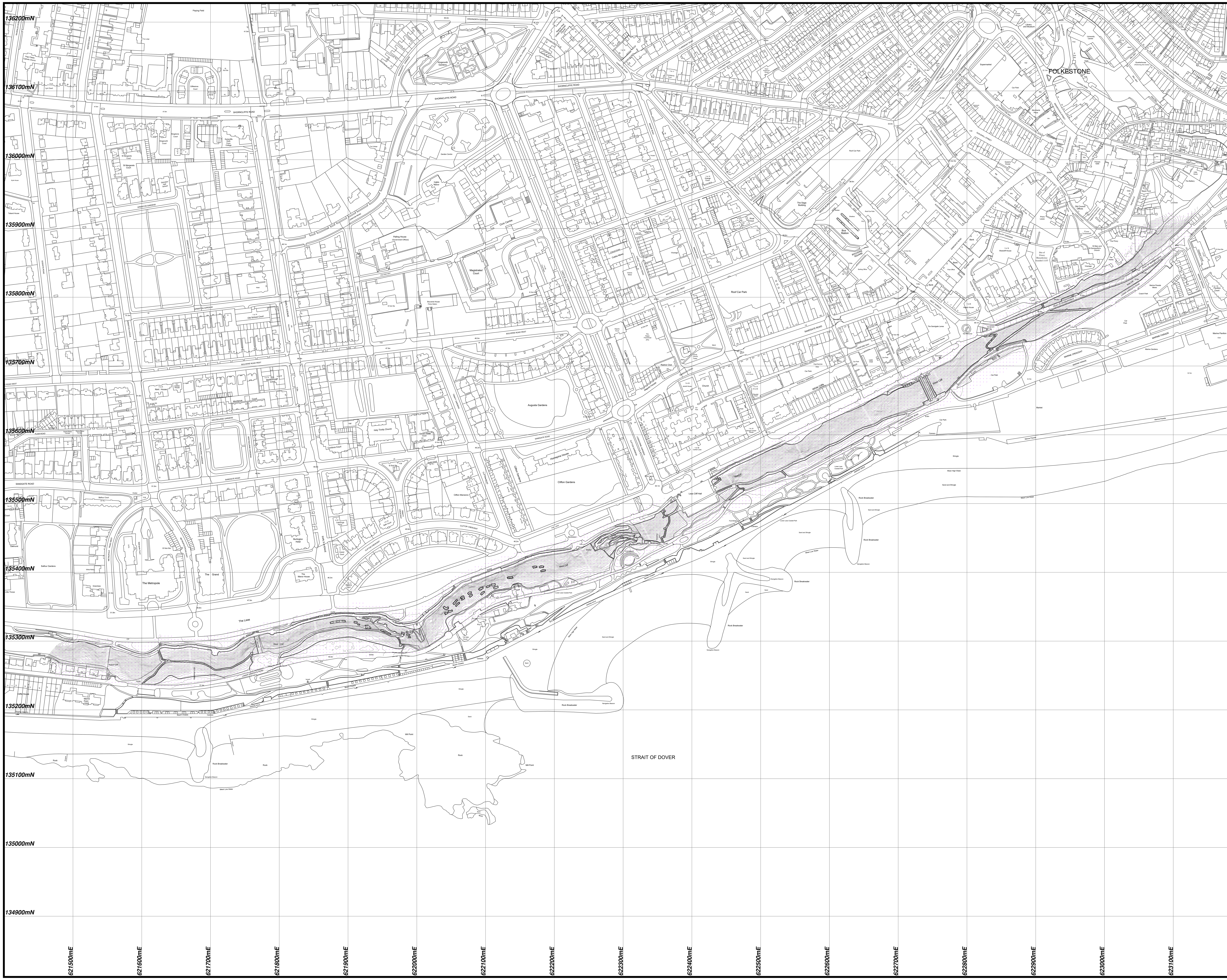

LEGEND

SERVICES

AC	Air Conditioning
AV	Air Vent
CAJB	Cable Junction Box
CATV	Cable Junction Box
CD	Cable Duct
CIP	Cable Inspection Point
EIC	Electric Inspection Cover
EJB	Electric Junction Box
EP	Electricity Pole
ER	Earthing Rod
FH	Fire Hydrant
GIC	Gas Inspection Cover
GJB	Gas Junction Box
GV	Gas Vent
JB	Junction Box
MK(E)	Service Marker (electric)
MK(G)	Service Marker (gas)
MK(W)	Service Marker (water)
OHW	Overhead Wire
SC(G)	Stop Cock (gas)
SC(W)	Stop Cock (w)
STP	Support for Telephone Tole
SV	Stop Valve
TIC	Telephone Inspection Cover
TJB	Telephone Junction Box
TP	Telephone Pole
WIC	Water Inspection Cover
WM	Water Meter

LEVEL

DPC	Damp Proof Course
THL	Threshold Level
T.O.C	Top of Chimney
T.O.W	Top of Wall
WL	Water Level

INTERNAL

CLG	Ceiling Level
DHL	Door Head Level
FL	Floor Level
SCLG	Suspended Ceiling Level
US	Underside
USB	Underside of beam
WCL	Window cill level
WHL	Window head level

DRAINAGE

BD	Back Drop
BL	Base/Bed Level
CL	Cover Level
CP	Catch Pit
DC	Drainage Channel
DP	Down Pipe
G	Gully
IC	Inspection Cover
IL	Invert Level
MH(C)	Manhole (combined)
MH(F)	Manhole (foul)
MH(S)	Manhole (surface water)
RE	Rodding eye
RWP	Rain Water Pipe
SEG	Side Entry Gully
SL	Silt Level
SVP	Soil Vent Pipe
UTL	Unable to Lift
VP	Vent Pipe
WO	Wash Out

FEATURES

B	Bollard
BH	Bore Hole
BP	Brick Pillar
BS	Bus Stop
CPS	Concrete Paving Slabs
FB	Flower Bed
LB	Litter Bin
LC	Lighting Column
P	Post
PB	Post Box
RNP	Road Name Plate
RS	Road Sign
RW	Retaining Wall
SP	Sign Post
SU	Step(s) Up
TCB	Telephone Call Box
TH	Trial Hole
TS	Tree Stump

CONTROL

OSBM	Ordnance Survey Bench Mark
STN	Survey Station
TBM	Temporary Bench Mark

Tree (girth/spread/height/species/no. of boles)
Direction of Lean
Photograph Number, Location & Direction
Survey Station

Gate - Gates
Fence
Building
Over Head Building Line
Face of Wall
Back of Retaining Wall
Line
Change of Surface
Edge of Undergrowth

Banking
Top of Bank
Bottom of Bank
Kerb
Drop Kerb
Verge
10.25 Contour With Value
E OHW T Over Head Wire
Hedge/Tree Line

For future survey work or setting out, J C White Geomatics limited quoted survey control coordinates & levels must be used. Under no circumstances should any other surveyed points on the drawing be used other than as a gross error check.

Tree girths and spreads are quoted as a mean size, and shown to scale.

Whilst every effort is made to identify tree species and gauge heights, no responsibility can be taken for the accuracy of this information.

Whilst every effort is made to ensure that pipe diameters, invert levels and drainage types are correct, the accuracy of this information cannot be guaranteed, and it is strongly recommended that existing information is checked prior to the commencement of any detailed design and construction works.

No responsibility can be taken for drainage information obtained from Statutory Authority records.

All coordinates & levels are based on Ordnance Survey grid & datum.

All levels have been surveyed using airbourne Lidar measurement techniques. While extensive checks have been carried out to verify the information, care should be taken when interrogating and using this survey data.

Contour interval 1 metre.

Ordnance Survey digital data supllied by client.

N

J. C. WHITE
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Shrine Barn, Shrine Farm, Sandling Road, Postling, Hythe, Kent, CT21 4HE
Tel : 01303 261212 Fax : 01303 264040
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- GPS Surveys
- Volumetric Surveys
- Topographical Surveys
- Measured Building Surveys
- Laser Scanning
- Setting Out
- Boundary Disputes
- Engineering Surveys
- Deformation & Settlement Surveys
- Scan to BIM Modelling

CLIENT

Folkestone & Hythe District Council

JOB TITLE

Leas Cliff,
Folkestone,
Kent.

DRAWING TITLE

UAV Level Survey

JOB No. *24/08/006*	DATE *March 2024*
SURVEYED BY [redacted]	DRAWN BY [redacted]

SCALE *1:2500*	DWG. No. *1*	REV. No.
CAD PLOT DATE *28.03.2024*	ORIGINAL SHEET SIZE *A1*	CADFILE NAME *2408006 - Leas Cliff Lidar Survey_04.dwg*

Visual Slope Stability Assessment

The Leas & Road of Remembrance
Folkestone

Prepared for:

Folkestone & Hythe District Council
Property Services
Civic Centre
Castle Hill Avenue
Folkestone
Kent
CT20 2QY

EPS Project Reference:	UK24.6951
Date Issued:	26th June 2024
Report Status:	Issue 1

THE LEAS & ROAD OF REMEBRANCE, FOLKESTONE

NON-TECHNICAL CLIENT SUMMARY

This report presents the findings of a visual slope stability assessment which was carried out to assess potential reasons for slope failure and assess the possibility of future landslips.

- The site spans approximately 1.6km to the south of The Leas & The Road of Remembrance in Folkestone, the majority of the area is designated as a conservation area. This work was commissioned to initially identify areas of slopes where slope failure / slips are most likely to occur based on a visual assessment of the accessible areas of the slopes.

- Ground conditions are reported to comprise interbedded sandstone and limestone of the Hythe Formation, sandstone, siltstone and mudstone of the Sandgate Formation and sandstone of the Folkestone Formation. The Hythe Formation and Folkestone Formations are classified as a Principal Aquifers while the Sandgate Formation is classified as a Secondary Aquifer.

- The slope throughout the investigated area shows signs of instability and previous failure due to various factors, including slope angle, vegetation, and the presence of artificial structures. Recent landslides occurred during/after heavy rainstorms, likely as a result of loosening of shallow soils and the creation of slip surfaces. Dense vegetation, particularly mature trees, may have exacerbated these landslides by uprooting and further destabilizing the soil.

- This assessment identified potential characteristics of slope instability, such as cracking footpaths, leaning railings, and exposed roots, which could potentially predict future landslides that could be triggered by heavy rain/storms.

- A monitoring program is recommended, especially around storms, to manage and mitigate the impact of potential future slope failures.

By their very nature, the above bullet points represent a simplified summary of our work and **must not** be relied upon to form the basis for key decisions for the proposed development. A full picture is provided in the following report, or alternatively give us a call and we'll talk you through it.

Project Reference:	UK24.6951
Title:	Visual Slope Stability Assessment – The Leas & Road of Remembrance, Folkestone
Client:	Folkestone & Hythe District Council
Date:	26th June 2024
EPS Contact Details:	7B Caxton House Broad Street Cambourne Cambridge CB23 6JN T: 01954 710666 E: info@epstrategies.co.uk W: www.epstrategies.co.uk
Status:	Issue 1

Author:	**Reviewed:**	**Authorised:**
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
Consultant	Principal Consultant	Director

The report has been written, reviewed and authorised by the persons listed above. It has also undergone EPS' in house quality management inspection. Should you require any further assistance regarding the information provided within the report, please do not hesitate to contact us.

The National Planning Policy Framework requires a competent person to prepare site investigation information, which is defined as a person with a recognised relevant qualification, sufficient experience in dealing with the type(s) of pollution or land instability, and membership of a relevant professional organisation. EPS considers that it fulfils these criteria and would welcome any request for staff CVs or case studies to demonstrate it.

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Figures

Appendices

1 INTRODUCTION

In April 2022, Environmental Protection Strategies Ltd (EPS) was commissioned by Folkestone & Hythe District Council to complete a Visual Slope Stability Assessment at The Leas & Road of Remembrance in Folkestone ('the site'); see Figure 1.

The work was commissioned to initially identify potential areas of the existing slope where failure / slips may occur based on a visual assessment of the accessible areas of the slopes.

This report presents the findings, conclusions, and recommendations of the Visual Slope Stability Assessment undertaken for the site as instructed.

1.1 Objectives

To perform a visual assessment of the slopes site in accordance with the principles and requirements of BS5930:2015+A1:2020 *'Code of practice for ground investigations*', the following tasks were undertaken.

Desk Study / Background Information:

a) Examining the site history - late 1800s to present day, through collection of historical maps of the area, site records, records held by relevant local authorities, the Environment Agency and review of other information databases.
b) Characterising the site's environmental and geological sensitivity through examination of existing geological, hydrogeological, topographical, and historical maps and aerial photographs of the area.

Visual Slope Stability Assessment:

- Walkover survey and identification of accessible areas of the slopes.
- Recording of key visual characteristics of the slope.
- Obtaining of photographic records.

Reporting:

- Identifying potential areas of future failure / slips through a combination of historical map and site-specific data review and through the creation of idealised cross sections.

The findings of these investigations and their conclusions are presented in the following sections.

1.2 Project Limitations and Constraints

The purpose of this report is to present the findings of a Phase I Geo-Environmental Desk Study conducted at the location(s) specified. When examining the data collected from the investigations made during the assessment, EPS makes the following statements:

This report does not include specific investigation for the presence of either Potential Asbestos Containing Material (PACM) or Japanese Knotweed at the subject site however, if obvious evidence of either is observed during EPS site walkover, details will be provided in this report. Specialist contractors should be commissioned to make detailed assessments and recommendations if these materials are suspected.

2 SITE CHARACTERISATION

The following section provides a summary of the information collected in relation to the site location and history.

2.1 Site Location and Description

The area of investigation spans approximately 1.6km to the south of The Leas & The Road of Remembrance in Folkestone, the majority of the area is designated as a conservation area. According to a recent lidar survey commissioned by the Client, the highest point of the area of investigation is located to the far west; levels along the promenade, which marks the northern extent of the area range from around 53m at the north west. This promenade gradually slopes downwards to the east to a level of around 39m at the western end of The Road of Remembrance, which slopes down more steeply to the east to a level of approximately 5m AOD at the eastern end of this road. Levels along Lower Sandgate Road, which spans much of the Lower Leas Coastal Park, range from approximately 49m AOD in the west, to approximately 5m AOD in the east, and while the general trend of Lower Sandgate Road dropping towards the east, there are some undulations in the coastal park.

The western extent of the site is defined by the Lower Sandgate Road West Car Park at the west of the coastal park and by the junction at the eastern end of the Road of Remembrance and Lower Sandgate Road East / Marine Terrace. The lidar survey provided by the Client is included as Appendix A.

The Leas is a road running east to west above the Lower Leas Coastal Park. To the south of The Leas, a promenade runs parallel to both the coastal park and the coast. Several smaller footpaths extend from the promenade. Some of these footpaths run parallel to the promenade, while others provide access to lower parts of the coastal park, navigating through sloped areas sometimes with steps (such as The Metropole Steps at the western end of the coastal park) and sometimes through caves and rock exposures (known locally as the Zig Zag Path in the central area of the coastal park, parts of this path appear to be man-made).

For the purposes of this assessment, the coastal park has been categorised into three levels. The first of these levels is the highest, where the promenade and small footpaths run to the south of The Leas. Sloping down from this level, there is an intermediate level where the road known as Lower Sandgate Road which provides access to the coastal park and to the south of Lower Sandgate Road. The land also slopes down to Folkestone beach which also includes a promenade. In certain parts of the coastal park, there is also an additional level marked by some footpaths between the promenade and footpaths at the top of the slope and between Lower Sandgate Road within the coastal park.

It should be noted that only the areas between the highest level and Sandgate Road, which spans the length of the coastal park, have been inspected as part of this assessment as the lower level between the beach and the coastal park is heavily vegetated and there is seemingly currently no anecdotal evidence of slope instability between the coastal park and the beach.

Two notable failures, in the form of slips of the slope between the upper level and the coastal park, are understood to have occurred in recent times. One of these is located in the western part of the coastal park, south of Earls Avenue, at the top of and beyond the north of the promenade, this slip is henceforth referred to as S1 and detailed descriptions of the characteristics of S1 are presented in Section 3. The other slip (referred to as S2 throughout this report) between the promenade and the coastal park occurred more centrally within the western section of the coastal park, between the Adventure Playground on the northern side of Lower Sandgate Road and the footpath directly adjacent to a structure known as The Vinery / The Leas Esplanade adjacent to the promenade at the top of the slopes.

No other large-scale failures of the slope were apparent throughout the coastal park area although indications of such failures cannot be ruled out due to the fact that much of the slope between the coastal park and the promenade south of The Leas is obstructed by dense vegetation including large mature deciduous trees and smaller shrubs, bushes and weeds.

