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PASMINCO COCKLE CREEK SMELTER SITE

Groundwater Monitoring and Management Strategy

Submitted to:
Ferrier Hodgson

REPORT

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1.0 INTRODUCTION

Golder Associates (Golder) is pleased to present this groundwater monitoring and management strategy (GMMS) for the Pasminco Cockle Creek Smelter (PCCS) (subject to Deed of Administration) site. This strategy document has been prepared to accompany the 75W application to combine the remediation programs for the PCCS site and the Incitec Fertilizer Limited (IFL) site.

The purpose of this GMMS is to provide a high-level summary of the regulatory requirements and associated monitoring and management activities related to groundwater contamination at the PCCS site (including the IFL site).

A groundwater monitoring and management plan (GMMP) will follow this strategy document. The GMMP is being prepared as an update to the existing Interim Groundwater Monitoring Program (IGMP) (WSP 2011); to provide further details regarding the post-remediation groundwater monitoring requirements, groundwater quality objectives and the manner in which progress towards the objectives will be demonstrated.

1.1 Background

The PCCS site has been in use since the 1890s for various industrial purposes including smelting of a range of heavy metals including lead and zinc, resulting in contamination of the site. A remediation order (RO; No. 23008) was issued by the NSW Department of Environment and Conservation (DEC) (now the NSW Environment Protection Authority (EPA)) on 1 July 2003 under Section 14 of the *Contaminated Land Management Act 1997*. Remediation of the site commenced in 2008, generally comprising excavation of contaminated soil from across the site and placement of the soil in an on-site containment cell.

The PCCS site was subdivided into six remediation areas, or parcels, in the Remediation Environmental Management Plan (REMP) (comprising Remediation Parcels 1 to 5, and the containment cell), to facilitate a staged remediation and validation process. Parcels 1, 2, 4, 5 and the containment cell are collectively referred to as the 'main site', and are the subject of RO 23008.

Groundwater monitoring for the site is regulated by the Environment Protection Licence (EPL) 5042 and the major projects approval conditions issued by the Department of Planning and Infrastructure (DoPI) in 2007 (Reference 06_0184). Groundwater monitoring was previously outlined in the IGMP, prepared by WSP (WSP 2011).

Please refer to Figure 1 for the site location and Figure 2 for the site layout showing the remediation parcels and the containment cell. A detailed description of the site and a summary of the site history are presented in Appendix A to this report.

1.2 Objectives

This GMMS was prepared to address following objectives:

- Provide a summary of the various approval conditions and regulatory requirements related to groundwater contamination at the site;
- Describe the conceptual site model for groundwater contamination at the site, including groundwater occurrence and flow directions, contamination sources, and potential receptors for contaminated groundwater;
- Describe the groundwater monitoring program for the PCCS site, including the IFL site, to address the following requirements:
  - Assess temporal trends in groundwater quality in response to the soil remediation program beneath and at the downgradient boundary of the main PCCS site, and adjacent to Cockle Creek;
  - Assess the performance of the South West Dam (SWD) and Hawkes Dam (HD) boundary hydraulic containment systems;
  - Assess the performance of the groundwater cut-off drains associated with the containment cell; and

- Update the groundwater monitoring conditions in the site Environment Protection Licence (EPL) 5042.

Additional post-remediation considerations that will be addressed in the forthcoming GMMP will include:

- Develop criteria for demonstrating fulfilment of the groundwater objectives of the RO;
- Develop criteria for the cessation of groundwater extraction from the South West Dam (SWD) and Hawkes Dam (HD) boundary hydraulic containment systems;
- Develop criteria for the containment cell cut-off drains to indicate when:
  - Treatment of intercepted groundwater is no longer required; and/or
  - Extraction of groundwater is no longer required;
- Provide estimated timeframes for:
  - Evaluating interim remediation goals; and
  - Evaluating and (if warranted) revising the GMMP.

1.3 Regulatory Requirements for Groundwater Monitoring and Management

The requirements and conditions relating to groundwater monitoring and management at the PCCS site include the following:

- Relevant conditions from the Part 3A project approval, which are listed in Table 1; and
- The RO, dated 01 July 2003 requiring remediation '*so that the premises are no longer contaminated in such a way as to present a significant risk of harm*'.

Table 1: Part 3A Project Approval Conditions (2007) relating to Groundwater Monitoring and Management

Condition	Description
5.3	*The Proponent (PCCS) prepare and implement a Groundwater Monitoring Program for the remediation and post remediation activities as part of the management plans required under conditions 7.4 (for remediation activities) and 8.6 (for post remediation activities). The Program shall be submitted to the DEC for approval prior to the commencement of remediation. The Program shall be developed to assess trends over an appropriate timeframe and measurement of seasonal variation. The Program shall include, but not necessarily be limited to:* *a) Requirements to monitor both the shallow and deep aquifer in and around the containment cell(s) commencing no later than six months after the date of this approval;* *b) An aim of determining the connectivity between the shallow and deep aquifers, and use of the data for the fate and transport model required under condition 3.2, which will inform the consideration and approval of the cell(s) design);* *c) Groundwater quality monitoring parameters, including also parameters that modify toxicity;* *d) Construction details and location of monitoring bores and frequency of sampling; and* *e) Reporting requirements.*
5.4	*Groundwater interception and monitoring shall be continued until it is demonstrated to the satisfaction of the DEC (now DECCW) that there is no longer a significant risk of harm posed*

Condition	Description
	by the contamination on or moving off the site.
5.5	*The groundwater monitoring in the shallow and deeper aquifer around the containment cell(s), outside the groundwater interception system, shall be continued until such time as the DEC (now DECCW) agrees that it is no longer required.*
7.2	*The Proponent shall prepare and implement an **Interim Groundwater Remedial Plan** in accordance with Site Audit Statement No. WRR127/3 dated 16 December 2005. The Interim Groundwater Remedial Plan, reviewed by the Site Auditor, and any associated Site Audit Report and Site Audit Statement shall be submitted to the DEC (now DECCW).*
8.7	*"... b) a **Water Management Plan.** The Plan shall detail measures that will be employed to manage water on the site, and to minimise the discharge of pollutants to lands and/ or waters throughout the life of the project. The Plan shall be based on best environmental practice and shall address any requirements of the Department and the DEC. The Plan shall include, but not necessarily be limited to:* *i) details of the operation of the effluent treatment plant;* *ii) details of surface water, groundwater and leachate management controls;* *iii) maintenance requirements for groundwater pumping systems and other water management systems in place;* *iv) surface water, groundwater and leachate quality monitoring requirements for the operation of the containment cell (s); and* *v) corrective actions to any recorded exceedance to adopted criteria. ..."* This plan addresses groundwater and cutoff drain monitoring issues that relate to condition 8.7.

In addition, monitoring requirements for the groundwater cutoff drains around the Containment Cell are specified in EPL 5042 and in the Project Approval (06_0184). The EPL groundwater monitoring requirements for the containment cell are summarised in Table 2.

