FEBRUARY 2018

PROJECT DESCRIPTION STATEMENT

SAND REPLENISHMENT, CONSTRUCTION OF WAVE DEFLECTOR AND RELATED MARINE WORKS

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The undersigned also confirms that one has no conflict of interest with regards to the Client, or any associated Third Parties.

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List of Abbreviations

ERA	-	Environment and Resources Authority
MTA	-	Malta Tourism Authority
NWLP	-	North West Local Plan
PA	-	Planning Authority
PDS	-	Project Description Statement
SPD	-	Suction Pump Dredger
SSD	-	Sand Suction Dredger
UST	-	Undercurrent Stabiliser Technology

1 PREAMBLE

1.1 INTRODUCTION

1.1.1.1.1 This Project Description Statement forms part of Development Application PA 1820/18 which proposes the following: *Sand replenishment of Ghadira Bay, including the construction of a wave deflector and related marine works*. This application has been filed with the Planning Authority by Perit Stephan Vancell on behalf of Mr James Camenzuli, who is representing Project Malta Ltd. The application was submitted to the Planning Authority [PA] on the 30th January 2018.

1.1.1.1.2 As part of this application, the Environment and Resources Authority [ERA] were consulted. During preliminary meetings held with ERA a "Project Description Statement" [PDS] was requested. This PDS provides a description of the proposed works; a synopsis of their likely impacts; and the possible mitigating measures.

1.1.1.1.3 The project is sub-divide into three stand-alone phases which will be constructed over a number of years. These phases will nevertheless offer a unique solution to re-dress the sand dune habitat degradation together with the moving inland of the shoreline and the consequent loss in sandy beach area which took place when Triq il-Qammieh was being constructed in the latter part of the 1900's.

1.1.1.1.4 Phase 1 will be immediate and concerns the extension of the sandy beach by a stretch measuring over 1 km in length and an average width of over 20m. This beach replenishment will make use of sand, dredger-pumped from a safe zone within the sandy area of Ghadira bay. The safe zone is delineated in such a manner so as to ensure that the extensive *Posedonia Oceanica* Meadows found in the bay are not adversely affected. Raising back the sand which was eroded over time from the sea shore (albeit more expensive than using imported "alien" sand) implies that the sand being used for replenishment of the beach has identical characteristics to the sand already found within Ghadira Bay. This process is a reversible one and can be considered to be a process where one is reverting back to the 1960 situation where the shore-line was some 25m further out to sea than its present-day position.

1.1.1.1.5 Phase 2 will involve the introduction of sub-surface sea current deflectors in order to ensure that the replenished beach is protected in stormy weather. These deflectors will be designed in such a manner so as to facilitate the creation of an artificial reef.

1.1.1.1.6 Phase 3 will involve the raising of Triq il-Qammieh bordering the sandy beach in order to facilitate the inward natural migration of the sand dunes. The road will be raised on a number of cantilevered structures supported by a central column. The existing road and concrete walls will then be removed in order to enable nature to take over. Re-organisation of the competing uses of the beach would have to be considered in order to facilitate a more balanced spatial use of the plethora of competing uses.

1.1.1.1.7 It is being emphasised that at this time, special reference is being given to **Phase 1** of the project which will be carried out before summer 2018. Ghadira beach is today at its limit capacity – especially during the peak summer months where both tourists and locals flock to the area to enjoy the sandy beach. It is expected that the situation will be further exasperated by the expected increase of tourists and the increase in population due to inward migration of foreign nationals coming to the island to satisfy its workforce shortages. Phases 2 and 3 are still subject to further studies and the exact details are still to be determined. However, a pretty detailed overview is still being provided in this document; even though separate PDS's will be submitted prior to the initiation of both Phase 2 and Phase 3.

1.1.1.1.8 Phase 1 of the project (hereinafter referred to as the 'the scheme') is proposed by Mr James Camenzuli on behalf of Projects Malta Ltd. hereinafter referred to as 'the applicant'.

Figure 1: Location of Site of Proposed Project and Surroundings

2 DESCRIPTION OF THE PROPOSED DEVELOPMENT AND ITS CONTEXT

2.1 JUSTIFICATION FOR THE PROPOSAL

2.1.1 Site Description

2.1.1.1.1 Mellieha Bay, also known as Ghadira Bay, is the largest sandy beach in Malta and is located along the northern-western coast of the island. The beach directly abuts Triq il-Qammieh, which is situated just a few metres above sea level and then rises uphill towards l-Ahrax (vide Figure 2). The beach is considered as one of the most family-friendly beaches, mainly due to its easily-accessible nature and its shallow water which extends tens of metres off the shoreline.

2.1.1.1.2 Ghadira Bay is also home to various bars, kiosks, restaurants and facilities providing beach-related activities such as windsurfing, kite surfing, canoeing and water-skiing, as well as a floatable and inflatable water platform which is very popular with the children.

2.1.1.1.3 The sandy area can be classified into two beaches separated by a section of rocky outcrop. The northern beach is the widest and longest stretch of sand and is home to most of the activities mentioned above. The southern beach is considerably smaller and offers a quieter and more relaxing atmosphere.

2.1.1.1.4 The North West Local Plan (2006) indicates that the site is situated within an environmentally sensitive area, which has been scheduled through the following designations (vide Figures 3,4, and 5);

- Level 4 Area of Ecological Importance (G.N. 491/06);
- Special Protection Area (Wild Birds Directive – 79/409/EEC);

- Special Area of Conservation (L.N.257/03 & G.N.223/05);
- Natura 2000 (Habitats Directive – 92/43/EEC);

2.1.1.1.5 The offshore area is also designated for protection in view of the presence of *Posedonia Oceanica* meadows. The western seashore of the Maltese islands is covered by *Posedonia Oceanica* meadows, which exert a crucial role in the ecosystem of Mediterranean coastal waters. *Posedonia Oceanica* meadows are endemic to the Mediterranean Sea and are now identified as a priority habitat type for conservation under the Habitats Directive (Dir 92/43/CEE). The project will be adjusted accordingly so as to eliminate any possible impact on the protected species, especially since the leaves of Posedonia offer a natural protection to the sandy beaches, and their removal would lead to an exponential increase in sand erosion.

2.1.1.1.6 Across the road from Ghadira Bay lies the Ghadira Nature Reserve, which is made up of seven hectares of brackish lake and salt-marsh habitat. The Reserve is home to a variety of small mammals and reptiles and a stopover for migratory birds crossing the Mediterranean. Ghadira Nature Reserve is a fully protected bird sanctuary, a Ramsar site, and a Special Area of Conservation within the EU Natura 2000 network.

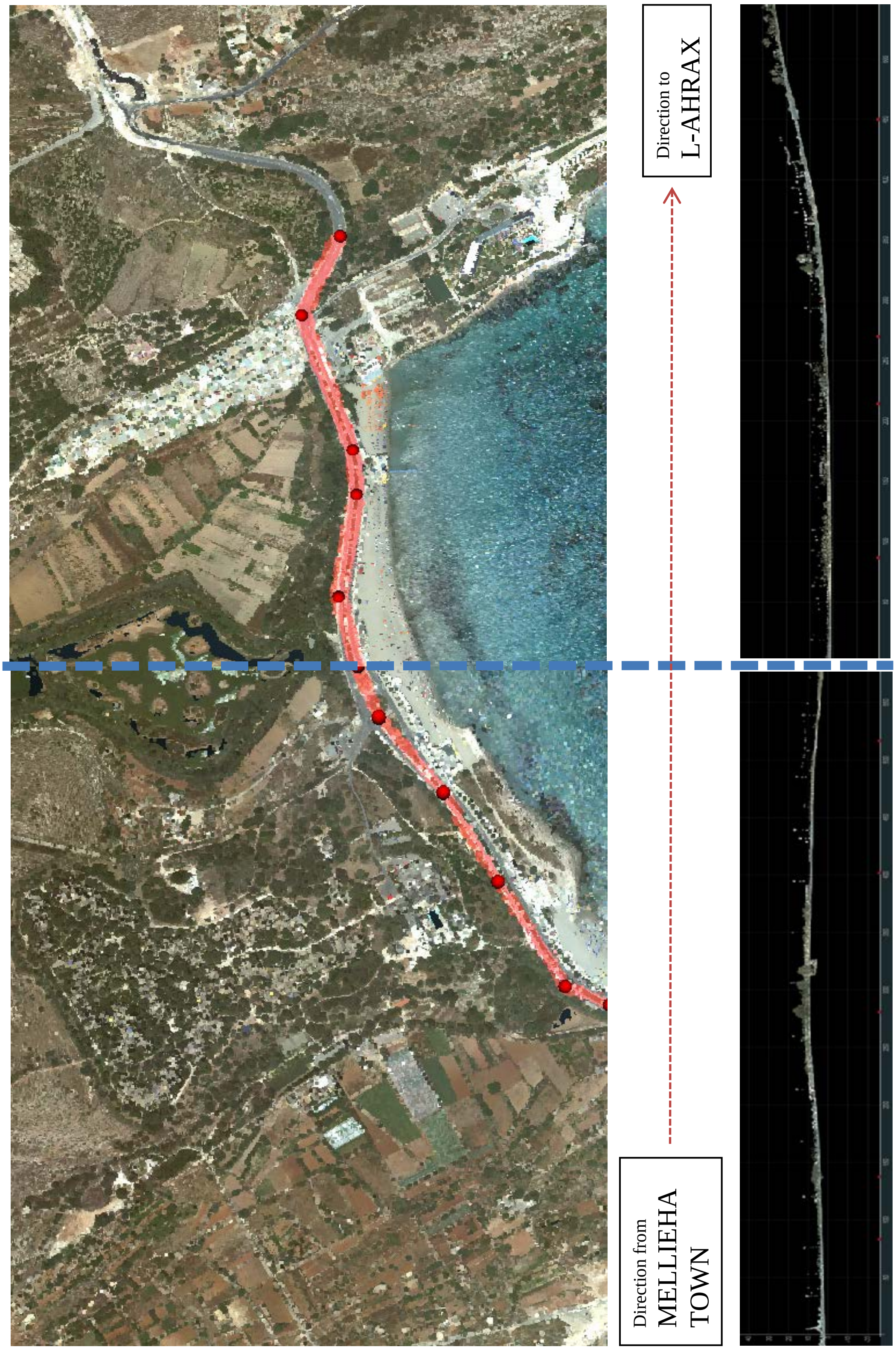


Figure 2: Grid LiDAR data showing 2012 Aerial Photo & elevation graph (x: height above sea level; y: distance) of Triq il-Qammieh (Direction from Mellieha town to l-Ahrax)

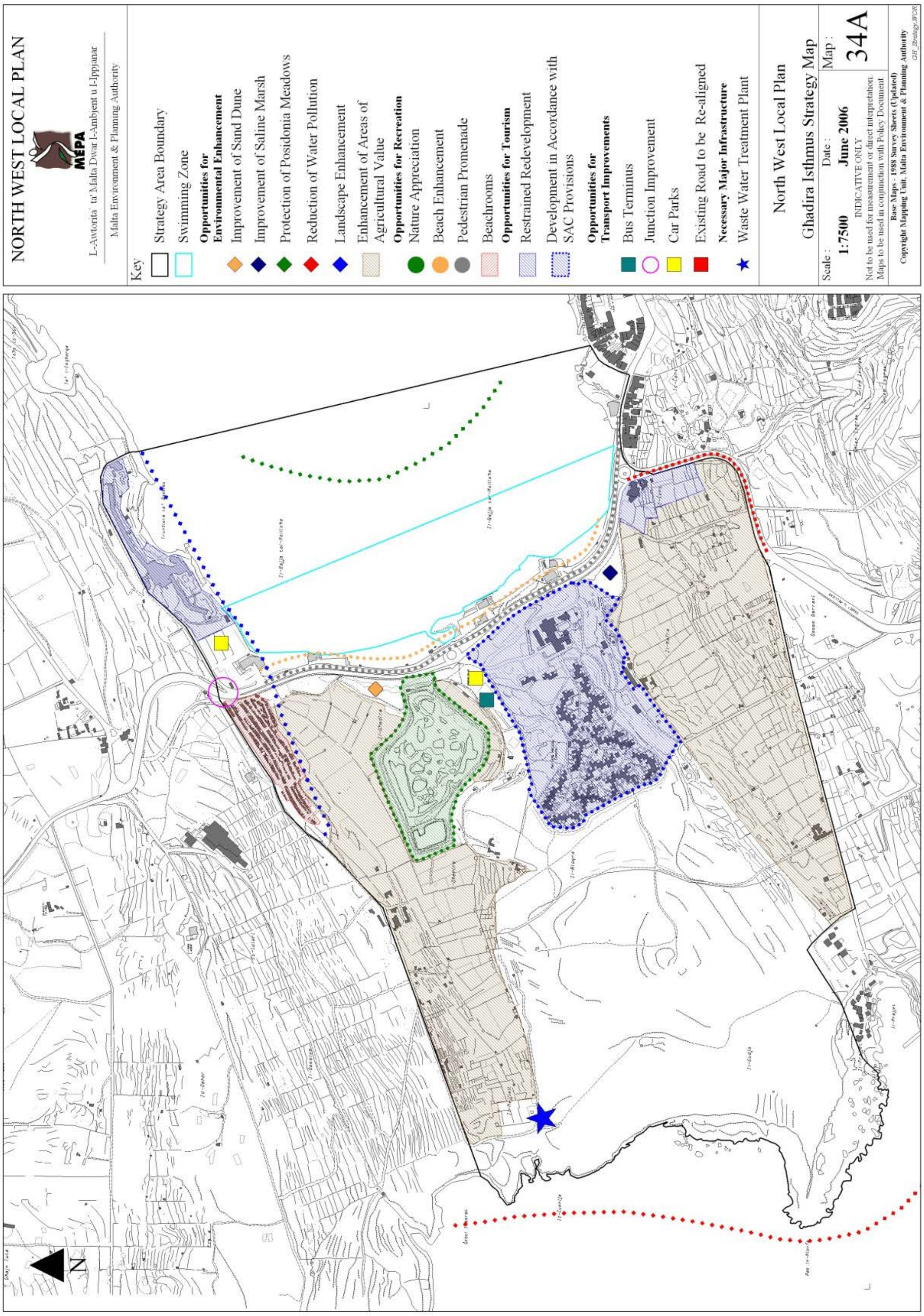


Figure 3: Ghadira Isthmus Strategy Map (NWLP, 2006)

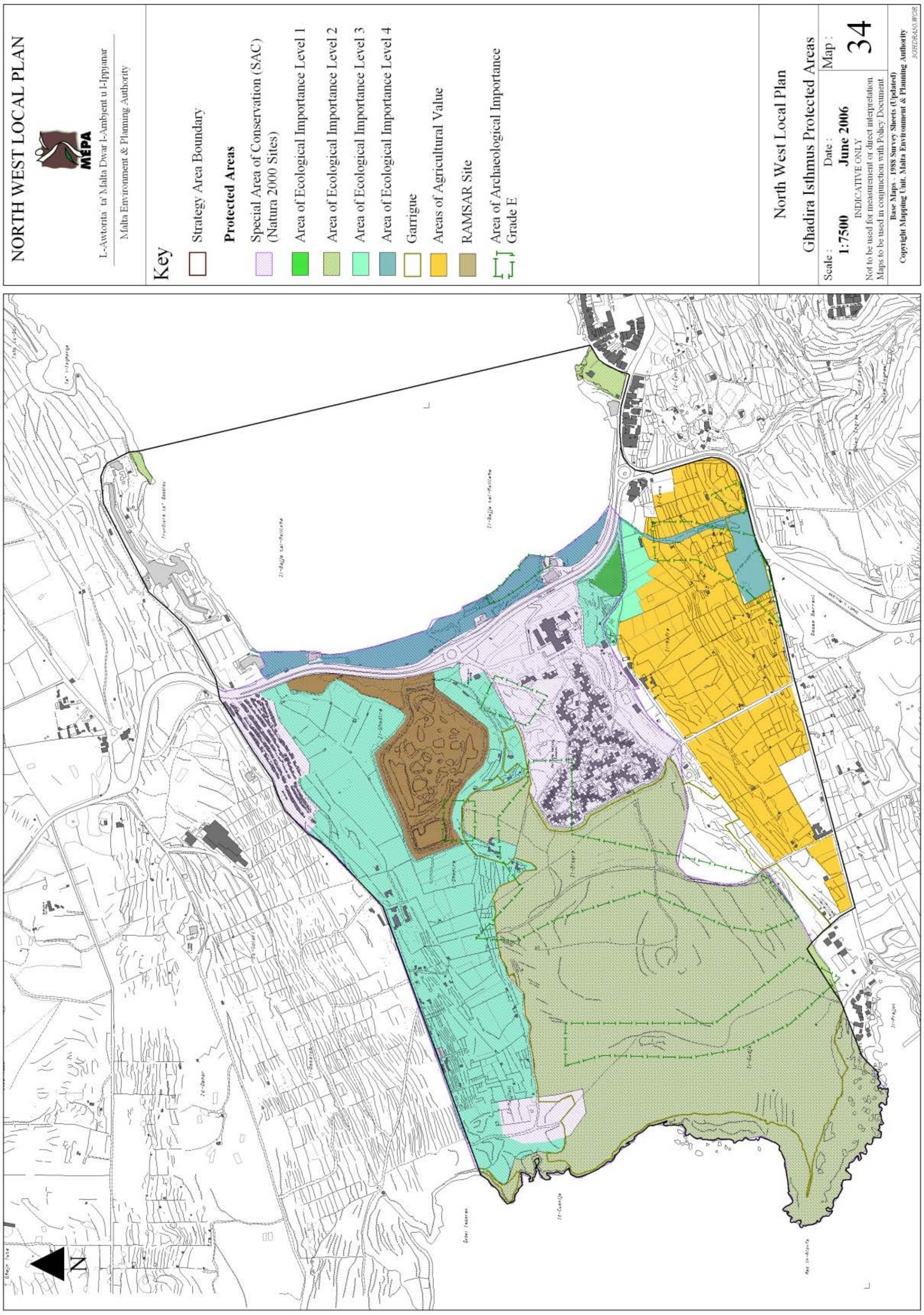


Figure 4: Ghadira Isthmus Protected Areas (NWLP, 2006)

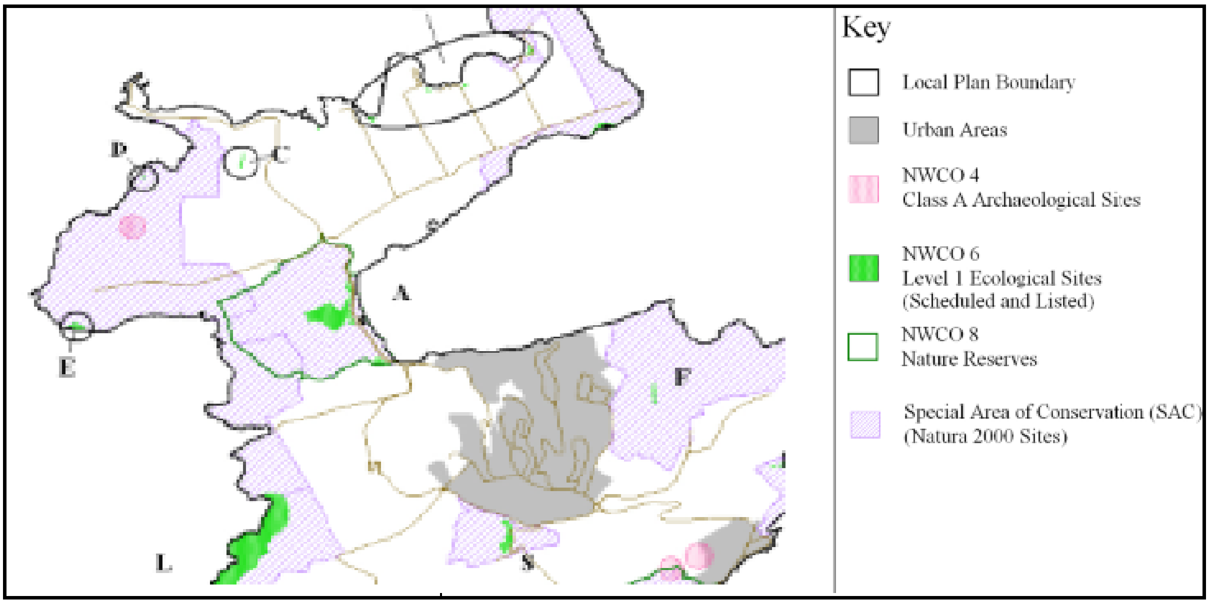


Figure 5: Level 1 & Class A Protected Areas for Ecology, Archaeology Nature Reserves & SAC's (NWLP, 2006)

Figure 6: Aerial Photo Google Maps - Ghadira Bay

2.1.2 Background

2.1.2.1.1 The tourism industry contributes to approximately 15% of the Maltese nation's gross domestic product (GDP). In general, the influx of tourists has steadily increased throughout the past 30 years and tourism is now considered a major pillar of the nation's economy.

2.1.2.1.2 It is to be noted that total tourism expenditure in 2016 amounts to some €1,708.9 million. Tourists increased by 10.2% between 2016 and 2015; totalling some 1,965,928 with tourist nights increasing by 5.7% amounting to some 14.9 million nights with a corresponding increase of 4.3% in expenditure amounting to €1.7 billion (Source MTA *Tourism in Malta- Facts & Figures 2016*).

2.1.2.1.3 It is to be noted that although statistics for the use of Ghadira bay *per se* are not published – yet it is evident that the bay is the largest sandy beach and attracts so many tourists and locals that it can be considered to be at the limit of its carrying capacity. Although the carrying capacity of the beach is to be eventually calculated and measures taken to safeguard its use; yet immediate action is necessary to remediate this precarious situation. Patron spill over to other beaches can eventually exasperate the situation at the few sensitive sandy beaches which exist in the northern part of the Maltese Islands. Beach replenishment and extension eases such pressures - especially during the peak summer months.

2.1.2.1.4 Even though substantial efforts have been made by the Malta Tourism Authority to continuously diversify the tourism industry, the Maltese summer climate, its crystal clear waters and its sandy beaches still play a major role when attracting tourists to the Maltese Islands. Moreover, the Maltese coastal beaches offer an undisputable recreational value to the local population.

2.1.2.1.5 The sandy beaches make up only 2% of the entire coastline of the Maltese Islands (Anderson & Schembri, 1989). These 'pocket' beaches are less than 1km in length. The sand dune systems are not very well developed due to several factors, either through natural processes (due to a small tide range, limited inter tidal exposure, etc.) or through human interventions. The only site which has a relatively complete dune system is the one in Ramla Bay on Gozo. Other beaches have minor dune systems, such as Ghadira, Ramla tat-Torri, Golden Bay and Santa Marija Bay. These dunes have a limited extent and rarely exceed 1.5m in height (vide Figures 8/9).

2.1.2.1.6 Degradation of the beaches has also been accelerated through ill-conceived planning and construction works, mainly with regards to transport infrastructure and commercial development. Consequently, most of the Islands' beaches are now greatly diminished.

2.1.2.1.7 Climate change may also be a contributing factor to the diminishing sandy beaches. Current data indicates that the mean global temperature has been steadily increasing, thus leading to an increase in the mean sea level. A rising sea level leads to the reduction in the depth of the sandy beaches.

2.1.2.1.8 During the past decade the Malta Tourism Authority has overseen several beach replenishment projects. However, this is considered a significant challenge, since inland development has hindered the natural replenishment of the beach, and thus measures have to be taken which ensure that the replenishment works carried out are not naturally reversed within a few years.

2.1.2.1.9 The Maltese bays' magnetic effect on the tourist and local populations, coupled with the ever-degrading and diminishing sandy beaches has led to severe overcrowding, especially during the summer months (vide Figure 7). Ghadira Bay is no exception. During the peak season the beach is virtually invisible beneath a swarm of people, along with deckchairs, umbrellas, etc.

2.1.2.1.10 Ghadira bay is skirted on the western and southern sides by an arterial road (Triq il-Qammieh) and by a restaurant / lido on the northern side (vide Figure 6). The initial phase of the project will entail the seaward (eastward) extension of the sandy beach.

Figure 7: Typical summer overcrowding at Ghadira Bay (Northern Beach)

Figure 8: Sand dune system in Ramla Bay (Gozo)

Figure 9: Remnants of sand dune in Ghadira Bay

2.1.3 Objectives

2.1.3.1.1 The main aim of this project is the sustainable sand replenishment of Ghadira Bay using environmentally sensitive methods. This will increase the depth of sand whilst contemporarily extending the width of the sandy beach.

2.1.3.1.2 The intention of this PDS is to provide a detailed description of the replenishment methods being considered; and will highlight the environmental impacts and benefits resulting from the implementation of the project.

2.1.3.1.3 The sand replenishment methodology adopted as well as the expected impact can be considered to manifest minimal disturbance to the existing marine environment. The process will consider the use of raising sand carried away by the waves through natural beach erosion processes. The sand replenishment procedures adopted are such so as to ensure that the *Posedonia Oceanica* Meadows are not affected adversely, and ensuring minimal impact on the flora and fauna as well as the ecosystem of the area.

2.1.3.1.4 The project as is being proposed will provide a long-term, environmentally sustainable solution to reverse the sand erosion while facilitating natural sandy beach replenishment at Ghadira Bay. The environmentally sensitive nature of the area is being given the utmost importance and will be prioritised during the implementation of the project. It is being envisaged that the environmental benefits of the proposed development will outweigh any environmental impacts – particularly once mitigating measures are put in place.

2.1.3.1.5 More importantly, the long-term solutions being proposed in the latter phases (particularly Phase 2) will eliminate the need for continuous replenishments, thus allowing adversely affected marine species to re-colonise the affected area, mitigating any future detrimental interventions while rendering the project economically sustainable. In fact, these measures (particularly Phase 3) intend to promote the natural inward migration of the sand dunes creating a regenerated dune habitat.

2.1.3.1.6 Given that Maltese sandy beaches are a scarce resource, the scheme as is being depicted seeks to address several competing activities, whilst being economically and environmentally beneficial to the Maltese Islands. The scheme intends to (include but is not limited to);

- address the negative social impacts resulting from overcrowding;
- address the negative environmental impacts resulting from overcrowding;
- provide ample space for the general public to exercise their preferred way of relaxing / bathing, be it through the use of deckchairs, umbrellas, etc.;
- provide a sustainable solution for the ever-increasing influx of tourists;
- provide an opportunity for the surrounding businesses to increase revenue, and consequently contribute positively to the Maltese economy;
- facilitate sand dune migration inland in a way which reflects the natural state of the beach prior to the construction of Triq il-Qammieh;
- provide an opportunity for species of flora and fauna (such as sand dune communities) to thrive and possibly re-colonise their natural habitat which, through past development and interventions, may have been adversely affected; and

- provide long-term solutions which reduce / eliminate the need for future replenishments.

2.1.4 Demand

2.1.4.1.1 The scheme will be implemented within one of the most frequented beaches in Malta, which is famous for its easily-accessible nature and the numerous activities available. Therefore the project as proposed will cater for a constantly increasing significant number of tourists and members of the local population.

2.1.4.1.2 The Ghadira Bay sandy beach replenishment project will cater for the ever-increasing demands highlighted above and is intended at contributing significantly to the social, environmental and economic sectors.

2.2 DESCRIPTION OF THE PROPOSED PROJECT

2.2.1 Proposed Site

2.2.1.1.1 The location of the proposed site is shown in Figure 1 above. Ghadira Bay is the largest sandy beach in Malta and is located along the northern-western coast of the island. The beach directly abuts Triq il-Qammieh, which is situated just a few metres above sea level and then rises uphill towards l-Ahrax.

2.2.1.1.2 The proposed site covers a total area of approximately 270,000m². This includes the proposed extension seawards of approximately 38,000m² to the existing sandy beach, and the underwater area from which pockets of sand may be transferred to the shoreline as shown in Figure 10.

2.2.2 General Characteristics of the Sandy Beach

2.2.2.1.1 The Feasibility Study conducted by CTB Ltd. (Annex 2) indicates that sandy beaches can be classified into Types I, II and III (vide Figure 11), as proposed by Hattori and Kawamata (1981). These can be broadly described as follows;

- Type I – an accretive beach profile with a step on the foreshore, in which sand transport is dominant in the surf zone and the shoreline tends to advance;
- Type II – forms a bar near to the wave-breaking position and the bar sometimes migrates either landward or seaward. Under certain conditions, which depend mainly upon the wave characteristics in the near-shore zone, the Type II beach can intermittently transform to the Type I or the Type III.
- Type III – the erosive storm beach profile without bars; a dominant offshore sand transport develops in the near-shore zone.

2.2.2.1.2 The Feasibility Study highlights that the beach at Ghadira Bay can at present be considered to be predominantly stable Type II classification. This is corroborated since the 2012 and 2016 aerial photos do not indicate any significant difference to the shoreline. In fact, a study of seasonal variations suggests that the beach is in equilibrium between accretion and erosion.

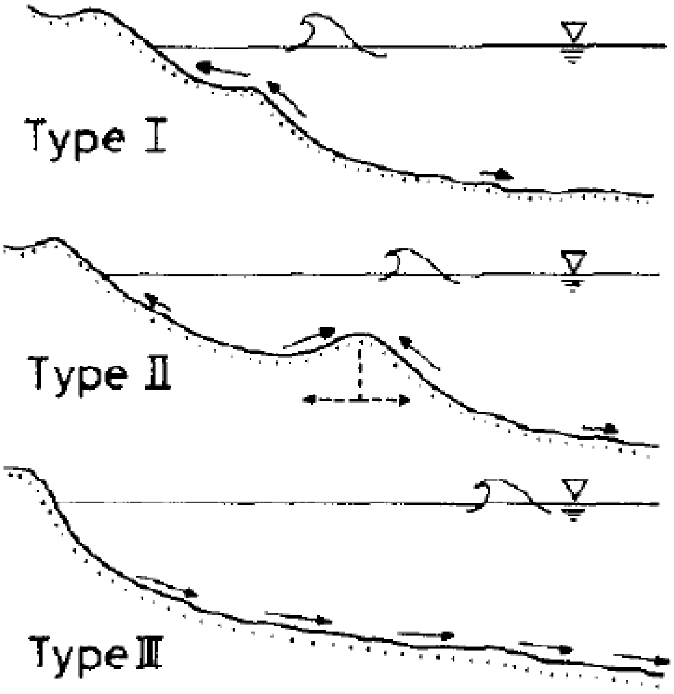


Figure 10: The three classifications of beach types as proposed by Hattori and Kawamata (1981)

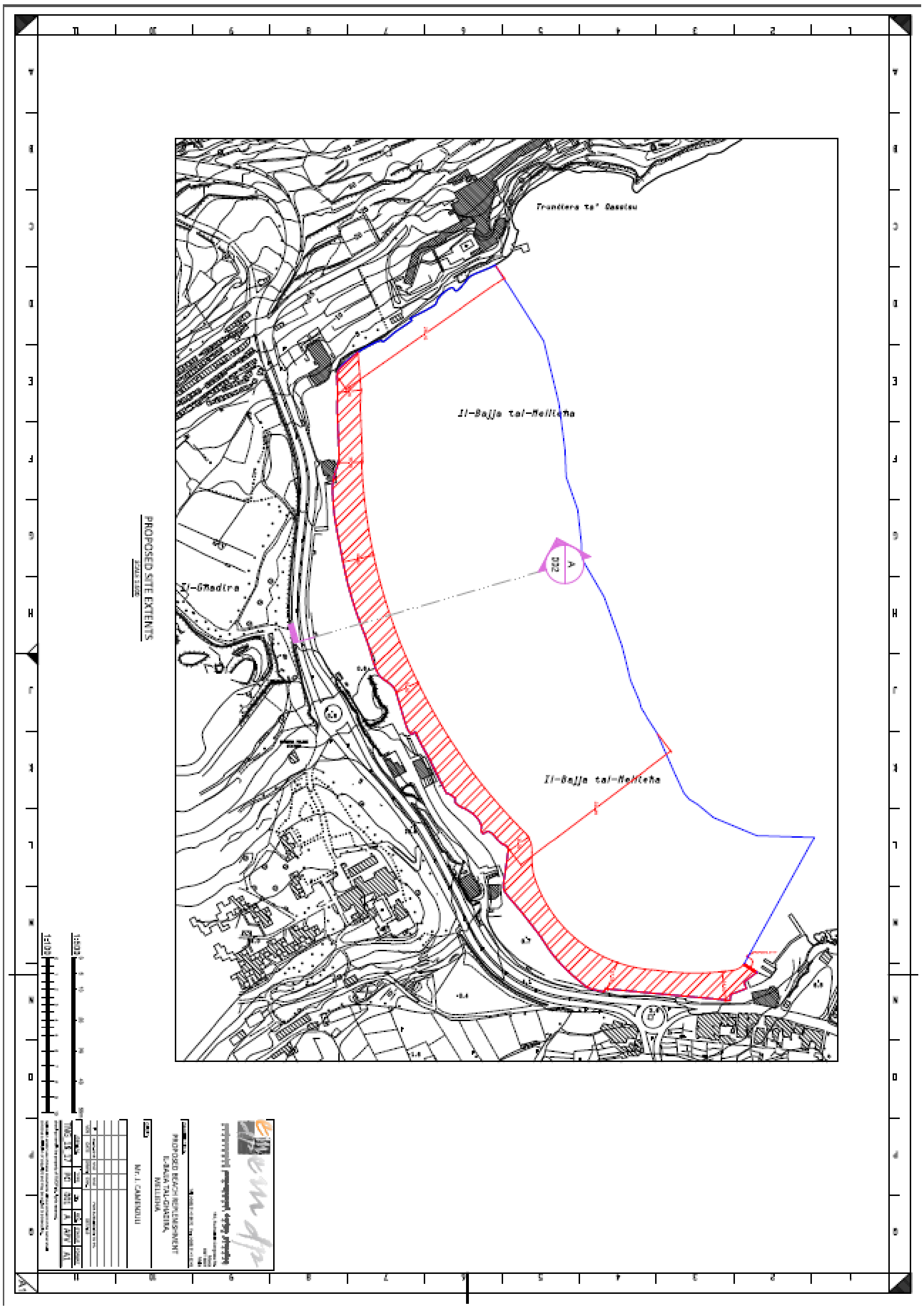


Figure 11: Proposed Site Extent

2.3 PROPOSED DEVELOPMENT

2.3.1 Overview

2.3.1.1.1 The development being proposed through PA 1820/18 consists of the ''Sand replenishment of Ghadira Bay, including the construction of a wave deflector and related marine works.'' PA 1820/18 covers the independent project falling within the parameters of Phase 1 of the Scheme.

2.3.1.1.2 The overall scheme will be carried out in three distinct independent phases which can be considered as independent projects in their own right, The three projects are as following:

- PHASE 1 – Sand replenishment using suction dredging and the construction of a wave deflector intended at partially protecting the newly-replenished sandy beach;
- PHASE 2 – The construction of submerged wave deflectors acting as artificial reefs and intended at encouraging inland sand dune migration, whilst ensuring sand retention even during sever storm conditions;
- PHASE 3 – The construction of an elevated three lane dual carriageway to replace Triq il-Qammieh, intended at encouraging inland sand dune migration.

2.3.2 PHASE 1 – Sand Replenishment and the Construction of a Wave Deflector

2.3.2.1.1 The first project of the scheme shall be implemented before summer 2018, and through this PDS it is being analysed / described in detail. Further studies have to be carried out prior to the following two projects which will follow the implementation of the independent project falling under Phase 1. The time lines for the independent projects falling under Phases 2 and 3 are not yet determined.

2.3.2.2 *Sand Replenishment*

2.3.2.2.1 The methodology being proposed to replenish the beach using sand carried away through erosion and deposited on the sea bed in the near shore area well away from the *Posedonia Oceanica* Meadows.

2.3.2.2.2 From tests carried out by Solidbase Ltd. (found in annex); the sand grain of the sea shore is grainier and heavier than that found at the sea-bed of the bay. It is expected that the finer sand dredged from the sea bed will be more easily eroded.

2.3.2.2.3 The topmost 200mm sand layer located at some 10m from the shoreline towards the landward side will be collected, sieved (in order to remove coarse contaminants) and stockpiled in an area protected by concrete blocks in order not to be dispersed back into the environment.

2.3.2.2.4 Sand from Ghadira bay sea bed will be raised and deposited on land using a **sand suction dredger**. The sand suction dredger will dislodge the sand and pump sea floor sand and sediment to the sand pits located in various sand reclamation areas located along the beach. Pumping of sand is to be made in a controlled manner.

2.3.2.2.5 The sand deposited in the sand pits and stock piles is then levelled in layers using appropriate mechanised graders. The finer sea bed sand will be deposited in the lower layers; whilst the upper layers will be formed from the coarser landward stockpiled sand. Sand will be distributed in order to create a seaward extension of a sandy beach by a further 20 m to 40 m. In order for this to happen, a sand burn is to be created along the seashore. The sand burn and the immediate near shore sea bed profile will be created through the use of the coarser "dry" beach stock piled sand. This implies that the reclaimed sandy shore line will extend for an area inland and a larger area seawards.

2.3.2.2.6 Of all the alternative dredging methods available, the use of an appropriate sand suction dredger with adjustable suction force is considered as having the least environmental impact when considering protection of the surrounding flora and fauna. A preliminary marine ecological study has been carried out to determine the exact location of the protected *Posedonia Oceanica* Meadows. Although a strict buffer zone is to be established in order to ensure that the said *Posedonia Oceanica* Meadows are not adversely affected, attention is to be given in order to ensure the lowest impact to other existing flora and fauna species.

2.3.2.2.7 The proposed works will take place in an established "Safe Zone" so that the Posedonia Meadows are not adversely affected and the variable suction pump will be operated within areas devoid of this protected species. The "Safe Zone" is separated from the *Posedonia Oceanica* Meadows by an established buffer zone.

2.3.2.2.8 The "Safe Zone" has been established through 3D image analyses of the coast and near shore areas. The 3D model has been created through a series of transects taken from LiDAR data available on the PA website. Transects are located at 50m distances (measured in a north-south direction); whilst readings along each transect were taken at 10m distances. Transect profiles were taken along a west-east direction. The LiDAR data grid is located on a north-south east-west axis in order to facilitate the data capture process. Each reading point provides coordinate data in x,y, and z directions.

2.3.2.2.9 The 3D model was corroborated through the use of comparative analysis of aerial photography as well as physical dives in the area.

2.3.2.2.10 The 3D model analysis establishes and clearly identifies the location of Posedonia. The exclusion buffer zone was then identified and the "Safe Zone" dredging locations established. Prior to any works being carried out, physical verification of the "Safe Zone" through the carrying out of a number of dives will be carried out. Also, on site analysis shall be carried out to verify the data derived from the 3D model.

2.3.2.2.11 It is being proposed that the sandy beach shoreline is extended seawards by some 20m to 40m, therefore increasing the landwards sandy beach area by some 20,000m² to 40,000m². Since the sandy beach is currently in state of equilibrium between erosion and accretion, it was highlighted in the Feasibility Study (section 6.4) that it would be preferable to construct the slope of the new beach to a gradient similar to the existing near-shore value. The Study emphasises that if the approach slope in the newly-made shallow water area is too steep, more severe wave breaking will occur compared to the current situation and the waves will run up onto the new beach. Consequently this will lead to the undesired scenario where the newly placed sand is dragged back offshore to re-establish a profile similar to that which exists today.

2.3.2.2.12 As such, it was considered essential that the proposed typical sectional drawings are in line with the recommendations set out in the study, and it is clear (vide Figure 12) that the deposition of the sand will be carried out in a way which retains, more or less, the same slope gradient – with the coarser sand being located in the upper layers of the shore and near shore areas.

2.3.2.2.13 It is to be noted that the slope gradient of the sand profile of the bay (which is generally perpendicular to the shoreline) is not in line with the LiDAR grid data (which is located in a north-south and east-west grid). Therefore once the 3D model is created a "Working Grid" perpendicular to the bay has been established in order to delineate sand profiles therefore facilitating the study, sand replenishment process, and monitoring of the proposed works taking place at Ghadira bay. Two defined physical locations were established in order to facilitate the setting out of the "Working Grid".

2.3.2.3 *The Construction of a Wave Deflector*

2.3.2.3.1 The scheme also includes the construction of a wave deflector, protruding from the Sea Shell Dive Centre area located at the far southern end of the bay.

2.3.2.3.2 The Feasibility Study conducted by CTB Ltd. highlights that owing to the bathymetric configuration, more wave energy dissipation occurs over the northern part of the approach waters to the frontage, and significant wave heights in this area are lower. The southern area is characterised by larger waves penetrating closer in to the frontage, which leads to an increased susceptibility for sand erosion.

2.3.2.3.3 Therefore, the wave deflector intends at primarily protecting this area of the sandy beach from the incoming waves, which usually have relatively high significant wave height. Moreover, the wave deflector will serve to dissipate or reflect the incoming waves in a way which reduces beach erosion and possibly encourage deposition of the sand.

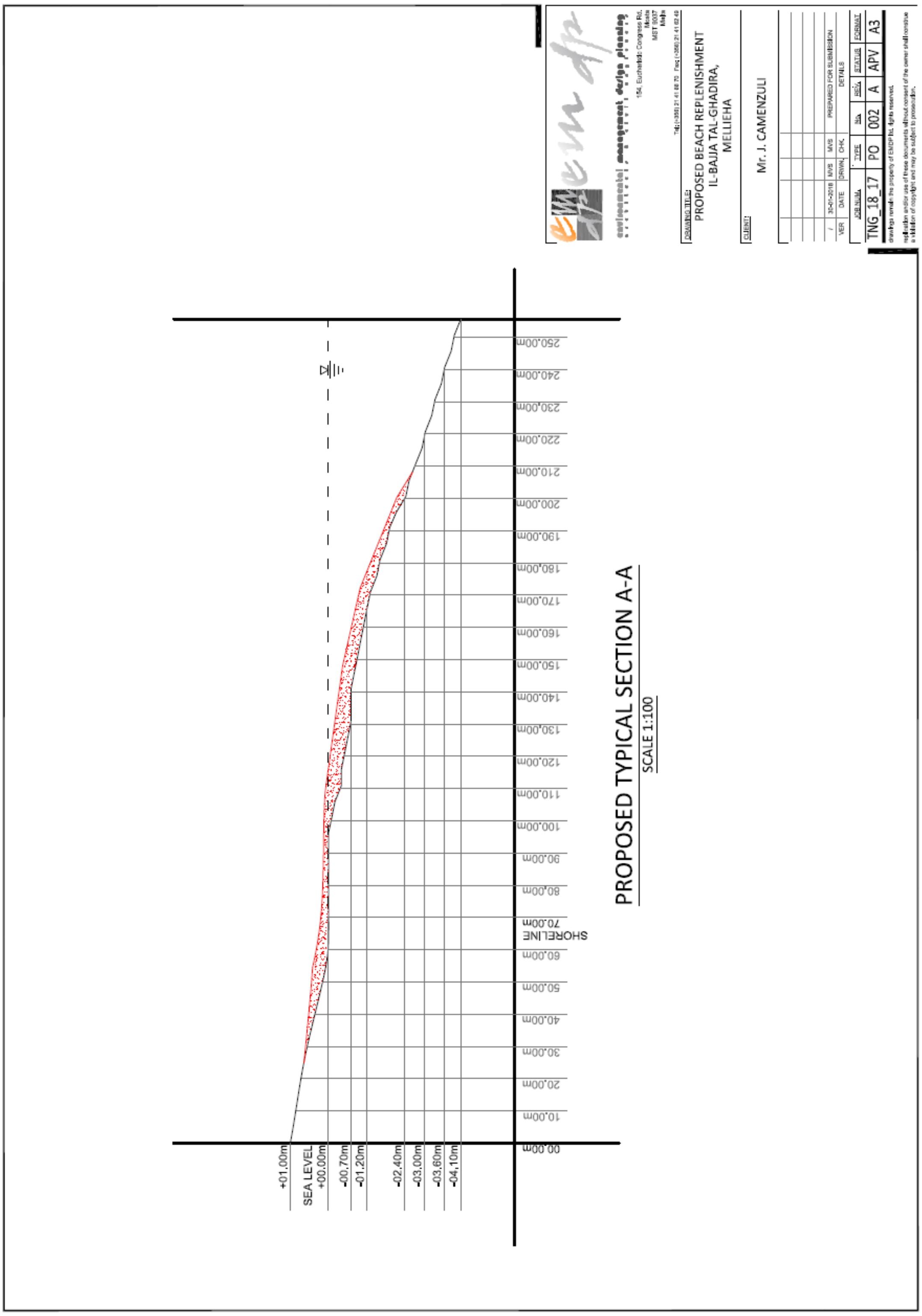


Figure 12: : Sectional drawing showing proposed deposition of sand and extension of existing shore line by approximately 40m.

2.3.3 PHASE 2 - The Construction of Submerged Wave Deflectors

2.3.3.1.1 It is projected that once the project delineated in Phase 1 is completed; Phase 2 of the scheme will seamlessly follow from the first Phase. This includes the construction of submerged wave deflectors situated around the sandy beach and intended to deflect, dissipate or reduce the wave / current energy reaching the shoreline.

2.3.3.1.2 Phase 2 will be implimented over a two year period. Phase 2 is being considered consequential to the completion of the project faling within Phase 1 of the scheme. Given the urgency for Phase 1 of the scheme and the need to facilitate operational requirments (given that the area where the sand can be reclaimed from the seabed is quite restricted and would be further restricted through the creation of the wave deflectors) the client has no option but to run the risk of implimenting Phase 1 prior to Phase 2. If significant bad weather will take place prior to Phase 2 being implimented; there runs the risk that all the work carried out in Phase 1 would have to be repeated since the replenished sandy beach could be eroded back to the present day profile.

2.3.3.1.3 Approaching waves / currents which are characterised by a lower energy value are prone to deposit sand and sediment on the beach and act as a natural beach nourishment agent. Therefore the submerged wave deflectors will promote the natural inward migration of the sand, and possibly the creation of the sand dunes and consequent sand dune habitates which are now almost extinct due to the adjacent road and other physical interventions in the area.

2.3.3.1.4 This phase of the project is still subject to further marine and ecological studies which are being carried out contemporarily with the completion of Phase 1. Moreover, this proposal will be subject to a Mathematical and possibly Physical Wave Model, which will provide an accurate presentation of the current, and different phased interventions envisaged to form part of the project.

2.3.4 PHASE 3 - The Construction of an Elevated Dual Carriageway

2.3.4.1.1 The creation of sand dune communities will not take place unless the physical barrier formed by the road hampering the creation of a proper sand dune regime is removed. Phase 3 of the scheme includes the erection of an elevated 3 lane dual carriageway under which the inward progression of the sand dunes can occur.

2.3.4.1.2 It is intended that eventually Triq il-Qammieh is elevated and suspended on vertical columns, in a way which resembles a bridge-like cantilevered structure. The environmental, social and economic feasibility of such a project is still to be determined, and the proposal will be subject to further studies. Such a project would also require the management of concessions, where it will be determined whether certain structures (such as kiosks) should be removed or permanently / temporarily shifted in a way which does not impede the process of sand dune migration.

2.3.4.1.3 Phase 3 of the project is expected to take place within the following 5 years; depending on the availability of funds and Government priorities. Phase 3 can only occur once the projects outlined within Phase 2 and Phase 1 of the scheme are completed. Phase 3 will also depend on the travel modes being considered for the island of Gozo; since at present most traffic travelling to Gozo passes through this stretch of road.

2.3.4.1.4 It is intended that once the elevated carriageways are in place, the existing road structure will be removed and the sandy bay will be allowed to flourish with minimal interference. The resulting scenario will be the natural inward migration of the sand dunes and the creation of newly established sand dune communities and habitats.

2.3.4.1.5 Throughout the implementation of the scheme the area will be monitored in order to ensure that the projected indicators are achieved and natural processes are taking place as projected. It might be considered that once Phase 3 of the project is implemented; re-colonisation of sand dune communities is encouraged through careful and precise re-colonisation interventions – thus speeding up the regeneration process.

2.4 PROJECT MANAGEMENT

2.4.1.1.1 The studies carried out in the preparation of this PDS only relate to the implementation of Phase 1 of the scheme, i.e. the beach replenishment through suction dredging and the construction of a water deflector at the southern end of Ghadira Bay. The projects forming part of this phase can be considered to stand alone and can be implemented independently of other projects falling within Phase 2 and Phase 3.

2.4.2 Sandy Beach Replenishment

2.4.2.1.1 The land and sea areas where the works will be carried out will be cordoned off and appropriate security and surveillance monitoring put in place. Personnel will be deployed on a 24/7 roster in order to ensure that proper Health and Safety procedures are in place and the site is secure. Sand replenishment works are to be phased and appropriate sections identified in order to allow uninterrupted use of the bay.

2.4.2.1.2 The initial stages of the project will relate to the shifting of sand from the areas highlighted in Figure 21 in order to extend the sandy beach by 20m to 40m in the seaward direction.

2.4.2.1.3 This part of the project will require the use of heavy machinery, mainly:

- *A sand suction dredger:* The sand suction dredger [SSD] consists of a sand dredging machine which is driven or towed to the proposed location. The SSD usually consists of a pump, which sucks the sand loosened from the seabed by an attached cutting head, which is then pumped out to the desired location through flexible pipe work.

- *A number of wheel diggers with front loading bucket*: The medium sized wheel digger will be utilised on the sandy beach in order to shift the sand as necessary. It is to be noted that for the purposed first phase of the project use of heavy dozers and/or tracked machinery will not be allowed; in order to minimise impacts on the existing sand communities.

- *A grader*: The grader will level off the sand to the desired level

- *A crane:* A crane will be required in order to lift the digger and grader placing them on the beach, thus eliminating the need to create new access points.

- A number of tipper trucks: These will be necessary to transport the sand throughout the beach area in order to speed up the beach replenishment process.

- A number of long reach excavators with proprietary modified chiselling tools: these excavators will be used to smoothen out and chisel the sand profiles.

2.4.2.2 *Description of Works*

2.4.2.2.1 The topmost 200mm sand layer found some 10m inland from the seashore will be collected and sieved in order to remove coarse contaminants. This coarser sand will be stockpiled in appropriate areas protected by containment walls created of 1m cubed reinforced concrete blocks which will be removed once the works are completed.

The containment walls will be some 3m in height and will allow for the containment of sand which otherwise will be dispersed back to the beach in an uncoordinated and uncontrolled manner,

2.4.2.2.2 Sieved Coarse contaminants will be separated and disposed off in an appropriate manner in accordance with current national regulations.

2.4.2.2.3 The stock-piling of land based coarse sand will take place contemporarily to the harvesting of finer sand from the sea bed.

2.4.2.2.4 A series of sand pits will be created in order to ensure that the pumped sand will not be carried away back to sea by the excess water. If sand pits are not made and sand pumped into the aforementioned areas, the pumped sand-sea water mix will create furrows in the sand, carrying the pumped material back to sea.

2.4.2.2.5 Sand pits will be placed a few metres inside the existing shoreline. Sand pits will be created by the placing of reinforced concrete demountable precast units (complete with hoisting eyes) which will act as retention plinths. The structure will be rendered water retaining and levelled through the use of sand bags as depicted in Figures 13 and 14.

2.4.2.2.6 A rigid inflow pipe will be inserted in line with the lower end of the plinths. Whilst the overflow of water will be allowed through rigid pipes located along the higher edge of the plinths. The rigid inflow pipe will be connected to the suction dredger located out at sea through flexible pipe-work. Similarly rigid water overflow pipes will be connected to flexible pipe-work which will lead overflow water back to sea. In this way sand located downstream of the sand pit will not be adversely effected by erosion through the creation of furrows.

2.4.2.2.7 Once the sand pits are in place and the pipe-work is all connected; the site manager will give the necessary clearance in order that the dredger will commence with the pumping of sand from the identified

“Safe Zone” areas (vide Figure 16). Dredging will take place in an arc and will only be allowed to go down to a specific depth. It is not the intention to create a “bowl” from the continuous suction of sand from one location. Rather dredging will take place in a well-defined and designed manner in order to create a sub-sea profile which will assimilate to the current Type II classified sea bed profile. Specialist consultants will provide the appropriate dredging profile that the contractor will have to follow in order to create a sculptured sea bed which is less prone to erosion.

2.4.2.2.8 As the sand starts piling up, the overflowing seawater will seep back to the sea as shown in Figures 14 and 15. The accumulated sand in the sandpit will be allowed to settle and the excess water drained. Accumulated sand will be carried to different pre-arranged locations using the front loading bucket of the wheeled digger and/or the use of tipper trucks depending on the distance to be travelled in order to deposit the sand as part of the beach reclamation exercise. Long reach wheeled excavators will then chisel the near shore below waterline sea bed. It might be necessary that areas further out to sea will be chiselled by the same wheeled excavators loaded on barges working from further out at sea. A grader will then spread the sand to a pre-designed profile creating a burn along the landside of the newly created shoreline.

2.4.2.2.9 The cut and fill exercise is not arbitrary; but is to follow a well-designed layered cross sectional profile which will be provided along the various transects located on the “Working Grid”. The coarser land originated sand will be used along the topmost near shore areas; while the finer sand harvested from the sea bed will be used on the lower layers. Surveyors are to establish that the profile created is in line with the designed sculptured profile.

Figure 13: Examples of permanent concrete sand pit using precast concrete units used for beach replenishment

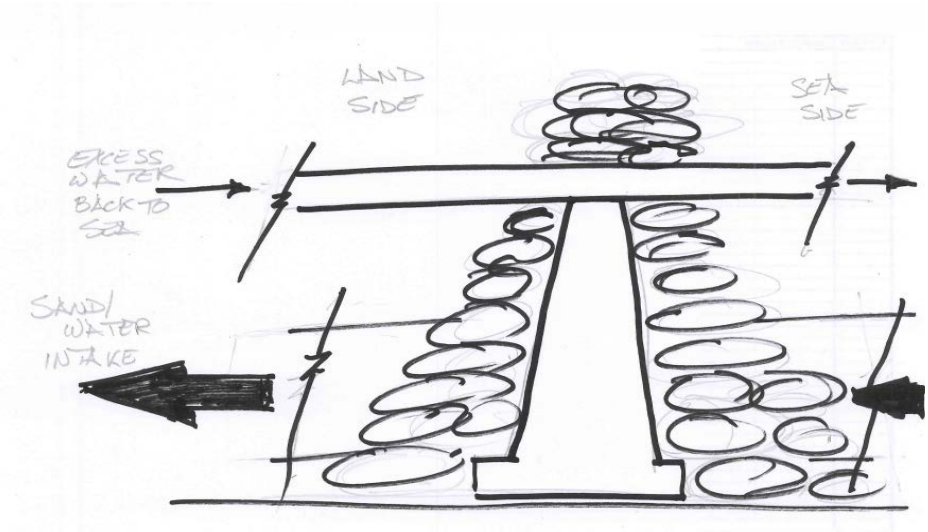


Figure 14: Sectional sketch through proposed wall, showing concrete demountable precast units (complete with hoisting eyes), sand bags and overflow of water

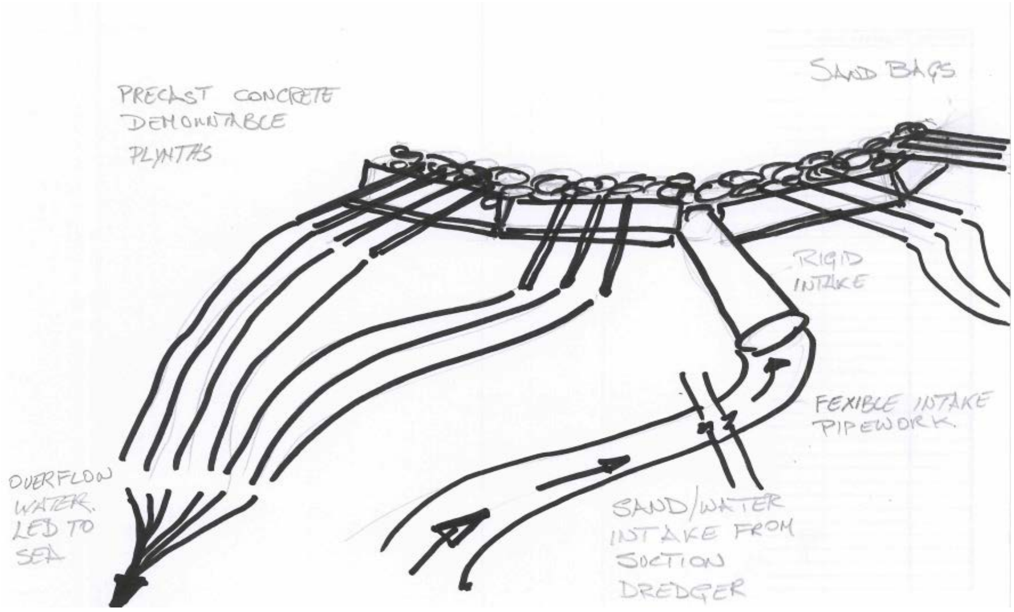


Figure 15: Sketch showing the creation of a sand pit which allows for the pumping of sand and overflow of water. The sand pit structure will be removed once sand replenishment will have been completed

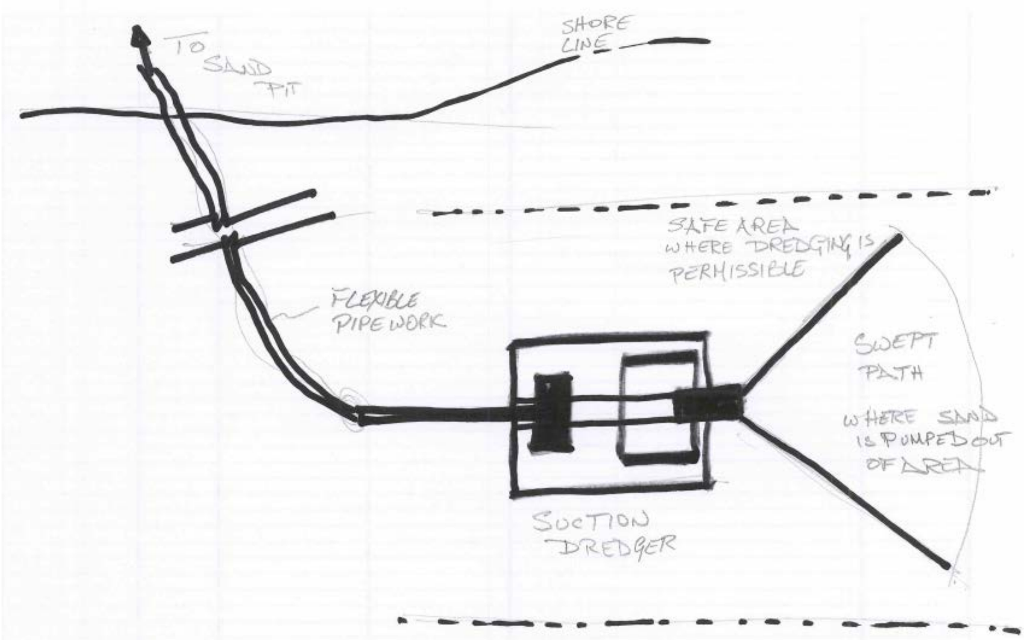


Figure 16: Sketch showing suction sand dredging operating within well-defined area and pumping to shore to the demountable sand pit areas.

