Newtown Forbes GWB: Summary of Initial Characterisation.

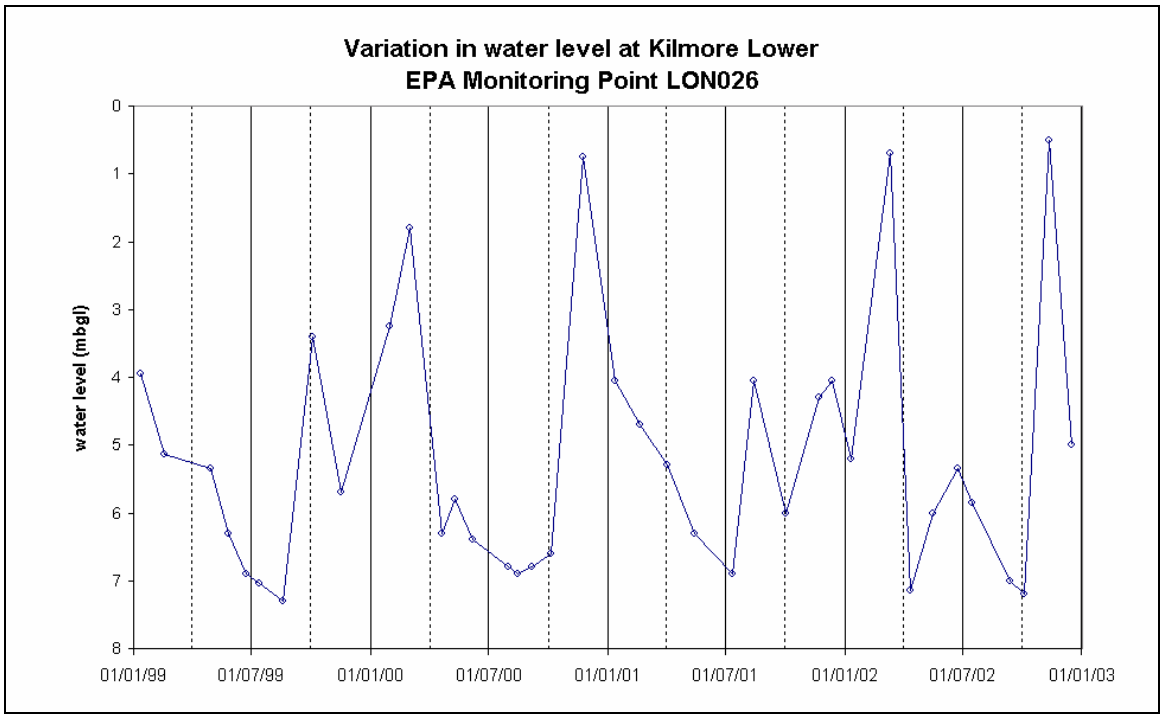
Hydrometric Area Local Authority	Associated surface features	Associated terrestrial ecosystem(s)	Area (km^2)
26 – Camlin/Rinn Longford Co. Co.	**Rivers:** Camlin, Fallan. **Streams:** Clooncoose. **Loughs:** Forbes.	(001818) Lough Forbes Complex; (000442) Brown Bog; (002103) Royal Canal.	80

Topography	This GWB occurs just east of Lough Forbes and the River Shannon. The land in the west of the body is flat with ground elevations of just 40-50 mAOD. The northeast of the body is part of a broad east west trending valley (50-80 mAOD), narrowing to the east, between higher ground to the north and south. The highest ground (80 mAOD) occurs along the northern boundary of the body, the land slopes down gently to the south.	
Geology and Aquifers	**Aquifer categories**	**Rk^c:** Regionally important karstified aquifer dominated by conduit flow.
	Main aquifer lithologies	This GWB is composed of Dinantian Pure Bedded Limestones with a small area of Dinantian Dolomitised Limestones.
	Key structures	Few faults are mapped in this area; this may reflect the thick till cover and poor exposure in some areas. The dips over the GWB area are generally less than 10^o. The Newtown Forbes GWB is bounded to the east by the Longford Town Inlier, a northeast trending anticline with a core of exposed Lower Palaeozoic rocks which is part of the Longford Ballinalee GWB. The northern boundary of the body is the fault-bounded contact with the Ordovician Metasediments and Dinantian Upper Impure Limestones of the Longford Ballinalee GWB.
	Key properties	There are no hydrogeological data available specific to this GWB. The body is covered by thick deposits of glacial drift and peat deposits with little rock outcrop. The bedrock is mapped as Undifferentiated Visean Limestone (VIS), Dinantian Pure Bedded Limestone, which in other areas where more data is available has been found to be susceptible to karstification and dolomitisation. West of this GWB pure bedded limestones occur which are highly karstified where groundwater flow is concentrated in conduits and rapid groundwater flow velocities are recorded. The limestones of this GWB are similar in lithology however due to this thick overlying deposits no karst features are recorded and little is know about the extent of karstification of the limestones. Dinantian Pure Bedded Limestones are generally found to have well developed fracturing. Fissures are often enlarged by solution, which results in a highly permeable aquifer with rapid groundwater flow. (data sources: Rock Unit Group Aquifer Chapters, Roscommon GWPS and Source Reports, see references)
	Thickness	An exploration borehole drilled in the east of the body encountered just under 300 m Dinantian Pure Bedded Limestone (Tara Prospoecting Ltd. 1992). Most groundwater flow in the Dinantian Pure Bedded Limestone has been found in other areas to flow in an epikarstic layer a few metres thick and in a zone of interconnected solutionally-enlarged fissures and conduits that extends approximately 30 m below this. Deeper inflows can occur in areas associated with faults or dolomitisation. During the drilling of trial wells in the adjoining Lanesborough GWB, south of Lanesborough, County Longford, significant inflows of groundwater were encountered below 50 m, associated with zones of dolomitised limestone bedrock (Cullen, K.T. & Co., 1991).
Overlying Strata	**Lithologies**	The western side of this GWB is covered by extensive areas of peat, much of which is being harvested on a large scale. The peat areas are generally underlain by lacustrine clay and marl. Smaller areas of till also occur in the west of the body. There is an area of fen peat (3 km^2) north of Cloondara and the Camlin River. The north-eastern side of this GWB is primarily covered by till with frequent areas of alluvium adjacent to streams and rivers. The area of rock outcrop or rock close to the surface is very limited in this GWB although some small areas do occur within the till covered areas. *Subsoil Types identified in body by Teagasc Parent Material Mapping: Cut Peat (Cut); Till – Sandstone Till (TDSs), (TLPDSs), (TLPSsS), (TLs), Alluvium (A); Rock outcrop & rock close to surface (Rck); Karstified Limestone outcrop & Karstified Limestone close to surface (KaRck); Fen Peat (FenPt); Alluvium (A); Clayey (AcEsk).* *[Information to be added at a later date]*
	Thickness	There is no Groundwater Protection Scheme available for this body and therefore there are very few data available on depth to rock in this GWB. Rock outcrop and recorded shallow rock is rare within this GWB. In general the subsoil cover is thought to be quite thick, up to and greater than 10 m thick. Four points of > 10 m subsoil have been recorded just north and northeast of the centre of the body.
	% area aquifer near surface	[Information to be added at a later date]
	Vulnerability	A Groundwater Vulnerability Map is not currently available for County Longford. It is probable that there are few areas of Extreme vulnerability present, however categorising areas of High, Moderate and Low Vulnerability is not possible at this time. [Information to be added at a later date]

