EnviroRisk

APPROVALS - SUSTAINABILITY - COMPLIANCE

Environmental Evaluation Report: March 2016

for

Incitec Pivot Limited

trading as Southern Cross Fertilisers

ENVIRONMENTAL REPORT

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The report is reliant on the accuracy and completeness of information provided by the Client and is based on risk reasonably capable of being identified in the timeframe for the assessment and with reference to the provided data, plans and support documents.

Risk scenarios are based on reasonably foreseeable environmental impact based risks, with semi-quantitative methods adopted for the assessment. The risk scenarios evaluated are invariably under site specific conditions and apply to the site under consideration as operating at the time of the inspection date(s).

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APPENDICES

GLOSSARY

AHD	Australian Height Datum
AS/NZS	Australian and New Zealand Standard
BLG	Below Ground Level
HDPE	High Density Poly Ethylene (plastic liner)
EE	Environmental Evaluation
EAS	Eastern Aquifer System
ERA	Environmental Risk Assessment
GSF	Gypsum Stockpile Facility
IPL	Incitec Pivot Limited
MSDS	Material Safety Data Sheet
PG	Phosphogypsum (interchangeable referred to as 'gypsum' in this report)
PHM	Phosphate Hill Mine
RL	Relative Level
SCF	Southern Cross Fertilisers Pty Ltd
TDS	Total Dissolved Solids
WAS	Western Aquifer System

GENERAL INFORMATION

Report No:	160330
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Revision No.	Summary of Amendments	Reviewed by	Issued by	Issue Date
Draft		J Leonard	S Jenkins	19 Oct 2015
0	Clarification on pond tears, Galah Creek not Dead Horse, Numbering GSMB20. Legends	IPL Mgt	S Jenkins	12 Nov 2015
1	Update following receipt of AECOM 3A investigation reports, C&R final report and March site inspection	J Leonard	S Jenkins	30 Mar 2016

EXECUTIVE SUMMARY

Incitec Pivot Limited (IPL), trading as Southern Cross Fertilisers, operates a fertilizer manufacturing facility within their phosphate mining lease at Phosphate Hill, Queensland.

The manufacturing process produces a slurry phosphogypsum waste material that is pumped to form large stockpiles within purpose designed storage cells. Acidic process waters that leach from the stockpiles are directed into lined ditches and ponds and allowed to evaporate, or are recirculated back into the plant for re-use as re-slurry liquor.

There are presently:

- five(5) gypsum storage cells, labelled: Cell 1 and 2 (now combined into one stockpile),Cells 4A and 4B (now combined into one stockpile) & Cell 5A;

- a stormwater holding pond, Cell 3A, and two(2) evaporation ponds, labelled Cell 3B, and 'evaporation pond'; and

- a series of toe drains and ditches that contain and direct process water and captured stormwater back to the storage and evaporation ponds or to the slurry recirculation plant.

The entire area containing the phosphogypsum stacks, surge ditches, toe drains, dykes and evaporation ponds is approximately 110 Ha in size and is termed the Gypsum Stockpile Facility (GSF).

The approximate boundary of the GSF in reference to IPL's mining activity is illustrated below:

