Laune Muckross GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
22 Kerry Co. Co.	**Rivers:**.Cottoner's, Laune, Gweestin, Caragh, Deenagh, Flesk, Behy, Finow, Owneykeagh, Loe, Gaddagh, Owngarrif, Woodford, Gweestin, **Lakes:** Yganavan, Farrantoreen, Ykeel, Maghantoorig, Nagat, Nambrackdarrig, Caragh, Ardagh, Loch, Muckross, Doo, Guitane.	Lough Yganavan and Lough Nambrackdarrig (000370), Sheheree Bog (000382), Doo Loughs (000350).	164

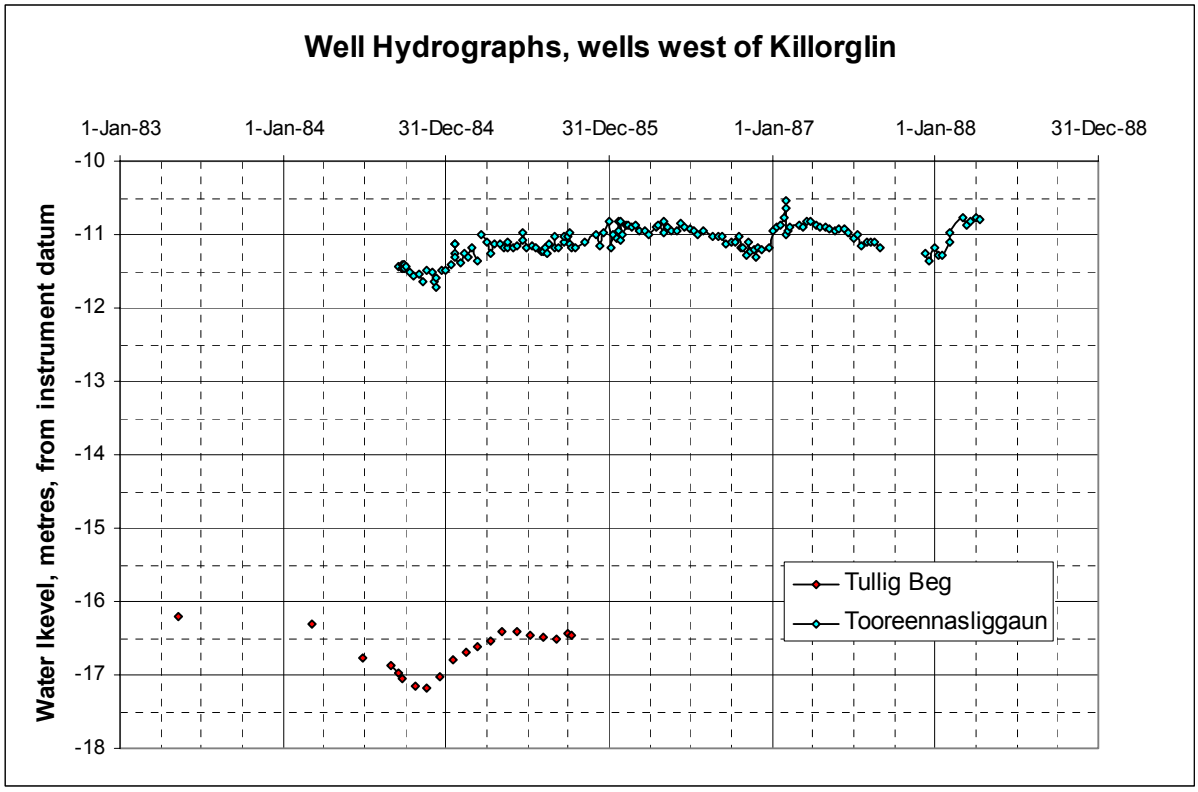
Topography	This GWB occupies the lowlands that extend from east of Lough Leane, to the coast and Castlemaine Harbour in the west. The River Laune flows west from Lough Leane along the northern boundary of the body. Ground elevations in the GWB range from 10-150 m OD. The lowest ground (<30 m OD) occurs in the west of the body, along the coast, along the River Laune, and around the shores of Lough Leane and Lough Cara. West of Lough Leane the body is generally flat to gently sloping (from the south to the River Laune) elevations are highest around the margins of the body (40-60 m OD). Three small hills rising to 50 m OD (capped by Namurian bedrock) occur west of Killorglan. East of Lough Leane ground elevations slope more steeply from the lakeshore to the north, east and south (20-100 m OD). The highest ground in the body (150 m OD) occurs along the southern boundary of the body, east of Lough Leane.	
Geology and Aquifers	**Aquifer categories**	**Rkd**: Regionally important karstified aquifer dominated by diffuse flow. **Ll:** Locally important aquifer which is moderately productive only in local zones. This GWB is overlain by a potential gravel aquifer extending from Killarney to Killorglin which is described in the ……GWB.
	Main aquifer lithologies	Dinantian Pure Unbedded Limestones, Dinantian Upper Impure Limestones and Dinantian Lower Impure Limestones occur in this GWB. The limestones are overlain by small occurrences of Namurian Undifferentiated in the northwest of the GWB. In the west of the GWB the different limestone types