Deal ICM

Model Build Summary Report

Document control sheet

BPP 04 F8
version 15; Mar 2013

Project:	Deal SWMP		
Client:	Kent County Council	Project No:	B1940800
Document title:	Model Build Summary Report		
Ref. No:	B1940800/MB001		

	Originated by	Checked by	Reviewed by
ORIGINAL	NAME **Debra Gray**	NAME **Lewis Maani**	NAME **Lewis Maani / Alastair Davis**
Approved by	NAME **Jose Tavares**	As Project Manager I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**	INITIALS
DATE **August 2013**	**Document status**	**CLIENT REVIEW**	

REVISION	NAME **Debra Gray**	NAME **Lewis Maani**	NAME **Lewis Maani / Alastair Davis**
Approved by	NAME **Jose Tavares**	As Project Manager I confirm that the above document(s) have been subjected to Jacobs' Check and Review procedure and that I **approve them for issue**	INITIALS
DATE **November 2013**	**Document status**	**CLIENT ISSUE**	

Contents

1 Introduction

1.1 Project Background

In September 2011 Kent County Council (KCC) produced a Preliminary Flood Risk Assessment (PFRA). The intended purpose of this assessment was to aid in the management of local flood risk and deliver the requirements of the Flood Risk Regulations (2009). It provided a high level overview of flood risk across KCC and helped to identify areas of significant flood risk that need to be investigated further.

Following on from this, the PFRA showed that there are areas which are at risk of flooding within the KCC administrative boundary. In addition the Environment Agency Flood Map for Surface Water[1] (FMfSW) confirmed this.

Deal Town, amongst other areas, was identified as one of these areas for further investigation with a history of flood risk in the town. In March 2012, Kent County Council commissioned Jacobs to undertake a Surface Water Management Plan (SWMP) with the purpose of identifying what the local flood risk issues exist and what potential flood risk management measures should be considered to mitigate these.

The Deal SWMP required the construction of a detailed ICM model representing both the above ground (surface water) and below ground (drainage system) flood mechanisms.

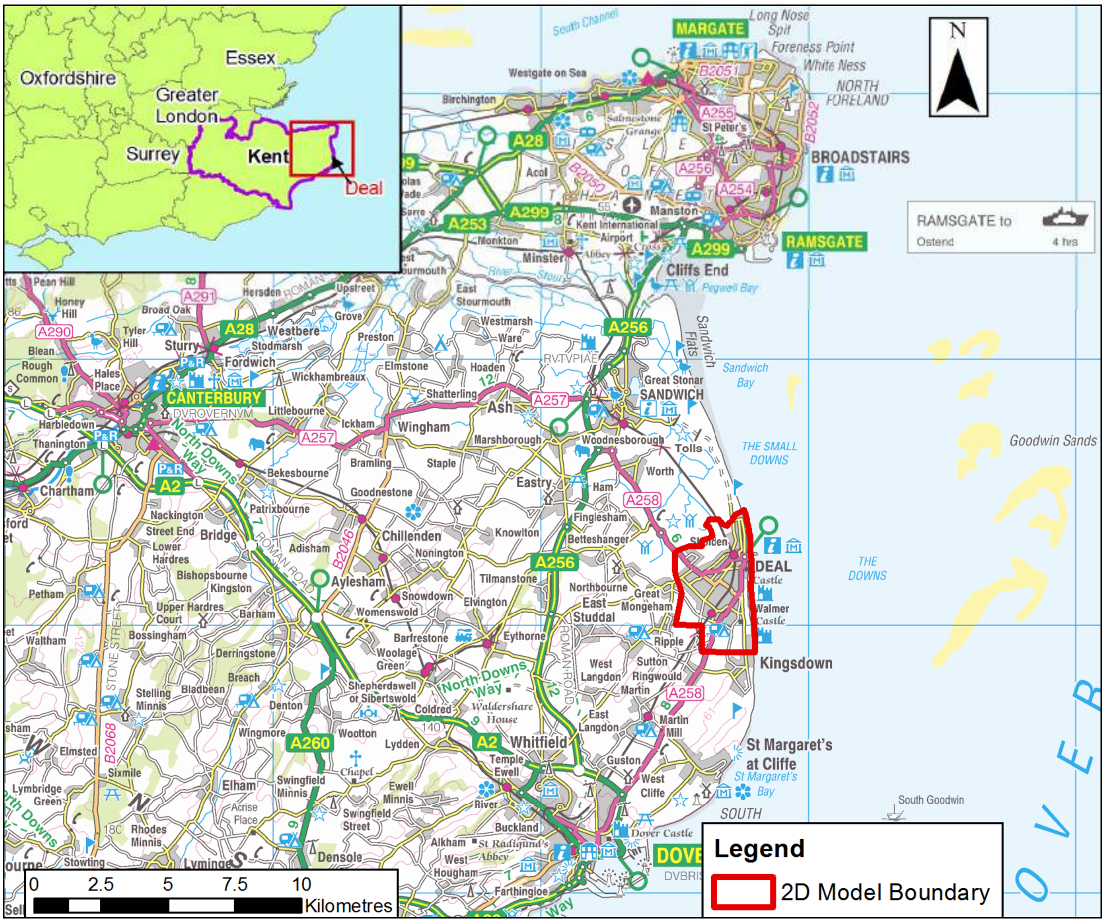


Figure 1.1: Location plan of study area

1 http://www.geostore.com/environment-agency/WebStore?xml=environment-agency/xml/dataLayers_FMSW.xml

1.2 Objectives of the Modelling and Approach Adopted

This appendix provides an outline of the steps involved in the construction of the Deal ICM model. In addition, the methodology relating to the model build is discussed and information relating to the model construction (i.e. input data), verification and the design runs are also provided. It is intended as a summary model build report to accompany the Deal SWMP study report.

The Deal ICM model (shown in Figure 1.2) is an integrated catchment model representing both the above (surface water flooding) and below ground (Drainage system) processes. These two elements are outlined below:

- **1D Drainage Network:** This involved the update and construction of the 1D (one dimensional) component of the model including the representation of the drainage network (i.e. Foul, Storm and Combined pipes).
- **2D Zone:** This involved construction of the 2D (two dimensional) component of the model including the 2D zone which represents the overland surface. Information relating to topography and landuse are used to inform the 2D zone and generate a 2D mesh.

This integrated approach is required to ensure that flood mechanisms are more accurately represented across the catchment area and to allow for the model to be used to identify different sources of flooding.

The objective of the modelling was to develop a linked 1D/2D model of Deal Town to better understand the mechanisms and possible consequences of surface water flooding. The results would then be used to inform the identification potential suitable flood risk management options to mitigate flooding.

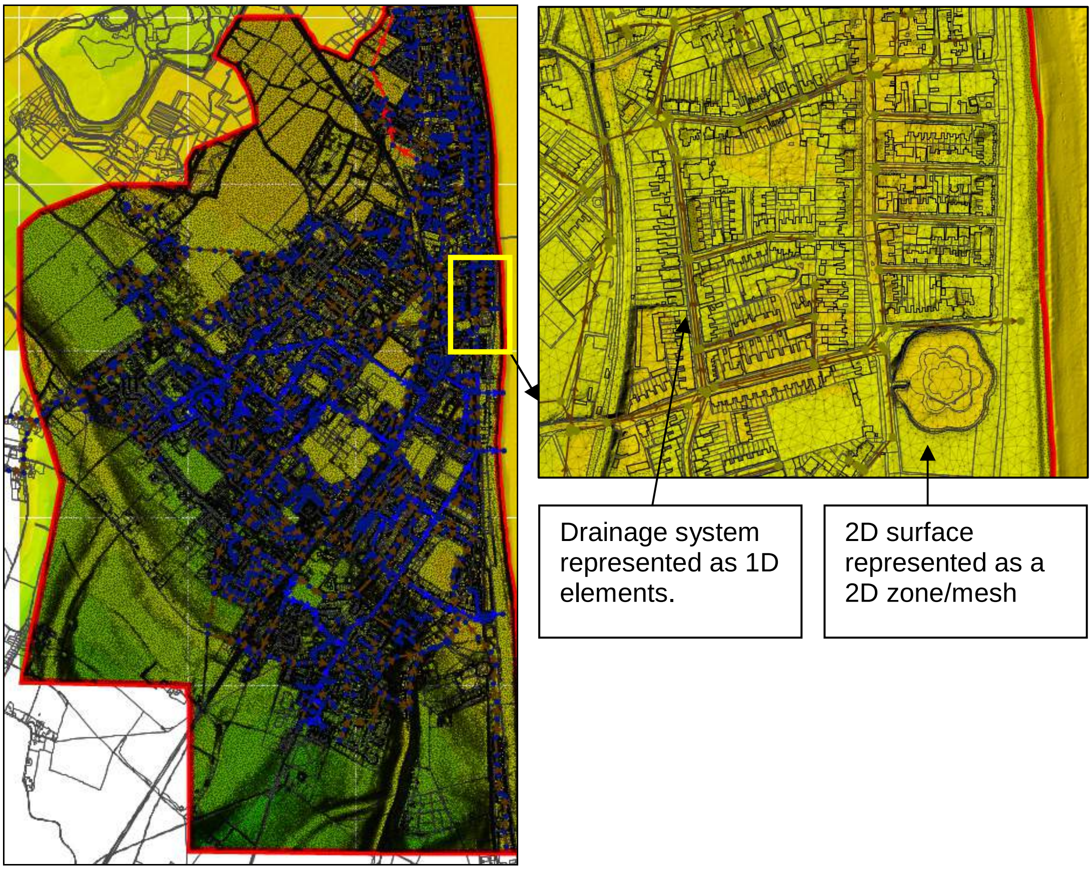


Figure 1.2: Deal SWMP ICM Model

1.3 Study Area

Deal town lies on the west coast of Kent County Council administrative area (as shown in Figure 1.1). The modelled area extends over an area of approximately 12 km². The topography within the catchment is generally steep across the upper catchment ranging from 62 mAOD and then slopes down through the lower catchment towards the coastline. The catchment is predominantly urban, with green space and vegetated areas in the north and south of the catchment.

There are several recorded incidents of local flooding in Deal in addition to those presented on the FMfSW (as discussed in Section 1.1). These records report surface water and sewer flooding issues in both localised areas (i.e. individual properties) and across wider parts of the town (i.e. roads and streets being affected). In addition, two historical flood events (June 2007 and August 2010) have resulted in flooding incidents in the study area.

Figure 1.3 overleaf shows the Deal catchment and some of the key features located in the modelled area. Figure 1.4 shows the location of recorded flood incidents in addition to the FMfSW outlines across the study area[2].

[2] The study area boundary was extended to the south west as part of the modelling.

