

	REPORT No.: EN.1591.61.PR087	Rev: 0
VOLUNTARY MANAGEMENT PROPOSAL PROGRESS REPORT NO. 34		

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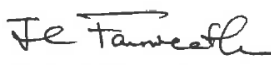
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REVISION 0

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REVISION HISTORY

REV	STATUS	DATE	PREPARED	REVIEWED	AUTHORISED
0	Issued	30 November 2020	 James Stening	Caroline Vernon (Golder Associates) CEnvP 	 James Fairweather

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DISTRIBUTION

1. Matthew Hart, Contaminated Sites Section, EPA (hard copy with 2 copies of Attachment A)
2. Greg Russell, NSW Department of Industry, Lands & Water (CD Version)
3. Toni Cains, South Eastern Sydney Local Health District (hard copy)
4. Dr Mark Ferson, NSW Health (hard copy)
5. Judith Betts, Bayside Council (hard copy and CD version)
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LIST OF ACRONYMS

ACRONYM	DEFINITION
ADWG	Australian Drinking Water Guidelines
AHD	Australian Height Datum
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
IPART	Independent Pricing and Regulatory Tribunal
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

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ACRONYM	DEFINITION
PCE	Perchloroethylene (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
USEPA	United States Environment Protection Agency
VC	Vinyl chloride (chloroethene)
VMP	Voluntary Management Proposal
VOC	Volatile organic compound
VSD	Variable speed drive

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EXECUTIVE SUMMARY

This document is the 34th Progress 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 April 2020 to 30 September 2020, however if more recent and relevant information is available it is also included.

Voluntary Management Proposal

A revised VMP was approved by NSW EPA on 29 April 2020. This report is the second Progress Report prepared under the 2020 VMP.

An updated 2020-2024 Groundwater and Surface Water Monitoring Program was submitted to NSW EPA in August 2020. The proposed changes from the 2017-2020 Program were relatively minor.

The September 2020 Biennial Groundwater and Surface Water Monitoring Event was the last monitoring event to be carried out in accordance with the 2017-2020 Program.

Hydraulic Monitoring

Assessment of hydraulic data for the September 2020 monitoring event, with consideration of the six-step evaluation approach adopted by JBS&G (2019), indicates that effective hydraulic containment of the target capture zones was achieved at Botany Industrial Park (BIP), Primary Containment Area (PCA) and at the Secondary Containment Area (SCA) during the monitoring period and overall the Botany Groundwater Cleanup (BGC) Project remedy objectives were met during this period.

The effects of reduced groundwater extraction due to the GTP maintenance shutdowns in March 2020 were compounded by high rainfall during the monitoring period. Reduced groundwater extraction rates were associated with reduced performance and efficiency caused by pump and well biofouling, particularly within the deep aquifer in the eastern portion of SCA due to the prolonged well replacement process following the failure of extraction well EWF28D in April 2019.

Chemical Monitoring

The September 2020 sampling program represents an annual monitoring event focused on collecting data critical to the assessment of groundwater and surface water quality with respect to environmental and human health receptors. The assessment includes considerations of:

- Concentrations of shallow groundwater chlorinated hydrocarbons (CHCs) against long-term trends and changes in contaminant distribution (including parametric tests).

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- Concentrations of CHCs against assumptions and results considered in the Consolidated Human Health Risk Assessment (CHHRA) (EnRiskS, 2018).

A parametric test has been used to identify increasing/decreasing trends in contaminant concentrations at sampling locations. The assessment of data trends for monitoring locations indicates that whilst there have been a number of increases (including historical maxima) and decreases in contaminant concentrations, the changes were either relatively small or are consistent with expected plume behaviour as a result of groundwater extraction from the three containment lines.

In general, the September 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 reported in the September 2020 monitoring round were less than the ANZG (2018) Trigger Values for all the samples collected at the discharge interface (0.1 m port). The samples collected from BP42 at the 0.5 m and 2.0m ports (0.428 mg/L and 1.37 mg/L respectively) were above the ANZG (2018) Trigger Value for vinyl chloride (VC) (0.1mg/L), as well as the Trigger Value for TCE (0.33 mg/L) at the 2.0 m port of BP42 (0.434 mg/L).

