

13. Soils, Geology and Hydrogeology

13.1 Introduction

13.1.1 General

Ground conditions along the proposed road development have been interpreted based on desk study information, geophysical data and intrusive ground investigation data from a preliminary ground investigation carried out for the proposed scheme.

13.1.2 Impact Assessment Methodology

As no formal methodology exists for assessing the extent and degree of impact of the geological and geotechnical factors, the following approach has been adopted, having regard to the EPA "Guidelines on the information to be contained in EISs", March 2002, and in conjunction with the Institute of Geologists of Ireland "Geology in Environmental Impact Statements – a guide", September 2002.

The specific impact assessment methodology for the hydrogeological assessment of effects on both Hugginstown Fen and Danganbeg Wetland are detailed in Appendices 13.1 and 13.2, respectively. These wetland sites are shown on Figures 13.1, 13.2 and 13.3, in Volume 2 of this EIS.

13.1.3 Desk Study

The geological desk study availed of the following sources:

Geological Survey of Ireland Six Inch Drift Maps

The six inch drift maps (6 inch to 1 mile, 1:10,560) were commissioned for the entire country in the late 1800's and are available for consultation in the Geological Survey offices. Essentially these sheets consist of walkover survey information hand written onto the first edition Ordnance Survey County series six-inch maps, which date from around 1850. These sheets give general information on soil deposits and sometimes quite detailed information on bedrock outcrops.

Geological Survey of Ireland 1:100,000 Series, Sheet 19 and Sheet 23

The 1:100,000 series bedrock maps that cover the area of the proposed route are Sheets 19 and 23, produced in 1995 and 1994

respectively. These maps outline the buried geology and geological structures within the area.

13.2 Ground Investigation and Monitoring

As identified in Section 4.5.1 of this EIS, preliminary ground investigations were carried out along the line of the proposed route.

The investigations comprised a total of 248 trial pits, 166 cable tool boreholes and 143 probe holes to assess overburden characteristics, 133 rotary coreholes, and 46 rotary percussive drill holes to assess bedrock characteristics and depth to bedrock. The preliminary ground investigation made use of both in-situ testing and geotechnical laboratory testing on bulk samples retrieved from the trial pits and boreholes and rock retrieved from the rotary coreholes.

In total just over 14km of the proposed route was surveyed using geophysical techniques which consisted of Electromagnetic Conductivity (EM-31) to determine type and thickness of overburden, as well as Seismic Refraction and 2D-resistivity to determine depth to bedrock, overburden thickness and bedrock characteristics.

In the vicinity of the Tomard Lower road overbridge, Ch. 75+000 the proposed road was surveyed using geophysical techniques which consisted of a microgravity survey and 2D resistivity profiling to determine depth to bedrock, over burden thickness and bedrock characteristics to establish the location of possible cavities or solution features in the bedrock.

Detailed surface and groundwater investigations have been undertaken at Hugginstown Fen and Danganbeg Wetland. The details of these investigations are outlined in Appendix 13.1 and 13.2, respectively.

13.3 Existing Environment (General)

13.3.1 Solid Geology

The solid geology in the study area comprises two general formations:

- Lower Carboniferous Limestones with thin sandstones and shale formations that underlie the northern and southern undulating lower ground sections of the proposed road, and;

- Old Red Sandstones of the Upper Devonian and early Carboniferous periods that underlie the middle, high ground section of the proposed road.

Carboniferous Limestones:

Mainline Ch. 1+650 to Ch. 6+000, Ch. 24+000 to Ch. 49+200, Ch. 60+000 to Ch. 76+500 and Junction 6 to N10 Link Road. N9/N10 Link Road and Kilkenny Link Road.

The low-lying areas that the proposed road passes through, to the north of Waterford City approximately as far as Ch. 6+000, are underlain by Limestone bedrock of the Ballysteen and Waulsortian formations.

The Ballysteen formation consists of well-bedded relatively clean calcarenitic limestones that pass gradationally up into finer grained and more muddy limestones.

The Waulsortian formation is made up of massive unbedded lime-mudstones with abundant spar-filled cavities.

The proposed road crosses a short section of the Ballymartin formation between Ch. 24+000 and Ch. 25+000. This formation consists of a succession of interbedded dark grey muddy limestones and calcareous shaly mudstones.

The Ballysteen formation underlies the proposed road between the proposed location of the Knocktopher junction and the King's River. This formation is associated with a slightly more rolling topography than the other, lower lying limestone areas.

The proposed road crosses a short section of ground underlain by Waulsortian Limestones to the south of the King's River.

The Butlersgrove formation, made up of a dark grey, well-bedded muddy bioclastic limestones interbedded with thin calcareous shales, underlies much of the proposed route from the King's River north to the railway crossing around Ch. 44+500. The section of the proposed route west of the River Nore crossing and north of the rail crossing from Ch. 44+500 to Ch. 75+000 is underlain by the Ballyadams formation. This formation consists of a grey thick-bedded crinoidal calcarenitic wackestone and packed limestone with clay wayboards (palaeosoils) resting on karsified, erosional surfaces towards the top. Evidence of shallow karsification is present along joints and fractures.

Locally the limestone is dolomitized southwest of the River Barrow (Ch. 75+000) or adjacent to faults. Voids were encountered at the

proposed Tomard Lower overbridge during the preliminary ground investigation works.

The Milford formation underlies the proposed route from Ch. 75+000 north to Powerstown. The formation comprises medium–dark grey, well-bedded, strong limestones.

Old Red Sandstones

Mainline Ch. 6+000 to Ch. 24+000:

The Carrigmaclea Formation is the older of the two sandstone formations encountered and forms much of the high ground around Mullinavat. The formation comprises a sequence of red, brown or pink quartz cobble conglomerates, pebbly sandstones and cross-stratified sandstones. The red beds are capped by yellow sandstones and red and green mudstones and mudflake conglomerates of the Kiltorcan Formation. This formation contains micaceous Sandstones of white and red hues and interbedded yellow to green silty Mudstones.

The Porter's Gate formation records a sequence of shallow water beach sandstones, tidally influenced sandstones and mudstones and the earliest shallow water limestones followed by sub-tidal mudstones.

A thin distinctive shale formation - the Ballyvergin Shale, occurs between the Port's Gate and the Ballymartin Formations to the north. The formation is too thin to be represented on the GSI 1:100,000 map, but forms an important marker horizon. The formation is characterised by grey-green non-calcareous mudstones with thin silt lenses and laminae.