A structure known as The Channel Suite is present adjacent to the promenade approximately midway along the coastal park, this structure, which is associated with the Lead Cliff Hall, has an upper level comprising a viewing platform beneath which are function rooms accessed via a path down the slope from the promenade.

For the purposes of this report, the eastern extent of the coastal park is considered to be an old, inactive lift (known as the Folkestone Leas Lift) linking the promenade to the lower level. It should be noted that the eastern section of the coastal park slopes downwards to the east so that the intermediate level between the beach and the promenade south of the Leas disappears and the inactive lift at eastern end of the coastal park is present from a ground level similar to that of the beach. Between the inactive lift and the western end of the Road of Remembrance, a slope spanning a distance of around 130m is present however, this area is densely vegetated with no footpaths through the slope and hence could not be inspected. Despite some low-level vegetation being present in this area, the slope surface was partly visible and reinforcement (possibly from a former structure) were observed to be protruding from parts of this slope which was seen from the promenade.

The western end of the Road of Remembrance marks the eastern extent of the road known as The Leas and the Road of Remembrance slopes downwards from an elevation of approximately 38.5m AOD at its western end to an elevation of approximately 5.3m AOD at its eastern end. While the slope to the south of the Road of Remembrance could also not be inspected in any detail due to the vegetation obscuring any potential observations, the slope on the northern side of the Road of Remembrance, the road to the south of what appear to be private residential properties could be seen.

Several trees presumed to be large (based on the size of the remaining stumps) have recently been felled on the northern side of the Road of Remembrance across its western extent. A large failure of the slope north of the Road of Remembrance has occurred and is evident along the central and eastern parts of the road, this locality which is also described in greater detail in Section 3 is referred to as S3 throughout this report. A plan showing the approximate extent of the area of investigation is presented as Figure 2.

2.2 Geo-Environmental Setting

<table>
<tr><th>Detail</th><th colspan="3">Description</th></tr>
<tr><td>Geology</td><td colspan="3">The bedrock geology is mapped as a combination of interbedded sandstone and limestone of the Hythe Formation, sandstone, siltstone and mudstone of the Sandgate Formation and sandstone of the Folkestone Formation.

Some superficial clay and silt Head Deposits are mapped close to the Road of Remembrance and superficial Storm Beach Deposits are mapped southwest and southeast of the coastal park along the coast / beach.</td></tr>
<tr><td rowspan="4">Recorded Landslides</td><td colspan="3">A total of five landslides are reported to have occurred within the area of investigation by the British Geological Survey. Details of these are summarised the below table:</td></tr>
<tr><th>Location
(EPS Reference)</th><th>Date</th><th>Comment</th></tr>
<tr><td>Easting: 621886
Northing: 135307</td><td>Unknown</td><td>The location of this landslide corresponds to the locality referred to by EPS as S1 however no further information on this landslide is provided by the BGS.</td></tr>
<tr><td>Easting: 621975
Northing: 135305</td><td>2023</td><td>Although the specific coordinates do not align with the locality of it, this landslide event broadly correlates to the locality referred to by EPS as S1 within this report and has been reported by local news in November 2023.</td></tr>
</table>

<table>
<tr><th>Detail</th><th colspan="3">Description</th></tr>
<tr><td rowspan="4"></td><td>Easting: 622510
Northing: 135548</td><td>1985</td><td>This landslide is recorded to have occurred in 1985 to the east of The Channel Suite in the central part of the coastal park. References are made to council records and academic papers in which the landslide has been discussed.</td></tr>
<tr><td>Easting: 623044
Northing: 135838</td><td>2014</td><td>This landslide is recorded to have occurred in 2014 in very close proximity to the locality referred to as S3 and was reported by local news however the article is no longer available.</td></tr>
<tr><td>Easting: 623032
Northing: 135843</td><td>2024</td><td>This landslide is recorded to have occurred in 2024 in the locality referred to as S3 and was reported by local news in February 2024.</td></tr>
<tr><td colspan="3">In addition to the landslides that have been recorded in the grounds of the coastal park and along the Road of Remembrance, the wider surrounding area also has several recorded landslides including some well-known, large scale landslides that have been studied in detail and which are referenced in academic papers. One of these examples is the Folkestone Warren Landslide, this occurred in 1915 and was one of the largest on the English coast which caused serious damage to local transport infrastructure.</td></tr>
<tr><td>Coal Mining</td><td colspan="3">While the area does fall within the Kent Coal Mining Reporting Area there are no records of any coal mining related features such as coal workings, mines, or outcrops in the local area.</td></tr>
<tr><td>Hydrogeology</td><td colspan="3">Consideration has been given to the aquifer status of the different geologies in the area as the aquifer status of geological strata can give an initial indication of the anticipated permeability of such units which, in turn can be useful in considering how groundwater and surface water can affect such geologies through erosion and other weathering processes.

The Hythe Formation and Folkestone Formations are classified as Principal Aquifers while the Sandgate Formation is classified as a Secondary Aquifer.</td></tr>
<tr><td>Known Drainage, Utilities & Subsurface Features / Structures</td><td colspan="3">While detailed records are unavailable, during EPS' visual inspection of various localities within the area, a number of drainage type features were noted. These included drains extending outwards from slope faces such as those at the 'Zig Zag Path' and other smaller outcrops in the western part of the coastal park as well as some drains visible from the paths adjacent to the promenade at the higher levels. The stone walls alongside some of the paths in the western park of the coastal park in</td></tr>
</table>

Detail	Description
	which drains were present appeared to be cracked and bulging in some locations. It is also likely that the structures at the top of the slope along the promenade have subsurface elements. For example, at C2 The Vinery / The Leas Esplanade, the substructure is partially visible and appears to be founded on a concrete slab at the top of the slope. Other structures that likely include subsurface elements are the Metropole Steps at the west end of the coastal park (along with some other paths and steps throughout the park), the 'Zig Zag Path', The Channel Suite associated with Leas Cliff Hall (supported by steel beams attached to concrete pads that likely extend vertically into the slope), and the Folkestone Leas Lift, which spans the slope profile at the eastern end of the coastal park.

3 VISUAL SLOPE STABILITY ASSESSMENT

This section presents an initial visual assessment of the stability of the slopes within the Lower Leas Coastal Park (between Sandgate Road and the promenade) and of the slope on the northern side of the Road of Remembrance.

Where visible between breaks in trees and due to limited vegetation, the ground conditions making up the slopes appear to comprise a surficial layer of brown, sometimes loose, slightly clayey, silty sandy topsoil. The soil from the landslides / slips (S1, S2 & S3) appeared to comprise a combination of possible clayey silt and sand with some gravel. Outcrops of rock likely to be a combination of sandstone and limestone were also visible in the slope faces as a result of the soil being removed during the various landslides / slips.

3.1 Visual Inspection

The visual inspection of the area took place on 10th May 2024. Each landslide / slip (S1 – S3) is described in more detail in the following subsections which also include selected photographs taken by EPS during the visual inspection.

The following subsections also provide detailed descriptions of two individual localities throughout the area (L1 & L2) where characteristics have been observed that could suggest similar landslide / slips may occur at these locations. These are marked on Figure 2 and an idealised cross section showing the general profile of the slope at each of the localities are presented as Figure 3 and 4. It should be appreciated that the idealised cross sections have been constructed from the lidar survey provided by the client and that there are limitations to the data obtained from lidar surveys (such as accuracy, density / frequency of data, quality of data due to variations in vegetation etc).

3.1.1 Landslide / Slip S1

‘S1’ is the western most landslide / slip that occurred on the part of the slope annotated as ‘West Cliff’ on the lidar survey. At this location, it was observed that a landslide had occurred from the southern side of the footpath adjacent to the promenade at the top of the slope and material had subsequently slid down to the intermediate path approximately mid-way up the slope between the coastal park / Sandgate Road with loose material from the landslide also noted to have slid further down beyond the intermediate footpath.

At the crest of the slope at S1, the railings had collapsed and the concrete substructure beneath the asphalt footpath and in which the railings where founded, could also be seen to have collapsed (see Photo 1A). While the asphalt was cracked close to the edge of the footpath, no significant cracks were apparent further away from the edge of the path at S1. The material that was present across the surface of the intermediate footpath appeared to be loose silty sand and this material also appeared to be present beneath the asphalt path at the top of the slope. A lot of vegetation including roots, rootlets and larger tree roots and branches were noted to be strewn across the intermediate footpath as was some general waste / litter.

***Photo 1/1A** - Images taken from the footpaths on the 'West Cliff' between the coastal park and the promenade at the top of the slope / cliff looking at the slip surface.*

***Photo 2/2A** - Aerial images showing the extent of the landslide / slip from the footpath below the promenade across the intermediate footpath between the promenade and the coastal path and further south between the intermediate footpath and the coastal park.*

The slip surface at S1 appeared to also comprise loose material which was slightly darker in colour compared to the loose material strewn across the intermediate footpath and visible at the very top of the slope (brown compared to light brown / beige). This suggests that some topsoil (which would typically be darker than the natural soils making up the majority of the profile) may be intermixed with the natural soils closer to the intermediate footpath.

Beyond the extent of S1, cracks were noticed in the footpath extending both east and west from where the landslide intersected with the intermediate footpath. This suggests that some movement of the underlying soil may have also occurred along this footpath. Although where these cracks were noticed, the slope was vegetated making it difficult to identify of movements on the slope surface as stone wall retaining type features were also present above (north of) the path extending east from the location of S1.

Some footpaths, which are bound by stone walls adjacent to the slope between the coastal park and the promenade are present within the vicinity of S1. Drains were noted to be present in some of these stone walls which would presumably drain onto the footpath during and after heavy rainfall and at some locations, the stone walls were noted to be cracked and bulging which could suggest that the drains are inadequate and that the pressure of water behind the wall has caused the wall to be damaged and / or that the pressure of the soils behind the wall (which could have been increased due to landslide and slip events) have caused the damage.

3.1.2 Landslide / Slip S2

At the location of slip S2, loose material was observed to be present across the surface from the top of the slope, this was marked by a footpath adjacent to the promenade down to the bottom of the slope at the northern extent of an adventure playground within the grounds of the coastal park.

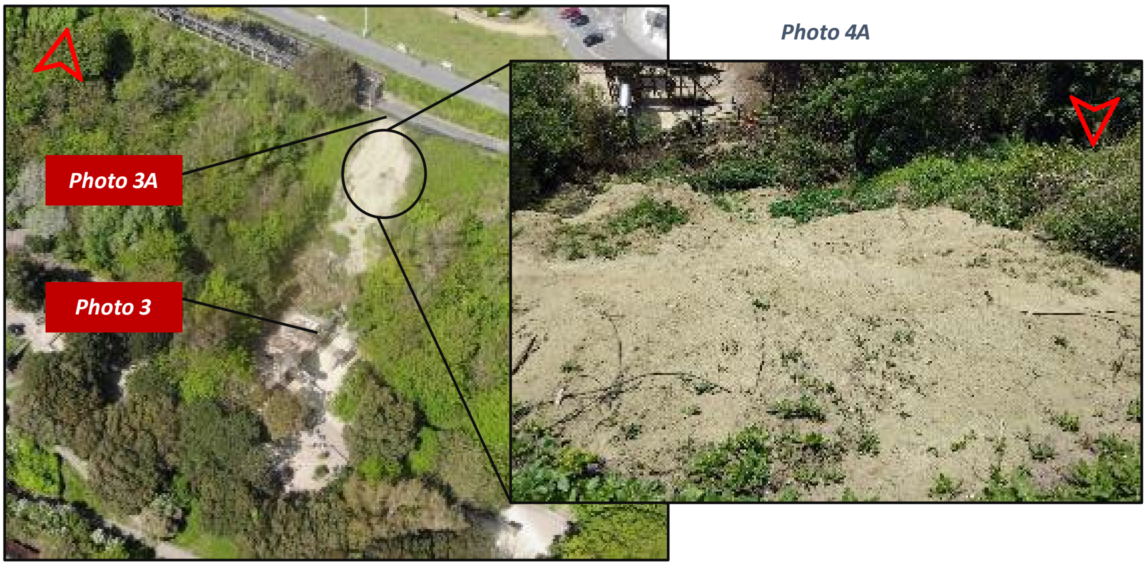
Photo 3/3A *- Images taken from the northern extent of the adventure playground and at the top of the slope showing the extent of the landside that occurred to the immediate east of 'The Vinery / The Leas Esplanade'. Photo 3A shows the continued and ongoing damage to the recently repaired asphalt path and railings.*

Photo 3A

At the top of the slope at this location, the asphalt footpath and railings has been recently repaired following the landslide / slip, however it is understood that shortly after (within a few days) of the asphalt footpath being repaired, cracks in the new asphalt appeared and the level of the asphalt close to the edge of the path dropped and the railings began to lean southwards towards the slope suggesting that the underlying soils at the top of the slope at S2 remain loose and susceptible to further movement (see Photo 3A). A drainage gulley was also noted to be present at the eastern extent of 'The Vinery' structure. This gulley appeared to be configured to discharge surface water runoff from 'The Vinery' and adjacent footpath and given that during heavy rain and storm events water would be discharged to a focussed point, such drainage may also contribute to the landslide / slip at S2.

Loose material present across the slip surface was similar to that observed at S1; light beige silty sand, however, at S2 there were seemingly more frequent fragments of sandstone / limestone present both within the loose material and visible on the slip surface of the slope. Many fallen trees, branches and roots were also visible on the slope as were some tree stumps and branches that appear to have been cut / felled following the landslide / slip. At the toe of S2, a retaining type feature was visible, this feature which was constructed from steel pillars extending vertically into the ground and joined by 'I' beams between the pillars was finished with timber slats some of which were seemingly damage / broken / removed by the landslide / slip.

Photo 4/4A *- Aerial image showing the extent of the landslide / slip at S2 between the footpath adjacent to the promenade and the adventure playground with the coastal park. Photo 4A is an image taken from the top of the slope at S2 showing loose material and seemingly competent rock exposures.*



3.1.3 Landslide / Slip S3

Along the eastern section of Road of Remembrance (to the east of the coastal park) a landslide / slip that is greater in its lateral extend was observed. This landslide / slip occurred from the slope above (north of) the Road of Remembrance. During EPS' inspection, it appeared that loose material that had slid onto the road itself had been removed and cleared however some large collapsed trees remained and were obstructing the road, some of these appeared to have been partly cut and the roots of some of these trees appeared to 'stuck' within the loose soils on the northern side of the road.

Photo 5 *- Aerial image showing the extent of the landslide / slip at S3 along the eastern section of the Road of Remembrance.*

section of the road.

While it cannot be confirmed, due to the dense vegetation and fencing obstructing access, the lower part of the slope on the southern side of the Road of Remembrance did not appear to be affected significantly by the landslide / slip at S3 and no indication of movement on this part of the slope was apparent along the southern side of the Road of Remembrance (i.e. no cracks in the footpath were noted and the railing did not appear to be leaning down the slope).

Along the western and upper part of the road, beyond the recent landslide/slip area, two types of retaining features were noted. The first, starting from the western end of the road, appears to be a simple, inclined stone wall. The second, less extensive feature, extends to the recent landslide/slip area and seems to be a simple concrete retaining structure (possibly crib lock) with a slight incline.

The slope above (north of) both retaining features had many tree stumps, remnants of tree felling commissioned after the landslide/slip at S3. Along the path at the top of this part of the slope, there was no obvious evidence of movement, such as cracking in the asphalt footpath or concrete slabs, or leaning of the railings. Some steps and a tunnel-like feature were also noted in this part of the slope, which appeared unaffected by the recent landslide/slip further east at S3.

The slip surface at S3 (shown partially in Photo 9) appeared to comprise a combination of loose light brown / beige silty sand and darker brown, possibly slightly clayey and seemingly slightly damp (in some places) topsoil. It is possible that the slightly damp soils are a result of the material that moved during the landslide / slip drying out and it is not considered that damaged drainage was a reason for the damp soil as no evidence of such drainage was apparent (although this cannot be ruled out). Some large cobbles and boulders of sandstone / limestone may have been present on the slip surface and similar fragments of rock could have also slipped from the slope onto the road however given that the road has been cleared prior to EPS' inspection, this cannot be confirmed.

Based on the dense trees to the east of the landslide/slip at S3 (see Photo 7), it is assumed that mature trees were also present along much of the landslide/slip area, as evidenced by the trees obstructing the Road of Remembrance. At the top of the slope above the Road of Remembrance, the land appears to be part of a private property, separated by a mature hedgerow (which may have included adjacent mature trees removed by the landslide/slip). The stability and structural integrity of this property may need to be assessed in greater detail beyond the remit of this visual slope stability assessment as there is an obvious potential risk to damage of this property as a result of future landslip / slip events and smaller scale ongoing erosion / weathering of the slope immediately below the bounds of this property.