Recharge	**Main recharge mechanisms**	Diffuse recharge will occur over the entire GWB 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. Percolation of recharge will be somewhat restricted in the west of the body due to the extensive covering of peat and the typically associated underlying lacustrine clay or clayey till. Subsoil permeability has not currently been mapped in detail in County Longford but the sub peat subsoil in the east of the body would be expected to be of 'low' permeability. Percolation of recharge in the northeast of the body will depend on the permeability of the till in that area. *Note: Subsoil permeability has not currently been mapped in detail in County Longford.* *[Information to be added at a later date]*
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	**Large springs and high yielding wells (m^3/d)**	Drumlish Road, Longford – Three trial wells drilled and tested for Longford County Council. Drawing from Dinantian Sandstones and Dinantian (early) Sandstones, Shales and Limestones. Estimated safe yields of 1500 m^3/d for TW1, 1900 m^3/d for TW2 and 1200 m^3/d TW3 (K.T. Cullen & Co., 1999) (GSI Well Numbers 2027SWW119, 2027SWW120, 2027SWW121) From GSI Borehole Database: From Limestones: 2027SWW116 Gowlan, 102 m^3/d; 2027SWW109 Mullagh, 157 m^3/d; 2027SWW108 Mullagh 131 m^3/d
	Main discharge mechanisms	The main discharges are to Lough Ree and the River Shannon in the west and to some springs and streams crossing the body. There may be some groundwater discharge in 'lagg zones' at the margins of the raised bogs or at flushes within the bogs where the underlying 'low' permeability subsoils are thin or absent. .
	Hydrochemical Signature	There are no EPA Groundwater Monitoring data available for this GWB. Hydrochemical analyses carried out on samples trial wells just north of Longford Town in 1999 showed hardness ranging from 246-394 mg/l, alkalinity from 230-365 mg/l and EC from 445-680 mg/l. Iron and Manganese exceeded the E.U. Potable Water MAC (0.21-0.23 mg/l Fe and 0.22-0.73 mg/l Mn). The hydrochemical signature of groundwater from trial wells TW1, TW2 & TW3 is demonstrated in an expanded Durov plot in Figure 2 below.
Groundwater Flow Paths		Groundwater will flow through fissures, faults, joints and bedding planes. In pure bedded limestones these openings can be enlarged by karstification which significantly enhances the permeability of the rock. In pure bedded limestones fracture systems are generally well-connected and widespread and support regional-scale flow systems. Flow path lengths can be up to a several kilometres in length. Overall groundwater flow in this body will be towards the rivers crossing the body and west and northwest to the River Shannon. Groundwater may become partially confined in some areas in this GWB where there are extensive areas of peat and low permeability subsoil.. Water levels in karstified limestone generally show rapid response to rainfall. Water level data for a well within this GWB are shown in Figure 1 attached. The south and south-western boundary of this body is formed by the Inny/Lough Ree-Camlin/Rinn surface water catchment boundary. The topography is very subdued at this point and the current surface water catchment boundary may not coincide with the groundwater divide. There may be some groundwater flow between the Lanesborough GWB and the Newtown Forbes GWB.
Groundwater & Surface water interactions		There is often a high degree of groundwater and surface water interaction in areas underlain by karstified limestone. In this GWB however there are no karst features currently recorded and there is thick subsoil cover in many areas. Where subsoil cover is thin or absent some collapse features providing a direct connection between the surface and the groundwater systems may still occur. Because of the close interaction between surface water and groundwater in karstified aquifers in areas where subsoil cover is thin or bypassed, surface water and groundwater quality are also closely linked. Any contamination of surface water is rapidly transported into the groundwater system, and vice versa. There is an area of Fen Peat north of Cloondara (Teagasc Parent Material Mapping). Fens are highly groundwater dependant ecosystems.

