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ENVIRONMENTAL PROTECTION AGENCY
2 1 OCT 2005

17 October 2005

Dr Jonathan Derham
Licensing Unit
Environmental Protection Agency
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Dear Jonathan

Roadstone Blessington Illegal Landfill and Waste Licence Application 213-01

In response to your letter of 1st September **2005,** asking for my assistance on the hydrogeological aspects of the applicant's objection to the Agency's proposed refusal of a Licence, I attach my observations.

Please let me know if you have any questions in relation to my report, or if I can assist further in any way.

Yours sincerely,

EurGeol Geoff Wright PGeo
Senior Hydrogeologist
Groundwater Section

Roadstone Blessington Illegal Landfill & Waste Licence Application 213-01

I have examined the relevant parts of the documentation supplied in connection with the above application, in particular:

- The EPA Inspector's Report on the Licence Application, dated 5 July *2005*
- The letter of objection to EPA from Roadstone Dublin Ltd, dated **8** August *2005,* and the accompanying submission and appendices.
- The relevant Environmental Impact Statement (EIS) and appendices.

I shall first deal in turn with hydrogeological issues as they are listed in the Applicant's **"Response to stated reasons for refusal of waste licence",** referring to the Applicant's page numbers and section numbers.

Page 5, Section 2.1:

The first reason stated by the Agency for refusal of a licence included the sentence:

> "The zone of contribution of the Blessington wellfield lies directly in the path of and down/cross gradient of the proposed landfill cells."

In my opinion, this statement is incorrect and not supported by the scientific evidence.

- As is shown in Roadstone's Figure 1, the Zone of Contribution (ZOC) to the Blessington 'wellfield', as delineated in the Geological Survey's Source Protection Report, lies several hundred metres to the southwest of the illegal dumps and of the site of the proposed engineered landfill.
- The general direction of groundwater flow, as evidenced by all the measured groundwater levels, is roughly south-southeast, towards the Pollaphuca Reservoir. Any contamination from the illegal dumps, and any leakage from the engineered landfill, which may enter the underlying groundwater, will therefore flow towards the south-southeast. Hence the wellfield is not 'directly in the path of and is not 'down gradient of the proposed landfill. It might be said to be 'cross-gradient of the landfill, which simply means it is not down-gradient of it.
- The size and shape of the ZOC were delineated (by GSI) for an abstraction rate approximately 50% higher than that abstracted at the time, and also incorporated an additional allowance for a groundwater flow direction +/- 20° either side of the mean estimated direction. Hence the ZOC incorporates substantial safety factors which make it larger than would be necessary to account for the actual abstraction.
- The scientific evidence is that any contamination from areas 1, 4, and *6,* or from the proposed engineered landfill, could not enter the ZOC unless:
    a) The abstraction rate from the wellfield were to increase very substantially (e.g. *2-3* times) above its present rate, thus greatly enlarging the ZOC, or
    b) New evidence were presented to demonstrate that the direction of groundwater flow from beneath areas 1,4 or **6** is, in fact, towards the southwest, i.e. roughly at right angles to its currently estimated direction.

In my opinion, the scientific evidence supports the Applicant's assertion on Page ***6,*** Section *2.*I.B, that

"Theproposed landfill facility is not located within the 'zone of contribution of the Blessington wellfield"',

and that (second bullet):

"there is no realistic risk that groundwater from beneath the proposed landfill facility could reach and contaminate the Blessington wellfield."

Page 9, Section 3.1.2: Modelling of existing wells:

Some misunderstandings may have arisen concerning the various modelling exercises which the Applicant has undertaken, perhaps due in part to a lack of clarity in presentation.

The Applicant has undertaken three separate modelling exercises:

Quantitative Risk Assessment (QRA)

Quantitative Risk Assessments (QRA) for leachate movement from the existing waste dumps. These appear to ignore actual directions of groundwater flow, and hence ***assume*** a potential hydraulic connection between the waste dumps and the receptors even where no such connection appears to exist.