13.3.2 Overburden/Soils

This section provides a summary of overburdens along the road development.

The following types of materials have been identified along the scheme:

- Topsoil;
- Glacial drift; and
- Sands and gravels.

13.3.2.1 Mainline Ch. 1+600 to Ch. 6+000

Top Soil

Averaged 0.3m thick in trial pit logs, varied to 0.2m and in some areas 0.1m thick.

Glacial Drift

- Slightly gravely sandy CLAY with cobbles and boulders to slightly sandy slightly

gravely CLAY with cobbles and boulders with consistency varying from soft to stiff.

- Material found as soft to firm in low-lying areas with higher ground on either side and at depths of up to 4.7mBGL. In elevated locations, material consistency is firm to stiff.
- Fines content of between 30% - 50%.
- Sand content of 30% to 40%.
- Natural moisture contents are predominantly dry of the plastic limit, and range from 10% - 19%.
- Liquid Limits between 26% - 39%.
- Plasticity Indices: 11% - 21%.

Sands and Gravels

Isolated pockets were encountered, these contain between 10% and 50% fine sized particles.

13.3.2.2 Mainline Ch. 6+000 to Ch. 24+000

Top Soil

Varies from 0.2m to 0.3m thick in trial pits, occasionally up to 0.5m thick.

Glacial Drift

- Glacial deposits are sandy gravely CLAYS with cobbles and boulders. These deposits have between 50% and 70% sand and gravel sized particles with index properties that class them as clays of low plasticity.
- Natural moisture contents are predominately slightly dry of the plastic limit and range from 9% to 18%.
- Around Mullinavat high ground areas, Liquid Limits range from 25% to 30% with Plasticity Indices of 10% to 14%.
- North of this area Liquid Limits range from 20% to 25% with Plasticity Indices of 7% to 10%.

Sands and Gravels

Isolated pockets were encountered along the line of the proposed road. These granular materials have fines contents of between 5% and 20%. Between Ch. 17+500 and Ch. 19+000 the overburden consists of very sandy CLAY grading to clayey SAND in places.

13.3.2.3 Mainline Ch. 24+000 to Ch. 49+200

Top Soil

Varies from 0.2m to 0.3m thick.

Glacial Drift

- Deposits described as sandy gravely CLAYS with cobbles and boulders.
- Between 60% and 80% sand and gravel sized particles.
- Plasticity Index classes them as clays of low plasticity.
- Natural Moisture contents range from 7% to 15%, with occasional moisture contents to 20%.

Sands and Gravels

Encountered in many locations. These sands and gravels contain between 20% and 30% fine sized particles.

13.3.2.4 Mainline Ch. 60+000 to Ch. 76+500

Topsoil

Varies from 0.1m to 0.5m thick in exploratory holes. Localised silts, laminated clays and peat occur adjacent to the east bank of the River Barrow.

Glacial Drift

- The glacial deposits are generally described as slightly sandy slightly gravely CLAYS with cobbles and boulders with consistency varying from very soft to very stiff, generally firm to stiff.
- Sand and gravel content for these deposits is 20% to 60%.
- Liquid limits range from 17% to 37%. Plasticity Indices of 5% to 25%.
- Moisture contents are typically from 10% to 20%, with occasional higher moisture contents occurring in the wetter deposits in the top 1-2m below ground level which are more readily influenced by prevailing weather conditions and deeper localised zones around water bearing silty sand and gravel lenses.

Sands and Gravels

The proposed road crosses areas of localised granular deposits adjacent to existing watercourses and thin sand and gravel lenses over the remainder of the proposed route overlying bedrock and mixed above/below with

glacial drift. These granular deposits contain between 15% and 80% fine sized particles.

13.3.2.5 Kilkenny Link Road

Topsoil

Averages from 0.3m thick to 0.2m in trial pits. Topsoil was identified in boreholes as 0.1m thick in some areas.

Glacial Drift

The glacial deposits are described as sandy gravely CLAY with cobbles and boulders. Sand and gravel content for this material range from 50% to 60%. Liquid Limit of 25% to 30%. Plasticity Indices of 9% to 13%.

Sands and Gravels

The proposed Link Road crosses areas of granular deposits adjacent to existing watercourses and a number of isolated sand and gravel lenses over the remainder of the proposed route.

13.3.2.6 Junction 6 to N10 Link Road and N9/N10 Link Road

Topsoil

Averages of 0.3m thick in trial pits.

Glacial Drift

The glacial deposits are described as slightly sandy gravely Clay with cobbles and boulders. Sand and gravel content for this material of 5% to 30%. Liquid limit of 17% to 36%. Plasticity indices of 7% to 18%.

Sands and Gravel

Isolated sands and gravels under till deposits were encountered during the preliminary ground investigations.

13.3.3 General Hydrogeology

Introduction

The land through which the proposed road passes is drained by three main rivers and their tributaries, as discussed in Chapter 12.

The quaternary sediments encountered along the route of the proposed road generally consist of clay, tills and granular deposits. The granular deposits are generally interbedded with less permeable material and these low permeability materials can protect underlying aquifers and can restrict recharge.

The two groupings of bedrock geology present, Old Red Sandstones and Lower

Carboniferous rocks, both have particular aquifer characteristics.

Old Red Sandstones

The Carrigmaclea Formation (generally cropping out on high ground) is impermeable, except along faults, and is considered an aquitard.

The Kiltorcan Formation, which crops out in the area to the south of Thomastown is part of an extensive aquifer. Sandstone units dominate the upper part of the formation and mudstone the lower part. The aquifer is confined down dip by the overlying Carboniferous rocks, and artesian conditions have been reported.

Lower Carboniferous Rocks

The two main aquifers in the lower Carboniferous strata of the region are the dolomitised limestones and the karsified limestones.

There has been extensive dolomitisation of parts of the Ballysteen, Waulsortian and Butlersgrove Formations in this area. As a result, the permeability of these rocks has been increased considerably. The dolomitised limestones discharge via a number of large springs, which emerge close to the channels of the Nore and King's Rivers.

The karsified limestone aquifer in the area consists of the Ballyadams Formation. The permeability of this aquifer is variable and is restricted by the presence of clay wayboards.

