 21: Soil map of Angola. Source: (Madeira, Ricardo, & Raposo, 2006).

In Cabinda, the main types of soil, as defined by the Food and Agriculture Organization of the United Nations (FAO), are correlated with the two distinct zones:

- Eroded argisols (acidic soils with a higher clay content in the subsoil than in the upper layer), associated with the mountainous interior of the Province; and
- Sandy arenosols (or psammitic soils) in the coastal lowlands. The predominant soil sub-types being oxy-psamic, psamo-regosols, and psamo-fersialitic. These are soils with coarse textures, in which the percentage of quartz sand is greater than 85% and whose distribution coincides with the Plio-Pleistocene sandy cover.

The northern part of Cabinda has predominantly Ferralsol soil type, in particular the northeastern part, between Dinge and Buco-Zau. These soils are considered to be fertile, eroded and leached soils that form in the humid tropics as a result of chemical weathering and humus accumulation beneath forest vegetation. In the southwest part of the province, closer to the coast, the soils become more complex and include lightly leached, calsialitic, alluvial, psamitic and idiomorphic soils, all of which are associated with wetlands and/or riverbeds (Missão de Pedologia de Angola e Moçambique, 1968).

6.4.2 Local Pedology

Local baseline soil conditions were assessed based on a review of available data on the geology and soils in the study area, together with the use of aerial and satellite imagery, a geotechnical site assessment, and field observations.

The geotechnical report and support documents are provided in the folder ANNEX A – Baseline Supporting Data, under PART 1 – Results of Physical Baseline, within the folder named "Geotechnical Study_June 2023".

The soils in the Project area are of the ferralsol type (Figure 22), with an orange hue, in some places more reddish.

Ferralsols are characterized by being very developed soils, very deep, with clayey or clayey loam texture, excellent porosity, red to yellow colour, low natural fertility, well drained, and very acidic. In these soils, migration processes are restricted by the high degree of clay stability or immobility. They therefore have excellent physical properties, but when used for agriculture, they require good chemical and organic fertilization, liming and erosion control (Quinhentos, 2013).

The ferralsols encompass the ferralitic soils (weakly ferralitic, typical ferralitic and psamo-ferralitic) and partially the paraferralitic soils. These soils are highly altered, with a clay fraction consisting essentially of kaolinitic minerals and iron minerals, and often aluminum (SiO_2/Al_2O_3 ratio less than 1.8), with a low mineral reserve, cation exchange capacity of less than 15 $cmol_c\ kg^{-1}$ and degree of base saturation in Bo horizons generally less than 50% (Neto A. G., 2017).

Weakly ferralitic soils dominate (with a moderate degree of ferralitization), while typical ferralitic soils (with a high degree of ferralitization) are related, in the most humid regions, to certain types of rocks that are very favourable to an intense ferralitic alteration.

In the study area, the weakly ferralitic soils have a wide range of pH values (4.20-6.70) which correspond to a reaction from extremely acidic to neutral; this pattern of variation is close to what was generally reported for the Ferralitic Soils of Angola (Neto A. G., 2017). This variability in pH values must also correspond to a large variation in the exchange aluminium concentration, given that this tends to increase strongly as pH values fall below 5.5.

Based on the data from the desktop studies consulted, it appears that the exchange Al^{3+} concentration in weakly ferralitic soils is generally less than 1 $cmol_c\ kg^{-1}$, which is lower than that reported for many oxisols and other types of soils.

Figure 22: Ferralsols in the area surrounding the Project.

6.4.3 Soil Monitoring Campaign

A soil monitoring campaign was carried out in the Project area in the last week of March 2023. Methodology and results are presented below.

Laboratory certificates and the Field report are provided in the folder ANNEX A – Baseline Supporting Data, under PART 1 – Results of Physical Baseline, within the folder named "Results_Soil and Air Quality 1st campaign".

6.4.3.1 Methodology

For the local soil baseline characterization, a sampling effort was developed, with the collection of 3 sampling points within the Project's construction perimeter (Table 4). Their locations are shown in *Figure 23*.

For the soil sampling, the NBR 9603: 2015 standard was considered. The upper layers of 2 cm were removed. After cleaning the surface, an amount of soil around 50 cm^3 (100 g) was collected from 2 to 10 cm deep.

It was then collected soil from 10 to 20 cm deep and discarded.

It was then collected an additional 50 cm^3 (100 g) below 20 cm, which was mixed with the first sample (from 2 to 10 cm), creating a compound sample that was sent to laboratory analysis.

Table 4: Coordinates of collection points.

Point	Description	Latitude	Longitude
S01	Inside the Airport perimeter	5° 20' 15,003'' S	12° 14' 48,901'' E
S02	Inside the Airport perimeter	5° 20' 49,883'' S	12° 14' 03,810'' E
S03	Inside the Airport perimeter	5° 23' 3,929'' S	12° 14' 13,313'' E

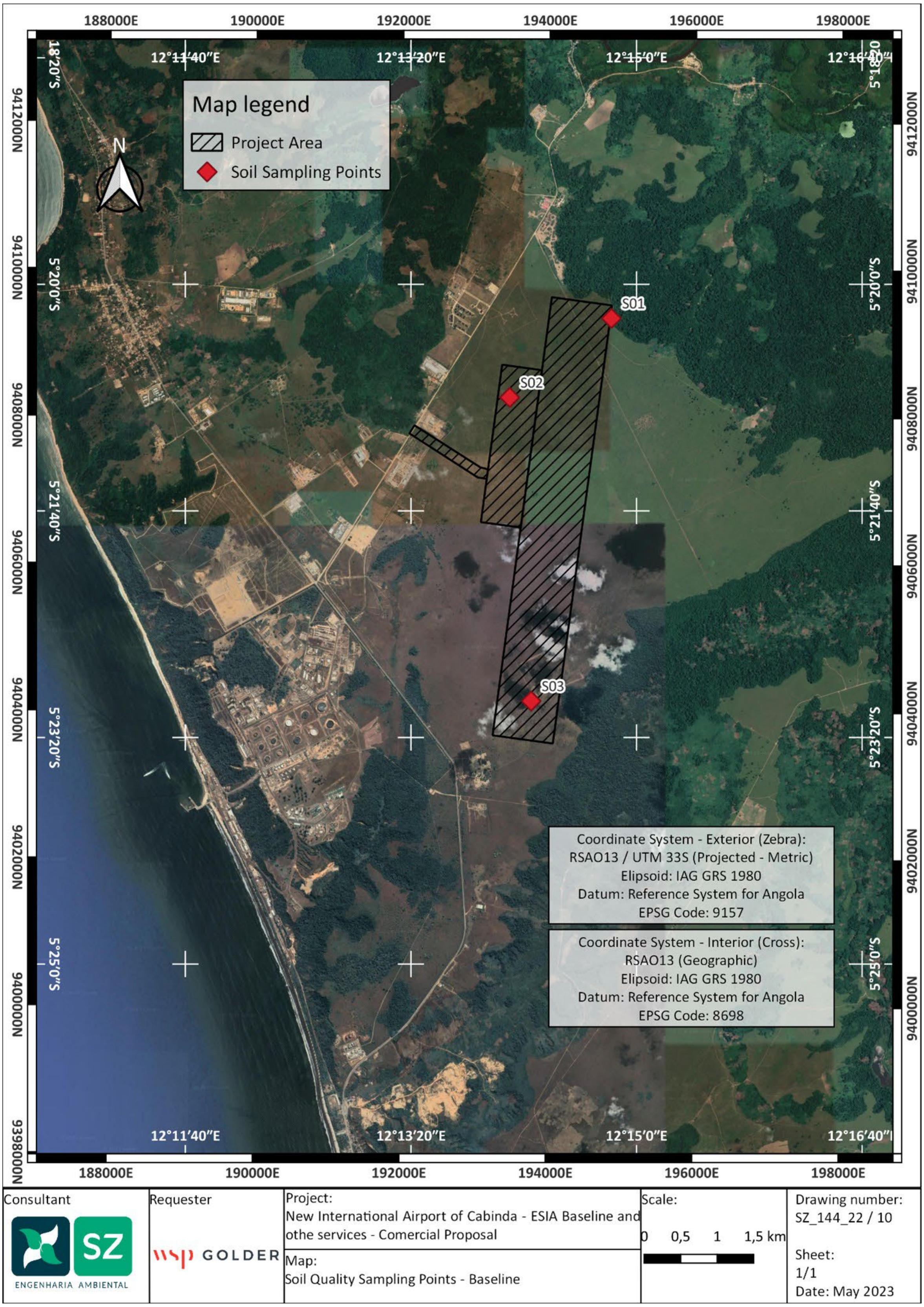


Figure 23: Soil Sampling Points.

6.4.3.2 Results and Discussion

Angola lacks national standards for soil quality. As such, the Dutch Pollutants Standards are used here as reference values since they are internationally recognized as valid and robust benchmarks to define concentration limits for soil. The Dutch Standards adopt the concept of Target values and Intervention Values, where the former provides a reference indication for long-term environmental quality, assuming negligible risks for the ecosystem, and the latter are representative of the level of contamination above which a serious case of contamination exists.

Also, the Italian Contamination Threshold Values from Legislative Decree 152/2006 are used as Project standards for the isomer sets of hydrocarbons (≥ C12) in soil, since the Dutch Pollutants do not provide limits for those parameters.

The reference values above mentioned are found in Chapter 04 of the ESIA (Legislative chapter).

The analytical results for the 3 sampling points are presented in Table 5 below. In the last column of the table are presented the adopted Project standards, as defined in Chapter 04 of the ESIA.

Table 5: Analytical results of the soil samples.

Soil quality Parameter		Units	Results			Standard Deviation of results			Project Standards
			S01	S02	S03	S01	S02	S03	
Heavy metals	Fe	mg/Kg	24,2	24,2	21,4	1,1	1,1	1,6	-
	Hg	mg/Kg	≤0,001	≤0,001	≤0,001	0	0	0	0,3
	Pb	mg/Kg	≤0,001	≤0,001	≤0,001	0	0	0	85
	Mn	mg/Kg	13,7	16,5	16,5	1,9	1,3	1,4	-
	Cu	mg/Kg	2,7	3,1	1,9	0,8	0,4	0,2	36
	Cr	mg/Kg	0,9	1,3	0,51	0,05	0,2	0,03	100
	Cd	mg/Kg	0,11	0,27	0,36	0,02	0,05	0,04	0,8
	Ni	mg/Kg	2,4	1,8	0,94	0,3	0,2	0,05	35
	Zn	mg/Kg	8,3	6,5	9,7	0,6	0,2	0,4	140
	Al	mg/Kg	0,58	0,74	0,72	0,06	0,08	0,08	-
Aromatic Hydrocarbons	Benzene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	10
	Toluene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	10
	Ethylbenzene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	30
	Xylene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	100
	VOCs	µg/Kg	≤0,02	≤0,02	≤0,02	0	0	0	-
Petroleum Hydrocarbons (TPH)		µg/Kg	≤0,02	≤0,02	≤0,02	0	0	0	50000
Hydrocarbons C<12		µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	10000
Hydrocarbons C>12)		µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	50000
Radionuclides	Ra	mg/Kg	≤0,0003	≤0,0003	≤0,0003	0	0	0	-
	Th	mg/Kg	≤0,0003	≤0,0003	≤0,0003	0	0	0	-
Polycyclic Aromatic Hydrocarbons (PAH)	Pyrene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Naphthalene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Perylene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Anthracene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Phenanthrene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Coronene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Acenaphthene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Acenaphthylene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Benzopyrene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Benzofluoranthene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Benzoperylene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Chrysene	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	-
	Total	µg/Kg	≤0,003	≤0,003	≤0,003	0	0	0	1000

The results marked in gray were below the detection limit of the determination methodology of the laboratory, and the values for these pollutants are then considered non-relevant.

All parameters related to hydrocarbon and radiological contamination are below the detection levels and indicate that the greenfield site where the Project will be located does not have any previous history of contamination, which is compatible with the historical uses of the site (forest and greenfield only).

Regarding heavy metals, all values are considered low and compatible with the natural presence of these elements in soil composition, also indicating the nonexistence of previous contaminations on the site.

Considering the results obtained, all of them are below the Project standards considered, therefore it can be concluded that no soil contamination was identified in the Project's site.

6.5 Hydrology and Surface Water

6.5.1 Regional Hydrology

In statistical terms, and using a scale of 1: 1 000 000, Angola has 6,152 rivers, with a length of 154,035.44 km. Classifying based on the order of magnitude, Angola consists mostly of springs (rivers of the first order), making up 4,764 rivers, corresponding to 77.4% of the total number of rivers and an extension of 96,390,72 km. The rivers of the second order of magnitude have a length of 27,677.01 km and make a total of 1,048 rivers (17.04%). The third order of magnitude extends over 15,715.30 km and comprises a total of 263 rivers (4.28%). The fourth order of magnitude occupies 10,010.01 km and a total of 62 rivers, corresponding to 1.01%. The fifth order of magnitude covers 3776.09 km in a total of 12 rivers (0.2%). Finally, the rivers of the sixth order of magnitude cover a length of 466.32 km in a total of 3 rivers (0.05%) (INRH, 2020).

Angola's hydrographic network is divided into 11 hydrographic regions, which are further divided into 22 hydrographic units (*Table 6*).

Table 6: Hydrographic regions, units and river basins of Angola. Source: INRH (2020).

Hydrographic region	Hydrographic unit	River Basins
Congo/Zaire	Cuango	Cuanza, Lucolo, Lucunga, M'Bridge, Zaire
	Kassai	Zaire
Cuanza	Alto Kwanza	Cuanza, Zaire
	Baixo Kwanza	Cuanza, M'Bridge, Perdizes, Zaire, Litoral
	Médio Kwanza	Cuanza
Zambeze	Zambeze	Cuando, Zaire, Zambeze
Midwest	Catumbela	Balombo, Catumbela, Cavaco, Cubal Da Hanha, Queve
	Midwest	Balombo, Cubal Da Hanha, Cuhula, Evale, N'Gunza, Quicombo, Litoral
	Longa	Catata, Cuanza, Longa, Mengueje, Queve, Sangando, Tanda, Litoral
	Queve	Cuanza, Queve, Litoral
Cubango	Cubango	Cuanza, Cubango, Cunene, Cuvelai
Cunene	Alto Cunene	Catumbela, Coporolo, Cunene, Queve
	Baixo Cunene	Cunene, Curoca
	Médio Cunene	Bentiaba, Bero, Coporolo, Cunene, Curoca
South-west	Coporolo	Coporolo, Equimina, Mormolo, Ndungo, Litoral
	South-west	Bentiaba, Bero, Carunjamba, Catara, Chileva, Chilulo/Chapéu Amado, Curoca, Equimina, Giraul, Inamagando, Mapungo, Mutiambo, Litoral
Northwest	Bengo	Bengo, Cuanza, Litoral
	Dande	Dande, Lifune, Loge
	Northwest	Lifune, Loge, Lucolo, Lucunga, Luela, M'Bridge, Onzo, Sange, Sembo, Uezo, Zaire, Zombo, Litoral
Cuando	Cuando	Cuando

Hydrographic region	Hydrographic unit	River Basins
Cuvelai	Cuvelai	Cunene, Cuvelai
Cabinda	Cabinda	Chiloango, Lubinda, Lucula, Lulondo, Zaire, Litoral

As observed in *Table 6*, the province of Cabinda is a hydrographic region itself and is classified as a single hydrographic unit. Six river basins are present in the unit, namely: Chiloango, Lubinda, Lucula, Lulondo, Zaire, and Litoral (*Figure 24*). The basins cross the borders of Angola and are shared with the Republic of Congo and the Democratic Republic of Congo. They are considered exoreic because they drain into the sea.

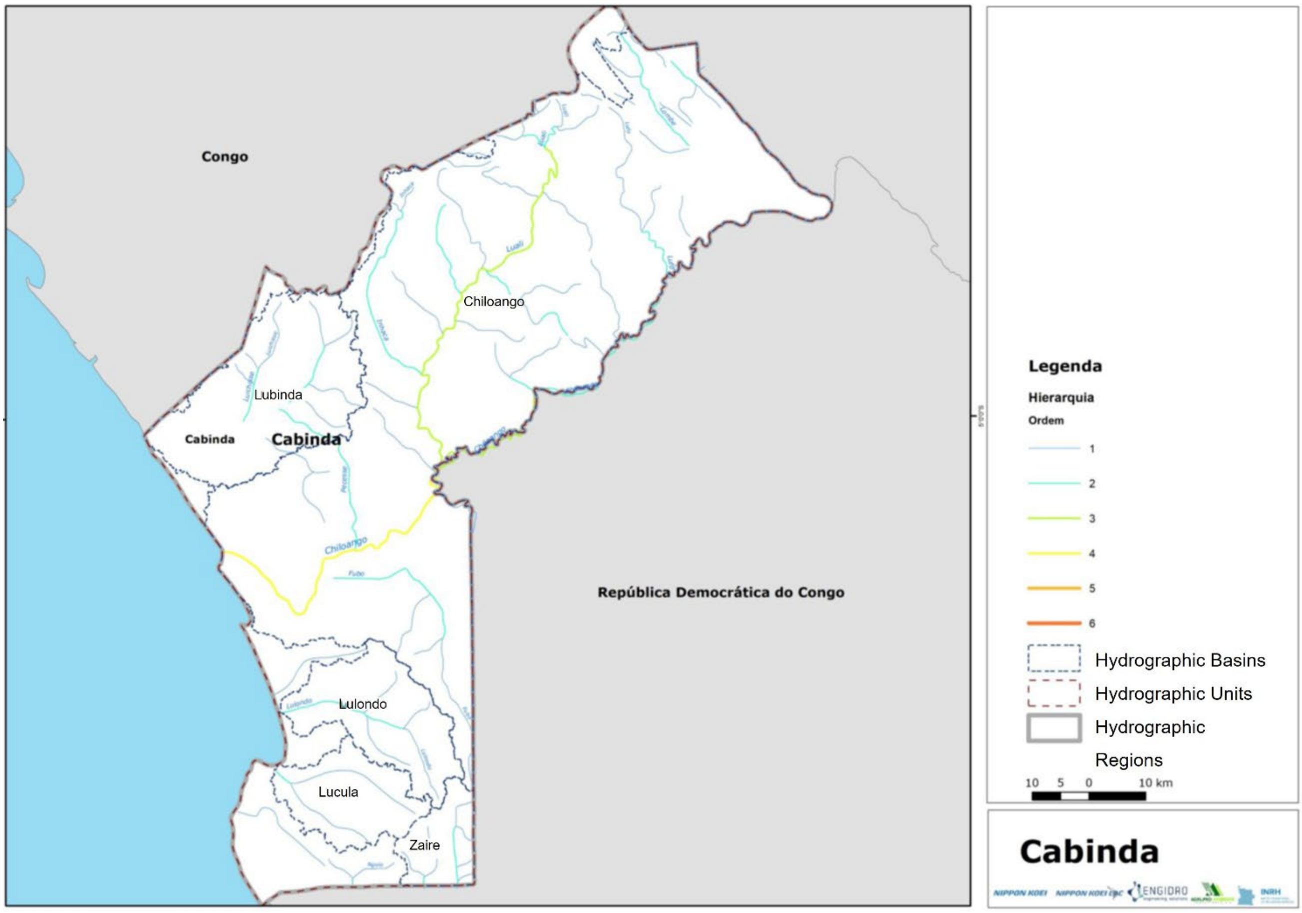


Figure 24: Hydrographic Network in Cabinda. Source: INRH (2020).

The province of Cabinda has a very dense hydrographic network, dominated by the rivers Chiloango, Lulondo, Lualo, Fubo, Lucola and their tributaries. It should be noted the presence of numerous lagoons and swamp areas. These are found mainly in low water areas, whose altitudes do not exceed a dozen meters, and in the plains close to the main rivers.

6.5.2 Local Hydrology

The Project site is located within the Chiloango river basin. This is the largest basin in the hydrographic unit of Cabinda. It has a total surface area of 12,570.5 km^2, a perimeter of 515 km, a maximum elevation of 880 m and an average height of 237 m. The basin extends from the coastal areas of the Atlantic Ocean in Cabinda, slightly enters the territory of the Republic of Congo and more significantly into the territory of the Democratic Republic of Congo, through the sub-basins of the tributaries of the Lukula River. The average annual runoff of the

Chiloango river basin is 266,70 mm per year and an average annual precipitation regime equal to 1101.4 mm, contributing to an average annual flow of 114.9 m³/s (Gomes, 2018).

Figure 25 below shows the Chiloango River and its tributaries. The approximate location of the Project site is also indicated.

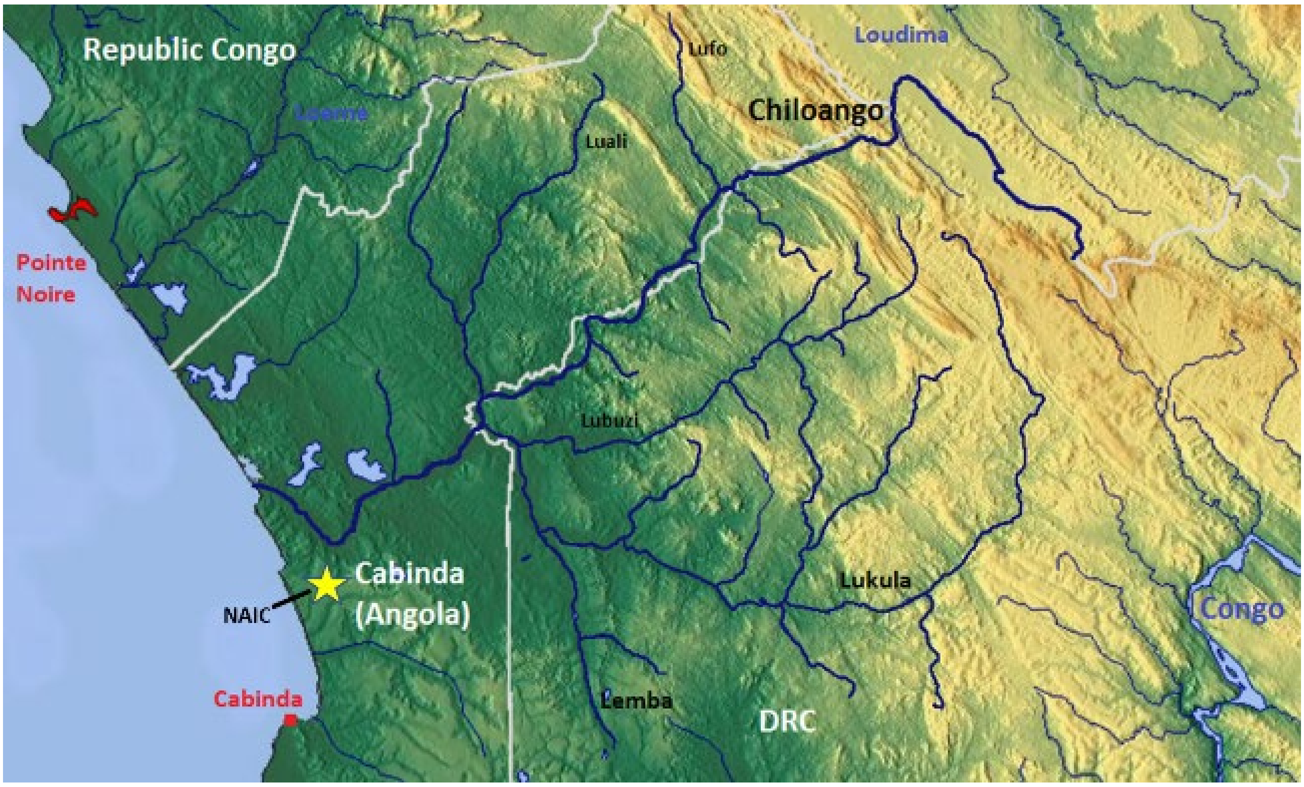


Figure 25: Chiloango River and its tributaries. The location of NAIC (rough estimation) is also seen in the figure. Source: Hans Braxmeier & Peter in s - *File:Shiloango OSM.png - Wikimedia Commons*.

6.5.3 Surface Water Quality and Use

Regarding the presence of surface water in the Project footprint, no permanent water rivers or ponds were identified or reported in the close vicinities to the Project during the site visits carried out in the area. However, some watercourses are present in the Area of Influence, including the Chiloango River, the main river in the province (and only permanent), whose distance from the Project is approximately 4 kilometers. Other watercourses have been reported to be present in the AoI, however they are temporary and water runs only during the wet season. The area around the Project site has several obstacles such as landmines, inaccessible dense forest, very steep ravines, the private area of the Malongo oil field, and the possible encounter with separatist/rebel groups in the forest areas. These obstacles were not a problem for water sampling.

As for water uses, since there are no available water resources in the Project site, there is no registered use. In the surrounding communities however, as stated in the socio-economic surveys, there is use of the surface water resources of the region, especially from the Chiloango River and some lakes and ponds, to provide water to the households, being extracted directly by the population by rudimentary means.

A water extraction system is present in Sassa Zau-Bissassanha, managed by the Cabinda Public Water Company (EPASCABINDA-EP). It entered in operation in July 2022, with a capacity of 51.840 m³/day and it supplies the Cabinda city (by the Tchizo Distribution Center) and also Lândana village, by the Luvula-Lândana Distribution Center. The ETA (Water Treatment Station), located a few kilometres from the Project site, will depend on the collection from the Chiloango River and is located in the village of Bissassanha, in a land with an area of 17,836.90 m², with an administrative building, pre-oxidation and rapid mixing tank, building dosing tank, 3 decanters, filter room, manoeuvring chamber, treated water tank, pump building, fans and auxiliaries, generator building, sludge line, roads, fence and guardhouse, totaling 6,431.55 m² of gross floor area construction (Jornal 24 Horas, 2022). Some photographs taken during the field visit are shown in *Figure 26*.

Figure 26: Photographs of the ETA Sassa Zau, taken during the site visit on February 7th, 2023.

No data regarding the ETA effluents quality parameters was made available. Also, there is no publicly available source for effluent water quality monitoring data.

6.5.4 Surface Water Monitoring Campaign

In October 2023, Saioz specialists collected two water samples in the Chiloango River, that flows to the North of the Project area, for subsequent laboratory analysis.

The sampling points selection criteria was based on the fact that there are no other water bodies (e.g., lakes, streams) besides the Chiloango River in the airport vicinity. The closest water body identified by the field team was the Illunga Lagoon, located 3.6 km far from the Project footprint. A small stream tributary of the Chiloango River has been identified close to the Project; however, this is a temporary stream, which flows only during rain events and is dry the rest of the time.

The sampling points, referenced as WR01 (located upstream) and WR02 (downstream), have the following geographical coordinates (Table 7).

Table 7: Geographic coordinate for the Water Sampling (Coordinate System: RSAO13 - EPSG Code: 8698 – Official coordinate system for Angola).

Monitoring Point	Latitude	Longitude
WR01 – Upstream	5° 18' 17,840" S	12° 15' 23,860" E
WR02 – Downstream	5° 17' 49,820" S	12° 14' 31,110" E

The location of the sampling points in relation to the Project footprint is shown in Figure 27.

