Spink Quarry, Knockbaun, Abbeyleix, Co. Laois

Spink Quarry

Environmental Impact Assessment Report

Appendix 7.2
Groundwater Body Reports (GSI 2004)
&
Swan PWS GWPZ Report

Prepared by:

J Sheils Planning & Environmental Ltd

31 Athlumney Castle, Navan, Co. Meath

LAGAN
Part of the Breedon Group

Castlecomer Sandstone GWB: Summary of Initial Characterisation

Hydrometric Area Local Authority	Associated surface water bodies	Associated terrestrial ecosystems	Area (km^2)	Outcrop Area (km^2)
15 – Nore Kilkenny Co Co Carlow Co Co Laois Co Co	Castlecomer Stream, Clogh, Dinin (Nore), Monefelim,	None	224	102

Topography		Underlies the Castlecomer Plateau, an elevated saucer-shaped upland. The highest point lies at 337 m OD on the eastern rim. Other locations on plateau rim (East, West, North and South) range 290 – 330m OD. The lowest point lies at c. 100 m OD in the Dinin valley.
Geology and Aquifers	Aquifer type(s) Main aquifer lithologies	**Lm**: Locally important, generally moderately productive, fractured sandstone aquifer. Most of the groundwater body is confined, the unconfined portion being a relatively narrow strip around the perimeter of the plateau. **Clay Gall Sandstone (CG):** Medium and fine grained quartz sand with some feldspar. *Swan Sandstone Member (CQss):* Laminated dark grey fine-grained siliceous sandstone.
	Key structures.	• The rocks are folded into a syncline by at least one major phase of folding, causing considerable fracturing within the two sandstone formations, which reacted to the stress in a more brittle manner than the surrounding shales. • The aquifer outcrops around the rim of the plateau, but dips down to depths of over 246 m below ground in the centre of the plateau. • Away from the main recharge-outcrop area, the groundwater is confined by the overlying low permeability Westphalian shales. This is reflected by artesian pressures in wells drilled closer to the centre of the plateau (e.g. the Swan public supply in County Laois). • Several important faults cross the body. Some of these juxtapose the two sandstones and allow flow between them. Some faults act as barriers to flow.
	Key properties	• Well testing (Misstear et al. 1980) suggests transmissivities in the order of $10m^2/day$ (range $1m^2/d$ - 500 m^2/d) and permeabilities in the order of 0.1 m/day (range 0.01 m/d - 50 m/d). • Permeability and Transmissivity is sometimes enhanced near faults.
	Thickness	• The Swan Sandstone does not occur everywhere within the Plateau but can be up to 28 m thick. • The Clay Gall Sandstone ranges from 2m to 58m in thickness.
Overlying Strata	Lithologies	Thin glacial till above shale bedrock (generally less than 5m). Moyadd Coal (MC): Black shale, siltstone and minor sandstone, typically 55 m thick. Lickfinn Coal (LF): Sandstones, shales, fireclay (fossil soil) and up to eight coal seams.
	Thickness	50 m to 250 m.
	% area aquifer near surface	There is a very small proportion of the aquifer exposed at the surface.
	Vulnerability	Generally LOW except at perimeter recharge area, where it is typically EXTREME. In areas where the rock is exposed at the surface, the land is 'rushy', small springs are frequent at breaks-in-slope and drainage densities are high.
Recharge	Main recharge mechanisms	Rainfall recharge in unconfined portion.
	Est. recharge rates	Long term average rainfall about 1030 mm (Met Eireann). Potential Evapotranspiration (PE) estimated at 457 mm (EPA); Actual Evapotranspiration (AE) estimated as 95% of potential, i.e. 434 mm. Potential recharge estimated as 596 mm. Surficial cover over bedrock is generally < 5 metres. Annual recharge over the outcrop of the sandstone aquifers is 300 mm, i.e. just over 50% of effective rainfall.
Discharge	Springs and large known abstractions	Swan WSS (Co. Laois): 500 m^3/d. Overflow discharge from Swan artesian borehole is 60 m^3/d (0.7 l/s). BILBOA (11), Coan Creamery (7), Muckalee Co-Op (Ballyfoyle (20)), Clogh/Castlecomer RS (Gallery - 820), Castlecomer Co-Op (45), Carlow WS (Ardnataggle - 909), Athy Town GWS (Spring at Wolfhill) (450), Fermoylan.
	Main discharge mechanisms	The Dinin is gauged at Massford Bridge (Hydrometric Station # 15017), and at Castlecomer, 5 km further south (Station # 15013). Long term average runoff at Castlecomer is 2.78 m^3/sec (573 mm/year), estimated dry weather flow is 0.110 $m^3/sec.$, and estimated 95 percentile flow is 0.210 $m^3/sec.$ At the Swan Bridge beside Swan WSS, the river dried up in the dry summer of 1975, i.e. there was no flow Most discharge is to the Swan WSS and the Dinin River. The specific dry weather flow is relatively low (0.7 $l/sec/km^2$)

	Hydrochemical Signature	Hydrochemical data are available from the Swan WSS well in Laois and from GSI sampling. Waters close to recharge-outcrop area have a calcium-bicarbonate signature. Waters in the deeper, confined parts of the aquifer have a sodium bicarbonate signature, a result of ion exchange, reflecting long residence times. Waters are 'moderately soft' to 'moderately hard'; Concentrations of iron and manganese, apparently of natural origin, consistently exceed the EU MAC. The bedrock strata of this aquifer are **Siliceous.** Carbon isotope dating of water from Swan WSS (1976) determined a corrected age of 1440 ($^{+}$/-170) years.
Groundwater Flow Paths		Water infiltrates at the exposed areas around the perimeter. Some will discharge outwards to the surrounding basins. The remainder flows towards the center of the syncline, ultimately discharging to the River Dinin, unless it is captured *en route* by boreholes.
GW/SW Interactions		Some potential recharge probably rejected at margins Main discharge is to River Dinin.
Conceptual model		The Body comprises a Locally Important fractured sandstone aquifer, which is unconfined in a small strip around the perimeter and confined over most of its area in the centre of the Plateau. Rainfall recharge occurs only in the unconfined portion. Downward leakage from confining layers isunlikely because of artesian pressure. Groundwater flows through the Body from the perimeter inwards, with some discharging into the Dinin River. Artificial discharge mainly occurs from Swan WSS.
Attachments		Borehole hydrograph
Instrumentation		Stream gauges: 15017, 15013, 15036, 15016 Borehole hydrograph: (LS 31/1) Water quality: Swan WSS (LS 31/1), Fermoylan (#7 - S602839), Athy Town WS (#5 – S602839), Castlecomer Yarns (#40 - S536733)
Information Sources		Daly, D., Lloyd, J.W., Misstear, B.D.R., & Daly, E.P., 1980. Fault control of groundwater flow and hydrochemistry in the aquifer system of the Castlecomer Plateau, Ireland. Quarterly Journal of Engineering Geology, London, vol. 13, pp 167-175. Daly, D. & Misstear, B.D.R., 1976. A preliminary hydrogeological survey of the Castlecomer Plateau, S.E. Ireland. Unpublished M.Sc. dissertation, University of Birmingham, England. E.P.A. 1997. Nitrates in Groundwater: County Kilkenny, County Laois. Environmental Protection Agency. Misstear, B.D.R., Daly, E.P., Daly, D., & Lloyd, J.W., 1980. The groundwater resources of the Castlecomer Plateau. Geological Survey of Ireland, Report Series RS 80/3.
Disclaimer		Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

Ballingarry GWB: Summary of Initial Characterisation.