2.4.2.2.10 The area to be replenished will be located above mean sea level up to the newly created sea shore and below mean sea level up to a stretch which at least is considered equivalent to the width of the reclaimed beach. In order to reduce erosion, the sea bed will be sculptured to follow the existing beach profile albeit at a distance from the original shoreline equivalent to the reclaimed beach width, The underwater sea bed profile will be created using mechanised means either from land or from sea through the use of mechanised arm equipment mounted on long reach excavators which can operate from land along the seashore or located on barges.

2.4.2.2.11 Once the excess sand is removed from the sand pit and the stock pile they will be dismantled and rebuilt in a new location. The sand will be levelled and left to form a natural profile. Access to the sandy beach will be restricted for a period of time – thus allowing the sandy beach to be left to regenerate naturally. This settling period will depend on the time allowed to execute and complete the works. The project is envisaged to be used by June 2018.

2.4.2.2.12 Once this period elapses the hoarding restricting entry into the area will be removed and the replenished sandy beach reinstated.

2.4.2.3 *Volume of Sand Required*

2.4.2.3.1 As highlighted above, the beach will be extended by a minimum of 20m and a maximum of 40m, according to the sand volume available and the relevant wave, ecological and marine studies.

2.4.2.3.2 A rough estimate of the volume of sand required has been calculated as shown in Tables 1, 2 and 3. Deposition of sand will also be carried out on the beach itself up to 10m inwards from the present shoreline - this is necessary in order to level and profile the beach in such a manner so as to limit erosion. Therefore, an extension of 20m will require the deposition of sand over a total breadth of 30m. Moreover, it was calculated that the new shoreline will extend up to 0.5m above sea level.

2.4.2.3.3 A vertical sectional transect through the proposed replenishment area will reveal a 2D right angled triangle $(Area = \frac{1}{2}BxH)$. If this Area is multiplied by the total length (L) of the beach (approximately 1000m), the approximate volume of the sand required for the beach extension can be determined (vide Figure 17).

2.4.2.3.4 The approximate volume of sand required was calculated according to the desired extension of the beach. Five different scenarios were envisaged, with the beach extension ranging from 20m to 40m from the present shoreline (vide Table 1). The results indicate that the approximate volume of sand required for each scenario ranges from 27,000m^3 to 69,000m^3.

2.4.2.3.5 Note that these calculations are not taking into consideration the subsea/sea-bed profiling which is necessary if the Type II classification of the beach profile is to be achieved. If sea-bed profiling is to be considered then further sand deposition will have to take place.

2.4.2.3.6 It is being assumed that the sea-bed will follow the same inclination for the same breath of beach being reclaimed. This will give rise to a rectangular parallelogram cross section – which will have a cross sectional area = D(B-10) (vide Figure 18). It is assumed that this additional cross sectional area will allow for gradual deposition of sand by wave motion. Although not exactly following the assumed profile; yet the assumed cross section will compensate for the amount of sand necessary for the natural angle of repose cross section to be created. As such, the approximate volume of sand to be deposited below sea level in order to retain a similar slope gradient was calculated in Table 2. The results indicate that the approximate volume of sand required for each scenario ranges from 8,000m^3 to 32,000m^3.

2.4.2.3.7 Therefore the **total volume of sand required** for each scenario was calculated by adding the results from Tables 1 and 2 (vide Table 3). The approximate results indicate that the total volume of sand ranges from a minimum of 35,000m³ for a 20m beach extension to a maximum of 101,000m³ for a 40m beach extension.

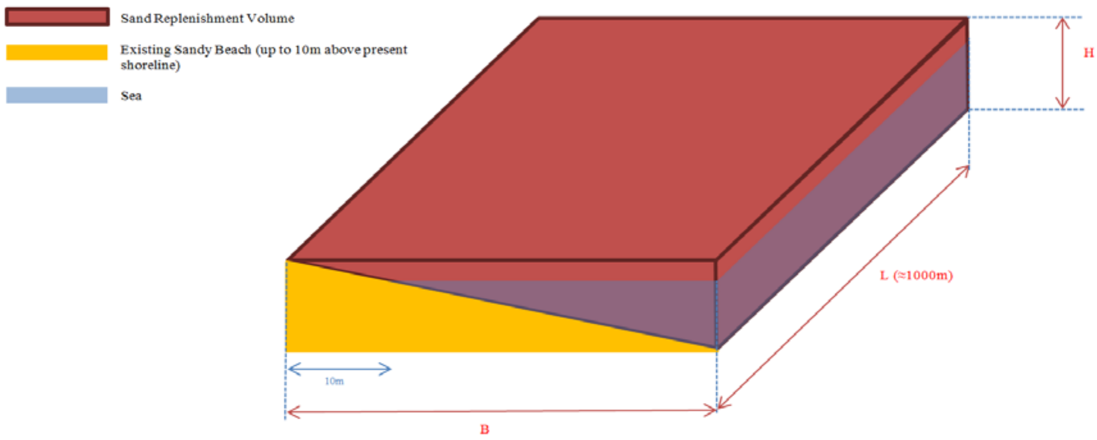


Figure 17: Volume of sand required for beach extension - sketch showing values L, B, H -

		Approx. length of beach to be replenished (L)	Approx. breadth of beach to be replenished (above sea level)	Approx. breadth of beach to be replenished (below sea level)	Total approximate breadth of beach to be replenished (B)	Approximate depth at lowest point of proposed beach ext. (D)	Total approximate depth of sand required (D+0.5m) (H)	Approximate Volume of sand required $\frac{1}{2}$(LxBxH)
Beach Ext.	20m	1000m	(-)10m	(+)20m	30m	0.4m	0.9m	**27,000m³**
Beach Ext.	25m	1000m	(-)10m	(+)25m	35m	0.5m	1.0m	**35,000m³**
Beach Ext.	30m	1000m	(-)10m	(+)30m	40m	0.6m	1.1m	**44,000m³**
Beach Ext.	35m	1000m	(-)10m	(+)35m	45m	0.7m	1.2m	**54,000m³**
Beach Ext.	40m	1000m	(-)10m	(+)40m	50m	0.8m	1.3m	**69,000m³**

Table 1: Approximate volume of sand required for beach extension ABOVE sea level

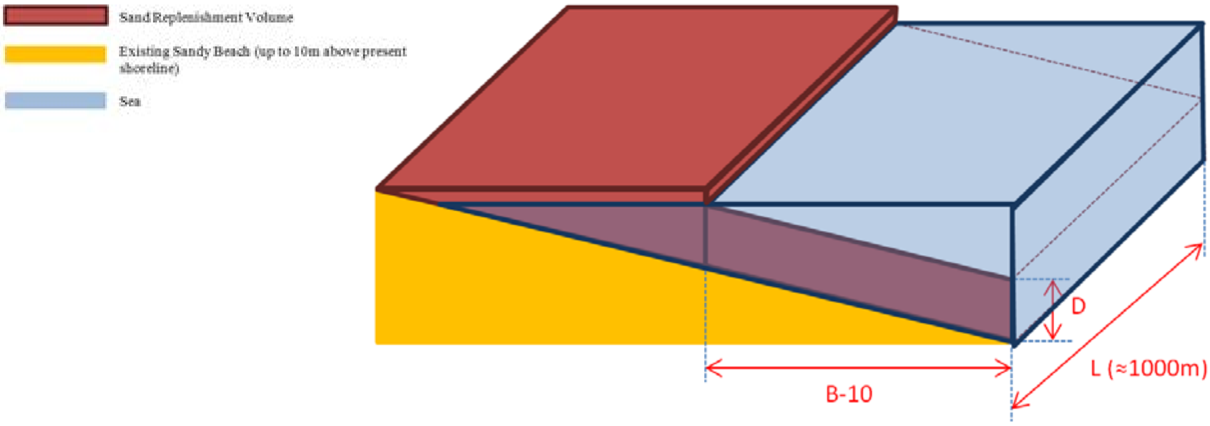


Figure 18: Volume of sand required below sea level to retain similar slope gradient

		Approx. length of beach to be replenished (L)	Total approx. breadth of sloping beach to be replenished (below sea level) (B-10)	Approximate depth of sloping sand to be deposited (D)	Approximate Volume of sand required D[B-10)
Beach Ext.	20m	1000m	20m	0.4m	**8,000m³**
Beach Ext.	25m	1000m	25m	0.5m	**12,500m³**
Beach Ext.	30m	1000m	30m	0.6m	**18,000m³**
Beach Ext.	35m	1000m	35m	0.7m	**24,500m³**
Beach Ext.	40m	1000m	40m	0.8m	**32,000m³**

Table 2: Approximate volume of sand required BELOW sea level to retain similar slope gradient

		Approximate volume of sand for beach extension (A)	Approximate volume of sand below sea level (to retain similar slope gradient) (B)	TOTAL APPROXIMATE VOLUME OF SAND REQUIRED (A+B)
Beach Ext.	20m	27,000m³	8,000m³	35,000m³
Beach Ext.	25m	35,000m³	12,500m³	47,500m³
Beach Ext.	30m	44,000m³	18,000m³	62,000m³
Beach Ext.	35m	54,000m³	24,500m³	78,500m³
Beach Ext.	40m	69,000m³	32,000m³	101,000m³

Table 3: Total approximate volume of sand required according to length of beach extension

2.4.2.4 *Volume of Sand Available*

2.4.2.4.1 In order to determine whether the existing volume of sand further out at sea is sufficient for the replenishment requirements highlighted above, certain environmental issues were prioritised.

2.4.2.4.2 It has been taken into consideration that Ghadira Bay is committed by large areas of Posedonia Oceanica meadows, which are protected by

EU legislation. As such, a 3-Dimensional model of the bottom of the bay has been devised through a series of 19 transects (North to South) taken from LiDAR data (vide Figures 18, 20). Since this data reflects the situation in 2012, these results shall be verified at a later stage by a qualified marine ecologist, who will inspect the site in question and confirm the exact location of the protected species such as Posedonia Oceanica.

2.4.2.4.3 The 3D model specifies the location of Posedonia (light brown) and a 30m exclusion buffer (green). The red line reflects a sea depth of 2m, which acts as a buffer from the shallow waters.

2.4.2.4.4 The area ideal for the sand dredging operation was thus determined. This area is devoid of Posedonia Oceanica, and is characterised by a sea depth exceeding 2m. The resulting model shown in Figure 21 indicates that the total area ideal for the operation is that of approximately 80,000m^2 (33,000m^2 + 47,000m^2).

2.4.2.4.5 Special reference was given to the report submitted by Cachia (Annex 1) which highlighted the approximate depth of sand throughout the bay. Comparison between these results and the resulting 3D model shows that most of the identified area consists of sand having a depth of 1.5m to 2+m. Therefore if a minimum of 1.5m depth is taken into consideration, the volume of sand available is that of 80,000m^2 x 1.5m = **120,000m^3,** which far exceeds the requirements highlighted in Table 1. Therefore it can be confirmed that a 20m-40m extension of the sandy beach is possible. Nevertheless we are of the opinion that in order to have a proper safety factor in place; sand reclamation should be such so that the shoreline should not extend more than 30m seawards from its current position.

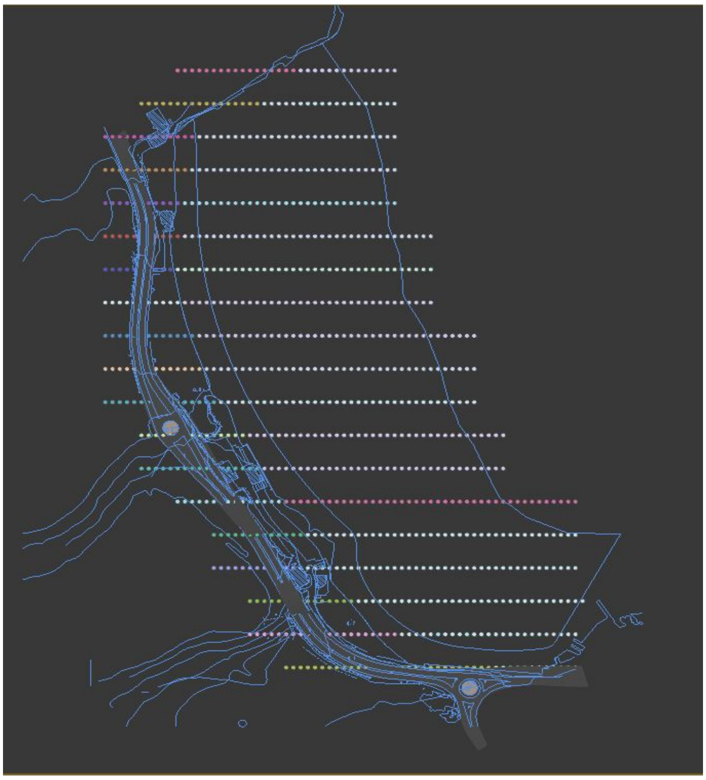


Figure 19: Plan of Ghadira Bay, showing transects 1-19 (north to south)

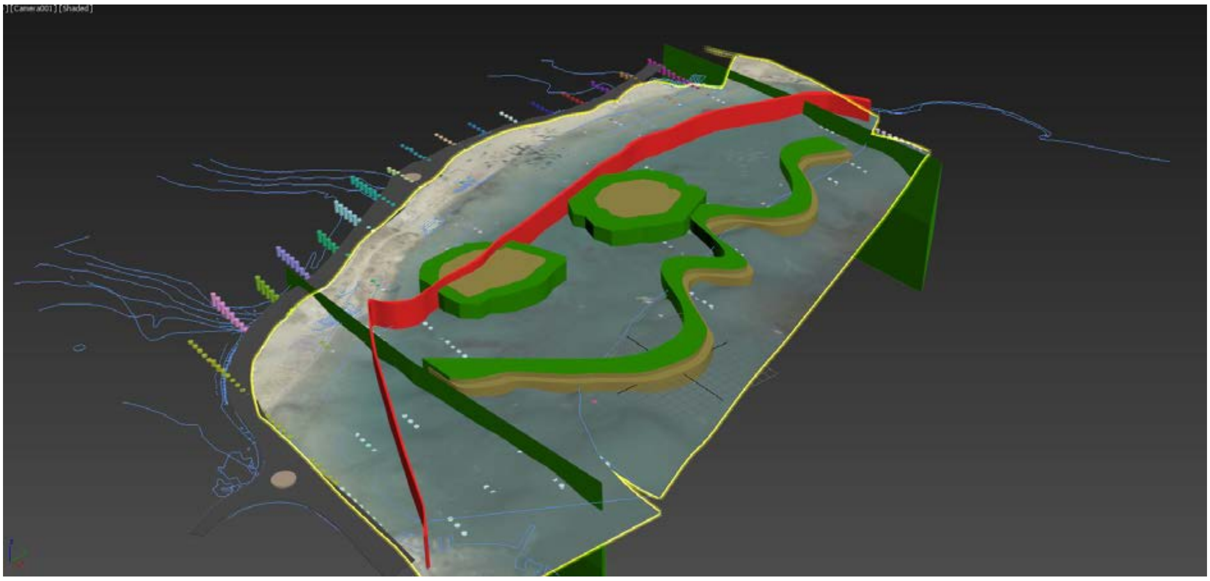


Figure 20 3D Image of Ghadira Bay, showing exclusion buffer zones

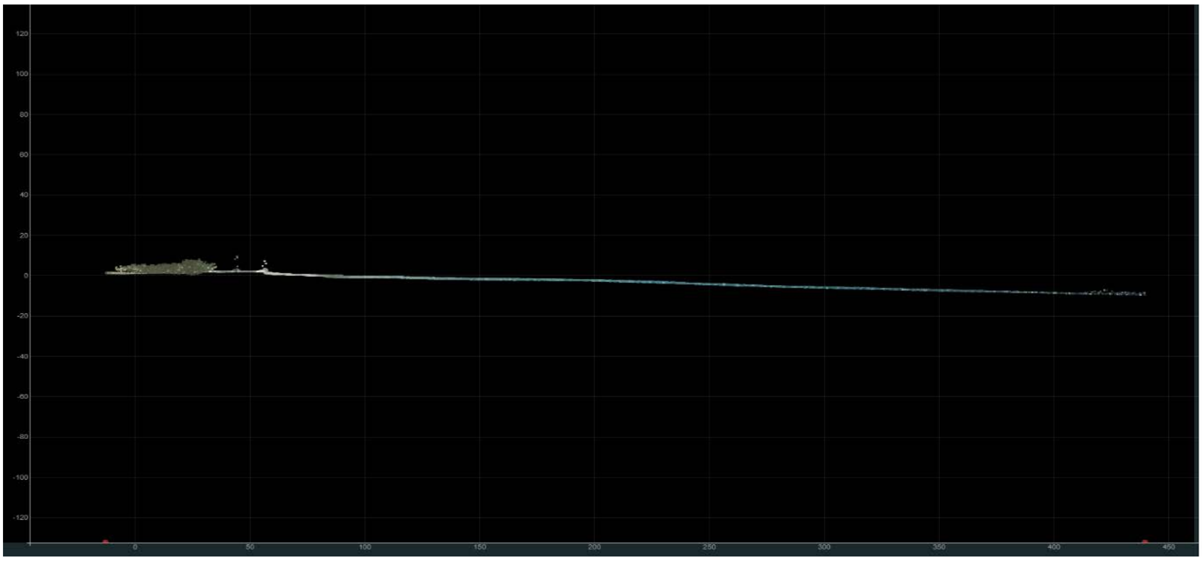


Figure 211: Image showing elevation of transect (7) taken from LiDAR data

Figure 22: Birds-eye view of 3D image showing two large pockets ideal for dredging, having a combined area of 80,000m³

2.4.2.5 *Sand Dredging Process*

2.4.2.5.1 The site manager will be provided with scaled plans reflecting the 10m x 10m grids, which shall then be used as working grids along axis A,A' (vide Figure 23). The grid has been superimposed on a scaled 3D image indicating the buffer zones and safe zones (vide Figure 24). The scaled plans are available in Appendix 1 – which provides a 3D model graphical representation of Ghadira Bay.

2.4.2.5.2 The "working grid" shall serve as a reference from which the site manager can accurately deduce the location of the suction dredger and the depth of profile to be dredged. It is being recommended that the dredging process is phased. Each phase is delineated, and the area cordoned off. Silt curtains and appropriate containment booms will be put in place. The dredged seabed is to be sculptured in layers to the designed profile. This is crucial in order to reduce erosion of the dredged area.

2.4.2.5.3 Dredging will occur in an arc which will generally effect a grid area measuring some 10m x 10m ($100m^2$). The dredging works are then shifted 10m perpendicular to the line of reference and the same north to south process is repeated. This process is repeated until all the 10m x 10m grids located within the phase delineated area has been covered. The various phases will not exceed the "safe zone" delineation.

2.4.2.5.4 The UTM coordinates corresponding to the points of reference are as such: **A** (441382mE, 3981209mN), **A'** (441901mE, 3980389mN). Point **A** was taken from the easternmost corner of 'Sol Beach Bar & Restaurant' and point **A'** was taken from the cemented area beneath 'Oh Yeah Malta'. Photos of the corresponding reference points are shown in Figure 23.

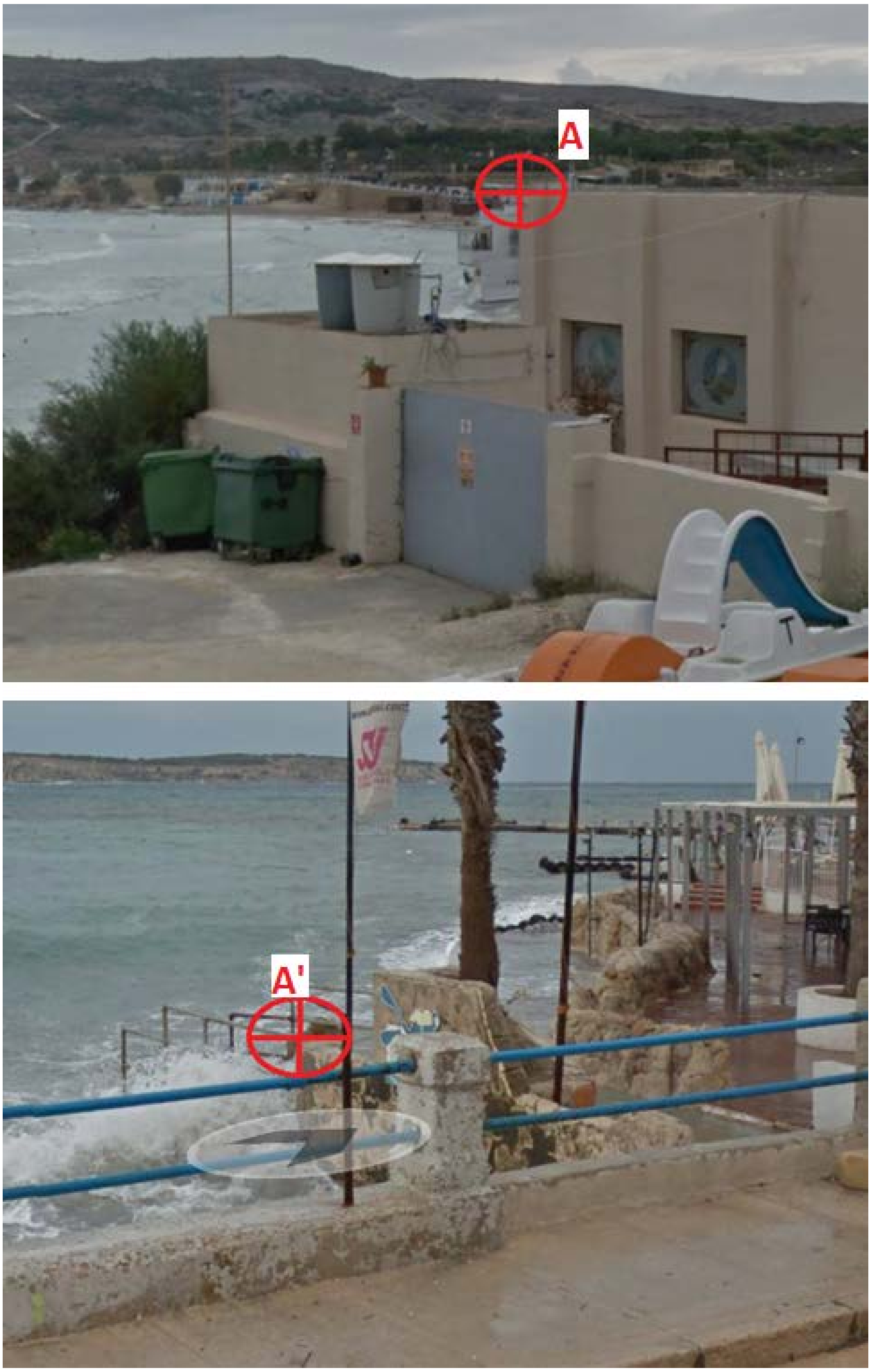


Figure 23: Photos showing location of reference points A, A'

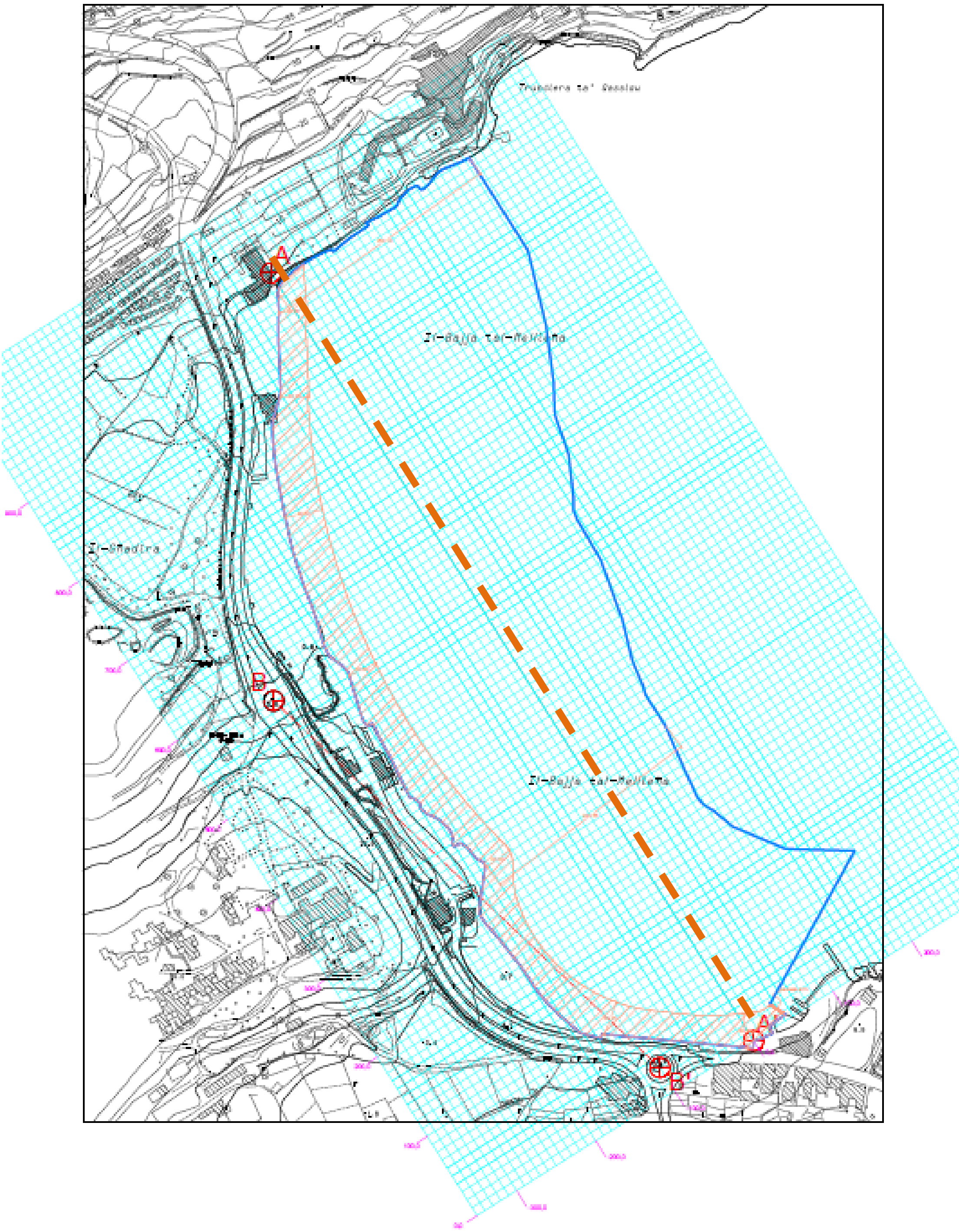


Figure 244: Plan showing the 10m x 10m grids and axis AA' (scaled version provided in Appendix 001)

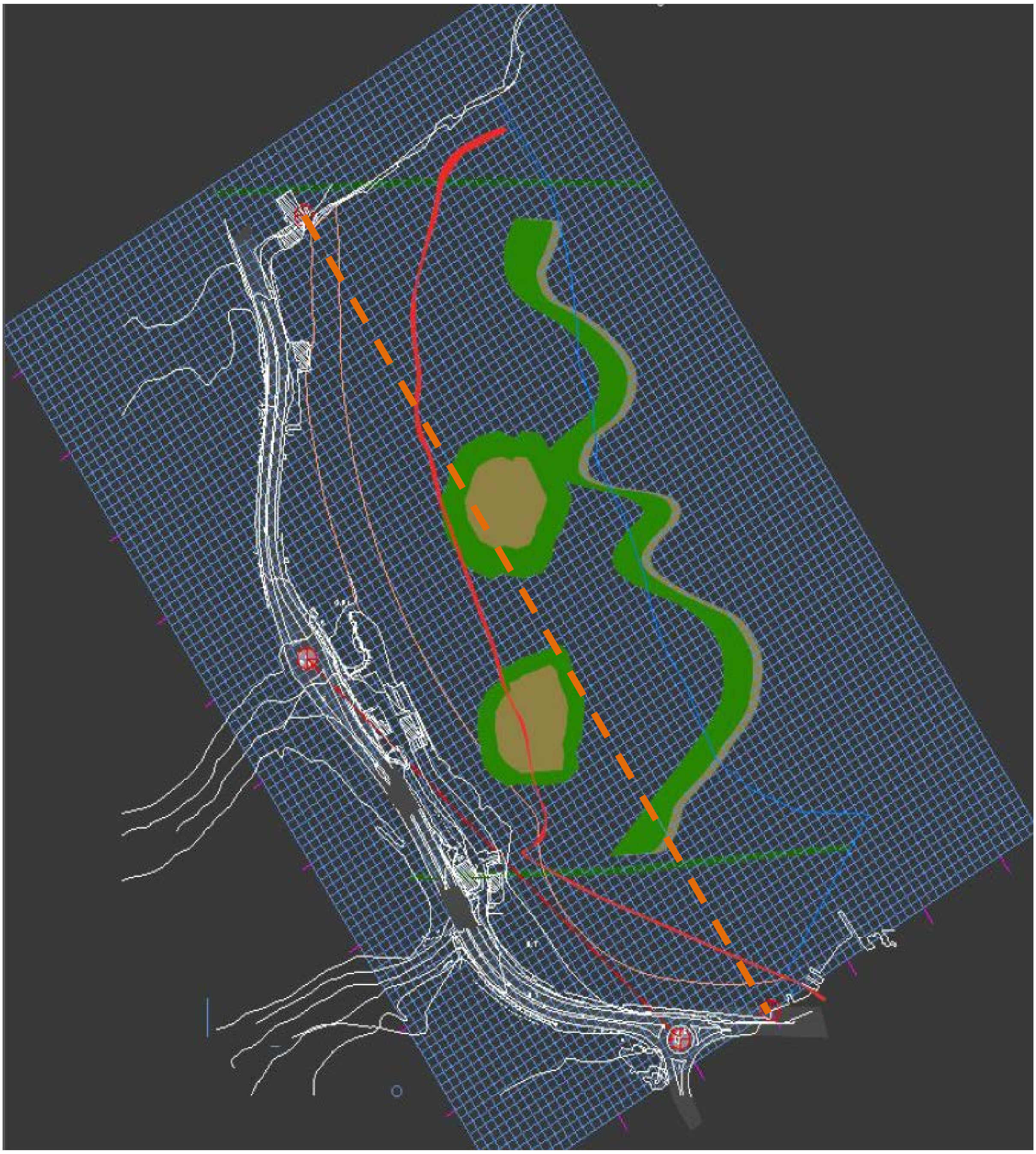


Figure 255: Plan showing superimposition of 10m x 10m grids over the buffer zones derived from 3D model (scaled version provided in Appendix 001)

2.4.3 The Construction of a Wave Deflector

2.4.3.1.1 The land and sea areas where the works will be carried out will be cordoned off and appropriate security and surveillance monitoring put in place. Personnel will be deployed on a 24/7 roster in order to ensure that proper Health and Safety procedures are in place and the site is secure.

2.4.3.1.2 Contemporary to the sand dredging process, infrastructural works related to the construction of the wave deflector will commence. The wave deflector shall protrude from beneath the Sea Shell Dive Centre located at the far southern end of the bay and shall extend more than 20m from the new shoreline as suggested in the Feasibility Study.

2.4.3.1.3 The Feasibility Study conducted by CTB Ltd. highlights that owing to the bathymetric configuration, more wave energy dissipation occurs over the northern part of the approach waters to the frontage, and significant wave heights in this area are lower. The southern area is characterised by larger waves penetrating closer in to the frontage, which leads to an increased susceptibility for sand erosion.

2.4.3.1.4 Therefore, the wave deflector intends at primarily protecting this area of the sandy beach from the incoming waves, which usually have relatively high significant wave height. Moreover, the wave deflector will serve to dissipate or reflect the incoming waves in a way which reduces beach erosion and possibly encourage deposition of the sand.

2.4.3.1.5 The wave deflector may also be of environmental value since it may act as an artificial reef. Artificial reefs have a role in enhancing the physical complexity of featureless sand bottoms, in order to attract a diverse assemblage of organisms, especially algae and fish (vide Figure 23).

Figure 26: A wooden underwater retaining wall on an artificial reef at Mabul Island

2.4.3.1.6 This part of the project will require the use of heavy equipment and machinery, mainly:

- *Floating barges:* Floating barges will be utilised for the transport of heavy machinery / equipment to the construction site areas which cannot be reached from shore;
- *A suction pump dredger:* The suction pump dredger [SPD] consists of a dredging machine which is driven or towed to the proposed location. The SPD usually consists of a pump, which sucks the rock and debris resulting from the excavation site and pumps it to a container which is towed to the construction site on a floating barge;
- *A sea floor excavator with rotary cutter:* The sea floor excavator (SFE) will be utilised for the excavation of the seabed through the

use of an attached rotary cutter, which serves as an adequate tool for the excavation of rocky seabeds;

- *A marine crane transport boat*: A marine crane transport boat [MCBT] shall be utilised for the transport and placing of caissons or tetrapods on the seabed;
- *A concrete mixer:* A concrete mixer shall be utilised for the pumping of concrete within the sea wall structure and shall be towed on a floating barge to the areas inaccessible by land based cranes

2.4.3.1.7 Heavy machinery associated with the construction works shall operate from an adequate area located behind the Sea Shell Dive Centre, which is also easily accessible through Triq il-Qammieh (Figures 31 and 32). Floating barges shall be utilised for the transport of heavy machinery to the areas which are not accessible by land and or areas which will be adversely effected by land transportation. There is a general presumption against using land based transport in the immediate vicinity where the wave deflector will be built. It would be preferable if all logistics (unless absolutely inevitable) will be sea based.

2.4.3.2 *Description of Works*

2.4.3.2.1 A rotary cutter shall be utilised to dig a trench within the seabed which fractionally exceeds the area of the wave deflector footing. A SPD shall suck the excavated waste and debris from the excavation site, which shall then be pumped into a barge which is towed to the site in question (vide Figure 27). The SPD shall ensure that construction run-off waste is kept to a minimum, thus minimising the negative impact on the surrounding environment and the turbidity of the sea.

2.4.3.2.2 A concrete mixer will then be towed on a floating barge to the site in question. The toe will then be put in place and reinforced concrete will then be pumped within the trench with the help of commercial divers, in order to provide a solid immovable base to the wave deflector (vide Figure 28). A rigid structure is essential, especially during stormy days, since the structure will face continuous pounding from the sea waves approaching the shore.

2.4.3.2.3 A MCTB will then be utilised for the transport and placing of interlocking caissons (vide Figure 29). With the help of commercial divers, the caissons will be placed to interlock in the reinforced concrete toe until the height reached is just below sea level. Further to the Feasibility Study carried out by CTB Ltd. (Annex 2) it may be decided at a later stage that the caissons are replaced by tetrapods, which are more adept at dissipating the incoming wave / current action.

2.4.3.2.4 The concrete mixer and pump are then towed back to the site on the floating barge. The interlocking caissons are reinforced by concrete pumped out from the concrete mixer with the help of commercial divers (vide Figure 30).

2.4.3.2.5 Access to the southern beach and the land area behind Sea Shell Dive Centre will be restricted during the construction period. Once this period elapses the hoarding restricting entry into the area will be removed and Phase 1 of the scheme will be completed.

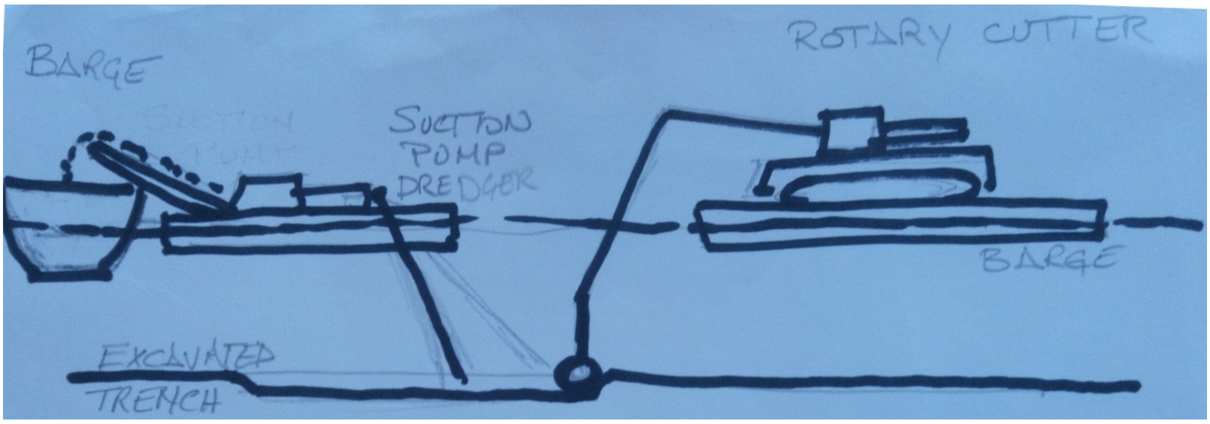


Figure 277: Sketch showing excavation of trench

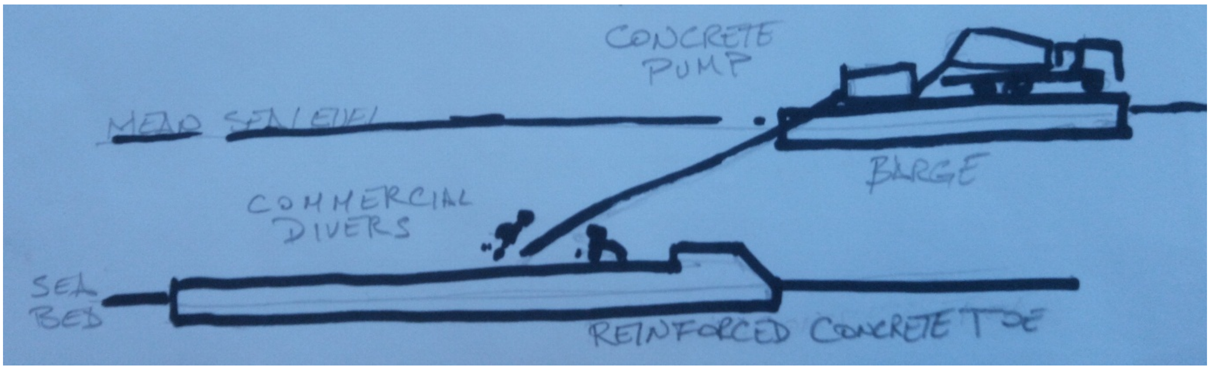


Figure 288: Sketch showing the formation of a reinforced concrete base

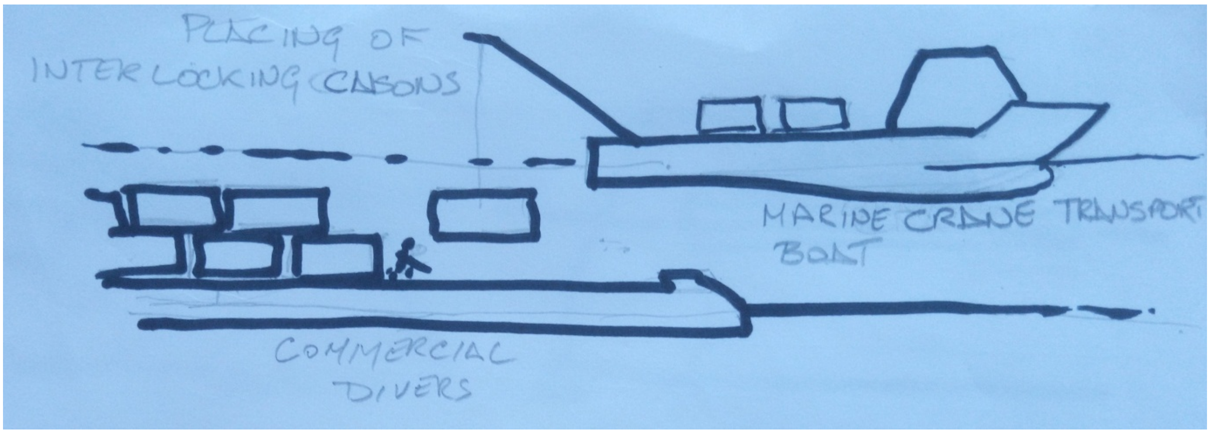


Figure 299: Sketch showing the placing of interlocking caissons

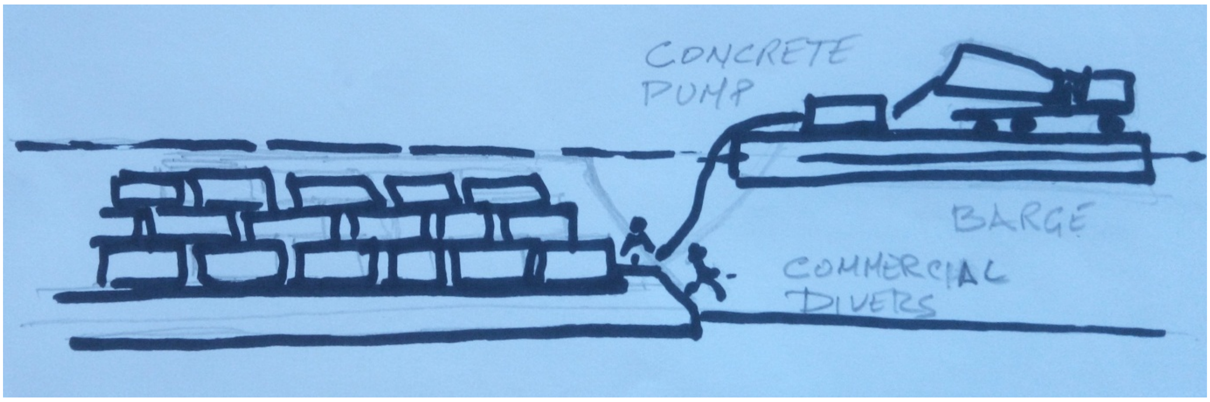


Figure 30: Sketch showing the reinforcement of the structure with concrete.

2.5 ACCESS, TRANSPORTATION, AND RELATED INFRASTRUCTURE

2.5.1.1.1 The sandy beach area is currently accessed by pedestrians through a series of ramps / access steps situated along the entire length of the beach (vide Figure 13). These access points will not be affected during the implementation of the project.

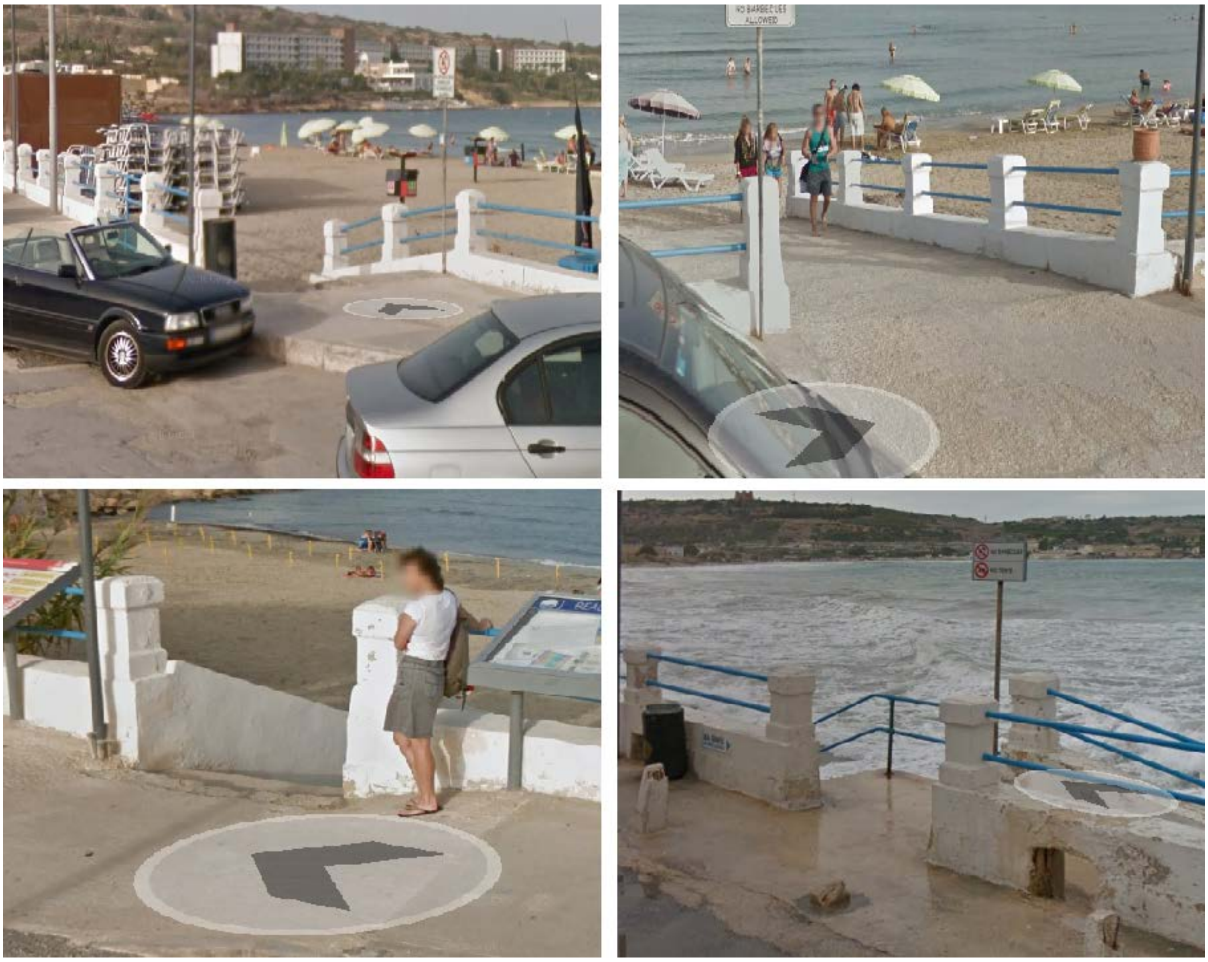


Figure 31: Existing pedestrian access points leading from pavement to the beach

2.5.1.1.2 During the construction phase the front-loading bucket wheel digger, graders and mechanised long reach wheeled excavators will be utilised for the shifting and sculpturing of the sand areas as explained in section 2.4. These machines where possible, will be placed on the sandy beach through the use of a crane in order to eliminate the need for new access points to be constructed / devised.

2.5.1.1.3 Heavy machinery will also be utilised for the construction of the wave deflector. The deflector shall protrude from the Sea Shell Dive Centre, which is located on the southern area of the bay. This location is adequately accessed through Triq il-Marfa as shown in Figure 14.

2.5.1.1.4 The area from which the heavy machinery could operate is committed throughout the year by a number of parked boats on trailers, especially during the winter months (vide Figure 15). During the construction phase of the scheme, these boats must be temporarily removed, while the adjacent slipway must temporarily cease to operate until such time that the project is finalised.

Figure 32: Aerial Photo showing access to construction site from Triq il-Marfa

Figure 33: Photo showing area from which heavy machinery could operate

2.6 WATER, SEWERAGE, RUNOFF MANAGEMENT, ENERGY, TELECOMMUNICATIONS AND ANCILLARY INFRASTRUCTURE

2.6.1.1.1 During the implementation of Phase 1 of the scheme, water, electricity and sewerage service will not be affected in any way, since the proposed works concern the sandy beach area, which is currently easily accessed. Moreover, the extended area of the beach will not, in any way, affect the rainwater run-off management.

2.6.1.1.2 Such issues may only arise upon implementation of Phase 3 of the scheme, and will be addressed through the necessary studies and consultations contemporarily during the execution of Phase 1 and 2.

2.7 WASTE MANAGEMENT

2.7.1.1.1 During the sand replenishment phase, it is not envisaged that any significant waste will be created. However construction waste consisting of rock and debris will be produced during the excavations for the foundations of the wave deflector. As such, a SPD will be utilised to immediately suck the resulting debris and minimise any negative impacts on the surrounding natural environment. A silt curtain will surround the area where works will be effected.

2.8 LONGER-TERM DEVELOPMENTS

2.8.1.1.1 Longer-term developments are being devised, which seek to limit eventual erosion and promote inward migration of the sand dunes. The longer-term developments being devised mainly relate to Phases 2 and 3 of the scheme. As highlighted in Chapter 2, the projected works include the construction of submerged wave deflectors and the erection of an elevated dual carriageway under which the inward progression of the sand dunes can occur.

2.8.1.1.2 Other environmentally sustainable beach nourishment methods are also being explored, such as the use of Undercurrent Stabiliser Technology (UST), which has been proven to routinely reverse unnatural erosion. These will probably form part of the studies that will be carried out as part of Phase 2 of the scheme.

3 ASSESSMENT OF ALTERNATIVES

3.1 Alternative sites

3.1.1.1.1 Similar projects within other bays around the Maltese Islands have already been implemented during the last decade. However, it was determined that the project at Ghadira Bay is given priority due to social, economic and environmental issues, mainly;

- as highlighted in chapter 2, Ghadira Bay is one of the most sought after beaches in Malta due to its relatively large sandy area, easily-accessible nature and activities offered. Therefore Ghadira Bay was prioritised since it is more susceptible to overcrowding;
- it was noted during initial stages that the Posedonia Oceanica meadows are located relatively far away from the shoreline when compared to other beaches. This facilitated and encouraged fast-tracking of the process;
- as highlighted in chapter 2, longer-term developments are being shaped for Ghadira Bay. Therefore it is essential that this project is fast-tracked so that further development may commence after the end of summer months. These future developments will ensure that the beach is protected during the winter months and reduces the risk of beach erosion;
- Ghadira Bay is home to a number of businesses (water sports, restaurants, lidos, etc.) which may be hampered by development which is carried out during summer months;

3.1.1.1.2 Instead of extending the shoreline outwards, the carrying capacity of the beach can be increased thorough the demolition of existing facilities and the access road (Triq il-Qammieh).

3.1.1.1.3 Loss of facilities along the seashore of Ghadira bay will imply that the beach will lose its attractiveness since patrons will not be able to service themselves adequately. This will increase pressures on other sandy beaches; therefore shifting pressures on beaches which to date have

3.1.1.1.4 Triq il-Qammieh, is considered a major link between Malta and the Island of Gozo and its closure would lead to significant transport and traffic issues. In particular closure of this road would require that a new road will be created. Alternative sea ports would have to be created in order to facilitate links between mainland Malta and the island of Gozo. The bays to the north of Ghadira bay would also be closed off with the consequent loss of a number of hotels and tourist related facilities. Furthermore, this alternative method would lead to a significant reduction in facilities which contribute to Ghadira Bay's magnetic effect on tourists and locals.

3.2 Alternative technologies

3.2.1 Mechanical Dredging

Figure 34: Mechanical Dredging Bucket

3.2.1.1 *Bucket Dredging and Grab Dredging*

3.2.1.1.1 Mechanical dredging refers to the use of heavy mechanical machinery in order to dig up the sea bottom and transfer it to another location (vide Figure 20). This equipment is usually brought in on a barge, towed by specialised boats / ships. The equipment used can be very similar to that of residential construction equipment where a bucket is used to scoop and haul up sediment. There are also specialized pieces of equipment that are used to drill or dig up the dirt on a more continual basis.

3.2.1.1.2 Bucket dredgers usually consist of a chain of buckets that fill while scraping over the bottom. The buckets are turned upside down and empty moving over the tumbler at the top. The dredged material is loaded in barges (vide Figure 21). A grab dredger picks up seabed material with a clam shell bucket, which usually hangs from an on-board crane or a crane barge (vide Figure 22).

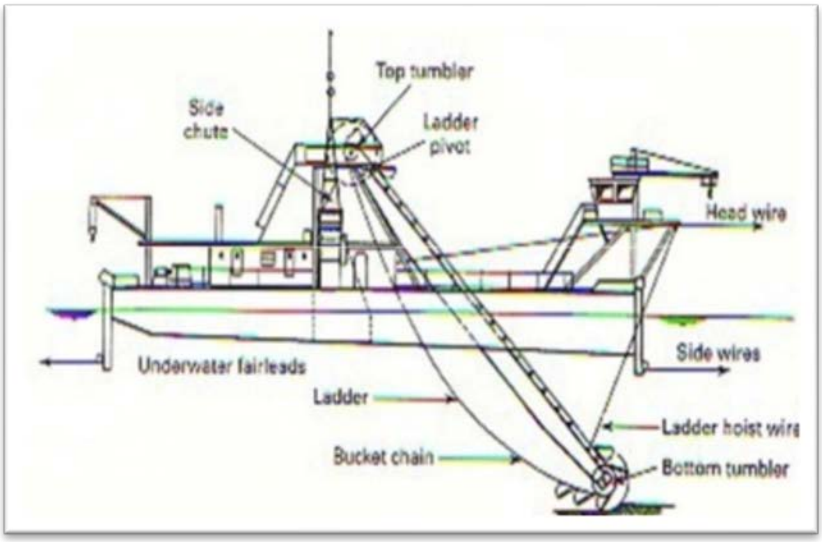


Figure 35: Typical bucket dredging technique

Figure 36: Typical grab dredger with clam shell bucket

3.2.1.2 *Reasons for elimination*

3.2.1.2.1 These methods raise several concerns which render them unsuitable for the proposed project, mainly since;

- the bucket will scoop up all sediment within the area, which may lead to adverse impacts on sedimentary biota and underwater flora and fauna;
- any harmful substances or contaminants located just beneath the seabed may be brought up and dispersed throughout the area, thus leading to adverse impacts on sedimentary biota and underwater flora and fauna;
- the barges used for the transfer of machinery to the proposed location may be mechanically drilled to the sea bottom to ensure stability. This leads to the total destruction of the benthic habitat within the area;
- large rocks located further out in the bay act as a protection to the sandy beach near the shore. These large rocks may be scooped up as well, thus reducing beach protection. Consequently, the sandy beach may be subject to a faster erosion process.
- This process generates significant amounts of fines and therefore increases turbidity etc. adversely effecting adjacent sea habitats.

3.2.1.2.2 In view of the issues highlighted above, mechanical dredging should not be utilised since this process may be of severe detriment to the benthic environment.

3.2.2 Alternative Hydraulic Dredging

3.2.2.1 *Cutter-suction*

3.2.2.1.1 A cutter-suction dredger's (CSD) suction tube has a cutting mechanism at the suction inlet. The cutting mechanism loosens the bed material and transports it to the suction mouth. The dredged material is usually sucked up by a wear-resistant centrifugal pump and discharged either through a pipe line or to a barge. Cutter-suction dredgers are most often used in geological areas consisting of hard surface materials (for example gravel deposits or surface bedrock) where a standard suction dredger would be ineffective. In recent years, dredgers with more powerful cutters have been built in order to excavate harder rock without the need for blasting.

Figure 37: Typical Cutter-Suction Dredger

3.2.2.2 *Auger-suction*

3.2.2.2.1 This process functions like a cutter -suction dredger, but the cutting tool is a rotating Archimedean screw set at right angles to the suction pipe. Auger dredgers are used for a wider variety of applications including river maintenance and sand mining.

Figure 38: Typical auger suction equipment

3.2.2.3 *Reasons for elimination*

3.2.2.3.1 These methods raise similar issues to those related by mechanical dredging, mainly since;

- the augur, cutting and trailing equipment will obliterate the sea floor, which may lead to adverse impacts on sedimentary biota and underwater flora and fauna;
- any harmful substances or contaminants located just beneath the seabed may be brought up and dispersed throughout the area, thus leading to adverse impacts on sedimentary biota and underwater flora and fauna;
- the barges used for the transfer of machinery to the proposed location may be mechanically drilled to the sea bottom to ensure stability. This leads to the total destruction of the benthic habitat within the area.