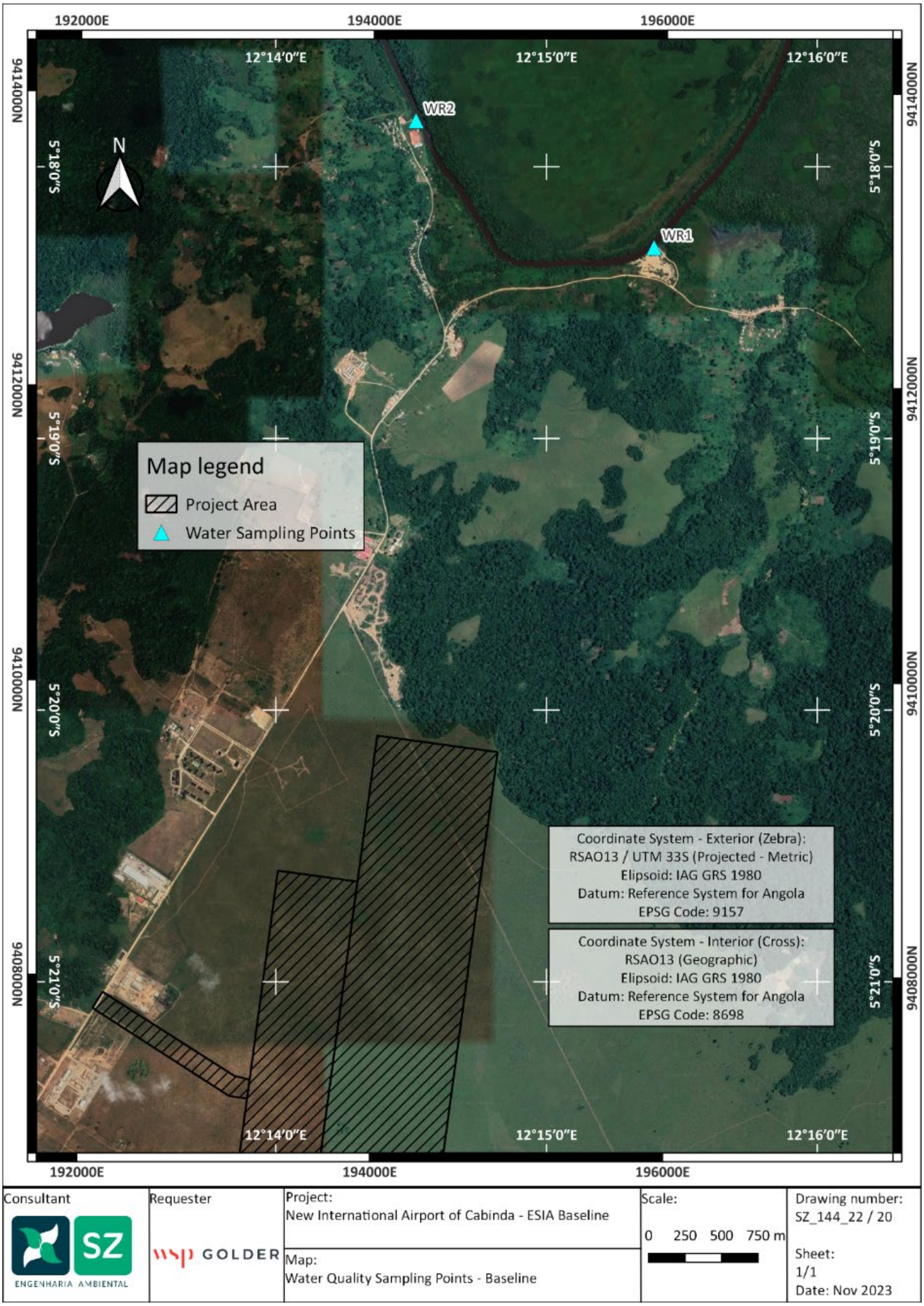


Figure 27: Water sampling locations.

6.5.4.1 Methodology

For the sampling of the surface waters, the reference standards applied were NBR 9897/1987 and NBR 9898/1987. The following procedures were applied:

- Before collecting each sample, the bottles were washed with the respective surface water;
- The samples were collected and placed in 1000 ml bottles, until the volume was completely filled;
- The samples were placed in a thermal box containing ice to keep them at a low temperature;
- The samples were sent directly to the laboratory in Luanda, on the same day via air transport, for subsequent quality analysis;
- In the laboratory, 3 analyzes were developed for each sample, to determine mean values and standard deviations.

The official reports provided by the laboratory describe the type of analysis conducted and the methodology used to determine each parameter. The reports are found in the folder ANNEX A – Baseline Supporting Data, under PART 1 – Results of Physical Baseline, within the folder named “Results_Surface Water”.

Figure 28 includes the photographs of the sampling locations.

WR1 (Upstream) WR2 (Downstream)

Figure 28: Photographs of the water sampling locations.

6.5.4.2 Results

The analytical results are presented in Table 8. The reference standards used are those described in Chapter 04 “Legal Requirements” of this ESIA study.

In Angola, water quality standards have been established under Presidential Decree No. 261/11 of October 6th. The Regulations[12] consist in 4 chapters and 10 Annexes which set the standards and measures to be applied

[12] WATER Presidential decree.pdf.

to improve the quality of water for its main uses, including minimum environmental water quality standards for surface water.

As detailed in the above mentioned Chapter 4 of the ESIA, due to the lack of IFC EHS indications or any other international standards to be adopted for surface water, the Angolan national standards were compared with the Environmental Quality Standards (EQS) for surface waters set out in the European Directive 2008/105/EC[13], which defines internationally recognized thresholds to ensure a good chemical status of surface waters and the protection of most sensitive species from direct toxicity, also including predators and humans via secondary poisoning. The EQS were also used to make up for missing parameters among the national standards considered important for the protection of surface waters. The more stringent values between the two standards were adopted as Project standards. Values that exceeded the limits are highlighted in light red color in the table.

The main source of water for the Project will be through the Cabinda Water Supply Network, which pumps water from the Chiloango River. This water will receive treatment before being made available for supply, however, due to the results of the sample analyzes obtained, especially for fecal coliforms, WSP considered it useful to also compare the results with the Project standards for drinking water, also determined in the Chapter 04 of the ESIA. They are listed in the rightmost column of Table 8.

Table 8: Analytical results of the water samples.

Parameter (units)	WR01	WR02	Project Standard for Surface Water	Project Standard for Drinking-Water
Total suspended solids (TSS) (mg/L)	0.107	0.106	-	-
Total petroleum hydrocarbons (TPH) (mg/L)	0.02	≤ 0.02	-	0.05
Biochemical oxygen demand (BOD_5) (mg/L)	14.4	12.0	-	3
Chemical Oxygen Demand (COD) (mg/L)	16.35	17.18	5	-
Magnesium (Mg) (mg/L)	5.1	5.9	-	-
Calcium (Ca) (mg/L)	≤ 0.1	≤ 0.1	-	-
Sodium (Na) (mg/L)	0.833	1.4	-	-
Potassium (K) (mg/L)	1.533	1.633	-	-
Fluoride (F^-) (mg/L)	≤ 0.1	≤ 0.1	-	0.7 – 1.5
Chloride (Cl^-) (mg/L)	15.974	17.746	250	200
Hydrogen carbonates (HCO_3^-) (mg/L)	88.5	102.1	-	-
Sulphate (SO_4^{2-}) (mg/L)	4.755	3.651	250	150
Silicate (SiO_2) (mg/L)	9.4	11.4	-	-
Ammoniacal nitrogen (NH_4^+) (mg/L)	1.591	1.819	1	0.05
Nitrate (NO_3^-) (mg/L)	0.322	0.119	-	25
Nitrite (NO_2^-) (mg/L)	0.073	0.075	-	-
Phosphate (PO_4^{3-}) (mg/L)	1.39	0.538	1	0.4

[13] EUR-Lex - 32008L0105 - EN - EUR-Lex (europa.eu).

Parameter (units)	WR01	WR02	Project Standard for Surface Water	Project Standard for Drinking-Water
Oxidability (mg/L)	2.9	2.2	-	-
Silver (Ag) (mg/L)	≤ 0.005	≤ 0.005	-	-
Boron (B) (mg/L)	0.106	0.274	-	1.0
Arsenic (As) (mg/L)	≤ 0.003	≤ 0.003	0.1	0.01
Aluminium (Al) (mg/L)	0.417	0.422	-	-
Chromium (Cr) (mg/L)	0.562	0.694	0.05	0.05
Lead (Pb) (mg/L)	≤ 0.003	≤ 0.003	0.0072	0.01
Zinc (Zn) (mg/L)	≤ 0.01	≤ 0.01	0.5	0.5
Nickel (Ni) (mg/L)	0.005	0.005	0.02	0.07
Mercury (Hg) (mg/L)	≤ 0.005	≤ 0.005	0.000005	0.0005
Cadmium (Cd) (mg/L)	≤ 0.005	≤ 0.005	0.00008	0.001
Copper (Cu) (mg/L)	≤ 0.005	≤ 0.005	0.1	0.02
Iron (Fe) (mg/L)	0.472	0.593	-	0.1
Manganese (Mn) (mg/L)	0.072	0.089	-	0.05
Barium (Ba) (mg/L)	0.4	0.333	-	0.1
Dioxin PCDD (mg/L)	≤ 0.001	≤ 0.001	-	-
Dioxin PCDF (mg/L)	≤ 0.001	≤ 0.001	-	-
Total coliforms (CFU/100mL)	3583	5408	-	0
Faecal coliforms (CFU/100mL)	742	2136	-	20

6.5.4.3 Results Discussion and Conclusions

The results obtained show that most of the parameters comply with the selected Project standards; however, the results point out the existence of organic and nutrient contamination, affecting both the sampling points. Specifically, the resulting values of concern consist of high levels of Chemical Oxygen demand (COD), Ammoniacal nitrogen (NH_4^+) and Phosphate (PO_4^{3-}).

The higher is the COD value, the more serious is the pollution of organic matter by water. The existence of NH_4^+ in surface water usually indicates domestic pollution. The high quantities of PO_4^{3-} generally indicates that waterways are polluted by human and animal waste, cleaning wastewater and fertilizer runoff.

Although there are no Project limit values for total coliforms and faecal coliforms in surface water, when the results obtained are compared with the limits of drinking water, it becomes clear that there is a considerable concentration of coliforms in the samples collected. The existence of faecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the faecal material of humans or other animals. This could explain the high values of COD, NH_4^+ and PO_4^{3-} found. There are several communities located along the course of the Chiloango River (small to medium rural villages), which likely lead to an inflow of wastewater into the river; this could account for higher levels of nutrients and coliforms.

In addition, near and in the Province of Cabinda, the Chiloango river is margined by dense forest areas, which can contribute to significant organic matter input to the river, that could also influence the level of COD.

It is also interesting to note that along the Congo Borders and the northeast corner of Cabinda, between Moukéké and Kai-Mbaku, there are some extensive agricultural areas, located around the Chiloango River, which could also be a relevant input of nutrient contamination.

Regarding heavy metals, values at least 10 times higher than the established limits were obtained for Chromium in both samples. Chromium is a potentially toxic metal occurring in surface water as a result of natural and anthropogenic sources. Leaching from topsoil and rocks is the most important natural source of chromium entry into bodies of water. The values found in surface water, although high, are compatible with the chromium values found in the survey carried out for soils in March 2023. Therefore, it is believed that the chromium content found are likely of natural origin. However, the samples collected for soils are inside the Project footprint, around 2 km far from the surface water sampling points, hence it could be that the chromium content found for soils is not linked to the surface water content.

Nevertheless, according to the WHO[14], the natural chromium content of surface waters is approximately 0.0005 – 0.002 mg/L. The WHO also states that in general, the chromium content of surface waters reflects the extent of industrial activity. Since the faecal coliform pollution found probably indicates the discharge of domestic sewage, the hypothesis that the high chromium content is also linked to anthropogenic activities cannot be ruled out.

6.6 Hydrogeology and Groundwater

6.6.1 Regional Hydrogeology

The Geological Institute of Angola makes available data regarding the aquifers present in each region of the country. For Cabinda, four main hydrogeological units are identified in Figure 29 and described in Table 9.

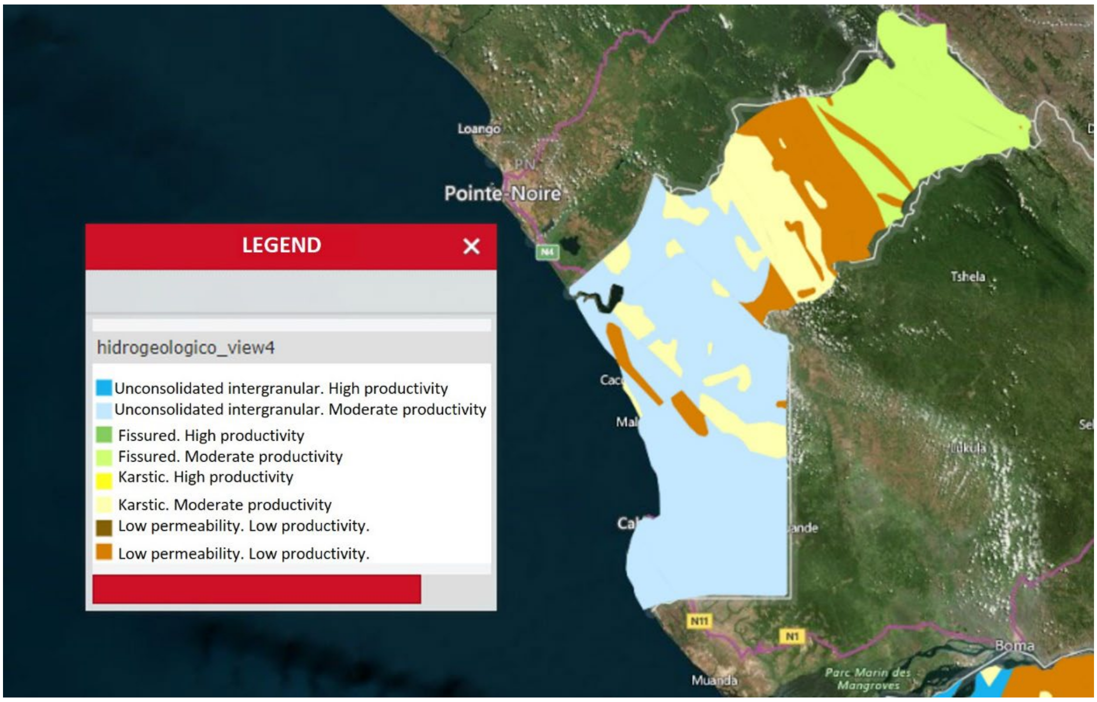


Figure 29: Hydrological chart of Cabinda. Source: IGEO.

[14] Microsoft Word - GDWQ.2ndEdit.Chromium.doc (who.int)

Table 9: Hydrogeological units of Cabinda Province. Source: IGEO.

Category	Type of Aquifer	Productivity	Description
A2 (Light blue)	Unconsolidated intergranular	Moderate	Unconsolidated to consolidated sand, gravel, arenite, locally calcrete, bioclastite
D2 (orange)	Low permeability	Low	Clay, clayey loam, mud, silt marl
C2 (yellow)	Karstic	Moderate	Limestone and dolostone
B2 (light green)	Fissured	Moderate	Paragneiss, quartzite, schist, phyllite and amphibolite

6.6.2 Local Hydrogeology

When consulting the IGEO hydrogeological chart in more detail to identify the Project area, it is observed that the A2 zone is predominant (*Figure 30*).

The aquifer is from the Quaternary period, characterized by alluvium of unconsolidated sediments, and its productivity depends on the lithology present (although in general it is considered of moderate productivity). If it is dominated by permeable sands and gravels, it is more productive, but if it is dominated by fine grained sediments of low permeability, is less productive. Other factors that also influence productivity are the consistency and lateral extension of the aquifer. In general, alluvial sediments in river valleys form the best aquifers in Angola (BGS Earthwise, 2022).

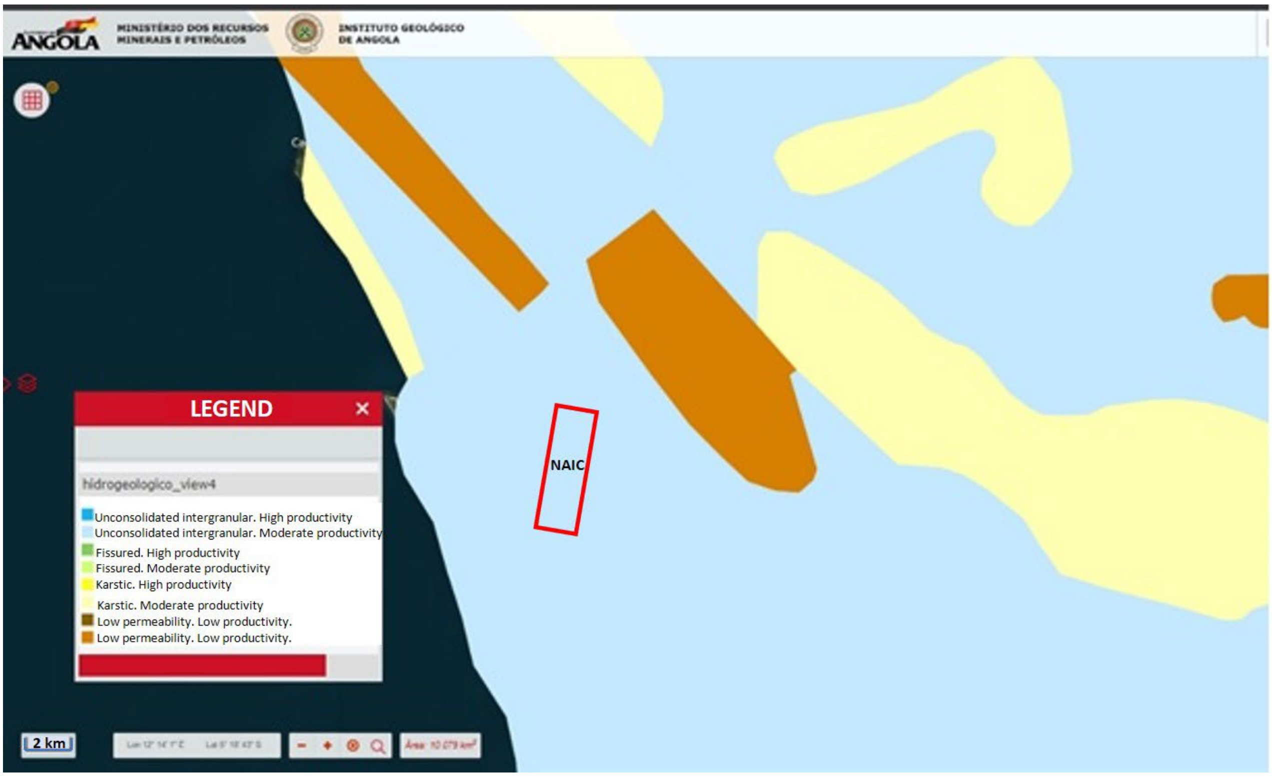


Figure 30: Hydrogeological chart of the Project area (approximate location and footprint). Source: IGEO.

On the Project area has been installed a water well aimed at supplying water for construction purposes. The company MAFUKABINDA L.d.a. drilled the water well borehole by operating direct rotation with injection of bentonite sludge and biodegradable polymers.

The technical report prepared for the water well is provided in the folder ANNEX A – Baseline Supporting Data, under PART 1 – Results of Physical Baseline, within the folder named “Water Well and Groundwater”.

The borehole reached a depth of 192 m and has been equipped with a submersible pump to extract the water (i.e., a Grundfos SP14-31 pump with a motor capacity of 7.5 kW, pushed to a depth of 140 meters below the local ground level).

According to the hydrogeological data collected, the aquifer flows about 96 m below the local ground level; the area is underlain by alluvial sand, silt and coarse gravels Pliocene-Quaternary deposits.

Above the groundwater level, the hydrogeological survey revealed the existence of clay layers, which generally act as barriers and protect the aquifer from potential infiltrating contaminants.

6.6.3 Groundwater Quality and Use

As stated in the socio-economic surveys, the surrounding communities’ households use mainly surface water for their needs, and there are no groundwater extraction points in use in the community. Therefore, no identifiable groundwater points available for sampling in the vicinities of the Project have been found.

From literature, it has been found that some groundwater in alluvial aquifers in Angola (case of the area of the Project) is reported to have high iron and sulphate concentrations, likely linked to low precipitation and high potential evapotranspiration. In some deltas and lower parts of floodplains, groundwater quality is influenced by salt water (BGS Earthwise, 2022).

The only groundwater point available for sampling is from the water well that has already been drilled in the Project site.

Following the water well drilling, the *Centro de Analises de Poluicao e Controlo Ambiental (Departamentos de Analises Fisico-Quimicas e Biologicas)* conducted, in December 2023, the sampling and analysis of the groundwater. The results are provided in the folder ANNEX A – Baseline Supporting Data, under PART 1 – Results of Physical Baseline, within the folder named “Water Well and Groundwater”, by the file named “AGUA DE FURO -ref 280- 20240116.pdf”.

The analyses results have been reviewed for the local groundwater baseline characterization.

The analytical results are presented in Table 10. The reference standards used are those described in Chapter 04 “Legal Requirements” of this ESIA study.

The Dutch Pollutants Standards were used as reference standard values for the deep groundwater. Also, the Italian Contamination Threshold Values from Legislative Decree 152/2006 were used as Project standards for the Total Hydrocarbons content in groundwater since the Dutch Pollutants do not provide limits for those parameters.

Table 10: Analytical results of the groundwater.

Parameter (units)	Resulting value	Unit measure	Project Standard for Groundwater
pH 25°C	6.90		-
Color	None	-	-

Parameter (units)	Resulting value	Unit measure	Project Standard for Groundwater
Total suspended particles	18	mg/l	-
Temperature	29.4		-
Conductivity	81	µS/cm	-
Odour	None	-	-
Nitrates	1.4		-
Manganese	5	µg/l	-
Copper	5	µg/l	1.3
Zinc	3	µg/l	24
Boron	<0.05	µg/l	-
Nickel	47	µg/l	2.1
Arsenic	<0.02	µg/l	7.2
Cadmium	<0.005	µg/l	0.06
Chromium	0	µg/l	2.5
Lead	<0.1	µg/l	1.7
Barium	2000	µg/l	200
Sulphates	3	mg/l	-
Chlorides	<10	mg/l	100
Phosphates	6	mg/l	-
COD	<3	mg/l	-
Dissolved oxygen	47	O2 saturation %	-
Biochemical oxygen consumption	3	mg/l	-
Total coliforms	0	/100ml	-
Salmonella	Yes	/500ml	-
Escherichia coli	None	Colony forming units/100ml	-
Total Phosphorus	1.01	mg/l	-
Nitrogen Ammonia	0.07	mg/l	-
Iron	0.26	mg/l	-

The results obtained show that most of the parameters comply with the selected Project standards; however, the results point out the existence of Copper, Nickel and Barium. The existence of metals might be of natural origin, mainly taking into consideration the local lithological conditions. In case groundwater is used as drinking water, the Barium and Nickel levels are considerably higher than the limits established for drinking water in accordance with Angolan national standards and the WHO (100 µg/l for Barium, and 70 µg/l for Nickel).

The resulting value of Phosphates (which appear to be high, even though not considered within the Project groundwater standards) might be due to agricultural activities, as detailed in section 6.5.4 for the surface water.

The surface water deriving from Chiloango River and the groundwater intake from the water well, prior its usage, shall be treated by taking into consideration the contaminants measured.

6.7 Air Quality

As has been highlighted in the main international reference documents regarding this theme, ambient air quality is a key environmental component, in particular for public health and for the quality of life of citizens. Atmospheric pollution has direct repercussions on human health and ecosystems.

In addition to human activity, many natural phenomena (volcanic eruptions, forest fires, sandstorms) release pollutants into the atmosphere, which are sometimes transported over long distances, depending on atmospheric dispersion conditions.

The concentrations of pollutants in the ambient air mainly depend on the emitted quantities and on the meteorological conditions that influence their distribution and also physical-chemical reactions between the different pollutants.

Emissions of air pollutants result from almost all socioeconomic activities. Among these, the following stand out:

- Road traffic, especially in urban areas, as a source of nitrogen oxides (NO_x), carbon monoxide (CO), particulate matter (PM), benzene (C_6H_6) and other volatile organic compounds (VOCs)
- Industrial sources, with regard to emissions of sulphur dioxide (SO_2), NOx and Particulate Matter.

Different pollutants have different residence times in the atmosphere and various types of impacts whether on human health, ecosystems or the climate, resulting in both chronic and acute effects of air pollution. Acute effects translate the high concentrations of a given pollutant that, when reached, can soon have repercussions on the receptors. Chronic effects are related to longer exposure and lower concentration levels. Although this level is lower, exposure takes place over a prolonged period, which means that effects may appear from accumulated exposure to these pollutant levels.

In addition to direct exposure to air pollutants, some of these pollutants, such as certain heavy metals and persistent organic pollutants, accumulate in the environment and can enter the food chain causing indirect exposure to them.

Atmospheric emissions generate problems at different scales, from a local scale, for exemplar high concentrations of Carbon Monoxide (CO), Carbon Dioxide (CO_2), Nitrogen or Sulphur Oxides (NO_x and SO_x) associated with car traffic, along congested roads, or near industrial activities, to a global scale, where the best example is that of climate change.

There are several other important pollutants, such as polycyclic aromatic hydrocarbons (PAH) with potential carcinogenic effects, present in fine particles emitted by biomass combustion processes and road vehicles, particularly diesel, which are also responsible for other effects on humans, such as irritation of the mucous membranes of the eyes, nose, throat and bronchi, but also heavy metals present with the breathable particulate matter, that can have multiple health effects, dependent of the compounds present.

In terms of the main effects of air pollutants, it is also worth considering possible weather damage:

- Contribution to changes in the radiative balance and indirect effects on the climate;
- Reduction of atmospheric visibility;
- Damage to materials and buildings due to exposure to acidifying pollutants and O3.

In addition to the direct effects of each pollutant, there are also interactions between the different pollutants that result in the potentiation of their adverse effects. Table 11 outlines the main interactions and impacts of the various pollutants (*Extracted from Portuguese ENAC 2020 – National Strategy for the Adaptation to Climate Change 2020*).

Table 11: Interactions and impacts caused by air pollutants in a multi-pollutant / multi-effect approach (ENAC 2020 Portugal).

Impacts	Traditional Pollutants						Green House Gases Effect			
	PM	SO_2	NOx	COV	NH_3	CO	CO_2	CH_4	N_2O	PFCs HFCs SF_6
Health Impacts										
PM										
O3										
Vegetation Impacts										
O3										
Acidification										
Euthofization										
Climate Impacts										
Direct and Long Term effects										
Indirect and Short Term Effects										

6.7.1 Angolan Characterization

As has happened in developing countries that are starting their industrialization process, in Angola there has also been a high influx of population to urban centres. The growth of unplanned urban areas and the anarchic development of various industrial sectors have been factors that have contributed to the increase in air pollution levels.

The only public reference report available, regarding pollutant Emissions into the atmosphere, is the Report on the General State of the Environment of Angola (REAA), from 2006. According to this document, the predominant pollutant Emissions in the country come from the combustion of fossil fuels, originating from:

- High number of vehicles in circulation;
- Diesel generators used to supply energy;
- Torches from oil production (oil platform flares); and
- Fires.

Road transport is responsible for most CO (carbon monoxide), NMVOC (non-methane volatile organic compounds) and lead emissions. CH_4 (methane) emissions come almost entirely from the final disposal of urban solid waste, while water treatment plants can be considered significant sources of NH_3 (ammonia) and NO_2 (nitrous oxide).

The large geographical area, existing water masses and meteorological factors also condition the existing air quality.

According to the REAA 2006, several other factors indicate the existence of high amounts of suspended particles and other pollutants in the country, namely:

- Unpaved roads;
- Land without vegetation;
- Prolonged dry seasons;
- High temperatures;
- Factories and industries with uncontrolled atmospheric emissions.