The initial QRA (August and December **2003)** modelled the predicted migration of leachate from the existing waste dumps (in areas 1 **, 4** and **6)** towards a theoretical well (the receptor) located 100 metres down-gradient of Area **6.**

Subsequently the QRA was re-run (August **2005),** using a number of actual wells **as** potential receptors, and also using different input parameters (permeability and recharge) **as** requested by EPA.

Landsim ***modelling***

The Landsim modelling simulated the leachate movement from the proposed engineered landfill facility towards the closest actual receptor ('Murphy's well').

Modelling of flow to existing wells and derivation of zones of contribution

This modelling simulated groundwater flow to the Wicklow CC wells and another well at Deerpark, In order to derive zones of contribution to those wells. In other words, it used computer modelling to do what the **GSI** source protection report had done by simpler means.

The results of this modelling broadly confirmed the original **GSI** delineation of the ZOC for the Council wells, allowing for the various additional safety factors incorporated into the **GSI** work.

The reliability of numerical groundwater modelling depends, ***inter*** *alia,* on:

(a) Using a satisfactory conceptual model of the relevant groundwater system – I believe that the Applicant's conceptual model is satisfactory, i.e. it reflects (in a simplified way) the realities of the underground system.

(b) Using a reliable model.

(c) Using realistic but appropriately conservative input parameters. In this case, I believe that the Agency's earlier concerns about some of the input parameters, particularly the aquifer permeability and the aquifer recharge, were well founded. The modelled storativity (1 **8.2%** quoted) is within the range requested by the Agency.

Significance of permeability, recharge and storativity parameters:

(a) Permeability or Hydraulic Conductivity (symbol 'k')

The permeability of an aquifer is of critical importance in any modelling exercise, **as** it is also critical in the real underground system. Permeability is the principal factor in determining the rate **(as** volume per unit time) at which groundwater **(and** any contaminants it contains) moves underground. Other factors are also involved - primarily the hydraulic gradient and the porosity - but whereas these parameters may vary in aquifers by about two orders of magnitude (e.g. porosity from **0.3** to **0.003** and hydraulic gradient from 0.1 to .001), permeability can vary ovkr ten orders of magnitude. Hence errors in estimating permeability can have a much greater effect on predictkd outcomes than errors in the other two parameters.

A detailed discussion on permeability estimations is given as Appendix I below. At this point, it seems sufficient to say that I believe that a permeability of 7 m/day is approximately correct.

I disagree with the Applicant's repeated assertions (a) that a value of 0.864 m/d would be more representative, and (b) that a value of 7 m/d is 'very conservative' and represents a 'worst case scenario'.

If the general permeability in the aquifer were as low as 0.864 m/d, the Wicklow Council wells could not sustain their current pumping rates and the Blessington gravel deposit would hardly be classifiable as a usable aquifer. In fact, data from some of the pumping tests in the aquifer show that much higher permeabilities are likely in places. Moreover, when the Applicant modelled flow in the aquifer (using MODFLOW) it was found necessary to use permeabilities of 2 m/d and **6** m/d (in different parts of the aquifer, with different hydraulic gradients) in order to satisfactorily model the groundwater system and match up the predicted groundwater levels with the modelled levels. Other documentation by the Applicant (EIS, Appendix 6M, Appendix A) notes:

> "Hydraulic conductivity – a value of 20m/day (ie 3 times greater than modelled) is a *reasonable* ***maximum*** representing a possible higher permeability zone..." (my italics)

While the Applicant is correct in saying that the permeability in the aquifer is patchy (citing the GSI report), it should be pointed out that groundwater flow in patchy aquifers will follow the more permeable parts and effectively bypass the less permeable parts. Hence, if modelling of a 'worst-case scenario' is desired, it would be appropriate to use a permeability of 20m/day.

(b) Annual Recharge (or Infiltration)

The starting point for recharge estimates must be the ***effective*** rainfall, i.e. gross rainfall minus actual evapotranspiration. For Blessington, this is estimated at 460 mm/year (**GSI** Source Protection Report).

