“Cork & Waterford”

ANNUAL IAH FIELDTRIP

4-5th October 2014

Timetable

SATURDAY 4TH OCT

9:45am **Stop 1**: Dawn Meats factory, Carroll’s Cross, Kilmacthomas, Co. Waterford (meeting point – front car park)

12:00pm **Stop 2:** Midleton Distillery

12:00-12:55pm LUNCH - Malt House Restaurant, Distillery Heritage Centre

1:00pm **Stop 2:** Midleton Distillery site visit (meeting point – car park at main distillery site entrance on Dungourney Road)

c. 3:00pm **Stop 3**: UCC campus (meeting point to be confirmed)

Overnight in Cork City and dinner at 8:00pm (Ambassador Hotel)

SUNDAY 5TH OCT

10:15am meeting point - car park at Topaz garage, Kildorrery where we will reduce to smaller number of cars as parking is limited at today’s stops

Stop 4: Shanbally Spring

Stop 5: Polleagh Swallow Hole

Stop 6: Sinking stream at Bregoge

Stop 7: Viewing Point followed by return to Kildorrery to collect cars

2:00pm LUNCH - Fir Grove Hotel, Mitchelstown

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4-5th October 2014

Site Location Maps & Directions

SATURDAY 4TH OCT

9:45am **Stop 1**: Dawn Meats factory, Carroll’s Cross, Kilmacthomas,

12:00pm LUNCH Malthouse Restaurant, Midleton Distillery Heritage Centre

1:00pm **Stop 2:** Midleton Distillery

c. 3:00pm **Stop 3**: UCC campus

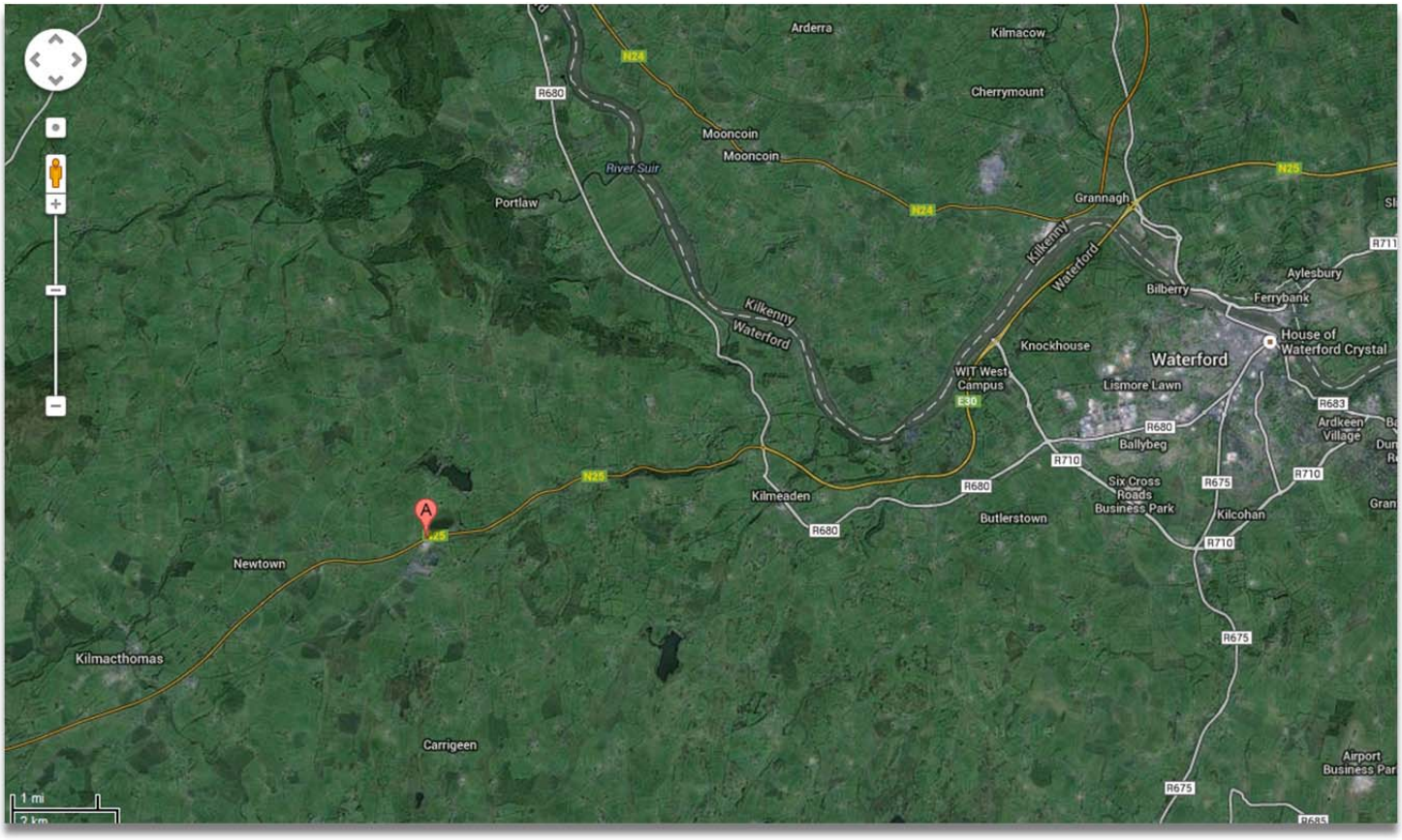
8:00pm Dinner & overnight at Ambassador Hotel

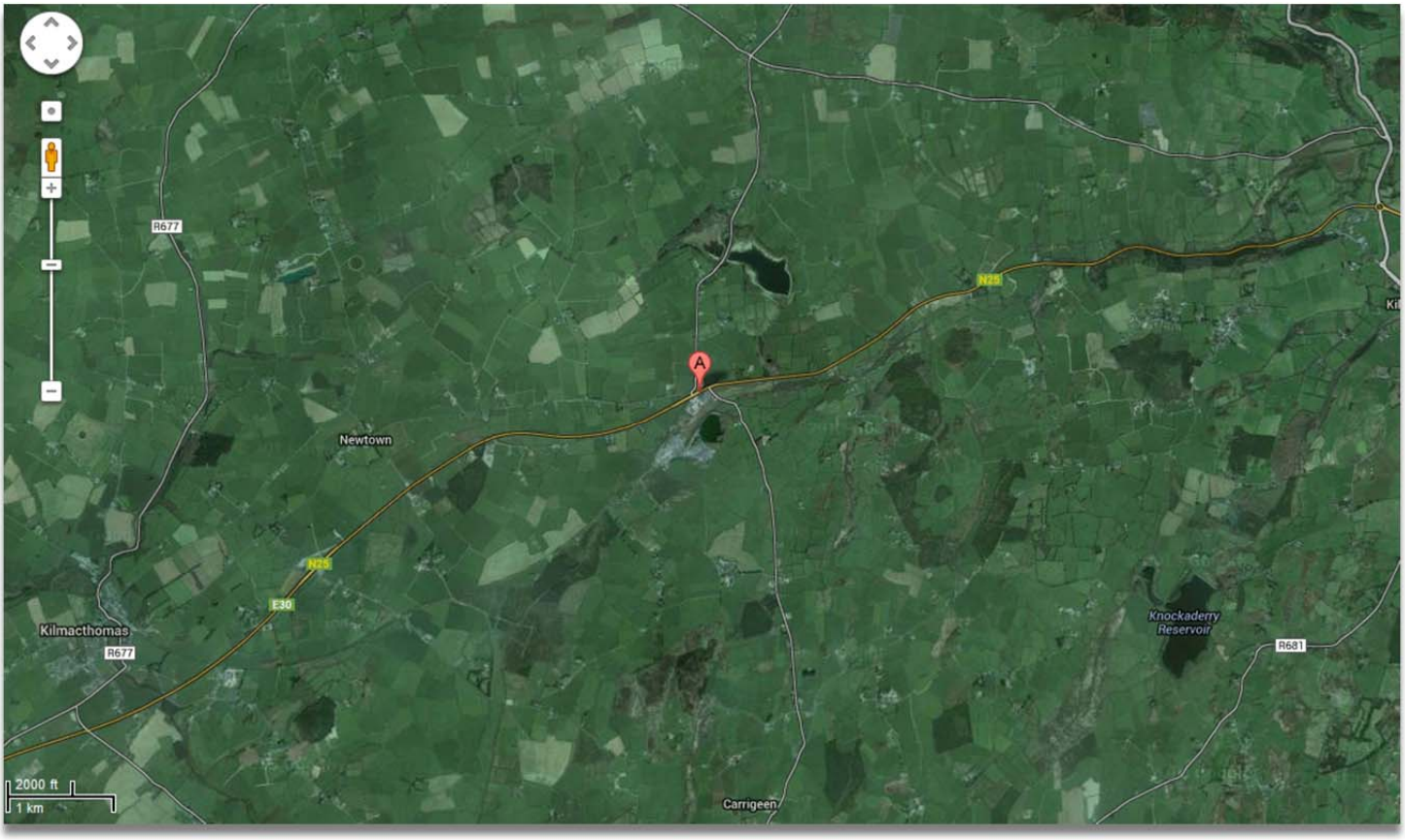
SUNDAY 5TH OCT

10:15am **Stops 4-7** Kildorrery

2:00pm LUNCH - Fir Grove Hotel, Mitchelstown

Stop 1 – Saturday 4th 9:45am *Dawn Meats factory, Carroll's Cross, Kilmacthomas, Waterford*
Meeting Point – Car Park