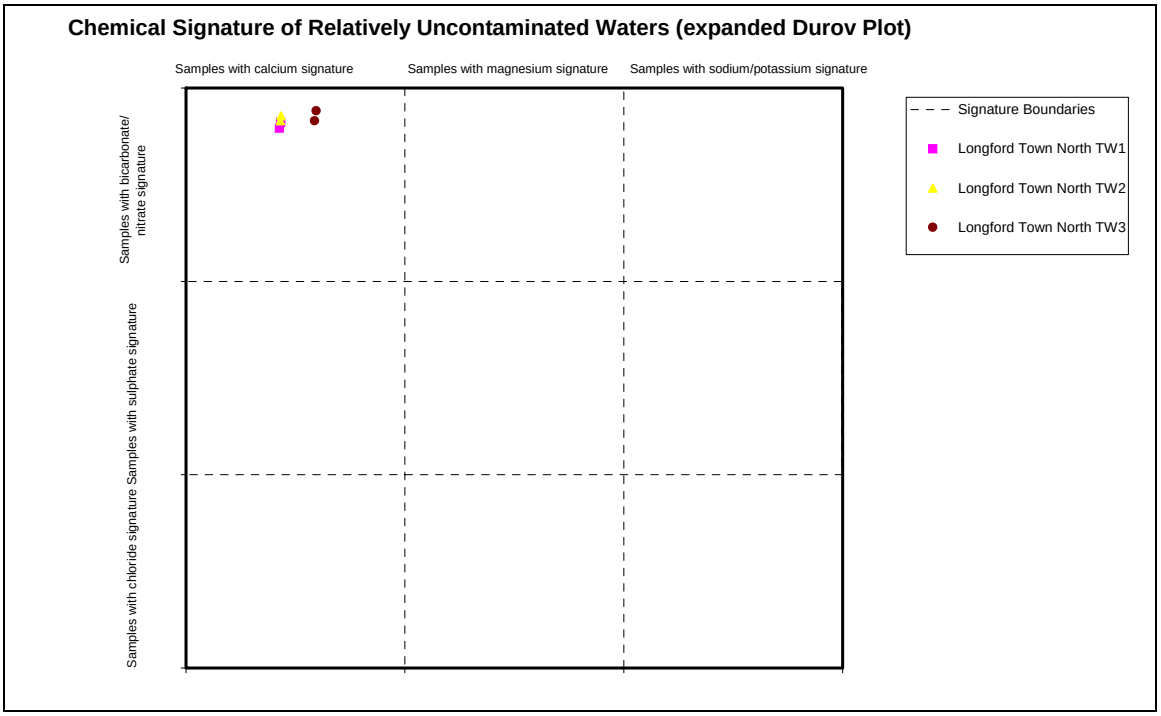
Conceptual model	• This GWB is bounded to the north west by the River Shannon and Lough Forbes. It is bounded to the north and east by the Ordovician Metasediments and Dinantian Upper Impure Limestones of the Longford Ballinalee GWB. It is bounded to the south and southwest by the Inny/Lough Ree-Camlin/Rinn surface water catchment boundary. However the topography is quite subdued at this point and it is possible that this surface water catchment boundary does not coincide with a groundwater divide. There may be some groundwater flow between the Newtown Forbes GWB and the Lanesborough GWB. • The GWB is generally flat and low-lying with large areas of peat land in the west of the body. Ground elevations range from 40-80 mAOD. • This GWB is composed of primarily pure bedded limestones where are generally highly permeable and in other areas have been found to be highly susceptible to karstification. • Groundwater flows along interconnected fractures, joints, faults and bedding planes. In pure bedded limestones these openings can be enlarged by karstification which significantly enhances the permeability of the rock. West of this GWB pure bedded limestones occur which are highly karstified where groundwater flow is concentrated in conduits and rapid groundwater flow velocities are recorded. The limestones of this GWB are similar in lithology however due to this thick overlying deposits no karst features are recorded and little is know about the extent of karstification of the limestones. • Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. Percolation of recharge will be somewhat restricted in the west of the body due to the extensive covering of peat and the typically associated underlying lacustrine clay or clayey till. • Groundwater may become partially confined in some areas in this GWB where there are extensive areas of peat and low permeability subsoil • Groundwater flow in this body is expected to be concentrated in an upper weathered and epickarstic zone and an underlying zone of interconnected fissures generally extending to a depth of 30 m, some of which may be enlarged by karstification. • In pure bedded limestones the degree of interconnection between fractures zones is high and they support regional scale flow systems. Flow paths can potentially be several kilometres in length. Groundwater storage is generally low. • Groundwater will discharge to Lough Ree and the River Shannon in the west and to some springs, streams and rivers crossing the body. • In areas underlain by karstified limestone there is the potential for a high degree of interaction between surface water and groundwater, however large areas in this GWB are covered by thick layers of subsoil and peat underlain by low permeability till. There is an area of Fen Peat north of Cloondara. Fens are highly groundwater dependant ecosystems.
Attachments	Groundwater hydrographs (Figure 1); Hydrochemical Signature (Figure 2)
Instrumentation	**Stream gauges:** 26019, 26022, 26213 **EPA Water Level Monitoring boreholes:** Kilmore Lower (LON 026), Kilmore Upper (LON 028) EPA Representative Monitoring boreholes: None
Information Sources	K.T.Cullen & Co. Ltd. Report on the Drilling and Testing of Trial Wells in the Longford Town – Newtown Forbes Area, Co. Longford. January 1999. Report for Longford County Council. K.T. Cullen & Co., 1991. Consultant Hydrogeologist's Reports on Carrowroe Aquifer and Aquifer Protection Plan. Lanesborough Regional Water Supply. From *Lanesborough Regional Water Supply- Preliminary Report - Appendix B*, P.H. McCarthy Son & Partners Consulting Engineers March 1991. Prepared for Longford County Council. Lee, M. and Kelly, C. (2003) Roscommon Central Regional Water Supply Scheme (Ballinagard Spring and Proposed Production Boreholes) Groundwater Source Protection Zones. Geological Survey of Ireland Report to Roscommon Co. Co., 14 pp. Morris J.H., Somerville I.D. and MacDermot C.V. (2002). *Geology of Longford-Roscommon.* A Geological Description to Accompany the Bedrock Geology 1:100,000 Bedrock Series Sheet 12. With contributions by D.G. Smith, M. Geraghty, B. McConnell, K. Carlingbold, W. Cox, D. Daly. Geological Survey of Ireland, 121pp. (Publication Pending) Tara Prospecting Ltd. 1992. Renewal report for PL 2780 for the year ending 1992 – Diamond drill hole 2780/1.
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 hydrographs
(EPA Groundwater Level Monitoring)



