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VOLUNTARY MANAGEMENT PROPOSAL PROGRESS REPORT No. 33

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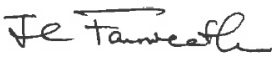
0	Issued	12 June 2020	 James Stening	 Caroline Vernon (Golder Associates) CEnvP 	 James Fairweather

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LIST OF ACRONYMS

ACRONYM	DEFINITION
ADWG	Australian Drinking Water Guidelines
AHD	Australian Height Datum
ANZECC	Australia and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand Governments
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BAF	Biological Aerated Filter
BGC Project	Botany Groundwater Cleanup Project (hydraulic containment and treatment project as described in the EIS)
bgl	Below ground level
BIP	Botany Industrial Park
BP	Bundle piezometer
CFM	Chloroform (trichloromethane)
CHC	Chlorinated hydrocarbon
CHHRA	Consolidated Human Health Risk Assessment
cis-1,2-DCE	cis-1,2-dichloroethene
CLC	Community Liaison Committee
CoPC	Chemical of potential concern
CPRC	Community Participation and Review Committee
CTC	Carbon tetrachloride (tetrachloromethane)
DNAPL	Dense non-aqueous phase liquid
DoD	Department of Defence
EDC	Ethylene dichloride (1,2-dichloroethane)
EIS	Environmental Impact Statement
EP&A Act	Environment Planning and Assessment Act
EPA	Environment Protection Authority
EPL	Environment Protection Licence
GEEA	Groundwater Extraction Exclusion Area
GIR	Groundwater Injection and Recovery
GRAMP	Groundwater Remediation and Management Plan
GTP	Groundwater Treatment Plant
HCB	Hexachlorobenzene
HCBD	Hexachlorobutadiene
HHRA	Human Health Risk Assessment
IMC	Independent Monitoring Committee
ISCO	In Situ Chemical Oxidation
JBS&G	JBS&G Australia Pty Ltd, an environmental consultancy
KBR	Kellogg, Brown and Root Pty Ltd, an engineering contractor
KMH	KMH Consulting Pty Ltd, an independent compliance auditor
LOR	Laboratory Limit of Reporting
MoU	Memorandum of Understanding
NCUA	Notice of Clean Up Action
NHMRC	National Health and Medical Research Council
NRAR	Natural Resources Access Regulator
NSW	New South Wales
OBLC	Orica Botany Liaison Committee
PCA	Primary Containment Area

ACRONYM	DEFINITION
PCE	Perchlorethylene (tetrachloroethene)
PRP	Pollution Reduction Program
QRA	Qualitative Risk Assessment
RAP	Remedial Action Plan
REF	Review of Environmental Factors
RO	Reverse osmosis
RWG	Regulatory Working Group
SCA	Secondary Containment Area
SCW	Scheduled Chemical Waste
SEPP	State Environmental Planning Policy
SESLHD	South Eastern Sydney Local Health District
SWC	Sydney Water Corporation
TBA	To be advised
1,1,2,2-TeCA	1,1,2,2-tetrachloroethane
1,1,2-TCA	1,1,2-trichloroethane
1,2,4-TCB	1,2,4-trichlorobenzene
1,2,4,5-TeCB	1,2,4,5-tetrachlorobenzene
TCE	Trichloroethene
TfNSW	Transport for NSW
TO	Thermal Oxidiser
TOC	Total Organic Carbon
TWA TLV	Time Weighted Average Threshold Limit Value
TWSA	Trade Waste Service Agreement
URS	URS Australia Pty Ltd, an environmental consultancy
USEPA	United States Environment Protection Agency
VC	Vinyl chloride (chloroethene)
VMP	Voluntary Management Proposal
VOC	Volatile organic compound
VSD	Variable speed drive

EXECUTIVE SUMMARY

This document is the 33rd report submitted in accordance with the Voluntary Management Proposal (VMP) under the *Contaminated Land Management Act 1997* and includes progress on the revised Groundwater Remediation and Management Plan (GRAMP) (Orica, 2020). It provides a progress update on groundwater monitoring, Groundwater Treatment Plant (GTP) performance, related environmental management activities and community outreach initiatives. Unless stated otherwise, the reporting interval covered by this report is 1 October 2019 to 31 March 2020, however if more recent and relevant information is available it is also included.

Voluntary Management Proposal

A proposed 2017-2020 Groundwater and Surface Water Monitoring Program was submitted to the NSW EPA on 31 March 2017. In an email received 23 May 2017, the NSW EPA advised that they had reviewed the document and found the proposed changes to be acceptable for the ongoing groundwater and surface water monitoring from 2017 to 2020. An Amendment Notice for the VMP was issued on 19 June 2017.

A revised VMP was approved by NSW EPA on 19 May 2020. This report is the first report prepared under the 2020 VMP.

Hydraulic Monitoring

Assessment of hydraulic data for the March 2020 monitoring event, with consideration of the six-step evaluation approach adopted by JBS (2012) and Golder (2013), indicates that, although some inconsistencies in hydraulic containment were noted, in particular at the Secondary Containment Area (SCA), the overall Botany Groundwater Cleanup (BGC) Project remedy objectives were met during this period.

Water levels were generally lower than during the previous monitoring period (i.e. September 2019) predominantly as a result of consistently lower than average rainfall. Lower groundwater extraction rates associated with reduced pumping performance and efficiency caused by well biofouling and the failure of EWF28D at the SCA was also evident.

Overall, effective hydraulic containment at the Botany Industrial Park (BIP), and within the target capture zones of the intermediate and deep aquifers at the Primary Containment Area (PCA) was evidenced by the averaged groundwater flow pattern and the achievement of target water levels for the monitoring period.