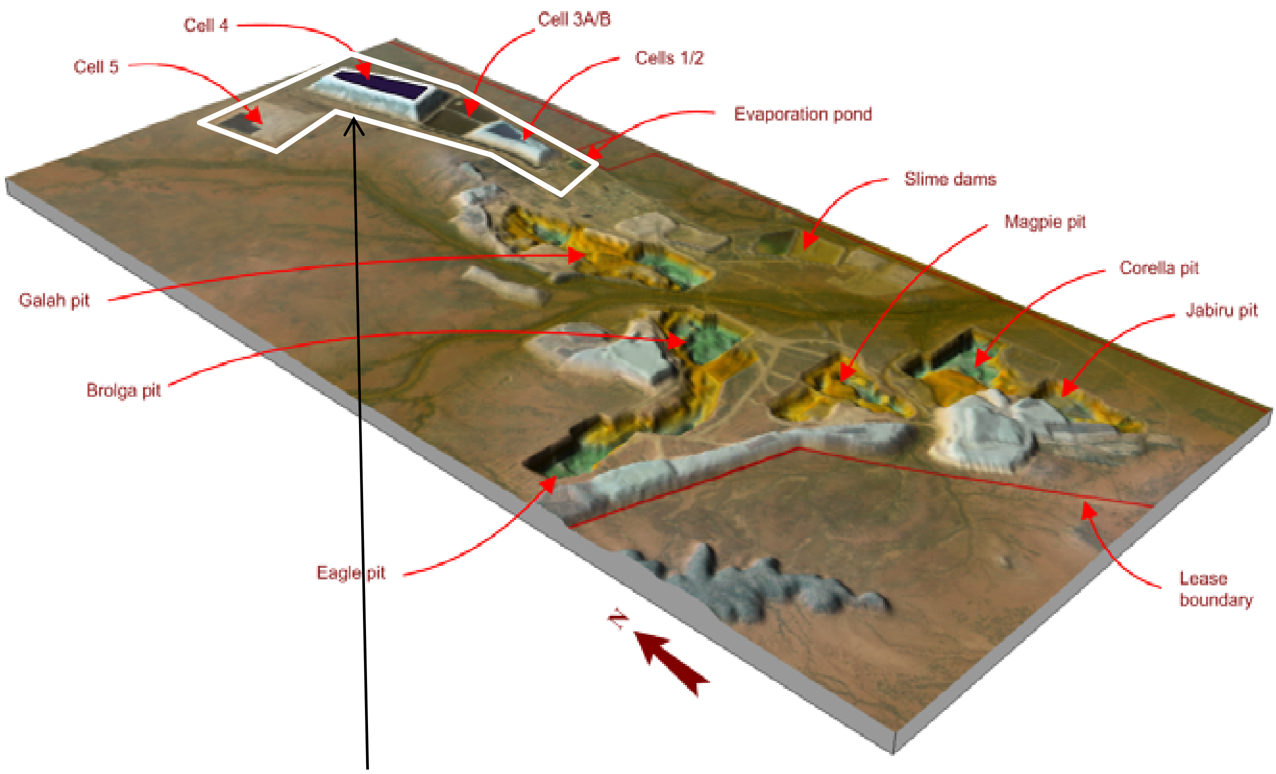

Figure E1: Location of the GSF in reference to the mining activities.

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In May 2014 an incident involving a D6 dozer that inadvertently entered water storage pond Cell 3A resulted in an investigation into a potential compromise of the pond liner. Over the following months Cell 3A was emptied and tears were noted within the flexible geomembrane liner system.

In March 2015 the Department of Environment and Heritage Protection (EHP) issued notice to conduct an '*Environmental Evaluation'* based on '*reasonable grounds that the activity is causing, of is likely to cause, environmental harm*'. The *Environmental Evaluation* notice made reference to the entire Gypsum Storage Facility (GSF) and not just Cell 3A.

EnviroRisk was tasked with assisting IPL in providing a response to the requirements within the *Environmental Evaluation* associated with reporting on the risk of environmental harm to groundwater quality and undertaking a remediation options analysis. Further information to support the *Environmental Evaluation* has been prepared by C&R Consulting (Regional Groundwater Investigation) and AECOM (Geotechnical and Environmental Assessment of Cell 3A). Data within these reports has been integrated into a program designed to respond to all of the *Environmental Evaluation* requirements. IPL has substantially responded to all notice conditions other than the remediation options analysis which, by necessity, requires installation of additional groundwater bores and risk assessment to complete which is underway.

This report provides, as of March 2016, the *Environmental Evaluation* response. This has involved:

1) Identifying the likely contaminants within the GSF that pose an environmental risk.
2) Preparing a conceptual site model for the hydrogeological setting beneath and immediately surrounding the GSF.
3) Reviewing the adequacy of current groundwater monitoring systems to adequately identity a risk of harm; either current or likely.
4) Establishing, as best possible, the extent of any actual impact on groundwater quality against reference water quality criteria so as to evaluate any potential risk of impairment.
5) Determining the adequacy of current leak detection monitoring for the GSF and identify areas for improvement.

A conceptual site model has been prepared and has identified that the GSF is positioned directly atop the north-south running Mehaffey Fault (or fault zone). The location of the fault has been inferred based on different rock lithologies, groundwater elevations and groundwater chemistry on opposite sides of the 'fault'.