Hydrometric Area Local Authority	Associated surface water bodies	Associated terrestrial ecosystems	Area (km^2)
15 – Nore Laois, Kilkenny, S. Tipperary	Owveg, Cloghnagh, Castlecomer Stream, Dinin, Muckalee, Arigna, Munster, King's, Ballintaggart Stream, Bregagh, Nore, Brownstown Stream,	Dunmore Cave	412

Topography		This groundwater body contains the Slieveardagh Hills and the lower southwestern areas of the Castlecomer Plateau. There is a drainage divide along the Slieveardagh Hills. Water flows north to the Erkina river, which then flows east to the Nore. The Nore then flows south over this groundwater body between the Slieveardagh Hills and the Castlecomer Plateau. Further downstream the Nore meets the Kings River which has collected the south flowing tributaries from the Slieveardagh Hills.
Geology and Aquifers	Aquifer type(s)	**Pl** – Poor Aquifer, generally unproductive except for local zones **Pu** – Poor Aquifer, generally unproductive
	Main aquifer lithologies	BE - Bregaun Flagstone Formation - Thick-bedded flaggy sandstones and siltstones KN - Killeshin Siltstone Formation – clayey siltstone and silty mudstone MC - Moyadd Coal Formation - Black shales, siltstones and occasional sandstone
	Key structures.	There are no significant structural features which would have an important effect on the groundwater flow regime.
	Key properties	No information is available on the hydrogeological properties of this groundwater body. Estimated transmissivities can be considered to range 1 – 6m^2/d.
	Thickness	Effective thickness is not expected to be large but the bedrock may permeable to depths of around 25m in some areas.
Overlying Strata	Lithologies	Glacial till with significant areas where rock is close to surface. There are also some important gravel aquifers overlying this groundwater body, which are considered as separated groundwater bodies.
	Thickness	Thickness is greater in the west where it is typically <3m but there are larger areas where it is >1m. To the east the rock is close to surface over almost all of the area.
	% area aquifer near surface	70%
	Vulnerability	The vulnerability is mixed between EXTREME and HIGH to the southwest. In the east the area is almost entirely EXTREME.
Recharge	Main recharge mechanisms	Most recharge to this groundwater body will occur in two main areas: firstly in the southwest along the peaks of the Slieveardagh Hills and secondly in the elevated areas of the Castlecomer Plateau in the northeast. In other areas the thickness and permeability can virtually prohibit water reaching the bedrock. Potential recharge may be significantly higher than actual recharge since the bedrock is not considered to be permeable and it is likely that a large proportion will run off to adjacent rivers.
	Est. recharge rates	*[Information will be added at a later date]*
Discharge	Springs and large known abstractions	Clonmantagh (Spring), Ballingarry (Presentation Convent - 30), Briska WS (8),
	Main discharge mechanisms	Discharge from this ground water body will occur locally because no regional flow system is expected to exist. Discharge will be to the local streams as baseflow.
	Hydrochemical Signature	The bedrock strata of this groundwater body are **Siliceous**.
Groundwater Flow Paths		Groundwater flow paths in this area are considered to be short because the bedrock is not considered to constitute a major aquifer. Therefore it is likely that most groundwater flow circulates in the upper tens of metres, recharging and discharging in local zones. The age of the groundwater is considered to be young.
Groundwater & surface water interactions		Groundwater will discharge locally to streams and rivers crossing the aquifer and also to small springs and seeps. Owing to the poor productivity of the aquifers in this body it is unlikely that any major groundwater - surface water interactions occur. Baseflow to rivers and streams is likely to be relatively low.
Conceptual model		This groundwater body consists of the Wesphalian shales in the Nore Valley, extending from the Slieveardagh Hills to the Castlecomer Plateau. The groundwater body stretches the whole width of the Nore River basin. The groundwater development and monitoring in this area is concentrated on the gravel aquifers which overly the body. Flow within the bedrock will not be very large and will be constricted to the upper few metres of the bedrock. Recharge and discharge will occur locally to surface water features. This groundwater body is considered to be extremely vulnerable.

Attachments	
Instrumentation	Stream gauge: 15022 Borehole Hydrograph: none EPA Representative Monitoring boreholes: Note all monitoring points and most sources are in overlying gravel aquifers.
Information Sources	
Disclaimer	Note that all calculation and interpretations presented in this report represent estimations based on the information sources described above and established hydrogeological formulae

Swan Water Supply Scheme

Groundwater Source Protection Zones

Prepared by:
Geoff Wright

Geological Survey of Ireland

In collaboration with:

Laois County Council

November 2000

‘Note:
Since this report was published, the Source Protection Area and, possibly, other component maps have been updated based on improved geoscientific evidence and hydrogeological knowledge. The most up-to-date version of the Source Protection Areas (SPAs) and other maps can be found on the Geological Survey Ireland website (https://www.gsi.ie/en-ie/data-and-maps/Pages/default.aspx).’

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THE SWAN WATER SUPPLY SCHEME

1 Introduction

The objectives of this report are:

- To delineate source protection zones for the Swan Water Supply Scheme (WSS).
- To outline the principal hydrogeological characteristics of the area.
- To assist Laois County Council in protecting the water supply from contamination.

2 Well Location and Site Description

The Swan source is located approximately 10 km north-northeast of the town of Castlecomer. There are two Council boreholes at the site. The Production Well, drilled in 1970, is close (about 50 m) to the Clogh River, while the Observation Well is about 400 metres away to the north, and even closer to the river. There is also a private borehole just east of the Production Well, nearer the river.

The water is chlorinated and pumped to 'Hackett's Reservoir' (capacity 80,000 gallons – 364 m^3). The source serves a population of about 1000 people.