6.7.2 Available Regional Data

There is no official air quality monitoring network in Angola that could provide regular long-term data for a more robust characterization of the reference situation.

Some air quality monitoring stations, with periodic data reporting, have been identified in the country (near Luanda region, 400 km to the South of the Project), however since they are located too far from the Project site they were not considered for this assessment.

Outside Angola, the closest station to the Project with public data available is associated with the Université Pedagogique Nationale, in Kinshasa, Democratic Republic of the Congo (350 km to the East of the Project). However, this was also considered to be located too far from the Project in order to provide useful data, therefore it was not considered.

There are also several territorial air quality data obtained from satellite observations, in multiple projects developed by NASA and with data made available on the NASA EarthData – Worldview portal, such as the MERRA 2 data[15] and the Global 3-Year Running Mean Ground-Level Nitrogen Dioxide (NO2) Grids from GOME, SCIAMACHY and GOME-2[16]. However, these are data based on modelling and long-distance observations, developed for a large scale, and so their analysis is more limited for the purpose of assessing the Project's specific implementation area. These tools can, however, give a broader view of the countries general air quality and influences.

The database MERRA-2, which provides data beginning in 1980, is the first long-term global reanalysis to assimilate space-based observations of aerosols and represent their interactions with other physical processes in the climate system. From this database, it was obtained Monthly mean, Time-averaged, Single-Level data for dust, at surface level, namely for $PM_{2.5}$, covering the African continent. For the current assessment, it was considered the most recent year period, namely from May 2022 to April 2023, with a total of 12 raster matrixes with PM2.5 values, in Kg/m^3, as shown in Figure 31.

[15] MERRA-2 tavgM_2d_aer_Nx: 2d,Monthly mean,Time-averaged,Single-Level,Assimilation,Aerosol Diagnostics V5.12.4, Global Modeling and Assimilation Office (GMAO), Goddard Earth Sciences Data and Information Services Center (GES DISC). Accessed 28 January 2023.

[16] Geddes, J.A., R.V. Martin, B.L. Boys, and A. van Donkelaar. 2017. Global 3-Year Running Mean Ground-Level Nitrogen Dioxide (NO2) Grids from GOME, SCIAMACHY and GOME-2. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/H4JW8BTT. Accessed 28 January 2023.

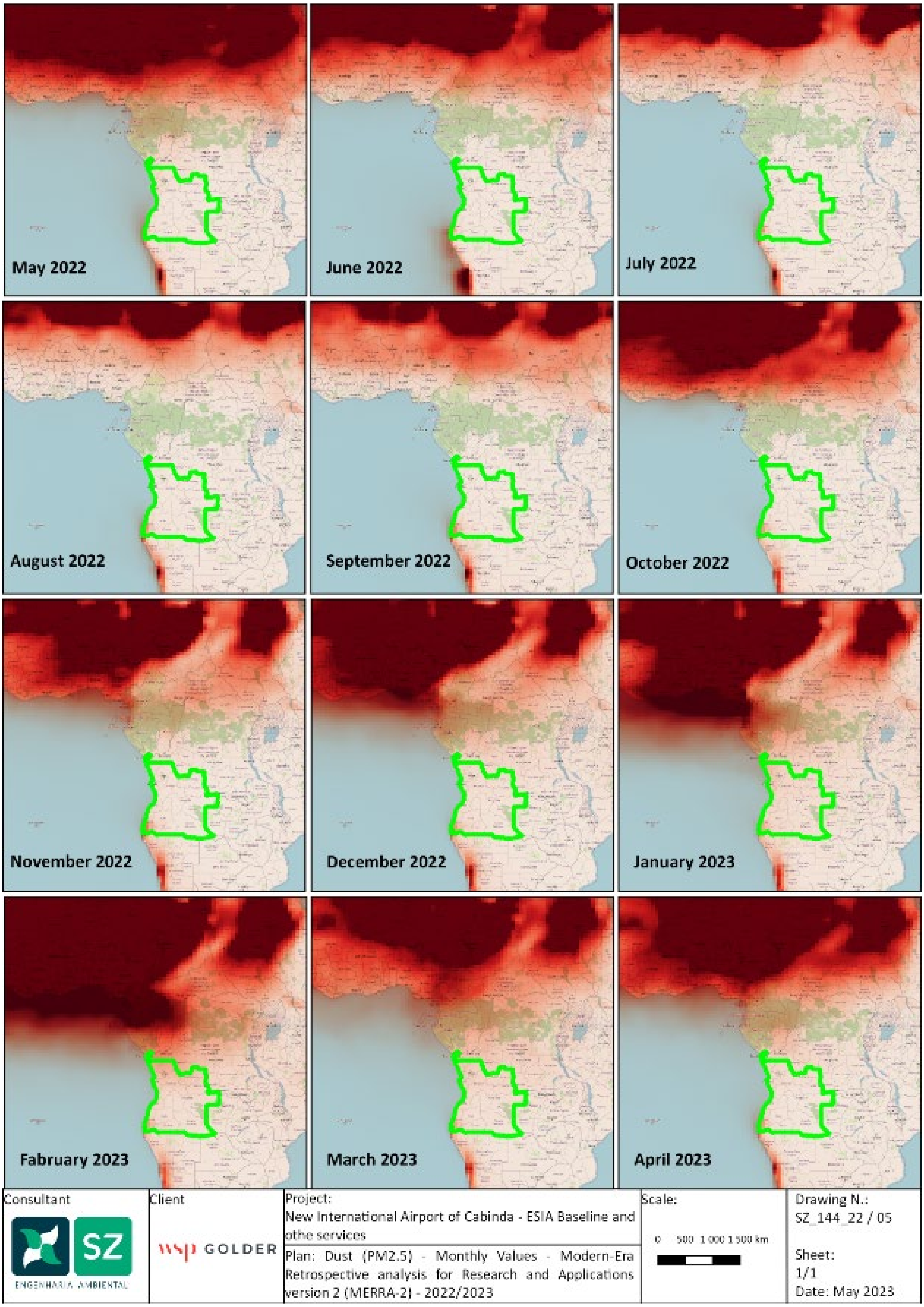


Figure 31: 2022 Monthly Average PM2.5 surface raster maps from MERRA-2.

As observed in the above map, Angola seems to be partly influenced by the dust originating in the Sahel region, in the north, and also by the Namib Desert in the south. The Sahel influence extended to the northern side of Angola from November 2022 to March 2023.

The MERRA-2 database also provides a country based monthly mean values of pollutants from 1980 to 2020. Considering the data available for Angola, it was estimated the general monthly mean values for the general territory, presented in Figure 32.

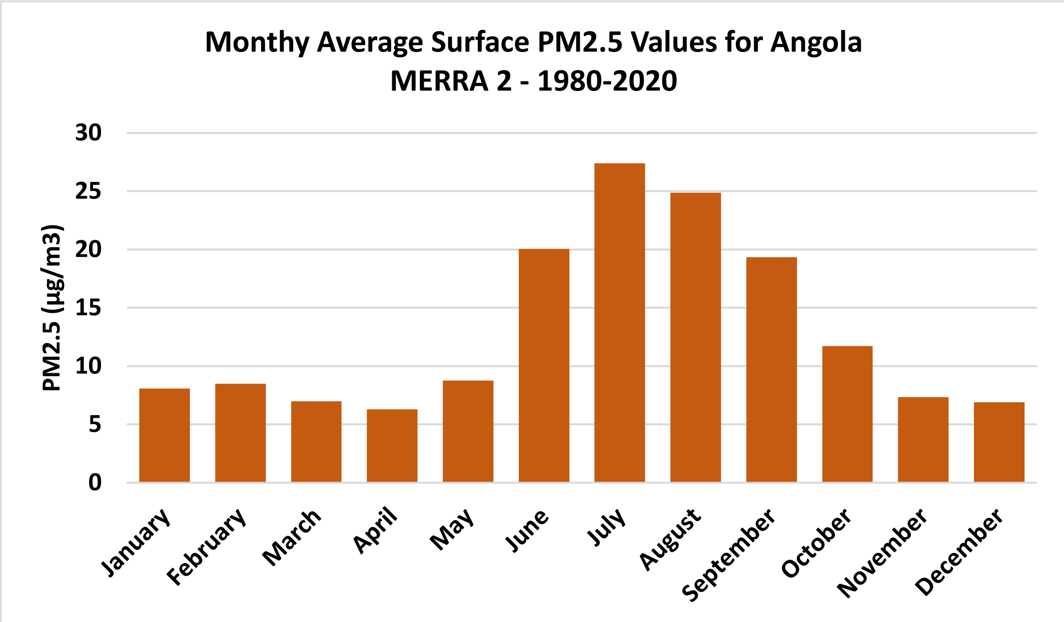


Figure 32: Monthly Average PM2.5 surface values for Angola from MERRA-2, from 1980 to 2020 – Nasa EarthData.

The mean results obtained by the MERRA 2 values show a better air quality in the wet season, between October and April, and with worse air quality levels in the dry season, between May and September.

Another database available in the NASA EarthData portal, associated with air quality at the surface level, is the Global 3-Year Running Mean Ground-Level Nitrogen Dioxide (NO_2) Grids from GOME, SCIAMACHY and GOME-2, whose data for the African region is presented in Figure 33.

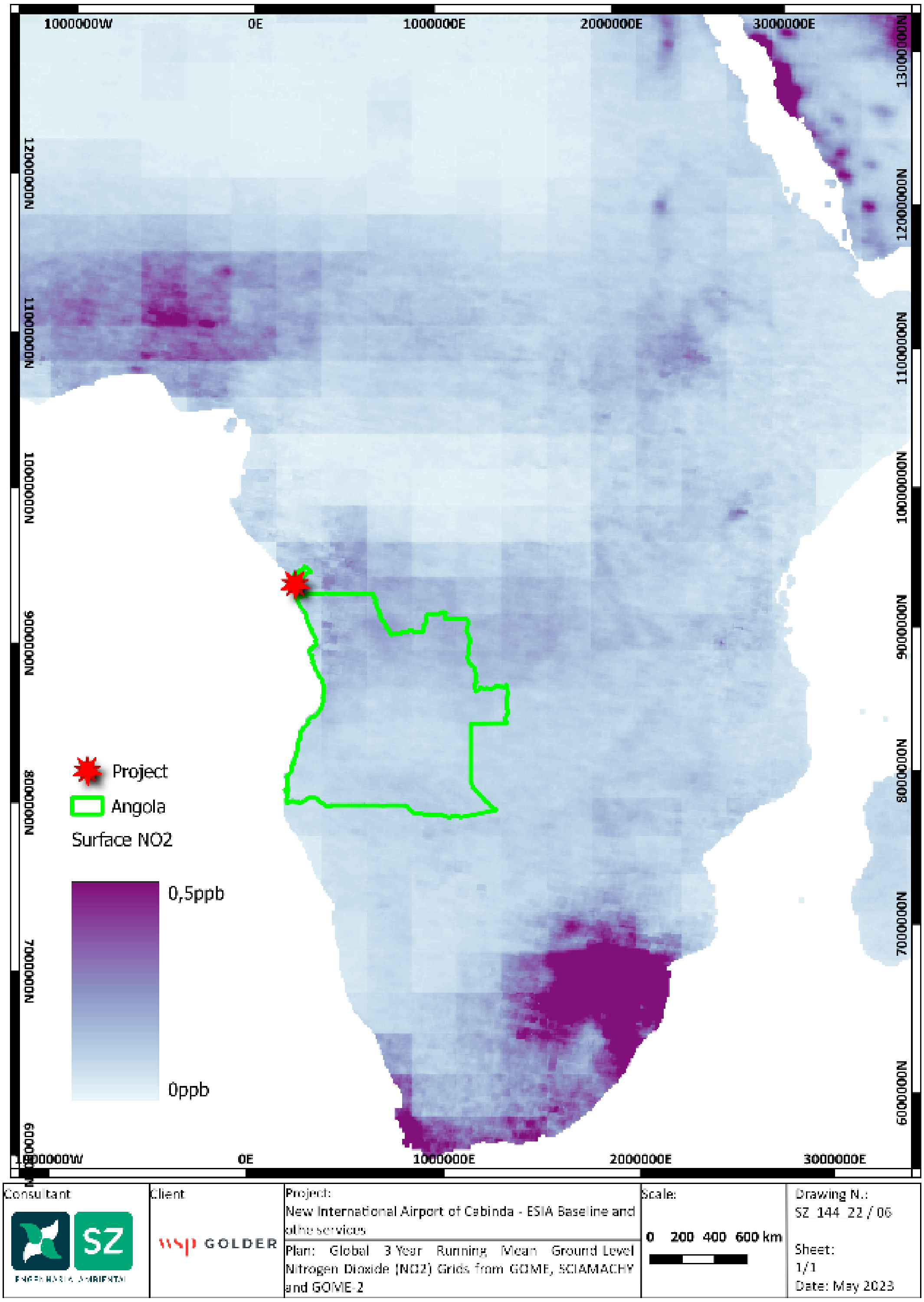


Figure 33: 3-Year Running Mean Ground-Level Nitrogen Dioxide (NO2) at surface level – Nasa EarthData.

The above map shows low expected values of Nitrogen Dioxide in all of the Angolan Territory. It should be noted that this tool has a large mapping area and does not have the necessary detail to take into account the local emissions and sources. Considering the industrial areas of Cabinda, namely the unit associated with the Malongo Oil Base and refinery, with several sources of industrial emissions, it should be expected a higher concentration of several pollutants, including NO_2, in the region around the future airport. However, that is not necessarily mapped by the large scale of the GOME, SCIAMACHY and GOME-2 studies.

Another relevant information provided by the Nasa EarthData is the Country Trends in Major Air Pollutants dataset[17], which is a framework of public-health-focused air quality indicators that quantifies over 200 countries trends in exposure to Particulate Matter ($PM_{2.5}$), Ozone (O_3), Nitrogen Oxides (NOx), Sulphur Dioxide (SO_2), Carbon Monoxide (CO), and Volatile Organic Compounds (VOCs), based on pollutant concentration data derived from the European Centre for Medium-Range Weather Forecast's (ECMWF) Atmospheric Composition Reanalysis 4 (EAC4) data sets.

The following figures present the available spatial average data, from the period 2003 to 2018, for Angola, for these pollutants.

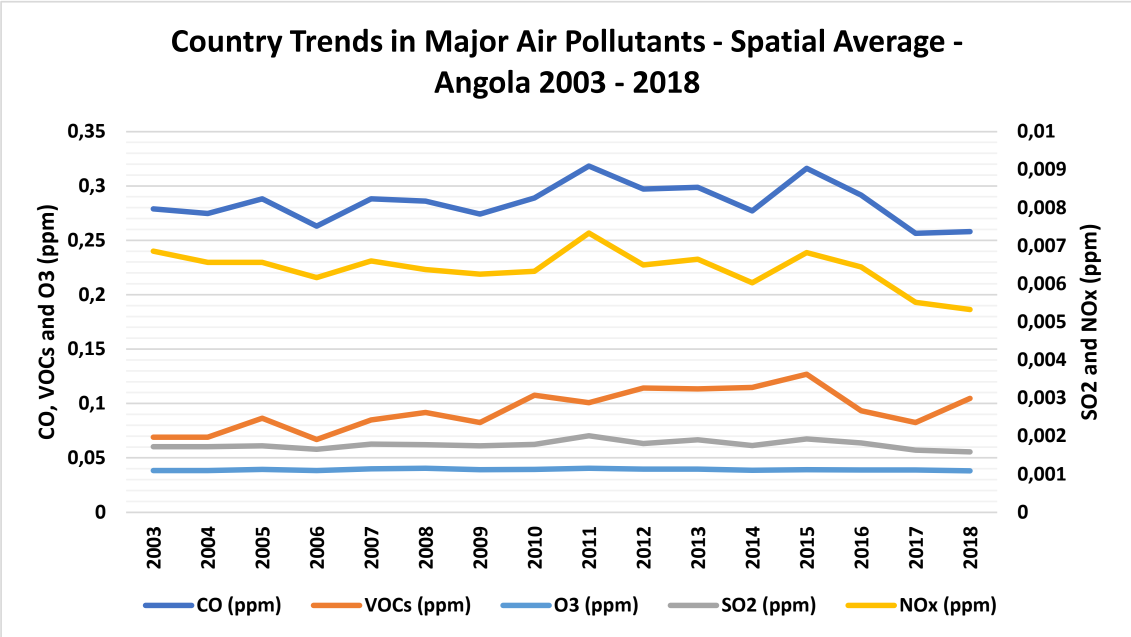


Figure 34: Country Trends in Major Air Pollutants data set – Angola – 2003/2018– Nasa EarthData.

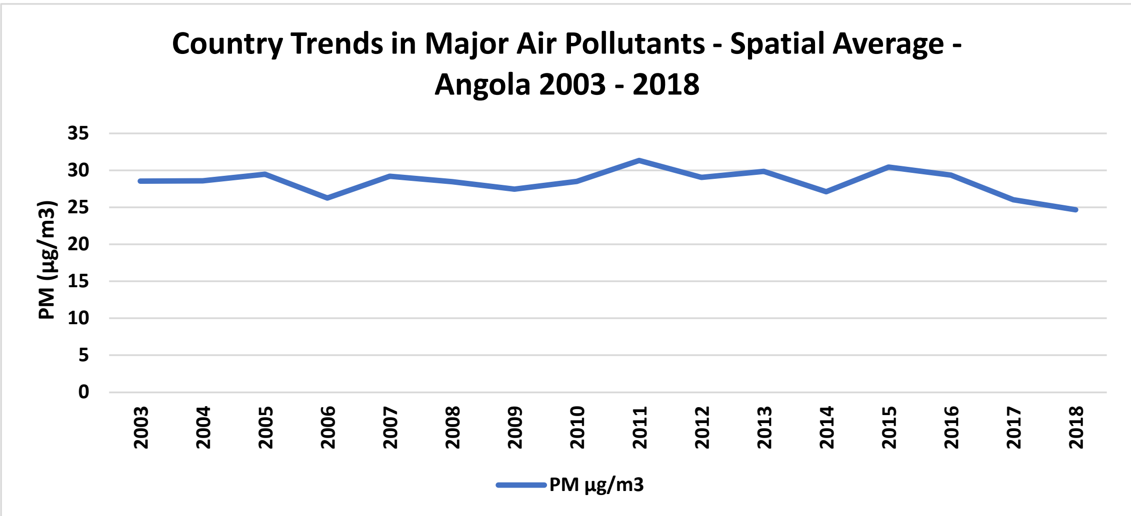


Figure 35: Country Trends in Major Air Pollutants data set – Angola – 2003/2018 - PM– Nasa EarthData.

The above figures show a slight increased tendency for major air pollutants in the country until 2015, with a reduction in the years 2017 and 2018, except in VOCs, which registered a new increase in 2018.

[17] Wolf, M. J., D. C. Esty, H. Kim, M. L. Bell, S. Brigham, Q. Nortonsmith, S. Zaharieva, Z. A. Wendling, A. de Sherbinin and J. W. Emerson. 2022. Country Trends in Major Air Pollutants. Palisades, New York: NASA Socioeconomic Data and Applications Center (SEDAC). https://doi.org/10.7927/et1q-jj80. Accessed 28 of January of 2023.

6.7.3 Project Local Conditions

In the Project area, the main sources of air pollutant emissions, identified in the field survey were:

- Road traffic and respective exhaust emissions, including both light and heavy vehicles, with special emphasis on the EN100 road, that connects the southern and northern part of the province, along the coast;
- Major industrial units with emission points (chimneys) and diffuse emissions, associated with the Malongo Base and all associated units related to the gas and oil sector, and also the port activities (Caio Port);
- Areas of loose soil, especially dirt roads that access the different communities, and that can be a source of particles by wind activities;
- Other small scale emitting sources, such as generators for electrical production in houses, commerce and industry as well as some commerce and services with diffuse and occasional emissions, such as restaurants, repair shops, small industries, etc.
- With regard to the Project itself, the expected existing sources associated with the operation of the airport are the aircraft operation, with emissions from the engine’s exhaust, as well as increase in road traffic, with vehicle tail emissions and also some additional emissions from support equipment, such as emergency generators.

According to what is explained in climatic and weather baseline of this document, it was possible to conclude that in Cabinda the winds are predominant from the South. As such, the emissions from the project operations will, most of the time, affect receivers to the north, especially the communities of Malongo, Bissassanha and Sassa Zau.

As for other sensitive receivers to air pollutant emissions, it should be considered mainly the communities around the airport, with resident population.

Due to the effects of pollution in the foliage of flora and the quality of natural areas, the forested areas around, with more dense tree coverage, are also considered potential sensitive receivers to air pollution.

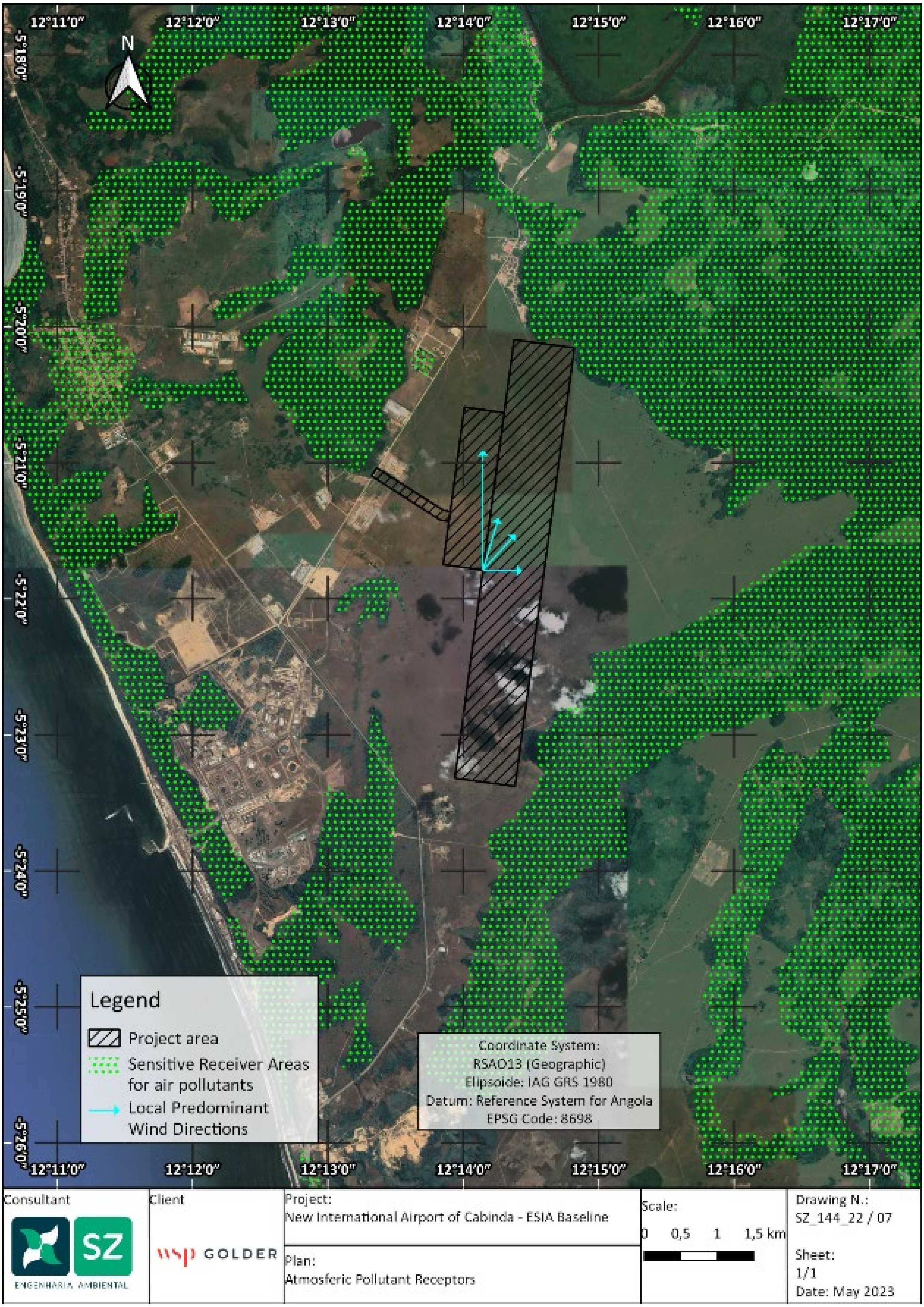


Figure 36: Sensitive Areas to Air Pollution in the Project's region.

6.7.4 Air Quality Monitoring Campaign – 1st Survey

6.7.4.1 Methodology

For the purposes of characterizing the local reference baseline, in terms of air quality, measurements were taken during the field work, including field measurements and laboratory post-processing. The sampling points considered are presented in Figure 37 and Table 12.

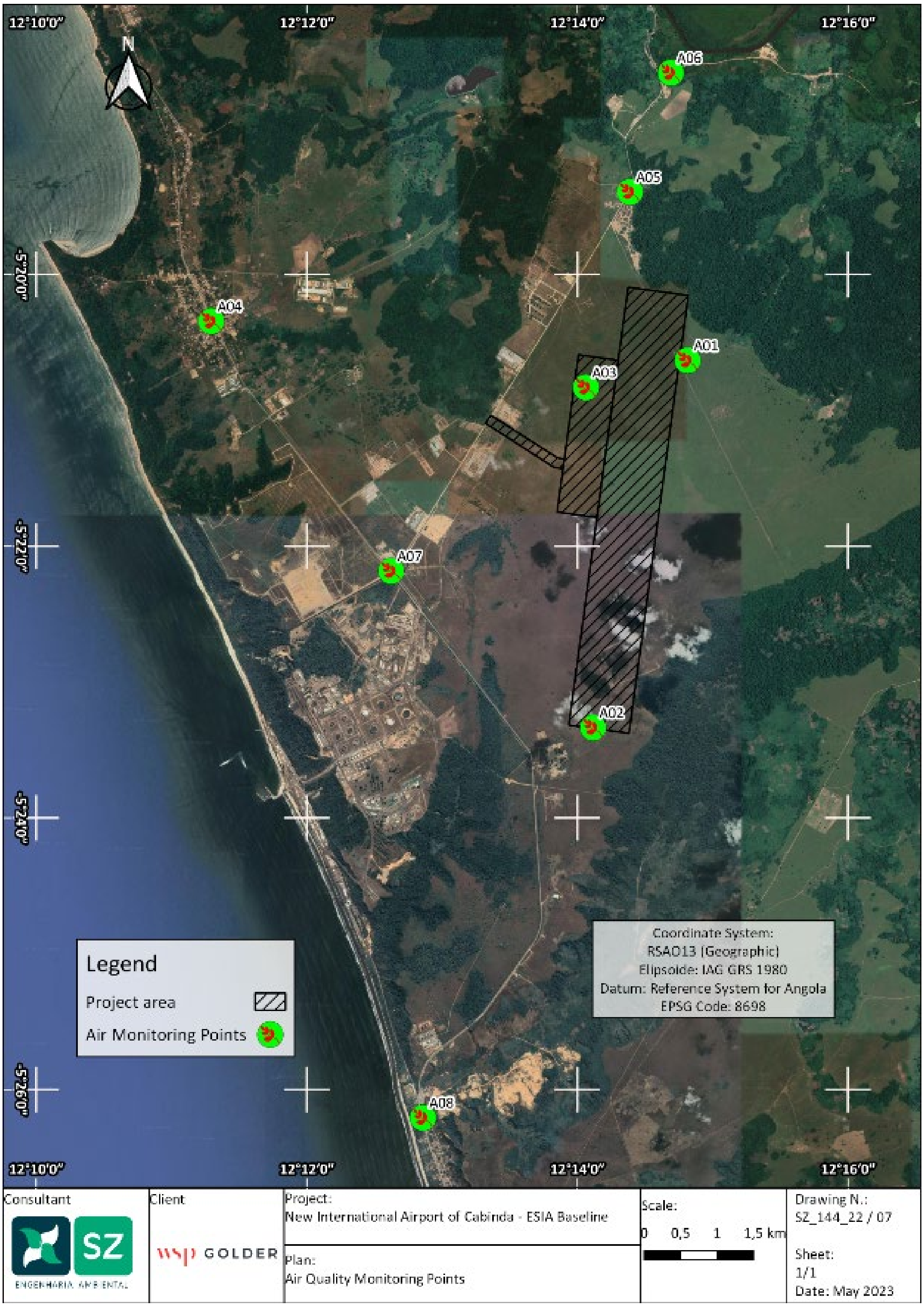


Figure 37: Air Quality Sampling Points.

