Clones GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
Hydrometric Area 36 Monaghan Co. Co. Cavan Co. Co. N.I.	**Rivers:** Erne, Finn, Magheramy, Maghery. **Streams:** 126 unnamed streams **Lakes:** Aghafin Little, Bells, Billary, Bishops, Black, Bun, Cam, Castle, Clen, Clonandra, Clonkeen, Commons, Corfeehone, Corrarod, Curragh, Dawson's, Derreary, Derrygeeraghan, Derryhoo, Drumalee, Drumaveale, Drumgorry, Drumlaney, Drummoy, Drumroo, Gortnawinny, Gubdoo, Hermitage, Hilton, Holy, Laural Hill, Little, Bane, Garrow, Oony, Sarah, Lyons, Magherarny, Munilly, Parisee, Putigan, Rahultan, Ramages, Ramullingan, Rathkeevan, Roskeeragh, Round, Shankill, The Garden, Tonawolly, Uragh.	Lough Oughter and associated lakes, Kilroosky Lough Cluster (O'Riain, 2004).	138

Topography		This elongated, SW-NE aligned, GWB is bordered by less productive aquifers to the south and southwest, and by a karstified aquifer along the central western border. Faults provide the northern boundary and the eastern boundary comprises a topographic divide (Hydrometric Area 03). The topography falls from east to west: c.80 mAOD to 50 mAOD. Drumlins (various alignment) of up to 30 m in height are superimposed on the general, westwards sloping topography. Over the majority of the GWB, the surface water flow south-westwards (Rivers Magheramey and Finn) to discharge into the Upper Lough Erne, north of the GWB.
Geology and Aquifers	**Aquifer categories**	The GWB is divided into 2 aquifer units **Rf:** Regionally important fissured aquifer (c.50% area) occurs to the north and south, sandwiching a band of **Lm:** Locally important aquifer which is generally moderately productive.
	Main aquifer lithologies	Dinantian Age rocks underlie the GWB, comprising Pure Bedded Limestones (2.33%), Shales and Limestones predominantly to the north (49.45%), early/Mixed Sandstones, Shales and Limestones (25.34%) to the south, and Lower Impure Limestones (19.36%) inbetween. A small area of Pure Bedded Limestones are located along the eastern boundary and a band of Sandstones occur to the south (3.53%). Refer to Table 1 for details.
	Key structures	The SW-NE aligned rock succession is divided by c.10 NW-SE trending faults. The faulting has resulted in displaced blocks and by the rocks dipping by c.15-30° to the northwest.
	Key properties	There are 34 well yields recorded within this GWB ranging from 25-1795 m^3/d (averaging c.410 m^3/d). Of these, 9 well have specific capacities between 5-88 $m^3/d/m$, averaging c.40 $m^3/d/m$. Three transmissivity values exist: 80, 400 and 475 m^2/d (Swartz et al, 2002). The data highlight that high yields and transmissivities are achievable. Storativity is also expected to be good. Although data are not available for NI, it is assumed that the rocks have a similar permeability as it is likely to be strongly influenced by the high degree of faults and associated fracturing that occur throughout (Swartz et al, 2002). The 123 available groundwater levels range from 0.3-24 m below ground level. Just under 70% of these are less than 5 m below the surface. The data are inadequate to calculate groundwater gradients although the flow is expected to be south-westwards/westwards, towards the R. Finn and then the Upper Lough Erne. *Modelling of the Monaghan PWS also indicates that the zone of influence extends beyond the western boundary of the Monaghan GWB and into the Clones GWB i.e. due to the pumping, groundwater is potentially be pulled from the aquifer in the Clones GWB to the PWS (Swartz, 2001).* *(Source Protection Report; Monaghan GWPS*)
	Thickness	Most groundwater flux in all rock groups is expected to be in the uppermost part of the aquifer. This is thought to comprising a broken and weathered zone typically less than 3 m thick, a zone of interconnected fissuring that is likely to extend to a maximum of 40 m thick, and a possibly zone of isolated poorly connected fissuring typically less than 150 m.
Overlying Strata	**Lithologies**	The GWB is predominantly covered by till (53%), with small proportions of peat (16%) and alluvium (6%). Part of the GWB is within NI, for which no data are available (17%).
	Thickness	From the available outcrop, borehole and topographic information, the subsoil is generally thicker (>3 m) throughout the GWB. The subsoil is frequently thinner in the larger, inter-drumlin areas, especially in the southwest, where there is a higher proportion of outcrop. The drumlins themselves generally constitute areas of thick subsoil (>10 m).
	% area aquifer near surface	*[Information will be added at a later date]*