Elevated groundwater levels at the SCA do not support consistent hydraulic containment of the target capture zones at the SCA. Evidence of hydraulic containment on the basis of reverse hydraulic gradients was apparent in the shallow aquifer of the SCA and intermediate aquifer in the eastern and western portion of the SCA. A flat hydraulic gradient can be inferred in water levels achieved in the intermediate aquifer within the central portion of the SCA. However, elevated averaged groundwater levels were particularly evident in the eastern portion of the deep aquifer at SCA where the failure of extraction well EWF28D in April 2019 has reduced groundwater extraction efficiency.

Assessment of contaminant concentrations at Springvale Drain and Penrhyn Estuary, located downgradient of the SCA, indicates that the BGC Project remedy

objectives continue to be achieved, noting the expected lag for CHC migration due to the relatively flat hydraulic gradient between the SCA and Penrhyn Estuary.

It should also be noted that the slow migration rates between the SCA and Penrhyn Estuary allow for potential recapture of CHCs that migrate beyond the SCA during periods of poor hydraulic containment.

Well rehabilitation works and the planned installation of two deep extraction wells (EWF25D and EWF28D) in June 2020 (pending regulatory approval) are expected to improve pump performance and contaminant recapture within the eastern portion of the SCA. In addition, pump performance and hydraulic containment are expected to improve following the maintenance works completed during the scheduled GTP shutdown in March 2020.

Chemical Monitoring

The March 2020 sampling program represents a biannual monitoring event focused on assessment of volatile chlorinated hydrocarbon (CHC) concentrations in pore water, groundwater and surface water at Penrhyn Estuary and surface water at Springvale Drain and Floodvale Drain. Groundwater sampling was undertaken at key locations downgradient of the SCA in order to supplement the dataset that will be used to assess contaminant trends in the annual/biennial monitoring reports.

Reported CHC concentrations at BP01, BP117, MWF15, MWF17, MWF18 and MWF19 located on the shoreline of Penrhyn Estuary can be generally characterised by stable or decreasing trends in most CHC concentrations.

Increasing CHC contamination trends (both long- and short-term trends) are noted at MWF15D for EDC; at MWF17S for EDC and CFM; at MWF19I for EDC and CFM; and at MWF18D for EDC, PCE, TCE, CFM and VC, however these are not considered to represent a significant change in contaminant distribution.

An historical maximum concentration was reported for TCE at MWF18D. The increasing trend of TCE in the deep aquifer at MWF18 potentially represents limited migration of groundwater containing higher concentrations of dissolved phased TCE associated with the Southern Plumes within and upgradient of the central portion of the SCA. TCE was not detected in downgradient surface water monitoring locations, however consideration is being given to the augmentation of the monitoring program downgradient of this location to ensure adequacy of coverage within Penrhyn Estuary.

An historical maximum concentration was reported for PCE at BP117. CHC concentrations are historically highly variable at this monitoring location and consistent with or lower than those reported at downgradient monitoring locations. These increases potentially represent remnant Southern Plumes contamination being flushed from the generally stagnant area by the heavy rainfall in February 2020 or a result of inconsistent hydraulic containment.

The overall CHC concentrations within this area remain significantly lower than historical concentrations reported prior to operation of the SCA and the downgradient CHC concentrations in surface water remain low. Furthermore, the planned installation of new and replacement extractions wells (EWF25D and EWF28D) is

expected to improve hydraulic containment of the eastern portion of the SCA, upgradient of this location.

Continued monitoring of this location in consideration of the downgradient pore water transect locations is required to ensure the remedy objectives of the BCG at Penrhyn Estuary continue to be met.

In general, the March 2020 Penrhyn Estuary pore water data are consistent with previous monitoring rounds with the concentrations of the chemicals of potential concern generally decreasing with decreasing depth towards the discharge interface.

The concentrations of the key contaminants of concern in pore water reported in the March 2020 monitoring round are less than the ANZG (2018) Trigger Values for all samples with the exception of VC at BP42 in the 0.5 m and 2 m sample ports. It is noted that VC concentrations at BP42 are historically highly variable, the concentrations are significantly lower than the historical maximum concentrations for those depths, and VC concentrations did not exceed the trigger values at the discharge interface (0.1 m sample) ports nor in nearby surface water samples. No historical maximum concentrations for key contaminants were reported in samples collected from Penrhyn Estuary pore water during the March 2020 monitoring round.

The review of historical surface water monitoring data shows CHC concentrations have been generally consistent with, or less than, those reported in previous monitoring events. Comparison of the March 2020 surface water data with historical data shows CHC concentrations in Springvale Drain (in particular 1,2-dichloroethane (EDC)) have generally decreased several orders of magnitude compared to historical maximum concentrations. The decrease in EDC concentrations within surface water is attributable to the operation of the hydraulic containment system reducing groundwater levels and subsequently reducing groundwater seepage to Springvale Drain. Similarly, concentrations of all CHCs in Floodvale Drain significantly decreased following the commencement of groundwater extraction and remain low.

Key contaminant concentrations reported in the March 2020 monitoring round were less than the relevant ANZG (2018) Trigger Values at all locations. No historical maximum concentrations for key contaminants were reported in surface water samples collected during the March 2020 monitoring round.

Human Health Risk Assessment

There were no additional data presented in the March 2020 monitoring round that affect the conclusions of the recently-updated Consolidated Human Health Risk Assessment (CHHRA) (EnRiskS, 2018) that the calculated risks to human health are considered to be low and acceptable.

GTP Operation

The GTP continues to operate effectively. There was a scheduled maintenance shutdown of the GTP and groundwater extraction network from 28 February to 4 April 2020.

Routine pigging of the PCA header and SCA underbore header were carried out prior to the shutdown to ensure that flow is not restricted in these pipelines from the containment lines to the GTP.