- o this process generates significant amounts of fines and therefore increases turbidity etc. adversely effecting adjacent sea habitats.

3.3 Downscaling of the project, or elimination of project components

3.3.1.1.1 As highlighted in chapter 2, the sand must be deposited in layers in a way which respects the existing slope gradient, so as to maintain the current equilibrium between erosion and accretion of sand.

3.3.1.1.2 Should the project be downscaled and the proposed extension of the beach is reduced, the sand will be deposited on a smaller area, thus increasing the slope gradient (vide Figure 25). This will lead to larger waves reaching the shoreline, which might result in the undesired scenario where the newly placed sediment is dragged back offshore to re-establish a profile similar to that which exists today.

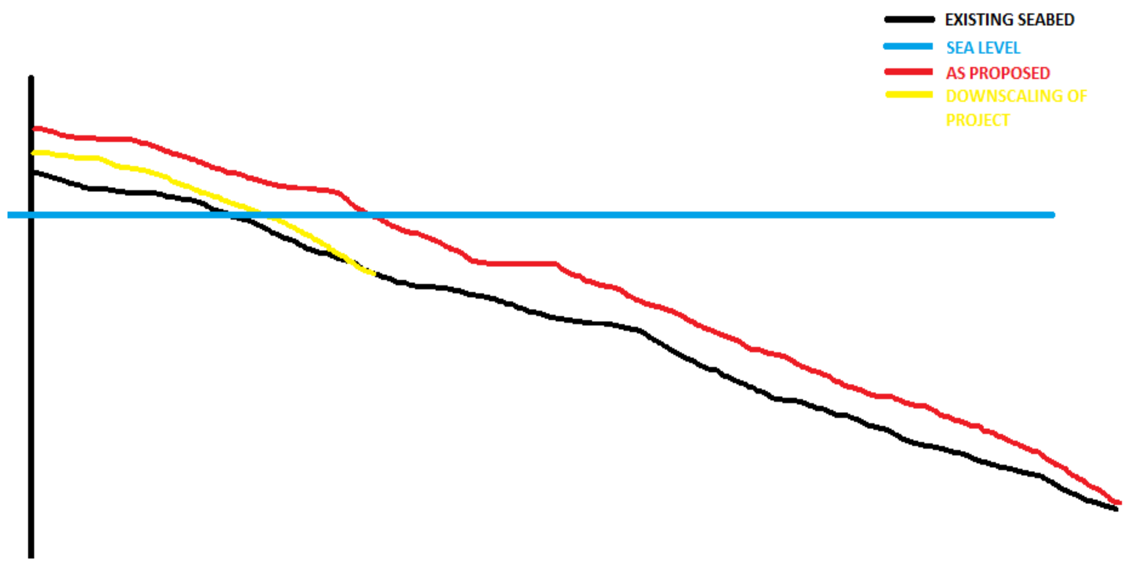


Figure 39: Sketch showing difference in slope gradient between the proposed and downscaled deposition of sand

3.4 Zero-option (do-nothing scenario) – i.e. an assessment of the way the site would develop in the absence of the proposed project

3.4.1.1.1 As highlighted in the Feasibility Study conducted by CTB Ltd., it is highly likely that the Ghadira Bay sandy beach is in a state of equilibrium between erosion and accretion of sand. Therefore, should the project not be carried out, it can be concluded that any significant changes to the current shoreline will only take place gradually (if at all), and it is foreseen that no sudden changes will take place.

3.4.1.1.2 However several other natural / human-induced factors may contribute to a slow degradation process of the beach such as:

- Sea level rise: which can be a significant contributor to a changing shoreline since the sea depth, sediment size, wave heights and periods are intrinsically linked.
- Slope processes: includes a wide range of land and sea interactions which result in the collapse, slippage or topple of coastal cliff blocks. These processes involve rainfall, water seepage and soil weathering.
- Vertical land movements: may include tectonic movement or sediment settlement. It may have both positive impact and negative impact on coastline evolution.
- Removal of vegetation: removal of vegetation from coastal areas may lead to a change in land cover patterns and beach erosion processes.
- Cleaning of the bay: During late spring / early summer, the beaches are cleared from the clusters of dead Posedonia leaves which accumulate in winter. When these leaves are gathered, a

considerable amount of sand may be picked up and transported elsewhere.

3.4.1.1.3 Further to the above, it is envisaged that in the absence of the proposed project, the sandy beach shoreline will gradually migrate inwards over a number of years / decades.

3.4.1.1.4 The do nothing option will lead to further degradation of the bay since the carrying capacity of the beach is nearing its limit especially during peak time in summer. It is necessary that in order for the beach to keep on functioning appropriate management procedures are in place. Extending the beach in an environmentally friendly manner will have the least impact on the existing activities taking place in the area.

3.5 Hybrids / Combinations of the above

3.5.1.1.1 The chosen methodology is aimed at providing environmentally sustainable methods for the proposed beach replenishment. All the alternative technologies mentioned above are envisaged as having an adverse effect on the natural environment, and are thus being eliminated. Moreover, these technologies require different procedures and different access arrangements which render them unsuitable for the completion of the project within the given timeframe. Given the environmental sensitivity of the site in question, minimal interference is being sought in terms of the access points being provided and the implementation of the project itself.

4 Environmental Baseline and Potential Impacts and Mitigation measures

4.1 Marine Ecology

4.1.1 Overview

4.1.1.1.1 A preliminary marine ecological assessment has been carried out by a qualified marine biologist (Annex 3). This will be followed by a detailed study which is currently being drafted. A site visit was also carried out in order to compile a preliminary list of species within the area.

4.1.2 Ecological Survey

4.1.2.1.1 The ecological assessment highlights that Sea grass cover in the bay consists of both fragmented and continuous *Posedonia Oceanica* beds. In shallow waters (2 – 4 m), *P. Oceanica* occurs as small patches of varying size while in deeper waters (5 – 10 m), the patchy stands were often replaced by reticulate beds. Moreover, vegetation belonging to the *Cymodocea nodosae* is present in several places within the study area as mono specific stands. It was also observed as small patches amongst the *P. Oceanica* meadows in several areas.

4.1.2.1.2 The preliminary study states that an impoverished fauna is exhibited within the shallow areas. In fact, only 15 different species were observed during the visit. These species were listed in Table 1 of the report (Annex 3).

4.1.3 Mitigation Measures

4.1.3.1.1 Preliminary observations indicate that impacts to the ecology of the area are expected to be low and direct loss of benthic habitats should be insignificant. However, the study emphasises that the sand replenishment methodology to be adopted should be as such as to limit the disturbance to the marine environment.

4.1.3.1.2 The study also suggests that a buffer zone of minimum 20 metres away from *P. Oceanica* meadows should be maintained from the dredging site to ensure no damage is carried out to this ecosystem. Monitoring of the marine environment following the beach replenishment works should be carried out using *P. Oceanica* as a biological indicator.

4.1.3.1.3 Moreover, the long-term solutions being proposed in the project description statement should reduce the need for continuous replenishments, thus allowing adversely affected marine species to re-colonise the affected area without future detrimental interventions.

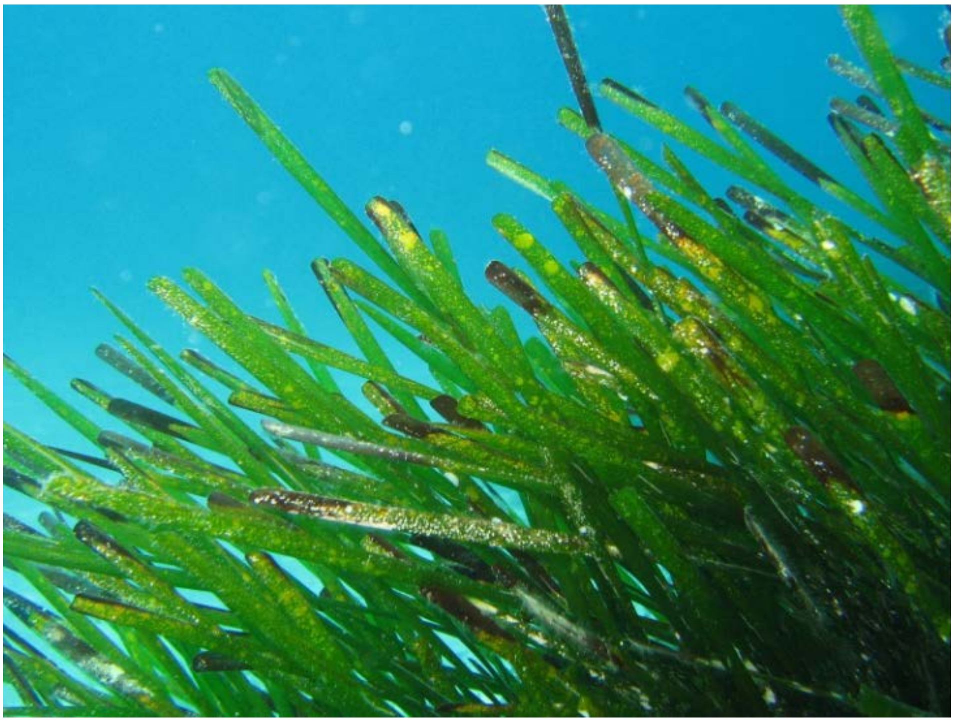


Figure 40: Photo of *Posedonia Oceanica*

4.2 Noise and Vibrations

4.2.1 Impacts

4.2.1.1 Most of the works will be carried out at sea, while the construction material required for the wave deflector shall be transported by the MCTB. Therefore the projected vibrations are expected to be minimal.

However, the sand dredging process and the construction of the wave deflector are expected to give rise to some noise emissions.

4.2.2 Mitigation Measures

4.2.2.1 The following mitigation measures are being taken in hand:

- The construction phase shall be carried out, and concluded, before summer. Therefore the works are to be carried out during periods which minimally impact the current users;
- There will be noise attenuators on all dredging and pumping activities located at sea. These will be put in place in order to ensure that there will not be a higher noise level than 45dBA;
- Sand will be pumped during the night to the predetermined sand pits;
- During the morning all the preparatory works are to be put in place. These are to include the installation of silt curtains and protection booms. Furthermore, the land areas are to be sealed off in order to ensure that no unauthorised persons approach the site;
- Adequate monitoring on land and sea is to be put in place;
- Land operations, which will require the use of heavy land-based machinery, will take place early in the morning in order to reduce the impact on the surrounding habitats, especially those at Ghadira Natural Reserve;

- Sculpturing of the seabed will also take place during the early morning;
- The construction works relating to the wave deflector will be made during the day and all works will primarily be accessed from the sea.

4.3 Bathymetry

4.3.1 Impacts

4.3.1.1.1 The sand replenishment works to be carried out will result in changes to the existing bathymetry of the bay. This may lead to adverse effects on the sand erosion vs accretion processes, mainly since the waves will approach the advanced shoreline before sufficient dissipation of the wave / current energy has occurred.

4.3.2 Mitigation Measures

4.3.2.1.1 The deposition of the sand will be carried out in a way which retains, more or less, the same slope gradient. This encourages earlier dissipation of wave energy and enables the beach to retain the existing equilibrium between erosion and accretion.

4.4 Water Quality

4.4.1 Overview

4.4.1.1.1 Turbidity is the measure of relative clarity of a liquid. It is an optical characteristic of water and is an expression of the amount of light that is scattered by material in the water when a light is shined through the water sample. The higher the intensity of scattered light, the higher the turbidity. Materials that cause water to be turbid include clay, silt, finely divided inorganic and organic matter, algae, soluble coloured organic compounds, plankton and other microscopic organisms. High concentrations of particulate matter affect light penetration and productivity, recreational values and habitat quality

4.4.2 Impacts

4.4.2.1.1 During construction phase, it is expected that sea water turbidity is temporarily affected, mainly through the suction and pumping process of the suction dredger.

4.4.3 Mitigation Measures

4.4.3.1.1 Water turbidity tests will be carried out before and after construction phases through a certified lab. The water turbidity will be constantly monitored and the project may be adapted accordingly.

4.4.3.1.2 During the excavations for the concrete base of the wave deflector, a suction pump dredger will be utilised in order to immediately suck the excavated rock and debris.

4.4.3.1.3 The bay will be allowed a settling period, during which the loosened sediment is allowed to resettle and water turbidity is naturally restored to the original level.

4.4.3.1.4 Silt curtains and protection booms are to be utilised through the implementation of the proposed works in order to trap or contain the resulting debris and limit the adverse impact on the natural environment.

4.5 Health and Safety Considerations

4.5.1.1.1 All necessary Health and Safety precautions and procedures shall be adopted throughout the execution of the works, which shall include but may not necessarily be limited to;

- Personnel will be deployed on a 24/7 roster in order to ensure that proper Health and Safety procedures are in place and the site is secure;
- A qualified First Aider is to be on site at all times, with access to a first aid kit;
- Appropriate facilities for the workers are to be provided both at sea and on land;
- If any diving inspections are being carried out, the dredging machinery should not operate within a 50m radius of the diving inspections;
- The land and sea areas where the works will be carried out will be cordoned off and appropriate security and surveillance monitoring put in place;
- In case of stormy weather (especially strong north-easterly winds), the dredging works shall be temporarily paused and the sand dredger and marine equipment towed to a safe berth until weather conditions improve.

4.6 Monitoring

4.6.1.1.1 The project will be constantly monitored in order to ensure that the limits set are respected during construction. The baseline studies as well as the 3D model are to be followed in order to ensure that minimal impact on the environment. The monitoring programme will take place by an independent environmental monitor who will report to the client, ERA and PA.

4.6.1.1.2 Prior to commencement of works sound, vibration, turbidity and ecological baseline data will be obtained through appropriately established studies.

4.6.1.1.3 There will be put in place a sound monitor at Ghadira natural reserve. The sound levels at Ghadira natural reserve are to be set after due consideration to the species inhabiting the area is given. The sound monitoring is to be on a 24/7 basis and operations will have to be stopped if agreed limits are exceeded. This is particularly relevant since night operations are not being excluded given the tight dead line.

4.6.1.1.4 Turbidity monitoring will take place during the works on site and will involve periodic readings at specified locations along the Posedonia Oceanica meadows buffer zone, as well as within the particular precincts where works are taking place during the particular project phase. Once the base line is made the limits can be set.

4.6.1.1.5 Sample areas of Posedonia Oceanica meadows will be monitored on a weekly or biweekly basis in order to ensure that the works carried out do not adversely affect their natural habitat.

4.6.1.1.6 Use of 1m sampling locations will be put at the seabed in order to monitor the flora and fauna of the particular area. These will be monitored throughout the works as well as before and over a period of years once the works are completed.

5 CONCLUSION

5.1.1.1.1 The project as depicted will provide a long-term, environmentally sustainable solution to the sandy beach replenishment at Ghadira Bay. The environmentally sensitive nature of the area is being taken into consideration and will be prioritised during the implementation of the project. It is envisaged that the environmental, social and economic benefits of the proposed development will outweigh any environmental impacts. Moreover, the long-term solutions being proposed will encourage inward sand dune migration and reduce the need for continuous replenishments, thus allowing adversely affected marine species to re-colonise the affected area without future detrimental interventions.

5.1.1.1.2 This is to be seen as an initial phase of a much longer and larger scheme. The aim of allowing the sand dunes and the sand dune communities to flourish and migrate inwards is to be considered an asset.

APPENDIX A

3D MODEL ANALYSES
GRAPHICAL REPRESENTATION OF GHADIRA BAY

1 INTRODUCTION

1.1 Preamble

1.1.1.1.1 This graphical representation of Ghadira Bay has been prepared for Projects Plus Ltd. and is to form part of a Project Description Statement [PDS] being submitted to the Planning Authority [PA] as part of Development Application PA 1820/18 - *Sand replenishment of Ghadira Bay, including the construction of a wave deflector and related marine works*.

1.2 METHODOLOGY

1.2.1.1.1 The following 3D Models and graphical representations have been derived through data taken from LiDAR, which is accessed and available to the general public through the PA website.

1.2.1.1.2 A series of 19 transects (North to South) have been identified and listed as shown in Figure 1. The exact coordinates of these transects were inserted into the LiDAR data model, which provides accurate 3-dimensional information (x,y,z axes), mainly the exact coordinates (UTM model) and the height above / below sea level (in metres).

1.2.1.1.3 These models were then utilised for the creation of a 3D model of the Ghadira Bay seabed. 10m x 10m grid squares were superimposed on the 3D model in order to determine the exact locations and areas.

1.2.1.1.4 The 3D model analysis establishes and clearly identifies the location of Posedonia. The exclusion buffer zone was then identified and the "Safe Zone" dredging locations established. The areas committed by the protected species *Posedonia Oceanica* were indicated in a light brown colour and a 30m exclusion buffer zone was indicates in green. Moreover, the red buffer indicates a sea depth of 2m. The models aim at providing an accurate representation of the ideal dredging areas enclosed between the red and green buffers. In fact, Figure 2 indicates that the ideal dredging areas exceed **80,000m²**.

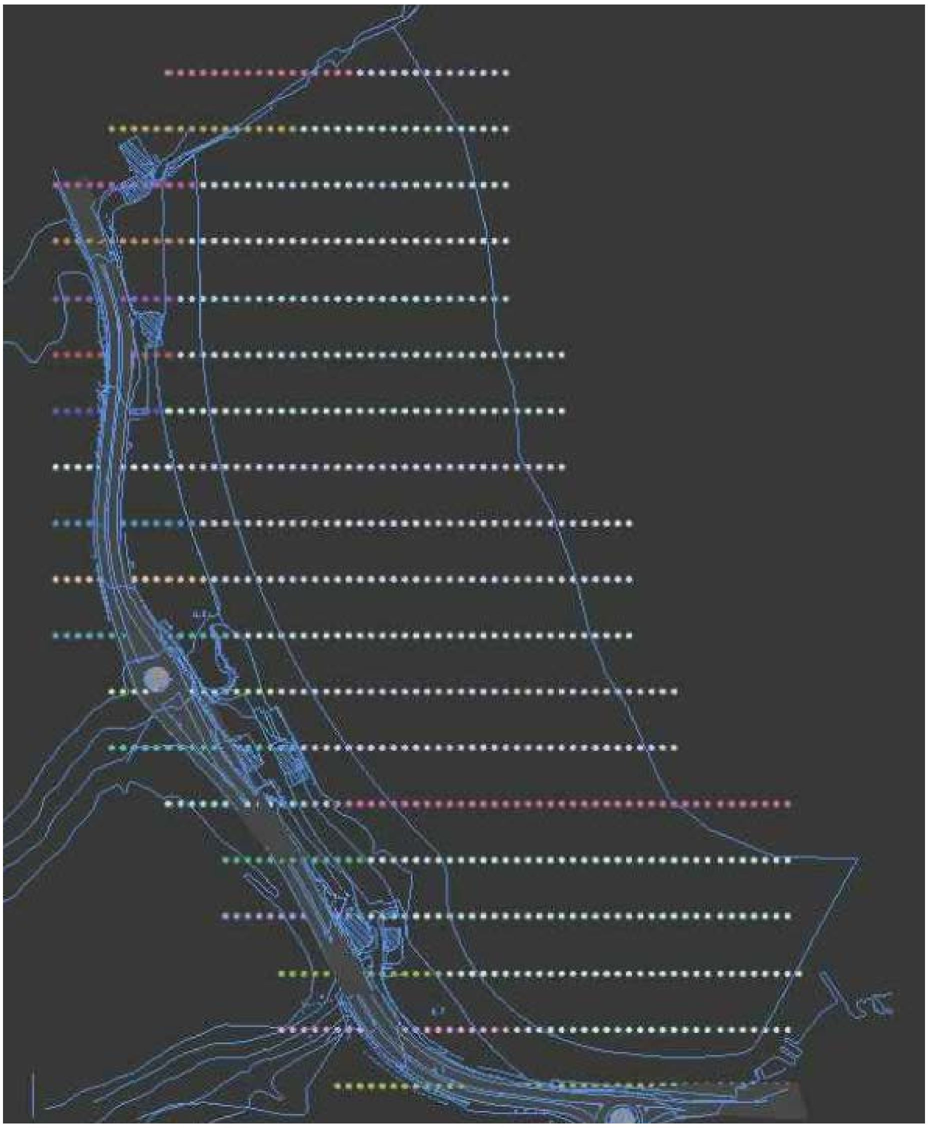


Figure 1: Image showing transects 1-19 (north to south)

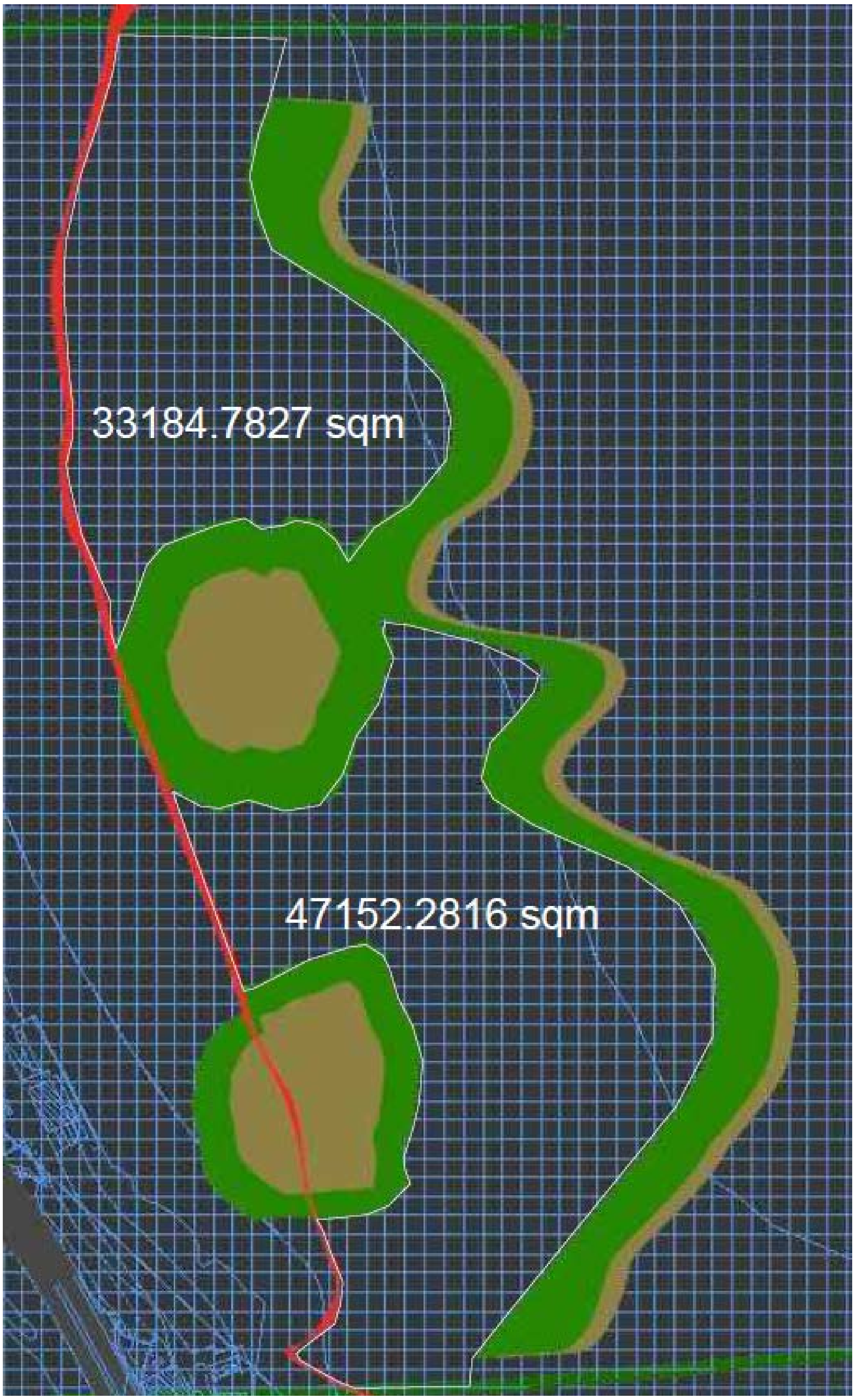
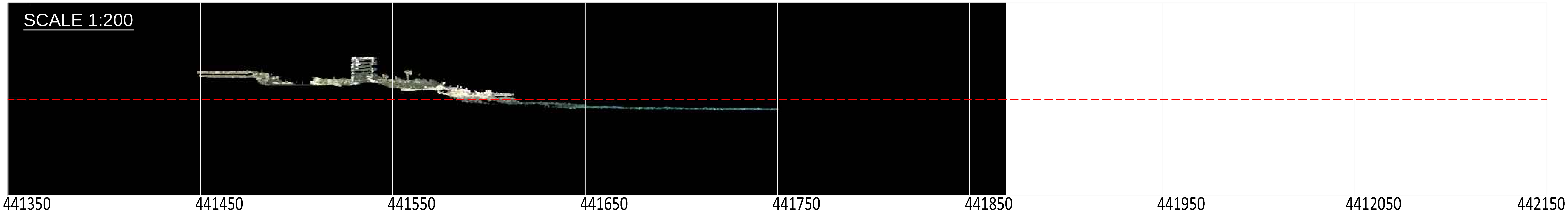
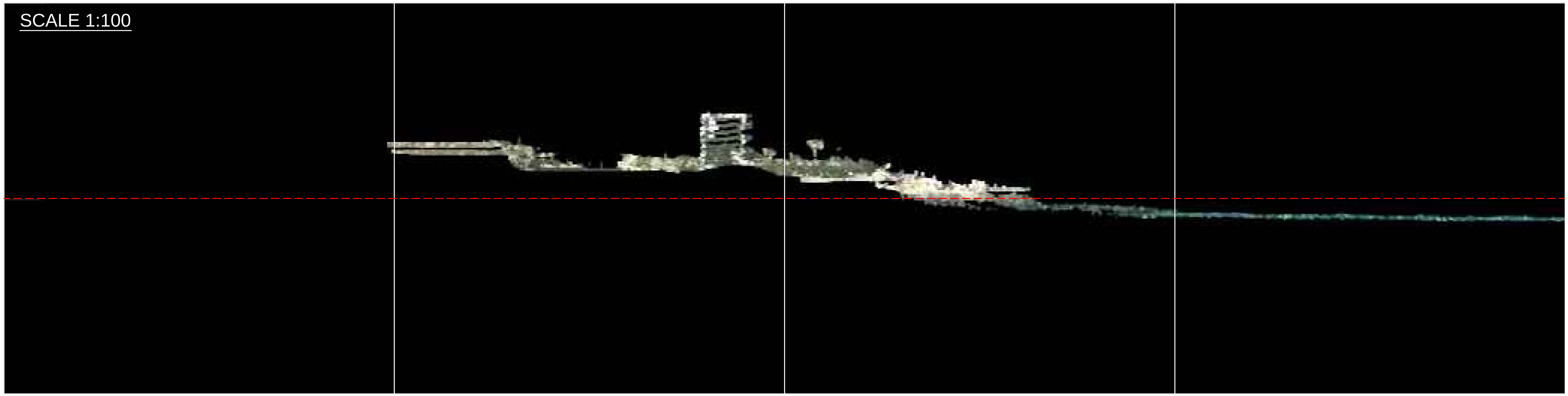


Figure 2: Image showing resulting areas ideal for dredging

2 TRANSECTS TAKEN FROM LiDAR DATA

2.1.1.1.1 Scaled models of the nineteen (19) transects taken from LiDAR data are being provided. Each point of each transect identifies the height (or depth) above / below sea level as well as the UTM coordinates.





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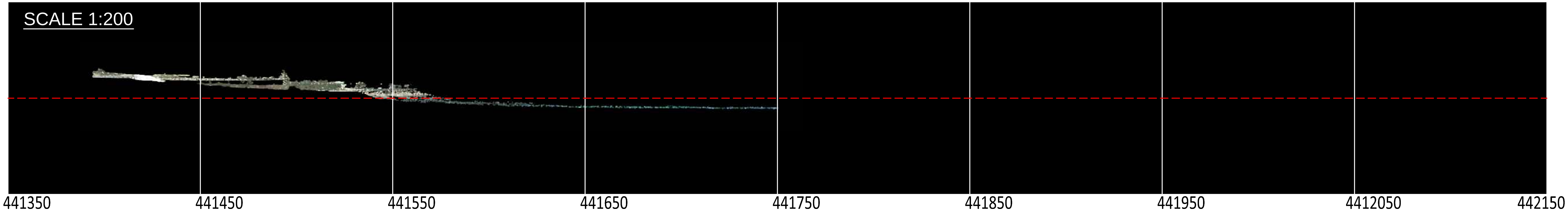

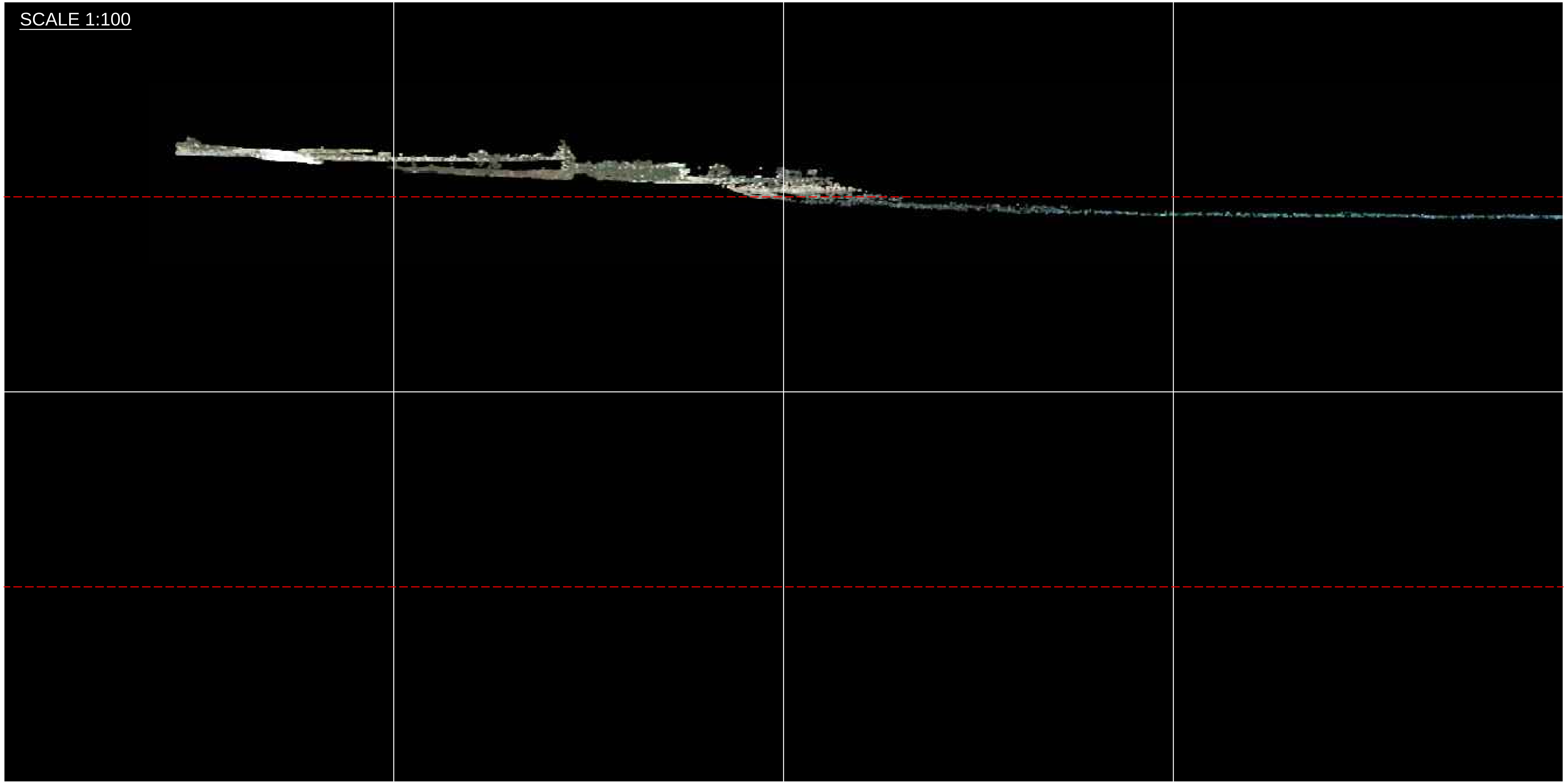

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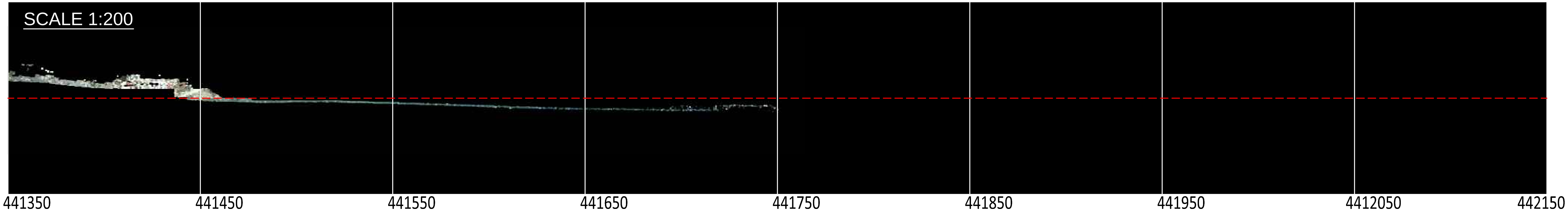

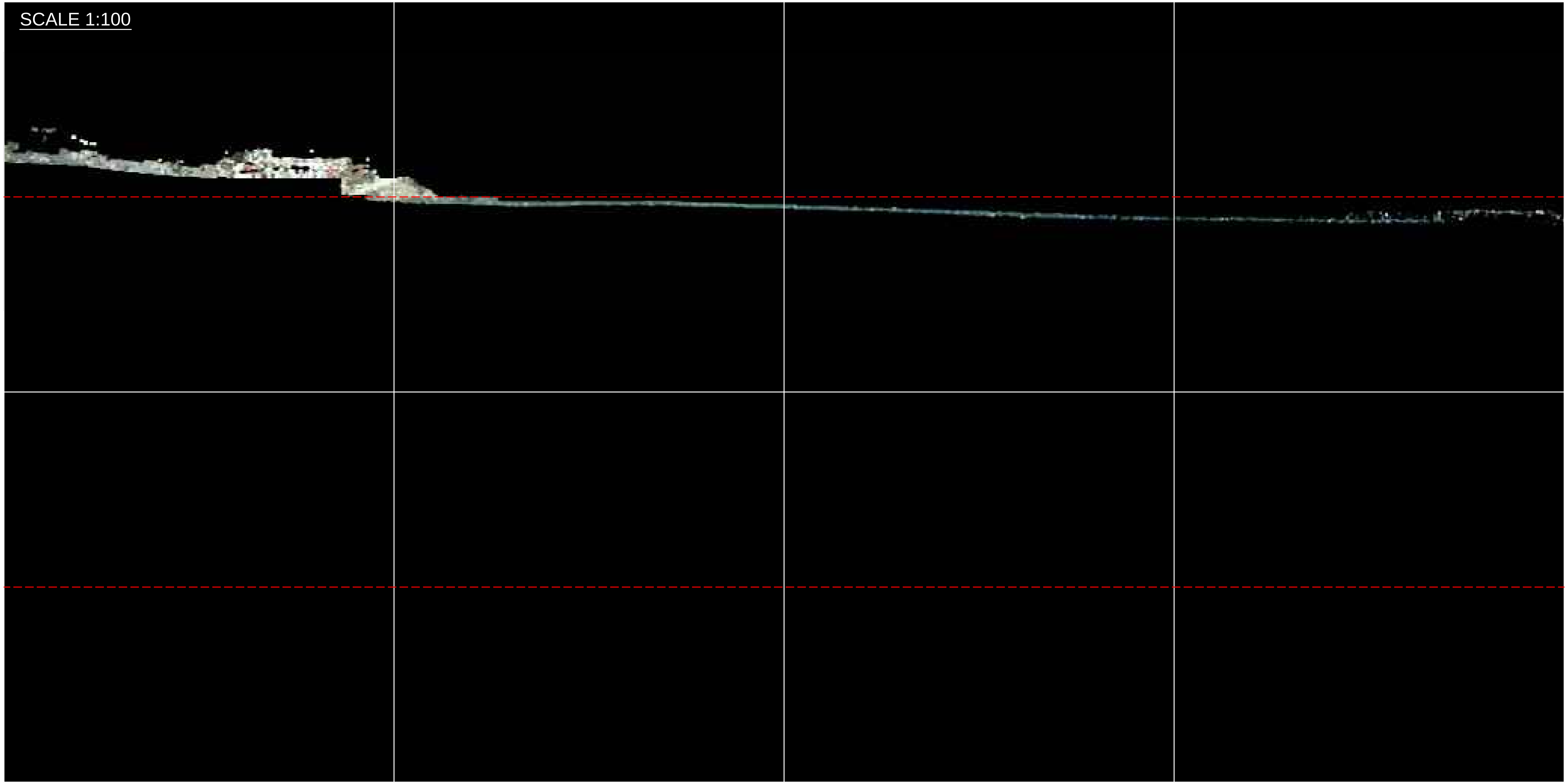

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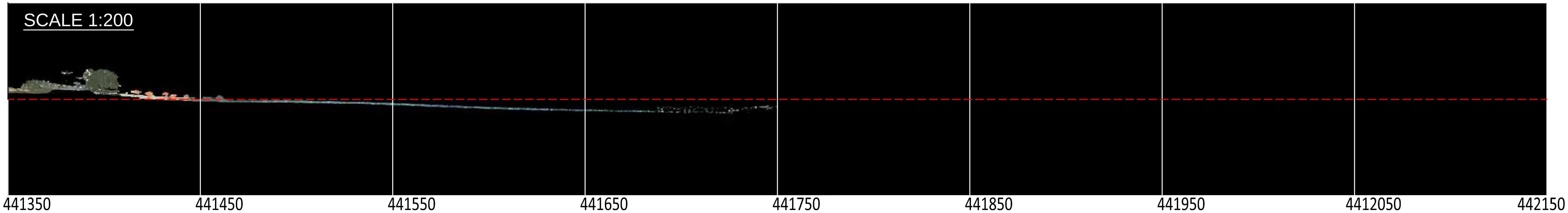

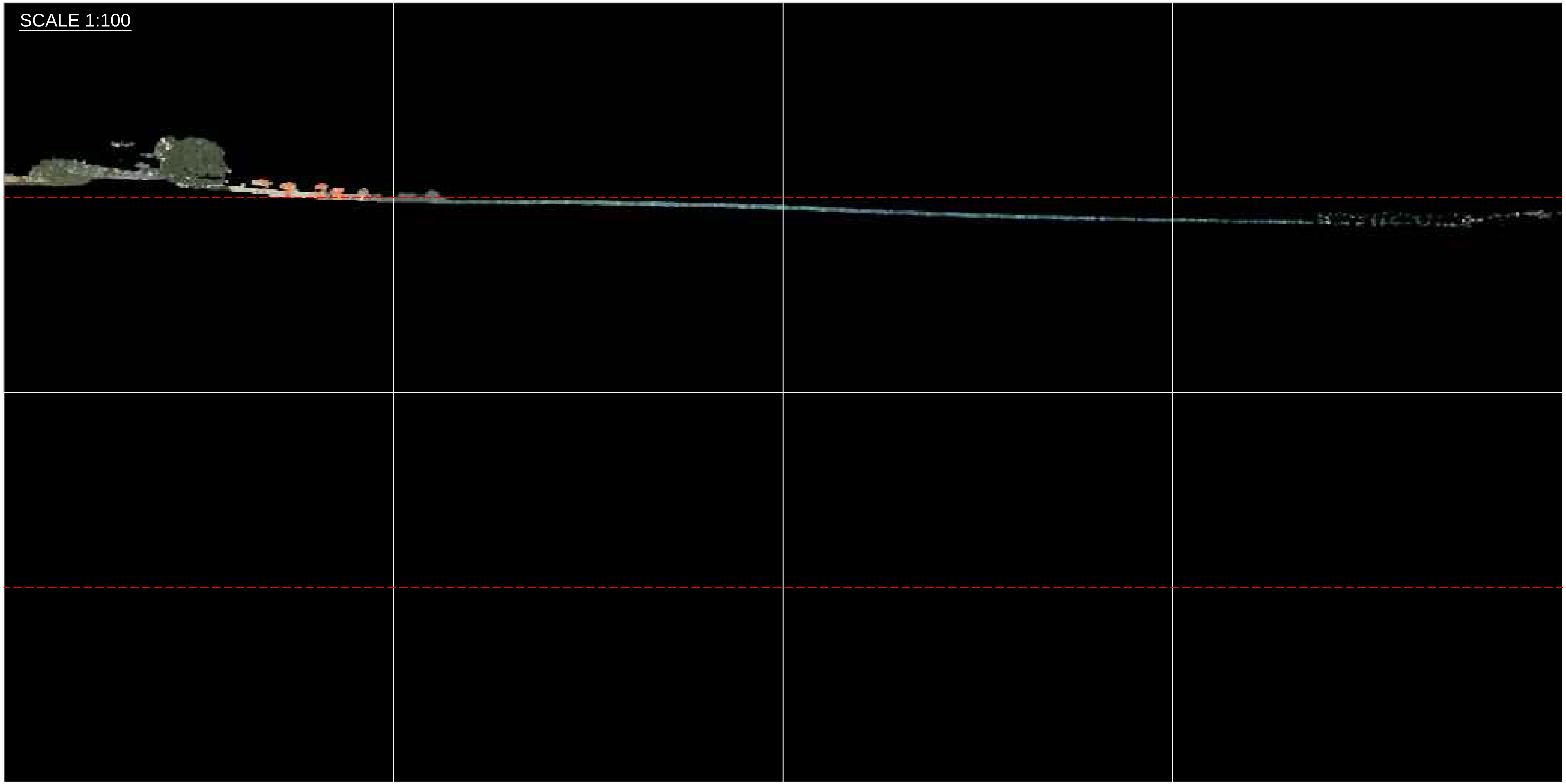

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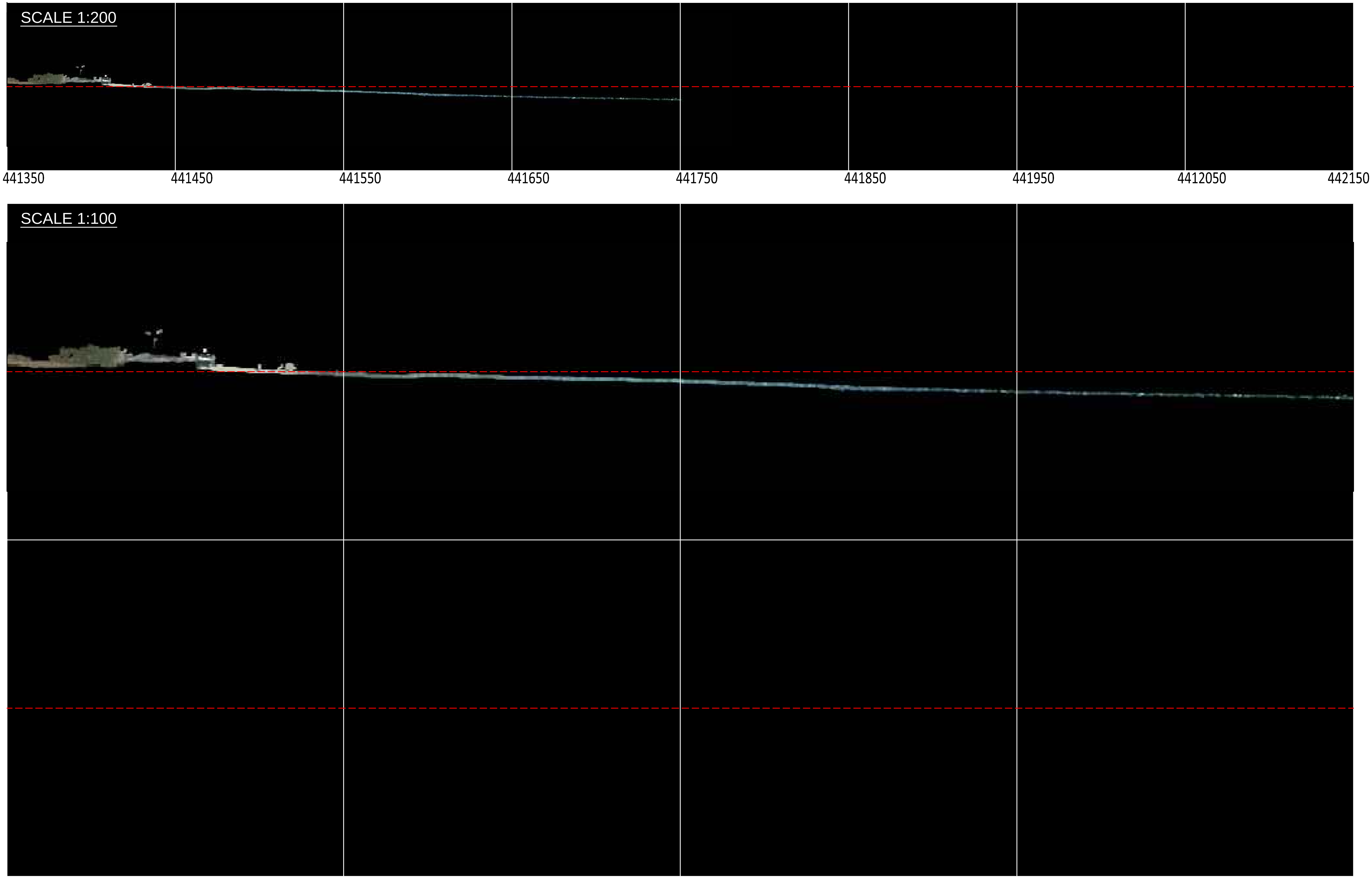

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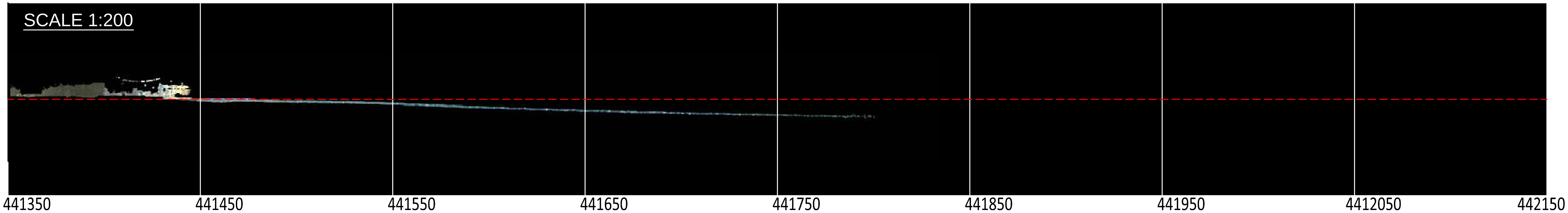

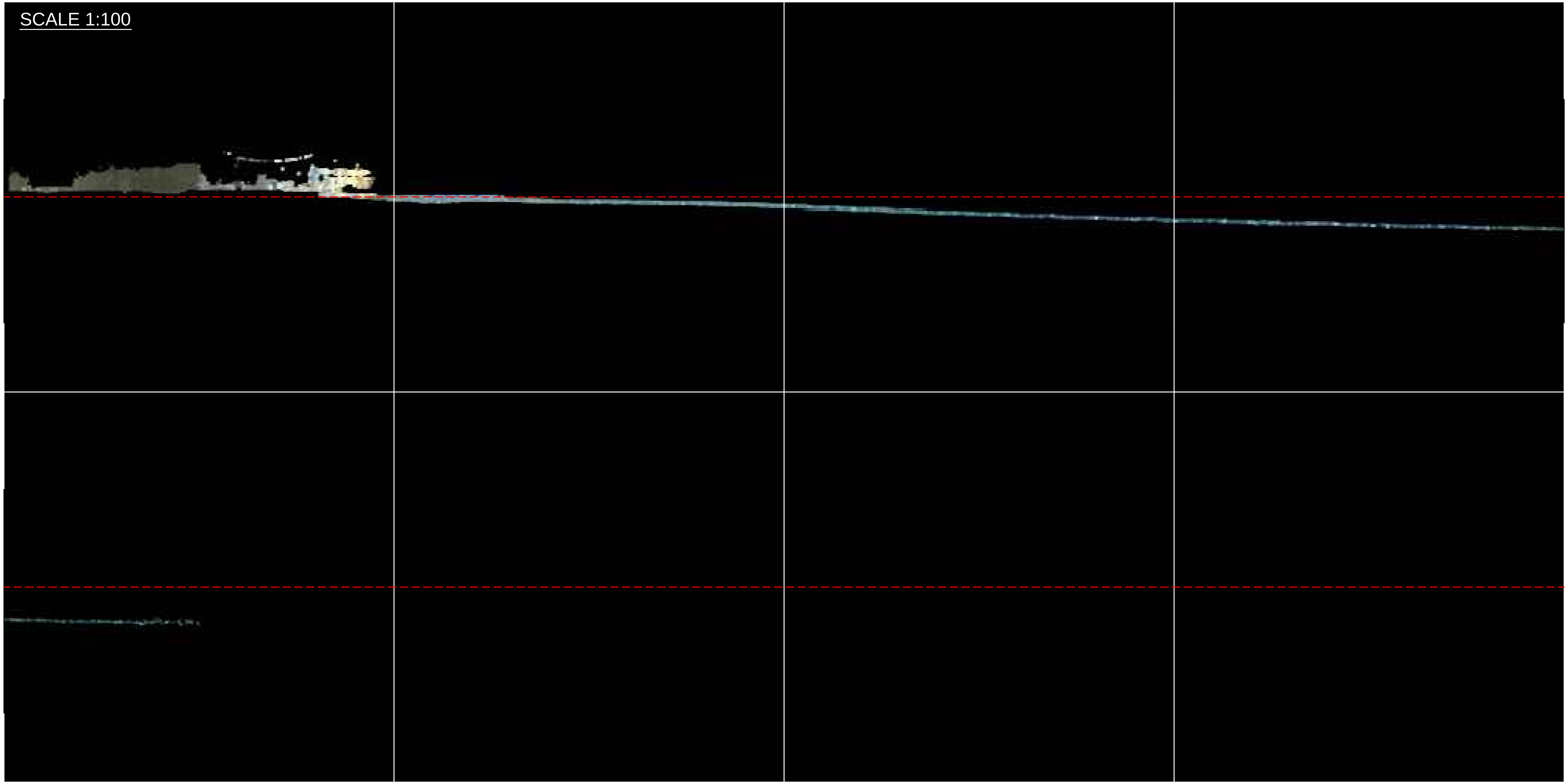

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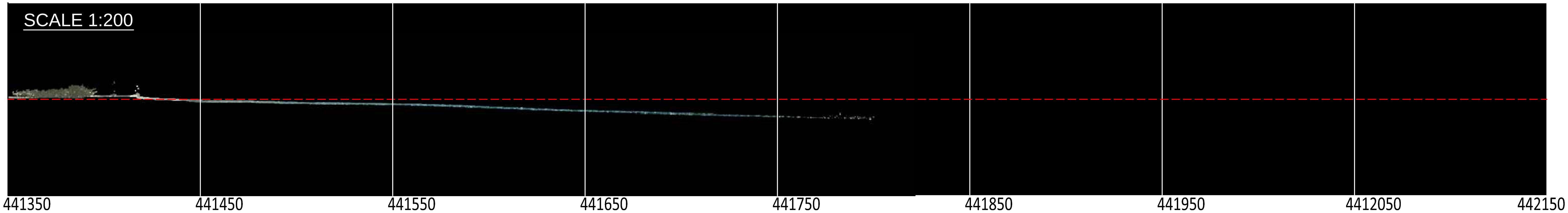

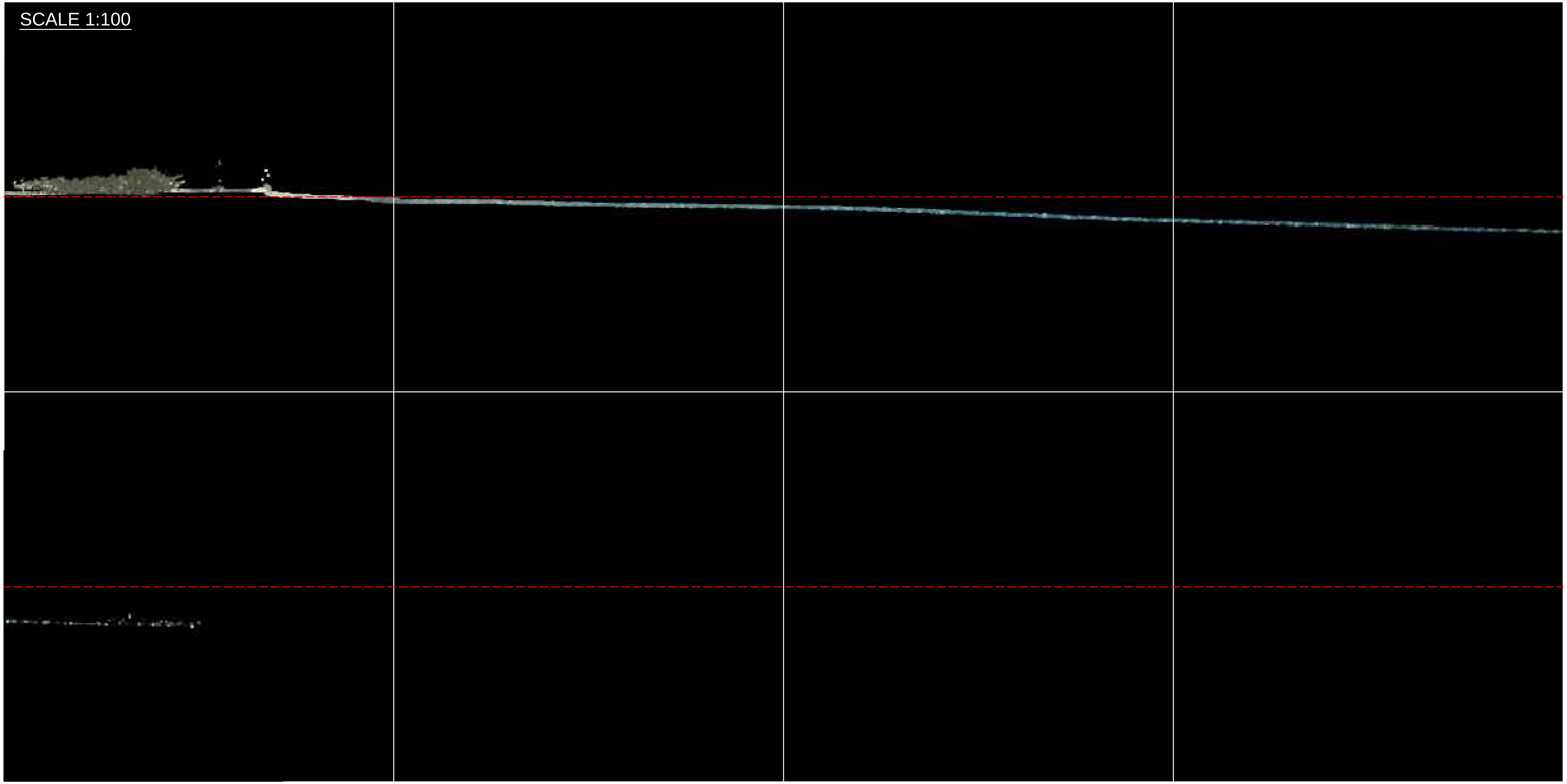

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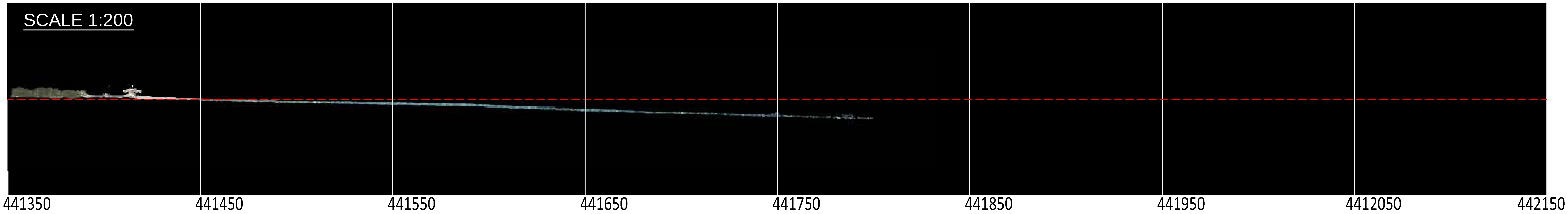