***Photo 7** - Image showing the landslide / slip at the eastern extent of the Road of Remembrance.*

A simple concrete retaining feature spans much of the slope (see Photo 8), with loose soil and dense vegetation having slipped over most of it. In some locations, the concrete retaining wall was not visible due to an abundance of soil and possibly because large trees had damaged the concrete. Additionally, a seemingly disused structure (see Photo 9) is present adjacent to the northern side of the road. This structure is a two-storey concrete building set back into the slope, with former doorways visible on the western side. The visible sections of the structure did not appear to have been damaged by the landslide/slip.

Photo 8 *- Image showing the inclined retaining wall structure and western extent of the landslide / slip along the Road of Remembrance.*

Photo 9 *- Image of the landslide / slip above a small retaining feature / structure on the northern side of the Road of Remembrance and disused unknown structure.*

3.1.4 Locality L1

L1 is illustrated in Figure 3 and is located at the western extent of the coastal park adjacent to the staircase (known as The Metropole Steps) from Lower Sandgate Road to a footpath adjacent to the promenade at the top of the slope. Here the staircase extends northeast from Lower Sandgate Road to approximately two thirds the height of the slope before the staircase then changes direction to lead upwards to the northwest.

The part of the slope adjacent to the steps extending northwest (southeast from the footpath at the top of the slope) is locality L1. At this location, many exposed small roots and rootlets are present and vegetation is relatively sparse between the small to medium sized deciduous trees with seemingly loose topsoil present between the trees, these observations could be indicators or erosional and weathering processes in this area. The majority of the trees appeared to be slightly leaning southwards in the direction of the falling slope and beyond the area where soil is visible at the surface and not obstructed by low level vegetation.

The steepness of the slope increases as you move up towards the promenade with the calculated slope profile in Figure 3 identifying a maximum angle of approximately 48 degrees in the area of 'loose soils' which could also contribute to instability. Photos 10 and 11 taken from 'L1' are presented below:

Photo 10 *- Image showing the slope at L1 taken from The Metropole Steps*

Photo 11 *- Image showing the slope at L1 taken from The Metropole Steps.*

3.1.6 Locality L2

L2 is positioned in the eastern section of the coastal park to the immediate west of The Channel Suite structure associated with Leas Cliff Hall. Here, an asphalt footpath leads down from the promenade to a lower level of the structure and L2 is located within a slight clearing between the trees to the west of the structure. In this clearing, while there is some low-level vegetation, the majority of the slope surface was noted to comprise loose and slightly damp soil with some evidence of small scall slips / movement of the soil.

Mature trees were slightly slanted on this section with the roots of the trees more exposed on the lower (southern) side of the trees which could suggest ongoing erosion and weathering of this part of the slope. Some collapsed trees were also apparent on this section of the slope and these can be observed in photo 12 and 13 below. The lidar survey provided by the Client shows a staircase to extend from the footpath leading to the lower level of the Leas Cliff Hall down to Lower Sandgate Road within the coastal park however this staircase was not observed during EPS' inspection, signs on the upper footpath / promenade indicated that there was no access to Lower Sandgate Road via the footpath and it is possible that the footpath was obstructed by fallen trees, vegetation and small-scale landslides / slips.

Similar to L1, the steepness of the slope at L2 increases as you move up towards the promenade with the calculated slope profile in Figure 3 identifying a maximum steepness of approx. 43 degrees in the area of 'loose soils' near the footpath which could also contribute to instability. Photos 12 and 13 taken from 'L2' are presented below:

Photo 12 *- Image showing the exposed soil and tree roots at L2*

Photo 13 *- Image showing a collapsed tree at L2*

4 DISCUSSION, CONCLUSIONS & RECOMMENDATIONS

It is known that certain parts of the slope throughout the area of investigation are subject to instability as evidenced by recent slips/failures. This is likely due to a combination of factors such as the angle of the slope (which varies across the area), but is typically quite high, the type and degree of vegetation (which in turn can both inhibit and promote weathering and erosion of the soils making up the shallow soil profile) and the presence of artificial structures such as retaining features, footpaths and buildings (sometimes acting as a surcharge at the top of the slope). It is also understood that the recent landslips (S1 – S3) discussed in this report occurred during or shortly after very heavy rain and storm events.

Whilst the mechanism by which the recent landslips occurred is not completely clear, the slips that have been observed appear to be more near surface and 'translational" in nature and are considered likely to have occurred due to a combination of factors. The heavy rainfall and storms leading up to the landslips are likely to have loosened the shallow soils on the slope as well as potentially having created slip surfaces within the slope through higher permeability interfaces within the profile of the slope (for example between areas of topsoil / weathered sandstone / limestone and competent sandstone / limestone). While some vegetation can increase the stability of slopes, it is also possible that the recent landslips were worsened by the dense vegetation on the slopes, in particular, the mature trees which most likely had extensive root systems. Once the mature trees became unstable (through heavy winds in addition to loosened soils surrounding the main roots as a result of rainfall) and began to lean, the trees may have been uprooted, further loosening the soils and potentially creating a mechanism by which initial smaller scale landslips are worsened.

Given the degree to which vegetation can contribute to potential landslide and slip events, it is noteworthy that while the felling of large trees on the slope can assist in potentially reducing the likelihood of future events, the effect of the canopies and upper limbs / branches of large trees covering and hence reducing / limiting the slope surface being impacted by weathering and erosion processes (rainfall and wind for example) should not be overlooked. There is likely to be an optimal balance between reducing the height of large trees (to reduce their overall load and potential to lean and collapse causing landslides and slips) and retaining a suitable amount of the tree so that the stability provided by the tree's root systems is not lost. The promotion of lower-level vegetation would also likely be a positive contributor to the overall stability of the slope in combination with a well-maintained plan to responsibly manage the reduction in height of certain trees.

This visual slope stability assessment is not intended to be an extensive assessment of the stability of the slope present throughout the entire area of investigation. Where possible however, characteristics of the slope have been identified that may be associated with future landslips which may be triggered by storms and heavy rainfall. These characteristics have been determined based on EPS' experience with slope stability and failures and the observations made during the visual slope stability assessment, specifically those at the recent landslides / slips (S1 – S3) and the accessible areas where the slope surface is visible (L1 & L2).

Characteristics that could suggest that there is ongoing movement in the ground profile making up the slope can include cracking and subsidence of footpaths at the crest of and along the slope, leaning of railings and trees and cracking and changes in angles of retaining features, loose soils and exposed roots and a lack of low-level vegetation on the slope. These characteristics are also not exhaustive and other more specific and local scale indications of slope instability could be observed prior to any future landslide events, which as previously mentioned, would most likely be triggered by heavy rainfall and storms.

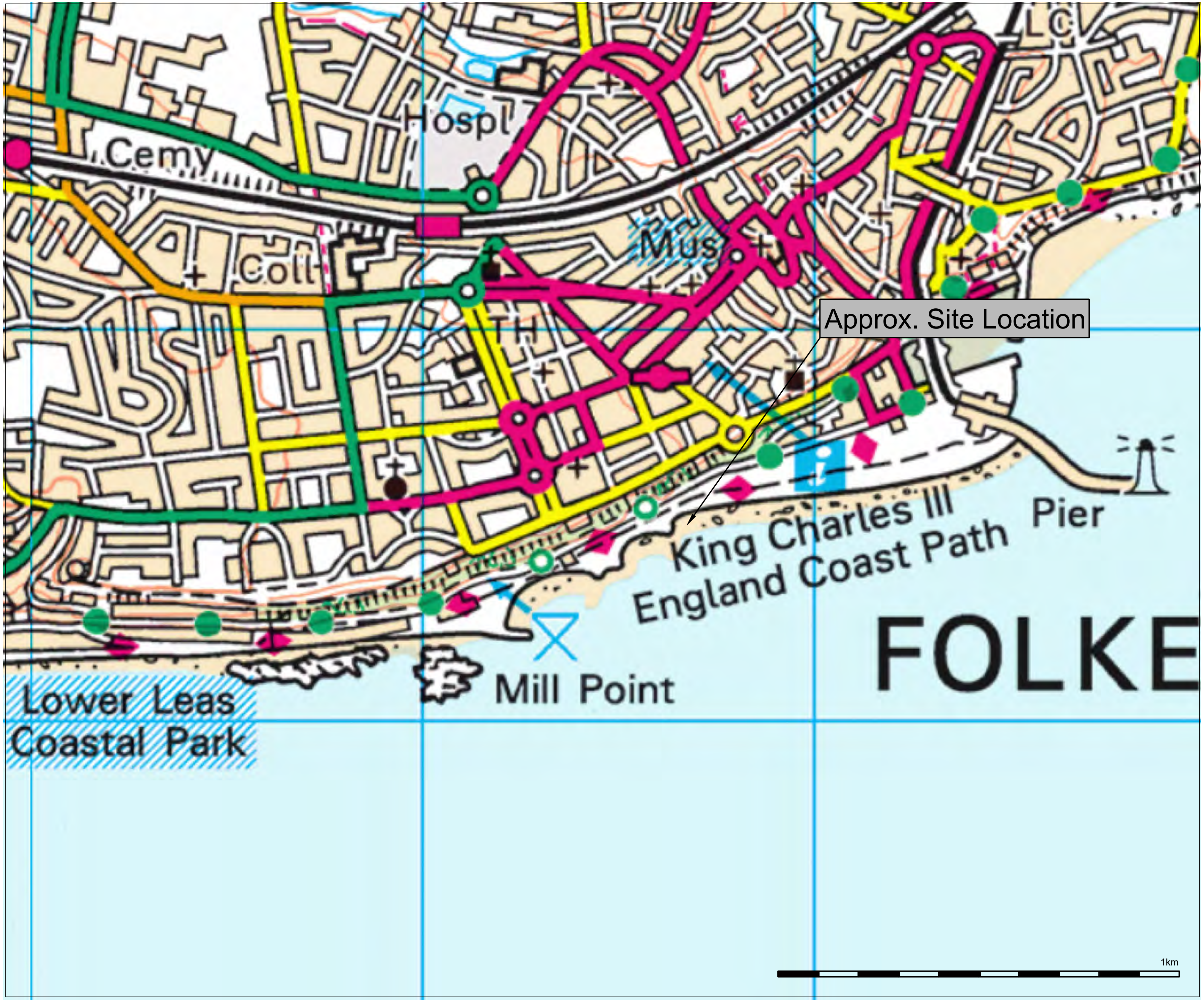
One of the key aims of this phase of works was to identify potential areas where instability is most likely so that the Client can consider more localised and focussed assessment in the future as well as potential short-term solutions to protect members of the public (such as the closing of certain footpaths) from future slope failure events. It has not been possible to identify many areas with high potential instability, this is because the nature of the slope which, for the most part is heavily vegetated and inaccessible.

There are almost certainly more areas than the two initially identified within this report (L1 & L2) which share characteristics that could be indicative of a 'high' risk of landslide / slips. Therefore, it is recommended that these characteristics be considered during the Clients ongoing and continued consideration of the slope and any future works within the coastal park and along the Road of Remembrance.

It would also be prudent to establish a qualitative monitoring programme for areas of the slope which share the key characteristics of potential instability and future landslips, especially before, during and after heavy rainfall and storm events if possible.

Careful consideration should also be given to any construction or redevelopment works (including potential measures to improve stability / repair footpaths etc) that could lead to the further destabilisation of the slope, both the upper section above the coastal park but also the lower section between the coastal park and the beach (that has not been assessed as part of this report). It should be appreciated that future works within the coastal park could have an effect on the stability of the upper and lower slope and it would also be prudent to make an assessment of any existing properties and structures that can be affected by further slips and failures and the associated implications. For example, if future slips or failures occurred at S2 or S3, the 'The Vinery' and the respective private residential dwelling at the top of these parts of the slope could be damaged and intervention could be necessary. Such restrictions may also be necessary to other parts of the coastal park including the footpaths between the coastal park and the upper promenade.

FIGURES



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Rev	Date	Drawn	Description	Ch'k'd

The Geotechnical and Environmental Engineers
www.epstrategies.co.uk

Site
The Leas & Road of Remembrance
Folkestone

Client
Folkestone & Hythe District Council

Title
Figure 1 - Site Location Plan

Surveyed:		Drawn by:	[redacted]
Checked by:	[redacted]	Date:	June 2024
Scale [A4 Sheet]	1:50,000	Drawing Reference	UK24.6951_01
Job No	UK24.6951	Rev	01

N

KEY:

LINES OF CROSS SECTION

RECENT LANDSLIDE LOCALITIES

Rev	Date	Drawn	Description	Ch'k'd

eps

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Site

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Folkestone

Client

Folkestone & Hythe District Council

Title

Figure 2 - Locations of Recent Slips & Localities

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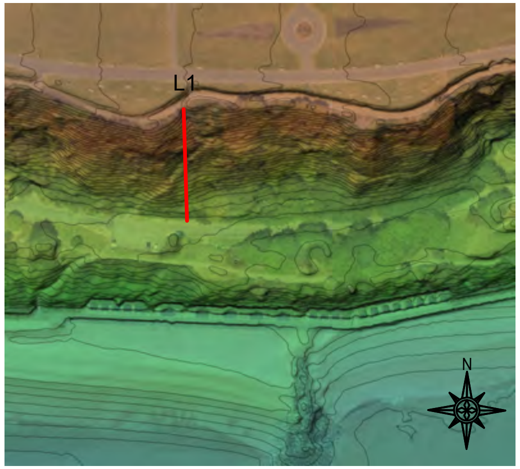
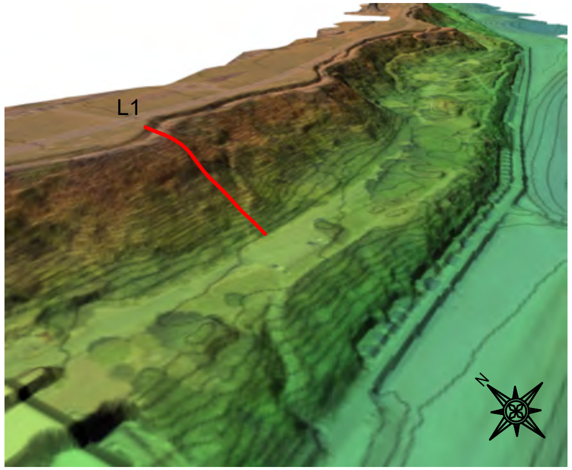
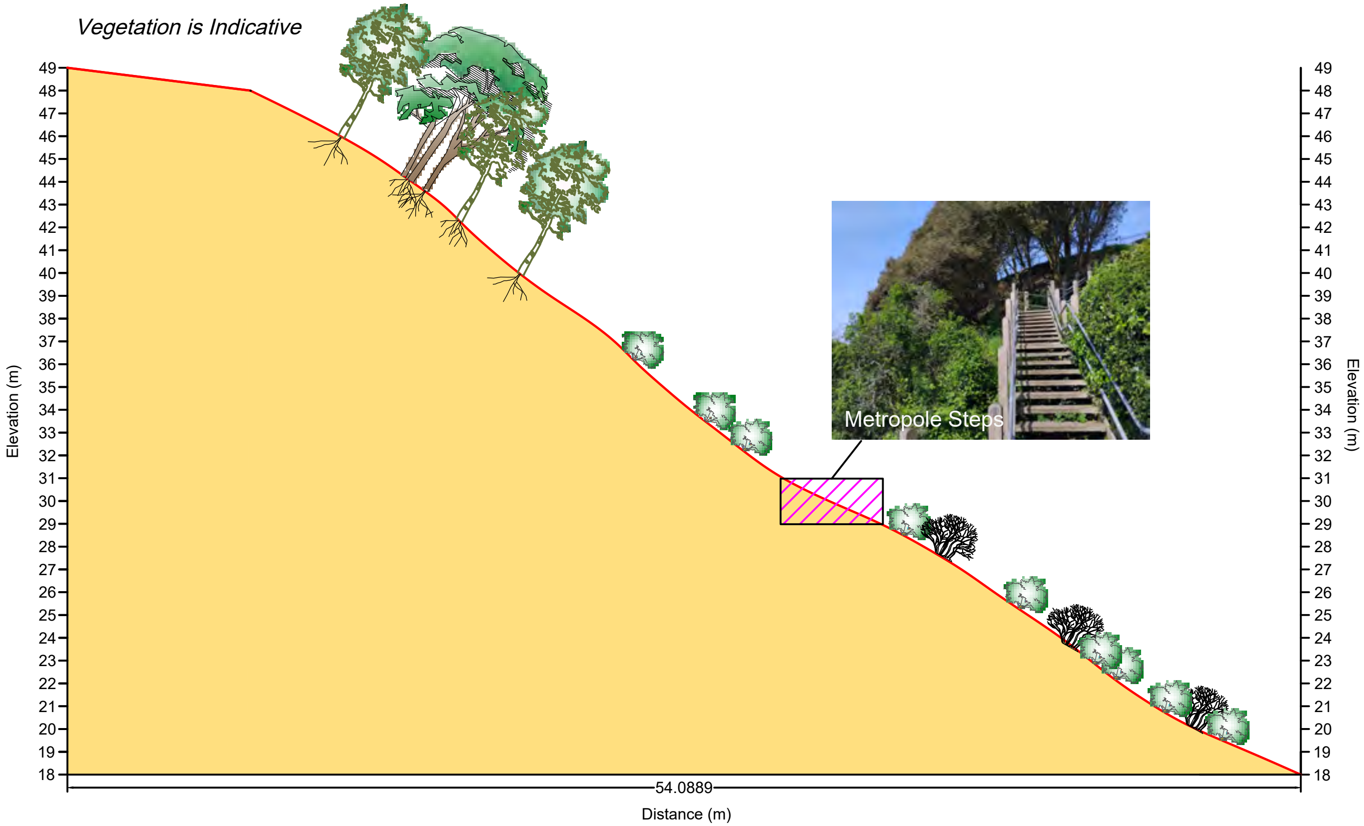
Checked by:	[redacted]	Date:	June 2024
Scale [A4 Sheet] 1:2500	Drawing Reference UK24.6951_02		
Job No UK24.6951	Rev 01		