It should be noted that the VC and TCE concentrations in surface water samples within the estuary in proximity to BP42 were less than the ANZG (2018) Trigger Value.

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

The review of historical surface water monitoring data shows CHC concentrations have been highly variable between monitoring events. Comparison of the September 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 September 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 September 2020 monitoring round.

Assessment of hydraulic and chemical data for the September 2020 monitoring event, with consideration of the revised six-step evaluation approach adopted by JBS&G (2019), indicates that, although effective hydraulic containment of the target capture zones was inconsistent during the period, overall the BGC Project remedy objectives were met.

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Human Health Risk Assessment

There were no additional data presented in the September 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 11 to 20 September 2020 to facilitate annual testing of the plant's emergency trip systems and to carry out a number of planned maintenance items. There were also several trips during the reporting period resulting in two or three days offline on each occasion.

Operations have not been adversely affected by COVID-19.

The approximate total volume of groundwater treated since pump and treat activities commenced in 2005, including this period, is 26,356 ML with approximately 1,046 ML treated during this reporting period.

The estimated total mass of chlorinated hydrocarbons destroyed in the thermal oxidiser, including this period, is 1,503 tonnes with approximately 21.4 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 is continuing and may run up until the next scheduled maintenance shutdown in February 2021.

NSW EPA conducted its annual review for EPL 2148 with GTP personnel on 6 August 2020. No issues were identified.

A biennial Operational Audit for the Independent Pricing and Regulatory Tribunal (IPART) was carried out in October 2020. The independent report was submitted in mid-November. No significant issues were identified.

Containment Line Infrastructure

In April 2019, the well screen of the eastern-most deep groundwater extraction well in the SCA was identified as irreparably damaged, necessitating replacement of the entire well. It was decided to take the opportunity to replace one of the nearby shallow wells with a deep well to thereby improve hydraulic containment of the deeper parts of the aquifer in that area. Following a protracted works approval process with Transport for NSW and the Natural Resources Access Regulator, the two new wells were installed in August and September 2020. In early October both extraction points were commissioned, and pumping commenced. The effect has been quick and evident: hydraulic containment at the eastern end of the SCA has been notably improved.

Community Consultation

One ordinary meeting of the Orica Botany Liaison Committee (OBLC) was held during the six-month reporting period: 21 July 2020.

At the OBLC meeting held on 21 July, Dr Denis O'Carroll presented highlights and thoughts related to the 2020 Strategy Review Workshop. The following IMC Task

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(no. 33) was actioned from community members for Dr O'Carroll: Dr Denis O'Carroll to record his presentation using UNSW video resources for sharing with absent Committee Members (with the possibility of providing a simplified version for wider circulation following Committee feedback).

The resultant video was shared with OBLC members in August 2020.

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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, 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). In accordance with the review schedule in the VMP, the monitoring program was reviewed and revised earlier this year. The 2020-2024 Groundwater and Surface Water Monitoring Program (Golder, 2020) was submitted to NSW EPA in August 2020.

The September 2020 monitoring event is the last to be carried out under the 2017-2020 monitoring program (Golder, 2017). As specified in that monitoring program, the September 2020 round is an annual monitoring event.

This document is the 34th report submitted in accordance with the initial and replacement VMPs and includes progress on the GRAMP (Orica, 2020). It is the second 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 April 2020 to 30 September 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 <https://www.orica.com/Locations/Asia-Pacific/Australia/Botany/Botany-Transformation-Projects/Groundwater-Cleanup#.X8QZoGgzYuU> and a distribution list is provided at the beginning of this document.

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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 NSW EPA in May 2017. It was updated in August 2020. The 2020-2024 Groundwater and Surface Water Monitoring Program (Golder, 2020) will be adopted for the next (biannual) monitoring event in March 2021.

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.

