Borrisokane GWB: Summary of Initial Characterisation.

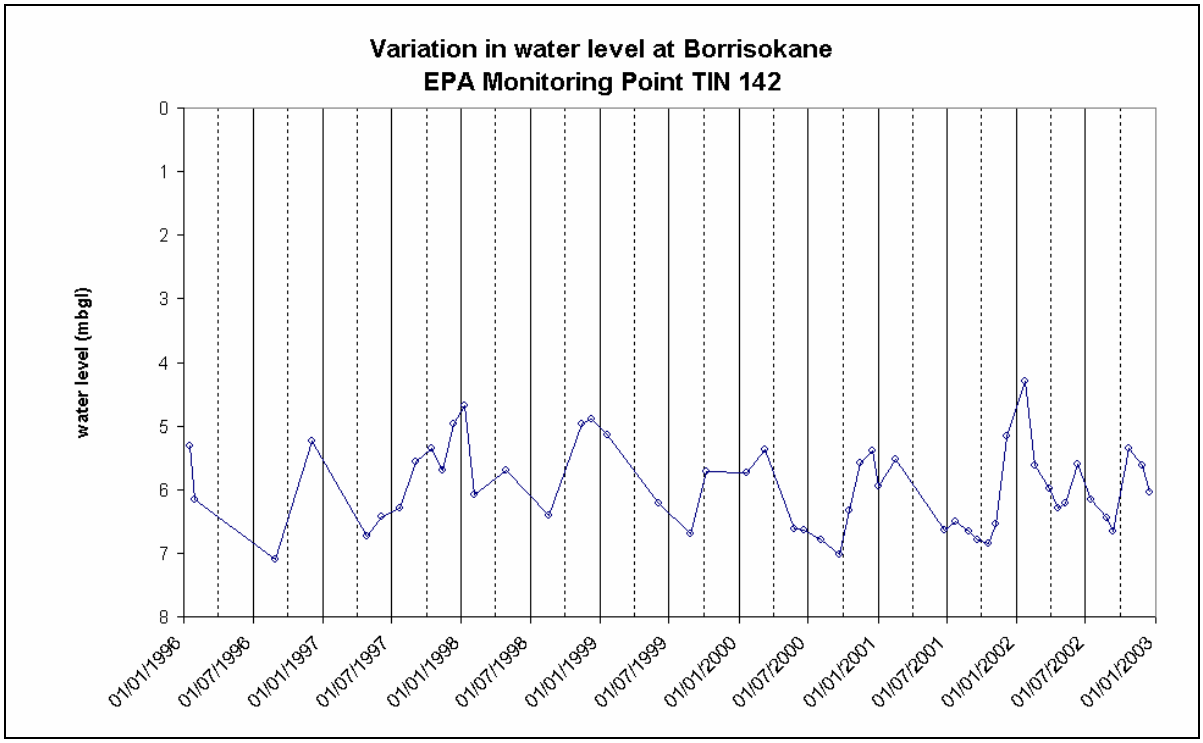
Hydrometric Area Local Authority	Associated surface water features	Associated terrestrial ecosystem(s)	Area (km^2)
25 - Lough Derg catchment North Tipperary Co. Co.	Rivers: Ballyfinboy, Carrigahorrig. Streams: Ardcrony.	Fiagh Bog (000932), Liskeenan Fen (formerly Liskeenan Turlough) (001683)	30