KEY:

LINE OF CROSS SECTION

Rev	Date	Drawn	Description	Ch'k'd

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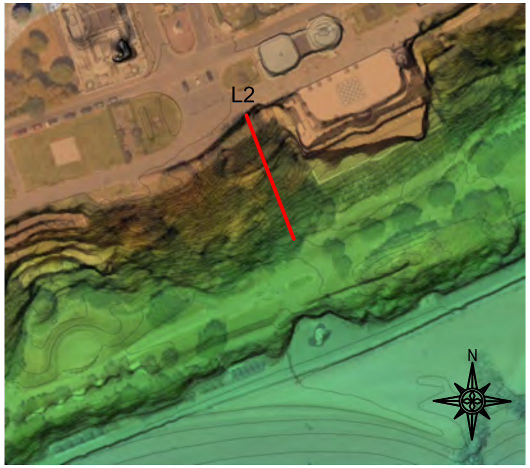
Folkestone & Hythe District Council

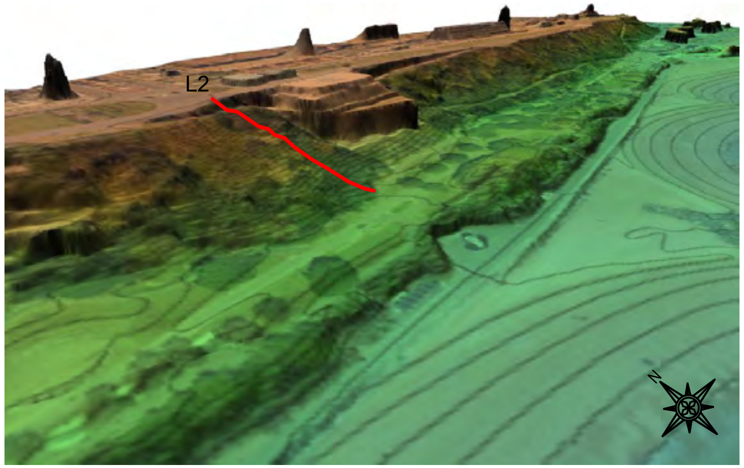
Title
Figure 3 - Cross Section L1

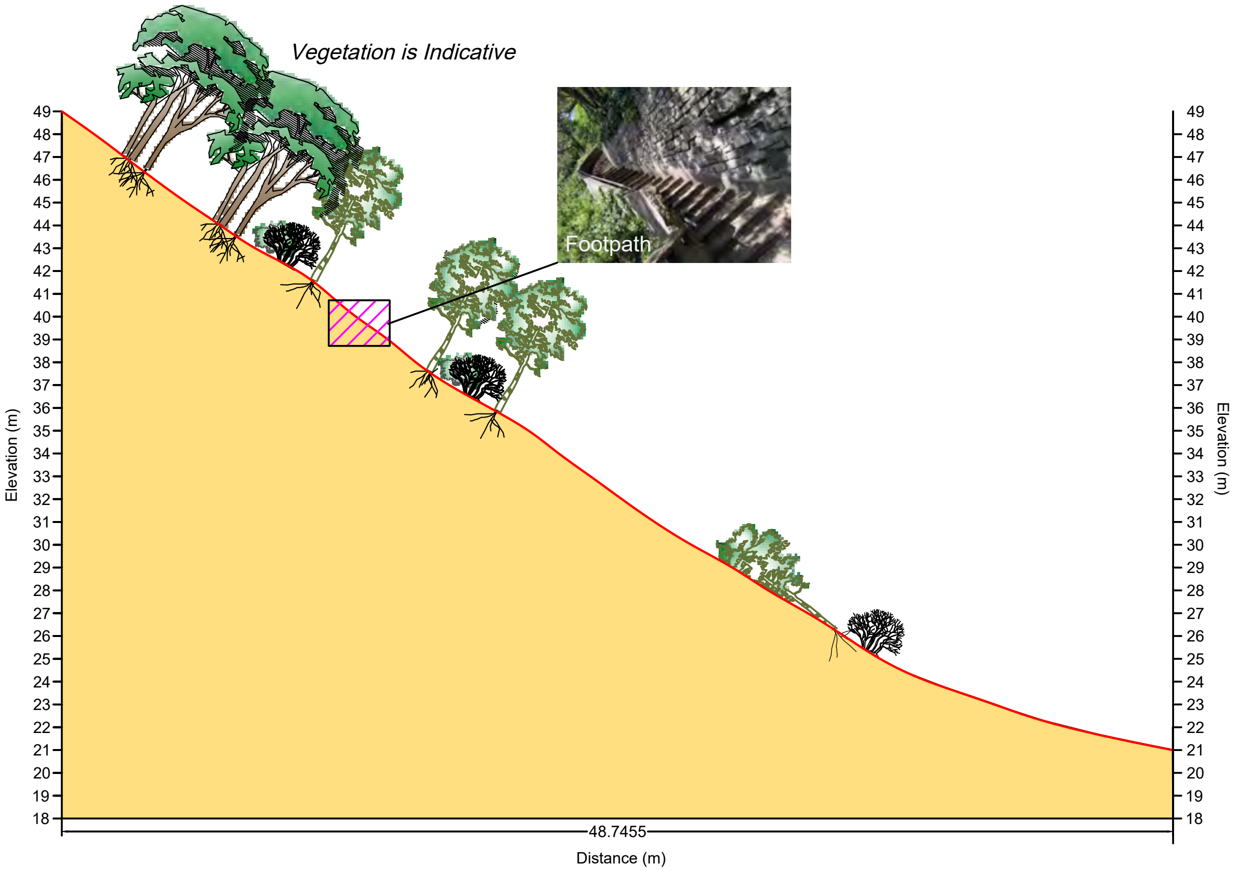
Surveyed:		Drawn by:	[redacted]
Checked by:	[redacted]	Date:	June 2024

Scale [A4 Sheet]	Drawing Reference
Not to Scale	UK24.6951_03

Job No	Rev
UK24.6951	01







KEY:

LINE OF CROSS SECTION

Rev	Date	Drawn	Description	Ch'k'd

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Site

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Folkestone

Client

Folkestone & Hythe District Council

Title

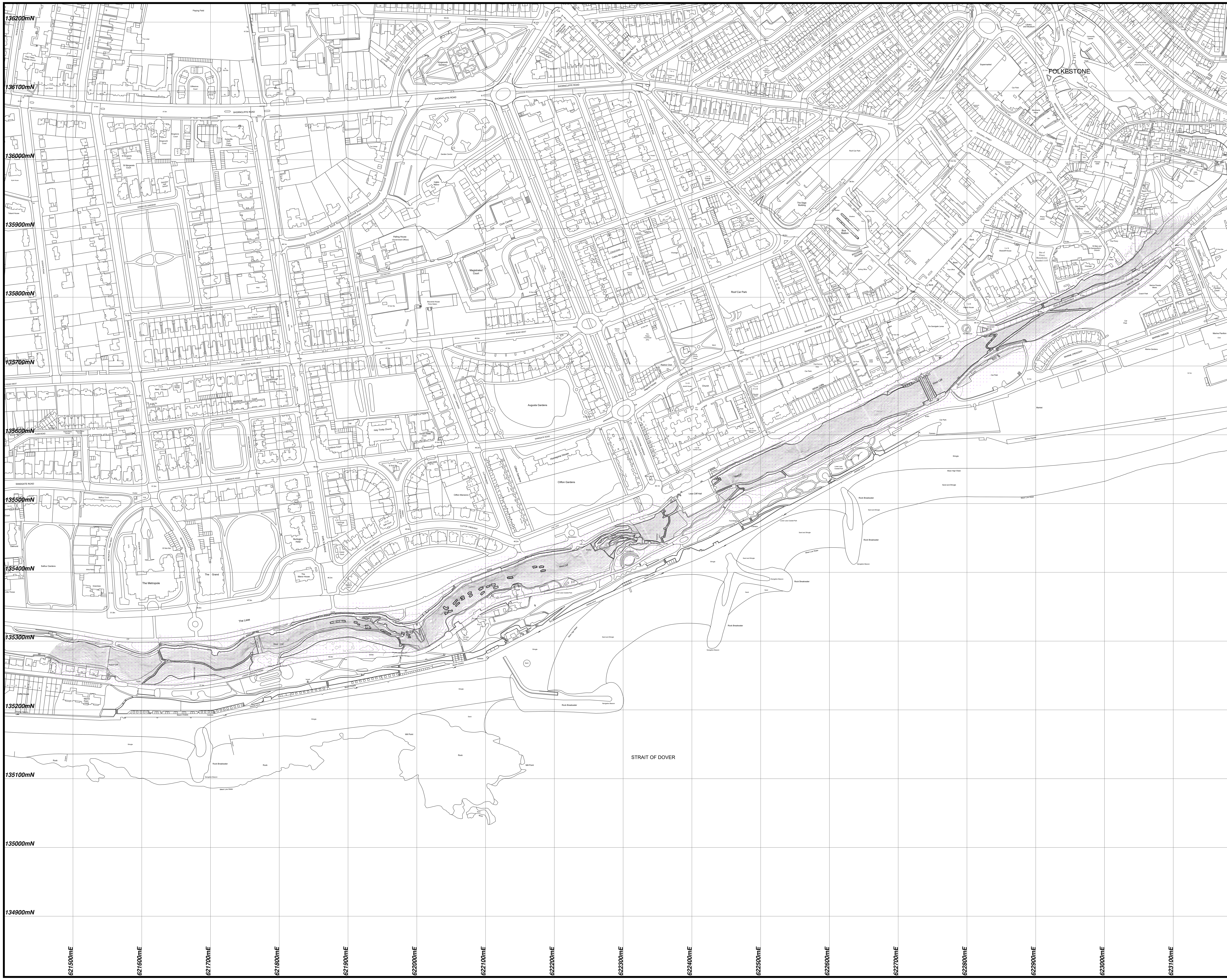
Figure 4 - Cross Section L2

Surveyed:		Drawn by:	[redacted]
Checked by:	[redacted]	Date:	June 2024
Scale [A4 Sheet] Not to Scale		Drawing Reference UK24.6951_04	
Job No UK24.6951		Rev 01	

APPENDICES

APPENDIX A

Lidar Survey (Provided by Client)



LEGEND

SERVICES

AC	Air Conditioning
AV	Air Vent
CAJB	Cable Junction Box
CATV	Cable Junction Box
CD	Cable Duct
CIP	Cable Inspection Point
EIC	Electric Inspection Cover
EJB	Electric Junction Box
EP	Electricity Pole
ER	Earthing Rod
FH	Fire Hydrant
GIC	Gas Inspection Cover
GJB	Gas Junction Box
GV	Gas Vent
JB	Junction Box
MK(E)	Service Marker (electric)
MK(G)	Service Marker (gas)
MK(W)	Service Marker (water)
OHW	Overhead Wire
SC(G)	Stop Cock (gas)
SC(W)	Stop Cock (w)
STP	Support for Telephone Tole
SV	Stop Valve
TIC	Telephone Inspection Cover
TJB	Telephone Junction Box
TP	Telephone Pole
WIC	Water Inspection Cover
WM	Water Meter

LEVEL

DPC	Damp Proof Course
THL	Threshold Level
T.O.C	Top of Chimney
T.O.W	Top of Wall
WL	Water Level

INTERNAL

CLG	Ceiling Level
DHL	Door Head Level
FL	Floor Level
SCLG	Suspended Ceiling Level
US	Underside
USB	Underside of beam
WCL	Window cill level
WHL	Window head level

DRAINAGE

BD	Back Drop
BL	Base/Bed Level
CL	Cover Level
CP	Catch Pit
DC	Drainage Channel
DP	Down Pipe
G	Gully
IC	Inspection Cover
IL	Invert Level
MH(C)	Manhole (combined)
MH(F)	Manhole (foul)
MH(S)	Manhole (surface water)
RE	Rodding eye
RWP	Rain Water Pipe
SEG	Side Entry Gully
SL	Silt Level
SVP	Soil Vent Pipe
UTL	Unable to Lift
VP	Vent Pipe
WO	Wash Out

FEATURES

B	Bollard
BH	Bore Hole
BP	Brick Pillar
BS	Bus Stop
CPS	Concrete Paving Slabs
FB	Flower Bed
LB	Litter Bin
LC	Lighting Column
P	Post
PB	Post Box
RNP	Road Name Plate
RS	Road Sign
RW	Retaining Wall
SP	Sign Post
SU	Step(s) Up
TCB	Telephone Call Box
TH	Trial Hole
TS	Tree Stump

CONTROL

OSBM	Ordnance Survey Bench Mark
STN	Survey Station
TBM	Temporary Bench Mark

Tree (girth/spread/height/species/no. of boles)
Direction of Lean
Photograph Number, Location & Direction
Survey Station

Gate - Gates
Fence
Building
Over Head Building Line
Face of Wall
Back of Retaining Wall
Line
Change of Surface
Edge of Undergrowth

Banking
Top of Bank
Bottom of Bank
Kerb
Drop Kerb
Verge
10.25
Contour With Value
E OHW T
Over Head Wire
Hedge/Tree Line

For future survey work or setting out, J C White Geomatics limited quoted survey control coordinates & levels must be used. Under no circumstances should any other surveyed points on the drawing be used other than as a gross error check.

Tree girths and spreads are quoted as a mean size, and shown to scale.

Whilst every effort is made to identify tree species and gauge heights, no responsibility can be taken for the accuracy of this information.

Whilst every effort is made to ensure that pipe diameters, invert levels and drainage types are correct, the accuracy of this information cannot be guaranteed, and it is strongly recommended that existing information is checked prior to the commencement of any detailed design and construction works.

No responsibility can be taken for drainage information obtained from Statutory Authority records.

All coordinates & levels are based on Ordnance Survey grid & datum.

All levels have been surveyed using airbourne Lidar measurement techniques. While extensive checks have been carried out to verify the information, care should be taken when interrogating and using this survey data.

Contour interval 1 metre.

Ordnance Survey digital data supllied by client.

N

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- GPS Surveys
- Volumetric Surveys
- Topographical Surveys
- Measured Building Surveys
- Laser Scanning
- Setting Out
- Boundary Disputes
- Engineering Surveys
- Deformation & Settlement Surveys
- Scan to BIM Modelling

CLIENT

Folkestone & Hythe District Council

JOB TITLE

Leas Cliff,
Folkestone,
Kent.