have not been differentiated on the bedrock map as they are in the east of the body. The area is identified only as Undifferentiated Dinantian Limestone which is nominally grouped with the Dinantian Pure Unbedded Limestones. It is expected that a yet unmapped succession of Dinantian Lower Impure Limestones, Dinantian Pure Unbedded Limestones and Dinantian Upper Impure Limestones, similar to that which occurs in the east of the body and in the Castlemaine GWB, occurs within this area. The Pure Unbedded Limestones are considered to be the dominant lithology. This GWB is overlain by extensive areas of sand and gravel. These deposits have not yet been proved to be very productive but are of sufficient depth and extent to be considered a potential gravel aquifer. These deposits consist of a mixture of glacial moraines and out-wash gravels. The heterogeneity of these deposits means that their ability to act as aquifers is limited.
	Key structures	The Variscan (Hercynian) Orogeny (mountain building episode), compressed rocks in the South Munster region from the south into a series of folds on east west axes, and created an extensive network of fractures (often predominantly north-south), which in the pure limestones were subsequently enlarged by karstification. The rocks of this GWB occur in the Dingle Bay syncline, which lies between the two major east-west trending anticlinal structures, the Dingle and Iveragh Peninsulas. Mapping of structural features is limited in this area due to thick overburden cover and lack of exposure particularly in the west of the GWB, however, in the adjoining Castlemaine GWB more structural details are available. Major faults occur trending north northwest –south southeast and the rocks are well jointed. A study in the Maine River Basin showed that about 80% of joints are orientated NNE-SSW. The open nature of the joints allows groundwater movement and facilitates conduit development by solution (Scanlon, 1985). It is likely that similar conditions exist in the Laune Muckross GWB

