BOTANY GROUNDWATER CLEANUP PROJECT

STRATEGY REVIEW WORKSHOP

TUESDAY 31 March 2009

WORKSHOP REPORT

The Botany Groundwater Cleanup (BGC) Project Strategy Review Workshop was held following a request from the Community Liaison Committee (CLC) for more details on the inputs to and outcomes of a Strategy Review for the BGC Project that was conducted by Orica in November 2007. The outcomes of the Strategy Review were presented to the CLC in September 2008. A key presenter at the workshop was Professor Bernie Kueper, from Queen's University in Canada. Independent Monitoring Committee member, Professor Ian Acworth was invited by the CLC to attend the workshop. The workshop was held on 31 March 2009, chaired by John Kent.

This report summarises the presentations made at the workshop, and lists comments, questions or issues raised by participants, and the responses provided by members of the Botany Transformation Projects team, Prof B Kueper, Prof I Acworth and the government representatives present. Where necessary, additional information has been added to this report to clarify the verbal responses provided at the workshop. The presentations made to the workshop are available at www.oricabotanytransformation.com.

A list of workshop participants and apologies is provided at the end of this report. Participant names are recorded in italics under each comment or question.

1. Background to the Strategy Review – James Stening (Orica)

J Stening provided information about the events leading up to the Notice of Clean Up Action (NCUA) that was issued to Orica by the NSW Environment Protection Authority (EPA – now part of the Department of Environment, Climate Change and Water [DECCW]) in 2003. He described achievements to date, remediation technologies that Orica has investigated and trialled, and the reasons for the Strategy Review.

The following comments, questions and responses are noted in relation to the background to the Strategy Review:

Comment/Question/ Matter Raised	Response
Did the 90% of contaminant mass removed by the permeable reactive iron barrier trials include EDC? *Prof I Acworth*	90% relates to all contaminants. Reactive iron barriers cannot degrade EDC, so all of the EDC present in the groundwater at the trial location passed through. However, the location was selected because the relative concentration of EDC was low compared with the target contaminants from the former Solvents Plant and TCE Plant. Orica has successfully conducted bioremediation field trials for the removal of EDC at Southlands. *J Stening*
Why didn't Springvale Drain get cleaned up earlier? *L Newnam*	The cleanup of Springvale Drain was one of the first activities undertaken by Orica after August 1996, when the first detailed investigations of the groundwater contamination issues at Botany were reported. The drain was realigned and cleaned up in 1998/99. *J Stening*

Comment/Question/ Matter Raised	Response
How long have we known about the groundwater plumes? *G Blaschke*	ICI conducted initial investigations (Stage 1 environmental survey – essentially a 'snapshot') in 1989 and more detailed investigations from 1993 to 1996 (Stage 2). This is when the scope of the remediation works was first developed. Investigative drilling and analytical techniques were not very advanced until the late 1980s. *J Stening*

2. Dense non-aqueous phase liquid (DNAPL) behaviour – Prof B Kueper

Prof B Kueper presented information about the characteristics of dense non-aqueous phase liquid (DNAPL), how it behaves in both groundwater and different geological formations, the development of remedial technologies that address DNAPLs, and the difficulties associated with cleaning up DNAPL source areas. He also described the behaviour of DNAPL in the Botany aquifer. The following comments, questions and responses are noted:

Comment/Question/ Matter Raised	Response
How does the geology in Prof Kueper's DNAPL modelling shown in his animated Powerpoint presentation compare with that at Botany? *G Blaschke*	The modelling sample had coarser sands and was more heterogeneous than soils at Botany. The fine layers lead to a lateral spread of contamination. *Prof B Kueper* The geology shown in the model is similar to the bottom of the Botany aquifer. The top of the aquifer was formed by wind blown sands. *Prof I Acworth*
Does groundwater cause DNAPL to move faster? *G Blaschke*	DNAPL moves more slowly in saturated soil than through unsaturated soil because the DNAPL has to compete for pore space between the soil particles with the water. If the soil is above the water table (unsaturated soil), then there is less resistance for the DNAPL to enter and move through the pore spaces. *Prof B Kueper*
If you were to drill into a pool of DNAPL and extract the DNAPL, is a residual left behind? *G Blaschke*	Yes, the residual makes up about 25% of the pore space and it would be left behind. *Prof B Kueper*
What is the threat to humans and the environment when DNAPL is distributed/dispersed? *N Hillier*	DNAPLs create sources of contamination in groundwater and in soil vapour, which is how the contamination is typically dispersed into the wider environment. Exposure to elevated concentrations of chlorinated hydrocarbons (CHCs) in soil, groundwater or vapour could present unacceptable risks to human health and/or the environment. There is no unacceptable risk to humans or the environment if the groundwater plumes are being adequately addressed. *Prof B Kueper*
Should we disturb the DNAPL? *N Hillier*	Guidelines on the remediation of DNAPL recommend exercising caution when dealing with DNAPL and to avoid any activities that might mobilise the source areas. Caution should be taken and a very good reason is needed to disturb DNAPL. *Prof B Kueper*