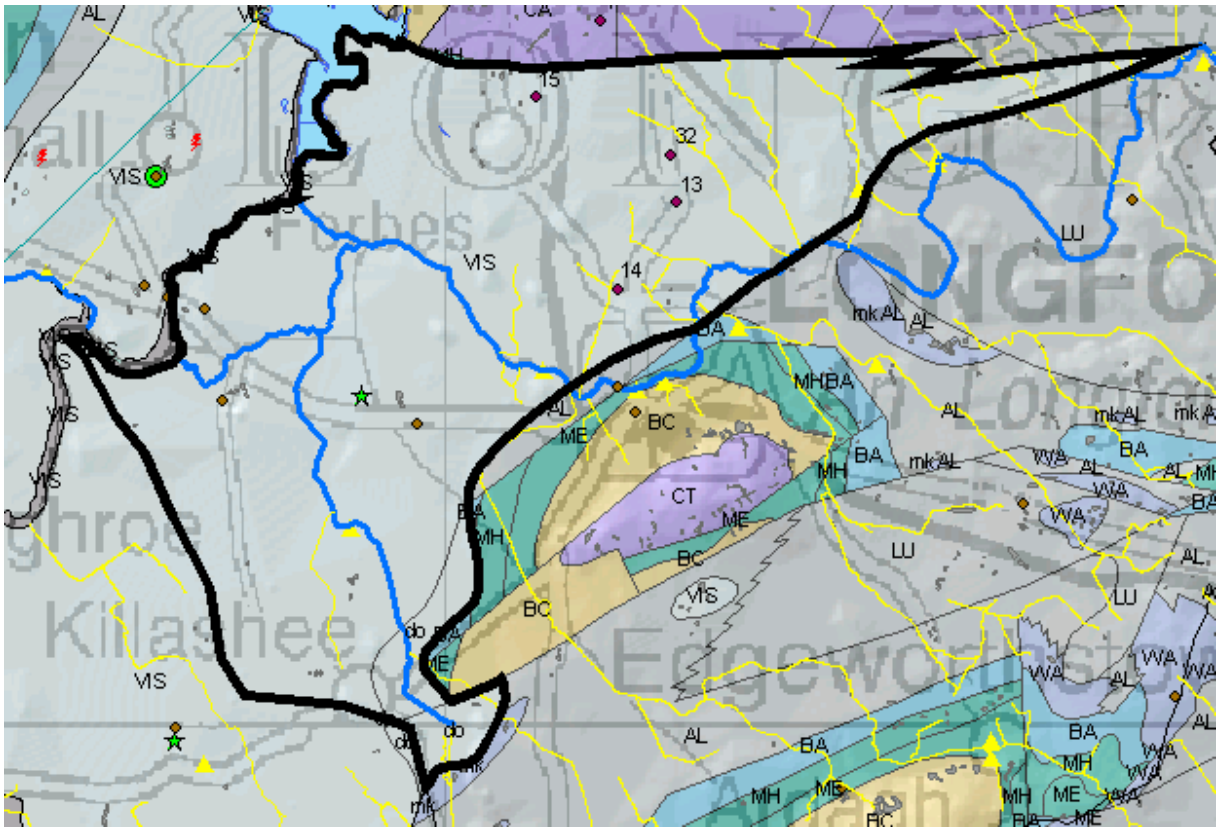
.

Figure 2: Hydrochemical signature
(K.T. Cullen & Co 1999 Hydrochemical Monitoring of Trial Wells*)



**K.T.Cullen & Co. Ltd. Report on the Drilling and Testing of Trial Wells in the Longford Town – Newtown Forbes Area, Co. Longford. January 1999. Report for Longford County Council.*

Newtown Forbes GWB (For Reference)