DRAWING TITLE

UAV Level Survey

JOB No.	*24/08/006*	DATE	*March 2024*
SURVEYED BY	[redacted]	DRAWN BY	[redacted]
SCALE *1:2500*	DWG. No. *1*	REV. No.	
CAD PLOT DATE 28.03.2024	ORIGINAL SHEET SIZE A1	CADFILE NAME 2408006 - Leas Cliff Lidar Survey_04.dwg	

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Cliff at the Lower Leas Park Playground, Folkestone

Cliff Mitigation High Level Options Report

Prepared for

Folkestone Hythe District Council

Document no: A124037-TGEE-GEN-XX-RP-C-0001
Revision: P01
Date: 16/10/2024

Design once, engineer right

Tony Gee
Consulting Engineers

Document Issue Record

Project:	Cliff at the Lower Leas Park Playground, Folkestone
Report Title:	Cliff Mitigation High Level Options Report
Client:	Folkestone Hythe District Council
Document No:	A124037-TGEE-GEN-XX-RP-C-0001
Revision:	P01
Status	S2 - Suitable for information / reference
Date:	16/10/2024
Filename:	A124037-TGEE-GEN-XX-RP-C-0001 Options Report

Rev	Date	Description and Purpose of Issue	Prepared	Reviewed	Approved
P01	16/10/24	FHDC review & comments	[redacted]	[redacted]	[redacted]

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Tony Gee

Contents

Summary

This report presents high-level options review to mitigate the impact of the landslide at the cliff behind the playground at the Lower Leas Coastal Park. The report presents a desk study (section 2) primarily focused on site geology and our observations from the site visit (section 2.5).

Based on our desk study and the site visit we have concluded that the top of the cliff directly under the footpath leading to 'The Vinery' structure is a major concern as a result of the landslip which left this part of the cliff at a very steep angle. Below this, the cliff generally appears to be stable due to presence of more component sandstone beds but there are overhanging rock and highly/completely weathered zones. We could not inspect the part of the cliff where landslip material is still present.

Due to the nature of the Folkestone Formation, where the sandstone is poorly cemented rock mass with intermitted sand lenses, local small-scale falls will continue to occur due to the mechanical breakdown of the structure of the formation as a result of root wedging and climate related weathering.

Based on our observations, we presented for options. All the options require reinforcing the top of the cliff. Due to the site constraints, soil nailing is considered the most appropriate mitigation measure.

Option 1 – Soil nailing and passive (draped) netting (section 4.3)

Option2a – Soil nailing and king-post retaining wall (section 4.4)

Option 2b – Soil nailing and sheet pile retaining wall (section 4.5)

Option 3 – Soil nailing and debris flow barrier (section 4.6)

The options which are considered but not included are also provided in section 4.7.

Appendix B to this report provides the option sketches.

1. Introduction

Tony Gee and Partners LLP ('Tony Gee') was commissioned by Folkestone and Hythe District Council (FHDC) to provide a "high-level" options development for cliff stabilisation at the playground at the Leas Park, Folkestone.

1.1. Background

In February - March 2024 period, the cliff behind the adventure playground area at the Leas Park, Folkestone experienced a landslide. The footpath at the top of the cliff, the Madeira Walk, adjacent to "The Vinery" had been experiencing distress, likely to be slope movement, which resulted in repairing the asphalt pavement and the railings by the FHDC . However, new cracks appeared shortly on the repaired section and the fence leaned towards the cliff the slope failed on the 2nd of March landslide happened.

The section of the footpath on top of the land-slipped area and the toe of the slope are currently cordoned off to prevent public access.

1.2. Scope

This options report has been produced following site walkover surveys, desk study and back-analysis of the slope. The scope of the report is summarised below:

- Summarise the observations made during the site walkover surveys
- Summarise our observations made through a brief desk study focusing on site geology and historical borehole information
- Present options for cliff stabilisation and slip retention solution
- Provide recommendations for future investigations and design

2. Project description

2.1. Site location

The site is located at national grid reference TR 22141 35393. The nearest postal code is CT20 2DZ. Within the area is the Lower Leas Coastal Park playground, consisting of numerous playground equipment and structures. At the time of writing, whilst the park is open, the area immediately behind one of the climbing structures is cordoned off.

2.2. Available information

The following documents were received from FHDC:

- Visual Slope Stability Assessment, The Leas and Road of Remembrance Folkestone, Report by EPS, Report No. UK24.6951, 26/06/2024.
- Leas Cliff UAV level survey, by JC White Geomatics, March 2024, DWG file and "2408006 - Leas Cliff Lidar Survey - Sheet 1.pdf"

The visual slope stability assessment reporting by EPS provided a background and observations on various landslides in Folkestone, including the Leas Cliff (numbered as 'S2'). The report provides observations on the landslip zone and the area. It mentions a drainage gulley at the east of 'The Vinery' which appeared to be discharging surface (rain) water runoff from 'The Vinery' and the adjacent footpath. The report does not provide details whether the surface runoff is charged to a chamber or drained to the slope. In the conclusion section, the report discusses possible factors for the landslides. It argues that although the actual mechanism is not clear, the slips (including the one this report focuses on) appeared to be translational shallow slips which were likely to be triggered due to a combination of factors such as heavy precipitation which contributed softening resulting in the formation of slip surfaces. They also state that vegetation, such as trees, may have contributed to slope movements due to the effect of strong wind and self-weight.

2.3. Historical information

The online resources on the history of the Leas state that there was a major landslide in 1784 which occurred along the stretch of land now known as the Upper Lease. This slippage of the agricultural field owned by Lord Radnor above the cliff created a stretch of land (a few metres wide) to build a new road on, now known as the Lower Sandgate Road, to create an access between the port and Sandgate Village, connecting it to London route. This road is now a pedestrianised walkway, part of the Lower Leas Coastal Park, and passing in front of the current playground, linking the park to the Harbour at the east and Sandgate Village at the west. The Toll House, now privately owned residential building, which is approximately 100 m west of the playground and the failed cliff, was constructed by 1820.

Online photos from various sources show the drainage gulley at 'The Vinery'. Photo 1 suggest that the gulley directly discharging surface runoff to the cliff. However, note that the landslip did not occur directly under the gulley but some metres away from it. Therefore, it may not have contributed to the failure, but it carries a risk to the cliff directly below it.

Photo 1. Photographs showing the same drainage gulley at the 'Vinery' before and after cleaning in 2021 (taken from Folkestone Town Sprucer Facebook Page, posted 09/11/2021)

The paved footpath likely contributed to surface water ingress to the slope by directing some surface runoff to the cliff (Photo 2).

Photo 2. New cracks at the crest of the cliff shortly before the landslide. The pavement was repaired when the cracks first appeared (photo taken during our site visit)

2.4. Topography

A UAV (drone) survey was specified and conducted by the client. The survey data was provided to Tony Gee. Note that the resolution is limited due to the type of survey and the survey failed to identify detailed features and structure such as the existing fences at the toe of the cliff. The survey does not clearly identify the footpath behind the cliff either.

As can be seen, the cliff overlooking the adventure park is steep, with several sections approaching 60^{o}, locally 40^{o}. Note that the almost vertical exposed cliff below 'The Vinery' does not appear steep on the survey.

The head of the cliff varies in elevation within the area but is within the range of 46.0 to 47.0 m OD at the Upper Leas and approximately 43.5 m OD at The Vinery/footpath, and the toe of the cliff within the playground area is typically around 16.5 m OD (±0.5 m). Therefore, the cliff height is around 27 m at this location.

Topographic layout and the sections are included in the Appendix A.

2.5. Site walkover survey and failure mechanism

A site visit was carried out by a Tony Gee engineer on the 20th of August, 2024. The site was bounded by a fence at the playground area. The cliff was partially accessible at either side of the fence. However, the area where the landslide debris has accumulated was inaccessible due to vegetation cover. Behind this area, the cliff face was exposed after the slip (Photo 3) and comprises Folkestone Formation.

The slip is approximately 8-10 m wide at the top of the cliff, widening at the toe to around 15 m. Cliff height is possibly over 30 m. Locally, bamboo is growing at the lower slope and toe area, but it is unlikely that this growth contributed to the slip.

At top of the cliff, within a depth of approximately 2 m below pavement level of the Upper Leas footpath, the cliff is currently at around 70-80 degrees (post failure). Here, there are no sandstone blocks observable within the cliff face, suggesting the sand forming the cliff must be cemented in order to support the steep face angle. However, numerous shallow rain channels/rills are present, suggesting the soil cement is weak and that the material can be easily eroded. Above this zone, large tension crack can be seen along the pavement.

Photo 3. Photograph showing landslip, taken from toe of the slope

Below this is sandstone exhibiting various degrees of weathering. The slipped material is very loose to loose sand with occasional sandstone blocks, vegetation and tree trunks (tree stumps and branches were already cut and removed). In general, this section appears to be similar particularly where the sandstone is present although there are locally overhanging rock.

The upper few metres of the slope (6-8 m perhaps) is exposed and, at failure, the vegetation including tree trunks moved with the soil. This material with vegetation and roots, together with the steel pillar frame appeared to be retaining the soil against the face and prevented the debris from reaching the playground area.

Towards the east end of the slip, next to sandstone cliff exposure, there is landslip material consisting of fine to medium sand which formed a sand flow type structure (Photo 4).It is apparent, considering the slipped material and the adjacent slope (outside the slip area), that the slip failure is a translational slip where an approximately 1m thick weathered material from the upper and mid-slope has displaced over the lower slope. Softening of the slope due to water ingress as a result of very wet 2024 autumn-winter period is considered one of the reasons of the slope, especially at the location shown in Photo 4. It is likely that the weight of trees possibly overcame the strength of the roots which could be a contributing factor to the slip. Hence, it is likely that there is an increased level of risk at the adjacent slopes with trees.

Photo 4. Slipped sandy material, with chert cobble and sandstone bands above. The window shows exposed sandstone blocks at the east (right) of this zone

Close to the base of the slope behind railway sleeper, there is a universal column (UC) pillar frame connected laterally by the UCs/I-beams. Wooden facing/cladding (timber slats) was attached to this frame, possibly to hide it from view. This cladding was locally damaged and broken due to slip. At the location of the slip, the frame locally moved down the slope (Photo 5). At the toe, UC column appears almost vertical, suggesting shallower footing (not exposed). Spacing between UC columns is circa 1.45 m c/c, with 5^{o} inclination downward towards east. Steel work is rusty outside otherwise in good condition.

Photo 5. UC column fence with attached timber cladding moved due to slop. Small window shows sheared UC column pillar frame

At the toe of the cliff there is a timber retaining wall (approximately 0.5 m high) hiding the toe of the slope (Photo 6). A concrete footpath is between the retaining wall and the playground. It looked stable and without displacements.

Photo 6. Timber beams form the boundary of the cliff

2.6. Local geology

2.6.1. Superficial and solid geology

The relevant geology map published by the British Geological Survey is sheet number "305 & 306", 'Folkestone & Dover', 1:50,000 scale, solid and drift, published in 1990. The excerpt in Figure 1 is taken from this map.

The Folkestone Formation is present and can be seen exposed at the cliff. The Sandgate Formation underlies the Folkestone Formation which itself overlies the Hythe Formation.

At the site location, landslip (mass movement) deposits are covering the toe. At either side of these mass movement deposits; the map shows Storm Beach Deposits which is considered to be at the beach level. The map indicates that at the location the Storm Beach Deposits, if present (and quite possibly not), they may be overlain by the landslip material. The large scale (1:10,560) geological map extract in Figure 2 indicates that the landslip material was originated from Folkestone and Sandgate formations. Hence, it should consist of sand, sandstone and chert, as described in Figure 2.

The general information for these two geological Formations is provided by the BGS online Lexicon, as reproduced below. They are all marine shallow-water deposits of Early Cretaceous age. Folkestone Formation is described as "*in Sussex, Kent and Surrey the formation comprises medium- and coarse-grained, well-sorted cross-bedded sands and weakly cemented sandstones ….* "

The Sandgate Formation is described in the Lexicon as "*fine sands, silts and silty clays, commonly glauconitic; some sands limonitic or calcareous; some soft sandstones …The top is* *taken at the top of the dark clays of the Marehill Clay Member (where it is present); elsewhere at the upward change from argillaceous units into well-sorted, medium to coarse sands of the overlying Folkestone Formation. The boundary is generally sharp, but rarely exposed. … the base of heterogeneous sediments of the Sandgate Formation, overlying the uniform Hythe Formation succession.*" Therefore, the top of Sandgate Formation at the site could be sandy but becoming clayey soon.

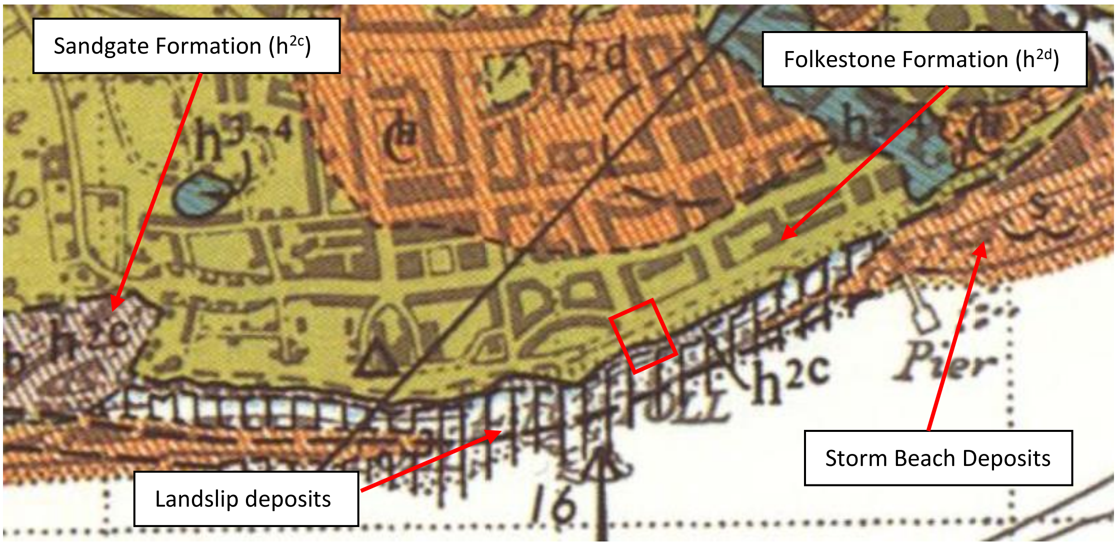

Figure 1. Local geology, solid and drift, from BGS Sheet No. 350 & 360. C08/084-CSL British Geological Survey ©NERC. All rights reserved.

The large scale, 1:10,560 BGS map is TR23NW from 1967 which shows that the area where the Leas Park playground is located was formed of slipped Folkestone Formation and Sandgate Formations (Figure 2). The landslip occurred in 1784 upon which the park was founded. BGS GeoIndex Onshore online map indicates that the landslip material consists of sand, silt and clay.

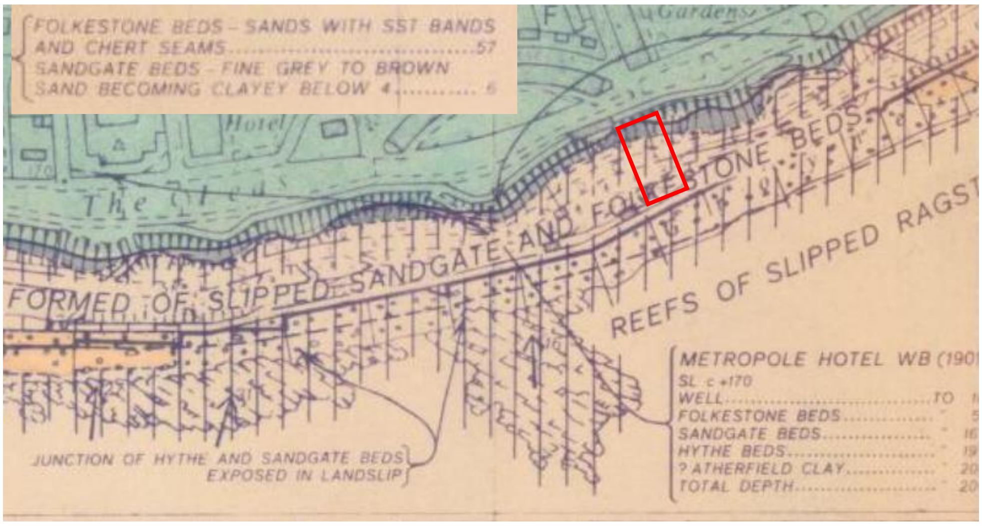

Figure 2. BGS 1:10,560 scale map showing the area (red rectangular). C08/084-CSL British Geological Survey ©NERC. All rights reserved.

The junction between the Folkestone and Sandgate Formations is considered to be covered by the historical landslip material.

Figure 2 shows the junction of Sandgate and Hythe Formation approximately at the toe of the existing beach (now backfilled with shingles for coastal protection). Reefs of slipped ragstone was shown at the beach level, which is exposed during low tide. Ragstone (sandy limestones) occurs in the Hythe Formation in Kent.