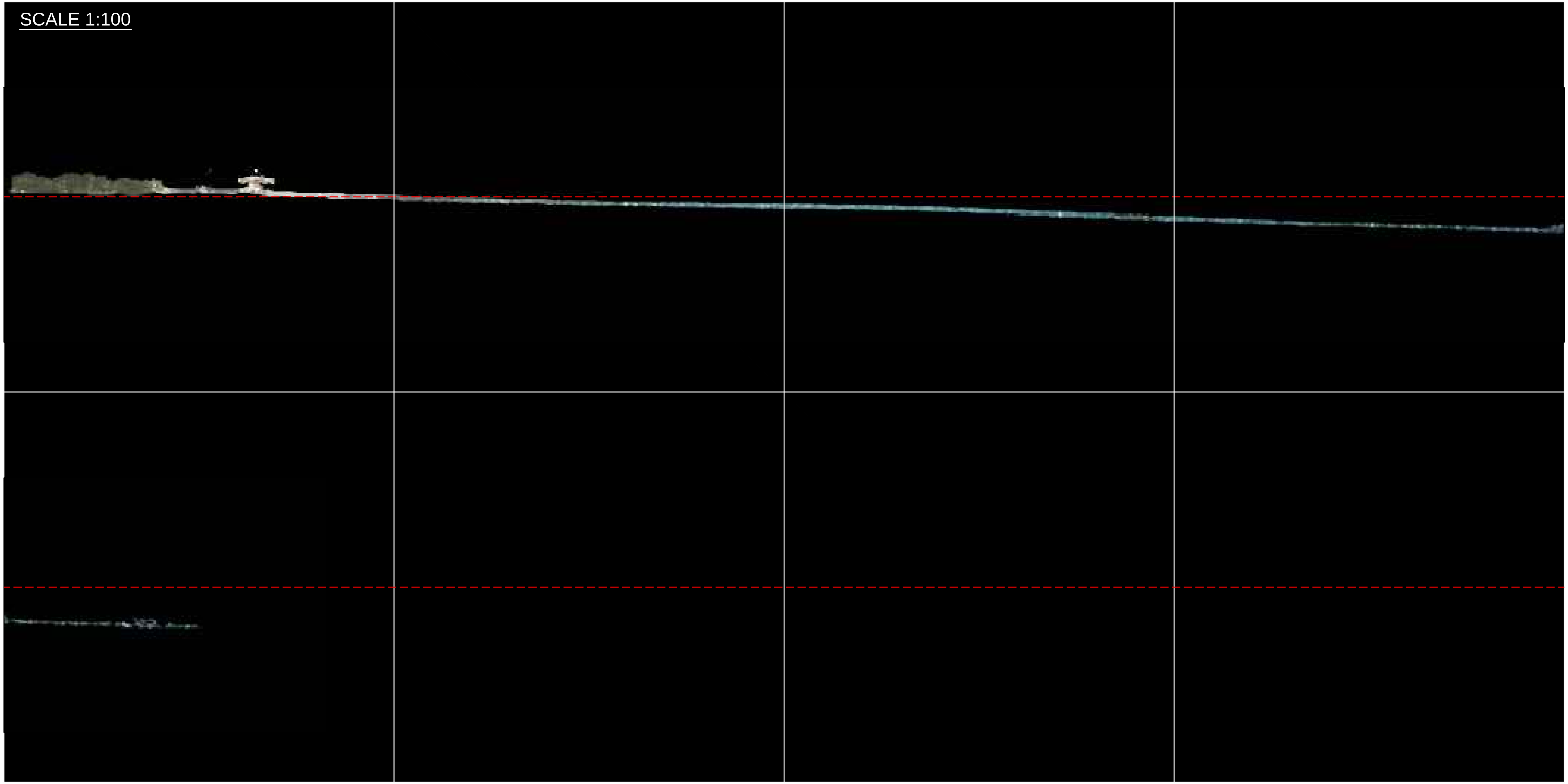

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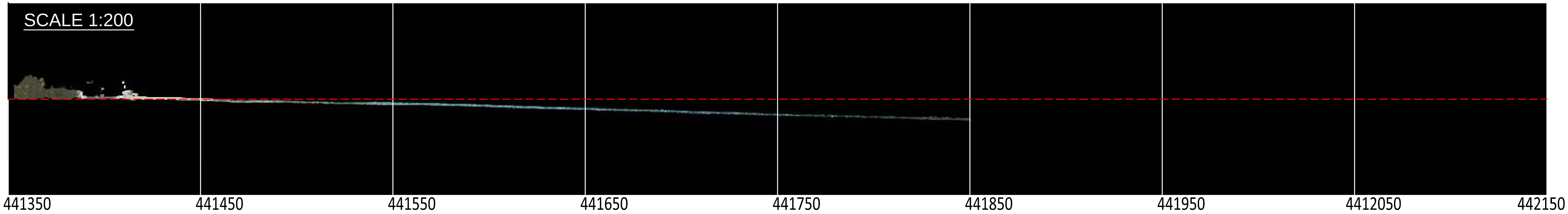

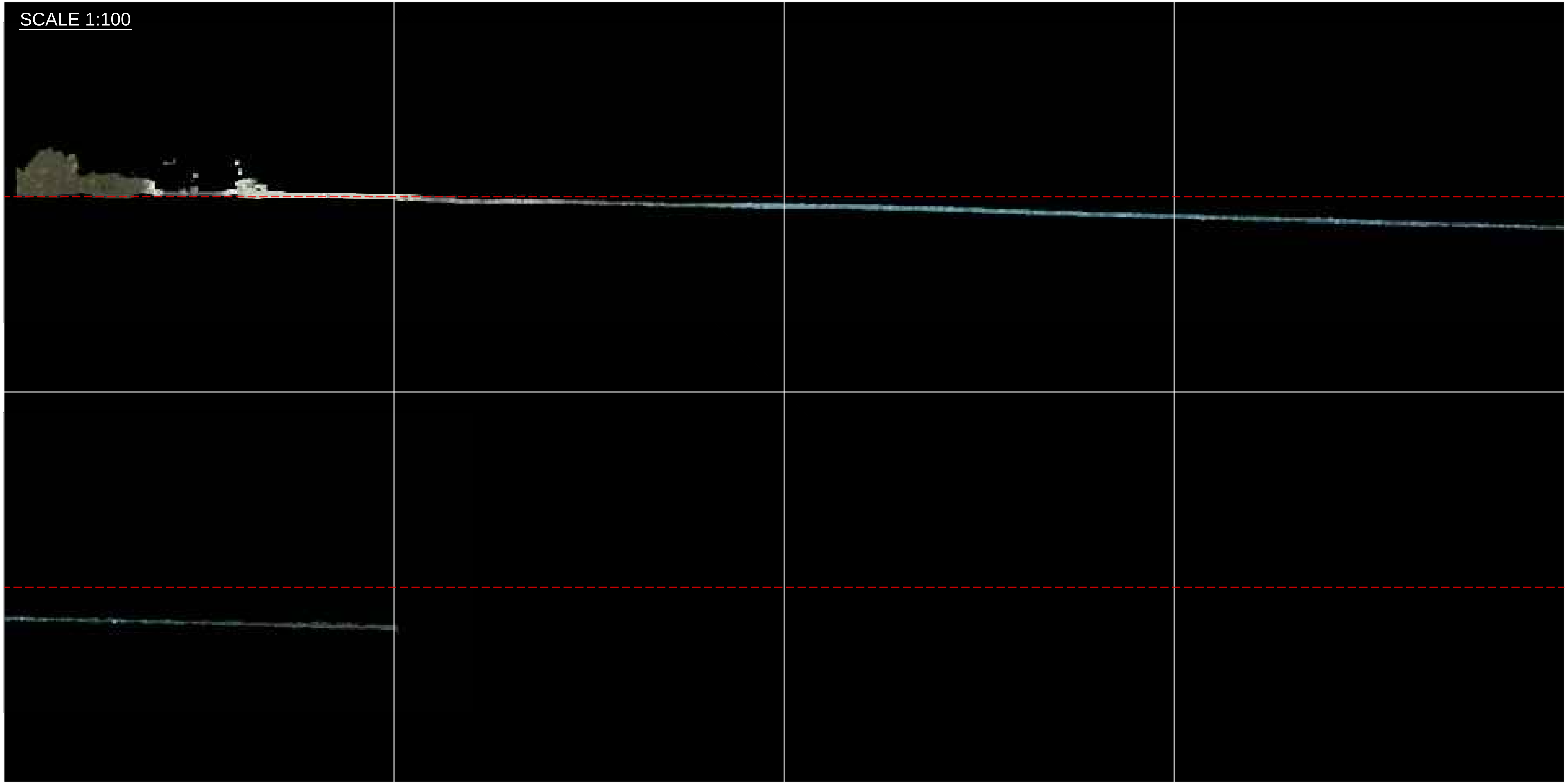

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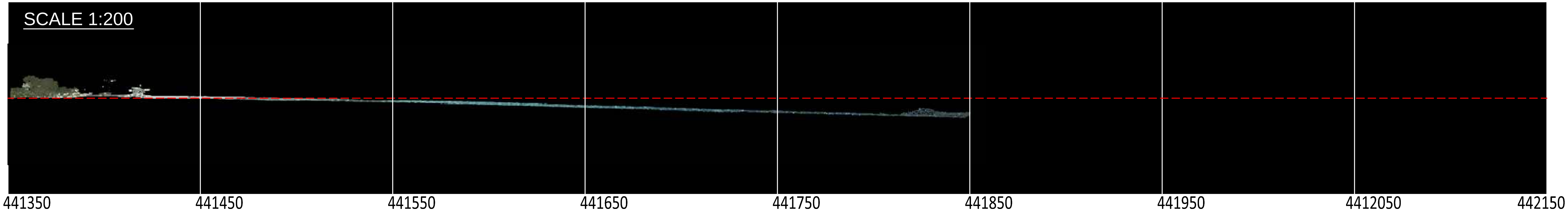

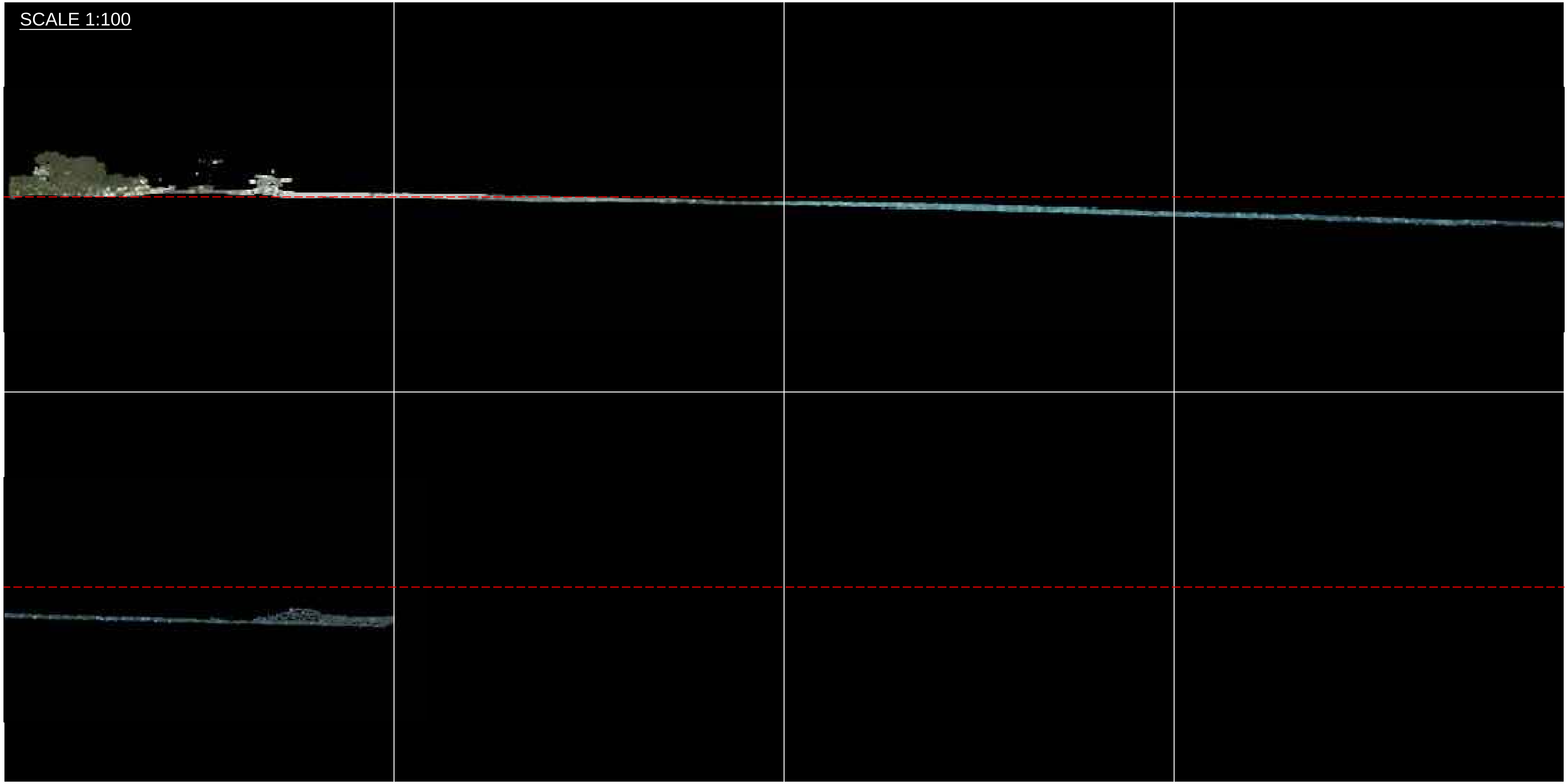

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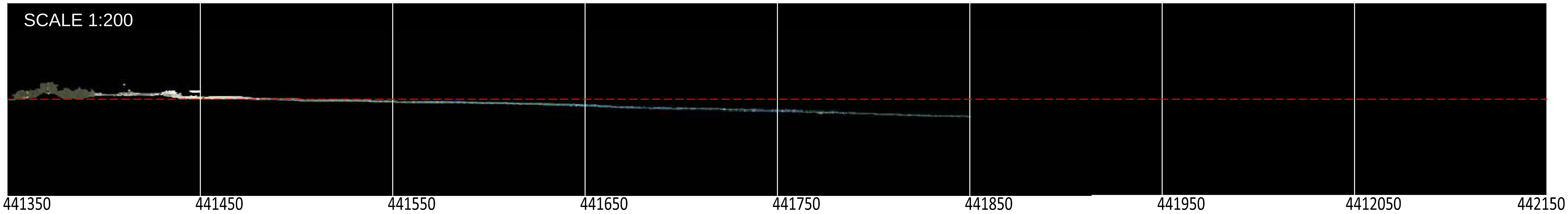

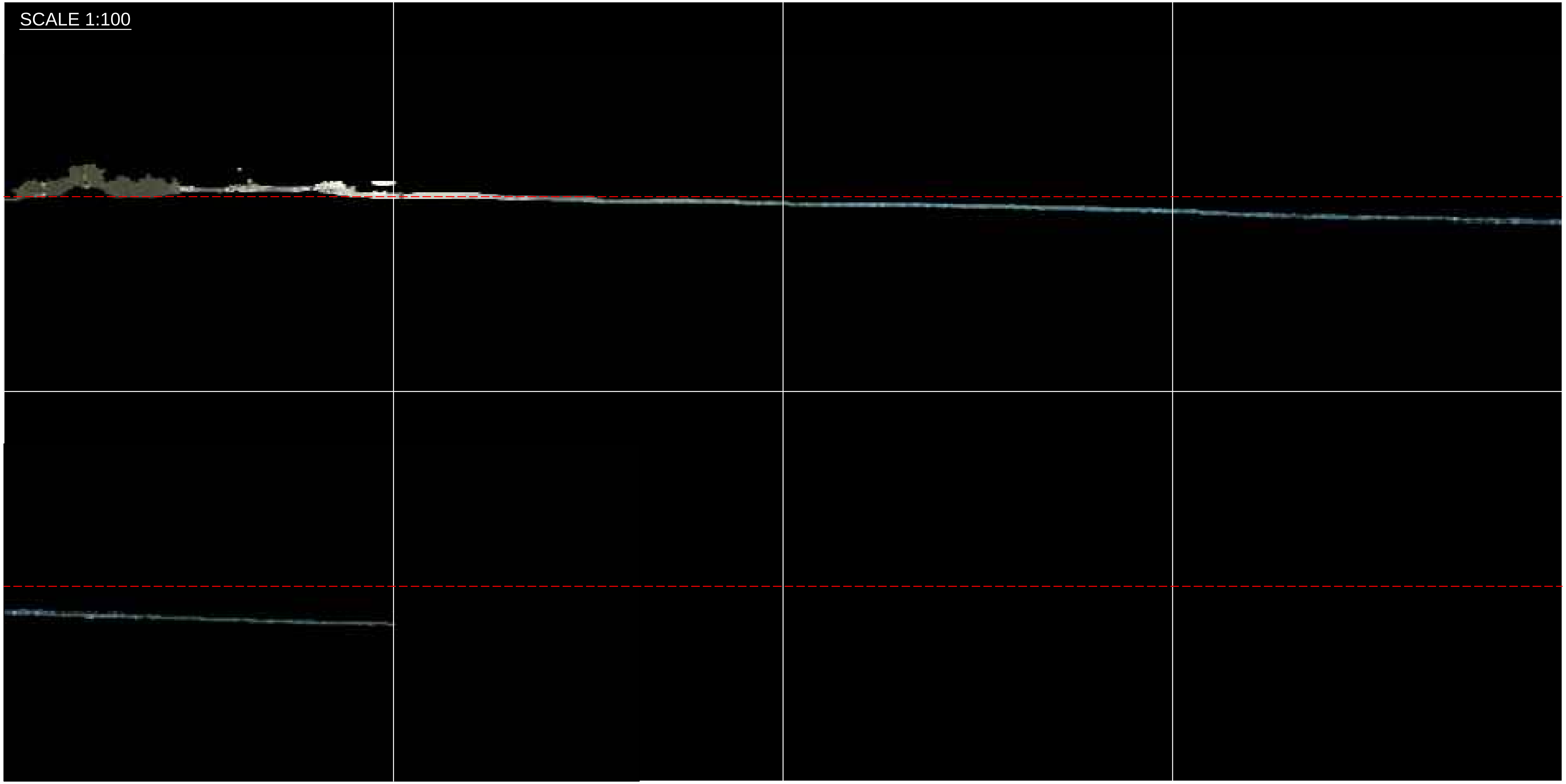

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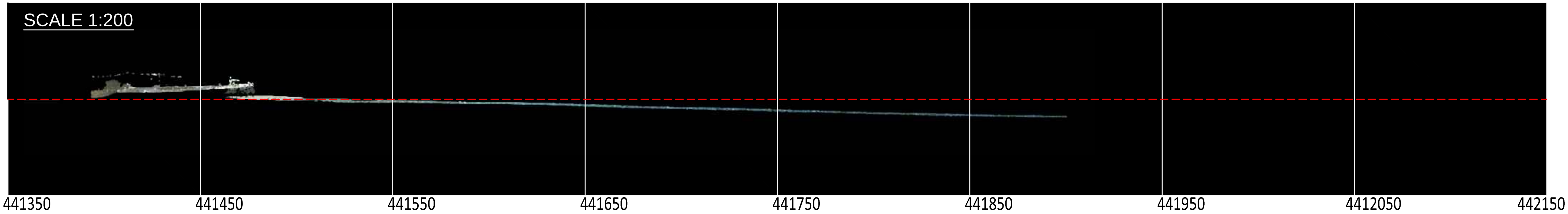

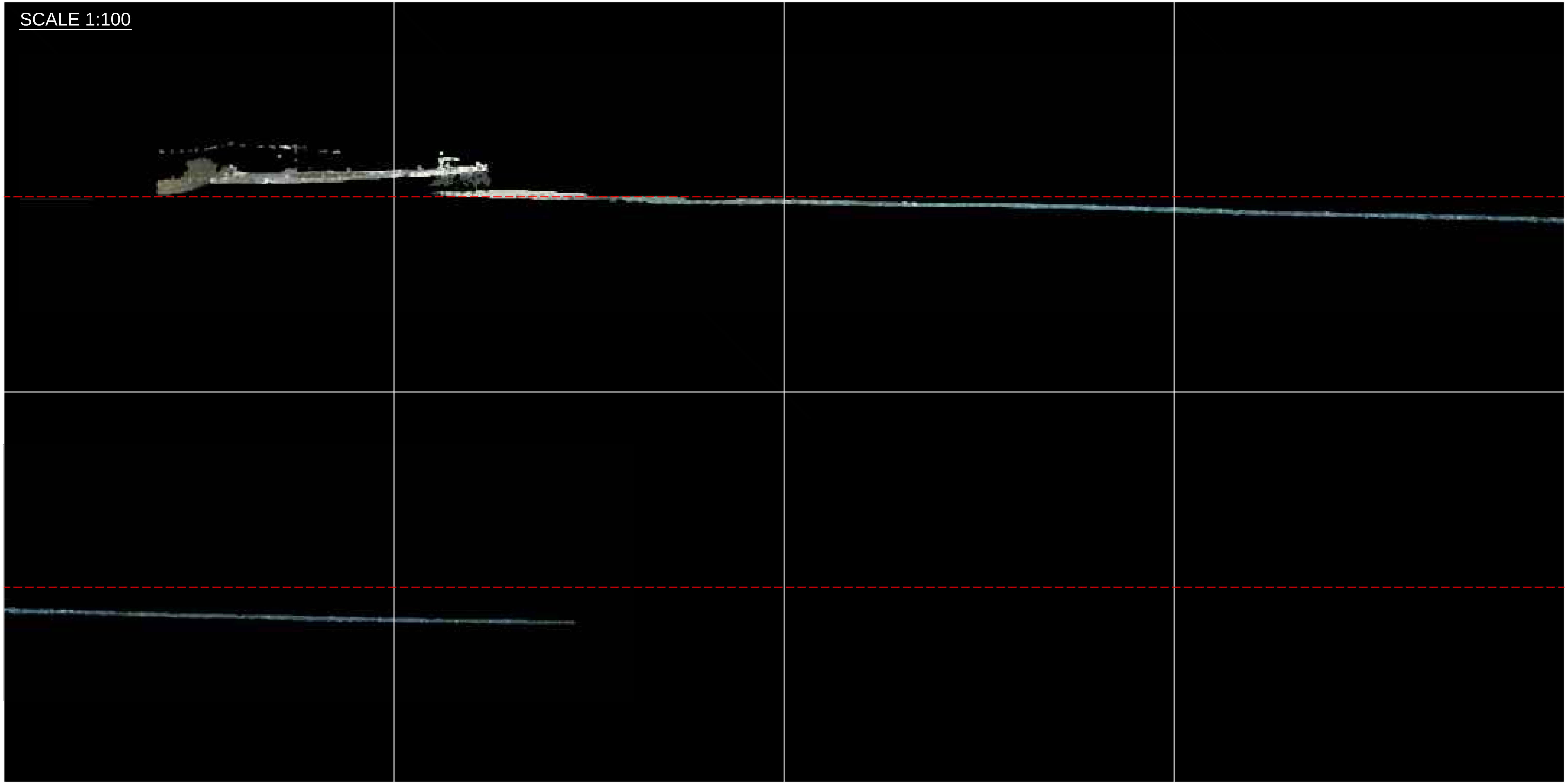

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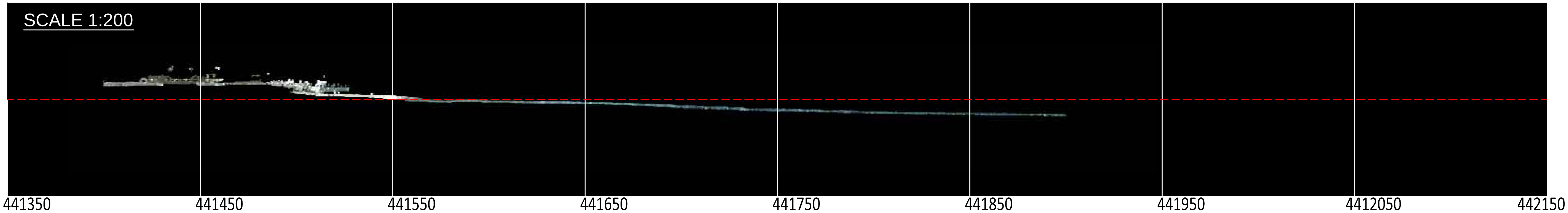

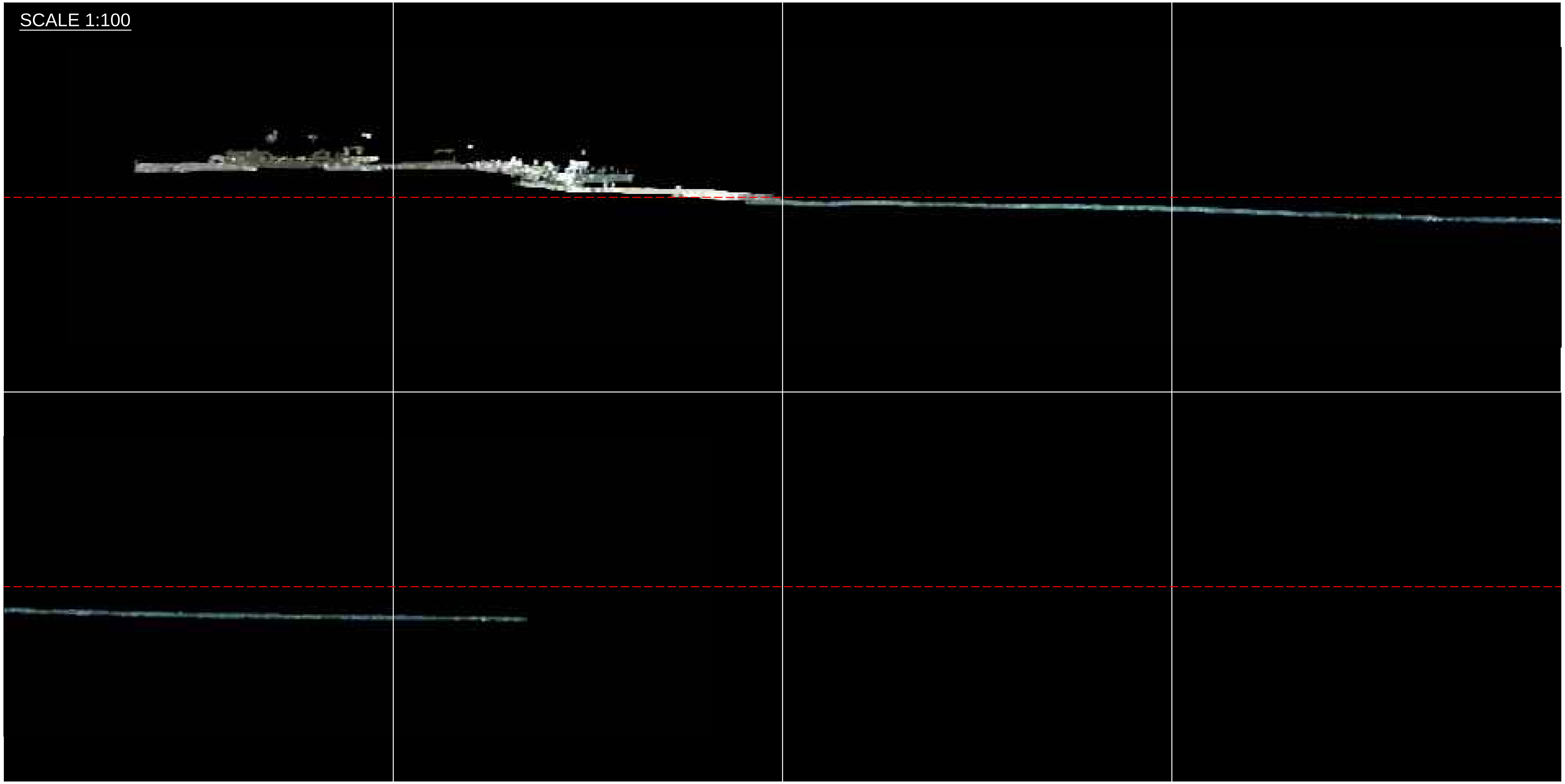

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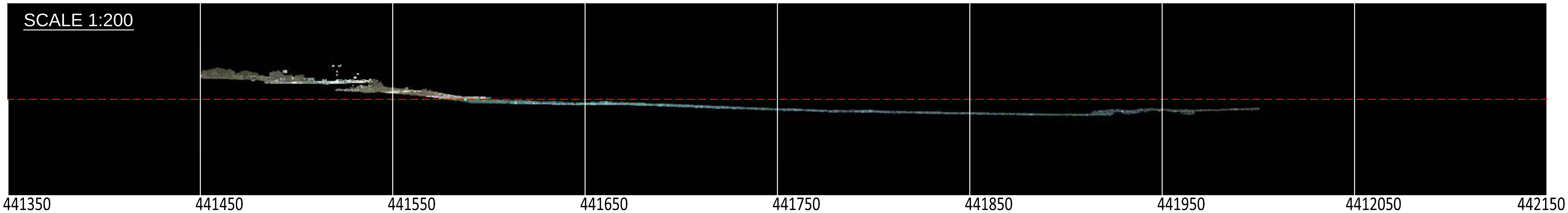

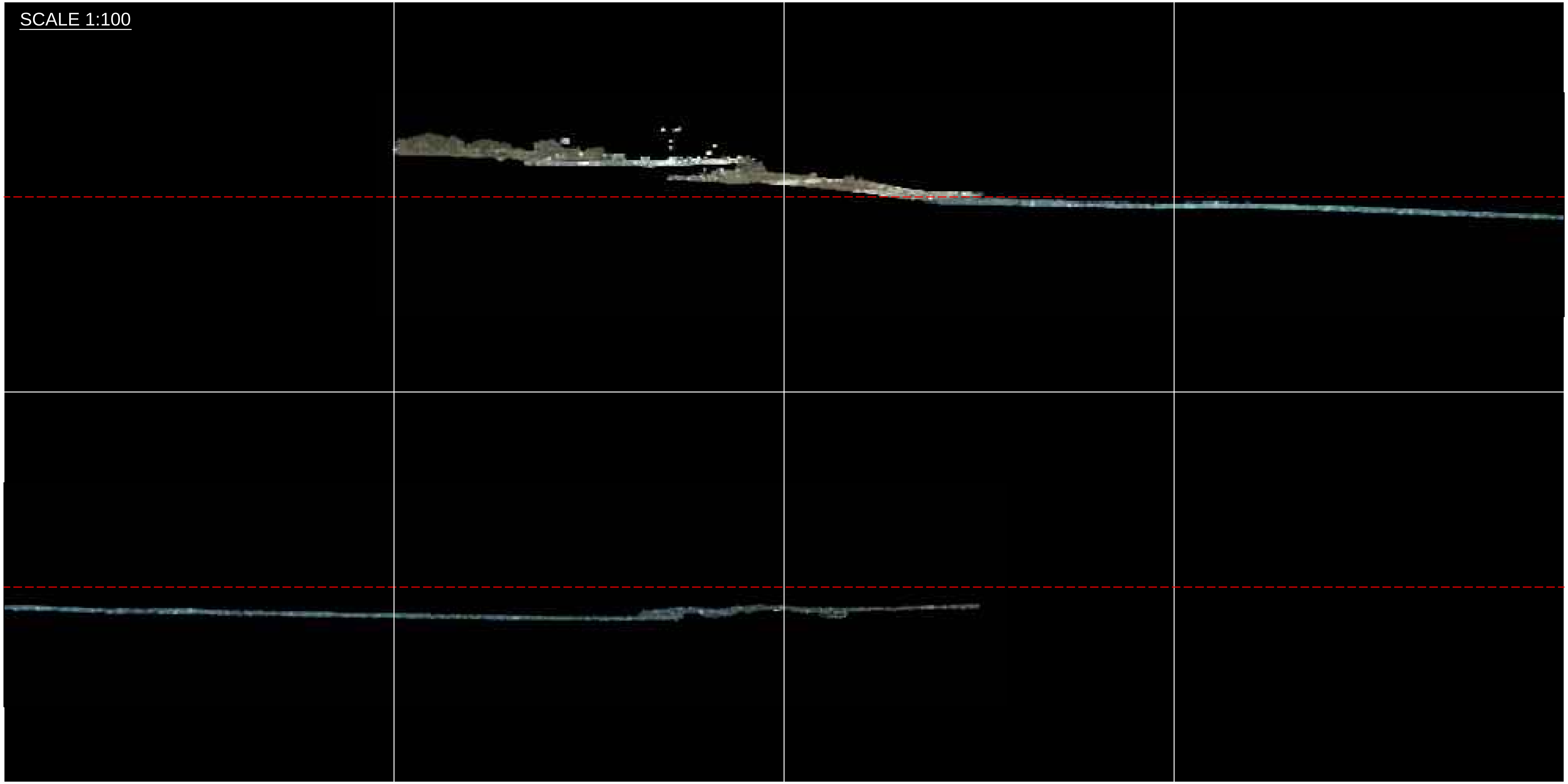

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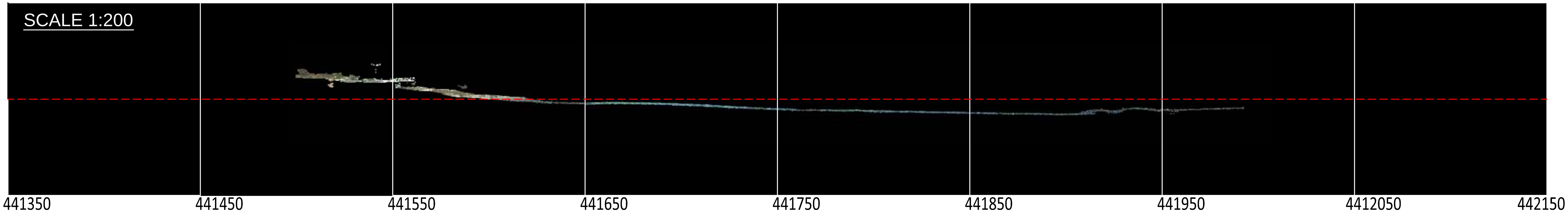

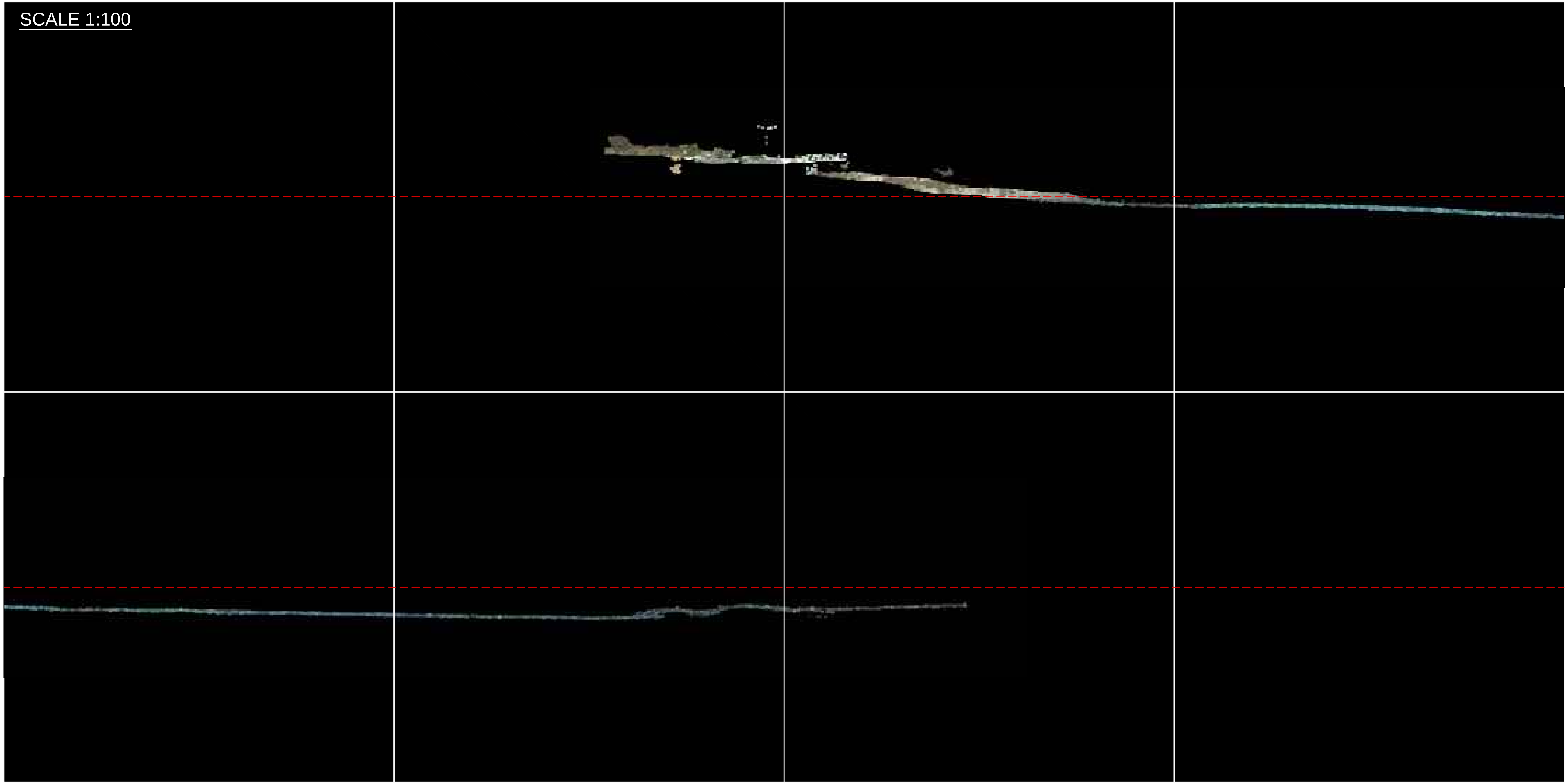

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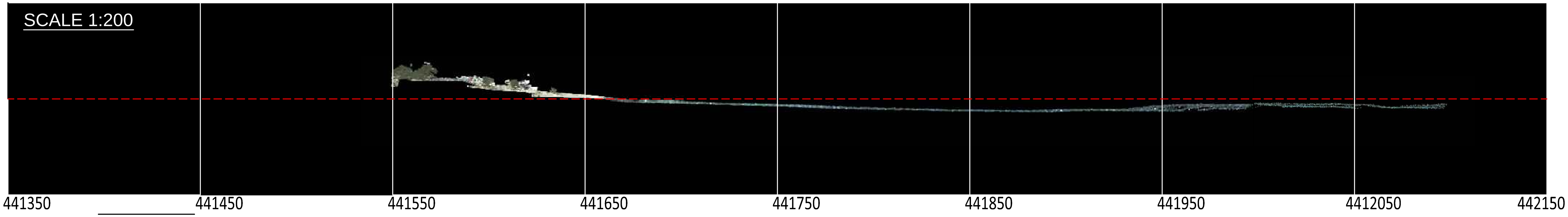

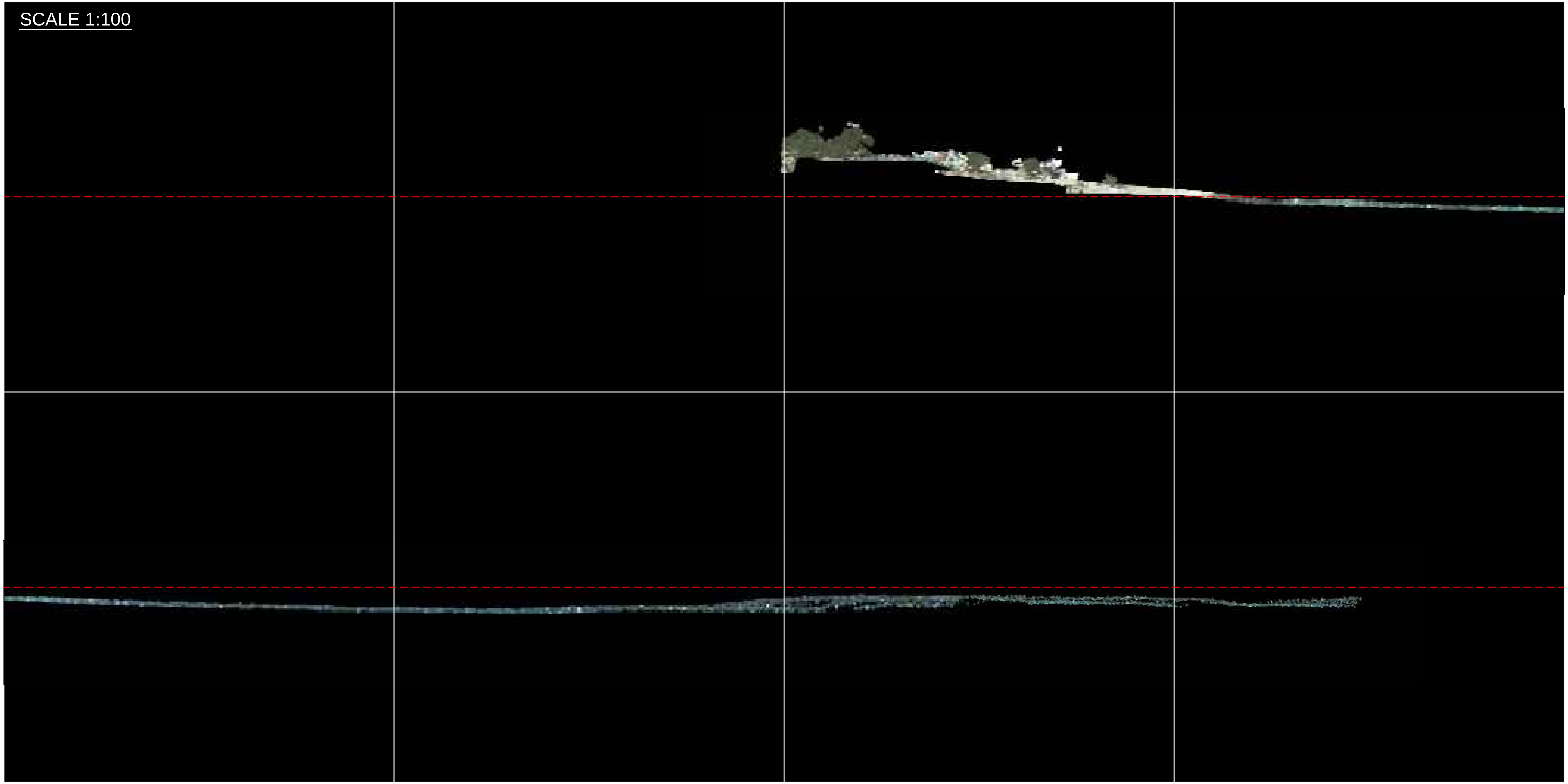

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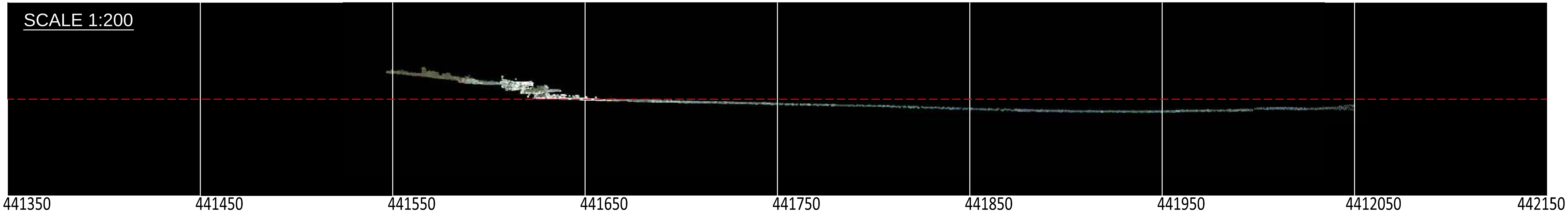

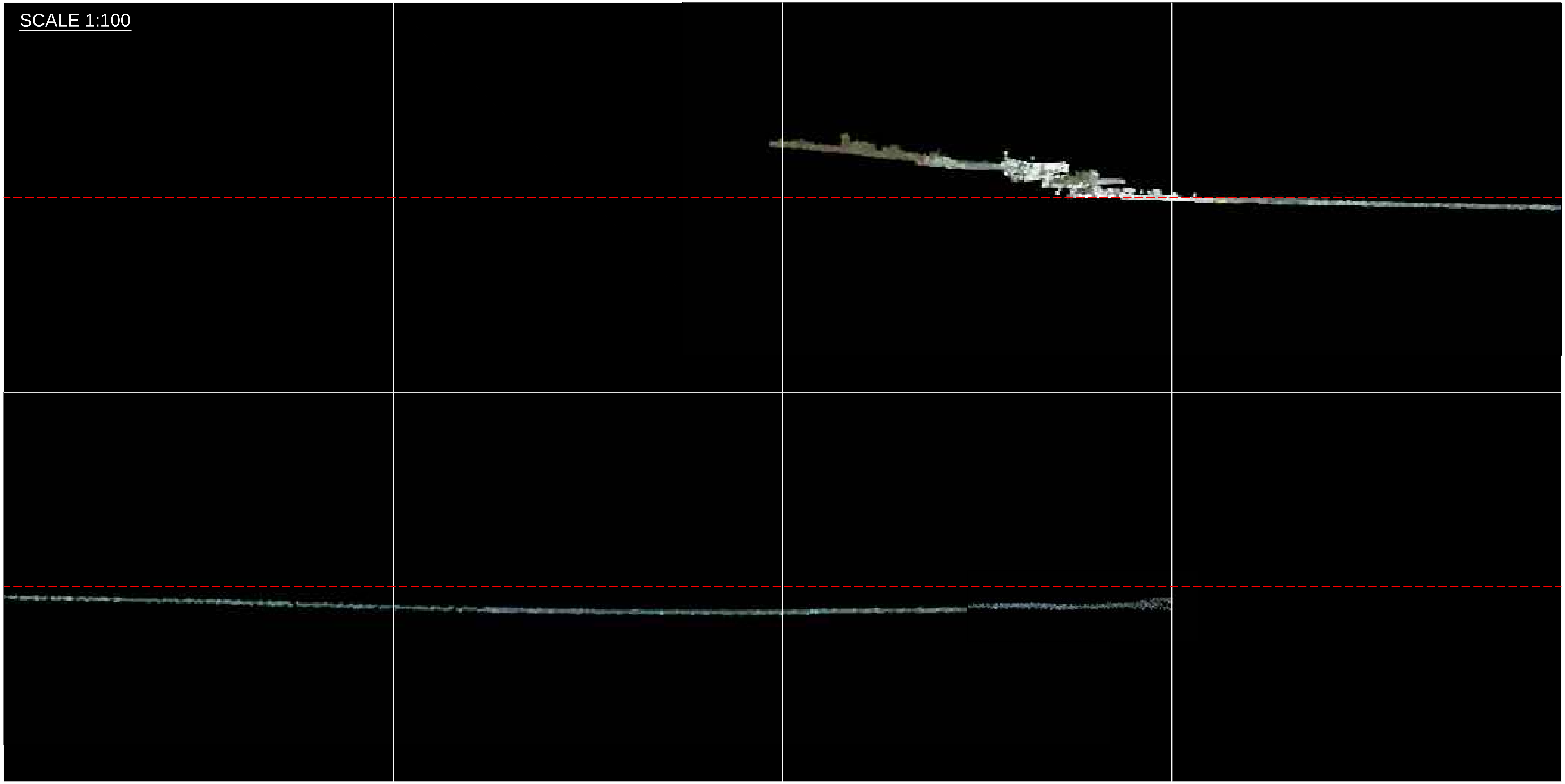

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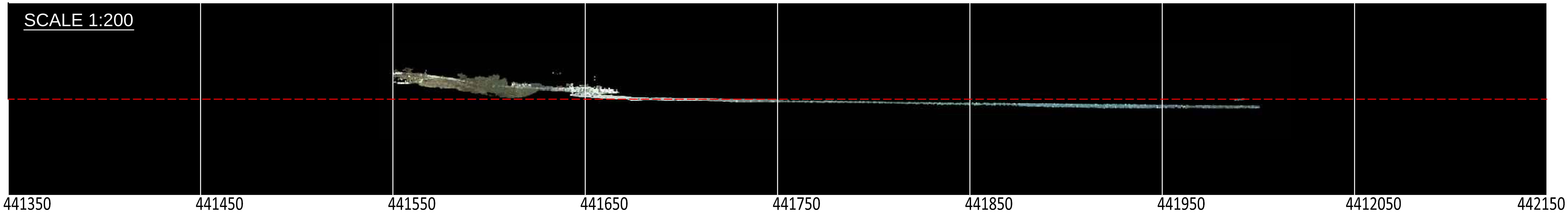

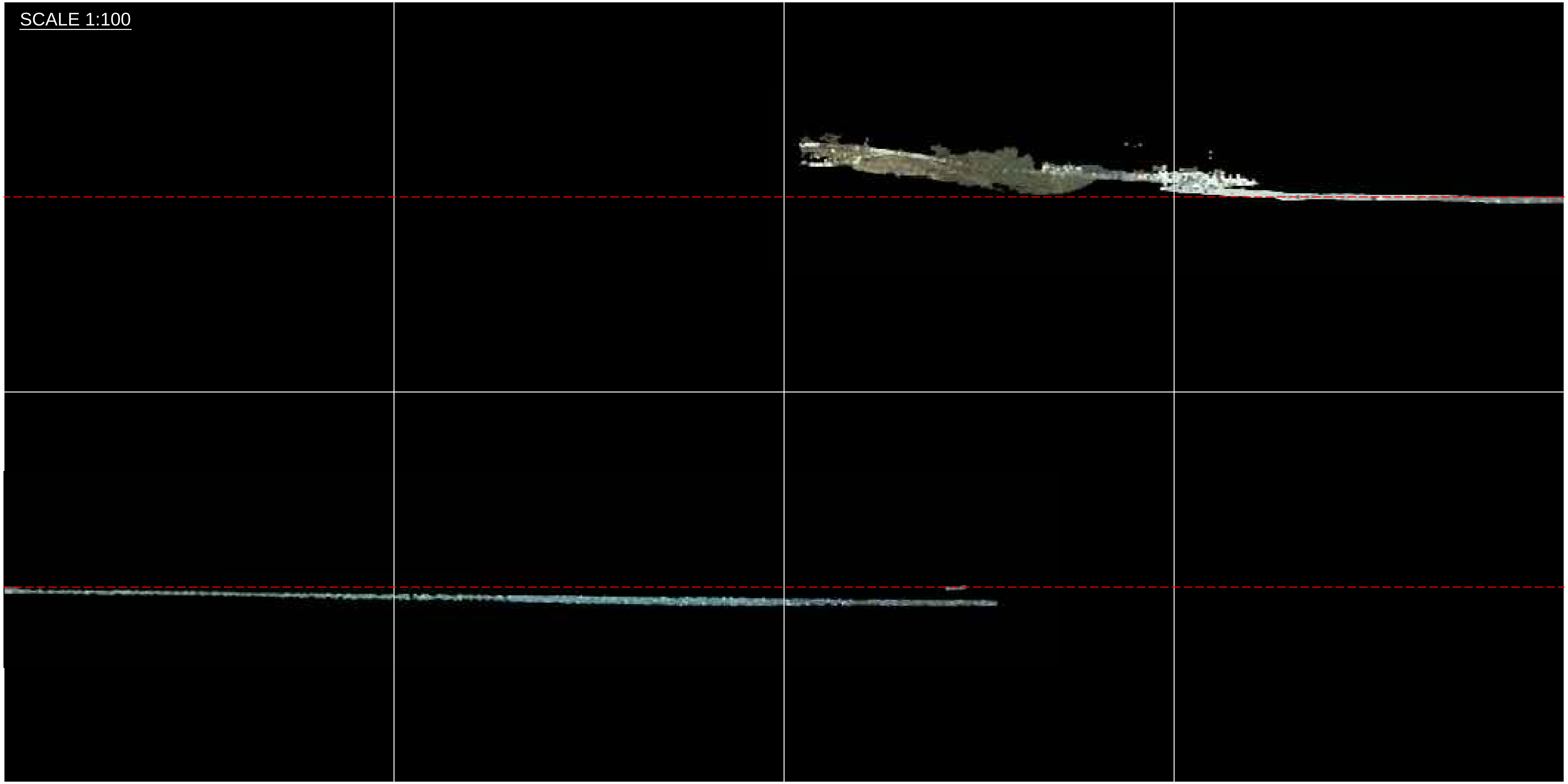

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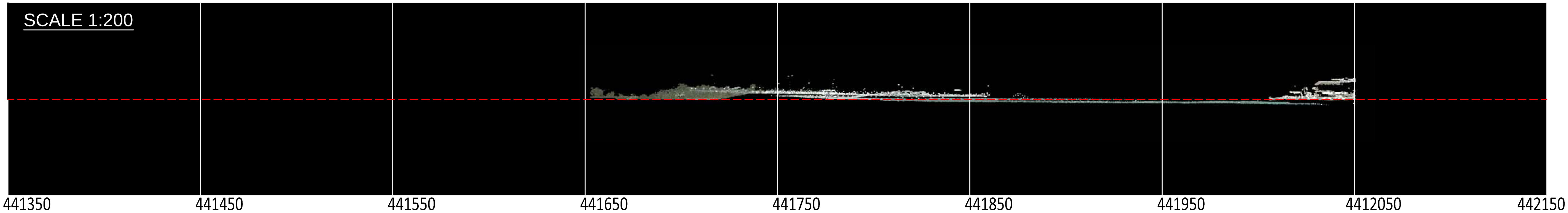

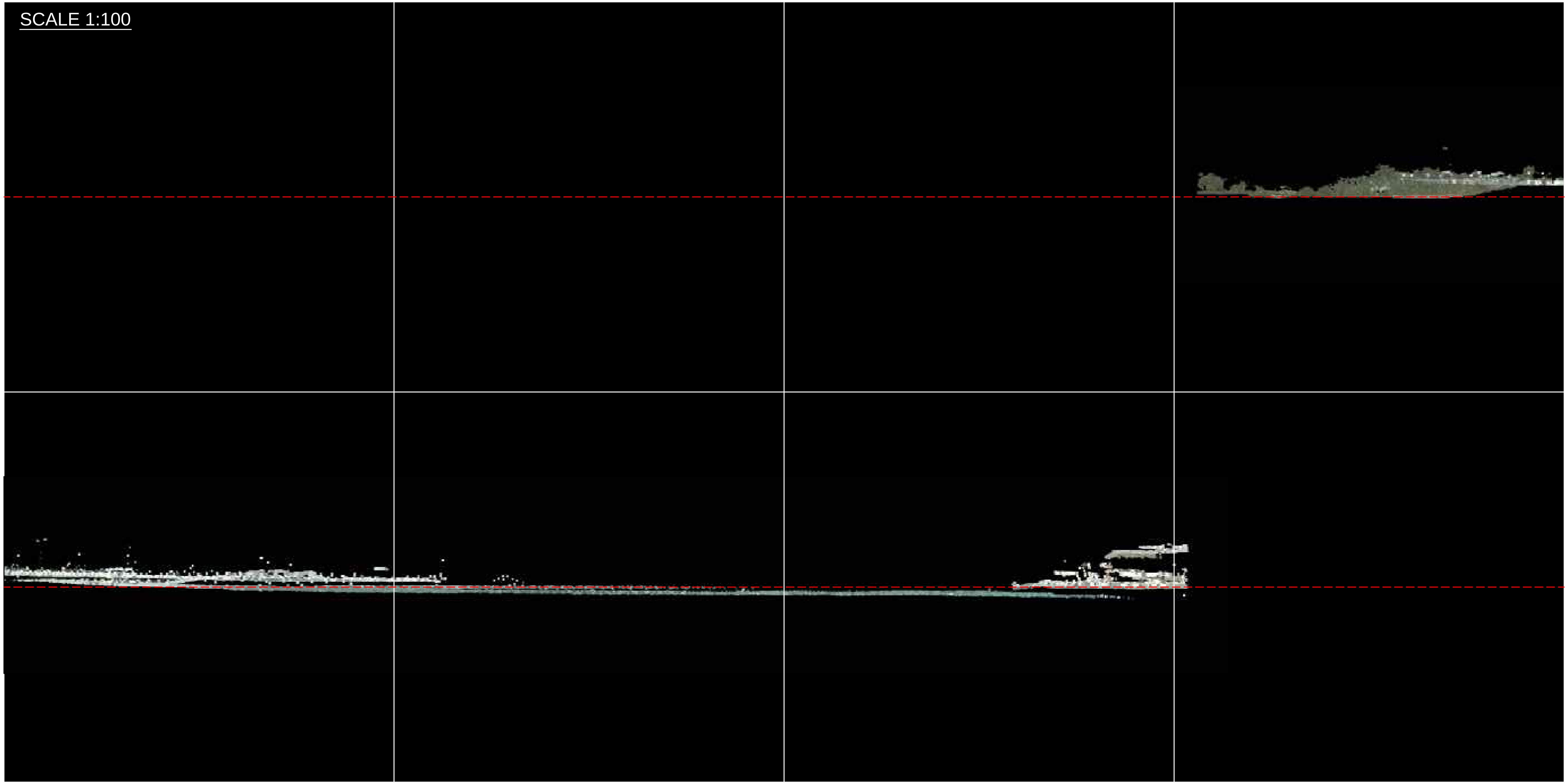

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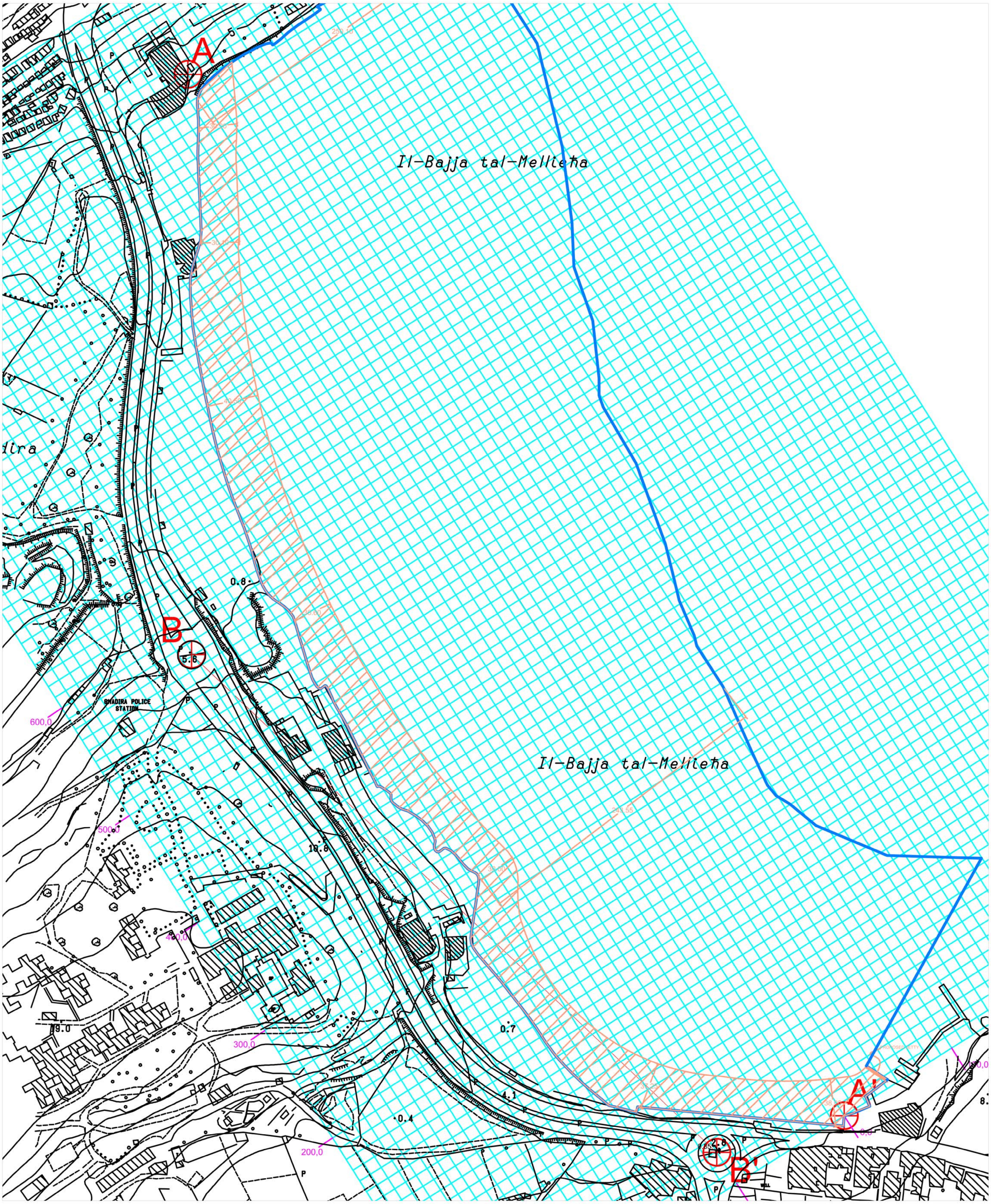
3 TRANSECTS TAKEN FROM LiDAR

3.1.1.1.1 The 19 transects taken from LiDAR data have been inserted into a 3D model, through which a number of 3D graphical representations have been created. These models will be of utmost value during the implementation of the project, and will be utilised during the sand dredging operations.

