Swanage Seafront

Client: Swanage Town Council
Surveyor: Design Base

PRELIMINARY GEO-ENVIRONMENTAL AND GEOTECHNICAL ASSESSMENT

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Version 1

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EXECUTIVE SUMMARY

A ground investigation has been carried out at Swanage Seafront to obtain geo-environmental and geotechnical data to assist in the sites management and future development.

The desk study has shown that the site was developed from arable land to the formal recreational / amenity area in the late 1920's. The subsequent intrusive geo-environmental investigation and laboratory testing confirmed that the site is generally uncontaminated.

No radon or ground gas protection measures are required.

The slope that forms the eastern boundary of the site was noted to display signs of movement including tension cracks, hummocky ground and deflection of existing structures.

It is considered that the instability is shallow seated, and stability measures could be fairly simple in both design and implementation (e.g. the installation of a deep land drainage system, and upgrading of existing structures by soil nailing etc.).

Geotechnically, the site is underlain by significant depths of soft becoming firm clay. The relatively low shear strength of formation soils requires either deeper trench fill or piled foundations for proposed new structures. A uni-directional trench fill with transverse ground beams is favoured in stabilised landslipped areas.

A design CBR value of 2% is recommended for road foundation design.

1 INTRODUCTION

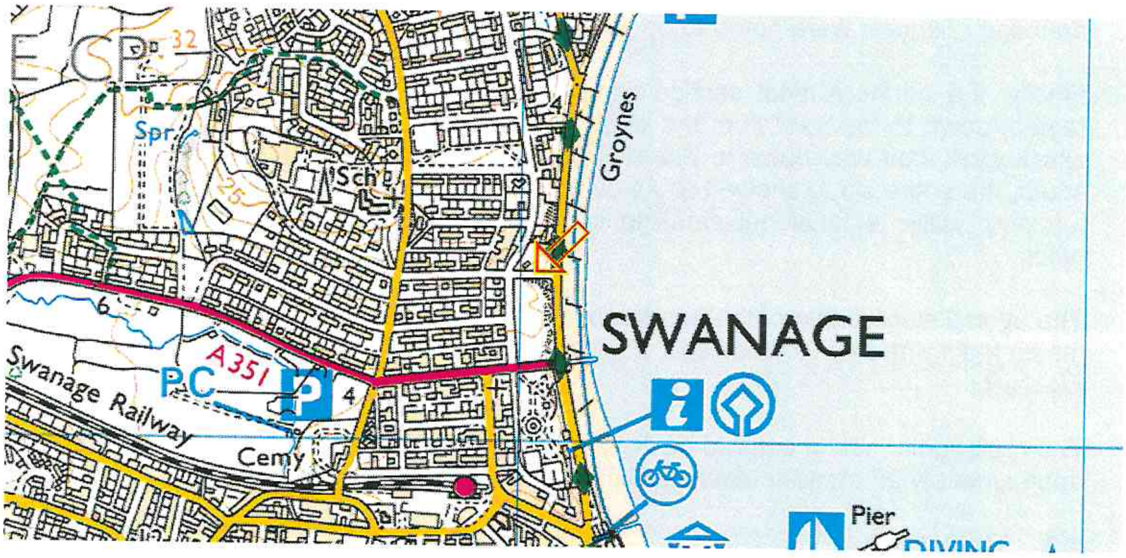
1.1 General

South West Geotechnical (SWG) was instructed by Design Base on behalf of Swanage Town Council to carry out a geo-environmental and geotechnical assessment at a site known as Swanage Seafront, Swanage, Dorset, to provide information for a preliminary options appraisal and management strategy.

This assessment comprises a desk study, (including the acquiring of a full GroundSure report and historical maps), a walkover survey and intrusive investigation with associated chemical and geotechnical testing and interpretive reporting.

1.2 The Site

The site is located to the east of Swanage Town, and forms the coastal transition zone between the town itself and the English Channel. The site is centred on National Grid Reference 403025,79297. The site's location is shown in Figure 1 and the Ordnance Survey extract below:



The overall site comprises a linear parcel of land trending north-south between De Moulham Road to the west, Shore Road to the east, and is split by Walrond Road which runs east-west through its central portion. It can be split into four definable sections by the various land uses:

The southern section, known locally as Sandpit Field, is bordered to the south by the A351, to the east by Shore Road with the beach beyond, to the west by De Moulham Road and to the north by Walrond Road. The majority of this section comprises a generally flat, undeveloped grassy area. A ~6m high bank that slopes down from the west to the east forms the eastern boundary, with Shore Road at the toe of the slope. The slope is landscaped and maintained as a formal public garden with terraced grassed areas and formally planted beds. Of particular notes is a circular depression, ~20m diameter in the central part of the flat grassed area at the upper level. No signs of slope movement or instability were noted in this section.

The overall slope angle of the eastern bank in the southern section is around 20 degrees, measured from crest to toe, and it is around 6m high. A typical section is shown as Figure 3.

The southern central section is bordered to the south by Walrond Road, to the east by Shore Road and to the west by De Moulham Road. The northern boundary is defined by a stone wall with holiday cabins beyond (northern central section). It generally comprises a partly terraced grassed area that slopes gently down from the west to the east. The eastern boundary is defined by a ~2m high retaining wall. A path runs north-south along the eastern boundary on which park benches are placed. A weather station is located in the south western corner. Signs of slope instability were also noted, generally comprising circular (~10m radius) back scars, hummocky ground, extensional cracking in the path and overturning of the small retaining wall.

A third northern central section comprises a largely terraced hillside upon which timber holiday cabins are situated. The slope has been extensively modified and terraced to accommodate the holiday cabins with steps and small (1-2m) to medium (~2-3m) retaining walls. The entire section displays signs of slope instability. Several of the retaining walls have been overturned or overtopped and remediated. Extensive cracking and deflection of retaining walls were noted. The area has been covered in hard standing, and additional drainage measures have been installed into some of the walls. The drainage channels were noted to be wet.

Finally, the northern most section comprises a gently then steeply sloping grass area (again, down to the east from the west) with a combination of steps and retaining walls which work their way down to Shore Road below. Similarly to the previous setion to the south, the entire slope showed signs of instability, including cracking and displacement of retaining walls, extensional cracking in paths, tilting hand rails and leaning telegraph poles.

The overall slope angle of the eastern bank in the northern section is around 27 degrees, measured from crest to toe, and it is around 11m high. A typical section is shown as Figure 4.

The rectangular site is centred on National Grid Reference 403043 79319 and measures approximately 284m north south and 52m east west.

1.3 Limitations

Information given in this report is based on the ground conditions encountered during the site work, and on the results of laboratory and field tests performed during the investigation. However, there may be conditions at the site which have not been taken into account, such as unpredictable soil strata, contaminant concentrations, and water conditions between or below exploratory holes. It should be noted that groundwater levels usually vary due to seasonal and/or other effects and may at times differ to those measured during the investigation.