3 Well Details

PRODUCTION WELL (LS 31/1)

GSI no.	:	2317NE W079
Grid ref. (1;50,000)	:	S 5636 8245
Townland	:	Moyadd
Owner	:	Laois County Council
Well type	:	Borehole
Elevation (top of casing)	:	170.01 m OD (Malin Head)
Elevation	:	170.4 m OD (pumphouse floor)
Depth	:	39 m
Depth of casing	:	? 2 m (from geophysical logging)
Depth of pump	:	30 m
Diameter	:	200 mm (8")
Depth-to-rock	:	c. 16 m
Main Aquifers	:	Swan Sandstone (12-23 m, from geophysical logging, 1976)
Static water level	:	>174 m O.D. (Artesian, overflows naturally)
Artesian flow	:	6-10 l/sec (5000-8000 gph)
Pumping water level	:	6 m b.g.l
Drawdown	:	c. 10 m
Pumping rate	:	916 m^3/d (8400 gph)
Abstraction	:	590 m^3/d (130,000 gpd)
Hours of pumping	:	12 – 14 hours per day

Pumping test summary (1976):

pumping rate:	571 m^3/d
drawdown:	0.35 m (after3.25 hours)
specific capacity:	1630 m^3/d/m (after3.25 hours)
transmissivity:	487 m^2/d

OBSERVATION WELL (LS 31/2)

GSI no.	: 2317NE W080
Grid ref. (1;50,000)	: S 563 828
Owner	: ? Laois County Council
Townland	: Moyadd
Well type	: Borehole
Elevation	: 177.3 m OD (Malin Head).
Depth	: 131 m
Depth of casing	: ? 16 m (from geophysical logs)
Diameter	: 200 mm (8")
Depth-to-rock	: c. 16 m
Main Aquifers	: Swan Sandstone (17-26.5 m); Clay Gall Sandstone (56-89 m)
Static water level	: 178.7 m O.D. (artesian, overflows naturally)
Artesian flow	: 0.7 litres/sec. (560 gph)
Pumping test summary (1976):	

pumping rate:	262 m^3/d
drawdown:	22.5 m (after 3.25 hours)
specific capacity:	11.6 $m^3/d/m$ (after 3.25 hours)
transmissivity:	4.8 m^2/d

4 Methodology

Desk Study

Geological information was derived from GSI Bedrock 1:100,000 mapping (Sheet 18). Basic source details, including borehole locations, chemistry data and pumping test data, were obtained from Council staff and from GSI files, and from the M.Sc. thesis by D. Daly & B.D.R. Misstear (1976) and papers by D.Daly et al (1980) and Misstear et al (1980).

Site visits and fieldwork

Aoibheann Kilfeather mapped the subsoil types and assessed depth to bedrock throughout the area. Water samples for analysis by the State Laboratory and Health Board were taken in November 1997 and June 1999.

Assessment

Analytical equations and hydrogeological mapping were utilised to delineate protection zones around the source.

5 Topography and Drainage

The catchment area of the Swan borehole lies near the northern end of the Castlecomer Plateau. The Swan village itself is situated in the valley of the Clogh River, at an elevation of about 170 metres O.D. To the east, west and north the ground rises to elevations of over 250 metres O.D.

The Clogh River joins the Dinin River some 4.75 km south of the Swan. The Dinin is gauged at Massford Bridge, some 0.5 km further downstream (Hydrometric Station # 15017), and at Castlecomer, 5 km further south (Station # 15013). Long term average runoff at Castlecomer is 2.78 m^3/sec. (573 mm/year), estimated dry weather flow is 0.110 m^3/sec., and estimated 95 percentile flow is 0.210 m^3/sec. At the Swan Bridge beside the source, the river dried up in the dry summer of 1975, i.e. there was no flow.

6 Geology

6.1 Bedrock geology

The geological succession in the area of The Swan comprises sandstones, shales and thin coal seams of Westphalian age (Table 1). Figure 1 shows a geological log of borehole LS 31/2.

A major fault (The Swan Fault) is postulated to run north-south between LS 31/1 and LS 31/2 (unpublished note by E.P. Daly, 1976; D.Daly et al, 1980). However, this fault is not depicted on GSI Bedrock Sheet 18 or on Map 1 of the Groundwater Protection Scheme maps.

Table 1. Geological succession

Formation name	Description	
Coolbaun Formation (CQ)	Shales, sandstones, fireclays and thin coal seams	170 to 250 m thick
Swan Sandstone member (CQss)	Laminated dark grey fine-grained micaceous sandstone	Up to 28 m thick; Penetrated by Production and Observation wells
Moyadd Coal Formation (MC)	Silty shales, siltstones, thin sandstones and two coal seams	15 to 50 m thick
Clay Gall Sandstone Formation (CG)	Light grey, fine- to medium-grained massive sandstone containing shards of shale (clay galls), overlain by siltstone, with coal seam (Wards Coal Seam) towards top	2 to 58 m thick. Not penetrated by Production Well
Bregaun Flagstone Formation (BE)	Generally flaggy-bedded sandstones and siltstones with lesser amounts of silty grey, often micaceous shales	
Killeshin Siltstone Formation (KN)	Mainly grey muddy siltstones or silty mudstones, with lesser amounts of sandstone and shale	

6.2 Geological structure

The Swan lies on the Castlecomer Plateau, which is a large elevated structural basin. The rocks were folded by the Variscan Orogeny (c. 300 million years ago). The main compression was east-west which created north-south trending folds, but the rocks at the northern and southern ends of the plateau dip towards the centre, thus creating the basin-like structure. The folding also created two major sets of faults along ENE-WSW and NNW-SSE directions. D. Daly et al (1980) demonstrated that some faults act as barriers to groundwater flow, while other enhance groundwater flow. In relation to the Swan source, the most important fault is the (postulated) Swan Fault, which roughly follows the valley of the Clogh River and appears to enhance groundwater flow by creating a zone of higher permeability along its course.

Locally, the rocks in the area of the Swan dip southwards or southwestwards at moderate angles.

6.3 Quaternary (subsoils) geology

The Quaternary mapping by Aoibheann Kilfeather shows thin glacial till, limestone-dominated, underlying most of the land around the Swan. Along the Dinin valley, for about 600 m north of the Production Well, and also to the south, there is a narrow strip of alluvium close to the river (around

50 m wide). As the observation borehole shows, this alluvium can be up to at least 16 m deep and may comprise coarse gravel.

Further north, the till thins out and rock is very close to the ground surface (generally within one metre), though there are also two patches of thin till.

6.4 Depth-to-rock

The depth to bedrock in the catchment is generally less than 5 metres (Daly & Misstear 1976), but to the east and northeast of The Swan there is an area of somewhat deeper surficial deposits, reaching a maximum depth of over 10 metres. At the Production Well, bedrock was hit at about 2 metres, but at the Observation Well 400 metres to the north, 16 metres of coarse stream gravels and boulders were encountered above bedrock.

7 Hydrogeology

7.1 Data availability

The hydrogeological data are taken from the three publications by D. Daly, E.P. Daly, Misstear and Lloyd (see references).

7.2 Groundwater levels

Piezometric contours have been drawn (Misstear & others 1980). Groundwater flow is from north to south. The gradient is approximately 0.05 (1/20).

Water levels in LS 31/1 vary only slightly, according to measurements taken between 1973 and 1976 (data in Appendix I).

7.3 Rainfall, Evaporation and Recharge

Long term average rainfall is about 1030 mm (Met Eireann).

Potential Evapotranspiration (PE) is estimated at 457 mm (EPA), so Actual Evapotranspiration (AE) is estimated as 95% of the potential, i.e. 434 mm.

Potential recharge is estimated as (1030 – 434) 596 mm. The surficial cover over the bedrock is generally less than 5 metres thick. For the purposes of this report, it is assumed that annual recharge over the outcrop of the sandstone aquifers is 300 mm, i.e. just over 50% of effective rainfall.

