Milltown Malbay GWB: Summary of Initial Characterisation.

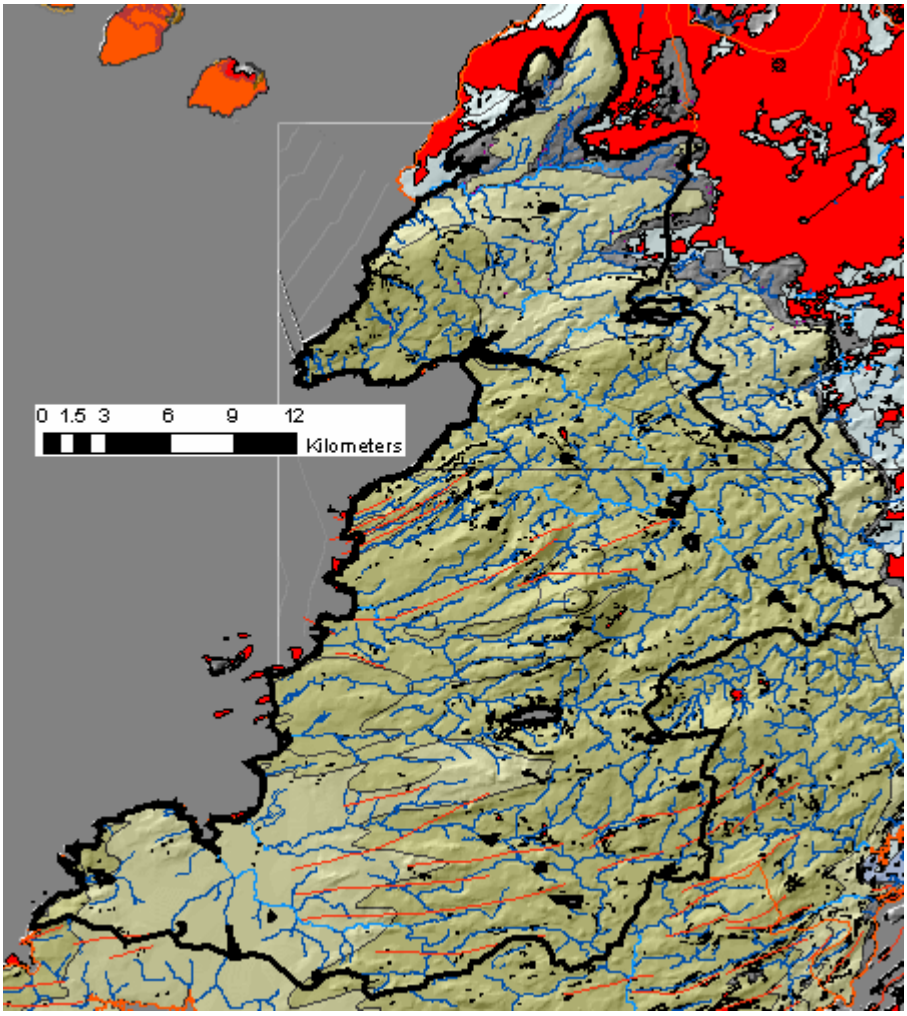
Note that parts of the eastern GWB boundary may alter. This description is written for the current status.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystems	Area (km^2)
28 - Inagh Catchment Clare Co. Co.	Rivers: Aille, Aughyvackeen, Ballymacraven, Inagh, Cullenagah, Skivileen, Doonbeg, Annageeragh, Annagh, Deelagh, Cooleen, Freagh, Ballinphonta, Glendine, Kildeema, Aughaglanna, Aughaveema, Inch, Creegh. Loughs: Garrig, Goller, Doonagore, Luogh, Lickeen, Cloonomra, Beg, Moona, Neppy, Aillbrack, Drumcallaun, Abullaunduff, Caum, Keagh, Drumanure, Druminishin, Nagraghaun, Rooskagh, Acorraun, Doonbeg, Farrihy, Black, Tullaher, Moanmore, Cloonmackin, Akit, Boolynagreana, Donnogan, Doo, Creevagh, Naminna, Donnell, Boleybeg, Nacrag, Acrow, Cahermurphy, More, Achryane, Knocka, Boolydoolavaun, Corraige, Rosconnell, Rushaun, Leckaun, Islandgar, Bougha, Burke, Corroe, Redmeadow, Derrygarve, Fairyhill.	Black Head – Poulsallagh complex (000020); Farrihy Lough (000200); Tullaher Lough and Bog (000070); Carrowmore Point to Spanish Point and Islands (001021); White Strand/ Carrowmore Marsh (001007); Ballyteige (Clare) (000994); Lough Goller (000048).	766

Topography	The groundwater body is situated in the west of Co. Clare. The coast forms the western boundary of the GWB. In the east and south, surface water catchment divides (Inagh) bound the GWB. The northern boundary is marked by the appearance at surface of the underlying karstified Dinantian Pure Bedded Limestones. The GWB is elongated north-south. The majority of the GWB is less than 100 mAOD, although ground elevations reach 391 mAOD. The higher elevations (150+ mAOD) are concentrated in three places: around Slieve Eilbhe (311 mAOD) at the north of the GWB, along a SW-NE ridge running inland from the Cliffs of Moher (highest point Knocknalarabana, 200 mAOD); in a line of hills oriented NW-SE, of which the highest point is at Slievecallan (391 mAOD). Surface drainage is generally from east to west. In the area south of Licannor Bay, the NE-SW drainage pattern is controlled by the folding of the rocks; elsewhere, this influence on the second order streams is not so strong.	
Geology and Aquifers	Aquifer category(ies)	The vast majority of the GWB comprises **Ll** : Locally important aquifers which are moderately productive only in local zones. In the north of the GWB, a small area of Namurian Shales is classified as a **Pu:** Poor aquifer which is generally unproductive. There is a very small area of pure limestone aquifer classified as an **Rk^c**: Regionally important karstified aquifer dominated by conduit flow in the northeast of the GWB.