	Vulnerability	From the Monaghan GWPS, the areas of Extreme and High Vulnerability in the eastern part of the GWB are limited to the lower lying inter-drumlin areas. The majority of this area is classified as Moderately vulnerability, due to thicker Moderate permeability subsoil over the main drumlin zones. Areas of Low vulnerability are sporadic in the eastern portion, depending on where the thicker Low permeability areas are. A similar pattern would be expected in the remainder of the GWB.
FsRecharge	**Main recharge mechanisms**	Diffuse recharge occurs via rainfall percolating through the subsoil and rock outcrops – especially in the inter-drumlin areas where subsoil is thinner. In areas of Low Vulnerability (thick, low permeability subsoil), only a fraction of the effective rainfall can filter through and recharge the aquifer. However, a large proportion of the GWB is covered by Moderately permeability subsoil, which will allow for some recharge to occur.
	Est. recharge rates	*[Information will be added at a later date]*
Discharge	**Large springs and high yielding wells (m^3/d)**	Sources: Clones PWS: 1221 m^3/d, 1000 m^3/d, 917 m^3/d, 350 m^3/d, 325 m^3/d, 308 m^3/d. Springs: None identified. Excellent Wells: 1794 m^3/d, 1046 m^3/d, 665 m^3/d, 648 m^3/d, 605 m^3/d, 518 m^3/d (2 wells), 500 m^3/d, 486 m^3/d (see Sources for additional wells) Good Wells: 311 m^3/d, 310 m^3/d, 262 m^3/d, 218 m^3/d, 216 m^3/d, 174 m^3/d, 173 m^3/d (3 wells), 164 m^3/d, 150 m^3/d, 122 m^3/d, 120 m^3/d, 112 m^3/d (2 wells) 109 m^3/d.
	Main discharge mechanisms	The main groundwater discharges are to the rivers, streams, lakes and springs within the GWB. The main discharge zones are likely to be along the Upper Lough Erne to the west of the GWB and along the R. Finn to the south. The baseflow proportion of the total streamflow is expected to be higher than for the adjacent Ll/Pl GWBs (Cavan, Killashandra), due to the generally higher aquifer transmissivities associated with this GWB.
	Hydrochemical Signature	***National classification:*** Dinantian rocks (excluding Sandstones) 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) ***National classification:*** Dinantian Sandstones Calcareous. Generally Ca-HCO_3 signature. Alkalinity (mg/l as $CaCO_3$): range of 5-524; mean of 153 (65 'non limestone subsoils' data points) Total Hardness (mg/l): range of 5-502; mean of 162 (67 'non limestone subsoils' data points) Conductivity (μS/cm): range of 39-1184; mean of 408 (69 'non limestone subsoils' data points) *(Calcareous/Non calcareous classification of bedrock in the Republic of Ireland report)*
Groundwater Flow Paths		In the absence of inter-granular permeability, groundwater flow is expected to be concentrated in fractured and weathered zones and in the vicinity of fault zones. The presence of limestone interbeds can result in high permeability zones as a result of dissolution and dolomitisation, however in the absence of detailed drilling it is difficult to know how extensive these high permeability zones are. Where sandstones dominate there will be an increased likelihood of more open fractures and consequently higher fissure permeability. Groundwater flow is thought to be generally of a regional scale. Where unconfined, long flow path lengths (up to 2000 m) would be expected in the Pure Bedded Limestones. Although shorter flow paths are frequently associated with the remaining Dinantian rocks (c.30-300 m), the higher degree of fracturing in this instance suggest that paths may be of a similar magnitude to the Limestones. Groundwater flow directions are expected to be south-westwards, towards the Upper Lough Erne. *Dinantian Aquifer Chapters (Pure, Impure and Mixed Limestones/Sandstones); Monaghan GWPS*
Groundwater & Surface water interactions		Groundwater will contribute baseflow to the streams and rivers flowing across this GWB, especially in the inter-drumlin areas, where subsoil is generally thinner.