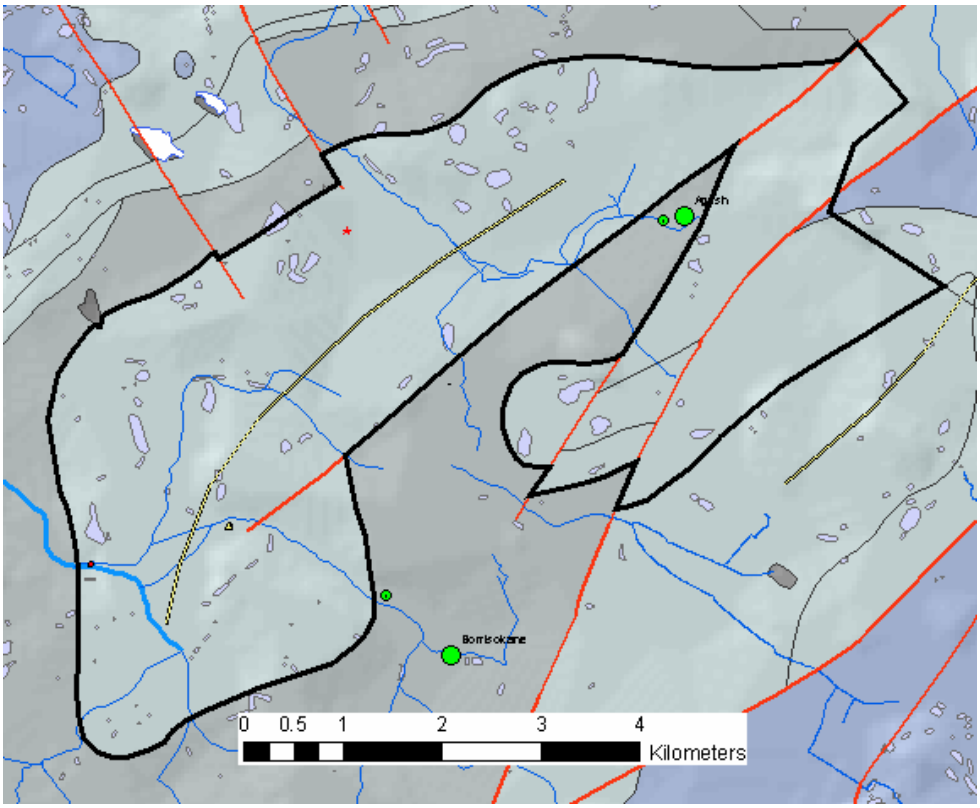
Topography	The GWB is irregular in shape. The main part is narrow (2.5 km) and orientated NE-SW; a spur leads off the NE end. The GWB is flat-lying to very gently undulating, with elevations in the range 60-70 mAOD over most of the GWB. Elevations rise to just over 90 m along the eastern boundary, which is a topographic divide The ground between rivers and streams is generally about 10 m above the river level. Overall, the drainage density is relatively high, due to the very low gradients. Surface drainage is approximately SE to NW, with streams and rivers very gently incising into the substrate.	
Geology and Aquifers	Aquifer categories	Most of the GWB comprises an **Rk^d**: Regionally important karstified aquifer dominated by diffuse flow. There are small areas (totalling < 1.5 km^2) of an **Lm:** Locally important aquifer which is generally moderately productive. There is a very small area (< 0.1 km^2) of **Ll:** Locally important aquifer which is moderately productive only in local zones.
	Main aquifer lithologies	Dinantian Pure Bedded Limestone is the major rock unit group in the GWB. Most of these rocks are coarse-grained limestones that have subsequently been diffusely karstified, but there is a small area (<1.5 km^2) of fine-grained limestone (Lismaline Micrite) that was less susceptible to karstification. Hence, it is an **Lm** aquifer. In the NE, there is a very small area (< 0.1 km^2) of Dinantian Pure Unbedded Limestone.
	Key structures	The rocks occur in the centre of a large syncline ('Borrisokane syncline'), whose axis plunges to the WSW. Strata dip SE and NW towards the centre of the syncline at angles ranging between 5° and 15°. Minor folds associated with the major structure are present. Significant faults cross-cut the limbs of the fold, and are orientated NW-SE and SW-NE. A major SE-NW fault that extends from east Co. Clare to West Co. Offaly (the Knockshigowna Fault) displaces strata within this GWB, and there is also a major fault parallel and close to the fold axis. Deformation associated with the folding will have caused fracturing, in addition to the deformation caused by the faulting. Joints and fractures may be more open on the axes of the minor anticlines.
	Key properties	This GWB consists primarily of highly transmissive diffusely karstified limestones. There are no data for this GWB but, in the same limestones 24 km to the ENE in Co. Offaly, modelled transmissivities at Tully and Hollimshill WSs were 140 m^2/d and 650 m^2/d respectively (Cronin, 1998 & 1999). Field transmissivities of 52-530 m^2/d have been recorded at Hollimshill and 13 m^2/d at Tully. Modelled permeability was 4.5 m/d at Tully and 13 m/d at Hollimshill. At Agall Spring, also to the NE in the Tullamore GWB, porosity is taken to be about 0.02 (Kelly, 2001). The groundwater gradient is relatively flat within the permeable limestone aquifer. The natural hydraulic gradient is estimated to be approximately 0.002 (Kelly, 2001 – Tully WS). High permeability zones caused by fissuring in the vicinity of faults may be present across the area and may cause local changes to the hydraulic gradient. Pure Bedded Limestones, such as those found in this GWB are susceptible to karstification, which enhances the permeability of the rocks although few karst features are currently recorded for this GWB. Storativity in such aquifers will be low (approximately 0.015-0.03). The small areas of Lm and Ll aquifers, which are comprised of limestones less susceptible to karstification, will have lower transmissivities than the rest of the GWB. *(data sources: Rock Unit Group Aquifer Chapters, GWPS Reports, Source Reports, see references)*
	Thickness	The coarse-grained Dinantian Pure Bedded Limestones reach a maximum cumulative thicknesses of around 300 m. The fine-grained Dinantian Pure Bedded Limestone (Lismaline Micrite) is about 40 m thick in most places. Notwithstanding the considerable combined thickness of the units, most groundwater flow is likely to take place in the top ~30 m, in the zone that comprises a weathered layer of 1-2 metres (epikarst) and a diffusely karstified (coarse-grained limestones) or connected fractured (fine-grained limestones) layer below this. Deeper groundwater flow occurs along fault zones and large fractures.
Overlying Strata	Lithologies	*[Information to be added at a later date]*
	Thickness	Subsoil thickness data are sparse. Data for the GWB and surrounding area indicate thicknesses in the range 1-5 m. There is outcropping rock and probably 'rock close' across much of the GWB.
	% area aquifer near surface	*[Information to be added at a later date]*
	Vulnerability	The majority (~60%) of the GWB has 'High-Low' groundwater vulnerability. Extreme vulnerability occurs in large zones over the remainder of the GWB.
Recharge	Main recharge mechanisms	Diffuse recharge will occur over the GWB via rainfall soaking through the subsoil and directly to the aquifer via outcrop. The generally well-drained appearance of the land indicates that recharge is readily accepted. However, where the water table is very close to ground surface, recharge may be rejected. Point recharge occurs at turloughs in low water table conditions.
	Est. recharge rates	*[Information to be added at a later date]*