7.4 Hydrochemistry and Water Quality

The Swan borehole yields groundwater which is different from most other groundwaters in County Laois, in that it has undergone the process of 'ion exchange' during its passage through the rocks, whereby calcium and magnesium ions have been exchanged for sodium ions.

In 1976 samples were taken at the surface (overflow) and at four different depths (21 m, 40 m, 65 m 100 m) in the Observation Well (LS 31/2). The 21 m and 65 m samples corresponded to the Swan Sandstone and Clay Gall Sandstone aquifers respectively. The results indicate that the three upper samples have very similar chemical characteristics, i.e. major ion concentrations, alkalinity, total dissolved solids, hardness and pH. The 65 m sample (Clay Gall Sst) has more sodium, less calcium and magnesium (lower hardness) and a higher pH, indicating that its longer travel time has resulted in more cation exchange, producing a softer water. The lowermost sample seems to represent a relatively stagnant water which has exchanged most of its calcium and magnesium for sodium.

Carbon[14] *Dating*

Carbon isotope dating of water from the Production Well carried out in 1976 determined a corrected age of 1440 ($^{+}$/-170) years. This demonstrates that water moves very slowly through the aquifer, and tends to confirm the low permeability derived from pumping tests in the aquifer as a whole.

Nitrates and Nitrogen

Nitrate values for the Swan borehole have generally been very low. The values in the first two samples, from the 1970s, are significantly higher than later analyses, although still low (the reason for this is not known, but some contamination through sampling is possible). In general, nitrate values from the two aquifers, as reported in 1976, are very low, mostly below 1 mg/l.

Other Nitrogen products (Ammonia) also show low values.

Table 2: Nitrate values from Production Well LS 31/1

Date	NO_3 mg/l	Data source
6/3/72	2.25	GSI/State Lab.
28/5/76	3.60	GSI/State Lab.
24/10/83	0.27	GSI/State Lab.
17/6/91	0.20	E.P.A./Laois C.C.
7/10/91	0.30	E.P.A./Laois C.C.
18/5/92	<0.10	E.P.A./Laois C.C.
14/12/92	<0.10	E.P.A./Laois C.C.
9/11/93	0.10	E.P.A./Laois C.C.
22/5/95	<0.10	E.P.A./Laois C.C.
27/11/95	<0.10	E.P.A./Laois C.C.
7/12/97	<0.10	GSI/State Lab.
8/6/99	<0.10	GSI/State Lab.

Other Parameters

Concentrations of iron and manganese consistently exceed the EU MAC. However, these concentrations appear to be entirely of natural origin.

Overall quality

With the exception of the iron and manganese levels, the water is of excellent quality, with low levels of nitrate, chloride, and bacteria.

7.5 Pumping test data

Pumping tests were carried out on the two boreholes in 1976. Pumping in each of the boreholes caused cessation of artesian flow in the other, demonstrating that the Swan Fault is transmissive.

Pumping test data from LS 31/1 and LS 31/2 gave very different transmissivities: 487 m^2/d and 4.8 m^2/d respectively. The lower value is more in keeping with values from other tests in these aquifers (K5/53: 1.2 m^2/d; LS 31/49: 6.7 m^2/d; K2/13: 14.3 m^2/d). The anomalously high value in LS 31/1 is ascribed to the proximity of the Swan Fault.

Pumping test data are in Appendix I.

7.6 Conceptual Model

The Swan borehole taps the confined Swan Sandstone (about 10 metres thick) which is dipping southwestwards. The sandstone is recharged at its outcrop, about 1-1.5 km to the north and northeast. Although the Clay Gall Sandstone is not penetrated by the Production Well and is generally less transmissive than the Swan Sandstone, it represents a potential additional resource which could be exploited by additional (deeper) production wells at the site. Accordingly, it is proposed to include the outcrop of the Clay Gall Sandstone (east of the Moyadd Fault) within the source protection areas.

7.7 Aquifer category

Considering their general permeability, transmissivity and consistency of yield, the main Westphalian sandstones (Swan Sandstone and Clay Gall Sandstone) are classified as **Locally Important Aquifers, generally moderately productive (Lm)**.

8 Groundwater Source Protection Areas

Source protection areas are delineated for an output of 700 m^3/d, the peak rate currently abstracted.

8.1 Outer Source Protection Area (SO)

The Outer Protection Area is bounded by the catchment area to the source, i.e. the zone of contribution (ZOC), which is defined as the area required to support abstraction from long-term recharge.

If long-term recharge is taken as 300 mm/year and the discharge is 700 m^3/d or 255,000 m^3/year, the recharge area needs to be approximately 0.85 km^2. Since the mapped outcrop of the Swan Sandstone is about 200 m wide, this would require an outcrop of some 4.25 km in extent (east-west).

An alternative approach is to consider the throughflow in the aquifer contributing to the source. If average Transmissivity is 5 m^2/d, discharge is 700 m^3/d, and hydraulic gradient is 0.05, then the contributing width of aquifer should be approximately 2.8 km.

The northern and eastern boundaries of the ZOC are based on the surface hydrological (topographic) catchment to the source. The western boundary is taken to be the Moyadd Fault, which is known to be a flow barrier. The downstream boundary was determined from the Uniform Flow Equation:

Distance = $Q/2.\pi.T.i$, where:

Q = discharge rate, m^3/d

T = aquifer Transmissivity, m^2/d

I = hydraulic gradient

Thus the distance to the downstream boundary = $700/2 \times \pi \times 5 \times 0.05 = 445$ m

The final catchment proposed (Map 3) is a compromise between the two approaches, and includes a strip of Swan Sandstone outcrop about 3.5 km long, east of the Moyadd Fault. This can be justified on the basis that (a) recharge may be more than 300 mm/year, (b) overall transmissivity may be higher than 5 m^2/d.

8.2 Inner Source Protection Area (SI)

The Inner Protection Area is normally defined by a 100 day time of travel to the source and is delineated to protect against the effects of potentially contaminating activities which may have an immediate influence on water quality at the source, in particular from microbial contamination.

For the Swan borehole, assuming a permeability of 0.5 m/d, a gradient of 0.05 and a porosity of 0.05, the 100-day time of travel zone can be estimated at 50 m. This area is entirely within the confined aquifer and therefore does not need to be defined nor afforded special protection.

9 Groundwater Vulnerability

The GSI guidelines for assessing and mapping groundwater vulnerability are set out in 'Groundwater Protection Schemes' (DELG/EPA/GSI 1999). Basically the groundwater vulnerability depends on the permeability and thickness of the subsoils overlying the first groundwater encountered. In the case of the area around the Swan borehole, the first groundwater encountered would normally be within the Coolbaun Formation which overlies the main aquifer, the Swan Sandstone. However, the Coolbaun Formation is largely composed of shales and mudstones, is a Poor Aquifer and has a very low permeability, particlarly in the vertical direction. Hence the Coolbaun Formation affords a high degree of protection from pollution to the Swan Sandstone.