	Key properties	Pure unbedded limestones in this region are generally highly productive. The rocks generally contain numerous faults and joints which have been enlarged by karstification. In this GWB there are some surface karst features east of Lough Leane and along the shores of the lake. Transmissivity in the pure unbedded limestones can range up to a few thousand m^2/d. Pumping tests in the same rock type in the Cloyne GWB (Waulsortian Limestone) gave a range of transmissivity of 200 to over 2000 m^2/day. Groundwater gradients are generally low (0.001-0.005). Some variations in the hydrogeological properties observed within the pure unbedded limestones have been observed in the adjoining Castlemaine GWB to the north, due to some variations in the permeability of the different rock units (Scanlon, 1985). Steeper hydraulic gradients are expected where impure limestones occur. In the impure limestones, transmissivities will be lower; generally in the range 5-20 m^2/d but may be higher where karstification has occurred. Overlying sand and gravel deposits that are in continuity with the underlying limestone provide additional storage to the bedrock aquifer. Data on the hydrogeological properties of these deposits, a mixture of glacial moraines and out-wash gravels is limited. No high yielding boreholes are recorded. Water level records for two wells near Killorglin are shown in Figure 1. The water level fluctuation is very small which may be attributed to the high storativity in the deep sand/gravel deposits. The moraines have a high clay content and subsequently a lower permeability and so do not yield large quantities of water. They also can contain massive boulders which make drilling difficult. The cleaner outwash gravels have a higher sand and gravel content and are more likely to bear water. The heterogeneity of these deposits means that their ability to act as aquifers is limited however they do have a role in providing additional storage for the underlying bedrock aquifer.
	Thickness	The Dinantian Pure Unbedded Limestones (Waulsortian Limestone) is approximately 600m thick in the Castleisland–Tralee-Ardfert area (Pracht, 1997). Most groundwater flow may occur in an epikarstic layer a couple of metres thick and in a zone of interconnected solutionally-enlarged fissures and conduits that extends approximately 30 m below this. However deeper flows also occur and boreholes can intersect fissuring and karstification at depths of down to 60 m below OD. In the Impure Limestones that occur in this GWB, most groundwater flow may occur in an upper weathered layer of a few metres and a zone of interconnected fissures often not extending more than 15 m from the top of the rock, although occasional deep inflows associated with major faults can be encountered. Impure limestones are also much less susceptible to karstification.
Overlying Strata	**Lithologies**	This GWB is overlain by glacial till, sand and gravel deposits, blanket peat and alluvium deposits along the rivers and streams. Sand and gravel deposits extend from Killarney to Killorglin and continue out to the coast. In many areas they are not identified by Teagasc subsoil mapping as they are overlain at the surface by blanket peat and glacial till. These deposits consist of a highly heterogeneous mixture of glacial moraines and out-wash gravels. The moraines have a higher clay content and subsequently a lower permeability. The cleaner outwash gravels have a higher sand and gravel content and therefore a higher permeability. However, the individual areas of each type have not yet been identified. In the west of the body an iron pan has developed over sand and gravel deposits resulting in a perched water table and the development of blanket peat over sand and gravel deposits. East of Lough Leane is the large paved area of Killarney town. Some undifferentiated lake sediments have also been identified east of the lake. At the mouth of the River Maine at Castlemaine Harbour, are some estuarine sediments. The glacial till is identified by Teagasc mapping to be mainly derived from Devonian Sandstones to the south, with a small area of tills derived from the Namurian Sandstones and Shales to the north. Areas of rock outcrop are limited in this GWB. Most outcrop occurs in the east of the body along the shores of Lough Leane. *Subsoil Types identified in Laune Muckross GWB by Teagasc Parent Material Mapping (Draft): Alluvium (A); Blanket Peat (BktPt); Sandstone sands and gravel (Devonian) GDSs; Lake sediments undifferentiated (L); Made Ground (Made); Beach/Raised Beach Sand (Mbs); Estuarine sediments (silts/clays) (Mesc); Rock outcrop and rock close to surface (Rck); Till – Devonian Sandstone Till (TDSs), Namurian Sandstone and Shale Till (TNSSs).*
	Thickness	Depth to bedrock data are very limited in this GWB. Available data indicate that subsoil thickness ranges from 0 to 39m. In general subsoils are thinner in the east of the body around the shores of Lough Leane, although subsoils of up to 39 m have been encountered north of the lake. In the west of the body subsoils are generally expected to be quite deep. Sand and gravel deposits of up to 30 m bgl have been encountered beneath a few metres of blanket peat in the west of the body. Areas of rock outcrop are rare. Where the underlying limestone is highly karstified it is likely to a very irregular bedrock surface. Subsoil depths in these areas can therefore be highly variable within short distances.
	% area aquifer near surface	
	Vulnerability	No Groundwater Vulnerability map is currently available for Co. Kerry. It is probable that areas of Extreme vulnerability are present around the shores of Lough Leane and in the vicinity of areas of rock outcrop and shallow rock, however fully delineating remaining areas of High, Moderate and Low Vulnerability is not possible at this time.