Discharge	Important springs and high yielding wells (m^3/d)	There is one Excellent yielding (> 400 m^3/d) borehole at Borrisokane (George Hayes, 436 m^3/d) and two Good yielding (100 m^3/d < yield < 400 m^3/d) boreholes (at Tombrickane Townland and at Ardcroney GWB) known in the GWB. There are no large springs known in the GWB.
	Main discharge mechanisms	The main discharges are to the streams and rivers crossing the GWB and, during high water table conditions, to the turloughs. Some groundwater flows into the adjacent Ballinderry GWB where it discharges at the Aglish WS spring (a large part of the Source Protection Area to the Aglish WS is situated in the NE of this GWB).
	Hydrochemical Signature	No relevant hydrochemical data are available to assess the hydrochemistry in this GWB. By analogy with other pure limestone aquifers, the groundwater is likely to be Hard to Very Hard, with corresponding high alkalinity and conductivity, and a neutral pH. It will have a calcium–bicarbonate signature.
Groundwater Flow Paths		These rocks are devoid of intergranular permeability; groundwater flows through a diffuse network of solutionally-enlarged fissures and small conduits, and along faults. An epikarstic layer 1-2 m thick is also present at the top of this diffusely karstified aquifer. The epikarst is thought to be relatively modern, being formed after the last ice age. Groundwater flux is thought to be concentrated in the top 30 m or so of the aquifers. The groundwater flow regimes in the epikarst and diffusely karstified zones will be hydraulically connected, with the degree of interconnection depending on the faults and joints associated with the structural deformation. Typically, the epikarst distributes recharge into the saturated zone in the subsurface. In very high water table conditions, however, it will form a very high transmissivity layer. The aquifer is mainly unconfined, and the water table is likely to generally follow the topography. In this flat-lying area, groundwater levels will be generally shallow, ranging from near ground level near streams and rivers, up to around 10-15 mbgl away from surface water bodies under local topographic highs. Rivers and streams are considered generally to be in hydraulic continuity with the aquifer and gaining water from the aquifer. In very low water table conditions, however, streams may be losing if the water table falls below the water level in the rivers. The hydrograph in Figure 1 was recorded at a location mid-way between recharge and discharge areas. The typical annual water table fluctuation is about 2 m. Local groundwater flow will be from the higher ground between surface water bodies to the rivers and streams, where it discharges. In the north of the GWB, regional groundwater flow directions are northwestwards, following the general decrease in elevation towards Lough Derg. In the SW, groundwater flows southwestwards, to the Ballyfinboy River. In the SE, groundwater flows southwestwards, following the topography. Groundwater flow path lengths are on the order of 500–1500 m over the bulk of the GWB. In discharge zones, flow paths will be much shorter, at around 100–300 m.
Groundwater & Surface water interactions		Groundwater sustains flows in the gaining rivers and streams crossing the GWB. In low water table conditions, rivers may be losing, but there is no data to support this. The nature of the karstic system leads to rapid interchanges of water between surface and underground. The epikarst redistributes diffuse recharge in the subsurface. Turloughs accept surface water into the groundwater system and also discharge groundwater to surface, depending upon water table elevation. There are several ecosystems that are dependent on groundwater: Fiagh Bog is a calcium-rich fen, not a true bog. Liskeenan Fen is a small turlough-like fen. It floods in winter via a swallow-hole. Is the only such fen in the area, since the others have been drained.
Conceptual model		• The GWB is bounded to the north, west and SW by the contact with the low transmissivity rocks of the Ballinderry GWB. A surface water catchment boundary which is an implied groundwater divide defines the GWB margin in the east and SE. The area is almost flat-lying, with only gentle undulations in topography. • The GWB is composed primarily of highly transmissive diffusely karstified rocks. Small areas of lower transmissivity fractured aquifers occur in the SE of the GWB. All rocks within the GWB have low storativity. • Groundwater flow in this aquifer will be concentrated in an approximately 30 m zone at the top of the bedrock aquifer. This zone is likely to comprise an epikarstic layer of a few metres, below which is a network of diffuse solutionally-enlarged joints and small conduits, fractures and faults. The epikarst redistributes recharge in the subsurface and, in high water table conditions, is a very high transmissivity layer. Deeper groundwater flow can occur along permeable fault zones or deeper fractures. • Recharge occurs diffusely through the subsoils and at outcrop across the entire GWB. Potential recharge may be rejected in areas where the water table is very close to the surface. Point recharge also occurs at swallow holes. In low water table conditions, streams may recharge the aquifer along parts of their lengths. • The aquifers in the GWB are unconfined. Near rivers and streams, the water table is close to the surface. Beneath higher ground, significant unsaturated zones may exist. Depending upon topography, the water table can vary from 2 mbgl up to around 15 m below ground surface. Water table fluctuations in discharge areas will be relatively low (on the order of 1-2 m) whereas, in the high ground underlain by volcanic rocks or local topographic highs in the limestones, the water table elevation may vary considerably. • Flow path lengths are generally long (up to 1500 m). In discharge zones, flow paths will be much shorter, at around 100–300 m. On a local scale, groundwater discharges to the streams and smaller rivers crossing the aquifer. Local groundwater flow directions are determined by topography and local drainage patterns. In the north of the GWB, regional groundwater flow directions are northwestwards, following the general decrease in elevation towards Lough Derg. In the SW, groundwater flows southwestwards, to the Ballyfinboy River. In the SE, groundwater flows southwestwards, following the topography. • Groundwater discharges to the generally gaining streams and rivers crossing the GWB, and, in high water table conditions, to the turloughs in the NW of the GWB. A volume of groundwater will also cross-flow into the lower transmissivity Ballinderry GWB. A large part of the Source Protection Area to the Aglish WS is situated in the NE of this GWB, although the spring point is in the adjacent Ballinderry GWB. • Fen ecosystems within the GWB are dependent on groundwater.
Attachments		Groundwater hydrograph (Figure 1).
Instrumentation		Stream gauges: 25132*, 25326. *(Station marked with * has specific dry weather flow calculated.)* EPA Water Level Monitoring boreholes: Borrisokane (TIN142)