Comment/Question/ Matter Raised	Response
Will the recommended management approach for DNAPL lead to more capping of contaminated sites? *N Hillier*	Undertaking a risk assessment is the first step in planning remediation for a site. Capping has not been looked at as a solution for the Botany groundwater contamination. Capping is typically used at landfill sites and often applied to control a vapour pathway. *Prof B Kueper* The site filling proposed at Southlands is proposed to create a barrier between the ground surface and asbestos contamination, and to raise the site level to avoid flooding. *Orica*
Is it correct to say the DNAPL is not going to disappear, that containment lines may prevent it moving but capping won't? *G Blaschke*	Capping will prevent the infiltration of rain water into the aquifer and the movement of vapours out of the aquifer. The benefit of containment lines is that they can control the flow of contaminated groundwater. DNAPL will not last forever, but will typically last for a very long time. *Prof B Kueper*
Could sheet piling be used to stop the contamination from migrating?	The use of sheet-piling (i.e., installing vertical metal sheets into the ground to stop the flow of groundwater) cannot occur at Botany because of the depth of the aquifer and also the amount of ground surface occupied by operating plant and equipment. *Prof B Kueper/J Fairweather*
Does the speed at which the groundwater flows have an impact on the DNAPL? *N Hillier*	Yes, if groundwater moves twice as fast, the DNAPL can dissolve twice as fast. However, dissolved contaminants then 'attach' themselves to soil particles by a process called adsorption. The reversal of this process, which is called desorption, is much slower than the process of dissolving DNAPL. This is the issue that Orica is confronting, and is the reason why the cleanup of the Botany groundwater will take a very long time. DNAPL contamination can be contained by containing the groundwater. *Prof B Kueper*
Would injecting large volumes of groundwater accelerate the rate at which DNAPL could dissolve? *J Burgess*	Yes, in theory and in practice. Re-injection of groundwater has been used at many sites to dissolve DNAPL. *Prof B Kueper* The possibility of doing this at Botany is very limited, given the high groundwater level and the possibility of causing flooding as a consequence. *S Corish*
Could Orica use the Groundwater Treatment Plant and TASR (GIR) to speed up the groundwater cleanup? *S Hall*	Orica had considered this scenario but it is not feasible. The groundwater level is very high, which means that there is not a large enough unsaturated zone where water could be injected into the ground. The GIR system has been designed to be used as a backup to the GTP during prolonged shutdowns of the GTP only, Injecting water into the GIR system area to speed DNAPL dissolution could reduce the capacity of the aquifer to contain extracted groundwater when it is most needed (i.e., during a prolonged GTP shutdown).

Comment/Question/ Matter Raised	Response
	J Stening/S Corish/Prof I Acworth
There now appears to be more DNAPL pools than what was originally thought. Is this because of pumping? *N Hillier*	No. All the DNAPL currently present would have resulted from original historic contamination (due to leaks and historic handling and storage practices) at BIP. Most of the inferred source areas were identified in the Stage 2 survey conducted in 1993-1996. Improvements and refinements of our understanding of the DNAPL source areas' characteristics and distribution have been made since then through further detailed investigations. Most of the source areas have been inferred from the nature and extent of downgradient groundwater contamination. *Prof B Kueper/J Stening/J Fairweather*
Do you have any information regarding the impact of DNAPL on marine life? *G Blaschke*	DNAPL contamination is located close to where it initially entered the ground and doesn't migrate in the same way the contaminated groundwater does. Subsequently, it will not reach the estuary or Bay. Surveys of marine biota had identified impacts from historic contamination in surface waters. The two contaminants detected in marine biota were mercury and HCB, which were not sourced from DNAPL contamination. *Orica*

3. Information considered as part of the Strategy Review – J Stening

J Stening spoke about the information that was considered as part of the Strategy Review for the BGC Project. This included estimates of the contaminant mass in the aquifer (prepared by URS Australia), solute transport modelling (prepared by A D Laase Hydrologic Consulting, USA) and the Conceptual Site Model that was prepared by URS Australia. The modelling shows that the containment areas at Botany are effective at preventing ongoing contaminant migration past the containment lines.