2 DESK STUDY AND WALKOVER

2.1 General

A desk study was undertaken to provide background information, comprising the consultation of:

- Old Ordnance Survey maps.
- Geological maps and memoirs.
- GroundSure Environmental Reports.

After the review of the desk study a site walk over was conducted to examine any issues raised in the desk study, and identify any other features of environmental interest.

This information was used to produce an "initial conceptual model" of the site so that a preliminary risk assessment could be carried out.

2.2 Site History

A full set of historical Ordnance Survey maps of the site were obtained as part of the GroundSure report. The significant points relating to this site in particular are listed below:

Map Date	Observations
1889	The overall site is undefined along the western edge, however the eastern boundary is defined by a road. The site and surrounding area is shown to be undeveloped, comprising subdivided arable fields. Substantial ground workings, noted as a 'sand pit' is shown in the southern section of the site.
1902	No significant change. The 'sand pit' workings have been extended inland to the west. Some residential development is shown to the south and De Moulham Road forms the southern boundary to the site.
1928	The formal boundaries of the site are now shown. The eastern slope of the southern section is shown to comprise formal gardens, and the 'sand pit' feature is no longer shown. A circular feature is shown in the central area of the southern section. The central section is noted as 'Recreation Ground' and the holiday chalets to the north of this are also shown. Walround Road now separates the southern and central sections. In the wider area substantial residential development has taken place. The park area to the south of the site has been landscaped into a war memorial gardens and recreational ground.
1954	No significant change to the site. The northern section has been terraced. Further development in the wider area is shown. A rectangular feature is shown in the south western corner of the central section of the site. A series of groins have been installed in the foreshore / beach.
1962/63	No significant change.
1974/75	No significant change. The Carrie hotel has been built to the west of the site. Continued development of the surrounding area noted. An electrical substation is shown in the north western corner of the site.
1985/6	No significant change.
1995	No significant change. A breakwater has been constructed in the foreshore area to the southeast of the site. The hotel to the west of the

	site is no longer shown.
2012	No significant change. The 'works' to the west of the site has been redeveloped for residential housing. The former hotel site to the west of the site has been redeveloped.

In summary, a study of historical maps shows the site to have been formalised as the seafront area by 1928. Prior to this, the site appears to have remained as undeveloped arable land, with the exception of a quarry / sand pit. At approximately the same time and through the 30's and 40's the surrounding area also underwent significant change, with extensive residential housing being built.

The GroundSure Historical Maps are presented as Appendix A.

2.3 Site Geology

The geology of Swanage Bay comprises relatively weak rocks of the Wealden Group comprising clays, silts and sandstones. The sedimentary strata comprise interbedded layered sequences of mudrocks, siltstones and sandstones which have undergone limited uplift and deformation.

Superficial beach deposits are noted to east of the site.

The site is in an area where less than 1% of properties are above the action level for radon. Therefore, no radon protection measures are required.

Some made ground is recorded in the southern part of the site relating to the ground workings / sand pit noted on the historical maps. In addition, based on the historical mapping, the site has been previously developed and landscaped (with some cut slopes noted). Therefore, some made ground and reworked natural ground is expected.

The geology report noted a moderate risk of landslides and the local area is well documented as an area of slope instability (predominantly translational and rotational failures).

The Geology Report is presented as Appendix B.

2.4 Environmental Search

A GroundSure Environmental Report was obtained as part of the desk study. The key points relating to the site are listed below:

Authorisations, Incidents and Registers

- The site is not recorded on the contaminated land register as a contaminated (Part IIA) site.
- There are no IPC or IPPC Authorisations listed within 500m of site.
- There are no licensed Discharge Consents listed within a 500m radius of the site.
- There are no recorded pollution incidents within 500m of site.

Landfill and other Waste Sites

No landfill sites (Environment Agency registered, historical or non-operational) or other waste facilities are reported within 500m of the site.

Current / Historical Industrial Land Use

The GroundSure report notes one industrial feature on site: an electricity substation. Several other features are noted within 250m of the site, including further substations,and railway land ~200m to the south.

No petrol or fuel sites are recorded within 250m of the site.

Hydrogeology

The closest surface water feature is a culverted tertiary river that runs along the sites southern boundary.

The underlying strata are classified, according to the Environment Agencys Groundwater Protection Policy 2010, as a Secondary Type A aquifer, described as: Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as 'minor aquifers'.

The closest ground water abstraction (also a potable abstraction) is recorded 1934m to the south of the site.

The closest surface water abstraction is recorded 1620m to the northwest of the site.

The GroundSure Environmental Report is presented as Appendix C.

2.5 Geo-environmental Site Walkover

A site walkover survey was undertaken on 19 March 2013.

The site was noted to comprise an undeveloped amenity / recreational area, with some holiday chalets in the northern end of the site. The site appeared to be well maintained, with no visual or olfactory evidence of contamination noted. There were no signs of fly-tipping, tanks or signs of distressed vegetation. An electrical substation is located adjacent to the site's northeastern boundary.

During the walkover survey, a significant construction project was noted in the adjacent site to the south, including several retaining walls. Discussions with the principal contractor indicated that the project was experiencing substantial issues with slope instability. This was highlighted by the use of ballasted blocks at the toe of the newly formed cut slope and long (12-15m soil nails) being prepared to be installed into the newly formed cut face. Access to the cut slope for logging was not permitted.

The existing site layout is presented as Figure 2; this also forms the exploratory hole location plan. Photographs showing the sites current condition are presented as Appendix G.

3 INITIAL CONCEPTUAL MODEL

In order for land affected by contamination to cause harm, there must be a source of contamination, a receptor that can be harmed and a pathway by which the receptor can be exposed to the contamination. Based on the information collected and described in the previous sections, the following initial conceptual model of contaminative sources, pathways for contamination transmission, and potential receptors of contamination is considered below.

A commercial land use model has been used for this assessment.

3.1 Potential Sources

Historically, the site has remained undeveloped up until the present day. The site was formalised as a park / recreational area with a small amount of holiday chalets in the central part of the site in the late 1920's, and it has remained for this land use until the present day. Therefore, generally the site's historical land use is not considered to have caused significant contamination of the ground.

However, a small quarry / sand pit was noted in the southern part of the site on the historical maps. This feature was noted to have been infilled by the late 1920's. In addition the sites topography has been modified during construction, with several small cut / fill slopes and retaining walls. The fill could be generically contaminated (general brownfield contaminants including metals and hydrocarbons) if imported from an off site source (although this is considered unlikely).

The site currently comprises an undeveloped recreational area. No visual or olfactory signs of contamination were noted during the walkover survey. Therefore, no significant contamination is anticipated from present on-site land uses.

However, the old maps indicate that an electricity sub-station has been present to the northwest of the site from the 1970's until the present day. Polychlorinated bi-phenyls (PCB's) may be found where they were used as dielectric fluids in capacitors in electricity sub-stations. However, because of the age of the sub-station, the sub-station is unlikely to contain PCB's, though the possible presence of PCB's beneath the substation should not be discounted.

The site is located in a residential setting. Therefore, based on desk study information past and present adjacent land-uses are considered unlikely to have caused contamination of the ground beneath the site.