Hydrogeological analysis indicated that the Mehaffey Fault(s) hydraulically separates two main aquifer systems; a system east of the fault referred to here as the Eastern Aquifer System (EAS), and that on the western side of the fault referred to as the Western Aquifer System (WAS). Both aquifer systems include a number of different stratigraphic units with both permeable (aquifer) zones and lower permeability (aquitard) zones that function as multilayered, leaky aquifer systems. The EAS includes: the Swift Formation; and the Ninmaroo Formation. The WAS includes three stratigraphic units namely: the Inca Formation; Beetle Creek Formation; and Thortonia Limestone.

Recent monitoring reveals that the depth to groundwater in the EAS (e.g. approximately 216mAHD; or approximately 54m below ground level (bgl)) is about 6m higher than the WAS that lies to the west of the Mehaffey Fault (e.g. approximately 210mRL). However, historically the groundwater depth in the WAS was significantly higher. Dewatering of pits and extraction of groundwater for production needs has lowered the water table in the WAS western aquifer system by some 24m over the past two decades. These observations support the conclusion that the Mehaffey Fault acts as a hydrogeological barrier boundary that restricts west-east groundwater flow.

The variation in depth of the water table on both sides of the Mehaffey Fault is clearly identifiable within Figure E2 below.

Groundwater flow within the aquifer systems beneath the GSF area is generally to the south i.e. towards the manufacturing facility and the mine extraction pits. Groundwater quality up-gradient of the mine site has been identified as being slightly saline (i.e. TDS in EAS = 600 mg/L approx. and TDS in WAS = 1200 mg/L approx.) with an environmental value equating to livestock drinking water [C&R, 2015]. The nearest known neighbouring station bore (Coolbah bore) that extracts groundwater for livestock purposes is more than 7km from the GSF boundary.