Table 12: Geographic coordinate for the Air Quality Monitoring Points (Coordinate System: RSAO13 - EPSG Code: 8698 – Official coordinate system for Angola).

Monitoring Point	Latitude	Longitude
A01	5° 20' 38,000" S	12° 14' 48,901" E
A02	5° 23' 20,148" S	12° 14' 06,989" E
A03	5° 20' 49,883" S	12° 14' 03,810" E
A04	5° 20' 20,634" S	12° 11' 17,659" E
A05	5° 19' 23,563" S	12° 14' 23,329" E
A06	5° 18' 30,985" S	12° 14' 41,442" E
A07	5° 22' 10,945" S	12° 12' 37,440" E
A08	5° 25' 72,361" S	12° 12' 51,555" E

The air quality monitoring was developed from 28th to 30th of March 2023, using a HAZ SCANNER EPAS Model monitoring and sampling station.

It should be noted that the Air Quality sampling and noise monitoring was done in the same points, so the following photographic records (Figure 38) present both equipment (noise and air quality) during the monitoring.

Laboratory certificates, the Field report, and the latest equipment calibration certificates are provided in the folder ANNEX A – Baseline Supporting Data, under PART 1 – Results of Physical Baseline, within the folder named "Results_Soil and Air Quality 1st campaign".

Point A01

Point A02

Point A03

Point A04

Point A05

Point A06

Point A07

Point A08

Figure 38: Photographic records of the air quality monitoring.

The following air quality parameters were measured or sampled:

- Temperature;
- PM2.5;
- PM10;
- O_3;

- SO_2;
- NO;
- NO_2;
- Metals:
  - Sb;
  - As;
  - Pb;
  - Cr;
  - Co;
  - Cu;
  - Mn;
  - Ni;
  - V;
  - Cd;
  - Tl;
- Volatile Organic Compounds (VOCs).

The field monitoring for Particulate Matter (PM), Ozone, Sulphur Oxides, Nitrogen Oxides and VOCs was done by several consecutive measurements and the determination of daily average values and standard deviation.

The rest of the parameters were determined in laboratory assessment, with three repetitions for standard deviation estimate.

It was also obtained, from the local weather station in Cabinda (Cabinda Airport) the available hourly values for the weather parameters registered by this station during the sampling period, to assess possible pollutant propagation conditions in the sampling days (see figures below). It should be noted that the Cabinda Airport does not have data available for the 28th of March.

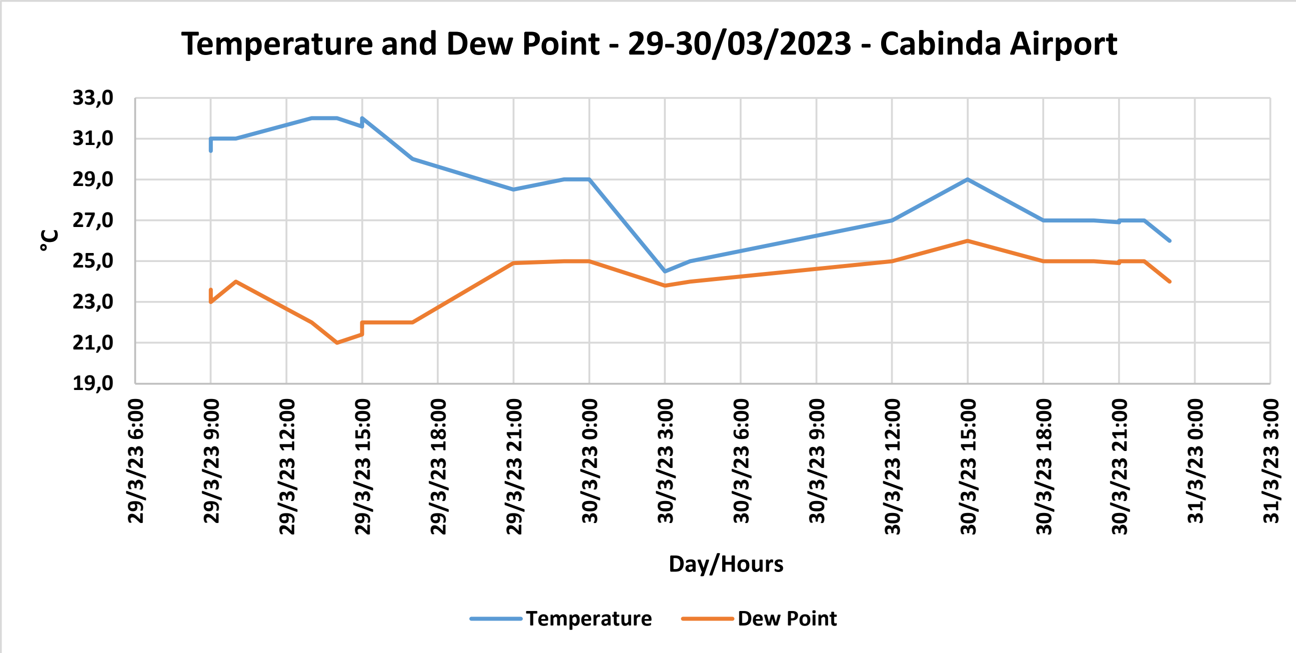


Figure 39: Temperature Records for the Sampling Days – Cabinda Airport Weather station.

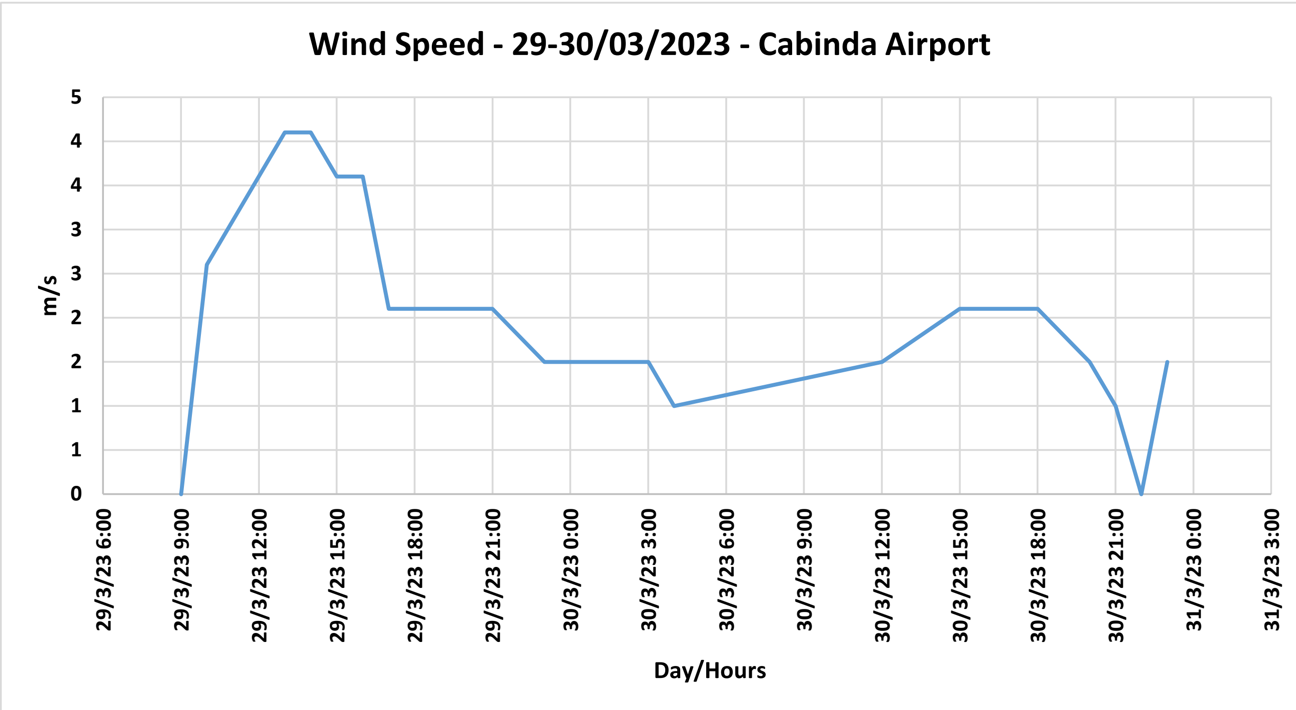


Figure 40: Air Velocity Records for the Sampling Days – Cabinda Airport Weather station.

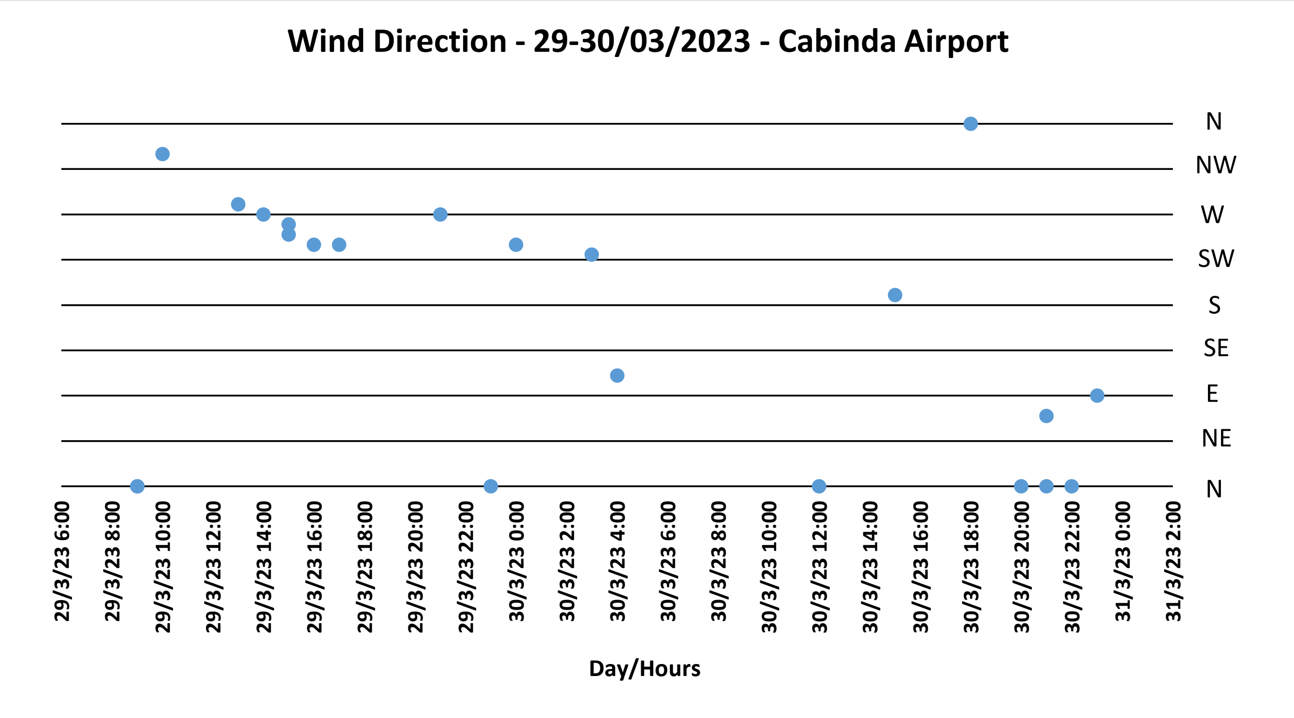


Figure 41 – Air Direction Records for the Sampling Days – Cabinda Airport Weather station.

Angola still lacks national standards for air quality and other environmental aspects such as soil quality and noise and vibration. The IFC General EHS Guidelines[18] recommends that in the absence of national standards, a country should adopt the current edition of the WHO Guidelines for Air Quality[19] for ambient air quality. Therefore, they will be used as the standards for this Project.

In addition, large industrial establishments are present in the Project AoI, and air pollutants released by industry such as particulate matter may contain heavy metals, potentially representing human health and environmental risks. Since the IFC and WHO do not provide standards for the concentration of heavy metals in the air, the Italian Contamination Threshold Values from Legislative Decree 155/2010 were adopted for the Project.

As daily average values were determined, the results were compared to the Daily Project Standards as established in Chapter 04 of the ESIA (for 24-hour, short-term exposure).

6.7.4.2 Results and Discussion

In Table 13 are presented the results obtained in the field monitoring and sampling.

Table 13: Obtained results in Air Quality monitoring on the project location.

Air measurement parameters	Unit	Results								Project Standards
		A01	A02	A03	A04	A05	A06	A07	A08	
Temperature	°C	26	27	23	23	28	27	27	26	-
PM2.5	µg/m³	≤ 1	≤ 1	**170**	**111**	5	5	1	1	15
PM10	µg/m³	24	12	**185**	**163**	**127**	**127**	13	24	45
O3	µg/m³	**157**	**140**	**112**	**117**	**221**	**230**	2	**105**	100

[18] IFC General EHS Guidelines: 1.1 Air Emissions and Ambient Air Quality Final - General EHS Guidelines_APRIL 29.doc (ifc.org)

[19] World Health Organization, 2021. *WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.*

Air measurement parameters		Unit	Results								Project Standards
			A01	A02	A03	A04	A05	A06	A07	A08	
SO2		µg/m³	**166**	**152**	**116**	**117**	**91**	**94**	**184**	**208**	40
NO		µg/m³	179	36	1	5	3	2	111	88	-
NO2		µg/m³	**180**	**173**	4	4	**213**	3	**63**	**145**	25
Metals:	Sb	µg/m³	≤0,003	≤0,003	≤0,003	≤0,003	≤0,003	≤0,003	≤0,003	≤0,003	-
	As	µg/m³	**0,008**	≤0,005	0,006	0,013	≤0,005	≤0,005	≤0,005	≤0,005	0,006
	Pb	µg/m³	0,008	≤0,005	≤0,005	0,006	≤0,005	≤0,005	0,006	≤0,005	0,5
	Cr	µg/m³	0,009	0,011	0,014	0,017	0,019	0,022	0,014	0,016	-
	Co	µg/m³	0,030	0,015	≤0,005	0,009	≤0,005	≤0,005	0,008	≤0,005	-
	Cu	µg/m³	0,080	0,030	0,020	0,007	0,011	0,013	0,063	0,019	-
	Mn	µg/m³	0,016	0,071	0,036	0,021	0,016	0,018	0,027	0,024	-
	Ni	µg/m³	≤0,002	≤0,002	≤0,002	≤0,002	≤0,002	≤0,002	0,003	0,005	0,02
	V	µg/m³	≤0,003	≤0,003	≤0,003	≤0,003	≤0,003	≤0,003	≤0,003	≤0,003	-
	Cd	µg/m³	**0,070**	**0,026**	**0,050**	**0,008**	≤0,003	**0,006**	**0,041**	0,004	0,005
	Tl	µg/m³	≤0,005	≤0,005	≤0,005	≤0,005	≤0,005	≤0,005	≤0,005	≤0,005	-
Volatile Organic Compounds (VOCs)		ppb	0	0	0	0	0	0	0	0	-

The results marked in gray were below the detection limit of the determination methodology of the laboratory, and the values for these pollutants are then considered non-relevant in those points.

That is particularly true with Nickel, Vanadium, Thallium and Antimony which are below the detection level in almost all points or with low values obtained.

As for the main air quality parameters, namely Particulate Matter, Ozone, Sulphur Dioxide and Nitrogen Oxides, all points monitored present air quality problems, with high levels or particles ($PM_{2.5}$ or PM_{10}) in half of the points.

All monitoring points register high levels of Sulfur Dioxide (SO_2), and Ozone (O_3), above the Project standards, also registering values for Nitrogen Dioxide (NO_2) above Project standards in points A01, A02, A05, A07 and A08.

As for other pollutants, it was also registered the presence of some heavy metals in the particle matter collected, with values above the Project standards for Arsenic in A01 and Cadmium in all points except A05 and A08. Cadmium registers a concentration average of 0,03 µg/m^3.

It should also be mentioned the presence of Chromium, Copper and Manganese in all points, although it has not been proposed any Project standard for these pollutants. Chromium registers an average of 0,02 µg/m^3, while Copper (Cu) and Manganese (Mn) have an average of 0,03 µg/m^3. The main source of metal's emission identified in the field is suspended soil (high level of particles in the atmosphere). As can be seen in the Soil Analysis (section 6.4.3.2), traces of heavy metals are present in the soil (from natural sources). The region has several areas of uncovered loose soil, including dirt roads, soil extraction areas, ravines and ditches, etc. which promote soil suspension by wind, soil movement activities and road traffic in dirt roads. The high contribution of the unpaved/dirt roads in the Project's surroundings will possibly contribute to high levels of suspended particles, due to wind influence, that result in high levels of PM_{10} and that can also carry some heavy metals from the soil.

Besides soil suspension, the presence of these pollutants in the air is also possibly associated with all the heavy industry present around the Malombo oil base and the road traffic from the EN100.

The values obtained do not indicate a specific tendency of pollution distribution in the territory or relevant differences in air quality between sampling points.

It should be mentioned that a noticeable variability in the results was obtained in the survey, considering the proximity of monitoring points and the general similar environmental conditions. This could be due to the chosen survey period (1 day with subsampling along the day), which could lead to larger influence of particular sources and events and temporary propagation conditions, with larger variability between points when compared to a longer period continuous survey campaign. Therefore, although results of this survey are still valid, the chosen methodology might not have been adequate to the site conditions variability. A longer duration campaign, covering a larger survey period and different propagation and emission conditions was then considered important to be performed. The results of the second air quality campaign are described in the section below.

6.7.5 Air Quality Monitoring Campaign – 2nd Survey

In the context of the ESIA development, and in response to a request received from the Lenders' ES consultant to have a 1-month air quality monitoring in separate seasons for the purpose of Project baseline, a long-term air quality monitoring campaign was carried out in October/November 2023 to complement the short-term survey already developed in March 2023.

Given the scarcity of air quality data in Cabinda and the difficulties in retrieving the mobile station, the best approach proposed for this new campaign was organised in two phases as follows:

- Phase 1 – Gaseous monitoring using the EPAS continuous monitor.
- Phase 2 – Monitor for BTEX (benzene, toluene, ethylbenzene and xylene), SO_2 (sulphur dioxide), NO_2 (nitrogen dioxide) and O_3 (ozone) through the passive samplers;

Phase 1 was conducted by Saioz Engenharia Lda (Saioz) as the first campaign, from October 5th to November 2nd, 2023 whilst Phase 2 was carried out with the support of WSP South Africa from October 11th to November 9th, 2023.

Due to the initial difficulties in defining the two phases, including the preparation of the logistics of the two teams on the field, this survey was conducted during a transitional period from the dry season to the wet season (since in Cabinda, September is the last month of the dry season).

Below, the methodology and outcomes of the two surveys will be described separately.

6.7.5.1 Phase 1 - Air Quality Survey

The same eight monitoring point locations used in the 1st campaign in March 2023 were considered for the 2nd campaign, with exception of point A03, which was slighted moved to the north. This is due to the presence of the OEC construction camp, which introduced new emission sources near the Project, especially near the monitoring point A03. As such, it was considered a change in this point between the two campaigns, in order to set it further away from this new emitting source.

The monitoring points have the following geographical coordinates (Table 14Table 7):

Table 14: Geographic coordinate for the Air Quality Monitoring Points (Coordinate System: RSAO13 - EPSG Code: 8698 – Official coordinate system for Angola).

Monitoring Point		Latitude	Longitude
A01		5° 20' 38,002" S	12° 14' 48,901" E
A02		5° 23' 20,148" S	12° 14' 06,989" E
A03	1st Campaign	5° 20' 49,883" S	12° 14' 03,810" E
	2nd Campaign	5° 19' 59,070" S	12° 14' 07,830" E
A04		5° 20' 20,634" S	12° 11' 17,659" E
A05		5° 19' 23,563" S	12° 14' 23,329" E
A06		5° 18' 30,985" S	12° 14' 41,442" E
A07		5° 22' 10,945" S	12° 12' 37,440" E
A08		5° 25' 72,361" S	12° 12' 51,555" E

The location of the monitoring points in relation to the Project footprint is shown in Figure 42 below. The old and new position of point A03 is also shown.

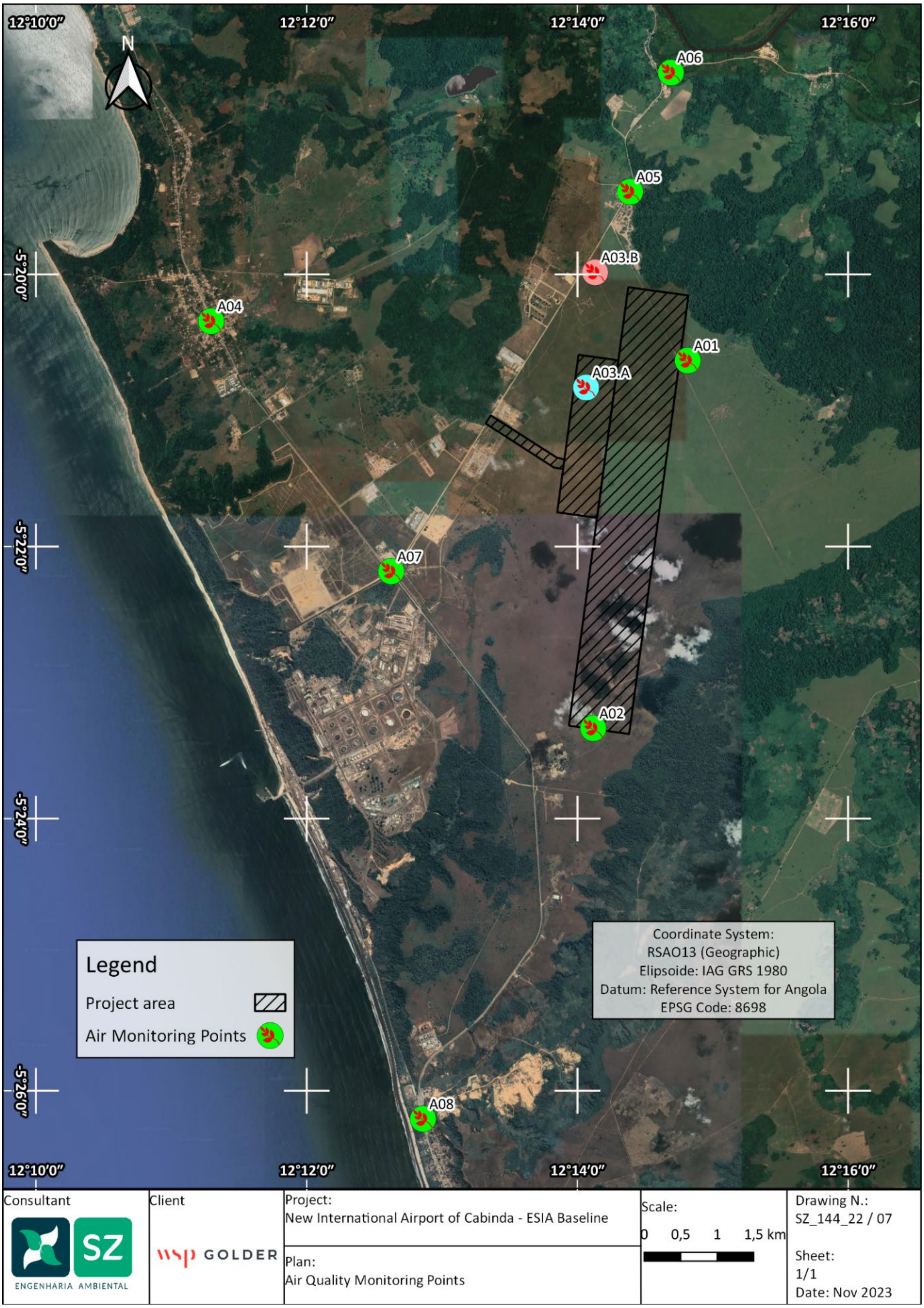


Figure 42: Air Quality monitoring points (survey carried out by Saioz).

6.7.5.1.1 Methodology

The long-term campaign, representing a one-month survey and developed between 5th of October and 2nd of November 2023, covered 4 different weeks, all weekdays (Monday to Sunday) and different hours distributed along the day, between 08:30 and 17:30, with a total of 8 monitoring sub-periods in each point. The survey plan is showed in Table 15.

A HAZ SCANNER EPAS Model monitoring station was used to measure the air quality, for 30 minutes data acquisition time, in each monitoring sub-period.

The following air quality parameters were measured in the 2nd campaign:

- Wind direction;
- Wind speed;
- Temperature;
- PM 2.5; and
- PM 10.

Table 15 : Survey Plan – 2nd Campaign.

Dates	Week Number (2023)	Weekday	Start of Monitoring session							
			A01	A02	A03	A04	A05	A06	A07	A08
05/10/2023	40	Thursday	11:30	12:10	13:00	13:45	14:40	15:30	16:15	17:00
06/10/2023		Friday	13:00	15:00	16:00	17:00	8:30	10:00	11:00	12:00
21/10/2023	42	Saturday	17:00	8:30	10:00	11:00	12:00	13:00	15:00	16:00
22/10/2023		Sunday	12:00	13:00	15:00	16:00	17:00	8:30	10:00	11:00
23/10/2023	43	Monday	16:00	17:00	8:30	10:00	11:00	12:00	13:00	15:00
24/10/2023		Tuesday	11:00	12:00	13:00	15:00	16:00	17:00	8:30	10:00
01/11/2023	44	Wednesday	15:00	16:00	17:00	8:30	10:00	11:00	12:00	13:00
02/11/2023		Thursday	10:00	11:00	12:00	13:00	15:00	16:00	17:00	8:30

The measurement method is based on ASQ/ANSI/ISO 9001:2015 and the measurement was carried out in accordance with the following procedure:

1) The locations pre-defined by the proponent were identified.
2) The equipment was positioned facing south in order to capture pollutants and the direction of the wind.
3) The equipment was connected following the procedures in the technical sheet.
4) After 15 minutes of equipment calibration, the measured data were recorded at 30 min intervals at each point.

The official report provided by the laboratory is provided in the folder ANNEX A – Baseline Supporting Data, under PART 1 – Results of Physical Baseline, within the folder named “Results_ Air Quality 2nd campaign”.

In addition, temperature, wind speed, and wind direction were also registered during the sampling period to assess possible pollutant propagation conditions over the sampling days. The HAZScanner meteorological sensors were used for this purpose.

Photographs of the sampling locations are shown in Figure 43.

Point A01

Point A02

Point A03

Point A04

Point A05

Point A06

Point A07

Point A08

Figure 43: Photographs of the air monitoring points A01 to A08.

6.7.5.1.2 Results

Results of the weather parameters recording (temperature, wind speed, and wind direction) are shown in Figure 44, Figure 45, and Figure 46. The results for the eight air quality monitoring points are shown in Table 16. A summary of this results, considering the global averages, both for the individual monitoring points and the weekdays is shown in Table 17.