J Stening reported that the estimated mass of CHCs in the Botany aquifer is 14,500 tonnes, but that this value could actually range from 9,600 tonnes to 19,400 tonnes. He explained how this estimate had been developed and the limitations of it. At the time of the workshop, 670 tonnes of CHCs have been recovered by Orica and treated at the SSU and GTP. The following comments, questions and responses are noted:

Comment/Question/ Matter Raised	Response
When did ICI commence using an inventory of the volumes of product produced and transported out of the Botany site? Wouldn't this have identified the significant leaks that were occurring? *N Johnston*	Orica has found minimal inventory records for this period, although it would be expected that good records of raw material purchases and product sales would have been kept. Similarly, there are no records of significant losses of containment, other than the instance in 1973 of a tank leaking EDC, which had been identified through inventory checks. Record keeping was probably not as accurate as it is today. *J Stening*
Orica would surely have much tighter controls on chemical storages these days. *N Johnston*	Yes, Orica now has appropriate bunding around its chemical storages. Losses in the past had also been from drummed waste stored in open areas which had leaked onto the ground, maintenance activities, and leaks from drains and

Comment/Question/ Matter Raised	Response
	pits. These days these sorts of practices are much more tightly managed. *J Stening*
It was estimated that 300 L of CHC leaked daily over a number of years. It was also noted that in the 1970s it was common practice to dump waste at sea. This was reported by the ABC show Four Corners in 1971. *J Burgess*	It was agreed that past practices and regulations were not adequate and had resulted in the legacy of contamination we are dealing with today.

4. Workshop with international experts in December 2007 – J Stening

J Stening provided details on the next step in the Strategy Review which was a workshop attended by local and international experts. He shared the conclusions reached at the workshop: that while a thermal remedy may be technically able to remove DNAPL at Botany, the benefits of DNAPL source depletion are limited in terms of reducing the overall cleanup timeframes and improving the management of risks to human health and the environment.

5. Feedback from Prof B Kueper – Prof B Kueper

Prof B Kueper presented further information about the Botany site. He stated that the GTP is the largest extraction system in the Southern Hemisphere and that the Botany plumes extend for approximately 1.5 km. He recommends continued monitoring to be sure that the containment lines are functioning properly. The following comments, questions and responses are noted:

Comment/Question/ Matter Raised	Response
Is it correct that there is not one site (worldwide) that has been cleaned to drinking water standards? *Prof I Acworth*	Yes, in relation to complex contaminated sites, no groundwater contamination site in the world has been cleaned to drinking water standards and no plume has been completely removed at any such site in the world. Some small dry-cleaning contamination sites may have been remediated to drinking water standards, but not any large complex sites like Botany. *Prof B Kueper*
What is 'dissolving'? *G Blaschke*	In the case of DNAPL, dissolving occurs when groundwater flows past the DNAPL and the DNAPL molecules are attracted to the water molecules, detach themselves from other DNAPL molecules and then become dispersed in the groundwater. At Botany the groundwater is then extracted and treated at the GTP. *Prof B Kueper* In the BGCP it is important to focus on the plume (of dissolved contaminants) as it is mobile – DNAPL is not. O*rica*
Are the contaminants completely destroyed at the GTP? *G Blaschke*	Yes. *Orica*
Does extraction of the groundwater destroy the bugs in	No. Extraction is containing the contamination, not draining the aquifer. Although the top level of the groundwater table

Comment/Question/ Matter Raised	Response
the aquifer that need certain levels of water? *G Blaschke*	is lowered in the vicinity of the containment lines, this represents only a small reduction in the overall height of groundwater in the aquifer. Bugs are adaptable, and different bugs live in the higher [more oxygenated] levels of the aquifer. *Prof B Kueper/Orica*
The session has been very informative and has clarified my understanding of DNAPL. It has put everything into context. *J Gennissen*	Noted
A few weeks ago community members had been glum about progress of the BGC project. But on looking back, we recognise what has been achieved and see that history has been made. The CLC has come a long way. Things have not always been what they now are. In the past Orica and the community would not have come together to share information like this and there was nowhere for the community to access expert advice. The CLC has kept a dialogue flowing. This must continue. *N Hillier*	L Archer invited participants to share any ideas they might have about sharing information from the workshop with the wider community.
Botany issues were identified in 1999, the NCUA was issued in 2003. The community was told the cleanup was world's best practice and that the cleanup would take 25 years. Part of the plume has already reached Botany Bay. There have been 'No Fishing' signs at Georges River for 40 years. There is no good news to pass on to our community networks. NSW Fisheries do not come to CLC meetings. The DoP should be here. Sydney Ports and others are impacting on the Bay. Development Applications are approved in isolation. The cumulative impact matters. Botany Bay and Catchment Alliance (BB&CA) noted that	The Chair noted that the containment lines ensure that the plume isn't going further, and that the contaminants are being treated at the GTP. He acknowledged that there is still a long way to go and that ongoing consultation with the community is essential.