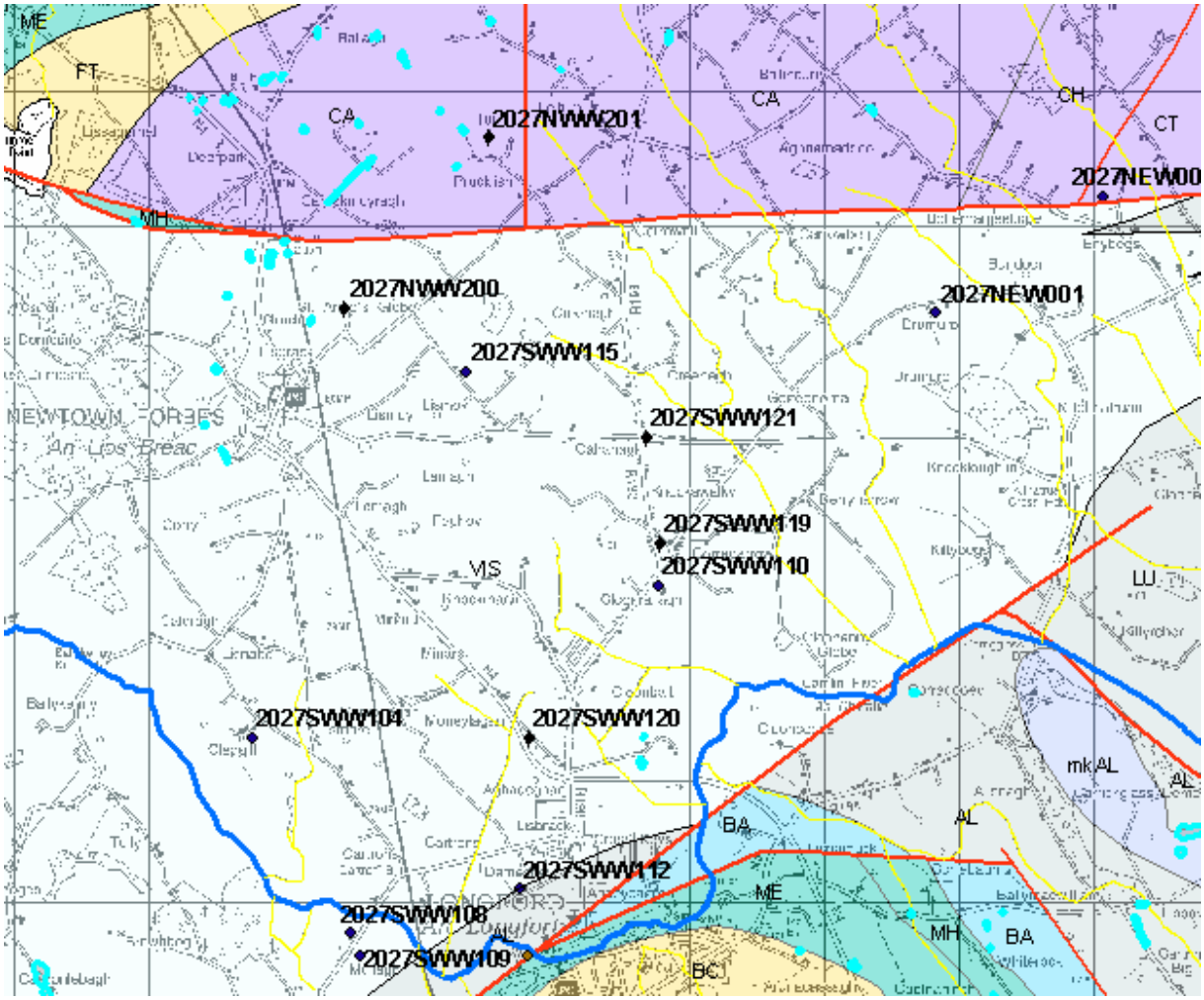


List of Rock units in Newtown Forbes GWB

Rock unit name and code	Description	Rock unit group
Visean Limestones (undifferentiated) (VIS)	Undifferentiated limestone	Dinantian Pure Bedded Limestones
Dolomitised Limestone (do)		Dinantian Dolomitised Limestone
Note: Dinantian Sandstones and Dinatian (early) Sandstones, Shales and Limestones unmapped but encountered in trial drilling north of Longford Town.		

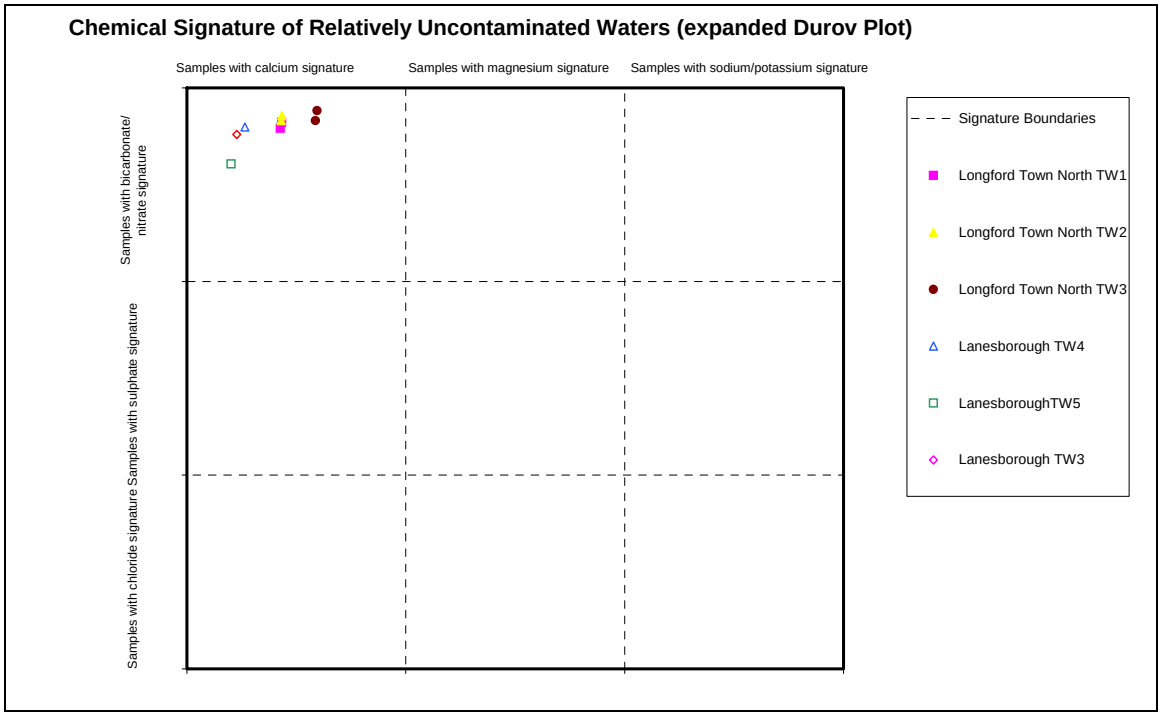
Notes on Newtownforbes GWB

Geodata for the Newtown Forbes Area



Surface drainage in the north-western part of the body flows south across and out of the GWB to meet the Camlin river just southeast of the body, before the river swings northwards to cross the western part of this GWB. The Fullan River flows south to north towards the River Shannon.

Comparing chemistry of Longford Trial wells and Lanesborough Wells.