The results obtained were compared to the Daily Project Standards (based on WHO Guidelines for Air Quality[20]) as established in Chapter 04 of the ESIA.

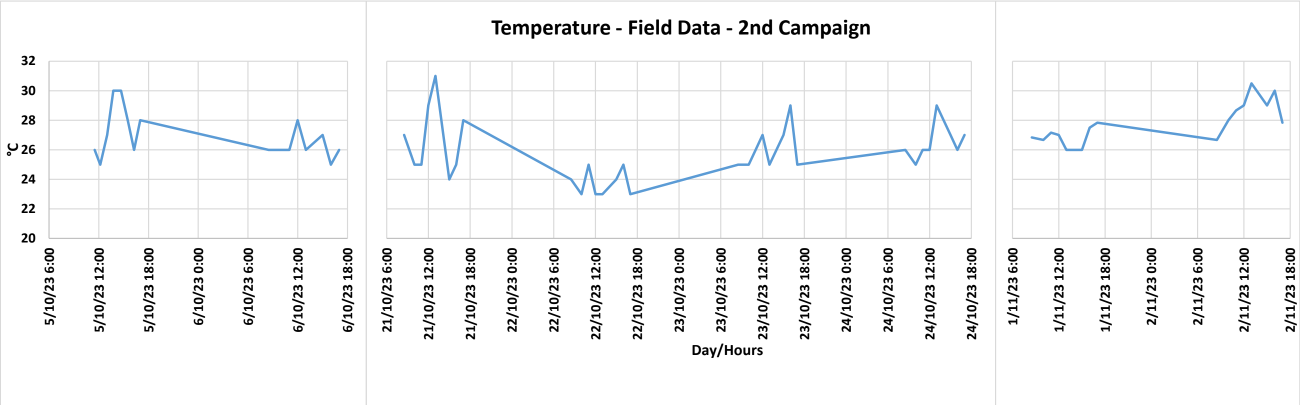


Figure 44 : Temperature Records for the Sampling Days – 2nd Campaign – Field Data (HAZ Scanner).

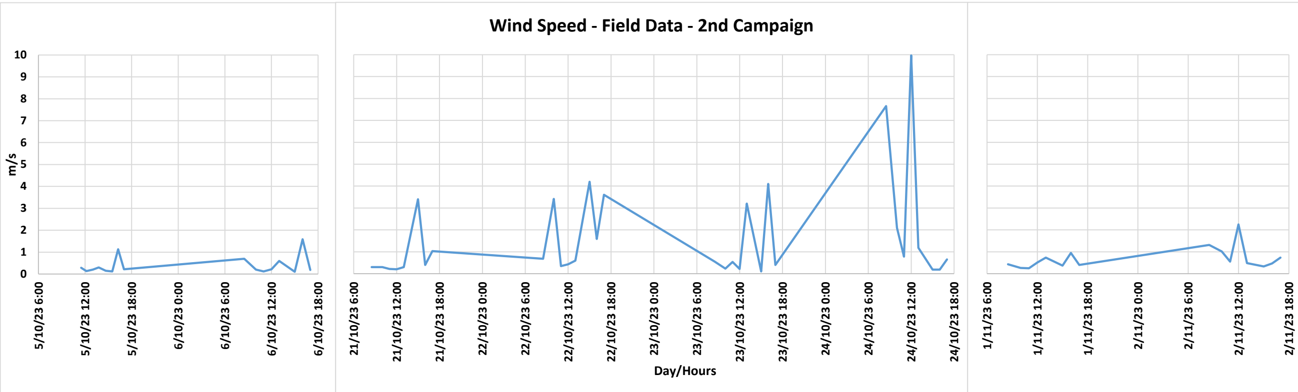


Figure 45 : Air Velocity Records for the Sampling Days – 2nd Campaign – Field Data (HAZ Scanner).

[20] World Health Organization, 2021. *WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.*

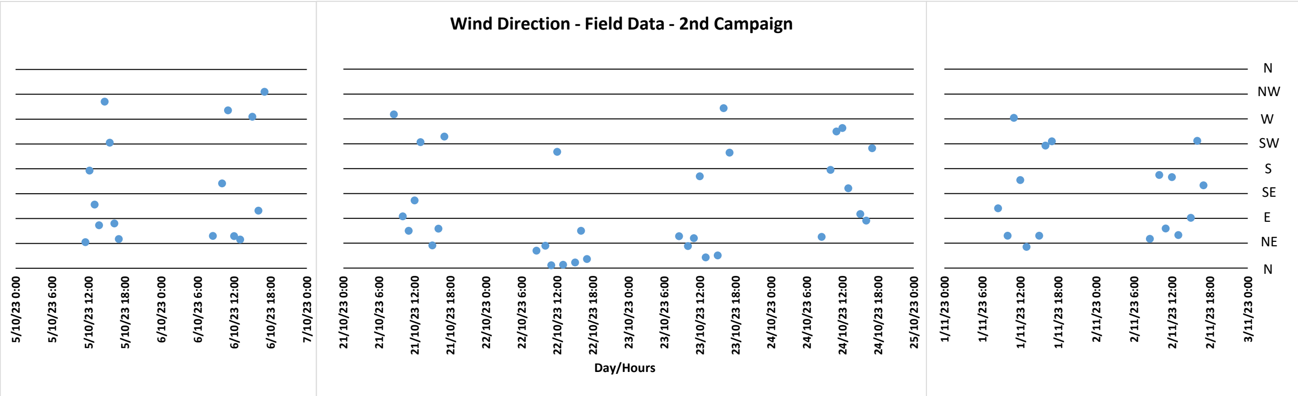


Figure 46 : Air Direction Records for the Sampling Days – 2nd Campaign - Field Data (HAZ Scanner).

Table 16: Obtained results in Air Quality monitoring on the Project location – 2nd Campaign, Saioz – October/November 2023.

Points	Parameter	Dates							
		05/10/2023	06/10/2023	21/10/2023	22/10/2023	23/10/2023	24/10/2023	01/11/2023	02/11/2023
A01	PM10 (µg/m³)	225	213	10	2	12	3	38	86
	PM2.5 (µg/m³)	133	127	1	1	10	1	8	49
	WS (m/s)	0,3	0,6	1,0	0,4	4,1	0,8	0,4	1,0
	WD (Degrees)	47	52	238	210	290	247	59	169
	T (°C)	26	26	28	23	29	26	26	28
A02	PM10 (µg/m³)	159	188	8	9	26	9	70	6
	PM2.5 (µg/m³)	124	121	1	5	15	1	29	2
	WS (m/s)	0,1	0,1	0,3	0,6	0,4	10,0	1,0	0,6
	WD (Degrees)	177	274	278	6	209	253	222	72
	T (°C)	25	27	27	23	25	26	28	29
A03	PM10 (µg/m³)	13	10	2	158	3	17	18	36
	PM2.5 (µg/m³)	6	2	1	104	1	1	2	8
	WS (m/s)	0,2	1,6	0,3	4,2	0,6	1,2	0,4	2,3
	WD (Degrees)	116	105	94	10	58	144	229	165
	T (°C)	27	25	25	24	25	29	28	29
A04	PM10 (µg/m³)	13	213	5	131	152	159	18	61
	PM2.5 (µg/m³)	5	146	1	161	96	81	3	14
	WS (m/s)	0,3	0,2	0,2	1,6	0,2	0,2	0,4	0,5
	WD (Degrees)	78	320	67	67	40	98	108	60
	T (°C)	30	26	25	25	25	27	27	31
A05	PM10 (µg/m³)	2	179	8	2	16	2	4	98
	PM2.5 (µg/m³)	1	111	10	1	6	1	2	60
	WS (m/s)	0,2	0,7	0,2	3,6	0,5	0,2	0,3	0,3
	WD (Degrees)	302	59	122	16	54	86	59	91
	T (°C)	30	26	29	23	26	26	27	29
A06	PM10 (µg/m³)	2	149	14	111	15	2	113	10
	PM2.5 (µg/m³)	1	90	21	32	1	1	27	2
	WS (m/s)	0,1	0,2	0,3	0,7	0,2	0,7	0,3	0,5
	WD (Degrees)	228	154	228	32	166	217	272	230
	T (°C)	28	26	31	24	27	27	27	30
A07	PM10 (µg/m³)	18	171	2	124	8	149	65	28
	PM2.5 (µg/m³)	7	103	1	166	2	80	10	6
	WS (m/s)	1,1	0,1	3,4	3,4	3,2	7,7	0,5	0,7
	WD (Degrees)	81	286	41	40	19	56	159	150
	T (°C)	26	26	24	23	25	26	27	28
A08	PM10 (µg/m³)	189	188	5	148	7	110	16	174
	PM2.5 (µg/m³)	99	97	1	84	1	124	2	59
	WS (m/s)	0,2	0,2	0,4	0,4	0,1	2,1	0,7	1,3
	WD (Degrees)	53	58	71	5	23	178	38	53
	T (°C)	28	28	25	25	27	25	26	27

WS – Wind Speed; WD – Wind Direction; T – Temperature.

Table 17 : Summary of results –2nd Campaign – October/November 2023.

Point	Global Averages				
	PM10 (µg/m³)	PM2.5 (µg/m³)	Wind Speed (m/s)	Wind Origin (half-winds)	T (°C)
A01	73	41	1,1	SSE	27
A02	59	37	1,6	S	26
A03	32	16	1,3	ESE	26
A04	94	63	0,5	ESE	27
A05	39	24	0,7	E	27
A06	52	22	0,4	S	28
A07	70	47	2,5	ESE	26
A08	104	58	0,7	ENE	26
Global Values (Project Area)	**66**	**39**	**1,1**	**SE**	**27**
Weekday					
Monday	30	17	1,2	ESE	26
Tuesday	56	36	2,8	SSE	27
Wednesday	43	10	0,5	SE	27
Thursday	70	36	0,6	SE	28
Friday	164	100	0,5	SSE	26
Saturday	7	5	0,8	SE	27
Sunday	85	69	1,9	NE	24
Project Standards (24-hours)	**45**	**15**	-	-	-

6.7.5.1.3 Discussion

The results obtained show a relevant disturbance associated with particles in the region, with average values of PM10 and PM2.5 above the considered Project's Standards in several monitoring points.

There is great variability between monitoring days and locations, and it is not possible to identify specific sources or tendencies, showing relevant variations is dust emissions and dispersion conditions.

The high level of particles is probably related to a mix of local sources, including local industry, road traffic (in some cases unpaved) and the existence of extensive areas with bare soil, leading to dust suspension by wind gusts.

It should also be mentioned the existence, during the campaign, of several bushfires. As was identified during the biodiversity surveys, the communities around the Project use fires to clear vegetation for agriculture and as support in hunting activities. These bushfires are usually carried out at the end of the dry season and transition to the wet season, when the vegetation is dry (herbaceous and shrubland habitats). This coincided with the monitoring period of the 2nd campaign and could be considered another local emission source of particles.

In comparison to the first air quality campaign performed in March 2023, many monitoring points have also shown levels of PM2.5 and PM10 above the standard limits (specially PM10), demonstrating that the concentration of PM in the Project area is likely to be elevated at least during a large part of the year.

6.7.5.2 Phase 2 - Air Quality Survey (through passive samplers)

Eight monitoring point locations have been selected for the survey carried out by WSP specialists. Their geographical coordinates are shown in Table 18.

Table 18 : Geographic coordinate for the Air Quality Monitoring Points, passive samplers (Coordinate System: RSAO13 - EPSG Code: 8698 – Official coordinate system for Angola).

Monitoring Point	LAT	LONG	Site Description
Passive_N1	05° 20' 32.856" S	012° 14' 05.064" E	East of NAIC construction site
Passive_N2	05° 23' 06.21" S	012° 14' 15.684" E	North of military base
Passive_N3	05° 20' 08.808" S	012° 14' 29.616" E	Along old fence line south-east of shipping containers
Passive_N4	05° 20' 20.652" S	012° 11' 17.664" E	In front of the Malembo Communal Administration
Passive_N5	05° 19' 46.704" S	012° 14' 19.896" E	Discard Shipping Containers
Passive_N6	05° 18' 41.4" S	012° 14' 36.564" E	Cassai Road, near the primary school
Passive_N7	05° 21' 05.724" S	012° 11' 39.408" E	Cassai Road, near the Military base
Passive_N8	05° 26' 02.796" S	012° 12' 50.652" E	Fútila Intersection

The locations of the monitoring points in relation to the Project footprint are shown in Figure 47 below. The monitoring locations of the survey carried by Saioz are also plotted in the map for comparison.

Figure 47 : Air Quality monitoring points (Phase 1 and 2).

6.7.5.2.1 Methodology

The specialists from WSP South Africa have carried out the following methodology:

- Radiello passive samplers have been used to measure BTEX (benzene, toluene, ethylbenzene and xylene), SO2 (sulphur dioxide), NO2 (nitrogen dioxide) and O3 (ozone). Figure 48 shows the main components of the Radiello passive samplers.

Figure 48 : The components of radiello passive samples. The essential parts of radiello are the adsorbing cartridge, the diffusive body, the supporting plate and the adhesive label with the bar code indication. Source: https://radiello.com/components/**.**

Radiello is an accurate, precise and certified instrument (EN 13528: 2002; EN 14662-4.5: 2005) that has no energy consumption, does not involve the use of heavy and bulky pumps, does not require surveillance, and produces no noise. The diffusive surface is cylindrical rather than flat, as in traditional axial diffusive samplers, and the adsorbent is contained within a coaxial cylindrical system.

- The passive samplers have been installed on existing infrastructure such as light posts and fence posts, at eight existing air quality monitoring points in and around the proposed international airport;
- Supporting plates, diffusive bodies, and shelters have been used to install and operate the passive samplers. After its assemblage, the sampler was exposed to the air and the start date and time were recorded;
- The passive samplers have been deployed on site for four weeks. The start and end date of recording are shown in Table 19;

Table 19 : Start and end dates of recording for the eight passive samples.

Monitoring Point	Recording Start Date	Recording End Date	Exposure [days]
Passive N1	2023-10-11	2023-11-08	28
Passive N2	2023-10-11	2023-11-08	28

Monitoring Point	Recording Start Date	Recording End Date	Exposure [days]
Passive N3	2023-10-11	2023-11-09	29
Passive N4	2023-10-11	2023-11-09	29
Passive N5	2023-10-11	2023-11-09	29
Passive N6	2023-10-11	2023-11-09	29
Passive N7	2023-10-11	2023-11-09	29
Passive N8	2023-10-11	2023-11-09	29

- After this period, the tubes containing the adsorbing cartridges and properly labelled were sent to a SANAS (South African National Accreditation System) Laboratory in South Africa for analysis.

The official report provided by the laboratory is provided in the folder ANNEX A – Baseline Supporting Data, under PART 1 – Results of Physical Baseline, within the folder named "Results_ Air Quality 2nd campaign".

6.7.5.2.2 Results

The results obtained are shown in Table 20.

The results of NO_2, SO_2 and O_3 were compared to the Daily Project Standards (based on WHO Guidelines for Air Quality[21]). In light red in the table are evidenced the values that surpassed Project standards.

No Project standards have been established for BTEX. However, the values found are much below the limits set by well-recognized international entities for the substances considered (benzene, toluene, ethylbenzene and xylene). The California Office of Environmental Health Hazard Assessment (OEHHA)[22], for example, applies the following limits for BTEX in general air:

- Benzene: limit of 3 µg/m³ (for 8-hour inhalation and chronic inhalation);
- Toluene: limit of 5,000 µg/m³ (acute reference exposure level), limit of 830 µg/m³ (for 8-hour inhalation), and limit of 420 µg/m³ (for chronic inhalation);
- Ethylbenzene: limit of 2,000 µg/m³ (for chronic inhalation);
- Xylenes (technical mixture of m, o, p-isomers): limit of 22,000 µg/m³ (acute reference exposure level), and limit of 700 µg/m³ (for chronic inhalation).

[21] World Health Organization, 2021. *WHO global air quality guidelines: Particulate matter (PM2.5 and PM10), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.*

[22] Air Chemicals - OEHHA.

Table 20 : Obtained results in Air Quality monitoring on the Project location – 2nd Campaign, WSP specialists – October/November 2023

Monitoring Point	Concentration								
	NO_2 [µg/m3]	SO_2 [µg/m3]	O3 [µg/m3]	Benzene [µg/m3]	Ethylbenzene [µg/m3]	Toluene [µg/m3]	m,p-Xylene [µg/m3]	o-Xylene [µg/m3]	Xylene [µg/m3]
Passive N1	2,67	0,10	173,95	0,26	bdl	0,36	bdl	bdl	0,00
Passive N2	1,98	0,04	154,35	0,33	bdl	0,40	bdl	bdl	0,00
Passive N3	2,55	0,10	176,80	0,27	bdl	0,34	bdl	bdl	0,00
Passive N4	2,78	0,11	198,78	0,34	bdl	0,51	0,42	bdl	0,42
Passive N5	2,63	0,07	154,55	0,32	0,26	0,35	0,84	0,32	1,16
Passive N6	3,49	2,88	187,83	0,40	bdl	0,47	0,43	bdl	0,43
Passive N7	2,11	0,05	181,12	0,20	bdl	0,29	bdl	bdl	0,00
Passive N8	4,99	0,30	220,49	0,80	0,42	1,23	0,82	0,31	1,13
	Project Standards								
	25	40	100	-	-	-	-	-	-

* bdl = below detection limit

6.7.5.2.3 Discussion

The concentrations for all pollutants, except ozone, are quite low.

The concentrations of ozone are elevated in all monitoring points. Ground-level ozone comes indirectly from pollution emitted from cars, power stations, oil production, refineries, combustion processes, among others. Ground-level ozone is created by chemical reactions between oxides of nitrogen (NOx) and volatile organic compounds (VOCs). The high concentrations found could be associated to the presence of existing activities in the Project area, such as the Malembo Thermal Power Station and the Malongo Oil Complex. High concentrations of ozone in air can impact human health (people at greatest risk of harm from breathing air containing ozone include people with asthma) as well as sensitive vegetation and ecosystems, including forests, parks, wildlife refuges and wilderness areas. In particular, ozone can harm sensitive vegetation during the growing season[23].

The concentrations of ozone from the passive samplers are similar to the concentrations measured by Saioz during the first campaign (March 2023), meaning that the concentration of ozone in the Project area is likely to be elevated during a large part of the year.

On the other hand, the concentrations of NO_2 and SO_2 were considerably lower than the concentrations measured by Saioz in the first campaign. This could be due to the differences of weather characteristics from the different seasons; or due to a higher concentration of SO_2 and NO_2 in the air on the days of monitoring the first campaign, possibly coming from local industrial sources. However, it has been discussed that the survey approach used during the first campaign was not completely adequate to the site conditions variability, with

[23] Ground-level Ozone Basics | US EPA.

lower representativeness of results whilst the data collected though the second longer campaign are more representative and reliable.

6.8 Noise and Vibrations

6.8.1 Context

From a human point of view, exposure to ambient noise and vibrations may have harmful consequences on health, on the behaviour of individuals and on human activities, as well as psychological and social effects. It can then be considered that noise constitutes a cause of discomfort, an obstacle to verbal and sound communication, and may cause general fatigue and, in extreme cases, auditory trauma and extra-auditory physiological alterations. Vibration can also be a cause of discomfort and fatigue, and can result, in extreme cases, in physiological trauma, such as nerve damage, numbness and other injuries.

These aspects should be taken care of as a precaution and in view of the resulting economic costs that their correction may imply. The main objectives of controlling ambient noise and vibration are to protect the population from intruding disturbances that affect their daily activities and to prevent the growing increase in ambient noise and vibration, which will later translate into a decrease in quality of life.

Noise and vibration thus are assumed as very sensitive components of the environment, potentially negatively affecting people's quality of everyday life.

6.8.2 Noise Monitoring campaign

A noise monitoring campaign was carried out in the Project area from March 28th to 31st, 2023. Methodology and results are presented below.

The laboratory certificate is provided in the folder ANNEX A – Baseline Supporting Data, under PART 1 – Results of Physical Baseline, by the file named “Boletim_Ensaio_Ruido_SR_Cabinda”.

6.8.2.1 Methodology

For the characterization of the current sound environment, in the areas of influence of the Project under study, discrete short-term noise measurements were carried out, at eight locations inside and around the Project area, characterizing the pre-existing sound level in the region.

Considering the extended area of influence of the aircraft take-off and landing noise emissions, it was considered 5 points around the airport, namely:

- Near the closest sensitive receivers (housing communities) of the airport approach vectors:
    - To the North - Point R06, in Bissassanha;
    - To the South – Point R08 in Futila;
- Near the largest settlement in the region, in Malembo – Point R04;
- Near the main access roads to the future airport, in the crossover with National Road 100 (EN100) – Point R07;
- Near the road that links the airport to the northern communities (Bissassanha, Sassa Zau, Tchifimbo and Lelo), in the approach vector to the runway, close to an industrial unit (not sensitive) – Point R05

It was considered an additional 3 points inside the Project area, characterizing the existing sound levels in the North (Point R01) and South (Point R02) limits of the future airport, and also near the future terminal and airport entrance (Point R03).

The selected measurement points are marked in Figure 49. It should be noted that the noise measurement was developed prior to any construction activity, representing the baseline noise levels. Figure 50 shows some photographs took from the monitoring points.

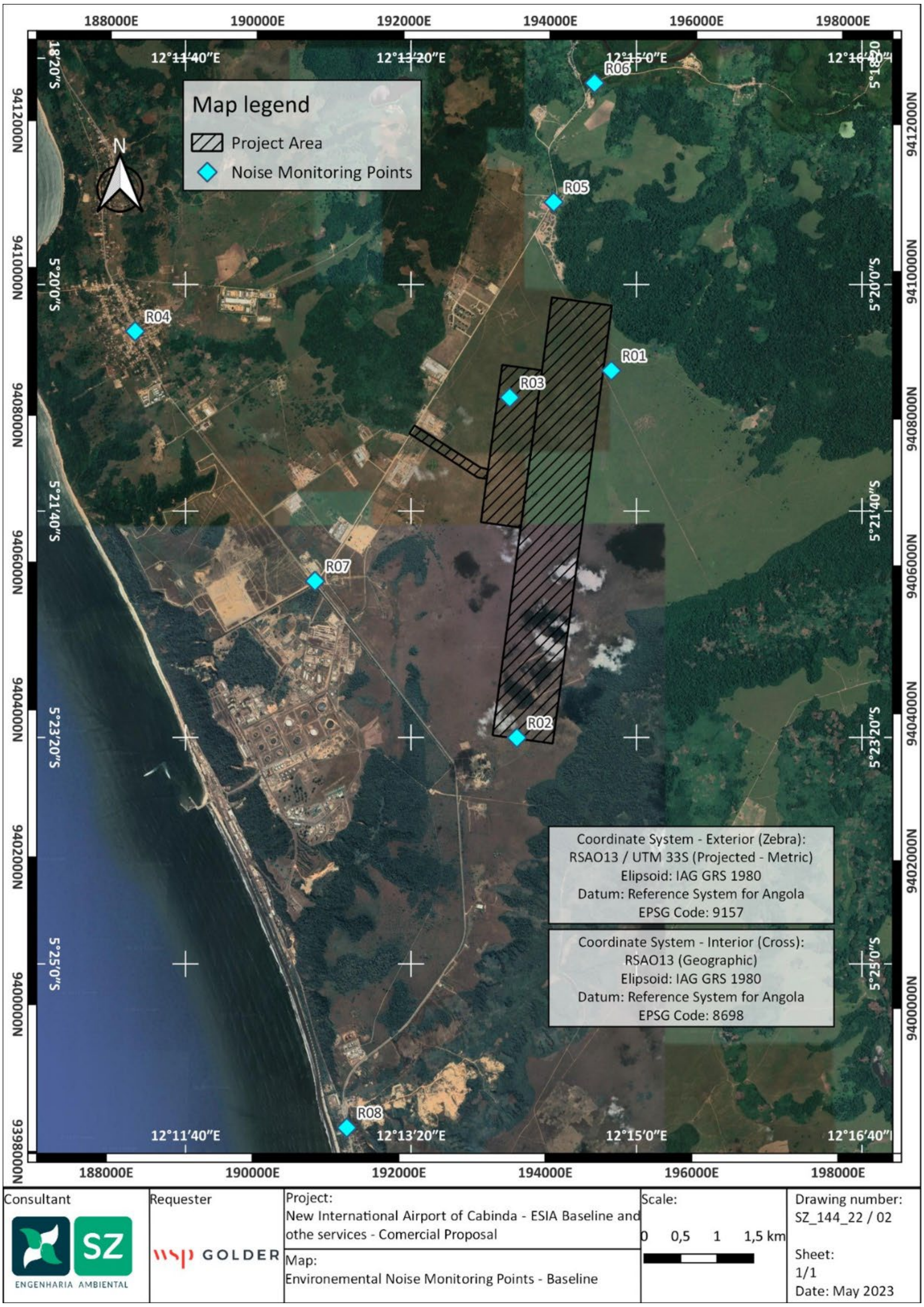


Figure 49: Noise monitoring - Points considered.

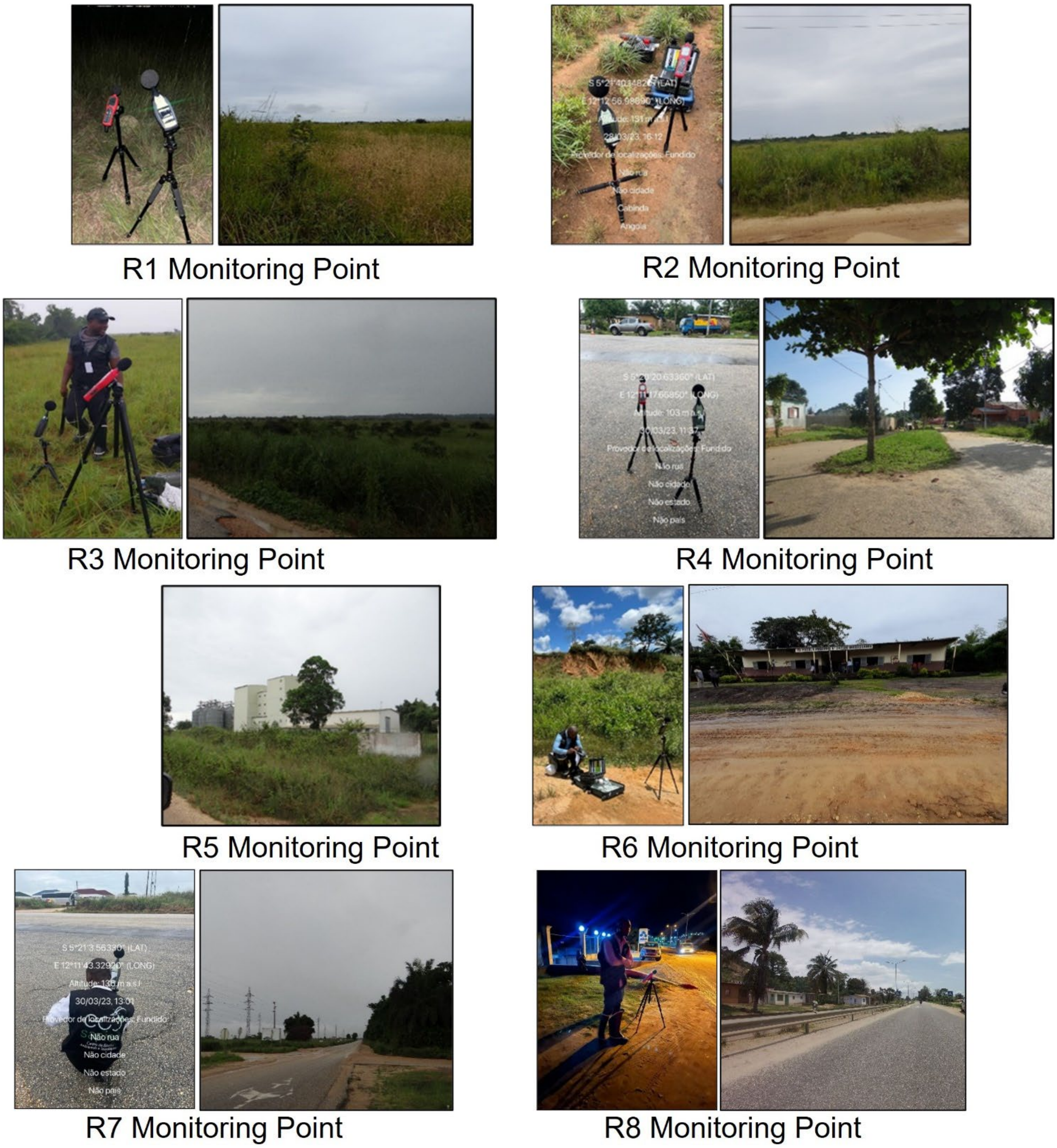


Figure 50: Photographs of the eight Noise Monitoring Points.

