

Environmental Engineering Research Centre, School of Civil Engineerir Queen's University Belfast, Belfast N. Ireland UK BT9 5AG

### **Perception of Industrial Contamination**



### Evaluating Risk

### Environmental Liability

- Perceived Ris
- Real Risk
- Human Health Impac
- Environmental Impact
- Social Impact

Cost vs. Benefit

- Time Scale
- Sustainable Society

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### Definition

"A Permeable Reactive Barrier is an engineered treatment zone of reactive material(s) that is placed in the subsurface in order to remediate contaminated fluids as they flow through it.

A PRB has a negligible overall effect on bulk fluid flow rates in the subsurface strata, which is typically achieved by construction of a permeable reactive zone, or by construction of a permeable reactive 'cell' bounded by low permeability barriers that direct the contaminant towards the zone or reactive media"

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### Active or Completed Full-Scale Sites



### **Case Study: Sustainable Brown-Field Re-Development EPSRC Waste and Pollution Management Study**



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- Portadown Gas Works Hydrogeology & Modelling BioGeochemistry Microbial Ecology Microbial Genetics Full-scale implementation Evaluation

- Economic Issues Brown-field development

Up to 1500 existing gasworks sites in the UK still requiring remediation; a significant proportion of UK derelict sites.

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- Water Quality
- Urban Redevelopment

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### ...Background































# Construction of BH8 (Multilevel to compare with BH7)Sample Port Construction : Note Stainless Steel filterImage: S

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Final Flow Field Pre Works

Note the effect of underground structures on pathlines.

(off-site migration or plume encountered where modelled predicted)









Model Prediction of Off-Site Migration of Plume

Concentrations of priority PAH's above regulatory consent (other evidence of MNA?)

Benzene (and other BTEX and DRO) do degrade before off-site migration































































Infiltration Trench Installation Vibro-Columns

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Contaminant (mg/l)	Groundwater Plume	Intercentor	After Aerobic PRB Reactor
DRO	13.3	2.6	<0.01
Acepanthlene	4.8	6.4	<0.01
Acenapthlyene	10.2	5.5	<0.01
Anthracene	1.0	1.6	<0.01
Flouranthene	0.6	0.9	<0.01
Flourine	5.7	9.8	<0.01
Nanthalene	320.8	57.7	<0.01
Phenanthrene	3.7	54	<0.01
Pvrene	0.4	0.4	<0.01
Substituted Phenol	4.3	0.6	< 0.01
Isomers			
Benzene	6.2	0.4	< 0.01
Toluene	1.7	0.07	< 0.01
Xylenes	1.0	0.05	< 0.01
TOC	83	20	3
Total Cyanides	10.5	8.9	1.5
Arsenic	0.06	0.12	0.07
Nitrate	<0.3	< 0.3	6.2
Ammonia	74	19.4	0.8
Sulphate	450	590	530
COD	295	NA	15 (?)
The following compounds Benzo(a)anthracene, Ben Indeno(123cd)pyrene, Chro	are not found above detec zo(a)pyrene, Benzo(b)flourd omium, Cadmium, Copper, Lec	ction limits in the groundwater inthene, Benzo(ghi)perylene, ad, Zinc, Nickel, Mercury	plume at the EPSRC WPM site: Chrysene, Dibenzo(ah)anthracene,

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Project		Cost
Site Preparation Works and Support for Reactive Barrier Installation	£	185,490
Installation of Slurry Wall and Reactor Cash discount for research purpose Net cost Installation of Slurry Wall and Reactor	£ £	212,720 30,000 <b>182,720</b>
Alterations to BT Phone lines	£	1,480
Monitoring borehole Installation	£	8,500
Total Cost Exclusive of VAT	£	378,190
Leveraged research support for the Portadown Project		
Total Contribution by EPSRC Supported Research Grant	£	388,747.00
Queen's University Belfast Civil Engineering (Source Re		



Constructed from Pre-cast Units with HDPE Liner

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- Became apparent these were not water tight. The HDPE had ripped causing a short size it and a
- Resulted in rebuild using PRB1 as template

### PRB2 - Rebuilding

- Rebuilt Feb-March 2003
- Used PRB1 as template
- Design Changes, limited to outlet pipe
- Direct concrete pour

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### **Mission Control**





### **Monitoring Wells**

- 50mm ID Monitoring wells installed
- PRB Multi level sampling (every 0.25m)
- Dataloggers installed



## Problem 1 – April/May 2003

- Lake Portadown
- PRB2 Floods over time
- Contractor failed to include Geo-Sock
- Install Infiltration Pipe Collection in GAC section
- Install Geosock
- Completed May 2003

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### Minor Works 1- May 2003

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# Problem 2 –July/August 2003

- PRB begins to flood again
- Outlet pipe blocked / infiltration trench problems?
- Install manhole/ MP15 downgradient
- Unblock GAC
- Increase infiltration trench dimensions
- Completed late Aug

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## Minor Works 2- August 2003





Unblocking of Outlet Pipe

### Problems come in threes

- Infiltration Trench
   extension
- Free 12" Water Mains Locating Service
- HASP Plan works!