Table 2: EPL Conditions relating to Groundwater Monitoring for the Containment Cell

Condition	Description
1) L1.2	*The height of groundwater in the shallow aquifer measured in each bore required by conditions E12.1, E12.2, E12.3 3 (Note: these are monitoring wells MW1S through to MW9S and MW1D through to MW9D as specified in Golder Drawing 06623099-D1029-RevC2) must be above the height of groundwater measured in the adjacent portion of the up-gradient and down-gradient groundwater cut off drain.*
2) E12.5	*The licensee must monitor at a quarterly frequency the height of groundwater (in metres relative to AHD) in the bores required by conditions E12.1, E12.2 and E12.3* (Note: these are monitoring wells MW1S through to MW9S and MW1D through to MW9D as specified in Golder Drawing 06623099-D1029-RevC2).
3) E12.6	*The licensee must monitor at a quarterly frequency the height of groundwater (in metres relative to AHD) in the drain in the up-gradient and down-gradient groundwater cut off drains.*

Condition		Description
4)	E12.7	*The licensee must monitor, at a 6 monthly frequency, the concentration of As, Cd, Pb, Hg, Se, Zn and nitrate in the groundwater monitoring bores required by conditions E12.1, E12.2 and E12.3 which are outside the up-gradient and down-gradient cut off drains (Note: these are monitoring wells MW1S through to MW9S and MW1D through to MW9D as specified in Golder Drawing 06623099-D1029-RevC2).*

The IGMP was initially prepared in response to a condition of the Site Audit Statement issued by the previous Site Auditor following review of the site-wide remediation action plan. The intent of the IGMP was to provide a method for evaluating groundwater quality during the remediation program, and monitoring the hydraulic control measures at the site boundary (as reflected in Condition 7.2 of the Project Approval). It is noted that the IGMP is considered to be synonymous with the "Interim Groundwater Remedial Plan" referenced in Condition 7.2.

Whilst the groundwater monitoring program described in the IGMP was considered to be suitable for achieving the various groundwater-related requirements during the remediation program, the following considerations warranted a review and update of the IGMP:

- A groundwater monitoring strategy was required as a condition of the 75W application to modify the Project Approval to incorporate the IFL site into the PCCS remediation program. The purpose of this condition is to ensure that the GMMS is suitable to address the groundwater monitoring and management requirements in the context of the project modification (i.e. the addition of the IFL site to the remediation program for the main PCCS site);
- The progression of the soil remediation program has resulted in a substantial physical alteration to the landform across the remediated portions of the site, with removal of contaminated fill material and residual soil overlying bedrock (refer to Appendix A for an indication of the extent of soil remediation as of August 2012). Accordingly, a substantial portion of what was previously considered to be the "shallow" aquifer has been physically removed, and consequently a number of monitoring wells within the remediation footprint have been destroyed. Hence, it was considered an opportune time to update the monitoring strategy to consider the physical modification of the site in the context of the monitoring objectives;
- As identified in our recent site wide environmental monitoring report (Golder 2012a), the loss of monitoring wells during remediation has resulted in a reduced ability to assess the capture zones of the boundary hydraulic containment systems. This issue was raised in review comments for various groundwater monitoring reports provided by the EPA (2011), with the expectation that recommendations for replacement monitoring infrastructure would be provided; and
- The IGMP does not consider post-remediation monitoring requirements, and does not address groundwater remediation objectives. These details will be developed in detail in the GMMP, to provide a framework for assessing achievement of groundwater remediation objectives, and to provide the Site Auditor with confidence that residual groundwater contamination will continue to be regulated until acceptable improvement in groundwater quality has been achieved.

2.0 CONCEPTUAL SITE MODEL

2.1 Hydrogeological Setting

During historical environmental investigations and installation of the groundwater monitoring network for the site, a shallow and deep aquifer were identified. The shallow aquifer was defined as comprising water-bearing unconsolidated material overlying bedrock, whereas the deep aquifer was defined as the succession of water-bearing strata within the underlying Newcastle Coal Measures.

Shallow Aquifer

The material comprising the shallow (unconfined) aquifer comprises a veneer of unconsolidated materials resting on an old erosional surface of fractured sedimentary rock. The veneer consists of clay, gravels, fill and other waste materials, is not continuous across the site, and in places is dry (UTS, May 2005). As such, the shallow aquifer has diverse hydrogeological properties (Fitzwalter, July 2005).

The shallow aquifer generally thickens from east/southeast to west/northwest towards Cockle Creek. Previous site investigation has confirmed that buried stream channels are presented in the shallow aquifer at the SWD in the form of lenses of gravel-rich sediments with high hydraulic conductivity. At Hawkes Dam, the gravel-rich sediments were less abundant and the shallow aquifer is inferred to consist primarily of a relatively low permeability silty-clay sequence (CH2M HILL, March 2005). The difference in the shallow aquifer lithologies between the SWD and HD was reflected in calculated hydraulic conductivity values at SWD being two orders of magnitude higher than at HD (RES, July 2005).

Groundwater was generally encountered between 0.2 metres below top of casing (mbtoc) and 10.0 mbtoc in the shallow wells installed across the site. Review of borehole logs in the northern portion of Parcel 4 indicated a bedrock high in this area, with the depth to weathered rock typically less than 2 mbgl. The shallow aquifer in this area (approximately between the infilled gully and the Saltwater Dam) comprises a very thin layer of residual soil and fill material; groundwater storage and flow in this area considered to be negligible. Similarly, the majority of Parcel 2 on the upper slopes of Munibung Hill comprises a thin residual soil layer that grades quickly into weathered rock, and the shallow aquifer (as defined above) is considered to be largely absent (WSP, January 2011).

Groundwater in the shallow aquifer is inferred to recharge primarily through direct infiltration of rainfall. The groundwater flow direction in the shallow aquifer is approximately towards the west / northwest, on the assumption that there is a continuous water table across the site.

It should be noted that the shallow aquifer (as defined in this section) has been physically removed from a substantial portion of the PCCS site (particularly Parcel 4) as a consequence of the soil remediation program. A similar outcome is anticipated for the forthcoming remediation areas, including the IFL site. Hence, the definition of the “shallow aquifer” may need to be revisited with respect to the post-remediation monitoring objectives.

Deep Aquifer

The deep aquifer occurs within the bedrock strata underlying the unconsolidated sediments and fill across the site. The bedrock lithology was generally logged as comprising siltstone, mudstone and shale with minor occurrences of sandstone and coal. The deep aquifer is best described as a succession of permeable water-bearing layers in the bedrock stratigraphy, separated by lower permeability layers of siltstone and shale. The results of pumping tests have indicated a limited vertical hydraulic connection between the shallow aquifer and the shallowest occurrence of the deep aquifer within the upper weathered rock horizon (RES, July 2005).

The depth to bedrock varies across the site, ranging from 0.3 mbgl (at the IFL boundary) to approximately 15 mbgl (at the SWD site boundary). The bedrock elevation generally mirrors the site topography and drops to the west / northwest from highs in the east towards Cockle Creek (CH2M HILL, March 2004).

The deep aquifer was inferred to be recharged from rainfall infiltration in outcrop areas on Munibung Hill to the east, and to a lesser extent through a limited vertical hydraulic connection with the shallow aquifer (WSP,

2011). Deep groundwater is currently assumed to be affected by dewatering of underground mine workings, which is considered to have resulted in regional depressurisation of the coal measures.