Recharge	**Main recharge mechanisms**	Surrounding uplands provide abundant runoff which supplies recharge to the limestone aquifer. Diffuse recharge will occur via rainfall percolating through the subsoil and areas of outcropping rock. The proportion of the effective rainfall that will recharge the aquifer is determined by the thickness and permeability of the subsoil. In the west of the body an iron pan has developed over sand and gravel deposits resulting in a perched water table and the development of blanket peat over sand and gravel deposits. This iron pan where present will restrict percolation of recharge. Where moronic sand and gravel deposits occur with a high clay content they may also restrict percolation of recharge to the underlying aquifer. However these low permeability deposits have not been separately identified to date. In the east of the body some karst features (swallow holes) are recorded, which will provide the means for point recharge to the karstified aquifer.
	Est. recharge rates	
Discharge	**Large springs and high yielding wells (m^3/d)**	*Note: The following data needs to be checked and updated by RBD Project Consultants.* Data from GSI Well Database: Banshagh (Klinge Ltd., Killorglin) (1091 m^3/d); Coolmagort (Dunloe Castle Hotel) (445 m^3/d); Ardagh (Gleneagle) (654 m^3/d). Data from EPA Groundwater Sources List: Lackabane (Hotel Europe, Killarney) (682 m^3/d).
	Main discharge mechanisms	Groundwater discharges to Lough Leane and to the rivers and streams crossing the GWB. The River Laune is likely to be the primary discharge line.
	Hydrochemical Signature	There are no EPA hydrochemical monitoring data specific to this GWB currently available. Data from areas with a similar geology (eg Castlemaine GWB) is used to identify the hydrochemical signature of this GWB. Groundwater in this body will be dominated by calcium and bicarbonate ions. Hardness can range from moderately hard to very hard (200 to >400 mg/l (as $CaCO_3$). Spring waters tend to be softer as throughput is quicker and there is less time for the dissolution of minerals into the groundwater. Groundwater alkalinity will be high, up to 400 mg/l (as $CaCO_3$). Alkalinity will be generally less than hardness, indicating that ion exchange (where calcium or magnesium are replaced by sodium) is not significant. These hydrochemical signatures are characteristic of clean limestone. Like hardness and alkalinity, electrical conductivities (EC) can vary greatly. Typical limestone water conductivities are of the order of 500-700 µS/cm. Lower values suggest that the residence times of some of the sources are very short reflecting a karstic system with rapid flow velocities. Chloride levels in groundwater in this body can be elevated near the coast.
Groundwater Flow Paths		These rocks have no intergranular permeability. Groundwater flow occurs in the many faults and joints, enlarged by karstification. Based on data from the similar Castlemaine GWB to the north it is likely that at least part of the groundwater flow may be through enlarged conduits within the limestone (particularly in the Cloonagh Limestone/Cracoean Reef) however overall groundwater flow in the Waulsortian Limestone is generally thought to be diffuse rather than focussed due to the high frequency fractures and jointing. Groundwater flow is complicated in the west of the body where the bedrock aquifer is overlain by deep sand and gravel deposits which are in turn overlain by blanket peat over an iron pan. A shallow perched water table has been encountered in the overlying peat. Beneath the peat, water levels in the sands and gravels can be quite deep (10-20 m bgl). Water level data from two wells in the sand and gravel deposits area shown in Figure 1. Where the pure unbedded limestones are closer to the surface, water levels would be expected to be closer to the surface (<10 m). In general groundwater is unconfined in this GWB. Groundwater gradients are expected to be relatively flat in the sand and gravel and in the Waulsortian Limestones (not mapped separately in west of body). Hydraulic gradients are likely to be steeper at the margins of the GWB where the impure and less permeable limestones occur. Groundwater flows down gradient to Lough Leane and the River Laune which serves as the primary line of discharge. The highly permeable aquifer supports a regional scale flow system. Groundwater flow paths can be up to several kilometres long, but may be significantly shorter in areas where the water table is very close to the surface.
Groundwater & Surface water interactions		The nature of the karstic system leads to rapid interchanges of water between surface and underground. Where the karstified bedrock is close to the surface, swallow holes and caves receive surface water, and groundwater is discharged to surface as springs or as baseflow to rivers crossing the groundwater body.

