Kilkishen GWB: Summary of Initial Characterisation.

<table>
<tr><th colspan="2">Hydrometric Area
Local Authority</th><th>Associated surface water features</th><th>Associated terrestrial ecosystem(s)</th><th>Area (km^2)</th></tr>
<tr><td colspan="2">27 - Fergus catchment
Clare Co. Co.</td><td>Rivers: Rine, Ardsollus, Liskenny, O'Callaghansmills.
Loughs: Dromoland, Gash, Kilgory, Lecarrow, Liskenny, Atober, Anoggaun, Garr, Cullaunyheeda, Clonnloum, Avuddig, Avoher, Clonlea, Gornacorragh, Ballymacloon, Craggaunoween, Derragher, Kilkishen, Deerpark, Poulahoyle, Shandangan, Clonbrick, Snugborough, Companyfield, Knopoge, Ataska, Knocknacunag, Granaghanbeg, Ballycar, Fin.</td><td>Doon Lough (000337), Cullaunyheeda (001017), Dromoland Lough (001008), Ballycar Lough (000015), Lough Gash Turlough (000051), Fergus Estuary and Inner Shannon, North Shore (002048)</td><td>112</td></tr>
<tr><td>Topography</td><td colspan="4">The GWB is elongated in a ENE-WSW direction, and is about 23 km long by 6 km wide. In general, the ground is 10- 40 mAOD, and flat-lying to gently undulating. Ground elevation within the GWB ranges from sea level to just over 90 mAOD. The highest ground is localised under a few small hills, one of which is underlain by Volcanic rocks. Drainage density is relatively high, since this area is generally low-lying.</td></tr>
<tr><td rowspan="5">Geology and Aquifers</td><td>Aquifer categories</td><td colspan="3">The majority of the GWB comprises an Rk^c: Regionally important karstified aquifer dominated by conduit flow. There are narrow (~300 m) strips of Lm: Locally important aquifers which are generally moderately productive around the north, east and south parts of the GWB perimeter. There is also a small (< 1 km^2) area of Lm aquifer where the volcanics occur in the centre of the GWB.</td></tr>
<tr><td>Main aquifer lithologies</td><td colspan="3">Dinantian Pure Bedded Limestones form the majority of the aquifer in the GWB. Some parts (around the edges and in a band in the centre) of the bedded limestone succession are cherty, and have been less susceptible to karstification. There is a small area of Volcanic rock in the centre of the GWB.</td></tr>
<tr><td>Key structures</td><td colspan="3">The rocks are folded into a major ENE-WSW syncline; bedding dips at low angles of approximately 10-20^o. There are numerous N-S and NE-SW faults cross-cutting the fold. These are in the Quin Shear Zone, which is an ENE-trending fault zone located in the East Clare Syncline, and runs from the Fergus Estuary through O'Callaghan's Mills towards Scarriff. On the western edge of this GWB, there is another deep-seated area of deformation – the Fergus Shear Zone – which trends NNE in a narrow band from the Fergus Estuary through Ennis towards Gort.</td></tr>
<tr><td>Key properties</td><td colspan="3">Karstification is ubiquitous in this GWB. As with most karstic systems, permeability and transmissivity data are very variable. Transmissivity in karstified aquifers with conduit flow can range from <1 m^2/d up to a few thousands of m^2/d. Due to groundwater being generally concentrated in conduits, very low yielding or failed wells can occur adjacent to very high yielding boreholes. Groundwater travel times through the conduits are rapid (up to 240 m/h in the Lower Fergus Valley). A dye-tracing study at the Pouladower spring (in the adjacent Ennis GWB) indicates N-S travel times of 141-181m/h and E-W travel times of 67-149 m/h. Rapid velocities recorded for groundwater in this area imply flow through relatively sizeable conduits. Storativity in this aquifer is low (effective porosity ~1.5-2.5%). Borehole logs show evidence of loose dolomitised "sand" in "sand" filled cavities within this GWB; dolomitisation will enhance the overall permeability of the aquifer, and will increase the specific yield to up to 0.1.