Groundwater in the deep aquifer generally flows in a westerly / north-westerly direction.

2.2 Groundwater Contamination Sources

Groundwater quality beneath and down hydraulic gradient from the site was impacted primarily by metals associated with historical on-site soil contamination sources. Specific historical on-site contamination sources included:

- Waste disposal area (currently the Containment Cell);
- Fill material, including extensive filling with slag derived from smelting activities;
- Processing plants and material storage areas, such as zinc refinery and acid plant;
- Dams that receive surface water runoff and/or waste water from the site; and
- The IFL site operations.

In addition, the use of the Hawkes Dam water for road-washing and dust-suppression activities and the dust deposited across the site are likely to have contributed to the contamination in the groundwater and are regarded as secondary sources of contamination.

2.3 Contaminant Mobilisation and Migration Pathways

The most likely mechanism of metals contribution to groundwater from historical on-site contamination sources would have been leaching from contaminated surface soils and fill material during infiltration of rainfall recharge (or seepage from historical dams) to the shallow aquifer.

Metals in groundwater are likely to have adsorbed to mineral surfaces in the shallow aquifer, or co-precipitated with mineral precipitates within the aquifer matrix. These mechanisms are well-documented attenuation processes for metals in groundwater, and can provide long-term immobilisation of metals as long as the geochemical conditions within the aquifer remain stable.

Once dissolved metals are introduced to groundwater they would migrate with groundwater flow, and would be subject to various natural attenuation processes acting to retard the rate of migration (and total flux) of metals along the groundwater flow path.

2.4 Receptors for Contaminated Groundwater

The primary receptor for contaminated shallow groundwater beneath the main site is generally considered to be Cockle Creek. The conceptual site model for the site assumes that shallow groundwater discharges to Cockle Creek, which is a reasonable assumption, despite a general lack of detailed assessment into the surface water-groundwater interaction along this reach of Cockle Creek.

There are currently no water supply bores located within or down hydraulic gradient of the main PCCS site, and it is likely that restrictions on bore installation would be implemented with regard to future land uses. Hence water supply bores are not considered to represent a realistic exposure scenario for the site.

Deep groundwater is assumed to pass beneath Cockle Creek, and is considered to be regionally affected by depressurisation related to underground mine workings. As discussed in further detail later in this report, groundwater quality in the deep aquifer appears to reflect low impact from the historical site operations. Hence the primary focus of this groundwater assessment is contamination related to the shallow aquifer, and this is reflected in the PCCS Part 3A Approval conditions.

3.0 GROUNDWATER MONITORING AND MANAGEMENT

3.1 Groundwater Remediation Strategy

Although not explicitly defined previously, the preferred groundwater remediation strategy for the site comprises the removal of contamination sources through the excavation of contamination soil and fill material, followed by monitored natural attenuation (MNA) of the residual groundwater contamination. The contaminated soil and fill material is being placed into an on-site Containment Cell with an upgradient and a downgradient groundwater cutoff drain. The extracted groundwater from the cutoff drains is currently treated in an existing on-site Effluent Treatment Plant (ETP). It is noted that the current ETP will be decommissioned during the course of the remediation program, and will be replaced with a new leachate treatment plant to be constructed near the Containment Cell to address post-remediation leachate and wastewater management requirements.

In addition to the groundwater cutoff drains around the Containment Cell, groundwater is captured by hydraulic containment systems at the two principal areas of off-site migration (as defined during previous studies). The boundary containment systems are interim management measures designed to intercept contaminated groundwater in the shallow aquifer, and direct it to the ETP. The boundary containment systems will continue to operate until an acceptable endpoint related to groundwater quality improvement has been achieved; the details of this endpoint will be developed in the forthcoming GMMP.

Implementation of an MNA strategy, supplemented during remediation by the interim hydraulic containment measures described above, is considered to be a reasonable remediation strategy where extensive removal and containment of the contamination source from across the site is being performed. Following completion of the soil remediation program, the shallow aquifer in which the majority of contaminated groundwater currently resides will have been physically removed from most of the site. The final landform will be subject to limited grading and filling with clean imported material to achieve a developable ground surface, with a much thinner profile of unconsolidated material likely to be present above bedrock. The new “shallow” aquifer that eventually re-establishes across the site will comprise of rainfall recharge into the thin unconsolidated sediments, and flow in the upper weathered portion of the underlying bedrock. Residual groundwater contamination may continue to be present in the upper weathered rock aquifer in some portions of the site following completion of the soil remediation program; in the absence of a bulk contamination source it is anticipated that background groundwater quality conditions will be re-established within a relatively short timeframe.

The post-remediation groundwater monitoring strategy will support the MNA approach by assessing the change in groundwater quality following completion of the soil remediation program, including certain general chemistry parameters to enable geochemical modelling if required. Groundwater monitoring objectives related to the groundwater remediation strategy are outlined in Section 1.2.

3.2 Current Groundwater Monitoring Program

3.2.1 Site Wide and Boundary Groundwater Monitoring Network

Groundwater monitoring at the site commenced in 2003 and a large number of monitoring wells have since been installed, many of which have been destroyed due to the ongoing remediation works. The location of monitoring wells at the site is presented in Figures 3 to 6. Table 3 provides a summary of existing and destroyed monitoring wells. Please note that the monitoring wells for the IFL site have not yet been added to this list, but will be considered in preparing the GMMP.

The monitoring wells installed at the site are generally associated with one of the following groupings:

- **Background** – wells installed up- or cross-hydraulic gradient from the principal on-site contamination sources, considered to be representative of regional groundwater quality. It is noted that various factors are likely to have affected groundwater quality in the vicinity of the PCCS site, including the use of slag fill material in the surrounding neighbourhoods, and the influence of dust deposition from historical smelter stack emissions contributing to a diffuse metals source.

- **Intermediate** – wells installed within the main PCCS site between the upgradient and downgradient site boundaries. These wells generally represent "source zone" groundwater quality, and historically have reflected the most significant groundwater quality impacts at the site.
- **Downgradient boundary (main PCCS site)** – wells installed along the western downgradient site boundary to assess the quality of groundwater migrating off-site. The wells have historically been concentrated at the two locations on the main site boundary previously identified as the principal areas of off-site migration of shallow groundwater: the SWD groundwater catchment, and the HD groundwater catchment. These currently include three groundwater extraction wells at the SWD site boundary, and two groundwater extraction wells at the HD site boundary, to intercept contaminated shallow groundwater from the site and direct it to the ETP.
- **Downgradient boundary (Tripad)** – wells installed between the western downgradient boundary of the Tripad property (Parcel 3) and Cockle Creek. These wells represent shallow groundwater quality downgradient from both the Tripad and main PCCS sites, immediately adjacent to the closest inferred receiving environment for discharge of shallow groundwater from the sites. A number of "intermediate" wells were previously installed within the Tripad property boundary, but were all destroyed during remediation and subsequent earthworks at the site.
- **IFL Site** – with the proposed incorporation of the IFL property into the remediation program for the main PCCS site, including the associated IFL environmental monitoring programs, the monitoring wells within the IFL property boundary will be equivalent to "intermediate" wells within the main PCCS site. It is noted that the IFL wells listed in Table 4 comprise the licenced groundwater monitoring points in EPL 208 for the IFL site. The existence and serviceability of the wells is currently unknown, but will be confirmed for the purposes of the ongoing monitoring program.