Conceptual model	• This GWB occupies the lowlands that extend from east of Lough Leane, to the coast and Castlemaine Harbour in the west. Ground elevations in the GWB range from 10-150 m OD. West of Lough Leane the body is generally flat to gently sloping (10-60 m OD). East of Lough Leane ground elevations slope more steeply from the lakeshore to the north, east and south (20-150 m OD) • This GWB is bounded to the north by the contact with the low permeability Namurian rocks of the Scartaglin GWB and the surface water catchment boundary between the Laune and the Maine catchments. The southern boundary is formed by the contact with the low permeability sandstones of the Cahersiveen GWB. • The GWB is composed mainly of diffusely karstified, highly productive pure limestones with some less permeable impure limestones also with the body. The limestone bedrock in this body is thought to be well fractured and jointed. In the pure limestones these openings can be enlarged by karstification, which improves the permeability these limestones. Karst features are recorded in the east of the body and around the shores of Lough Leane. The impure limestones are less susceptible to karstification. • This GWB is overlain by sand and gravel deposits extending from Killarney to Killorglin. In many areas these deposits are not identified by Teagasc subsoil mapping as they are overlain at the surface by blanket peat and glacial till. These deposits range in depth from 0-30 m and consist of a highly heterogeneous mixture of glacial moraines and out-wash gravels. These deposits have not yet been proved to be very productive but are of sufficient depth and extent to be considered a potential gravel aquifer. The heterogeneity of these deposits means that their ability to act as aquifers is limited, however they do provide additional storage for the underlying limestone aquifer. • In the west of the body an iron pan has developed over sand and gravel deposits resulting in a perched water table and the development of blanket peat over sand and gravel deposits. • Where the pure unbedded limestones are closer to the surface, water levels would be expected to be closer to the surface (<10 m). In general groundwater is unconfined in this GWB. Groundwater gradients are expected to be relatively flat in the sand and gravel and in the Waulsortian Limestones (not mapped separately in west of body). Hydraulic gradients are likely to be steeper at the margins of the GWB where the impure and less permeable limestones occur. • Diffuse recharge will occur via rainfall percolating through the subsoil and areas of outcropping rock. There will also be runoff from surrounding uplands. In the west of the body an iron pan has developed over sand and gravel deposits resulting in a perched water table and the development of blanket peat over sand and gravel deposits Beneath the peat, water levels in the sands and gravels can be quite deep (10-20 mbgl).. This iron pan where present will restrict percolation of recharge. Where morainic sand and gravel deposits occur with a high clay content they may also restrict percolation of recharge to the underlying aquifer. In the east of the body some karst features (swallow holes) are recorded, which will provide the means for point recharge to the karstified aquifer. • Where karstified bedrock is close to the surface, such as around the shores of Lough Leane there will be rapid interchange of water between the surface and underground.
Attachments	Groundwater Hydrograph (Figure 1)
Instrumentation	**Stream gauges:** 22004, 22006, 22007, 22009, 22017, 22019, 22030, 22031, 22035, 22040, 22041, 22071, 22072, 22083. **EPA Water Level Monitoring boreholes:** none **EPA Representative Monitoring points:** none
Information Sources	Conlon V & Wright G (1998) *County Kerry Aquifer Classification (draft).* Geological Survey of Ireland Report to Kerry Co. Co., 18 pp. Scanlon B (1985) *A Groundwater Study of the Maine River Basin, Co. Kerry*. Geological Survey of Ireland Report Series, RS 85/1. Geological Survey of Ireland, Dublin. Pracht M (1997) *Geology of Kerry-Cork: a geological description, to accompany bedrock geology 1:100,000 scale map, Sheet 21, Kerry - Cork.* Geological Survey of Ireland. 70pp Wright G (1979) Groundwater in the South Munster Synclines. In: Hydrogeology in Ireland, Proceedings of a Hydrogeological Meeting and associated Field Trips held in the Republic of Ireland from 22 to 27 May, 1979. Published by the Irish National Committee of the International Hydrological Programme.
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

