ROADSTONE DUBLIN LIMITED

Submission on the Hydrogeological Observations of the Geological Survey of Ireland (GSI) in relation to the Waste Licence Application for Remediation of Unauthorised Landfill Sites at Blessington, Co. Wicklow

WASTE LICENCE APPLICATION No. 213-1

30th NOVEMBER 2005

Volume 1 of 2

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BY HAND

30 November 2005

Dr. Jonathon Derham
Licensing Unit
Environmental Protection Agency
PO Box 3000
Johnstown Castle Estate
Co. Wexford

Dear Dr. Derham,

Re: Roadstone Dublin Ltd. – Waste licence Application for Remediation of Unauthorised Landfill Sites at Blessington, Co. Wicklow (Licence Ref. No. 213-1)

Submission on GSI letter to EPA dated 17 October 2005

Thank you for your letter of Nov 3rd 2005, and the attached report from the Geological Survey of Ireland (GSI).

Roadstone Dublin Ltd. (Roadstone) are pleased to note the decision of the EPA to seek the opinion of the GSI in this vital aspect of the Waste License Application, as it is the issue of hydrogeology which is at the core to the EPA Inspector's decision to recommend refusal of this application.

The GSI upheld our position on the three core issues at the heart of the EPA's Inspectors critique of the application, namely:

1. The inspector's contention that "The zone of contribution of the Blessington well field lies directly in the path of and down/cross gradient of the proposed cells" is "incorrect and not supported by the scientific evidence" (GSI).

2. The appropriate groundwater protection response "is as stated" in the GSI's letter to the applicant, dated November 17th 2003 and that "it is not appropriate to reclassify an aquifer to achieve a particular protection response in a particular case"

3. In the case of the numerical groundwater modelling, the GSI state that "The Applicants conceptual model is satisfactory", and that the "input parameters requested by the agency are appropriate". These were run on the QRA models submitted with our response to the proposed decision of the Agency. The GSI concur with the parameters for permeability, hydraulic gradient and effective porosity, used in these QRA's, all of which concluded that there was no significant risk to drinking water supplies arising from the presence of the waste in the ground.

We note that the GSI suggested that "If modelling a "worst-case scenario" it would be appropriate to use a permeability of 20m/day" and "that an explicit risk assessment should be undertaken for the

(Pollaphuca) reservoir". This scenario has been modelled by Mouchel Parkman as part of our response to your letter and is enclosed. It concludes in all cases that "as expected the existing waste bodies do not pose a credible threat to water supply from either the active groundwater wells in Blessington or the Pollaphuca Reservoir even in the worst case scenario".

The EPA gave four reasons for its proposed decision to refuse the application. We feel that the GSI report and our further modelling clearly supports our position on the first reason, hydrogeology. Regarding the second reason, the issue of waste volumes to be addressed, the inspectors report was equally incorrect in our view and we believe that the data supplied in our objection clearly demonstrates this. On the third reason, the issue of availability of alternative disposal sites, we believe that the further research carried out as part of our objection to the proposed decision clearly demonstrates that there is limited availability of suitable licensed facilities within the region to address this problem.

The fourth reason for refusal related to the alleged inadequacy of the proposed measures to be adopted in addressing the physical removal of the waste. The attenuation measures proposed were set out in Section 2 of the EIS accompanying the application. However if further measures were deemed to be appropriate by the inspector, this would be more appropriately dealt with by condition rather than as a reason for refusal of the entire application. The inspector himself acknowledged that a license would be required to remove the waste from Area **6,** in any event.

We are concerned that the Inspector wrote a very strong report recommending refusal of the application based on erroneous interpretations most critically on the crucial issue of hydrogeology. This undermines the credibility of his report and has had the effect of delaying unnecessarily the remediation of the site.

We would like to restate our fundamental position in this matter. Roadstone were not aware that dumping had taken place on our land at the time it happened and Roadstone never made any gain, financial or otherwise, from this activity but are willing to remediate the site, subject to grant of a license, at significant cost.

In the interests of the community of Blessington and for the protection of the environment, the EPA, Wicklow County Council and Roadstone are all agreed that the waste needs to be removed as quickly as possible, especially from Area **6.** All are further agreed that the residual waste needs to be placed in a licensed and engineered repository, either within the site or elsewhere.

If, following review of our objection to the proposed decision of the Agency, this further report from the **GSI** and our consultant's review of **it,** it is decided to proceed as proposed and refuse the license application, this will have the effect of further and, in our view, unnecessarily delaying the rehabilitation of the site. To avoid this further and unnecessary delay, we would urge the Agency to consider granting a license to excavate and process the waste where necessary, subject to appropriate conditions, and directing instead that the residual waste be disposed at a licensed landfill, **whether at the proposed facility or other licensed facility offsite.**

We remain available to meet with you or discuss further the issues raised by this report, if you deem it appropriate.

Yours sincerely,

Mark Prendergast

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Our Ref 721128/2/5

29 November 2005

Dear Dr Derham

Roadstone Dublin Limited - Waste Licence Application 213-1, Blessington Co. Wicklow

We are in receipt of your letter of 03 November 2005 regarding the above waste licence application and the objection of 08 August 2005.

We have read the letter to you from the GSI dated 17 October 2005 written by their Senior Hydrogeologist Geoff Wright.

The first reason stated by the Agency (12 July 2005) for refusal of a licence was

> "The zone of contribution of the Blessington well field lies directly in the path of and down/cross gradient of the proposed cells"

We are pleased to note on this major aspect the GSI say;

> "...this statement is incorrect and not supported by the scientific evidence"

and agrees with our assessment.

We also note that the GSI do not agree that the aquifer should be reclassified from $R3^1$ to R4 as suggested in 2.2 of the Inspectors Report of 05 July 2005, and gives detailed reasons why $R3^1$ is appropriate.

In final part of the GSI letter it suggests that

> "...an explicit risk assessment should be undertaken for the Reservoir..."

the reservoir in question being the Pollaphuca Reservoir. Mouchel Parkman (MP) have undertaken such a quantitative risk assessment, using hydraulic conductivities of 7m/d

and 20m/d suggested by the GSI to model what is considered to be the average and worst case situations respectively.

Our risk assessment report is attached which shows, as expected, that the existing waste bodies do not pose a credible threat to the water supply from either the active groundwater wells in Blessington or the Pollaphuca Reservoir, even in the worst case situation. We say 'as expected', because MP have previously modelled a number of situations which have not shown any significant impact on receptors much closer to the current waste sites or the proposed landfill.

Roadstone Dublin Ltd. (Roadstone) has previously commissioned four QRA reports from MP from 2003 to 2005 relating to groundwater and the potential for contamination. These are set out in the Bibliography included on page 23 of the objection submission dated 08 August 2005 (Report No. JBA 2901_10/SPD01). These were in response to an ongoing dialogue with the EPA and Wicklow County Council in order to better model and define the situation, none of which have found a risk to existing water supplies. Different professional views have been expressed regarding the parameters used in such QRAs, but the company view has been that the studies should encompass the full range of opinion, and believe this is the case. One area of disagreement relates to areas 1, 4 and 6 and the permeability and continuity of the capping (silty deposits). We accept that this capping was not engineered, but we note the GSI believe;

> "...it will probably slow down the infiltration".

The other areas where views have differed relate to permeability of the aquifer. The GSI correctly state that permeability is a key factor in modelling and say "The permeability of an aquifer is of critical importance in any modelling exercise, as it is also critical in the real underground system". And in reference to hydraulic gradient and the porosity "-errors in estimating permeability can have a much greater effect on the predicted outcomes than errors in the other two parameters."

The four QRA reports from MP from 2003 to 2005 on the potential for groundwater contamination from existing waste deposits on site, together with the QRA attached to this letter, are summarised in the Table below. The table shows the conclusions of these QRAs, the main input parameters and compounds predicted to arrive at receptors.

In tandem with the QRAs, Roadstone has had conducted extensive groundwater monitoring, the scope of which has been agreed with and reported to the EPA. This includes boreholes directly in the path of groundwater flow down dip from existing waste deposits. The waste has been present at the site since 1991/2, some 13 years, a significant period. The groundwater monitoring shows no significant impact at the down

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dip boreholes. This suggests to us that in all the modelling parameters we have used are conservative, even those that use 0.86 m/day permeability. Notwithstanding we have modelled at 20m/day as suggested by the GSI, even though we think this is at the extreme of possibilities.

Additionally, the proposed new repository has been modelled using LandSim with both a hydraulic conductivity of 7m/d and 20m/d and in both cases predicts no contamination of the groundwater aquifer below the site let alone at the Pollaphuca Reservoir.

MP feel it is worthwhile to restate Roadstone's overall objective in the matter, which is to remediate the unauthorised landfills in the shortest practical time and to have a waste licence for this activity to excavate, process where necessary and dispose of the residual waste at a licensed landfill facility whether at the applicants proposed facility or elsewhere.

Please let us know if you require any further information or clarification from us.

Yours sincerely

Dr Chris Chappell
Regional Manager
For and on behalf of Mouchel Parkman

cc. Mark Prendergast (Roadstone)
enc. Table summarising Quantitative Risk Assessments

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Report	Date	Description	Hydraulic Conductivity (K) m/d	Infiltration mm/y	Storativity	Contaminants Above Screening Levels	Conclusion
4000043/OR/3	August 2003	Original Model. Areas 1 and 4 to the Burgess Stream and Area 6 to a theoretical well 100m down gradient of Area 6	0.86	110	0.182	Area 1: Fluoride, lead and sulphide Area 4: Fluoride, Sulphide Area 6: Sulphide	The risks posed by the unauthorised deposited waste at the sites is generally considered low
4000043/OR/4 (1st Addendum to 4000043/OR/3)	December 2003	Area 6 only. Contamination modelled to a theoretical well 100m down gradient of Area 6.	20 (very conservative w case)	375	0.182	Area 6: Ammoniacal nitrogen. TPH aromatic >C8-10, TPH aromatic >C10-12, TPH aromatic >C12-16, sulphide, fluoride. barium and nitrite	Contaminants unlikely to reach receptors. This is an extreme worst case modelling exercise
4000043/OR/8A (Second addendum to Quantitative Risk Assessment and Modelling Strategy)	May 2005	Response to a letter from the Environmental Protection Agency to John Barnett and Associates (JBA) (agents for Roadstone Dublin Limited) dated 30th March 2005. Modelled Areas 1, 4 and 6 to active abstractions	0.864	375	0.182	Area 1: Fluoride. lead and sulphide Area 4: Fluoride, Sulphide Area 6: Ammoniacal nitrogen, TPH aromatic>C8-10, TPH aromatic >C10-12, TPH aromatic>C12-16, sulphide. fluoride. barium and nitrite	No change in the contaminants that exceed the RTVs. potential risks to the abstraction wells addressed by the risk management strategy
Modelling for Appeal 721128/OR/2A (3rd Addendum to 4000043/OR/3)	27/7/2005	Part of submission responding to the EPA decision to refuse Waste licence Application. Area 1 modelled to Murphy's well. Area 2 modelled to Deerpark well. Area 6 modelled to Deerpark, Devonshire and Wicklow County Council wellfield	7	365	0.182	Area 1: Fluoride, sulphide, lead Area 4: sulphide Area 6 – to all receptors: sulphide	No credible threat to wells in Blessington area
721128/OR/5 (4th addendum to 4000043/OR/3)	29/11/2005	Submission in response to GSI comments. Polluphuca Reservoir modelled as a receptor from Areas 1,4 and 6. Sensitivity analysis done for all appeal modelling (721128/OR/2A and to Polluphuca Reservoir) with a hydraulic conductivity of 20m/d	20	365	0.182	Area 1: sulphide, lead Area 4: sulphide Area 6:sulphide, selenium, strontium	No significant risk to Pollaphuca Reservoir

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INVESTIGATION INTO UNAUTHORISED TIPPING ON LANDS AT BLESSINGTON, CO. WICKLOW

Environmental Risk Assessment and Management Strategy

Addendum 4 - Response to Geological Survey of Ireland Letter

29th November 2005

Produced for
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Non Technical Summary

The Geological Survey of Ireland (GSI) were consulted by the Environmental Protection Agency (EPA) regarding the Appeal by Roadstone Dublin Limited (Roadstone) as to the refusal of a Waste Management Licence application by Roadstone. The GSI were supportive of Roadstone in a number of matters, particularly:

- The Zone of Contribution of the Blessington Wellfield was not in the path of the groundwater of the current waste deposits or the proposed new remediation landfill cells.
- The groundwater flow was to the Pollaphuca Reservoir.
- The Groundwater Protection Classification should not be changed, the effect of the change being the prohibition of any engineered remediation landfill.

The GSI did suggest that an explicit risk assessment should be undertaken for the Pollaphuca Reservoir, and they suggested some parameters used in the assessment should be more conservative than those used previously used by Mouchel Parkman (MP). This related particularly to hydraulic conductivity where the GSI suggested a 'worst case' hydraulic conductivity of 20m/d compared to 7m/d used by MP.

MP have undertaken further risk assessments using the GSI hydraulic conductivity parameters. This new study has found:

- The existing waste deposits do not pose a credible threat to water supply from either the active groundwater wells in Blessington or the Pollaphuca Reservoir.
- The new remediation landfill proposed for the relocation of waste from existing deposits will pose no significant risk to the Pollaphuca Reservoir, or indeed the groundwater directly beneath it.

The new study concludes that the concerns expressed in the Inspector's Report, 5 July 2005, regarding the risk assessment models are unfounded.

1 Introduction

1.1 Terms of Reference

This report has been written in response to a letter from the Environmental Protection Agency (EPA) and comments from the Geological Survey of Ireland (GSI) regarding an appeal by the Applicants: Roadstone Dublin Limited (Roadstone) against the proposed decision of the EPA to refuse a licence to remediate unauthorised landfills, process and relocate waste *to* an engineered waste repository on Roadstone land at Blessington. The comments from the GSI were in a letter dated 17/10/2005 to the EPA and were in response to a request from the EPA.

1.2 Objective

The objective of this report is to present

1. the results of modelling carried out with the Pollaphuca Reservoir as the receptor from Areas 1, 4, 6 and the proposed repository with a hydraulic conductivity MP consider to be suitably conservative (7m/d).

2. a sensitivity analysis on
   I. the models previously presented in reports 721128/OR/2A (P20 models with active abstractions as receptors) and 721128/OR/3B (LandSim model); and
   II. the models with the reservoir as a receptor using the hydraulic conductivity that the GSI consider to be the worst case (20m/d).

This report outlines changes made to previous models and does not contain details of the modelling process. Therefore the report should be read in conjunction with the documents already submitted during the appeal process, which are:

- Parkman (now Mouchel Parkman, MP) report 4000043/OR/03 entitled 'Environmental Risk Assessment and Management Strategy' (the QRA); and MP report 4000043/OR/8A entitled 'Second Addendum to Quantitative Risk Assessment & Management Strategy' which together form Appendix 6A of the Environmental Impact Statement (EIS) for the proposed scheme;
- The third addendum to the QRA: Report 721128/OR/2A entitled 'Application for Waste Licence - Modelling for Appeal'; and
- Report 721128/OR/3B entitled 'Comment on the Hydrogeological Setting of the new Landfill Site at Blessington".

1.3 Contents

This report contains the following information

- Chapter 2 summarises the comments made **by** the GSI
- Chapter 3 discusses the revised **P20** and LandSim models
- Chapter **4** gives the results of the revised modelling.
- Chapter 5 summarises the findings of the report and give conclusions regarding how this revised model impacts on Roadstone's appeal against the EPA decision.

2 Summary of GSI Comment

Roadstone received a letter from the EPA dated 3rd November 2005 which contained comments from the GSI relevant to hydrogeological aspects of Roadstone's objection to refusal of their waste licence application. The letter is reproduced in Appendix A.

The following summarises the GSI's comments on the hydrogeological aspects.

1. The GSI have commented on Roadstone's response to the following reason the EPA has given for refusing the waste licence application;

The siting of the proposed landfill facility on the locally important unconfined aquifer in proximity to the Wicklow County Council Blessington wellfield would constitute an unacceptable risk of environmental pollution. The zone of contribution of the Blessington wellfield lies directly in the path of and down/cross gradient of the proposed landfill cells

In response to this reason the GSI letter states that 'the scientific evidence supports the Applicant's assertion that…. "The proposed landfill facility is not located within the zone of contribution of the Blessington wellfield"... and that … "there is no realistic risk that groundwater from beneath the proposed landfill facility could reach and contaminate the Blessington wellfield."'

2. In the Inspectors Report on a Licence Application, dated 5th July 2005, the Inspector raises queries regarding the hydraulic conductivity of the gravel aquifer, the value *of* storativity and the annual infiltration.

The GSI confirm that "the Applicants conceptual model is satisfactory" and that the parameters already modelled as part of the appeal process (described in report 721128/OR/2) are in line with the EPA's suggestions and reasonably simulate conditions in the aquifer.

Those parameters are:

- Hydraulic conductivity (K). Which MP have modelled as 7m/d in their submission objecting to the licence refusal, although they believe this to be highly conservative. The GSI comment that they believe 7m/d to be a reasonable representation of the aquifer.

- Infiltration (Annual Recharge). MP have modelled an infiltration of about 370mm/y although they believe this to be conservative since the waste bodies are covered with fine grained clays which will act to reduce infiltration in the source area. The GSI consider this infiltration to be reasonable in

Areas 1, 4 and 6; but that a reduced infiltration would be acceptable when modelling the proposed repository.

- Storativity. MP have used an effective porosity of 0.182 throughout their modelling. The GSI confirm that they consider it to be satisfactory.

The GSI suggest that the Polluphuca Reservoir is explicitly modelled as a receptor; and that although the value of hydraulic conductivity already simulated is reasonable to simulate conditions in the aquifer that if a worst case scenario was to be investigated then a hydraulic conductivity of 20m/d would be appropriate.

3. In the Inspectors Report on a Licence Application, dated 5th July 2005, the Inspector suggests that the Groundwater Protection Response should be re-designated from to $R3^1$ to R4.

The GSI state that their advice to the Applicant's consultants, stated in their letter dated 17th November 2003, remains unchanged i.e. that the appropriate designation for the Blessington aquifer is $R3^1$.

In summary, the GSI suggest that the modelling done by MP, and submitted in the third addendum to the QRA in Report 721128/OR/2 entitled '3rd addendum to the QRA' is appropriate but that:

- The reservoir could be modelled explicitly as a reservoir; and
- That should a worst case scenario be considered, a hydraulic conductivity of 20m/d should be used.

3 Model Set **Up**

The following models were run

1. P20 - to simulate transport from Area 1, 4 and *6* to the Pollaphuca reservoir;
2. P20 - to carry out a sensitivity analysis on models simulating transport from Area 1, 4 and *6* to both active abstraction in Blessington and the Pollaphuca reservoir with an aquifer hydraulic conductivity of 20m/d;
3. LandSim - to simulate transport from the proposed engineered repository to the reservoir; and
4. LandSim - to carry out a sensitivity analysis on the model simulating transport from the proposed engineered repository both to active abstractions and the Pollaphuca reservoir with an aquifer hydraulic conductivity of 20m/d.

The sensitivity analysis has been carried out to investigate the unlikely possibility that the worst case hydraulic conductivity is 20m/d.

3.1 P20 Model

The same Contaminants of Concern (CoC), were considered during this modelling exercise as those identified in the 3rd addendum to the QRA report (721128 OR 2).

3.1.1 Reservoir as Receptor

The model was rerun to simulate transport of potential contaminants from each of Areas 1, 4 and *6* to the reservoir. In each case, the model used was the same as that described in the Modelling for Appeal report, with the following exceptions:

- Travel distance. In the 3rd addendum to the QRA report, the travel distances were measured from the down gradient edge of each area to active abstractions in the Blessington wellfield. In this modelling exercise, the minimum down-gradient distances between each area and the Pollaphuca Reservoir were used (Table 1). The distances were measured from the Site Location Plan (Drawing 4000043/A/10 in the QRA (report 4000043/OR/03) along travel paths following the groundwater contours described **in** the QRA report.

Table 1: Distance Between each Source Area and the Pollaphuca Reservoir

Area	Distance to the Reservoir (m)
1	**1500**
4	**1700**
6	850

- Hydraulic gradient. The hydraulic gradients used are given below

Table **2** : Hydraulic **Gradients**

Area	Hydraulic gradient
1	0.0098 (average gradient around Area 1 and between Area 6 and the reservoir)
4	0.0102 (average gradient around Area **4** and between Area 6 and the reservoir)
6	0.007 (gradient between Area 6 and the reservoir)

3.1.2 Sensitivity Analysis

Each of the original models from the 3rd addendum to the QRA report (721128 OR 2) plus the models introduced in the report, i.e. with the reservoir as the receptor, were rerun with the hydraulic conductivity changed from 7m/d to 20m/d.

3.2 LandSim

3.2.1 Introduction

The "LandSim" program is **a** probabilistic tool used to model the behaviour of a landfill over its life-cycle and to determine the resulting impact (if any) on groundwater receptors. In the context of Blessington, it has been used to model the performance of the proposed new site only.

Background

Previous LandSim modelling was submitted to the **EPA** as part of the original waste management license application for the proposed new site. This determined that using conservative and site-specific values, the site was unlikely to pose a significant risk to:

1. The groundwater beneath the site
2. The nearby Burgess Stream;
3. The nearest identified potentially down-gradient abstraction (the Murphy **Household's well):**
4. Any other local groundwater abstraction; or
5. The County Council Wellfield in Blessington

Abnormal scenarios, such as overtopping and uncontrolled head rise within the proposed repository were also modelled and mitigation measures recommended where necessary.

This license application was subsequently rejected and in their Inspector's report of the 5th July 2005, the EPA made comments about the choice of some input parameters. In response to this, a second phase of LandSim Modelling was undertaken and submitted to the EPA (Mouchel Parkman, August 2005). Key changes were:

1. Permeability was increased from 2 to 7 m/d;
2. Infiltration rates were changed very slightly; and
3. A different range of porosity values was used

That phase of modelling again predicted there would be no significant impact on the identified receptors or indeed on groundwater beneath the site itself.

Current Scope of Works

The current phase of works describes the modification of the LandSim model to reflect the GSI's comments.

3.2.2 *Method*

Reservoir Receptor

The LandSim model was set up to calculate transport from the proposed repository to the Pollaphuca Reservoir as a receptor.

In line with the previous modelling, the abnormal scenarios for an uncontrolled leachate head rise were also calculated to the Reservoir.

Sensitivity Analysis

The LandSim model was used to simulate flow from the proposed repository to groundwater beneath the site and the Pollaphuca reservoir.

As described in previous reports, the impact on the aquifer beneath the site has been assessed with regard to the EC Groundwater Directive, namely that there should be no discernible discharge of a List I substance from the base of the unsaturated zone and no pollution with List II substances (defined as a breach of quality standards) beneath the site. The possible impact of List I/II substances at the reservoir has also been determined in a similar way (i.e. no discernible concentrations and no pollution respectively). However, it should be noted that if there is no impact beneath the site itself, it automatically follows that there will be no impact at the reservoir or any other receptors.

Further transport modelling has not been performed to examine the effects of changed parameters on the risks associated with overtopping, as they were previously investigated and found to be potentially significant (Mouchel Parkman, May 2005). Mitigation measures were recommended in that report and as they are independent of the ground permeability, they will still negate any resultant impact on groundwater when implemented.

4 Results

4.1 P20 Results

4.1.1 Reservoir Receptor

The results of the modelling exercise are presented in the P20 spreadsheets in Appendix B of this report. The remedial target values (RTVs) calculated for soil, leachate and groundwater in each of the source Areas 1, **4** and 6 are compared to the highest (i.e. worst case) measured concentrations in soil, perched water and groundwater in Tables 3, **4** and 5 respectively. The maximum soil and perched groundwater concentrations were taken from the original QRA report. Concentrations formatted in **bold** type are greater than the RTVs and indicate exceedences which warrant further consideration.

It should be noted that the RTVs presented are results produced by the model. In many cases, the numbers are extremely high and do not represent possible soil concentrations or groundwater concentrations. These numbers (generally >$1x10^5$) should be interpreted as indicating that these contaminants would not pose a risk to the receptor at any concentration if dissolved phase migration was the transport mechanism.

Table 3: Area 1 Comparison of Tier 3 RTVs to Maximum Site Concentrations with the Reservoir as the Receptor

Analyte	Tier 3 RTVs			Maximum Site Values		
	Soil mg/l	Perched mg/l	Groundwater mg/l	Soil mg/l	Perched mg/l	Groundwater mg/l
Sulphate as SO2	359	3.82E+03	608		1390	
Fluoride as F	1.8	1.91E+01	3.04		0.8	2.7
Sulphide	0.00045	4.77E-03	0.00076			**0.05**
Ammoniacal Nitrogen as N	411.9	6.92E+02	307	9.5	16.6	0.8
Phosphorus as P	3.95	4.20E+01	6.69		**71.06**	1.03
Lead as Pb	6033	1.91E-01	0.03			**0.075**
Selenium as Se	1.84	1.91E-01	0.03		0.012	
Strontium	1.80	1.19E+01	3.04	**748**	5.96	0.34
Aromatic C8-C10	8.67E+19	1.47E+19	2.14E+21	42.3	0.1107	0.0035
Aromatic C10-C12	4.00E+28	4.33E+27	5.62E+30	42.3	0.1107	0.0035
Aromatic C12-C16	8.13E+46	4.44E+45	4.32E+50	42.3	0.1107	0.0035
Aromatic C16-C21	6.13E+63	1.06E+62	4.29E+68	42.3	0.1107	0.0035
Aromatic C21-C35	1.75E+216	3.83E+213	1.97E+234	42.3	0.1107	0.0035
Aliphatic C8-C10	6.62E+146	5.35E+144	1.29E+159	42.3	0.1107	0.0035
Aliphatic C10-C12	No Impact	No Impact	No Impact	42.3	0.1107	0.0035
Aliphatic C12-C16	No Impact	No Impact	No Impact	42.3	0.1107	0.0035
Aliphatic C16-C21	No Impact	No Impact	No Impact	42.3	0.1107	0.0035
Aliphatic C21-C35	No Impact	No Impact	No Impact	42.3	0.031	
tert-Butylbenzene	0.0064	1.91E-02	0.003	**0.034**	**0.04**	
Phenol	1.25E+74	6.28E+74	4.46E+82		0.129	
Fluorene	No Impact	No Impact	No Impact		0.209	
Phenanthrene	1.86E+216	3.61E+214	3.52E+235	0.323	0.656	
Anthracene	7.371E+140	1.43E+139	4.35E+152		0.897	

Analyte	Tier 3 RTVs Soil mg/l	Perched mg/l	Groundwater mg/l	Maximum Site Values Soil mg/l	Perched mg/l	Groundwater mg/l
Fluoranthrene	1.674E+244	1.21E+242	No Impact	0.69	1.054	
Pyrene	5.67E+104	4.10E+102	1.88E+113	0.619	0.283	
Benzo(a)anthracene	No Impact	No Impact	No Impact	0.339	0.311	
Chrysene	No Impact	No Impact	No Impact	0.361	0.329	
2-Methylnaphthalene	1.75E+92	2.38E+91	4.78E+100		330.288	0.042
Bis(2-ethylhexyl)phthalate	No Impact	No Impact	No Impact	63.063	1390	

Blank entry indicates not measured or less than laboratory detection limit
Bold entries have concentrations greater than RTVs

Table 4: Area 4 Comparison of Tier 3 RTVs to Maximum Site Concentrations with the Reservoir as the Receptor

Analyte	Tier 3 RTVs Soil mg/l	Perched mg/l	Groundwater mg/l	Maximum Site Values Soil mg/l	Perched mg/l	Groundwater mg/l
Total Cyanide	No Impact	No Impact	No Impact		0.11	
Fluoride as F	8.45	8.97E+01	3.45		0.9	1.7
Sulphide	0.002	2.24E-02	0.00086			**0.05**
Ammoniacal Nitrogen as N	7502.75	1.26E+04	633	16.6	7	1.5
Arsenic as As	105.51	8.97E-01	0.035	13.7	0.015	
Nickel as Ni	0.17	1.79E+00	0.069		**41**	
Strontium	8.45	8.97E+01	3.45		1.03	0.35
Aliphatic C8-C10	1.30E+173	1.05E+171	2.97E+173	42.3	0.0038	
Aliphatic C10-C12	No Impact	No Impact	No Impact	42.3	0.0038	
Aliphatic C12-C16	No Impact	No Impact	No Impact	42.3	0.0038	
Aliphatic C16-C21	No Impact	No Impact	No Impact	42.3	0.0038	
Aliphatic C21-C35	No Impact	No Impact	No Impact	42.3	0.0038	
Aromatic C8-C10	8.66E+24	1.47E+24	3.25E+23	42.3	0.0038	
Aromatic C10-C12	1.40E+35	1.15E+34	5.82E+33	42.3	0.0038	
Aromatic C12-C16	4.06E+56	2.22E+55	2.56E+55	42.3	0.0038	
Aromatic C16-C21	1.92E+76	3.34E+74	9.94E+74	42.3	0.0038	
Aromatic C21-C35	7.89E+253	1.73E+251	No Impact	42.3	0.0038	
Phenol	5.95E+88	2.99E+89	1.85E+90			0.02

Blank entry indicates not measured or less than laboratory detection limit
Bold entries have concentrations greater than RTVs

Table **5:** *Area 6 Comparison of Tier 3 RTVs to Maximum Site Concentrations with the Reservoir as the Receptor*

Analyte	Tier 3 RTVs			Maximum Site Values		
	Soil mg/l	Perched mg/l	Groundwater mg/l	Soil mg/l	Perched mg/l	Groundwater mg/l
Total Cyanide	No Impact	No Impact	No Impact	18.2	0.14	
Sulphide	0.0019	1.98E-02	0.00039			**0.05**
Ammoniacal Nitrogen as N	1027	1.72E+03	37.38	15.7	26.8	0.4
Arsenic as As	93.13	7.92E-01	0.0155	17.1	0.014	
Boron as B	7.45	7.92E+01	1.56		27	
Selenium as Se	7.64	7.92E-01	0.0156		0.013	
Strontium	7.45	7.92E+01	1.556	**298**	1.64	
Zinc as Zn	0.75	7.92E+00	0.1556	**544**	0.26	
Benzene	84.9	2.55E+02	5.8		0.212	
Aliphatics C6-C8	1.48E+61	7.33E+59	7.94E+58		0.077	
Aliphatic C8-C10	1.44E+120	1.16E+118	4.96E+117	68.6	0.2043	0.0212
Aliphatic C10-C12	No Impact	No Impact	No Impact	68.6	0.2043	0.0212
Aliphatic C12-C16	No Impact	No Impact	No Impact	68.6	0.2043	0.0212
Aliphatic C16-C21	No Impact	No Impact	No Impact	68.6	0.2043	0.0212
Aromatic C8-C10	4.12E+17	6.98E+16	2.54E+15	68.6	0.2043	0.0212
Aromatic C10-C12	6.13E+24	6.64E+23	2.92E+22	68.6	0.2043	0.0212
Aromatic C12-C16	5.61E+39	3.06E+38	1.97E+37	68.6	0.2043	0.0212
Aromatic C16-C21	3.01E+53	5.23E+51	4.65E+50	68.6	0.2043	0.0212
Aromatic C7-C8	1.67E+8	1.61E+08	4530000	68.6	0.2043	0.0212
Aromatic C21-C35	6.15E+175	1.34E+173	2.07E+173	68.6	0.2043	0.0212
Chlorobenzene	1.18E+16	1.31E+16	4.64E+14		0.033	
Ethylbenzene	1.22E+29	8.42E+28	4.12E+27	0.05	1.317	
Styrene	1.53E+67	3.22E+66	3.92E+65		0.461	
Isopropylbenzene	849	2.55E+03	58		0.088	
Propylbenzene	85	2.55E+02	5.80		0.056	
1,2,4-Trimethylbenzene	7.12E+139	2.41E+138	1.61E+138		0.104	
1,3,5-Trimethylbenzene	7.12E+139	2.41E+138	1.61E+138		0.239	
1,4-Dichlorobenzene	2.43E+65	3.09E+64	3.61E+63		0.21	
sec-Butylbenzene	84.8	2.54E+02	5.796		0.089	
tert-Butylbenzene	0.0264	7.92E-02	0.00156		0.096	
n-Butylbenzene	0.715	7.92E+02	0.00156		0.127	
Naphthalene	2.56E+75	3.49E+74	5.356E+73		0.467	
Phenol	1.85E+61	9.31E+61	1.066E+61		0.0044	
Chloroethane	4.36E+15	2.39E+16	8.55E+14		1.003	

Blank entry indicates not measured or less than laboratory detection limit.
Bold entries have concentrations greater than RTVs

4.1.2 Discussion

Incidences where site measured values exceed the Tier 3 Groundwater RTVs derived from modelling are detailed in the table below. Soil and perched water exceedences will not be discussed unless there **is** a corresponding exceedence in groundwater.

Table 6 : Exceedences of Tier 3 Groundwater **RTVs** by site measured values

Area	CoCs Showing Exceedences
1	Sulphide Lead
4	Sulphide
6	Sulphide

The travel times between the source areas and Pollaphuca reservoir were calculated for those contaminants predicted to exceed the RTVs. The travel time calculation sheets are given in Appendix C.

The table below summarises the predicted travel times to reach the Pollaphuca reservoir alongside the travel times to reach active abstractions taken from report 721128 OR 2.

Table 7: Predicted Times** to **Reach Receptors

Area	Analyte	Travel Time (yr) to Reservoir	Closest Active Well
1	Sulphide	10.9	2.1
	Lead	3.2E+6	8.6E+5
4	Sulphide	12.4	4.6
6	Sulphide	8.65	2.8

These are the same compounds as were predicted to reach the active wells in Blessington in the 3rd addendum to the QRA with the exception that fluoride, which is not predicted to reach the Pollaphuca reservoir. As expected the predicted travel times are greater to the reservoir than the wells since the travel distance is further and correspondingly the RTVs are higher than previously predicted in the first report.

As previously explained, the time for lead to reach any receptors is extremely large and in reality lead will precipitate out before reaching any active wells or the reservoir. It is expected that sulphide will not reach any receptors at significantly high concentrations since in aerobic conditions, such as this sand and gravel unit, it will oxidise to sulphate which has a much higher drinking water standard.

4.1.3 Sensitivity Analysis

The results of the sensitivity analyses of each modelling scenario are compared to the maximum site concentrations and previously derived RTVs in the tables below. RTVs formatted in **bold** type are less than the maximum site concentrations and indicate exceedences. All model output sheets are given in Appendix D.

The Wicklow County Council wellfield is not considered as a receptor since the GSI agree that it is not down gradient of the site and therefore is not a legitimate receptor.

Area 1

Murphy's Well Receptor

Table 8: Sensitivity of RTVs for Area 1 protective of Murphy's Well to Hydraulic Conductivity

Analyte	Max site values			K=7m/d, Receptor = Murphy's well Tier 3 RTVs			K=20m/d, Receptor = Murphy's Well Tier 3 RTVs		
	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)
Sulphate as SO2		1390		22.5	2400	310	590	6.27E+03	310
Fluoride as F		0.8	**2.7**	1.12	12	**1.55**	2.95	3.14E+01	**1.55**
Sulphide			**0.05**	0.00028	0.003	**0.0004**	**0.00074**	7.84E-03	**0.00039**
Ammoniacal Nitrogen as N	9.5	16.6	0.8	**0.54**	9.3	**1.57**	**4.63**	7.78E+00	**0.399**
Phosphorus as P		71.06	1.03	**2.48**	26.4	3.41	6.49	6.90E+01	3.41
Lead as Pb			**0.075**	3789	0.12	**0.015**	9916	3.14E-01	**0.0155**
Selenium as Se		0.012		1.16	0.12	0.015	3.02	3.14E-01	0.0155
Strontium	748	5.96	0.34	1.13	12	1.55	2.95	3.14E+01	1.55
Aromatic C8-C10	42.3	0.1107	0.0035	1.70E+06	2.90E+05	3.00E+05	258	4.36E+01	3.07
Aromatic C10-C12	42.3	0.1107	0.0035	5.13E+09	5.56E+08	1.20E+09	16808	1.82E+03	149
Aromatic C12-C16	42.3	0.1107	0.0035	1.50E+17	8.30E+15	7.50E+16	201456243	1.10E+07	1245989
Aromatic C16-C21	42.3	0.1107	0.0035	2.10E+24	3.70E+22	1.20E+24	3.13E+12	5.44E+10	8192772899
Aromatic C21-C35	42.3	0.1107	0.0035	1.30E+88	2.90E+85	4.90E+91	8.64E+50	1.89E+48	3.33E+48
Aliphatic C8-C10	42.3	0.1107	0.0035	7.10E+58	5.70E+56	7.40E+60	9.06E+32	7.32E+30	4.33E+30
Aliphatic C10-C12	42.3	0.1107	0.0035	4.30E+187	4.60E+184	1.10E+198	1.37E+112	1.48E+109	1.04E+111
Aliphatic C12-C16	42.3	0.1107	0.0035	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C16-C21	42.3	0.1107	0.0035	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
tert-Butylbenzene	0.034	0.031		**4.00E-03**	1.20E-02	5.55E-03	**0.010**	3.14E-02	0.0015
Phenol		0.04		1.00E+27	5.10E+27	4.30E+29	7.97E+12	4.01E+13	7.54E+12
Fluorene		0.129		3.80E+58	7.30E+56	4.70E+60	2.51E+67	9.52E+65	5.61E+66
Phenanthrene	0.323	0.209		1.40E+117	5.10E+115	1.90E+124	5.03E+48	9.79E+46	1.81E+47
Anthracene		0.656		2.40E+86	4.70E+84	9.70E+90	1.97E+34	3.81E+32	1.93E+32
Fluoranthrene	0.69	0.897		4.00E+99	2.90E+97	3.50E+104	6.24E+57	4.51E+55	1.24E+56
Pyrene	0.619	1.054		1.60E+40	1.20E+38	8.60E+40	1.02E+21	7.41E+18	2.29E+18
Benzo(a)anthracene	0.339	0.283		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Chrysene	0.361	0.311		7.80E+155	1.10E+153	2.00E+164	5.85E+91	8.07E+88	1.90E+90
2-Methylnaphthalene		0.329		1.50E+36	2.00E+35	5.20E+37	2.66E+19	3.63E+18	8.81E+17
Bis(2-ethylhexyl)phthalate	63.063	330.288	0.042	No Impact	No Impact	No Impact	1.29E+204	2.19E+201	3.46E+205

Reservoir Receptor

Table 9: Sensitivity of RTVs for Area 1 protective of Pollaphuca Reservoir to Hydraulic Conductivity

Analyte	Max site values			K=7m/d. Receptor = reservoir Tier 3 RTVs			K=20m/d. Receptor = reservoir Tier 3 RTVs		
	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)
Sulphate		1390		359	3.82E+03	608	920	9.77E+03	608
Fluoride		0.8	2.7	1.8	1.91E+01	3.04	4.60	4.89E+01	3.04
Sulphide			0.05	0.00045	4.77E-03	0.00076	0.0011	1.22E-02	**0.00076**
Ammoniacal Nitrogen	9.5	16.6	0.8	411.9	6.92E+02	307	34.7	5.83E+01	**4.21**
Phosphorus		71.06	1.03	3.95	**4.20E+01**	6.69	10.12	1.08E+02	6.69
Lead			0.075	6033	1.91E-01	0.03	15453	4.89E-01	**0.030**
Selenium		0.012		1.84	1.91E-01	0.03	4.71	4.89E-01	0.030
Strontium	748	5.96	0.34	**1.80**	1.19E+01	3.04	**4.60**	4.89E+01	3.04
Aromatic C8-C10	42.3	0.1107	0.0035	8.67E+19	1.47E+19	2.14E+21	1303606974	2.21E+08	48981202
Aromatic C10-C12	42.3	0.1107	0.0035	4.00E+28	4.33E+27	5.62E+30	6.66E+13	7.22E+12	2.62E+12
Aromatic C12-C16	42.3	0.1107	0.0035	8.13E+46	4.44E+45	4.32E+50	1.76E+24	9.63E+22	9.48E+22
Aromatic C16-C21	42.3	0.1107	0.0035	6.13E+63	1.06E+62	4.29E+68	2.06E+34	3.58E+32	8.37E+32
Aromatic C21-C35	42.3	0.1107	0.0035	1.75E+216	3.83E+213	1.97E+234	9.09E+127	1.99E+125	7.84E+128
Aliphatic C8-C10	42.3	0.1107	0.0035	6.62E+146	5.35E+144	1.29E+159	6.87E+84	5.55E+82	7.98E+84
Aliphatic C10-C12	42.3	0.1107	0.0035	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C12-C16	42.3	0.1107	0.0035	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C16-C21	42.3	0.1107	0.0035	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C21-C35	42.3	0.031		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
tert-Butylbenzene	0.034	0.04		**0.0064**	**1.91E-02**	0.003	**0.016**	4.89E-02	0.003
Phenol		0.129		1.25E+74	6.28E+74	4.46E+82	2.46E+39	1.24E+40	5.63E+40
Fluorene		0.209		No Impact	No Impact	No Impact	4.67E+172	1.77E+171	2.76E+176
Phenanthrene	0.323	0.656		1.86E+216	3.61E+214	3.52E+235	6.79E+126	1.32E+125	6.02E+128
Anthracene		0.897		7.371E+140	1.43E+139	4.35E+152	4.25E+82	8.22E+80	7.37E+82
Fluoranthrene	0.69	1.054		1.674E+244	1.21E+ 242	No Impact	1.51E+145	1.09E+143	1.66E+147
Pyrene	0.619	0.283		5.67E+104	4.10E+102	1.88E+113	1.95E+58	1.42E+56	2.86E+57
Benzo(a)anthracene	0.339	0.311		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Chrysene	0.361	0.329		No Impact	No Impact	No Impact	4.48E+229	6.18E+226	6.58E+233
2-Methylnaphthalene		330.288	0.042	1.75E+92	2.38E+91	4.78E+100	2.85E+51	3.89E+50	3.83E+51
Bis(2-ethylhexyl)phthalate	63.063	1390		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact

Area **4**

Deerpark Receptor

*Table 10: Sensitivity of **RTVs** for Area **4** protective of Deerpark Well to Hydraulic Conductivity*

Analyte	Max Site Values			K= 7m/d, Receptor = Deerpark well Tier 3 RTVs			K= 20m/d, Receptor = Deerpark well Tier 3 RTVs		
	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)
Total Cyanide		0.11		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Fluoride		0.9	1.7	7.65	81.2	2.42	21	2.28E+02	2.42
Sulphide			**0.05**	0.0019	**0.02**	**0.0006**	0.0054	5.69E-02	**0.0006**
Ammoniacal Nitrogen	16.6	7	1.5	**2.94**	493	16.5	68	1.15E+02	**1.24**
Arsenic	13.7	0.015		95.5	0.81	0.024	268	2.28E+00	0.024
Nickel		41		0.15	1.6	0.05	0.43	4.55E+00	0.048
Strontium		1.03	0.35	7.65	81.2	2.42	21	2.28E+02	2.42
Aliphatic C8-C10	42.3	0.0038		1.40E+111	1.10E+106	3.00E+109	3.82E+60	3.08E+58	8.26E+56
Aliphatic C10-C12	42.3	0.0038		No Impact	No Impact	No Impact	1.61E+200	1.74E+174	2.70E+196
Aliphatic C12-C16	42.3	0.0038		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C16-C21	42.3	0.0038		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C21-C35	42.3	0.0038		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aromatic C8-C10	42.3	0.0038		4.10E+14	7.00E+13	4.80E+12	2202685	3.73E+05	4559
Aromatic C10-C12	42.3	0.0038		1.30E+21	1.40E+20	1.20E+19	3891722555	4.22E+08	5457561
Aromatic C12-C16	42.3	0.0038		8.30E+34	4.50E+33	7.20E+32	7.80E+16	4.27E+15	6.23E+13
Aromatic C16-C21	42.3	0.0038		6.40E+47	1.10E+46	2.90E+45	1.36E+24	2.37E+22	3.84E+20
Aromatic C21-C35	42.3	0.0038		2.20E+164	4.90E+161	8.50E+162	1.25E+92	2.73E+89	1.09E+88
Phenol			0.02	1.00E+55	5.10E+55	1.90E+55	9.83E+26	4.95E+27	8.70E+25

Reservoir Receptor

*Table 11: Sensitivity of RTVs for Area **4** protective of Pollaphuca Reservoir to Hydraulic Conductivity*

Analyte	Max site values			k=7m/d Receptor = reservoir Tier 3 RTVs			k=20m/d Receptor = reservoir Tier 3 RTVs		
	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)
Total Cyanide		0.11		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Fluoride as F		0.9	1.7	8.45	8.97E+01	3.45	23.5	2.50E+02	3.45
Sulphide			**0.05**	0.002	2.24-.02	**0.00086**	0.0059	6.25E-02	**0.00086**
Ammoniacal Nitrogen as N	16.6	7	1.5	7502.75	1.26+04	633	247	415	5.9
Arsenic as As	13.7	0.015		105.51	8.97E-01	0.035	294	2.50E+00	0.035
Nickel as Ni		41		0.17	1.79E+00	0.069	0.47	5.00E+00	0.069
Strontium		1.03	0.35	8.45	8.97E+01	3.45	23.5	2.50E+02	3.45
Aliphatic C8-C10	42.3	0.0038		1.30E+173	1.05E+171	2.97E+173	7.12E+95	5.75E+93	5.07E+92
Aliphatic C10-C12	42.3	0.0038		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C12-C16	42.3	0.0038		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C16-C21	42.3	0.0038		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C21-C35	42.3	0.0038		No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aromatic C8-C10	42.3	0.0038		8.66E+24	1.47E+24	3.25E+23	1.45E+11	2.46E+10	461378460
Aromatic C10-C12	42.3	0.0038		1.40E+35	1.15E+34	5.82E+33	2.83E+16	3.06E+15	6.47E+13
Aromatic C12-C16	42.3	0.0038		4.06E+56	2.22E+55	2.56E+55	1.38E+28	7.52E+26	2.01E+25
Aromatic C16-C21	42.3	0.0038		1.92E+76	3.34E+74	9.94E+74	2.36E+39	4.10E+37	1.35E+36
Aromatic C21-C35	42.3	0.0038		7.89E+253	1.73E+251	No Impact	9.05E+143	1.98E+141	3.85E+140
Phenol			0.02	5.95E+88	2.99E+89	1.85E+90	2.37E+45	1.19E+46	4.61E+44

Area 6

Deerpark

*Table 12: Sensitivity of RTVs for Area 6 protective of Deerpark **Well** to Hydraulic Conductivity*

Analyte	Maximum Site Values			Tier 3 RTV					
				K=7m/d Receptor = Deerpark			K=20m/d Receptor = Deerpark		
	Soil (mg/kg)	Perched water (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched water (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched water (mg/l)	Groundwater (mg/l)
Total Cyanide	18.2	0.14		No Impact	No Impact	No Impact	1.0034E+114	1.00E+113	6.9798E+110
Sulphide			0.05	3.10E-03	3.30E-02	**3.66E-04**	8.79E-03	9.34E-02	**3.66E-04**
Ammoniacal Nitrogen	15.7	26.8	0.4	1.36E+02	2.28E+02	2.60E+00	7.00E+01	1.17E+02	4.61E-01
Arsenic	17.1	0.014		1.55E+02	1.32E+00	1.46E-02	4.40E+02	3.74E+00	1.46E-02
Boron		27		1.24E+01	1.32E+02	1.46E+00	3.52E+01	3.74E+02	1.46E+00
Selenium		0.013		1.27E+01	1.32E+00	1.46E-02	3.60E+01	3.74E+00	1.46E-02
Strontium	298	1.64		**1.24E+01**	1.32E+02	1.46E+00	**3.52E+01**	3.74E+02	1.46E+00
Zinc	544	0.26		**1.24E+00**	1.32E+01	1.46E-01	**3.52E+00**	3.74E+01	1.46E-01
Benzene		0.212		2.93E+00	8.79E+00	1.02E-01	5.79E-01	1.74E+00	6.83E-03
Aliphatics C6-C8		0.077		4.81E+38	2.40E+37	5.02E+35	4.04E+19	2.01E+18	8.90E+15
Aliphatic C8-C10	68.6	0.2043	0.0212	3.29E+78	2.70E+76	9.49E+74	4.39E+42	3.35E+40	1.76E+38
Aliphatic C10-C12	68.6	0.2043	0.0212	7.25E+244	7.80E+241	2.43E+241	7.85E+140	8.49E+137	6.65E+135
Aliphatic C12-C16	68.6	0.2043	0.0212	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C16-C21	68.6	0.2043	0.0212	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aromatic C8-C10	68.6	0.2043	0.0212	1.40E+10	2.40E+09	3.26E+07	3.18E+04	2.69E+01	2.19E+01
Aromatic C10-C12	68.6	0.2043	0.0212	5.37E+14	5.80E+13	8.62E+11	6.13E+06	5.40E+03	2.73E+03
Aromatic C12-C16	68.6	0.2043	0.0212	3.25E+24	1.80E+23	3.05E+21	8.20E+11	6.64E+05	1.90E+08
Aromatic C16-C21	68.6	0.2043	0.0212	5.35E+33	9.30E+31	1.81E+30	1.23E+17	4.48E+10	9.28E+12
Aromatic C7-C8	68.6	0.2043	0.0212	1.47E+04	1.42E+05	1.77E+02	2.79E+01	2.13E+15	1.07E-01
Aromatic C21-C35	68.6	0.2043	0.0212	1.86E+116	4.10E+113	2.36E+112	8.00E+64	1.75E+62	9.65E+59
Chlorobenzene		0.033		8.64E+08	9.60E+08	1.30E+07	3.86E+03	4.26E+03	1.72E+01
Ethylbenzene	0.05	1.317		4.02E+17	2.80E+17	4.28E+15	2.42E+08	1.67E+08	6.92E+05
Styrene		0.461		1.25E+43	2.60E+42	5.77E+40	3.99E+22	8.41E+21	3.76E+19
Isopropylbenzene		0.088		2.93E+01	8.79E+01	1.02E+00	5.79E+00	1.74E+01	6.83E-02
Propylbenzene		0.056		2.93E+00	8.79E+00	1.02E-01	5.79E-01	1.74E+00	6.83E-03
1 2 4 trimethylbenzene		0.104		9.43E+91	3.20E+90	1.35E+89	4.81E+50	1.62E+49	8.37E+46

				Tier 3 RTV					
	Maximum Site Values			K=7m/d Receptor = Deerpark			K=20m/d Receptor = Deerpark		
Analyte	Soil (mg/kg)	Perched water (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched water (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched water (mg/l)	Groundwater (mg/l)
1 3 5 trimethylbenzene		0.239		9.43E+91	3.20E+90	1.35E+89	4.81E+50	1.62E+49	8.37E+46
1 4 Dichlorobenzene		0.21		5.45E+41	6.93E+40	1.51E+39	4.28E+21	5.44E+20	2.43E+18
sec butylbenzene		0.089		2.93	8.97	0.102	0.578598006	1.74E+00	0.006831531
tert butylbenzne		0.096		4.39E-02	0.132	1.46E-03	1.25E-01	3.74E-01	1.46E-03
n- butylbenzene		0.127		1.19	1.32E-01	1.46E-03	3.38E+00	3.74E-01	1.46E-03
Naphthalene		0.467		1.23E+48	1.70E+47	4.02E+45	5.51E+24	7.50E+23	3.42E+21
Phenol		0.0044		1.06E+38	5.30E+38	1.14E+37	1.91E+18	9.60E+18	4.28E+16
Chloroethane		1.003		2.53E+8	1.39E+9	1.89E+7	9.22E+2	5.06E+3	2.05E+1

Devonshire

Table 13: Sensitivity of RTVs for Area 6 protective of Devonshire Well to Hydraulic Conductivity

Analyte	Maximum Site Values			K=7m/d Receptor = Devonshire			K=20m/d Receptor = Devonshire		
	Soil (mg/kg)	Perched water (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched water (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched water (mg/l)	Groundwater (mg/l)
Total Cyanide	18.2	0.14		No Impact	No Impact	No Impact	1.05E+124	1.05E+123	7.68E+120
Sulphide			0.05	3.26E-03	3.50E-02	**3.84E-04**	9.25E-03	9.82E-02	**3.84E-04**
Ammoniacal Nitrogen as N	15.7	26.8	0.4	1.89E+02	3.20E+02	3.63E+00	8.15E+01	1.37E+02	5.38E-01
Arsenic	17.1	0.014		1.63E+02	1.39E+00	1.54E-02	4.62E+02	3.93E+00	1.54E-02
Boron		27		1.30E+01	1.39E+02	1.54E+00	3.70E+01	3.93E+02	1.54E+00
Selenium		0.013		1.34E+01	1.39E+00	1.54E-02	3.79E+01	3.93E+00	1.54E-02
Strontium	298	1.64		**1.30E+01**	1.39E+02	1.54E+00	**3.70E+01**	3.93E+02	1.54E+00
Zinc	544	0.26		**1.30E+00**	1.39E+01	1.54E-01	**3.70E+00**	3.93E+01	1.54E-01
Benzene		0.212		4.78E+00	1.43E+01	1.67E-01	7.16E-01	2.15E+00	8.46E-03
Aliphatics C6-C8		0.077		1.76E+42	8.70E+40	1.94E+39	2.69E+21	1.35E+20	6.00E+17
Aliphatic C8-C10	68.6	0.2043	0.0212	3.14E+85	2.50E+83	1.00E+82	2.78E+46	2.25E+44	1.14E+42
Aliphatic C10-C12	68.6	0.2043	0.0212	1.56E+266	1.70E+263	6.97E+262	1.51E+153	1.63E+150	1.36E+148
Aliphatic C12-C16	68.6	0.2043	0.0212	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C16-C21	68.6	0.2043	0.0212	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aromatic C8-C10	68.6	0.2043	0.0212	1.55E+11	2.60E+10	3.69E+08	9.22E+04	1.56E+04	6.35E+01
Aromatic C10-C12	68.6	0.2043	0.0212	1.52E+16	1.70E+15	2.51E+13	2.84E+07	3.07E+06	1.27E+04
Aromatic C12-C16	68.6	0.2043	0.0212	6.63E+26	3.60E+25	6.46E+23	1.09E+13	5.94E+11	2.54E+09
Aromatic C16-C21	68.6	0.2043	0.0212	6.51E+36	1.10E+35	2.31E+33	4.39E+18	7.61E+16	3.35E+14
Aromatic C7-C8	68.6	0.2043	0.0212	5.20E+04	5.02E+04	6.33E+02	4.74E+01	4.58E+01	1.82E-01
Aromatic C21-C35	68.6	0.2043	0.0212	3.02E+126	6.60E+123	4.44E+122	4.03E+70	8.83E+67	5.02E+65
Chlorobenzene		0.033		8.54E+09	9.40E+09	1.31E+08	1.06E+04	1.17E+04	4.73E+01
Ethylbenzene	0.05	1.317		1.94E+19	1.30E+19	2.13E+17	1.47E+09	1.02E+09	4.25E+06
Styrene		0.461		8.72E+46	1.80E+46	4.29E+44	3.85E+24	8.11E+23	3.67E+21
Isopropylbenzene		0.088		4.78E+01	1.43E+02	1.67E+00	7.16E+00	2.15E+01	8.46E-02
Propylbenzene		0.056		4.78E+00	1.43E+01	1.67E-01	7.16E-01	2.15E+00	8.46E-03
1 2 4 trimethylbenzene		0.104		1.20E+100	4.10E+98	1.93E+97	1.39E+55	4.71E+53	2.49E+51
1 3 5 trimethylbenzene		0.239		1.20E+100	4.10E+98	1.93E+97	1.39E+55	4.7E+53	2.49E+51
1 4 Dichlorobenzene		0.21		3.19E+45	4.10E+44	9.34E+42	3.72E+23	4.74E+22	2.14E+20
sec butylbenzene		0.089		4.78	1.43E+01	0.167	0.72	2.15E+00	0.0085
tert butylbenzne		0.096		4.62E-02	1.39E-01	1.54E-03	1.31E-01	3.93E-01	1.54E-03
n- butylbenzene		0.127		1.25	0.139	1.54E-03	3.55E+00	3.93E-01	1.54E-03
Naphthalene		0.467		3.20E+52	4.40E+51	1.12E+50	1.13E+27	1.54E+26	7.12E+23
Phenol		0.0044		5.26E+41	2.60E+42	6.02E+40	1.51E+20	7.61+20	3.43E+18
Chloroethane		1.003		2.58E+9	1.42E+10	1.98E+8	2.56E+3	1.41E+4	5.72E+1

Reservoir

*Table **14:** Sensitivity of **RTVs** for Area 6 protective of Pollaphuca Reservoir to Hydraulic Conductivity*

Analyte	Max site values			K=7m/d, Receptor = Reservoir Tier 3 RTVs			K=20m/d, Receptor = Reservoir Tier 3 RTVs		
	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)	Soil (mg/kg)	Perched (mg/l)	Groundwater (mg/l)
Total Cyanide	18.2	0.14		No Impact	No Impact	No Impact	9.68E+172	9.68E+171	3.07E+170
Sulphide			0.05	0.0019	1.98E-02	0.00039	0.0053	5.59E-02	**0.00039**
Ammoniacal Nitrogen	15.7	26.8	0.4	1027	1.72E+03	37.38	109	1.83E+02	1.29
Arsenic	17.1	0.014		93.13	7.92E-01	0.0155	263	2.23E+00	0.016
Boron		27		7.45	7.92E+01	1.56	21	2.23E+02	1.56
Selenium		0.013		7.64	7.92E-01	0.0156	21.5	2.23E+00	0.0156
Strontium	298	1.64		**7.45**	7.92E+01	1.556	**21.0**	2.23E+02	1.56
Zinc	544	0.26		**0.75**	7.92E+00	0.1556	**2.10**	2.23E+01	0.16
Benzene		0.212		84.9	2.55E+02	5.8	1.56	4.69E+00	0.03
Aliphatics C6-C8		0.077		1.48E+61	7.33E+59	7.94E+58	1.15E+32	5.72E+30	5.62E+28
Aliphatic C8-C10	68.6	0.2043	0.0212	1.44E+120	1.16E+118	4.96E+117	5.13E+66	4.14E+64	5.46E+62
Aliphatic C10-C12	68.6	0.2043	0.0212	No Impact	No Impact	No Impact	2.88E+212	3.11E+209	1.35E+208
Aliphatic C12-C16	68.6	0.2043	0.0212	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aliphatic C16-C21	68.6	0.2043	0.0212	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Aromatic C8-C10	68.6	0.2043	0.0212	4.12E+17	6.98E+16	2.54E+15	91331144	1.55E+07	120187
Aromatic C10-C12	68.6	0.2043	0.0212	6.13E+24	6.64E+23	2.92E+22	5.44E+11	5.89E+10	476720177
Aromatic C12-C16	68.6	0.2043	0.0212	5.61E+39	3.06E+38	1.97E+37	9.13E+19	4.99E+18	4.38E+16
Aromatic C16-C21	68.6	0.2043	0.0212	3.01E+53	5.23E+51	4.65E+50	7.54E+27	1.31E+26	1.23E+24
Aromatic C7-C8	68.6	0.2043	0.0212	1.67E+8	1.61E+08	4530000	1192	1.15E+03	8.4847711
Aromatic C21-C35	68.6	0.2043	0.0212	6.15E+175	1.34E+173	2.07E+173	5.64E+99	1.23E+97	2.14E+95
Chlorobenzene		0.033		1.18E+16	1.31E+16	4.64E+14	7205051	7.96E+06	61482
Ethylbenzene	0.05	1.317		1.22E+29	8.42E+28	4.12E+27	1.491E+14	1.03E+14	8.51E+11
Styrene		0.461		1.53E+67	3.22E+66	3.92E+65	1.07E+36	2.26E+33	2.27E+33
Isopropylbenzene		0.088		849	2.55E+03	58	15.64	4.69E+01	0.33
Propylbenzene		0.056		85	2.55E+02	5.80	1.56	4.69E+00	0.033
1,2,4-Trimethylbenzene		0.104		7.12E+139	2.41E+138	1.61E+138	3.28E+78	1.11E+77	1.61E+75
1,3,5-Trimethylbenzene		0.239		7.12E+139	2.41E+138	1.61E+138	3.28E+78	1.11E+77	1.61E+75
1,4-Dichlorobenzene		0.21		2.43E+65	3.09E+64	3.61E+63	6.12E+34	7.88E+33	7.89E+31
sec-Butylbenzene		0.089		84.8	2.54E+02	5.796	1.56	4.69E+00	0.033
tert-Butylbenzene		0.096		0.0264	7.92E-02	0.00156	0.074	2.23E-01	0.0016
n-Butylbenzene		0.127		0.715	7.92E+02	0.00156	2.02	2.23E-01	0.0016
Naphthalene		0.467		2.56E+75	3.49E+74	5.356E+73	1.36E+40	1.85E+39	1.96E+37
Phenol		0.0044		1.85E+61	9.31E+61	1.066E+61	1.56E+31	7.86E+31	7.82E+29
Chloroethane		1.003		4.36E+15	2.39E+16	8.55E+14	1.96E+6	1.07E+7	8.31E+4

4.1.4 Discussion of Sensitivity Analyses

Increasing the hydraulic conductivity from 7m/d to 20m/d has the result of increasing the RTVs of compounds, such as metals, which do not tend to stick to clay particles since there is more dilution by groundwater. However, it has the effect of reducing the RTVs for those compounds which do stick to clay particles since groundwater flow is more rapid and the simulation does not allow as much time for compounds to break down and this effect is not as large as the effect of more dilution in groundwater.

It should be noted that even with the hydraulic conductivity increased to 20m/d very few compounds are predicted to reach receptors and it should be stressed that, in the opinion of the authors of this report, it is extremely unlikely that the flow path between the sites and the receptors have a hydraulic conductivity of 20m/d. This sensitivity analysis has been completed purely with the aim of reassuring the EPA that all professional opinions have been considered.

4.2 LandSim

The results from the LandSim modelling have been extracted from the LandSim modelling outputs (full details of which are included in Appendix E). These are summarised in Table 15 to 18 below. The tables report values at: the base of the unsaturated zone; groundwater at the proposed landfill site boundary; and at the groundwater adjacent to the reservoir. The values reported are the highest concentrations at the modelled time slices. The 95th percentile confidence interval value has been quoted, which is generally assumed as a worse-case result for that particular model. Species are List I substances, except where otherwise indicated.

4.2.1 Reservoir Receptor

Table 15: Summary of LandSim Model Run 1 (K=7m/d to Reservoir) – Units mg/l). Filename (poula1v1.sim)

Species	Highest Conc. at base of Unsaturated Zone	Highest Conc. in aquifer at site boundary	Highest Conc. in groundwater adj. to Reservoir	Quality Standard	Impact on Groundwater beneath site?*	Impact on Reservoir?*
Ammonium (List II)	2E-6	7E-9	1E-9	0.12	No	No
Benzene	0	0	0	0.001	No	No
Chlorobenzene	0	0	0	0.001	No	No
Cyanide (total)	0	0	0	0.01	No	No
Naphthalene	0	0	0	0.001	No	No
Nickel (List II)	0.005	0.0002	0.0003	0.02	No	No
Phenols (List II)	0	0	0	0.0005	No	No
TPH aromatic C8-C10	0	0	0	7.7E-6	No	No
Pyrene	0	0	0	6.25E-6	No	No

4.2.2 Sensitivity Analysis

Table 16 : Summary of Model Run 2 (K=20m/d to Reservoir) – Units mg/l). **Filename (poula2v1.sim)**

Species	Highest Conc. at base of Unsaturated Zone	Highest Conc. in aquifer at site boundary	Highest Conc. in groundwater adj. to Reservoir	Quality Standard	Impact on Ground water beneath site?*	Impact on Reservoir?*
Ammonium (List II)	2E-6	3E-9	1E-9	0.12	No	No
Benzene	0	0	0	0.001	No	No
Chlorobenzene	0	0	0	0.001	No	No
Cyanide (total)	0	0	0	0.01	No	No
Naphthalene	0	0	0	0.001	No	No
Nickel (List II)	0.005	9E-5	9E-5	0.02	No	No
Phenols (List II)	0	0	0	0.0005	No	No
TPH aromatic C8-C10	0	0	0	7.7E-6	No	No
Pyrene	0	0	0	6.25E-6	No	No

Table 17: Summary of Model Run 3 (K=7m/d to Reservoir, Uncontrolled Head Rise Scenario) – Units mg/l). **Filename (poula3v1.sim)**

Species	Highest Conc. at base of Unsaturated Zone	Highest Conc. in aquifer at site boundary	Highest Conc. in groundwater adj. to Reservoir	Quality Standard	Impact on Ground water beneath site?*	Impact on Reservoir?*
Ammonium (List II)	4E-6	2E-8	4E-9	0.12	No	No
Benzene	0	0	0	0.001	No	No
Chlorobenzene	0	0	0	0.001	No	No
Cyanide (total)	0	0	0	0.01	No	No
Naphthalene	0	0	0	0.001	No	No
Nickel (List II)	0.008	0.0004	0.0005	0.02	No	No
Phenols (List II)	0	0	0	0.0005	No	No
TPH aromatic C8-C10	0	0	0	7.7E-6	No	No
Pyrene	0	0	0	6.25E-6	No	No

Table 18: Summary of Model Run I (K=20m/d to Reservoir, Uncontrolled Head Rise Scenario) – Units mg/l. **Filename (poula4v1.sim)**

Species	Highest Conc. at base of Unsaturated Zone	Highest Conc. in aquifer at site boundary	Highest Conc. in groundwater adj. to Reservoir	Quality Standard	Impact on Ground water beneath site?*	Impact on Reservoir?*
Ammonium (List II)	4E-6	2E-8	4E-9	0.12	No	No
Benzene	0	0	0	0.001	No	No
Chlorobenzene	0	0	0	0.001	No	No
Cyanide (total)	0	0	0	0.01	No	No
Naphthalene	0	0	0	0.001	No	No
Nickel (List II)	0.008	0.0004	0.0005	0.02	No	No
Phenols (List II)	0	0	0	0.0005	No	No
TPH aromatic C8-C10	0	0	0	7.7E-6	No	No
Pyrene	0	0	0	6.25E-6	No	No

4.2.3 Discussion

The results show that even during the sensitivity analysis, there is **no significant risk of a groundwater impact:**

1. beneath the site;
2. on the Pollaphuca Reservoir;
3. on the Burgess Stream; and
4. on any current or future abstractions in the Blessington area

This also applies for the uncontrolled leachate head rise scenario and for overtopping, subject to implementation of the mitigation measures previously outlined (Mouchel Parkman, 2005).

5 Conclusion

This work has been done in light of the comments made by the GSI regarding hydrogeological aspects of Roadstone's appeal against the EPA's refusal of the waste licence application for their lands at Blessington.

As described in the 3rd addendum report to the QRA (721128 OR 2A) the models are very conservative since:

- the infiltration in the source areas takes no account of the low permeability clay horizons which will act to significantly reduce infiltration, in reality we believe that our original estimate of 110mm/y is more representative of the conditions in the source zone than the effective infiltration of 370mm/y in the uncapped sand and gravel deposits elsewhere in the locality; and

- the hydraulic conductivity of 7m/d represents what MP consider to be a worst case scenario and was derived from an area known to be unusually permeable. In fact, our field tests in the vicinity of the areas of unauthorised waste resulted in a maximum value for hydraulic conductivity of 0.86m/d.

In this report, which forms the **4th** addendum to the QRA, the models have been rerun from Areas 1, **4** and 6 with the Pollaphuca Reservoir as the receptor and it has been found that the remedial targets are less stringent than when active abstractions are considered to be receptors. Therefore, we are still of the opinion that the existing waste bodies do not pose a credible threat to water supply from either the active groundwater wells in Blessington or the Pollaphuca reservoir.

The LandSim model has been re-run with the Pollaphuca Reservoir as a receptor and this has demonstrated that the proposed remediation landfill site will pose no significant risk to the Pollaphuca Reservoir.

In order to present a complete as possible assessment of all professional views we have also carried out a sensitivity analysis on the RTVs in Areas 1, **4** and 6 and the LandSim model, using a hydraulic conductivity value of 20 m/d as requested by the GSI. This exercise was recommended by the GSI to be considered as a worst case. However, the GSI agree that our modelling with 7m/d is appropriate and this work has been carried out despite our belief that it is extremely unlikely that the aquifer has an average hydraulic conductivity of 20m/d.

In summary, the report illustrates that the Pollaphuca reservoir is not at significant risk from the waste in Areas 1, **4,** and 6 or the proposed remedial repository. Therefore, following the additional modelling presented in this report and the modelling already presented in the initial appeal submission (which the GSI has agreed is appropriate), we consider we have successfully shown the concerns expressed by the inspector regarding the model to be unfounded.