The vulnerability of the Swan Sandstone (and, where relevant, the Clay Gall Sandstone) is important principally in the area where it outcrops, some 1-1.5 km north and northeast of the source. In this area, the overlying subsoils have been mapped as generally less than 3 m thick, and therefore the groundwater is classed as 'extremely' vulnerable to pollution.

10 Groundwater Source Protection Zones

Combining the Source Protection Areas with the vulnerability ratings produces just one Groundwater Protection Zone for the Swan source, as shown in Figure 3:

- Outer Protection Area / Extreme (SO/E)

11 Land Use and Potential Pollution Sources

Land use in the area is predominantly agricultural. Historically, the area was one of the major coal mining regions in Ireland. There are disused mines in the area.

The aquifer tapped by The Swan Source is a confined sandstone which is well protected from contamination near the source by the relatively impermeable shales which overlie and confine it, and by the positive hydraulic pressure in the aquifer, which tends to keep out any contaminated infiltration. The quality of water in the borehole could be threatened by:

1. Contamination in the recharge area up-gradient. Since the travel time from the recharge area to the borehole is very long (of the order of 1000 years), no microbial contamination can reach the source from the recharge area, so the threat is only from persistent chemicals.
2. Contamination through other boreholes penetrating the same aquifer up-gradient. This may be the most potent threat. However, such contamination is unlikely as long as an artesian pressure is maintained.
3. Contamination via preferential flow paths to the aquifer, e.g. where an artesian pressure is absent and the Swan Sandstone is cut by the Swan Fault.

12 Conclusions and Recommendations

1. The Swan groundwater source enjoys a high level of protection from contamination by virtue of its confined condition and long distance from its recharge area.
2. The source has a very low risk of contamination by pathogenic organisms.
3. Contamination of the aquifer by persistent chemicals could occur but would not be likely to affect the source for many hundreds of years under present conditions.
4. The risk of contamination would be greatly increased if the aquifer were to be overexploited so that a positive artesian pressure ceased to be maintained. In that case, the chief risk would arise from contamination of other boreholes penetrating the aquifer(s).
5. The recharge area of the aquifer, some 1-1.5 km up-gradient (to the north and northeast) constitutes the Outer Protection Area and should be protected and monitored to preserve the quality of the supply for future generations.

13 References

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E.P.A. 1997. Nitrates in Groundwater: County Laois. Environmental Protection Agency.

Misstear, B.D.R., Daly, E.P., Daly, D., & Lloyd, J.W., 1980. The groundwater resources of the Castlecomer Plateau. Geological Survey of Ireland, Report Series RS 80/3.

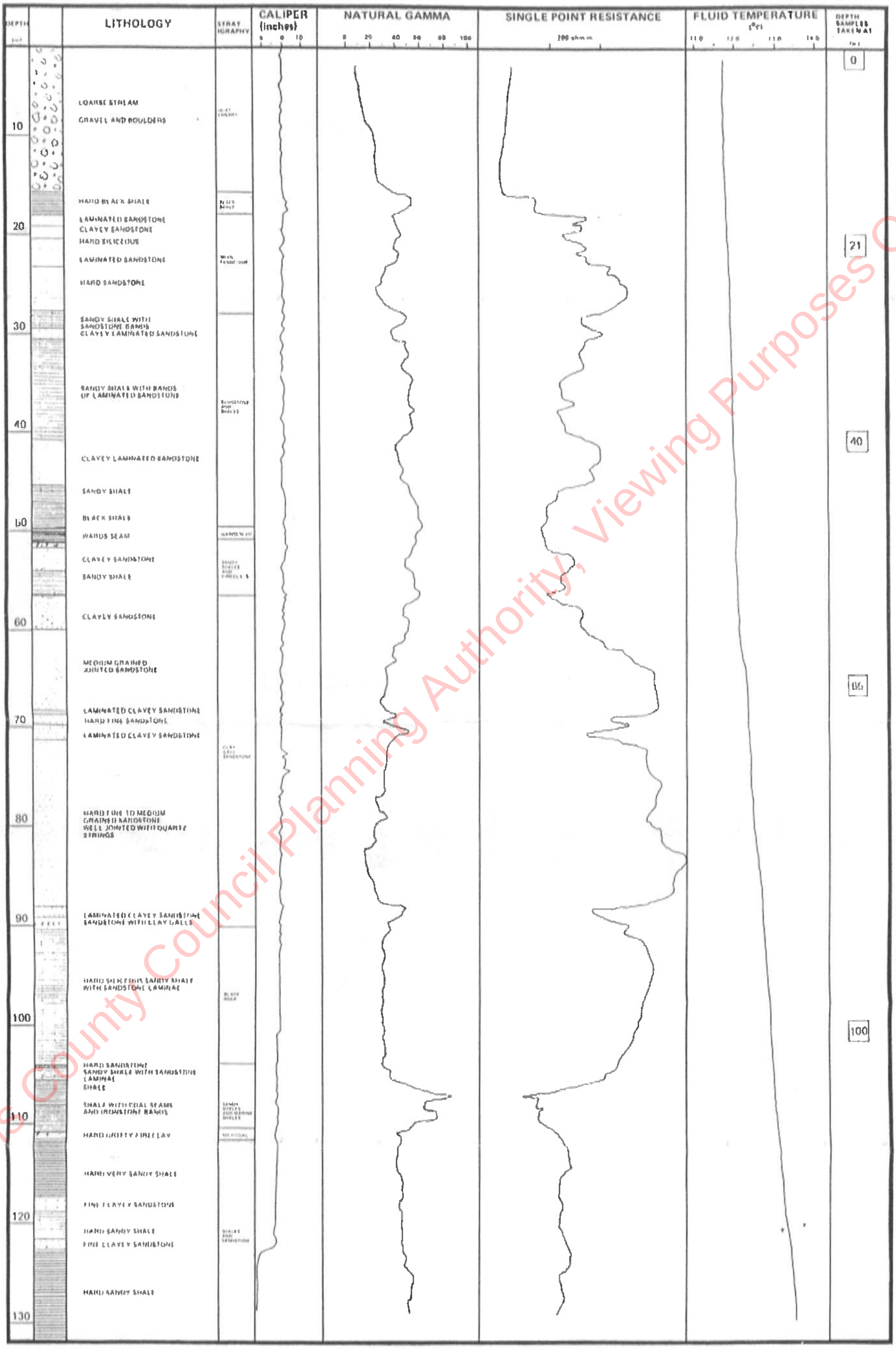


FIGURE 1 Detailed Geological and geophysical logs of borehole No. LS 31/2 at Swan, County Laois.