The GroundSure report indicates that the site is in an area where less than 1% of properties are above the action level for radon and that no radon protection measures are required for new properties. Therefore, radon is discounted as a potential contaminant at this stage.

3.2 Pathways

In accordance with the CLEA model for standard commercial land-use, the following potential migration pathways are considered potentially linking contamination to humans:

- Ingestion of soil
- Dermal contact with soil and indoor dust

- Inhalation of indoor and outdoor dust and vapours

If present, groundwater flow is considered to be the main migration pathway linking any contamination to controlled waters receptors.

3.3 Receptors

When taking into account the residential land use, end-users are considered as potential receptors of contamination, with an adult female, being the critical receptor.

The stream to the south of the site and the groundwater beneath the site are considered to be the main potential controlled water receptors. It should be noted that the underlying geology has been reported as a Secondary Type A aquifer.

3.4 Preliminary Risk Assessment

On the basis of the desk study information and walkover survey the risk of significant contamination on the site is considered to be **low**, however, some unquantified geo-environmental risks remain.

Therefore, in order to fully quantify the risk to human health and controlled waters a Phase 2 investigation was considered necessary.

4 FIELDWORK

4.1 General

The targeted investigation was carried out on 19th and 20th March 2014 in accordance with BS5930 (1999): British Standard Code of Practice for Site Investigation, British Standard BS10175 (2011): Investigation of Potentially Contaminated Sites – Code of Practice and and Eurocode 7 (2007): Part 2 Ground Investigation and Testing. Prior to breaking ground, all positions were CAT scanned.

The field work comprised the following scope of works:

- Nine window sample boreholes (one with with in-situ SPT tests)
- Ten dynamic cone penetrometer tests (DPSH method)
- TRL DCP probes (CBR tests)
- Chemical and geotechnical laboratory testing

The exploratory hole logs are contained in Appendix A and the exploratory hole locations are shown on the exploratory hole location plan, enclosed as Figure 2.

Representative samples were generally taken at regular intervals and changes in strata for further examination and subsequent laboratory testing. Geo-environmental samples were also collected from the near surface deposits, as, in accordance with the CLEA model, contamination is assumed to be within the near surface deposits for most exposure pathways.

The exploratory holes were located across the site to provide adequate site coverage while targeting both potential sources of contamination and provide sufficient information for foundation design.

4.2 Window Sampling

Nine window sample boreholes were carried out using a Competitor percussive rig, which used a 63.5kg weight dropping a vertical distance of 750mm (BS 5930 Section 4, Clause 22.9) to drive a soil sampling tube into the ground. The boring produces a continuous sample in diameters ranging from 100mm down to 36mm, in clear rigid plastic liners. The holes were advanced to a maximum depth of 2.00m.

Standard Penetration Tests (SPTs) were undertaken at 1.00m intervals.

On completion the window sample boreholes were backfilled with arisings.

4.3 Dynamic Probing

The ten dynamic probes were formed immediately adjacent to the window sample holes and at other locations using the same Competitor 130 tracked rig utilising a 63.5kg weight falling 750mm. The dynamic probes used 32mm rods attached to a 50mm 90 degree cone (BS 5930 Section 4, Clause 26.2 – DPSH method). The cone diameter, driving weight and fall distance are all identical to that used in the Standard Penetration Test (BS 5930 Section 4, Clause 25.2), which enables an approximate correlation between the two. The test records the number of blows required to drive the test cone 100mm, and is referred to as the N_{100} value.

4.4 In-Situ TRL Dynamic Cone Penetrometer Testing

Five in-situ TRL Dynamic Cone Penetrometer (DCP) tests were undertaken to provide an indication of California Bearing Ratio (CBR) value for use in road/ track pavement design.

The Transport Research Laboratory (TRL) DCP uses an 8kg hammer dropping through a height of 575mm and a 60° cone having a maximum diameter of 20mm. The penetration and number of blows are recorded up to a maximum depth of 1.00m BGL. The penetration rate is recorded as the cone is driven into the subgrade and is used to calculate the strength of the material (CBR value) through which the cone is passing.

4.5 Ground Conditions

In summary the investigation confirmed the published geology, and the ground conditions were noted to be relatively uniform and consistent across the site.

The window sample boreholes encountered a thin mantle of grass and topsoil over soft becoming firm to stiff clay to the completed depths of between 2.50m and 5.00m. The clay was noted to become friable with a faint lithorelict structure with depth, with moderately to widely spaced discontinuities. The only notable exception to this was a thin band of mudstone / hard clay in WS7 at 1.75m and made ground in WS3.

Made ground was encountered to the full depth of WS3 at 3.00m. It comprised of both silty sandy gravelly clay and silty gravelly clayey sand. The dynamic probe completed alongside the window sample borehole confirmed the low strength of this material.

A summary of the findings, with depth to the base of each respective stratum encountered, is presented in the following table:

Stratum	Depth to base of strautum (m)								
	WS1	WS2	WS3	WS4	WS5	WS6	WS7	WS8	WS9
Topsoil / MG	0.22	0.25	>3.00	0.10	0.10	0.20	0.45	0.20	0.20
Soft Clay	3.00	2.90		1.10	1.90	1.00	1.80	2.00	1.40
Firm Clay	>5.00	>4.00		>3.00	>2.50	>3.50	>3.50	>4.00	3.00

The following SPT-N values were recorded in WS1:

- 1m – N=1
- 2m – N=4
- 3m – N=20
- 4m – N=21

The dynamic probes were driven to a variety of depths between 10m in DP1 and 3.4m in DP10. The probes generally showed the near surface soils to have little appreciable strength, with typical N100 of 0 in the top 2m. Beneath this definable soft near-surface layer, N100 values steadily rose to N100 of ~5 and above.

4.6 Environmental Observations

No olfactory or visual signs of obviously contaminated soils were encountered during the investigation. The only notable made ground was recorded in WS3, as described above.

4.7 Groundwater

Groundwater was not encountered during the investigation apart from a slow seepage in WS3 at 1.5m.

For full information of the strata encountered, reference should be made to the individual exploratory hole records presented as Appendix D.

5 LABORATORY TESTING

5.1 Environmental

On the basis of the desk study, walkover survey and subsequent intrusive investigations, chemical testing was undertaken on six samples for the following determinands:

- pH, organic matter, Sulphate (water soluble).
- Metals: Arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, zinc and cyanide
- Speciated Polyaromatic Hydrocarbons (PAH): Acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h) anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, pyrene.
- Total Petroleum Hydrocarbons (TPH)
- Speciated Total Petroleum Hydrocarbons (TPH), aliphatic >C5-C6, aliphatic >C6-C8, aliphatic >C8-C10, aliphatic >C10-C12, aliphatic >C12-C16, aliphatic >C16-C21, aliphatic >C21-C35, aromatic >C5-C7, aromatic >C7-C8, aromatic >C8-C10, aromatic >C10-C12, aromatic >C12-C16, aromatic >C16-C21, aromatic >C21-C35.
- Benzene, toluene, ethylbenzene, p & m-xylenen and o-xylene

All samples were screened for asbestos as part of the subcontractors sample handling policy.