The summary in Table 3 indicates that the majority of destroyed wells are from the "intermediate" grouping – wells installed at various locations within the main site boundary, which has been the focus of remediation activities.

In addition the number of shallow aquifer monitoring wells in the vicinity of the HD and SWD boundary containment systems is substantially reduced, with the surviving wells generally located in close proximity to the extraction wells. This has resulted in a limited ability to assess the capture zone of the containment systems through groundwater contour analysis. It is noted that during the first three years of operation of the boundary containment systems, whilst the majority of the monitoring network was intact, groundwater contour analysis demonstrated satisfactory capture of shallow groundwater. Despite the current reduction in the monitoring well network, the hydraulic properties of the shallow aquifer in which the systems were installed would be unchanged. Accordingly there is no reason to expect that capture is not continuing to be achieved as long as the pumped volumes are relatively consistent over time.

The progression of the remediation program will inevitably result in the decommissioning of the boundary extraction wells to facilitate the removal of contaminated fill and soil material in these areas. As soil remediation has generally progressed from east to west across the site, by the time the boundary extraction wells are removed, the upgradient shallow aquifer that the systems were designed to intercept will also have been physically removed. Hence, reinstatement of the boundary extraction systems following remediation is unlikely to be warranted, as the significant contamination the systems were designed to intercept will be substantially diminished. The perimeter cutoff drains around the Containment Cell are also expected to reduce the upgradient shallow groundwater contribution in the vicinity of the HD containment system. As a contingency measure, selected boundary *monitoring* wells will be reinstated as 100 mm diameter wells to facilitate conversion to *extraction* wells in the unlikely event that significantly contaminated groundwater continues to be detected at the boundary following remediation.

The GMMP will include proposed locations for selective reinstatement of destroyed monitoring wells, either in the locations of destroyed wells for pre- and post-remediation comparative purposes, or in strategically appropriate locations for assessment of the MNA monitoring objectives.

With regard to the ongoing remediation of the main PCCS site and the proposed incorporation of the IFL site in accordance with the 75W application, the current monitoring regime is considered to be suitable to achieve compliance with the regulatory requirements and approval conditions. Selective replacement of monitoring wells will ensure that an appropriately robust monitoring network is maintained for the remainder of the remediation program and into the post-remediation monitoring stage.

Table 3: Summary of Existing and Destroyed (shaded grey) Monitoring Wells

Purpose	Shallow Aquifer	Deep Aquifer
Background	FW1, BH12, BG1A (BH1A)	BG2A, BG3A (BH1)
	-	CWE2, CWE3, CWE4
Intermediate (Hawkes Dam Catchment)	BH9	BH8D
	B9, B12, BH21, A17, CH7, GABH109, GABH110, GABH114, GABH106, GABH107, GABH108, A4/GABH112, IN1, IN2, IN4	IN1A, IN2A, IN4A
Intermediate (South West Dam Catchment)	B21	-
	G1, G3, B29, B28, C21, IN5, BH15	IN5A, IN6A, IN7A
PCCS Downgradient Boundary (Hawkes Dam Catchment)	HDP2, HDP3, HD2, OS5, CH15	HD2A, CH15A, OS5A
	HDP1, HD1, HD3, CH9, BH20	CH12A
PCCS Downgradient Boundary (South West Dam Catchment)	SWDP1, SWDP2, SWDP3, BH2, CH1, CO1, CO2, CO3, SWD3	CO1A, CO2A, CO3A, CH3A, BH3D, SWD2, SWD5
	C3, C4, C5	SWD1
Tripad Downgradient Boundary	MW4S, MW5S, MW6S, MW7S, MW8S, MW9S	MW4D, MW5D, MW9D, PH1
	MW2S, MW3S	MW1D, MW2D
IFL Site [1]	129S, 124S ,138S, 108S, 112S, BH19, I2, BH7, BH14	138D, 136D, 108VD, 104D

Notes:

1. IFL monitoring wells listed as they appear in EPL 208; the existence and serviceability of the wells will need to be verified.

3.2.2 Containment Cell

The Containment Cell has been designed with upgradient and downgradient groundwater cutoff drains to limit the ingress of shallow groundwater into the cell footprint, and to prevent the migration of contaminated groundwater from the cell footprint into the surrounding aquifer, respectively. The upgradient cutoff drain has been installed, and installation of the downgradient cutoff drain is currently in progress.

A groundwater monitoring program has been developed for the Containment Cell to assess the capture performance of the cutoff drains within the shallow aquifer. The monitoring program comprises the installation and monitoring of clusters of monitoring wells along transects at pre-defined locations along the drains. In addition, groundwater samples are collected from the sumps that the cutoff drains report to for laboratory analysis, and groundwater extraction volumes from the sumps are recorded.

Monitoring wells were installed along three transects (T1 to T3) across the upgradient groundwater, with each monitoring transect comprising:

- Two shallow and deep well pairs installed approximately five metres up and down hydraulic gradient of the cuttoff drain;
- A third well pair installed approximately 20m up hydraulic gradient from the drain; and
- A standpipe installed within the drain itself for measurement of water levels within the drain.

The cutoff drain is considered to be performing if water levels measured in the shallow monitoring wells up and down hydraulic gradient of the drain are higher than the measured water level in the corresponding standpipe in the drain, or higher than the invert level of the drainage pipe at the bottom of the cutoff drain if water is not present within the standpipe (indicating that intercepted shallow groundwater is freely draining to the collection sumps). Water levels measured in the deep monitoring wells are used to assess whether the cutoff drain is influencing groundwater flow in the deeper aquifer, and are not directly linked to the shallow aquifer performance criteria for the drain.

Groundwater monitoring of the upgradient cutoff drain has been performed since 2009 by both WSP and Golder. Monitoring results to date have largely confirmed an inward hydraulic gradient toward the cutoff drain within the shallow aquifer. Hence, the specified program is considered to be suitable for demonstrating the performance of the upgradient cutoff drain, and is anticipated to be equally applicable to the downgradient cutoff drain. It is noted that subtle differences are anticipated in the water level response for certain monitoring transects, depending on their position relative to the prevailing groundwater flow directions across the site and the water table elevation relative to the invert elevation of the drain. However the relationship between water levels in the inner monitoring wells and the standpipe in the drain should be readily demonstrated irrespective of the transect location.

The monitoring program for the containment cell cutoff drains is considered to be robust and suitable for demonstrating compliance with the EPL requirements and project approval conditions. The design of the monitoring transects may in fact be overly conservative, and refinements may be considered in the development of the forthcoming GMMP if deemed appropriate and justified.

3.3 Groundwater Monitoring and Reporting Frequency

Groundwater monitoring events for the main PCCS site have historically been performed for three separate (although related) monitoring and reporting regimes:

- Boundary monitoring events – originally performed on a quarterly schedule, but a six-monthly schedule was endorsed by the Site Auditor in 2010;
- Site wide monitoring events – performed on a six-monthly schedule; and
- Containment Cell cutoff drain monitoring events – performed on a quarterly schedule in accordance with the EPL; and
- Tripad monitoring events – performed on an irregular schedule since 2008 to document pre- and post-remediation groundwater quality trends.