The classification of each rock unit in Co. Kilkenny that has aquifer potential is given in the County Kilkenny Groundwater Protection Scheme, July 2002, produced by Kilkenny County Council and the Geological Survey of Ireland. According to the aquifer classification used by the GSI (DELG/EPA/GSI, 1999), there are three main aquifer categories:

- Regionally Important (R) Aquifers;
- Locally Important (L) Aquifers; and
- Poor (P) Aquifers.

The classification of the bedrock formations encountered by the proposed road is given in Table 13.1 Summary of Aquifer Classification

The Kilkenny Groundwater Protection Scheme lists groundwater supply sources in use in Co. Kilkenny. The closest of these sources to the proposed road is the Bennettsbridge Source, located approximately 5km from the proposed road.

The thick sand and gravel deposits adjacent to the River Barrow are classified as a minor aquifer (1994, GSI). The sand and gravel deposits along the River Nore are classified as a major aquifer.

Groundwater monitoring in borehole standpipes show groundwater levels to vary between 1m and 14m south of Ch. 49+000. South of Mullinavat groundwater levels vary between 1m and 6m below existing ground level.

During the Preliminary Ground Investigation north of Ch. 60+000 groundwater was generally encountered at between 1 and 15 meters in depth. Initial standing water readings at the nineteen piezometers installed suggest a high water table in overburden around 1.0mBGL north of Ballyvalden (Ch. 63+000).

A well survey was conducted along sections of the proposed road. The chainage ranges over which this survey was carried out are given below:

- A – Ch. 10+140 to Ch. 11+500;
- B – Ch. 21+300 to Ch. 22+900;
- C – Ch. 27+800 to Ch. 29+600;
- D – Ch. 43+000 to Ch. 43+760; and
- E – Ch. 7+000 to Ch. 8+200.

Information requested from well owners included:

- Location of any wells;
- Water level and total depth of well;
- Pump size and type; and
- Usage details.

A summary of the well details provided is given in Table 13.2.

In addition, a holy well identified as a site of archaeological importance, exists adjacent to the proposed road at Ch. 24+400 (refer to Chapter 17).

13.4 Hugginstown Fen Hydrogeology

The road development runs along the eastern boundary of Hugginstown Fen (cSAC) (Ch.17+400 to 19+700), as shown on EIS Figure 13.2 in Volume 2. This site is a valley fen that overlies limestone based glacial till material which in turn overlies the local sandstone bedrock (Kiltorcan Formation). The cover provided by the till over the bedrock is

shallow along the elevated valley sides (<3m) but is thicker in the trough of the valley below the fen.

The ecological aspects of Hugginstown Fen has been given detailed consideration in Chapter 11 of this EIS.

Desk and site-specific investigations at the fen have provided the following understanding of the fen's hydrogeology and hydrology (refer to Appendix 13.1 for the details of the assessment of the hydrogeology at Hugginstown Fen):

- Groundwater springs discharge mainly along the eastern margin of the fen and these nutrient rich waters maintain the fen and flush ecology;
- A central drain (Drain D1) in the southern part of the fen that drains south to the Derrylackey River has significantly impacted on surface water and groundwater recharge in the southern fen;
- Result of groundwater gradients indicate that drainage has not significantly impacted the northern bulrush swamp area;
- The very northern part of the fen drains to a separate catchment (Drain D3), to that of the Little Arrigle River which flows north to the River Nore;
- The chemistry of the groundwater indicates that it is alkaline and of calcium/magnesium bicarbonate water type. It has moderate mineral and nutrient content and generally good water quality;
- The aquifers in order of significance that feed the fen are (a) the limestone based glacial till with sands and gravels that occur in significant depths along the margins of the fen and underneath it. It is this till that impacts the alkaline and nutrient rich chemistry to the groundwater before discharging to the fen, and (b) the sandstone bedrock known as the Kiltorcan Formation which transports recharged groundwater (from rainfall) along the upper slopes of the valley; and
- A number of wells occur within the area of Hugginstown Fen, but little information exists on well yields and depth of bedrock.

13.5 Danganbeg Wetland Hydrogeology

The section of the proposed road development relevant to the Danganbeg Wetland site is from Ch. 24,600 to Ch. 27,450. The proposed road passes from the south through the townland of Glebe north via intersection at R699, northwards flanking the western boundary of Danganbeg wetland before wrapping around the western edge of high ground at Knockadrina Wood. This site is shown on EIS Figure 13.2 in Volume 2.

The ecological aspects of Danganbeg Wetland has been given detailed consideration in Chapter 11 of this EIS.

The Danganbeg site is a young wetland/ fen environment that is groundwater fed by highly mineralised water. Desk and site-specific investigations at the wetland site have provided the following understanding of the wetlands's hydrology (refer to Appendix 13.2 for the details of the assessment of the hydrogeology at Danganbeg Wetland):

- Groundwater is fed by a combination of groundwater and spring discharge;
- Spring discharge is concentrated at the eastern and western boundaries of the wetland along a contour range of 65mOD to 62mOD (c.63mOD). Three types of spring emergence occur at Danganbeg. These are diffuse seepage into vegetation, distinct point source seepage and overland flow towards the central wetland, and capture of springs by drains that take the water away from the wetland vegetation;
- The groundwater at depth passes under the springs and discharges under the wetland, sustains the central wetland environment;
- Springs at the eastern side of the wetland have been identified as having links to Annex 1 habitats (alkaline fen and, possibly, petrifying springs with tufa formation). This is the most sensitive part of the wetland (also see Chapter 11 in relation to Terrestrial Ecology);
- The drains at the site are extensive (EIS Figure 13.2 in Volume 2) and have drained the wetland considerably. In particular the manipulation of spring discharge by capturing these high mineral content waters and carrying it away to discharge to

the south of the wetland has lead to de-mineralisation of the western wetland;

- Groundwater and surface water moves from north to south generally determined by local topography. The catchment is a broad "pan" valley with flow from the north, east and west coalescing within the wetland and discharging via a drain that flows south to the Little Arrigle River; and
- Danganbeg wetland catchment is approximately 6210ha (6.21km²). In terms of catchment size, the wetland makes up a very small percentage of the total catchment at 2.7%, of which fen and swamp flora make up c. 1.7%. This indicates that a large surface area provides the recharge to this small wetland.

13.6 Predicted Impacts (Operational)

13.6.1 Potential Contamination of Soil

Traffic flows on the proposed road over what is predominantly a green field site at present will result in a risk of contamination of the soils in the vicinity of the route. Potential sources in contamination include petrol or diesel spillage or a spillage of goods being carried on the road.