The contaminant test results are presented as Appendix F.

5.2 Geotechnical

All geotechnical laboratory testing was carried out in accordance with BS1377:1990 - Parts 1-9 Methods of test for soils for civil engineering purposes. The testing was scheduled by SWG and the results are presented in Appendix G of this report.

Seven Atterberg limit (index property) test with natural moisture content determination was carried out.

Representative soluble sulphate and pH tests were undertaken to provide information regarding aggressive ground conditions.

The results of the geotechnical laboratory testing are given in Appendix E.

6 GEO-ENVIRONMENTAL ASSESSMENT

6.1 Basis for Assessment

In accordance with the latest guidance, the following qualitative risk assessment has been undertaken using a source-pathway-receptor analysis method. The results of the contamination laboratory testing, undertaken on soil samples collected during the targeted investigation, as outlined in earlier sections of this report, have been compared to Generic Assessment Criteria (GAC) to assess the potential risk posed to human health by soil contamination.

6.2 Environmental Test Results

The results of the environmental laboratory testing, presented as Appendix F, have been summarised and compared to GAC values for commercial developments.

Where Soil Guideline Values (SGV's), published by DEFRA and derived from the Contaminated Land Exposure Assessment (CLEA) model, are available, the results of the laboratory testing have been compared against these for the proposed end-use.

LQM/ CIEH GAC's have been recently developed by Land Quality Management Ltd jointly with the Chartered Institute of Environmental Health, and provide values for substances not covered in the current CLEA guidelines and are compliant with UK policy and guidelines. In particular, these include components of TPH and PAH. Where other guidelines are not available, the Dutch standards provide an initial comparison figure.

A summary of the assessment is given in the following table:

Determinant	SGV / GAC mg/kg	Source of GAC	Recorded Range mg/kg	Location of exceedances
Arsenic	640	SGV 2009	4-17	
Cadmium	14000	SGV 2009	<0.5-0.5	
Chromium	30400	LQM/CIEH	<2-36	
Copper	524	LQM/CIEH	<4-12	
Cyanide	1 / 20	Dutch	<2	
Lead	750	SGV 2002	<3-16	
Mercury (inorganic)	3600	SGV 2009	<1	
Nickel	1800	SGV 2009	<3-27	
Selenium	13000	SGV 2009	<3	
Zinc (total)	665000	LQM/CIEH	4-34	
TPH (Total)	10	Screen	<10-58	
TPH aliphatic C5-C6	3400	LQM/CIEH	<0.1	
TPH aliphatic C6-C8	8300	LQM/CIEH	<0.05	
TPH aliphatic C8-C10	2100	LQM/CIEH	<1	
TPH aliphatic C10-C12	10000	LQM/CIEH	<1	
TPH aliphatic C12-C16	61000	LQM/CIEH	<1	
TPH aliphatic C16-C35	1600000	LQM/CIEH	<6-115	
TPH aromatic C5-C7	28000	LQM/CIEH	<0.01	
TPH aromatic C7-C8	59000	LQM/CIEH	<0.05	
TPH aromatic C8-C10	3700	LQM/CIEH	<1	

TPH aromatic C10-C12	17000	LQM/CIEH	<1	
TPH aromatic C12-C16	36000	LQM/CIEH	<1	
TPH aromatic C16-C21	28000	LQM/CIEH	<1-22	
TPH aromatic C21-C35	28000	LQM/CIEH	<6-168	
Napthalene	200	LQM/CIEH	<0.1	
Acenapthylene	85000	LQM/CIEH	<0.1-0.15	
Acenapthene	84000	LQM/CIEH	<0.1-0.22	
Flourene	64000	LQM/CIEH	<0.1-0.19	
Phenanthrene	22000	LQM/CIEH	<0.1-5.78	
Anthracene	53000	LQM/CIEH	<0.1-1.16	
Flouranthene	23000	LQM/CIEH	<0.1-24.5	
Pyrene	54000	LQM/CIEH	<0.1-20.4	
Benz(a)anthracene	90	LQM/CIEH	<0.1-9.77	
Chrysene	140	LQM/CIEH	<0.1-10.6	
Benzo(b)flouranthene	100	LQM/CIEH	<0.1-13.7	
Benzo(k)flouranthene	140	LQM/CIEH	<0.1-5.06	
Benzo(a)pyrene	14	LQM/CIEH	<0.1-9.17	
Dibenz(a,h)anthracene	13	LQM/CIEH	<0.1-0.65	
Indeno(1,2,3-cd)pyrene	60	LQM/CIEH	<0.1-6.35	
Benzo(g,h,i)perylene	650	LQM/CIEH	<0.1-5.54	

From the assessment undertaken above it can be seen that all of the determinants tested are within the relevant GAC / SGV thresholds for a commercial land use, although slightly elevated hydrocarbons were recorded in WS3.

In addition, no detectable quantities of benzene, toluene, ethylbenzene, p & m-xylenen and o-xylene were noted in the six samples tested.

6.3 Geo-environmental Discussion and Recommendations

6.3.1 Human Health

The desk study, walkover survey and subsequent targeted intrusive investigation has shown that the site is generally uncontaminated.

Six samples were tested for a wide range of contaminants, considered to present a potential risk to future site users. All of the selected samples did not exceed recognised and accepted assessment criteria for a commercial land use.

Therefore, generally the site is deemed fit for purpose and does not present a risk to current / future site users or the wider environment.

Usually, it would be recommended that further testing be undertaken at this stage to further delineate the area of made ground encountered in WS3. However, until detailed development proposals are known, the information obtained to date is considered sufficient.

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The chemical test results are all within the UKWIR 2010 guidance values for the selection of materials for water supply pipes, therefore no special precautions are required to protect water supplies, with the following exception.

As previously mentioned, the results of the single sample of made ground in WS3 show slightly elevated levels of hydrocarbons. Therefore, should potable water supply pipes be placed in this material they will need to be upgraded to withstand hydrocarbon attack.

It should also be noted that although the sampling and testing regime is deemed adequate for the scale of this particular development, it does not fully comply with all published guidelines and hot spots of contamination that have not been encountered may exist. Should unexpected ground conditions or any visual or olfactory signs of contamination be encountered during ground works, a suitably qualified Engineer should be contacted so that appropriate recommendations may be provided.

6.4 Groundwater

As discussed above, there are no significant sources of contamination on site, and therefore there are no identifiable hazards to controlled waters, including groundwater. Therefore no remediation works are necessary.

6.5 Ground Gas

The site is in an area where less than 1% of properties are above the action level for radon. Therefore, no radon protection measures are required for new developments.

There are no recorded landfill sites within 250m, of the site, and significant organic made ground was not encountered during the investigation. Therefore, no further action is required in this regard when considering the sites current and proposed land use.

7 GEOTECHNICAL DISCUSSION AND RECOMMENDATIONS

At the time of writing, specific development proposals have not been finalised, and the purpose of this report is to provide general geotechnical advice regarding slopes and foundations.

