Appendix B. Groundwater Assessment

Background

The assessment of the geology, hydrogeology and groundwater flood risk for the Southend-on-Sea area was completed as part of the 2011 draft SWMP to follow on from the Phase 1 SWMP assessment in 2010. It is considered that the data presented within the assessment is representative of present day conditions.

Introduction

Groundwater flooding occurs as a result of water rising up from the underlying aquifer or from water flowing from springs. This tends to occur after long periods of sustained high rainfall, and the areas at most risk are often low-lying where the water table is more likely to be at shallow depth. Groundwater flooding is known to occur in areas underlain by principal aquifers, although increasingly it is also being associated with more localised floodplain sands and gravels.

Groundwater flooding tends to occur sporadically in both location and time, and tends to last longer than fluvial, pluvial or sewer flooding. Basements and tunnels can flood, buried services may be damaged, and storm sewers may become ineffective, exacerbating the risk of surface water flooding. Groundwater flooding can also lead to the inundation of farmland, roads, commercial, residential and amenity areas.

It is also important to consider the impact of groundwater level conditions on other types of flooding (e.g. fluvial, pluvial and sewer flooding). High groundwater level conditions may not lead to widespread groundwater flooding. However, they have the potential to exacerbate the risk of pluvial and fluvial flooding by reducing rainfall infiltration capacity, and to increase the risk of sewer flooding through sewer / groundwater interactions.

Under the FWMA, it is the responsibility of LLFAs to investigate groundwater flooding working with other Risk Management Authorities, including the Environment Agency, who has a strategic overview role for flood risk management and hold historic data and monitor groundwater levels.

Figure B-0: Rising Groundwater in Shoeburyness

An initial assessment of groundwater flood risk was carried out as part of the Phase 1 SWMP study; this found that there is potential for groundwater flooding across the Borough of Southend-on-Sea with evidence of high groundwater levels and groundwater flooding in parts of Shoeburyness (as illustrated in Figure B-0 above). One of the main recommendations was to carry out a more detailed assessment of the susceptibility to groundwater flooding across the Borough.

This section provides an intermediate assessment of groundwater flooding susceptibility, and includes:

- Identification of potential groundwater flooding mechanisms;
- Evidence of groundwater flooding;
- Determination of areas susceptible to groundwater flooding; and
- Recommendations for further investigation.

Geology

Figure B2 provides geological information for the Southend-on-Sea Borough and the surrounding area from the British Geological Survey (BGS) 1:50,000 scale geological series. Figure B3 provides geological cross sections for the study area and these have been used to improve the conceptual understanding of the area. The BGS 1:10,000 scale geological series does not exist for a more detailed geological assessment. However, 135 borehole logs were obtained from the BGS to provide local data and their locations are shown in Figure B2.

Bedrock geology

The bedrock geology of the area comprises the Upper Chalk[36], which in turn is overlain by Lower London Tertiaries (Thanet Sand and Woolwich Beds) and London Clay Formation. The Claygate Member (formerly the Claygate beds) rests conformably on the London Clay Formation and is exposed in the western and northwestern edge of the study area. Fragmented outcrops of London Clay Formation are present in the western part of the study area on both sides of Prittle Brook where superficial deposits are absent.

The Lower London Tertiaries are mainly sands which vary in thickness from approximately 45 m in the north to more than 50 m adjacent to the River Thames Estuary in the south. The Lower London Tertiaries are overlain by the London Clay Formation across the whole region. The full thickness of London Clay is known only where the formation is capped by the Claygate Member and is around 130m. The thickness of the overlying Claygate Member ranges from 17 m to 23 m.

Superficial Geology

The superficial geology of the area consists of Alluvium, Head, River Terrace Deposits, Beach and Tidal Flat deposits, Tidal Flat Deposits and Blown Sand.

The River Terrace Deposits mainly consist of sand and gravel or silt and clay. They dominate the outcrop geology in the study area. The River Terrace Deposits comprising silt and clay range in thickness from 2m to 7m and generally overlie the River Terrace Deposits with sand and gravel (Figure B3). The thickness of River Terrace Deposits consisting of sand and gravel varies between approximately 2 and 18 m, the latter occurring in the Priory Park area. In the vicinity of Shoeburyness to the east of the study area, River Terrace Deposits include buried sand channels ranging in thickness from 11m to 13m. The River Terrace Deposits are also locally overlain by Head deposits which are variable in composition and their thickness ranges from 0.5m to 3.5m over the region.

Alluvium comprising clay, silt and sand is associated with Eastwood Brook, one of the tributaries of the River Roach, in the north-western part of the study area.

The Tidal Flat Deposits comprising silty clay with sand lenses are located by the coast in Southchurch, Shoeburyness, Pig’s Bay and Two Tree Island. These deposits are 1 m to 5 m thick in Southchurch and 3 m to 5 m thick at Shoeburyness. A thin basal sand and gravel horizon usually underlies the Tidal Flat Deposits. The Beach and Tidal Flat Deposits occur within the Thames Estuary.

East of Southend pier, a narrow strip of Blown Sand with an approximate thickness of 2 m is present along the coastline (Eastern Esplanade) and this overlies the Tidal Flat Deposits.

BGS grid data has been used to generate the superficial thickness contour map presented in Figure B4. It is noted that the reliability of the data is dictated by the distribution of existing geological borehole logs. The map indicates that the average thickness of superficial deposits is approximately 10 m around the eastern (Shoeburyness) and central part of the Council area, though in some locations it can reach a thickness of more than 20 m such as Two Tree Island.

[36] According to new nomenclature for the Chalk, the term ‘Upper Chalk’ is no longer in formal use, and the unit has been split into several formations including the ‘Lewes Nodular Formation’, ‘Seaford Chalk Formation’, ‘Newhaven Chalk Formation’ and ‘Culver Chalk Formation’. For ease of reporting, the term ‘Upper Chalk’ is retained.

Hydrogeology

The hydrogeological significance of the various geological units within the study area is provided in Table B-1. The range of permeability likely to be encountered for each geological unit is also incorporated in Table B-1, based on the BGS permeability data (Figure B5 and C6).

Table B-1: geological units in Southend-on-Sea and their hydrogeological significance

Geological Units		Permeability (based on BGS permeability map)	Hydrogeological Significance
Superficial Geology	Alluvium	High to very low	Variable (but probably an aquitard)
	Blown Sand	High	Secondary aquifer
	Tidal Flat Deposits	Low to very low	Aquitard
	Beach and Tidal Flat Deposits	Moderate to very low	Variable (but probably an aquitard)
	Head	Moderate to very low	Variable (probably an aquitard but may locally form a secondary aquifer)
	River Terrace Deposits (silt and clay)	Low to very low	Aquitard
	River Terrace Deposits (sand and gravel)	Very high to high	Secondary aquifer
Bedrock Geology	London Clay Formation	Moderate to very low	Aquiclude[37]
	Lower London Tertiaries	N/A	Principal aquifer
	Chalk	N/A	Principal aquifer

'Aquifer' - allows significant groundwater movement
'Aquitard' - allows some groundwater movement
'Aquiclude' - does not allow groundwater movement
'N/A' not available

Bedrock Hydrogeology

The London Clay Formation is an aquiclude and does not permit groundwater flow. It is classified as unproductive stratum.

The physical properties for secondary aquifers in England and Wales[38] suggests *'The Thanet Sand Formation, Lambeth Group and the Harwich Formation are often considered as a single groundwater unit, known as the 'Basal Sands' aquifer, which is in hydraulic continuity with the Chalk…..in the 19th Century, water supplies to London were obtained from these beds, but in the early 20th Century this practice was abandoned almost entirely in favour of deeper bores into the Chalk'*. Therefore the 'Basal Sands' are considered to behave as an aquifer, allowing significant groundwater flow.

The underlying Upper Chalk is classified as a principal aquifer and in this region is thought to be in hydraulic continuity with the overlying 'Basal Sands' aquifer. The significant thickness of London Clay Formation confines these aquifers and they are not pertinent to the current study.

Superficial Hydrogeology

Head deposits are expected to behave as an aquitard, although sand horizons may locally form a secondary aquifer depending on their lateral extent and thickness.

Alluvium along Eastwood Brook, Tidal Flat Deposits, and Beach and Tidal Flat Deposits along the coastline are expected to behave as aquitards.

The sand and gravel River Terrace Deposits are expected to behave as a secondary aquifer, although in many areas these are overlain by the silt and clay River Terrace Deposits aquitard. The sand and gravel River Terrace Deposits are of primary interest to the current study.

[37] The BGS permeability data set suggests a moderate to very low permeability. However, the London Clay is expected to behave as an aquiclude.
[38] Jones, H K, Morris, B L, Cheney, C S, Brewerton, L J, Merrin, P D, Lewis, M A, MacDonald, A M, Coleby, L M, Talbot, J C, McKenzie, A A, Bird, M J, Cunningham, J, and Robinson, V K. (2000) The physical properties of minor aquifers in England and Wales. British Geological Survey Technical Report, WD/00/4. 234pp. Environment Agency R&D Publication 68.

Groundwater Levels

Bedrock Geology

Groundwater level data for one borehole located at the North Thames Gas Works has been obtained from the Environmental Agency. The borehole monitors the principal aquifer (Chalk with Lower London Tertiaries) and the piezometric level is approximately 2 m below ground surface. Groundwater level data were also requested from the water supply company, Essex and Suffolk Water. However, they do not have any abstraction or observation boreholes in the Southend-on-Sea area.

Superficial Geology

The Environment Agency does not monitor groundwater levels in the superficial deposits. In addition, it is understood that the Council no longer hold site investigation reports, which often contain limited groundwater level data. However, borehole logs have been collated from the BGS and a number of these provide details of groundwater levels. The boreholes were drilled in different years and so groundwater contours cannot be constructed, although comments on groundwater levels can provide an indication of depth to groundwater.

A summary of the data obtained from BGS logs is provided in Figure B7. Rest water levels are presented where possible, although some of the logs only identify water strikes[39]. However, it is clear that the River Terrace Deposits form a perched aquifer over the London Clay aquiclude, with a groundwater table between around 0.5 m and 10.0 m below ground level, based on the limited available data.

Water Supply Abstractions

In the 1960s and 1970s numerous abstractions targeted the un- / semi-confined Chalk aquifer in the heavily confined Chalk in the region around east Southend-on-Sea. As a consequence of local over-abstraction, a pronounced cone of depression developed in this area, with saline water ingression into the Chalk aquifer (Entec UK Limited[40]). The abstractions ceased in the 1980s, leading to a strong recovery in groundwater levels of up to 40 m.

There is one existing groundwater abstraction within the Southend-on-Sea administrative boundary, located at Prittlewell. However, this is only licensed for around 10 Ml/year and the actual uptake is around 0.002 Ml/d or 2 m3/day. This abstraction will only have a minor impact on the water balance.

Artificial Groundwater Recharge

Water mains leakage data for the administrative area of SBC were requested from Essex and Suffolk Water. Additional recharge to perched groundwater tables by leaking mains could result in a local rise in groundwater levels. This rise might not prove significant under dry conditions, but could exacerbate the risk from groundwater flooding and other sources of flooding following periods of heavy rainfall.

Unfortunately the water company does not assess leakage estimates at this level of detail. However, for the area of Essex served by Essex and Suffolk Water, the reported leakage level for 2006/07 was 68.0 Ml/d (Essex and Suffolk Water, April 2008). It would be possible to estimate leakage in the Southend-on-Sea administrative area by apportioning total leakage for the Essex area based on population estimates. This is outside of the scope of the current study, but the method could be used in future investigations.

The drainage/sewer network can act as a further source of artificial recharge. When pipes are installed within principal or secondary aquifers, the groundwater and drainage network may be in partial hydraulic connection. When pipes are empty, groundwater may leak into the drainage network with water flowing in through cracks and porous walls, draining the aquifer and reducing groundwater levels. During periods of heavy rainfall when pipes are full, leaking pipes can act as recharge points, artificially recharging the groundwater table and subsequently increasing groundwater levels with

[39] A ‘water strike’ can be used as a ‘rest water level’ if the water table is within the superficial aquifer. However, there are locations where the aquifer is fully saturated and confined by an overlying clay aquitard. In this situation the ‘water strike’ can be at significant depth (interface between aquifer and aquitard), but the water level in the borehole will rise to a ‘rest water level’ owing to pressure within the confined aquifer.

[40] Entec UK Limited, June 2006. Essex Groundwater Investigation. Hydrogeological Conceptualisation of the South Essex Reporting Unit. Issue 2.

potential impacts on groundwater quality. Further details on sewer network and groundwater interactions were requested from Anglian Water, although at the time of writing, no additional information had been received.

Surface Water / Groundwater Interactions

Groundwater / surface water interactions will be limited by the extensive historic modification of surface water courses. For example, approximately 7.6 km of channel improvements have been carried out on Eastwood Brook through Southend-on-Sea, including channel straightening, deepening, and lining the bed and banks with concrete to increase the capacity and flow rate (Environment Agency, August 2008)[41]. The lining of the bed and banks with concrete will limit surface water and groundwater interactions.

It has been reported that during the summer months, base flows in Prittle Brook and Eastwood Brook are very low due to the small volumes of groundwater that can be stored naturally in the superficial deposit aquifers present in the area (Environment Agency, August 2008). However, they may also be low owing to limited hydraulic connectivity with the superficial geology aquifers resulting from the river channel modifications. Without groundwater level data for the superficial geology aquifers, it is not possible to gain an understanding of the relationship between surface water and groundwater.