2.6.2. Historical borehole records

Table 1 to Table 4 indicates the stratigraphy observed in the historical BGS boreholes/wells and the borehole logs from the available local ground investigation data.

Table 1. Stratigraphy at historical BGS borehole (well) TR23NW119 at Hotel Metropolitan (1896). The approximate distance from the Leas Park site is 550 m.

Stratum	Top of stratum (m OD)	Bottom of stratum (m OD)	Thickness (m)	Description
Folkestone Formation	50.3	34.8	15.5	Hard sand, rock and sand intermittent
Sandgate Formation	34.8	-1.20	36.0	Approximately 8.8m thick sand overlying 2.4 m sand and clay overlying sand
Hythe Formation	-1.20	-8.22	7.02	Clay

Table 2. Stratigraphy at BGS borehole BH09W at Folkestone Harbour, drilled in 2016. The approximate distance from the site is 550 m.

Stratum	Top of stratum (m OD)	Bottom of stratum (m OD)	Thickness (m)	Description
Made Ground	7.0	5.0	2.0	None given in Geo Report for Folkestone Harbour
Beach Deposits	5.0	0.15	4.85	GRAVEL for the top 2m of stratum, becoming SANDY with depth
Landslip Material	0.15	-4.85	5.0	CLAY for top 1m of stratum, becoming SILTY with depth
Hythe Formation	-4.85	-14.0 (terminated)	>9.15	CLAY

Table 3. Stratigraphy at BGS borehole TR23NW163, drilled in 1968. The approximate distance from the site is 680 m.

Stratum	Top of stratum (m OD)	Bottom of stratum (m OD)	Thickness (m)	Description
Topsoil	40.2	39.8	0.4	Sandy TOPSOIL
Made Ground	39.8	39.0	0.8	Firm grey brown silty sandy CLAY
Folkestone Formation	39.0	30.2 (terminated)	>8.8	Silty SAND, with bands of sandstone and clayey silty SAND

Table 4. Stratigraphy at BGS Borehole TR23NW54/A-B, drilled in 1879. The approximate distance from the site is 1500 m northeast.

Stratum	Top of stratum (m OD)	Bottom of stratum (m OD)	Thickness (m)	Description
Made Ground	8.5	5.2	3.3	-
Folkestone Formation	5.2	3.8	1.4	Sand
Sandgate Formation	3.8	-29.0	32.8	Sand and sandy CLAY, becoming coarse sandstone
Hythe Formation	-29.0	-37.5	8.5	Limestone, sandy clay, rock, clayey sand, limestone, clayey sand and stone bans succession

2.6.3. Stratigraphy

A stratigraphic cross section of the cliff can be found below in Figure 3. Due to difficulty of estimating the dip directions of the top of formations which can change a few metres vertically, it is not possible to clearly identify the Folkestone-Sandgate formations junctions.

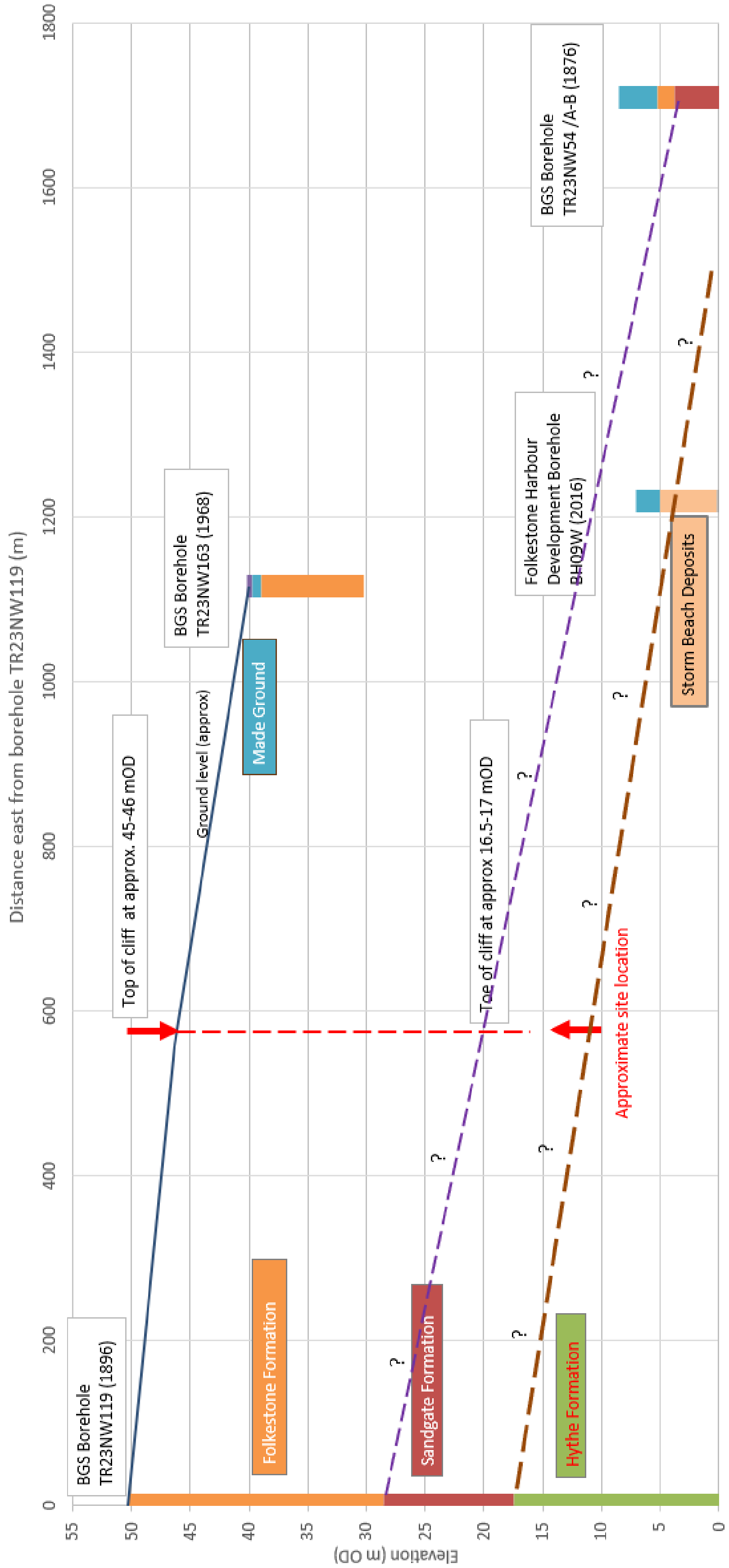

Figure 3. Stratigraphic Cross Section of the Leas Cliff

2.7. Back-analysis of cliff

A back-analysis was carried out to simulate translational slip similar to the recent landslide and to derive preliminary geotechnical parameters.

2.7.1. Preliminary geotechnical parameters from literature

Richards and Barton (1999) carried out small shear box tests on undisturbed weakly cemented (dry) samples of Folkestone Formation taken from Folkestone Copt Point (intact samples obtained by block sampling from quarry faces). The samples comprised of approximately 15% coarse sand, 60% medium sand, 10% fine sand (remaining 15% was fine content). Two tests were carried out where the loading was normal and parallel to the stratification to evaluate anisotropy in strength. The samples underwent dilation during shearing. The test results gave peak angle of shearing resistance and effective cohesion of 41.4° and 16.8 kPa, and 52° and 39 kPa for loading parallel and normal to the stratification, respectively. They noted that the peak shear strength was strongly influenced by the interlocking rather than porosity and total cement content. The development of interlocking (thus fabric cohesion) was related to grain size. However, when cementation disappears or significantly reduced due to weathering, Folkestone Formation can behave as medium dense to dense sand where the angle of shearing resistance can be 35-40°.

2.7.2. Back-analysis of shallow slip

The back-analysis of the slope failure was carried out using GeoStudio Slope/W software.

The following assumptions were used in modelling:

- Back-analysis simulated shallow landslide with 0.5-1.0 m thick surface material slipping. Therefore a weathered zone with a similar thickness was modelled at the face of the slope overlying the more competent cliff material.
- The stratigraphy consisted of Folkestone Formation only.
- The geotechnical parameters were based on the literature values but modified in order to enable a shallow slip.
- Porewater pressure conditions being simulated by, pore water pressure ratio, R_u, which is an approximate way of describing porewater pressures within the slope when there is no actual field piezometric data. The ratio R_u is a dimensionless coefficient defined as a ratio of the pore pressure and overburden stress at a certain point within a slope.
- No surcharge (such as weight of vegetation) was modelled on the slope to eliminate the complications in modelling.
- Shallow slip failure (factor of safety slightly less than 1.0) was simulated by iteratively adjusting strength parameters of the weathered cliff zone and R_u.

Slope/W model with shallow slip (around 1.2 m thick) with a factor of safety less than 1.0 can be seen within Figure 4.

Note that that the section used in the analysis is from drone topographical survey after the landslide. Poor resolution prevents to capture the detailed slope features. It also fails to correctly identify the location of the slope which should start just below the top of the cliff (shown with dashed circle in Figure 4). However, the slip circle identifies the areas below this section. Based on the site observations, this is also the area where the slip also occurred.

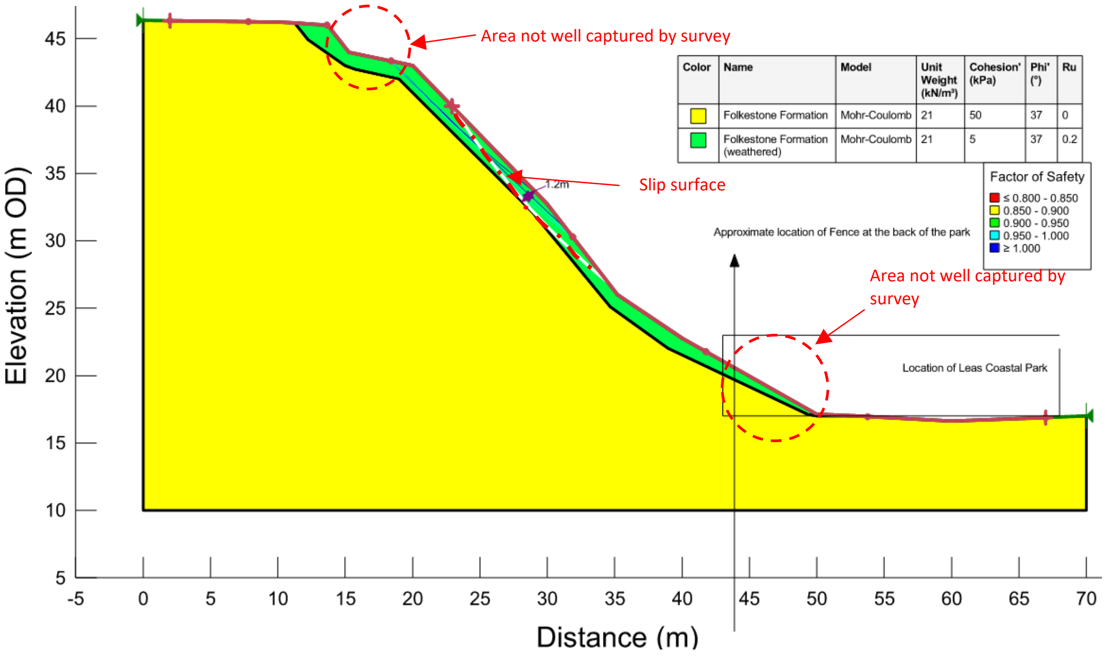

Figure 4. Input model for back-analysis.

Based on the back-analysis results, the preliminary soil parameters are shown in Table 5.

Table 5. Geotechnical parameters from back-analysis.

Strata	Bulk unit weight (kN/m^3)	Drained cohesion (kN/m^2)	Angle of shearing resistance, (°)	Porewater pressure ratio R_u
Folkestone Formation (weathered)	20	5	37	0.2
Folkestone Formation (underlying)	21	50	37	0

The parameters above can form the basis of the development of preferred option.

3. Landslide risk consideration

In this section, background vulnerability and risk outcome considerations were presented to develop a rationale for the mitigation measures.

3.1. Landslide trigger reasons

The geology consisting of poorly cemented Folkestone Formation sands and weakly cemented sandstone, and, to a lesser degree, Sandgate Formation is known to be susceptible to landslides, especially the former forms steep cliffs.

The formation along the Folkestone coast is known to experience landslides. However, climate change driven weather cycles suggest that landslides at the area are significantly affected by wet-dry cycles and high porewater pressures as a result of intense or prolonged rainfall. Lack of vegetation maintenance, coastal weathering and site-specific elements such as lack of drainage or drainage/surface-run off discharging to the slope can be other reasons.

3.2. Vulnerability and risk at the site

The scope of this report does not include deterministic or probabilistic landslide risk assessment. However, in order to provide options for the purpose of mitigation measures, the vulnerability assessment and risk evaluation need to be discussed.

Considering the location of the cliff adjacent to the playground, children can be considered to have higher vulnerability to fast-moving landslide / debris flow because they cannot escape if the landslide happens during play time. Children may not be able to react quickly and sufficiently to endangering processes in comparison to the adults. At the same time, temporal probability for a person being present at the site during the landslide is also variable. The playground is occupied mostly during the day so potential consequence of a landslide may be less severe. . Public perception of landslide risk and its consequences at this playground site will be significant comparing to, for instance, a rural cliff.

3.3. Risk outcome

The risks to public that use the area in relation to possible landslide at the site can be reviewed under three groups:

i. Risks are tolerable or generally acceptable. Hence, no mitigation options could be considered.

ii. Risks are tolerable but may not be acceptable. Thus, unacceptability is subject to the marginal cost of further risk reduction and perception of the risk by authorities and the public.

iii. Risk are intolerable and unacceptable. Hence, risk mitigation options are required.

As discussed above, given the fact that this landslide occurred at a cliff in front of the playground, and presuming that the playground will not be relocated due to lack of available space within the Lower Leas Park, it is considered that landslide risk at the site is intolerable and unacceptable. Therefore, the risk mitigation is necessary.

3.4. Risk mitigation strategies

Two strategies which are considered applicable for this site are summarised below:

1. **Controlling the movement of landslide debris** – This strategy consists of controlling the landslide soil/rock mass without attempting to stabilise the slope. They are based on the principle of reducing/eliminating the likelihood of landslide reaching the area at risk. ‘Containment’ systems e.g. catch fences, or netting are typical measures in this strategy.

   These systems aim to absorb, hence reduce the energy of a fast-moving landslide mass and prevent it to reach the asset or people. As a passive containment system, loose mesh, or drape netting will allow landslide material to move down the slope while keeping it from becoming air-launched, thus reducing its kinetic energy. Active netting consists of a tight mesh anchored to the slope by rock bolts to keep the landslide debris close to the face. On the other hand, a catch fence positioned and sized such that it can absorb the energy of a falling landslip mass and contain it within the slope preventing debris flow or loose rock reaching to the area at risk.

   Containment systems are usually considered as cheaper alternatives to full scale cliff stabilisation.

2. **Reducing/eliminating likelihood of landslides** – This strategy typically involves cliff stabilisation measures (e.g. regrading to a shallow angle, slope reinforcement using soil nails/rock bolts, retaining wall systems together with backfilling), drainage, rock scaling or a combination of various measures. Because the aim is to strengthen the slope, these measures are often more expansive.

Note that some other strategies which includes avoidance as relocation of the playground to a less hazardous area or early warning systems are considered not applicable unless the FHDC decides otherwise. It is assumed that the playground cannot be relocated due to lack of available space within the Lower Leas Park. In addition, early warning system is considered not applicable for this relatively small-scale cliff in an urban setting.

4. Mitigation measures

With consideration of the project driver and success criteria and available the data review presented herein; the options were detailed below.

4.1. Aspects of the cliff influencing decision on mitigation options

Based on our observations during the site visit and the topographic survey which approximates the existing cliff slope angles, the mitigation strategy and options will need to consider the following zone of interests and risks, as presented in Table 6.

Table 6. Zones of interest and associated risks

Zone of interest A: 1. Existing footpath (Maderia Walk) at and The Vinery structure. 2. Exposed cliff with steep slope angles at top 2-3m. 3. Similar slope angles at each side of the failure where the cliff is still stable. **Risks:** This very steep section of the cliff has a high risk of failure.	