Whilst the current monitoring schedule is proposed to be maintained, the following revisions are proposed to be implemented:

- Groundwater monitoring results will be reported six-monthly within a consolidated environmental monitoring report, rather than as separate reports. This is intended to simplify the reporting and

regulatory review process, and to promote an integrated assessment of groundwater conditions across the full extent of the conceptual site model for the site; and

- The monitoring wells down hydraulic gradient from the Tripad property are proposed to be incorporated into the ongoing monitoring regime for the main PCCS site. Integrating the Tripad monitoring into the main PCCS site monitoring program is required for two reasons:
  - to provide assurance to the Auditor that a mechanism exists for the ongoing monitoring and regulation of residual groundwater contamination beneath and down hydraulic gradient from the Tripad site, such that a site audit statement can be issued for the proposed land use; and
  - to assess the capability of the MNA strategy to achieve appropriate groundwater quality objectives adjacent to the primary receiving environment for shallow groundwater (Cockle Creek), in accordance with the requirements of the RO for the main PCCS site.

4.0 CONCLUSIONS AND RECOMMENDATIONS

A groundwater monitoring program has been implemented at the PCCS site that is considered to be sufficiently robust to comply with the regulatory requirements and approval conditions for groundwater monitoring and management at the site. The proposed incorporation of the IFL site and associated monitoring requirements to the PCCS remediation program is expected to be suitably addressed by the current groundwater monitoring regime. The IFL site is situated in the upgradient portion of the PCCS site, and historical and current groundwater monitoring across the PCCS already accounts for the contribution of contaminated groundwater from the IFL site.

Recommendations for selective reinstatement of monitoring wells to replace destroyed wells and supplement the existing monitoring wells will be provided in the forthcoming GMMP. The replacement wells will be installed upon regulatory approval of the GMMP document, and as required during the remainder of the remediation program to supplement the inevitable loss of additional wells.

The forthcoming GMMP will also include discussion of the remedial objectives for groundwater at the site in order to demonstrate compliance with regulatory requirements, and to rationalise the interim groundwater management measures currently in place. This will include development of appropriate groundwater quality objectives for the downgradient site boundary, and ultimately the Cockle Creek compliance boundary, and interim milestones to demonstrate progress towards the remedial objectives.

5.0 REFERENCES

Bunderra Redevelopment Project (February 2012), *Quarterly Report on SWMP and CWMP at the Pasminco Cockle Creek Smelter Site* (dated 24 February 2012)

CH2M HILL (January 2004), *Pasminco Cockle Creek Smelter, Remedial Action Plan* (ref: 312188.04, dated January 2004)

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Report Signature Page

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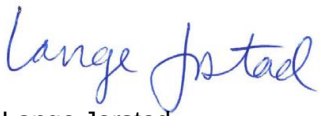

Daniel Dohle
Senior Waste Management Engineer

Lange Jorstad
Principal Hydrogeologist

DD:PR/LBJ/dd:pr

A.B.N. 64 006 107 857

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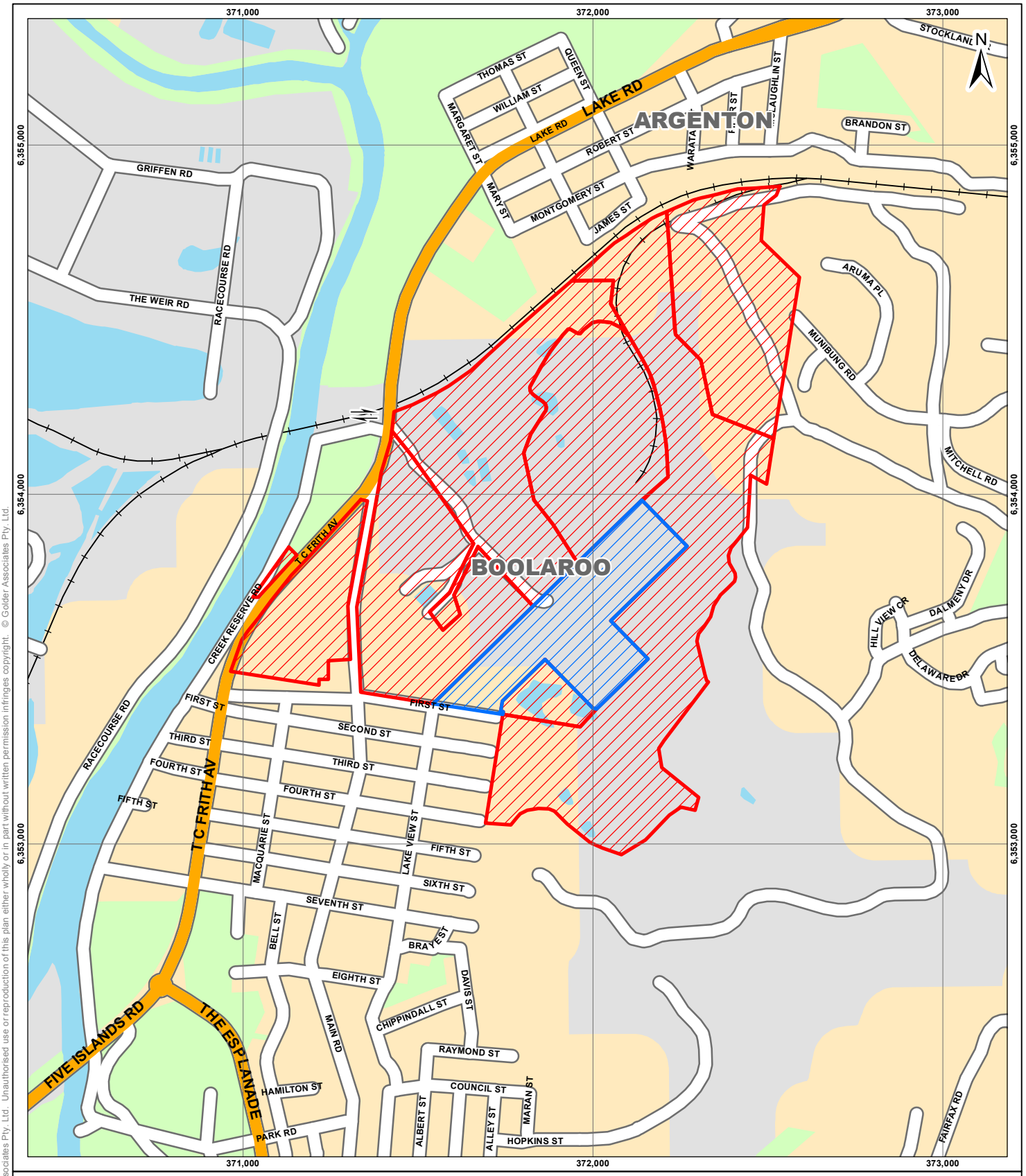
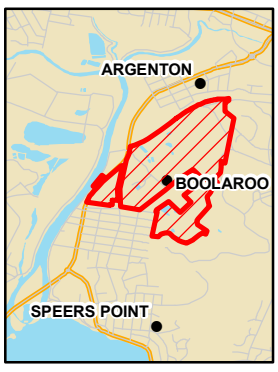