Assessment of Groundwater Flooding Susceptibility

Groundwater Flooding Mechanisms

Based on the current hydrogeological conceptual understanding, there are four key groundwater flooding mechanisms that may exist:

- **Superficial aquifers along Prittle Brook (Priory Park and downstream of the Park), Eastwoood Brook (Eastwood Area) and upstream of the Barge Pier Ditch:** groundwater flooding may be associated with the substantial sand and gravel River Terrace Deposits, or to a lesser degree, sand lenses within Tidal Flat Deposits and Head deposits, where they are in hydraulic continuity with surface water courses. Stream levels may rise following high rainfall events but still remain “in-bank”, and this can trigger a rise in groundwater levels in the associated superficial deposits. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars, which have been constructed within the superficial deposits. The Cassini reproduction of the historic Ordnance Survey map (1919 – 1926) is presented in Figure B8. Within the UK, houses with cellars / basements were largely built within the Victorian era and into the early 1900s. Therefore, the developed areas on Figure B8 are more likely to comprise properties with cellars / basements.
- **Superficial aquifers in various locations:** a second mechanism for groundwater flooding is also associated with substantial River Terrace Deposits (gravel and sand) and Blown Sand, or sand lenses within Tidal Flat Deposits and Head deposits, but occurs where they are not hydraulically connected to surface water courses. Perched groundwater tables can exist within these deposits, developed through a combination of natural rainfall recharge and artificial recharge e.g. leaking water mains. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars.
- **Superficial aquifers along the coastline (Two Tree Island and east of Southend Pier to Pigs Bay):** a third mechanism for groundwater flooding could occur where River Terrace Deposits (gravel and sand), Blown Sand, or sand lenses within Tidal Flat Deposits are present behind coastline flood defences. It is possible that tidal fluctuations propagate northwards through the superficial deposits, increasing the potential for groundwater flooding. The properties at risk from this type of groundwater flooding are probably limited to those with basements / cellars.
- **Impermeable (silt and clay) areas downslope of superficial aquifers in various locations:** a fourth mechanism for groundwater flooding may occur where groundwater springs / seepages form minor flows and ponding over impermeable strata where there is poor drainage (artificial or natural).
- **Made ground in various locations:** a final mechanism for groundwater flooding may occur where the ground has been artificially modified to a significant degree. If this ‘made ground’ is of substantial thickness and permeability, then a shallow perched water table may exist. This could potentially result in groundwater flooding at properties with basements, or may equally be considered a drainage issue. Areas mapped by the BGS as containing made ground are shown in Figure B-2. It is noted that the made ground deposits are mostly over the River Terrace Deposits and may either form a continuous aquifer with these superficial deposits, or provide a low permeability cap, depending on the composition of the made ground.

[41] Environment Agency (2008) South Essex Catchment Flood Management Plan. Final Plan.

Evidence of Groundwater Flooding

No groundwater flooding incidents within the study area have been reported to the Environment Agency. However, there is one incident reported to SBC between 1998 and 2005, related to the flooding of a basement in the Eastern Esplanade area (Figure B7). It is possible that this groundwater flooding incident was caused by a perched groundwater table within the Blown Sand deposits. Evidence of high groundwater levels and some minor groundwater flooding was also observed in Shoeburyness (as illustrated in Figure B-0).

There are also two groundwater flooding incidents reported to the fire service (Figure B7); one located near to the Victoria Station and a second to the west of Leigh-on-Sea. These were both basement flooding incidents. However, the flood incident west of Leigh-on-Sea is located on the London Clay Formation aquiclude, and so this may not be a groundwater related incident.

Groundwater Flooding Susceptibility Datasets

The BGS has produced a dataset showing areas susceptible to groundwater flooding (2010) on the basis of geological and hydrogeological conditions (Figure B9). This dataset is considered to represent the present day flood risk, The map indicates that susceptibility to groundwater flooding is very high to high in some areas where Head deposits and River Terrace Deposits are present at the surface; along Prittle Brook, Eastwood Brook, Shoeburyness (eastern part of the study area) and around Southchurch in the central part of the study area. As expected, these locations coincide with those areas where the BGS has identified higher permeability (see Figure B10).

The approximate areas within the study area that are identified by the BGS as being susceptible to groundwater flooding seem accurate. However, it is possible that the various categories from 'very high' to 'very low' may not be entirely accurate given the poor availability of groundwater level data to the BGS; the Environment Agency does not monitor superficial groundwater levels for the study area. Nonetheless, it is possible to validate the BGS data at the location of the groundwater flooding incident along the Eastern Esplanade; the data indicates a 'very high' susceptibility where the Blown Sand deposits are present at outcrop. In addition, the shallow water strikes within the River Terrace Deposits are also in areas identified by the BGS as having a 'high' to 'very high' susceptibility to groundwater flooding.

The BGS groundwater flooding susceptibility data indicates a high susceptibility to groundwater flooding in areas where Head deposits outcrop. However, in reality the Head deposits are variable in composition (clay, silt and sand) and their thickness and lateral extent is limited over the study area. In addition, there were no identified water strikes in the BGS geological logs for the Head deposits. Based on the current assessment, it is thought that the Head deposits are not as susceptible to groundwater flooding as indicated by the BGS data.

Finally, those areas identified by the BGS as having no susceptibility to groundwater flooding could still be affected where groundwater springs / seepages form minor flows and ponding over impermeable strata. This mechanism may have resulted in the regular ponding of water observed at Jenna Close (adjacent to the former River Shoe), where it is possible that groundwater seepages from the River Terrace Deposits seep onto the relatively impermeable Tidal Flat Deposits.

Importance of Long Term Groundwater Level Monitoring

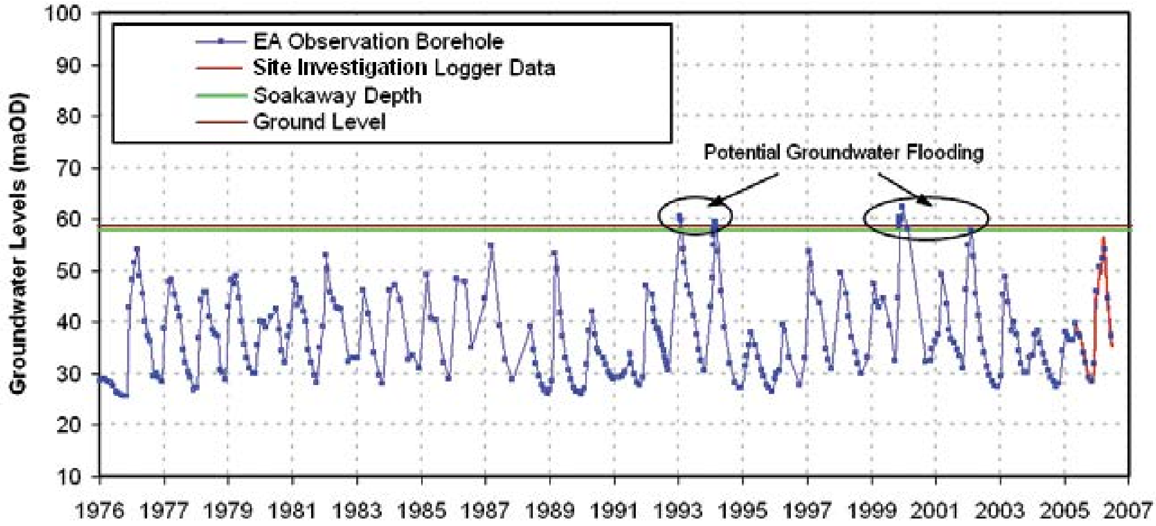
Groundwater flow direction, depth to groundwater, topography and the degree of artificial influence in the subsurface (e.g. leaking water mains or groundwater abstractions) play an important role when considering the susceptibly of an area to groundwater flooding. Unfortunately groundwater level data for the superficial aquifers is limited to recorded water strikes or rest water levels on BGS borehole logs, which only provide groundwater levels at one location and for one point in time. Without long term (and continuous) groundwater monitoring, it is not possible to derive groundwater level contours, understand groundwater / surface water interactions or likely maximum seasonal fluctuations. Therefore it is not possible to provide a detailed assessment of groundwater flooding susceptibility or provide detailed advice on suitability for infiltration SuDS until more detailed information on long term groundwater levels and seasonal groundwater fluctuations.

It is probably not sufficient to rely on the work undertaken by developers through the planning application process, unless longer term (and continuous) monitoring is included as a condition attached to planning approval. Groundwater levels are often only measured once, or, at most, for a number of weeks. It would be advisable for SBC, in combination with the Environment Agency, consider the long term monitoring of superficial deposit groundwater levels. It is recommended that this monitoring is initially focussed on future development areas in order to inform a detailed assessment of suitability for infiltration SuDS.

It is also important to understand how changing policies relating to infiltration SuDS can impact upon groundwater levels. For example, the historic mapping (Figure B8) indicates that much of the Shoeburyness area, where sand and gravel River Terrace Deposits are present at surface, was undeveloped in the early 1900s. This area has subsequently been developed and natural recharge to the aquifer will have reduced, possibly leading to a lowering of groundwater levels if not balanced by an increase in artificial recharge through leaking pipes. The introduction of infiltration SuDS (e.g. soakaways) may slowly reverse this process, leading to a subsequent rise in groundwater levels. This could prevent soakaways from operating and the reduction in unsaturated zone thickness may not be acceptable to the Environment Agency owing to its responsibilities under the Water Framework Directive. It may also cause groundwater flooding of infrastructure, basements / cellars etc that were designed and constructed during a period of reduced groundwater recharge.

Long term groundwater level monitoring could be implemented to support decision making with respect to future land development and future co-ordinated investments to reduce the risk of flooding and inform the assessment of suitability for infiltration SuDS.

Figure B-2: Schematic demonstrating the importance of long term groundwater level monitoring



Water Framework Directive and Infiltration SuDS

The Anglian River Basin Management Plan (RMBP) sets out how the Water Framework Directive objectives will be met for the study area. The RBMP was published by the Environment Agency in December 2009 and outlines measures that are required by all sectors impacting the water environment. Draft updates to the RBMPs are presently out to consultation until April 2015. The Anglian RBMP[42] is considered within the current study, since infiltration Sustainable Drainage Systems (SuDS) have the potential to impact the water quality and water quantity status of aquifers.

Improper use of infiltration SuDS could lead to contamination of the superficial deposit or bedrock aquifers, leading to deterioration in aquifer quality status or groundwater flooding / drainage issues. However, correct use of infiltration SuDS is likely to help improve aquifer quality status and reduce overall flood risk.

A consultation which Defra ran between September and October 2014 regarding the implementation of the Sustainable Drainage Provisions in Schedule 3 to the FWMA[43] proposed a new role for local planning authorities in assessing applications for SuDS in new development alongside planning applications. Should these proposals be implemented, SBC will have significant new responsibility to ensure the best drainage approach is implemented for maximum benefit in the Borough.

Key Water Level Considerations (Figure B9)

The areas that may be suitable for infiltration SuDS exist where there is a combination of high ground and permeable geology. However, consideration should be given to the impact of increased infiltration SuDS on properties further down gradient. An increase in infiltration / groundwater recharge will lead to an increase in groundwater levels, thereby increasing the susceptibility to groundwater flooding at a down gradient location. This type of analysis is beyond the scope of the current report.

[42] Environment Agency (2009) Anglian district river basin management plan https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/309814/River_Basin_Management_Plan.pdf
[43] https://www.gov.uk/government/consultations/implementation-of-the-sustainable-drainage-provisions-in-schedule-3-to-the-flood-and-water-management-act-2010 [accessed 03.12.2014]

It is important to be aware of groundwater level conditions at a potential development site. The maximum likely groundwater levels should be assessed, to confirm that soakaways will continue to function even during prolonged wet conditions. The areas where there is increased susceptibility to groundwater flooding are shown on Figure B9.

Key Geological Considerations (Figure B6)

The minimum permeability data obtained from the BGS can be used to identify areas that are potentially suitable for infiltration SuDS (Figure B6). There also exist maximum permeability data (Figure B5). However, the minimum permeability is understood to be more representative of the bulk permeability.

The key areas where infiltration SuDS are potentially suitable are associated with the outcrop of sand and gravel River Terrace Deposits.

Key Water Quality Considerations

Where possible, infiltration SuDS should also be located away from areas of historic landfill and areas of known contamination or risk of contamination. This is to ensure that the drainage does not re-mobilise latent contamination or exacerbate the risk to groundwater quality and possible down gradient groundwater receptors, such as abstractors, springs and rivers. A preliminary groundwater risk assessment should be included with the planning application.

Summary of Groundwater Flood Risk

- The River Terrace Deposits form a significant perched aquifer over the London Clay aquiclude across much of the central and eastern parts of the SBC administrative area. In addition, the Blown Sand deposits (Eastern Esplanade) and possibly the Head deposits in localised areas, will behave as aquifers. The Environment Agency and Council do not currently monitor groundwater levels in the superficial deposits;
- Borehole logs have been obtained from the British Geological Survey. These indicate that the River Terrace Deposits are water bearing and the groundwater table is between around 0.5 m and 10.0 m below ground level, based on the limited available data;
- A number of potential groundwater flooding mechanisms have been identified. Of significance are those flooding mechanisms associated with the superficial aquifers and their hydraulic continuity with surface water courses and Thames Estuary tidal fluctuations. Properties at most risk are those with basements / cellars, and areas where these properties are likely to exist have been identified;
- No groundwater flooding incidents within the study area have been reported to the Environment Agency. However, there exists one incident reported to the Council between 1998 and 2005, related to the flooding of a basement in the south seafront area. It is possible that this groundwater flooding incident was caused by a perched groundwater table within the Blown Sand superficial deposits;
- The BGS has produced a dataset showing areas susceptible to groundwater flooding on the basis of geological and hydrogeological conditions. The map indicates that susceptibility to groundwater flooding is very high to high in some areas where Head deposits and River Terrace Deposits are present at surface; along Prittle Brook, Eastwood Brook, Shoeburyness (eastern part of the study area) and around Southchurch in the central part of the study area;
- Those areas where the BGS has identified no susceptibility to groundwater flooding may still be affected where groundwater springs / seepages form minor flows and ponding over impermeable strata. This mechanism may have resulted in the regular ponding of water observed adjacent to the Barge Pier Ditch, where groundwater seepages from the River Terrace Deposits may seep onto the relatively impermeable Tidal Flat Deposits; and
- Without long term groundwater monitoring, it is not possible to derive groundwater level contours or understand maximum seasonal fluctuations and potential climate change impacts. Therefore, at this stage, it is not possible to provide a detailed assessment of groundwater flood risk or provide detailed advice on suitability for infiltration SuDS.

Figures

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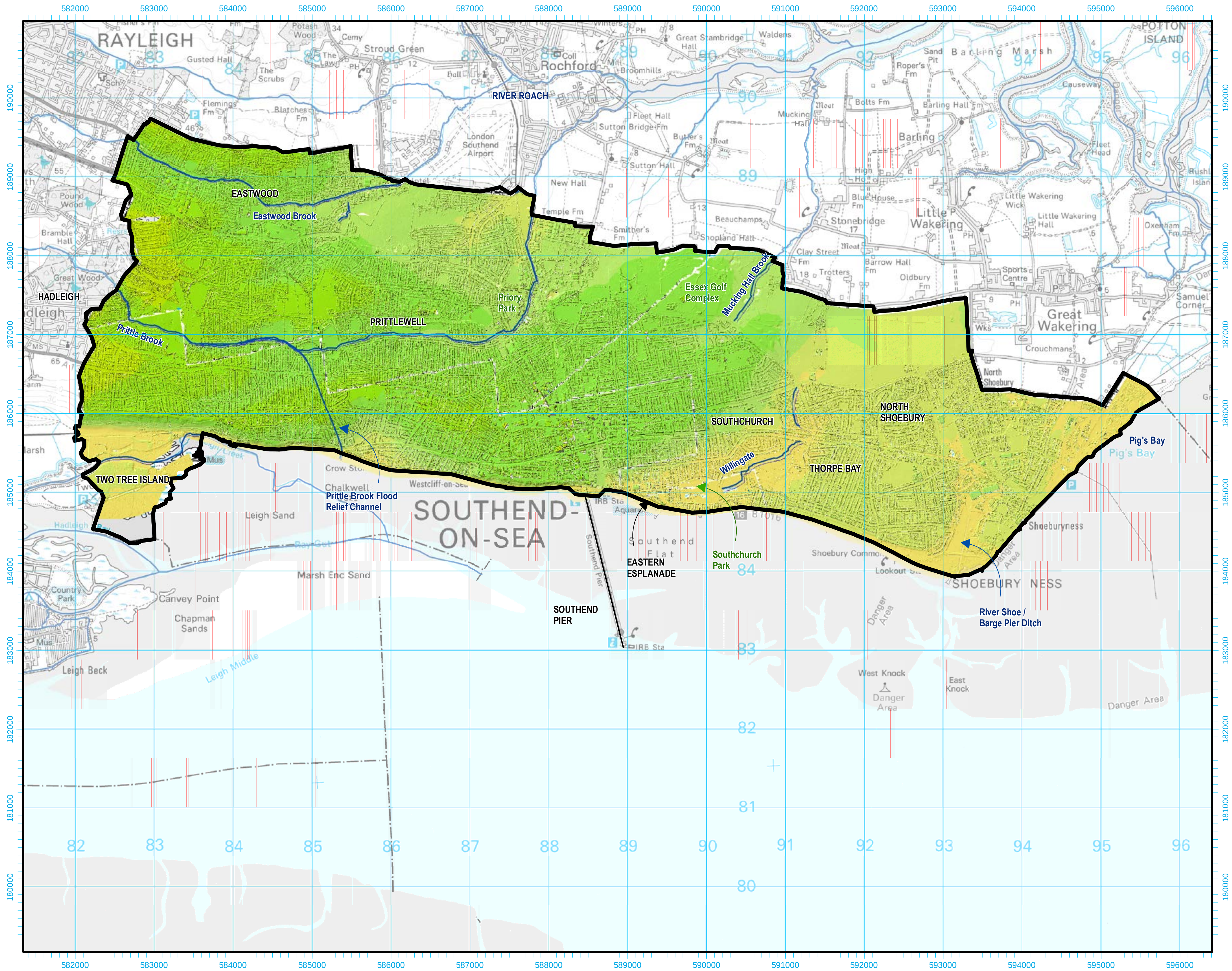

Legend

- Southend-on-Sea Borough Council Boundary
- High Elevation
- Low Elevation

Drawing Status
DRAFT

Job Title
Southend-on-Sea Surface Water Management Plan

Drawing Title
Topography and Hydrology

Scale at A3	1 : 50 000		
Drawn by: SC	Date: 21/09/2010	Approved: TRH	Date: 21/09/2010

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FIGURE B1

Base Map Details
Projection: Transvers Mercator
Scale Factor: 0.999601
Origin: 2° West, 49° North
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Units: metres
Datum: OSGB 1936

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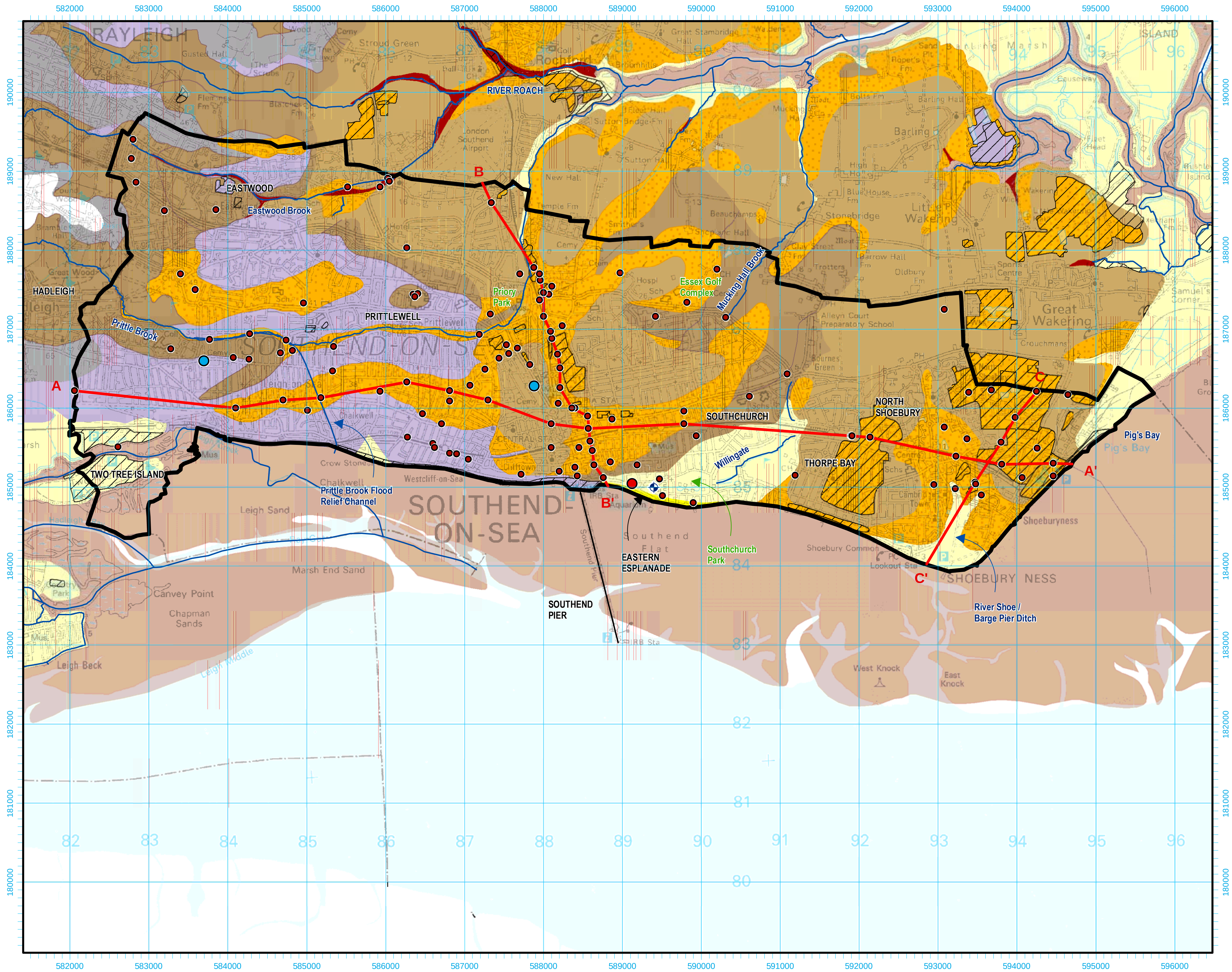

Legend

- Southend-on-Sea Borough Council Boundary
- BGS Borehole Logs
- Fire Service Groundwater Flooding Incidents
- Council Groundwater Flooding Incident
- Environment Agency Observation Borehole
- Cross Section Line
- Made, Worked and Infilled Ground

Superficial Geology

- Alluvium (Clay, Silt and Sand)
- Beach and Tidal Flat Deposits (Clay,Silt and Sand)
- Blown Sand
- Head (Clay, Silt and Sand)
- River Terrace Deposits (Sand and Gravel)
- River Terrace Deposits (Silt and Clay)
- Tidal Flat Deposits (Clay and Silt)

Bedrock Geology

- Claygate Member
- London Clay

Note: Chalk and Lower London Tertiaries are not present at outcrop.

Drawing Status
DRAFT

Job Title
Southend-on-Sea Surface Water Management Plan

Drawing Title
Geological Map

Scale at A3	1 : 50 000		
Drawn by	Date	Approved	Date
Bahar Vural	25/10/2010	Stephen Cox	25/10/2010

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FIGURE B2

Base Map Details
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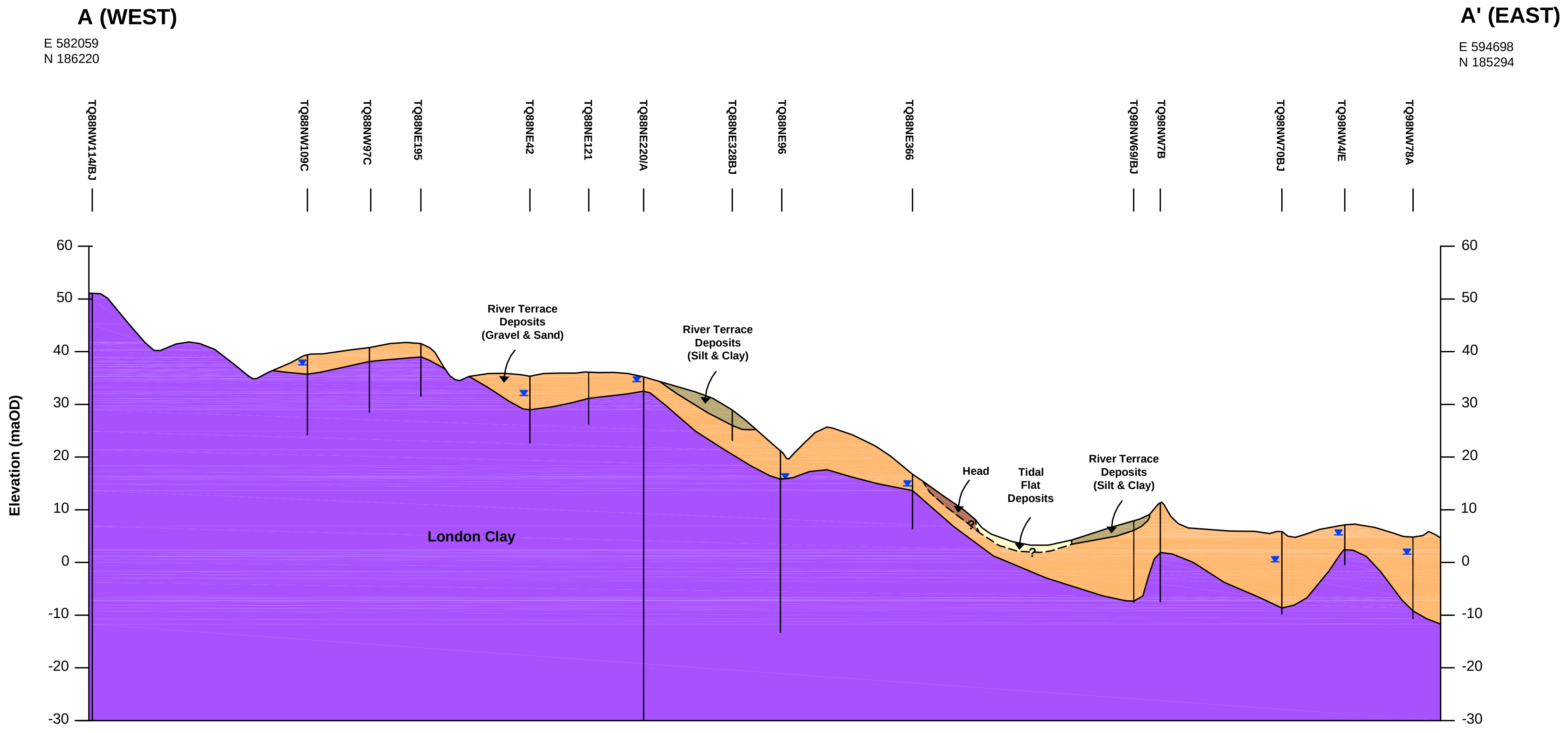

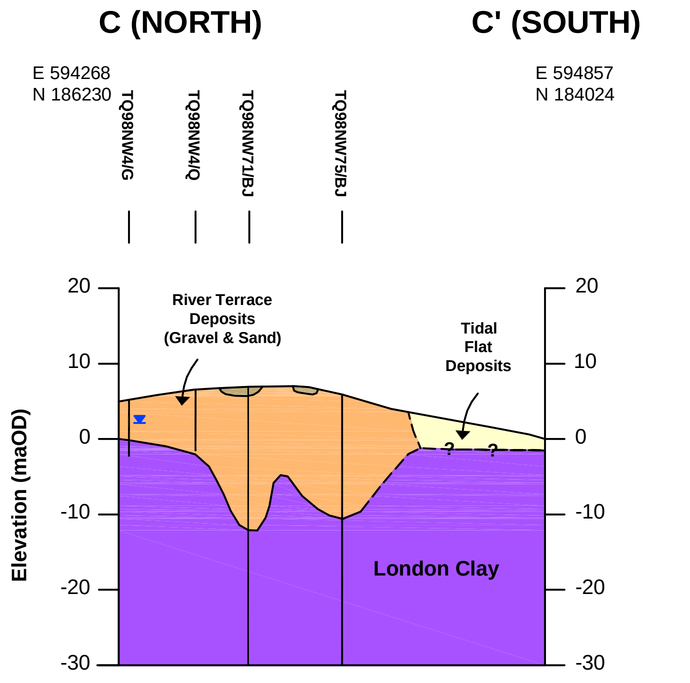

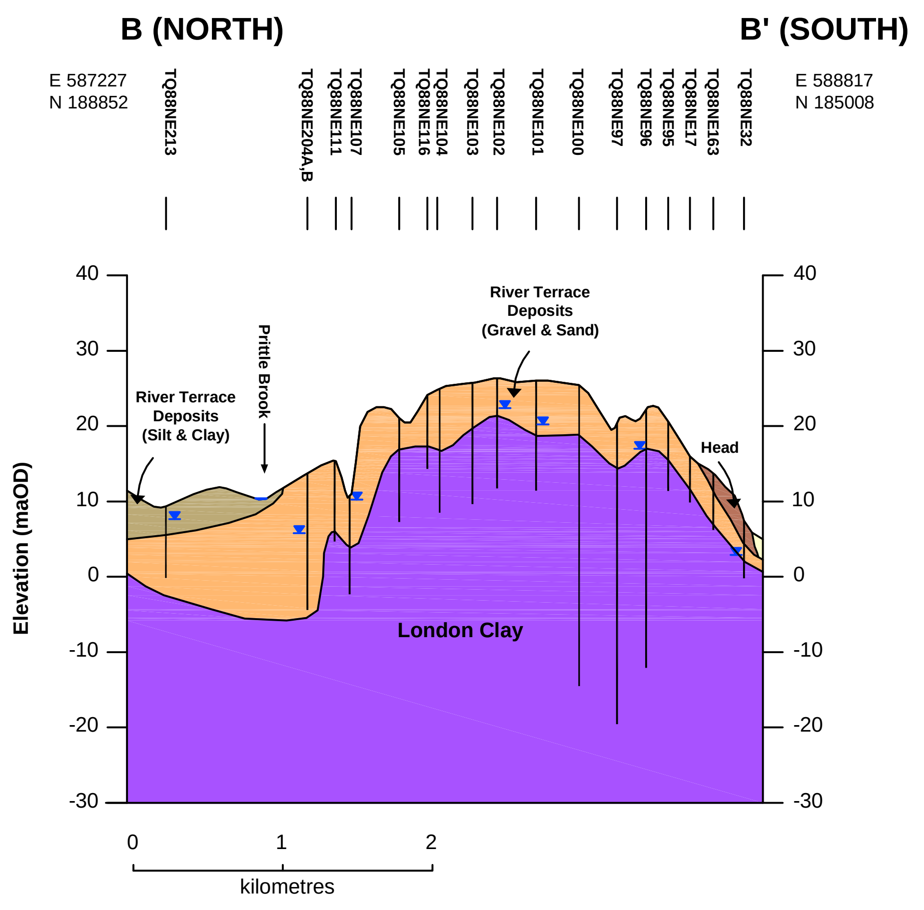

NOTES

Water level data in BGS boreholes recorded in different years

Drawing Status: DRAFT	Scale at A3
	Drawn by: Bahar Vural · Date: 11/08/2010 · Approved: Stephen Cox · Date: 11/08/2010
Job Title: Southend-on-Sea Surface Water Management Plan	
Drawing Title: GEOLOGICAL CROSS SECTIONS	FIGURE B3

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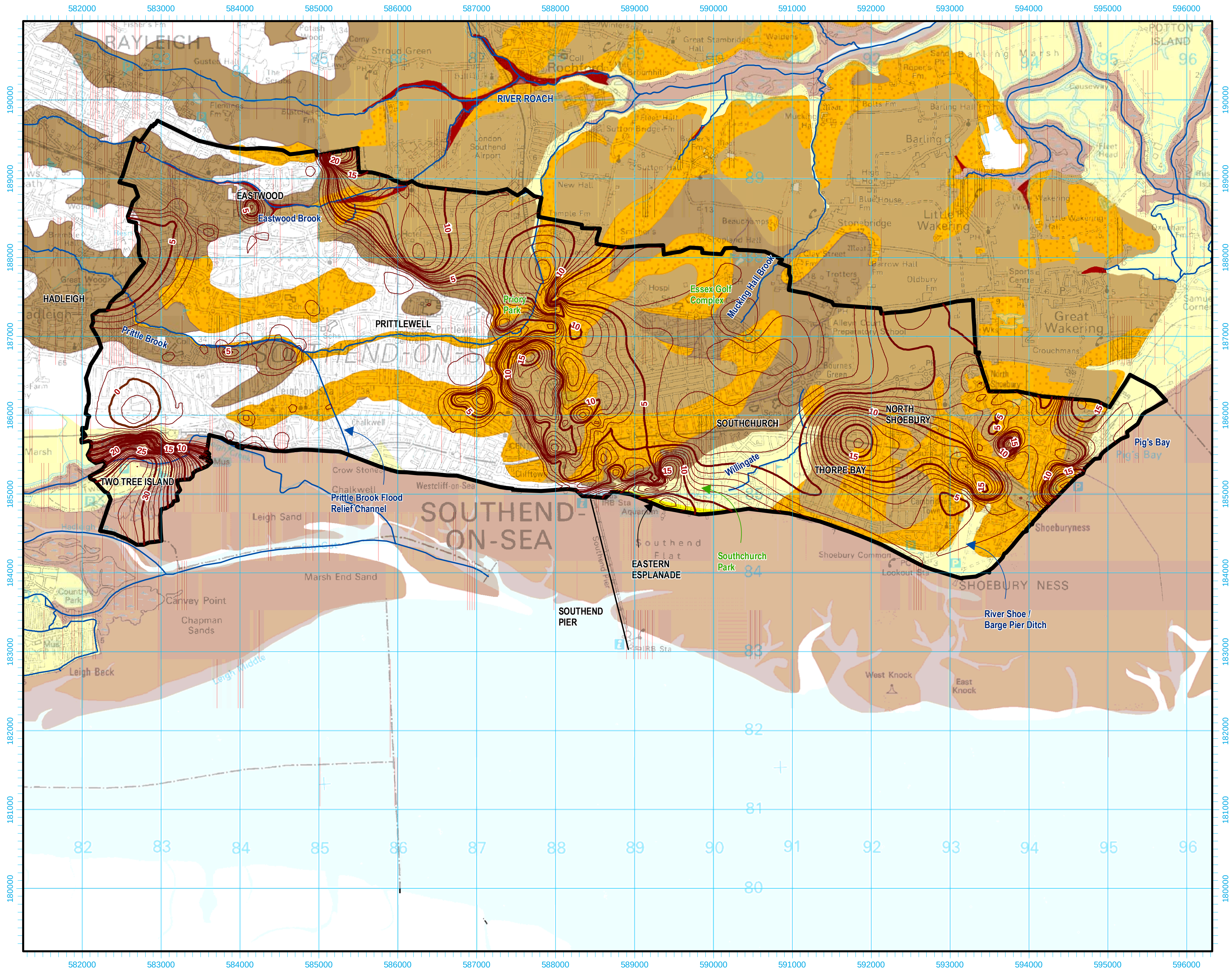

Legend

Southend-on-sea Borough Council Boundary

BGS Drift Thickness (m)

Superficial Geology

- Alluvium (Clay, Silt and Sand)
- Beach and Tidal Flat Deposits (Clay,Silt and Sand)
- Blown Sand
- Head (Clay, Silt and Sand)
- River Terrace Deposits (Sand and Gravel)
- River Terrace Deposits (Silt and Clay)
- Tidal Flat Deposits (Clay and Silt)

Drawing Status

DRAFT

Job Title

Southend-on-Sea Surface Water Management Plan

Drawing Title

Drift Thickness Contour Map

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Drawn by Bahar Vural	Date 25/10/2010	Approved Stephen Cox	Date 25/10/2010

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FIGURE B4

Base Map Details
Projection: Transvers Mercator
Scale Factor: 0.999601
Origin: 2° West, 49° North
Coordinates: 400000,-100000
Units: metres
Datum: OSGB 1936

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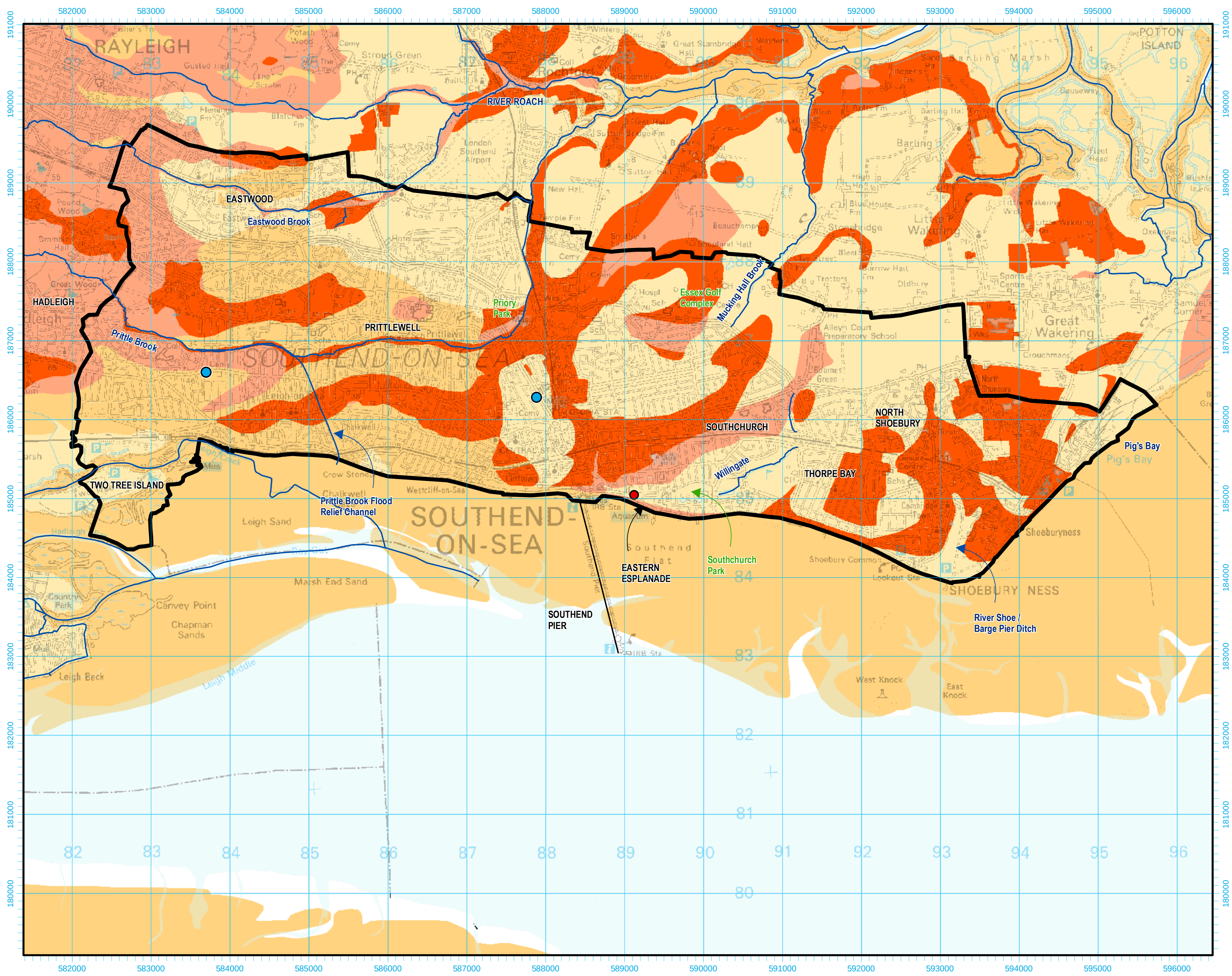

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Base Map Details
Projection: Transvers Mercator
Scale Factor: 0.999601
Origin: 2° West, 49° North
Coordinates: 400000,-100000
Units: metres
Datum: OSGB 1936

Legend

- Council Groundwater Flooding Incident
- Fire Service Groundwater Flooding Incidents
- Southend-on-sea Borough Council Boundary

BGS Maximum Permeability

- Very High
- High
- Moderate
- Low

Drawing Status: **DRAFT**

Job Title: **Southend-on-Sea Surface Water Management Plan**

Drawing Title: **BGS Maximum Permeability Map**

Scale at A3: 1 : 50 000

Drawn by	Date	Approved	Date
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FIGURE B5

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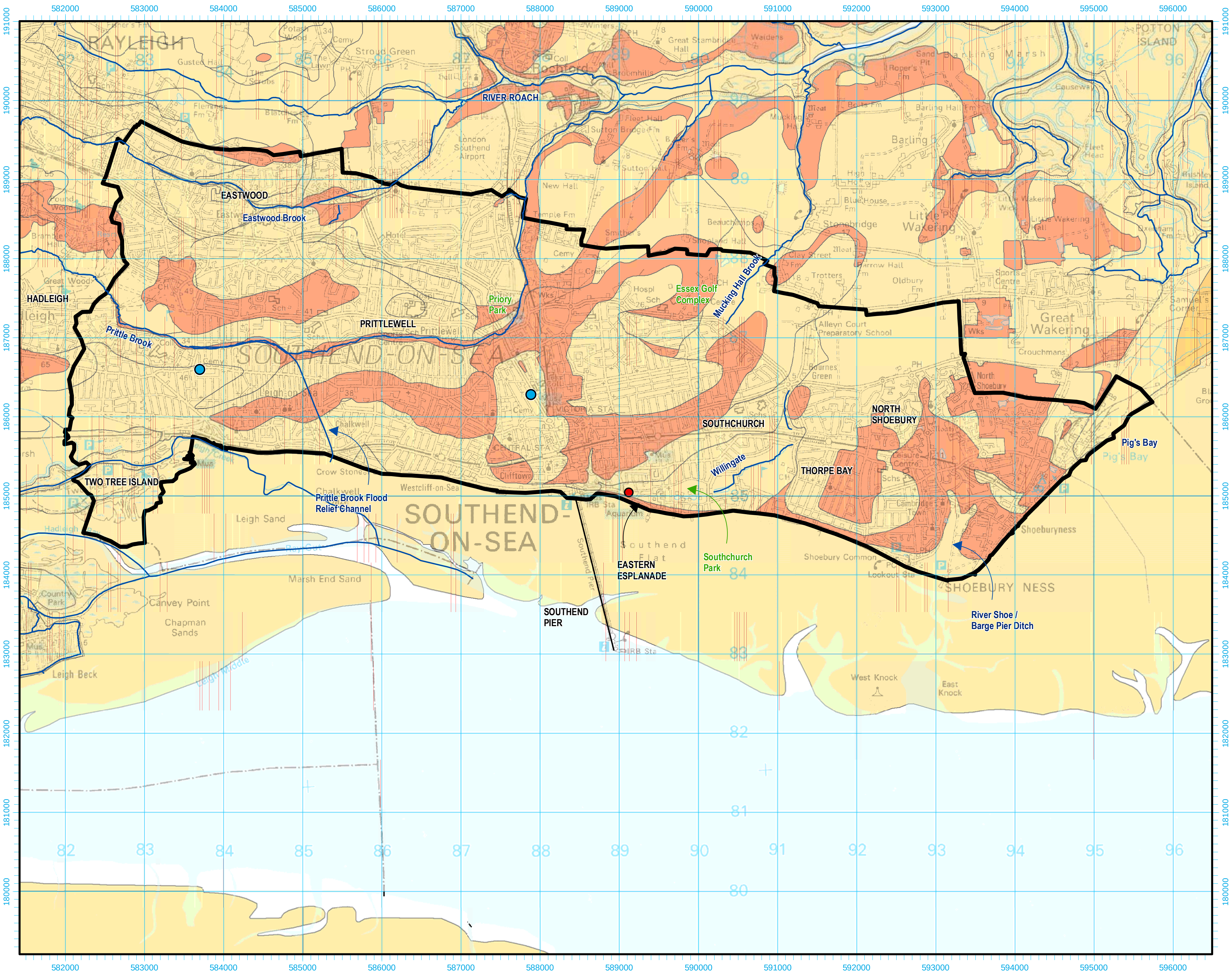

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Base Map Details
Projection: Transvers Mercator
Scale Factor: 0.999601
Origin: 2° West, 49° North
Coordinates: 400000,-100000
Units: metres
Datum: OSGB 1936

Legend

- Council Groundwater Flooding Incident
- Fire Service Groundwater Flooding Incidents
- Southend-on-sea Borough Council Boundary

BGS Minimum Permeability

- High
- Moderate
- Very Low

Drawing Status
DRAFT

Job Title
Southend-on-Sea Surface Water Management Plan

Drawing Title
BGS Minimum Permeability Map

Scale at A3: 1 : 50 000

Drawn by	Date	Approved	Date
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FIGURE B6

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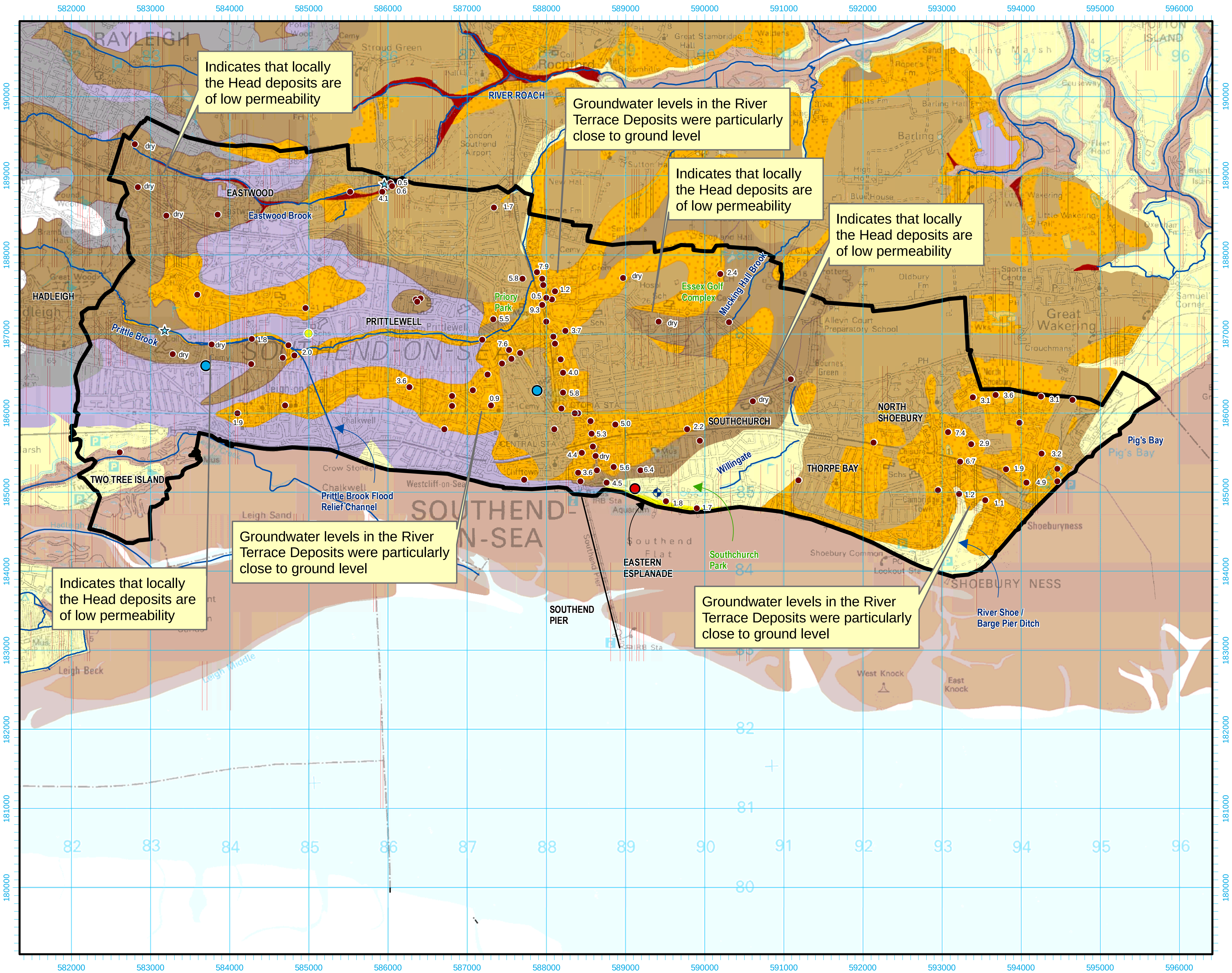

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Legend

- Southend-on-sea Borough Council Boundary
- BGS Borehole Logs - Superficial Deposits
- Council Groundwater Flooding Incident
- Fire Service Groundwater Flooding Incidents
- Environment Agency Observation Borehole

Environment Agency RBMP Monitoring

- Groundwater Monitoring
- Continuous Flow Monitoring

Superficial Geology

- Alluvium (Clay, Silt and Sand)
- Beach and Tidal Flat Deposits (Clay,Silt and Sand)
- Blown Sand
- Head (Clay, Silt and Sand)
- River Terrace Deposits (Sand and Gravel)
- River Terrace Deposits (Silt and Clay)
- Tidal Flat Deposits (Clay and Silt)

Bedrock Geology

- Claygate Member
- London Clay

6.7 Depth to groundwater (m)*

*Note: Rest water levels have been used where provided on the BGS borehole log. However, in some cases only a water strike is provided.

Drawing Status: **DRAFT**

Job Title: **Southend-on-Sea Surface Water Management Plan**

Drawing Title: **Drift Deposits BGS Log Water Level Information**

Scale at A3: 1 : 50 000

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FIGURE B7

Base Map Details
Projection: Transvers Mercator
Scale Factor: 0.999601
Origin: 2° West, 49° North
Coordinates: 400000,-100000
Units: metres
Datum: OSGB 1936

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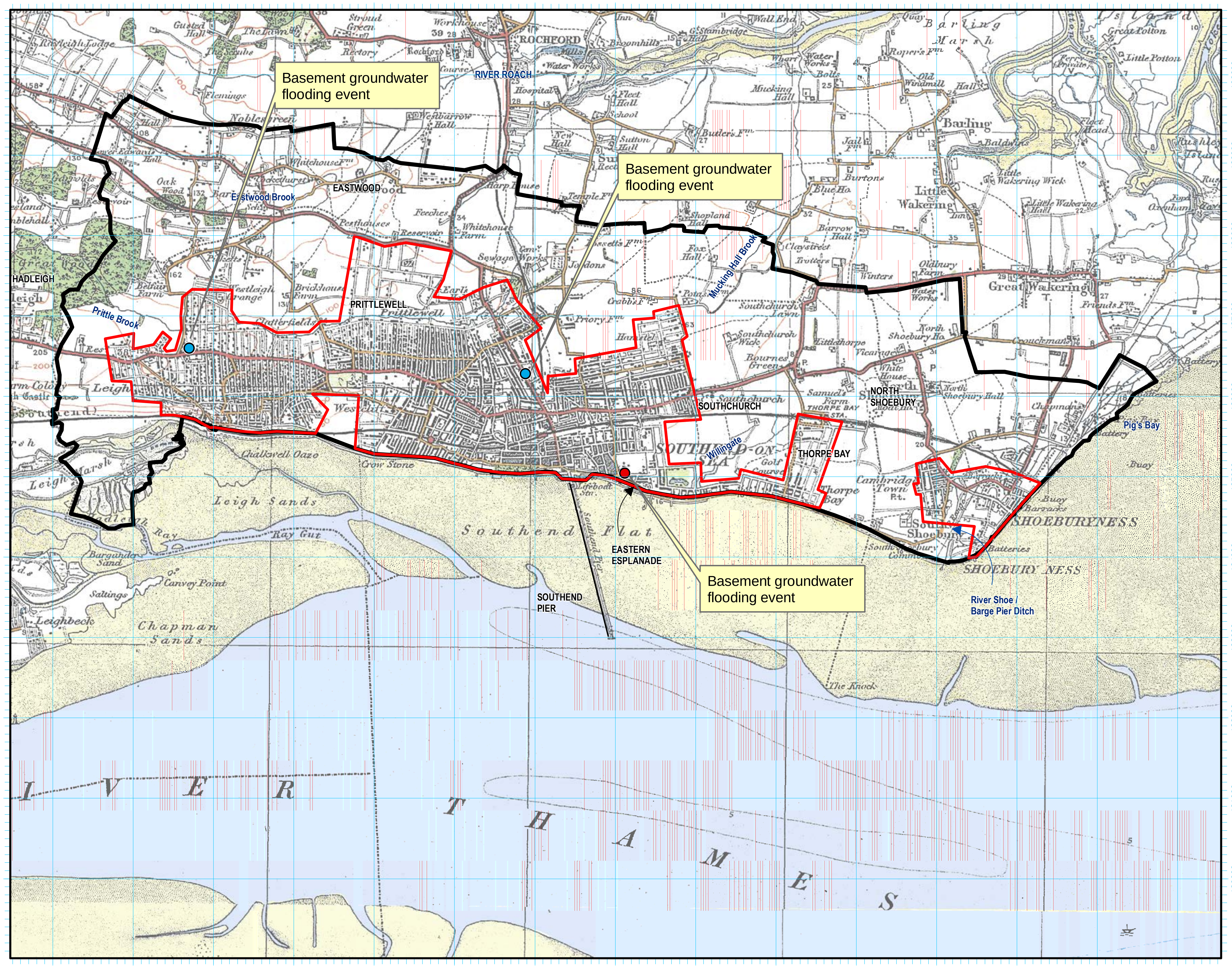

Legend

- Southend-on-sea Borough Council Boundary
- Key Developed Areas
- Council Groundwater Flooding Incident
- Fire Service Groundwater Flooding Incidents

Base Map Details
Projection: Transvers Mercator
Scale Factor: 0.999601
Origin: 2° West, 49° North
Coordinates: 400000,-100000
Units: metres
Datum: OSGB 1936

Drawing Status
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Job Title
Southend-on-Sea Surface Water Management Plan

Drawing Title
Historic Mapping Ordnance Survey 1919 - 1926

Scale at A3	1 : 50 000		
Drawn by SC	Date 25/10/2010	Approved TRH	Date 25/10/2010

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FIGURE B8

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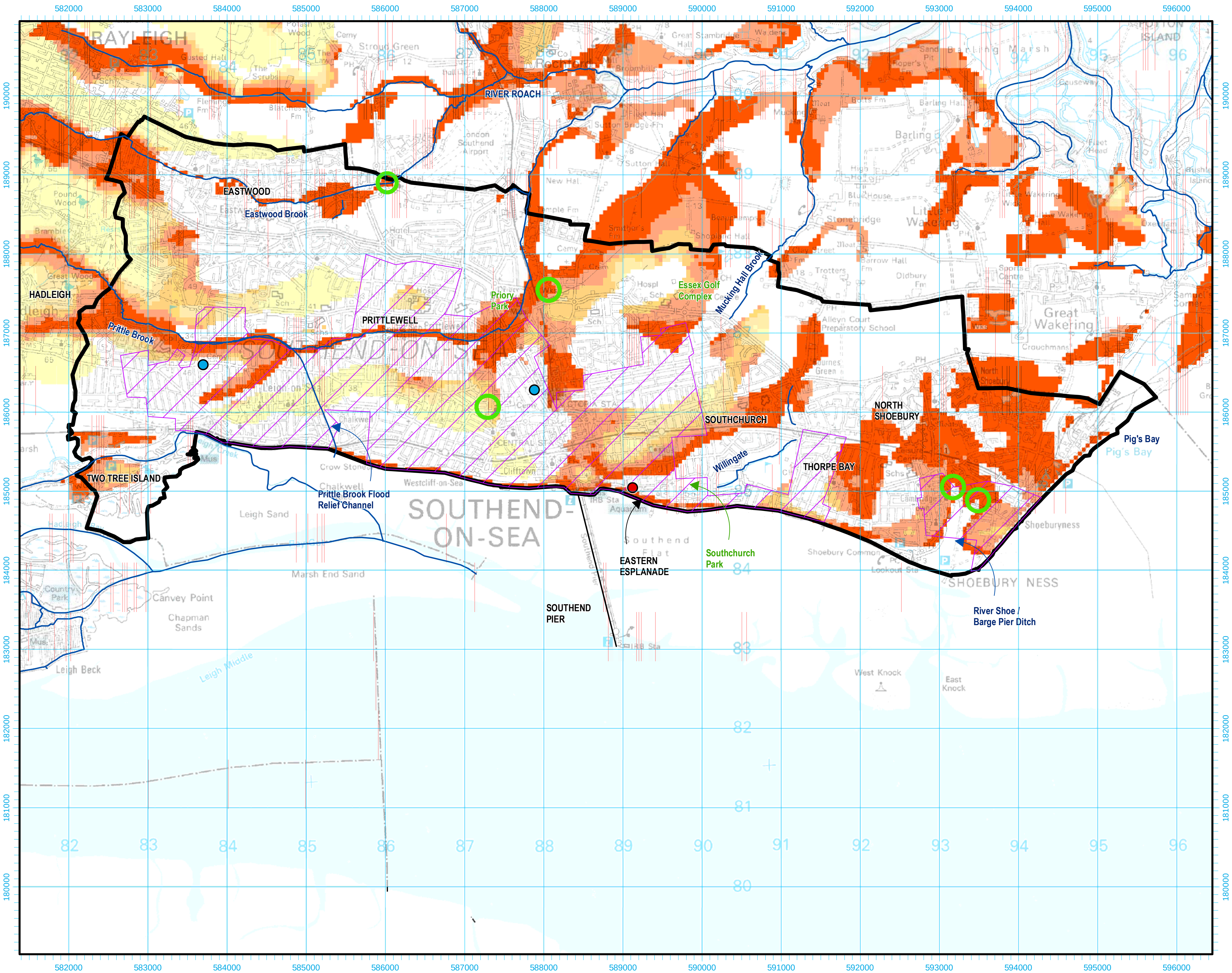
K:\JOBS\D133118 Southend-on-Sea SWMP S2 to S4\700 Technical\711 GIS\01 Layout\BGS Groundwater Flooding Susceptibility Map.mxd



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Legend

- Southend-on-sea Borough Council Boundary
- Council Groundwater Flooding Incident
- Fire Service Groundwater Flooding Incidents
- Area where Basements / Cellars are Likely

BGS Groundwater Flooding Susceptibility

- Very High
- High
- Moderate
- Low
- Very Low
- Groundwater levels close to surface, based on BGS borehole log records.

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'Digital groundwater flooding susceptibility map reproduced from British Geological Survey (c) 2010'

Base Map Details
Projection: Transvers Mercator
Scale Factor: 0.999601
Origin: 2° West, 49° North
Coordinates: 400000,-100000
Units: metres
Datum: OSGB 1936

Drawing Status
DRAFT

Job Title
Southend-on-Sea Surface Water Management Plan

Drawing Title
BGS Groundwater Flooding Susceptibility Map

Scale at A3	1 : 50 000		
Drawn by	Date	Approved	Date
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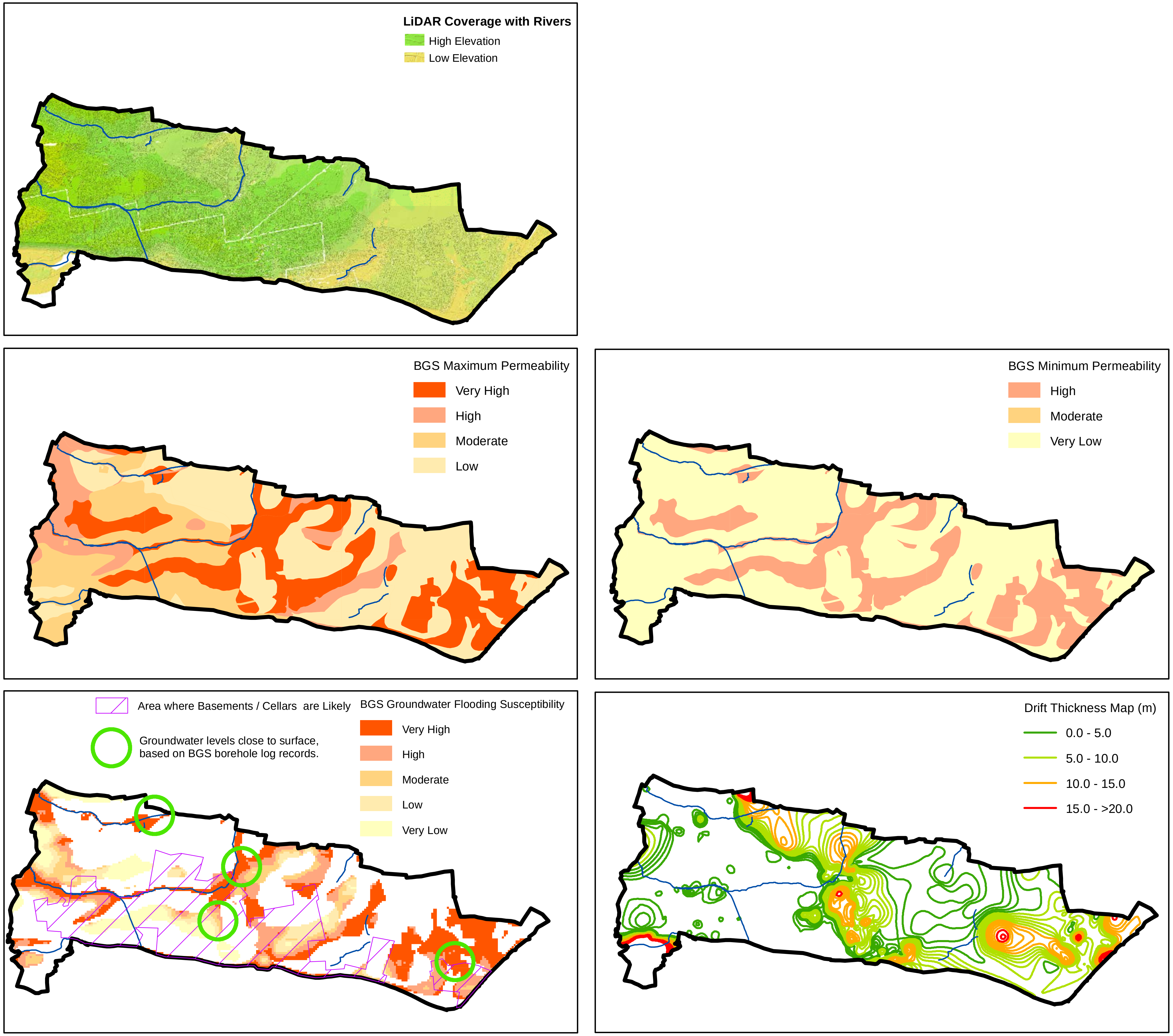
FIGURE B9



'Digital permeability, groundwater flooding susceptibility and drift thickness map reproduced from British Geological Survey (c) 2010'

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Legend

Southend-on-sea Borough Council Boundary

Drawing Status

DRAFT

Job Title

Southend-on-Sea Surface Water Management Plan

Drawing Title

Summary Map

Scale at A3	1 : 100 000		
Drawn by	Date	Approved	Date
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FIGURE B10

Appendix C. uFMfSW Property Counts

Property counts have been completed for the Southend-on-Sea Borough area and the CDA areas utilising the uFMfSW[44] depth mapping and National Receptor Database45. The following tables summaries the counts for the 3.3% AEP, 1% AEP and 0.1% AEP events.

CDA1: Eastwood										
Property Type		3.3% AEP			1% AEP			0.1% AEP		
		0.1m	0.3m	0.5m	0.1m	0.3m	0.5m	0.1m	0.3m	0.5m
Residential		367	146	55	726	328	123	1,802	925	383
Commercial & Industrial		37	20	5	61	33	15	122	85	47
Critical Infrastructure	Emergency Services	0	0	0	0	0	0	0	0	0
	Hospital	0	0	0	0	0	0	0	0	0
	Schools & Education	3	3	0	3	3	1	4	4	3
	Surgery or Health Care	0	0	0	0	0	0	1	1	1
	Residential Home	0	0	0	0	0	0	0	0	0
	Sewage Treatment	0	0	0	0	0	0	0	0	0
	Electricity Sub Station	1	0	0	1	1	0	1	1	0
	Other	39	19	8	76	43	18	143	95	50
Total		447	188	68	867	408	157	2,073	1,111	484

CDA2: Prittle Brook										
Property Type		3.3% AEP			1% AEP			0.1% AEP		
		0.1m	0.3m	0.5m	0.1m	0.3m	0.5m	0.1m	0.3m	0.5m
Residential		417	186	68	981	496	196	2,682	1,637	774
Commercial & Industrial		26	11	5	64	31	9	128	86	50
Critical Infrastructure	Emergency Services	0	0	0	0	0	0	0	0	0
	Hospital	0	0	0	0	0	0	0	0	0
	Schools & Education	3	1	0	4	2	0	8	4	0
	Surgery or Health Care	1	1	0	1	1	0	4	2	0
	Residential Home	0	0	0	0	0	0	0	0	0
	Sewage Treatment	0	0	0	0	0	0	0	0	0
	Electricity Sub Station	0	0	0	1	0	0	6	5	2
	Other	48	25	14	102	57	29	232	153	83
Total		495	224	87	1,153	587	234	3,060	1,887	909

[44] Published by the Environment Agency, December 2013
[45] Downloaded from the Environment Agency GeoStore (October 2014).