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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.
P2	Convene a Strategy Review Workshop every four years to which it will invite a minimum of three international experts in the field.	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 14 th 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 are 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. Orica will inform the community of developments in the Orica BGC Project through:	Ongoing compliance	

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Cond.	Summary of Requirement	Status	Reference Documents / Comments
	<p>a) Regular OBLC meetings (nominally three times a year unless otherwise agreed to by OBLC members); and</p> <p>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. Reports older than three years may be archived from the website and be made available on request.</p>		<p>a) The OBLC meets nominally three times per year (see Section 6.1)</p> <p>b) https://www.orica.com/Locations/Asia-Pacific/Australia/Botany/Botany-Transformation-Projects/Groundwater-Cleanup#.X8QZoGgzYuU</p>
P5	<p>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.</p> <p>Orica will conduct groundwater monitoring in accordance with <i>Groundwater Treatment Plant Groundwater and Surface Water Monitoring Program 2017 – 2020</i> (Golder, 2017), noting that the frequency and scope of the monitoring program will be reviewed periodically. The next scheduled review will occur in May 2020.</p>	Ongoing compliance	<p>The current monitoring program <i>Groundwater Treatment Plant Groundwater and Surface Water Monitoring Program 2017 – 2020</i> (Golder, 2017) was approved by NSW EPA on 23 May 2017.</p> <p>As specified in the monitoring program (Golder, 2017), the September 2020 event was an annual monitoring event. It is the last monitoring event to be carried out under the 2017-2020 monitoring program.</p> <p>A 2020-2024 Groundwater and Surface Water Monitoring Program (Golder 2020) was submitted to NSW EPA in August 2020. It will be adopted for the next (biannual) monitoring event in March 2021.</p> <p>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 <i>A Systematic Approach for the Evaluation of Capture Zones at Pump and Treat Systems</i> (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 (JBS&G, 2019). The revised report has been used for assessment of hydraulic containment in the September 2020 monitoring event report (Attachment A).</p>
P6	Orica will implement a suitable monitoring program for the assessment of risk to human health, which is primarily based on	Ongoing compliance	All reports now submitted to NSW EPA include relevant appraisal of potential risk to human health and hence identify any requirement to update the

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Cond.	Summary of Requirement	Status	Reference Documents / Comments
	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) (CHHRA). The scope of this monitoring program will be subject to regular review and possible modification with EPA consent.		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 NSW EPA on 19 June 2018, has been posted on the Orica project website.
P6	At the end of February every year, should data collected in the previous 12 months determine that risk profiles have changed, an annual Addendum will be issued summarising the changes to the risk profiles outlined in the CHHRA. If the risk profiles have not been altered significantly no addendum will be issued.	Ongoing compliance	No addendum was required to be issued in February 2020 as the risk profiles had not been altered significantly. The next review of the risk profiles is scheduled be completed in February 2021.
P6	Every four years, the entire CHHRA will be revised to take into account more recent consolidated monitoring data and changes to relevant exposure scenarios, toxicological data and risk calculation methods. The next revision will be completed in July 2022. Orica will have this document reviewed by an independent expert.	Pending	The next revision of the CHHRA is scheduled be completed in July 2022.

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 NSW EPA up until now in September each year. On 19 May 2017 NSW 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

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- 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 April 2020 to 30 September 2020.

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

NSW EPA conducted its annual review for EPL 2148 with GTP personnel on 6 August 2020. No issues were identified.

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3 SEPTEMBER 2020 MONITORING EVENT

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

The September 2020 monitoring event was an annual monitoring event and was the 34th 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 – September 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).

The VMP includes an ongoing requirement for Remediation Strategy Review Workshops to be convened every three years. The fourth such workshop was held in February 2017, with the outcomes summarised in 2017 Botany Groundwater Strategy Review Workshop Summary Report (Orica, 2017).

The 2017 Workshop recommended updating the 6 Step Capture Zone Analysis as defined in USEPA (USEPA, 2008), to incorporate more recent (since 2012) data and modelled capture targets. The JBS (2012) assessment was recently updated (JBS&G, 2019) and addresses that recommendation. This annual monitoring report uses the updated (2019) version as the basis for assessment of hydraulic containment performance.

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The JBS&G (2019) evaluation uses multiple lines of evidence within the six ‘steps’ framework to assess hydraulic containment. It concludes that the remediation objective of the BGC Project (i.e. *“to achieve protection for slightly to moderately disturbed ecosystems using the Australian and New Zealand Guidelines for Marine and Fresh Water (ANZG, 2018)”* in surface water at Penrhyn Estuary is being achieved.

The JBS&G (2019) assessment provides a framework for assessment of key metrics for evaluation of the success of hydraulic containment during ongoing monitoring. The following section reviews the recent hydraulic monitoring data for the September 2020 ‘Annual’ monitoring round using the six lines-of-evidence ‘steps’ considered by JBS&G (2019).