A
B
A'
B'
700,0
600,0
500,0
400,0
300,0
200,0
100,0
0,0
-100,0
-200,0
-300,0
100,0
0,0



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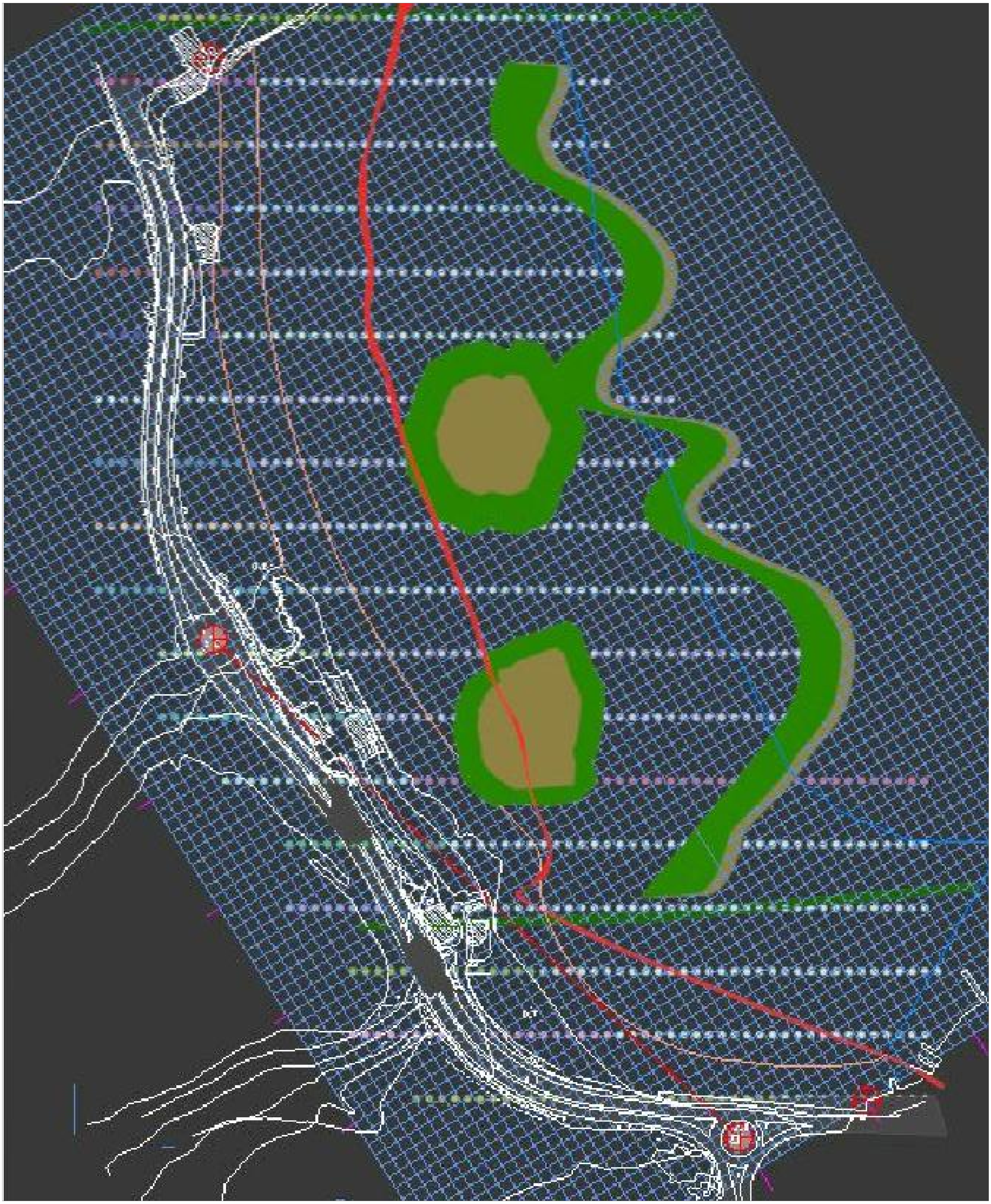

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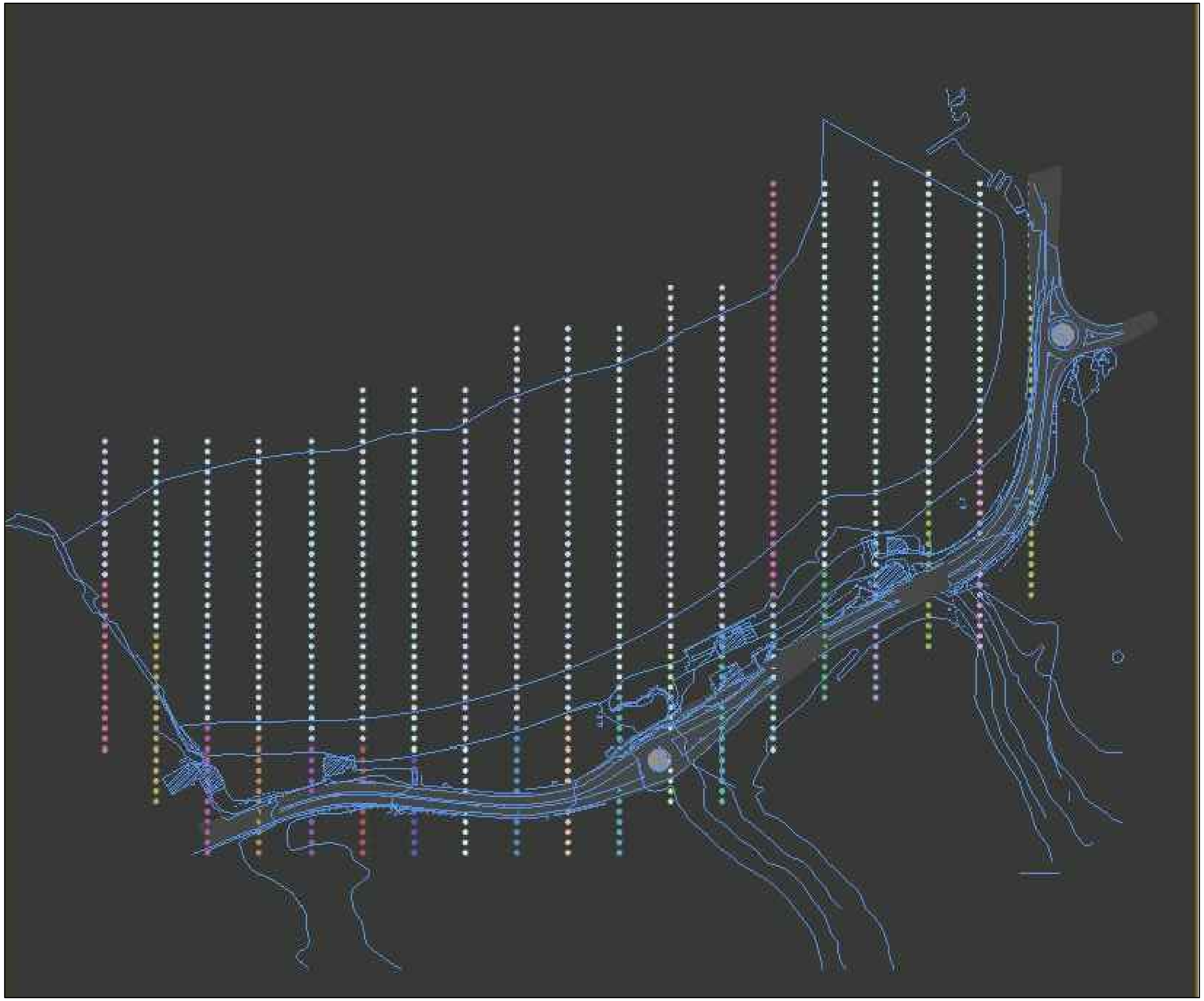

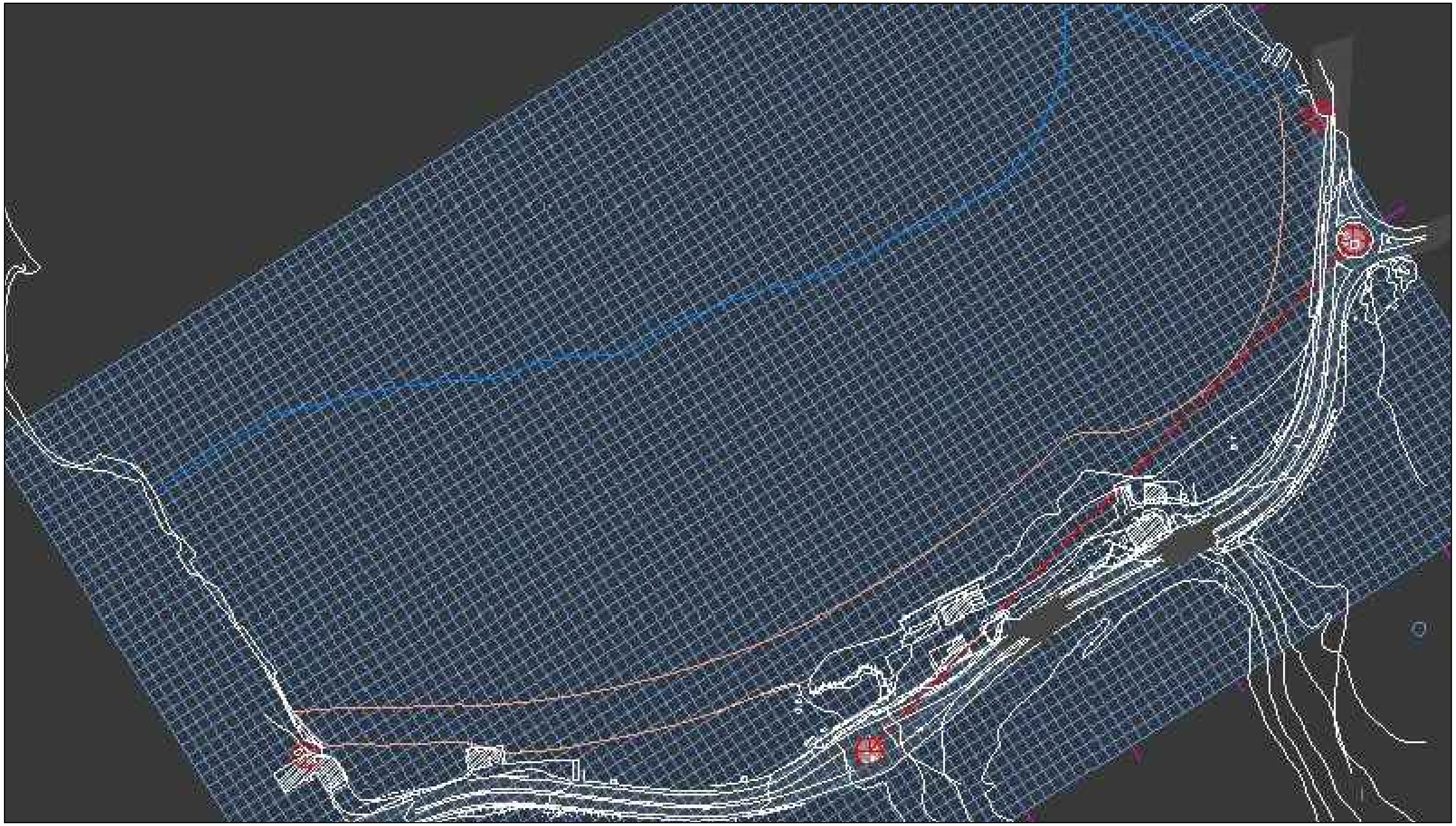

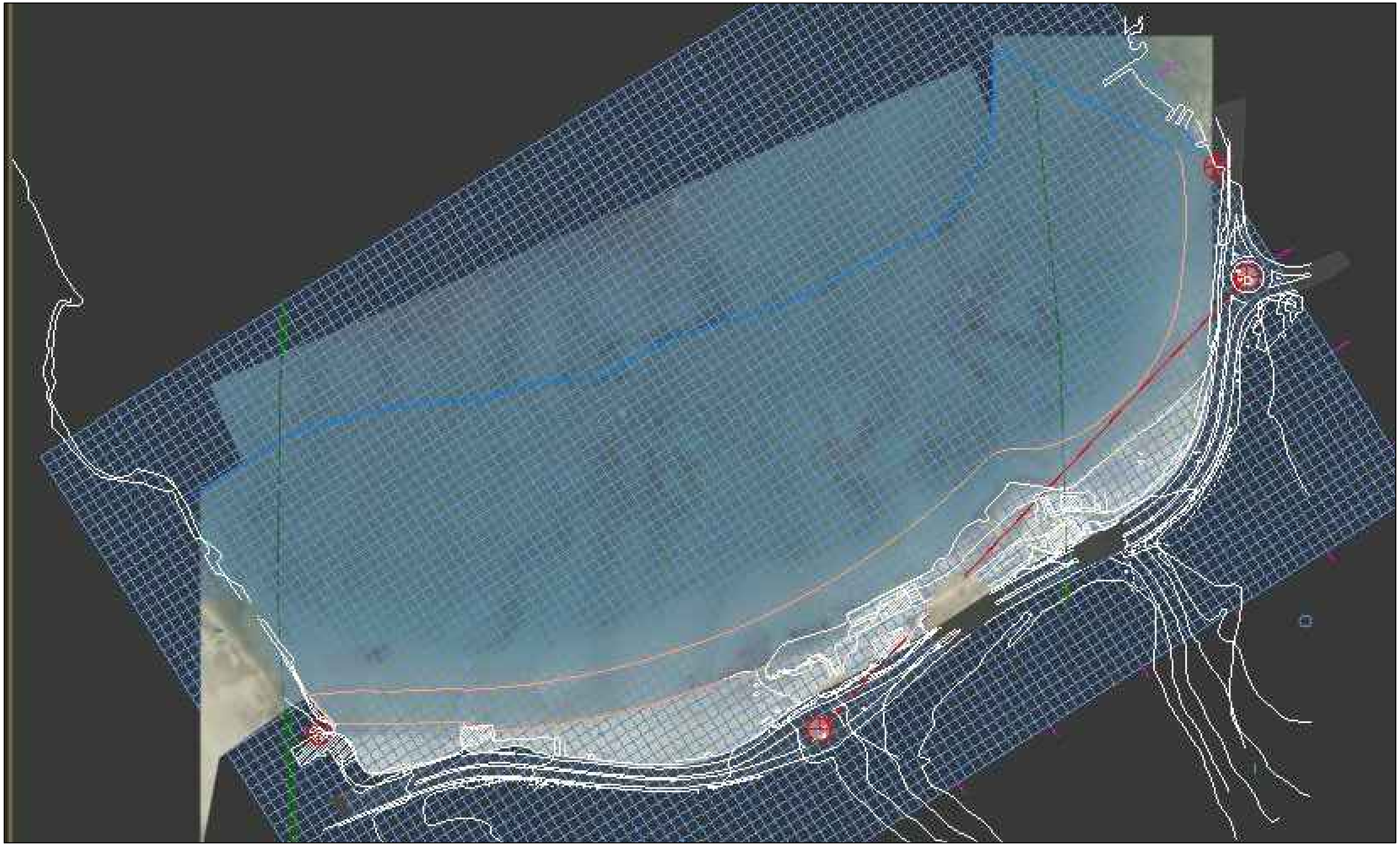

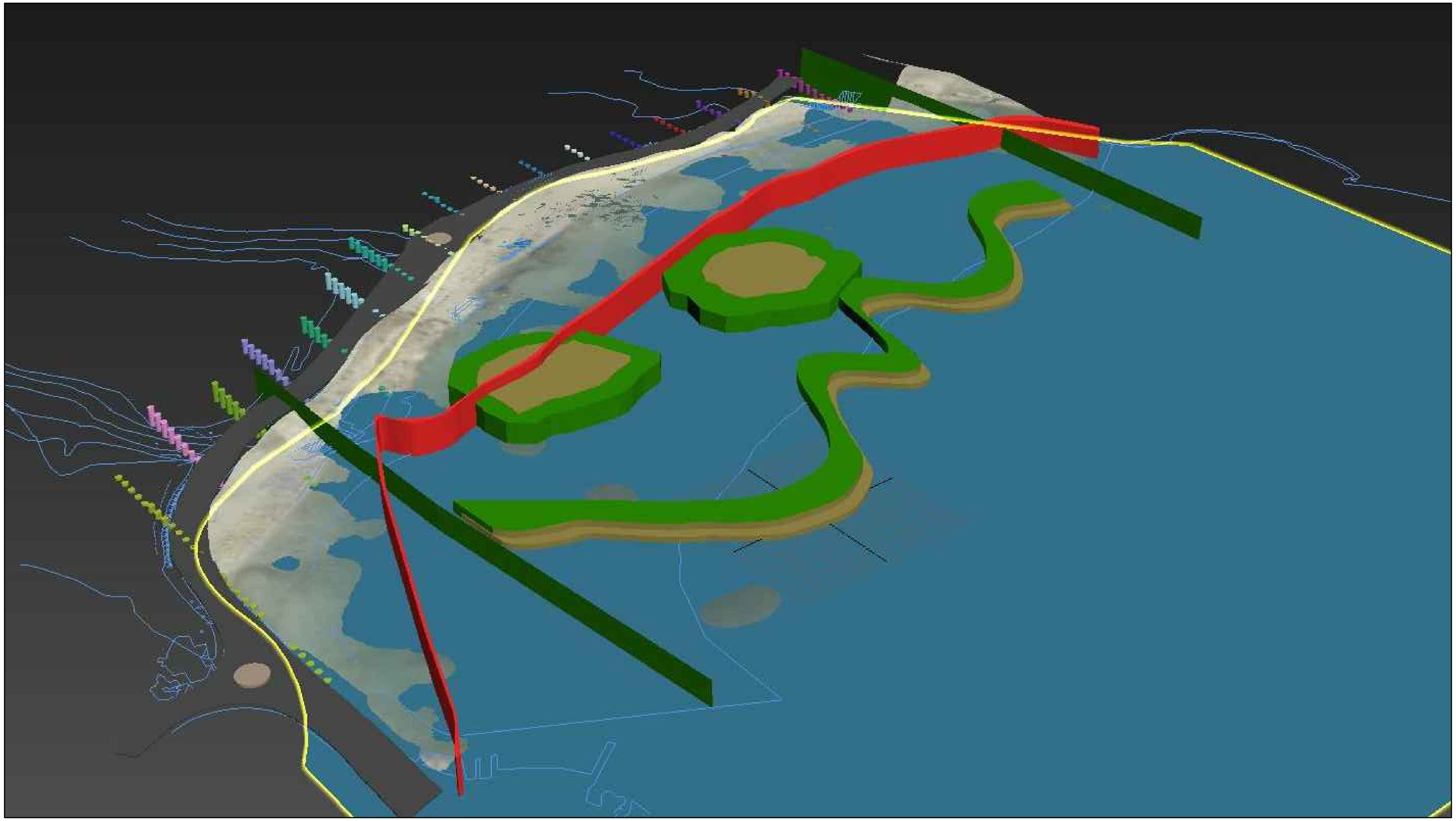

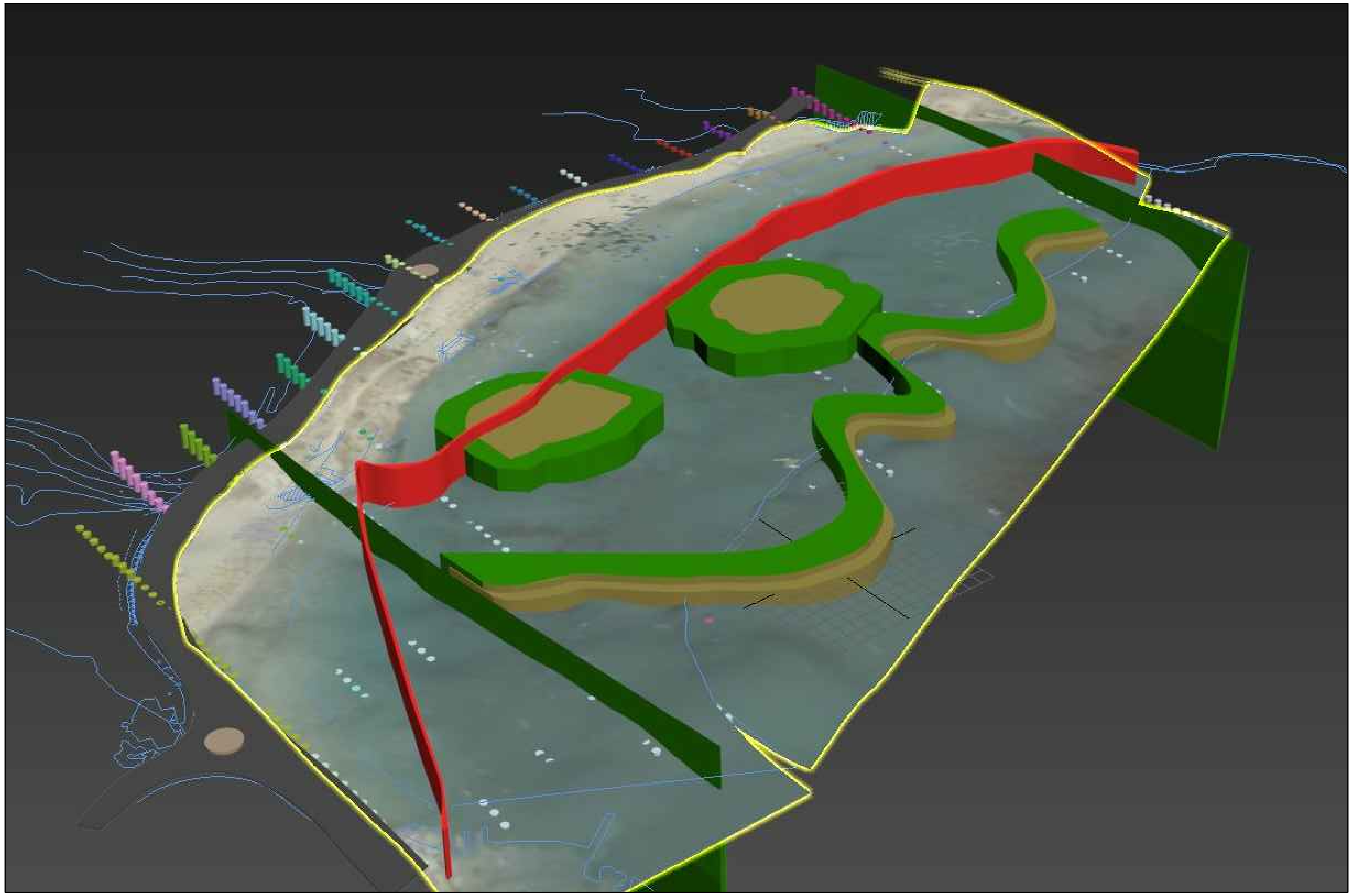

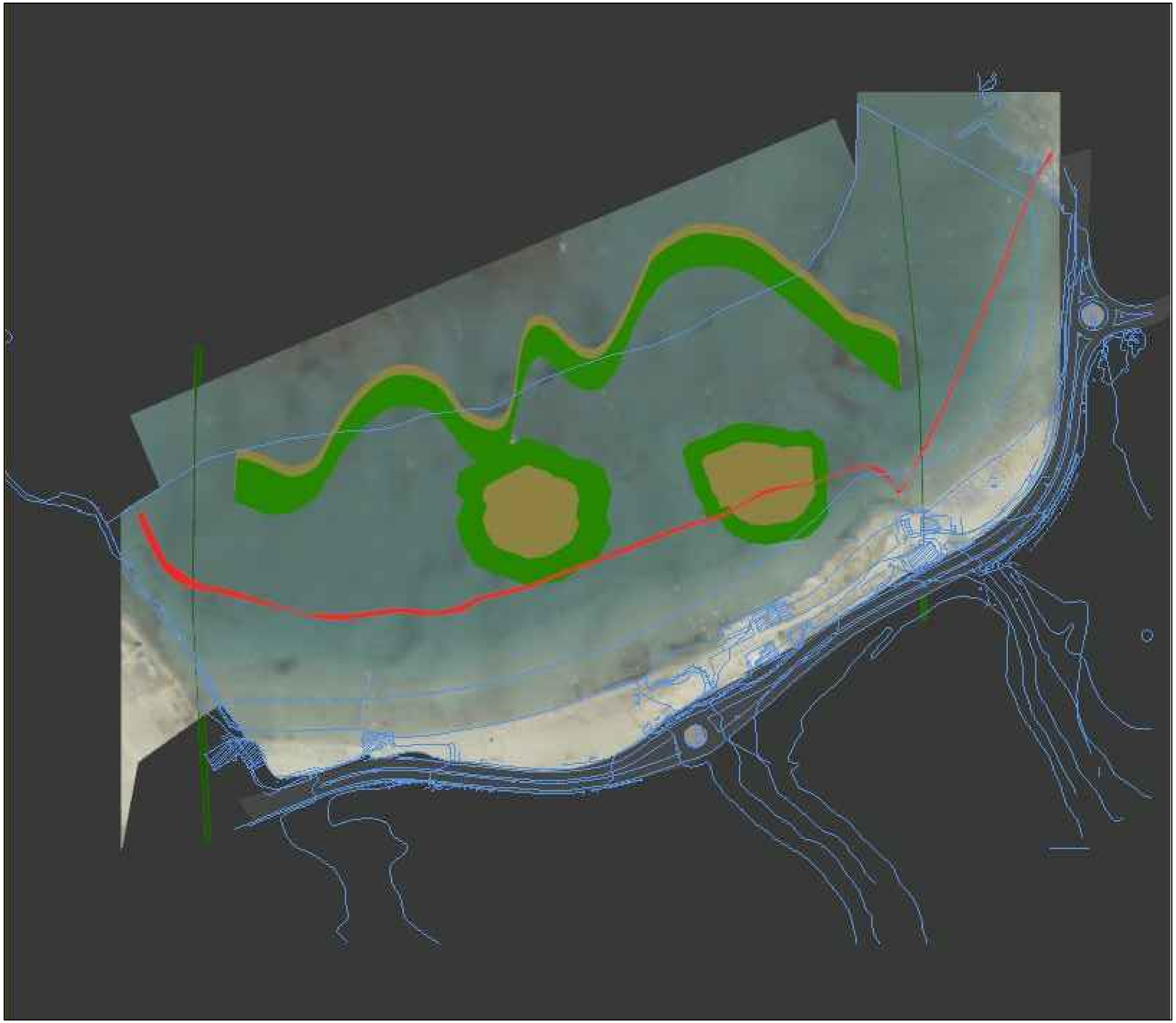

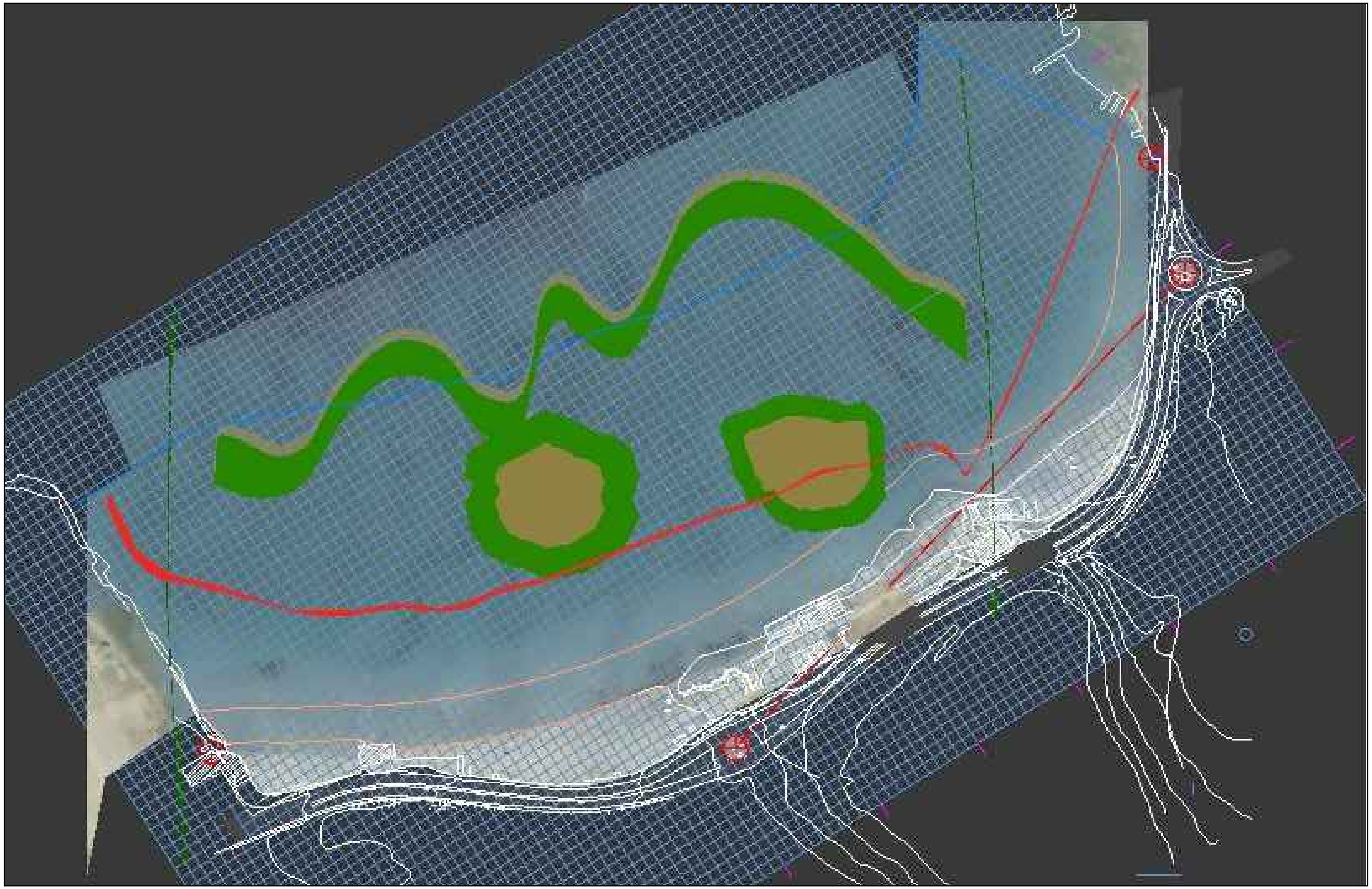

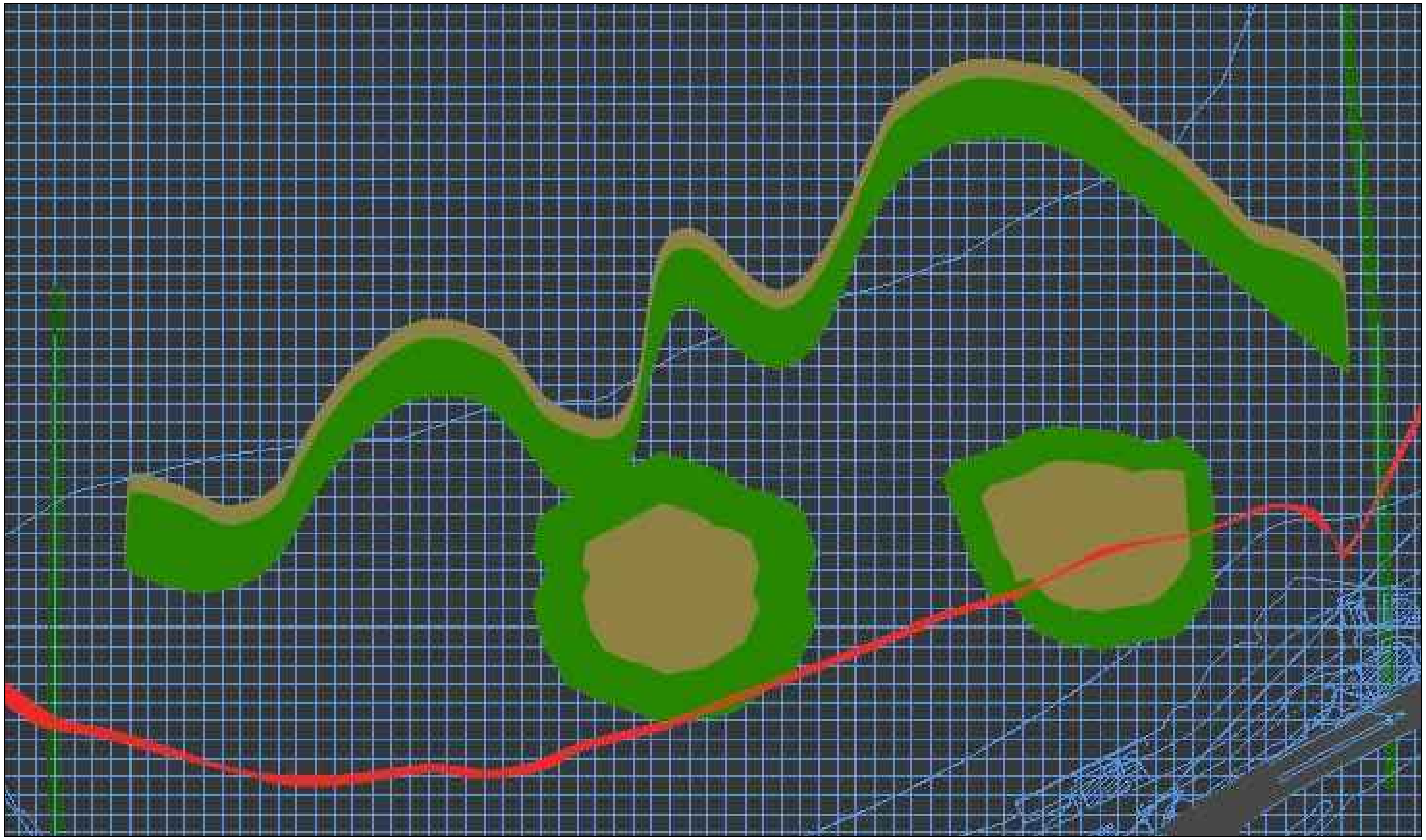

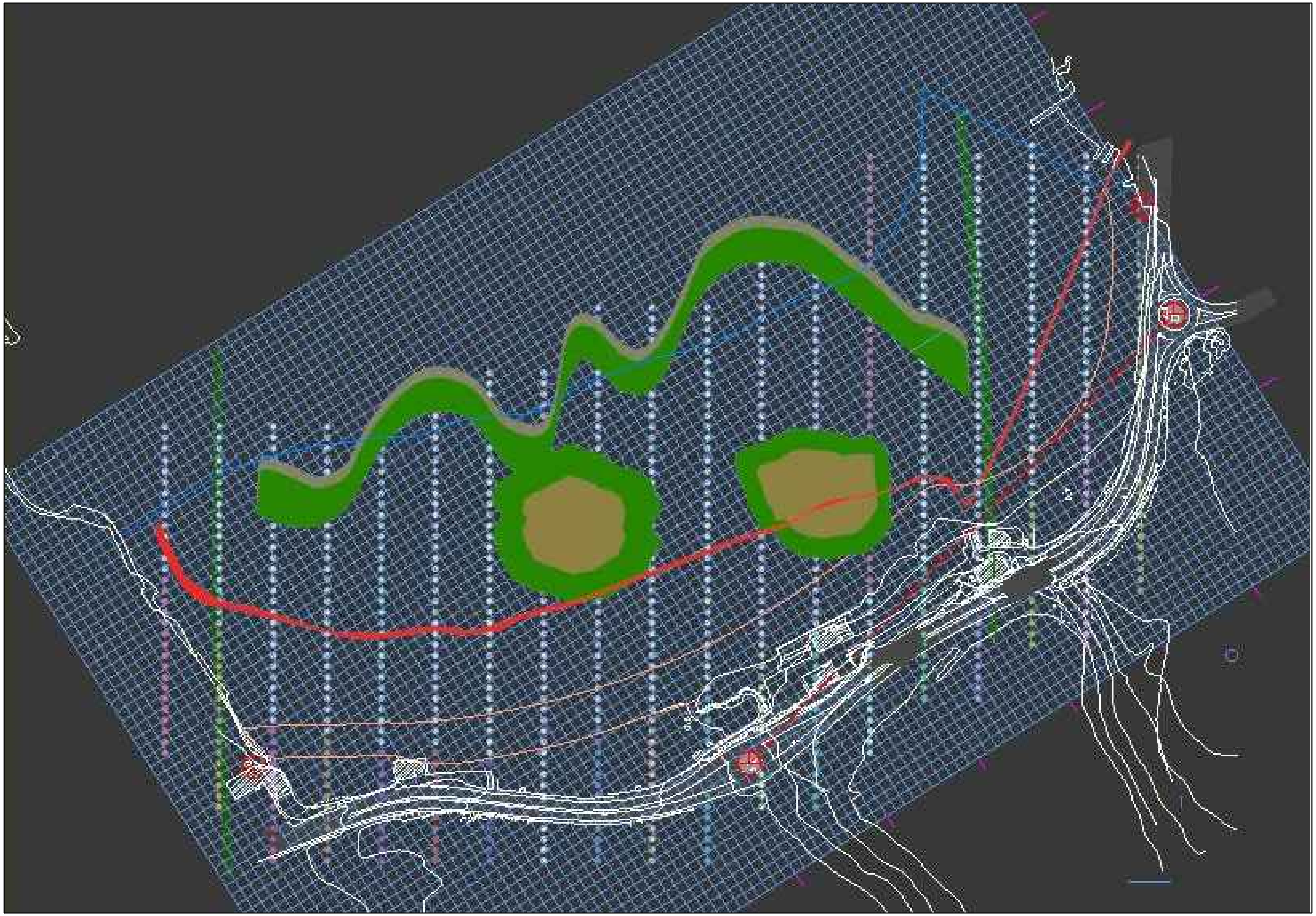

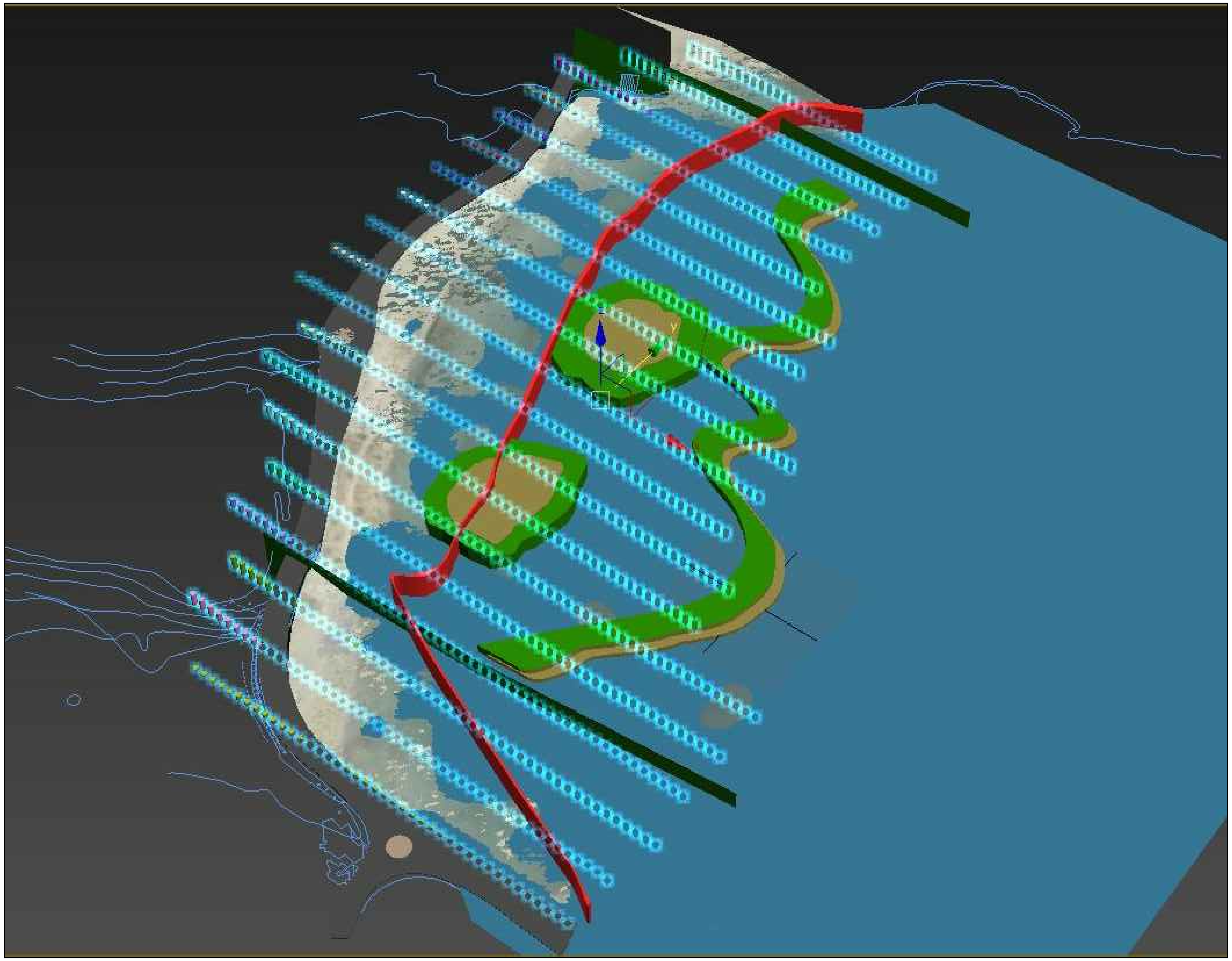

ANNEX 001

UNDERWATER FIELD SURVEY (ANDREI CACHIA)

Underwater field survey performed in support of the 'Monitoring of Existing Sand Thickness' at Ghadira Bay, Mellieha

Carried out for Projects Malta and Foundation for Tourism Zone Development

18-11-2017

Prepared by Andrei Cachia
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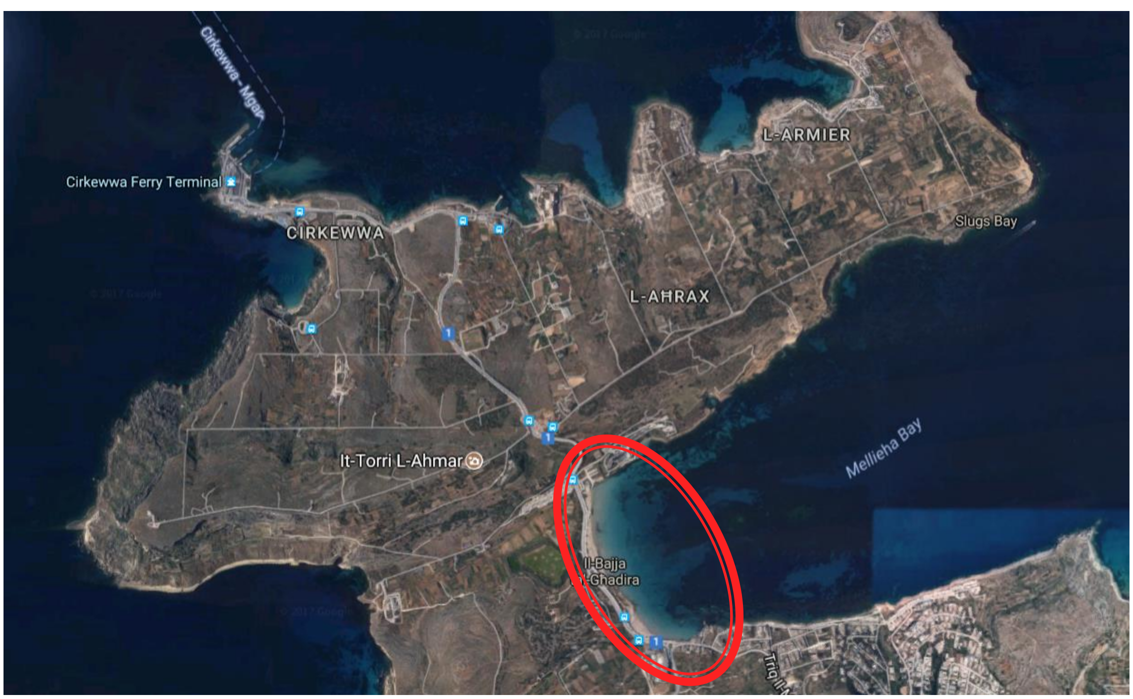

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Underwater and Subterranean Surveyor
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This report is to be read in conjunction with the table / photos & figures within the same report.

Intro:

This report serves as a compendium for much of the baseline data used to support the analysis of sand thickness at Ghadira bay in Mellieha. The reason for this is to decide if this could be pumped / relocated inwards in order to widen the bay's sandy platform.

The results of these investigations have been incorporated into the table shown in pages 3-8 and fig shown in page 16.

The area studied defines a rectangular area approximately 150 meters west to east, by 820 meters north to south. The western boundary of the shallow-water area is approximately one-hundred meters from shore.

The site area was surveyed along transects on 50-meter centres both North to South and West to East.

The operation was carried out by two divers – alternating the pricking operation. Coverage of all the area was done using a dinghy and the main tool for the operation was a 2m steel rod which was penetrated in the seabed at each location. This was the maximum length that could be used whilst avoiding bending of the rod.

Results show depth of sand at these locations, either showing a 2m penetration with the possibility of having more thickness of sand or else, less thickness being due to either one of the following two reasons; 1) rock bed at the bottom or 2) dense sand avoiding further penetration.