The approximate total volume of groundwater treated since pump and treat activities commenced in 2005, including this period, is 25,310 ML with approximately 834 ML treated during this reporting period.

The estimated total mass of chlorinated hydrocarbons destroyed in the thermal oxidiser, including this period, is 1,482 tonnes with approximately 14.3 tonnes destroyed during this reporting period.

A pilot-scale trial of Moving Bed Biofilm Reactor (MBBR) technology commenced at the GTP in November 2019. The trial will likely run until late 2020.

Strategy Review Workshop

The fifth Botany Groundwater Strategy Review Workshop was held on 2 and 3 March 2020. A special meeting was held on the following evening to allow community members of the OBLC to discuss the outcomes of the Workshop with the three international experts and IMC hydrogeologist Dr Denis O'Carroll, who attended the Workshop. A report on the Workshop was issued to the EPA on 30 April 2020.

The primary conclusions for the 2020 Workshop are:

- The existing remedial strategy (hydraulic containment effected through large-scale 'pump and treat' of groundwater) is appropriate, effective and concluded to remain the most viable option for containment and source reduction through the foreseeable future;
- No recent remediation technology developments, or complementary technologies, are identified at this time that would merit exploration of their applicability to the BGC Project; and
- The review of source zone remediation options indicates uncertain performance relative to the current situation and high cost.

Notwithstanding the above outcomes, it was also noted that:

- Flushing and mass extraction alone (i.e., without natural attenuation) will not likely achieve remediation end goals in the short or medium term;
- In situ degradation is contributing to faster decay of the plumes and sources;
- The mechanisms of 'back-diffusion' and desorption create secondary sources which impact long-term persistence of plumes and their response to pumping.

Accordingly, a series of actions were captured in the context of moving towards an enhanced project direction aimed to:

- Optimise GTP performance in key areas of the plumes where practical and cost beneficial;
- Continue to investigate and enumerate existing back-diffusion/desorption and natural attenuative processes with the goal of defining a transition condition that could allow for cessation of operating the GTP;
- Continue to evaluate options to enhance natural attenuative processes to accelerate the rate of cleanup progress; and
- Continue to evaluate timing, metrics and potential effects on the receiving environment of shutting down the 'pump and treat' system

while maintaining the 'pump and treat' system for the medium to long term.

Community Consultation

Two ordinary meetings of the Orica Botany Liaison Committee (OBLC) was held during the six-month reporting period: 19 November 2019 and 10 March 2020.

The IMC Task 31 (for Dr O'Carroll to attend the Strategy Review Workshop and present at the Community Forum held at UNSW on 4 March 2020) has been completed. It resulted in IMC Task 32 (for Dr O'Carroll to prepare a plain English version of the Workshop findings, to document the overall context of the project, and the long-term view, for tabling with the Committee).

1 INTRODUCTION

The NSW Environment Protection Authority (EPA), issued Orica Australia Pty Ltd (Orica) with Notice of Clean Up Action (NCUA) No. 1030236 on 26 September 2003, under the *Protection of the Environment Operations (POEO) Act 1997*.

Following effective completion of the principal NCUA actions and consultation with the Community Liaison Committee (CLC) and Orica, the NSW EPA determined that the project would be best managed by a Voluntary Management Proposal (VMP) under the *Contaminated Land Management Act 1997*. An initial VMP was approved on 5 November 2010 (Approval No. 20101714), which replaced the NCUA as the regulating tool following the NCUA being revoked on 3 December 2010. A revised VMP was approved on 13 August 2015 (Approval No. 20151711). On 19 May 2020 that VMP was replaced with a revised VMP (Approval No. 20201704).

A revised Groundwater Remediation and Management Plan (GRAMP) (Orica, 2020) was submitted as an attachment to the 2020 VMP; it outlines the monitoring requirements as per the referenced Groundwater Treatment Plant (GTP) – Groundwater and Surface Water Monitoring Program (Golder, 2017). The GTP monitoring program includes three types of monitoring events: biannual, annual and biennial (in order of sampling program magnitude). The monitoring program is expected to be reviewed and revised later this year.

As specified in the GTP monitoring program (Golder, 2017), the March 2020 program is a biannual monitoring event.

This document is the 33rd report submitted in accordance with the initial and replacement VMPs and includes progress on the GRAMP (Orica, 2020). It is the first report prepared under the 2020 VMP. It provides a progress update on groundwater, pore water and surface water monitoring, hydraulic monitoring, GTP performance, related environmental management activities and community outreach initiatives. The reporting interval for this report is 1 October 2019 to 31 March 2020, however if more recent and relevant information is available, it is also included.

Previous reports are available at the relevant section of the website *http://www.orica.com/Locations/Asia-Pacific/Australia/Botany/Botany-Transformation-Projects* and a distribution list is provided at the beginning of this document.

2 COMPLIANCE SUMMARY

2.1 Voluntary Management Proposal

The objectives of the 2020 VMP are as follows:

- To protect human health and the environment via hydraulic containment of the chlorinated hydrocarbon contaminant plumes and source areas (as outlined in the GRAMP) (Orica, 2020). In the case of Penrhyn Estuary and Botany Bay, the hydraulic containment works will prevent contaminant migration to these receptors via groundwater or surface water in order to achieve protection for slightly to moderately disturbed ecosystems using the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZG, 2018);
- To monitor the nature and extent of the contamination to identify any potential exposures to the contamination that require management; and
- To investigate potential technologies to remediate source zones and plumes.

To achieve these objectives Part 3 of the VMP establishes a clear set of undertakings relating to each of the following components of the project:

- Maintenance and optimisation of hydraulic containment;
- Source area management;
- Contingency measures for the GTP;
- Community consultation;
- Chemical monitoring programs for groundwater and surface water (from which the data are used in assessment of risk to human health and the environment);
- Assessment of risk to human health and the environment (including additional monitoring programs for relevant environmental media); and
- Reporting requirements.