Appendix 1

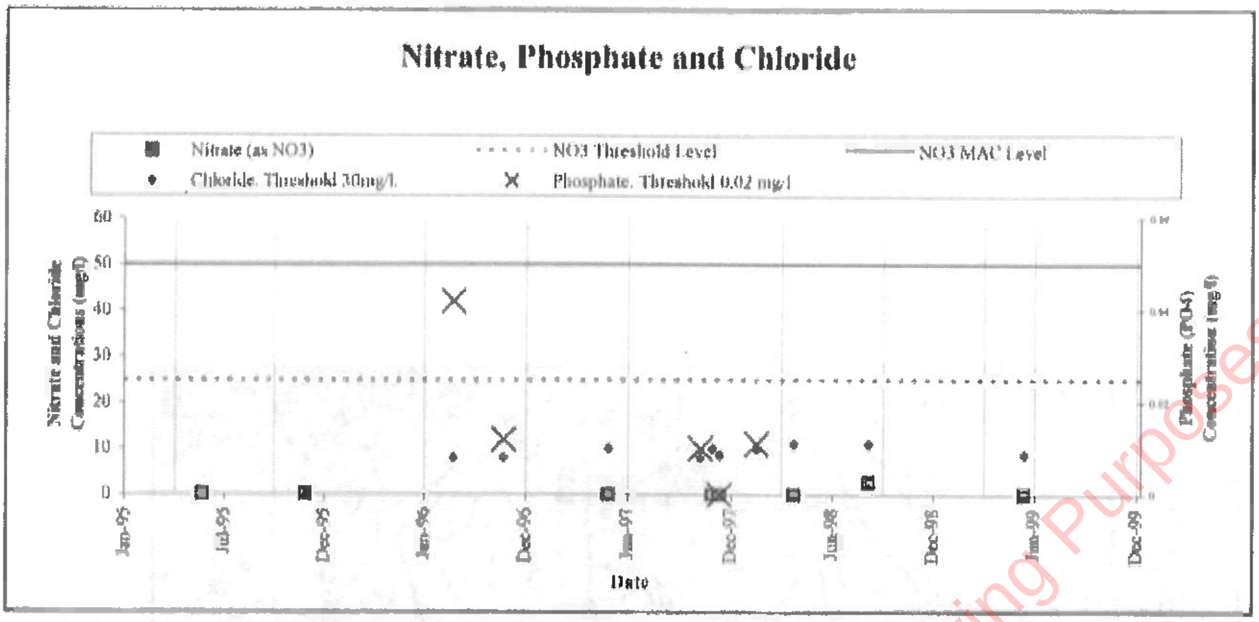
Pumping Test Data

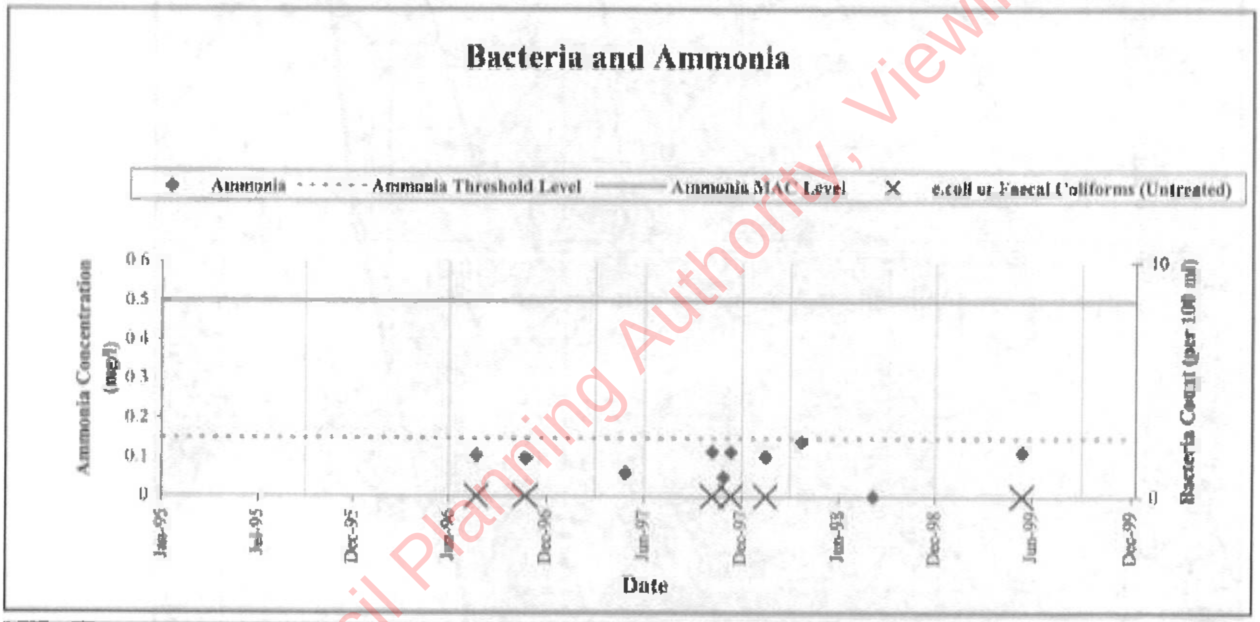
The Swan consumption test 3/2/83-8/3/83			
consumption since last reading	hrs since last reading	gallons/hour used	
92000	24	3833.333	
101000	18.5	5459.459	
116500	16	7281.25	
96000	17	5647.059	
120500	33	3651.515	
122000	20	6100	
107000	27.5	3890.909	
98400	24.5	4016.327	
89000	18.5	4810.811	
119000	27	4407.407	
102000	26	3923.077	
122700	24	5112.5	
76000	14.5	5241.379	
125400	32.5	3858.462	
106000	24.5	4326.531	
88700	19	4668.421	
101400	31.5	3219.048	
129400	21	6161.905	
80600	18.5	4356.757	
95000	21	4523.81	
144000	32	4500	
89000	23.5	3787.234	
91000	17.5	5200	
101200	28.5	3550.877	
89000	17	5235.294	
150000	33	4545.455	
111400	24	4641.667	
80400	20.5	3921.951	
120500	28	4303.571	
69100	15	4606.667	
121400	29.5	4115.254	
74200	17.5	4240	
144400	33	4375.758	
3474200	777.5	4468.424	
		4591.324	
		7281.25	
Total = 3,474,200 gallons pumped in 777.5 hrs = 4468 g/h = 487 m3/d			
Max rate was 7280 g/h = 794 m3/d			