Conceptual model	• The GWB is bounded by less productive aquifers to the south and southwest. Karst aquifers make up the remaining western boundary and faults comprise the northern boundary. There is a topographic divide along the eastern boundary. General elevations increase eastwards, from 50 mAOD to 80 mAOD. Drumlins (additional 30 m in height) are located throughout the GWB. • All of the rocks in this GWB are of Dinantian age and are categorised as either Rf or Lm. Pure Bedded Limestone to the north, Shales and Limestones, Lower Impure Limestones, and early Sandstones, Shales and Limestones (to the south) are the main rock groups. All rock groups are considered to have the potential for relatively high fissure permeability and good transmissivities. The unconfined groundwater flux is likely to be in the uppermost part of the aquifer comprising a broken and weathered zone typically less than 3 m thick, and zone of interconnected fissuring, to a maximum of 40 m thick. There may also be some flow through isolated fissuring typically less than 150m. • Estimated transmissivity values range from 80-475 m^2/d and are thought to be represent the entire GWB as permeability is likely to be strongly influenced by the high degree of faulting and associated fracturing. Storativity is also thought to be good. • The aquifer is thought to be able to support regional scale flow systems, with flow paths up to 2000 m with groundwater discharging to the rivers/streams crossing the aquifer, and to small springs and seeps. • Recharge will occur diffusely through the thinner/more permeable subsoil and rock outcrops although is likely to be limited where subsoil is thicker and especially of a low permeability. • The main discharges are to the streams, rivers, lakes and springs within the GWB. Overall, the flow direction is likely to be to the southwest, as determined by the topography. • Modelling suggests that part of the Monaghan Source Protection Area falls within the eastern portion of the GWB.
Attachments	Figure 1. Figure 2. Table 1.
Instrumentation	**Stream gauges:** 36019, 36025, 36036, 36134, 36140, 36142, 36154, 36171 **EPA Water Level Monitoring boreholes:** (MON 101 – short record), (MON 137) **EPA Representative Monitoring points:** (CAV 30), (CAV 48), (CAV 51), (MON 10), (MON 21), (MON 22), (MON 39), (MON 45), (MON 47), (MON 48), (MON 50), (MON 51), (MON 52)
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. O' Riain, G. 2004. *Water Dependent Ecosystems and Subtypes (Draft)*. Compass Informatics in association with National Parks and Wildlife (DEHLG). WFD support projects. Swartz, M and Daly, D. (2002) *County Monaghan Groundwater Protection Scheme Report*. Main Report. Final Report to Monaghan County Council. Geological Survey of Ireland. Swartz, M. (2001) *Monaghan Public Water Supply – Groundwater Source Protection Zones*. Final Report to Monaghan County Council. Geological Survey of Ireland.
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 Clones GWB

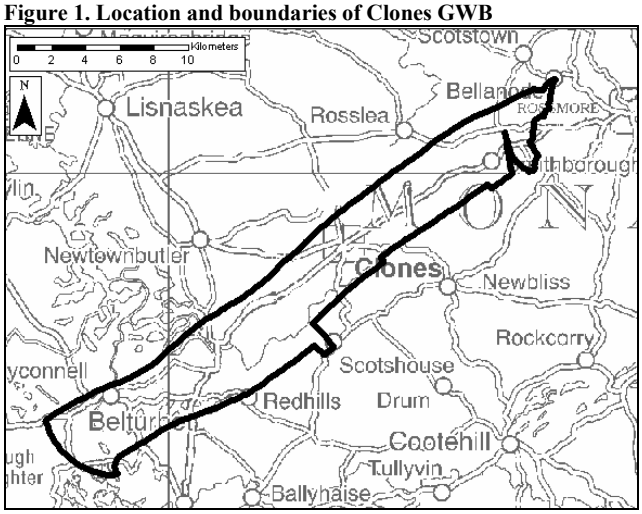

Table 1. List of Rock units in Clones GWB

Rock Unit Name	Code	Description	Rock Unit Group	**Aquifer Class.**	% Area
Drumgesh Shale Formation	DH	Dark shale, fine-grained limestone	Dinantian Shales and Limestones	Lm	49.45%
Cooldaragh Formation	CH	Pale brown-grey flaggy, silty mudstone	Dinantian (early) Sandstones, Shales and Limestones	Rf	21.09%
Ballysteen Formation	BA	Dark muddy limestone, shale	Dinantian Lower Impure Limestones	Rf	19.36%
Ulster Canal Formation	UC	Calcareous sandstone, shale, micrite	Dinantian (early) Sandstones, Shales and Limestones	Rf	4.25%
Fearnaght Formation	FT	Pale conglomerate & red sandstone	Dinantian Sandstones	Rf	3.53%
Ballyshannon Limestone Formation	BS	Crinoidal limestone & silty shale	Dinantian Pure Bedded Limestones	Rf	2.17%
Dartry Limestone Formation	DA	Dark fine-grained cherty limestone	Dinantian Pure Bedded Limestones		0.16%

Figure 2. Groundwater hydrographs (EPA Groundwater Level Monitoring)