On highly permeable soils and subsoils, as on this site, the majority of effective rainfall will infiltrate. If this were not so, the surface drainage network in the area would be much better developed than it is. The **GSI** Source Protection Report estimated that about **370** mm per year will infiltrate, i.e. 80% of effective rainfall. A similar value (375 mm/yr) was independently estimated by KT Cullen & Co. in a 1997 report (Further Information on Ashton Vulnerability, July 1997, reproduced in Appendix 6E of the Roadstone EIS).

The question of the appropriate recharge value to use depends, as the Applicant states, on the context in which the recharge takes place. In my view, the recharge value used in the **GSI** Source Protection Report (370 mm/yr as an average) is appropriate where recharge takes place to the aquifer in general. A lower value may be appropriate where recharge is impeded by a capping of less permeable material.

For an engineered landfill, where a carefully installed quality-controlled cap would be in place, a much lower value would be appropriate.

In relation to the waste in areas 1, 4, and ***6***, the permeability and continuity of the capping (silty deposits) appears unproven. Where potential recharge is impeded by a discontinuous capping, the diverted recharge may move laterally until it encounters the nearest permeable material, and then infiltrate vertically. Hence it may infiltrate quite close to the waste and, on meeting a further low permeability layer, may migrate sideways into the waste. Hence a non-engineered cap is likely to be much less successful in reducing total infiltration to the waste than an engineered cap, although it will probably slow down the infiltration.

(c) Storativity

Storativity or effective porosity strongly influences the estimated groundwater velocity (or linear seepage velocity) – i.e. the actual speed with which groundwater (and any contaminants it contains) moves from one point to another, e.g. from beneath a landfill to a receptor well.

The relevant formula is:

$V = k \times I / \Phi$, where

k – permeability, e.g. 7 m/d

I – hydraulic gradient, e.g. 0.0125

Φ – effective porosity, e.g. 0.18 (18%)

The higher the effective porosity, the lower the velocity. Gravel aquifers are generally characterised by a high porosity, high permeability, and low hydraulic gradient, and by relatively slow groundwater flow.

In the Applicant's modelling, an effective porosity of 18.2% (0.182) is stated to have been used, and this is satisfactory.

Conclusion:

The model input parameters requested by the Agency are appropriate for the conditions described. If modelling of a 'worst-case scenario' is desired, it would be appropriate to use a permeability of 20m/day. A low recharge/infiltration rate is appropriate for modelling of the proposed engineered landfill.

Page 13, Section 3.2.4: Groundwater Protection Response

The appropriate groundwater protection response for a proposed landfill at the Blessington site is as stated in our letter to the Applicant's consultants dated 17 November 2003 and attached to the EIS as Appendices 1A and **6K.** This advice remains unchanged.

Given the comment in the Inspector's Report (pages **8-9)** that, in his opinion, the Blessington Gravel Aquifer "should be designated and given a GSI/DOELG/EPA matrix response of R4", some additional observations seem appropriate:

(a) A response rating of R4 would require ***either*** that the site should be accepted as lying within the Zone of Contribution for a large groundwater supply source (e.g. Wicklow County Council's Blessington wellfield), ***or*** that the Blessington Gravel Aquifer should be re-classified as a Regionally Important (rather than Locally Important) Aquifer.

(b) As noted above, there is no evidence that areas 1, 4 and **6,** or the proposed engineered landfill, lie within the Zone of Contribution of the Blessington wellfield. (They do, however, clearly lie within the ZOC for the Cookehill water well, of which I was previously unaware.)

(c) At the time of preparing the Blessington Source Protection Report, the Blessington Gravel Aquifer was not considered sufficiently large, or continuous, or productive, to warrant classification as a Regionally Important Aquifer. No new evidence has been produced to change that view. While it is appreciated that the Council wells are quite productive, and that the Council supply is very important to the town and its population, the aquifer simply does not meet the GSI's criteria for designation as regionally important:

- While the mapped extent of the gravel deposit at Blessington (about 9 km^2) is just short of the basic areal criterion of 10 km^2, there is doubt as to the continuity of the aquifer within that area - e.g. at least one dry well near the Council's wellfield, two other dry wells elsewhere, and considerable volumes of less permeable deposits (silts, fine sands, etc.) in several exploratory/monitoring wells.
- It is not clear that there is at least 5 metres of saturated aquifer across the entire mapped area of the gravel deposit.
- The yields of the Council wells, while substantial, are a good deal less than are known from confirmed regionally important aquifers, such as at the Curragh (Kildare).

It should also be pointed out that, while it would be appropriate to re-classify an aquifer on foot of new information about the extent, continuity or productivity of that aquifer, it is not appropriate to re-classify an aquifer in order to achieve a particular groundwater protection response in a particular case.

Further comments

The ultimate destination for migrating leachate from Areas 1,4, and 6, and from the proposed landfill

If some degree of contamination occurs, however slight, and the contaminated water does not migrate to the various water wells, nor to the Burgess Stream, its ultimate destination must be the Pollaphuca Reservoir.

Hence the primary receptor (apart from the groundwater itself) at risk from the illegal landfills, and from any leakage from the proposed engineered landfill, is the Pollaphuca Reservoir. Dublin City Council has expressed concern about this risk.

It appears that this risk has not been explicitly predicted. Instead, predictions have been made for the closer receptors, namely the Burgess Stream, the 'theoretical well' down gradient of Area **6,** and the various existing water wells.

The Reservoir, being further away, should be at a lower risk than the closer receptors. However, I suggest that an explicit risk assessment should be undertaken for the Reservoir.

Geoff Wright
Senior Hydrogeologist
Groundwater Section

17 October *2005*

Appendix I: Permeability Estimation

Section **3.5.4** on page 12 of Appendix 6A, says that the range of hydraulic conductivity **(k)** in the gravels, as indicated by three pumping tests, was 5 x 10^{-8} to **9 x** 10^{-5} m/sec, equivalent to **0.004** to **8** m/day.

Section 3.5.5 says that in discussions with the EPA, a 'k' value of 1 x 10^{-6} m/sec was "considered representative of the aquifer as a whole", but that it was decided to adopt a more conservative value of I x 10^{-5} m/sec or **0.864** m/day.

I consider that these values are well below what would be expected in this gravel aquifer, based on the following evidence:

(a) 'k' values for gravel aquifers in hydrogeological literature

Fetter ***(Applied Hydrogeology,*** 3rd Ed, **1994,** page 323) cites values of **0.864** to **864** mld for "coarser, water-sorted glacial materials", such as are the Blessington deposits are understood to be.

Terzaghi & Peck ***(Soil Mechanics in Engineering Practice,*** 2nd Ed, **1967,** page 55) likewise suggest that "Clean sands, clean sand and gravel mixtures" should have a permeability in the range of 1 x 10^{-3} to 1 cm/sec **(0.864** to **864** mld). Thus a value of **0.864** m/d would be at the very lowest end of the scale for such deposits.

Brassington ***(Field Hydrogeology,*** **1988,** page 57) indicates that "clean sand, and sand and gravel" typically has a hydraulic conductivity in the range of 10 to 100 m/d.

(b) 'k' values in previous experience of the Blessington gravel aquifer

The GSI's Groundwater Source Protection Report for the Blessington Gravel Aquifer (part of the Co. Wicklow Groundwater Protection Scheme) documents two pumping tests in boreholes PW1 and PW2 at the Council depot, near Blessington village. PWI was tested at 455 m^3/d for 72 hours. PW2 was tested at 305 m^3/d for 72 hours. The report also records two other tests carried out nearby, for Ballymore Homes Ltd and Margrove Ltd.

From these data, it is clear that the Blessington sand and gravel aquifer has a high permeability and transmissivity, at least in places. However, the lack of water in the first WCC borehole (33.5 m deep) at the Council Depot suggests patchy permeability.

The table below summarises the test results.

Well	**PW1**	**PW2**	**Ballymore Homes, BH2**	**Margrove Ltd, TW1**
Depth of borehole, m	**18.6**	**14.6**	**11.66**	**12.2**
Date of Test	20-23/2/96	27-3011 1/95	17-20/5/95	8-12/7/96
Duration of test	72 hours	72 hours	72 hours	4 days
Discharge rate, m^3/d	**455**	**305**	**662**	**340**
Drawdown @ end of test, m	**5.33**	**9.66**	**0.305**	**2.4**
Specific capacity @ 72 hrs, m^3/d/m	**85.4**	**31.6**	**2170**	**142**
Estimated T m^2/d (Logan)	104	**38.5**	**2647**	173
Saturated thickness (m) (start of test)	**15.88**	**10.77**	**8.55**	**7.4**
Saturated thickness (m) (end of test)	**10.55**	1.11	**8.25**	**7.4**
Estimated mean k, m/d (based on start-of-test saturated thickness)	**6.55**	**3.57**	**321**	**23.4**
Note: allowances for well losses, aquifer dewatering and partial penetration could substantially increase these values.				

Appendix II: Brief Curriculum Vitae

EurGeol Geoffrey Richard Wright PGeo, CGeol, M.Sc, B.Sc.

Senior Hydrogeologist
Groundwater Section
Geological Survey of Ireland

Academic Qualifications:

B.Sc. (Hons) in Geology, Imperial College of Science and Technology, University of London, 1966. M.Sc. in Hydrogeology, University College London, 1967.

Professional affiliations:

Fellow of the Geological Society of London since 1968, Chartered Geologist, 1990.

Corporate Member, Institution of Geologists, London, 1979.

Professional Member, Institute of Geologists of Ireland, 1999.

European Geologist, 2002.

Member of the International Association of Hydrogeologists since 1976; President of Irish Group 1997-2000, previously Secretary 1980-83 and Treasurer 1986-88.

Career record:

1. **1967-1971:** Assistant Engineering Geologist with Binnie & Partners (consulting water engineers), Westminster, London.

2. **1971-1975:** Hydrogeologist with Hunting Technical Services, Borehamwood, Hertfordshire.

3. **1975-1988:** Senior Geologist (Hydrogeologist), Geological Survey of Ireland, Head of Groundwater Section from **1979.** Work included advising local authorities on groundwater resources development and protection, especially in counties Cork, Kerry, Limerick, Waterford, Dublin & Wicklow.

- Team Leader and report editor for two major EC-funded projects, producing national reports on Groundwater Resources Availability (completed 1979, published 1982) and Groundwater Quality and Vulnerability (completed 1983).
- Geological Survey representative on the Water Pollution Advisory Council (1980-86); instigated and authored **WPAC** report on Groundwater Pollution.
- Authored GSI information circulars on Water Wells (1979), Waste Disposal Sites (with Donal Daly, 1982), and Pumping Tests (1985).

4.1988-1994: Council for Conservation of Environment & Water Resources (CCEWR) / Public Authority for Water Resources (PAWR) / Ministry of Water Resources (MWR), Sultanate of Oman (on Career Break from GSI).

Head of Muscat Area Section, CCEWR/ PAWR/MWR; Acting Head/Head of Regional Affairs Department, CCEWR/PAWR/MWR; Deputy Head/Acting Head, Directorate-General for Regional Affairs, MWR.

5. **1994** to date: Geological Survey of Ireland, Senior Geologist, Groundwater Section.

Supervised county groundwater protection schemes for Tipperary (South Riding) Meath, Wicklow, Laois, South Cork, and North Tipperary. Supervising author of Groundwater Source Protection Report for Blessington, Co. Wicklow.

- Associate editor of Ground Water journal 1997-2000.