FIRST DRAFT OF NEWTOWN FORBES GWB WITH REF TO WELLS AND KARST
Newtown Forbes GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface features	Associated terrestrial ecosystem(s)	Area (km^2)
26 – Camlin/Rinn Longford Co. Co.	**Rivers:** Camlin, Fallan. **Streams:** Clooncoose. **Loughs:** Forbes.	(001818) Lough Forbes Complex; (000442) Brown Bog; (002103) Royal Canal. Area of fen peat north of Cloondara identified by Teagasc Parent Material Mapping	80

Topography	This GWB occurs just east of Lough Forbes and the River Shannon. The land in the west of the body is flat with ground elevations of just 40-50 mAOD. The northeast of the body is part of a broad east west trending valley (50-80 mAOD), narrowing to the east, between higher ground to the north and south. The highest ground (80 mAOD) occurs along the northern boundary of the body, the land slopes down gently to the south.	
Geology and Aquifers	**Aquifer categories**	**Rk^c:** Regionally important karstified aquifer dominated by conduit flow. (Note: Dinantian Sandstones and Dinantian (early) Sandstones, Shales and Limestones were encountered in trial boreholes drilled in a small area north of Longford Town in the townlands of Cahahagh, Cloonrallagh, Aghadegnan and Cartrons in 1999 (K.T. Cullen & Co., 1999). In nearby GWB areas these rock types have aquifer categories of **Lm:** Locally important aquifer which is generally moderately productive and **Ll:** Locally important aquifer which is moderately productive only in local zones, respectively. See Main aquifer lithologies.)
	Main aquifer lithologies	This GWB is composed of Dinantian Pure Bedded Limestones with a small area of Dinantian Dolomitised Limestones. (Note: Trial boreholes drilled in a small area north of Longford Town in 1999 encountered up to 50 m of Dinantian Sandstone within an area previously mapped as Dinantian Pure Bedded Limestones (undifferentiated) (K.T. Cullen & Co., 1999). Diantian (early) Sandstones, Shales and Limestones were also encountered. The actual extent of these rocks in this area is currently unknown and consequently has not been delineated on bedrock and aquifer maps to date.)
	Key structures	Few faults are mapped in this area; this may reflect the thick till cover and poor exposure in some areas. The dips over the GWB area are generally less than 10^o. The Newtown Forbes GWB is bounded to the east by the Longford Town Inlier, a northeast trending anticline with a core of exposed Lower Palaeozoic rocks which is part of the Longford Ballinalee GWB. The northern boundary of the body is the fault-bounded contact with the Ordovician Metasediments and Dinantian Upper Impure Limestones of the Longford Ballinalee GWB. North of Longford Town an as yet unmapped structure has resulted in the occurrence of Dinantian Sandstones encountered in trial boreholes (K.T. Cullen & Co., 1999).

	Key properties	The pure limestone bedrock of this GWB is karstified and dolomitised which significantly improves fissure permeability. Dolomitisation can also result in an increase in the porosity of the rock. Permeability and transmissivity in such aquifers is highly variable however as karstification and dolomitisation can be unevenly distributed. Transmissivity in karstified aquifers with conduit flow can range from less than 1m^2/d up to a few thousand m^2/d, depending on whether or not the conduit flow system is intersected. As part of an EIS for Ballingard Spring public supply in the neighbouring Funshinagh GWB to the west, which is similarly composed karstified pure bedded limestone, individual pumping tests were undertaken on five boreholes between June and September 1994. The estimated transmissivity from the individual pumping tests ranged from 60 m^2/d in the lower permeability rock to 180 m^2/d in the high permeability zones (Lee, M. & Kelly, C., 2003). Test pumping in dolomitised Waulsortian Limestone in other areas, in the Lisheen mine and the Galmoy mine, showed transmissivity in the ranges of 20 – 1366 m^2/d and 100-2500 m^2/d respectively (Dolomite Aquifer Chapter). Pumping tests carried out on three trial wells in the adjoining Lanesborough GWB at Carrowroe and Rathcline south of Lanesborough indicate that the three wells have a specific capacity in the range of 75-85 m3/d per metre of drawdown. The wells intersect a zone of very weathered, broken and fissured brown dolomite. Rapid groundwater flow velocities have been recorded in karstified limestone. Tracer tests carried out in the Funshinagh GWB recorded minimum velocities of 24 m/hr in the Ballinagard tracer test (Roscommon County Council, 1991) and 70 m/hr recorded in the Lough Funshinagh to Atteagh Corn Mill Spring tracer test. Rapid velocities recorded for groundwater in these areas imply flow through relatively sizeable conduits. Groundwater gradients calculated in the vicinity of Ballingard Spring source (Funshinagh GWB) were low ranging from 0.002-0.007 (Lee, M. & Kelly, C. 2003). In karstified pure bedded limestone such as that found in this GWB, enlargement of the fracture network by solution and dolomitisation, and the generally well-connected and widespread fracture systems result in a highly permeable aquifer with rapid groundwater flow. The Dinantian Sandstones intersected in trial boreholes in a small area north of Longford Town consisted of an upper zone of very broken beige quartzitic sandstone with dense orange-brown clay filling fractures. Large inflows were noted from this zone. This was underlain by solid beige quartzitic sandstone with intermittent fracture zones. Specific capacities of 100-160 m^3/d/m were recorded for these trial wells. (data sources: Rock Unit Group Aquifer Chapters, Roscommon GWPS and Source Reports, see references)
	Thickness	The Dinantian Pure Bedded Limestones are generally well over 100 m thick. Most groundwater flows 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. Deeper inflows can occur in areas associated with faults or dolomitisation. During the drilling of trial wells in the adjoining Lanesborough GWB, south of Lanesborough, County Longford, significant inflows of groundwater were encountered below 50 m, associated with zones of dolomitised limestone bedrock (Cullen, K.T. & Co., 1991). A small area of Dinantian Sandstones and some Dinantian (early) Sandstones, Shales and Limestones were encountered in trial holes drilled just north of Longford Town ((K.T. Cullen & Co., 1999). The Dinantian Sandstones are greater than 50 m thick consisting of an upper very broken zone of 15-20 m with large groundwater inflows, underlain by more solid sandstone with intermittent fracture zones.
Overlying Strata	**Lithologies**	The western side of this GWB is covered by extensive areas of peat, much of which is being harvested on a large scale. The peat areas are generally underlain by lacustrine clay and marl. Smaller areas of till also occur in the west of the body. There is an area of fen peat (3 km^2) north of Cloondara and the Camlin River. The north-eastern side of this GWB is primarily covered by till with frequent areas of alluvium adjacent to streams and rivers. The area of rock outcrop or rock close to the surface is very limited in this GWB although some small areas do occur within the till covered areas. In the northeast of the body peat areas are less common. *Subsoil Types identified in body by Teagasc Parent Material Mapping: Cut Peat (Cut); Till – Sandstone Till (TDSs), (TLPDSs), (TLPSsS), (TLs), Alluvium (A); Rock outcrop & rock close to surface (Rck); Karstified Limestone outcrop & Karstified Limestone close to surface (KaRck); Fen Peat (FenPt); Alluvium (A); Clayey (AcEsk).* *[Information to be added at a later date]*
	Thickness	There are very little data available on depth to rock in this GWB. There are only a limited number of areas of rock outcrop or shallow rock within the body. In general the subsoil cover is thought to be quite thick, up to and greater than 10 m thick. Four points of > 10 m subsoil have been recorded just north and northeast of the centre of the body.
	% area aquifer near surface	[Information to be added at a later date]
	Vulnerability	A Groundwater Vulnerability Map is not currently available for County Longford. There are currently insufficient data on depth to bedrock and subsoil permeability available to comment on the Groundwater Vulnerability. [Information to be added at a later date]