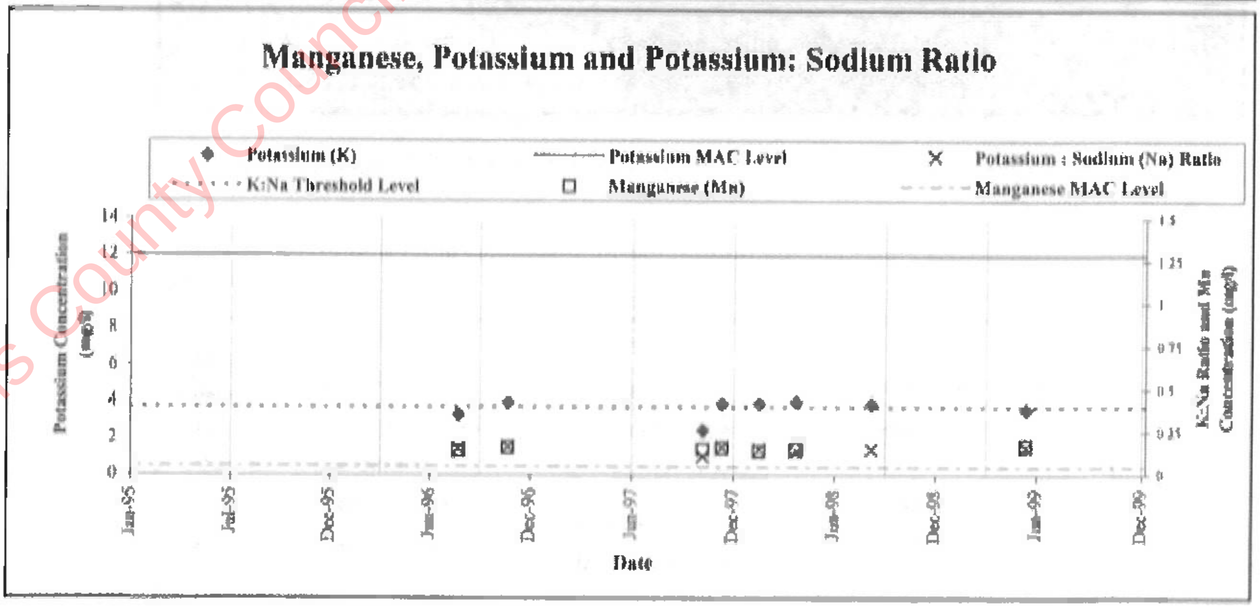
Appendix 2

(Water Quality) Hydrochemistry Data

Figure 47-The Swan
Key Indicators of Agricultural and Domestic Groundwater Contamination.

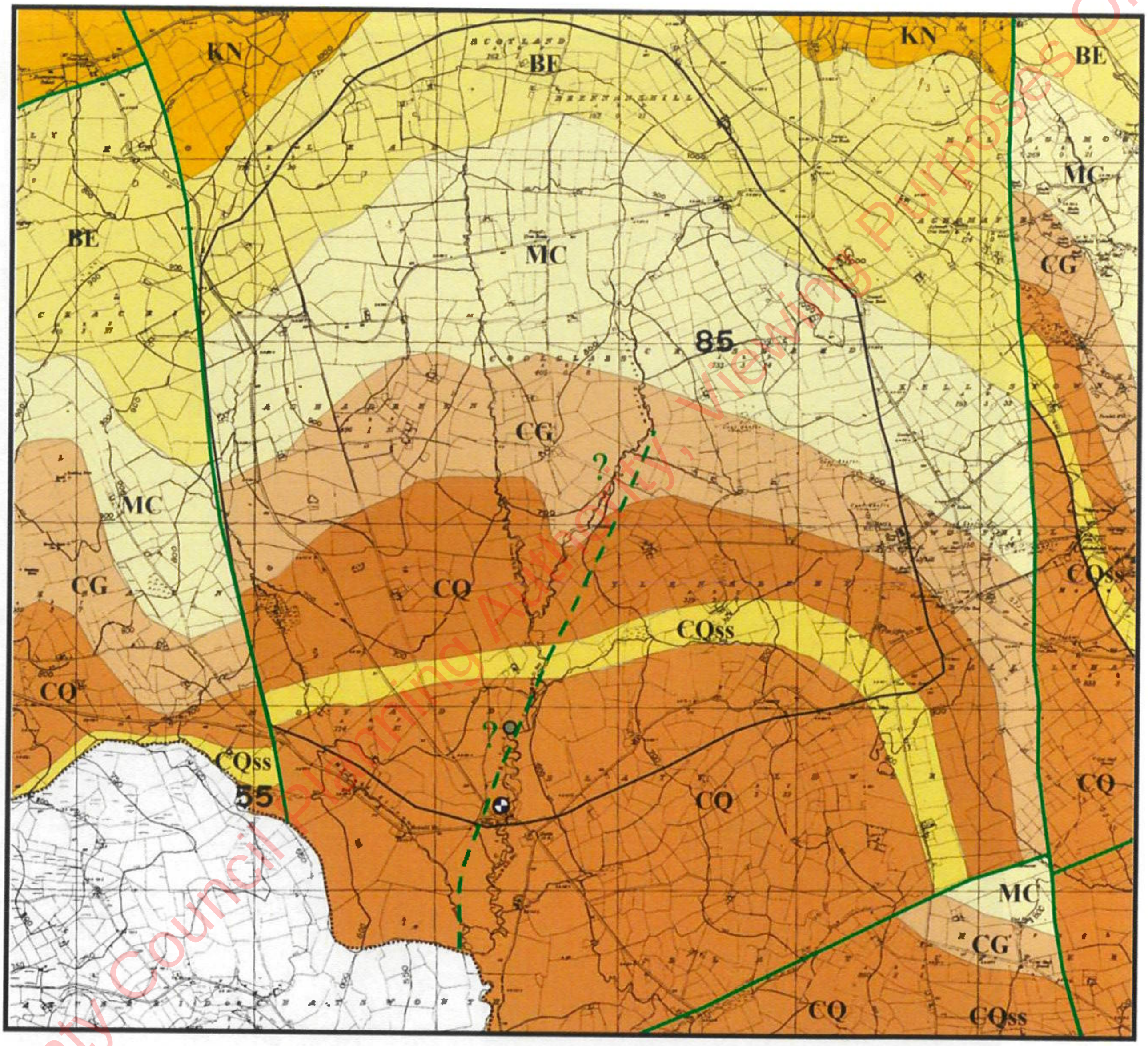






Sources: GSI sampling and available EPA and Council data.