Pasminco Cockle Creek
Smelter Site, Boolaroo, NSW

Pasminco Cockle Creek Smelter Limited

SITE LOCALITY



LEGEND

- Remediation Work Areas Boundary (PCCS Site)
- IFL Property

0 50 100 200 300 400 500 metres

SCALE (at A4) 1:15,000

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: 117623127
DATE: 28/09/2012
DRAWN: FA / KB
CHECKED: KY

FIGURE 1

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PASMINCO COCKLE CREEK SMELTER SITE, BOOLAROO, NSW

FERRIER HODGSON

REMEDIATION WORK AREAS AND MONITORING WELL LOCATIONS

LEGEND

- Shallow Monitoring Well
- Deep Monitoring Well
- Pumping Well
- Containment Cell Monitoring Well
- Destroyed Monitoring Well

Remediation Work Areas

- 1 Cardiff West Estate
- 2 Munibung Hill
- 3 Triangular Paddock
- 4 Old Smelter Site
- 5 Mixed Use Zone
- Cell
- Assumed extent of the "Infilled Gully"
- Approximate Dam Locations

NOTES

1. Remediation work areas are approximate.
2. Remediation work areas sourced from WSP 2011, "Site-wide Pre-remediation Groundwater Report - April 2011, Figure 3" (ref: 18760_RP01 Rev 1, dated Nov 2011).
3. Infilled Gully sourced from WSP 2011, Figure 2.

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0 50 100 200 300 400 metres

SCALE (at A3) 1:8,000

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FIGURE 2

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PASMINCO COCKLE CREEK SMELTER SITE, BOOLAROO, NSW

FERRIER HODGSON

REMEDIATED WORK AREAS AND MONITORING WELL LOCATIONS - NORTHERN DETAIL

LEGEND

- Shallow Monitoring Well
- Deep Monitoring Well
- Pumping Well
- Containment Cell Monitoring Well
- Destroyed Monitoring Well

Remediated Areas

- Angophora Reserve
- Cardiff West Estate
- Parcel 2
- Parcel 3
- Parcel 4
- Parcel 5
- Assumed extent of the "Infilled Gully"
- Approximate Dam Locations

NOTES

1. Remediated areas are sourced from RCA 2012 "Remediation and Validation Status August 2012, PCCS, Boolaroo (ref: 5542m-413/1 Rev3, dated 24/08/12)

2. Infilled Gully sourced from from WSP 2011, "Site-wide Pre-remediation Groundwater Report - April 2011, Figure 2" (ref: 18760_RP01 Rev 1, dated Nov 2011).

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0 25 50 100 150 200 metres

SCALE (at A3) 1:4,000

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FIGURE 3

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PASMINCO COCKLE CREEK SMELTER SITE, BOOLAROO, NSW

FERRIER HODGSON

REMEDIATED WORK AREAS AND MONITORING WELL LOCATIONS - SOUTH-WESTERN DETAIL

LEGEND

- Shallow Monitoring Well
- Deep Monitoring Well
- Pumping Well
- Containment Cell Monitoring Well
- Destroyed Monitoring Well

Remediated Areas

- Angophora Reserve
- Cardiff West Estate
- Parcel 2
- Parcel 3
- Parcel 4
- Parcel 5
- Assumed extent of the "Infilled Gully"
- Approximate Dam Locations

NOTES

1. Remediated areas are sourced from RCA 2012 "Remediation and Validation Status August 2012, PCCS, Boolaroo (ref: 5542m-413/1 Rev3, dated 24/08/12)

2. Infilled Gully sourced from from WSP 2011, "Site-wide Pre-remediation Groundwater Report - April 2011, Figure 2" (ref: 18760_RP01 Rev 1, dated Nov 2011).

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0 20 40 80 120 160 metres

SCALE (at A3) 1:3,000

Coordinate System: GDA 1994 MGA Zone 56

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FIGURE 4

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PASMINCO COCKLE CREEK SMELTER SITE, BOOLAROO, NSW

FERRIER HODGSON

REMEDIATED WORK AREAS AND MONITORING WELL LOCATIONS - SOUTH-EASTERN DETAIL

LEGEND

- Shallow Monitoring Well
- Deep Monitoring Well
- Pumping Well
- Containment Cell Monitoring Well
- Destroyed Monitoring Well

Remediated Areas

- Angophora Reserve
- Cardiff West Estate
- Parcel 2
- Parcel 3
- Parcel 4
- Parcel 5
- Assumed extent of the "Infilled Gully"
- Approximate Dam Locations

NOTES

1. Remediated areas are sourced from RCA 2012 "Remediation and Validation Status August 2012, PCCS, Boolaroo (ref: 5542m-413/1 Rev3, dated 24/08/12)

2. Infilled Gully sourced from from WSP 2011, "Site-wide Pre-remediation Groundwater Report - April 2011, Figure 2" (ref: 18760_RP01 Rev 1, dated Nov 2011).