Zone of interest B: 4. Blocky sandstone visible below this area. 5. Overhanging rock. 6. Intermittent weathered zones containing sand **Risks:** Rock fall	
Zone of interest C: 7. Landslide debris 8. Possible Folkestone / Sandgate Formation boundary **Risks:** Condition of slope and extent of slip unknown. Removal of landslip material will be exposed steeper and de-vegetated slope.	

Zone of interest D: 9. Existing failed steel pillar frame and timber fence **Risks:** Presence of fence with unknown founding depth retaining landslip material which may result in local instability during debris removal works	
Zone of interest E: 10. Closeness of the cliff to the playground. 11. Some playground equipment located on the cliff near the toe **Risks:** Likely metastable steep cliff (particularly the very steep zone at the top) which already experienced landslide. Playground structure founded on the slope which is affected by mitigation works	

4.2. Key points in mitigation measures

As shown in Table 6, the options for mitigation must consider the following:

- The steep cliff from approximately middle of the cliff to the crest comprising poorly cemented sandstone (Zone of Interest A in Table 6) is currently exposed to weather elements. There is some erosion already observed here where rainfall seems to be left shallow rain channels the rainwater flushed the soil. The failure of this part will result in collapse of the pavement above as suggested in Photo 2. Therefore, the area shown in Zone A will needs to be reinforced. Due to site constraints and the steep high cliff the most feasible strengthening option is to use high-strength steel mesh and soil nails together with steel facing plates to prevent wedge failure.
- At Zone B, blocky sandstone is visible with locally overhanging rock and intermittent weathered zones. A 'containment' system, without any scaling the rock, can be adapted extended from Zone B to Zone C .
- At Zone C, same containment system can be adapted depending on the nature of the slope after the landslip material, the existing steel pillar structure (Zone D) and timber fence will be removed without disturbing the underlying slope.
- At Zone E, beyond the toe of the cliff the area is flat and occupied by the playground. A short timber retaining wall is situated at the toe and in front there is a concrete footpath. It is considered that the timber retaining wall forms the site boundary and the limit of slope mitigation measures. Therefore, the engineering solution must remain as "thin" as possible so as not to unnecessarily impede into the playground. One key aspect of this boundary is that an additional retaining system will need to be required here to provide additional barrier to prevent landslip material under the containment system reaching the playground and allow clearing out the material collected at the base of the slope.
- It is also considered that any measures will need to be constructable with the minimum of temporary working space and disturbance (noise, vibration and dust).

4.3. Option 1 - Soil nailing and passive (draped) netting with king-post retaining wall

Overview

Option 1 consists of the following measures. The sketch presenting the elements and providing more technical details is in Appendix B:

- Soil nailed and netted steep cliff below the crest (Zone A shown in Table 6) to be reinforced this section of the cliff. The combined mesh (such as Geobrugg Greenax) here includes erosion control mat.
- Draped netting below the soil nailed section, Zone B and Zone C in Table 6, to reduce the energy of fast-moving landslide. Open end draped netting to allow to collect and remove landslip materials or rock in case of a landslide. The netting will require sufficient tensile and puncture strength to control larger debris such as sandstone cobbles or boulders. Netting will have smaller openings so that it can also retain finer particles like sand.
- Removal of the existing steel pillar wall (Zone D in Table 6)
- Construction of a king-post wall to separate the cliff from the playground preventing entrance to the cliff and to provide a second level of defence and area behind for maintenance, if landslip occurs and the landslip material is directed to the back of this

wall via draped netting. Such a wall should be a minimum of 2 m high. The king-post wall will consist of precast concrete planks which could be painted or decorated if needed. Alternatively, a timber fence in front could be built to hide concrete panels and the columns from the site. King post wall foundations will consist of similar steel profile which the wall posts will be built from. The depth of foundation embedment will be confirmed in detailed design once the option has been formally agreed.

Advantages

Option 1 includes following advantages:

- Soil nailing and draped netting are a well-known technique that can be quickly and easily constructed by a specialist contractor.
- Draped netting is cheaper to build due to low material and installation cost as an alternative to an active netting containment system which requires a dense soil nails/rock dowel arrangement with facing plates.
- With lowered energy of the sliding mass slowed down by the netting, a very stiff retaining wall at the toe is not required.
- King post wall is a lighter structure as it is considered that high energy debris flow or impact is already reduced by drape netting.
- The option offers a robust safe solution to ensure safety of children using the playground and safety of the playground equipment.

Disadvantages

- Closure of the playground, The Vinery and the section of the Maderia Walk at this location during works.
- Maintenance is required to remove landslip debris if landslide occurs.

Construction

- Soil nailing: drilling rig suspended from the crest, with the construction team accessing the cliff using rope access method.
- Passive netting is similar to soil nailing for the installation of the top row of rock bolts and via access to the toe of the cliff from the playground.
- Soil nailing and draped netting can be constructed using the same equipment and plant.
- King-post wall: Installation of the post socket via drilling and concreting from the playground area.

4.4. Option 2a - Soil nailing and king-post retaining wall

Overview

Option 2a consists of the similar elements as Option 1 (soil nailing at top of the cliff) except the drape netting. The sketch presenting the elements and providing more details is in Appendix B.

The kingpost wall will need to be constructed to withstand full kinematic energy from possible sliding mass in case of a landslide because the option excludes draped netting that would slow down the debris.

Therefore, it is likely that a new wall that is sufficiently to be sized to contain the envisaged failures will almost certainly need to be larger and stronger than the one suggested in Option 1. The king post wall will be designed to withstand against a very large force to ensure that it does not fail (thus can be function after the landslide) but may experience some deformation. A new wall, therefore, is likely to require posts that both need to be embedded deeper into the ground and formed from heavier section, and the panels that can better resist the dynamic impact forces. The foundation of this system will require to penetrate through the historical landslip material with unknown thickness (refer to section 2.6) into underlying Sangate Formation bedrock.

Erosion control blanket will be installed on the cliff.

Advantages

Option 2a includes similar advantages except those related to draped netting element.

Disadvantages

In addition to the disadvantages stated for Option 1, Option 2a includes additional disadvantages:

- Stiffer king-post wall elements
- Deeper and larger foundations into bedrock
- Regular maintenance to prevent tree growth on the cliff.

Construction

- Removal of landslip material and damaged/displaced steel pillar and timber wall via access from the playground.
- Soil nailing: drilling rig suspended from the crest, with the construction team accessing the cliff using rope access methods, again from the footpath at the crest.
- King-post wall: Installation of the wall socket via drilling and concreting from the playground area.
- Wall foundation will be through the historical landslip material into underlying Sandgate Formation (TBC via ground investigation).
- Installation of erosion blanket.

4.5. Option 2b - Soil nailing and steel sheet pile wall

Overview

Option 2b is an alternative to Option 2a where a steel sheet pile wall replaces the king-post wall. The sketch presenting the elements and providing more technical details is in Appendix B.

The sheet pile wall will need to be constructed to withstand full kinematic energy from sliding mass in case of a landslide. Therefore, a new wall will be sufficiently sized to contain the envisaged failures. Similar to Option 2a, the wall will be designed to withstand against a very large force to ensure that it does not fail and can perform after landslide but may experience some displacement. A new wall, therefore, is likely to require significant embedded deeper into the ground and formed from heavier steel sections to resist the dynamic impact forces.

Erosion control blanket will be installed on the cliff.

Advantages

Option 2b includes similar advantages as Option 2a.

Disadvantages

Option 2b includes below disadvantages:

- Large steel sheet pile profile.
- Embedment into bedrock requiring longer sheets.
- Difficulty to transport longer sheet piles to the site.
- Difficulty to handle and install long and large steel pile profiles requiring bigger plants (piling rig and a crane) and larger space for access and installation.
- Pile driving disturbing public and hard driving into the bedrock causing vibrations which may lead to further slips at and around the area.
- Piling platform requirement
- Cladding may require hiding steel piles from view.
- Regular maintenance to prevent tree growth on the slope.

Construction

- Removal of landslip material and damaged/displaced steel pillar and timber wall via access from the playground.
- Soil nailing: drilling rig suspended from the crest, with the construction team accessing the cliff using rope access methods, again from the footpath at the crest.
- Steel sheet pile wall: Pile driving requiring a piling rig and a crane to lift the piles. Installation from the playground area.
- Wall foundation will be through the historical landslip material into underlying Sandgate Formation (TBC via ground investigation).
- Installation of erosion blanket.

4.6. Option 3 - Soil nailing and debris flow barrier (catch fence)

Overview

Option 3 replaces the king-post or steel sheet pile wall with a debris flow barrier type structure. Debris flow barrier is a flexible ring net barriers made of high-tensile steel wire and considered as an alternative to a king post wall at the toe of the cliff. The system is developed to contain wet debris including vegetation or shallow landslides which may small size rocks. The fence is constructed using anchor posts and ground anchors as foundation. The barrier can incorporate additional energy absorption acting as a 'containment' mesh through the use of different diameters of rings. At impact, the reduced loads are then transferred to the posts acting as 'brake' elements.

In order to prevent small debris (sand and gravel) to reach the playground area and to hide the wall (so that children do not climb on it) there is a need to install a 'light' wall in front, which could be a timber post wall. This wall will need to be sufficiently distance from the debris flow barrier to allow maintenance to remove landslip material if needed.

Erosion control blanket can also be installed on the cliff.

The sketch presenting the elements and providing more details is in Appendix B.

Advantages

The advantages provided by the debris barrier.

- Ideal to reduce/stop dynamic loads such as debris flow.
- As a lightweight system, it is simple and quick to install, leading to simple construction with smaller operating plants.
- They are customised to suit the dimensions of the cliff, the anticipated debris material and its expected volume.
- The barrier height can be adjusted according to project needs.
- The location of the barrier can be further back from the toe of the cliff, allowing to deflect (so that it can absorb and reduce the kinetic energy of a fast-moving debris) by leaving sufficient space for maintenance.

Disadvantages

Option 3 includes the following disadvantages:

- To prevent small amount of wet debris or particles passing through the net, an additional light wall (e.g. timber post wall) is required.
- It may be less assuring for public if there is no 'solid' wall but a steel mesh separating the cliff from the playground.

Construction

- Debris flow barrier: Post installation followed by installing the steel ring net and lateral ropes which are anchored to the ground at the works end.
- Construction can be carried out using a rock bolt/soil nailing rig system.
- Installation of erosion blanket.

4.7. Options which are not considered

Gabion baskets / Legato® block wall

This option consisting of the placement of a gravity type retaining wall using gabion baskets or Legato® interlocking concrete blocks in front of the cliff. Building such wall will require a larger area at the base to provide sufficiently high wall, similar to the wall shown in Photo 7. A mass concrete foundation to place the units will be required to prevent uneven settlement along the wall. Some scaling of the cliff may be required to permit the placement on wall. The wall will be large in size to ensure that it does not fail if another landslide occurs at this location. There will be some space needed behind the top wall elements to collect any future landslip material. This option requires transport of large quantity of stones to fill the gabion baskets.

This option will still require reinforcement of the top of the cliff using soil nails.

Photo 7. Gabion wall in front of a cliff (image taken from Maccaferri's website)

Any other solutions relying on a small-scale retaining wall

Options comprising small-scale retaining walls (e.g. king-post walls or other steel structures) that are similar to the existing steel pillar frame are not considered. This is because such measures do not provide sufficient protection for the playground.

4.8. Carbon footprint comment

No detail carbon calculations were carried because of high-level options development without sizing the elements required for mitigation. However, it is our view that Option 1 (soil nailing with draped netting) may provide the lowest carbon footprint together with Option 3 (soil nailing and debris flow netting). Option 2 relies on much stiffer and larger wall elements (king-post wall in Option 2a or a sheet pile wall in Option 2b) which requires more steel and/concrete with higher carbon footprint.

5. Required surveys for preferred option development

The existing drone survey is insufficient to develop the preferred option. Therefore, a land based topographical survey.

A ground investigation consisting of a single borehole to reach the underlying bedrock is required for options comprising an embedded wall (Options 2a and 2b). The location of the borehole can be at and around the toe of the cliff which will be confirmed when the project progresses. It is considered that this borehole will advance with cable percussion through the superficial deposits followed by rotary drilling through the bedrock. The depth of the borehole may be between 10 to 15 m.

Both surveys will be required before the detailed design of the preferred option. If instructed, Tony Gee can provide specifications for both surveys.

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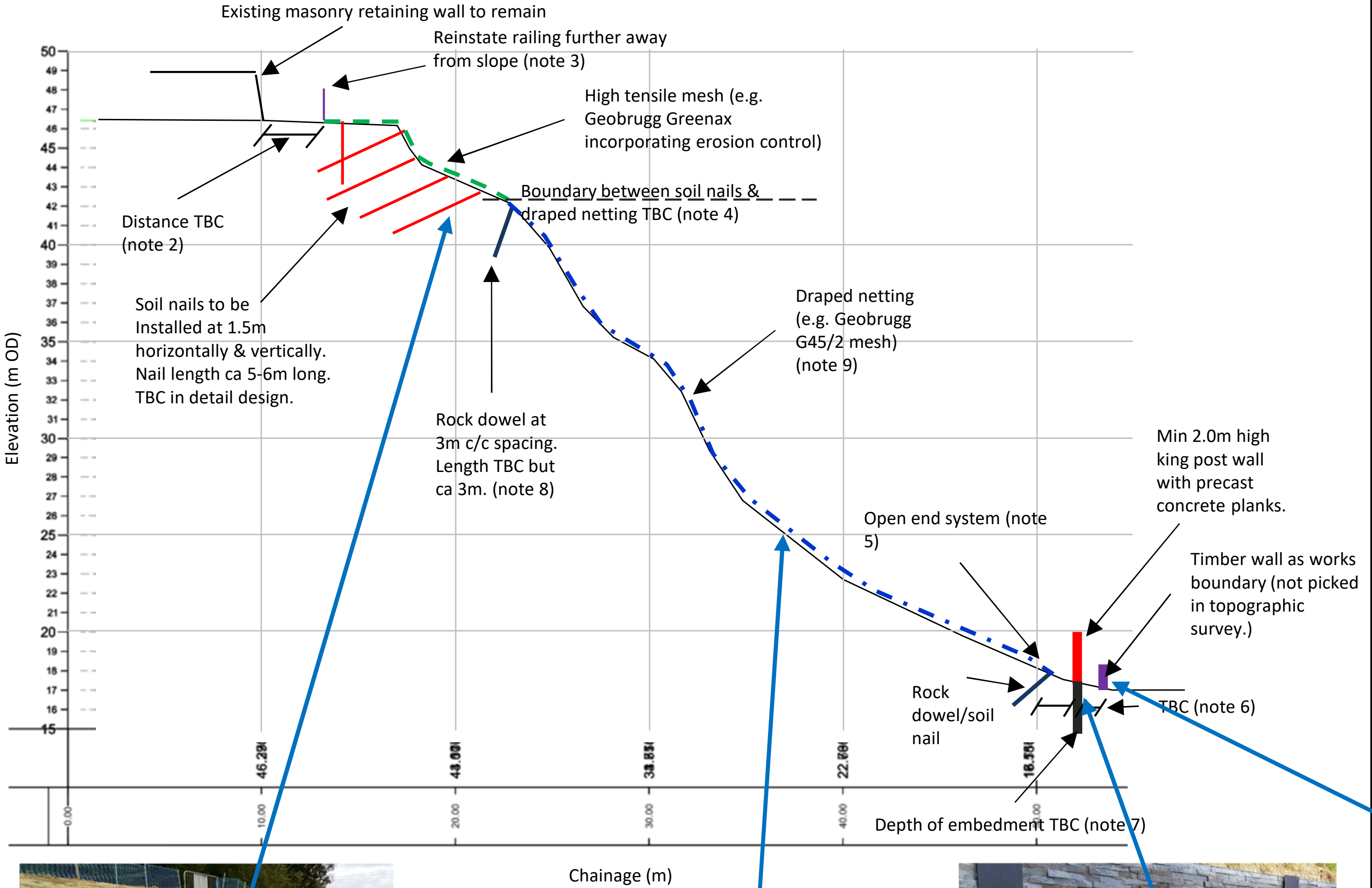
Appendix A – Topographic layout and sections


Posts
Shelter
West Cliff
Lower Leas Coastal Pa
19.1m
PCs

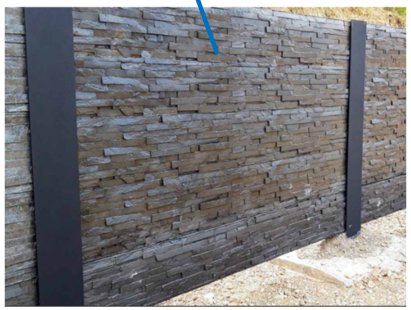

Level
Station=1+53.77
Source Elevation=60.498
Station=1+72.48
Source Elevation=55.988
EXISTING LEVELS
CHAINAGE
0.00
10.00
20.00
30.00
40.00
50.00
60.00
70.00
75.11
Alignment - A-A
Alignment - A1-A1
Alignment - B-B
Alignment - C-C