13.6.2 Soft Ground Areas

During the preliminary ground investigation a number of soft ground areas were identified which may not be able to support embankments or provide a suitable road sub-base.

Areas where soft ground was encountered include the area where the proposed road crosses the existing N9 and Dublin to Waterford railway line to the north of Waterford City, (Ch. 2+100), the area between Ch. 7+700 and Ch. 8+300, Ch. 24+000 and Ch. 26+500 (at Danganbeg), Ch. 29+800 to Ch. 30+200, the River Nore valley, (between Ch. 39+800 and Ch. 40+040, and the River Barrow floodplain between Ch. 75+620 and Ch. 75+900.

A number of isolated, local soft ground areas were also encountered over the length of the proposed road.

13.6.3 Hydrogeology – General

Impact on Regional and Local Aquifers

The area of the paved road surface is small when considered against the recharge area of the aquifers over which it passes therefore loss of infiltration to these aquifers is considered to be insignificant and the regional water levels will not be affected.

This risk to the aquifer of pollution will increase where the proposed road is built across greenfield areas, and the vulnerability to the aquifer will increase due to the position of drains and discharge points below the existing land surface (where the thickness of the protective overburden is reduced).

Impact on Public/Private Supply Wellfields

The drainage design for the proposed road is such that all road run-off will be collected and discharged, via interceptors where appropriate, to surface watercourses. Where river base flow contributes to groundwater recharge the natural process of dilution, dispersion and filtration should ensure that there is no impact on the quality of the groundwater at the location of any private wells.

If the water table is intercepted and drawn down due to a road cutting, which crosses the source of the catchment of a well, the following are the potential impact which may arise:

- The quantity of water available could be reduced;
- The year on year average water level in the well could drop;
- The well could, in the worst case scenario, dry up completely.

The closest public water supply source to the proposed road, the Bennettsbridge Source, is located on the eastern banks of the River Nore. As the proposed road passed through lands 4 km to the west of the river Nore, at grade or in minor cut and at any elevation around 30m higher than the source construction and operation of the proposed road will not impact on the Bennettsbridge ground water source.

The closest cut section on the proposed road on the eastern side of the River Nore is some 7km to the north of the Bennettsbridge Source with the proposed road elevation around 40m higher than the source construction and operation of the proposed road will not impact on the Bennettsbridge ground water source.

With reference to Table 13.2, the following are the private wells that may have their production impacted on: A2, A3, A4, A5, A6, D2, D3, D4, D5 and E4.

Well A7 is located on the centre line of the proposed road and will be removed. Well C2 is located within the footprint of the proposed road and will be removed.

Wells D1, D2 and D3 are located in areas where the observed water table level is lower than the level of the proposed cut and as such there is not anticipated to be any impact on these wells.

The holy well adjacent to mainline Ch. 24+400 (which is of archaeological importance) will experience some minor reduction in its recharge conditions. However, this is not anticipated to have any significant effect on the well's normal hydrogeological characteristics (refer to Chapter 17 for details on the holy well).

For the other wells listed in Table 13.2, the proposed level of the road cutting is above the existing groundwater level at the well location and the proposed road is not anticipated to impact these wells.

13.6.4 Impact on Wetland Sites

Impacts on the hydrogeology of both Hugginstown Fen and Danganbeg Wetland are primarily related to the construction stage of the road development (see section 13.7).

There will be no significant operational impact on the hydrogeology of Hugginstown Fen (refer to Appendix 13.1 for details).

While there will be some potentially significant impact on the hydrogeological regime at the north-western quadrant of Danganbeg Wetland, use of appropriate mitigation measures will reduce this to an insignificant impact (refer to Appendix 13.2 for details).

13.7 Predicted Impacts (Construction)

13.7.1 Rock Excavation Method

There is a number of cut sections along the proposed road where information from the preliminary ground investigation indicates that the removal of rock formations will be required. The method of removal can range from digging the material out with an excavator to ripping, to breaking and to blasting. Each of these methods represents an increase in mechanical

effort compared to the previous one and as such noise, dust and vibration levels will increase. Table 13.3 lists the area where rock excavation is likely to be required based on the preliminary ground investigation. This table also includes an estimation of the excavation method that will be required to remove the rock, again based on the preliminary ground investigation.

This estimation is based on the information obtained from relevant coreholes and trail pits performed at the cut zones. A detailed assessment of the rock mass during the detailed ground investigation will provide a more comprehensive outline of the rock type and rock levels obtained from more frequent exploratory locations at each cut zone and allow a better evaluation of the excavation methods.

13.7.2 Slope Stability

The proposed vertical profile of the road incorporates several large earthworks sections, including embankments of up to 16.0m high and 12.0 deep cuttings. Areas containing significant slopes (both cut and fill) identified during the preliminary ground investigation are presented in Table 4.9 (Chapter 4).

Many cuttings are likely to extend below the groundwater table and will therefore be susceptible to groundwater flow within the cutting side which may lead to erosion and instability.

Several of the proposed road cuttings along the route will involve excavating into bedrock. The rock encountered during the investigation generally consisted of Sandstones and Limestones (refer to Table 13.3 for details).

The Geological Survey of Ireland bedrock maps show the presence of six fault lines in close proximity of the proposed road at Ch. 4+500, Ch. 10+100, Ch. 14+500, Ch. 28+500, Ch. 33+500 and Ch. 39+800. The proposed road alignment is in fill or shallow cut at four of these locations, (Ch. 10+100, Ch. 14+500, Ch. 33+500 and Ch. 39+800 and as such the presence of the fault should not result in any slope instability issues.

For the remaining two fault locations, Ch. 4+500 and Ch. 28+500, the proposed road is in between 5m and 11m of cut. Seismic refraction surveys were carried out on these cut sections as part of the Preliminary Ground Investigations. The results of this survey at Ch. 4+500 indicate variable rock conditions through this cut section. This could be as a

result of a fault line crossing this cut that could cause slope instability problems at this location.

The results of the seismic refraction survey at Ch. 28+500 indicate good quality, intact rock throughout this cut section that should not result in any slope instability issues at this location.

13.7.3 Effects of Construction Dewatering

In areas where there are significant cuts, it is likely that construction dewatering will be required, in order to allow “dry” excavation and construction to take place. Table 13.4 lists the areas where construction dewatering is likely to be required based on the preliminary ground investigation.