CDA3: Temple Sutton										
Property Type		3.3% AEP			1% AEP			0.1% AEP		
		0.1m	0.3m	0.5m	0.1m	0.3m	0.5m	0.1m	0.3m	0.5m
Residential		90	43	14	248	104	32	640	365	173
Commercial & Industrial		0	0	0	1	1	1	2	2	1
Critical Infrastructure	Emergency Services	0	0	0	0	0	0	0	0	0
	Hospital	0	0	0	0	0	0	0	0	0
	Schools & Education	0	0	0	2	0	0	2	2	0
	Surgery or Health Care	0	0	0	1	0	0	1	1	0
	Residential Home	0	0	0	0	0	0	0	0	0
	Sewage Treatment	0	0	0	0	0	0	0	0	0
	Electricity Sub Station	0	0	0	0	0	0	0	0	0
	Other	1	0	0	12	2	1	35	16	8
Total		91	43	14	264	107	34	680	386	182

CDA4: Southchurch										
Property Type		3.3% AEP			1% AEP			0.1% AEP		
		0.1m	0.3m	0.5m	0.1m	0.3m	0.5m	0.1m	0.3m	0.5m
Residential		163	59	24	440	209	67	1,267	695	284
Commercial & Industrial		14	6	4	29	16	7	57	38	20
Critical Infrastructure	Emergency Services	0	0	0	0	0	0	0	0	0
	Hospital	0	0	0	0	0	0	0	0	0
	Schools & Education	1	0	0	2	2	0	5	3	0
	Surgery or Health Care	1	1	0	2	1	0	3	2	0
	Residential Home	0	0	0	0	0	0	0	0	0
	Sewage Treatment	0	0	0	0	0	0	0	0	0
	Electricity Sub Station	1	1	0	2	1	1	5	3	1
	Other	37	20	8	68	39	22	172	110	58
Total		217	87	36	543	268	97	1,509	851	363

CDA5: Shoeburyness										
Property Type		3.3% AEP			1% AEP			0.1% AEP		
		0.1m	0.3m	0.5m	0.1m	0.3m	0.5m	0.1m	0.3m	0.5m
Residential		18	7	4	86	30	7	517	228	67
Commercial & Industrial		7	4	1	14	9	4	40	19	9
Critical Infrastructure	Emergency Services	0	0	0	0	0	0	0	0	0
	Hospital	0	0	0	0	0	0	0	0	0
	Schools & Education	0	0	0	0	0	0	2	1	0
	Surgery or Health Care	0	0	0	0	0	0	1	0	0
	Residential Home	0	0	0	0	0	0	0	0	0
	Sewage Treatment	0	0	0	0	0	0	0	0	0
	Electricity Sub Station	0	0	0	0	0	0	1	0	0
	Other	5	1	0	30	9	3	97	31	11
Total		30	12	5	130	48	14	658	279	87

CDA6: Chalkwell										
Property Type		3.3% AEP			1% AEP			0.1% AEP		
		0.1m	0.3m	0.5m	0.1m	0.3m	0.5m	0.1m	0.3m	0.5m
Residential		70	39	18	185	93	38	609	317	118
Commercial & Industrial		8	1	1	19	10	4	49	22	7
Critical Infrastructure	Emergency Services	0	0	0	0	0	0	0	0	0
	Hospital	0	0	0	0	0	0	0	0	0
	Schools & Education	0	0	0	2	1	0	4	4	2
	Surgery or Health Care	0	0	0	0	0	0	1	1	0
	Residential Home	0	0	0	0	0	0	0	0	0
	Sewage Treatment	0	0	0	0	0	0	1	0	0
	Electricity Sub Station	0	0	0	0	0	0	1	0	0
	Other	29	16	13	56	25	13	154	68	31
Total		107	56	32	262	129	55	819	412	158

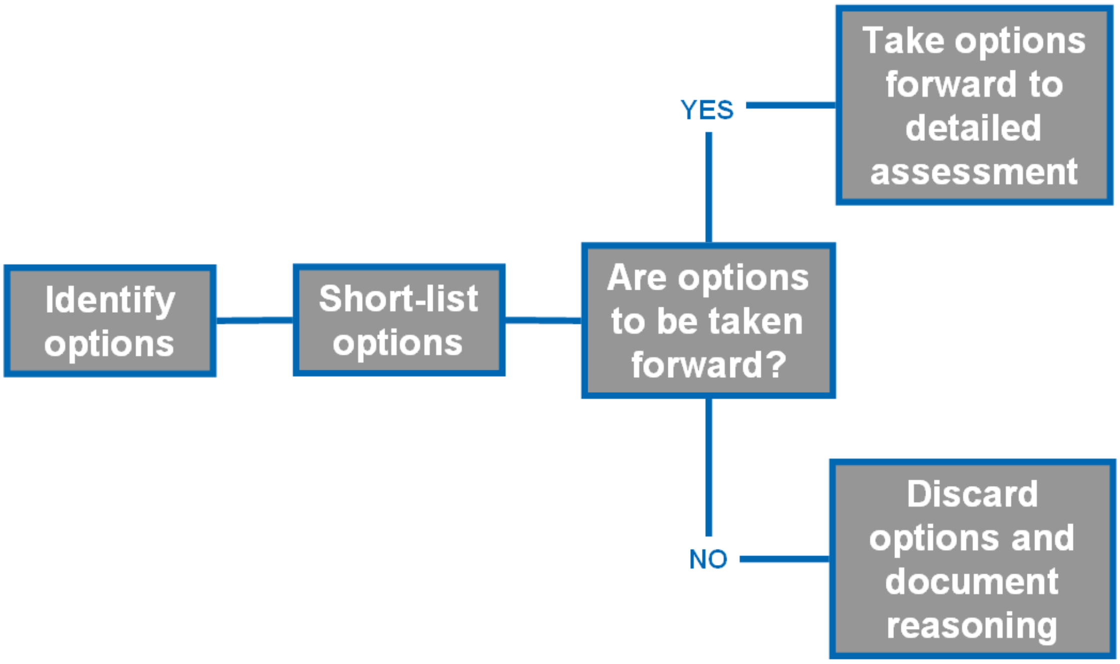
Southend-on-Sea Administrative Area										
Property Type		3.3% AEP			1% AEP			0.1% AEP		
		0.1m	0.3m	0.5m	0.1m	0.3m	0.5m	0.1m	0.3m	0.5m
Residential		1,252	526	202	3,112	1,420	513	10,204	5,183	2,132
Commercial & Industrial		133	59	23	270	141	59	645	385	193
Critical Infrastructure	Emergency Services	2	1	0	3	3	2	4	4	3
	Hospital	0	0	0	0	0	0	0	0	0
	Schools & Education	9	6	2	17	11	3	40	30	9
	Surgery or Health Care	2	2	0	5	2	1	14	10	3
	Residential Home	0	0	0	0	0	0	0	0	0
	Sewage Treatment	0	0	0	0	0	0	1	0	0
	Electricity Sub Station	2	1	0	7	2	1	17	9	3
	Other	215	100	56	494	245	117	1293	689	340
Total		1,615	695	283	3,908	1,824	696	12,218	6,310	2,683

Appendix D. Options Assessment

Overview

The options assessment presented here follows the guidance within Defra's SWMP Technical Guidance 2010 but is focussed on highlighting areas for further detailed analysis and 'quick win' actions.

Figure D-1: Process of identifying and short-listing options and measures (adopted from the Defra SWMP Guidance)



The Defra SWMP Technical Guidance defines measures and options as:

"A measure is defined as a proposed individual action or procedure intended to minimise current and future surface water flood risk or wholly or partially meet other agreed objectives of the SWMP. An option is made up of either a single, or a combination of previously defined measures."

This stage aims to identify a number of measures and options that have the potential to alleviate surface water flooding in Southend-on-Sea. It has been informed by the knowledge gained as part of the Phase 1 and Phase 2 assessment. Where possible, options have been identified with multiple benefits such as also alleviating flooding from other sources. At this stage the option identification pays no attention to constraints such as funding or delivery mechanisms to enable a robust assessment.

The options assessment considers all types of options including:

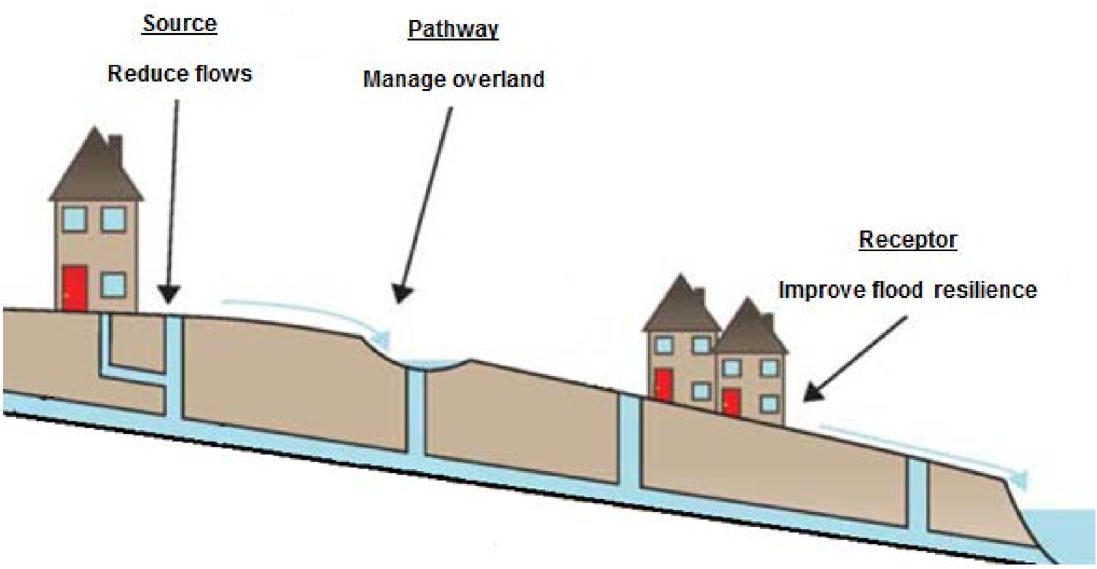
- Options that change the source of risk;
- Options that modify the pathway or change the probability of flooding;
- Options that manage or modify receptors to reduce the consequences;
- Temporary as well as permanent options;
- Options that work with the natural processes wherever possible;
- Options that are adaptable to future changes in flood risk;

- Options that require actions to be taken to deliver the predicted benefits (for example, closing a barrier, erecting a temporary defence or moving contents on receiving a flood warning);
- Innovative options tailored to the specific needs of the project; and,
- Options that can deliver opportunities and wider benefits, through partnership working where possible.

Identifying Measures

A number of measures have been identified for consideration within each CDA, following the source-pathway-receptor conceptual model, as illustrated in Figure D-2.

Figure D-2: Source-pathway-receptor conceptual model (adopted from Defra SWMP Technical Guidance, 2010)



The source-pathway-receptor model describes the conceptual mechanism of flooding. For flooding to occur, there must be a source of flooding, a receptor to flooding, and a pathway linking the two. The identification of possible flood alleviation measures has been based around this concept, as described below.

Source – source measures aim to reduce the rate and volume of surface water runoff through infiltration or storage, hence reducing the impact on the local drainage network.

Pathway – pathway measures seek to manage the overland (and underground) flow pathways of water in the urban environment.

Receptor – receptor measures intend to reduce the impact of flooding to those that are affected (people, properties and the environment).

Structural measures have been defined in the Defra SWMP Technical Guidance as those which require fixed or permanent assets to mitigate flood risk. Non-structural measures are defined as those which may not involve fixed or permanent assets, but contribute to the reduction of flood risk through influencing behaviour.

A high-level assessment was undertaken to assess the opportunities for each of these measures to be implemented within each of the CDAs. A summary of the results of this assessment is included in Table D-1.

Table D-1: Summary of measures opportunity assessment

		CDA1: Eastwood	CDA2: Prittle Brook	CDA3: Temple Sutton	CDA4: Southchurch	CDA5: Shoeburyness	CDA6: Chalkwell
Source	Green Roof	?	✓	?	✓	✓	?
	Rainwater harvesting	?	✓	?	✓	✓	✓
	Water-butts	✓	✓	✓	✓	✓	✓
	Soakaways	?	✓	?	✓	✓	?
	Swales	?	?	?	?	?	?
	Permeable paving	?	✓	?	✓	✓	✓
	Flood storage areas	✓	✓	✓	✓	✓	✓
Pathway	Increasing capacity in drainage systems	✓	✓	✓	✓	✓	✓
	Separation of foul and surface water sewers	X	?	X	?	?	?
	Improved maintenance regimes	✓	✓	✓	✓	✓	✓
	Managing overland flows	✓	✓	✓	✓	✓	✓
	Land management practices	✓	✓	✓	✓	✓	✓
Receptor	Improve weather warning	✓	✓	✓	✓	✓	✓
	Planning policies to influence development	✓	✓	✓	✓	✓	✓
	Temporary flood defences	✓	✓	✓	✓	✓	✓
	Raise community awareness / education	✓	✓	✓	✓	✓	✓
	Improved resilience and resistance measures	✓	✓	✓	✓	✓	✓

Measures Opportunity Assessment Criteria	
✓	There are clear opportunities for implementation of this mitigation measure within the CDA. Measure should be further considered in the Options Assessment.
?	There are some opportunities for the implementation of this mitigation measure within the CDA. Measure should be further considered within the Options Assessment.
X	There are no opportunities for the implementation of this mitigation measures within the CDA. This measure should be discounted.