Hydraulic monitoring data for the September 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 ANZG (2018) Trigger Value and assumptions used by JBS (2012), the current target capture zones (well pairs) were considered.

Assessment of hydraulic data for the September 2020 monitoring event, with consideration of the six-step evaluation approach adopted by JBS&G (2019) indicates that effective hydraulic containment of the target capture zones was achieved at Botany Industrial Park (BIP), Primary Containment Area (PCA) and at the Secondary Containment Area (SCA) during the monitoring period and overall the Botany Groundwater Cleanup (BGC) Project remedy objectives were met.

The effects of reduced groundwater extraction due to the GTP maintenance shutdowns in March 2020 were compounded by high rainfall during the monitoring period. Reduced groundwater extraction rates were associated with reduced performance and efficiency caused by pump and well biofouling, particularly within the deep aquifer in the eastern portion of SCA due to prolonged well replacement process following the failure of extraction well EWF28D in April 2019.

Effective hydraulic containment at BIP and within the target capture zones of the intermediate and deep aquifers at PCA was evidenced by the achievement of target water levels and/or the assessment of reverse hydraulic gradients immediately downgradient of the containment lines for the monitoring period. Hydraulic containment in the shallow aquifer at SCA, the eastern and western portions of the intermediate aquifer and the eastern and central-eastern portion in deep aquifer was also evident on this basis. However, evidence of effective hydraulic containment in the central portion of the intermediate aquifer and in the western end in the deep aquifer was less clear.

An assessment of long-term water levels for monitoring wells located adjacent to, and at significant distances from, the containment lines indicates that observed drawdowns are similar to those predicted by groundwater modelling (Laase, 2005 and Laase, 2017) and that no long-term downward trends that may be attributable to GTP operation, are evident. The data highlight the relatively localised effects of the hydraulic containment system and its low potential to adversely affect nearby infrastructure and licensed groundwater users.

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3.2 Chemical Monitoring

The September 2020 annual chemical monitoring program is focused on collecting data critical to the assessment of groundwater and surface water quality with respect to environmental and human health receptors. The assessment includes considerations of:

- Concentrations of shallow groundwater chlorinated hydrocarbons (CHCs) against long-term trends and changes in contaminant distribution (including parametric tests).
- Concentrations of CHCs against assumptions and results considered in the CHRA (EnRiskS, 2018).

A parametric test has been used to identify increasing/decreasing trends in contaminant concentrations at sampling locations. The assessment of data trends for monitoring locations indicates that whilst there have been a number of increases (including historical maxima) and decreases in contaminant concentrations, the changes were either relatively small or are consistent with expected plume behaviour as a result of groundwater extraction from the three containment lines.

Additional chemical monitoring was conducted during this monitoring round. These additional results will be reported separately but will be included for the future interpretation of plume dynamics and contaminant distribution in the August 2021 biennial monitoring event.

3.2.1 Groundwater Monitoring Wells

The September 2020 groundwater data are generally consistent with data from previous monitoring rounds. No samples were collected from Botany Industrial Park (BIP) during this monitoring period. On-site samples were only collected from Southlands.

Historical maximums were reported at:

- 1,2-dichloroethane (EDC) (50.7 mg/L) at MWF15 in the intermediate well. This is greater than the previous historical maximum reported in December 2007 (24 mg/L). The high concentration is likely due to two non-operational extraction wells along SCA (EWF25 and EWF28) which were recently replaced. This is not considered to represent a significant change in contamination distribution, and further monitoring and future rounds will determine if the concentrations at this location decrease due to the new extraction wells at SCA.
- EDC (0.208 mg/L), chloroform (CFM) (0.006 mg/L) and tetrachloroethene (PCE) (0.001 mg/L) at MWF19 in the intermediate well. The concentration for EDC is greater than the previous historical maximum reported in September 2010 (0.063 mg/L). There has been no detected concentration of CFM and PCE historically for this well. These concentrations are similar to those found in nearby extraction well EWF14 in the deep well and are not expected to represent a significant change in the contamination distribution.
- EDC (0.002 mg/L) at WG262 in the shallow well. Historically, there has been no detected concentration of EDC at this well. This is marginally above the

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limit of detection and is not considered to represent a significant change in contamination distribution.