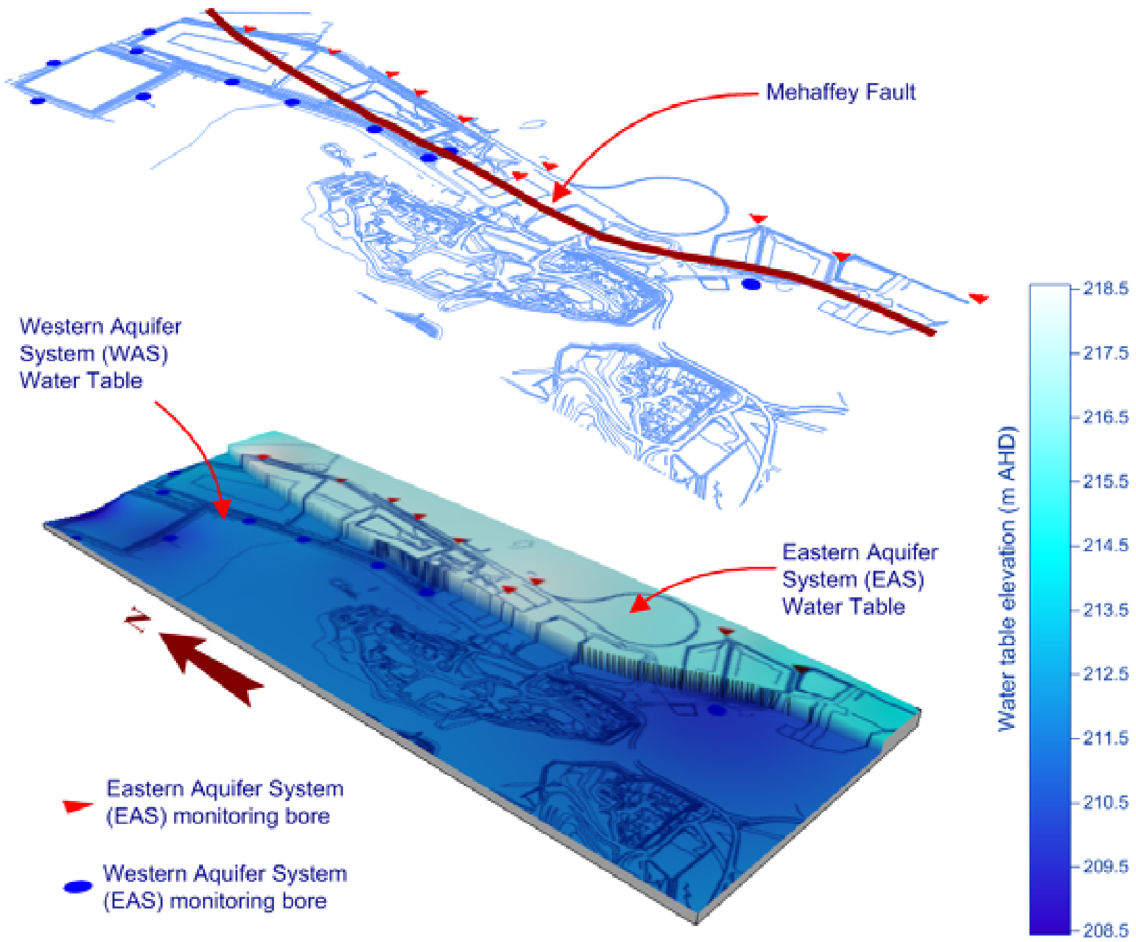


Figure E2: 3-Dimensional representation of the GSF area water table with the Mehaffey Fault forming a hydrogeological barrier boundary

An existing groundwater monitoring bore network exists across the mine site with bores surrounding the GSF. Groundwater quality monitoring, coupled with a physical inspection regime of the surge ditch, toe drains and ponds systems for obvious tears, represent the main routine integrity checks on whether leakage through the GSF geomembrane cell liners is occurring, or has potential to occur.

Prominent bores available to measure groundwater quality around the GSF as part of the liner integrity monitoring program are:

West Aquifer System Bores	East Aquifer System Bores
GSMB01A, GSMB02A GSMB04B, GSMB11, GSMB12, GSMB13, GSMB16, GSMB17, GSMB18	GSMB07A, GSMB09, GSMB14, GSMB15A, EPMB01, EPMB02, EPMB04, GW05A

Bore locations and their screened stratigraphic units are identified in Figure E3 below:

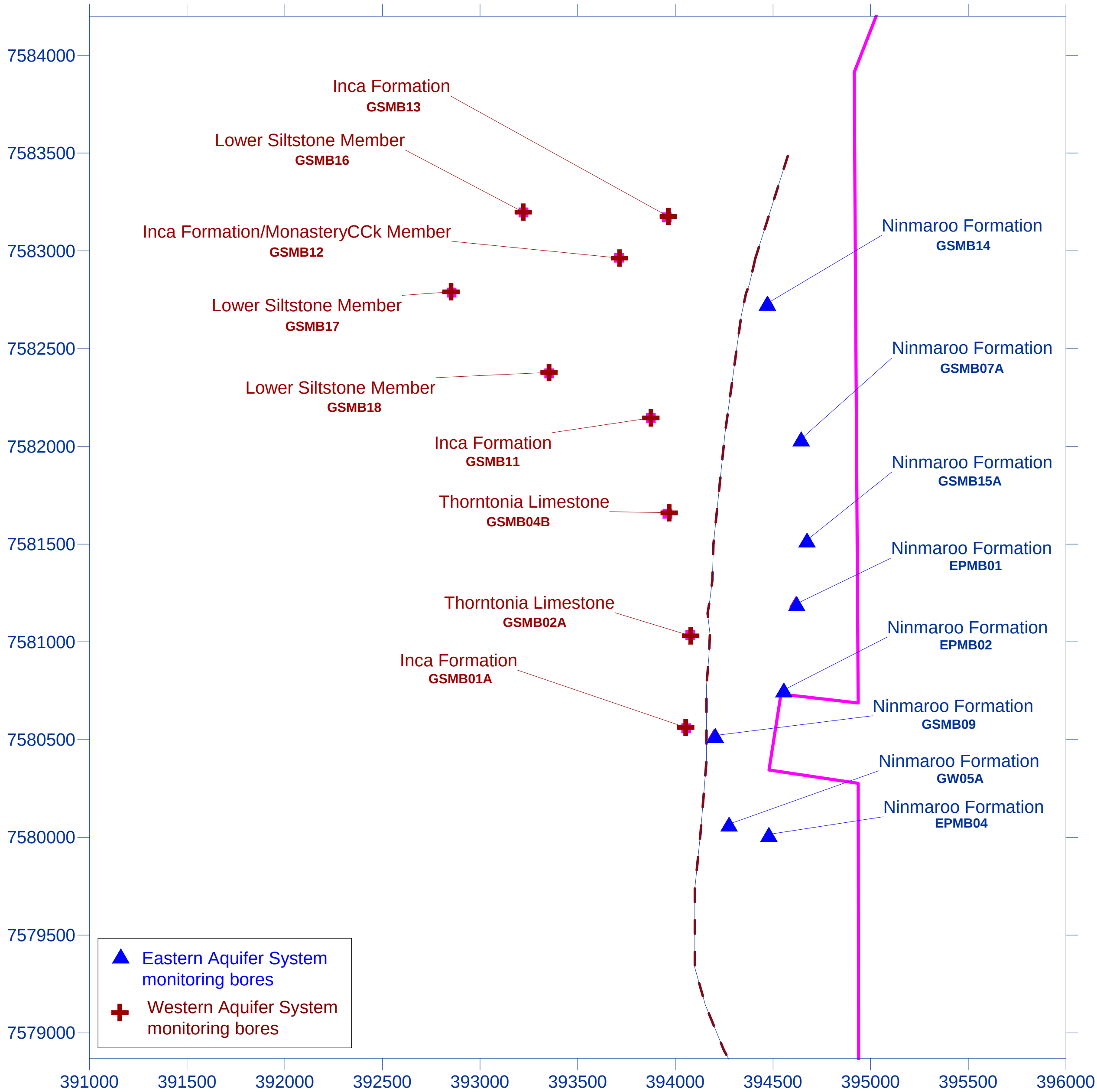


Figure E3: Monitoring bore network for the GSF.

An evaluation of process information and PG waste composition has established that the principal chemical indicators of contamination are identified as:

- pH, TDS (Electrical Conductivity), Calcium, Fluoride, Chloride, Sulphate, Nitrate, Phosphate, Arsenic, Cadmium, Uranium and Lead.

There are many other components within the GSF leachate yet the aforementioned chemicals are considered to represent the best lead markers of impact. There are also radionuclides that could be used as markers in the future.

Results attained over the past 5 years reveal no discernible impact trend for chemical contamination within groundwater other than a change in salt concentrations within two bores: Bore GSMB15A, south-east of evaporation pond Cell 3B and Bore EPMB01, east of Cell 1&2. Prominent ions contributing to an increasing TDS trend since 2009 are: calcium, sodium & chloride. An upwards trend appears to have commenced during the year 2009.

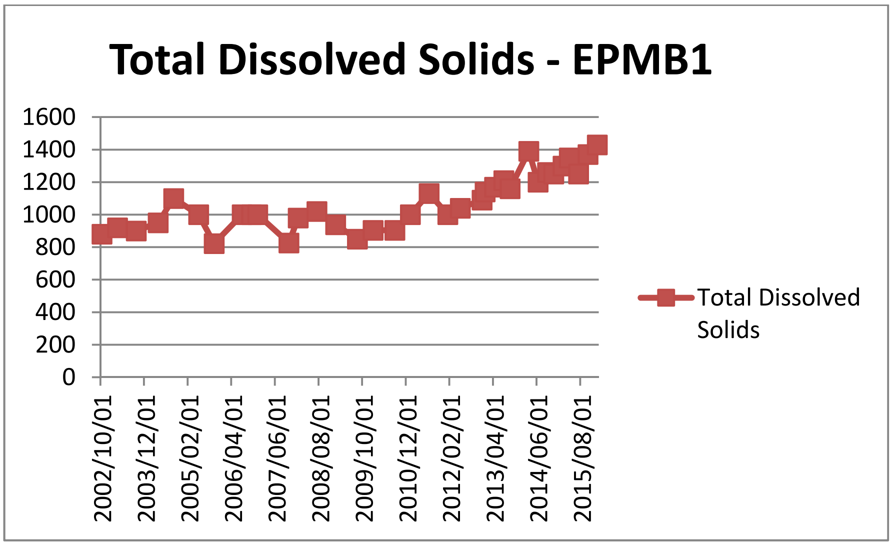


Figure E4: TDS (mg/L) trend in Bore EPMB01 (east of Cells 1&2)