The monitoring points have the following coordinates (Table 21), referenced by the geographic system RSAO13, defined in the Presidential Legislative Decree n. 9/18, of 18th of June, and by the projected metric system RSAO13 – UTM33S, which are the official coordinate systems for Angola.

Table 21: Noise Monitoring Points' Coordinates.

Point	RSAO13		RSAO13/ UTM 33S	
	Latitude (GMS)	Longitude (GMS)	P (m)	M (m)
R1 – Inside Airport - North	5° 20' 38,000" S	12° 14' 48,901" E	9.408.639 N	194.857 E
R2– Inside Airport - South	5° 23' 20,148" S	12° 14' 06,989" E	9.403.649 N	193.588 E
R3– Inside Airport – West (entrance)	5° 20' 49,883" S	12° 14' 03,810" E	9.408.268 N	193.470 E
R4 - Malembo	5° 20' 20,634" S	12° 11' 17,659" E	9.409.144 N	188.346 E
R5 – North of Airport – Industrial site	5° 19' 23,563" S	12° 14' 23,329" E	9.410.924 N	194.059 E
R6 – Bissassanha School	5° 18' 30,985" S	12° 14' 41,442" E	9.412.543 N	194.610 E
R7 – Near crossroad with EN100, near Malembo Powerstation	5° 22' 10,945" S	12° 12' 37,440" E	9.405.764 N	190.820 E
R8 – Futila community	5° 25' 72,361" S	12° 12' 51,555" E	9.398.344 N	191.289 E

The measurements were carried out using the following equipment:

- Sound level meter – Brüel&Kjær, model 2250;
- Microphone - Brüel&Kjær, model 4189
- Sound level meter and Condenser Microphone – Unit-T, model UT352;
- Calibrator – Brüel&Kjær, model 4231;
- Thermo-hygro-anemometer – HoldPeak, model HP-866B;

The sound level meters are of class 1 (2250) and class 2 (UT352) accuracy, in accordance with the IEC 61672 standard. The filters used comply with the requirements defined in IEC 61260. The measurement chain is calibrated using a class 1 acoustic calibrator, in accordance with EN IEC 60942.

Measurements were performed by sampling, with data being acquired with Fast Time Weighting, and A-Frequency Weighting.

The equipment was calibrated before the start of the measurements, and the calibration was confirmed at the end of the service, with no deviations from the calibration positions registered.

The Brüel&Kjær Sound Level Meter and Calibrator were verified, in 30 of December 2022, at an accredited calibration Laboratory, namely ISQ – Instituto da Soldadura e Qualidade, in Portugal, with the Verification Certificate number VACV736/22.

The Unit-T Sound Level Meter was verified on 1 August 2022 at EDC - Environmental Devices Corporation Laboratory, USA, with the Calibration Certificate Number EDCQP200-4.11.5.

Due to the lack of a national normative or legal reference, regarding acoustic indicators, the references of the “Environmental, Health, and Safety (EHS) Guidelines - Noise Management” of the IFC-World Bank, were considered. According to these references, the monitoring was developed for Day-time and Night-time periods, determining L_{Aeq} indicators for Day Period (L_d) and Night Period (L_n).

Taking into consideration the normal daylight period and working hours usual in Angola, the Day Period was established from 06:00 to 18:00, and Night Period, from 18:00 to 06:00.

Regarding data acquisition, the day period was monitored by a set of samples between 50 minutes and 1 hour duration, distributed during the day period, for a minimum of seven hours of sampling effort distributed in two different monitoring days. The night period was monitored by a set of samples between 30 and 50 minutes, distributed during the night period, for a minimum of five hours of sampling effort distributed in two different monitoring days.

The evaluation of these results, in the absence of national references, takes into account the values indicated in the "*Environmental, Health, and Safety (EHS) Guidelines - Noise Management*" of the IFC-World Bank, as indicated in Table 22.

Table 22: EHS Noise Level Guidelines.

Type of Receptor		L_{Aeq} Values		Increase in Background Levels
		Day-time	Night-time	
Sensitive (S)	Residential, institutional, educational	55 dB(A)	45 dB(A)	3 dB(A)
Non-Sensitive (NS)	Industrial, commercial	70 dB(A)		

6.8.2.2 Results and Discussion

In the following tables, it is then presented, for the considered monitoring points, the values obtained and the respective evaluation.

Table 23: Noise Baseline Results.

Points	Period	Days	Measurements start	Duration	L_{night} (dB(A))	L_{day} (dB(A))	Type of receptor	Guideline Levels		Assessment
								L_{night}	L_{day}	
R1	Day	28/03/2023	08:35 / 09:35	50 min / 50 min	61	57	NS	70	70	Compliant
		29/03/2023	13:59 / 16:10	1 h / 1 H						
	Night	28/03/2023	18:15 / 19:15	50 min / 50 min						
		29/03/2023	18:49 / 19:29	30 min / 30 min						
R2	Day	28/03/2023	10:40 / 11:40	50 min / 50 min	61	52	NS	70	70	Compliant
		29/03/2023	10:25	1 h						
		30/03/2023	16:57	1 h						
	Night	29/03/2023	20:45 / 21:45	50 min / 50 min						
		30/03/2023	18:04 / 18:45	30 min / 30 min						
R3	Day	28/03/2023	08:50 / 10:40	50 min / 50 min	63	55	NS	70	70	Compliant
		30/03/2023	14:19 / 15:29	1 h / 1 H						
	Night	28/03/2023	18:30 / 20:45	50 min / 50 min						
		30/03/2023	19:02 / 19:33	30 min / 30 min						
R4	Day	28/03/2023	10:55 / 11:55	50 min / 50 min	68	61	S	45	55	Non-Compliant in both Periods
		30/03/2023	11:32	1 h						
		31/03/2023	10:47	1 h						
	Night	28/03/2023	20:45 / 21:45	50 min / 50 min						
		30/03/2023	20:53 / 21:34	30 min / 30 min						
R5	Day	29/03/2023	08:35 / 09:35 / 13:53	50 min / 50 min / 1 h	66	60	NS	70	70	Compliant
		31/03/2023	13:21	1 h						
	Night	29/03/2023	18:15 / 19:15	50 min / 50 min						
		30/03/2023	20:13 / 20:43	30 min / 30 min						
R6	Day	29/03/2023	10:40 / 11:40 / 12:31	50 min / 50 min / 1 h	65	55	S	45	55	Non-Compliant in both Periods
		31/03/2023	12:11	1 h						
	Night	29/03/2023	18:30 / 19:30	50 min / 50 min						
		30/03/2023	19:38 / 20:18	30 min / 30 min						

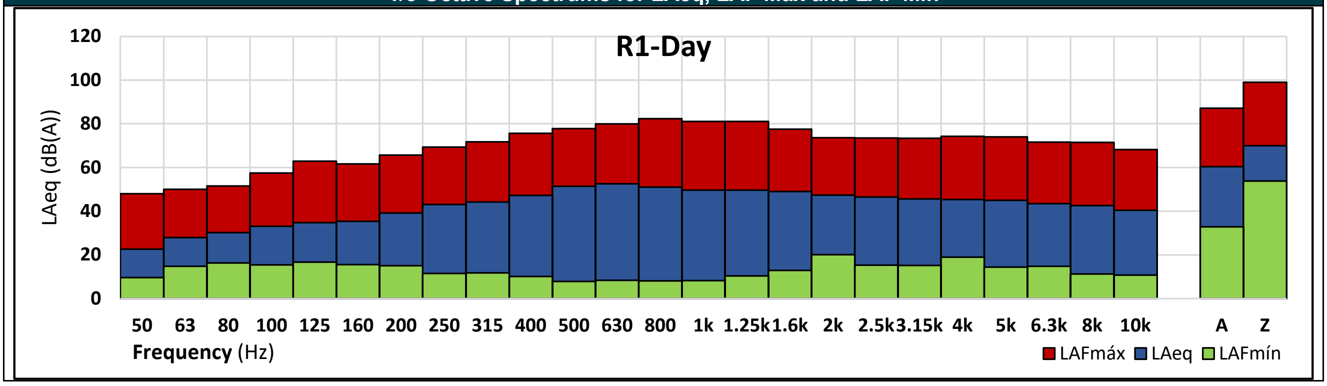
Points	Period	Days	Measurements start	Duration	L_{night} (dB(A))	L_{day} (dB(A))	Type of receptor	Guideline Levels		Assessment
								L_{night}	L_{day}	
R7	Day	30/03/2023	08:50 / 09:50	50 min / 50 min	70	65	NS	70	70	Compliant
		31/03/2023	14:36 / 15:37	1 h / 1 H						
	Night	31/03/2023	19:30 / 20:30	50 min / 50 min						
		30/03/2023	21:26 / 22:08	30 min / 30 min						
R8	Day	29/03/2023	10:40 / 11:40	50 min / 50 min	74	66	S	45	55	Non-Compliant in both Periods
		30/03/2023	10:21	1 h						
		31/03/2023	08:12	1 h						
	Night	29/03/2023	20:45 / 21:45	50 min / 50 min						
		28/03/2023	18:39 / 19:00	30 min / 30 min						

Table 24: Noise Baseline Results - 1/3 Octave Spectrum.

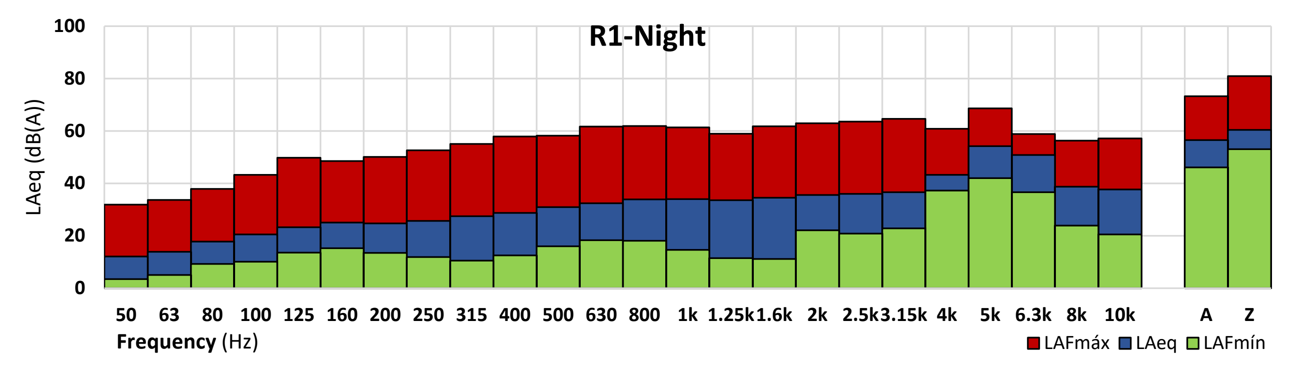
Point	Period	L_{Aeq} (dB(A)) by Frequencies: 50Hz	63Hz	80Hz	100Hz	125Hz	160Hz	200Hz	250Hz	315Hz	400Hz	500Hz	630Hz	800Hz	1kHz	1.25kHz	1.6kHz	2kHz	2.5kHz	3.15kHz	4kHz	5kHz	6.3kHz	8kHz	10kHz
R1	D	23	28	30	33	35	35	39	43	44	47	51	53	51	50	50	49	47	46	46	45	45	43	43	40
	N	12	14	18	21	23	25	25	26	27	29	31	32	34	34	34	34	36	36	37	43	54	51	39	38
R2	D	42	48	43	44	45	47	47	47	48	49	49	55	52	48	47	47	45	44	43	44	38	37	36	32
	N	10	14	15	16	15	16	18	22	23	25	27	32	27	25	25	26	28	33	37	42	32	50	47	26
R3	D	47	49	46	46	49	51	49	50	50	52	53	54	54	52	51	51	49	48	47	45	42	40	37	34
	N	27	31	33	36	38	42	42	41	42	41	41	42	42	43	42	41	43	42	44	45	42	44	37	35
R4	D	40	44	46	49	49	52	55	55	56	57	58	58	58	58	57	55	53	52	51	50	49	46	45	42
	N	44	48	51	55	53	59	59	61	58	60	61	58	59	56	54	52	48	47	47	43	41	41	37	33
R5	D	38	39	32	36	39	38	39	41	45	47	47	48	49	52	53	49	49	48	44	44	44	39	38	36
	N	33	34	35	38	40	42	45	47	49	52	57	58	56	59	66	63	52	50	49	55	52	51	41	36
R6	D	44	43	46	47	47	50	50	50	52	53	54	56	54	53	54	53	52	51	49	48	46	48	42	41
	N	24	22	26	29	30	34	37	39	41	41	40	40	39	40	40	38	40	40	35	46	43	45	41	27
R7	D	51	51	54	57	57	58	61	61	60	60	61	60	60	58	56	53	50	48	46	46	44	42	40	38
	N	47	51	55	58	57	60	62	62	59	61	62	59	60	59	57	54	50	48	46	50	46	52	40	36
R8	D	46	48	50	51	52	54	56	57	59	61	65	65	65	64	63	62	60	59	58	56	54	53	50	48
	N	33	42	39	42	46	47	49	53	53	54	56	57	57	56	53	51	49	48	47	45	43	49	39	34

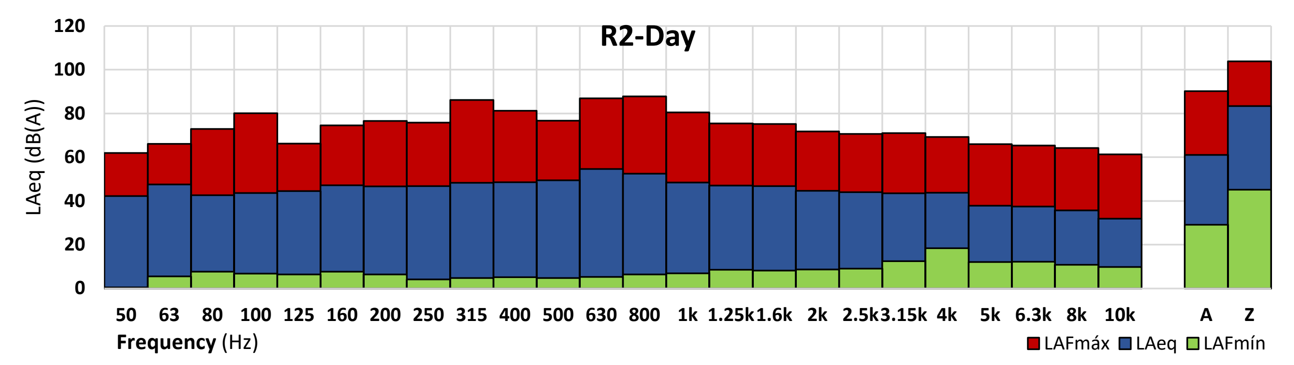
Table 25: Noise Baseline Results – 1/3 Octave Spectrum - Graphics.

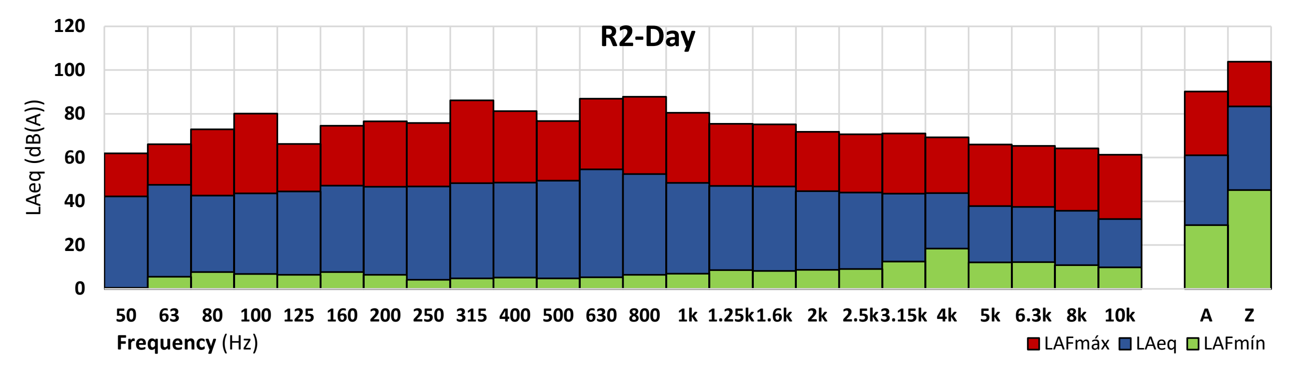
1/3 Octave Spectrums for LAeq, LAF Max and LAF Min