In general, where glacial till is encountered, dewatering will be minimal, whereas in areas with significant thickness and/or extent of granular materials or highly fractured rock, significant dewatering may be required. Care will also have to be taken to prevent undermining of slopes due to draining water out of granular materials.

13.7.4 Piling

Where construction of a structure is to take place in a zone where a thick stratum of soft soil exists, it is probable that piling will be considered as an alternative to fill removal or ground improvement.

The impact on the environment will be determined by the piling method. Driven piles are installed using percussive techniques and generate noise and vibration. The installation of bored piles requires the removal of ground material, which will be incorporated back into the road development where possible. Bored piles are quieter and cause less vibration.

13.7.5 Disposal of Excavated Material Unsuitable for Re-use/Deterioration of Re-useable Material

The construction of the proposed road will result in the removal of both overburden and bedrock deposits. Table 4.9 (Chapter 4 of this EIS) details significant cuttings and embankments that contribute to the earthworks discussed in this section.

The material to be excavated from cut sections is a natural resource and its use within the road development will be maximised by utilising construction techniques that remain and/or enhance the compactability of the material for re-use as engineering fill.

However, there will inevitably be a significant proportion of material, both soil and rock, that may not be re-used as engineering fill. It is likely that, unless alternative uses can be found, such as in landscaping areas or visual/noise barriers, the remainder of this material will require removal to a suitably licensed receptor.

Based on current estimates, the total volume of material to be excavated along the proposed road is expected to be of the order of 7.8 million m³.

For the purpose of preliminary design it is estimated that the total volume of overburden material to be excavated in 6.0 million m³ with 1.8 million m³ of rock.

Laboratory testing indicates that approximately 70% of excavated overburden will be reusable at its natural moisture content as an engineering fill for construction of road embankments. This would result in approximately 1.2 million m³ of overburden unsuitable for use as an engineering fill in its in-situ condition.

13.7.6 Spillages from Construction Plant

Due to the large quantity of machinery that will be present on the site it will be necessary to provide facilities for refuelling. There is a potential for spillage of fuel to occur during these operations, which can be mitigated as outlined in section 13.8.6.

13.7.7 Hydrogeology

Impact on Regional and Local Aquifers

In areas where there are significant cuts, it is likely that construction dewatering will be required in order to locally lower groundwater levels to allow “dry” excavation and construction to take place. This will have a local effect on aquifer water levels. Table 13.4 lists the areas where construction dewatering may be required based on the preliminary ground investigation.

Surface water runoff during construction may carry contaminants into the groundwater system via infiltration. Aquifers could be at risk of contamination if heavily polluted surface water were to infiltrate into the ground.

Impact on Public/Private Supply Wellfields

It is assumed that construction of the proposed road will lower the water table to a similar degree as the final constructed road design. Therefore the impacts on private wells during construction are similar to those outlined in

Section 13.6.3 Impact on Public/Private Supply Wellfields.

In areas with shallow overburden overlying the water table, runoff during road construction may affect the quality of the groundwater. This potential impact will only affect wells that are located “down hill” from the proposed road.

With reference to Table 13.2 wells B9, B10 and B11 are located in areas of shallow overburden with high groundwater levels and consequently may be affected by runoff from the road construction.

Wells D1, D2 and D3 are also located in areas of shallow overburden but as the water table is believed to be 8m+ deep in this area these wells are not considered to be at risk of being affected by construction runoff from the road.

As outlined in section 13.6.3, the holy well adjacent to mainline Ch. 29+400 will experience some minor reduction in its recharge conditions. However, this is not anticipated to have any significant effect on the well’s normal hydrogeological characteristics.

Impact on Hugginstown Fen

Following ground investigations and extensive data collected and assessed on the site’s hydrology and hydrogeology, the proposed road development is identified as having the following potential impacts on Hugginstown Fen:

- Two cuts are identified in the road alignment adjacent to the Fen (Cut 1 between Ch. 18+975 and Ch. 19+040, and Cut 2 between Ch. 19+235 and Ch. 19+338). Cut 1 occurs within the fen catchment and Cut 2 to the north of it. No significant hydraulic impact is identified on the water table and thus on the fen by these cuts;
- Reduction in fen catchment by 1.6% will not have a significant impact on Hugginstown Fen;
- Reduction in groundwater recharge by up to 1.8% will not significantly impact on Hugginstown Fen;
- Secondary potential impacts could result by earthworks activities during the construction phase;
- Secondary potential impacts could result by storm runoff generation by the new infrastructure; and

- There is a potential risk associated with accidental spillage during the operational life of the project.

There are potentially significant impacts associated with the location of the proposed road relative to Hugginstown Fen. However, with use of appropriate mitigation measures (outlined in section 13.8) these impacts will reduce to not significant (refer to Appendix 13.1 for further details).

Impact on Danganbeg Wetland

Investigations of the wetland have resulted in the following identification of potential impacts of Danganbeg wetland:

- Two cuts are proposed within Danganbeg Wetland catchment (Cut 1 between Ch. 25+535 and Ch. 25+910, and Cut 2 between Ch. 26+610 and Ch. 27+145). Cut 1 occurs to the southwest of the wetland, and is unlikely to have a significant hydraulic impact on Danganbeg wetland in terms of dewatering of the wetland ecology. Cut 2 occurs to the north of the wetland and may cause a minor hydraulic impact on the wetland in terms of dewatering of groundwater recharge;
- Excavation and replacement of materials in proximity to the wetland along Fill 2 are considered to pose a potentially significant negative impact on the hydrogeology and hydrology of the wetland east of Fill 2;
- The proposed road development has the potential to significantly adversely impact the springs and groundwater throughflow in the aquifer, thereby shutting off the water source to the wetland along the western part of the wetland;
- Road materials of a different chemistry to that of in-situ ground can lead to chemical changes that impact wetland environments;
- The proposed road development will reduce the Danganbeg hydrological catchment by <1%. This percentage reduction is insignificant in terms of the potential to impact to water levels in Danganbeg;
- Increased stormwater runoff from the proposed road surface has the potential to be a negative impact;
- Stripping and removal of soil/subsoils has a potential significant negative impact;
- Environmental risk arising from accidental road spillage during the life cycle of the

development is identified as a potential impact on Danganbeg wetland, due to the proximity of the proposed road to the wetland; and

- The proposed road will not lead to aquifer compression and reduction in horizontal permeability along the western fringe of the wetland. The local road realignment to the north of the wetland between Ch. 26,600 and 27,220 will not result in a significant impact.