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0 25 50 100 150 200 metres

SCALE (at A3) **1:4,000**

Coordinate System: GDA 1994 MGA Zone 56

PROJECT: **117623127**
DATE: **28/09/2012**
DRAWN: **FA / KB**
CHECKED: **PR / DD**

FIGURE 5

Golder Associates

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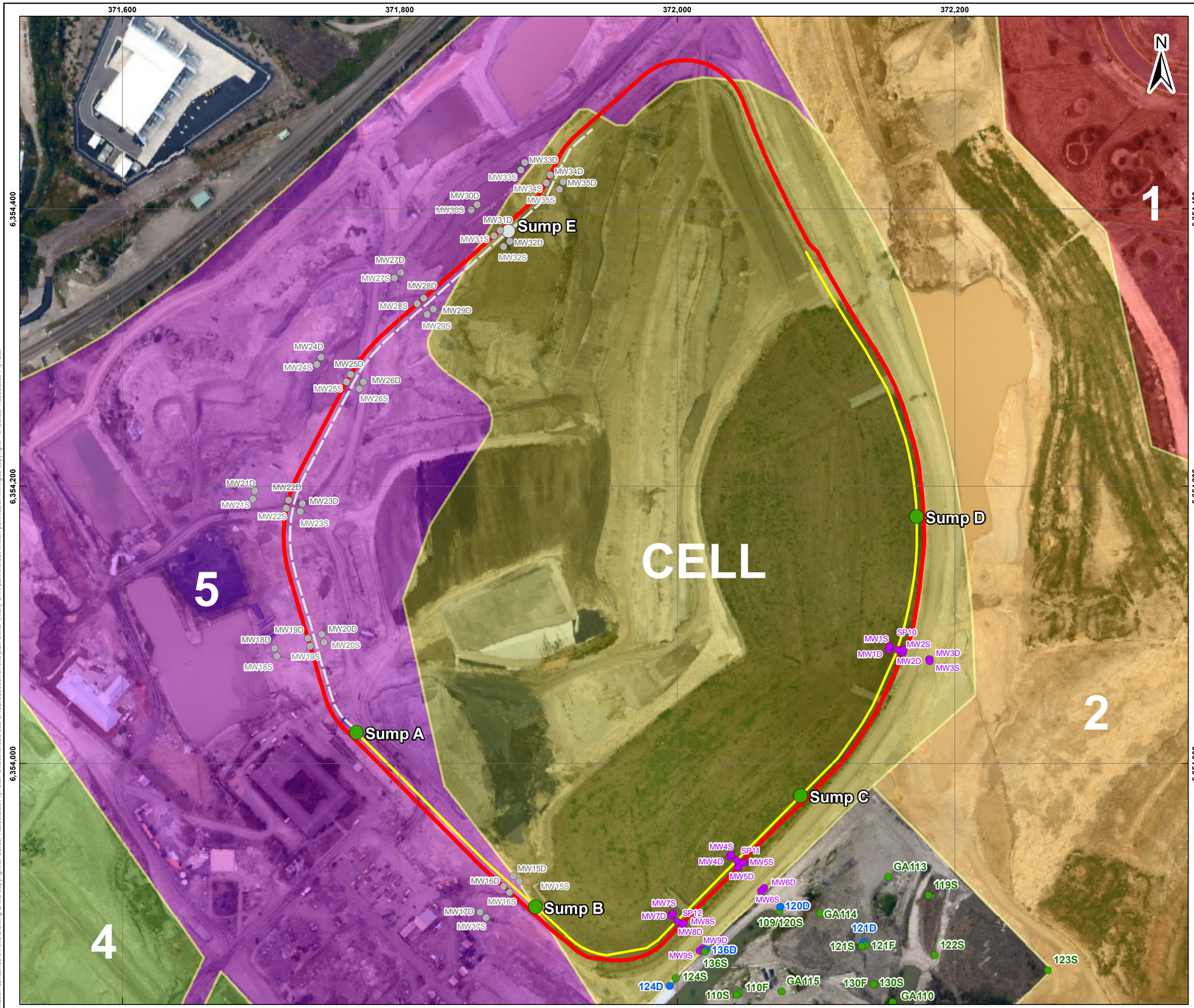

PASMINCO COCKLE CREEK SMELTER SITE, BOOLAROO, NSW

FERRIER HODGSON

CONTAINMENT CELL MONITORING PLAN

LEGEND

- Containment Cell Monitoring Well (Existing)
- Containment Cell Monitoring Well (Proposed)
- Sump Location (Existing)
- Sump Location (Proposed)
- Containment Cell Boundary
- Cutoff Drain Alignment (Existing)
- Cutoff Drain Alignment (Proposed)

Remediation Work Areas

- 1 Cardiff West Estate
- 2 Munibung Hill
- 3 Triangular Paddock
- 4 Old Smelter Site
- 5 Mixed Use Zone
- Cell

NOTES

1. Remediation work areas are approximate.
2. Remediation work areas sourced from WSP 2011, "Site-wide Pre-remediation Groundwater Report - April 2011, Figure 3" (ref: 18760_RP01 Rev 1, dated Nov 2011).

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0 10 20 40 60 80 100 metres

SCALE (at A3) 1:2,700

Coordinate System: GDA 1994 MGA Zone 56

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FIGURE 6

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APPENDIX A

Site Description and Site History

1.0 SITE DESCRIPTION

1.1 Site Location and Surrounding Land Use

The PCCS main site is located approximately 13 kilometre (km) south west of Newcastle and 2 km north of Lake Macquarie and is bordered:

- To the south by First Street beyond which are residential properties;
- To the west by Main Road beyond which is the Remediation Parcel 3 and Cockle Creek;
- To the North by a branch line of the Main Northern Railway; and
- To the east by the base of Munibung Hill.

The site locality map is presented in Figure 1.

1.2 Site Identification

Updated site identification information based on information presented by CH2M Hill (January 2004), RCA (2010) and a site survey provided by PCCS is summarised in below.

Table 1: Site Identification Information (CH2M HILL, 2004 and RCA, 2010)

Street Address	13a Main Road Boolaroo NSW 2284
Legal Description	Lot 201 DP 805914
Site Area	122.4 ha (approx.)
Geographical Coordinates	Latitude 32 56 90 S Longitude 151 37 70 E
Owner	PCCS Pty Ltd[1]
Zoning	The zoning of the site is as follows[2]: 2(1) Residential: Remediation Parcels (RP) 2 and 4, IFL site 2(2) Residential (Urban Living): RPs 3, 4, IFL site 3(2) Urban Centre (Support): RPs 4 and 5 4(1) Industrial (Core): Cell and IFL Site 4(2) Industrial (General): RPs 1 and 5 B4 Mixed Use: RP 5 7(2) Conservation (Secondary): RP 2
Local Government Area	City of Lake Macquarie Council
Parish	Kahibah
County	Northumberland

Notes:

[1] PCCS was placed in voluntary administration in September 2001. Ferrier Hodgson was appointed as Deed Administrators in October 2002 (WSP (2009)).

[2] Zoning for the PCCS site was reported as Sp. Industry 4b (Smelt works) / Environmental Protection 7a in CH2M HILL (2004) but has since been updated (Lake Macquarie LEP 2004, updated 13 January 2012)

1.3 Site History Progress of Remediation

The following sections provide a brief description of the remediation progress, as of the issue of this document, for each of the land parcels into which the PCCS site has been divided.

1.3.1 Remediation Parcel 1 – Cardiff West Estate (CWE)

Historical activities undertaken at the Remediation Parcel 1 included:

- Primarily open space area: no major operations or potentially contaminating activities were carried out on this area; and
- A clay pit area: This area is located on the north-western portion of the Parcel 1 and was historically used as a clay quarry and as a waste (containing lead) dump area.

The CWE catchment is relatively small and only produces a small amount of groundwater. The soil in this area has been fully remediated and a Validation Report has been approved by the former Site Auditor. The CWE area has been excised from the RO and the EPA have advised that no further monitoring is required at this area.

1.3.2 Remediation Parcel 2 – Munibung Hill

Remediation Parcel 2 has generally comprised open space area throughout the history of the site. No known operational or potentially contaminating activities have been carried out in this area.

Parcel 2 is considered to have only been lightly affected by dust-borne contamination associated with smelter stack emissions. The groundwater flow in this parcel is towards the west-northwest, sympathetic to surface topography, and flows on to the main site (in some parts via the Incitec site), or into the upgradient cutoff drain of the Containment Cell.

We understand that the majority of Parcel 2 has been remediated, effectively removing the source of contamination in this area.

1.3.3 Remediation Parcel 3 – Triangular Paddock

Based on the information presented in the WSP Report (2009, and May 2011), the history of Tripad can be summarised as follows:

- Tripad had historically been open space used for cattle grazing;
- The site is within the ‘fallout’ zone of emissions from stacks located on the main PCCS site. The dust emitted from the stacks included heavy metals which may have impacted the surface soil at the site.
- During the mid 1900s, cadmium-rich waste water is understood to have flowed from the smelter along a creek line through Tripad and collected in an effluent dam formerly located in the south eastern corner of the Tripad area (WSP, 2011);
- Although smelter infrastructure is understood not to have been located within Tripad, slag or similar material is understood to have been stockpiled within the southern portion of the site;
- Up to 1.4 metre (m) of fill material was placed in the northern portion of the site during the construction of the nearby Glendale Shopping Centre.