7.1 Ground Conditions

The ground conditions were noted to comprise a thin mantle of grass and topsoil over soft becoming firm to stiff clay, which was noted to become friable with a faint lithorelict structure with depth, with moderately to widely spaced discontinuities. The only notable exception to this was a thin band of mudstone / hard clay in WS7 at 1.75m and made ground in WS3.

Weak and variable made ground was encountered to the full depth of WS3 at 3.00m. This could represent backfilling to a former working or sandpit in this vicinity.

The classification tests indicate the residual soils are of medium volume change potential.

The dynamic probes generally showed the near surface soils to have little appreciable strength, with typical N100 of 0 in the top 2m. Beneath this definable soft near surface layer, N100 values steadily rose to N100 of ~5 and above.

Site observations noted signs of slope movement along the eastern boundary, including tension cracks, soil creep, humockey ground, overturned retaining walls, cracking and extensional movement within in existing structures and other movement indicators. In addition, problems associated with slope stability were reported in an adjacent site to the south that is currently under construction.

7.2 General Geotechnical Considerations

Based on the engineering geologist's site observations and the in-situ test results, it is considered that the slope along the eastern boundary of the site is relatively prone to soil creep, translational / circular slope failures. Anecdotal evidence, including the significant slope stability issues on an adjacent site to the south confirm this observation.

7.3 Slope Stability

The slope that forms the entirety of the site has been shown to generally comprise soft to firm clay to depths of around 2m, underlain by less weathered stiffer clay becoming a weak mudstone at depth.

It is likely that the instability on the site is confined to the top 2m or so of softer soils.

Slope stability analyses to determine the factor of safety (FoS) of the slope is not considered necessary at this stage, as observations conclude that the slope is only in a very marginal state of stability (i.e. FoS = approximately 1.0, which will fluctuate slightly either way depending mainly of prevailing groundwater conditions at any one time).

Clearly the FoS requires to be significantly higher, 1.3 as a minimum, before the bank and infrastructure above it can be safely developed.

In order to do this, it would be necessary to understand fully the controlling strength parameters and groundwater conditions. This would be best achieved based on a thorough literature review, further detailed intrusive investigation, inclinometer monitoring, groundwater monitoring, and laboratory testing.

Given the known marginal stability (i.e. FoS ~1.0), parameters so determined can be checked by back-analysis for greater confidence.

Without the benefit of the above exercise, and detailed development proposals, it is difficult to give positive design options for upgrading the stability, but it is considered likely that the installation of a deep land drainage system would provide an overall stable slope.

Existing damaged masonry walls and any other existing structures that a risk assessment identifies as below standard, are likely to need further upgrading, and soil nails anchored into the deeper mudstone may provide the simplest solution for these.

Any new cuttings into the slope will need to be carefully designed, and consideration could be given to anchored or piled structures, again relying on the deeper mudstone for support.

7.4 Foundations

For new structures that require more traditional foundations on the level parts of the site, it is considered that a safe nett allowable bearing pressure of 100 kN/m² may be placed on the firm clay by traditional spread / trench fill foundations at around 2.00m to 2.5m depth. Foundations must fully penetrate the near surface clays into the firmer material below.

When taking into account the relatively soft near surface soils, consideration could also be given to adopting a piled or vibro-piled foundation, down into the firm stiff clays at depth. This is particularly pertinent to the area of deep fill encountered in WS3, the extent of which will need to be investigated further.

Where structures are to be sited on previously landslipped soils, a uni-directional trench fill type spread foundation would be favoured over a piled solution. This is due to the fact that even after stabilisation works, the slipped mass may undergo a small amount of creep that could impact on the integrity of a slender piled foundation solution. Uni-directional trench fill involves the casting of deep mass or nominally reinforced concrete footings parallel to the slope contours, with ground beams and floor joists spanning between them to carry transverse walls and precast concrete floors.

Formation soils have been classified as medium volume change potential. Therefore, foundation depths will need to be adjusted to take into account of nearby trees and hedgerows. Similarly all floors will need to be fully suspended with a clear 100mm void below.

Allowable bearing pressures have been estimated from site observations and the correlation between N100 value and undrained shear strength of clays given in Huntley S L (1990) and Warren G (2007).

7.5 Groundwater and Excavations

Groundwater was not encountered during the investigation, therefore, de-watering of temporary excavations should not be required, although this would need to be reviwed after formal groundwater monitoring.

7.6 Aggressive Ground Conditions

Eight pH and soluble sulphate tests were undertaken at an MCERTS accredited specialist sub-contract laboratory. The results of the tests show soluble sulphate levels to be less than 500 mg/l, and the pH values of between 7.7 and 8.4. On this basis, no special precautions to protect buried concrete from sulphate attack are required (BRE SD1, 2005).

7.7 Road Pavement Design

Six TRL penetrometer tests were carried out to measure CBR values with depth. The results indicate that a CBR design value of 2% is appropriate for the natural soils. Road foundations should comprise 450mm of capping layer (minimum CBR of 15% and less than 10% fines) laid on a permeable geotextile separating layer, with 150mm of sub-base above.

7.8 Further Work

As previously discussed, further work is necessary to investigate the slopes and ground conditions in the area of made ground. The recommended scope of these works are summarised below:

- Literature review of existing reports and publications
- Installation of inclinometers and piezometers
- Trial pitting and cable boring to investigate area of made ground
- Cable boring for high quality samples on slopes
- Laboratory shear box testing for peak and residual strength parameters
- Stabilisation and foundation options appraisal.

It is recommended that the inclinometer monitoring be commenced as soon as possible as the quality of data from this exercise is time dependant.

John Hall
CGeol CEng MSc BSc
Director
May 2013

Neil Forrow
BSc (Hons) FGS
Director

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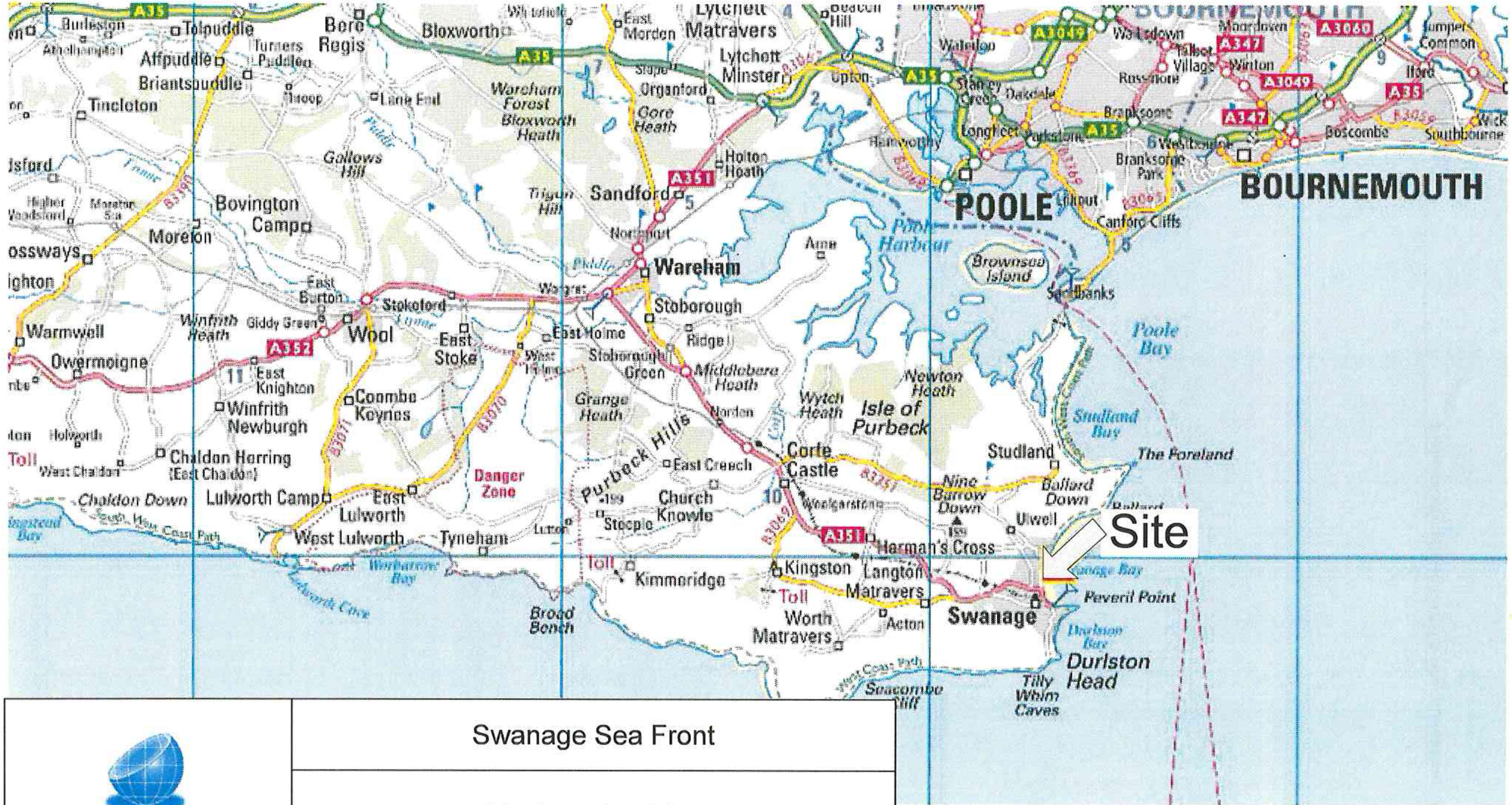
Figure 1

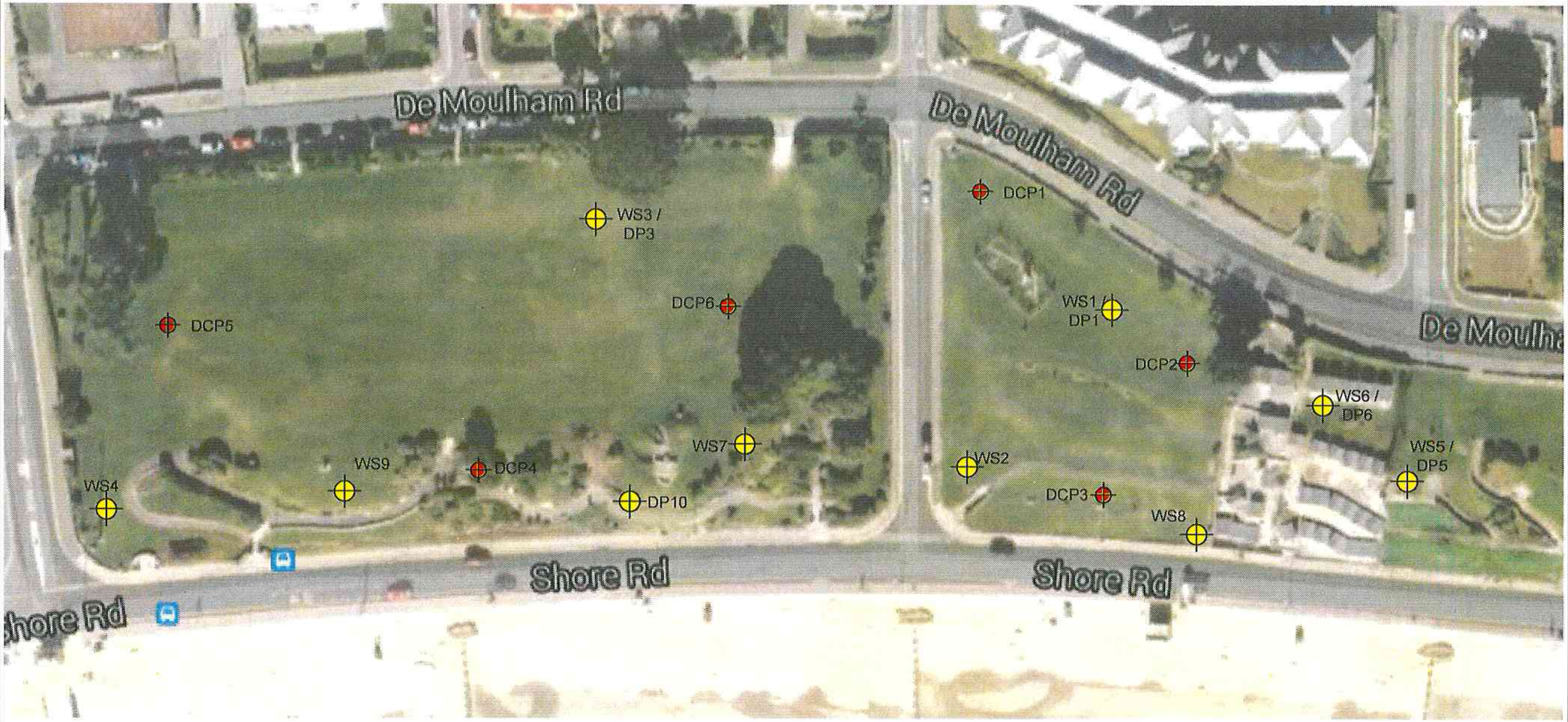
Site Location Plan



South West Geotechnical	Swanage Sea Front			
	Site Location Plan			
01884 252444	SIZE A4	JOB NO 5951	DWG NO Figure 2	REV 0
Drawn by NW	SCALE NTS	25 April 2014	SHEET 1 OF 1	