Drawing Number
Figure 1.3

Client
Kent County Council

Contractor
JACOBS

Status
DRAFT

Project
DEAL SMWP

Drawing Title
Detailed Catchment Area

Legend

2D Model Boundary

KeyFeatures

LiDAR Elevation (m)

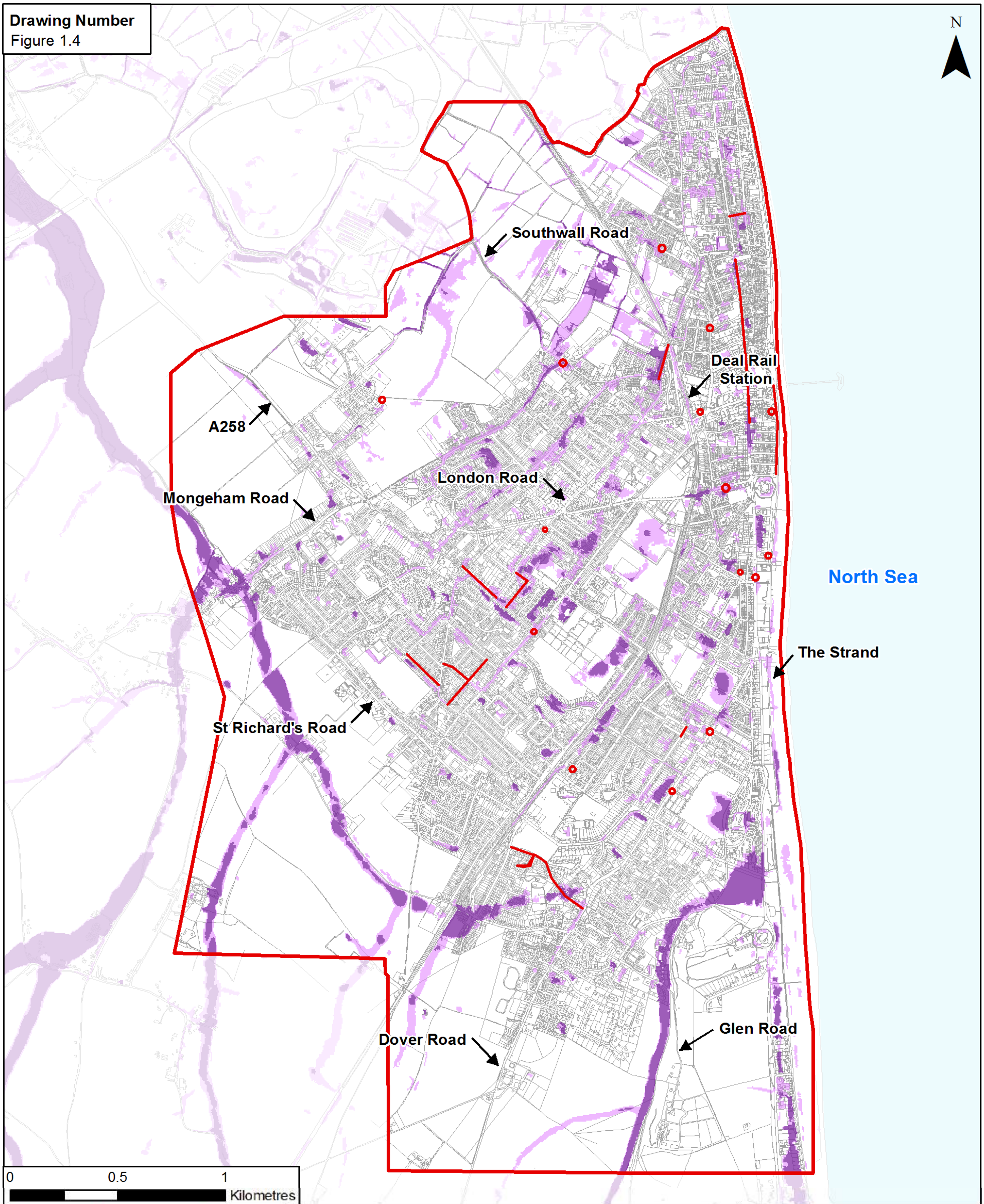
High : 61.7

Low : 0

Note:
Additional information relating to the landuse/landcover groupings (ie used to define infiltration and roughness zones) and associated feature codes are provided in the model build report.

Figure by	DSG	Date	13/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:23,000 at A4		
Drawing Number	Figure 1.3	Revision	00

Drawing Number
Figure 1.4



Client: Kent County Council

Contractor: JACOBS

Status: DRAFT

Project: DEAL SMWP

Drawing Title: Known Flood Locations

Legend

- Historic Flood Locations
- 2D Model Boundary

Flood Map for Surface Water

- Deep Flooding > 0.3m
- Shallow Flooding < 0.3m

Note:
Additional information relating to the landuse/landcover groupings (ie used to define infiltration and roughness zones) and associated feature codes are provided in the model build report.

Figure by	DSG	Date	15/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:23,000 at A4		
Drawing Number	Figure 1.4	Revision	00

2 ICM Model Build Methodology

The following sections provide an outline to the methodology adopted for the construction of the Deal Model including information relating to the model input data, approach and software used.

2.1 Software and Approach

The model was built and run using InfoWorks ICM version 3.5 modelling software (Innovyze, 2013). This was selected for the following reasons:

- An existing InfoWorks[3] CS 1D drainage model was available for the study area provided by Southern Water.
- It represents the 2D modelled surface using irregular triangles (of varying size, which make up individual elements within the mesh). This has the benefit of enabling greater detailing of the 2D surface in urban areas, thus increasing the model detail at certain locations whilst allowing a coarser representation in rural areas where the same level of detail may not be required. This helps to avoid long model run times associated with a high level of detail applied across the whole catchment;
- It allows for the modelling of river networks, sewer networks and overland flow routes in a single integrated model. This is an important consideration which will help in building a more dynamic view of the flood mechanisms and high risk areas within the catchment from these varied sources of flooding.

To simulate surface water flooding across the area of interest, the hydraulic model uses a Direct Rainfall approach which consists of applying a rainfall hyetograph representative of a storm event to every individual element within the 2D surface model (across the 2D zone).

During the course of a simulated event, the hydraulic model computes the rainfall that would be absorbed through natural infiltration into the ground, the rainfall runoff that would be routed overland by gravity and also the runoff volume that would drain into and be conveyed through the sewer drainage networks.

The overland flow routed through the urban environment (2D surface model) and the flow conveyed through the drainage systems are dynamically linked at each manhole. Within the 2D zone, manholes are normally defined as either “2D” (where flow interchange with the 2D zone can occur) or “Sealed” (no 1D - 2D interaction) depending on the associated drainage type (i.e. Storm, Foul or Combined). 2D manholes simulate drainage gullies in this configuration.

2.2 Sub-surface Drainage Networks Schematisation

The Southern Water sewer network (i.e. Storm, Foul or Combined) covering Deal Town was included in the model to represent the drainage system. It was assumed that the entire drainage network dataset (e.g. dimensions, invert levels, gradients) was correct on the basis that it was used as part of the modelling on the previous study. No verification of these datasets has been undertaken.

The Southern Water sewer model was imported into the ICM model. Manholes within the 2D zone were set to flood type “2D” allowing the surcharged water to interact with the 2D surface via these manholes. Manholes located outside the 2D zone have been set to flood type “Sealed” limiting the interaction with the surface.

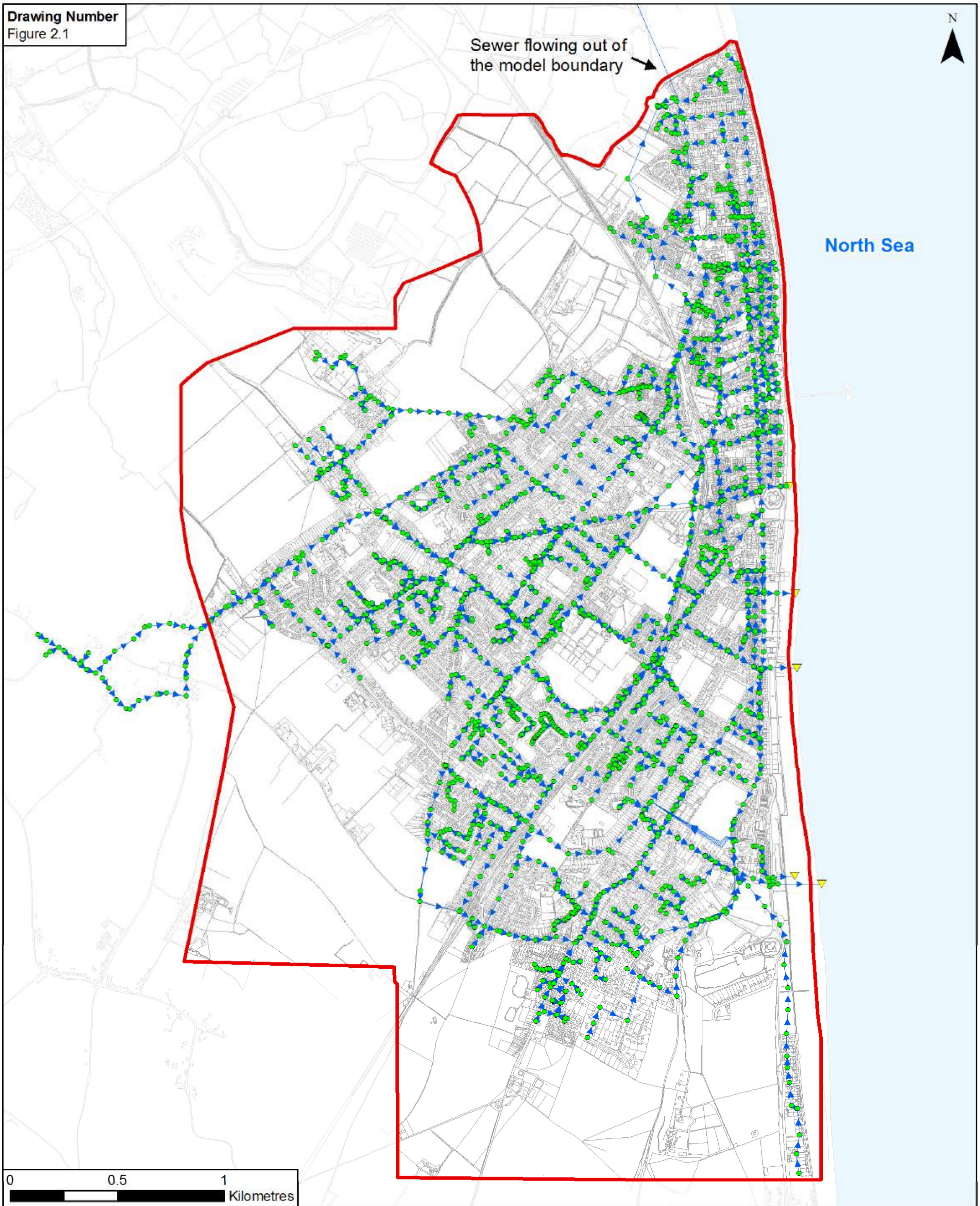
---

3 Infoworks CS models are readily compatible with Infoworks ICM and can be imported directly between software packages.

Data sources and inferences made were flagged within the model and comments have been added where appropriate.

The drainage network included in the model can be seen in Figure 2.1. It can be seen that network extends beyond the project area to the north. The flow out of the area has been assumed to be free flow conditions. The project area drains to the sea by gravity and to the north by rising main. Figure 2.2 shows the drainage network and the LiDAR (Light Detection and Ranging) ground model.

Drawing Number
Figure 2.1



Client: Kent County Council

Contractor: JACOBS

Status: DRAFT

Project: DEAL SWMP

Drawing Title: 1D Model Schematisation

Legend

2D Model Boundary

1D Drainage Network

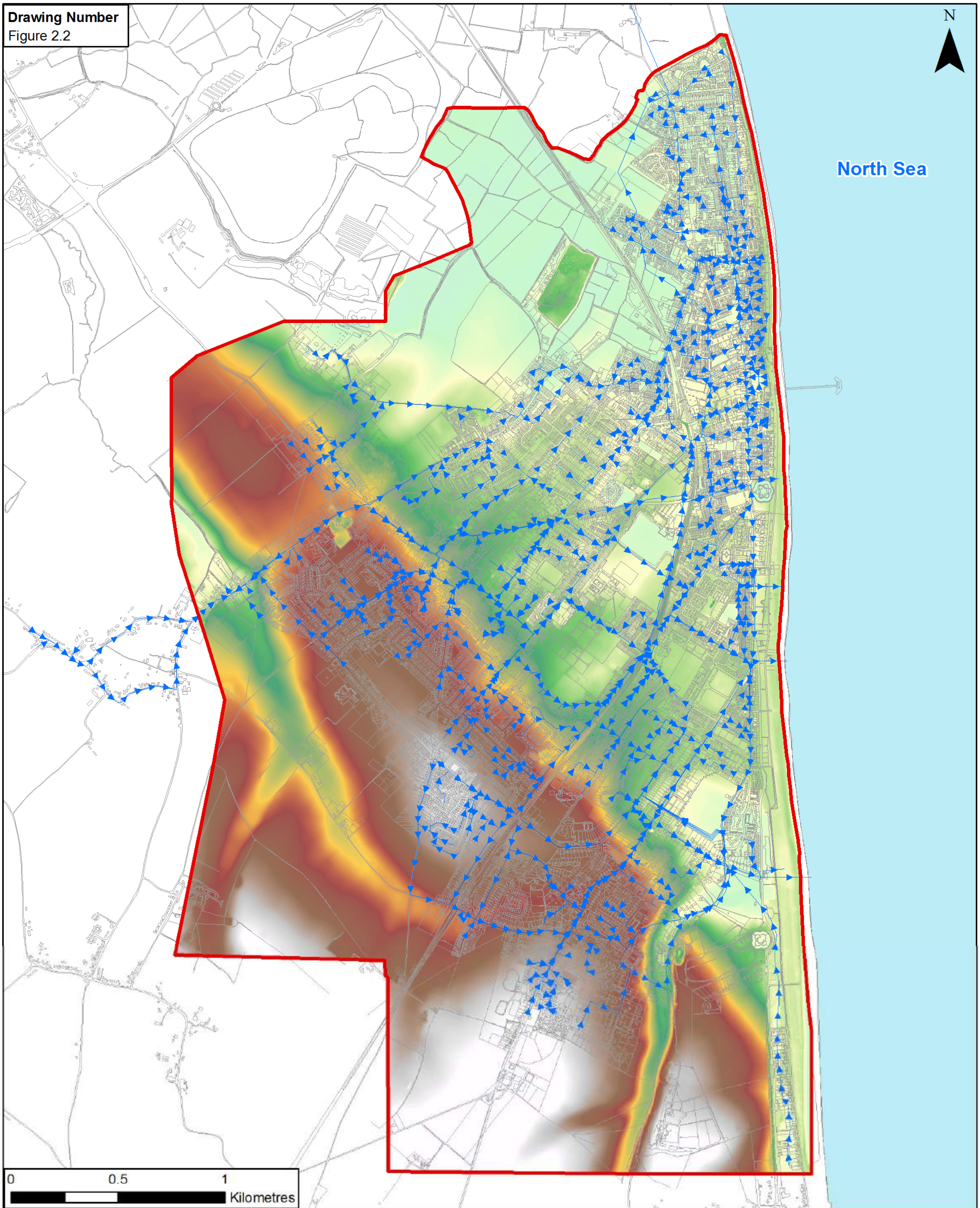
Node Type

2D

Outfall

Note:
The pipe network used for the modelling was adopted from the Southern Water Dataset.
Additional information is provided in Section 2.2 of the Model Summary Report.

Figure by	DSG	Date	13/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:23,000 at A4		
Drawing Number	Figure 2.1	Revision	00



Client: Kent County Council	**Legend**	Figure by: DSG	Date: 13/08/2013
Contractor: JACOBS	2D Model Boundary	Checked by: LM	Date
Status: DRAFT	1D Drainage Network	Reviewed by: AD	Date
Project: DEAL SWMP	**LiDAR Elevation (m)**	Approved by: JT	Date
Drawing Title: Drainage Network and LiDAR Ground Model	High : 62.1	Scale(s): 1:23,000 at A4	
	Low : -3.5	Drawing Number: Figure 2.2	Revision: 00

JACOBS

2.3 2D Surface Model Schematisation

2.3.1 Ground Model

The ground model used as part of the model build was developed based on the available LiDAR data provided for this study.

LiDAR is an optical remote sensing technology that can measure the distance (and subsequently elevation) to a target using pulses from a laser. In this context, LiDAR is captured from an aircraft to create a digital elevation model (DEM). It is important to note that the filtered LiDAR (i.e. with buildings and vegetation removed) was used for the modelling.

2.3.2 Roughness (Mannings n)

Hydraulic roughness, represented by Manning's roughness coefficient 'n' in the hydraulic model, is a mean of accounting for the effect on the resistance to flow of surface materials, irregularities, obstructions and vegetation.

Within the 1D elements of the model, roughness values in the pipe network were set to a standard Colebrook-White value of 0.6mm and no siltation.

In order to represent differences in roughness across the 2D zone, MasterMap data was used to define roughness groups based on different landcover types. The Mastermap data was processed to represent key groups for inclusion as roughness zones in the 2D zone/Mesh (by grouping relevant feature classes). Figure 2.3 below provides an example of the different landcover types derived from the Mastermap data.

Figure 2.3: Mastermap Landcover groups used to assign roughness and infiltration values

The Manning's n values attributed to each of the roughness zones are summarised in Table 1.

2.3.3 Infiltration

Infiltration is typically used to represent the natural infiltration of rainfall into the ground. In the case of the Deal model, a constant infiltration loss coefficient was applied to the different land cover types (i.e. roads and other hard standing surfaces would typically have a low infiltration loss whilst vegetation and agricultural areas are assigned a higher value).

The same Mastermap polygons generated for the roughness zones were used for the definition of infiltration zones (with a constant infiltration being applied to each landcover group). The parameters applied for Roughness and Infiltration Loss coefficients are listed in Table 1 below (Figure 2.4 shows the different landcover types covering the study area).

ID	MasterMap Feature Code	Landcover Group	Roughness	Infiltration Loss Coefficient (mm/hr)
0	10056(Natural/Unknown)	General green areas	0.06 (set as default)	15
1	10053	Property gardens /yards	0.06	15
2	10089, 10210	Water	0.02	0
3	10093, 10096, 10099	Embankments /cliffs	0.05	15
4	10172, 10119, 10123, 10054, 10056(Manmade), 10185, 10183	Roads /tracks /paths /roadside	0.025	0
5	10167	Rail	0.05	15
6	10111	Thick vegetation /trees	0.12	15
7	10021, 10062	Buildings /glass houses	0.5	0
8	10056(Natural-selected)	Short grass/ parks/ sport grounds	0.035	15

Table 1: Roughness and Infiltration Coefficients

Rainfall infiltration consists of two components; the first is an initial loss which corresponds to the amount of rainfall (in mm) that is initially lost to the model (wetting the surface and surface storage) and the second is the continuing loss which is a loss rate in mm/hr representing continuing infiltration. Losses through infiltration were applied to the model on a land use basis. Adopting a conservative approach, only permeable land use regions allowed infiltration[4]. Infiltration rates[5] used in this study were selected to represent typical ground conditions with regard to the soils and geology in the study area[6].

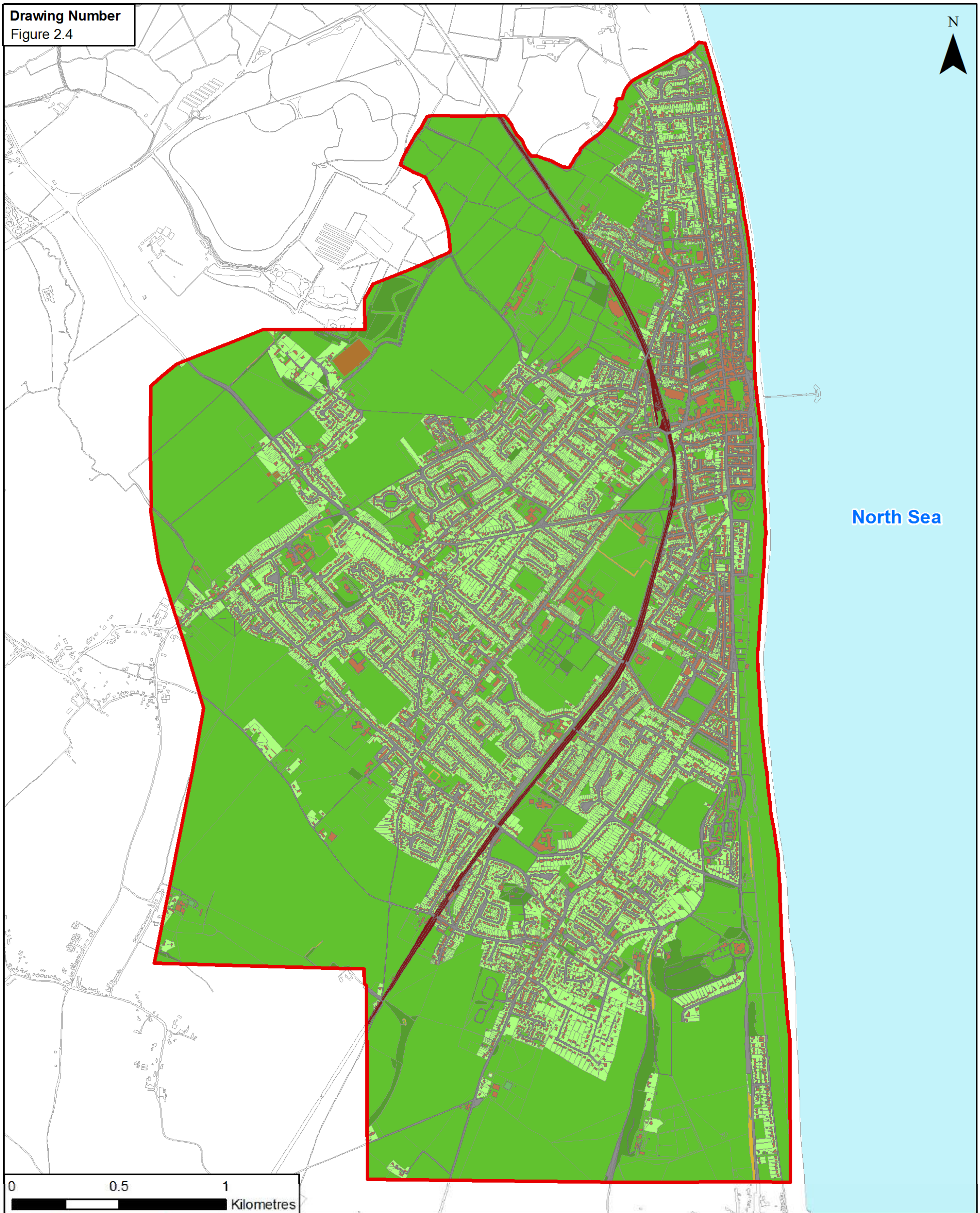
---

4 An infiltration loss of 15mm/hr was applied to permeable surfaces

5 http://www.fao.org/docrep/s8684e/s8684e0a.htm

6 The soil/geological characteristics in the catchment were sourced from: https://www.landis.org.uk/soilscapes/.

Drawing Number
Figure 2.4



Client: Kent County Council

Contractor: JACOBS

Status: DRAFT

Project: DEAL SWMP

Drawing Title: Landuse Polygons within the Study Area

Legend

2D Model Boundary

Landuse Groupings

- General green areas
- Property gardens and yards
- Embankments and cliffs
- Roads
- Rail
- Thick vegetation and trees
- Buildings and glasshouses

Note:
Additional information relating to the landuse/landcover groupings (ie used to define infiltration and roughness zones) and associated feature codes are provided in the model build report.

Figure by	DSG	Date	13/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:23,000 at A4		
Drawing Number	Figure 2.4	Revision	00

2.3.4 Mesh Definition

The 2D zone[7] is a boundary polygon which is used to define the 2D part of the model. It is used to generate the mesh. The following sections outline the various items represented in the 2D zone and included into the mesh.

ICM uses a 2D mesh to represent the modelled surface and is generated using the ground model and relevant polygons representing the different roughness and infiltration zones. These features define the ground levels, roughness and infiltration values in each element within the mesh.

Figure 2.5: 2D Mesh

The area of each triangle in the mesh is variable (based on the defined values during the meshing of the 2D zone. As a result, the 2D mesh resolution (element size) differs where there are more breakline features (i.e. such as buildings and road centrelines). This potentially can provide greater detail in areas of interest, whilst the wider catchment (i.e. rural areas and fields) typically result in larger triangles and mesh elements. To enhance this, the meshing parameters were set so that the minimum element size was 2m² and maximum mesh triangle area set to 100 m². In addition, terrain sensitive meshing was enabled (the threshold was set to 0.5m) to allow elements to represent more subtle changes in elevation across the 2D zone.

[7] Also refered to as 2D Model Boundary.

2.3.5 Buildings

It should be noted (as outlined in Section 2.3.1) that the use of filtered LiDAR data (i.e. with buildings and vegetation filtered out) to define the 2D zone means that buildings were not physically represented in the model.

Given the fact that any building is an obstruction to the flow and would have a major impact on the overland flow routes, a 150mm increase has been attributed to each building/house outline to model the impervious nature of buildings below the assumed 150mm threshold. Above this threshold level, water can move through the building, but is retarded through the use of porous polygons. Alternative approaches can be used to represent the presence of buildings. The use of a high Manning's n value for a building effectively makes it 'very difficult' for water to enter / flow through a building, but it does not make it impossible, in contrast to representing a building as a solid 'block' through which no water can flow.

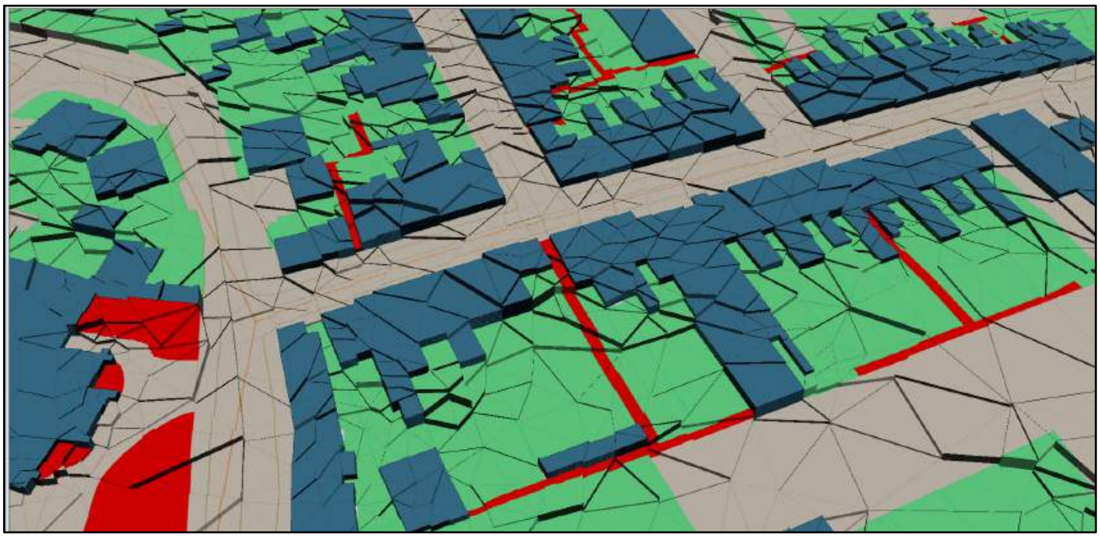


Figure 2.6: Mesh zones used to raise building footprints by 150mm

2.4 Boundary Conditions

The following section outlines the information used to inform the boundary conditions of the Deal Model.

The catchment around Deal is largely chalk and has few perennial watercourses. A semi-distributed conceptual rainfall runoff model, using Catchmod v4.03, was previously developed as part of the Dover SWMP to determine flows in the River Dour, the Alkham Bourne and the eight typically dry valleys in the Dover area. Due to the location and similar geology, the calibrated Dover Catchmod model was used to predict flows that could enter the Deal study area from the south under "wet" catchment conditions. These are represented in the model as point inflows and are very small compared to typical urban drainage flows (Figure 2.7 shows the location of these inflow locations).

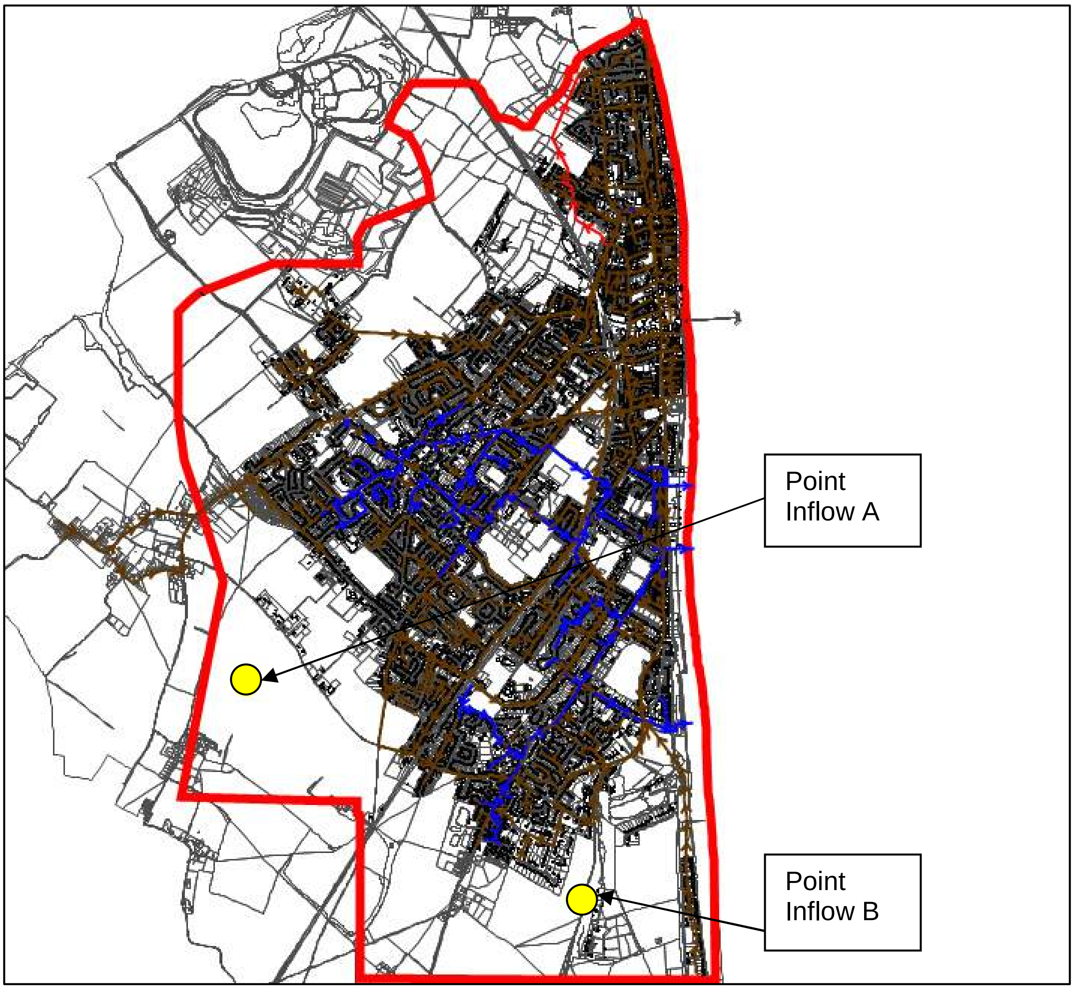


Figure 2.7: Location plan of point inflows within the study area

A Mean High Water Spring tidal boundary at Deal, calculated using United Kingdom Hydrographic Office Admiralty Tide Tables UK & Ireland Volume 1 NP201-13 (2013), has been applied to the 1D sea outfalls and is shown in Figure 2.8.

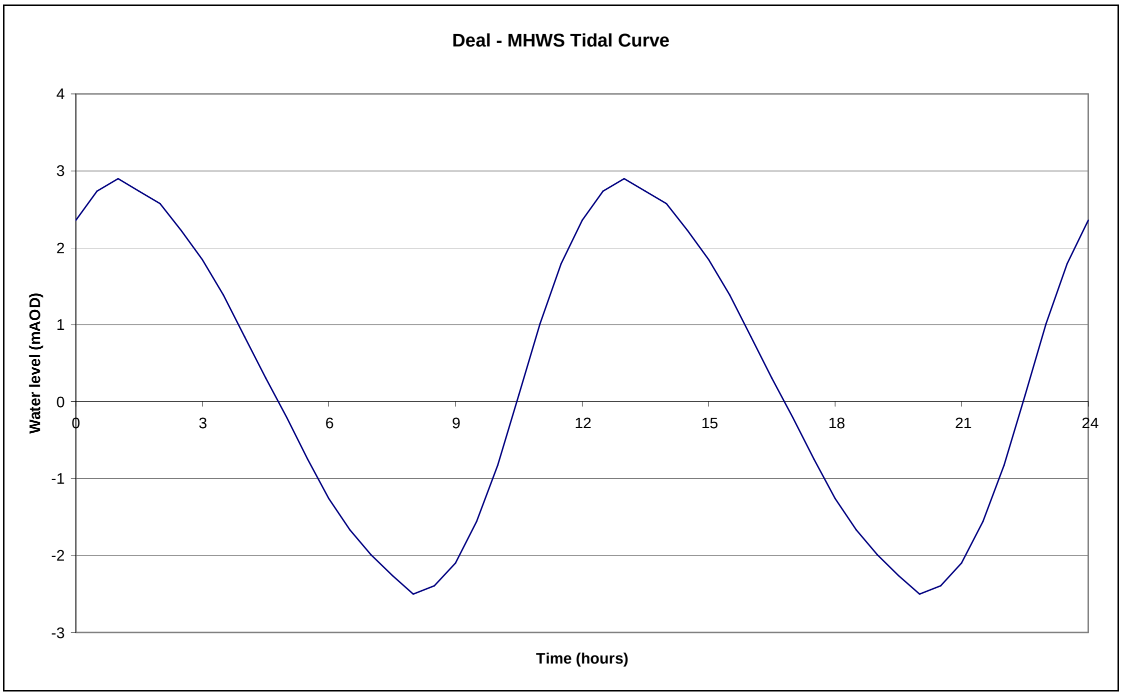


Figure 2.8: Mean High Water Spring Tide

2.5 Rainfall Approach

The following section outlines the rainfall approach adopted as part of this study. As mentioned in Section 2.1, the ICM model uses a Direct Rainfall approach which consists of applying a rainfall hyetograph representative of a storm event to every individual element within the 2D surface model.

The design rainfall was generated using the Revitalised FEH methodology (ReFH). ReFH Depth, Duration. Frequency (DDF) parameters were determined for the FEH catchment covering the Deal area. The 1 km² DDF parameters were then extracted and used to inform the InfoWorks FEH rainfall generator available within the ICM software[8].

As mentioned above the FEH rainfall event generator was used in ICM to apply a rainfall event across the 2D zone. In addition to the catchment descriptors, antecedent depth and wetness index, which are pre-defined initial conditions relating to the wetness and soil moisture of the ground, have been selected. Although these were deemed appropriate to reflect a conservative approach for this study no detailed analysis of the different initial conditions was carried out.

A series of rainfall hyetographs were then produced for various storm return periods and durations. The design events used were for the following Annual Exceedence Probabilities (AEP): 20%, 10%, 3.33%, 2%, 1.33%, 1% and 0.5%. The rainfall hydrographs of the above events are presented in figure 2.9 overleaf.

---

8 For UK catchments, the Meteorological Office studied all available rainfall to derive statistical rainfall relationships. A representative rainfall event can be generated for any location in the UK from these relationships, for any duration and return period. Volume 1 of The Wallingford Procedure describes the model in more detail.

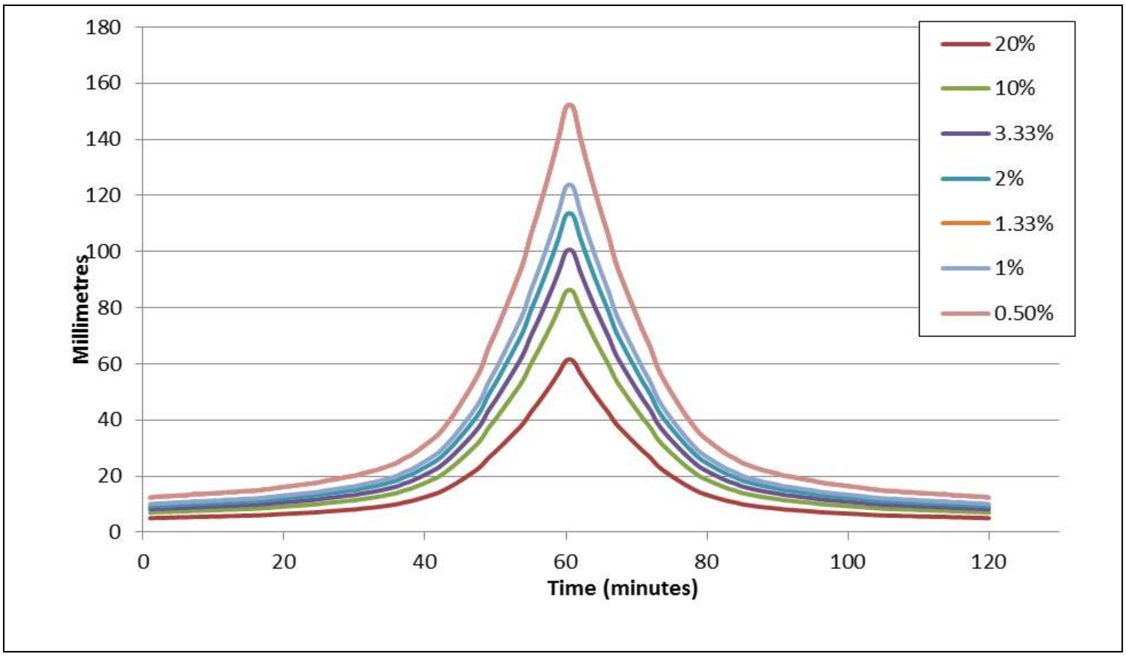


Figure 2.9: Deal Rainfall Hydrographs (ICM rainfall generator)

3 Model Runs and Verification

The following sections outline the model runs carried out following the construction of the Deal ICM model. In addition the subsequent steps relating to the model proving which include the model verification are discussed. The key assumptions and limitations associated with the model are also listed.

3.1 Critical Duration Analysis

The following section provides information relating to the critical storm duration analysis carried out. This purpose was to ensure the most appropriate (conservative) rainfall storm duration was used.

The base model was run with 60, 120, 180 and 360 minute storm durations for the 1 in 100-year return period storms to determine the critical storm duration applicable to the modelled catchment.

Following a review of the flood extents and maximum flood depths predicted by the model within the 2D zone, it was established that the 120 minute duration event is the critical storm duration for the modelled catchment.

It is important to note that although the rainfall storm duration was 120 mins the model simulation time was set to 360 minutes to ensure the peak and full response of the surface water catchment and drainage system was simulated.

3.2 Model Proving

For this study, no formal calibration of the ICM model was undertaken due to the lack of available information. Instead, verification of the model was carried out through model performance checks and comparison of areas of flooding predicted by the model with historic flooding records in the catchment.

Generally the flooding predicted by the model correlated well with recorded flood incident locations. A more detailed account of this comparison is available in the main study report.

3.3 Design Runs

The Deal model was run under a baseline scenario (existing situation) to simulate surface water flooding associated with a series of storm events with the following Annual Exceedence Probabilities (AEP): 20%, 10%, 3.33%, 2%, 1.33%, 1% and 0.5%.

3.4 Model Limitations and Uncertainty

The accuracy and validity of the model results is heavily dependent on the accuracy of the hydrological and topographic data included in the model. While the most appropriate available information has been used to construct the model to represent surface water flooding mechanisms, there are uncertainties and limitations associated with the model. These include assumptions made as part of the model build process.

The list below summarises the key sources of uncertainty in the model in addition to the limitations associated with the Deal Model

- The LiDAR data is defined at 1m horizontal resolution, as a result, small localised features such as kerbs heights or traffic calming measures might not be represented accurately within the ICM model. In addition as part of the filtering process at some locations, false depressions can occur due to buildings being extracted at basement rather than ground level. As a result there are inherent uncertainties in how accurately LiDAR reflects the topography of the area.
- The model does not allow for a detailed representation of the surface water entering the drainage network via road gullies and pipes discharging into the main sewers. Instead it is assumed that rainfall runoff enters into the system at the manholes.
- The FEH rainfall event generator was used in ICM (as outlined in Section 2.5) to apply a rainfall event across the 2D zone. In addition to the catchment descriptors, antecedent depth and wetness index, which are pre-defined initial conditions relating to the wetness and soil moisture of the ground, have been selected. Although these were deemed appropriate to reflect a conservative approach for this study no detailed analysis of the different initial conditions was carried out. This is an area which during future stages of this study should be investigated further.
- The representation of the drainage networks in the ICM relies entirely on the pipe/manhole data and Model provided by Southern Water. It is assumed that the datasets are correct.
- A key limitation is the lack of information available during the model proving stages. This data is important in appropriately verifying the model to more accurately reflect the current situation.

Efforts have been made to assess and reduce levels of uncertainty in each aspect of the modelling process. However further detail would be required should the model be used to support a more localised assessment of flood risk.

4 Baseline Model Outputs

4.1 Mapping Outputs

The detailed Deal Model can output 2D results, such as flood level, depth, velocity and hazard at regular intervals throughout a simulation. The maximum values associated with these outputs have been produced as 2D grids of 2m resolution. These 2D grids have been processed into flood maps.

It should be noted that flood hazard is automatically calculated by the hydraulic model as a function of depth and velocity (with a debris factor included), following the DEFRA methodology[9].

For this study, although maximum flood depths, velocities and hazard grids have been produced for all the design events, for the purpose of reporting, these have been mapped for the 3.33% and 1% AEP events.

When mapping/displaying model outputs, low value categories of flood depth (less than 50mm) and hazard rating (below a value of 0.75, also referred to as low hazard) are filtered out and not shown on the maps. This is for clarity purposes, to avoid reporting all surfaces being considered as flooded and to assist with the identification of high risk areas. However, model data relating to these low value categories is contained within the model outputs and can be displayed should this be required.

The hydraulic model can also produce 1D results in the form of flow, velocity and water level time series for each pipe and manhole included in the storm and combined drainage networks. Maximum values associated with these outputs are also available.

The model outputs for the baseline (existing) scenario were reviewed to identify the likely flood mechanisms at key locations. This allowed for the identification of flooding ‘hotspots’ or ‘problem areas’ where significant flood depths or high hazard were predicted.

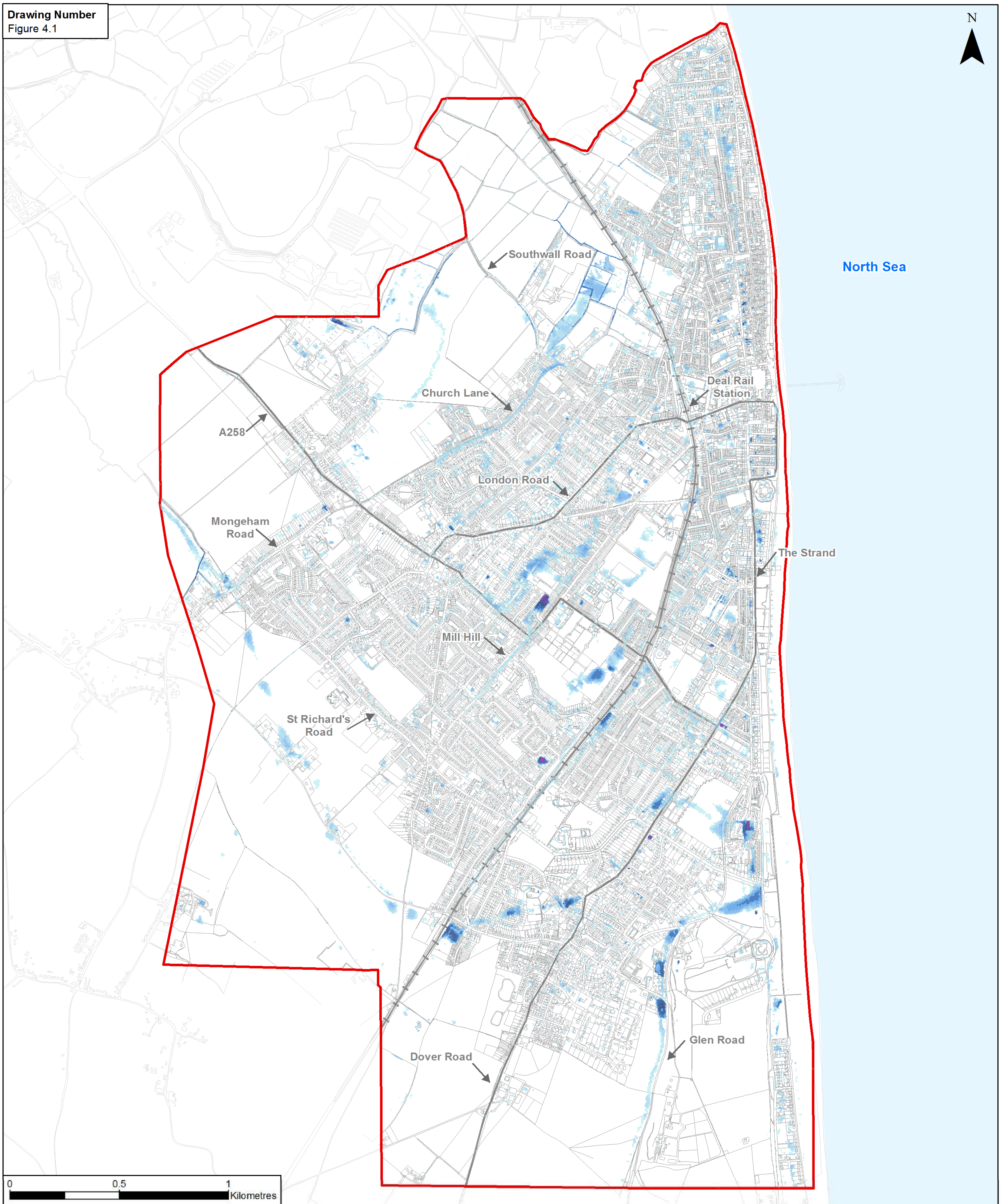
4.2 Results and Maps

The mapping outputs discussed above have been used to assess the existing flood risk and sources of flooding in the Deal’s Catchment. The overall catchment model outputs for Depth, Velocity and Hazard are presented overleaf (Figures 4.1 – 4.6). Electronic copies of the outputs for all design events modelled are also provided along with this report.

Most of the predicted flood depths remain below 0.5m for the 3.33% AEP event with a few patches of deeply flooded cells, mostly consisting of low topographic spots situated at the end or along an overland flowpath. Pluvial water conveyed by gravity in these areas ponds due to an obstacle across the flowpath (e.g. high ground or change in topographic slope).

[9] DEFRA (2008) Supplementary Note on Flood Hazard Ratings and Thresholds for Development Planning and Control Purposes

Drawing Number
Figure 4.1



Client: Kent County Council

Contractor: JACOBS

Status	DRAFT
Project	DEAL SWMP
Drawing Title	3.33% AEP Maximum Flood Depth within the Study Area
Map Type	Flood Depth
Annual Probability	3.33% AEP (1 in 30 yr)
Scenario	Existing

Legend

Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.7
- 0.7 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

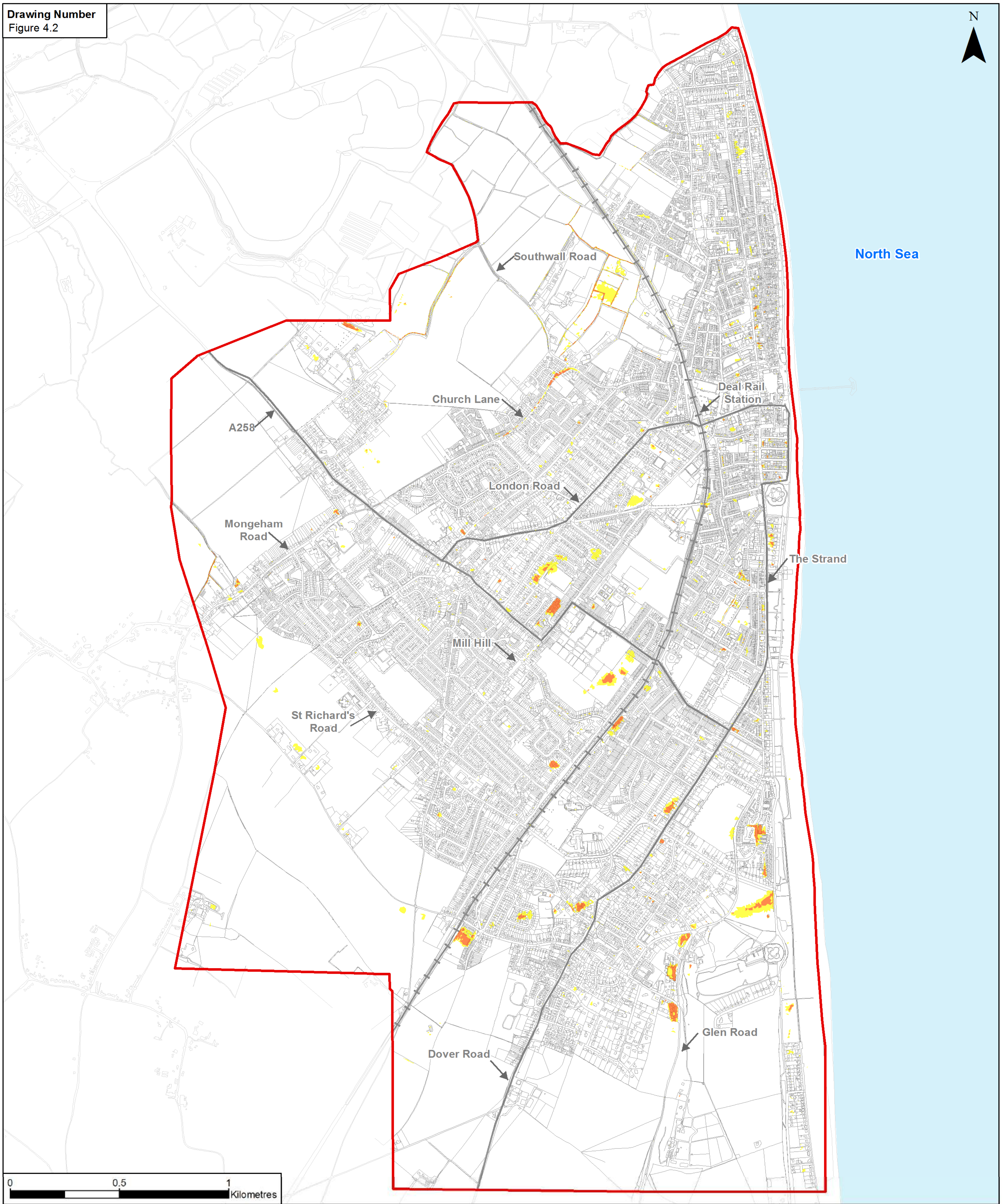
Key Features

- 2D Model Boundary
- Railway Line
- Major Roads

Notes:
In order to increase the clarity of mapping, depths less than 0.05m have not been displayed.

Figure by	DSG	Date	14/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:16,000 at A3		
Drawing Number	Figure 4.1	Revision	00

Drawing Number
Figure 4.2



Client: Kent County Council

Contractor: JACOBS

Status: **DRAFT**

Project: **DEAL SWMP**

Drawing Title: 3.33% AEP Flood Hazard within the Study Area

Map Type: Flood Hazard

Annual Probability: 3.33% AEP (1 in 30 yr)

Scenario: Existing

Legend

Flood Hazard

- Low (< 0.75)
- Moderate (0.75- 1.25)
- Significant (1.25 - 2.00)
- Extreme (> 2.00)

Key Features

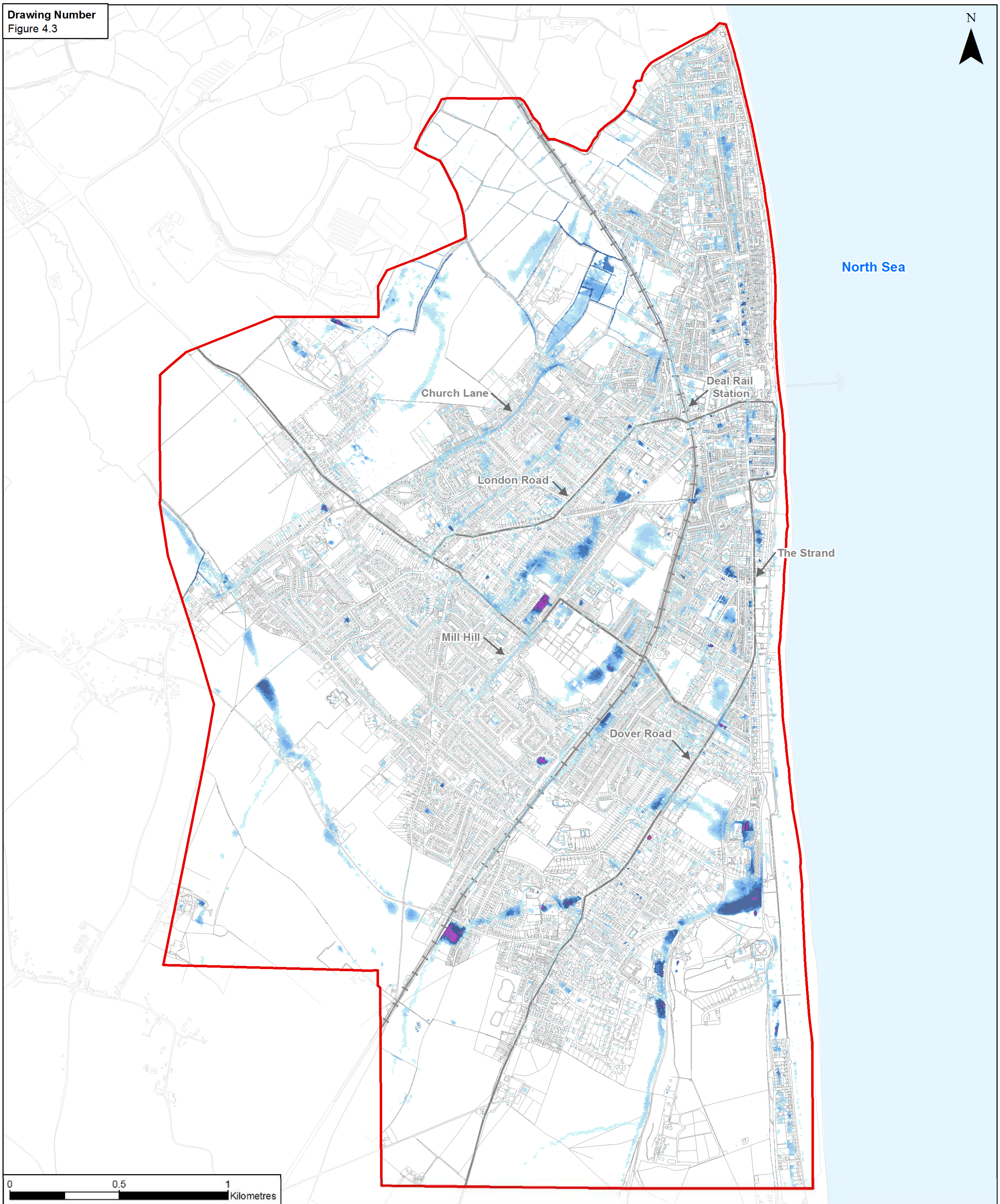
- 2D Model Boundary
- Railway Line
- Major Roads

Notes:
Flood Hazard Rating is calcuated using the DEFRA Hazard formula:
$HR = d \times (v + 0.5) + DF$

Where:
d = depth of flooding (m)
v = velocity of floodwaters (m/s)
DF = Debris Factor

Figure by	DSG	Date	14/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:16,000 at A3		
Drawing Number	Figure 4.2	Revision	00

Drawing Number
Figure 4.3



Client: Kent County Council

Contractor: JACOBS

Status: DRAFT

Project: DEAL SWMP

Drawing Title: 1% AEP Maximum Flood Depth within the Study Area

Map Type: Flood Depth

Annual Probability: 1% AEP (1 in 100 yr)

Scenario: Existing

Legend

Flood Depth (m)

- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.4
- 0.4 - 0.5
- 0.5 - 0.7
- 0.7 - 1.0
- 1.0 - 1.5
- 1.5 - 2.0
- > 2.0

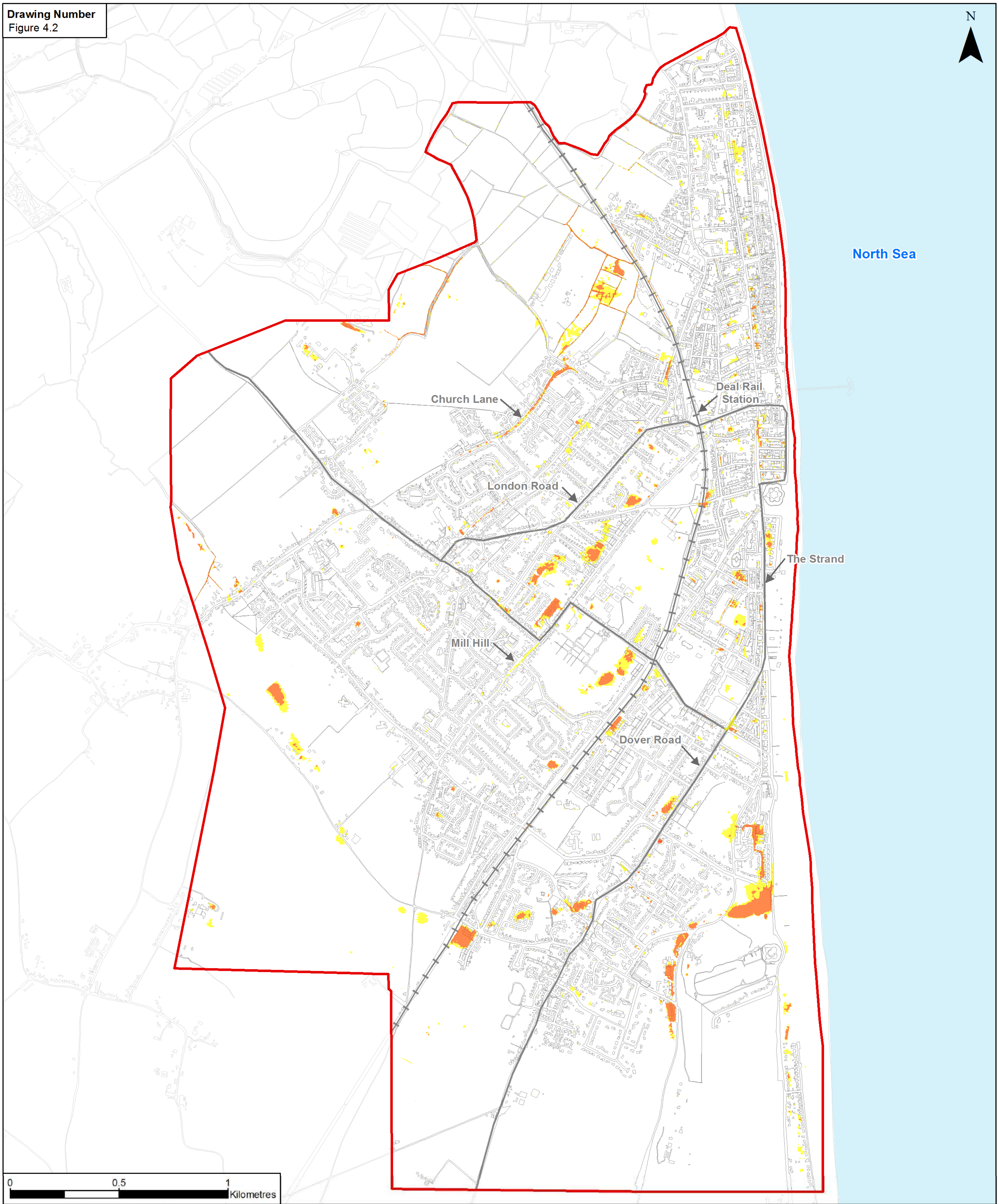
Key Features

- 2D Model Boundary
- Railway Line
- Major Roads

Notes:
In order to increase the clarity of mapping, depths less than 0.05m have not been displayed.

Figure by	DSG	Date	14/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:16,000 at A3		
Drawing Number	Figure 4.3	Revision	00

Drawing Number
Figure 4.2



Client: Kent County Council

Contractor: JACOBS

Status: DRAFT

Project: DEAL SWMP

Drawing Title: 1% AEP Flood Hazard within the Study Area

Map Type: Flood Hazard

Annual Probability: 1% AEP (1 in 100 yr)

Scenario: Existing

Legend

Flood Hazard

- Low (< 0.75)
- Moderate (0.75- 1.25)
- Significant (1.25 - 2.00)
- Extreme (> 2.00)

Key Features

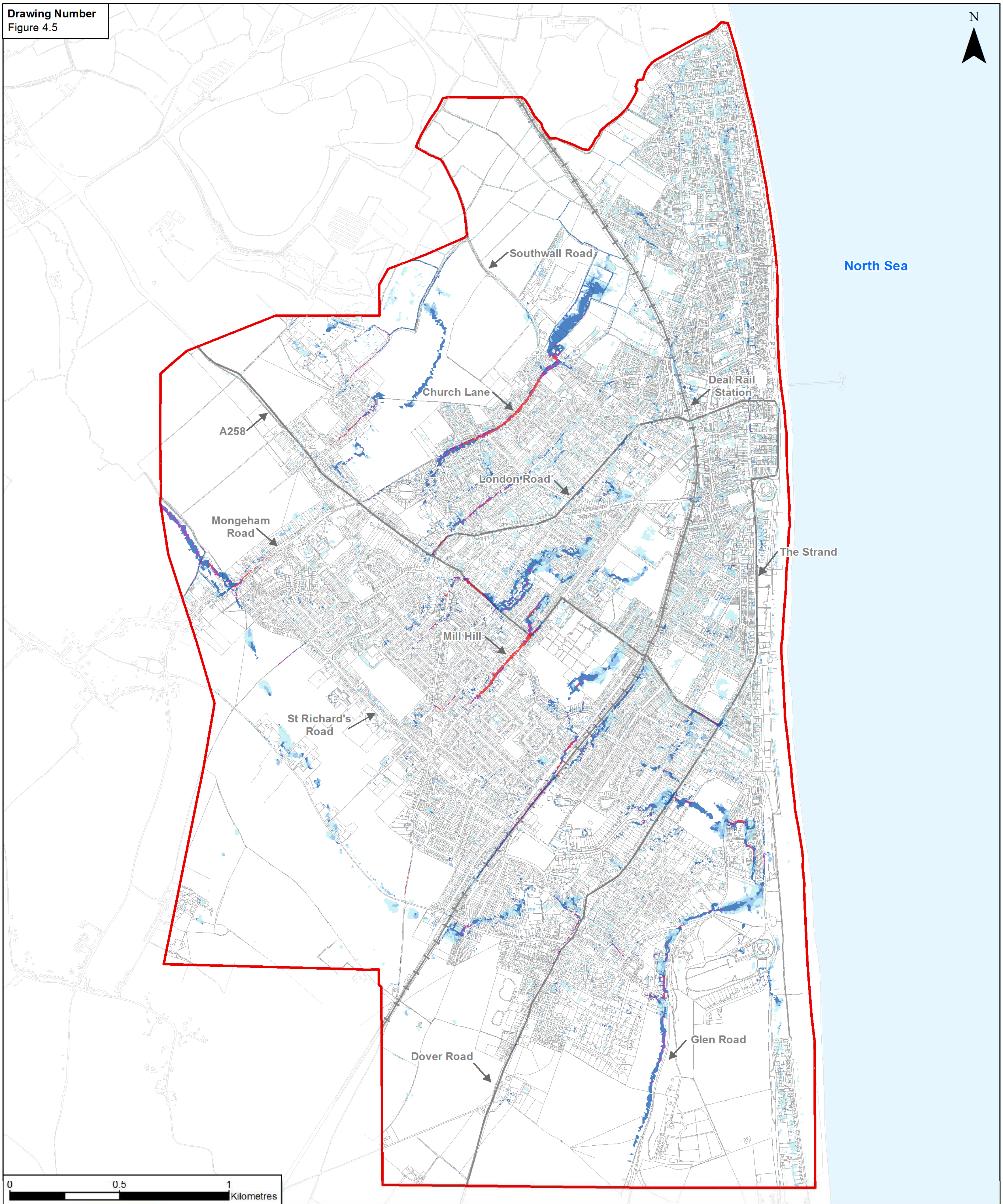
- 2D Model Boundary
- Railway Line
- Major Roads

Notes:
Flood Hazard Rating is calcuated using the DEFRA Hazard formula:
HR = d x (v + 0.5) + DF

Where:
d = depth of flooding (m)
v = velocity of floodwaters (m/s)
DF = Debris Factor

Figure by	DSG	Date	14/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:16,000 at A3		
Drawing Number	Figure 4.4	Revision	00

Drawing Number
Figure 4.5



Client: Kent County Council

Contractor: JACOBS

Status: DRAFT

Project: DEAL SWMP

Drawing Title: 3.33% AEP Flood Velocity within the Study Area

Map Type: Flood Velocity

Annual Probability: 3.33% AEP (1 in 30 yr)

Scenario: Existing

Legend

Flood Velocity (m/s)

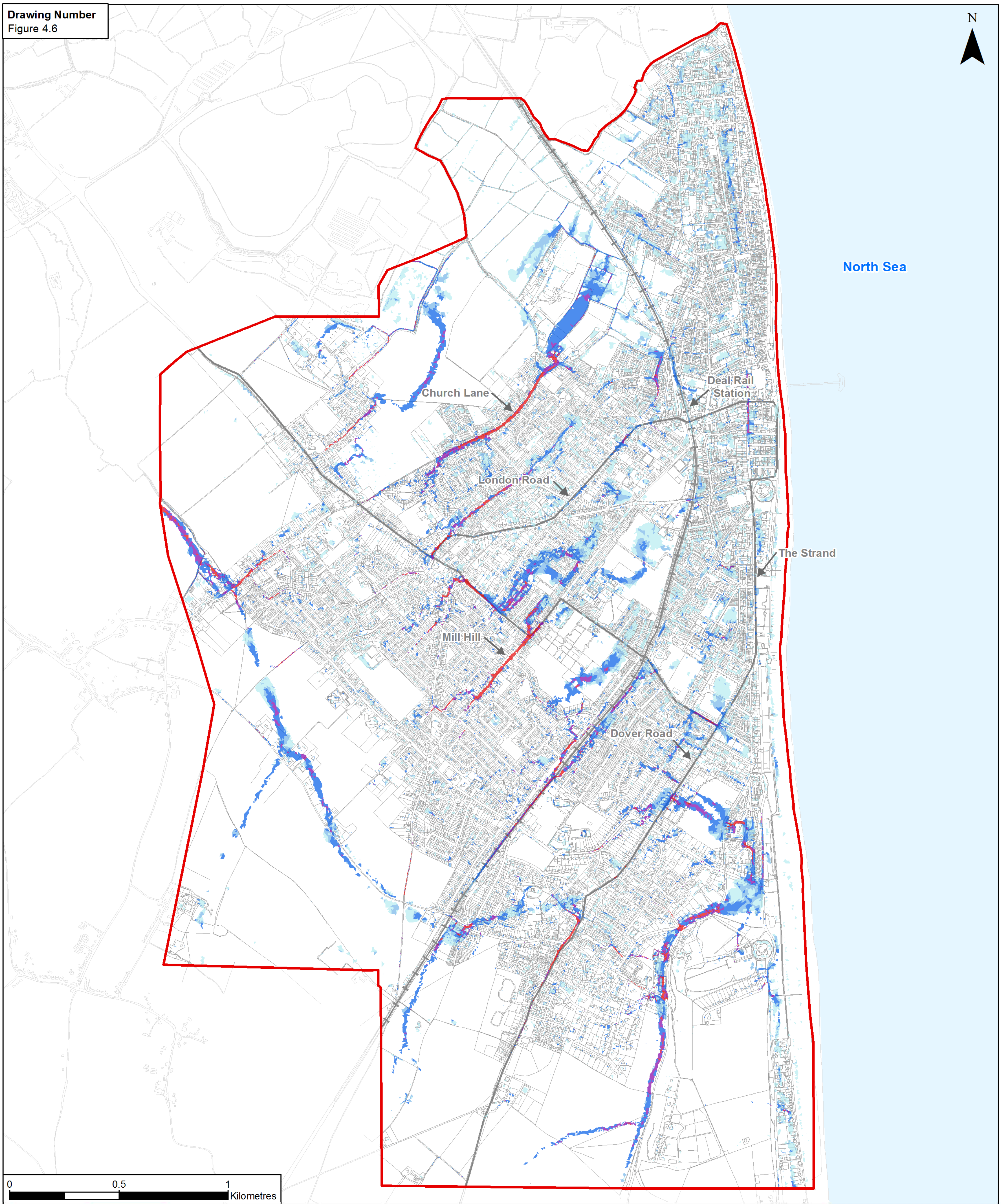
- < 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Key Features

- 2D Model Boundary
- Railway Line
- Major Roads

Figure by	DSG	Date	14/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:16,000 at A3		
Drawing Number	Figure 4.5	Revision	00

Drawing Number
Figure 4.6



Client: Kent County Council

Contractor: JACOBS

Status: **DRAFT**

Project: **DEAL SWMP**

Drawing Title: 1% AEP Flood Velocity within the Study Area

Map Type: Flood Velocity

Annual Probability: 1% AEP (1 in 100 yr)

Scenario: Existing

Legend

Flood Velocity (m/s)

- < 0.05
- 0.05 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5

Key Features

- 2D Model Boundary
- Railway Line
- Major Roads

Figure by	DSG	Date	14/08/2013
Checked by	LM	Date	
Reviewed by	AD	Date	
Approved by	JT	Date	
Scale(s)	1:16,000 at A3		
Drawing Number	Figure 4.6	Revision	00

Maximum velocities across the modelled area are generally moderate (0 to 0.5m/s) with the exception of Church Lane and Mill Hill Road, where high velocities (>1 m/s) are predicted. Areas where velocities are in the order of 0.5m/s correspond to streets and roads with a steep topographic gradient and acting as preferential flowpaths. The steep nature of the upper catchment results in these high velocities. To the south of the catchment elevations are lower and the topography flatter towards the coast

Flood hazard rating across the model area is mostly low to moderate with the exception of the relatively deep flood cells, mentioned above, where predicted flood depths are high enough to represent a significant hazard. Examples of these areas are along the railway embankment south of Station Road. In addition high velocities west of Liverpool Road result in significant Hazard.

Further detail on the areas at risk of flooding along with the flooding mechanisms is provided in the next section.

4.3 Summary of Flood Mechanisms

As discussed in Section 4.2, the key flood mechanisms and characteristics of flooding and specific ‘Hot Spot’ or ‘problem areas’ within the Deal’s Catchment can be summarised as follows:

- Surface flooding across the catchment area drains to topographic low spots with low threshold properties being at a significantly higher risk.
- The existing road network plays an important role at conveying surface flow, from North to South through the catchment. Specifically, Church Lane and Mill Hill Road all act as key flow routes.
- The response from the drainage system during the observed events shows that the drainage system along the major flow routes is largely surcharged with a significant amount of flow being transferred down these flow routes.

Therefore the flood risk management measures considered for the Deal area have been specifically tailored to reduce the flooding to these areas, taking into account the key flooding mechanisms. These are described in the Deal SWMP study Report.

5 Modeling Conclusions

This report has described the modelling methodology associated with the construction of an Integrated Catchment Model carried out to assess surface water flood risk within the Deal area.

The main driver was to appropriately identify key flood risk areas within the modelled area through the integrated modelling of both the above ground and below ground processes.

It is important to note that any modelling results are heavily related to all assumptions inherent to the modelling approach adopted for this study; in particular those associated with the sub-surface drainage systems. Assumptions have been adopted to provide a conservative estimation of the surface water flood risk within the area of interest.

The key conclusions can be summarised as follows:

- This report has described the modelling methodology associated with the detailed model of the Deal catchment, carried out to assess surface water flood risk.
- The catchment model was run for a series of storm events under baseline conditions. Flood depth and hazard maps were produced and along with the model results; these allow for an accurate determination of flood risk areas and key flood mechanisms.
- It is important to note that the modelling results are heavily related to all assumptions undertaken in this study, in particular those associated with the sub-surface drainage system and the storm duration; assumptions have been adopted to provide a conservative estimation of the surface water flood risk within the area of interest.
- This integrated catchment model can be considered as a tool to help manage surface water flood risk and could be used for a high level assessment of potential flood alleviation options. However consideration should be given to the calibration of the model prior to using any outputs for informing detailed design of flood alleviation measures.