Figure 1: Groundwater level hydrographs in Laune Muckross GWB
(GSI Well Hydrographs)



Laune Muckross GWB (For Reference)

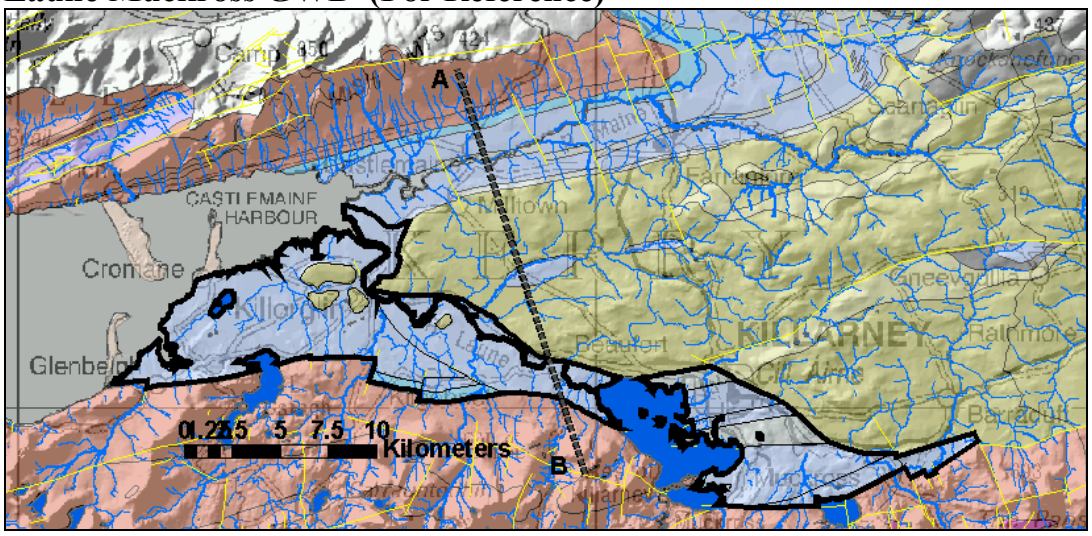


Figure 2: Schematic Cross Section through the Laune Muckross GWB
(From Geology of Kerry–Cork Sheet 21. 1:100,000 Bedrock Map Series, Geological Survey of Ireland.)

List of Rock units in Laune Muckross GWB

Rock unit name and code	Description	Rock unit group
Namurian (undifferentiated) (NAM)	Black shale & sandstone	Namurian Undifferentiated
Dinantian limestones (undifferentiated) DIN	Undifferentiated limestone	Dinantian Pure Unbedded Limestones
Dirtoge Limestone Formation (DI)	Bioclastic cherty grey limestone	Dinantian Upper Impure Limestones
Cloonagh Limestone Formation (CL)	Bedded bioclastic limestone	Dinantian Pure Unbedded Limestones
Rockfield Limestone Formation (RF)	Well-bedded argillaceous limestone	Dinantian Upper Impure Limestones
Waulsortian Limestones (WA)	Massive unbedded lime-mudstone	Dinantian Pure Unbedded Limestones
Ballysteen Formation (BA)	Fossiliferous dark-grey muddy limestone	Dinantian Lower Impure Limestones
Lough Guitane Volcaniclastics (GCv)	Massive & bedded volcaniclastic deposits	Basalts & other Volcanic rocks

Notes (cont.)