The coordinates of the analysis locations points, together with the sand thicknesses results and any remarks are shown in the below table:

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Waypoint No.	Coordinates	Sand Thickness (m) / Remarks
1	Latitude: 35.966863 deg, OR 35 deg 58 min 0.7068 sec Longitude: 14.355886 deg, OR 14 deg 21 min 21.19 sec	1.5m of sand - rod hit rock
2	Latitude: 35.967245 deg, OR 35 deg 58 min 2.082 sec Longitude: 14.356181 deg, OR 14 deg 21 min 22.252 sec	1.5m of sand
3	Latitude: 35.967627 deg, OR 35 deg 58 min 3.4572 sec Longitude: 14.356475 deg, OR 14 deg 21 min 23.31 sec	Rock, no sand at this point
4	Latitude: 35.968009 deg, OR 35 deg 58 min 4.8324 sec Longitude: 14.35677 deg, OR 14 deg 21 min 24.372 sec	Rock, no sand at this point
5	Latitude: 35.966884 deg, OR 35 deg 58 min 0.7824 sec Longitude: 14.355079 deg, OR 14 deg 21 min 18.284 sec	1.7m of sand - rod hit rock
6	Latitude: 35.967266 deg, OR 35 deg 58 min 2.1576 sec Longitude: 14.355374 deg, OR 14 deg 21 min 19.346 sec	1.6m of sand - rod hit rock
7	Latitude: 35.967648 deg, OR 35 deg 58 min 3.5328 sec Longitude: 14.355668 deg, OR 14 deg 21 min 20.405 sec	Rock, no sand at this point
8	Latitude: 35.96803 deg, OR 35 deg 58 min 4.908 sec Longitude: 14.355963 deg, OR 14 deg 21 min 21.467 sec	Rock, no sand at this point
9	Latitude: 35.967173 deg, OR 35 deg 58 min 1.8228 sec Longitude: 14.354331 deg, OR 14 deg 21 min 15.592 sec	1.7m of sand - rod could not penetrate further due to sand density
10	Latitude: 35.967542 deg, OR 35 deg 58 min 3.1512 sec Longitude: 14.354674 deg, OR 14 deg 21 min 16.826 sec	2m+ of sand

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11	Latitude: 35.967901 deg, OR 35 deg 58 min 4.4436 sec Longitude: 14.355009 deg, OR 14 deg 21 min 18.032 sec	Rock only
12	Latitude: 35.968261 deg, OR 35 deg 58 min 5.7396 sec Longitude: 14.355344 deg, OR 14 deg 21 min 19.238 sec	Rock only
13	Latitude: 35.967726 deg, OR 35 deg 58 min 3.8136 sec Longitude: 14.353506 deg, OR 14 deg 21 min 12.622 sec	1.9m of sand
14	Latitude: 35.967995 deg, OR 35 deg 58 min 4.782 sec Longitude: 14.353886 deg, OR 14 deg 21 min 13.99 sec	1.4m of sand
15	Latitude: 35.96829 deg, OR 35 deg 58 min 5.844 sec Longitude: 14.354304 deg, OR 14 deg 21 min 15.494 sec	2m+ of sand
16	Latitude: 35.968586 deg, OR 35 deg 58 min 6.9096 sec Longitude: 14.354722 deg, OR 14 deg 21 min 16.999 sec	1.4m of sand
17	Latitude: 35.968562 deg, OR 35 deg 58 min 6.8232 sec Longitude: 14.352946 deg, OR 14 deg 21 min 10.606 sec	2m+ of sand
18	Latitude: 35.968633 deg, OR 35 deg 58 min 7.0788 sec Longitude: 14.353333 deg, OR 14 deg 21 min 11.999 sec	1.8m of sand
19	Latitude: 35.968732 deg, OR 35 deg 58 min 7.4352 sec Longitude: 14.353874 deg, OR 14 deg 21 min 13.946 sec	2m+ of sand
20	Latitude: 35.96883 deg, OR 35 deg 58 min 7.788 sec Longitude: 14.354415 deg, OR 14 deg 21 min 15.894 sec	1.6m of sand
21	Latitude: 35.969162 deg, OR 35 deg 58 min 8.9832 sec Longitude: 14.35263 deg, OR 14 deg 21 min 9.468 sec	1.8m of sand - rod could not penetrate further due to sand density

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22	Latitude: 35.969206 deg, OR 35 deg 58 min 9.1416 sec Longitude: 14.353114 deg, OR 14 deg 21 min 11.21 sec	2m+ of sand
23	Latitude: 35.969256 deg, OR 35 deg 58 min 9.3216 sec Longitude: 14.353666 deg, OR 14 deg 21 min 13.198 sec	2m+ of sand
24	Latitude: 35.969306 deg, OR 35 deg 58 min 9.5016 sec Longitude: 14.354217 deg, OR 14 deg 21 min 15.181 sec	2m+ of sand
25	Latitude: 35.969632 deg, OR 35 deg 58 min 10.6752 sec Longitude: 14.352461 deg, OR 14 deg 21 min 8.86 sec	2m+ of sand
26	Latitude: 35.96967 deg, OR 35 deg 58 min 10.812 sec Longitude: 14.352977 deg, OR 14 deg 21 min 10.717 sec	1.8m of sand
27	Latitude: 35.969711 deg, OR 35 deg 58 min 10.9596 sec Longitude: 14.353529 deg, OR 14 deg 21 min 12.704 sec	1.9m of sand
28	Latitude: 35.969752 deg, OR 35 deg 58 min 11.1072 sec Longitude: 14.354081 deg, OR 14 deg 21 min 14.692 sec	2m+ of sand
29	Latitude: 35.970065 deg, OR 35 deg 58 min 12.234 sec Longitude: 14.352289 deg, OR 14 deg 21 min 8.24 sec	1.6m of sand - rod could not penetrate further due to sand density
30	Latitude: 35.970101 deg, OR 35 deg 58 min 12.3636 sec Longitude: 14.352787 deg, OR 14 deg 21 min 10.033 sec	2m+ of sand
31	Latitude: 35.97014 deg, OR 35 deg 58 min 12.504 sec Longitude: 14.35334 deg, OR 14 deg 21 min 12.024 sec	2m+ of sand

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32	Latitude: 35.97018 deg, OR 35 deg 58 min 12.648 sec Longitude: 14.353892 deg, OR 14 deg 21 min 14.011 sec	1.5m of sand
33	Latitude: 35.970612 deg, OR 35 deg 58 min 14.2032 sec Longitude: 14.35193 deg, OR 14 deg 21 min 6.948 sec	1.0m of sand - rock beyond the 1.0m
34	Latitude: 35.970615 deg, OR 35 deg 58 min 14.214 sec Longitude: 14.352485 deg, OR 14 deg 21 min 8.946 sec	1.4m of sand - rock beyond the 1.4m
35	Latitude: 35.970618 deg, OR 35 deg 58 min 14.2248 sec Longitude: 14.35304 deg, OR 14 deg 21 min 10.944 sec	2m+ of sand
36	Latitude: 35.97062 deg, OR 35 deg 58 min 14.232 sec Longitude: 14.353594 deg, OR 14 deg 21 min 12.938 sec	1.5m of sand
37	Latitude: 35.971038 deg, OR 35 deg 58 min 15.7368 sec Longitude: 14.351742 deg, OR 14 deg 21 min 6.271 sec	1.4m of sand - rock beyond the 1.4m
38	Latitude: 35.971041 deg, OR 35 deg 58 min 15.7476 sec Longitude: 14.352296 deg, OR 14 deg 21 min 8.266 sec	2m+ of sand
39	Latitude: 35.971044 deg, OR 35 deg 58 min 15.7584 sec Longitude: 14.352851 deg, OR 14 deg 21 min 10.264 sec	2m+ of sand
40	Latitude: 35.971047 deg, OR 35 deg 58 min 15.7692 sec Longitude: 14.353406 deg,OR 14 deg 21 min 12.262 sec	1.2m of sand
41	Latitude: 35.971497 deg, OR 35 deg 58 min 17.3892 sec Longitude: 14.351715 deg, OR 14 deg 21 min 6.174 sec	1.5m of sand, rod could not penetrate further due to sand density
42	Latitude: 35.971502 deg, OR 35 deg 58 min 17.4072 sec Longitude: 14.352268 deg, OR 14 deg 21 min 8.165 sec	1.4m of sand - rock beyond the 1.4m

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43	Latitude: 35.971505 deg, OR 35 deg 58 min 17.418 sec Longitude: 14.352823 deg, OR 14 deg 21 min 10.163 sec	2m+ of sand
44	Latitude: 35.971508 deg, OR 35 deg 58 min 17.4288 sec Longitude: 14.353377 deg, OR 14 deg 21 min 12.157 sec	2m+ of sand - However, rock formation in the vicinity
45	Latitude: 35.971923 deg, OR 35 deg 58 min 18.9228 sec Longitude: 14.351526 deg, OR 14 deg 21 min 5.494 sec	1.5m of sand - rod could not penetrate further due to sand density
46	Latitude: 35.971942 deg, OR 35 deg 58 min 18.9912 sec Longitude: 14.35208 deg, OR 14 deg 21 min 7.488 sec	2m+ of sand
47	Latitude: 35.971961 deg, OR 35 deg 58 min 19.0596 sec Longitude: 14.352634 deg, OR 14 deg 21 min 9.482 sec	2m+ of sand
48	Latitude: 35.97198 deg, OR 35 deg 58 min 19.128 sec Longitude: 14.353189 deg, OR 14 deg 21 min 11.48 sec	2m+ of sand
49	Latitude: 35.972383 deg, OR 35 deg 58 min 20.5788 sec Longitude: 14.351499 deg, OR 14 deg 21 min 5.396 sec	1.8m of sand - rod could not penetrate further due to sand density
50	Latitude: 35.97245 deg, OR 35 deg 58 min 20.82 sec Longitude: 14.352047 deg, OR 14 deg 21 min 7.369 sec	2m+ of sand
51	Latitude: 35.972518 deg, OR 35 deg 58 min 21.0648 sec Longitude: 14.352596 deg, OR 14 deg 21 min 9.346 sec	2 m+ of sand
52	Latitude: 35.972585 deg, OR 35 deg 58 min 21.306 sec Longitude: 14.353144 deg, OR 14 deg 21 min 11.318 sec	1.4 m of sand

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53	Latitude: 35.972831 deg, OR 35 deg 58 min 22.1916 sec Longitude: 14.351418 deg, OR 14 deg 21 min 5.105 sec	1.4m of sand - rod could not penetrate further due to sand density
54	Latitude: 35.973009 deg, OR 35 deg 58 min 22.8324 sec Longitude: 14.351928 deg, OR 14 deg 21 min 6.941 sec	2m+ of sand
55	Latitude: 35.973187 deg, OR 35 deg 58 min 23.4732 sec Longitude: 14.352437 deg, OR 14 deg 21 min 8.773 sec	2m+ of sand
56	Latitude: 35.973365 deg, OR 35 deg 58 min 24.114 sec Longitude: 14.352947 deg, OR 14 deg 21 min 10.609 sec	1.6m of sand
57	Latitude: 35.973268 deg, OR 35 deg 58 min 23.7648 sec Longitude: 14.351284 deg, OR 14 deg 21 min 4.622 sec	1.0m of sand
58	Latitude: 35.973537 deg, OR 35 deg 58 min 24.7332 sec Longitude: 14.351729 deg, OR 14 deg 21 min 6.224 sec	2m+ of sand
59	Latitude: 35.973805 deg, OR 35 deg 58 min 25.698 sec Longitude: 14.352174 deg, OR 14 deg 21 min 7.826 sec	2m+ of sand
60	Latitude: 35.974074 deg, OR 35 deg 58 min 26.6664 sec Longitude: 14.35262 deg, OR 14 deg 21 min 9.432 sec	1.5m of sand

Andrei Cachia – HSE Part 3 (Scotland)
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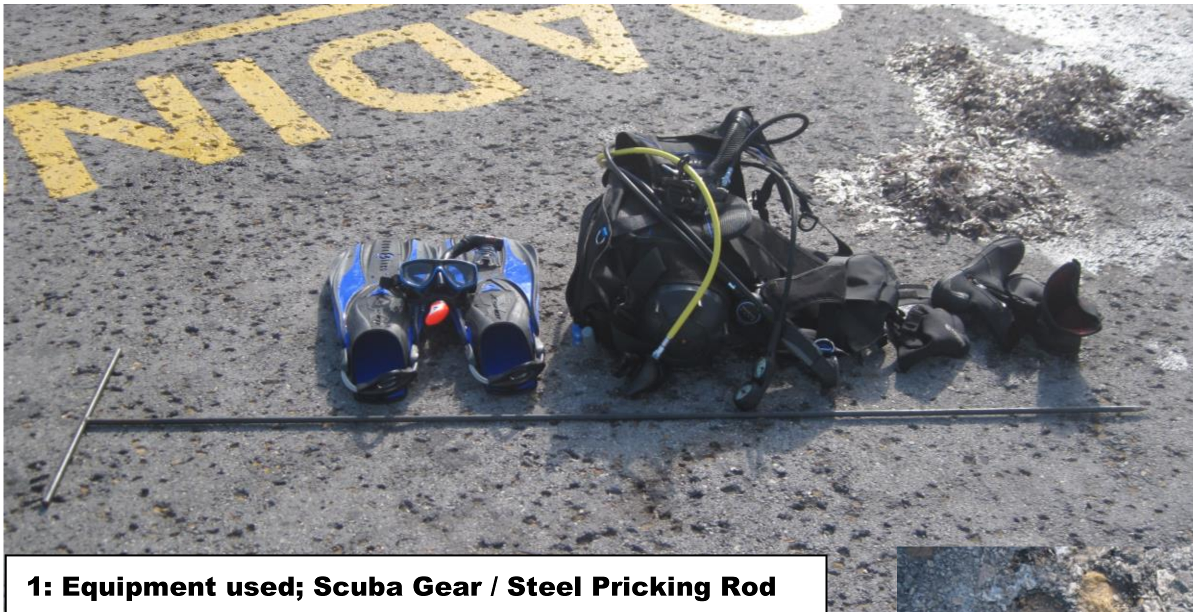

1: Equipment used; Scuba Gear / Steel Pricking Rod

2: Steel Rod Point

3: Dinghy used

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4: Diver in operation

5: Diver in operation

6: Diver measuring remaining exposed rod

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7: Diver in operation

8: Diver in operation

9: Diver in operation

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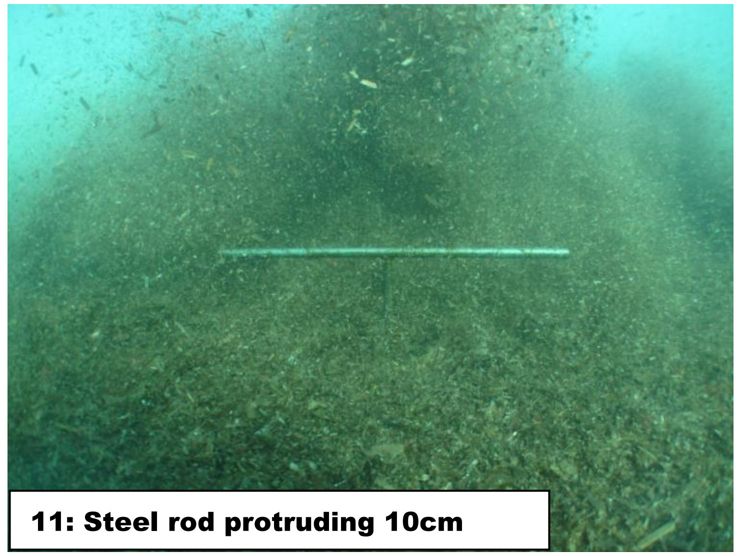
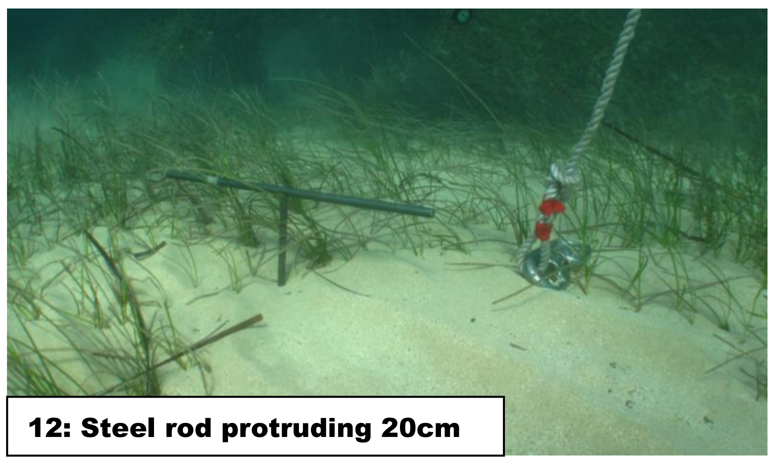
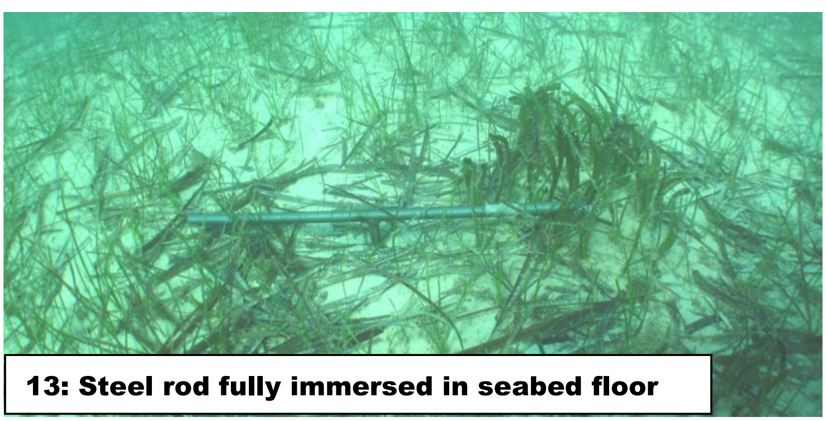
10: Steel rod in full view



11: Steel rod protruding 10cm



12: Steel rod protruding 20cm



13: Steel rod fully immersed in seabed floor

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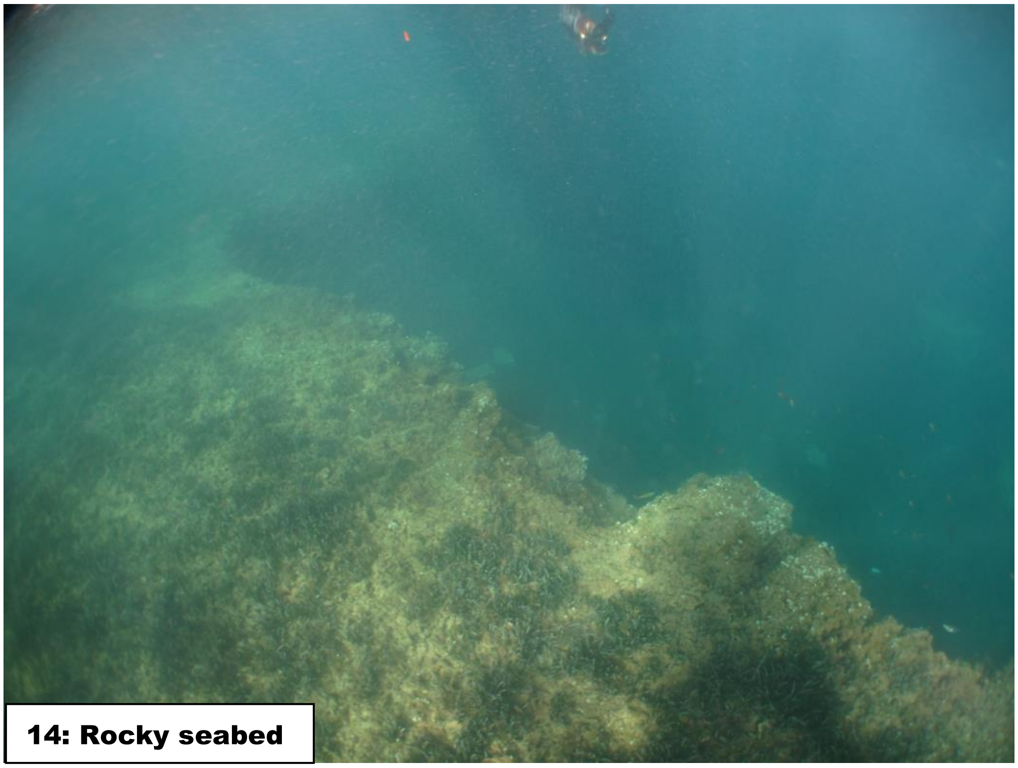

14: Rocky seabed

15: Rocky seabed

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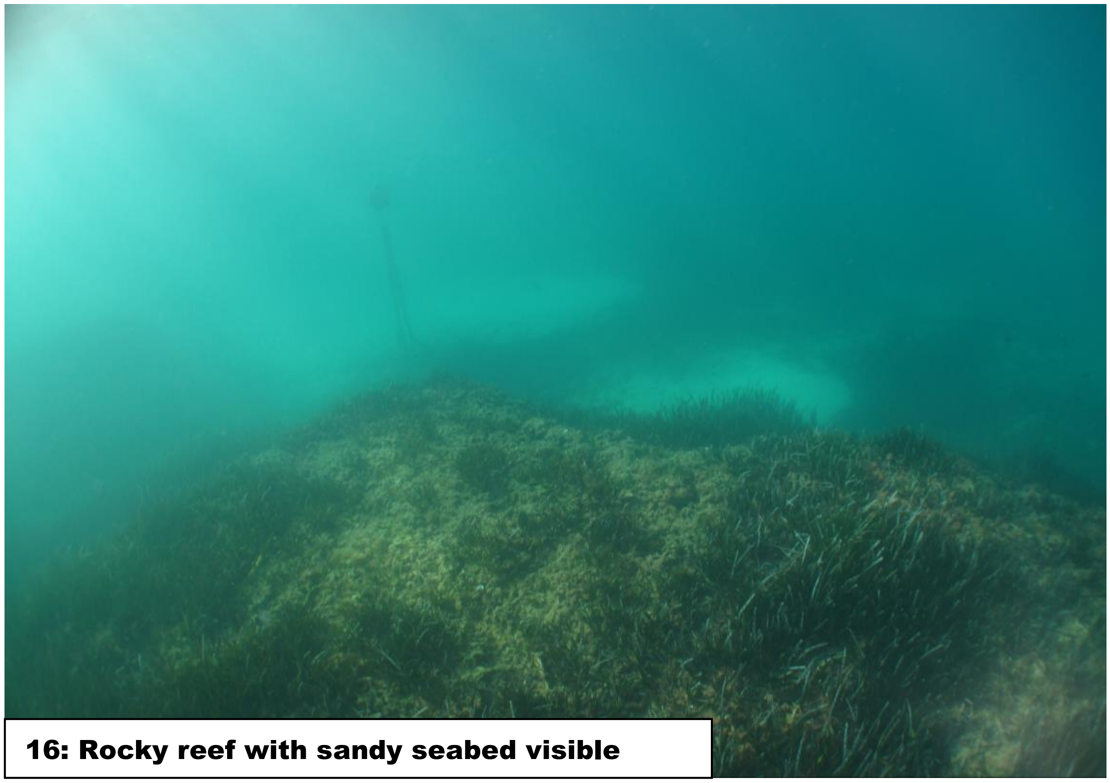

16: Rocky reef with sandy seabed visible

17: Rocky reef with sandy seabed visible in front

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18: Sandy seabed covered with Posedonia remnants

19: Sandy seabed floor covered with Posedonia remnants and shoots present (steel rod visible in the background)

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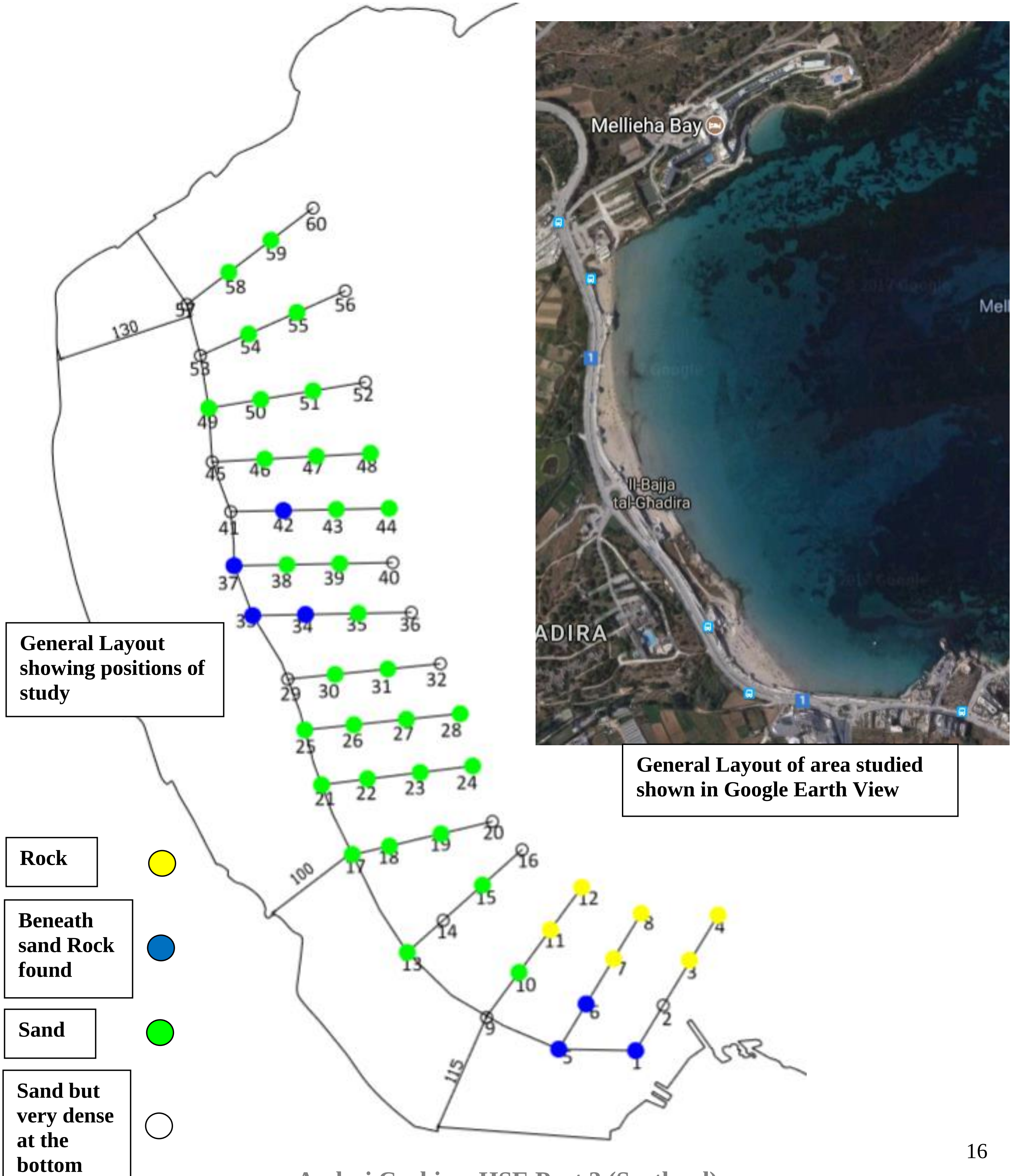

General Layout showing positions of study

General Layout of area studied shown in Google Earth View

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Signature: ………………………………………………… **Date:** ……………………….

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ANNEX 002

Ghadira Bay, Mellieha
Feasibility Study

21 March 2018

A5235

Contents

List of Figures

Document Status and Signatures

Document Status		
Document Reference: A5235/CC/TJC		
Issue Date	**Version**	**Rev**
15 February 2018	Final	F1
21 March 2018	Final with additional interpretation	F2

File location: N:\Jobs\A5000-A5249\A5235\3 - Reports and Specifications\A5235.Ghadira Bay Mellieha Feasibility Study - F2 21 March 2018.docx

Signed on behalf of CTP	
Prepared by:	**Richard Swift CEng MICE PhD BSc and Chris Clark CEng MIStructE MICE MCS**
Reviewed by:	**Chris Clark CEng MIStructE MICE MCS**

1.0 Brief

1.1 This report has been prepared for Foundation of Tourist Zone Development as detailed in our fee quotation dated 22 January 2018 subsequent email dated 25 January 2018 and in accordance with their instructions received on 25 January 2018.

1.2 CTP were instructed by Foundation of Tourist Zone Development on 25 January 2018 to carry out a feasibility study into the stability of a proposed extension to the sandy beach at Ghadira Bay, Mellieha, Malta. The study was to utilise data generated and obtained by CTP for previous studies in the area. The feasibility study was to form part of a Project Description Statement (PDS) to be submitted by the Client to the Planning Authority.

1.3 CTP has no responsibility to any other parties to whom this report may be circulated, in part or in full, and any such parties rely on the contents of this report solely at their own risk.

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2.0 Project description

2.1 The report by Andrei Cachia (2017) provides a set of detailed data concerning the depths of sand deposits around Ghadira Bay. The purpose of measuring the depths was to ascertain whether the existing sand deposits were of sufficient volume that they could be pumped or otherwise relocated to the inshore area, to widen the existing sandy platform of the beach. Therefore, the proposed beach modification project is a cut and fill operation rather than a recharge with new material. Figure 1 shows a plan of the proposed reclamation as it would appear at the southern corner of the existing frontage. The aim is to extend the reclamation across to the north side of the Bay.

Figure 1 – Plan of the proposed cut and fill reclamation as it would appear at the southern and of the frontage. The length of the proposed jetty is 20 metres. (Image provided by A, Cachia)

2.2 In Figure 1, the red line denotes the sand/water intersection of the proposed new extended beach; by visual inspection, it is located approximately 70 metres offshore of the seawall and the 70m off the existing sand /water interface along the beach.

3.0 Bathymetry of the site

3.1 Figure 2 shows a contoured plot of the bathymetry over the inner part of the Bay. The soundings over the outer area of the Bay are of considerably lower resolution and derive from Admiralty data. The bathymetry is complex, with rocky outcrops that exert a strong influence upon storm waves around the inner Bay. The beach area is gently sloping at a gradient of ~1/30 in the nearshore approach waters to the beach, levelling off to approximately 1/40 to 1/50 on the upper part. It is noted that the minimum soundings elevations are of order -0.3 to -0.1 metres CD and apparently, there is no beach survey data set.

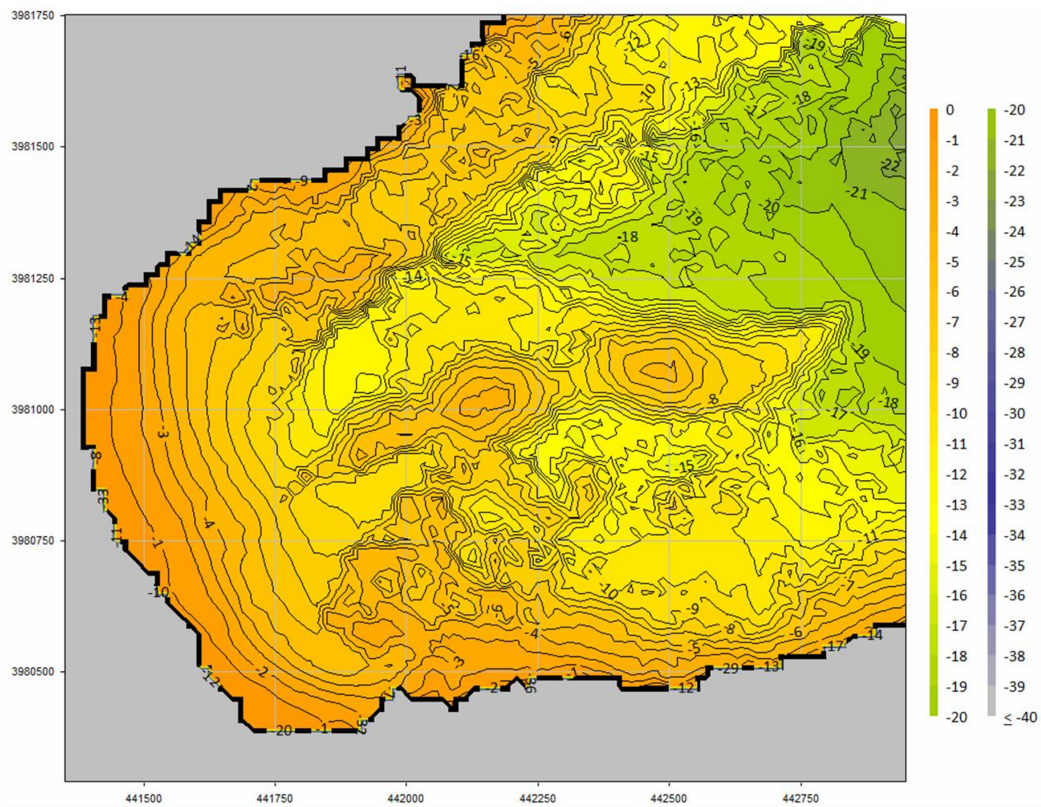
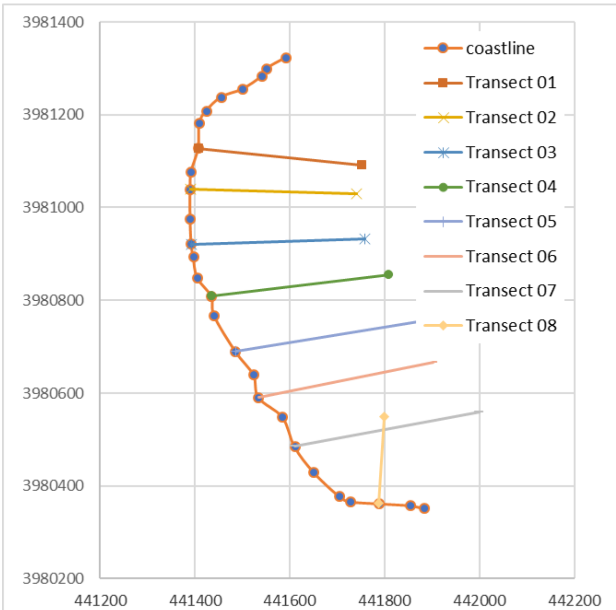
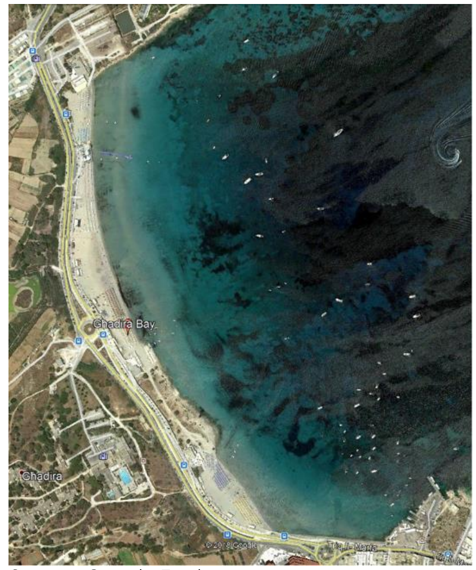


Figure 2 – Contoured plan of the seabed elevations to metres Chart Datum. CD is 0.577 metres below the Mean Sea Level

3.2 Figure 3 shows the layout of a set of transects that were taken through the soundings of the bathymetry; the soundings were those supplied to a previous project in 2013, which related to the Tunny Net area. The coastline boundary was derived from Admiralty data also supplied in 2013 and is presumed to be the outline to Mean High Water Spring tide.



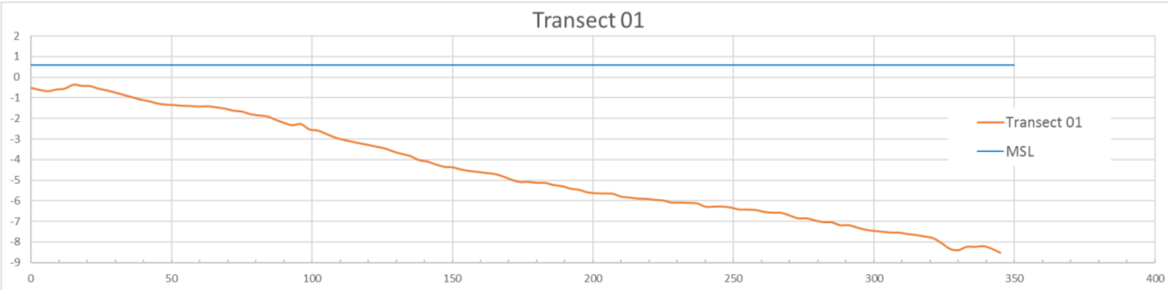


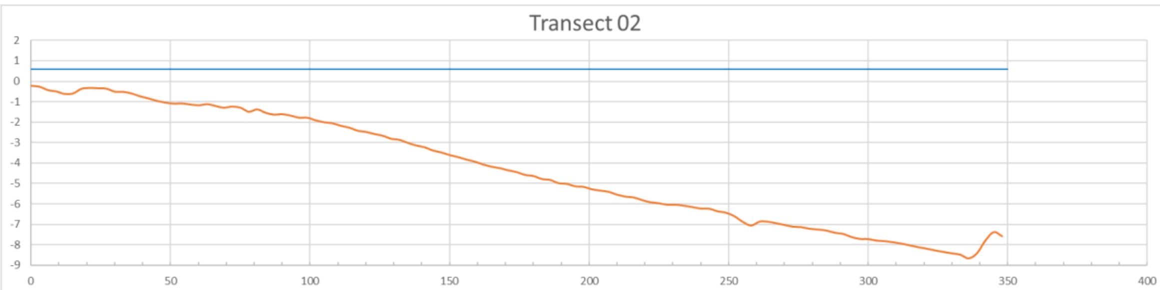
Source: Google Earth 2018

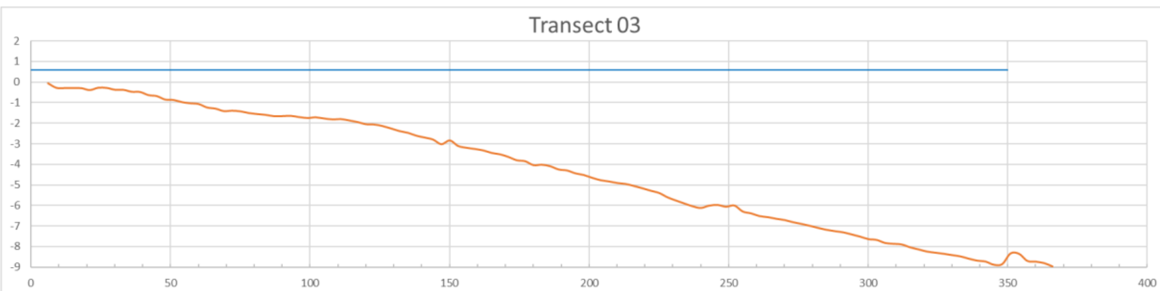
Figure 3 – Layout of the transects taken through the bathymetry

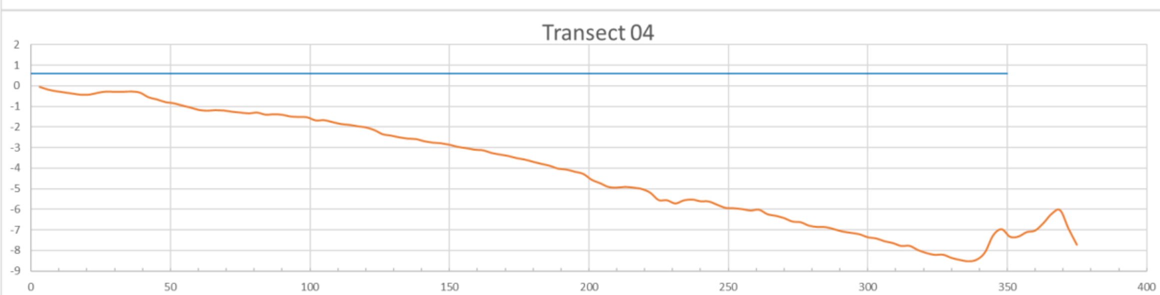
3.3 It appears that the beach elevations and defence were not captured by survey and that the soundings finished below the waterline intersection with the beach. Mean Sea Level is at 0.577 metres above CD.

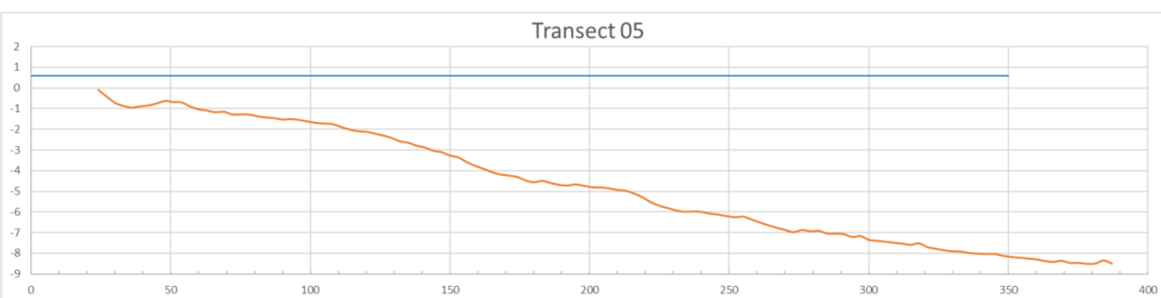
3.4 Figure 4 shows a set of eight transects taken at the locations indicated in Figure 3; the horizontal axis of each plot represents the distance measured from the Admiralty coastline boundary at the transect position under consideration. The vertical axis of each plot is the bathymetric elevation to Chart Datum.


Transect 01
Transect 01
MSL


Transect 02


Transect 03


Transect 04


Transect 05

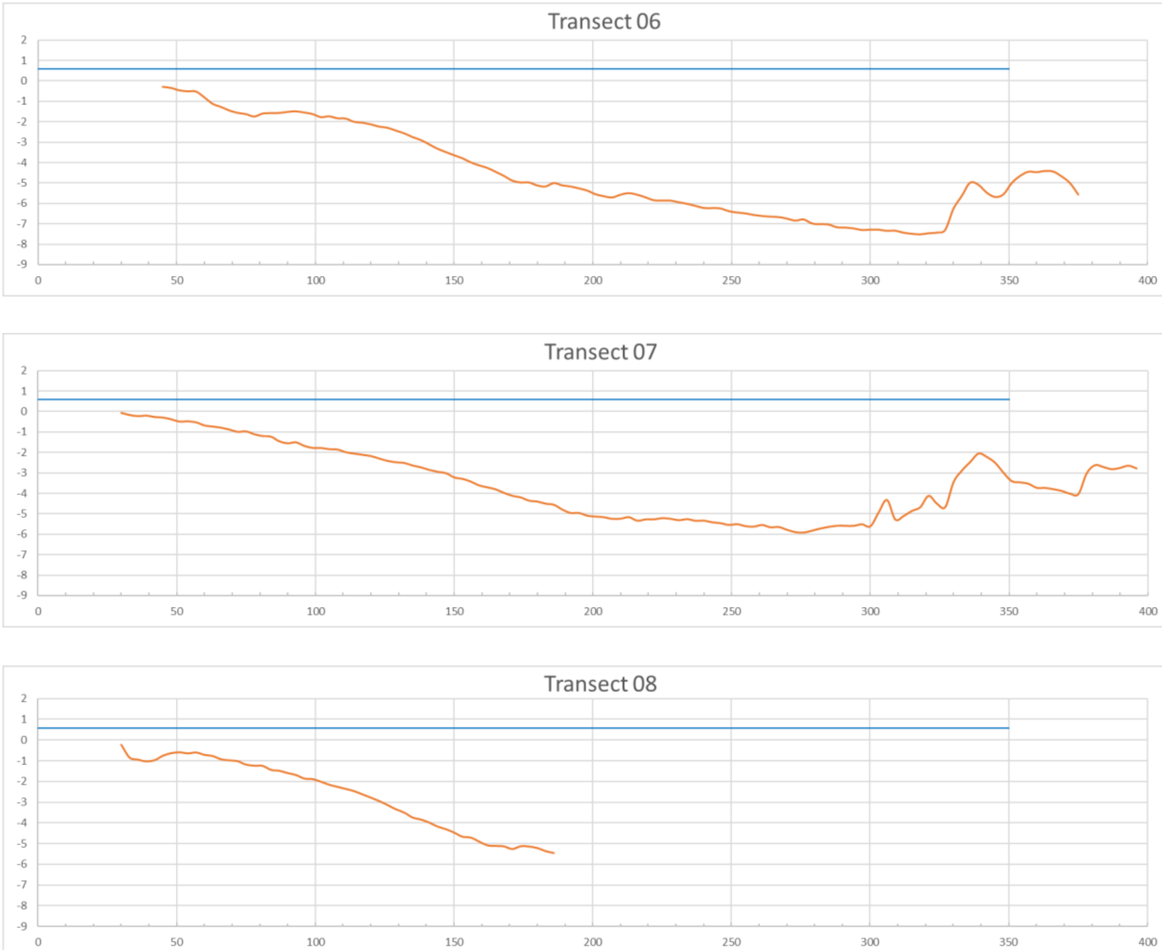


Figure 4 – Plots of the transects at the locations shown in Figure 3. The horizontal axis of each plot represents the distance measured from the coastline boundary at the transect position under consideration. The vertical axis of each plot is the bathymetric elevation relative to Chart Datum.

3.5 Transect numbers 1 to 5 all display a slight dip at the far-left hand end near to the coastline and just offshore of the dip, is a small rise in elevation followed by a slightly steepening downhill descent, moving further offshore. This kind of configuration is the Type II beach identified by Hattori and Kawamata (1981) and idealised in Figure 5.

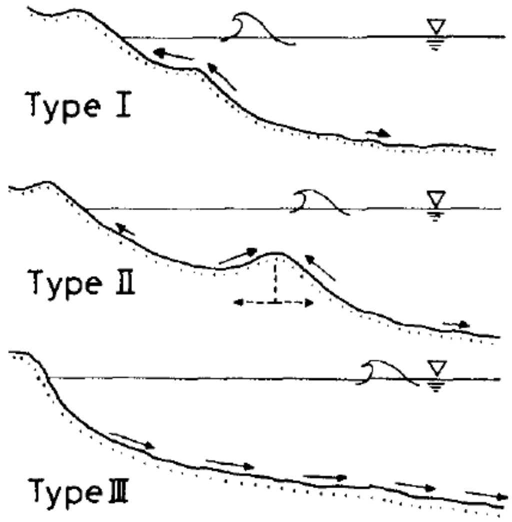


Figure 5 – The three classifications of beach types as proposed by Hattori and Kawamata (1981)

3.6 The Type II beach forms a bar near to the wave-breaking position and the bar sometimes migrates either landward or seaward. Under certain conditions, which depend mainly upon the wave characteristics in the nearshore zone, the Type II beach can intermittently transform to the Type I or the Type III, which are as follows:

- Type I – an accretive beach profile with a step on the foreshore, in which sand transport is dominant in the surf zone and the shoreline tends to advance, and…
- Type III – the erosive storm beach profile without bars; a dominant offshore sand transport develops in the nearshore zone.

3.7 The beach behaviour can become seasonal, based on the three morphological Types. It is noted that the resemblance that the beach has to a Type II in the transects, might be due mostly to scour at the southern end of the beach, induced by the hard defence line. Nevertheless, the nearshore bar persists in areas where there are no hard defences close to the waterline and in that sense, it can be regarded as a naturally-constructed beach form.

3.8 It is likely that the beach is predominantly a stable Type II at present, since the previous Google Earth aerial photograph, dated 2012, is little different from the currently available version – see Figure 6. However, it is believed that the erosion observed on Transect 05 is again probably due to the proximity of the rock outcrop, which constitutes a hard and potentially reflective local defence stretch. A similar situation probably applies at Transect 06.

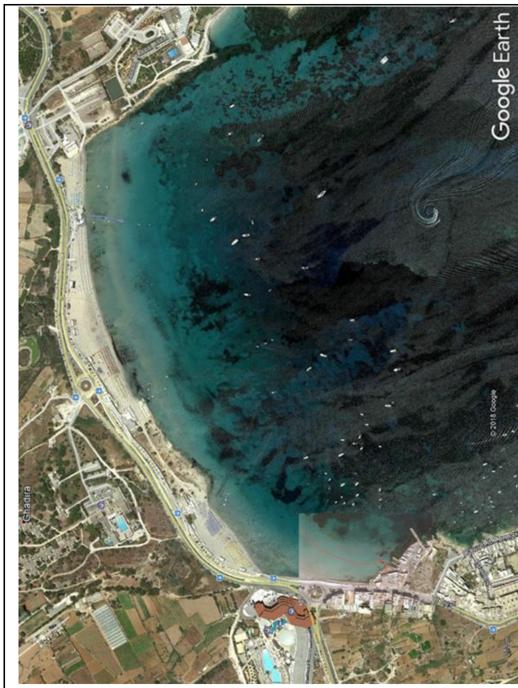


Image from Google Earth:
year given on image: 2018

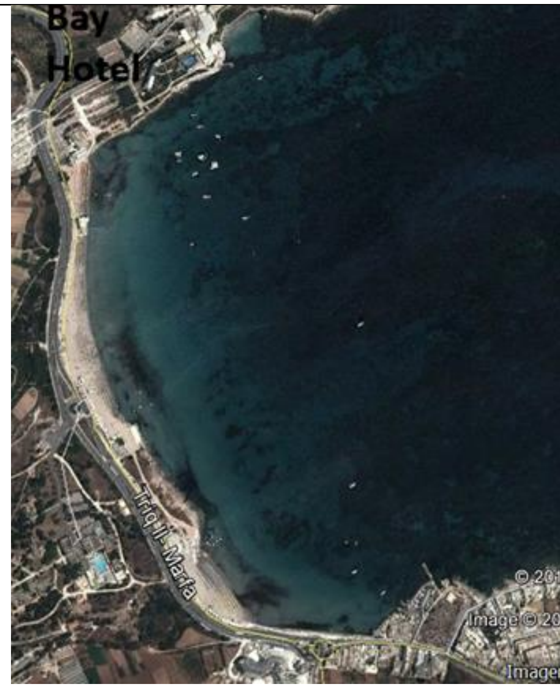


Image from Google Earth:
dated 26th May 2012

Figure 6 – The two most recent images of the beach from Google Earth

3.9 Transect 08 displays a significant dip in the bathymetry immediately adjacent to the start of the transect line and this effect is characteristic of erosion due to wave reflection off the vertical seawall on the far southern side of the frontage. Even when plotted to an equal scale on both axes, so that the correct proportion is maintained, the existence of the dip is clear. There is some evidence that the eroded material has been again deposited just offshore of the dip, forming a nearshore bar.

3.10 Over the northern half of the beach, the nearshore bar is clearly visible in the Google Earth aerial photography – see Figure 6. Over that area, the bar is remote from any reflective structures and this configuration does suggest that a stable Type II beach profile has formed there, as illustrated in Figure 5.

4.0 Beach Behaviour

4.1 Seasonal variations

4.1.1 Based on a large number of observations, Larson and Kraus (1989) provided a means of estimating whether a beach is typically accreting or eroding. The method was based upon considering the deep-water wave steepness, H_o/L_o and the dimensionless settling velocity H_o/wT and setting the beach behaviour into that context. In this method, H_o represents the mean deep-water wave height for a given sea state and L_o is the deep-water wave length, calculated from the peak wave period T. The term w represents the settling velocity.

4.1.2 The deep-water wave properties in the present study were obtained from the 35-year Met Office wave model time series and they were partitioned by season. The settling velocity was calculated using the solution offered by Soulsby (1997) for a median sediment size D_{50} of 275 microns, based upon data supplied by Solidbase (2018) and from a tabulated data set presented by Kenneth Pye Associates Ltd (2009). Figure 7 shows the results, which suggest that the beach might be seasonally balanced between erosion and accretion; however, it is noted that this approach can be used as a guide and not as a precise analysis. Ideally, the predictive method should be calibrated against a time series of beach profile observations.

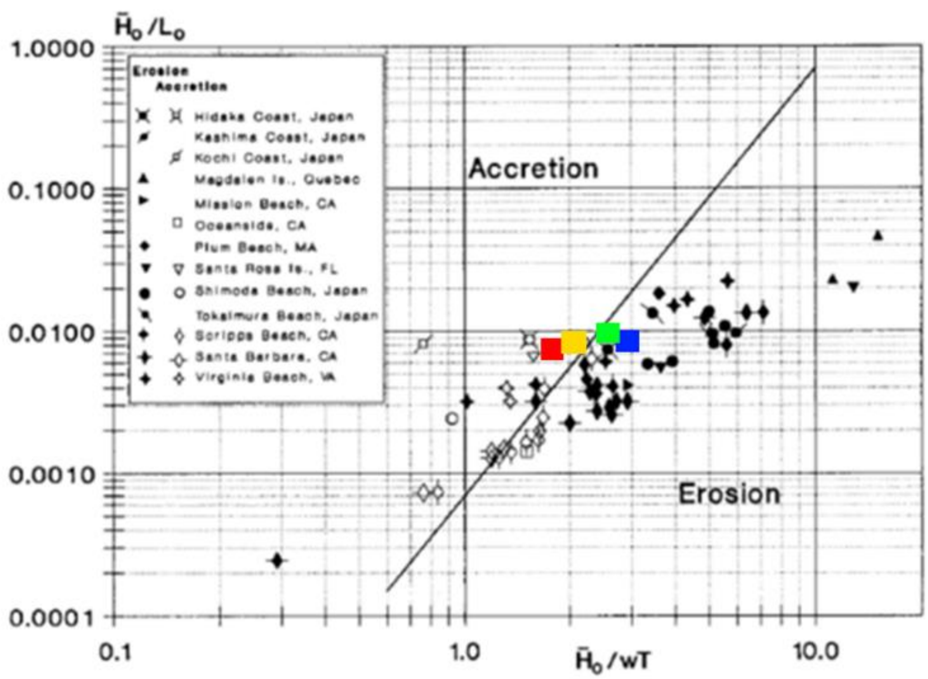


Figure 7 – Balance of erosion-accretion on the Ghadira beach, based upon the seasonally partitioned offshore wave data from the Met Office wave model, and according to the solution proposed by Larson and Kraus (1989). Seasons: spring – green; summer – red; autumn – orange; winter – blue. Data points from Larson and Kraus apply to eight beaches location in the US

4.1.3 Hattori and Kawamata (1981) proposed a method for estimating the balance between erosion and accretion, which included the beach slope, referred to as tan β in their paper. The later study by Larson and Kraus (1989) referred to the earlier work by Hattori and various associates, but preferred the approach as offered in Figure 7, which formed one of the bases for the USACE software product SBEACH, developed for predicting morphological changes on beaches.

4.1.4 In the present study, the Hattori and Kawamata (1981) method has been applied to the Ghadira input data and based upon an average approaching beach slope tan β of 0.035.

4.1.5 Figure 8 shows the result of applying the method proposed by Hattori and Kawamata (1981), in the context of ten sets of beach response data gathered in laboratory wave flumes. In Figure 8, the line 'C=0.5' constitutes the most likely separation line between erosion and accretion, whilst the authors acknowledged that there was a mixed region of beach response over the range 0.3 < C < 0.7. Figure 8 suggests that the Ghadira beach tends to be seasonally biased towards accretion. As in the case of the data sets offered by Larson and Kraus (1989), it is noted that this approach can be used as a guide and not as a precise analysis. Variations in beach slope and in sediment size D_{50}, from which the settling velocity is derived, can again provide different interpretations, with more accretion or more erosion being suggested.

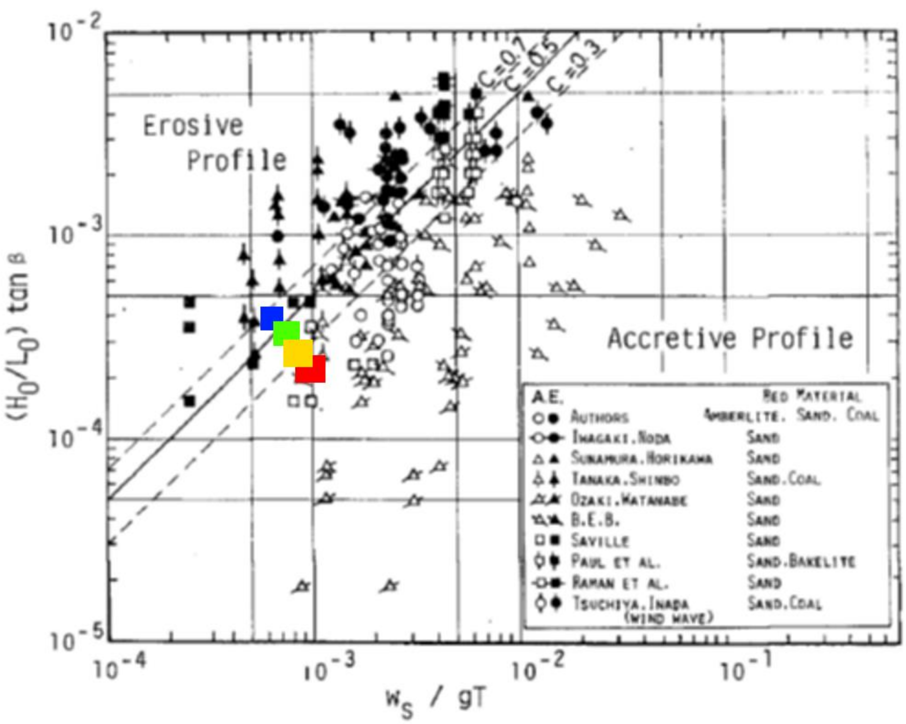


Figure 8 – Balance of erosion-accretion on the Ghadira beach, based upon the seasonally partitioned offshore wave data from the Met Office wave model, and according to the solution proposed by Hattori and Kawamata (1981).

Seasons: spring – green; summer – red; autumn – orange; winter – blue. Data points from Hattori and Kawamata apply to ten sets of experimental laboratory data published by various researchers.

4.1.6 The overall balance of the results by these two methods suggests that the beach is in equilibrium with its seasonal incoming wave climate, but that it lies on a borderline between erosion and accretion, with a slight preference for accretion, and that any substantial geomorphological changes, such as a cut and fill development, could initially invoke a severe response, as the beach attempted to re-adjust itself back to the situation that appertains today, which appears to be a stable equilibrium position, although perhaps not strongly accretive.

4.2 The existing nearshore equilibrium profile

4.2.1 The concept of the equilibrium beach profile was studied by Bruun in 1954 and then reported by Dean (1977). Later, Dean (1991) presented a detailed reconsideration of the equilibrium beach concept, including from the viewpoint of wave energy dissipation on beaches. Subsequently, the concept of the equilibrium beach was embedded in the US Army Corps of Engineers (USACE) Coastal Engineering Manual (CEM) (2002) coastal morphodynamics chapter and in more detail in their cross-shore sediment dynamics chapter (2006).

4.2.2 The recognised solution for the equilibrium beach profile is expressed as:

$h(y) = Ay^{2/3}$, where $A = 0.067w^{0.44}$,

where h(y) is the water depth to the profile at a horizontal distance y measured along the waterline from the sand/waterline interface, and w is the settling velocity of the beach sediment material, expressed in cm/sec. Several other expressions have been proposed for the parameter A; the USACE CEM (2006) referenced here, gives a set of A values in their Table III-3-3. Applying Soulsby's (1997) expression for the settling velocity to a sediment D50 of 275 microns produces an A value of 0.1195, whilst Table III-3-3 of the CEM (2006) results in a value of 0.12. The power factor of 2/3 can vary in practice between 0.4 and 0.8, although 2/3 generally provides a reasonable fit to observations.

4.2.3 Simple though the equilibrium beach solution is, experience has shown that it possesses general validity, owing to the almost universal tendency of beach profiles to begin with a tight power curve and to then straighten out as they approach deeper waters. This behaviour pattern is caused by the wave climate sorting the sediment sizes in the surf and nearshore zone.

4.2.4 Figure 9 shows a typical example of a set of profiles taken at different dates, at a location on a west of Wales beach, demonstrating that, even after a severe storm, a beach will quickly revert to the equilibrium form of a tight curve close to the waterline, followed by a near-straight profile in the nearshore. In Figure 9, Mean High Water

Spring (MHWS) is about +2.6 metres. During the storm of 2014, this section of beach was severely levelled off and an underlying clay stratum exposed, and a segment of rock protection immediately adjacent to it was displaced by storm wave forces, despite the rock size being of order 6 to 7 Tonnes. Nevertheless, the beach quickly recovered to the profile as indicated in Figure 9, after the storm.

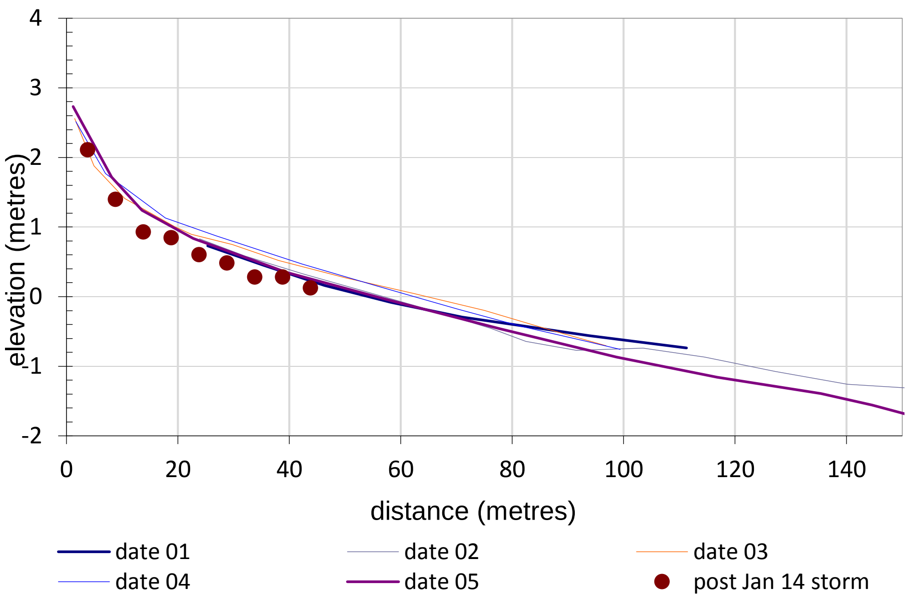


Figure 9 – Example of beach profiles from a location in west of Wales. The Jan 2014 storm referenced in the plot, was predicted to have a joint wave height – water level return period of between 50 and 100 years.

4.2.5 Figure 10, after Suanez et al (2015), shows a similar profile behaviour pattern. In Figure 10, MHWS is at about +4 metres of elevation.

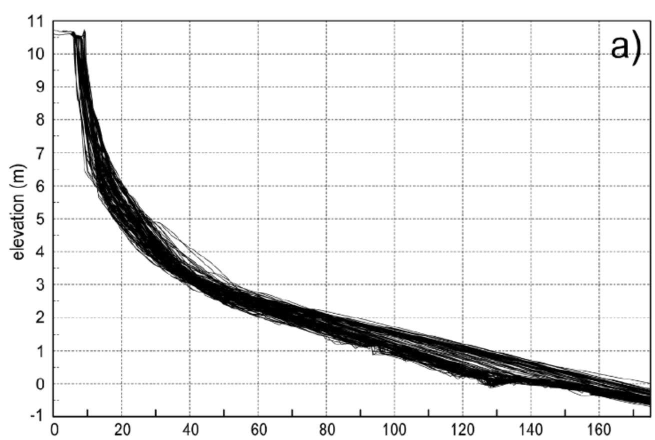


Figure 10 – Beach/dune profiles reported by Suanez et al (2015) at a beach in North Brittany, over the period 2004 to 2014.

4.2.6 Applying the equilibrium beach profile to the eight transects shown in Figure 4 and starting the profile from a point close to the Admiralty coastline, shows in all cases that the transects have achieved an equilibrium gradient across the foreshore, based upon the known sediment diameter. Figure 11, which applies to Transect 02, is a typical demonstration of this finding, which has a generality in all the transects. Beyond the nearshore bar, a foreshore equilibrium slope has developed, based upon the known sediment size. Seaward of the equilibrium slope section, the seabed can achieve a steeper slope, owing to the reduction in wave-induced stirring in the deeper water. Balanced against that, some sorting of sediment sizes can occur, with the larger material being shifted up the slope and onto the beach.

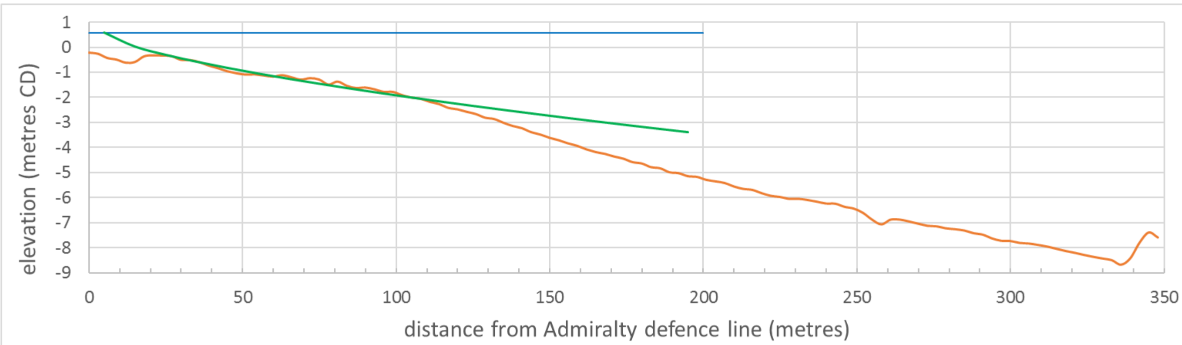


Figure 11 –Typical example of the level of agreement between the upper part of a transect (Transect 02 shown here) and an equilibrium beach profile. The blue line denotes Mean Sea Level and the green curve is the predicted equilibrium beach profile based upon sediment size.

5.0 Wave behaviour in the Bay

5.1 Wave model description

5.1.1 The Swan wave models developed in the previous Mellieha study of 2013 were used to provide some process-oriented observations regarding relevant wave-induced activity within the inner bay. The Swan model can describe the wave processes common to regional and local coastal areas, including wave shoaling, breaking, energy dissipation, wave refraction and wind-induced wave generation, in a directional spectral context. The model also has reflection and diffraction modelling capabilities; however, these tend to be restricted to simple one-line barrier configurations.

5.1.2 The Swan model consists of a regional model of 100-metre resolution within which is nested a 20-metre resolution model, covering all the area in the detailed soundings survey. The results presented here apply to the output from the nested 20-metre model. The Swan models were run for a significant wave height of 3 metres on the offshore boundary of the 100m resolution model, directed straight into the Bay for the North East. A value of 3 metres was chosen for the offshore boundary wave because it represents a moderately strong storm during the winter season, for waves coming from the direction of North around to East, as shown in Figure 12. Such an offshore storm intensity will be sufficient to provide an understanding of wave-induced characteristics in the Bay, without generating a distorted picture of severity. The 3m boundary significant wave height was accompanied by a wind speed of 13m/s, which is the mean wind speed for 3-metre waves coming from around 33.75°N to 56.25°N – that is the direction sector North East.

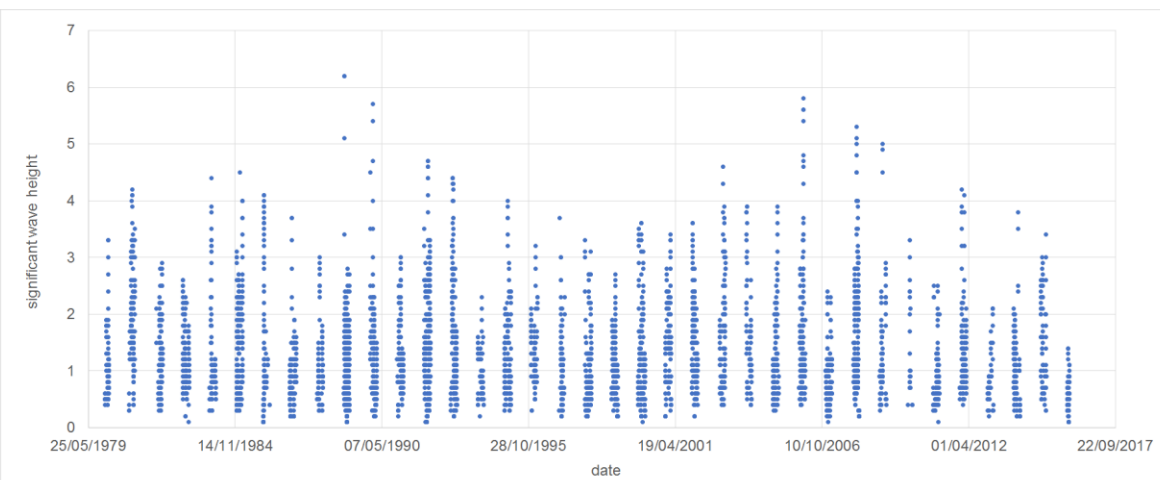


Figure 12 – time series plot of significant wave heights for waves coming from North around to East, in the 35-year Admiralty Wave Model time series

5.2 Results from the wave model

5.2.1 Figure 13 shows the predicted significant wave heights across the domain of the 20-metre resolution nested Swan wave model.

Owing to the bathymetric configuration, more wave energy dissipation occurs over the northern part of the approach waters to the frontage, and wave heights there are lower than along the southern part. The significant wave heights in this area are predicted to be 1.6 metres, whereas at the same distance from the frontage at the northern end, the wave height is only 1.1 metres. Larger waves make ingress into the frontage around the rock outcrop, thus adding to the potential for erosion in that area. The southern corner of the Bay is interesting, with larger waves penetrating closer in to the frontage, and a likelihood of promoting a generally lower seabed in the area adjacent to the vertical seawall. Since this is the area where a jetty is proposed as part of the scheme, it would be important at detailed design stage, to assess whether the structure could be used as protection to the beach.

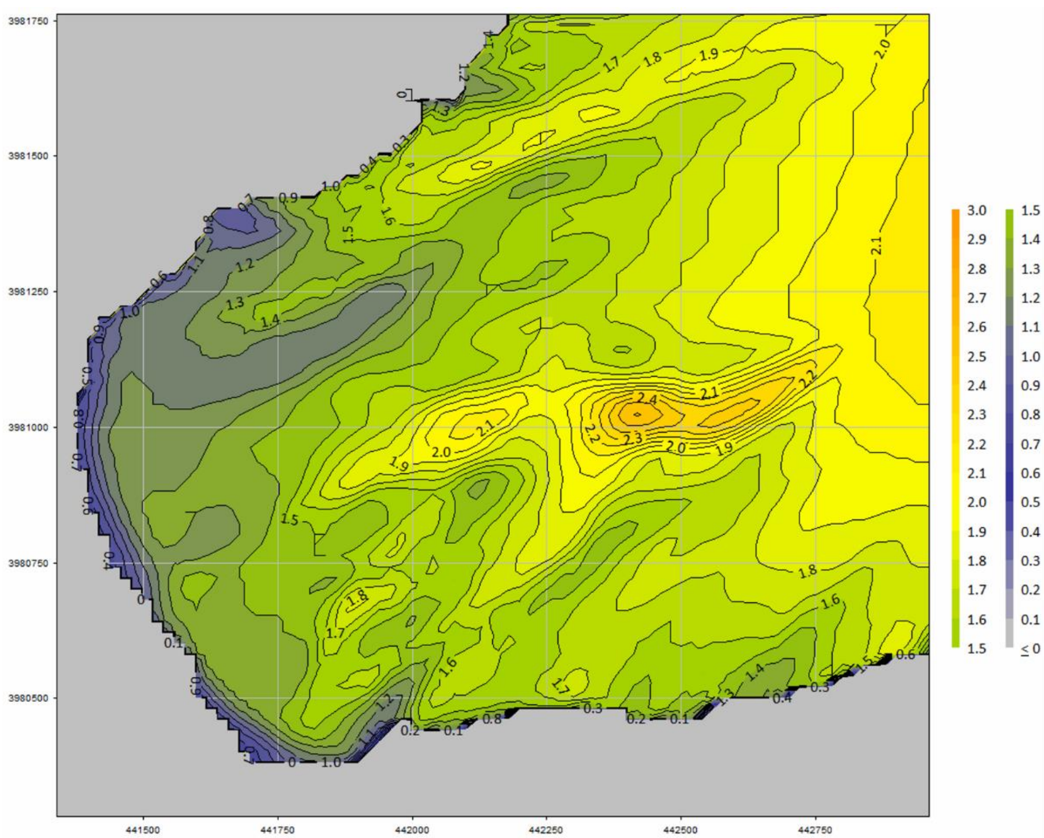


Figure 13 – Contour plot in metres of predicted significant wave heights across the domain of the 20-metre resolution nested wave model during the example storm; the significant wave height on the boundary of the driving 100-metre resolution model is 3 metres.

5.2.2 Figure 14 shows a contour plot of the predicted directions of wave energy transport in the model. All along the frontage, the wave directions are turning so that they are at right angles to the seabed contours, which are shown in Figure 2. When this occurs, a swash-aligned beach develops, with the crests of the waves coming in parallel to the contours of the bathymetry with the result that there is very little alongshore sediment drift. Inspection of the images in Figure 6 indicate that this is in fact the case. A swash-aligned amenity beach in an embayment is a beneficial situation, requiring no annual management of material to keep the volumes balanced along the frontage.

5.2.3 In the southern corner, Figure 14 shows that the waves can refract around to about 20° North and that the refraction process begins at a significant distance offshore of the frontage. This result suggests that a jetty built in this area could be partly outflanked by the process of refraction, so that erosion could still progress adjacent to the vertical seawall in the corner. A reflective wave model is required, to provide more detailed investigation of the wave behaviour relating to a jetty in this area.

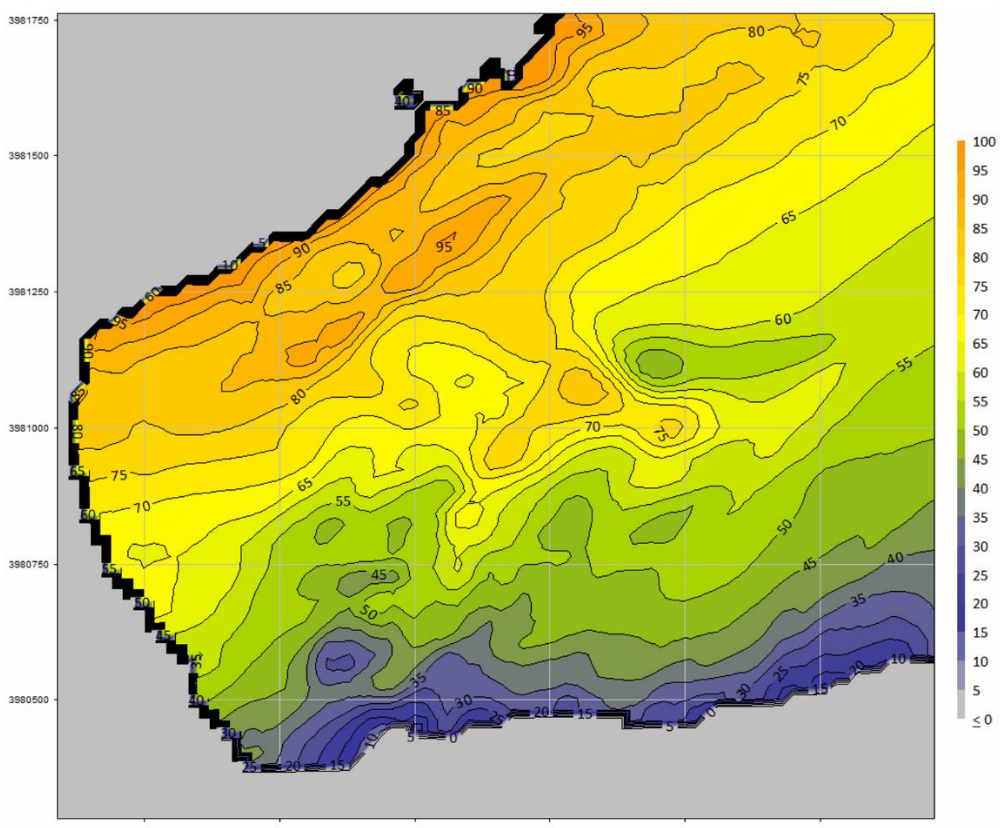


Figure 14 – Contour plot of predicted directions of wave energy transport coming from, during the example storm, presented in the Nautical reference frame, namely: 0° = from North; 45° = from North East; 90° = from East and so on

5.2.4 Figure 15 shows a plot of the predicted root mean square (RMS) wave-induced velocity $U_{b,rms}$ on the seabed. By way of physical clarification, the mean value of a process is equal to 0.886 times the RMS and the average of the upper 1/3 of the process is 1.416 times the RMS. Referring to the method given by Soulsby (1997), an estimate for the critical velocity of 275-micron sand in waves is approximately 0.18 metres/sec. On that basis, Figure 15 suggests that any sand out in the middle of the Bay might not move significantly during a storm, whilst the sand on the frontage would be transported during stormy conditions; that much is obvious and requires little further comment. It is equally obvious that the beach recovers from storm damage and is in a stable condition. Of more interest is the long patch of increased erosion potential along the frontage south of the rock outcrop and reaching a localised maximum at about 50 metres due north of the middle of the vertical seawall. If the beach was to be extended, then without protection, this area could become relatively susceptible to erosion, albeit it at a slightly further distance offshore than is the case today.

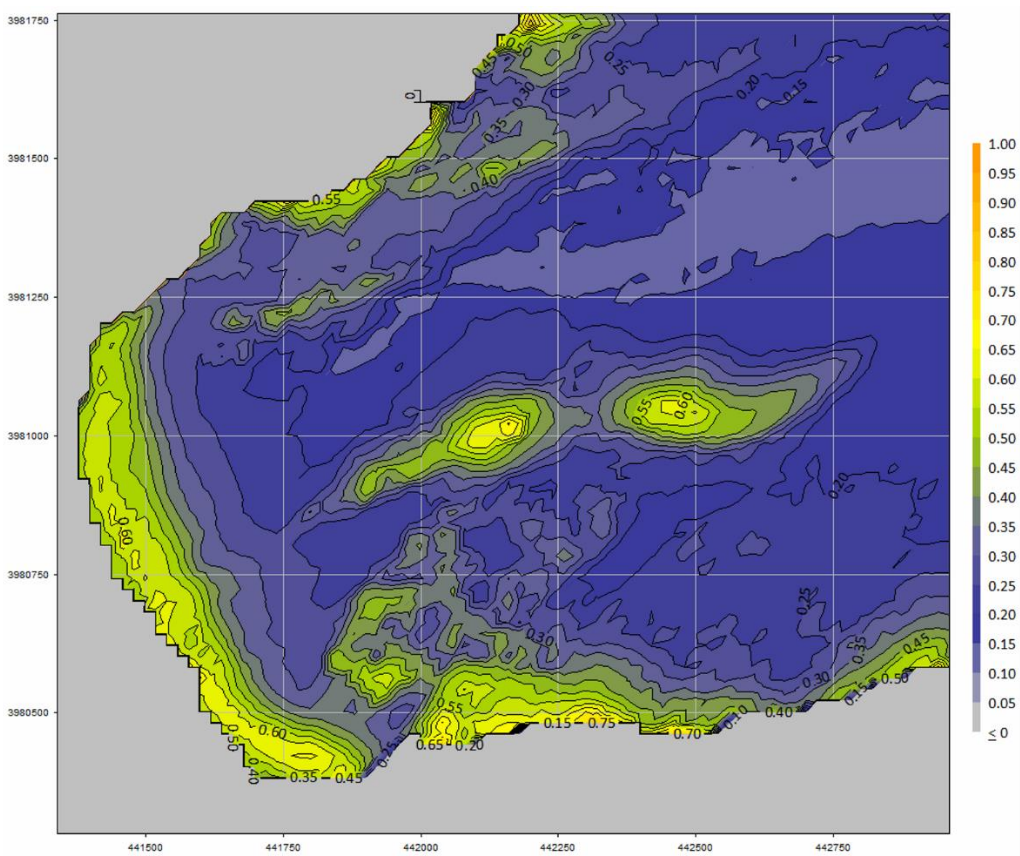


Figure 15 – Contour plot of the predicted root mean square wave-induced velocity on the seabed, during the example storm.

5.2.5 Figure 16 shows the predicted variation in average wavelength around the Bay during the model storm conditions. The wavelength is a function of water depth and wave period and since a directional spectrum has been used as input to the model, then mean wave direction also contributes to the results shown in Figure 16. Waves of a greater length will tend to move seabed material more readily than the shorter waves, because of their greater ability to penetrate to the seabed. Mean wavelengths tend to reduce with reducing water depth and therefore from a long-term geomorphological perspective, wavelength, water depth and erosion capacity will interact, until the seabed achieves a stable scenario.

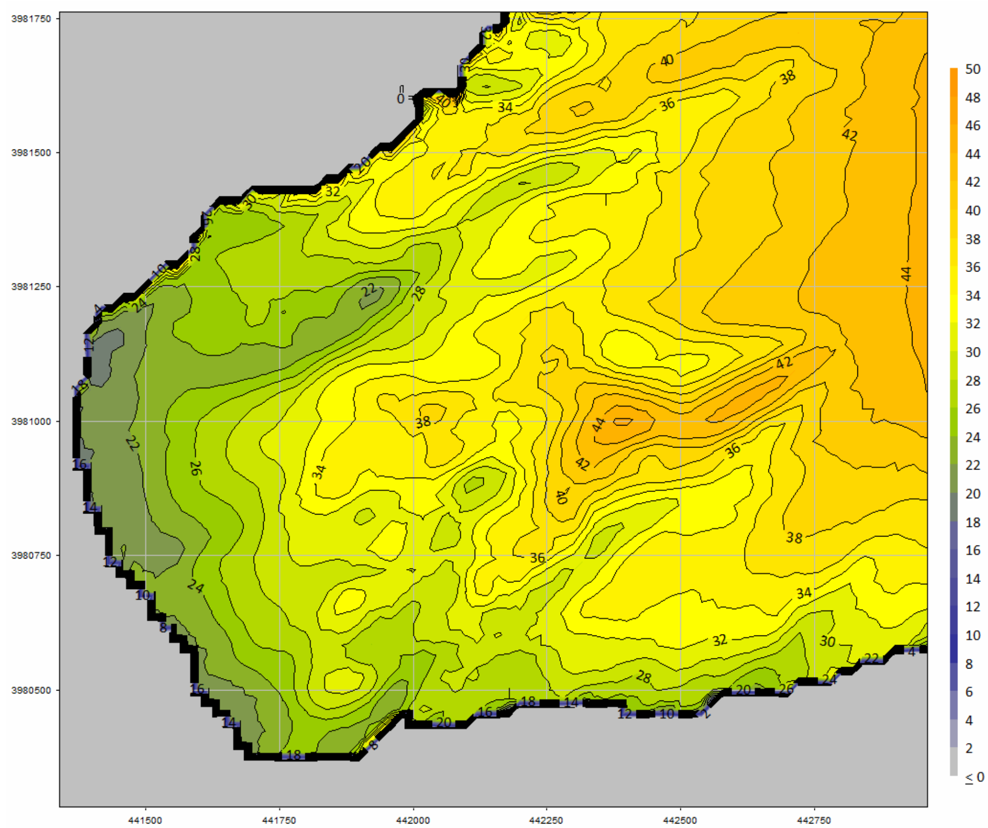


Figure 16 – Contour plot of predicted average wavelengths, during the example storm

5.3 <u>Outline results from a reflective wave model</u>

5.3.1 A reflective wave model was built of the Mellieha Bay area in 2015 as an internal development programme. The wave model was built using the product 'Artemis', which is part of the Telemac suite of programmes developed by EDF. The Artemis wave model can accommodate the processes of wave shoaling, refraction, breaking, reflection off, and diffraction around, structures. It can operate either with a single wave on the offshore boundary, or with a directional wave spectrum, specified by a significant wave height, peak period, mean direction and quantity of directional spreading of wave energy. The model of Mellieha Bay at present is in developmental form and requires some calibration. Therefore, the present results are intended to illustrate potential trends, rather than to predict precise values of wave height.

5.3.2 Figure 17 shows the general response of the model to a directional spectrum applied on the offshore boundary, with a significant wave height of 1 metre and a peak spectral period of 8 seconds.

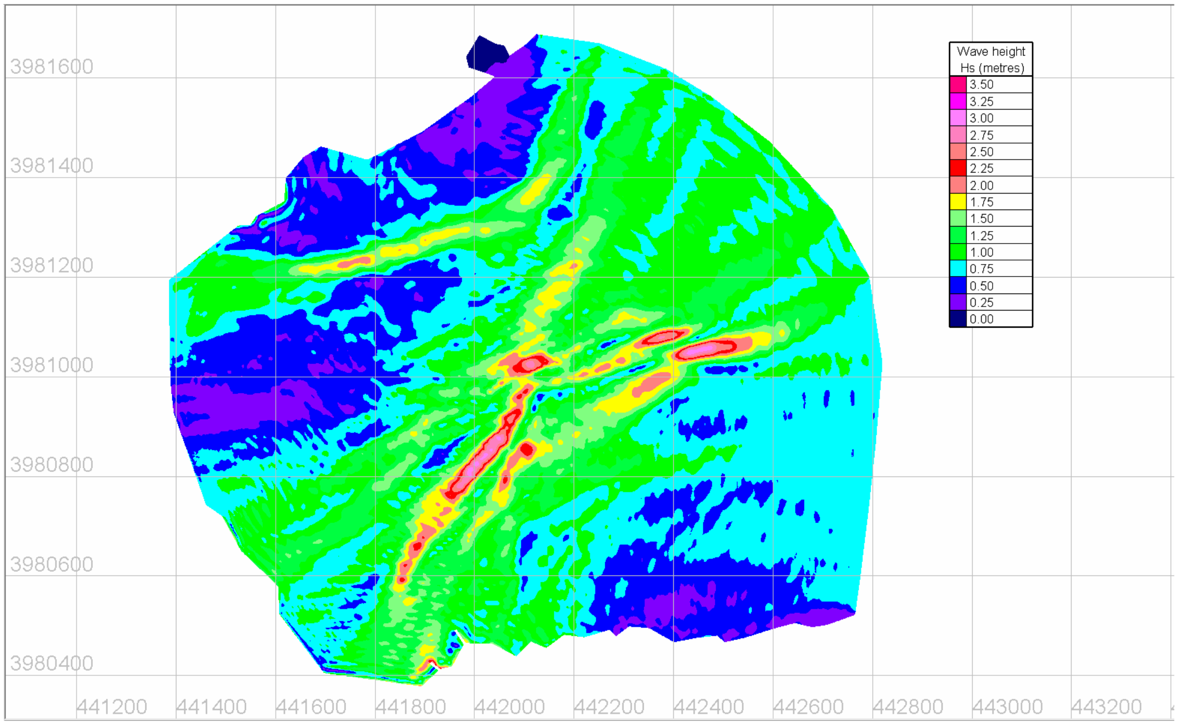


Figure 17 – Layout and response of the Artemis wave model

5.3.3 As shown in Figure 17, in the outer part of the Bay, it is the bathymetry that is generating the wave response, whereas closer to the frontage, wave reflections occur, particularly from vertical walls. The reflection of waves off vertical walls can be seen around the area of the Mellieha Bay Hotel on the north side of the Bay, and further modelling is required, to establish whether, under certain key offshore wave approach directions, reflections off these walls might exert a damaging effect upon the toe and slope of the new beach extension.

5.3.4 The substantial hard standing and fronting wall situated adjacent to the waterline, opposite to the Maxima Bar & Restaurant might also remain a potential source of difficulty during winter months, even with the extended beach scenario.
The vertical wall in the south-east corner of the Bay might also present a potential problem to the long-term stability of an extended beach, unless the beach is built to an equilibrium slope that is close to the existing and even then, softening of the southern boundary by a fronting rock armour slope might be desirable.

5.3.5 Figure 18 shows a local detail of waves around the south east corner of the model, with the existing bathymetry in place. If the beach were to be extended, this would not affect the behaviour of the waves in the approach waters, which would have the same depth as those applying today. It is believed that reflections off the seaward side of the new jetty, as illustrated in Figure 18, would lead to erosion of the new beach in this corner and that waves would eventually work around the back of the jetty and create damage there too. It is therefore suggested that the jetty should be provided with a rock armour seaward facing, to reduce the energy of waves reflected off the seaward side. Further modelling is required, to assess the impact of reflected waves and trapped wave energy acting upon key areas of the proposed new beach, in general. The model will also need to be built with the new beach bathymetry in place, and the results compared against the baseline scenario.

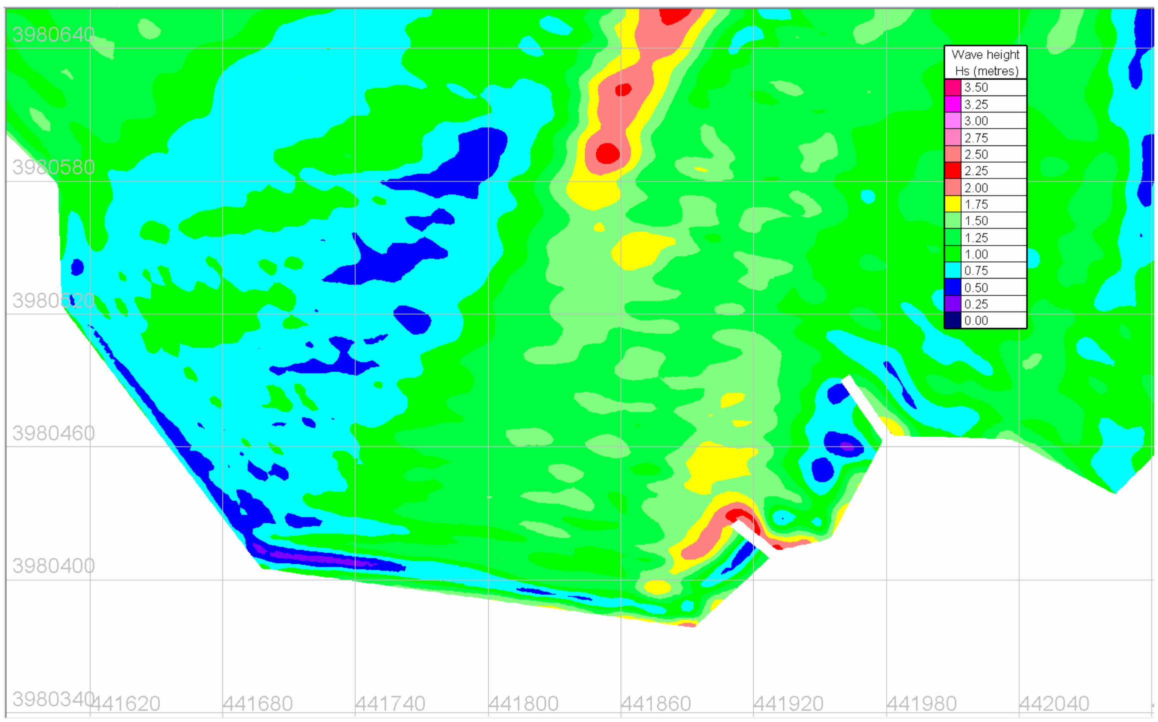


Figure 18 – Wave heights near the new jetty as predicted by the Artemis wave model.

6.0 Nearshore sediment characteristics and anticipated response

6.1 Figure 19 shows the existence of typical sand ripples on the seabed, in the slightly deeper water offshore of the beach area, as reported by Andrei Cachia (2017). It is possible to estimate the approximate level of wave activity and grain size of the seabed deposits in this area, from the sand ripples illustrated in Figure 19. Comparing against the diameter of the diver's cylinder, it appears that the sand ripple wave length could be of the order of 30 centimetres. This dimension would be commensurate with a wave motion orbital diameter on the seabed of about 44 centimetres, working in 4 metres of water with an average long-term significant wave height of 0.5 metres and average energy period of around 5 seconds, derived from the Met Office wave model data set.

6.2 According to Figure 20, such a result falls within the region of observed stable data and suggests that in the waters just offshore of the beach, the mean sediment size might perhaps be somewhat smaller than that on the beach itself and reported by Solidbase (2018). Such a result is expected, owing to the sorting of sediment size that occurs due to wave action over variable shallow-water bathymetry. It further suggests that if material is pumped from the deeper areas up onto the existing beach to advance the line, then the waves in the new breaking zone could rework the newly-deposited sediment and tend, in the long-term, to drag it back in the offshore direction. Clearly, if such a project were to progress in the form of a back-pumped scheme, then sediment size grading would need to be gathered for the existing nearshore deposits.

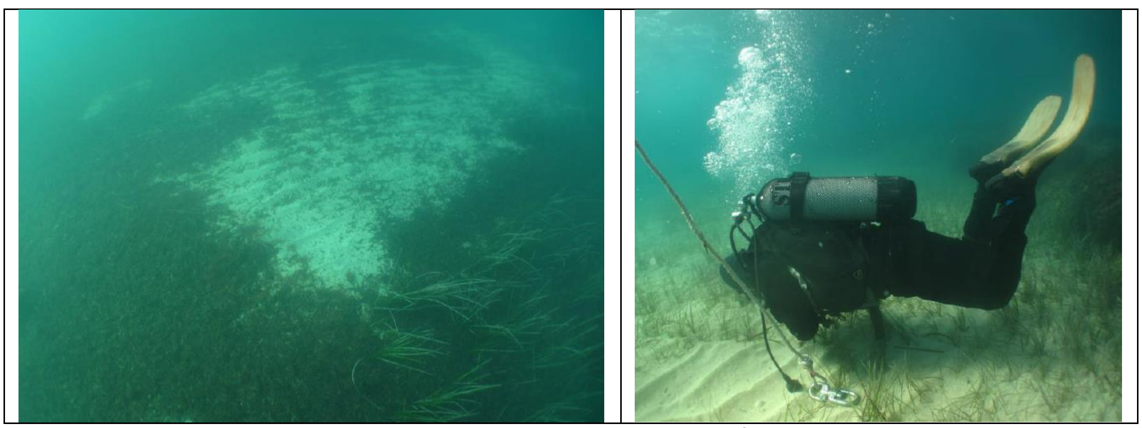


Figure 19– Sand ripples observed on the nearshore seabed (after Cachia, 2017)

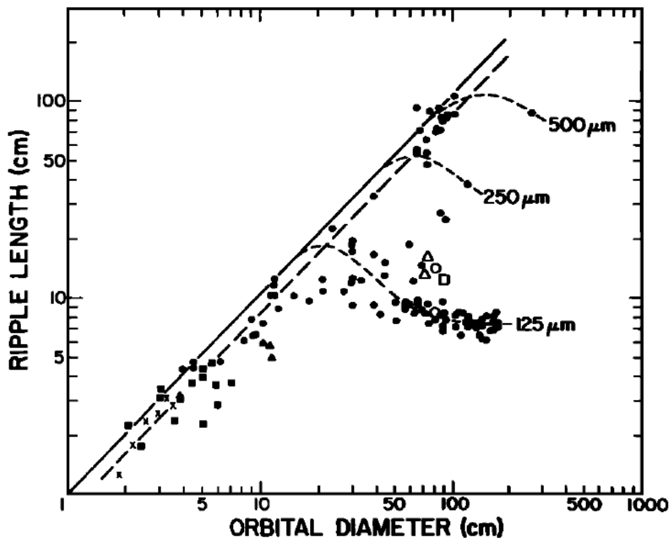


Figure 20 – Relation between wave orbital diameter and seabed sand ripple length, with contributions from sediment diameter (after US Army Corps and reported by the University of California)

6.3 The effect of back-pumping material onto the beach to advance the line would result in an increased nearshore approaching seabed slope compared with that which exists today. Consequently, waves would shoal up to a larger height than that which currently applies, and hence impart more energy to the advanced beach, at the waterline interface. Figure 13 indicates that, if the line is advanced, then at least over the southern part of the frontage, the wave heights arriving at the beach waterline will be somewhat larger than they are today. It is believed that this situation, combined with the steeper seabed approach slope, would cause the newly-placed sediment to be reworked by the long-term wave regime and be slowly dragged back offshore, to re-establish a profile similar to that which exists today, and which appears to be in near-perfect balance with the natural forces acting upon it. In order to reduce the tendency for the sediment to be dragged back to its current location it would be necessary to construct some form of restraint structure along the toe of the beach (e.g. a submerged rock berm). Such a structure would be designed to retain the sand beach in its re-profiled condition and would need to incorporate suitable filter layers to restrict wash out.

6.4 A second option would be to implement a recharge scheme using compatible material imported onto the beach. It would be preferable to construct the slope of the new beach to a gradient similar to the existing nearshore value. If the approach slope in the newly-made shallow water area is too steep, then again, more severe wave breaking will occur, compared to the present situation and the waves will run up onto the new beach. To a certain extent, this issue could be addressed by applying a slightly larger grain size than the existing material. If the recharge material is of a substantially larger size than the existing, then the disparity in sediment wave-induced response between the new and existing material might result in loss of some of the sand that the beach currently holds. A larger sediment size will tend to establish itself to a steeper slope than that which applies today, again inducing larger wave-generated forces at the waterline, which could result in over-working of the existing sediment and its removal further offshore. However, we understand that for environmental reasons a recharge solution is not considered appropriate.

6.5 Figure 21 shows that there is a comparatively large practical range of seabed slopes that can be accommodated by a given sand grain diameter; however, the reason for this is probably the difference in the incoming wave regimes between the sites in the Figure. The Figure also shows that the slope of the upper foreshore at Ghadira, which is of the order of 1/40 to 1/50, is in accord with the data sets, given the observed sediment sizes at the site.

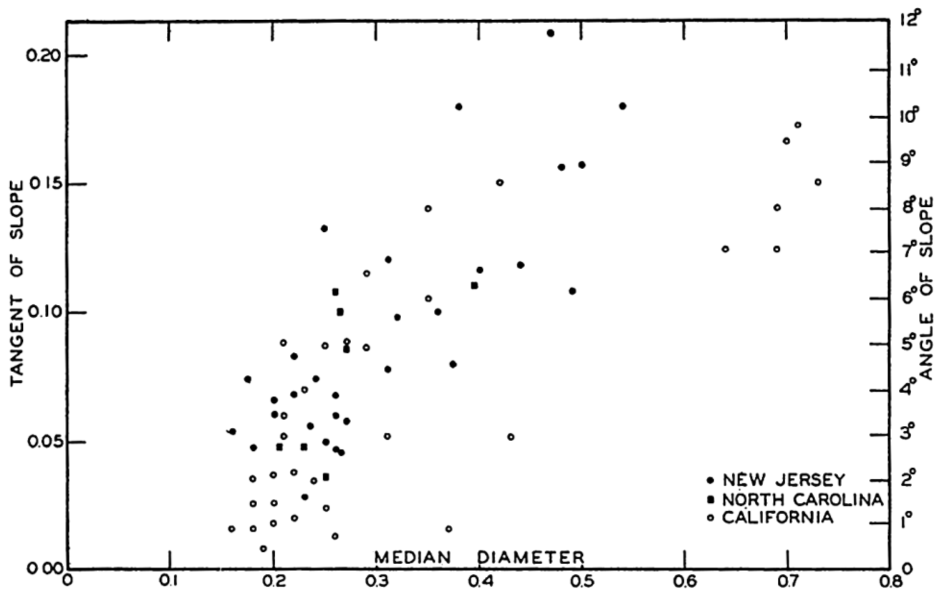


Figure 21 – Tangent of seabed slope as a function of median grain diameter in millimetres (after US Army Corps and reported by the University of California)

7.0 Conclusions and Summary

7.1 Based on the findings presented in this report we have concluded that:

- The beach is swash-aligned, with minimal evidence of alongshore sediment drift; wave modelling confirms that this is the case. This situation is beneficial, since it removes the need for annual maintenance sediment balancing.
- The beach has achieved a seasonal balance of erosion vs accretion that has kept it in place with little change in recent years.
- It appears that the beach is on a seasonal borderline area between erosion and accretion, and with accretion favoured.
- The beach has apparently developed an equilibrium profile in the nearshore approach waters, based upon the sediment sizes report by Solidbase (2018) and Kenneth Pye Associates Ltd (2009).
- Seabed slopes and sediment sizes are in accord with the concept that the beach is currently in a state of good equilibrium with the incoming wave climate.
- There is noticeably more wave-induced activity over the southern half of the frontage, with further increases occurring near to the southern corner. This may not be entirely due to erosion of the foreshore caused by the vertical seawall but could also derive from the overall nearshore bathymetric configuration in that area.
- Waves can refract around the headland at the eastern side of the vertical seawall and this behaviour needs to be considered in the design of the proposed jetty, because there is a risk that if the structure were too short, then it could be outflanked by refracting waves, thus promoting erosion of the new material placed behind. The proposed seawall at the southern end of the bay, whilst probably required to retain this end of the beach, will need to extend beyond the beach by some distance (to be determined during detail design) to be suitably effective.
- A cut and fill solution will result in an increased seabed slope on the offshore end of the profile, thus allowing larger waves to approach the new beach, than is the case with the existing configuration. Slightly larger waves will be able to approach the foreshore than is the case today, and they will break with more energy, owing to the increased bed slope. This behaviour could cause erosion of the filled beach area, with the material being eventually pulled back to the equilibrium condition that applies today. For these reasons a cut and fill solution would have to include submerged restraint or retaining structures along the extended beach toe. Such structures would probably be most suitable constructed with rock and fill to create an armour and filter layers.
- The present nearshore bed slope is in accord with expectations arising from its sediment size. It will therefore tend to return to that slope, if disturbed from its present state of equilibrium, by intervention. This effect could lead to the shoreward migration of the new sand/water interface line.

7.2 Proposed Configuration

7.2.1 Using the transects described in Section 3 of this report and taking into account the above conclusions we have developed cross sections through the beach to indicate the existing configuration plus possible configurations for a 40m and 70m extension to the beach width. The cross sections are shown on drawings A5235-SK01, 02, 03 included in Appendix A to this report. As can be seen the profile of the seabed is such that a 70m extension will require significantly more sand to be placed than a 40m extension. Our calculations indicate that for a 40m extension approximately 260,000m^3 of additional sand is required and for a 70m extension 500,000m^3. The 40m and 70m options have been selected based on our interpretation of the Client's proposals. Both are likely to be stable if the parameters described in this report and verified during detail design are adhered to in practice.

7.2.2 At the southern end of the beach some form of retaining and protection structure will be required. To minimise the effects of the wave climate expected in this area and to prevent excessive erosion of the beach locally a vertical seawall with an armoured protection slope is likely to be required extending some distance beyond the sand/water interface. At this stage we have suggested the wall will need to extend in the order of 20m beyond the waterline, however, this would need to be verified during detailed design.

7.3 Considerations for the next stage of design development

7.3.1 The following marine engineering issues will need to be addressed if the project moves forward.

I. A geotechnical investigation of the bay area and protection structure location including geotechnical characteristics and grading of the sand at various distances off the waterline and confirmation of the general geological configuration.

II. A more detailed reflective wave model to enable the design of the protecting seawall and armoured revetment to the southern end of the beach, toe retaining structures and to investigate in more detail the potential effects of waves reflected off the vertical walls adjacent to the Mellieha Bay Hotel complex at the northern end of the beach and to recommend design remedial measures.

III. Confirmation of the sand grading of the source sand and identification of a suitable borrow areas within the bay.

IV. A wave model analysis of the re-profiled beach including borrow areas to determine the short term effects of the change in seabed profile.

V. An analysis and design of the restraint and/or retaining structures necessary at the beach toe to prevent or restrict erosion of the extended beach profile.

VI. A topographic survey of the existing beach, defences and adjacent civil engineering structures.

VII. Confirmation of a design equilibrium profile for the nearshore zone and beach area, after implementation of the Scheme.

VIII. A more detailed bathymetric survey in the area proposed for new sand placement and mapping of rock outcrops.

IX. Evidence of seasonal changes in the beach profile (if possible).

X. Investigate the availability of LiDAR data, which is known to have been gathered under an EU-funded initiative. Such data is often gathered annually and would be helpful in investigating long-term changes in the beach profile.

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ANNEX 003

PRELIMINARY MARINE ECOLOGICAL ASSESSMENT (SANDRA AGIUS)

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1 PREAMBLE

1.1 INTRODUCTION

1.1.1.1.1 This document presents a preliminary ecological report as part of the Development Application PA 1820/18 which proposes the following: Sand replenishment of Għadira Bay, including the construction of a wave deflector and related marine works.

1.1.1.1.2 The project aims to carry out a sustainable sand replenishment of Għadira Bay using environmentally sensitive methods.

2 The Site

2.1 Site description

2.1.1.1.1 Għadira bay is a gently shelving beach with shallow water for approximately the first 50 metres off the shoreline. It is the largest sandy beach in Malta and is located along the northern-western coast of the island adjacent to the Għadira Nature reserve. Its easy accessibility and family-friendly nature make it one of the popular beaches in Malta.

Għadira Bay is also home to various bars, kiosks, restaurants and facilities providing beach-related activities such as windsurfing, kite surfing, canoeing and water-skiing, as well as a floatable and inflatable water platform which is very popular with the children. It has also been granted blue flag status on a yearly basis since 2012.

2.2 The current situation

2.2.1.1.1 Għadira Bay can be considered sheltered by headlands and therefore waves in the inner part of the bay are generally small. Significant wave action happens during the periods of strong North-Easterly wind. A study by PYE (2009) indicated that during these periods, the sand from the sand dune remains blows onto the existing road causing a hazard to the traffic and resulting in loss of sand and thus indicating that the road and associated structures have had a negative impact on the natural beach replenishment. The same study also highlighted a general retreat of the high water mark since 1957.

Figure 2: Aerial Photo Google Maps - Ghadira Bay

3 Ecological survey

3.1 Desk study methodology

3.1.1.1.1 A literature search was carried out for previous survey work and reports related to the study area. Although literature is scarce, studies by Borg et. al. (2009) and Borg and Schembri (2002), provide information regarding distribution of the *Posidonia oceanica* in the bay and associated species. The former is protected under the EU Habitats Directive and in Schedule III of LN 311/06. This species is also listed in Appendix 1 of the Bern Convention and Annex II of the Protocol concerning specially protected areas and Biological Diversity in the Mediterranean (SPABIM) of the Barcelona Convention.

3.1.1.1.2 Seagrasses form beds that constitute some of the most ecologically important shallow-water marine habitats worldwide. They provide a physical refuge for numerous invertebrate and fish species, food and an extended substratum for attached plants and animals. They also act as nursery areas for juveniles of many commercial exploited species.

3.1.1.1.3 Sea grass cover in the bay consists of both fragmented and continuous *P. oceanica* beds. In shallow waters (2 – 4 m), *P. oceanica* occurs as small patches of varying size (< 1 m to several metres across) on a rocky substratum. In deeper waters (5 – 10 m), the patchy stands were often replaced by reticulate beds consisting of *P. oceanica* growing on a soft sediment bottom and interspersed with bare sand.

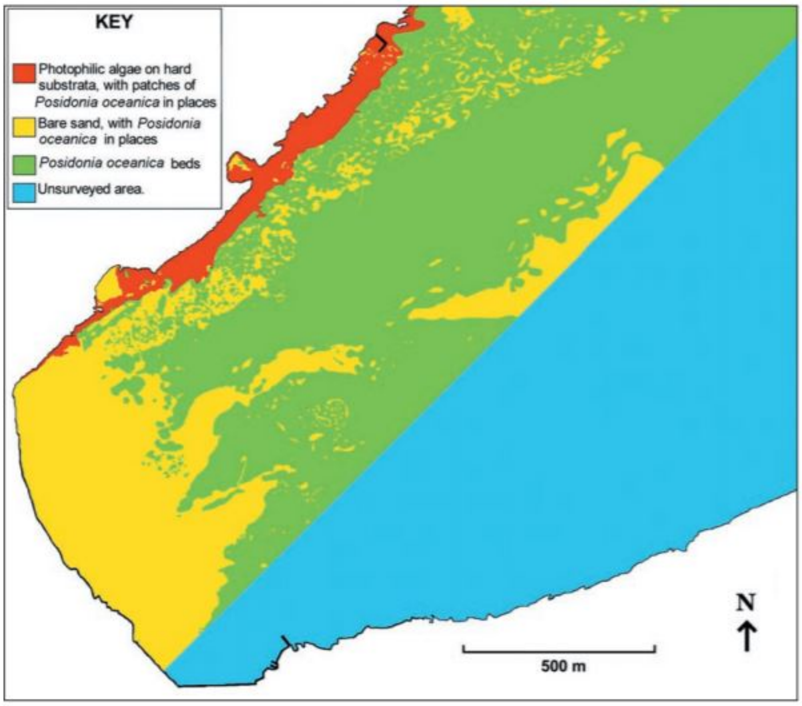


Figure 3: Map showing the small-scale distribution of main benthic habitat types in the north-western sector of Ghadira Bay. Source: Borg et al., 2009

3.1.1.1.4 Patches of naturally occurring dead *P. oceanica* matte interspersed amongst living matte are present in various places, at depths ranging between 5 m and 13 m. These patches of dead matte vary in size from < 1 m^2 to around $100m^2$.

3.1.1.1.5 The Relative Exposure Index (REI) value for Mellieħa, calculated by Borg et al., (2009) is low at 1.66×10^6 indicating that the beach falls in the category of a sheltered site.

3.1.1.1.6 Annex IV Species: The *P. oceanica* meadow present in Għadira Bay supports large populations of the Noble Pen-shell (*Pinna nobilis*). Since *P. oceanica* meadows present in the area under consideration are very extensive, the associated *P. nobilis* population is large.

3.2 Site visit

3.2.1.1.1 A site visit was also carried out to compile a preliminary list of species present in the area. This involved snorkelling along different areas of the site and documenting any species encountered. Only megafauna observed were documented at this stage.

3.2.1.2 Observations

3.2.1.2.1 The bay is prone to heavy passage of marine craft, mostly pleasure craft and recreational fishing boats. The inner parts of the bay are strewn with boat moorings, which have been increasing in number over the past few decades. Disturbance resulting from anthropogenic activities affects seagrass bed morphology through direct physical damage (e.g. deployment of moorings or damage by anchors) is present.

Figure 4: Anthropogenic disturbance at Ghadira bay

3.2.1.2.2 Vegetation belonging to the *Cymodocea nodosae* is present in several places within the study area as mono specific stands. It was also observed as small patches amongst the *P. oceanica* meadows in several areas. The *P. oceanica* meadows present in Għadira Bay were observed to exhibit a varied morphology ranging from very small patches to large and extensive continuous beds as also described by Pace and Schembri (2002). These serve to bind the soft sediment bottom present in most of the bay and act as a buffer to strong wave action during North Easterly winds.

3.2.1.2.3 The sandy area is extensive at depths under 4 metres. This exhibits an impoverished fauna with low species diversity where only 15 different species were observed during the visit. The species present include low numbers of breams notably *Lithognathus mormyrus* and *Oblada melanura* and various species of mullet with *Liza aurata* and *Oedalechilus labeo* being the most abundant. Other species were also encountered in areas characterised by *P. oceanica* meadows including the wrasses *Symphodus tinca*, *Coris julis* and *Symphodus ocellatus* together with other various species (Table 1). Fish were observed to be more abundant when associated with sea grass meadows.

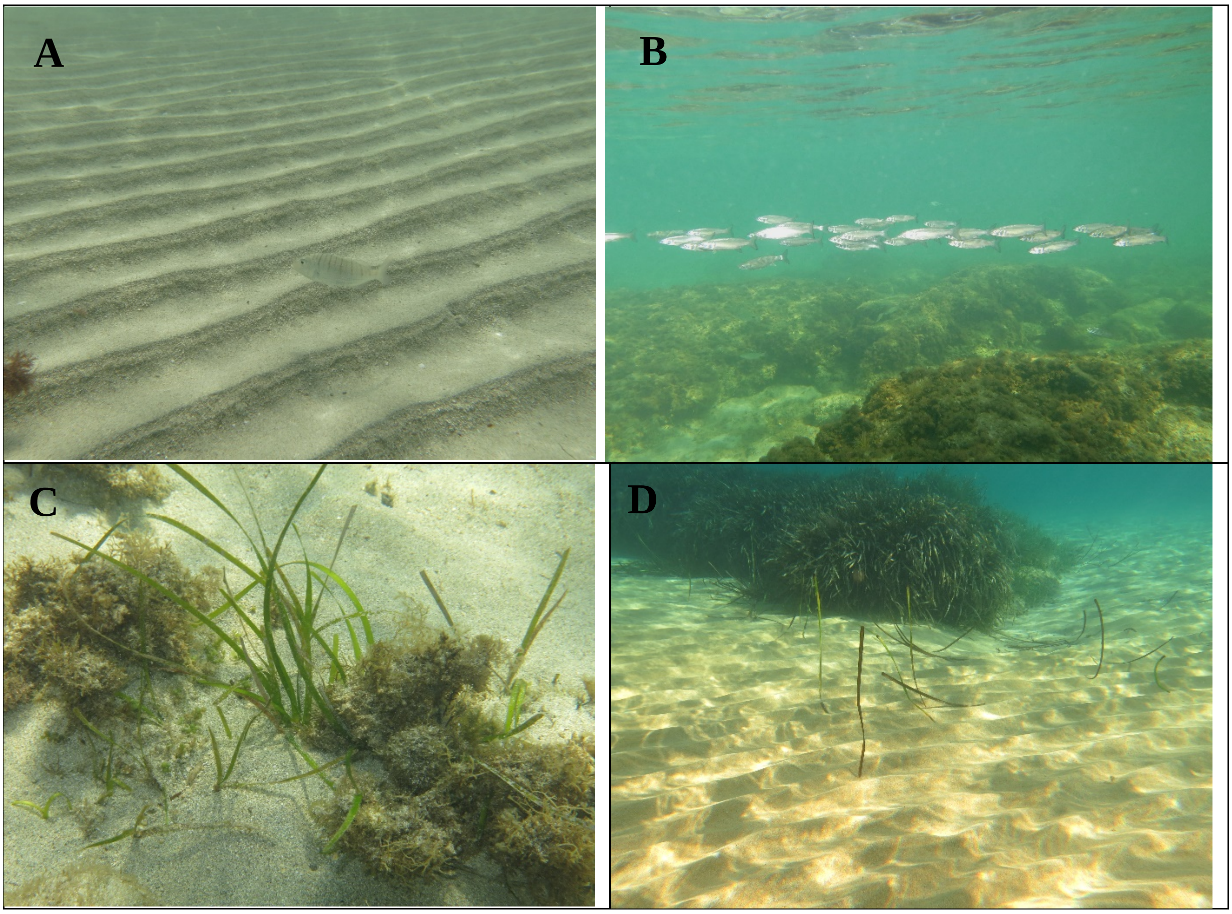


Figure 5: A) *L. mormyrus*, B) *M. cephalus* among rocky areas present in the site lateral boundaries, C) *C. nodosa*, D) *P. oceanica* meadow.

Species name	Common name	Presence observed	
		Sandy area	Area with sea grasses
Coris julis	Mediterranean rainbow wrasse		X
Thalassoma pavo	Ornate wrasse		X
Symphodus tinca	Peacock wrasse		X
Symphodus roissali	Five-spotted wrasse		X
Symphodus ocellatus	Ocellated wrasse		X
Symphodus melanocercus	Blacktailed wrasse		X
Gobius geniporus	Slender goby	X	X
Chromis chromis	Damselfish		X
Mullus surmuletus	Striped red mullet	X	
Serranus scriba	Painted comber		X
Liza aurata	Golden grey mullet	X	
Oedalechilus labeo	Boxlip mullet	X	
Chelon labrosus	Thicklip grey mulet	X	X
Diplodus annularis	Annular seabream		X
Diplodus vulgaris	Two banded seabream		X
Diplodus sargus	White seabream	X	X
Oblada melanura	Saddled seabream	X	X
Lithognathus mormyrus	Striped seabream	X	
Sarpa salpa	Salema porgy		X
Sparus aurata	Gilthead seabream	X	
Boops boops	Bogue		X
Trachinotus ovatus	Pompano	X	X
Echiichthys vipera	Lesser weaver	X	
Trachinus draco	Greater weaver	X	
Belone belone	Garfish	X	
Octopus vulgaris	Common octopus		X
Holothuria sp.	Sea cucumber	X	
Bothus podas	Wide-eyed flounder	X	
Caranx crysos	Blue runner		X
Atherina hepsetus	Mediterranean sand smelt		X
Spicara smaris	Picarel		X

Table 1: Preliminary list of species observed during the site visit in sandy areas and areas characterised by P. oceanica

3.2.1.2.4 A survey to document the exact location of the existing *P.oceanica* in the affected area will be carried out to provide a baseline against which to compare future monitoring. This is to consist of a survey along a transect system to characterise the benthic communities in the affected area. A three dimensional model of the transect profiles within the area under study is also being constructed.

4 Suggested mitigation measures

4.1.1.1.1 Since the sand being used will be lifted from the bay itself, impacts to the ecology of the area are expected to be low and direct loss of benthic habitats should be insignificant. However, the sand replenishment methodology to be adopted should be as such as to limit the disturbance to the marine environment.

4.1.1.1.2 The raising of sand by dredging should be carried out with minimal disturbance to the existing marine environment, especially the *P. oceanica* meadows. It is therefore recommended that such dredging of sand should be carried out in areas free from *P. oceanica*. Thus, a buffer zone of minimum 20 metres away from *P. oceanica* meadows should be maintained from the dredging site to ensure no damage is carried out to this ecosystem. Monitoring of the marine environment following the beach replenishment works should be carried out using *P. oceanica* as a biological indicator.

4.1.1.1.3 Long-term solutions being proposed in the project description statement should reduce the need for continuous replenishments, thus allowing adversely affected marine species to re-colonise the affected area without future detrimental interventions.

5 References

Borg, J.A. & Schembri, P.J. (2002) *Alignment of marine habitat data of the Maltese Islands to conform to the requirements of the EU habitats directive (Council Directive 92/43/EEC).* [Report commissioned by the Malta Environment & Planning Authority]. Malta: Independent Consultants; 136pp

Borg, J. A., Rowden, A. A., Attrill, M. J., Schembri, P. J., & Jones, M. B. (2009). Occurrence and distribution of different bed types of seagrass Posidonia oceanica around the Maltese Islands. Mediterranean Marine Science, 10(2), 45–62. https://doi.org/10.12681/mms.108

Pace, E. (2012) *Selective Analysis of Beach Erosion at Għadira Bay and some Mitigation Measures for Proposed Road Networks*. Unpublished BA(hons) Dissertation; Geography Department, University of Malta.

Pye, K. (2009) *Coastal Geomorphological Changes at Għadira Beach (Mellieħa Bay), Malta: Scoping Study.* External Research Report No. ER2299, Kenneth Pye Associates Ltd, Crowthorne, Berkshire, UK.

ANNEX 004

SAND AGGREGATE TEST REPORT (SOLIDBASE LTD)

Report

For

Sand Testing at Ghadira Beach, Mellieha

Contents

List of Figures

1. INTRODUCTION

1.1. COMPANY INFORMATION

Trade Name:	SolidBase Laboratory Ltd.
Registered Address:	SolidBase Laboratory Ltd. Tal-Ħandaq Industrial Estate New road in Ħandaq Road Ħandaq l/o Qormi QRM 4000
Telephone:	+356 21492807/8
Telefax:	+356 21492810
E-mail:	info@solidbasemalta.com
Website:	www.solidbasemalta.com
Managing Director:	Paolo Bugeja

1.2. COMPANY PROFILE

SolidBase Laboratory Ltd. (SBL) is an independent company that tests material destined to the construction industry.

The company offers a wide range of services backed up by highly trained professional staff and state-of-the-art equipment. Operations are conducted from its premises in Qormi. The total combined laboratory, offices and amenities floor area is approximately 600 m2. All the laboratory equipment complies with EU standards and regulations. Investment has also been made in human resources; a number of highly trained and dedicated consultants and technical people are employed. Our team ensures that SBL provides the architectural, design and construction industry with the expertise which is expected by our demanding clients.

SBL can also provide specialized services through agreements it has established with International companies. This ensures that services such as remote data logging and telemetry can be provided at competitive prices.

1.3. ACCREDITATION

SBL employs is accredited to EN ISO 17025:2005 as a QMS through which its objectives will be realized. The accreditation certificate is to be found in Attachment A.

2. Scope of Works

Solidbase Laboratory Ltd was commissioned by EMDP Co Ltd to conduct aggregate analysis on sand sampled at Ghadira Beach, Mellieha and at sea from the same beach. The tests required were the following:

Test	Standard	Accreditation Status
Sampling	EN 932-1:1997	Accredited
Particle Size Distribution	EN 933-1:2012	Accredited
Moisture Content	EN 1097-5:2008	Accredited

Figure 1 – Required Testing

3. Test Results

The reports of the tests are to be found in Attachment B and a summary of results is to be found in Attachment C. An explanation of the results follows.

3.1. PARTICLE SIZE DISTRIBUTION

The particle size distribution results indicate that the material extracted from the seabed (Reports 21 to 27) differ from the results taken from the land side of the beach (Reports 12 to 15). The results are also illustrated in separate graphs (Figure 3 and 4 respectively).

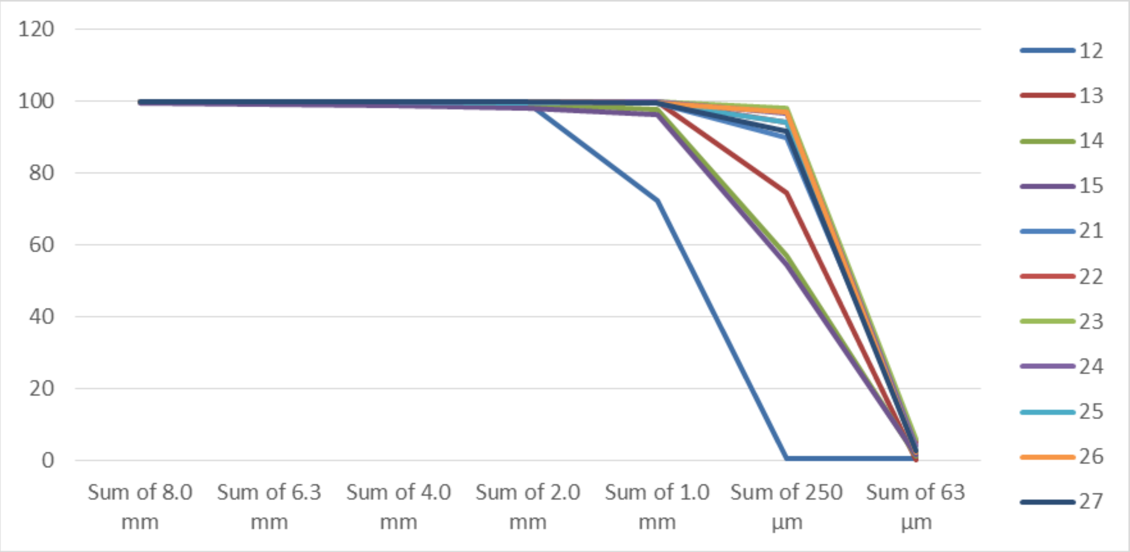


Figure 2 – Particle Size Distribution Test Results

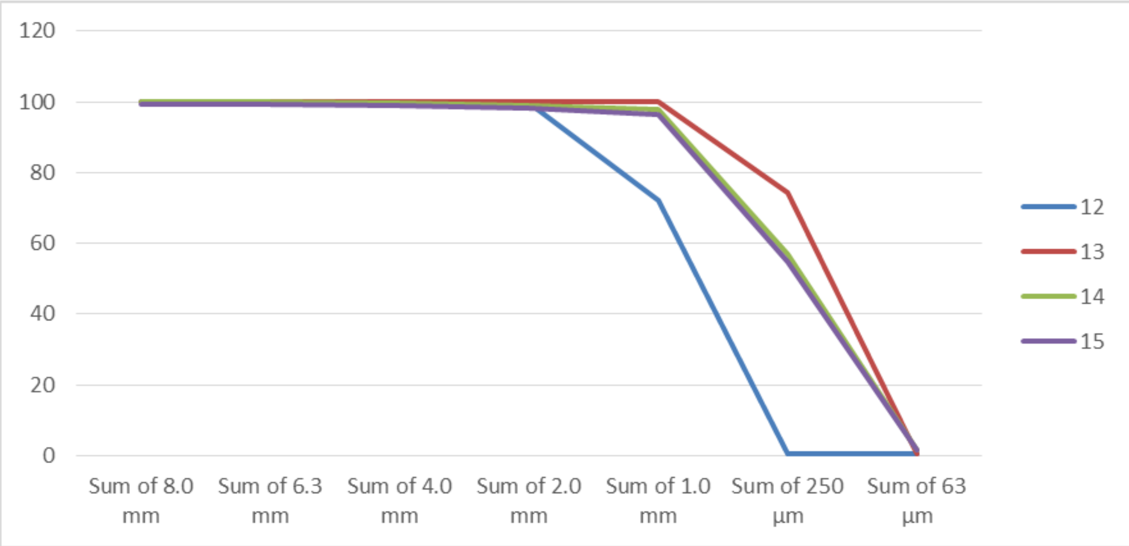


Figure 3 – Particle Size Distribution Test Results of samples taken 01/02/2018 from land side

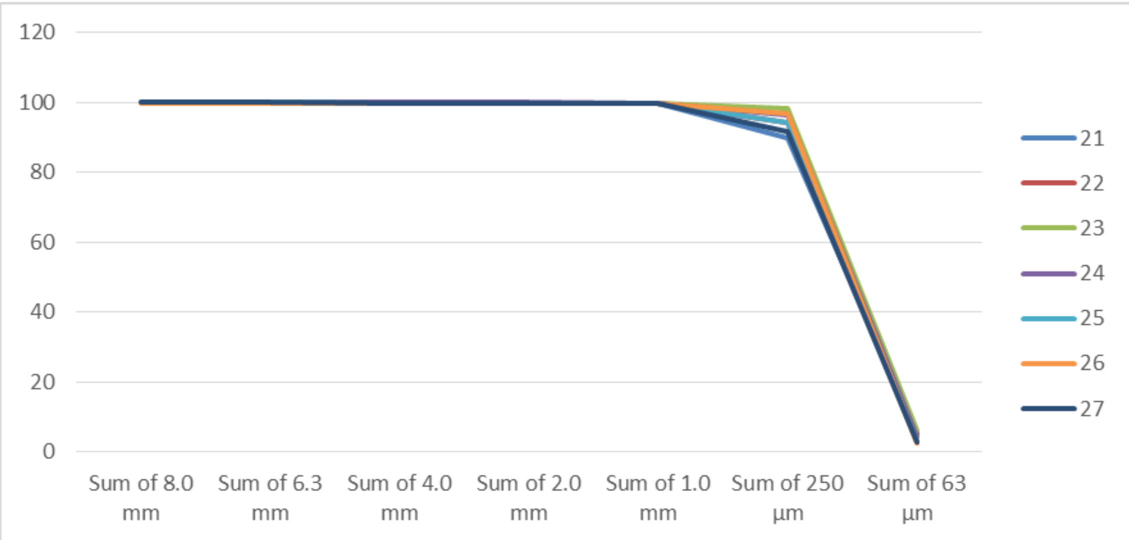


Figure 4 – Particle Size Distribution Test Results of samples taken 10/03/2018 from sea side

3.2. MOISTURE CONTENT

The Moisture Content illustrated in Figure 5 indicates differing results between the sampling made on the beach from those made in the sea.

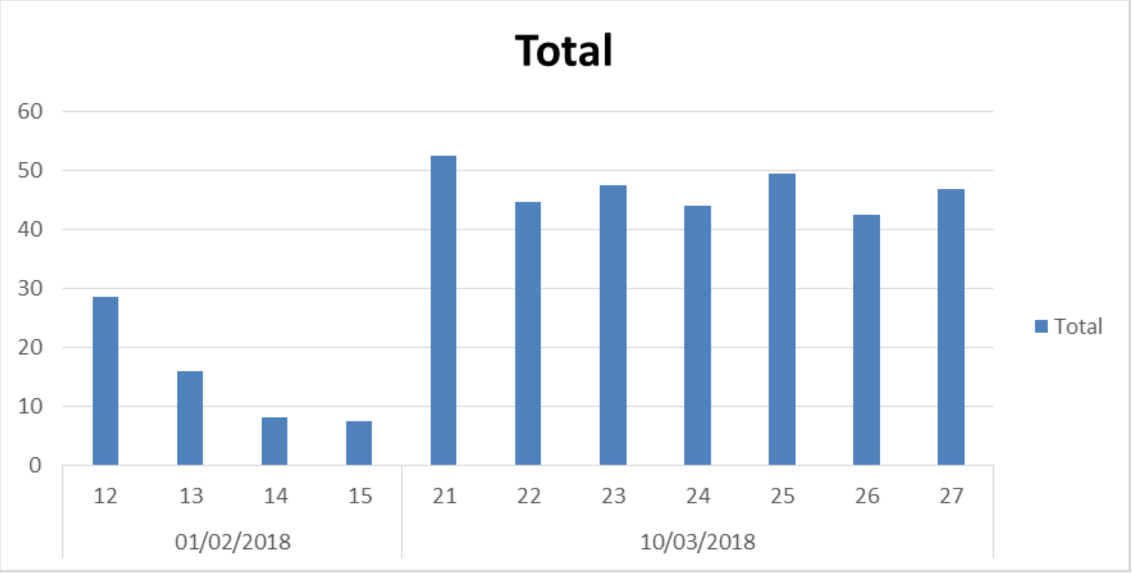


Figure 5 – Moisture Content Test Results

3.3. FINES CONTENT

The fines content results indicate lesser fines of the samples taken from the beach when compared to those taken from the sea. Figure 6 illustrates the fines content results.

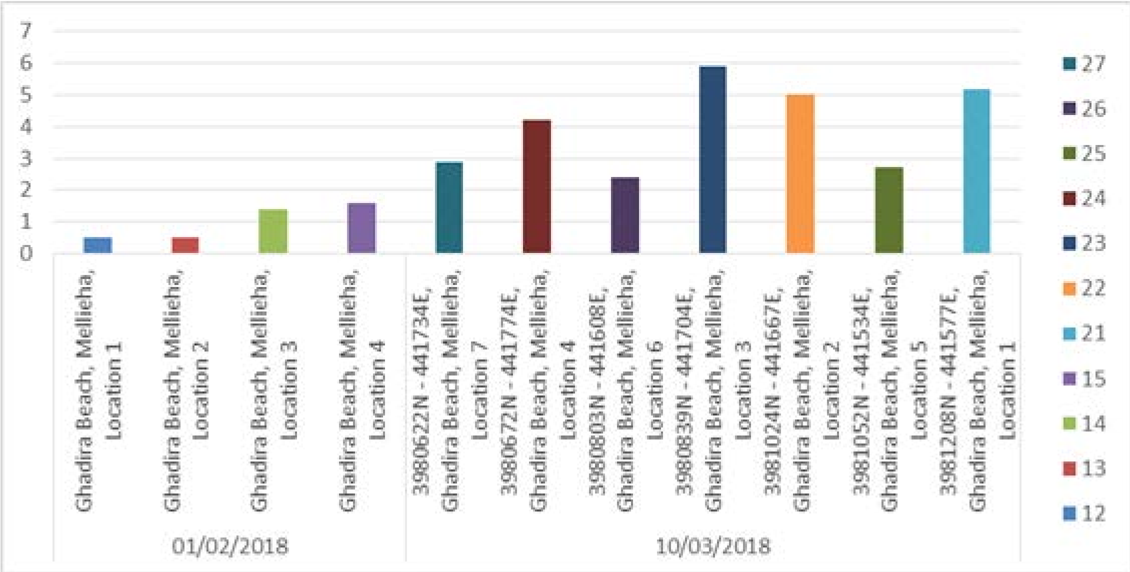


Figure 6 – Fines Content Test Results

4. Conclusions

From the tests conducted the following conclusions can be made:

- The material characteristics differ between the 2 general sample locations;
- It cannot be excluded that the material characteristics would differ with depth at each sampling location.

Appendix A

EN ISO 17025:2005 Accreditation Certificate

Solidbase Laboratory Ltd.
Scope of Accreditation

Contact person	Charles Grech
Address	Tal-Handaq Industrial Estate, N/S in Handaq Road, Qormi QRM 4000, Malta
Telephone	+356 21492807/8
Company Reg. No.	C33162
Email	info@solidbasemalta.com
Website	www.solidbasemalta.com

ACCREDITATION INFORMATION - TESTING LABORATORY

Accreditation No.	008
Accreditation Certificate No.	008/11
Accredited according to	EN ISO/IEC 17025:2005
Accreditation Scope No.	S008/11
Date of issue of this Scope	Friday, 04 August 2017

TESTING LABORATORY

Laboratory Locations

Location Details	***Activity***	***Location Code***
Address Tal-Handaq Industrial Estate, N/S in Handaq Road, Qormi QRM 4000, Malta	Testing of Construction Products	A

Site activities performed away from the locations listed above

Location Details	***Activity***	***Location Code***
Location indicated by Customer	Sampling	B

Solidbase Laboratory Ltd.
Scope of Accreditation

Material/ Product/ Matrix Tested/ Calibrated	Type of test/ calibration and/or property measured, range of measurment	Standard Specifications/ In-House Methods/ Equipment/ Techniques	Loc. code
Construction Material Testing			
Fresh Concrete	Making and curing of concrete cubes	EN 12390-2:2009	A / B
Hardened Concrete	Compressive strength testing of concrete cubes	EN 12390-1:2012; EN 12390-3:2009	A
Fresh Concrete	Slump testing of fresh concrete	EN 12350-2:2009	B
Fresh Concrete	Sampling of fresh concrete	EN 12350-1:2009	B
Bituminous mixtures	Preparation of samples for determining binder content, water content and grading.	EN 12697-28:2001	B
Bituminous mixtures	Sampling of bituminous mixtures from around augers of paver	EN 12697-27:2001	B
Bituminous mixtures	Determination of the maximum density	EN 12697-5:2009	A
Bituminous mixtures	Determination of bulk density using procedure A,B and D	EN 12697-6:2012	A
Bituminous mixtures	Marshall test	EN 12697-34:2012	A

Material/ Product/ Matrix Tested/ Calibrated	**Type of test/ calibration and/or property measured, range of measurment**	**Standard Specifications/ In-House Methods/ Equipment/ Techniques**	**Loc. code**
Bituminous mixtures	Soluble Binder Content using procedure B1.5	EN 12697-1:2012	A
Bituminous mixtures	Specimen preparation by impact compactor	EN 12697-30:2012	A
Hardened Concrete	Determination of density of concrete cubes	EN 12390-7:2009	A
Hardened Concrete	Testing concrete in structures. Cored specimens. Taking, examining and testing in compression	EN 12504-1:2009	A
Bituminous mixtures	Sampling of bituminous mixtures by coring	EN 12697-27:2001	B
Hardened Concrete	Depth of Carbonation	BRE Digest 405	B
Water	Determination of chloride content (using chloride reagent)	In-house method LOQP Section 6.3	B
Reinforced Concrete	Half Cell potential measurement	ASTM C876 - 2015	B
Hardened Concrete	Dust sampling in-situ and dust sampling from cores	In-house method LOQP Section 6.3	B
Reinforced Concrete	The locating of reinforcement by cover meter	BS 1881-204: 2015	B

Material/ Product/ Matrix Tested/ Calibrated	**Type of test/ calibration and/or property measured, range of measurment**	**Standard Specifications/ In-House Methods/ Equipment/ Techniques**	**Loc. code**
Hardened Concrete	Assessment of in-situ compressive strength in structures and pre-cast concrete components by cores	EN 13791:2007	A / B
Aggregates	Los Angeles Abrasion Test	EN 1097-2:2010	A
Hardened Concrete	Sounding	In-house method LOQP Section 6.4	B
Hardened Concrete	Analysis of chloride in concrete dust	BS 1881-124:2015	A
Soils and Granular	Unconfined Compressive Strength	ISRM Suggested Method for Determination of the Uniaxial Compressive Strength of Rock Materials, ET Brown 1981. ISRM Suggested Method for Determination of the Uniaxial Compressive Strength of Rock Materials, Modified by Annex W 'Strength Testing of Rock Material' of EN 1997-2:2007	A
Soils and Granular	Plate Bearing Test	DIN 18134: 2012	B
Precast Concrete Units	Methods of test for masonry units. Determination of dimensions and compressive strength	EN 772-1:2011, EN 772-16:2011	A

Material/ Product/ Matrix Tested/ Calibrated	Type of test/ calibration and/or property measured, range of measurment	Standard Specifications/ In-House Methods/ Equipment/ Techniques	Loc. code
Rock and Soils	Liquid limit (cone penetrometer) Plastic limit Plasticity index	BS 1377 Part 2: 1990	A
Rock and Soils	Particle Density (small pyknometer)	BS 1377 Part 2: 1990	A
Rock and Soils	Particle size distribution	ASTM D 422-63 (Reapproved 1998)	A
Rock and Soils	Odometer (one dimensional consolidation and swelling)	BS 1377 Part 5: 1990	A
Rock and Soils	Small shear box	BS 1377 Part 7: 1990	A
Aggregates	Particle Size Distribution	EN 933-1:2012	A
Aggregates	Moisture Content	EN 1097-5:2008	A
Aggregates	Water Absorption	EN 1097-6:2013	A
Aggregates	Flakiness Test	EN 933-3:2012	A
Aggregates	Shape Index	EN 933-4:2008	A

Material/ Product/ Matrix Tested/ Calibrated	Type of test/ calibration and/or property measured, range of measurment	Standard Specifications/ In-House Methods/ Equipment/ Techniques	Loc. code

END OF SCOPE

This scope of accreditation may be revised from time to time by NAB-MALTA. To obtain an up-to-date scope contact NAB-MALTA on +356 23952510 (*info@nabmalta.org.mt*).

Appendix B

Aggregate Reports

solidbase LABORATORY LTD.

AGGREGATE TEST REPORT

Client	EMDP Co Ltd		
Client Address	154 Eucharistic Congress Road	Certificate Date	2018-02-05
	Mosta MST 9037	Report No.	12
Client tel. No.	21416670	Sample No.	A18/0503
Client fax No.	21416249		
Attn.:	Spiteri Mariello Arch		
Project	EMDP Co Ltd - J122 - Aggregate: 18/030140		

Sampling

Test carried out to EN 932-1:1997

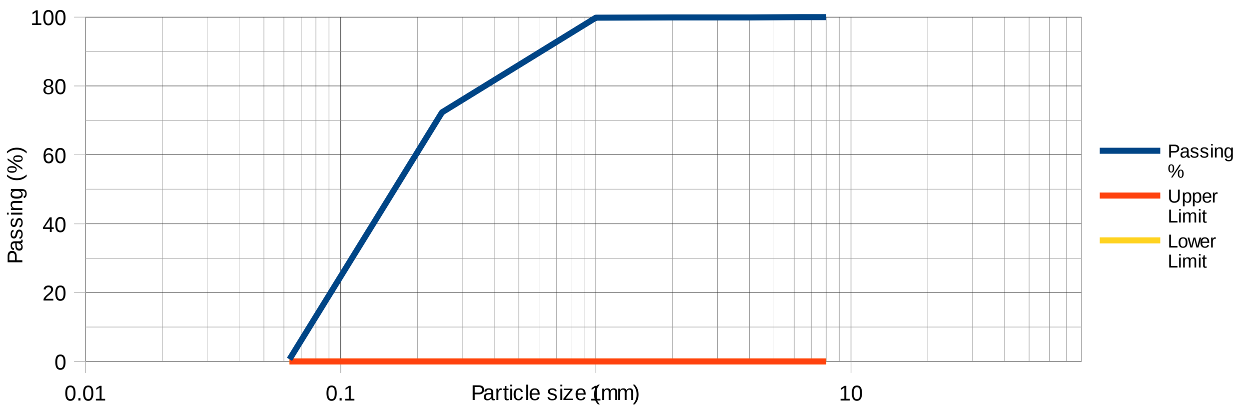
Supplier	N/A	Location of sampling	Ghadira Beach, Mellieha, Location 1
Date sampled	2018-02-01	Sampled by	Todosijevic Goran
Material type	Sea Sand	Date received	2018-02-01
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**99.9**	0.0	0.0
2.0	**99.9**	0.0	0.0
1.0	**99.8**	0.0	0.0
0.25	**72.3**	0.0	0.0
0.063	**0.6**	0.0	0.0
-	**-**	-	-
-	**-**	-	-

Fines content	0.5%
Fineness modulus	1.3
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

Tal-Handaq Industrial Estate,
N/S in Handaq Road,
Qormi, QRM 4000, Malta.
T: (356) 2149 2807/8
F: (356) 2149 2810
E: info@solidbasemalta.com
W: www.solidbasemalta.com
Co. No.: C 33162
VAT No.: MT 1695 3537

Moisture Content
Test carried out to EN 1097-5:2008

Moisture content	28.5%
Date tested	2018-02-05
Technician	Amoury Mustafa
Comments	None
Deviations	None

Darmanin Gilbert

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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Co. No.: C 33162
VAT No.: MT 1695 3537

solidbase LABORATORY LTD.

AGGREGATE TEST REPORT

Client	EMDP Co Ltd		
Client Address	154 Eucharistic Congress Road	Certificate Date	2018-02-05
	Mosta MST 9037	Report No.	13
Client tel. No.	21416670	Sample No.	A18/0504
Client fax No.	21416249		
Attn.:	Spiteri Mariello Arch		
Project	EMDP Co Ltd - J122 - Aggregate: 18/030141		

Sampling

Test carried out to EN 932-1:1997

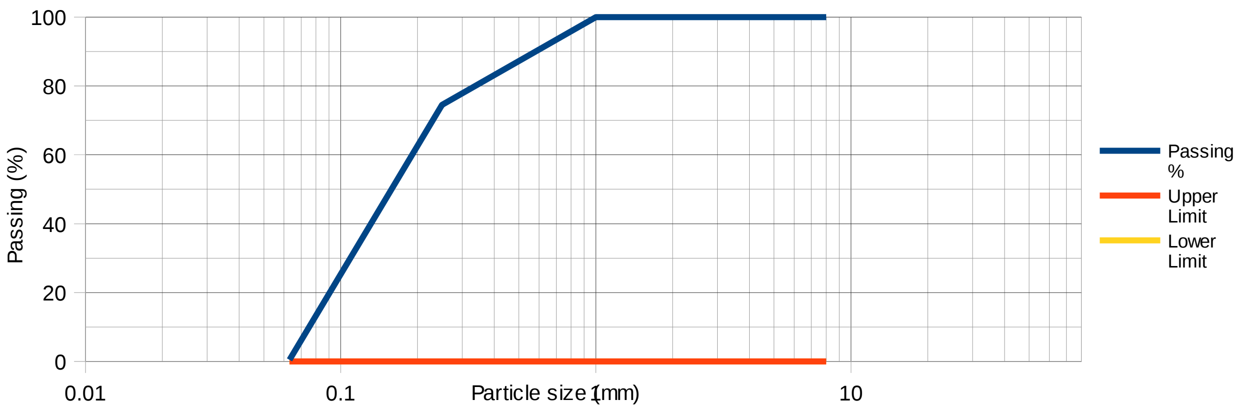
Supplier	N/A	Location of sampling	Ghadira Beach, Mellieha, Location 2
Date sampled	2018-02-01	Sampled by	Todosijevic Goran
Material type	Sea Sand	Date received	2018-02-01
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**100.0**	0.0	0.0
2.0	**100.0**	0.0	0.0
1.0	**100.0**	0.0	0.0
0.25	**74.5**	0.0	0.0
0.063	**0.5**	0.0	0.0
-	-	-	-
-	-	-	-

Fines content	0.5%
Fineness modulus	1.2
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

Tal-Handaq Industrial Estate,
N/S in Handaq Road,
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VAT No.: MT 1695 3537

solidbase LABORATORY LTD.

Moisture Content

Test carried out to EN 1097-5:2008

Moisture content	15.8%
Date tested	2018-02-05
Technician	Amoury Mustafa
Comments	None
Deviations	None

Darmanin Gilbert

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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VAT No.: MT 1695 3537

solidbase LABORATORY LTD.

AGGREGATE TEST REPORT

Client	EMDP Co Ltd
Client Address	154 Eucharistic Congress Road Mosta MST 9037
Client tel. No.	21416670
Client fax No.	21416249
Attn.:	Spiteri Mariello Arch
Project	EMDP Co Ltd - J122 - Aggregate: 18/030142

Certificate Date	2018-02-05
Report No.	14
Sample No.	A18/0505

Sampling

Test carried out to EN 932-1:1997

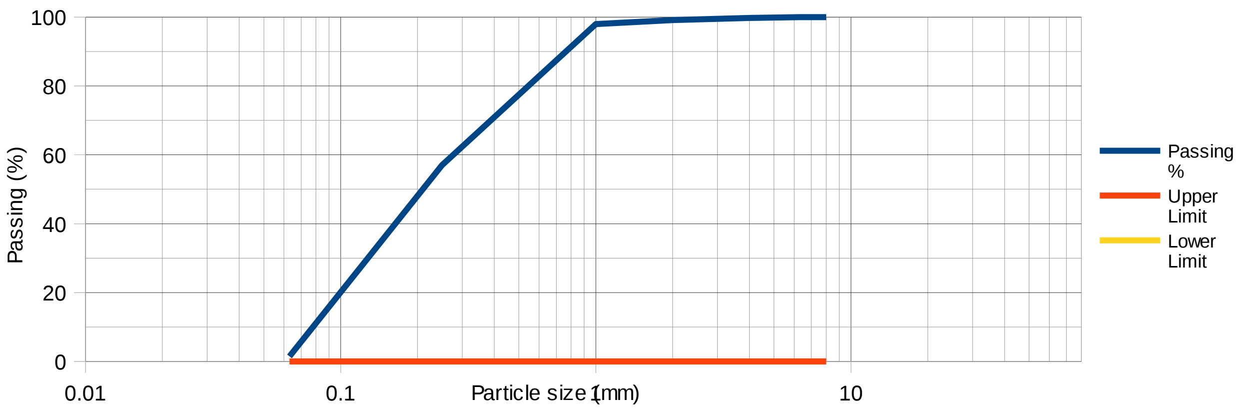
Supplier	N/A	Location of sampling	Ghadira Beach, Mellieha, Location 3
Date sampled	2018-02-01	Sampled by	Todosijevic Goran
Material type	Sea Sand	Date received	2018-02-01
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**99.7**	0.0	0.0
2.0	**99.1**	0.0	0.0
1.0	**97.9**	0.0	0.0
0.25	**57.0**	0.0	0.0
0.063	**1.5**	0.0	0.0
-	**-**	-	-
-	**-**	-	-

Fines content	1.4%
Fineness modulus	1.4
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

Tal-Handaq Industrial Estate, N/S in Handaq Road, Qormi, QRM 4000, Malta.
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Co. No.: C 33162
VAT No.: MT 1695 3537

Moisture Content

Test carried out to EN 1097-5:2008

Moisture content	8.1%
Date tested	2018-02-05
Technician	Amoury Mustafa
Comments	None
Deviations	None

Darmanin Gilbert

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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Co. No.: C 33162
VAT No.: MT 1695 3537

solidbase LABORATORY LTD.

AGGREGATE TEST REPORT

Client	EMDP Co Ltd
Client Address	154 Eucharistic Congress Road Mosta MST 9037
Client tel. No.	21416670
Client fax No.	21416249
Attn.:	Spiteri Mariello Arch
Project	EMDP Co Ltd - J122 - Aggregate: 18/030143

Certificate Date	2018-02-05
Report No.	15
Sample No.	A18/0506

Sampling

Test carried out to EN 932-1:1997

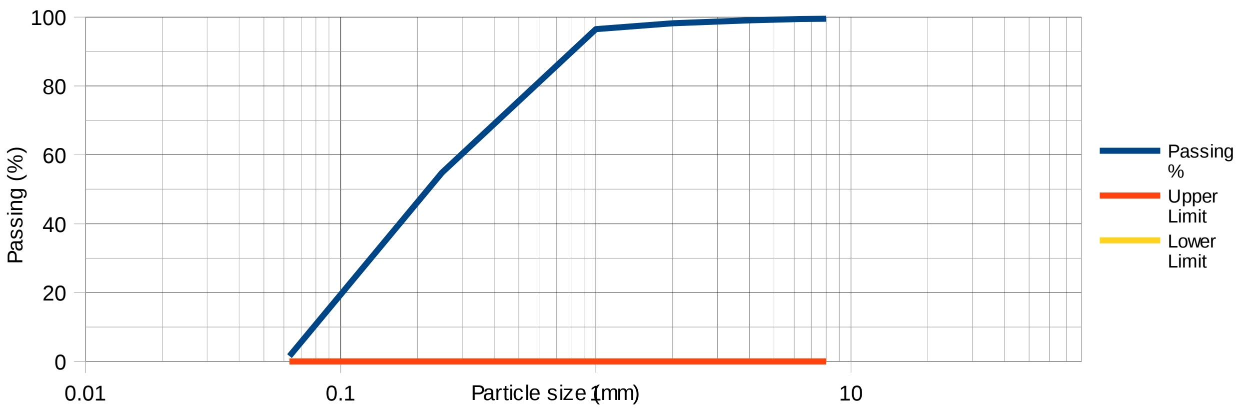
Supplier	N/A	Location of sampling	Ghadira Beach, Mellieha, Location 4
Date sampled	2018-02-01	Sampled by	Todosijevic Goran
Material type	Sea Sand	Date received	2018-02-01
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**99.5**	0.0	0.0
6.3	**99.4**	0.0	0.0
4.0	**99.0**	0.0	0.0
2.0	**98.2**	0.0	0.0
1.0	**96.5**	0.0	0.0
0.25	**54.8**	0.0	0.0
0.063	**1.6**	0.0	0.0
-	**-**	-	-
-	**-**	-	-

Fines content	1.6%
Fineness modulus	1.4
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

Tal-Handaq Industrial Estate, N/S in Handaq Road, Qormi, QRM 4000, Malta.
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Co. No.: C 33162
VAT No.: MT 1695 3537

Moisture Content
Test carried out to EN 1097-5:2008

Moisture content	7.3%
Date tested	2018-02-05
Technician	Amoury Mustafa
Comments	None
Deviations	None

Darmanin Gilbert

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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Co. No.: C 33162
VAT No.: MT 1695 3537

solidbase LABORATORY LTD.

AGGREGATE TEST REPORT

Client	EMDP Co Ltd		
Client Address	154 Eucharistic Congress Road	Certificate Date	2018-03-14
	Mosta MST 9037	Report No.	21
Client tel. No.	21416670	Sample No.	A18/0522
Client fax No.	21416249		
Attn.:	Spiteri Mariello Arch		
Project	EMDP Co Ltd - J122 - Aggregate: 18/031490		

Sampling

Test carried out to EN 932-1:1997

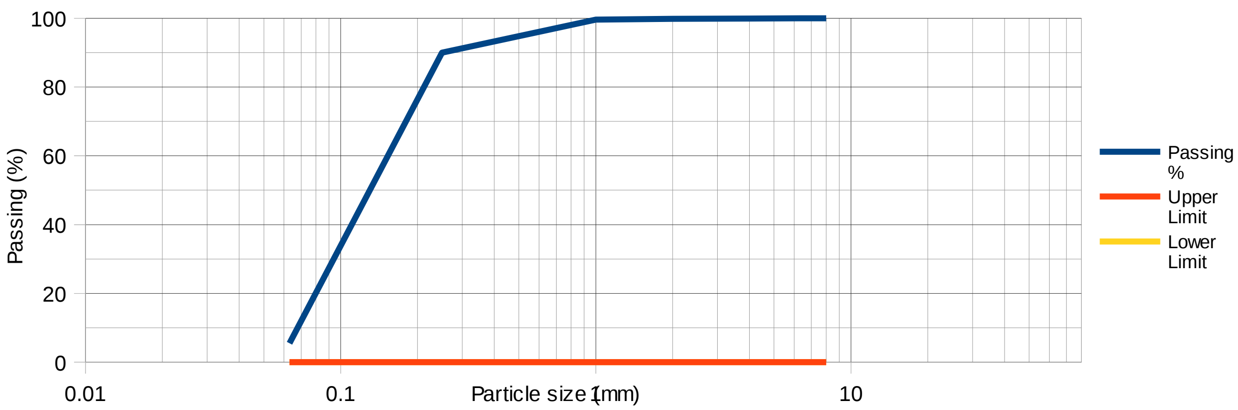
Supplier	N/A	Location of sampling	3981208N - 441577E, Ghadira Beach, Mellieha, Location 1
Date sampled	2018-03-10	Sampled by	
Material type	Sea Sand	Date received	2018-03-12
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**99.9**	0.0	0.0
2.0	**99.8**	0.0	0.0
1.0	**99.6**	0.0	0.0
0.25	**90.0**	0.0	0.0
0.063	**5.5**	0.0	0.0
-	**-**	-	-
-	**-**	-	-

Fines content	5.2%
Fineness modulus	1.1
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

Tal-Handaq Industrial Estate,
N/S in Handaq Road,
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VAT No.: MT 1695 3537

Moisture Content

Test carried out to EN 1097-5:2008

Moisture content	52.5%
Date tested	2018-03-14
Technician	Obrenic Srdjan (Sergio)
Comments	None
Deviations	None

Darmanin Gilbert

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

Tal-Handaq Industrial Estate,
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Qormi, QRM 4000, Malta.
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W: www.solidbasemalta.com
Co. No.: C 33162
VAT No.: MT 1695 3537

solidbase LABORATORY LTD.

AGGREGATE TEST REPORT

Client	EMDP Co Ltd
Client Address	154 Eucharistic Congress Road
	Mosta MST 9037
Client tel. No.	21416670
Client fax No.	21416249
Attn.:	Spiteri Mariello Arch
Project	EMDP Co Ltd - J122 - Aggregate: 18/031491

Certificate Date	2018-03-14
Report No.	22
Sample No.	A18/0523

Sampling

Test carried out to EN 932-1:1997

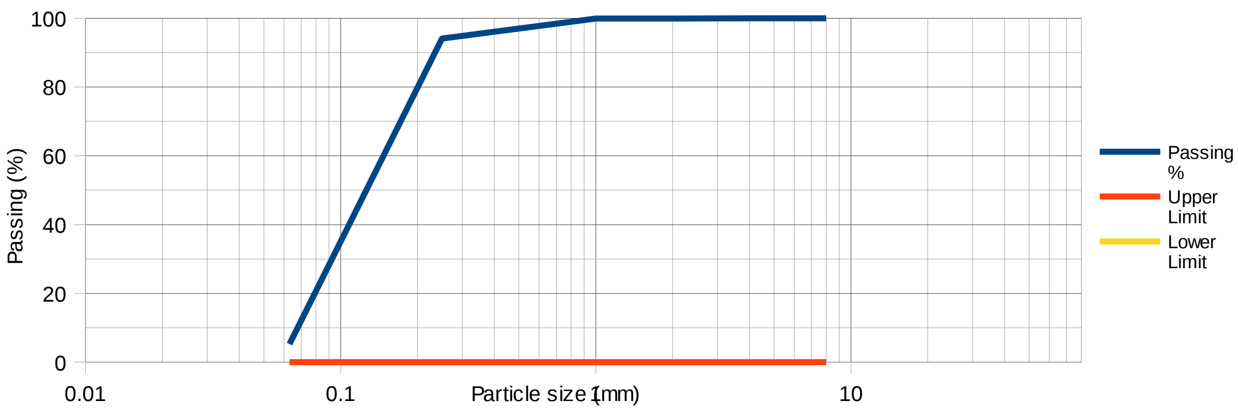
Supplier	N/A	Location of sampling	3981024N - 441667E, Ghadira Beach, Mellieha, Location 2
Date sampled	2018-03-10	Sampled by	
Material type	Sea Sand	Date received	2018-03-12
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**100.0**	0.0	0.0
2.0	**99.9**	0.0	0.0
1.0	**99.9**	0.0	0.0
0.25	**94.1**	0.0	0.0
0.063	**5.3**	0.0	0.0
-	**-**	-	-
-	**-**	-	-

Fines content	5.0%
Fineness modulus	1.0
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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Moisture Content

Test carried out to EN 1097-5:2008

Moisture content	44.7%
Date tested	2018-03-14
Technician	Obrenic Srdjan (Sergio)
Comments	None
Deviations	None

Darmanin Gilbert

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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AGGREGATE TEST REPORT

Client	EMDP Co Ltd
Client Address	154 Eucharistic Congress Road Mosta MST 9037
Client tel. No.	21416670
Client fax No.	21416249
Attn.:	Spiteri Mariello Arch
Project	EMDP Co Ltd - J122 - Aggregate: 18/031492

Certificate Date	2018-03-14
Report No.	23
Sample No.	A18/0524

Sampling

Test carried out to EN 932-1:1997

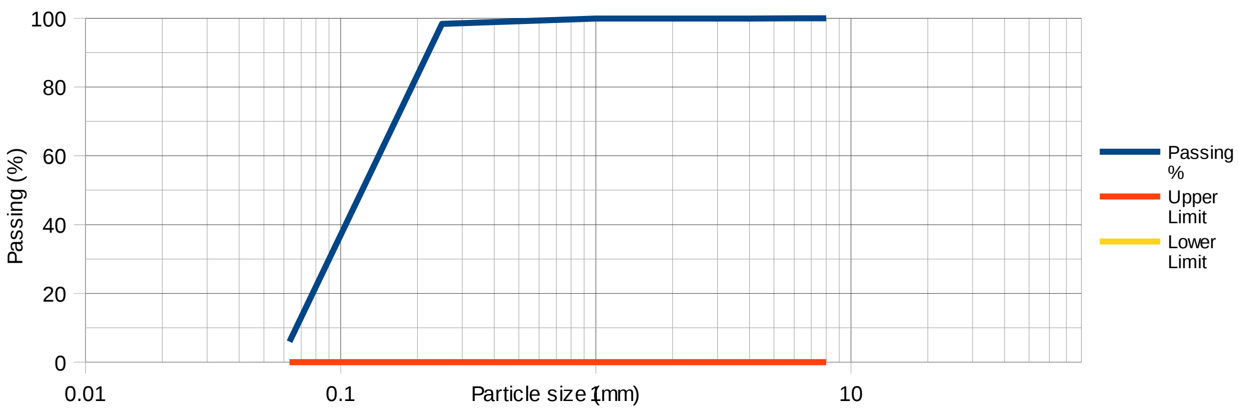
Supplier	N/A	Location of sampling	3980839N - 441704E, Ghadira Beach, Mellieha, Location 3
Date sampled	2018-03-10	Sampled by	
Material type	Sea Sand	Date received	2018-03-12
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**99.9**	0.0	0.0
2.0	**99.9**	0.0	0.0
1.0	**99.9**	0.0	0.0
0.25	**98.3**	0.0	0.0
0.063	**6.0**	0.0	0.0
-	**-**	-	-
-	**-**	-	-

Fines content	5.9%
Fineness modulus	1.0
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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Moisture Content
Test carried out to EN 1097-5:2008

Moisture content	47.5%
Date tested	2018-03-14
Technician	Obrenic Srdjan (Sergio)
Comments	None
Deviations	None

Darmanin Gilbert

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AGGREGATE TEST REPORT

Client	EMDP Co Ltd
Client Address	154 Eucharistic Congress Road
	Mosta MST 9037
Client tel. No.	21416670
Client fax No.	21416249
Attn.:	Spiteri Mariello Arch
Project	EMDP Co Ltd - J122 - Aggregate: 18/031493

Certificate Date	2018-03-14
Report No.	24
Sample No.	A18/0525

Sampling

Test carried out to EN 932-1:1997

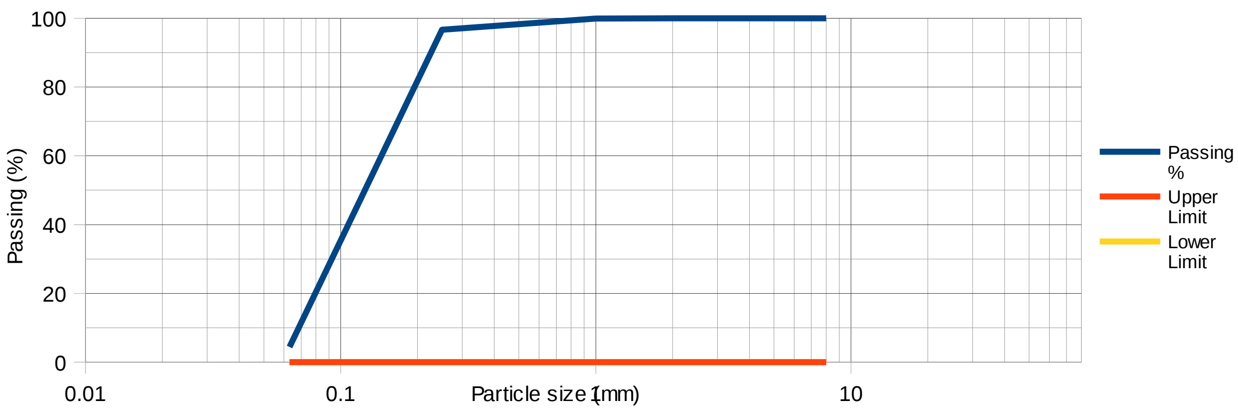
Supplier	N/A	Location of sampling	3980672N - 441774E, Ghadira Beach, Mellieha, Location 4
Date sampled	2018-03-10	Sampled by	
Material type	Sea Sand	Date received	2018-03-12
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**100.0**	0.0	0.0
2.0	**100.0**	0.0	0.0
1.0	**99.9**	0.0	0.0
0.25	**96.6**	0.0	0.0
0.063	**4.4**	0.0	0.0
-	-	-	-
-	-	-	-

Fines content	4.2%
Fineness modulus	1.0
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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Moisture Content
Test carried out to EN 1097-5:2008

Moisture content	44.1%
Date tested	2018-03-14
Technician	Obrenic Srdjan (Sergio)
Comments	None
Deviations	None

Darmanin Gilbert

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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AGGREGATE TEST REPORT

Client	EMDP Co Ltd		
Client Address	154 Eucharistic Congress Road	Certificate Date	2018-03-14
	Mosta MST 9037	Report No.	25
Client tel. No.	21416670	Sample No.	A18/0526
Client fax No.	21416249		
Attn.:	Spiteri Mariello Arch		
Project	EMDP Co Ltd - J122 - Aggregate: 18/031494		

Sampling

Test carried out to EN 932-1:1997

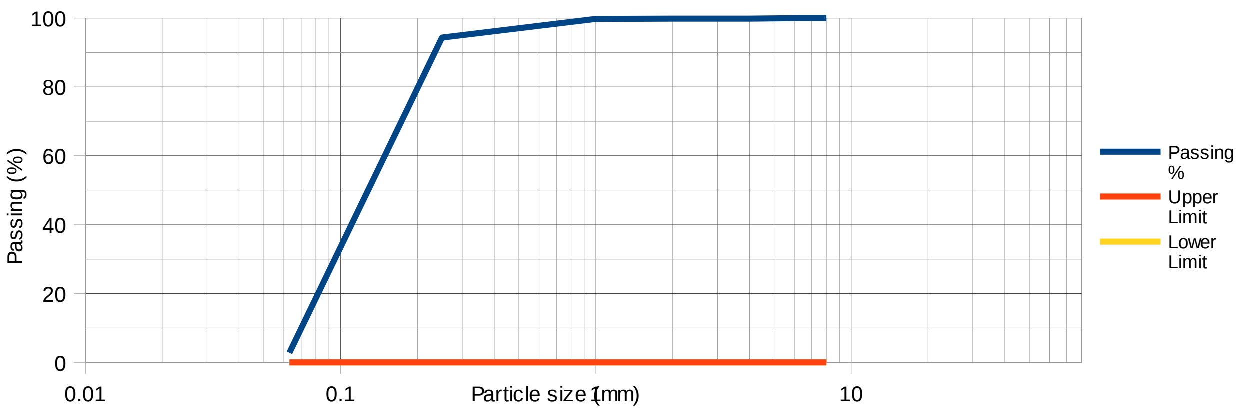
Supplier	N/A	Location of sampling	3981052N - 441534E, Ghadira Beach, Mellieha, Location 5
Date sampled	2018-03-10	Sampled by	
Material type	Sea Sand	Date received	2018-03-12
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**99.8**	0.0	0.0
2.0	**99.8**	0.0	0.0
1.0	**99.7**	0.0	0.0
0.25	**94.3**	0.0	0.0
0.063	**2.8**	0.0	0.0
-	**-**	-	-
-	**-**	-	-

Fines content	2.7%
Fineness modulus	1.0
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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Moisture Content
Test carried out to EN 1097-5:2008

Moisture content	49.4%
Date tested	2018-03-14
Technician	Obrenic Srdjan (Sergio)
Comments	None
Deviations	None

Darmanin Gilbert

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W: www.solidbasemalta.com
Co. No.: C 33162
VAT No.: MT 1695 3537

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AGGREGATE TEST REPORT

Client	EMDP Co Ltd
Client Address	154 Eucharistic Congress Road
	Mosta MST 9037
Client tel. No.	21416670
Client fax No.	21416249
Attn.:	Spiteri Mariello Arch
Project	EMDP Co Ltd - J122 - Aggregate: 18/031495

Certificate Date	2018-03-14
Report No.	26
Sample No.	A18/0527

Sampling

Test carried out to EN 932-1:1997

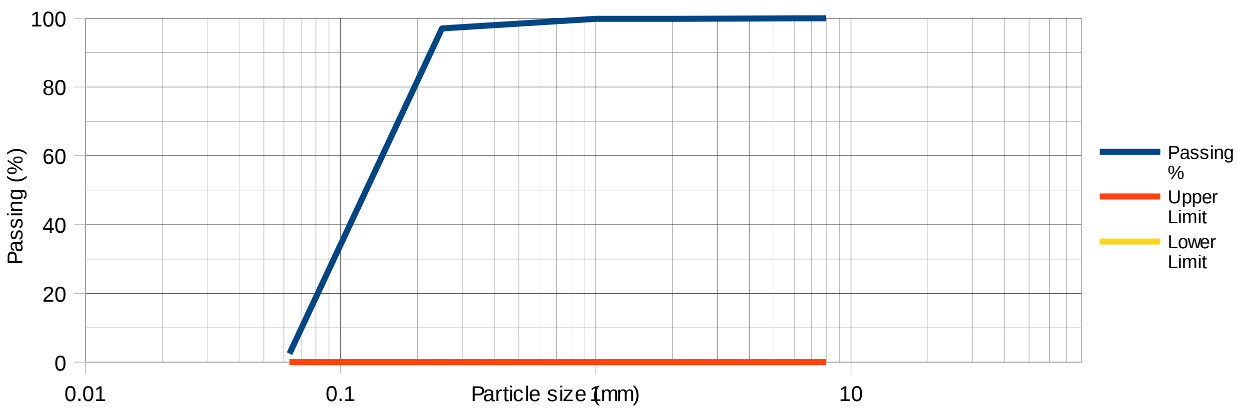
Supplier	N/A	Location of sampling	3980803N - 441608E, Ghadira Beach, Mellieha, Location 6
Date sampled	2018-03-10	Sampled by	
Material type	Sea Sand	Date received	2018-03-12
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**99.9**	0.0	0.0
2.0	**99.8**	0.0	0.0
1.0	**99.8**	0.0	0.0
0.25	**97.0**	0.0	0.0
0.063	**2.5**	0.0	0.0
-	**-**	-	-
-	**-**	-	-

Fines content	2.4%
Fineness modulus	1.0
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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Moisture Content

Test carried out to EN 1097-5:2008

Moisture content	42.6%
Date tested	2018-03-14
Technician	Obrenic Srdjan (Sergio)
Comments	None
Deviations	None

Darmanin Gilbert

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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W: www.solidbasemalta.com
Co. No.: C 33162
VAT No.: MT 1695 3537

solidbase LABORATORY LTD.

AGGREGATE TEST REPORT

Client	EMDP Co Ltd		
Client Address	154 Eucharistic Congress Road	Certificate Date	2018-03-14
	Mosta MST 9037	Report No.	27
Client tel. No.	21416670	Sample No.	A18/0528
Client fax No.	21416249		
Attn.:	Spiteri Mariello Arch		
Project	EMDP Co Ltd - J122 - Aggregate: 18/031496		

Sampling

Test carried out to EN 932-1:1997

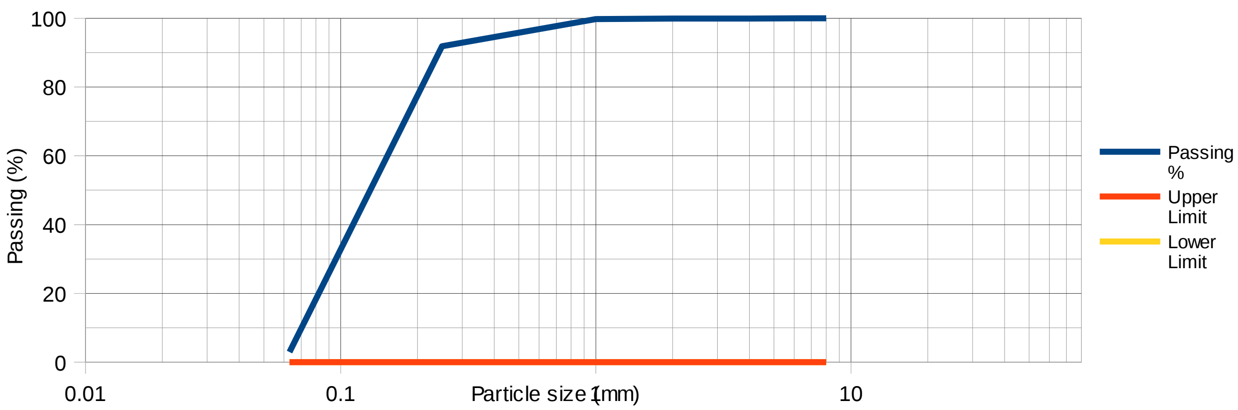
Supplier	N/A	Location of sampling	3980622N - 441734E, Ghadira Beach, Mellieha, Location 7
Date sampled	2018-03-10	Sampled by	
Material type	Sea Sand	Date received	2018-03-12
Material description	Sea Sand		
Comments	None		
Deviations	None		

Particle Size Distribution

Test carried out to EN 933-1:2012

Sieve Size (mm)	Passing %	Upper Limit	Lower Limit
8.0	**100.0**	0.0	0.0
6.3	**100.0**	0.0	0.0
4.0	**99.9**	0.0	0.0
2.0	**99.9**	0.0	0.0
1.0	**99.7**	0.0	0.0
0.25	**91.8**	0.0	0.0
0.063	**3.0**	0.0	0.0
-	**-**	-	-
-	**-**	-	-

Fines content	2.9%
Fineness modulus	1.1
Method of analysis	wet sieving



Comments	None
Deviations	None

The expanded level of uncertainty is less than 0.1%. The uncertainty evaluation has been carried out in accordance with NAB-Malta requirements.

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Moisture Content
Test carried out to EN 1097-5:2008

Moisture content	46.8%
Date tested	2018-03-14
Technician	Obrenic Srdjan (Sergio)
Comments	None
Deviations	None

Darmanin Gilbert

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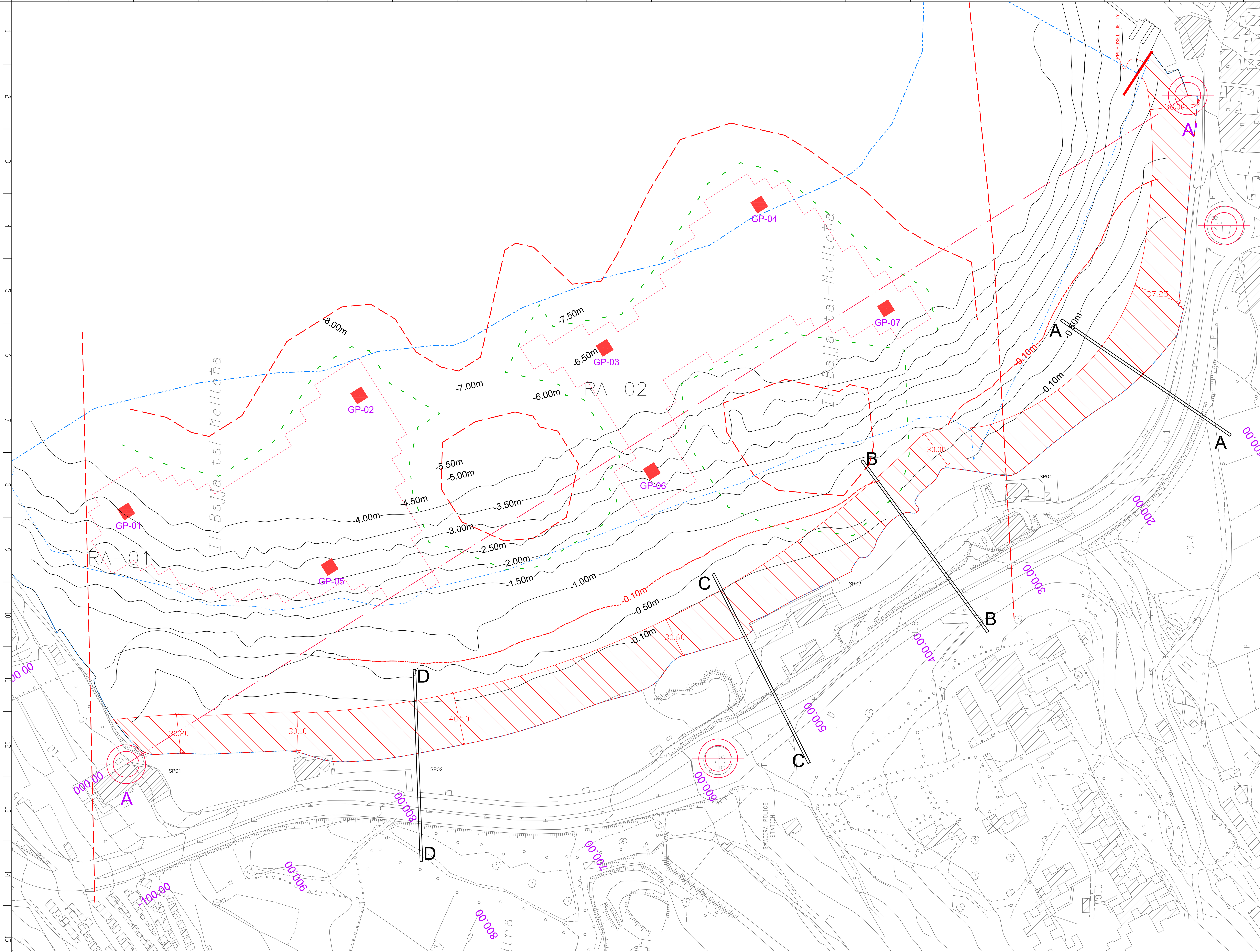
VAT No.: MT 1695 3537

Appendix C

Summary Aggregate Results

DATE	CERT No.	SAMPLE No.	POSITION	TYPE (MM)	8.0 mm	6.3 mm	4.0 mm	2.0 mm	1.0 mm	250 µm	63 µm	M.C. (%)	FINES CONTENT (%)	Fineness Modulus
01/02/2018	12	A18/0503	Ghadira Beach, Mellieha, Location 1	Sea Sand	99.97	99.94	99.9	99.8	72.29	0.59	0.6	28.5	0.5	1.27
01/02/2018	13	A18/0504	Ghadira Beach, Mellieha, Location 2	Sea Sand	100	100	100	100	99.98	74.5	0.49	15.8	0.5	1.25
01/02/2018	14	A18/0505	Ghadira Beach, Mellieha, Location 3	Sea Sand	99.96	99.96	99.7	99.1	97.87	57	1.46	8.1	1.4	1.42
01/02/2018	15	A18/0506	Ghadira Beach, Mellieha, Location 4	Sea Sand	99.47	99.41	99	98.2	96.49	54.8	1.64	7.3	1.6	1.43
10/03/2018	21	A18/0522	3981208N - 441577E, Ghadira Beach, Mellieha, Location 1	Sea Sand	100	100	99.9	99.8	99.6	90	5.49	52.5	5.2	1.05
10/03/2018	22	A18/0523	3981024N - 441667E, Ghadira Beach, Mellieha, Location 2	Sea Sand	100	99.99	100	99.9	99.86	94.1	5.26	44.7	5.0	1.01
10/03/2018	23	A18/0524	3980839N - 441704E, Ghadira Beach, Mellieha, Location 3	Sea Sand	100	100	99.9	99.9	99.85	98.3	6.04	47.5	5.9	0.96
10/03/2018	24	A18/0525	3980672N - 441774E, Ghadira Beach, Mellieha, Location 4	Sea Sand	100	99.99	100	100	99.93	96.6	4.42	44.1	4.2	0.99
10/03/2018	25	A18/0526	3981052N - 441534E, Ghadira Beach, Mellieha, Location 5	Sea Sand	100	100	99.8	99.8	99.72	94.3	2.83	49.4	2.7	1.03
10/03/2018	26	A18/0527	3980803N - 441608E, Ghadira Beach, Mellieha, Location 6	Sea Sand	99.96	99.96	99.9	99.8	99.79	97	2.53	42.6	2.4	1.00
10/03/2018	27	A18/0528	3980622N - 441734E, Ghadira Beach, Mellieha, Location 7	Sea Sand	100	100	99.9	99.9	99.68	91.8	2.99	46.8	2.9	1.05


Triq Il-Marfa
Triq Il- Marfa
Location 1
Location 2
Location 3
Location 4
© 2018 Google
Google Earth
2006
Imagery Date: 6/15/2017
35°58'13.20" N
14°21'01.02" E
elev
3 m
eye alt
569 m



EXISTING LAYOUT PLAN

SCALE: 1:100

1:100

1:200

NOTES;

TRANSECTS;
(TAKEN AT 10m INTERVALS)

BORDER OF EXCLUSION ZONE;
LIMIT OF POSIDONIA MEADOWS

BORDER OF BUFFER ZONE;
30m BUFFER AREA AROUND MEADOWS

2m DEPTH LIMIT

PROPOSED HOARDING

PROPOSED LIMIT OF SAND PITS

REFERENCE AXIS (A - A')

EXISTING REFERENCE POINTS

EXTENTS OF SAND REPLENISHMENT

ESTIMATED AREAS;

SAND PITS;

SP01 - 2,567 sq.m
SP02 - 4,458 sq.m
SP03 - 2,475 sq.m
SP04 - 3,837 sq.m

RECLAMATION AREAS;

RA-01 - 35,600 sq.m
RA-02 - 40,000 sq.m

UTM/GPS CO-ORDINATES;

REFERENCE POINTS;

A	33S (441382E, 3981209N) 35.97354°N 14.34983°E
A'	33S (441901E, 3980389N) 35.96618°N 14.35565°E

GRAB POINTS;

GP-01	33S (441577E, 3981209N) 35.97355°N 14.35200°E
GP-02	33S (441667E, 3981024N) 35.97189°N 14.35301°E
GP-03	33S (441704E, 3980839N) 35.97022°N 14.35343°E
GP-04	33S (441774E, 3980672N) 35.96916°N 14.35466°E
GP-05	33S (441534E, 3981052N) 35.97213°N 14.35153°E
GP-06	33S (441608E, 3980803N) 35.96989°N 14.35237°E
GP-07	33S (441734E, 3980622N) 35.96827°N 14.35378°E

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Malta
Tel: (+356) 21 41 66 70 Fax: (+356) 21 41 62 49

DRAWING TITLE:

GRAB POINTS REFERENCE PLAN
GHADIRA BEACH REPLENISHMENT
GHADIRA BAY, MELLIEHA

CLIENT:

Mr. J. CAMENZULI

VER	DATE	DRWN.	CHK.	DETAILS
ii	10-03-2018	MVS	VS	AMENDED LOCATIONS
iii	09-03-2018	MVS	VS	CORRECTIONS TO COORDINATES
i	09-03-2018	MVS	VS	FOR EXECUTION

JOB NUM.	TYPE	No.	REV.	STATUS	FORMAT
TG/0018/17	PO	000	C	APV	A0