Figure 2

Site Plan / Exploratory Hole Location Plan



SOUTH WEST GEOTECHNICAL	Swanage Sea Front				
	Site and Exploratory Hole Location Plan				
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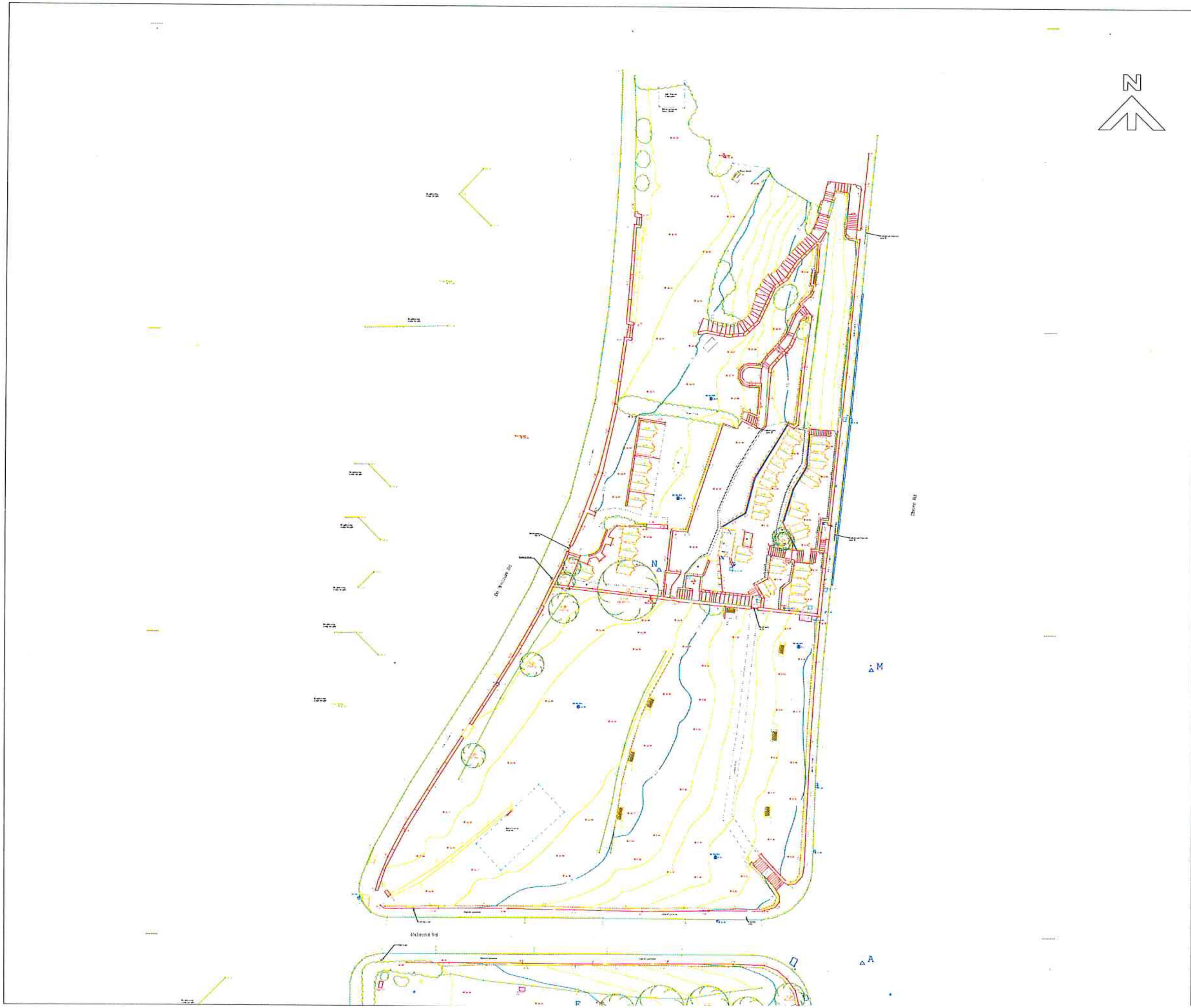
Drawn by NW	SCALE	NTS	25 April 2014	SHEET	1 OF 1



Notes

Station	Easting	Northing	Level
A	403568.350	79055.778	3.093
B	403563.557	79021.712	3.06[illegible]
C	403073.031	79153.527	2.967
D	40304[illegible].216	79165.024	[illegible]
E	403520.071	79087.960	10.463
M	403565.628	79344.138	3.184
N	403034.521	79360.557	13.101

Levels Relate to :- GPS Data (OS Datum)

Position Relates to :- GPS Data (OS Grid)