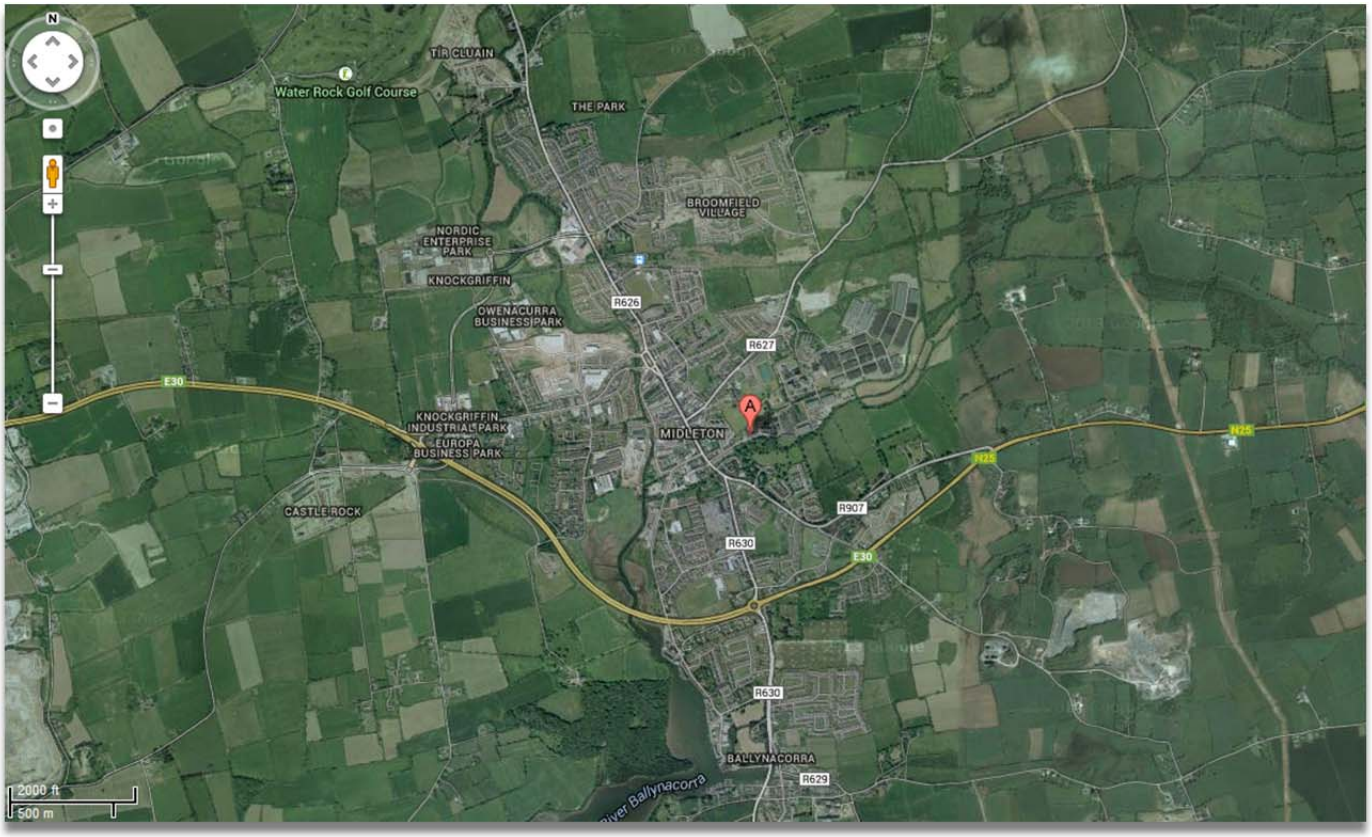


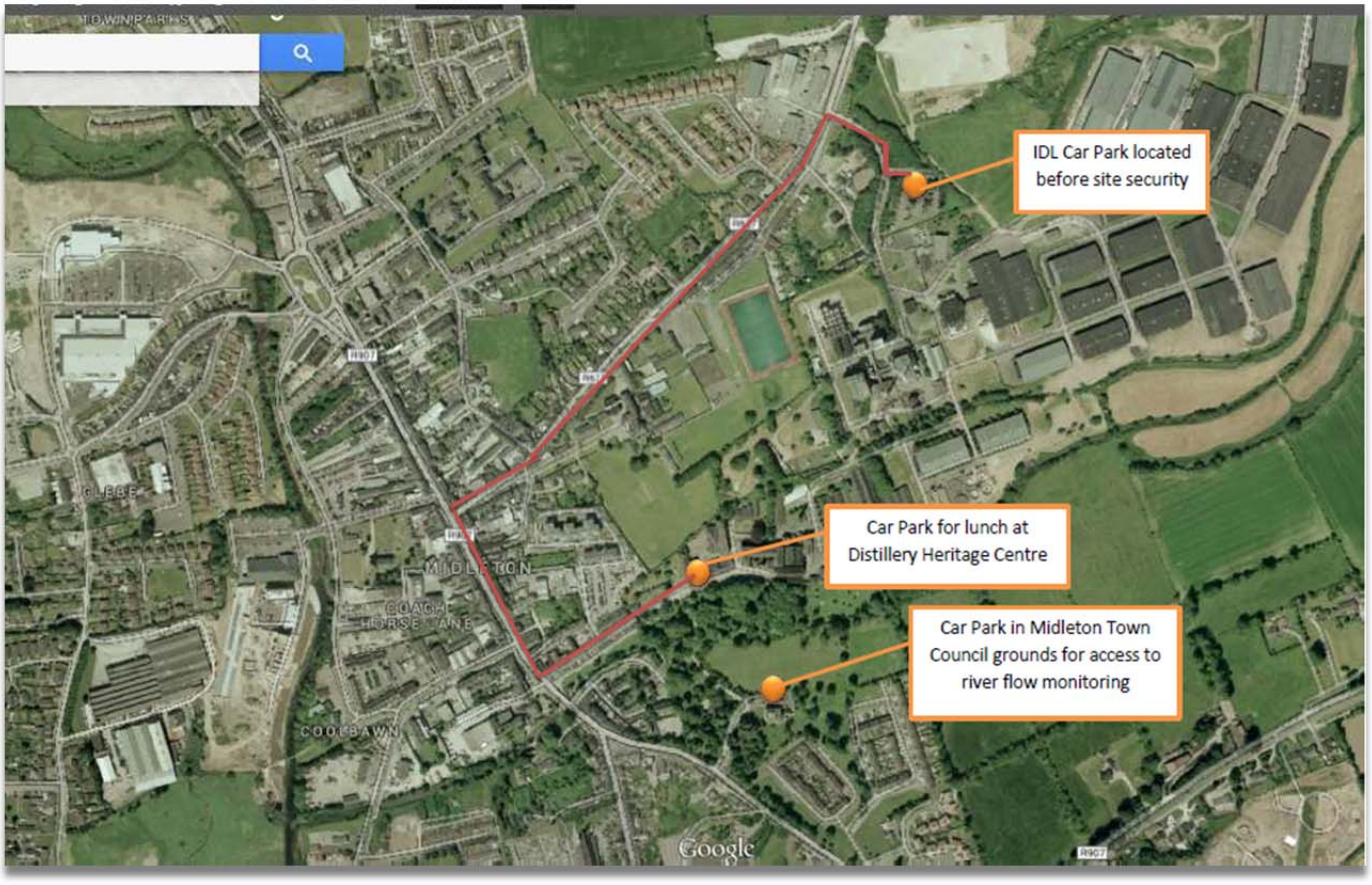


Stop 1 – Saturday 4th 9:45am *Dawn Meats factory, Carroll's Cross, Kilmacthomas, Waterford*
Meeting Point – Car Park

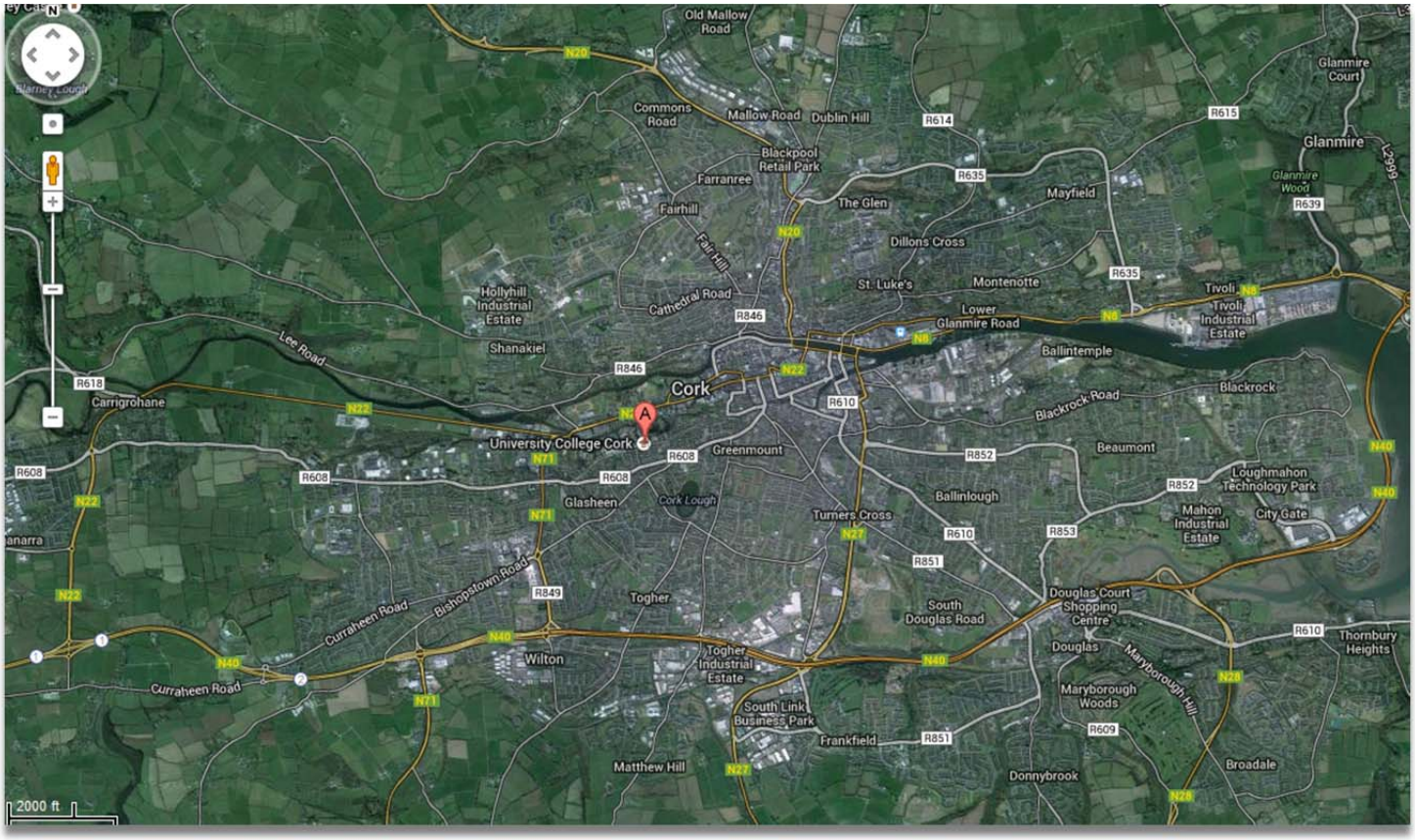
Lunch – Saturday 4th 12 Noon *Malt House Restaurant, Midleton Distillery Heritage Centre (parking at Heritage Centre car park)*

Stop 2 – Saturday 4th 1:00pm *Midleton Distillery*
Meeting Point – Car Park Located before site security on Dungourney Road (R627)