The groundwater contamination issues will require long-term management beyond the expiry date of this VMP. At that time, the objectives and management approach will be reviewed and modified as required.

The 2017-2020 Groundwater and Surface Water Monitoring Program (Golder, 2017) was accepted by the NSW EPA in May 2017. It is expected to be updated later this year.

A summary of the compliance status against VMP requirements is provided below.

Cond.	Summary of Requirement	Status	Reference Documents / Comments
P1	Maintain effective hydraulic containment of contaminants of concern at the Primary Containment Area (PCA) Containment Line.	**Ongoing compliance**	Summary of hydraulic containment of PCA provided in Section 3.1 and Attachment A of this report.

Cond.	Summary of Requirement	Status	Reference Documents / Comments
P1	Maintain effective hydraulic containment of contaminants of concern at the Secondary Containment Area (SCA) Containment Line.	**Ongoing compliance**	Summary of hydraulic containment of SCA provided in Section 3.1 and Attachment A of this report.
P1	Maintain effective hydraulic containment of contaminants of concern at the Botany Industrial Park (BIP) Containment Line commensurate with the available GTP treatment capacity and operational performance.	**Ongoing compliance**	Summary of hydraulic containment of BIP provided in Section 3.1 and Attachment A of this report.
P2	Conduct ongoing review of developments in remediation technologies and techniques for treatment of Dense Non-Aqueous Phase Liquid (DNAPL), sorbed mass and dissolved phase chlorinated hydrocarbon (CHC) contamination, and their practical applicability to the Botany Groundwater Cleanup Project.	**Work in progress**	On 2 and 3 March 2020 Orica conducted the fifth Botany Groundwater Strategy Review Workshop to discuss remediation strategy with a range of respected overseas and local experts. The inaugural Workshop was held in December 2007, the second in February 2011, the third in February 2014 and the fourth in February 2017. The revised remediation strategy arising from the 2007 Workshop was included in the VMP and supporting documents.
P2	Convene a Strategy Review Workshop every four years.	**Work in progress**	A workshop was held on 2 and 3 March 2020. A summary report of the outcomes of the review was issued on 30 April 2020.
P2	Provide an annual report to EPA that would assess the practical application and effectiveness of appropriate technologies in relation to the remediation. Every four years, this would also include a detailed summary of the outcomes of the Strategy Review Workshop.	**Ongoing compliance**	The 14th Annual Technology Report was issued on 30 April 2020.
P4	Continue and strengthen community/ stakeholder relationships that help to build awareness and transparency of the contamination, contamination risk, risk management and remediation process.	**Ongoing compliance**	Meeting minutes from the meetings of the Orica Botany Liaison Committee (OBLC), newsletters and newspaper columns included as part of the community/stakeholder program.
P4	Create a better understanding of public perceptions, information needs and community responses regarding current and emerging Botany Groundwater Cleanup (BGC) Project issues so that these can be anticipated and addressed.	**Ongoing compliance**	

Cond.	Summary of Requirement	Status	Reference Documents / Comments
	Orica must inform the community of developments in the Orica BGC Project by: a) Regular OBLC meetings (nominally three times a year unless otherwise agreed to by OBLC members); and b) Maintenance of an internet website providing information related to the BGC Project, which will provide access to copies of current reports prepared under this VMP.		a) The OBLC meets nominally three times per year (see Section 6.1) b) http://www.orica.com/Locations/Asia-Pacific/Australia/Botany/Botany-Transformation-Projects
P5	Orica will conduct chemical and hydraulic monitoring of groundwater and chemical monitoring of surface water to measure the effectiveness of hydraulic containment activities, to identify changes in the magnitude and extent of the contamination and to allow for the ongoing assessment of risks to human health and the environment. Orica will conduct groundwater monitoring in accordance with *Groundwater Treatment Plant Groundwater and Surface Water Monitoring Program 2017 – 2020* (Golder, 2017).	**Ongoing compliance**	The current monitoring program *Groundwater Treatment Plant Groundwater and Surface Water Monitoring Program 2017 – 2020* (Golder, 2017) was approved by the EPA on 23 May 2017. As specified in the monitoring program (Golder, 2017), the March 2020 event was a biannual monitoring event. A detailed assessment of hydraulic containment at BIP, PCA and SCA was undertaken by JBS (2012) using the United States Environment Protection Agency approach presented in *A Systematic Approach for the Evaluation of Capture Zones at Pump and Treat Systems* (USEPA, 2008). The assessment was updated by JBS&G and submitted to NSW EPA for review in September 2018. Following comments from NSW EPA, a revised report was prepared and submitted to NSW EPA in November 2019.
P6	Orica will implement a suitable monitoring program for the assessment of risk to human health, which is primarily based on groundwater and surface water monitoring. In addition, as described in the GRAMP, there are certain groundwater level and contaminant concentration conditions that will trigger the collection of additional soil vapour, flux emission and ambient air data. The trigger values are set out in the Consolidated Human Health Risk Assessment (EnRiskS, 2018). The scope of this monitoring program will be subject to regular review and possible modification with EPA consent.	**Ongoing compliance**	All reports now submitted to the EPA include relevant appraisal of potential risk to human health and hence identify any requirement to update the Consolidated Human Health Risk Assessment (CHHRA). The CHHRA has been updated and revised a number of times over the years. The latest version of the CHHRA (EnRiskS, 2018), approved by the EPA on 19 June 2018, has been posted on the Orica project website.

This report is the first report prepared under the 2020 VMP.