Recharge	**Main recharge mechanisms**	Diffuse recharge will occur over the entire GWB 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. Percolation of recharge will be somewhat restricted in the west of the body due to the extensive covering of peat and the typically associated underlying lacustrine clay or clayey till. Subsoil permeability has not currently been mapped in detail in County Longford but the sub peat subsoil in the east of the body would be expected to be of 'low' permeability. Despite the presence of peat and low permeability till however, point recharge to the underlying aquifer can still occur in areas underlain by karstified limestone by means of swallow holes and collapse features/dolines. Dolines have been recorded in the Carrick on Shannon GWB, County Roscommon, even in areas with thick peat deposits. (Hickey et al, 2002). Percolation of recharge in the northeast of the body will depend on the permeability of the till in that area. *Note: Subsoil permeability has not currently been mapped in detail in County Longford.* *[Information to be added at a later date]*
	Est. recharge rates	*[Information to be added at a later date]*
Discharge	**Large springs and high yielding wells (m^3/d)**	Drumlish Road, Longford – Three trial wells drilled and tested for Longford County Council. Drawing from Dinantian Sandstones and Dinantian (early) Sandstones, Shales and Limestones. Estimated safe yields of 1500 m^3/d for TW1, 1900 m^3/d for TW2 and 1200 m^3/d TW3 (K.T. Cullen & Co., 1999) (GSI Well Numbers 2027SWW119, 2027SWW120, 2027SWW121) From GSI Borehole Database: From Limestones: 2027SWW116 Gowlan, 102 m^3/d; 2027SWW109 Mullagh, 157 m^3/d; 2027SWW108 Mullagh 131 m^3/d
	Main discharge mechanisms	The main discharges are to Lough Ree and the River Shannon in the west and to some springs and streams crossing the body. There may be some groundwater discharge in 'lagg zones' at the margins of the raised bogs or at flushes within the bogs where the underlying 'low' permeability subsoils are thin or absent. .
	Hydrochemical Signature	The hydrochemistry of the carbonate rocks, especially pure limestones, is dominated by calcium and bicarbonate ions. Hardness can vary from slightly hard to very hard (typically ranging between 380–450 mg/l). Spring waters tend to be softer, as throughput is often quicker with less time for the dissolution of minerals into the groundwater. Groundwater alkalinity is variable, but can be high. Alkalinity is generally less than hardness indicating that ion exchange (where calcium or magnesium are replaced by sodium) is not a significant process. Lime-scale can be problematic. Like hardness and alkalinity, electrical conductivities (EC) can vary greatly. Typical limestone groundwater conductivities are of the order 500–700 µS/cm. Lower values suggest that groundwater residence times are very short. Groundwater in karstic aquifers is highly vulnerable to bacteriological and chemical pollution from point sources such as septic tank systems, farmyards, waste disposal sites, land spreading of organic waste and from polluted streams flowing underground. High levels of suspended solids can also be a problem in heavily weathered and fissured limestone. Hydrochemical analyses carried out on samples from the trial wells intersecting Dinantian Sandstones just north of Longford Town in 1999 showed hardness ranging from 246-394 mg/l, alkalinity from 230-365 mg/l and EC from 445-680 mg/l. The water in these trial wells was entering from quartzitic sandstone however the hardness level is quite high showing an influence from the surrounding Carboniferous Limestone. Iron and Manganese exceeded the E.U. Potable Water MAC (0.21-0.23 mg/l Fe and 0.22-0.73 mg/l Mn). The hydrochemical signature of groundwater from trial wells TW1, TW2 & TW3 is demonstrated in an expanded Durov plot in Figure 2 below.