Comment/Question/ Matter Raised	Response
Orica is trying, which is why it was not listed in BB&CA's brochure about polluters, but Orica still has a long way to go. The community needs to make sure Orica is there for the duration of the cleanup. *G Blaschke*	
As the regulator, the DECCW has achieved what it wanted to achieve: the protection of the environment and human health. I grew up in the area and saw many dead fish as a child. This is not the case anymore. The area now has fairly healthy estuaries and coastlines, and there are controls in place for better outcomes. Failure would have been if the contamination continued to affect Botany Bay. *N Johnston*	Noted
Things are very different to 20-30 years ago. For instance, there was no sewer connection at the BIP until 1958. Back then all the industrial sites discharged something to the environment. It is very difficult to apply today's standards to those days. Orica is here to clean up and remains committed to the project. Current operations have learned from our lessons of the past. *G Richardson*	Noted
Orica is required to continue to evaluate technologies and is committed to finding technologies not just for DNAPL depletion but also to clean up the contamination sorbed onto the soil particles. *J Stening*	Noted

Prof I Acworth and the DECCW were invited by the Chair to comment on the presentations. They provided the following comments:

Feedback from Prof I Acworth

Prof I Acworth reported that he has been working on the Botany aquifer for 20 years and was pleased to hear a realistic appraisal of the problems at Botany. He said he has always believed

that the cleanup would take up to 200 years and he believes Orica is doing all it can at this point of time. He said there is no magic solution to resolve the contamination quickly. He noted that the groundwater extraction bores only last about 20 years and recommends that the CLC considers what will happen if Orica ceases to exist in 100 years time.

Feedback from the DECCW

N Johnston acknowledged the importance of continuing to consider emerging technologies and stated that this would be reflected in the regulatory tools for the project. He said that in terms of CHCs, Botany is the most contaminated site in Sydney but there are 12 other groundwater contamination sites with similar issues. N Johnston said that parties with deep pockets were needed to ensure that remediation work commences and continues, and that it was fortunate that this is the case at Botany.

Actions/Tasks/Close

In closing, the Chair noted that the presentations had enabled better understanding of the Strategy Review; participants have learned that DNAPL is not moving, that the plumes have been contained and that there are hundreds of similar sites around the world. He noted that the contamination had been reduced by the 670 tonnes extracted to date and treated at the SSU and GTP.

The Chair called for tasks for the IMC. None was raised. Participants agreed to the following actions:

- Presentation slides are to be printed and distributed to participants. It was noted that a couple of slides in Prof Kueper's presentation would be excluded, for confidentiality reasons.
- J Stening's presentation to be uploaded onto the website.

The Chair thanked Prof B Kueper for his attendance, and Orica for coordinating the workshop. CLC members acknowledged J Stening and Prof I Acworth's contributions to the workshop.

6. Participants

The 31 March 2009 Groundwater Cleanup Project Strategy Review Workshop was attended by the following people:

Susan Hall	Aust. Environmental School.com
John Burgess	Aust. National Fishing Assoc.
Gary Blaschke	Botany Bay and Catchment Alliance (BB&CA)
Lynda Newnam	Botany Bay Explorers
Julia Gennissen	Botany Environment Watch / 3rd Ward Rockdale
Nancy Hillier	Botany Environment Watch
Warrick O'Brien	City of Botany Bay Council (CoBB)
John Kent	Community Liaison Committee Chair
David Gatherole	Dept. of Environment, Climate Change & Water (DECCW)
Matthew Hart	DECCW
Niall Johnston	DECCW
Bob Marr	DECCW
Kelvin Hawkins	Kellogg's
Lucy Archer	Orica

Stephen Corish	Orica
James Fairweather	Orica
Graeme Richardson	Orica
Wendy Salkeld	Orica
James Stening	Orica
Prof Bernie Kueper	Queen's University (Canada)
Ian Acworth	University of NSW / IMC member

Apologies were received from the following people:

Paul Shepherd	CoBB
Greg Russell	Dept. of Water and Energy
Helena Cooke-Yarborough	Kellogg's
Bronwyn Englaro	Randwick City Council
Christa Sams	Sydney Ports Corporation

7. List of abbreviations

BB&CA	Botany Bay and Catchment Alliance
BGC Project	Botany Groundwater Cleanup Project
BIP	Botany Industrial Park
CHCs	chlorinated hydrocarbons
CLC	Community Liaison Committee
CoBB	City of Botany Bay
DECCW	Dept of Environment, Climate Change & Water
DNAPL	dense non-aqueous phase liquids
DoP	Dept of Planning
EDC	1,2-dichloroethane, or ethylene dichloride
GIR	Groundwater Injection & Recovery
GTP	Groundwater Treatment Plant
ICI	Imperial Chemical Industries (ICI Australia is now Orica)
IMC	Independent Monitoring Committee
NCUA	Notice of Clean Up Action
SSU	Steam Stripping Unit
TASR	Temporary Aquifer Storage & Recovery (now referred as Groundwater Injection & Recovery [GIR])
TCE	trichloroethene