2.2 Environment Protection Licence No. 2148 (EPL 2148)

The GTP's operational environmental performance is regulated under the *POEO Act* as part of Orica's licence for its activities at Botany Industrial Park via EPL 2148. Orica reports compliance against EPL 2148 requirements via the submission of the annual return to the EPA up until now in September each year. On 19 May 2017 the EPA agreed to amend the licence fee period commencement date to 1 July, which brings forward the annual return submission date to late August. This followed a request by Orica to align the data collection period for EPL 2148 with the GTP's licences under the *Water Industry Competition Act 2006*.

Further amendments to EPL 2148 were made during the reporting period. An amended EPL was issued by NSW EPA under Variation Notice 1591963 on 19 May 2020. The following variations have been made to the licence:

- Condition A2 has been varied to remove Lot 1106 DP 1227173
- Condition A2 has been varied to reference drawing revision 2
- Condition L3.1 has been varied to replace reference to Point 15 with Point 16

No non-conformances were recorded for the reporting period 1 October 2019 to 31 March 2020.

In May 2020 NSW EPA carried out a five-yearly environmental risk assessment of EPL 2148.

3 MARCH 2020 MONITORING EVENT

Orica engaged Golder Associates Pty Ltd (Golder) to complete a monitoring event in March 2020 in accordance with the 2017-2020 Groundwater and Surface Water Monitoring Program (Golder, 2017).

The March 2020 monitoring event was a biannual monitoring event and was the 33rd monitoring event undertaken in accordance with the requirements of the VMP, which requires Orica to implement a comprehensive monitoring program within the Groundwater Extraction Exclusion Area (GEEA).

Groundwater level and groundwater and surface water chemical monitoring for volatile CHCs are undertaken biannually to measure effectiveness of containment and for ongoing assessment of potential risks to human health and the environment.

Groundwater, pore water and surface water samples are collected for volatile CHC analysis from the GEEA and Penrhyn Estuary, and surface water samples from Springvale Drain and Floodvale Drain.

Interpretation of chemical data is limited to significant changes in water quality that are identified during monitoring rounds. Parametric tests are used to identify increasing/decreasing trends in contaminant concentrations at sampling locations. Measured concentrations are also compared against those considered in the Consolidated Human Health Risk Assessment (HHRA) (EnRiskS, 2018).

Hydraulic containment at the SCA, PCA and BIP is assessed every six months.

Results and discussions are provided in the Golder report *Groundwater Treatment Plant – March 2020 Quarterly Groundwater and Surface Water Monitoring Report*. This report is bound separately as Attachment A. The remainder of this section has been extracted from the Golder report to summarise the monitoring events findings.

3.1 Hydraulic Monitoring

A detailed assessment of hydraulic containment at BIP, PCA and SCA was undertaken by JBS (2012) using the United States Environment Protection Agency approach presented in *A Systematic Approach for the Evaluation of Capture Zones at Pump and Treat Systems* (USEPA, 2008). Golder updated this assessment to incorporate more recent hydraulic and chemical monitoring data in September 2013 (Golder, 2013). The assessment concluded that effective hydraulic containment was being achieved at the containment lines and that the remedy objective of the BGC Project "*to achieve protection for slightly to moderately disturbed ecosystems using the Australian and New Zealand Guidelines for Marine and Fresh Water (2000)*" in surface water at Penrhyn Estuary was being achieved. USEPA (2008) nominates the following six steps for systematically performing a capture zone analysis:

- Step 1: Review site data, site conceptual model, and remedy objectives;
- Step 2: Define site-specific Target Capture Zone(s);
- Step 3: Interpret water levels;
    - potentiometric surface maps (horizontal) and water level difference maps (vertical)
    - water level pairs (gradient control points)

- Step 4: Perform calculations;
    - estimated flow rate calculation
    - capture zone width calculation (can include drawdown calculation)
    - modelling (analytical or numerical) to simulate water levels, in conjunction with particle tracking and/or transport modelling
- Step 5: Evaluate concentration trends; and
- Step 6: Interpret actual capture based on Steps 1-5, compare to Target Capture Zone(s), assess uncertainties and data gaps.

As noted by USEPA (2008), no single line of evidence will conclusively differentiate between successful and failed capture, rather, converging lines of evidence are used to increase confidence in the conclusions of the capture zone analysis.

Hydraulic monitoring data for the March 2020 monitoring period was assessed against the six steps considered by JBS (2012) in their assessment of hydraulic containment. On the basis of comparison of flux averaged concentration data against the adjusted ANZECC/ARMCANZ (2000)[1] Trigger Value and assumptions used by JBS (2012), the current target capture zones (well pairs) were considered.

Assessment of hydraulic data for the March 2020 monitoring event, with consideration of the six-step evaluation approach adopted by JBS (2012) and Golder (2013), indicates that, although some inconsistencies were noted, in particular at the SCA, the overall BGC Project remedy objectives were met during this period.

With the exception of parts of the SCA, groundwater levels were generally lower than during the previous monitoring period (i.e. September 2019) predominantly as a result of consistently lower than average rainfall. Lower groundwater extraction rates associated with reduced pumping performance and efficiency caused by well biofouling and the failure of EWF28D at SCA was also evident.

Overall, effective hydraulic containment at BIP, and within the target capture zones of the intermediate and deep aquifers at PCA was evidenced by the averaged groundwater flow pattern and the achievement of target water levels for the monitoring period.

Elevated groundwater levels at the SCA do not support consistent hydraulic containment of the target capture zones at the SCA. Evidence of hydraulic containment on the basis of reverse hydraulic gradients was apparent in the shallow aquifer of the SCA and intermediate aquifer in the eastern and western portion of the SCA. A flat hydraulic gradient can be inferred in water levels achieved in the intermediate aquifer within the central portion of the SCA. However, elevated averaged groundwater levels were particularly evident in the eastern portion of the deep aquifer at SCA where the failure of extraction well EWF28D in April 2019 has reduced groundwater extraction efficiency.