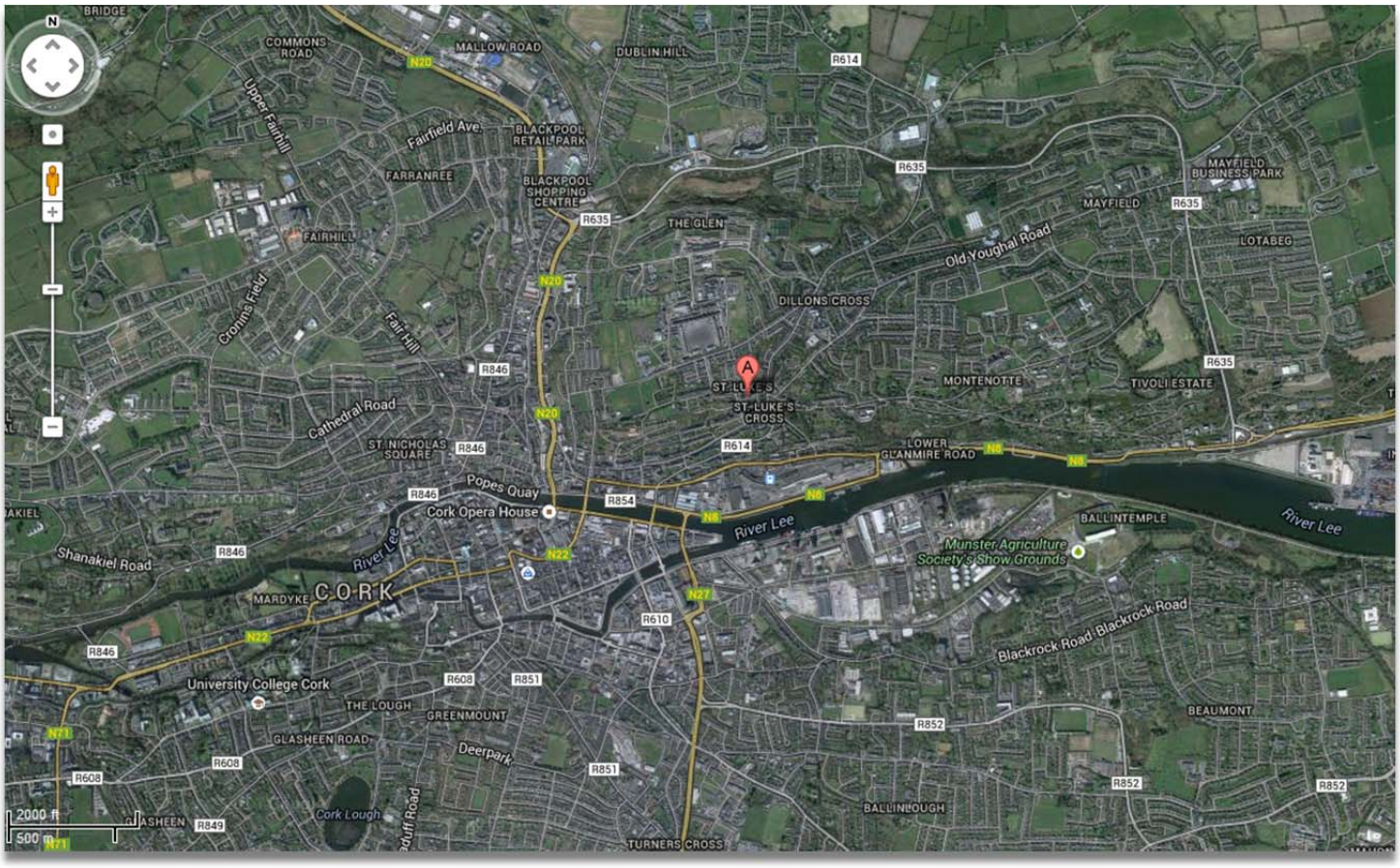


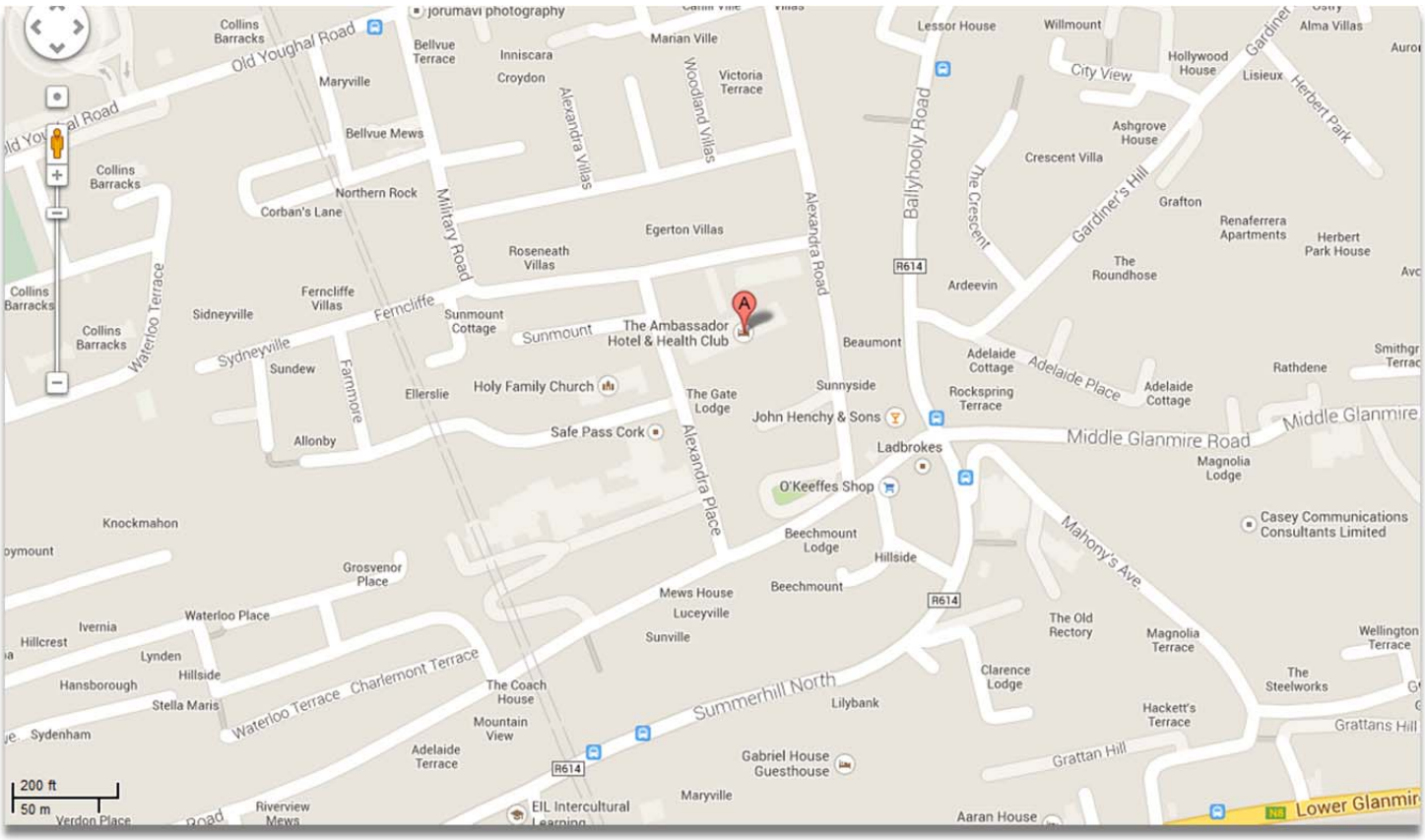


Stop 3 – Saturday 4th c. 3:00pm *UCC campus*
Meeting Point – to be confirmed



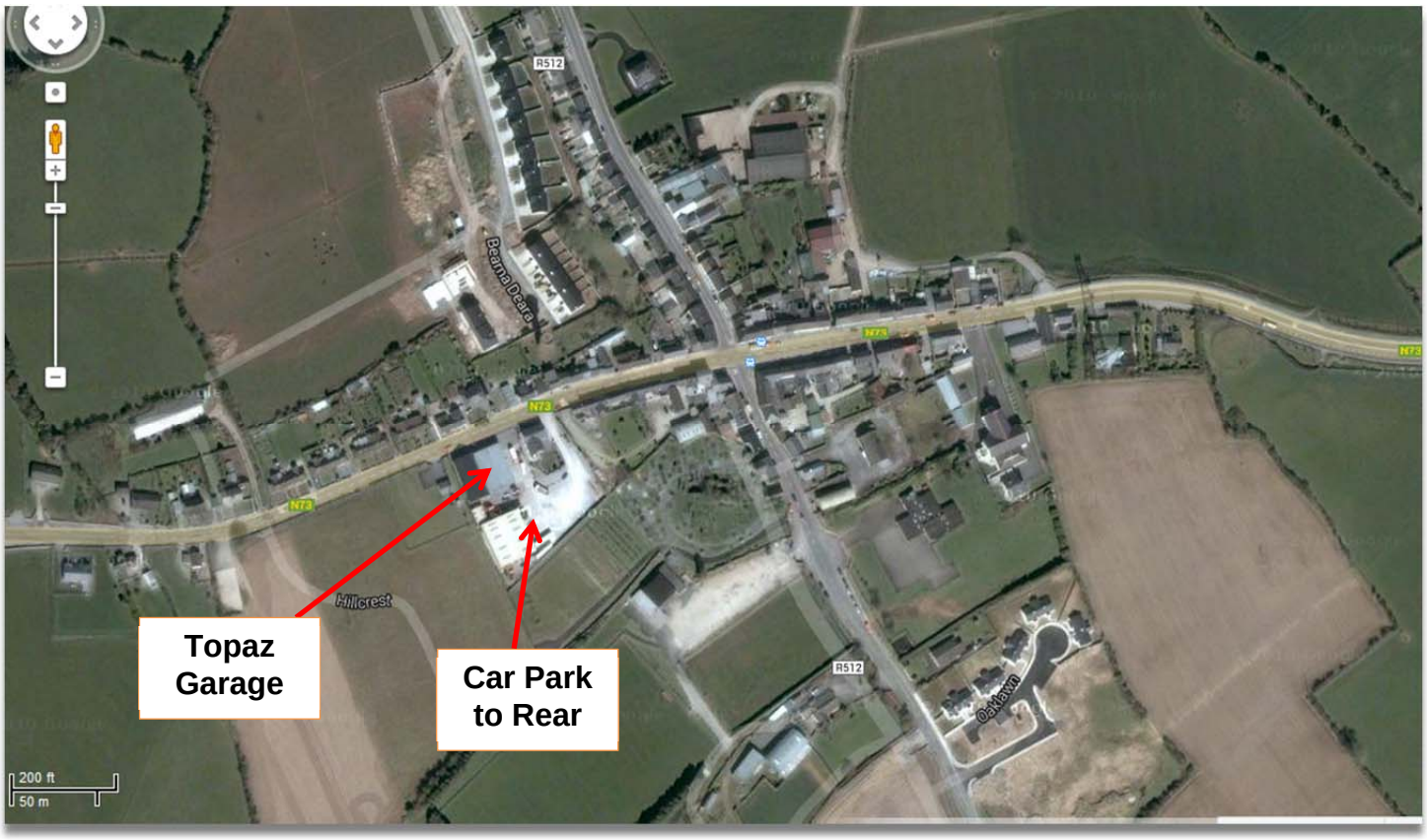
Dinner – Saturday 4th 8:00pm *Ambassador Hotel,*
Military Hill, St Luke's Cross, Cork City



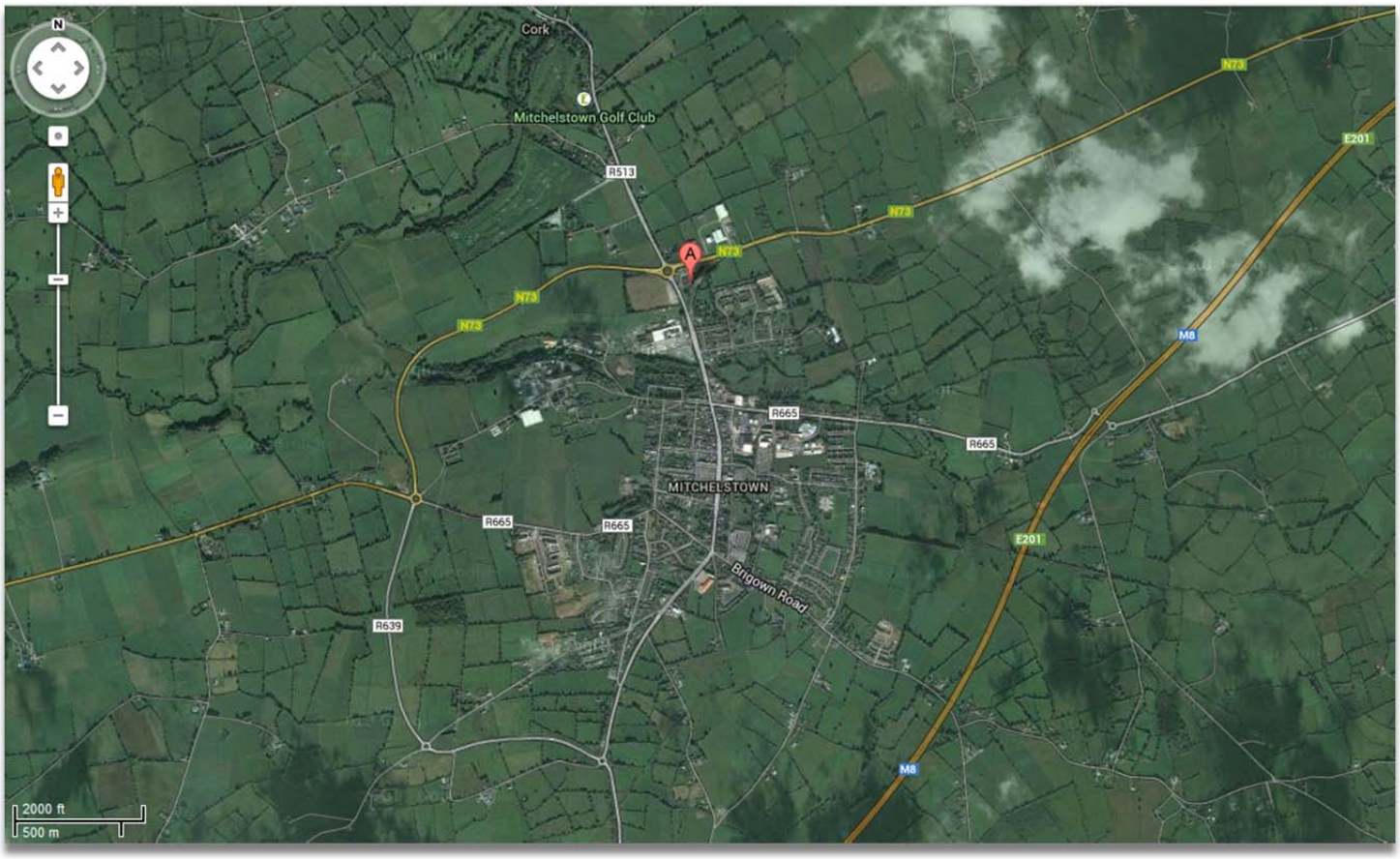


Stops 4-7 – Sunday 5th 10:15am *Kildorrery*

Meeting Point – car park to rear of Topaz (O'Sullivan's) Garage, Kildorrery



Lunch – Sunday 5th 2:00pm *Fir Grove Hotel, Mitchelstown*



IAH Annual Field trip 4th October 2014

Integrated Constructed Wetland, Dawn Meats, Carrolls Cross, Co. Waterford

This Integrated Constructed Wetland (ICW) provides complete treatment of wastewaters at the Dawn Meats meat processing facility at Carrolls Cross, Co. Waterford. The c.2 ha site (providing c.12,500m^2 treatment area) comprises 2 initial settlement cells set in parallel to facilitate management, followed by a serial cascade of 12 wetland cells. A screen prevents the larger fat and solids particulate matter from entering the ICW, Monitoring equipment, access pathways, roads and landscaped area facilitate management and help derive optimal benefits from the site.

The River Dawn flows through the ICW site, with the final discharge from the ICW to the Dawn River.

An ICW at Carrolls Cross was first developed in 2002 to treat storm water and wash water from the factory. The ICW was extended in 2012 to facilitate significant expansion of the factory.

The ICW is located to the south west of the factory buildings. The grounds surrounding the ICW are landscaped to provide amenities, aesthetics and biodiversity.

Table 1 provides an example of the concentration of the wastewater treated through the ICW (average concentrations for 2013) and the emission limit values (ELV) (discharge licence Waterford County Council). Discharge of the final effluent from the ICW is consistently below the emission limit values.

Table 1: Performance of ICW at Dawn Meats, Carrolls Cross, Co. Waterford

Parameter	Influent	Effluent	ELV
COD	610 mg/l	38 mg/l	120 mg/l
BOD	237 mg/l	4 mg/l	10 mg/l
Suspended Solids	205 mg/l	<10 mg/l	10 mg/l
Ammonia	36 mg/l	<0.5 mg/l	1 mg/l
Total Nitrogen	55 mg/l	4.5 mg/l	5 mg/l
Total Phosphorus	4.3 mg/l	<0.30-0.1mg/l	1 mg/l
Ortho-phosphates	4.8 mg/l	<0.2 mg/l	0.5 mg/l
Nitrates	NT	3.2 mg/l	5 mg/l
Faecal Coliforms	NT	N/D	500 cfu/100ml

Site assessment & ICW design considerations (some of the main items reviewed as part of the design process)

- Effluent quantity (present & future)
- Effluent quality
- Site and its topography, ground conditions, hydrology (surface and ground)

Influent/effluent monitoring & assessment of ICW performance

- Monthly influent & effluent quality monitoring
- Continuous influent and effluent flow monitoring
- Influent and effluent Parameters: BOD, suspended solids, ammonia, total phosphorus, FOG

Surface water & proposed groundwater monitoring

- Currently qualitative and quantitative monitoring upstream and down-stream of the discharge
- Parameter: BOD, suspended solids, ammonia and ortho-phosphate

River flows - Hydrometric low profile v-notch weir with elevated sides is located upstream of the discharge to measure all in-stream flows.

Groundwater monitoring (Proposed)

- 6 No. bore wells to be drilled on site, 3 at locations within the older Phase 1 of the ICW and 3 No. within the newer Phase 2.
- Wells to be drilled to appropriate depth to allow for bi-annual groundwater monitoring.
- Groundwater monitoring parameters: including pH, conductivity, Nitrate, Ammonium, chloride and ortho-phosphate.
- Borewells to be installed in October 2014

IAH FIELD TRIP

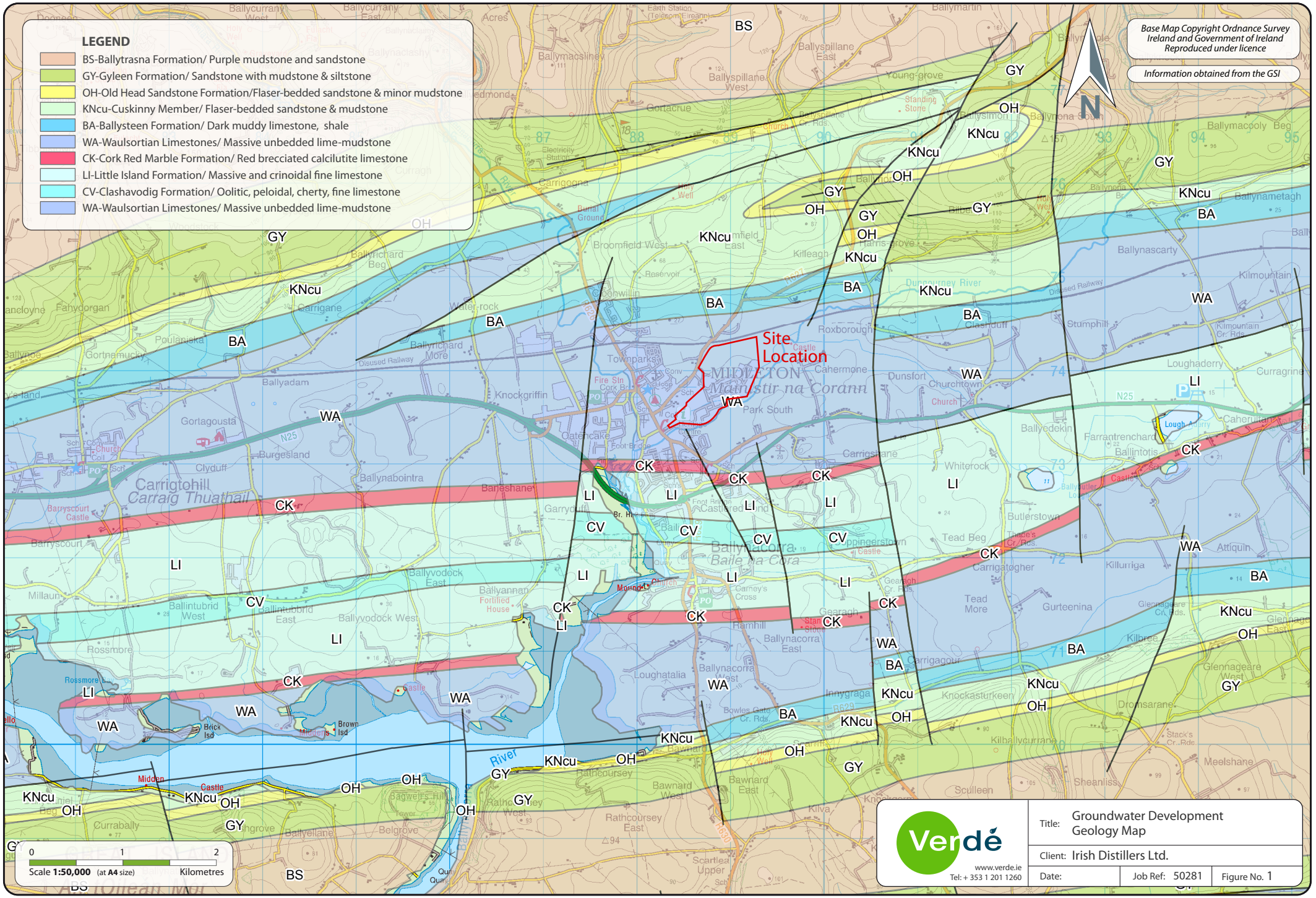
Saturday 4th October 2014

Stop 2: Midleton Distillery

(Donal Hogan & Deirdre Larkin)

- Overview of karst hydrogeology of site
- Well field development & groundwater abstraction monitoring
- Hydrological monitoring of adjoining river
- Development of groundwater mass balance (M.Sc Thesis)

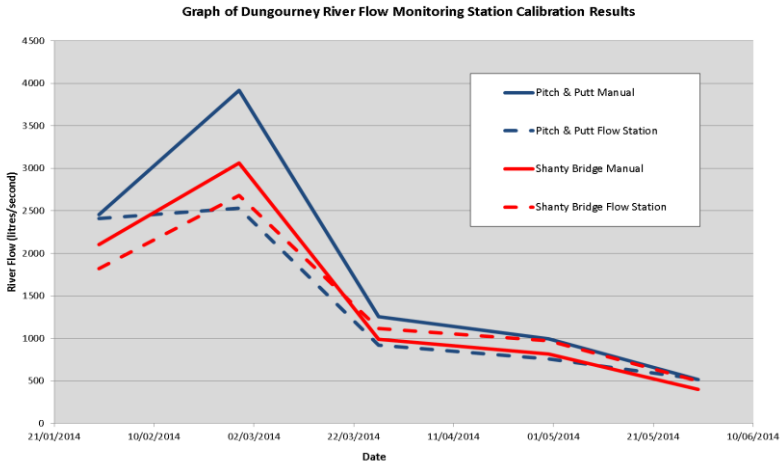
IDL Groundwater Production Well


LEGEND
BS-Ballytrasna Formation/ Purple mudstone and sandstone
GY-Gyleen Formation/ Sandstone with mudstone & siltstone
OH-Old Head Sandstone Formation/Flaser-bedded sandstone & minor mudstone
KNcu-Cuskinny Member/ Flaser-bedded sandstone & mudstone
BA-Ballysteen Formation/ Dark muddy limestone, shale
WA-Waulsortian Limestones/ Massive unbedded lime-mudstone
CK-Cork Red Marble Formation/ Red brecciated calcilutite limestone
LI-Little Island Formation/ Massive and crinoidal fine limestone
CV-Clashavodig Formation/ Oolitic, peloidal, cherty, fine limestone
WA-Waulsortian Limestones/ Massive unbedded lime-mudstone
Base Map Copyright Ordnance Survey Ireland and Government of Ireland Reproduced under licence
Information obtained from the GSI
N
Site Location
MIDLETON
Carrigtohill
Ballynacorra
0 1 2
Scale 1:50,000 (at A4 size) Kilometres
Verdé
www.verde.ie
Tel: + 353 1 201 1260
Title: Groundwater Development Geology Map
Client: Irish Distillers Ltd.
Date:
Job Ref: 50281
Figure No. 1


0 100 200 300 400 500
Scale 1:5,000 (at A4 size) Metres
LEGEND
PW5 Test Production Well Mar.-Apr. 2011
PW2 Test Production Well June 2010
PW1 Test Production Well 2007
MW4 Lower Field Monitoring Well Apr. 2010
GW3 Existing Monitoring Well
TW1 Trial Well Location 2000
Monitoring Station
2.19 Groundwater Level mA.O.D.
6.82 Surface Water Level mA.O.D.
mA.O.D. Metres Above Ordinance Datum
Groundwater Flow Direction
Groundwater Contours (metres)
Pumping
Groundwater Divide
N
Agricultural Land
Dis-used Railway
Culverted Drain
200m
Upstream Monitoring Station (Station 1) Shanty Bridge
6.71
Dungourney River
MW5
PW8 3.82
MW4 3.78
MW3 3.15
MW8 3.62
MW1 4.37
MW6 3.94
MW7 3.59
GW1 4.00
PW7 3.89
MW2 3.30
GW5
GW4 3.53
GW3 3.18
PW9 4.20
PW6 4.14
PW5 3.59
PW3 3.21
PW4 3.38
PW2 3.25
TW1
PW1 3.18
2.41 (Cavern)
GW2B 2.67
2.02
Warehouse 35 36
Warehouse 37 38
Warehouse 41 42
Warehouse 33 34
Warehouse 39 40
Warehouse 43 44 45
Warehouse 31 32
Warehouse 29 30
Warehouse 27 28
Warehouse 25 26
Retention Pond
EARTH BERM
EARTH BANK
Foxes Hollow
Weir
R127
Mill Stream
School Grounds
Fermenters
New Brew House
Brew House
Still House
Water Treatment
New Distillation Columns
New Still House
New Tank Farm
Spirit Store
Cast Store
New Water Treatment Plant
Waste Water Treatment
New Retention Pond
Warehouse A2
Warehouse A1
Downstream Monitoring Station
Agricultural Land
4.0
3.5
3.0
2.5
2.0
Verdé
www.verde.ie
Tel: + 353 1 201 1260
Title: Groundwater Contour Map (26/06/2014)
Client: Irish Distillers (IDL) in Midleton Cork
Date: June 2014
Job Ref: 50281
Figure No. 6

IDL Hydrological Monitoring Works

Manual River Flow Monitoring being undertaken to obtain baseline data prior to groundwater abstraction



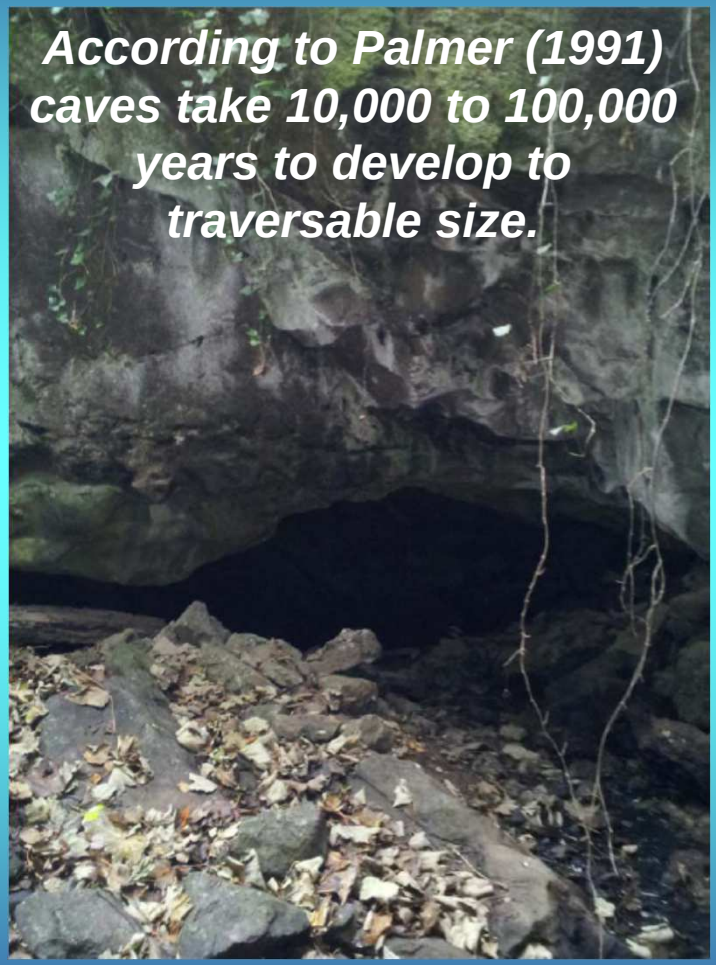
Ongoing calibration of Dungourney River automated flow monitoring stations with manual measurements

Dissertation Aims

1. Review existing available data for the IDL site to produce a site specific conceptual model.

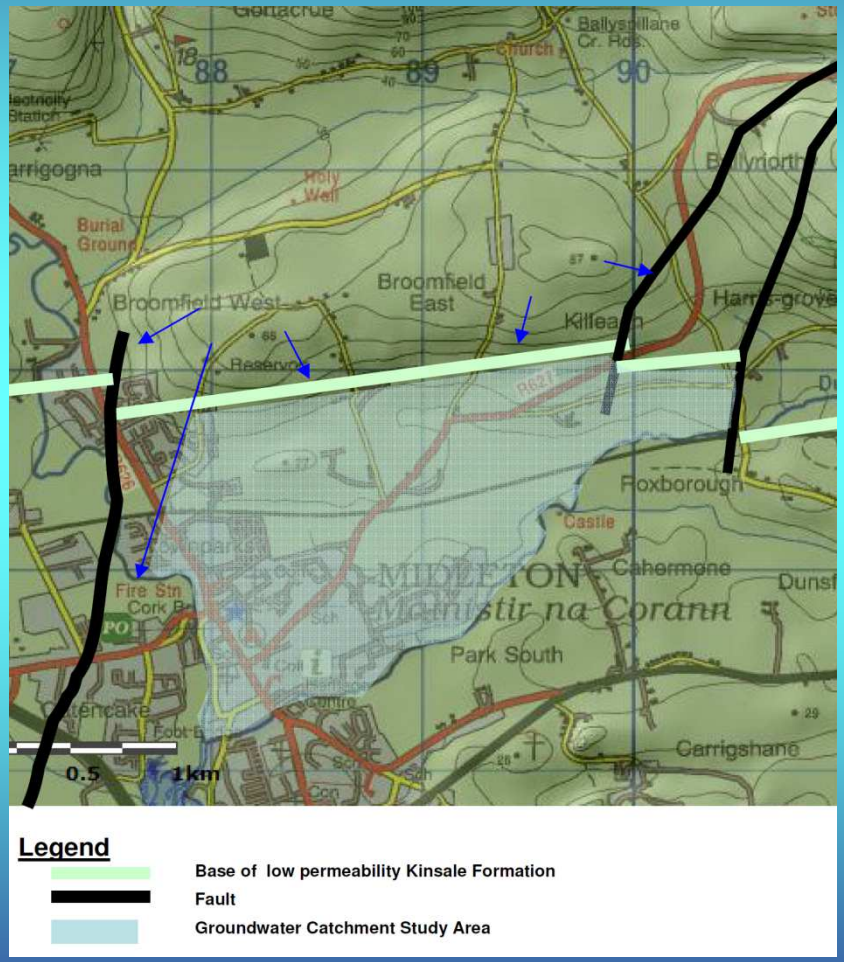
2. Assess Karst groundwater / surface water quality.

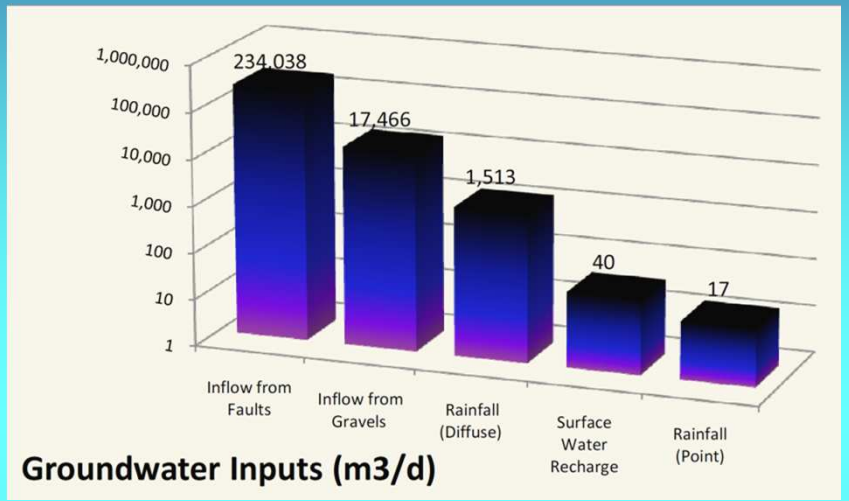
3. Create a groundwater Model to represent groundwater mass balance of a selected Model area (calibrated to IDL site).



Photograph 1. Karst Cave at IDL site

Aim 3: Present Groundwater Mass Balance





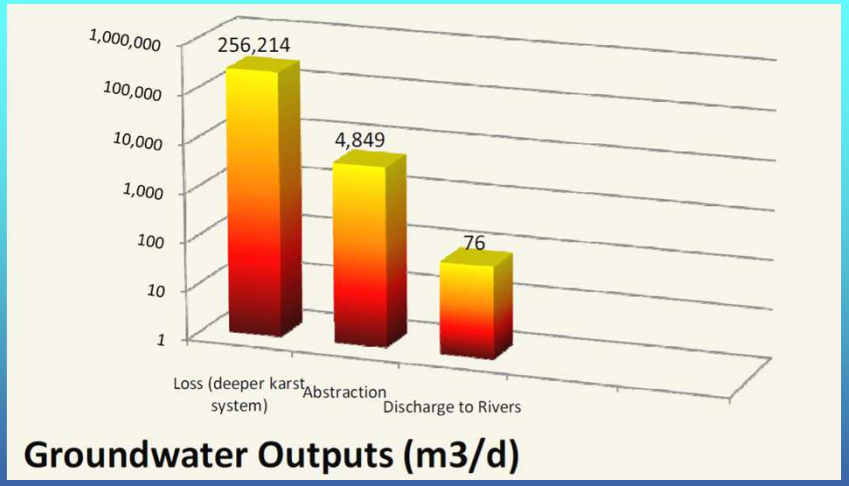


Figure 4. Selected Model Area (2.75km2, IDL Site to the south). Graphs represent groundwater mass balance inputs and outputs.

IAH Field Trip

Sunday 5th October 2014:

Krazy Kork Karst

Coran Kelly and David Drew

Photo by David Drew, looking down to the Awbeg river; Shanballymore Spring in middle right foreground

Contents

INTRODUCTION

Groundwater provides a significant proportion of the water supply in County Cork (approximately 80,000 people, over 40,000 m^3/d, drinking water returns, 2012) and particularly in North Cork, where nearly all the water is supplied from groundwater (over 30,000 m^3/d). Several of the karst spring sources (e.g. Glanworth, Castletownroche, Shanballymore, Mountnorth) have been the focus of source protection studies since the 2000's and several form part of the EPA Groundwater monitoring network (Figure 1).

The North Cork area forms part of what is referred to in geological circles as the "Munster Synclines or the "Munster Ridge and Valley" province; the characteristic form comprising east-west trending anticlines (sandstone ridges) and synclines (limestone valleys). The focus of the trip is within the Awbeg River valley, a tributary of the River Blackwater, which runs a course through the limestone karst lowland positioned between the Ballyhoura and the Nagle mountains. Along the river occur many springs, including 3 of the largest: Shanballymore and Castletownroche ('Spring 1' Redstone, Ballinvoher 'Spring 2'). Of these EPA monitor Shanballymore and Ballinvoher, both on the eastern bank of the Awbeg.

The field trip seeks to highlight and showcase aspects of the fluvio-karst landscape with visits to the following sites:

- Shanballymore Spring
- Polleagh Swallow Hole and 'Sluggera'
- Bregoge Sinking Stream
- Mammoth Cave.

Regional aspects of topography, geology etc are described along with a regional conceptual model and then a brief outline of each field stop is given.

TOPOGRAPHY AND LANDFORMS, HYDROLOGY AND KARST FEATURES

The landscape comprises a broad interfluve gently undulating between 60-110 m OD. The northerly extent of the plateau occurs at the foot of the Ballyhoura Mountains. At this point the land rises steeply to approximately 500 m OD from approximately 110 m. The Blackwater River demarks the southern extent of the plateau. The topography of the plateau can be subdivided into distinct landforms. Glacial deposits are present but glacial landforms are not very apparent. Though glacial landforms are not obvious there is a fluvial / karst intermix; fluvial in the main river valleys and karst on the interfluves (plateau) - a fluviokarst landscape (Figure 1).

The main rivers are the Awbeg, Funshion, Farahy (a tributary of the River Funshion) the Ogeen and Bregoge (tributaries of the River Awbeg). The Awbeg river initially flows west to east and then turns south just downstream of Shanballymore Spring, joining the Blackwater River south of Castletownroche. The Funshion river flows in a well defined valley, joining the Blackwater River, east of Fermoy. Each of the rivers flow along deep incisions which are particularly pronounced in places, for example, in the vicinity of Shanballymore spring to Castletownroche. The plateau is devoid of a surface drainage system. This is an area occupying over 100 km^2 (Figure 1).

The recognized karst landforms comprise springs, dry valleys, sinks, caves and dolines.

- The springs occur in the valley floors at the interface between the karst and fluvio environments.
- There are several dry valleys into each of the rivers, perpendicular to the main flow direction. For example, into the Awbeg just downstream of Shanballymore Spring.
- Active swallow holes are present, e.g., Shanagh, Polleagh, and Graig Upper.
- Local farmers indicate that small collapse features a few metres in depth and width ('sluggeras') appear in the fields, which usually filled back in by the farmers (sometimes significant loads, only for the sluggeras to reappear, and not necessarily in the same place). Such a feature is shown in the photographs, and was located within a few hundred metres northwest of Polleagh swallow hole and is reported to be been approximately 3m deep. On the site visit to Polleagh we will see a newly opened one not far from the swallow hole. Additionally, there are few enclosed infilled depressions dotted around the area, holding stagnant water. Dolines and depressions occur on the plateau but are notably uncommon.
- Outcrops generally display solutionally enlarged features, typically along N-S joints, and in one instance a conduit was found in dry valley at Ballydoyle (between Shanballymore Spring and Ballinvoher Spring).
- The Bregoge river is a known sinking stream with several mapped and obvious sinks in the river bed. The adjacent Ogeen is thought to infiltrate also but no obvious sinks are evident.

GEOLOGY

The bedrock map (Figure 1, based on the Geology of East Cork - Waterford Sheet 22, 1:100,000 Series, GSI, 1995) indicates that the valley areas are underlain principally by massive unbedded limestones and the Mountains are occupied by sandstones (Devonian) and shales (Namurian).

The geology is mapped in greater detail south and west of Shanballymore Spring and east of Kildorrery. Discussion with the GSI concluded that the limestones to the south of Shanballymore Spring are likely to extend northwest to meet with the corresponding units northwest of Shanballymore Spring and that the units east of Kildorrery would extend westwards and peter out. Much of the landform expression (e.g. Kildorrery hill and others) and the original field mapping indicate that the undifferentiated limestones north of Shanballymore are mainly massive unbedded limestones.

The mapping indicates considerable structural deformation with intense folding and faulting. Two major fault sets are widespread across the region; east-west trending (strike faults) and north-south trending (cross faults). A major synclinal feature is mapped to the east (Mitchelstown Syncline) and a smaller syncline to the southwest of Shanballymore Spring. The bedding where evident is often steeply dipping particularly in the exposures bounding the Awbeg River. Very steep bedding was also observed in a cave at Carraigleagh Cave [Grid reference: 169255 107959] which is marked in Figure 1, 2. There are also many outcrops that are massive and do not display bedding. The main jointing pattern is north – south.

SUBSOILS GEOLOGY

The area is dominated by two types of till: Till derived from Devonian Sandstone (TDSs) and Till derived from Namurian Sandstones and Shales (TNSSs). Karstified bedrock outcrop (KaRck) is distributed throughout the study area and the river valleys tend to be floored by alluvium (Figure 3). The soils are dominated by 'dry' soil types: typically acid well drained deep mineral soils (BminDW).

There are 'wet' soils coincident with lower portions of the landscape underlain by Till derived from Namurian Sandstones and Shales (TNSSs). The GSI drilled seventeen auger holes in Castletownroche (GSI, 2000) and the till comprises sandy SILT and sandy CLAY (BS 5930). Based on the absence of permanent surface water features and secondary indicators of low subsoil permeability, it is considered that the till is generally free draining and that the subsoils are dominated by 'moderately permeable' subsoil. Depth to bedrock varies greatly and unsystematically throughout the study area. Rock outcrops are distributed throughout the area. The GSI augering at Castletownroche indicates depths to rock up to 10 m in places, occasionally deeper.

SPRING DISCHARGES

The springs are principally concentrated along the Awbeg and Funshion with smaller springs discharging to the Farahy, Ogeen and Bregoge. Further, the largest springs are located north of Castletownroche discharging to the eastern bank of the Awbeg. In general the springs are single outflows. Only Shanballymore, Ballinvoher and Redstone have had any historical 'spot' flow data measured. A crude approximation of the outflows indicates a total discharge 250-350 l/s. The approximate topographic area that could discharge to springs is in the order of 115 km^2, which potentially could generate over 700 l/s, suggesting the majority of groundwater flow is to the rivers. There is anecdotal evidence that there are groundwater discharges issuing from the bed of the Awbeg and it is also a gaining stream and known in the angling world for smaller than average trout – owing to the lower than average temperatures. No springs are apparent from desk study/field mapping along the northern bank of the section where the Awbeg and Funshion meet the Blackwater.

REGIONAL HYDROGEOLOGICAL MODEL

- This model is a synthesis of the work from Mountnorth, Castletownroche and Shanballymore.

- The region comprises a fluvio-karst system – a karstic interfluve (plateau) with a fluvial system in the river valleys comprising principally the Awbeg and Funshion Rivers which are flowing the River Blackwater. Numerous small streams flow off the back of the non limestone ridges to the Blackwater.

- The geology although dominated by karstified limestones indicates that there may be a significant structural/geological control on groundwater behaviour particularly where folding and/or faulting is present. The karst system comprises solutionally enlarged channels and other karst features at the surface but it appears to comprise a more distributed, less hierarchically organised/focussed system, and on the whole does not appear to be as dominated by conduit flow as other karst areas. The nature of the karst is largely unknown.

- The springs, generally single outflows, occur along the banks of the rivers at the base of the karst plateaus, thus appear to be overflows for groundwater that is heading to the rivers. The largest springs occur on the Awbeg, particularly on the eastern side – Shanballymore and Ballinvoher being the largest. The springs may occur where there is a local focus of groundwater flow – possibly related to structure.

- It is unclear if the rivers are regional hydraulic boundaries. The analysis of the water level data, dry weather flow data, the dye tracing, the hydrogeological mapping and the surface water flow measurements indicate a complicated groundwater flow regime. There may be significant southerly component of flow across the limestone domain. The negative tracing

results support the concept that there is a significant flow component that does not arise at any of the springs. Anecdotal evidence (EPA hydrometric staff) suggests that there are discrete points of groundwater inflow along the bed of the Awbeg and it is known amongst anglers as having smaller than average trout due to relatively low temperatures.

- It is considered that the groundwater flow patterns comprises diffuse and conduit flow; with the springs representative of shallow, possibly conduit driven groundwater and that there is a significant component of deeper groundwater flowing south. It is possible that this component of groundwater ultimately discharges to the River Blackwater. Given the groundwater level data that is evident in the limestones along the Blackwater in the vicinity of Mallow and Oliver's cross there is a gradient that would allow for this to occur.

FIELD STOPS:

1 SHANBALLYMORE SPRING:

The spring is located 1.2 km west of Shanballymore village, 5.5 km southwest of Kildorrery; on the north bank of the Awbeg river. The spring discharges at the foot of a rock scarp, approximately 50 m back from the Awbeg river, at 56 mOD. The abstraction intake is in the uncovered sump area and the spring overflows to the Awbeg river over a rectangular weir (installed 2009). The water is pumped to the top of the hill, chlorinated and pumped to a nearby reservoir. During severe rain events the river floods the valley floor, backs up the spring discharge, drowning the weir. This appears to occur when the overflow is above 0.2 m^3/s.

Elevation (Ground Level)	56 m OD
Depth to rock	Rock at back of sump and where spring emerges
Static water level	Ground level (~0.5m above river)
Consumption (Co Co records)	2900-3500 m^3/d
Flow min-max including pumping	70 – 308 l/s
Mean Total Flow	140-145 l/s

2 POLLEAGH (SWALLOW HOLE, SLUGGERA):

Tracing tests were conducted during November 2009 and March/April 2010 in order to determine the zone of contribution to Shanballymore Spring. Dye was injected at suitable points of naturally concentrated recharge, within the maximum possible zone of contribution – an area of approximately 15 km^2 to attempt to characterise dominant flow directions, typical flow rates and distinguish the likely zone (s) of contribution to Shanballymore Spring.

Dye was injected into the main swallow holes (Figure 2) in November 2009 and monitored at all the springs. The weather was very wet and all rivers were at flood stage. At a few locations the sampling was compromised by river water mixing with spring water as the rivers flooded the valley floors, submerging the spring discharge points or backing up the overflows, e.g., Ballynamona, Ballywalter, Shanballymore, Ballinvoher, Clogher Demesne and at Farahy. The springs that appeared to be unaffected were Toberteigeen and Kearneys well and those upstream of Farahy Bridge. There were no positive results from the tracing programme and was considered at the time to be largely due to the high flows in the rivers. Consequently, a further tracing test was conducted in February 2010 at a lower stage. There were no positive results reported from this trace either. Interpretation of the results was that at the few sites of concentrated recharge the water is transmitted to the rivers in response to the regional hydraulic water table, rather than the springs. The springs are considered to be overflows of the groundwater that is heading to the river resulting from locally focussed groundwater. Table 1 provides a few details of the physical relationships between the Polleagh input sites and some of the monitoring sites.

Table 1 Polleagh Swallow hole relationships with selected monitoring sites

SPRINGS	**INPUT SITE Polleagh 75mOD**
Shanballymore **166231 107339** **56mOD**	Δ altitude **19m** Distance **2.9km** Gradient **0.0065**
Ballinvoher **168437 103583** **45mOD**	Δ altitude **30m** Distance **4.7km** Gradient **0.006**
Kearneys well (rockmills) **171956 108216** **50mOD**	Δ altitude **25m** Distance **2.9km** Gradient **0.086**
Farahy Upstream of Meadstown Bridge **170186 109636** **65mOD**	Δ altitude **10m** Distance **1.8km** Gradient **0.0056**

Inflow at bottom of Polleagh Swallow Hole (2/11/2009).

Polleagh Swallow hole 16/11/2009 (John Dillon, Tobin) High Flow

Polleagh Swallow Hole [169023 108238] Note elevation change (2/11/2009)

Sluggera in field close to Polleagh Swallow hole (Mr. Sweeney) [168868 108322].

3 BREGOGE, A SINKING STREAM:

"Those little streames so broken
He underground so closely did convay,
That of their passage doth appeare no token
Till they into the Mullaes water slide"

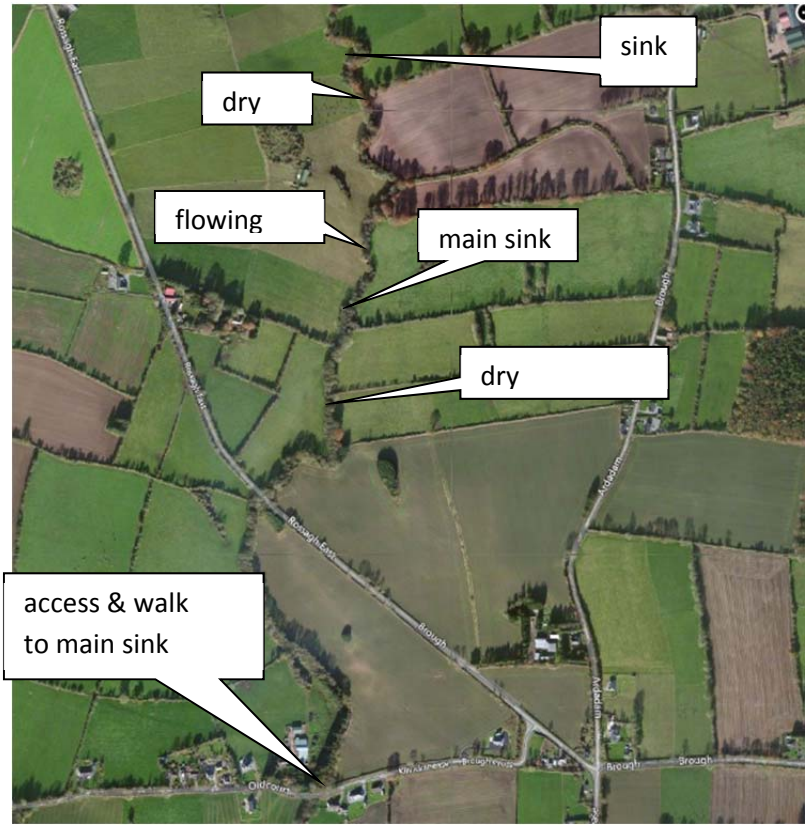
Spenser 15th Century

'He' is the Bregoge river, who stole the heart of the Mulla (R. Awbeg), destined to be married to the R. Blackwater. 'Brég' is a lie.

The visit will comprise a 2 km walk from Bregoge Bridge up along the river bed. The R. Bregoge (An Bhréagóg) is a tributary of the Awbeg river and comprises 4 small mountain streams originating on the Ballyhoura mountains.

The stream sinks in a number of mapped locations. It considered by Van Ree & Van Rot (1981) that the River Ogeen also loses flow along its reach but there are no visible features. Whilst there is a lack of data, visual observations and field work by Van Ree & Rot (1981) indicate that the lower Bregoge gains primarily through the inflows of springs in the vicinity of Doneraile. Furthermore it is suggested by Van Ree & Rot that the specific low flows in both the Bregoge and the Ogeen are lower than expected and consider that a proportion of groundwater flows east toward the Awbeg.

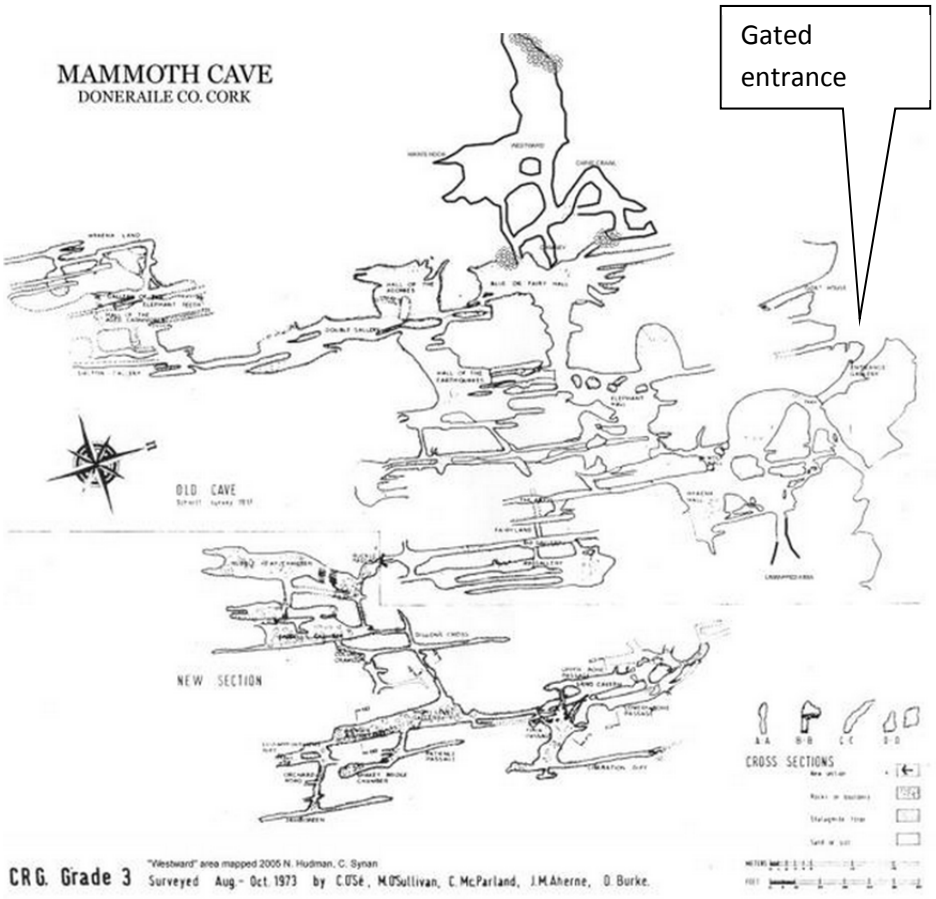
The electrical conductivity of the disappearing flow in the Bregoge is in the order of 100 µS/cm and in the order of 400 µS/cm where the river remerges; notably lower than the mean EC of springs located lower down the system, e.g., Shanballymore, Castletownroche, in the order of 600 µS/cm.



4 CASTLEPOOK (MAMMOTH) CAVE:

No access has been granted and there is a padlocked iron gate installed at the main entrance. However we will drive by to show its location.

Castlepook cave has been extensively mapped (Scharff, Seymourand Newton, 1918) and is well known for its Pleistocene fauna assemblage (mammoth tooth, hyena, etc.), thus indicating an age of more than 45,000 years (Drew and Jones, 2000; Mitchell, 1976). The karst is developed along the north-south and to a lesser extent the east-west jointing forming a grid network of passages with chambers developed at the intersections of major joint systems (see survey). The surveyed passage length is c.750m but the passages are developed in a restricted area of c. 110m x 60m. Grid network cave systems, disjunct from present day topography and hydrology are characteristic of the karsts of Cork, Waterford and Tipperary and are presumed to be remnants of an ancient karst landscape – possibly pre Quaternary.



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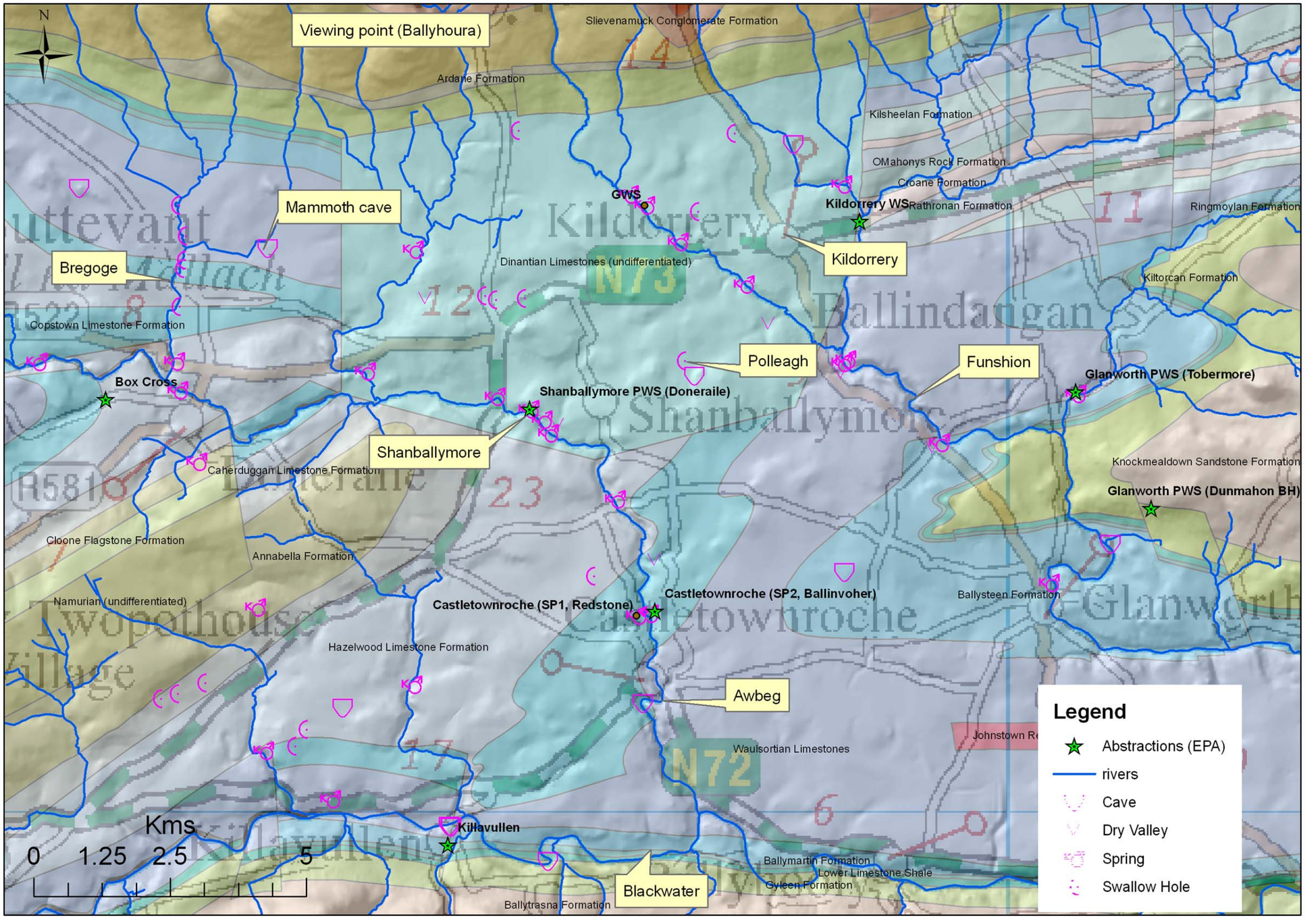

Figure 1 Geology, topography, hydrology, selected karst features and planned stops

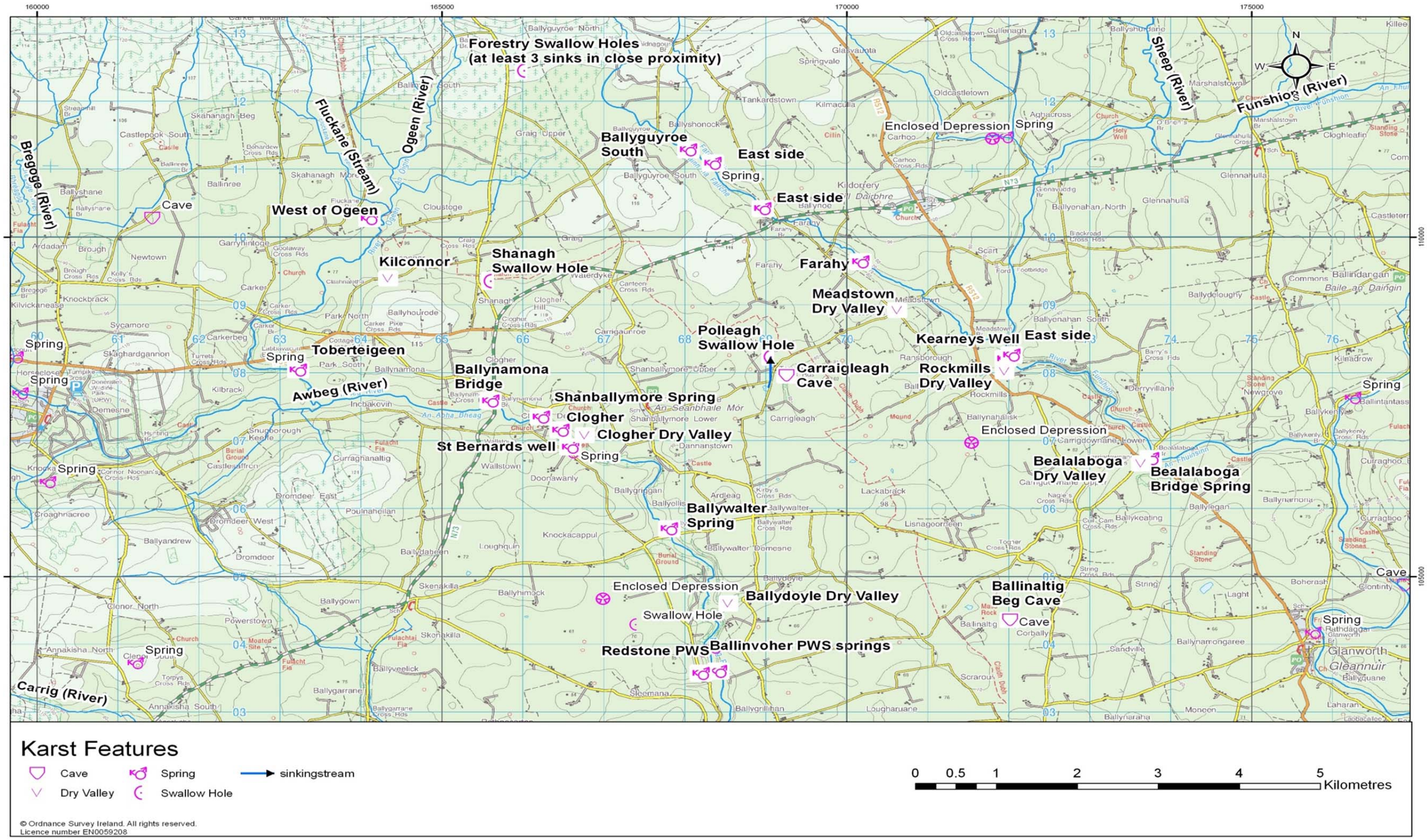

Figure 2 Selected Karst Features

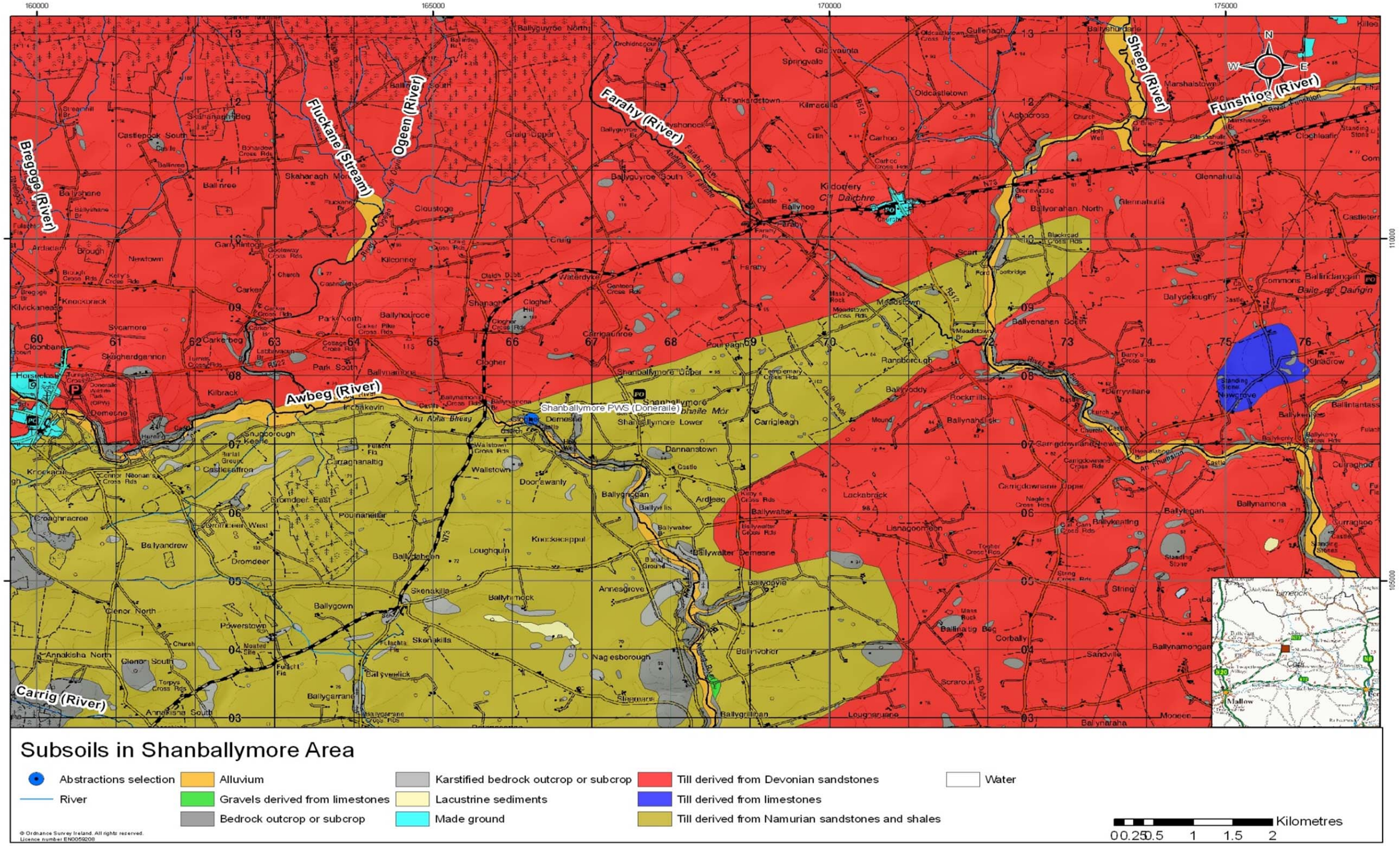

Figure 3 Subsoil Map