Table 1 Aquifer Properties

Source Name and GSI Well Number	*Transmissivity* (m^2/d)	Permeability (m/d)
Northern Region		
Longwood and Summerhill areas, Co Meath	30-40	
Tulla PS, Co Clare	13	
Southern Region		
Downing Bridge, North Co. Cork	3400	10-200
Cloyne, Southeast Co. Cork	200-2000	3-30
Croom, Co. Limerick (1413NWW201)	120	4.2
Fedamore, Co. Limerick (1413NEW140)	34	0.5
Lefanta, Co Waterford (2009SWW047)	3600	
Ardmore, Co Waterford (2007SE W014)	170	26.5
Dungarvan, Co Waterford (2009SEW069-072)	900-13000	25-190 (100)

The permeability of these limestones has developed in response to structural movements and karstification to deeper drainage levels that existed in the past. They are examples of a drowned karst terrain. The limestones are unconfined. Over a significant part of the valleys the limestones are overlain by sands and gravels with which they are in continuity and which provides them with additional storage. There are numersou karst features in these limestones, i.e. caves, swallow holes, collapse features and large springs.

The potential for saline intrusion is a constraint on development near the coast.

1.3.4 Hydrochemistry

The Waulsortian Limestone is a carbonate rock type. The hydrochemistry of the carbonate rocks is dominated by calcium and bicarbonate ions. Hardness is in the range from 200 mg/l to >400 mg/l (as $CaCO_3$), i.e. moderately hard to very hard. Spring waters tend to be softer as throughput is quicker and there is less time for the dissolution of minerals into the groundwater. This is particularly true where the limestones have been karstified.

Groundwater alkalinity is high, up to 400 mg/l ($CaCO_3$). Alkalinity is less than hardness indicating that ion exchange (where calcium or magnesium are replaced by sodium) is not significant. Typical limestone water conductivities are of the order of 500-700 µS/cm. Lower values suggest that the residence times of some of the sources are very short, for example at the Dower Spring where conductivities average 396 µS/cm. This value reflects a karstic system (in the Waulsortian) with rapid flow velocities. Table 2 shows major ions and other water quality parameters from a number of locations in the Waulsortian Limestones.

Table 2: Major ions and other water quality parameters in groundwaters from Waulsortian limestone aquifers.

Source	Sample date	pH (lab.)	Total Hardness (mg/l CaCO3)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Potassium (mg/l)	Total Alkalinity (mg/l CaCO3)	Sulphate (mg/l)	Chloride (mg/l)	EC (µS/cm)	Iron (mg/l)	Manganese (mg/l)
Dower Spring, Co Cork	Range	7.18-8.25								34.2-46.69	219-740		
Cloyne, Co Cork (Commons East BH)	Sep 1999	7.4	317.7	114	8.2	19.3	1.7	248	18.8	33.4	596	0.16	<0.05
Cloyne, co Cork (Lissanly BH)	Sep 1999	7.3	347.3	123	9.85	19.5	2	268	19	37.4	644	<0.1	<0.05
Croom, Co Limerick	Sep 1993		373	110	24.1	13.9	2.2	332	21.4	32.5	779	<0.01	<0.005
Fedamore, Co Limerick	Sep 1993		427	111	23.7	13.9	3.1	381	18.3	31.2	802	<0.01	<0.005
Mountbolus, Co Offaly			369							16-28	634		
Ballivor, Co Meath (PW1)	Sep 1995	7.1	378	132	11.9	9.899	2.078	302	56.5	15.7	711	0.069	0.071

Note: MDLs are Method Detection Limits.