	Main aquifer lithologies	The GWB is dominated by rock units from the Namurian Undifferentiated group. Large areas of Namurian Sandstones are found in the NW and SW of the GWB. A small area of Namurian Shales occurs in the north of the GWB. A small area (~2km^2) of Dinantian Pure Bedded Limestone is found in the northeast.
	Key structures	The rocks are folded into relatively small folds with wavelengths of about 3 km. The intensity of folding dies out northwards. The fold axes trend WSW-ENE; strata dip at right angles to the fold axes at angles from 10-50^o. There are some ENE-WSW faults mapped in the Miltown Malbay/ Slievecallan area. Faults are not mapped elsewhere but probably exist. Fractures and jointing may be more open on the fold axes.
	Key properties	Transmissivities in the Undifferentiated Namurian rocks and the Namurian Sandstones are generally in the range 2–20 m^2/d, although higher values may be achieved in faulted zones. South of the Shannon Estuary at Glin WS, a pumping test gave a transmissivity of 14 m^2/d [estimate range 7-27 m^2/d]. The Namurian Shales will have very low transmissivities, whilst the heterogeneous karstified limestone transmissivity may range from 2-2000 m^2/d. Aquifer storativities for all rock unit groups will be low. At Glin WS, estimated groundwater gradients are 0.04 - 0.05. Over the GWB, they are likely to be in the range 0.02 – 0.05. *(data sources: Rock Unit Group Aquifer Chapters, Clare GWPS and Source Reports, see references)*
	Thickness	In general, most groundwater will flow in the upper part of the aquifer in a layer likely to be about 10-15 m thick, comprising a weathered zone of a few metres and a connected fractured zone below this. However, deep water strikes (30-100+ m) are noted in this aquifer, and are associated with better yields and productivities, and wells are often overflowing. Permeable zones are met at deeper levels than in other rocks. In a 3 km deep exploration borehole drilled by Ambassador Oil near Doonbeg (in the adjacent Kilrush GWB), water was struck at 107 m and then intermittently until a depth of 610 m.
Overlying Strata	Lithologies	*[Information to be added at a later date]*
	Thickness	Subsoil thickness data for this GWB are sparse. Available data indicate that thicknesses range from 0 m to 17 m, with modal values of about 4-8 m. Subsoils are probably slightly thicker in the flat-lying area in the very southwest of the GWB, and along the Inagh/ Cullenagh River valley. Outcrop is mainly confined to along the courses of the upland streams, where the rivers have incised into the rock, and to ridged areas between rivers, such as near Doo Lough, in the centre of the GWB.