There are potentially significant impacts associated with the location of the proposed road relative to Danganbeg Wetland. However, with use of appropriate mitigation measures (outlined in section 13.8) these impacts will reduce to not significant (refer to Appendix 13.2 for further details).

13.8 Mitigation Measures

13.8.1 Soft Ground Areas

The most economical method of constructing in areas of soft ground where the soft deposits are relatively shallow involves excavating the soft material and replacing it with suitable fill. However where there are deeper soft soil deposits, more extensive measures may be required, such as piling, pre-consolidation or soil strengthening, e.g. using lime or cement mixed into the soil.

Any material excavated from these areas will need to be disposed of in landscape areas or off-site to a suitably licensed receptor.

Where possible, in poorly drained/waterlogged areas, pre-earthworks drainage will be used which will improve the engineering characteristics and stability of soft areas.

13.8.2 Rock Excavation

Where blasting is undertaken, it is likely that significant noise, dust and vibration will occur in the immediate vicinity of the works. Table 13.3 indicates which cut sections are likely to require blasting. Given that the actual magnitude of noise emissions or vibrations resulting from rock excavation/blasting is dependant on the construction methods and programme adopted, it is not possible to quantify them in the EIS. The mitigation measure given in Chapter 8 – Noise and Vibration will be applicable here also.

13.8.3 Side Slopes

Based on the information from the preliminary ground investigation 2:1 side slopes, (2 horizontal to 1 vertical) have been adopted for the preliminary design. It is to be expected that the detailed ground investigation will deliver information that will allow side slopes to be locally steepened up while areas requiring a shallower side slope may be identified.

Typically embankments higher than 9m to 10m will include some sort of basal strengthening in the form of geo-grid reinforcement or a rock fill starter layer. This strengthening will help to prevent failure occurring within the placed fill in the embankment.

Where cut slopes will be excavated below the groundwater table, suitable drainage measures will be implemented to ensure that outwash of the embankment face does not occur. Such drainage measures may involve a permanent lowering of the water table or the installation of granular counterfort drains within the slope. Cut off drains will also be installed at the top of the slopes where the natural ground slopes towards a cutting.

Where the presence of geological fault lines is suspected close to cut sections at Ch. 4+500 and Ch. 28+500 further information on the exact ground conditions at these locations will be gathered as part of the Detailed Ground Investigation.

13.8.4 Piling

The type of piling method selected will dictate the likely impact that the installation process will have on the environment.

Care will be taken where piling works are undertaken in the vicinity of watercourses or aquifers to ensure that there is no contamination of the water by the materials and equipment used in the construction.

In particular, where open bored piling is carried out in the vicinity of watercourses care will be taken to avoid concrete spills into the watercourse and the use of bentonite will be avoided.

Mitigation measures in relation to minimising impacts from dust, noise, and vibration are further detailed in Chapters 8 and 9 Noise and Vibration and Air Quality respectively.

13.8.5 Disposal of Excavated Material Unsuitable for Re-use

In order to maximise the re-usability potential of the excavated materials, they will be

handled and trafficked to a minimum and stockpiled in such a way as to minimise the effects of weathering. The time between excavation and re-use during wet weather periods will be kept to a minimum.

Where practical, lowering the moisture content of the excavated material towards its optimum will potentially increase the percentage of reusable overburden. However, site conditions do not always permit the drying out of excavated material. Indeed, persistent rainfall on exposed stockpiles of material for reuse can have the reverse effect.

13.8.6 Spillages from Construction Plant

All fuel will be stored/stocked within containment bunds within the site to prevent release into the ground. Where it is necessary to refuel plant on site, this will be done in a carefully managed manner. Emergency procedures will be put in place by the Contractor, so that the effects of accidental spillages can be minimised.

13.8.7 Hydrogeology

General

It is possible that with further information gathered as part of the detailed ground investigation, the level of impact to some of the affected wells could be reduced. Mitigation measures based on the existing information are outlined below.

Where aquifers may be impacted upon, care must be exercised in the design of drainage systems to ensure that these aquifers are not compromised, either by providing "closed" drainage systems in these areas or through the use of lined swales. This will prevent any runoff borne contaminants directly entering the groundwater system via infiltration.

Silt traps and oil interceptors/pollution control facilities for all drainage discharge will be included in the road design.

Recirculation of groundwater from excavation dewatering back into the same groundwater catchment, via an interceptor, will also minimise the potential effect of reduced spring and surface water flows.

Further monitoring of groundwater levels prior to and during the construction phase of the project will be undertaken to ensure that the groundwater table at the areas of cutting predicted during the design process agree with the conditions on site.

The following measures will be undertaken sequentially where the water table is lowered to such an extent that output from an adjacent well is reduced to less than the current requirements of the owner.

- If not already carried out, a pumping test will be conducted to determine the sustainable yield of the well;
- Consideration will be given to the need/benefit of drilling deeper in the existing well in order to increase the yield if deemed necessary;
- Soft ground areas may require removal and replacement or in-situ ground improvement. Ground improvement may involve additives such as cement or lime;
- If the well is deepened, the likely sustainable yield will be assessed either by airlifting at the end of drilling or by carrying out a pumping test;
- If well deepening does not satisfy the yield and quality objectives then another suitable location will be drilled and sufficient groundwater found to either supplement or replace the impacted well or an alternative water source will be provided;
- Where an existing well is to be removed a replacement well will be constructed;
- An environmental management plan will be developed and reviewed during the construction phase, with particular care required in the vicinity of Hugginstown Fen and Danganbeg wetland. Transfer areas will have adequate protective measures to guard against potential accidental spills and leakages. All equipment and machinery will have regular checking for leakages and quality of performance; and
- To mitigate and effectively deal with accidental spillage during the operational phase of the project, an emergency clean-up team will be contracted for service by the relevant local authority.

While there is no significant impact anticipated at the holy well adjacent to mainline Ch. 29+400, the construction methodology in the vicinity of this site will consider the detailed groundwater levels gathered at the next stage of design, to ensure the effects on the site are minimised.

Mitigation Measures for Hugginstown Fen

In relation to the impacts identified at Hugginstown Fen, the following mitigation measures will be implemented:

- To ensure that no impact arises from the cuts proposed, baseline monitoring over 24 months will be undertaken prior to development; during construction at an increased frequency to identify any change imposed by the development (early indicators); and post construction for a minimum of 12 months. This monitoring will enable continued characterisation of fen hydrology and any patterns, trends or fluctuations in water level and chemistry arising from seasonal variations or non-natural impact. This data will be assessed by a qualified wetland hydrologist;
- The realigned side road (Ch. 17+900 to 18+500) will have no significant sections of cutting and there will be no excessive stripping of soils in this area. Standard shallow road drainage (<0.4m depth) will be used;
- Local subsoil materials will be used, where possible, in the construction of the fill embankments (at Ch. 18+450), in order to maintain the same recharge characteristics of the in-situ substrate;
- The drainage system will include pollution controls and adequate hydraulic capacity to ensure containment. Closed drainage will be employed along the boundary of the cSAC, and all interceptors/settlement balance ponds be located outside of the cSAC designated area;
- Drainage controls during the construction phase will ensure containment of all run off within the site to designated discharge points. All waters arising from the construction site will be discharged outside of the cSAC designated area;
- Topsoil stripping for embankments will be minimised and where ground conditions are suitable, a geotextile will be used and placed directly on existing topsoil; and
- Ongoing monitoring of groundwater levels and chemistry will continue during the construction phase.

No mitigation measures are required for the reduction in fen catchment or for the reduction in groundwater recharge.

Appendix 13.1 contains the full details of the assessment of the hydrogeology at Hugginstown Fen.

Mitigation Measures for Danganbeg Wetland

The following mitigation measures will be implemented in relation to Danganbeg Wetland:

- Periodic transverse and vertical hydraulic barriers made of impermeable or low permeability materials will be installed every 50 –100m along the mainline within the wetland catchment (Ch. 25,540 to 26,620) to force groundwater to pass through the foundation and emerge on the opposite side to natural ground conditions; and
- During construction, groundwater intercepted will be pumped to soakaway structures downstream from the mainline to replenish dewatered waters.

The following engineering enhancements will be implemented at the detailed design stage along the length of Fill 2 to prevent a negative hydraulic impact on the wetland:

- Use of inert lightweight fill (e.g. polystyrene blocks) or a free draining granular fill to maintain permeability and throughflow of groundwater;
- Construction of embankment during dryer months to avoid excessive dewatering. Aside from the mainline, any sumps used will be filled and returned to or above pre-construction ground level conditions;
- Installation of low permeability vertical hydraulic barriers across the road at 50-100m intervals to force groundwater to cross the road into the wetland;
- Where possible, use locally excavated materials (alkaline based) from sites with no history of contamination. Synthesised geotextiles/polystyrene fill will be inert and unable to impart or absorb chemistry from passing groundwater. Other construction materials that have potential to change groundwater chemistry (e.g. cement, bentonite) will be reviewed with respect to throughflow of groundwater to the wetland. Mitigation measures such as using alternative materials or sleeving of items in sensitive areas will be considered;
- The realigned side road parallel to the mainline (at Ch. 26,600 to Ch. 27,200) and Cut 2 will be kept out of cutting where

possible. Where cut is a necessity, it will be not greater than 1 m in depth and less than the mainline Cut 2;

- A closed drainage system will be installed between Ch. 25+540 to Ch. 26+620 to prevent any potential leakage of contaminants into groundwater that contributes to the wetland;
- An attenuation pond will be constructed parallel to the mainline between Ch. 25,750 and Ch. 26,400. This pond will be fully lined and divorced hydraulically from groundwater interaction. Pollution control measures will be employed to maintain outflow water quality to existing baseline standards;
- Topsoil stripping for embankments will be minimised and where ground conditions are suitable, a geotextile will be used directly on existing topsoil to minimise potential for suspended solids release;
- Transport of suspended solids will be controlled by settlement/attenuation ponds prior to outfall to existing drains. These drains will bypass Danganbeg wetland;
- Drainage controls during the construction phase will ensure containment of all run off within the site to designated discharge points. All waters arising from the construction site will be discharged outside of the Danganbeg Wetland area; and
- Ongoing monitoring of groundwater levels and chemistry will continue during the construction phase.

Appendix 13.2 contains the full details of the assessment of the hydrogeology at Danganbeg Wetland.

Dumping of Soils

As outlined in Chapter 11 and 12 of this EIS, no dumping of soils will be allowed during the construction phase in certain areas, including cSAC designated watercourse crossings and the following:

- Hugginstown Fen cSAC; and
- Danganbeg Wetland.

The extent of each of these areas in the vicinity of the road development is shown on Figures 13.2 to 13.3 of this EIS.

13.9 Residual Impacts

The following residual impacts are anticipated to remain following the application of mitigation measures outlined in Section 13.8:

- Depending on ground conditions encountered, construction dewatering is likely to be required at certain locations. Road drainage and construction dewatering may affect well water levels adjacent to the road. This is not anticipated to be significant;
- There is likely to be a reduction in catchment size and associated groundwater recharge to Hugginstown Fen. The maximum reduction in catchment and associated impact on groundwater recharge is 1.6 to 1.8%. However, this is not considered to be a significant impact in terms of wetland hydrology;
- The permeability of subground conditions to the west of Danganbeg wetland will be changed. With the mitigation measures outlined, it will be improved in places such as in Fill 2. With the mitigation measures proposed, it is likely to lead to a positive impact on the wetland by manipulating construction design to improve recharge to the wetland; and
- Some local dewatering by cuttings may occur locally to Danganbeg wetland, but the hydraulic impact is likely to be of low magnitude and of insignificance to the wetland.

In order to complete the detailed design of the road, it will be necessary to carry out a further detailed ground investigation, with explorations at 50m to 75m spacings. This more extensive phase of investigation may show ground conditions to be different from those expected at this stage.

The assessment of possible effects on private water supply wells relies on the accuracy of the information provided by individual well owner gathered during the well survey carried out along the route.

13.10 Limitations, assumption and Difficulties Encountered

The ground investigations carried out to date consisted of borehole and trial pit explorations at spacings of approximately 200m to 250m, along with geophysical surveying. Carrying out explorations at these spacings would be considered best-accepted practice for a road road development at the Preliminary Design Stage.

The information gathered from this phase of investigation has been combined with desk study information and subjected to interpretation to develop an understanding of ground conditions between exploration locations. Access difficulties encountered along the route have resulted in less information on ground conditions than would normally be required being obtained for these areas.