Appendix B – Options sketches




Soil nailing with steel mesh and erosion control blanket
(Image taken from a Tony Gee project)


Draped (passive) netting
(Image taken from a Tony Gee project)

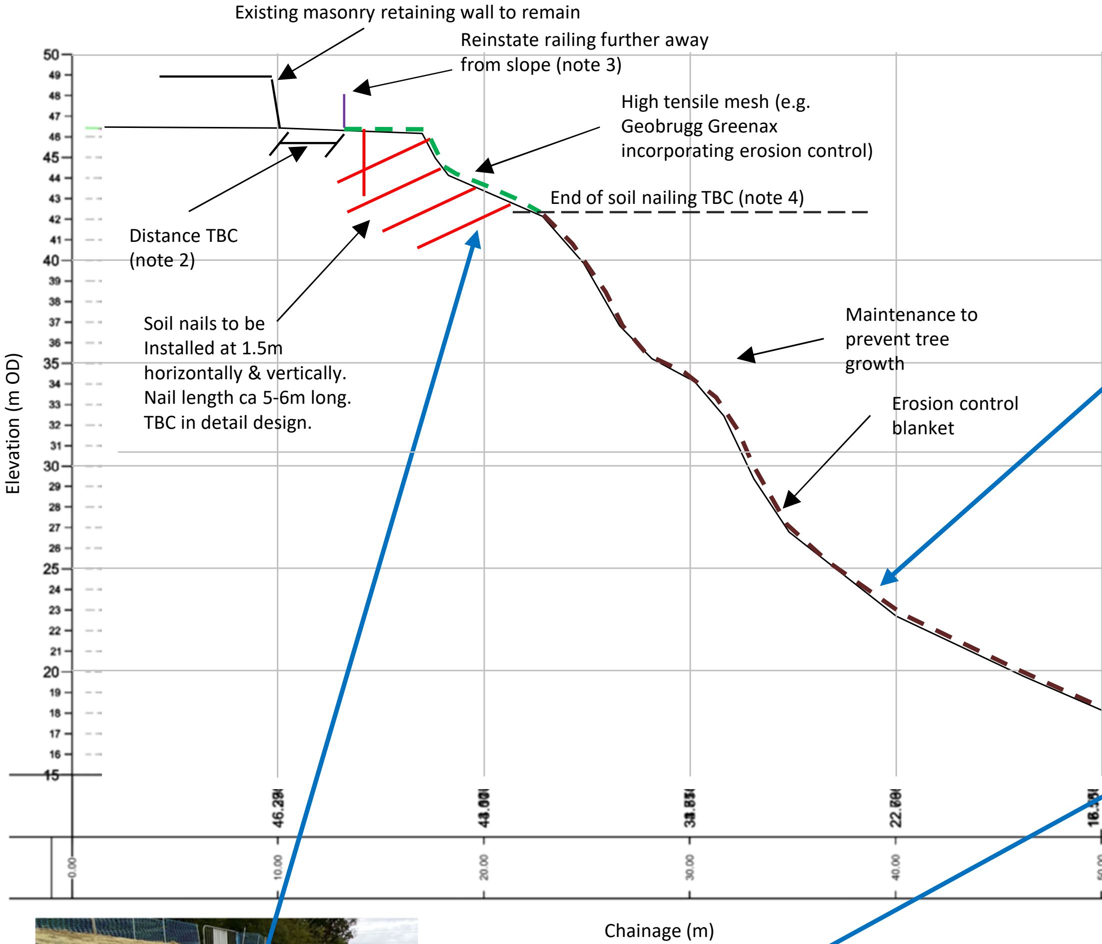

King post wall with a stone wall finish
(Image from retainingwallsolutions.co.uk)

Notes:

1. All dimensions are in millimetres unless otherwise specified.
2. The width of the footpath (Maderia Walk) may be reduced due to the slip and the top row of soil nails. Soil nails here can be buried within the new surfacing.
3. Railings to be reinstated away from the edge of the cliff due to cracks as a result of the landslide..
4. The boundary where the soil nailing ends and drape netting starts will be decided following land-based topographical survey. The as-built location will be decided by contractor based on the condition of the cliff during works.
5. Open end draped netting system allows opening the net to collect debris.
6. Distances will be confirmed once the option is taken forward.
7. At this location, the founding ground is assumed to be landslip material because of historical landslips. However, due to possible softer nature of landslip material the wall will require posts to be embedded deeper into the ground.
8. Netting is supported by a bearing cable system anchored by a rock dowel.
9. The netting is draped across the slope to maximise slope contact.

Cliff at the Leas Park Playground, Folkestone	Option 1 – Soil nailing and passive (draped) netting with king-post retaining wall
Folkestone Hythe District Council	

Tony Gee	Date	Project No.	Drawing No.
	15/10/2024	A124037	A124037-TG-SKE-CV-00001 Rev P01



Erosion control blanket
(Image belongs to Greenfix)

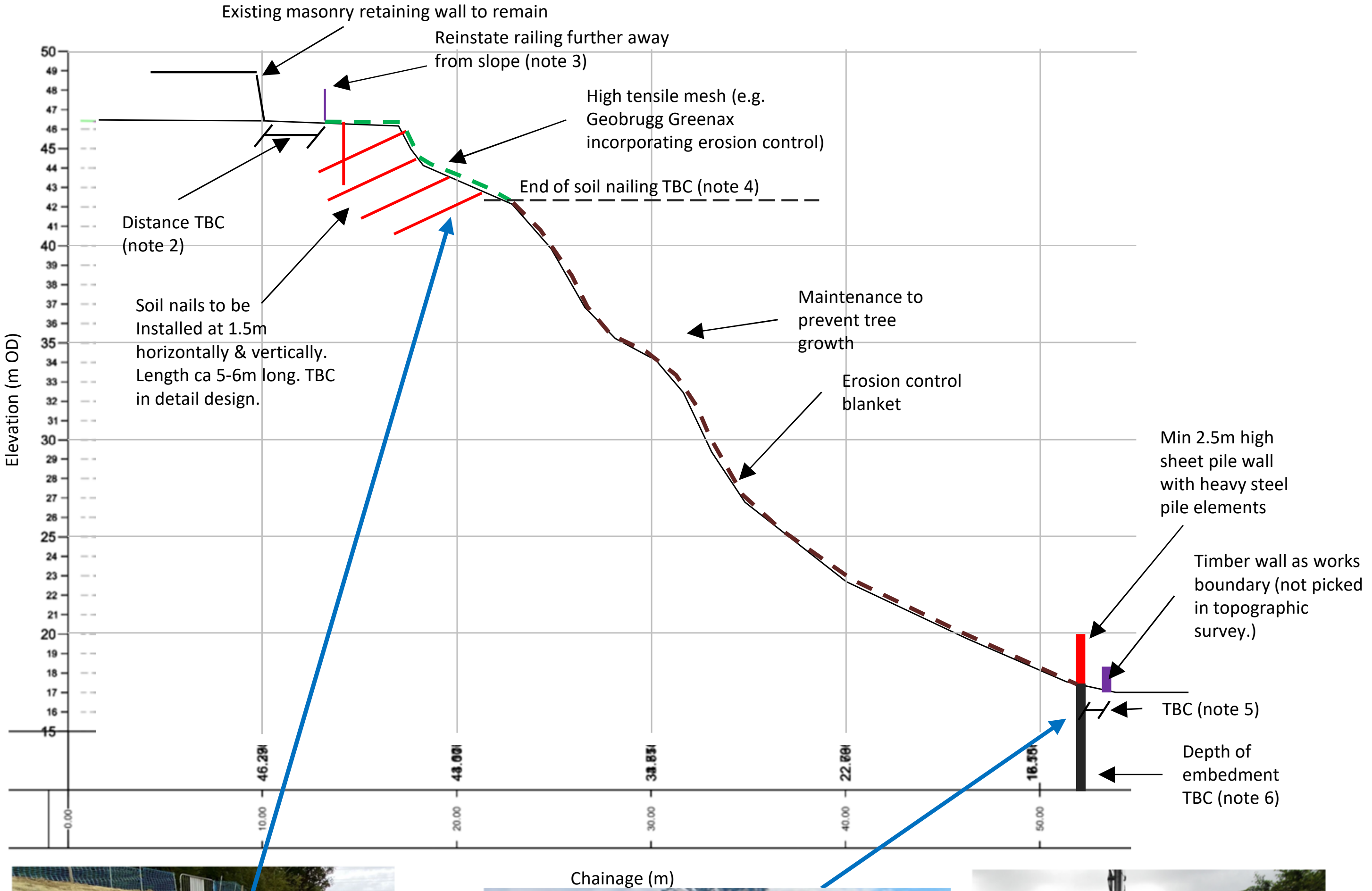
Soil nailing with steel mesh and erosion control blanket
(Image taken from a Tony Gee project)

Large size king-post wall
(Image belongs to Phi Group – A Keller Company)

Notes:

1. All dimensions are in millimetres unless otherwise specified.
2. The width of the footpath (Maderia Walk) may be reduced due to the slip and the top row of soil nails. Soil nails here can be buried within the new surfacing.
3. Railings may need to be reinstated away from the edge of the cliff due to cracks as a result of the landslide.
4. The boundary where the soil nailing following land topographical survey. Final location will be decided by contractor based on the condition of the cliff during works.
5. Distance between the king-post wall and the boundary timber wall will be confirmed once the option is taken forward.
6. At this location, the founding ground is assumed to be landslip material because of historical landslips. Depth of foundation to be confirmed once a ground investigation is carried out. However, due to possible softer nature of landslip material at this location and larger kinematic energy of landslip material, the wall will be bigger and will require posts to be embedded deeper into the bedrock.

Cliff at the Leas Park Playground, Folkestone	Option 2a – Soil nailing and heavy king-post retaining wall		
Folkestone Hythe District Council			
Tony Gee	Date 15/10/2024	Project No. A124037	Drawing No. A124037-TG-SKE-CV-00002 Rev P01



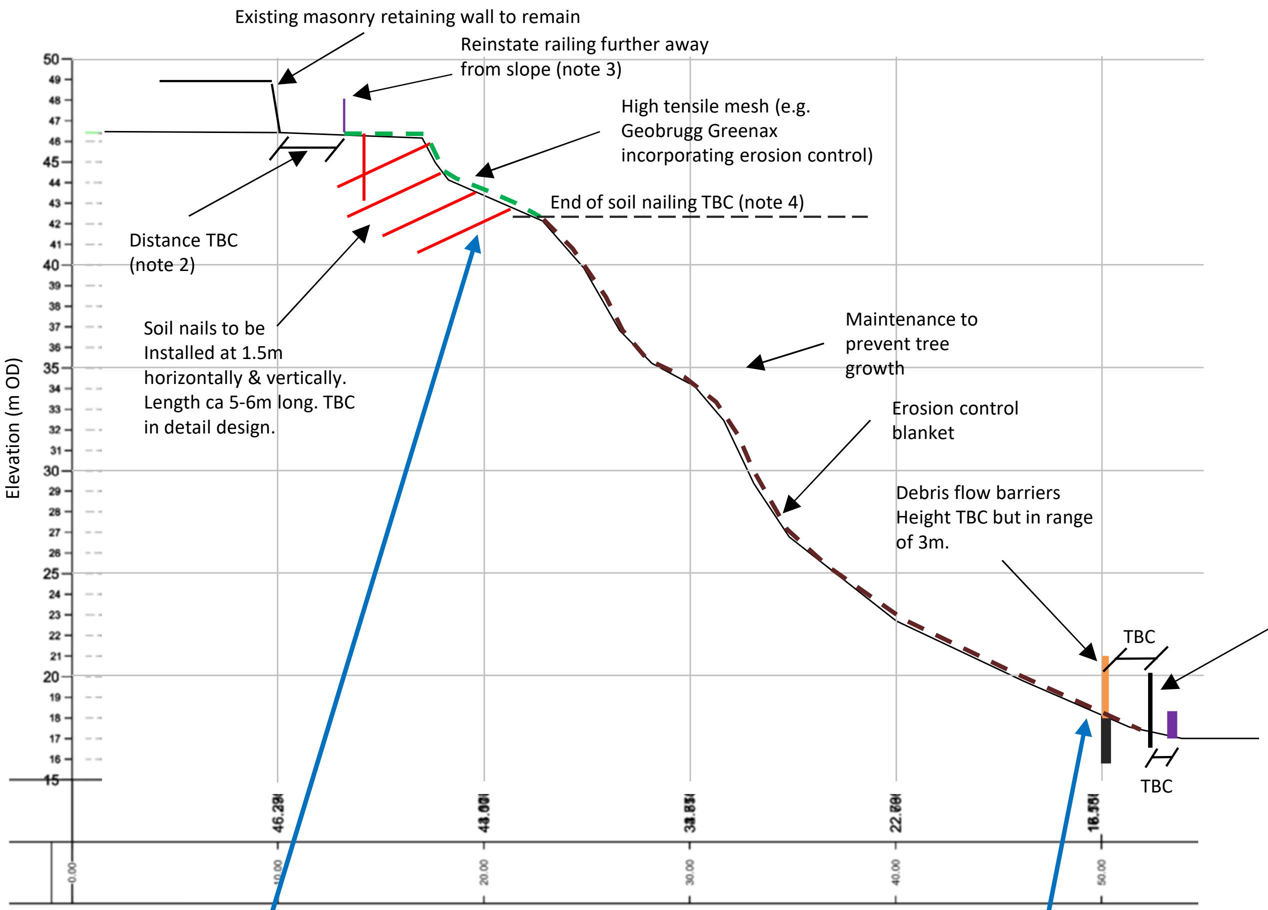
Soil nailing with steel mesh & erosion control blanket
(Image taken from a Tony Gee project)

Sheet pile wall
(Image taken from www.rjspiling.co.uk)

Notes:

1. All dimensions are in millimetres unless otherwise specified.
2. The width of the footpath (Maderia Walk) may be reduced due to the slip and the top row of soil nails. Soil nails here can be buried within the surfacing.
3. Railings may need to be reinstated away from the edge of the cliff due to cracks as a result of the landslide.
4. The boundary where the soil nailing following land topographical survey. The as-built location will be decided by contractor based on the condition of the cliff during works.
5. Distance between steel sheet pile wall and the boundary timber wall will be confirmed once the option is taken forward.
6. At this location, the founding ground is assumed to be landslip material because of historical landslips. Depth of foundation to be confirmed once a ground investigation is carried out. However, due to possible softer nature of landslip material at this location and larger kinematic energy of landslip material, the wall will be bigger and will require posts to be embedded deeper into the bedrock.

Cliff at the Leas Park Playground, Folkestone	Option 2b – Soil nailing and steel sheet pile wall		
Folkestone Hythe District Council			
Tony Gee	Date 15/10/2024	Project No. A124037	Drawing No. A124037-TG-SKE-CV-00003 Rev P01



Soil nailing with steel mesh and erosion control blanket

(Image taken from a Tony Gee project)

Debris flow barrier

(Images belong to Maccaferri)

Notes:

1. All dimensions are in millimetres unless otherwise specified.
2. The width of the footpath (Maderia Walk) may be reduced due to the slip and the top row of soil nails. Soil nails here can be buried within the pavement.
3. Railings may need to be reinstated away from the edge of the cliff due to cracks as a result of the landslide.
4. The boundary where the soil nailing following land topographical survey. The as-built location will be decided by contractor based on the condition of the cliff during works.
5. Distance between the debris flow barrier wall and the boundary timber wall will be confirmed once the option is taken forward.
6. At this location, the founding ground is assumed to be landslip material because of historical landslips. Depth of foundation to be confirmed once a ground investigation is carried out. However, due to possible softer nature of landslip material at this location and larger kinematic energy of landslip material, the wall will be bigger and will require posts to be embedded deeper into the bedrock.
7. Netting is supported by a bearing cable system anchored by a rock dowel.
8. The netting is draped across the slope to maximise slope contact.
9. Timber post wall or similar to prevent small amount of wet debris or particles passing through the debris flow debris barrier to reach the playground.

Cliff at the Leas Park Playground, Folkestone	Option 3 – Soil nailing and debris flow barrier		
Folkestone Hythe District Council			
Tony Gee	Date 15/10/2024	Project No. A124037	Drawing No. A124037-TG-SKE-CV-00004 Rev P01