Groundwater Flow Paths	Groundwater in the karstified pure bedded limestones will flow through fissures, faults, joints and bedding planes. In pure bedded limestones these openings are enlarged by karstification which significantly enhances the permeability of the rock. Pure bedded limestones are generally devoid of intergranular permeability however dolomitisation can result in an increase in the porosity and permeability of the rock. Karstification can be accentuated along structural features such as fold axes and faults. Groundwater flow through karst areas is extremely complex and difficult to predict. As flow pathways are often determined by discrete conduits, actual flow directions will not necessarily be perpendicular to the assumed water table contours, as shown by several tracing studies (Drew and Daly, 1993). Flow velocities can be rapid and variable, both spatially and temporally. In pure bedded limestones fracture systems are generally well-connected and widespread and support regional-scale flow systems. Flow path lengths can be up to a several kilometres in length. Overall groundwater flow in this body will be towards the rivers crossing the body and west and northwest to the River Shannon, but the highly karstified nature of the bedrock means that locally groundwater flow directions can be highly variable. The south and south-western boundary of this body is formed by the Inny/Lough Ree-Camlin/Rinn surface water catchment boundary. The topography is quite subdued at this point and given the karstified nature of the bedrock it is possible that this surface water catchment boundary does not coincide with a groundwater divide. There may be some groundwater flow between the Lanesborough GWB and the Newtown Forbes GWB. Groundwater may become partially confined in some areas in this GWB where there are extensive areas of peat and low permeability subsoil.. Water levels in karstified limestone generally show rapid response to rainfall. Water level data for a well within this GWB are shown in Figure 1 attached. Dinantian Sandstones have been encountered in a small area in the vicinity of trial boreholes north of Longford town. Insufficient information is available to identify the extent of sandstones. Groundwater flow in the Dinantian Sandstones is generally expected to be concentrated in fractured and weathered zones and in the vicinity of fault zones. Due to the dominant sandstone lithology the fissure permeability and the interconnection of fissures is expected to be quite high in Dinantian Sandstones, enabling regional groundwater flow. While expected to have generally a lower permeability than the Dinantian Sandstones, the Dinantian (early) Sandstones Shales and Limestones do have zones of enhanced permeability and would not be expected to form a significant barrier to flow from the Dinantian Sandstones.
Groundwater & Surface water interactions	There is often a high degree of groundwater and surface water interaction in areas underlain by karstified limestone. In this GWB however there are no karst features currently recorded and there is thick subsoil cover in many areas. Where subsoil cover is thin or absent some collapse features providing a direct connection between the surface and the groundwater systems may still occur. Because of the close interaction between surface water and groundwater in karstified aquifers in areas where subsoil cover is thin or bypassed, surface water and groundwater quality are also closely linked. Any contamination of surface water is rapidly transported into the groundwater system, and vice versa. There is an area of Fen Peat north of Cloondara (Teagasc Parent Material Mapping). Fens are highly groundwater dependant ecosystems.

Conceptual model	• This GWB is bounded to the north west by the River Shannon and Lough Forbes. It is bounded to the north and east by the Ordovician Metasediments and Dinantian Upper Impure Limestones of the Longford Ballinalee GWB. It is bounded to the south and southwest by the Inny/Lough Ree-Camlin/Rinn surface water catchment boundary. However the topography is quite subdued at this point and given the karstified nature of the bedrock it is possible that this surface water catchment boundary does not coincide with a groundwater divide. There may be some groundwater flow between the Newtown Forbes GWB and the Lanesborough GWB. • The GWB is generally flat and low-lying with large areas of peat land in the west of the body. Ground elevations range from 40-80 mAOD. • This GWB is composed of primarily of highly permeable karstified and dolomitised limestone. However, a small area of Dinantian Sandstones, which have an upper broken and weathered zone that is highly permeable, has been encountered in trial hole drilling just north of Longford Town. The actual extent of the sandstones in this area is currently unknown and consequently has not been delineated on bedrock and aquifer maps to date. Dinantian (early) Sandstones, Shales and Limestones were also encountered in one trial borehole. • Groundwater flows along interconnected fractures, joints, faults and bedding planes. In karstified limestone may of these flow paths have been enlarged by solution and groundwater flow can be concentrated in conduits. Rapid groundwater flow velocities have been recorded through groundwater tracing in adjoining GWBs with similar karstified limestone lithology. • Diffuse recharge will occur over the entire GWB via rainfall percolating through the subsoil. Percolation of recharge will be somewhat restricted in the west of the body due to the extensive covering of peat and the typically associated underlying lacustrine clay or clayey till. As much of this body is underlain by karstified limestone, there may be some point recharge to this groundwater body through swallow holes and collapse features. • Groundwater may become partially confined in some areas in this GWB where there are extensive areas of peat and low permeability subsoil • Much of the groundwater flow in karstified aquifers is concentrated in the upper epikarstic layer and in a zone of interconnected fissures, enlarged by karstification, generally extending to a depth of 30 m. In the Dinantian Sandstones encountered north of Longford town large inflows of water were obtained from an upper broken and weathered zone in the top upper 15-20 m of the rock. • In karstic aquifers, the degree of interconnection between fractures zones is high and they support regional scale flow systems. Flow paths can potentially be several kilometres in length. • Groundwater storage in karstified bedrock is low and the potential for contaminant attenuation in such aquifers is limited. • Groundwater will discharge to Lough Ree and the River Shannon in the west and to some springs, streams and rivers crossing the body. • In areas underlain by karstified limestone there is the potential for a high degree of interaction between surface water and groundwater, however large areas in this GWB are covered by thick layers of subsoil and peat underlain by low permeability till.. There is an area of Fen Peat north of Cloondara. Fens are highly groundwater dependant ecosystems.
Attachments	Groundwater hydrographs (Figure 1); Hydrochemical Signature (Figure 2)
Instrumentation	**Stream gauges:** 26019, 26022, 26213 **EPA Water Level Monitoring boreholes:** Kilmore Lower (LON 026), Kilmore Upper (LON 028) EPA Representative Monitoring boreholes: None
Information Sources	K.T.Cullen & Co. Ltd. Report on the Drilling and Testing of Trial Wells in the Longford Town – Newtown Forbes Area, Co. Longford. January 1999. Report for Longford County Council. K.T. Cullen & Co., 1991. Consultant Hydrogeologist's Reports on Carrowroe Aquifer and Aquifer Protection Plan. Lanesborough Regional Water Supply. From *Lanesborough Regional Water Supply- Preliminary Report - Appendix B*, P.H. McCarthy Son & Partners Consulting Engineers March 1991. Prepared for Longford County Council. Lee, M. and Kelly, C. (2003) Roscommon Central Regional Water Supply Scheme (Ballinagard Spring and Proposed Production Boreholes) Groundwater Source Protection Zones. Geological Survey of Ireland Report to Roscommon Co. Co., 14 pp. Morris J.H., Somerville I.D. and MacDermot C.V. (2002). *Geology of Longford-Roscommon.* A Geological Description to Accompany the Bedrock Geology 1:100,000 Bedrock Series Sheet 12. With contributions by D.G. Smith, M. Geraghty, B. McConnell, K. Carlingbold, W. Cox, D. Daly. Geological Survey of Ireland, 121pp. (Publication Pending)
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae