Newtown Ballyconnell GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water bodies	Associated terrestrial ecosystems	Area (km^2)
Hydrometric Area 36 Cavan Co. Co. Leitrim Co. Co. NI	***Rivers:*** Agacaslaughan, Ballymagauran, Bawnboy, Owensallagh, Rag, Blackwater, Woodford, Yellow, Erne, Finn, Relagh. ***Streams:*** Annadale, Templeport Lake. 217 unnamed streams. ***Lakes:*** Clonmullig Lough, Clonty Lough, Creeny Lough, Cullinaghan Lough, Derrycassan Lough, Derrykerrib Lough, Dooloughan Lough, Dromore Lough, Drumanny Lough, Drumcoura Lough, Drumderg Lough, Drumlaheen Lough, Drummgannon Lough, Faharlagh Lough, Fenagh Lough, Garadice Lough,Georges Lough,Gortnaleck Lough, Greenvile Lough, Grilly Lough, Holy Lough, Keshcarrigan Lough, Killynaher Lough, Killywillin Lough, Kiltyfinnan Lough, Kilylea Lough, Kilywilly Lough, Lakefield Lough, Long Lough, Lough Awaddy, Lough Conway, Lough Marrave, Lough Moodrike, Lough Moreoge, Lough Nacarriga, Lough Namoyle, Lough Naroosk, Lough Reane, Lough Rud, Lough Scur, Mullaghboy Lough, Shancorry Lough, St John's Lough, Templeport Lough, Togher Lough, Tomkinroad Lough, Tom's Or Kinshinny Loug, Tully Lough, Upper Lough Erne, Woodford Lough.	Lough Outher and Associated Loughs (O'Riain, 2004)	306

Topography		This irregularly shaped GWB is located between the Upper Lough Erne to the north-east, and Carrick-on-Shannon to the south-west (Figure 1). The GWB is bounded lower permeability rocks except to the south-west, which comprises a topographic divide (catchment boundary for the Upper Lough Erne). The landscape is characterised by drumlins of up to 50m in height. Generally, elevations ranging from 50 mAOD around Lough Erne to c.250 mAOD along the north-western boundary. Lakes are a common surface water feature in the GWB, and the main surface water flow direction is eastwards, towards the Upper Lough Erne.
Geology and Aquifers	**Aquifer type(s)**	The GWB is predominantly categorised by Regionally Important Karstified aquifer (c.95%). The majority of this (>90% of GWB) is dominated by conduit flow (**Rk^c**). Just under 3 km^2 is underlain by **Lm**: Locally important aquifer which is generally moderately productive.
	Main aquifer lithologies	The GWB mainly comprises three rock groups: Dinantian Pure Bedded Limestones (93.45%), Dinantian Pure Unbedded Limestones (3.81%) and Dinantian Sandstones (1.76%). In the remaining 1% area various rock types are recorded. Refer to Table 1 for details.
	Key structures.	Approximately 8 faults border (mainly E-W alignment) or bisect (mainly N-S) this GWB, and the rocks are dipping in all directions by 5-30°.
	Key properties	There are 27 well yields within this GWB ranging from 43-1700 m^3/d (averaging c.300 m^3/d). Of these, 6 well have specific capacities: 723, 117, 73, 37 6 and 3 m^3/d/m. The associated Productivity values (Wright, 2000) of these wells ranges from I to V. The data highlight the variability of yields and transmissivities, and indicate that high abstractions are achievable. Six boreholes in the GWB have long term water level records (Figure 2). High annual variation in groundwater levels (up to 8 m) have been recorded in one borehole in this rock group, which *may* suggest the potential for low storativity. However, 5 other boreholes in this GWB have little variation. Nine karst features have been recorded in the limestones in this GWB although there are likely to be more unrecorded features, as no specific work has been undertaken in this region. The available groundwater levels (34) range from 0-40 m below ground level, 75% of which are greater than 5 m below the surface (25% >10 m bgl; 20% >20 m bgl). The data are inadequate to calculate groundwater gradients although overall flow directions are generally to the east and northeast, with groundwater discharging into the Lower Lough Erne. *(Pure Bedded Limestones Aquifer Chapter*)
	Thickness	In the pure limestones, most groundwater flows in an epikarstic layer c.2-3 m thick and in a zone of interconnected solutionally-enlarged fissures and conduits that extends approximately 30 m below this. Most groundwater flux in the remaining aquifer is also likely to be in uppermost top 30 m (c.3 m broken, weathered material underlain by interconnected fissuring), although there will also be a zone of isolated, poorly connected fissures – typically less than 150 m bgl – in all of the rock types. The available water level data indicate that a proportion of the groundwater flow does occur in the zone of interconnected (solutionally-enlarged) fissures. Furthermore, eleven water strikes were recorded in three boreholes, ranging between 12-78 m below ground. These strikes indicate that flow also occurs in the deeper portion of the aquifer.
Overlying Strata	**Lithologies**	No data are available for 60% of this GWB (NI and Leitrim). However, of the remaining area, Till is the predominant subsoil in this GWB (c.70%), with a small proportion of peat (12%).
	Thickness	From the available outcrop and depth to bedrock data, subsoil covers the majority of the GWB, with only sporadic areas of outcrop that increase slightly towards the west. The data suggests that thick deposits (>10 m) occur in the central and eastern portions of the GWB. No data are available for the north-eastern tongue, which protrudes into NI.

	% area aquifer near surface	*[Information will be added at a later date]*
	Vulnerability	*No vulnerability maps are available for either Cavan or Leitrim.*
Recharge	**Main recharge mechanisms**	Both point and diffuse recharge occur in this GWB. Diffuse recharge occurs via rainfall percolating through thin subsoil and outcrops. In the pure limestones, point recharge to the underlying aquifer occurs via swallow holes, dolines and caves. Although recharge along 'losing' sections of streams is also associated with this particular type of karst aquifer, to date none have been recorded in this GWB. The presence of low permeability, thick till drumlins will promote surface runoff. The runoff may either discharge to the streams in the GWB or be diverted to areas of thinner subsoil, e.g. inter-drumlin areas, where recharge is more likely to occur. The stream density over the pure limestones appears to be lower than that of the adjacent Pl/Pu GWBs, suggests a high proportion of aquifer recharge, which is often associated with karstified rocks.
	Est. recharge rates	*[Information will be added at a later date]*
Discharge	**Important springs and high yielding wells**	Sources: None identified. Springs: Ballyconnel WSS (Abstraction 450 m^3/d, total yield undetermined). Excellent wells: Doon (436 m^3/d), Cloneary (475 m^3/d), Carn (480 m^3/d), Bawnboy (600 m^3/d), Burren (1570 m^3/d), Kilsob (1700 m^3/d). Good wells: Kiltynashellan (103 m^3/d), Cowney (109 m^3/d), Killarah (109 m^3/d), Doogary (109 m^3/d), Corboy (109 m^3/d), Glebe Owengallees (109 m^3/d), Drunlougher (109 m^3/d), Ardunsaghan (109 m^3/d), Drumcoura (109 m^3/d), Cornadarragh (112 m^3/d), Aghanweenagh (129 m^3/d), Tirnawannagh (130 m^3/d), Keshcarrigan (130 m^3/d), Cranaghan (138 m^3/d), Toberlyan (207 m^3/d), Ballymagauran (216 m^3/d), Stranadarragh (216 m^3/d), Carn (216 m^3/d), Creevy (218 m^3/d).
	Main discharge mechanisms	The main groundwater discharges are to the abundant lakes, as well as streams, rivers, and any springs (e.g. Ballyconnell Spring) found within the body. Given the permeable nature associated with karst aquifers, the baseflow proportion of the total streamflow is expected to be higher in this GWB than for the adjacent Pl/Pu GWB, especially where the subsoil is thinner i.e. in the inter-drumlin areas.
	Hydrochemical Signature	***National classification:*** Dinantian Pure Bedded Limestones Calcareous. Generally Ca-HCO_3 signature. Due to possible dissolution of evaporite minerals in the Monaghan-Cavan-Leitrim area,Na/K/Mg-HCO_3 and Ca-SO_4 signatures may also occur. Alkalinity (mg/l as $CaCO_3$): range of 10-990; mean of 283 (2454 data points) Total Hardness (mg/l): range of 10-1940; mean of 339 (2146 data points) Conductivity (μS/cm): range of 76-2999; mean of 691 (2663 data points) *(Calcareous/Non calcareous classification of bedrock in the Republic of Ireland report)*
Groundwater Flow Paths		As these rocks are generally devoid of inter-granular permeability, groundwater flows through fissures, faults, joints and bedding planes. In pure bedded limestones, these openings are frequently enlarged by karstification resulting in significantly enhanced rock permeability. Karstification can be also accentuated along structural features such as fold axes and faults. An epikarst layer in the upper few metres of the rock is likely to be present on top of the karstified aquifer. The majority of the available groundwater levels are 5-20 mbgl indicating that relatively shallow groundwater flow is dominant (probably through solutionally enlarged fissures and fractures, possibly epikarst as well), although a component of deep groundwater flow is suggested by the deeper water strikes and measured groundwater levels. Groundwater flow through karst areas is frequently extremely complex and difficult to predict. Although minimal hydrogeological investigation has been undertaken in this particular region, karst aquifers that are dominated by conduit flow are generally capable of rapidly transmitting large volumes of groundwater, which is frequently localised. Flow velocities are known to be variable, both temporally and spatially, with groundwater flows often exhibiting a rapid response to rainfall events, giving rise to 'spikey' hydrographs and springs with highly variable discharge. Rapid, localised flow through conduits often results in the aquifer having low storativity. Groundwater flow through discrete conduits may range from a) a relatively discontinuous water table, to b) actual flow directions deviating from the expected (i.e. perpendicular to the assumed water table contours), and in extreme cases c) flow across surface catchment divides/ beneath surface channels. This, however, depends on the frequency of faults, fissures and joints, which has not been established for this GWB. Groundwater flow is thought to be mainly unconfined. In the karstified aquifers, groundwater flow is regional scale – flow path lengths of several kilometres are not unusual although are likely to be shorter in discharge areas (c.100-300 m). Overall, groundwater flow will be generally eastwards, towards the Upper Lough Erne.
Groundwater & surface water interactions		There is a high degree of interconnection between groundwater and surface water in karstified limestone areas such as in this GWB. Swallow holes, dolines, caves, turloughs, springs, and 'losing' and 'gaining' streams all provide a direct route between surface water and groundwater systems. This rapid interchange between surface water and groundwater is often reflected in their similar water quality as contamination is also rapidly transported between the two systems.

Conceptual model	• The main surface water flow direction is eastwards, towards Upper Lough Erne.
	• All boundaries, except to the south-western, represent changes in the aquifer type. The south-western boundary comprises a topographic divide (catchment divide of the Upper Lough Erne). The topography is characterised by drumlins of up to 50m in height.
	• The main rock type in this GWB is a karstified limestone that is dominated by conduit groundwater flow (aquifer category $\mathbf{Rk^c}$). A minor proportion of the area is underlain by sandstones, which are considered to be characterised by a productive fracture flow system (**Lm**).
	• Most of the groundwater flux is in the uppermost 30 m of the aquifers. This occurs through a few metres (c.3 m) of broken, weathered bedrock and an underlying zones of interconnected joints, fissures, fractures and faults. In the pure limestones, the upper weathered zone is likely to equate to an epikarst layer and the underling joints, fissures, fractures and faults will be karstified (solutionally enlarged). Deeper groundwater flow can occur along permeable fault or fracture zones, which is suggested by the deeper water strikes.
	• Estimated transmissivity values and well yields are variable, reflecting zones of higher and lower permeability. In the pure limestones, the variation in borehole water levels may indicate the potential for rapid responses to rainfall, high groundwater flow velocities and also for low storativity.
	• In general, the permeable karstic systems is likely to support regional-scale flow systems. Long flow paths (kilometres in length) can be expected although are likely to be shorter in discharge areas (100-300 m). Similar flow path lengths would be expected in the sandstones.
	• Recharge occurs by:
	  ◦ diffuse means in all rock types – via outcrops and through thin subsoil, and
	  ◦ additional point mechanisms in the karstified limestones; swallow holes, dolines, caves and potentially along lengths of losing streams – mainly occurring where subsoils are thin i.e. areas of extreme vulnerability.
	• Due to the combination of point recharge and rapid flow through solutionally enlarged joint/fissure/fracture zones, there is minimal potential for contaminant attenuation in the limestone aquifer.
	• The main discharges are to the lakes, rivers and springs within the GWB. Overall, the flow direction is to the east, as determined by the topography.
	• There is a high degree of interaction between surface water and groundwater in this.

Attachments	Figure 1. Figure 2. Table 1.
Instrumentation	**Stream gauges:** 36005, 36020, 36021, 36022, 36023, 36027, 36028, 36029, 36071, 36073, 36091, 36158. **EPA Water Level Monitoring boreholes:** (CAV 004), (CAV 115), (CAV 119), (CAV 120), (CAV 138), (CAV 156), (LEI 025), (LEI 066). **EPA Representative Monitoring points:** (CAV 4), (CAV 11), (CAV 20), (CAV22), (CAV 31), (CAV39), (CAV 40), (CAV 44), (CAV 50), (CAV 52), (CAV 56), (CAV 57), (CAV 89), (CAV 109), (CAV 115), (LEI 5), (LEI 60).
Information Sources	Geraghty, M., Farrelly, I., Claringbold, K., Jordan, C., Meehan, R., and Hudson, M., 1997. *Geology of Monaghan-Carlingford. A geological description to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 8/9, Monaghan-Carlingford*. Geraghty, M. (ed.). Geological Survey of Ireland. 60 p. MacDermot, C.V. Long C.B. and Harney S.J (1996) *Geology of Sligo-Leitrim: A geological description of Sligo, Leitrim and adjoining parts of Cavan, Fermanagh, Mayo and Roscommon, to accompany bedrock geology 1:100,000 scale map, Sheet 7, Sligo - Leitrim*. With contributions from K. Carlingbold, G. Stanley, D. Daly and R. Meehan. Geological Survey of Ireland, 100pp. O' Riain, 2004. *Water Dependent Ecosystems and Subtypes (Draft)*. Compass Informatics in association with National Parks and Wildlife (DEHLG). WFD support projects. Wright G.R. (2000). QSC Graphs: *An aid to classification of data-poor aquifers in Ireland*. From: Robons, N.S. and Misstear, B.D.R. (eds) Groundwater in the Celtic Regions: Studies in Hard Rock and Quaternary Hydrogeology. Geological Society, London, Special Publications, 182.
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. Location and Boundaries of Newtown Ballyconnell GWB

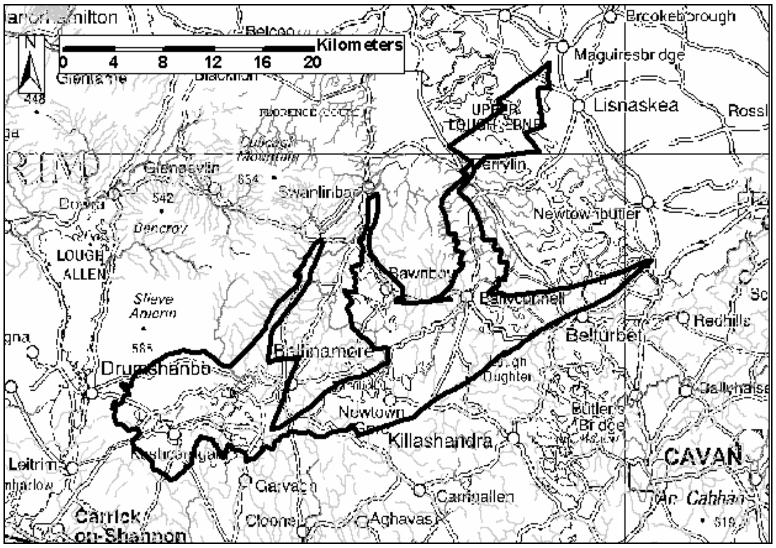
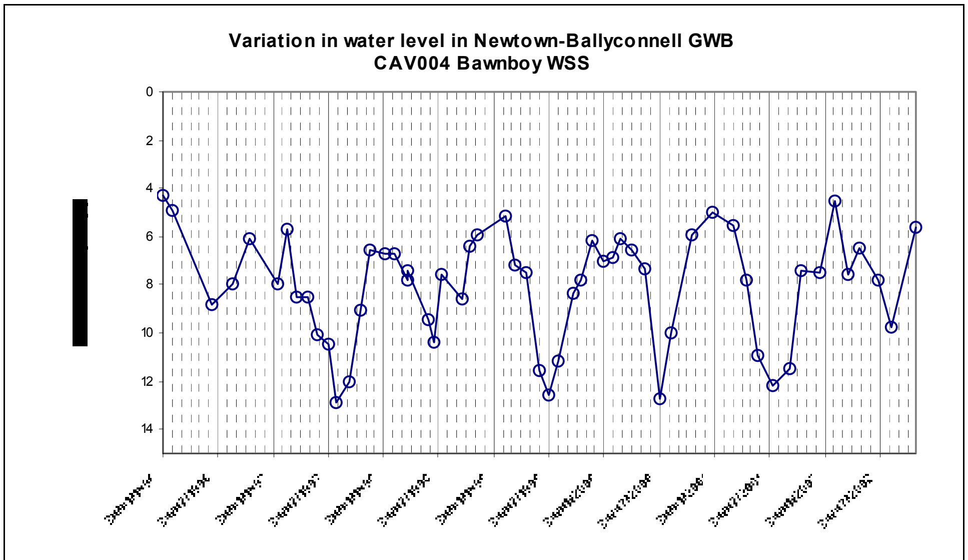
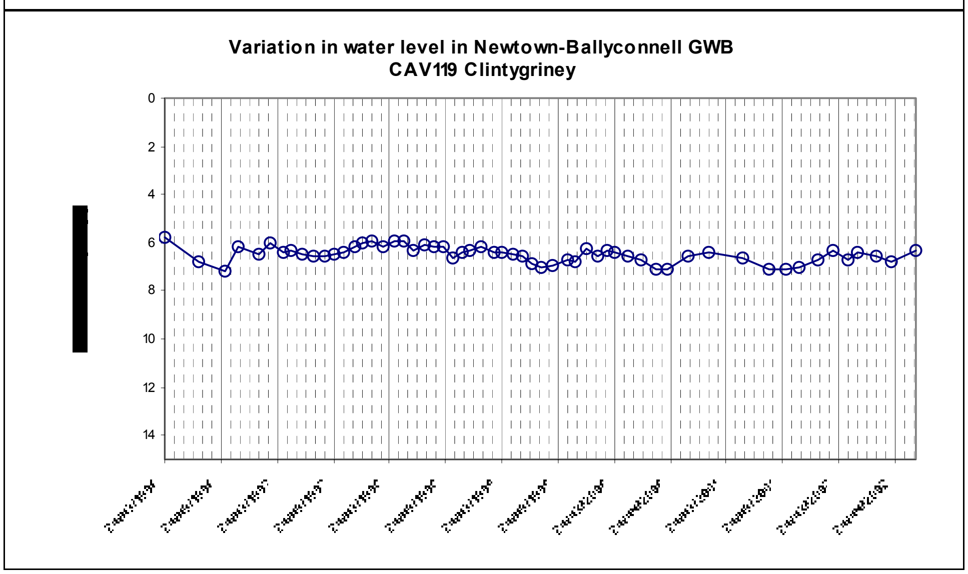


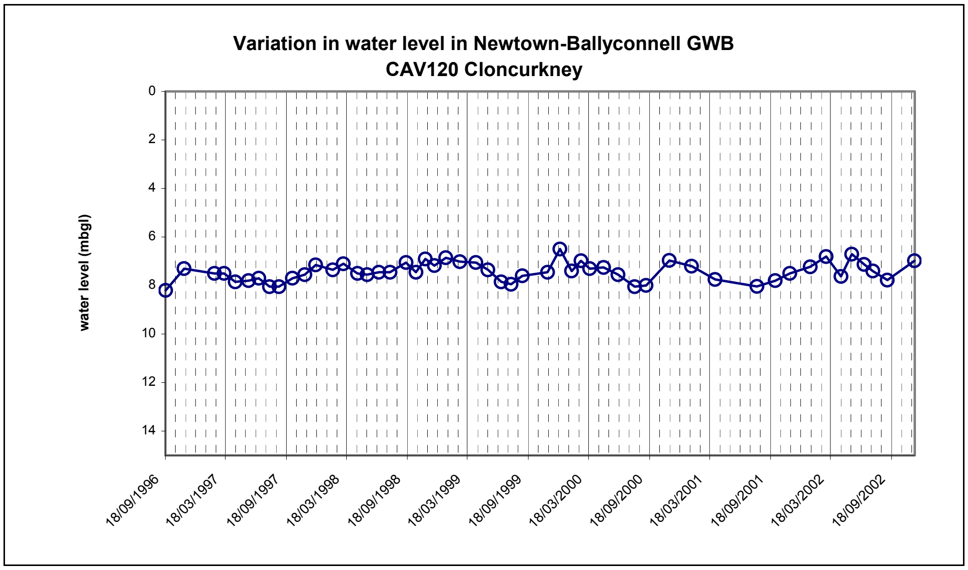
Table 2. List of Rock units in GWB

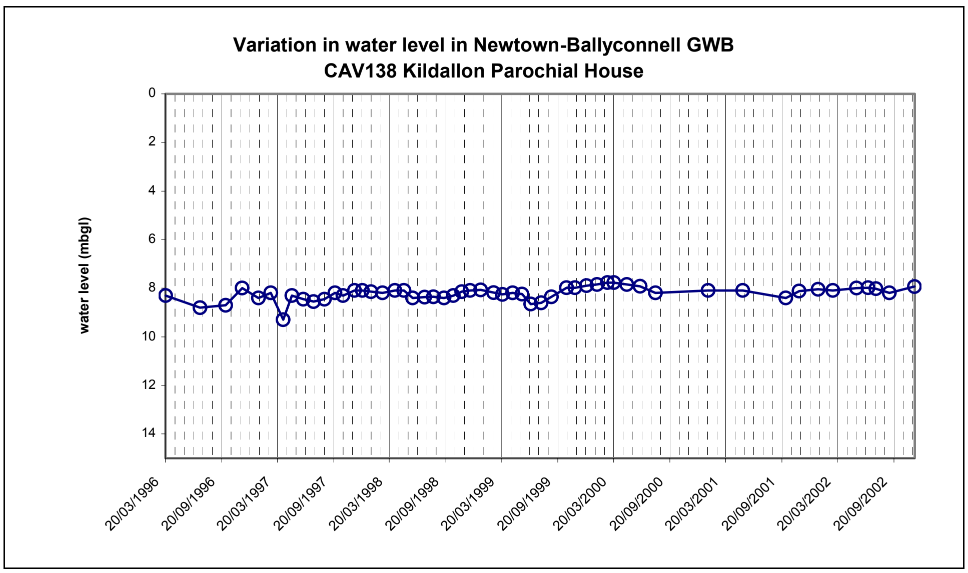
Rock Unit Name	Code	Description	Rock Unit Group	**Aquifer Class.**	% Area
Dartry Limestone Formation	crDA	Dark fine-grained cherty limestone	Dinantian Pure Bedded Limestones	Rkc	57.33%
Bricklieve Limestone Formation	BK	Bioclastic cherty limestone	Dinantian Pure Bedded Limestones	Rkc	22.81%
Ballymore Limestone Formation	BM	Dark fine-grained limestone & shale	Dinantian Pure Bedded Limestones	Rkc	5.00%
Mudbank Limestones	mk	Massive grey micritic limestone	Dinantian Pure Unbedded Limestones	Ll	3.81%
Ballyshannon Limestone Formation	BS	Crinoidal limestone & silty shale	Dinantian Pure Bedded Limestones	Rkd	3.29%
Crinoidal limestone	cr	Coarse crinoidal limestone	Dinantian Pure Bedded Limestones	Rkc	3.20%
Croghan Limestone Formation	CL	Dark cherty limestone, shale	Dinantian Pure Bedded Limestones	Rkc	1.82%
Glenade Sandstone Formation	GD	Pale orthoquartzitic sandstone	Dinantian Sandstones	Lm	0.94%
Keadew Formation	KW	Sandstone & thin mudstone	Devonian Old Red Sandstones	Pl	0.82%
Meenymore Formation	ME	Shale, laminated carbonate, evaporite	Dinantian Mixed Sandstones, Shales and Limestones	Ll	0.44%
Benbulben Shale Formation	BB	Calcareous shale with minor calcarenite	Dinantian Shales and Limestones	Ll	0.21%
Bundoran Shale Formation	BN	Dark shale, minor fine-grained limestone	Dinantian Shales and Limestones	Ll	0.20%
Clogher Valley Formation	CY	Mudstone & micritic limestone	UNKNOWN		0.12%
Ballysteen Formation	BA	Dark muddy limestone, shale	Dinantian Lower Impure Limestones	Ll	0.01%

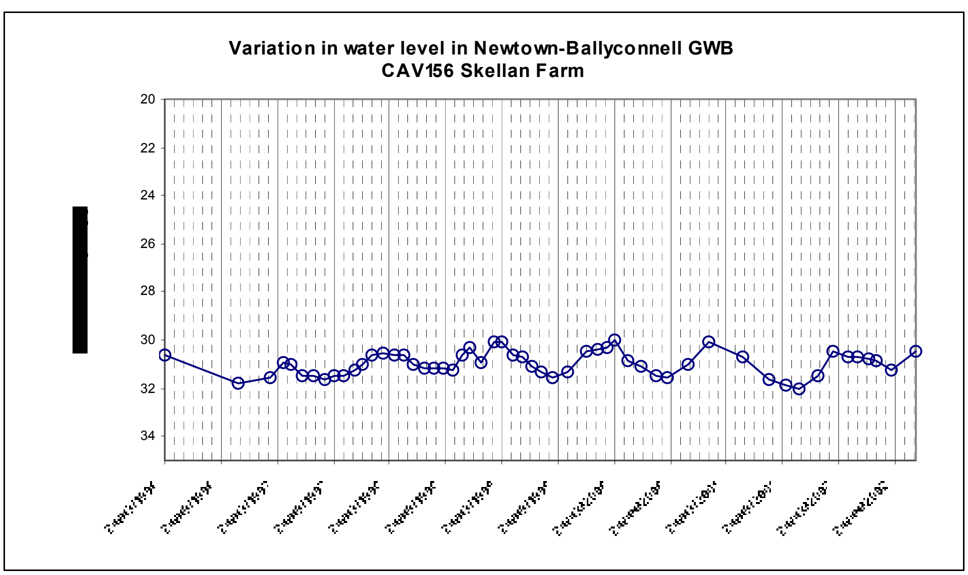
Figure 2. Groundwater hydrographs (EPA Groundwater Level Monitoring)

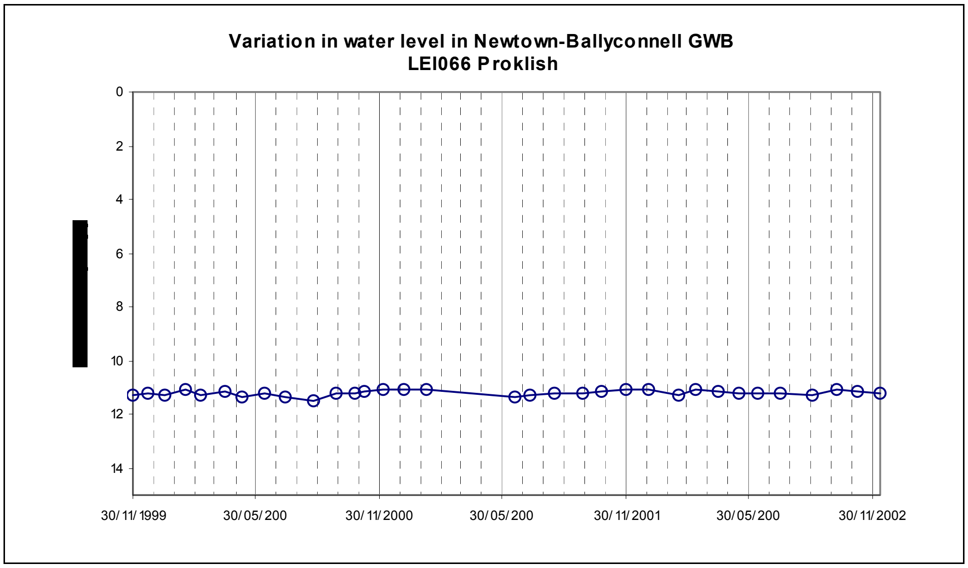





Variation in water level in Newtown-Ballyconnell GWB
CAV120 Cloncurkney
water level (mbgl)
0
2
4
6
8
10
12
14
18/09/1996
18/03/1997
18/09/1997
18/03/1998
18/09/1998
18/03/1999
18/09/1999
18/03/2000
18/09/2000
18/03/2001
18/09/2001
18/03/2002
18/09/2002


Variation in water level in Newtown-Ballyconnell GWB
CAV138 Kildallon Parochial House
water level (mbgl)
0
2
4
6
8
10
12
14
20/03/1996
20/09/1996
20/03/1997
20/09/1997
20/03/1998
20/09/1998
20/03/1999
20/09/1999
20/03/2000
20/09/2000
20/03/2001
20/09/2001
20/03/2002
20/09/2002


Variation in water level in Newtown-Ballyconnell GWB
CAV156 Skellan Farm
[redacted]
20
22
24
26
28
30
32
34


Variation in water level in Newtown-Ballyconnell GWB
LEI066 Proklish
[redacted]
0
2
4
6
8
10
12
14
30/11/1999
30/05/200
30/11/2000
30/05/200
30/11/2001
30/05/200
30/11/2002