- PCE (0.161 mg/L) and trichloroethene (TCE) (3.34 mg/L) at BP117 from the 1.5 m port. These concentrations are greater than the previous historical maxima reported in March 2020 for PCE (0.03 mg/L) and in March 2012 for TCE (3.31 mg/L).
- PCE (0.189 mg/L) and TCE (6.82 mg/L) at MWF18 in the deep well. These concentrations are greater than but also similar to the previous historical maxima reported in September 2010 for PCE (0.187 mg/L) and in March 2020 for TCE (3.97 mg/L).
- CFM (0.001 mg/L) at WG255 in the shallow well. Historically there has been no detected concentration of CFM in this well. This is not expected to represent a significant change in contamination distribution as this concentration is marginally above the limit of detection.

No other historical maximum concentrations for the groundwater wells were reported during the September 2020 monitoring round.

3.2.2 Penrhyn Estuary Pore Water

In general, the September 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 reported in the September 2020 monitoring round were less than the ANZG (2018) Trigger Values for all the samples collected at the discharge interface (0.1 m port). The samples collected from BP42 at the 0.5 and 2.0 m sample ports (0.428 mg/L and 1.37 mg/L respectively) were above the ANZG (2018) Trigger Value for vinyl chloride (VC) (0.1 mg/L), as well as the Trigger Value for trichloroethene (TCE) (0.33 mg/L) at the 2.0 m port of BP42 (0.434 mg/L).

It should be noted that the VC and TCE concentrations in surface water samples within the estuary in proximity to BP42 were less than the ANZG (2018) Trigger Value.

No historical maximum concentrations for the Penrhyn Estuary pore water samples were reported during the September 2020 monitoring round.

3.2.3 Surface Water

The review of historical surface water monitoring data shows CHC concentrations have been highly variable between monitoring events. Comparison of the September 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.

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Key contaminant concentrations reported in the September 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 September 2020 monitoring round.

3.3 Implications for Human Health Risk Assessment

A review of Springvale Drain surface water data collected in accordance with the CHHRA (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 100 days during the monitoring period. However, key contaminant concentrations were less than the relevant ANZG (2018) Trigger Values and less than considered in the CHHRA (EnRiskS, 2018) at all surface water sampling locations.

3.4 Conclusions

Assessment of hydraulic and chemical data for the September 2020 monitoring event, with consideration of the revised six-step evaluation approach adopted by JBS&G (2019), indicates that, although effective hydraulic containment of the target capture zones was inconsistent during the period, overall the BGC Project remedy objectives were met.

There are no data presented in the September 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

Overall, the GTP continues to operate effectively. There was an electricity supply failure to the plant on 22 May 2020 that caused the plant to be offline for three days for safe cooldown and warmup of the thermal oxidiser. A blower motor fault caused a trip and two days offline on 1 July 2020; a blower flowmeter malfunction on 15 August 2020 had the same effect. A scheduled maintenance shutdown of the GTP and groundwater extraction network occurred on 11 to 20 September 2020 to facilitate annual testing of the plant's emergency trip systems and to carry out a number of planned maintenance items.

Operations have not been adversely affected by COVID-19.

A summary of indicative GTP operational performance figures for 1 April 2020 to 30 September 2020 is provided below:

Average volumetric rate of groundwater treated (1 April 2020 to 30 September 2020)	5.7 ML/d ¹
Approximate total volume of groundwater treated since pump and treat activities commenced in 2005 (at 30 September 2020)	26,356 ML
Volume of groundwater treated during the period 1 April 2020 to 30 September 2020	1,046 ML
Estimated total mass of CHCs destroyed in the thermal oxidiser (at 30 September 2020)	1,503 tonnes
Estimated mass of CHCs destroyed in the thermal oxidiser during the period 1 April 2020 to 30 September 2020	21.4 tonnes

In the past several years GTP operations – and the volumes of groundwater treated in it – have been relatively steady. As the mass of dissolved-phase CHCs in the aquifer has been depleted, the average concentration of groundwater being pumped to the GTP has decreased. The daily mass of CHCs destroyed has gradually declined due to the reduction in CHC concentrations in extracted groundwater; it was approximately 128 kg per day during the reporting period (taking into account the GTP shutdowns).