	% area aquifer near surface	*[Information to be added at a later date]*

	Vulnerability	Groundwater vulnerability ranges from Low to Extreme across the GWB. In the southwest around the Doonbeg River, vulnerability is predominantly Low to High, except along the coast. Vulnerability also ranges from Low to High along most of the Inagh and Aughyvackeen River valleys. Over most of the rest of the GWB, vulnerability is Extreme. The exception is along the middle part of the eastern boundary, where Low vulnerability predominates. Outcropping rock is generally confined to areas greater than 100 mAOD elevation. Outcrops are often elongated in the same ENE-WSW direction as the fold axes.
Recharge	Main recharge mechanisms	Diffuse recharge will occur via rainfall percolating through the subsoil. The proportion of the effective rainfall that recharges the aquifer is largely determined by the thickness and permeability of the soil and subsoil, and by the slope. Due to the generally low permeability of the aquifers within this GWB, a high proportion of the recharge will then discharge rapidly to surface watercourses via the upper layers of the aquifer, effectively reducing further the available groundwater resource in the aquifer.
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	Important springs and high yielding wells (m^3/d)	Kilmihill Reservoir (164 m^3/d – GSI database), Lissycasey GWS (?2000 m^3/d – GSI database – could be yield not abstraction), Connolly WS (109 m^3/d – GSI database); North Clare Creameries (Ennistimon) (up to 98 m^3/d – GSI database); Newmarket Dairy Co. Ltd. (Kilmihil) (up to 218 m^3/d – GSI database); Kilmihill Creamery (up to 158 m^3/d – GSI database); Newmarket Dairy Co. (Moy More) (up to 164 m^3/d – GSI database); Liscannor Creamery (up to 157 m^3/d – GSI database) *[More information may be added at a later date]*
	Main discharge mechanisms	The main discharges are to the streams crossing and incising into the sandstone and shale rock units. Small springs and seeps are likely to issue at the stream heads and along their course. Seepages will develop on the coastal cliff faces. Minerals in the shales give rise to acidic surface runoff which has a high eroding capacity by the time it reaches the adjacent, lower-lying limestones. The boundary between the two rock types is typified by an extensive series of swallow holes and collapses where surface waters can get direct rapid access to the limestone groundwater system.
	Hydrochemical Signature	No data are currently available for this GWB. Groundwaters in the Ballylongford GWB (on the south side of the Shannon Estuary) are moderately hard (120-270 mg/l $CaCO_3$) and have moderate alkalinities (170-240 mg/l as $CaCO_3$). Measured electrical conductivity ranges from ~440-560 µS/cm. Spring waters (Tarbert WS) have a calcium bicarbonate signature. Groundwater sampled from a borehole (Glin WS) has a signature varying from Ca-HCO_3 to Na/K-HCO_3 and alkalinities greater than total hardness. This is typical of confined waters where ion exchange has occurred. Reducing conditions may also occur. Both iron and manganese can exceed allowable concentrations, these components coming from the shales. Phosphates occur naturally in the Clare Shales and can wash out into the local water courses, resulting in elevated, but naturally-occurring concentrations. Background chloride concentrations will be higher than in the Midlands, due to proximity to the sea. Groundwaters from the small area of karstic limestone will have a calcium-bicarbonate signature, and will range from moderately hard to very hard with concomitant moderate to high conductivities. This variation is caused by the flashy flow from the karst conduits.
Groundwater Flow Paths		The Namurian rocks are devoid of intergranular permeability; groundwater flow occurs in fractures, joints and faults. Generally, groundwater levels are 0-8 m below ground level (most < 3 mbgl), and follow the topography. Deeper water levels, of more than 60 mbgl are observed, however, which indicate that there may be zones that are hydraulically isolated from the rest of the aquifer. Unconfined groundwater flow paths are short (30-300 m), with groundwater discharging to seeps, small springs and streams. There is groundwater perched in the subsoils. Artesian conditions and deep inflow levels indicate that the lower part of the aquifer is confined by shales in the succession. Groundwater travel times in this zone are relatively slow. In the small area of karstic limestone, groundwater will travel rapidly though the epikarst and karstic conduits before emerging as surface water at the limestone/sandstone contact. Conversely, surface waters flowing off Namurian bedrock onto lower-lying limestones will sink partially or completely into the karst network in the limestones.