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### Groundwater Monitoring

Monitoring of Groundwater across site
PRB2 reducing contaminants concentration

# Groundwater Monitoring: Aug-Oct 2003



# Summary of Monitoring results

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In-Situ degradation studies Continued control of PRB

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BAR I - COME	lumite and l								-					S.	-	-
PAH by GCMS	units ug 1 Pl	RE .	-				_		_						_	
Sample Identity	INTERCEPTOR		PRE ZVI		PRE SAND I		PRE SAND 2		PRE SAND 3		PRE GACI		PRE GAC2		POST GAC2	
	July 2004	Aug 2004	July 2004	Aug 2004	July 2004	Aug 2004	July 2004	Aug 2004	July 2004	Aug 2004	July 2004	Aug 2004	July 2004	Aug 2004	July 2004	Aug 2004
saphthalene	13.738	23.165	0.395	0.32	0.593	0.09	4.075	0.04	1.072	0.05	<0.01	0.014	0.196	< 0.01	< 0.01	< 0.01
cenaphthylene	23.729	10.85	0.177	0.8	0.115	0.94	0.257	0.87	0.107	0.78	<0.01	0.07	0.112	< 0.01	<0.01	< 0.01
cenaphthene	282.978	35.835	0.059	1.58	0.207	0.25	0.159	0.19	0.059	0.17	<0.01	0.04	0.841	< 0.01	<0.01	< 0.01
luorene	39.192	32.959	0.06	2	0.066	0.23	0.125	0.17	0.058	0.29	<0.01	<0.01	0.132	<0.01	<0.01	< 0.01
henanthrene	18.813	16.826	0.042	0.2	0.027	0.25	0.144	0.2	0.063	0.23	<0.01	<0.01	0.095	<0.01	<0.01	< 0.01
athracene	19.155	0.783	0.048	0.07	0.03	0.02	0.038	0.02	0.023	0.01	<0.01	<0.01	0.014	< 0.01	<0.01	< 0.01
laoranthene	1.885	1.514	0.09	2.27	0.019	0.21	0.02	0.09	0.016	0.05	<0.01	<0.01	0.045	< 0.01	<0.01	< 0.01
yrene	1.386	1.208	0.149	3.2	0.017	0.11	0.018	0.08	0.017	0.02	<0.01	<0.01	0.036	< 0.01	<0.01	< 0.01
yelopenta(ed)pyrene	0.022	<0.01	<0.01	< 0.01	< 0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01	< 0.01	<0.01	< 0.01
lenz(a)anthracene	0.077	0.011	<0.01	< 0.01	< 0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01	< 0.01	<0.01	< 0.01
hrysene	0.101	0.02	<0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01	<0.01	< 0.01
lenzo(b)fluoranthene	0.035	<0.01	<0.01	< 0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01	<0.01	< 0.01
lenzo(k)fluoranthene	0.031	<0.01	<0.01	<0.01	< 0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01	<0.01	< 0.01
lenzo(e)pyrene	0.056	<0.01	<0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01	<0.01	< 0.01
lenzo(a)pyrene	0.083	<0.01	<0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01	<0.01	< 0.01
adeno(123ed)pyrene	0.031	<0.01	<0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01	< 0.01	<0.01	< 0.01
Abenzo(ah)anthracene	0.013	<0.01	<0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01
lenzo(ghi)perylene	0.032	<0.01	<0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01
unthanthrene	0.012	<0.01	<0.01	<0.01	< 0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	< 0.01	<0.01	< 0.01
AH 19 Total	401.369	123.171	1.02	10.43	1.074	2.09	4.836	1.64	1.415	1.59	<0.01	0.124	1.471	< 0.01	<0.01	< 0.01



http://www.prb-net.cub.ac.uk

http://www.prb-net.qub.ac.uk/eerg/dissemination/wpm/inde

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http://www.eti.ca/

www.claire.co.uk

Design, Installation and performance assessment of a zero valent iron Permeable reactive Barrier in Monkstown, Northern Ireland; CL:AIRE Technology Report:TDP3, Nov 2001; Beck, Harris Sweeney.(ISBN 0-9541673-0-9)

Guidance on the Design, Construction Operation and Monitoring of Permeable Reactive Barriers: Environment Agency, 2002. (ISBN 1-85705-665-5)