Information Sources	Cronin C., Daly, D., and R. Flynn, 1999. *Hollimshill Public Supply. Groundwater Source Protection Zones.* Geological Survey of Ireland Report, 12 pp. Cronin C., Daly, D., and R. Flynn, 1998. *Tully Public Supply. Groundwater Source Protection Zones*. Geological Survey of Ireland Report, 18 pp. Kelly, C. 2001. *Agall Water Supply Scheme. Groundwater Source Protection Zones.* Geological Survey of Ireland Report. Gatley, S. I. Somerville, J.H. Morris, A.G. Sleeman, and G. Emo, with contributions by W. Cox (Minerals), T. Hunter-Williams (Groundwater), and R. van den Berg and E. Sweeney (Carboniferous Volcanics), edited by A.G. Sleeman. A Geological description of Galway - Offaly, and adjacent parts of Westmeath, Tipperary, Laois, Clare and Roscommon to accompany the Bedrock Geology 1:100,000 Scale Map Series, Sheet 15, Galway - Offaly. Hunter Williams, N., Motherway, K. and Wright, G. (2002) *North County Tipperary Groundwater Protection Scheme (draft)*. Geological Survey of Ireland Report to North Tipperary Co. Co., 58 pp. Aquifer Chapters: Dinantian Pure Bedded Limestones, Dinantian Pure Unbedded Limestones.
Disclaimer	Note that all calculations and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

Figure 1: Groundwater hydrograph





Rock units in GWB

Rock unit name and code	Description	Rock unit group
Terryglass Formation (TS)	Grey calcarenitic & oolitic limestone	Pure Bedded Limestones
Borrisokane Formation (BK)	Pale grey coarse calcarenitic limestone	Pure Bedded Limestones
Lismaline Micrite Formation (LM)	Medium-grey micritic limestone	Pure Bedded Limestones
Waulsortian Limestone (WA)	Massive unbedded lime-mudstone	Pure Unbedded Limestones