(data sources: Rock Unit Group Aquifer Chapters, Clare GWPS and Source Reports, see references)</td></tr>
<tr><td>Thickness</td><td colspan="3">The total succession of the Dinantian Pure Bedded Limestones are 100's of metres thick. However, most groundwater flows in an epikarstic layer a few metres thick and in a zone of interconnected solutionally-enlarged fissures and conduits below this. Work relating to the flooding around Ennis (K.T. Cullen & Co., 2001) suggests that "karst features are generally 10 metres below ground level." Deeper groundwater flow can occur in areas associated with faults. On Aughinish island, on the south side of the Shannon Estuary, there are very deep (~ 60 mbsl) conduits that relate to an ancient baselevel. There may be such conduits in this area, but they are not known; field work would be required to confirm their presence or otherwise.</td></tr>
<tr><td rowspan="4">Overlying Strata</td><td>Lithologies</td><td colspan="3">[Information to be added at a later date]</td></tr>
<tr><td>Thickness</td><td colspan="3">There are little data for this area. Rock outcrops extensively in the centre and NW of the GWB. In between outcrops, subsoil thicknesses range from 1-13 m, and are probably in the range 1-6 m. In the SW and east of the GWB, there are fewer outcrops, and no DTB data to make subsoil thickness assessments.</td></tr>
<tr><td>% area aquifer near surface</td><td colspan="3">[Information to be added at a later date]</td></tr>
<tr><td>Vulnerability</td><td colspan="3">In the centre and NW of the GWB, groundwater vulnerability is mainly Extreme, with some Highly vulnerable areas. In the east, vulnerability is mainly High, with small Moderately vulnerable areas. In the SW of the GWB, groundwater vulnerability ranges from Low, along the coast, to Extreme, moving inland.</td></tr>
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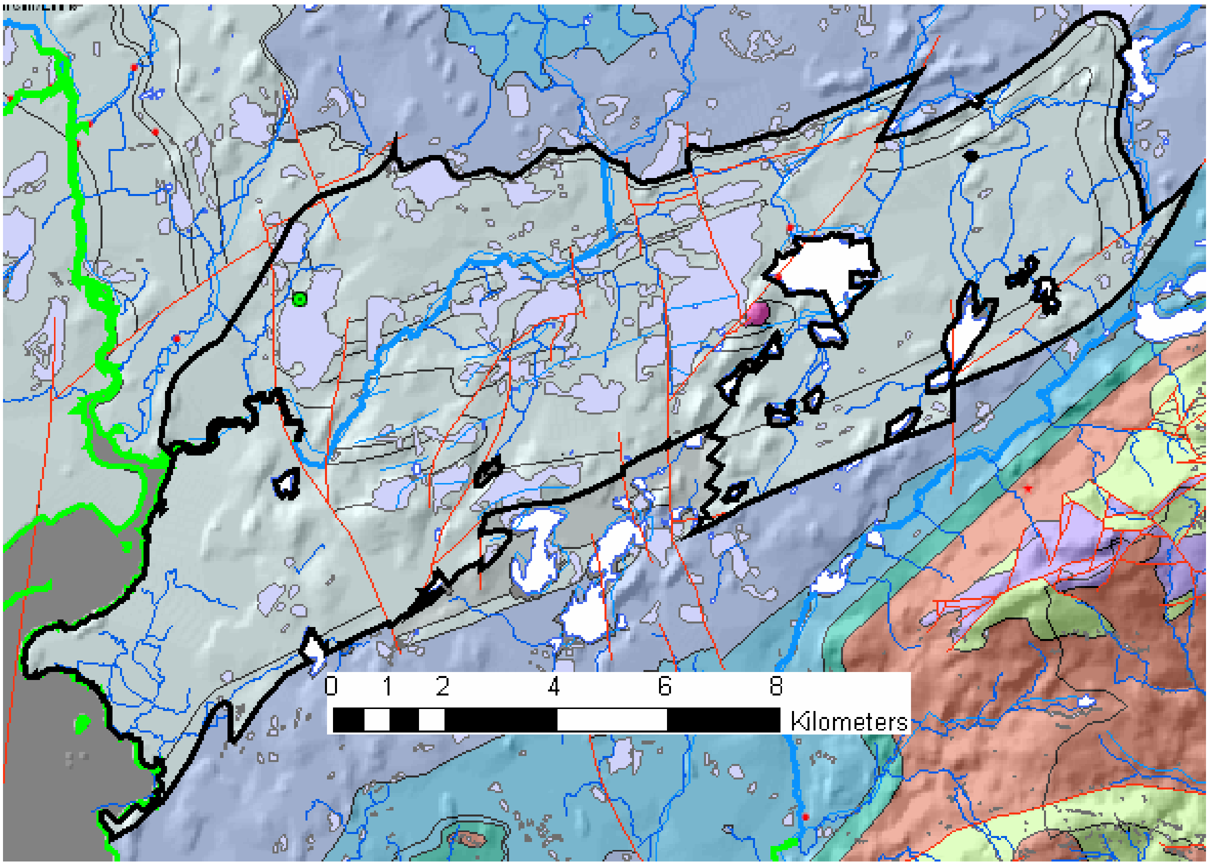
Recharge	Main recharge mechanisms	Both point and diffuse recharge occur in this GWB. Swallow holes and collapse features provide the means for point recharge. Linear/ point recharge may occur along river reaches and where rivers sink underground. Surface water draining off the lower permeability Tulla – Newmarket-on-Fergus GWB may sink into the aquifers of this GWB. Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. The lack of surface drainage in elevated parts of this GWB indicates that potential recharge readily percolates into the groundwater system. However, in low-lying areas with a high water table in this highly transmissive aquifer, there will be some rejected recharge, i.e. a proportion of the effective rainfall is rejected due to lack of storage space in the aquifer.
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	Important springs and high yielding wells (m^3/d)	At Dromoland Castle, there is one Excellent (> 400 m^3/d) and one Good (100 m^3/d < yield < 400 m^3/d) yielding borehole in this GWB. Only one other Good yielding borehole is known, at Caherscooby. Other boreholes have Moderate or Poor yields (< 100 m^3/d) with moderate or low productivities (III to V). The Rine River at Quin has "large springs" associated with it (Deakin and Daly, 2000).
	Main discharge mechanisms	The main discharges are to the streams and rivers crossing the body and to the springs found within the body. In winter groundwater will discharge to the turloughs found in the area via estavelles.
	Hydrochemical Signature	Groundwater sampled at Carrowmere GWS within this GWB has a calcium-bicarbonate hydrochemical signature. Analyses indicate that the groundwater at this source is Hard to Very Hard (250–400 mg/l as $CaCO_3$), with alkalinities of 200–330 mg/l (as $CaCO_3$) and conductivities of 690–916 µS/cm. Elsewhere in the limestones in the Fergus catchment, problems with *E. coli.*, iron, colour and turbidity are reported (Coxon and Drew, 1998). The sandstones and overlying peat to the east may be the origin of some of the suspended matter, although there may also be a contribution from ancient infilled unconsolidated deposits in karst depressions and/or the epikarst.
Groundwater Flow Paths		In general, there is no intergranular porosity or permeability in the rocks of this GWB. However, reported dolomitisation will have caused recrystallisation and the generation of space between dolomite crystals; hence, intergranular flow occurs in dolomitised zones. Dissolutional enlargement of bedding planes and joint, fracture and fault planes is the major mechanism that has created permeability. The GWB is highly karstified; localised high permeability zones give rise to rapid groundwater velocities. Groundwater is likely to flow in three main hydrogeological regimes: (1) an upper, shallow, highly karstified weathered zone, known as the epikarst, in which groundwater moves quickly, through solutionally enlarged conduits, in rapid response to recharge; (2) a deeper zone, where groundwater flows through interconnected, solutionally enlarged conduits and cave systems which are controlled by structural deformation (principally in the north-south and east-west directions) and bedrock lithologies. Groundwater flows along the less permeable, cherty units until it intersects a vertical fissure; and (3) a more dispersed slow groundwater flow component in smaller fractures and joints outside the main conduit systems. The epikarst is thought to be relatively modern, being formed after the last ice age, while the deeper karst is likely to be a remnant of not only recent solution, but also glacial and pre-glacial solution. All three groundwater flow regimes will be hydraulically connected in places with the degree of interconnection depending on the presence of less permeable bedrock units and the faults and joints associated with the structural deformation, particularly the north-south and east-west fault systems. K.T. Cullen & Co. (2001) concluded from drilling a programme in the Ennis area that karstification is generally limited to 10 m or less below the ground surface. The chertier lithologies around the N, E and S edges of the (Cregmahon and Ballycar limestones) and mapped along the centre of the GWB ('ch' lithology) are less susceptible to karstification, and may influence the direction of groundwater flow in their vicinity. The cherty zone in the centre of the GWB is likely to be a hydraulic barrier. It is probable that a high proportion of the groundwater flow is in direct-route, underground, solutionally enlarged conduits in the limestones, with a somewhat lesser contribution from the smaller, more diffuse network of fissures and conduits in the surrounding rock. The proportion of flow travelling through large conduits will vary with different water levels: there is likely to be more flow in the diffuse fissures at lower water levels. In this gently undulating, relatively low-lying area, groundwater levels vary from 0 mbgl to 26 mbgl. There are insufficient data to state definitively, but it appears that there are two relatively unconnected groundwater systems – (1) a shallow system in which water levels are roughly 0-6 mbgl and in which groundwater is in continuity with the rivers crossing the GWB; (2) a deeper system in which water levels are 15-26 mbgl, and which are significantly lower than the river water elevations and sometimes below sea level. In the main, boreholes with deep water levels have Poor or Moderate yields. This indicates that there are areas within the aquifer isolated from the main conduits. Weekly water level monitoring for over a year in 8 boreholes at the Kilbreckan Calcite Mine showed an average water level fluctuation of 2.4 m [1.76–4.2 m]. A groundwater gradient of 0.007 was estimated. Heavy rainfall can cause temporary high water levels in the shallow epikarst zones, and pulses of recharge can displace material which is normally relatively undisturbed. Groundwater levels will respond quickly to rainfall events due to the general absence of subsoil cover. Bacteria are a common problem in karst areas as groundwater travel times are so short and vulnerability generally extreme. The fluctuations in colour and bacteria and, occasionally, iron, are all typical of a karst environment with a rapid 'flashy' response to rainfall events and short residence times.

Groundwater & Surface water interactions	There is an effective hydraulic interconnection between groundwater and surface water in the karst limestone: much of the groundwater will spend at least some time on the surface and vice versa. For example, along the Rine River at Quin, there are large springs, swallow holes, estavelles and caves associated with it. Surface water flowing off the Devonian Sandstone and Impure limestones in the east sinks into the karst groundwater system and potentially reaches the springs. There are several groundwater-dependent ecosystems within the GWB, including naturally eutrophic loughs, calcareous loughs and alkaline fens, and turloughs. Lough Gash Turlough is one of the latest turloughs to dry out in any year and may fail to do so sometimes; as such it is highly rated for being at one of the extremes of turlough variation, i.e. wetness.