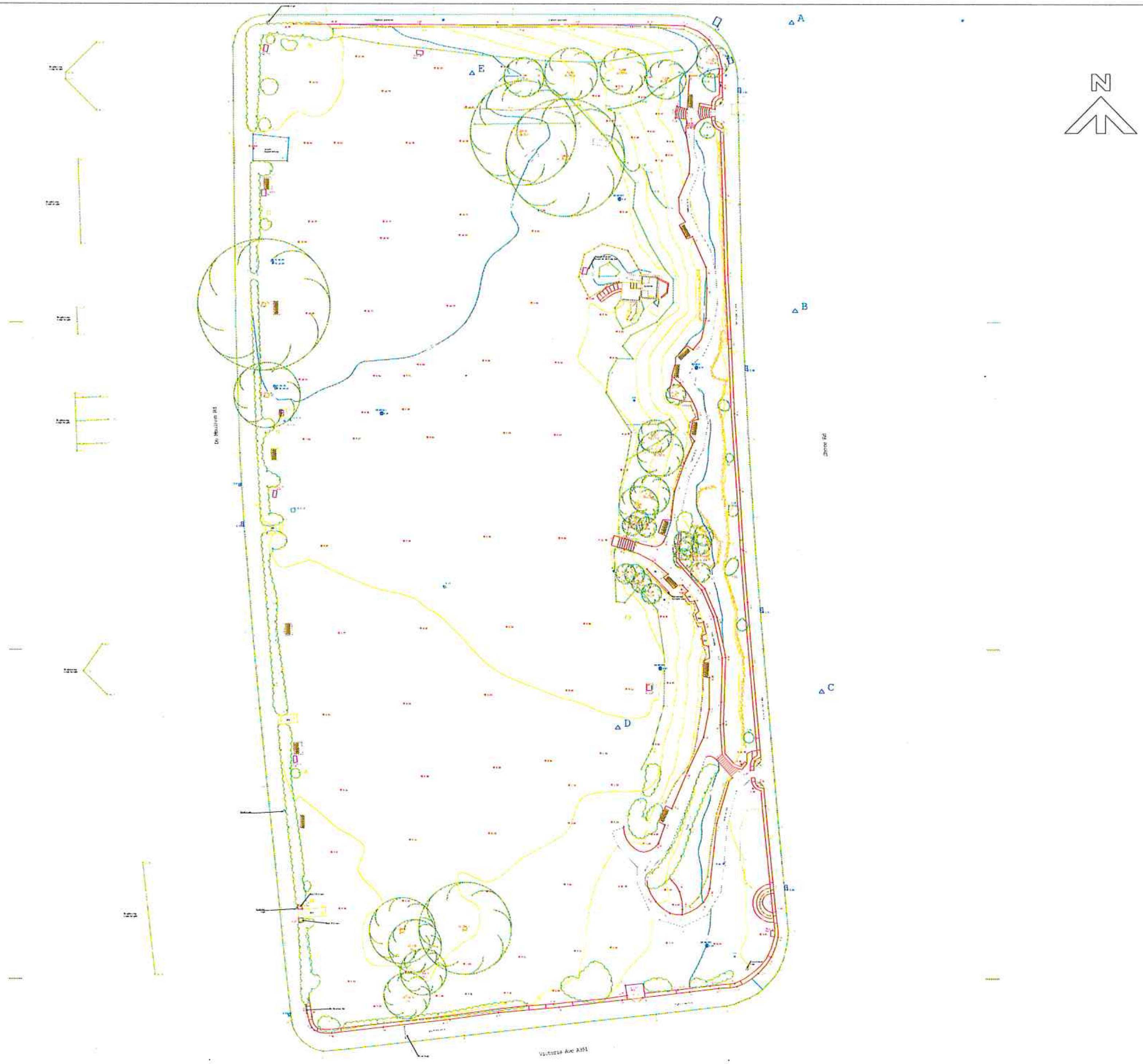
Note

Stations A, B, C, M & N are marked by PK nails in asphalt or concrete surfaces
Station E is a wooden peg in soft ground.

Rev.	Comments	By	Chkd	Date
-	-	-	-	[illegible]

DESIGNBASE
Surveying & Architecture
ADVANCED TECHNOLOGY ENHANCED DESIGN

Project: Swanage Seafront
Project Code: DB-648
CAD Drawing Name: Swanage Seafront Topo
Plan Status: Existing Topographic Survey
Date: April 2014
Scale: 1:200 @ A0
Drawn by: Design Base
Drawing Number: DB648 - 101
Revision: —



Notes :

Station	Easting	Northing	Level
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C	403072.031	75193.527	2.965
D	403042.210	75164.024	[illegible]
E	403020.071	75287.980	10.483
M	403059.629	75344.154	3.194
N	403034.531	75360.557	13.101

Levels Relate to :- GPS Data (OS Datum)

Position Relates to :- GPS Data (OS Grid)

Note

Stations A, B, C, M & N are marked by PK nails in asphalt or concrete surfaces. Station E is a wooden peg in soft ground.

Rev	Comments	By	Chkd	Date
-	-	-	-	-

DESIGNBASE

Surveying & Architecture

ADVANCED TECHNOLOGY | ENHANCED DESIGN

Project :
Swanage Seafront

Project Code :
DB-648

CAD Drawing Name
Swanage Seafront Topo

Plan Status
Existing Topographic Survey

Date
April 2014

Scale
1:200 @ A0+

Drawn by:
Design Base

Drawing Number
DB648 - 100

Revision
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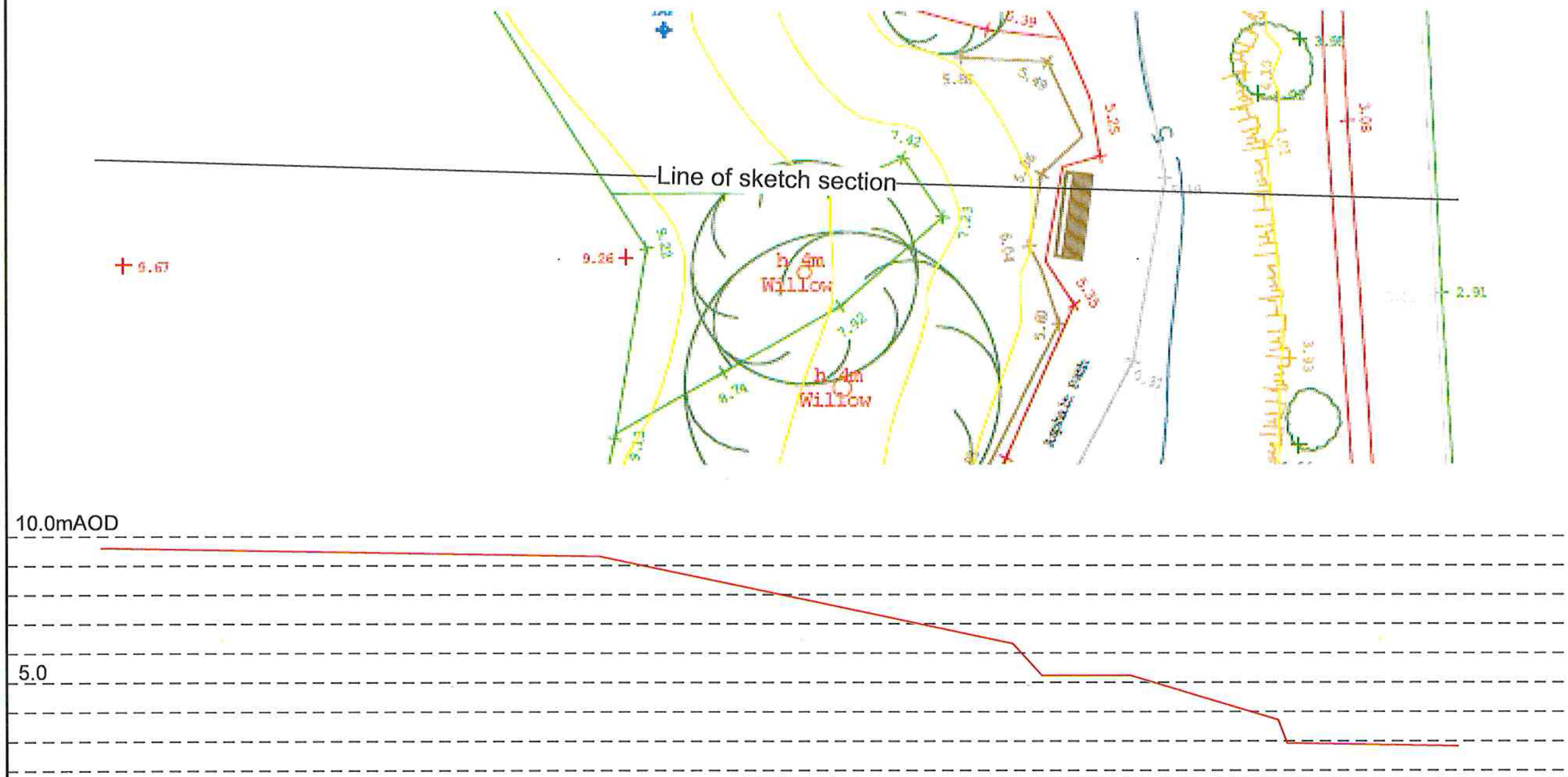
Figure 3

Northern Section

SOUTH WEST GEOTECHNICAL	Swanage Sea Front			
	Northern Section			
01884 252444	SIZE: A4	JOB NO: 5951	DWG NO: Figure 3	REV: 0
Sections.vsd	SCALE: 1:200	06 May 2014	SHEET: 1 OF 2	

Figure 4

Southern Section



SOUTH WEST GEOTECHNICAL	Swanage Sea Front					
	Southern Section					
01884 252444	SIZE A4	JOB NO 5951		DWG NO Figure 4		REV 0
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