Maps



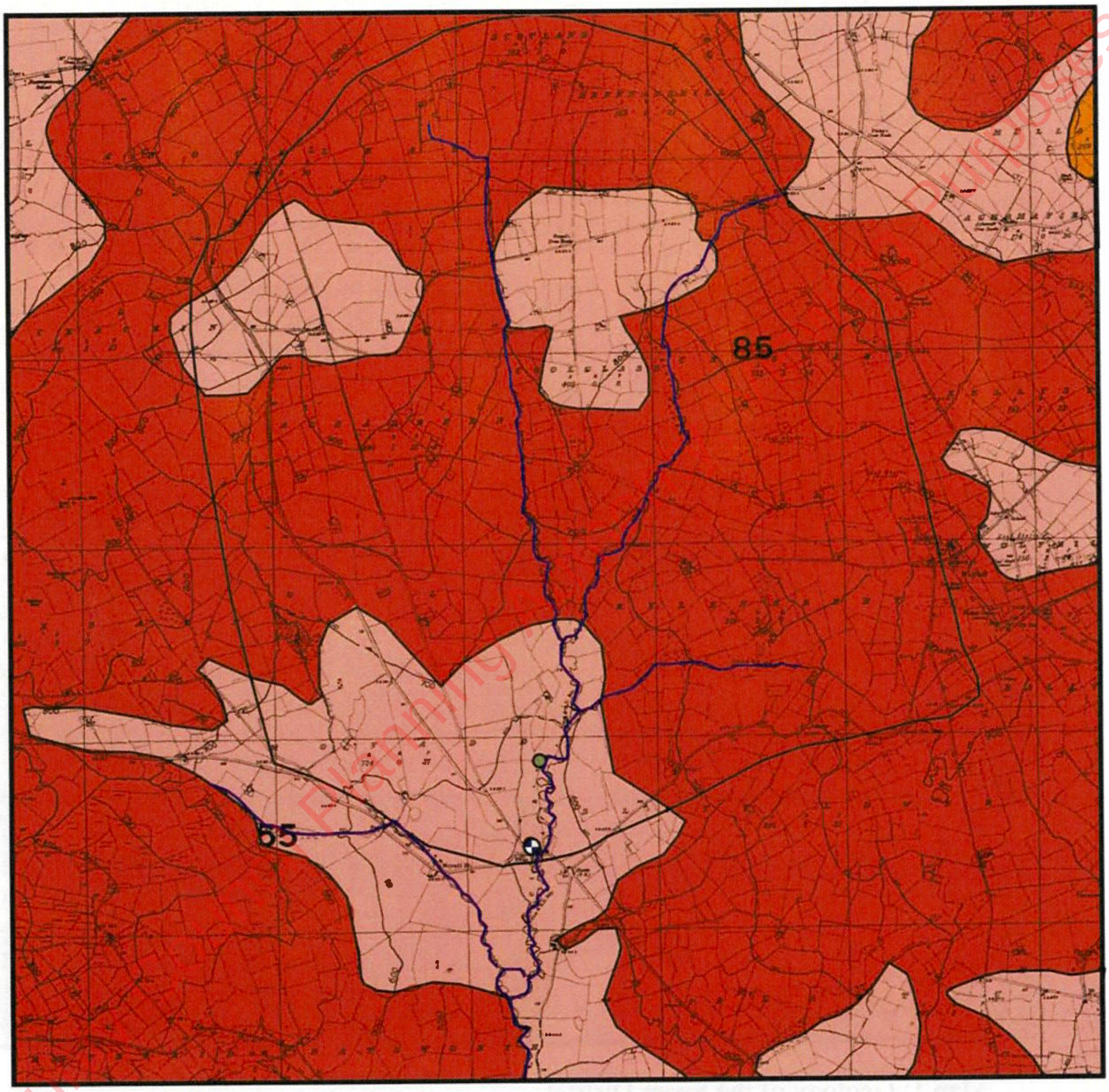
Map 1: Geology of the Swan District.

Legend

- CQ / CQss — Coolbaun Formation
- CG — Clay Gall Sandstone Formation
- MC — Moyadd Coal Formation
- BE — Bregaun Flagstone Formation
- KN — Killeshin Siltstone Formation
- Fault
- Suspected Fault
- Zone of Contribution
- Borehole
- Public Supply Well
- County Boundary
- Geological Boundary

Scale (Kilometres) 0 — 1.0

N



Map 2: Vulnerability classification of the Swan District

Legend

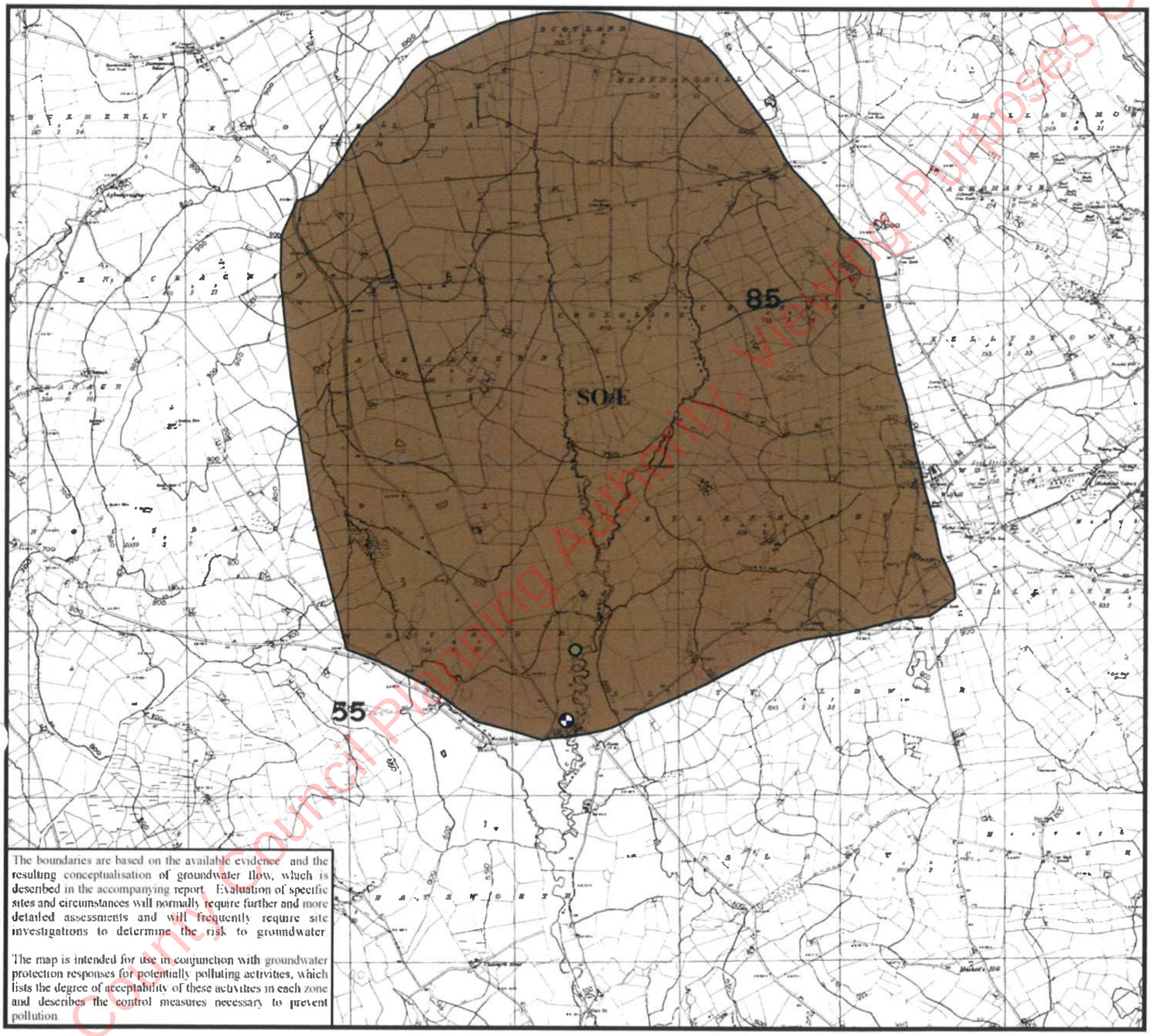
Vulnerability Classification

- Extreme (E)
- Outcrop/shallow rock/karst (E)
- High (H)
- Zone of Contribution
- Public Supply Well
- Borehole
- Streams

N

Scale (Kilometres)

0 1.0



Map 3: Groundwater Protection Zones for the Swan District