Conceptual model	• The terrain in this GWB is gently undulating and low-lying. It is bounded to the SW by the coast and estuary. The W/ NW boundary is coincident with a surface water and implied groundwater divide. The northern, eastern and southern boundaries are formed by the contact with the lower transmissivity rocks of the Tulla – Newmarket-on-Fergus GWB. • The GWB predominantly comprises highly karstified limestones in which groundwater is transmitted through a network of conduits and an epikarstic zone. The fault and fracture network and the bedding planes have been enlarged by dissolution, resulting in a highly transmissive aquifer with rapid groundwater flow in which the more permeable zones have specific orientations. The aquifer has low storativity. • Both diffuse and point recharge occurs. Recharge occurs diffusely through the subsoils or at rock outcrop. Point recharge occurs at the numerous swallow holes in the GWB and also along losing river stretches. • There appear to be two groundwater regimes in the karstic aquifer – a shallow, unconfined system, where the water table is generally shallow, within 7 m of ground surface and often within 3 m, and a deep, unconnected system where water levels are very deep (up to 26 mbgl), are below river levels, and can be below sea level. • Seasonal water table fluctuations vary: annual variation is on the order of 1.7 – 4.2 m (average fluctuation is about 2.4 m) and probably depends on the position within the groundwater system, being greater in recharge areas and lower in discharge areas. • There is a complex and dynamic relationship between rainfall, river flows and groundwater movement, which is largely controlled by the distribution and throughput capacity of the network of karstic conduits. Groundwater in this body is expected to show a rapid response to recharge, with rapid groundwater velocities. • Groundwater discharges to the rivers and streams crossing the GWB, to lakes, and, in winter, to the turloughs. Lough Gash is a turlough of particular interest, since it is particularly late-draining, and as a result supports a very distinctive plant community. • Rivers may be both losing and gaining, depending upon the location within the system, and also upon the time of year. In late summer, rivers may be losing, but gaining in the rest of the year. Groundwater level data indicate the potential for surface water to recharge groundwater.
Attachments	None.
Instrumentation	Stream gauges: 27022, 27071. EPA Representative Monitoring boreholes: Carrowmere GWS (CLA 6).
Information Sources	Coxon, C. and Drew, D. (1998) Interaction of Surface Water and Groundwater in Irish Karst Areas: Implications for Water Resource Management. *Proceedings of IAH Congress*, Las Vegas, Sept. 1998. Deakin, J. (2000) Ennis Public Supply – Drumcliff Spring, Co. Clare. Geological Survey of Ireland Report to Clare Co. Co., 13 pp. Deakin, J. (2000) Ennis Public Supply – Pouladower Spring, Co. Clare. Geological Survey of Ireland Report to Clare Co. Co., 13 pp. Deakin, J. and Daly, D. (2000) *County Clare Groundwater Protection Scheme.* Geological Survey of Ireland Report to Clare Co. Co., 67 pp. K.T. Cullen & Co. (2001) *Ennis Main Drainage and Flooding Study: Preliminary Report.* Volume III, Part II, Hydrogeology Final Report. Report for Ennis U.D.C. 51 pp. plus figures and appendices. Aquifer chapters: Dinantian Pure Bedded Limestones; Dinantian Pure Unbedded Limestones.
Disclaimer	Note that all calculations and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae



Rock units in GWB

Rock unit name and code	**Description**	**Rock unit group**
Burren Formation (BU)	Pale grey clean skeletal limestone	Dinantian Pure Bedded Limestones
Burren Formation & Oolitic limestone (ooBU)	Pale grey clean skeletal limestone	Dinantian Pure Bedded Limestones
Tubber Formation (TU)	Crinoidal & cherty limestone & dolomite	Dinantian Pure Bedded Limestones
Cregmahon Member (TUcm)	Crinoidal limestone with cherts	Dinantian Pure Bedded Limestones
Tubber Formation & Oolitic limestone (ooTU)	Crinoidal & cherty limestone & dolomite	Dinantian Pure Bedded Limestones
Aylecotty Member (SLay)	Thin bedded dark grey cherty limestone	Dinantian Pure Bedded Limestones
Cullaun Member (SLcu)	Crinoidal & conglomeratic limestone	Dinantian Pure Bedded Limestones
Visean Limestones (undifferentiated) (VIS)	Undifferentiated limestone	Dinantian Pure Bedded Limestones
Chert (ch)		Dinantian Pure Bedded Limestones
Oolitic limestone (oo)		Dinantian Pure Bedded Limestones
Ballycar Formation (BC)	Dark grey fine cherty limestone	Dinantian Pure Bedded Limestones
Turret Volcanic Member (SLtu)	Basaltic tuff & lava	Basalts & other Volcanic rocks