Assessment of contaminant concentrations at Springvale Drain and Penrhyn Estuary, located downgradient of the SCA, indicates that the BGC Project remedy

[1] The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000) have been updated in 2018 and superseded by ANZG (2018).

objectives continue to be achieved, noting the expected lag for CHC migration due to the relatively flat hydraulic gradient between the SCA and Penrhyn Estuary.

It should also be noted that the slow migration rates between the SCA and Penrhyn Estuary allow for potential recapture of CHCs that migrate beyond the SCA during periods of poor hydraulic containment.

Well rehabilitation works and the planned installation of two deep extraction wells (EWF25D and EWF28D) in June 2020 (pending regulatory approval) are expected to improve pump performance and contaminant recapture within the eastern portion of the SCA. In addition, pump performance and hydraulic containment are expected to improve following the maintenance operations completed as part of the scheduled GTP shutdown in March 2020.

3.2 Chemical Monitoring

The March 2020 sampling program represents a biannual groundwater chemical monitoring event focused assessment of volatile CHC concentrations in pore water, groundwater and surface water at Penrhyn Estuary and surface water at Springvale Drain and Floodvale Drain. Groundwater sampling was undertaken at key locations downgradient of the SCA in order to supplement the dataset that will be used to assess contaminant trends in the annual/biennial monitoring reports.

A parametric test has been used to identify increasing/decreasing trends in contaminant concentrations at sampling locations.

3.2.1 Penrhyn Estuary Groundwater

Reported CHC concentrations at BP01, BP117, MWF15, MWF17, MWF18 and MWF19 located on the shoreline of Penrhyn Estuary can be generally characterised by stable or decreasing trends in most CHC concentrations.

Increasing CHC contamination trends (both long- and short-term trends) are noted at MWF15D for EDC; at MWF17S for EDC and CFM; at MWF19I for EDC and CFM; and at MWF18D for EDC, PCE, TCE, CFM and VC, however these are not considered to represent a significant change in contaminant distribution.

An historical maximum concentration was reported for TCE at MWF18D. The increasing trend of TCE in the deep aquifer at MWF18 potentially represents limited migration of groundwater containing higher concentrations of dissolved phased TCE associated with the Southern Plumes within and upgradient of the central portion of the SCA. TCE was not detected in downgradient surface water monitoring locations, however consideration is being given to the augmentation of the monitoring program downgradient of this location to ensure adequacy of coverage within Penrhyn Estuary.

An historical maximum concentration was reported for PCE at BP117. CHC concentrations are historically highly variable at this monitoring location and consistent with or lower than those reported at downgradient monitoring locations. These increases potentially represent remnant Southern Plumes contamination being flushed from the generally stagnant area by the heavy rainfall in February 2020 or a result of inconsistent hydraulic containment.

The overall CHC concentrations within this area remain significantly lower than historical concentrations reported prior to operation of the SCA and the downgradient CHC concentrations in surface water remain low. Furthermore, the planned installation of new and replacement extractions wells (EWF25D and EWF28D) is expected to improve hydraulic containment of the eastern portion of the SCA, upgradient of this location.

Continued monitoring of this location in consideration of the downgradient pore water transect locations is required to ensure the remedy objectives of the BCG at Penrhyn Estuary continue to be met.

3.2.2 Penrhyn Estuary Pore Water

In general, the March 2020 data are consistent with previous monitoring rounds with the concentrations of the chemicals of potential concern generally decreasing with decreasing depth towards the discharge interface.

The concentrations of the key contaminants of concern in pore water reported in the March 2020 monitoring round are less than the ANZG (2018) Trigger Values for all the samples collected with the exception of VC at BP42 in the 0.5 and 2.0 m sample ports. It is noted that VC concentrations at BP42 are historically highly variable, the concentrations are significantly lower than the historical maximum concentrations for those depths, and VC concentrations did not exceed the trigger values at the discharge interface (0.1 m sample) ports nor in nearby surface water samples.

No historical maximum concentrations for key contaminants were reported in samples collected from Penrhyn Estuary pore water during the March 2020 monitoring round.

3.2.3 Surface Water

The review of historical surface water monitoring data shows CHC concentrations have been generally consistent with, or less than, those reported in previous monitoring events. Comparison of the March 2020 surface water data with historical data shows CHC concentrations in Springvale Drain (in particular 1,2-dichloroethane (EDC)) have generally decreased several orders of magnitude compared to historical maximum concentrations. The decrease in EDC concentrations within surface water is attributable to the operation of the hydraulic containment system reducing groundwater levels and subsequently reducing groundwater seepage to Springvale Drain. Similarly, concentrations of all CHCs in Floodvale Drain significantly decreased following the commencement of groundwater extraction and remain low.

Key contaminant concentrations reported in the March 2020 monitoring round were less than the relevant ANZG (2018) Trigger Values at all locations. No historical maximum concentrations for key contaminants were reported in surface water samples collected during the March 2020 monitoring round.

3.3 Implications for Human Health Risk Assessment

A review of Springvale Drain surface water data collected in accordance with EnRiskS (2018) did not indicate potential issues during the monitoring period with respect to workplace inhalation exposures adjacent to Springvale Drain. Water levels at MWB03S, which is located close to Springvale Drain where it flows under

McPherson Street, exceeded the risk review trigger level for a cumulative period of 23 days during the monitoring period, which is less than the period recommended by EnRiskS (2012a) (three months) for a further review of analytical data.