Table 13.1 Summary of Bedrock Formation Aquifer Classification

Aquifer Grouping	Geological Units ⁽¹⁾	Occurrence in Kilkenny	Aquifer Class ⁽²⁾
Karst Limestones	Ballyadams (BM, Bmdo)	Central and Northern Lowlands	Rk (k – Kastified bedrock aquifer)
Dolomite Aquifer	Waulsortian, Butlersgrove, Ballystene (Wado, Budo, Bado)	Central and Northern Lowlands	Rf (f – Fissured bedrock aquifer)
Waulsortian Limestone	Northern area	Northern Lowlands	LI (l – bedrock which is moderately productive only in local zones)
	Southern area	Southern Lowlands	Rk
Ballysteen Limestones	Ballysteen (BA)	Central and Southern Lowlands	LI
	Bullockpark Bay Member (BAbb)	Southern Lowlands	Lm (m – bedrock which is generally moderately productive)
Lower Limestone Shale	Ballymartin (BT)	Central and Southern Lowlands	PI
Kiltorcan Sandstone	Porter's Gate (PG), Kitorcan (KT)	Southern Uplands and Southern Lowlands	Rf
Southern Uplands Slates, Sandstones, Granites	Carrigmaclea (CI)	Southern Uplands	LI

⁽¹⁾ Other Geological units are also contained within each aquifer grouping. Only those encountered by the proposed road are mentioned here.

⁽²⁾ R – Regionally important Aquifer, L – Locally important aquifer, P – Poor aquifer

Table 13.2 Summary of Well Details

Section	Well Ref	Distance from Centre Line of Road, m	Chainage at Centre Line	Approximate Ground Level at Well Location, mOD	Approximate Level at Centre Line, mOD
Ch.10+400 - Ch. 11+500	A1	260	10+400	70	80
	A2	110	10+740	95	81
	A3	180	10+750	110	81
	A4	250	10+770	104	81
	A5	270	10+800	104	82
	A6	190	11+000	98	83
	A7	0	11+070	89	83
	A8	240	10+900	71	82
	A9	140	11+100	79	83
	A10	140	11+120	79	83
	A11	140	11+160	79	84
Ch. 21+300 - Ch. 22+900	B1	240	22+160	106	93
	B2	260	22+300	104	91
Ch. 27+800 - Ch. 29+600	C1	470	28+980	73	79
	C2	40	27+890	95	85
Ch. 43+000 - Ch. 43+760	D1	70	43+640	75	74
	D2	100	43+580	76	73
	D3	250	43+520	75	73
	D4	230	43+300	73	70
	D5*	160	43+100	77	69
Ch. 7+000 - Ch. 8+200	E1	160	7+000	73	75
	E2	160	7+080	75	78
	E3	140	7+160	77	81
	E4	110	8+100	101	92
Ch. 60+000 – Ch. 76+500		100**	66+250	66.8	67.7
		170**	66+350	67.0	67.3

Notes: * Well D5 is a private public supply scheme

** The offset refers to the offset from the mainline

Table 13.3 Cuttings Where Significant Rock is Likely to be Encountered During Excavation

Approximate Chainage (start and end of cut)	Approximate Depth of Cut, m		Comment
	Total	In Rock	
MAINLINE			
Ch.4+100 to Ch. 5+100	8	6	The rock will require ripping to remove it and will require hydraulic breaking to remove rock below 6mBGL.
Ch. 6+900 to Ch. 7+700	9	7	The rock will require ripping to remove it and will require hydraulic breaking to remove rock below 4mBGL.
Ch. 8+000 to Ch. 8+500	10	5	The rock will require ripping and hydraulic breaking to remove it over the full depth of the cut.
Ch. 10+300 to Ch. 11+700	7	5	The rock will require ripping to remove it with some local hydraulic breaking, particularly below 5m – 6mBGL.
Ch. 12+400 to Ch. 13+500	10	8	The rock should be rippable down to 4mBGL, with some breaking to get through local less fractured layers. Blasting may be required where the cut is deeper.
Ch. 21+300 to Ch. 22+700	7	6	Rock will require breaking as a minimum and may require blasting where cut is deeper than 6mBGL.
Ch. 28+000 to Ch. 29+700	11	10	Blasting/hydraulic breaking will be required to excavate rock. This requirement is backed up by evidence from exposed vertical faces in near by quarry at CH26+600.
Ch. 31+150 to Ch. 31+480	9	5	This rock will require breaking and hard ripping.
Ch. 35+000 to Ch. 36+000	11	9	Rock will require hard ripping, with some breaking to get through local fractures
Ch. 41+400 to Ch. 41+700	7	See Note ⁽¹⁾ Below	Based on close by information rock, if encountered will require hard ripping, possible with some breaking to get through local less fractured layers.
Ch. 42+900 to Ch. 43+500	8	5	Rock will require hard ripping with hydraulic breaking. Blasting may be required where cut is deeper than 4mBGL.
KILKENNY LINK ROAD			
Ch. 2+500 to Ch. 3+100	11	8	Rock will require hard ripping with hydraulic breaking. Blasting may be required.

⁽¹⁾ Ground investigation personnel were unable to access some areas along this section to obtain sufficient data to predict the depth of rock that will be encountered here.

Table 13.4 Areas Where Construction Dewatering May be Required

Chainage		Expected Material
From	To	
MAINLINE		
Ch. 1+600	Ch. 1+800	Clay (>10m)
Ch. 6+900	Ch. 7+650	Clay to 1m – 2m over rock
Ch. 8+100	Ch. 8+800	Clay to 5m over rock
Ch. 10+100	Ch. 12+100	Clay to 2m – 4m over rock
Ch. 12+250	Ch. 13+500	Clay to 1m – 2m over rock
Ch. 20+950	Ch. 22+800	Clay and Gravel to 7m over rock, rock at 1m in places
Ch. 27+450	Ch. 29+900	Clay and Gravel to >10m with depth to rock rising to 5m to 1m around Ch. 28+100
Ch. 35+000	Ch. 36+500	Clay and Sand to 3m to 10m over rock
Ch. 48+580	Ch. 49+200	Clay to 5m over rock/boulders
KILKENNY LINK ROAD		
Ch. 1+680	Ch. 2+240	Clay and Gravel (>10m)
Ch. 2+480	Ch. 3+180	Clay to 4m over rock
Ch. 3+280	Ch. 5+080	Clay to 7m over rock, depth to rock >7m in places
MAINLINE		
Ch. 60+000	Ch. 60+695	Clay to 13m, over sand and gravel (to>20m)
Ch. 75+960	Ch. 76+550	Sand and gravel probably to >8m.