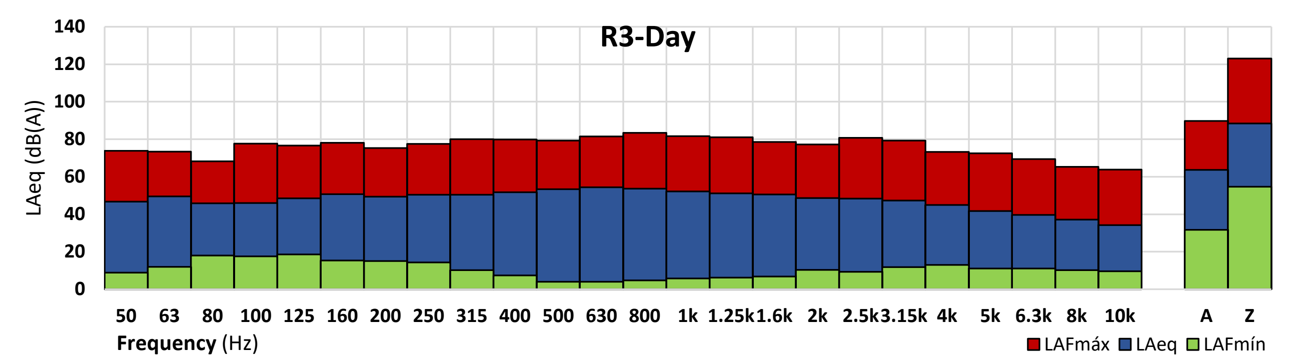


1/3 Octave Spectrums for LAeq, LAF Max and LAF Min

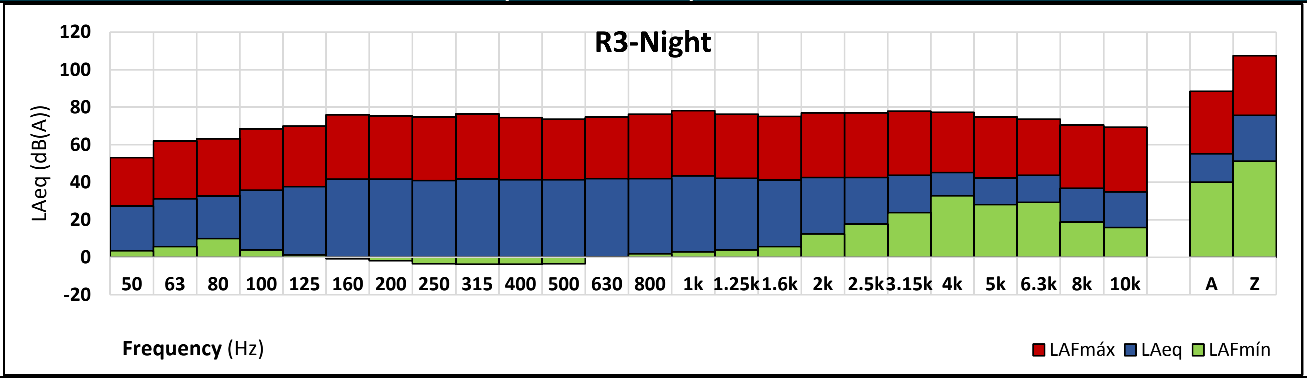


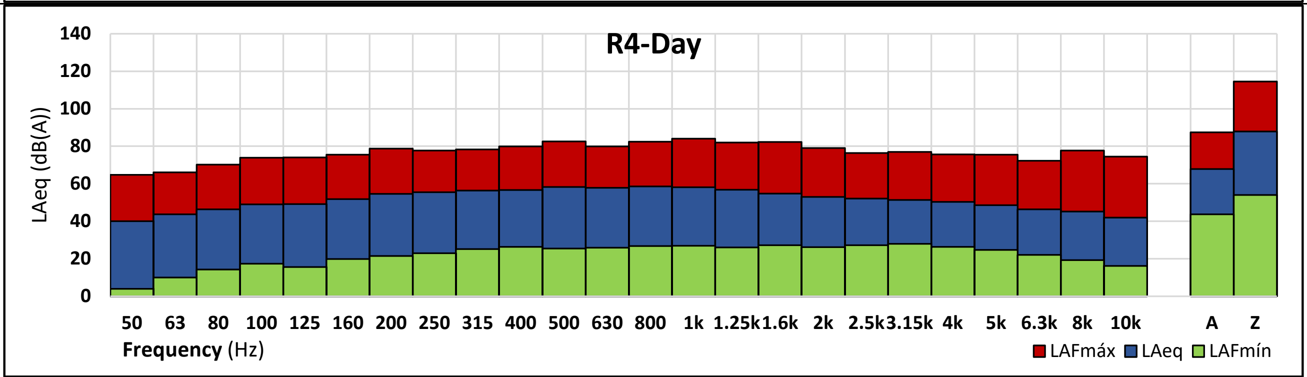


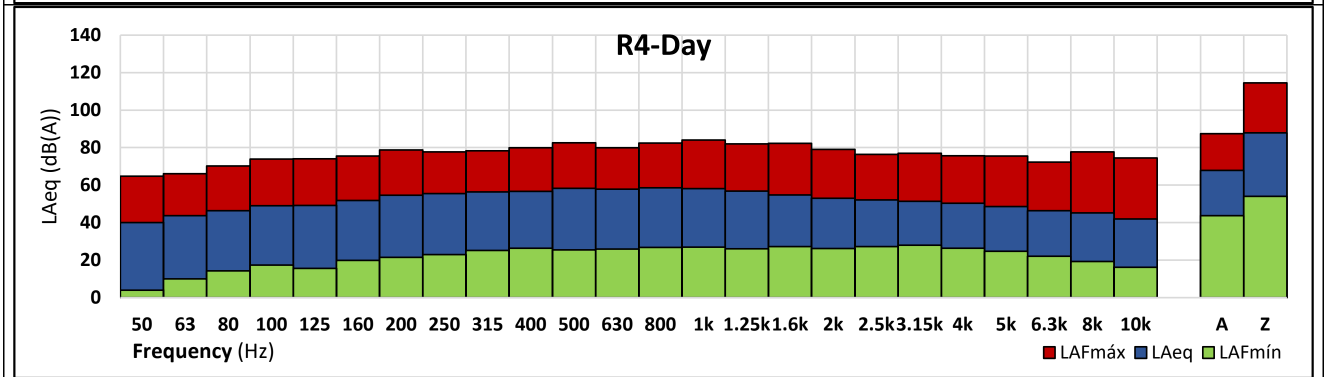


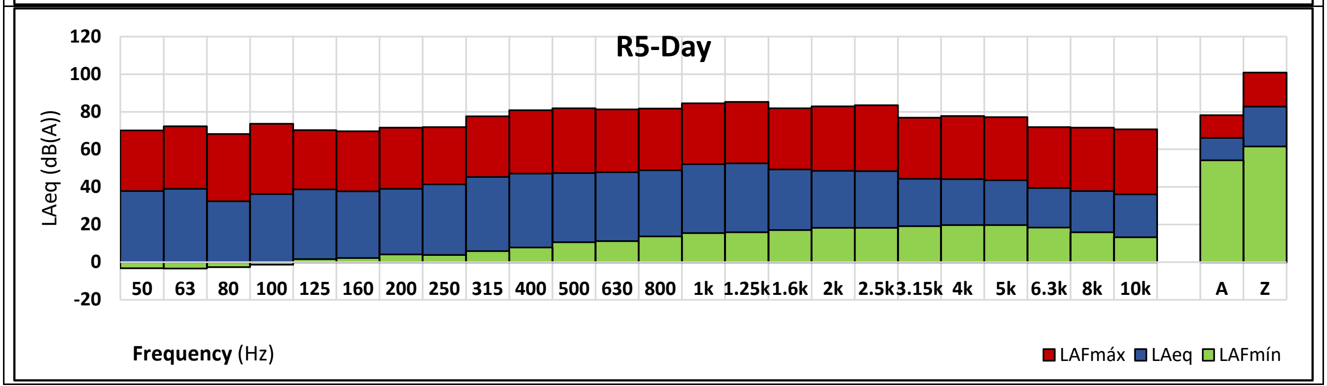


1/3 Octave Spectrums for LAeq, LAF Max and LAF Min

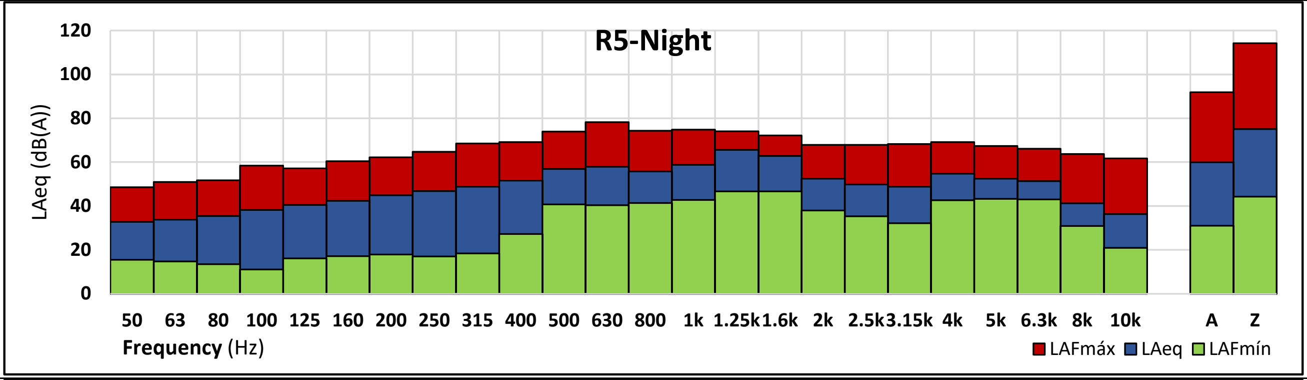


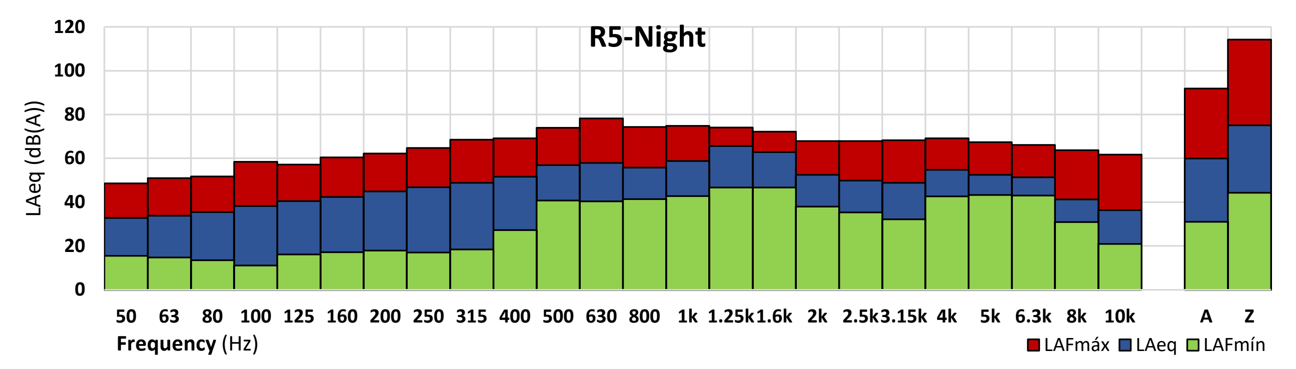


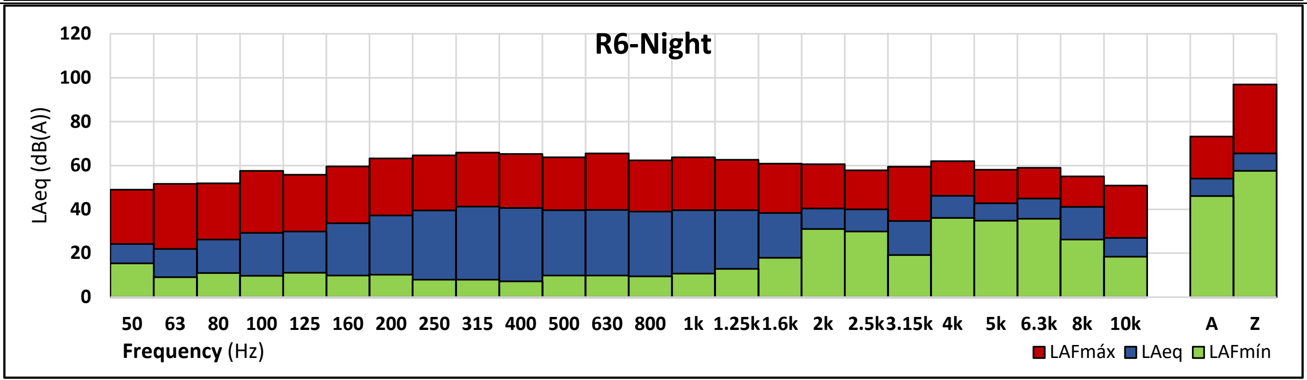


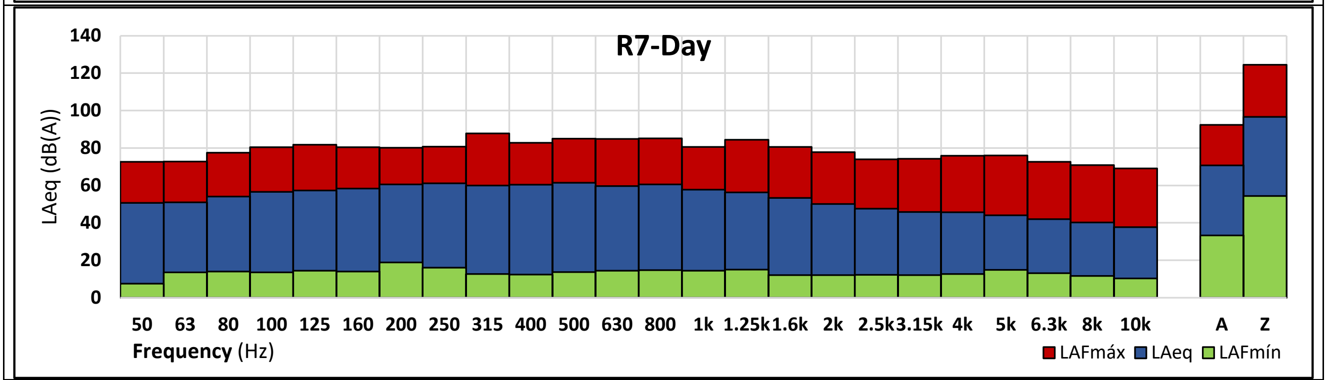


1/3 Octave Spectrums for LAeq, LAF Max and LAF Min

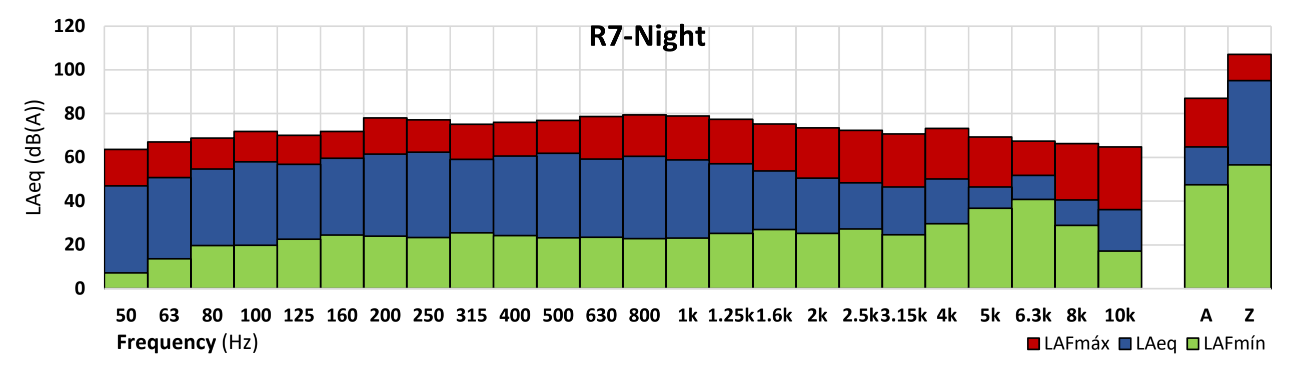


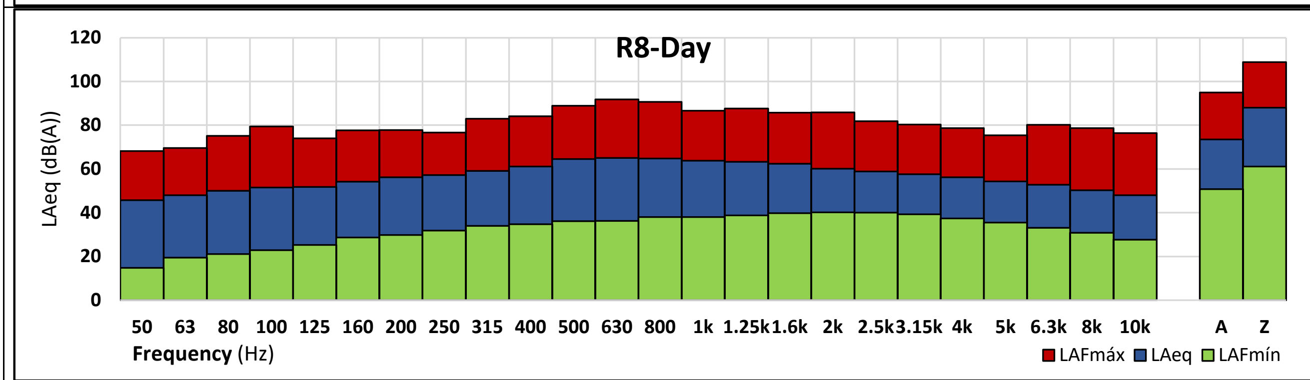


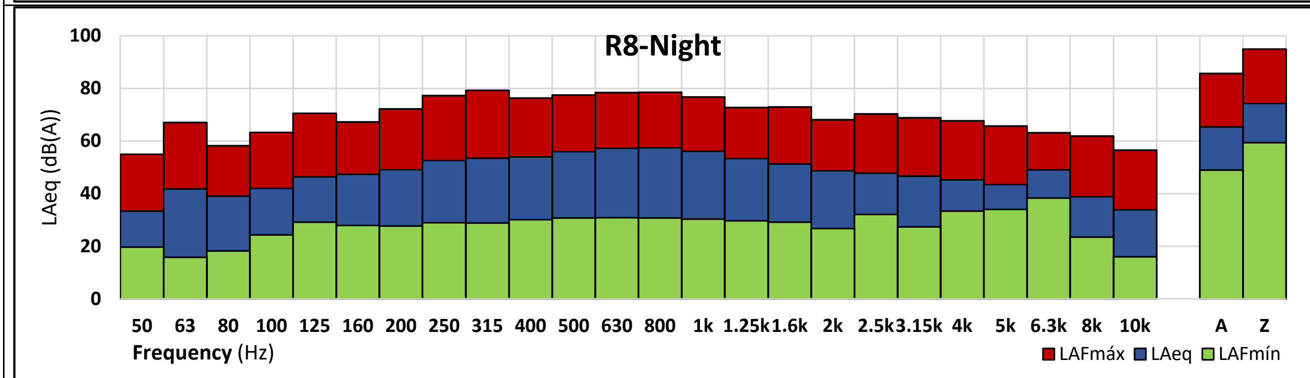




1/3 Octave Spectrums for LAeq, LAF Max and LAF Min







The results were obtained with the following measurement uncertainties, determined in accordance with the provisions of the NP ISO 1996-2:2019 standard and the internal procedures of the Saioz laboratory, for a confidence interval of 95%.

Table 26: Measurement Uncertainties Obtained (According to NP ISO 1996-2:2019 and Saioz procedures).

Point	Measurement Uncertainty	
	L_{day}	L_{Night}
R1	± 5,4	± 6,3
R2	± 5,7	± 6,5
R3	± 4,8	± 4,9
R4	± 4,6	± 4,2
R5	± 4,8	± 5,1
R6	± 4,9	± 5,4
R7	± 4,9	± 4,6
R8	± 4,8	± 6,1

By analysing the values obtained, it appears that the region is already subject to some noise disturbance for sensitive uses.

As described above, it is considered that several of the monitored points were located in non-sensitive areas. Only points R4, located inside the village of Malembo, next to the commune administration, R6, next to the School of Bissassanha and point R8, in the village of Futila, were assumed to be sensitive, due to registering residential or school uses in the surroundings.

All of these 3 points register high levels of noise, associated with the surrounding roads and community activities (commerce, services, others). This is especially relevant in Futila and Malembo, where road traffic on the EN100 leads to very significant noise values in both periods.

The remaining points do not have sensitive receptors (houses, health and educational services) in the surroundings, then being considered applicable the limits of non-sensitive zones. In these places, the values obtained are compliant with non-sensitive uses, namely 70 dB(A) for both periods. It should, however, be noted that point R7, which is also influenced by traffic on the EN100, registers values close to this limit.

Since the roads that serve the region are considered dominant residual sources, alongside the various industrial units and areas that are present in Malembo, during the field work it was also considered traffic counts, by sampling (15 minutes periods), in the main roads that surround the project.

Based on these counts, it was estimated the Average Hourly Traffic for Day period for each street, as presented in Table 27.

Table 27: Traffic counts developed during the measurements – Average values for day Period.

Emission Source	Average Hourly Traffic – Day Period	
	Light Vehicles	Heavy Vehicles
Existing road that will connect the EN100 to the NAIC	318	90
EN100 – Near Futila (Point R8)	318	66
EN100 – Near the crossing to the NAIC (Point R7)	506	122
EN100 – in Malembo (Point R4)	176	32

6.8.3 Emitting Sources and Sensitive Receivers

During the field work, the main sound sources currently existing in the Project's area of influence were identified.

The main areas with habitational use in the region surrounding the project were also identified, as well as other sensitive uses (educational and health services).

The Project is located in a greenfield and surrounded by greenfield areas and forest areas. To the West, we can find mainly industrial units and service infrastructures (water treatment plant, electrical plants and substations). Although there is, associated with the industrial sector, a dormitory area, in the Malembo Development Center, that can be considered a sensitive receiver.

The closest communities, with housing areas, but also schools and medical units, are Bissassanha, to the North and Futila, to the South, which are in line with the aircraft approach vectors to the airport. We can also find Malembo to the West and Chiela to the East, although these two communities are more than 5 kilometres away from the approach vectors to the airport, and are therefore nor likely to receive any noise emissions from the air traffic. Malembo could, however, be influenced by road traffic originating in the airport that goes to the north, though the EN100 road.

The main noise sources already present are located in the Malongo oilfield base, to the West, and along the road that connects the EN100 to the East, that will serve the future airport.

The main sound sources and receiving spots, existing in the project surroundings, are summarized in Figure 51.

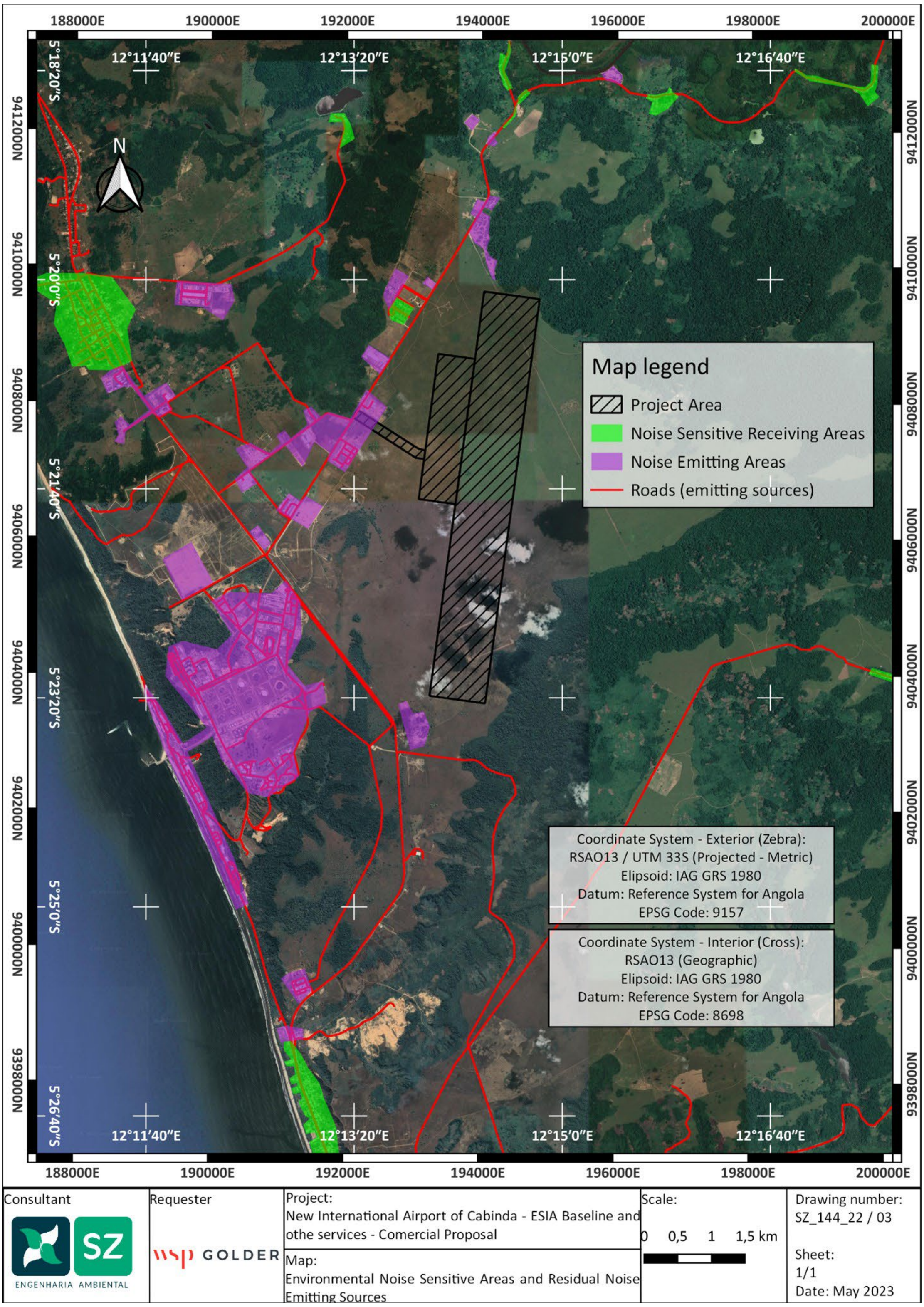


Figure 51: Identification of main noise emitting sources and sensitive receiving areas.

6.8.4 Vibrations

Regarding vibrations, there is no data available on local environmental vibration, nor are there any standards of legal requirements in Angola that address this topic.

As such, it was taken into account a Portuguese Standard that addresses the influence of vibrations on structures, namely the NP 2074:2015 Standard. This standard does not address the health effects of environmental vibration, but focuses on the assessment of direct damage in structures due to vibrational events, setting guidelines for maximum vibration values according to the type of structure affected.

This standard considers the classification of structures in three different classes:

- Sensitive Structures - Old buildings, façades with ceramic tiles, general beauty, the presence of chimneys or towers and heritage or commercial value;
- Current Structures – Most common structures, as habitational and office's buildings;
- Reinforced Structures – Recent Buildings in reinforced concrete or with metallic structural elements, for industrial use.

Most areas around the Project are recent industrial projects, mainly constructed in reinforce concrete and steel structures. It is then considered that most emitting areas characterized in the previous figure are reinforced structures, with low sensitivity to vibrational impacts.

On the other hand, the residential areas vary from "current structures", namely more recent buildings, with concrete and bricks, to "sensitive structures", namely older buildings or houses and structures with poor construction quality. The noise sensitive areas marked in the previous figure have a mixture of both types of buildings. The exception is the Malembo Development Centre residency, which is considered a "Current Structure".

Figure 52: Examples of Reinforced Structures in the study area (industrial units).

Figure 53: Examples of Current Structures in the study area (houses and service buildings).

Figure 54: Examples of Sensitive Structures in the study area (old or degraded buildings and poor-quality constructions).

6.9 Waste Management

6.9.1 Regional Overview

The law related to solid waste management became public through Presidential Decree No. 190/12, of 24 August. This legislation covers all activities, whether industrial or not, that produce waste that may directly affect the environment. It is also important to note the requirement of the existence of a Waste Management Plan, before the start of activity, for all public or private companies or entities that produce waste. This Plan must be submitted to the National Waste Agency for further evaluation and issuance of a validation certificate.

The waste produced must be identified, packaged and stored according to its category, and hazardous waste requires special care in its disposal, in accordance with the options contained in the aforementioned Diploma.

The entry into force of Executive Decree nº 17/13, of January 22, introduced into Angolan legislation the problem of specific management of Construction and Demolition Waste (CDW), which, due to its particularity, relevance and management difficulty, requires a specific framework diploma.

This Decree presents the methodologies and practices to be adopted in the design and execution phases of the project and focus on different requirements of CDW management, such as the use of CDW in the construction works, the sorting and fragmentation of CDW, the deposition of CDW in landfills, the reuse of soils and rocks, the CDW Prevention and Management Plan (CDWPMP), the management of CDW in private works, the transport and licensing of CDW management operations, among other articles.

Construction or Demolition Waste or Debris are waste resulting from the construction or demolition of a building or other types of buildings, regardless of their characteristics. In the execution of public contracts, it is necessary that the project design, for the execution of public works, be accompanied by a global Construction and Demolition Waste Prevention and Management Plan (CDWPMP).

On the other hand, in the management of CDW in private works, subject to licensing or prior communication, the CDW producer is obliged to:

- Promoting the reuse of materials and the incorporation of recycled construction and demolition waste in the works;
- Ensuring that there is an adequate sorting and storage system on site that allows for the selective management of construction and demolition waste;
- Comply with other applicable technical standards.

It should also be mentioned the Presidential Decree No. 265/18, of 15 November, which approves the Regulation for the Transfer of Waste destined for Reuse, Recycling and Recovery, defining the rules and procedures relating to operational and administrative control in transferring waste abroad.

Despite the advances in waste collection and the growth, albeit informal, of waste recycling circuits, the Municipal Solid Waste management in Angola still has, in fact, a long path to full effectiveness.

The only controlled sanitary landfill in operation of Angola is located in Luanda, the Mulenvos Landfill, which was designed with impermeable membrane, leachate collection system and controlled depositions. However, even this unit has several operational problems, and no fully functioning selective collection system established exists in the country.

All the other provinces, including Cabinda, where the Project will be implemented, still depend on municipal dumpsites, with no leachate control system or planned deposition.

Solving the environmental issues associated with waste management does not only involve regulating the sources of waste, closing dumps or creating more sanitary landfills, which is not really one of the most sustainable or effective ways of dealing with waste. Selective collection and recycling present more optimistic data and should be considered as viable options to deal with this issue.

As for the Angolan waste sector, the most recent information is provided by the Waste National Agency of Angola (ANR). ANR has developed a National Waste Conference in January 2023 in which it presented the Angolan Waste Management Status.

According to this presentation, Angola currently produces around 25 Million tons of waste annually, with a daily average of 0,750 kilograms of produced waste per inhabitant. The costs associated with the management of these waste quantities ascend to over 100 Million US Dollars per year.

The Angolan Waste Management Status presentation also discloses data related to waste production by type. It is then considered that the 25 million tons produced are segmented in the following percentages:

- 35% - Urban Waste;
- 15% - Industrial waste;
- 12% - Construction and demolition waste;
- 10% - HORECA Sector (Hotels, restaurants);
- 8% - Hospital waste;

- 20% - Other origins.

According to the Angolan Waste Management Status presentation, included in the National Waste Conference developed in January 2023 by ANR, Angola had 334 licenced Waste Management Operators.

The current framework for licencing waste operators in Angola considers 4 categories of operators, with the following number of licenced companies:

- Oil Sector (Hazardous Waste) – 20 companies;
- Non-Oil Sector (Non Hazardous Waste) – 275 Companies;
- Hospital Waste – 30 Companies;
- Mining and quarries waste – 9 companies.

Social awareness actions and environmental initiatives have grown in the country, increasingly defending the need to implement selective waste collection, emphasizing the role of informal collectors, promoting environmental education and civic awareness, and emphasizing the role of the citizen as a fundamental part of approach to this theme.

Considering the growing pressure for selective waste collection and valorisation, there has been some growth in recycling and valorisation unit operating in the country.

According to the information available in the Angolan Waste Management Status presentation, by ANR, the selective collection network included the following waste fractions and number of companies:

- Plastics: 22 companies;
- Glass: 4 Companies;
- Metal cans (Aluminium, steel): 19 Companies;
- Electronics: 6 companies;
- Metal waste/scraps: 31 companies;
- Tyres: 2 companies;
- Paper/Cardboard: 7 companies.

However, this information relates to information regarding collection systems, and not necessarily treatment/valorisation. Also, there is no available information regarding the location of these units by province. However, from research done and contact with the waste operators, most units that currently work in waste recycling and valorisation are located in Luanda area.

However, Presidential Decree No. 265/18, of 15 November, which approves the Regulation for the Transfer of Waste destined for Reuse, Recycling and Recovery, introduces significant limitation of the selection of recycling destinations. There are annual quotas allowed for the export of several waste types, and there is the need for specific licences to export waste, according to the available quotas. Some type of wastes, such as metals, for example, can have no quotas in some years, making it impossible to consider export as a possible waste destination, and as such, Cabinda operators are limited to sending those type of waste to Luanda, for recycling.

According to the Angolan Waste Management Status presentation, 75% of the produced waste is deposited in landfills, with only 20% diverted to recycling or valorisation (Figure 55). The final 5% receives other types of treatment.

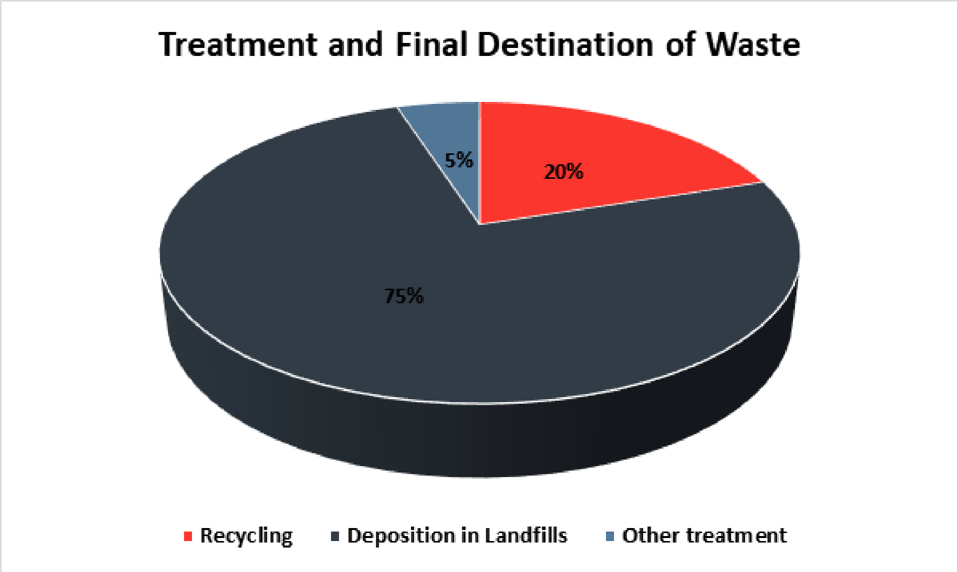


Figure 55: Treatment and Final Destination of Waste Produced.

The perspectives and goals for waste evolution in the country were established in the PESGRU – Strategic Plan for Urban Waste Management in Angola, which set a goal of 30% Valorisation for 2025 and 45% in 2030.

The general goals for recycling, considered in PESGRU, are presented in the following figure (Figure 56).

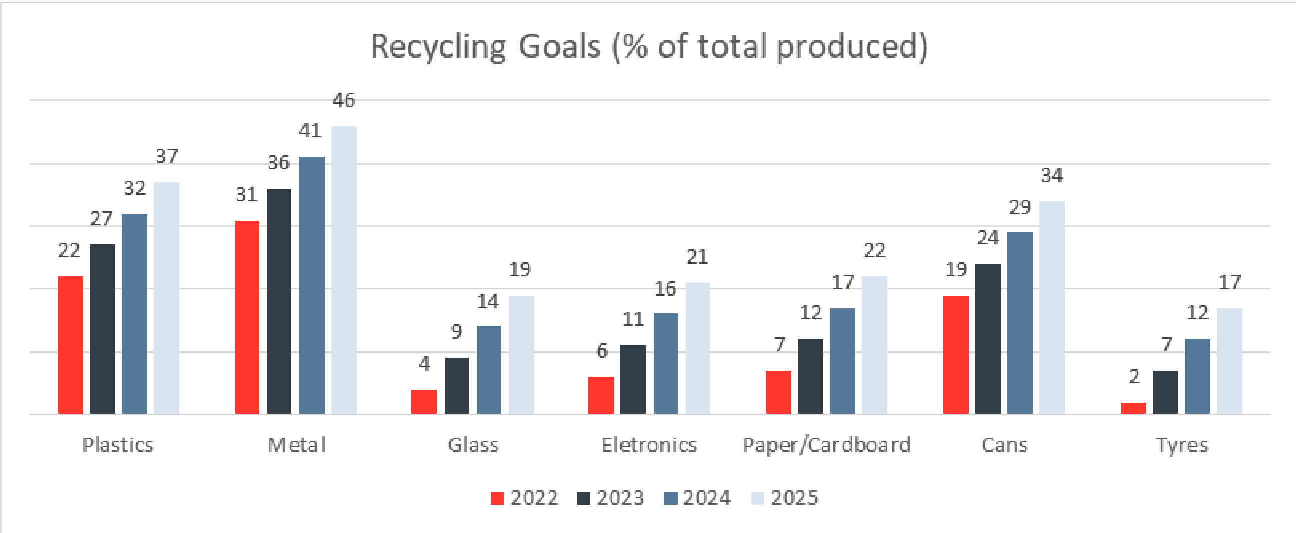


Figure 56: Recycling Goals for Angola (PESGRU).