There are no data presented in the March 2020 monitoring round that affect the conclusions of the CHHRA (EnRiskS, 2018) in relation to Penrhyn Estuary and Floodvale and Springvale Drains (i.e., provided groundwater is not extracted and used for any purpose, health risks associated with exposure to chemicals of potential concern are low and acceptable).

4 GROUNDWATER TREATMENT PLANT ACTIVITIES

4.1 GTP Performance

The GTP continues to operate effectively. There was a scheduled maintenance shutdown of the GTP and groundwater extraction network from 28 February to 4 April 2020.

Routine pigging of the PCA header and SCA underbore header was carried out prior to the shutdown to ensure that flow is not restricted in these pipelines from the containment lines to the GTP.

A summary of indicative GTP operational performance figures for 1 October 2019 to 31 March 2020 is provided below:

Average volumetric rate of groundwater treated (1 October 2019 to 31 March 2020)	3.5 ML/d[2]
Approximate total volume of groundwater treated since pump and treat activities commenced in 2005 (at 31 March 2020)	25,310 ML
Volume of groundwater treated during the period 1 October 2019 to 31 March 2020	834 ML
Estimated total mass of CHCs destroyed in the thermal oxidiser (at 31 March 2020)	1,482 tonnes
Estimated mass of CHCs destroyed in the thermal oxidiser during the period 1 October 2019 to 31 March 2020	14.3 tonnes

In the past several years GTP operations – and the volumes of groundwater treated in it – have been relatively steady. The daily mass of CHCs destroyed has gradually declined due to the reduction in CHC concentrations in extracted groundwater, and was approximately 95 kg per day during the reporting period (taking into account the GTP shutdown).

4.2 Thermal Oxidiser and Dioxin Air Emissions

Stack emissions testing was undertaken in November 2019, February 2020 and March 2020, with all results below the relevant licence limits.

[2] Excluding the offline time for the March 2020 maintenance shutdown, the average volumetric rate of groundwater treated during the reporting period was 5.5 ML/d.

4.3 Containment Line Infrastructure

The GTP continues to operate effectively. As reported previously, there was one scheduled shutdown of the GTP and groundwater extraction network during the reporting period to allow inspection and maintenance of the plant and equipment. The PCA header and SCA underbore header were also pigged in February 2020 to remove built-up sludge that can impede flow.

From time to time groundwater extraction wells require rehabilitation to remove sediments that have built up in the base of the well, as well as to reduce the impact of biological fouling of the well screen. During rehabilitation of the deep well EWD28D at the eastern end of the SCA in March 2019, it was found that there was a significant amount of sand and filter pack gravel in the well, which is indicative of poor screen integrity. Following consultation with Orica's environmental consultants, it was decided to decommission EWD28D and replace it with a new deep extraction well installed as close as practicable to EWD28D. It was further agreed that this presented an opportunity to augment the deep wells near the eastern end of the SCA with an additional deep well. Orica therefore proposes to replace the existing shallow extraction well at EWF25S with a deep extraction well. Orica has notified relevant statutory authorities, including the NSW EPA and Department of Primary Industry and Environment – Water. Approval for the works in Foreshore Road median strip has been obtained from Transport for NSW (TfNSW). Orica continues to liaise with the Natural Resources Access Regulator (NRAR) for the required approval amendments to change the extraction wells.

4.4 Groundwater Treatment Trials

A pilot-scale trial of Moving Bed Biofilm Reactor (MBBR) technology commenced at the GTP in November 2019. This microbiological technology is often used in wastewater treatment facilities, more commonly to remove nutrients.

If the trial indicates that the technology can successfully treat the CHCs in the groundwater and the technology proves to be cost-effective, the treatment process could be installed to replace the air stripping, thermal oxidiser and off-gas treatment processes. This would significantly reduce the environmental footprint of the GTP.

The trial is progressing well, with biologically-mediated degradation of the principle contaminants of concern occurring. Reduced flow rates, addition of electron donor (nutrients for the microorganisms) and – now that ambient temperatures are lower – water heating are being evaluated to improve the efficacy and efficiency of the biodegradation. The trial will likely run until late 2020.

5 STRATEGY REVIEW WORKSHOP

Condition P2 of the 2020 VMP states that Orica will:

- "Conduct ongoing review of developments in remediation technologies and techniques for treatment of Dense Non-Aqueous Phase Liquid (DNAPL), sorbed mass and dissolved phase CHC contamination, and their practical applicability to the Botany Groundwater Cleanup Project.
- Convene a Strategy Review Workshop every four years to which it will invite a minimum of three international experts in the field. The EPA will be consulted on the selection of the experts prior to the experts being engaged. The review process will involve consideration by the experts of the annual reports prepared by Orica (see bullet point below) and worldwide developments in technology in order to assess whether any current or emerging technologies (including developments in technology and its applications) are likely (individually or in combination) to provide a practicable solution and justify the conduct of field trials of those technologies. Appropriate representatives of the Independent Monitoring Committee (IMC) (as agreed with the Orica Botany Liaison Committee (OBLC) – refer P4) and the EPA will be invited to attend the workshop. The outcome of the Remediation Strategy Review Workshop will be considered in determining whether field trials of one or more remediation technologies should be conducted.
- Provide an annual report to the EPA that would assess the practical application and effectiveness of appropriate technologies in relation to the remediation. Every four years, this would also include a detailed summary of the outcomes of the Strategy Review Workshop (refer R3)."

The fifth Botany Groundwater Strategy Review Workshop was held on 2 and 3 March 2020. A report on the Workshop was issued to the EPA on 30 April 2020.

Updates on work arising from the 2017 Workshop actions were presented to the 2020 Workshop participants. In particular, Geosyntec Consultants issued a report and gave a presentation on the outcomes of their column studies and related DNAPL characterisation and contaminant mass transport work. Their work included assessment of additional groundwater data from the March and September 2019 monitoring events. The report indicated there is clear evidence of natural attenuation in the aquifer due to biological and abiotic degradation processes, and sorption and diffusion into low-permeability layers, which varies both laterally and vertically in the aquifer beneath and downgradient of the BIP.

Over the two days of the 2020 Workshop presentations were made by:

- Orica personnel and environmental consultants to provide background to the Orica Botany Groundwater Project and updates since the previous Workshop;
- A representative from NSW EPA to provide the Regulator's perspective; and
- The three international experts to provide their views on the current remediation strategy and achievements of the BGC Project to date, observations from comparable sites overseas, updates on available and emerging cleanup technologies, and views on whether any changes to the strategy would be warranted.

Attendees of the Workshop then participated in a facilitated discussion of recent developments and application of cleanup technologies, and what – if any – could be the best alternative strategies for long-term management and remediation.

The primary conclusions for the 2020 Workshop are:

- The existing remedial strategy (hydraulic containment effected through large-scale 'pump and treat' of groundwater) is appropriate, effective and concluded to remain the most viable option for containment and source reduction through the foreseeable future;
- No recent remediation technology developments, or complementary technologies, are identified at this time that would merit exploration of their applicability to the BGC Project; and
- The review of source zone remediation options indicates uncertain performance relative to the current situation and high cost.

Notwithstanding the above outcomes, it was also noted that:

- Flushing and mass extraction alone (i.e., without natural attenuation) will not likely achieve remediation end goals in the short or medium term;
- In situ degradation is contributing to faster decay of the plumes and sources; while
- The mechanisms of 'back-diffusion' and desorption create secondary sources which impact long-term persistence of plumes and plume response to GTP pumping.

Accordingly, a series of actions were captured in the context of moving towards an enhanced project direction aimed to:

- Optimise GTP performance in key areas of the plumes where practical and cost beneficial;
- Continue to investigate and enumerate existing back-diffusion/desorption and natural attenuative processes with the goal of defining a transition condition that could allow for cessation of operating the GTP;
- Continue to evaluate options to enhance natural attenuative processes to accelerate the rate of cleanup progress; and
- Continue to evaluate timing, metrics and potential effects on the receiving environment of shutting down the 'pump and treat' system

while maintaining the 'pump and treat' system for the medium to long term.

A special meeting was held on 4 March 2020 to allow community members of the OBLC to discuss the outcomes of the Strategy Review Workshop with the three international experts, IMC hydrogeologist Dr Denis O'Carroll and James Stening.

6 COMMUNITY CONSULTATION

This section provides an update in response to Condition P4 of the VMP, which specifies how Orica must inform the community of developments in the BGC Project. It provides information regarding the consultation activities undertaken by Orica to share information and obtain community feedback on the BGC Project.

6.1 Orica Botany Liaison Committee (OBLC)

Two ordinary meetings of the Orica Botany Liaison Committee (OBLC) were held during the six-month reporting period: 19 November 2019 and 10 March 2020. The next scheduled meeting is to be held on 21 July 2020.

6.2 Independent Monitoring Committee (IMC)

The IMC Task 31 (for Dr O'Carroll to attend the Strategy Review Workshop and present at the Community Forum held at UNSW on 4 March 2020) has been completed. It resulted in IMC Task 32 (for Dr O'Carroll to prepare a plain English version of the Workshop findings, to document the overall context of the project, and the long-term view, for tabling with the Committee).

6.3 Communication Tools

The following table provides an overview of activity this reporting period (or more recently) for the routine BGC Project communication tools used by Orica.

Communication Tool	Activity This Reporting Period Related to the BGC Project
BGC Project pages on http://www.orica.com/Locations/Asia-Pacific/Australia/Botany/Botany-Transformation-Projects	Information uploaded: • November 2019 OBLC meeting minutes and presentations. • Short video prepared by IMC representative Dr Denis O'Carroll on the BGC Project uploaded in November 2019. • November 2019 Orica VMP Progress Report. • November 2019 Biennial Groundwater and Surface Water Monitoring Event Report. • March 2020 OBLC meeting agenda and briefing paper. • Meeting minutes from the March 2020 Community Forum held at UNSW. • Botany Groundwater Strategy Review Workshop Summary Report. • Annual DNAPL and Groundwater Technology Review Report.

Communication Tool	Activity This Reporting Period Related to the BGC Project
	• 2020 Voluntary Management Proposal and GRAMP.
Local newspapers	Column published in the *Southern Courier* and *St George Leader* on 11 and 12 February 2020[3].
Email enquiries	No feedback received specific to the BGC Project.
Feedback facility on the Orica website	No feedback received specific to the BGC Project.
1800 Number Calls	No feedback received specific to the BGC Project.
Site tours	No site tours conducted during the reporting period.

6.4 Community Investment

Round 1 of the 2020 Orica Botany Community Investment Program will provide support to:

- Fighting Chance Australia t/a Avenue for the purchase of personal protective equipment to support people with disabilities and their support workers to access the community during the COVID-19 lockdown – $9,000.00.

Bayside Council has commenced construction of the new playground to enhance Grace Campbell Reserve. Orica has provided funding of $230,000 over three years for this project. Works are expected to be completed in July/August 2020.

[3] The *Southern Courier* and *St George Leader* are no longer published. These were the last column advertisements to be printed for the BGC Project.

7 REFERENCES

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ATTACHMENT A – QUARTERLY MONITORING REPORT – MARCH 2020

Groundwater Treatment Plant – March 2020 Biannual Groundwater and Surface Water Monitoring Report. Golder Associates Pty Ltd. 12 June 2020. *Separately bound report.*