There is potential to implement a range of measures within the Southend-on-Sea area; however, some measures are more suitable and feasible than others and therefore there is greater opportunity to implement these. The suitability of some source control measures depends on the land use within the CDA. Some source control measures (such as Sustainable Drainage Systems (SuDS)) can be unsuitable to retrofit, so there may be limited potential to implement such measures in CDA1 and CDA3 which are heavily urbanised with few development opportunities. CDA2, CDA4 and CDA5 have a greater potential to support a wider range of source control measures due to large areas of potential development.

However, there is some potential for most of the measures across Southend-on-Sea; therefore, these will be further considered as part of the options assessment stage.

Identifying Options

Following the identification of measures suitable for use within each CDA, a series of options were defined based on this assessment. Each of the standard measures identified above have been categorised within an option, which are based initially on a range of options (scheme categorisations) identified in Table D-2.

Table D-2: Potential options

Description		Standard Measures Considered
Do Nothing	Make no intervention / maintenance	• None
Do Minimum	Continue existing maintenance regime	• None
Improved Maintenance	Improve existing maintenance regimes e.g. target improved maintenance to critical points in the system.	• Improved maintenance regimes
Planning Policy	Use forthcoming development control policies to direct development away from areas of surface water flood risk or implement flood risk reduction measures.	• Planning policies to influence development
Source Control, Attenuation and SuDS	Source control methods aimed to reduce the rate and volume of surface water runoff through infiltration or storage, and therefore reduce the impact on receiving drainage systems.	• Green roof • Soakaways • Swales • Permeable paving • Rainwater harvesting • Detention basins • Ponds and wetlands • Land management practices
Flood Storage / Permeability	Large-scale SuDS that have the potential to control the volume of surface water runoff entering the urban area, typically making use of large areas of green space. Upstream flood storage areas can reduce flows along major overland flow paths by attenuating excess water upstream.	• Detention basins • Ponds and wetlands • Managing overland flows (online storage) • Land management practices
Separate Surface Water and Foul Water Sewer Systems	Where the CDA is served by a combined drainage network separation of the surface water from the combined system should be considered. In growth areas separation creates capacity for new connections.	• Separation of foul and surface water sewers
De-culvert / Increase Conveyance	De-culverting of watercourses and improving in-stream conveyance of water.	• De-culverting watercourse(s)
Preferential / Designated Overland Flow Routes	Managing overland flow routes through the urban environment to improve conveyance and routing water to watercourses or storage locations.	• Managing overland flows (preferential flowpaths) • Temporary or demountable flood defences

Description		Standard Measures Considered
Community Resilience	Improve community resilience and resistance of existing and new buildings to reduce damages from flooding, through, predominantly, non-structural measures.	• Improved weather warning • Temporary or demountable flood defences • Social change, education and awareness • Improved resilience and resistance measures
Infrastructure Resilience	Improve resilience of critical infrastructure in the CDA that is likely to be impacted by surface water flooding e.g. electricity substations, pump houses.	• Improved resilience and resistance measures
Other - Improvement to Drainage Infrastructure	Add storage to, or increase the capacity of, underground sewers and drains and improving the efficiency or number of road gullies.	• Increasing capacity in drainage systems
Other or Combination of Above	Any alternative options that do not fit into above categories and any combination of the above options where it is considered that multiple options would be required to address the surface water flooding issues.	

Options Assessment

A high-level assessment for each of the options has been developed to assess the potential benefits of each of the schemes, taking into consideration technical, economic, social and environmental factors. The approach to short-listing the measures is based the guidance in FCERM[46] and Defra's SWMP Technical Guidance. The scoring criteria are provided in Table D-3.

Table D-3: Criteria for options assessment and short-listing

Criteria	Description	Score
Technical	• Is it technically possible and buildable? • Will it be robust and reliable? • Would it require the development of a new technique for its implementation?	**U**: Unacceptable (measure eliminated from further consideration) **-2**: High negative outcome **-1**: Moderate negative outcome **0**: Neutral **+1**: Moderate positive outcome **+2**: High positive outcome
Economic	• Will benefits exceed costs? • Is the measure within the available budget? • What are the whole life costs of the option including asset replacement, operation and maintenance? Are there alternative routes of funding available such as the Anglian Eastern Regional Flood and Coastal Committee.	
Social	• Will the community benefit or suffer from implementation of the measure? • Does the option promote social cohesion or provide an improved access to recreation/open space? • Does the option result in opposition from local communities for example if an option involves the displacement of houses?	
Environmental	• Would the option provide a positive or negative on the environment for example, water quality and biodiversity?	
Objectives	• Will it help to achieve the objectives of the SWMP partnership? • Does the option meet the overall objective of alleviating flood risk?	

An Options Workshop was held with the Southend-on-Sea Borough Council on the 25th of November 2010 to discuss and agree the short-listed options identified for each CDA through the options assessment. The process aimed to ensure that inappropriate measures are eliminated early in the process to avoid investigation of options that are not acceptable to stakeholders. These options have been reviewed and updated as part of this SWMP update.

[46] Environment Agency (March 2010) *'Flood and Coastal Flood Risk Management Appraisal Guidance',* Environment Agency: Bristol.

The agreed short-listed options have been progressed to the preferred options stage where they will be costed and further developed. Table D-4 provides details of the short-listed options that are to be taken forward for further assessment during the next stage. The ‘Do Nothing’ (no intervention and no maintenance) and ‘Do Minimum’ (continuation of current practice) options have been taken forward to the detailed options assessment, in line with the FCERM Appraisal Guidance (FCERM-AG).

CDA	Option Category	Option Description	Technical	Economic	Social	Environmental	Objectives	Overall	Take Forward?	Scheme Details
Borough Wide	Improved Maintenance	Improved maintenance of drainage network	2	1	2	1	1	7	✓	Improved and targeted maintenance of drainage network. Suggest list of targeted areas (i.e. areas at highest risk within the CDAs).
	Planning Policy	Adapt spatial planning policies	2	2	1	1	1	7	✓	Adapt spatial planning policy for all new developments and driveway repaving, especially within identified high risk areas.
	Community Resilience	Improve community resilience to reduce damages from flooding	2	1	2	0	1	6	✓	Improve community resilience to flooding through establishing a flood warning system, improving emergency planning practices and encouraging the installation of household protection measures (such as flood-gates).
	Source Control, Attenuation and SuDS	Install rainwater harvesting systems and water-butts	2	2	1	1	2	8	✓	Install rainwater harvesting systems and water-butts in key risk areas in order to reduce the rate and volume of surface water runoff.
	Other	Community Awareness	2	2	2	0	1	7	✓	Increase awareness of flooding within communities at risk through the use of newsletters, drop-in surgeries, website and social media.
CDA1	Flood Storage / Permeability	Online flood storage (Eastwood Park)	2	1	1	1	2	7	✓	Investigate flood storage in Eastwood Park to retain flows and avoid flooding in the urban areas downstream. Eastwood Park covers a substantial area (over 50,000m^2) so only a small proportion of the park would be required to provide a significant volume for storage.
	Flood Storage / Permeability	Flood storage further up the catchment	2	1	1	1	2	7	✓	Investigate the feasibility of creating flood storage further upstream of Eastwood, in the neighbouring areas of Castle Point or Rochford, at the top of Eastwood Brook catchment.
	De-culvert / Increase Conveyance	Modify service crossings along Eastwood Brook	2	2	0	1	1	6	✓	Investigate the opportunity for service crossings along Eastwood Brook to be modified; currently they present a risk of blockage, as highlighted in the Phase 1 study.
	De-culvert / Increase conveyance	Re-profile existing ditches and watercourses	2	2	1	0	1	6	✓	Investigate the re-profiling of existing ditches and watercourses in order to increase conveyance capacity and online storage capacity within the banks of the watercourses.

CDA	Option Category	Option Description	Short-listing Options: Technical	Economic	Social	Environmental	Objectives	Overall	Take Forward?	Scheme Details
CDA2	Flood Storage / Permeability	Online flood storage (Belfairs Park)	2	1	1	2	2	8	✓	Investigate online flood storage in Belfairs Park in order to retain flows and avoid flooding in the urban areas downstream. Belfairs Park is a large open park which could provide significant storage capacity, which could be integrated into the existing golf course.
CDA2	Flood Storage / Permeability	Online flood storage (Priory Park)	2	1	1	2	2	8	✓	Investigate online flood storage in Priory Park in order to retain flows within the park and reduce the risk of flooding.
CDA2	De-culvert / Increase conveyance	Re-profile existing ditches and watercourses	2	2	1	0	1	6	✓	Re-profile existing ditches and watercourses in order to increase conveyance capacity and online storage capacity within the banks of the watercourses.
CDA2	Preferential / Designated Overland Flow Routes	Designate Rochford Road as a preferential overland flow path (urban blue corridor)	2	1	1	1	1	6	✓	Designate Rochford road as an urban blue corridor through adjustments to kerb heights and/or deepening of the road bed.
CDA3	Flood Storage / Permeability	Online flood storage within the CDA	2	1	1	1	2	7	✓	Investigate the feasibility of the construction of flood storage within Cluny Square, Temple Sutton Primary School and Archer Avenue.
CDA3	De-culvert / Increase conveyance	Increase conveyance through the A1159 embankment	2	1	1	0	1	6	✓	Increase the conveyance of the culvert beneath the A1159 embankment in order to allow additional flows to flow beneath the road.
CDA3	De-culvert / Increase conveyance	Temporary pumping system	2	2	1	0	1	6	✓	Install a temporary pumping system to pump water through the underpass beneath A1159 during times of heavy rain. This would avoid water ponding at the low point by Archers Close.
CDA4	Flood Storage / Permeability	Online flood storage within the Thorpe Hall Golf Course	2	1	1	1	1	6	✓	Investigate the feasibility of the construction of flood storage within the Thorpe Hall Golf Course. This could be achieved through re-profiling the ground levels or incorporating a storage pond into the design of the golf course.

CDA	Option Category	Option Description	Technical	Economic	Social	Environmental	Objectives	Overall	Take Forward?	Scheme Details
	Flood Storage / Permeability	Flood bund to the north of Bournes Green	2	2	1	0	1	6	✓	Investigate a bund to the north of Bournes Green to retain surface water in the fields and prevent it flowing south.
	Flood Storage / Permeability	Increase storage capacity within Southchurch Park	2	1	1	0	1	5	✓	Increase capacity of lakes and channels within Southchurch Park to allow more water to be held safely within the system during times of heavy flow.
	Source Control, Attenuation and SuDS	Agricultural land management practices	2	2	0	1	1	6	✓	Review agricultural land management practices to include methods which will reduce runoff from the agricultural land within the CDA.
	De-culvert / Increase conveyance	Increase capacity of Southchurch park pumping station	2	2	1	0	1	6	✓	Investigate increasing the capacity of the Southchurch Park pumping station in order to discharge more water into the sea during times of heavy flow.
	De-culvert / Increase conveyance	Increase drainage capacity north of Southchurch Park	2	1	1	0	1	5	✓	Investigate increasing the capacity of the drainage along the arterial roads leading south into Southchurch Park
CDA5	Flood Storage / Permeability	Online flood storage within the CDA	2	1	1	1	2	7	✓	Investigate the feasibility of the construction of flood storage in Gunners Park or Shoebury Park. An alternative site could be as part of the school development in north Gunners Park.
CDA5	Source Control, Attenuation and SuDS	Rainwater harvesting within proposed school development	2	1	1	1	2	7	✓	Install rainwater harvesting within the new school development in Gunners Park. This will reduce the rate and volume of surface water runoff into Gunners Park.
CDA5	Source Control, Attenuation and SuDS	Agricultural land management practices	2	2	0	1	1	6	✓	Review agricultural land management practices to include methods which will reduce runoff from the agricultural land within the CDA.
CDA5	Other – Improvement to	Install pumped drainage system in Gunners Park	2	1	1	0	2	6	✓	Investigate a pumping station to discharge water from Gunners Park directly into the sea.

CDA	Option Category	Option Description	Technical	Economic	Social	Environmental	Objectives	Overall	Take Forward?	Scheme Details
	Drainage Infrastructure									
CDA6	Flood Storage / Permeability	Bund to the south of Chalkwell Park	2	1	0	1	1	5	✓	Develop a bund or flood storage area to the south of Chalkwell Park to intercept overland flows generated from the park area to the north.
	Preferential / Designated Overland Flow Routes	The Ridgeway, Chalkwell Esplanade and Chalkwell Avenue.	2	0	1	0	2	5	✓	Increase height of kerbs along the Ridgeway, Chalkwell Esplanade and Chalkwell Avenue to allow for more water to be retained within the channel of the road, before spilling into properties.
	Source Control, Attenuation and SuDS	Retrofit source control SuDS within School buildings.	2	1	1	2	1	7	✓	Retrofit source control SuDS across large impermeable surfaces, such as schools.

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