The NSW EPA Accredited Site Auditor for the entire PCCS site, Mr Graeme Nyland, has reviewed and issued interim audit advice (IA) in regard to the validation report (Environ, February 2011). The IA for the Tripad validation report concluded that the soil in the Tripad site was remediated to a standard suitable for residential use and that a post-remediation groundwater monitoring program should be implemented prior to the issue of a SAR/SAS.

Following completion of the soil remediation program the Tripad site is no longer considered to represent a source of ongoing contamination to shallow groundwater, and the presence of residual groundwater contamination beneath the site is not considered to preclude the proposed residential land use, as long as institutional controls are implemented to prevent access and exposure to potentially contaminated shallow groundwater.

1.3.4 Remediation Parcel 4 – Older Smelter Site

Remediation Parcel 4 is the main plant area for post-1960 operations. The facilities associated with Parcel 4 included the smelter, zinc refinery, cadmium plant, sinter plant, acid plant, effluent treatment plant (ETP), raw materials store, South West Dam (SWD) and Freshwater Dam (FD).

This area contained the majority of the soil contamination on the PCCS site. The remediation of Parcel 4 is expected to be the primary factor in reducing contaminant concentrations within the South West Dam groundwater catchment.

The remediation of this area has progressed to the extent where the majority of Parcel 4 has been excavated to bedrock, effectively removing the shallow aquifer in this area. The following photos show conditions in the southern part of Parcel 4 as observed on 09 August 2012.

Photo 1: Parcel 4, viewing south towards the IFL site

Photo 2: Parcel 4, viewing west towards South West Dam

1.3.5 Remediation Parcel 5 – Mixed Use Zone

The facilities associated with Remediation Parcel 5 included:

- Acid and gas plants, and bulk storage area of sulphur;
- Site office, gatehouse and weighbridge;
- An extension of the dump and storage area from the containment cell; and
- Saltwater Dam (SD), and Hawkes Dam (HD).

This is the fifth and final land parcel for remediation on the PCCS site. The remediation in this area will be completed ahead of the closure of the Containment Cell. Certain sections of Parcel 5, in particular in the north and south, have already been remediated (Figures 3 to 5).

1.3.6 Containment Cell

This area was the main operational area before 1960 (including cement manufacture and ore lead refining). Construction works and filling of the Containment Cell is ongoing, and under the current proposal will include contaminated fill and soil from the IFL site. The upgradient groundwater cutoff drain has been completed, which is designed to capture upgradient shallow groundwater flowing towards the cell from Munibung Hill and the Incitec property, and hence improve the efficiency of the downgradient groundwater cutoff drain, which is currently being constructed.

1.3.7 IFL Site

The IFL site is located upgradient of a large portion of the main PCCS site and is bounded to the:

- North by Parcel 2;
- South by First Street and Parcel 4;
- West by Parcels 4, 5 and the Containment Cell; and
- East by Parcel 2.

The site has historically been operated as a fertiliser manufacturing plant, although the majority of infrastructure has now been removed. The IFL property currently includes contaminated fill material that has resulted in impacts to shallow, and potentially deeper, groundwater quality. This has been documented through monitoring wells installed immediately down hydraulic gradient from the IFL boundary.

Within the context of the conceptual site model for contaminant transport in groundwater at the site (refer to the main document, Section 2.0), contaminants entering groundwater on the IFL site (primarily via leaching from metalliferous fill material) would be transported westward with the prevailing direction of groundwater flow across the site (i.e. towards Parcels 4 and 5). Previous groundwater modelling for the PCCS site (UTS, 2005) has indicated that groundwater originating from the IFL site is likely to contribute to both the South West Dam and Hawkes Dam groundwater catchments, and a portion is also intercepted by the groundwater cut-off drains. Whilst specific details of the presence and operation of hydraulic containment controls on the IFL boundary are uncertain, monitoring results immediately down hydraulic gradient from the IFL boundary suggest that impacted groundwater has already migrated from the site and is likely to have been reflected in groundwater quality observations from the PCCS monitoring programs carried out to date.

Recent negotiations are likely to result in the remediation of the Incitec site being managed by PCCSS, including consideration of groundwater contamination issues. It is understood that PCCS is lodging an application with the Department of Planning and Infrastructure (DoPI) to combine the IFL and PCCS sites.

1.4 Topography and Hydrology

The site is located on the lower western slopes of Munibung Hill and generally falls towards west / northwest towards Cockle Creek. The site has been extensively levelled over the years of operation. Cutting and filling activities have also levelled many of the natural gullies and depressions which were present before site development. Fill material has included industrial by-products and waste materials from site industrial processes, including slags (CH2M HILL, January 2004).

The site is contained in the Munibung Hill catchment area and the drainage for the majority of the site is toward Cockle Creek (CH2M HILL 2004). There are a number of gullies which have been built over on the site, and surface water runoff on-site has been historically collected in a series of dams:

- Freshwater Dam: The FD dam is adjacent to the IFL site and the Remediation Parcel 2, with two major gullies jointed below and flowed toward Cockle Creek. The bedrock channel (known as infilled gully on Figure 2) has been filled and built over. Rain water captured in the Freshwater Dam was mostly consumed on-site and did not overflow into Cockle Creek unless extended periods of wet weather was experienced;
- South West Dam: The SWD dam is located on the south-west portion of the Remediation Parcel 4, and is situated in the flow path of the infilled gully. The Dam collects excess water from the Freshwater Dam and surface water runoff from the southern portion of the main site;
- Saltwater Dam: The SD is located within Remediation Parcel 5 and drains towards Cockle Creek. The inflow to the SD was mostly recycled cooling water which had been pumped out the Cockle Creek. However, since the closure of the site in September 2003, the Saltwater Dam receives contaminated water for treatment in the ETP; and

- Hawkes Dam: The HD was located on the north-western portion of the Remediation Parcel 5 and received surface water runoff from the northern area of the main site. Hawkes Dam water was used at the site for road-washing and dust-suppression activities. It is understood that the Dam has been filled during the remediating works.

Previous groundwater modelling (UTS, May 2005) suggested that groundwater levels are likely to be controlled by Freshwater Dam, South West Dam, and Hawkes Dam. The Saltwater Dam was considered to be disconnected from the shallow aquifer as water levels are much higher than the water table (UTS, May 2005).

In addition, the UTS report (May 2005) suggested that significant potential for off-site migration of groundwater from the main site via two areas: the South West Dam and the Hawkes Dam, and confirmed that installation of two pumping systems would control off-site migration of groundwater at the down gradient site boundaries. As such, two groundwater extraction systems were installed into the shallow aquifer in the vicinity of the dams and have been operational since early 2006.

Please refer to Figure 2 for the approximate dam locations.

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APPENDIX B

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Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Pty Ltd
124 Pacific Highway
St. Leonards, New South Wales 2065
Australia
T: +61 2 9478 3900

Golder Associates