NSW EPA conducted the annual review for EPL 2148 with GTP personnel on 6 August. No issues were identified.

¹ Excluding the offline time for the September 2020 maintenance shutdown and process trips, the average volumetric rate of groundwater treated during the reporting period was 6.9 ML/d.

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A biennial Operational Audit for the Independent Pricing and Regulatory Tribunal (IPART) was carried out in October 2020. The independent report was submitted in mid-November 2020. No significant issues were identified. A small measurement discrepancy was noted in a flowmeter to one of the on-site Treated Water customers. Overall, the report was very positive.

4.2 Thermal Oxidiser and Dioxin Air Emissions

Stack emissions testing was undertaken in May and November 2020, with all results below the relevant licence limits. The testing (by Queensland-based specialist service provider) was slightly delayed by border restrictions due to COVID-19, but within the relevant reporting quarters.

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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 proposed to replace the existing shallow extraction well at EWF25S with a deep extraction well. Orica notified relevant statutory authorities, including NSW EPA and Department of Primary Industry and Environment – Water.

Following a lengthy process, approval for the works in Foreshore Road median strip was obtained from Transport for NSW (TfNSW) and the Natural Resources Access Regulator (NRAR) to change the extraction wells. Construction of the wells occurred in August and September 2020, and both wells were commissioned and fully operational by October 2020. Initial indications confirm expectations that the operation of these two deep wells will significantly improve hydraulic containment at the eastern end of the SCA.

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. The trial is continuing and may run up until the next scheduled maintenance shutdown in February 2021.

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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.

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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.

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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)

One ordinary meeting of the Orica Botany Liaison Committee (OBLC) was held during the six-month reporting period: on 21 July 2020. (A meeting was also held on 10 November 2020.) The next scheduled meeting is to be held on 9 March 2021.

6.2 Independent Monitoring Committee (IMC)

IMC Task 31 (for Dr Denis O'Carroll, IMC hydrogeologist, to attend the Strategy Review Workshop and present at the Community Forum held at UNSW on 4 March 2020) subsequently gave rise to 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).

At the July OBLC meeting, Dr O'Carroll presented highlights and thoughts related to the 2020 Strategy Review Workshop. The following IMC Task (no. 33) was actioned from community members for Dr O'Carroll: Dr Denis O'Carroll to record his presentation using UNSW video resources for sharing with absent Committee Members (with the possibility of providing a simplified version for wider circulation following Committee feedback).

The resultant video was shared with OBLC members in August 2020.

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 https://www.orica.com/Locations/Asia-Pacific/Australia/Botany/Botany-Transformation-Projects/Groundwater-Cleanup#.X8QZoGgzYuU	<p>Information uploaded:</p> <ul style="list-style-type: none"> July 2020 OBLC meeting agenda and briefing paper. July 2020 OBLC meeting minutes and presentations. Presentation to the July 2020 OBLC by IMC representative Dr Denis O'Carroll on his findings of the 2020 Botany Groundwater Strategy Review Workshop. November 2020 OBLC meeting agenda and briefing paper.

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Communication Tool	Activity This Reporting Period Related to the BGC Project
	<ul style="list-style-type: none"> • June 2020 Orica VMP Progress Report. • March 2020 Biannual Groundwater and Surface Water Monitoring Event Report. <p>The BGC Project pages on the website underwent a significant upgrade in November 2020, consistent with the upgrade to the entire Orica website.</p>
Local newspapers	Column published in the <i>St George Leader</i> on 14 July 2020 ² .
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

Bayside Council has completed construction of the new playground to enhance Grace Campbell Reserve. Orica has provided funding of \$230,000 over three years for this project. The new playground will be officially opened on 5 December 2020.

² The *Southern Courier* and *St George Leader* are now only published online. As the *Southern Courier* is only available through paid subscription, column advertisements for the BGC Project are now only published in the *St George Leader*.

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7 REFERENCES

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ATTACHMENT A – QUARTERLY MONITORING REPORT – SEPTEMBER 2020

Groundwater Treatment Plant – September 2020 Annual Groundwater and Surface Water Monitoring Report. Golder Associates Pty Ltd. 30 November 2020. *Separately bound report.*