As for global data on waste treatment and recycling, as indicated in the Angolan Waste Management Status presentation, Angola has the following infrastructures and installations:

- Selective collection – 36 systems;
- Sorting and recycling units – 75 units;
- Composting Units – 20 Units;
- Non-sanitary dump sites – 59 Sites;
- Sanitary Landfills – 1.

6.9.2 Local Overview – Cabinda Province

The Cabinda Province is responsible for 1 Million tons per year, representing 4% of all waste produced in Angola.

Of the 334 licensed waste operators, only 7 are located in the Cabinda Province.

The list of operators licensed to operate in Cabinda are registered in the Waste National Agency of Angola (ANR website — anr.gov.ao). According to the information available in this list, the registered operators in the Cabinda area are:

- Organizações CJK (Oil Sector, Non-Oil Sector);
- Organizações Isaias (Non-Oil Sector);
- Luzolo e Bikuma, Lda (Non-Oil Sector);
- JPB (SU), Lda (Oil Sector);
- Buela Mioco, lda (Oil Sector, Non-Oil Sector);
- MPunzi, Lda (Oil Sector, Non-Oil Sector).

The list of ANR is available for 2021 and 2022 only. From this list, it is important to mention the Mpunzi waste operator because their facilities are located next to the future airport, near the northern limit of the Project's plot. MPunzi serves as waste operator for metal, wood, and municipal waste for several companies in the Malongo Oil Base, such as Petromar, Halliburton and Schlumberger, and they have their temporary deposition and waste disassembly and processing area in a land plot next to the future airport area.

In relation to waste collection systems, there are no relevant units in the Cabinda province, and the waste operators send the waste flows, for valorisation/recycling, to outside the province, either to Luanda or to export to other countries.

As stated, 75% of current waste produced in Angola is sent to landfills and dumpsites. The Cabinda province is served only by municipal dumpsites, the main one corresponding to the Cabinda City dumpsite (Yema dumpsite), located south of the city. As already discussed in Chapter 2 – Project description, the Yema dumpsite has been designated by the Municipal Administration of Cabinda at 60 Km from NAIC for disposal of solid wastes during construction phase. However, it is understood that the site is not properly managed, and there is no fence, the housekeeping is poor, and the waste cells are not lined nor provided with a leachate control system.

Nevertheless, Cabinda has planned a new sanitary landfill and waste collection and treatment centre, for waste separation and preparation for recycling and recovery, including an incinerator for hospital waste. This structure will be built in the Subantando Village, to the East of Cabinda City, and will serve most of the province, including the Malembo area, where the future airport will be developed. The structure will be at a distance of approximately 47 km from NAIC, a journey of around 1 hour by car (Figure 57). No scheduled date for the start of work has been yet defined, however in the field visit carried out in November 2023, the MoT confirmed that the structure will be ready in the next 3 years and that the contractor has already been selected. In this way, the structure will be functional during the last year of NAIC construction and during NAIC operations.

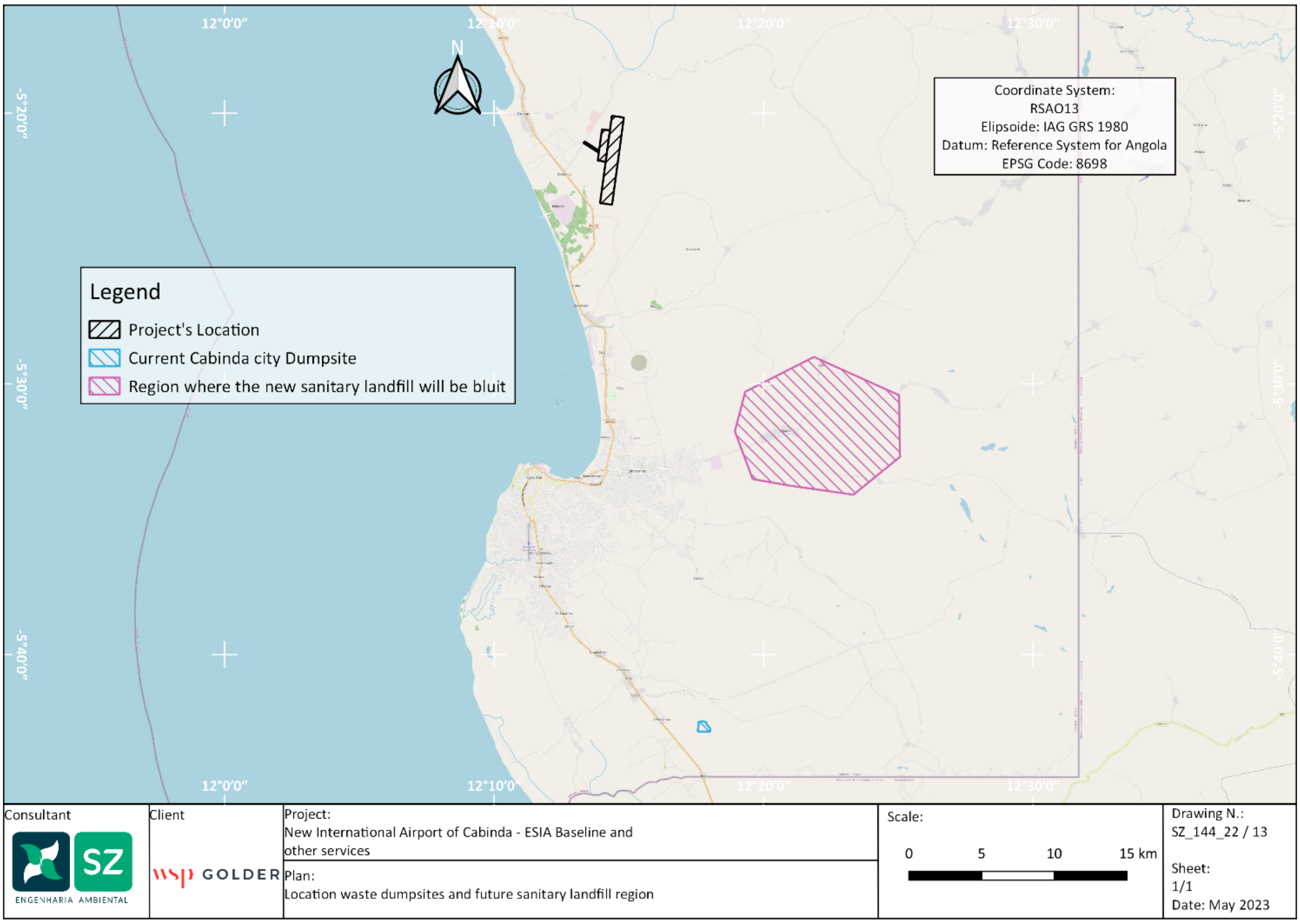


Figure 57: Current municipal waste dumpsites and planned area for the future sanitary landfill.

6.10 Wastewater Management

With regard to wastewater systems, there is no wastewater collection system in the Cabinda province. As such, the wastewater is handled individually by each household, industry, commerce, and service.

Most industries, such as those associated with the Malongo Oil Base, have their internal solutions for collecting and treating wastewater, with wastewater treatment plans (WWTP) in most industrial areas.

Also, the main services, commercial areas and other smaller scale industrial units also rely on individual wastewater treatment systems, mainly septic tanks.

Regarding households, namely in the Project's region, there is no functioning basic sanitation network and most houses do not have septic tanks.

The most common facilities are latrines, where families prepare an excavation of more than 3 meters deep, for the use of their physiological needs. Examples are shown in Figure 58.

Figure 58: Type of sanitary facilities in the commune of Malembo.

The available annual report from the water and sanitation public company of Cabinda, EPAS-Cabinda, namely from 2021, proposed, as structural projects to be developed, the connection of all main cities to sanitation networks, mentioning the start of design and planning of a wastewater collection network in Cabinda city and Landana Village.

This report confirms that there is no public collection system in operation and EPAS is still in the phase of assessment of existing conditions to start planning a future wastewater system.

The report mentions the existence of 3 wastewater treatment plants that are not operational, and that will be assessed to evaluate possible future integration in the collection and treatment system to be developed, namely:

- Urbanização 4 de Abril WWTP;
- Condomínio Cajueiro WWTP;
- Mangui Seco WWTP.

These WWTP were constructed as part of urbanization projects, to serve new urban areas developed, but were not made operational.

6.11 Energy Sources

Angola is a country with vast internal energy resources, such as a) oil and gas reserves; b) rivers, whose characteristics, together with its relief, make it one of the greatest water potentials on the African continent; c) forest resources, especially firewood, are important in the informal and subsistence economy of households, especially in rural and peri-urban areas; and d) great solar potential due to the extension of its territory and its geographic location, although still very little explored.

Currently, oil and biomass are the main sources of primary energy in Angola, with emphasis on the preponderance of biomass (biofuels + waste) in households in rural areas, which represent 37% of the total population. Figure 59 shows the Total Primary Energy Supply (TPES)[24] in 2020 in the country.

[24] The Total Primary Energy Supply (TPES) represents the amount of energy available, in a given period of time, to meet the domestic energy needs of a country. In other words, the total amount of primary energy that the country has at its disposal.

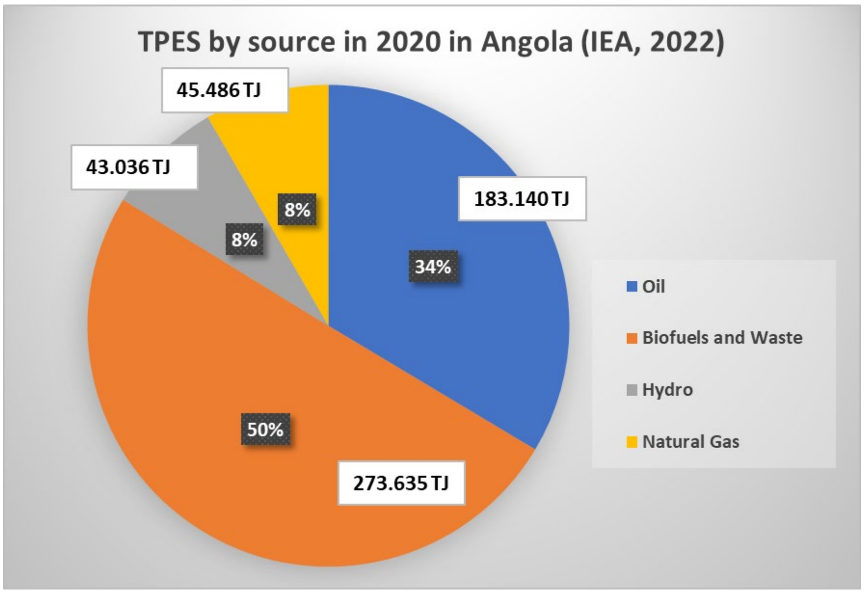


Figure 59: Angola Total Primary Energy Supply in 2020 (Source: IEA, 2022).

The sector responsible for most of the energy consumption in the country is residential, with around 57% of the total (IEA, 2022), as shown in Figure 60. The low that the industrial, commercial and service sectors have in energy consumption reflects the lower degree of development of these sectors at national level and their impact on the country's economy (ALER, 2022).

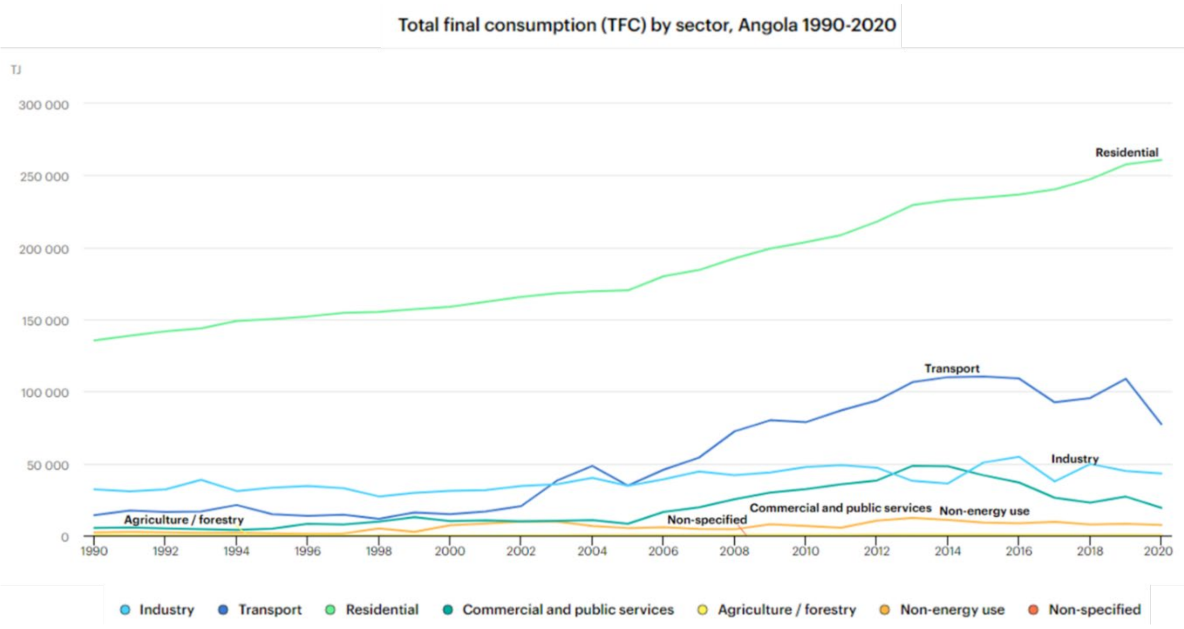


Figure 60: Total final energy consumption in Angola by sector, from 1990-2020.

6.11.1 Electricity System

Angola currently uses three options for electricity production: hydro, thermal and new renewables. Presently, electrification rates in Angola are estimated at 42.8% in urban areas and less than 10% in rural areas. As a result, both businesses and residents rely heavily on diesel generators for power. Most of the people with access to electricity are located in the 18 provincial capitals. The provinces in the interior of the country have the lowest levels of access rate (such as Bié, Cunene and Lunda Norte), which are around 10%, while in Luanda the access rate is 66% and in Cabinda 52%.

To address rural demand, the government is pursuing the development of small-scale off-grid projects, using both fossil fuels and renewable technologies (small hydro, solar, wind, and biomass), also named hybrid technology.

In 2021, the total installed electricity production capacity was 5,880.19 MW, of which 3,676.12 MW from hydro production, 2,169.07 MW from thermal production and 35.00 MW from hybrid production (solar+diesel). Currently, the Angolan power generation park is made up of 66 plants, of which 63 are public, 1 is a public-private partnership and 2 are private (ALER, 2022). The geographical distribution of the plants shows a great concentration in the North region. The five largest plants in the country (Table 28) are located in this region and represent around 72% of the total installed capacity.

Table 28: Five largest power plants in Angola (ALER, 2022).

Power Plant	Technology	Location	Installed Capacity (MW)
Laúca Dam	Hydroeletric power plant	Middle section of Kwanza River	2070
Cambambe	Hydroeletric power plant	Kwanza River – downstream	960
Capanda	Hydroeletric power plant	Kwanza River – upstream	520
Soyo	Natural gas-fired thermal power plant (combined cycle gas turbine)	City of Soyo, Zaire Province	750
Luanda OCGT	Natural gas-fired thermal power plant (open-cycle gas turbine)	City of Luanda	148

The Province of Cabinda has six power plants, with a combined installed capacity of 145 MW (Table 29).

Table 29: Power Plants in the Province of Cabinda (ALER, 2022).

Power Plant	Technology	Installed Capacity (MW)
CT Malembo	Thermal Power Plant	95
CT Chibodo	Thermal Power Plant	30,6
CT Santa Catarina	Thermal Power Plant	10,2
CT Buco_Zau	Thermal Power Plant	4,4
CH Belize	Hybrid	2,5
CH Dinge	Hybrid	2,5

The energy transmission infrastructure in Angola is made up of four separate grid systems: North, Central, South and East systems (Table 30). Together, they form a power park that extends over 5,235 km of transmission lines. The North System, which represents around 80% of the whole of the electric power production in the country, has the higher concentration of km of power line, forming about 67% of the national total (ALER, 2022). The city of Cabinda is within the North System. Currently, the North and Central systems are interconnected through two interconnection lines. The East system corresponds to isolated grids.

Table 30: Geographical distribution of Angolan Provinces by grid systems and km of power lines (Source: ITA, 2022).

Grid System	Provinces	Km of lines
North	Luanda, Bengo, Cuanza Norte, Malanje, Uíge, Zaire and Cabinda	1.523 (400 kV) 1.812 (220 kV) 191 (110 kV)
Central	Cuanza Sul, Benguela, Huambo and Bié	205,3 (400 kV) 893,27 (220 kV) 22,4 (150 kV)
South	Huíla, Namibe, Cunene and Cuando Cubango	168 (150 kV) 57 (132 kV)
East	Lunda Norte, Lunda Sul and Moxico	99 (110 kV)

Figure 63 illustrates the map of the electricity grid in the country, showing the interconnection systems.

The main players in the electricity sector in Angola are described in Table 31.

The National Electricity Distribution Company in Angola (ENDE – Empresa Nacional de Distribuição de Eletricidade) faces high technical and commercial loss rates estimated as high at 35%. This high rate of loss is due to illegal connections, non-payment and non-enforcement of payment requirements, and the fact that approximately 80% of electricity customers are un-metered. To improve its operations and revenues, in 2015 ENDE installed 1,500 smart electric meters in a pilot with equipment from U.S. companies, and has further plans to implement a broader smart meter program with 1.5 million units in key urban locations and increase its enforcement to eliminate illegal connections (ITA, 2022).

Table 31: Main players in the Angolan electricity sector (Source: Andrade, 2020).

Entity	Responsibilities
Ministry of Energy and Water – **MINEA**	■ Overall supervision of the sector ■ Prepares and implements energy policies and strategies
Regulatory Institute of Electricity and Water Services – **IRSEA**	■ Supervises, regulates the activities and quality of service of the entities involved in the production, transport, distribution and commercialization of electric energy.
Public Electricity Production Company – **PRODEL**	■ Responsible for electricity production, all public generation assets ≥ 5MW.
National Electricity Transport Network – **RNT**	■ Responsible for electricity transmission, management of high voltage lines and interconnections, monitors and manages contractual processes for the purchase and sale of electricity.
National Electricity Distribution Company – **ENDE**	■ Responsible for distribution and commercialization of electricity, grid extension, operating and managing the distribution network and all lines of 60KV and below.
Medio Kwanza Expense Office – **GAMEK**	■ Public utility company responsible for implementing and managing the hydroelectric projects on the Kwanza River, now the main hydroelectric projects in the country.

The Project electricity will be supplied by the Malembo Thermal Power Station, which is located adjacent to the NAIC, as can be seen in Figure 61 below. This is a 95 MW gas fired power plant owned by PRODEL. The plant has two turbines and dual system (diesel and gas), therefore in case of shortage of gas, the plant can also run on diesel. The plant is supplied with fuel gas from the Malongo oil field and has an average consumption of 80 m^3 per hour. It is expected that this will involve a new supply cable infrastructure of about 4.5 km to be constructed within the existing road corridor and site footprint.

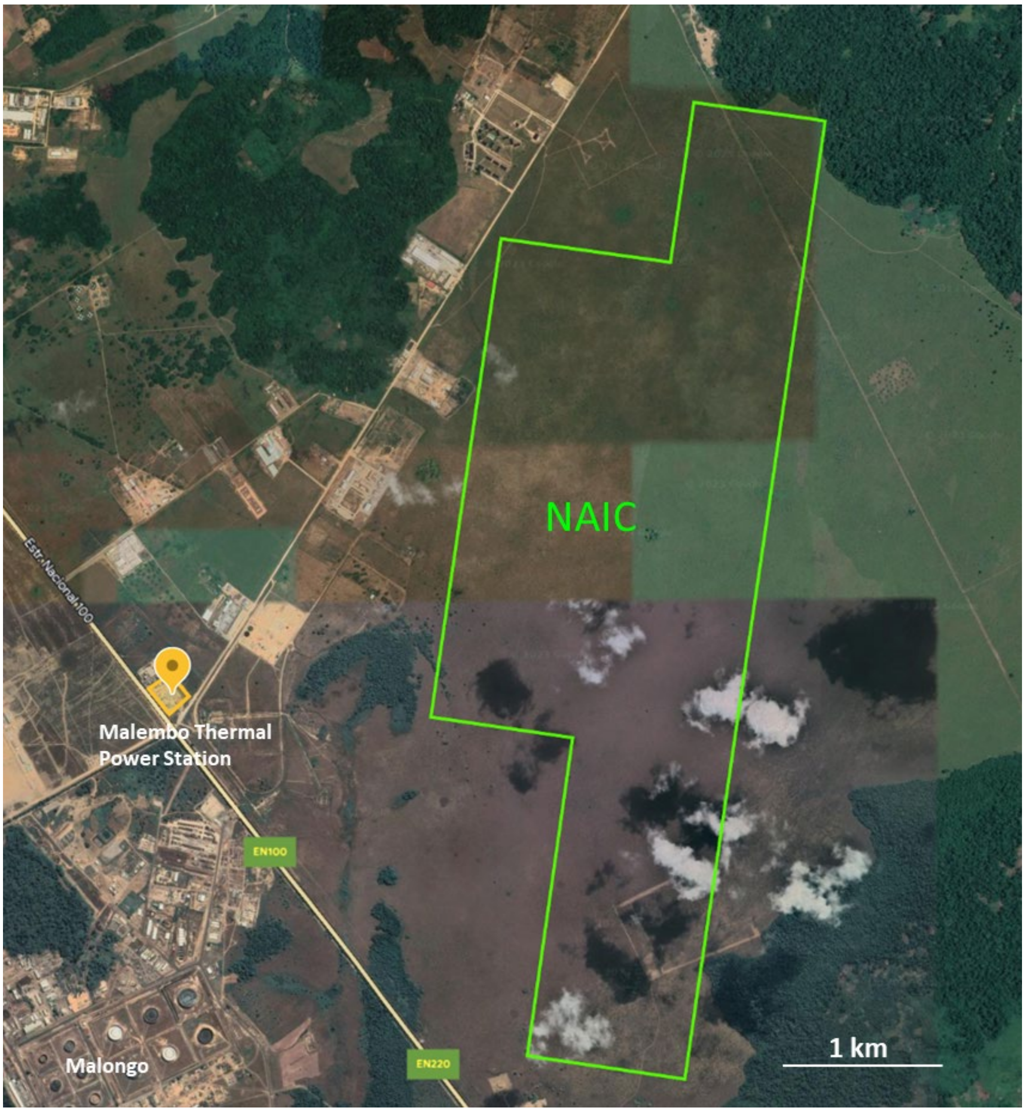


Figure 61: Location of the Malembo Thermal Power Station in relation to the NAIC footprint.

Figure 62: Photograph of the Malembo Termal Power Station taken during site visit.

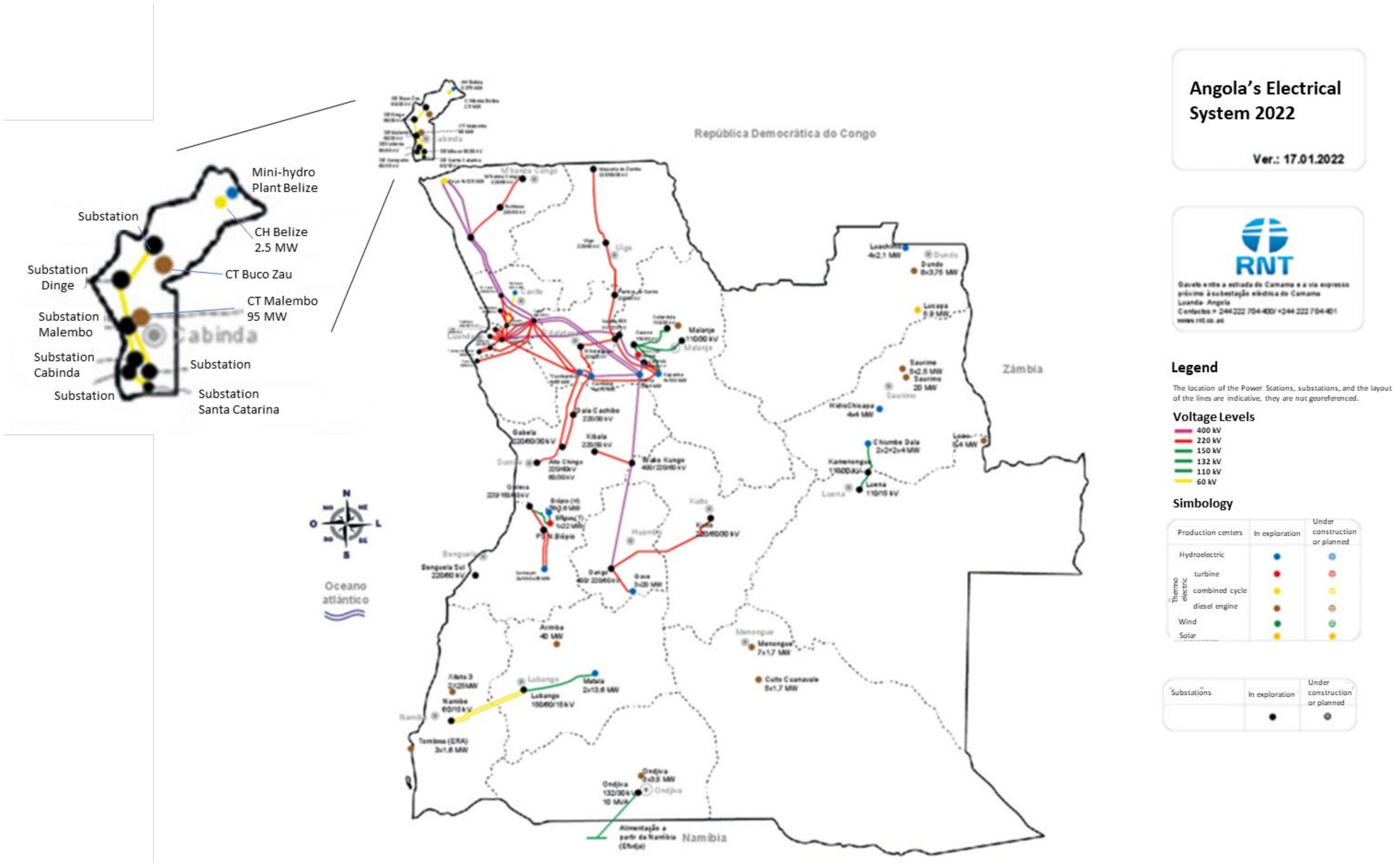


Figure 63: Map of Electricity Transmission lines in Angola, with a focus in the Cabinda Province. (Source: modified from ALER, 2022).

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