Groundwater & Surface water interactions		Due to the shallow groundwater flow in this aquifer the groundwater and surface waters are closely linked. The aquifer discharges readily to the overlying (gaining) streams. Specific dry weather flows in the Abbeyfeale GWB on the south of the Shannon are low (0.1 to 0.5 l/s/km^2 at 5 stations), indicating that the Namurian aquifers have low storage. Small springs and seeps contribute to river flows. Some of the NHAs within the GWB are groundwater-dependent. At the edge of the raised bog at Tullaher, there transitional mires and fens. Carrowmore Point NHA is extremely complex; marsh and swamp vegetation may depend on a component of groundwater flow. At White Strand, there is a freshwater marsh to the south of the dune system, and at Ballyteige, wet flushes occur throughout the area of wet meadows and heath. Lough Goller (000048) is drained by a river at the southeast end of the lake. The waters are slightly alkaline although the bedrock is sandstone and shale. The Aille River is fed by groundwater that is forced to the surface at the contact between this GWB and the karstic Slieve Elva GWB. Hence, the Aille River hydrochemistry is likely to be controlled by the karst limestone aquifer system.

Conceptual model	• The groundwater body is bounded to the west by the coast. The eastern and southern boundaries are surface water catchment divides. The northern boundary is formed by the contact with the karstic limestones of the Slieve Elva GWB. The GWB is elongated north-south. The terrain is a mixture of low-lying and hilly areas. • The groundwater body is composed primarily of low permeability siliceous rocks, although localized zones of enhanced permeability do occur along faults and in coarser layers. Groundwater flows along fractures, joints and major faults. In the small area of limestone, flow is through the epikarst and karstic conduits. • Recharge occurs diffusely through the subsoils and via outcrops. It occurs especially in areas where the subsoil is thinner or absent. • The aquifers within this GWB are both unconfined and confined. Most flow in this aquifer will occur near the surface; the effective thickness of the unconfined part of aquifer is likely to be about 10-15 m, comprising a weathered zone of a few metres and a connected fractured zone below this. The water table is from 0-8 m below ground level and follows topography. Deep inflow levels and artesian wells indicate confined conditions in higher permeability strata from which better yields can be obtained. Unconfined flow path lengths are relatively short, and in general are between 30 and 300 m. Confined flow paths may be significantly longer. • Groundwater discharges to the numerous small streams crossing the aquifer, and to the springs and seeps. Local unconfined flow directions are oblique to the surface water channels. Overall, the flow direction is to the west. • Surface waters flowing off the Namurian bedrock onto lower-lying limestones within the Slieve Elva GWB will sink partially or completely into the karst network in the limestones. In elevated areas, the boundary between the two rock types is typified by swallow holes or collapses. • However, in addition to surface water from this GWB sinking into the adjacent karstic system, the Aille River is fed by groundwater that is forced to the surface at the contact between this GWB and the karstic Slieve Elva GWB. Hence, the Aille River hydrochemistry is likely to be controlled by the karst limestone aquifer system. • Phosphates occur naturally in the Clare Shales and can wash out into the local water courses, resulting in elevated, but naturally-occurring concentrations. Phosphate-rich waters have the potential to travel rapidly large distances in the karst system, emerging at surface water features.
Attachments	None.
Instrumentation	Stream gauges: 27090, 28001, 28002, 28003, 28004, 28005, 28006, 28007, 28008, 28070.
Information Sources	Deakin, J. and Daly, D. (2000) *County Clare Groundwater Protection Scheme*. Geological Survey of Ireland Report to Clare Co. Co., 67 pp. Hudson, M. (1995) *Glin WS: Groundwater Source Protection Zones*. Geological Survey of Ireland Report to Limerick Co. Co., 8 pp. Aquifer chapters: Namurian Undifferentiated, Sandstone and Shale; Dinantian Pure Bedded 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
Ross Sandstone Formation (RS)		Namurian Sandstones
Gull Island Formation (GI)		Namurian Sandstones
Central Clare Group (CCG)		Namurian Undifferentiated
Shannon Group (SHG)		Namurian Undifferentiated
Clare Shale Formation (CS)		Namurian Shales
Lissylisheen Member (SLll)		Dinantian Pure Bedded Limestones