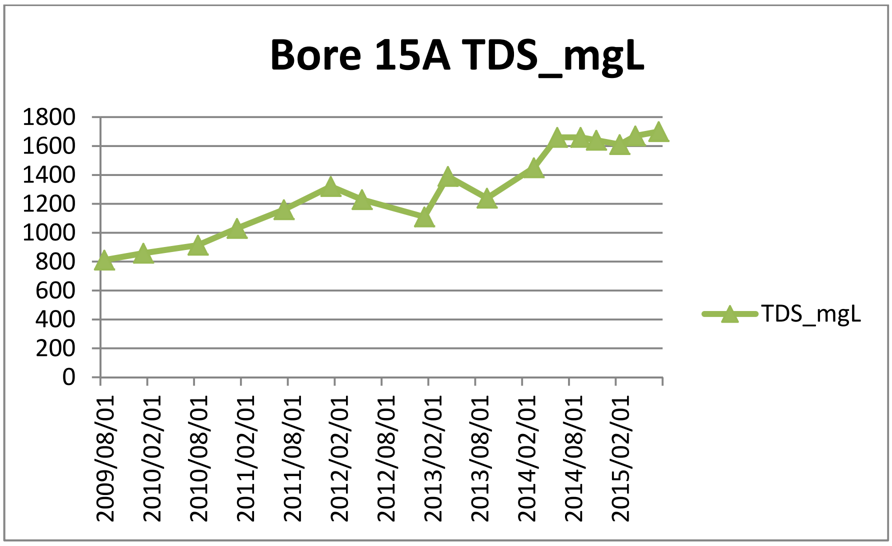


Figure E5: TDS (mg/L) trend in Bore GSMB15A (south-east of Cell 3B)

Bores EPMB01 and GSMB15A are down hydraulic gradient from Cells 3B and Cells1&2 and are well positioned to evidence impact should GSF water escape the membrane liner and ultimately enter groundwater. Of note is bore GSMB09 which is also down hydraulic gradient of Cell 1&2 but as of yet reveals no discernible impact trend. Should impact be occurring from the GSF, it does not appear to be widespread.

Other than TDS within bores EPMB01 and GSMB15A, none of the other twelve(12) bores being monitored surrounding the GSF reveal any excessive, or upward trending, contamination levels. However, some screened intervals within the bores to the west are well below the water table. This places a qualification on this assertion of no impact on the west side, as the water being measured is deep and may not be representative of the most likely impacted groundwater (i.e. should impact be present it will be more pronounced within the upper 5m).

A tabulated summary of data attained from groundwater monitoring is provided in Table E1 below. This table presents water quality chemistry against both the environmental value objective and also historic reference water quality used to gauge whether mine production activities have altered groundwater conditions.

The outcome of the impact assessment is that there are no chemical indicators at concentrations above the groundwater's environmental value of livestock drinking water. Two eastern bores however, are evidencing an upward trend in potentially lead indicators of impact. This aspect warrants further hydrogeological analysis to establish whether it is reflecting a 'likely' leak sourced from the GSF or otherwise.

Drilling works to construct additional groundwater monitoring bores required for impact appraisal and risk assessment purposes had to be postponed from January 2016 until the second quarter of 2016 due to heavy wet season rainfall in the region. An environmental risk of harm assessment and remediation options analysis will be progressed following the attainment of improved groundwater physical and geo-chemistry information.

The following program is being actioned to bridge data gaps associated with the impact assessment to enable a comprehensive response to all EE objectives and to evidence a best practice approach to leak detection monitoring:

- Construction of reference bores up-hydraulic gradient and distant from the GSF influence; one either side of Mehaffey Fault (i.e. bores WAS-RB and EAS-RB Figure E6) such that background groundwater quality and the water levels in both aquifer systems can be monitored and assessed.
- Installation of a new bore (GSMB19) at the southwestern corner of Cell 3A (adjacent to geotechnical investigation bore 'Pond3A_BH9') with a screen across the water table. The water levels in these two adjacent bores could be used to determine vertical hydraulic gradients. GSMB19 should be constructed at a sufficient casing diameter to accommodate a pump and rising main to enable pumping tests.

- Construction of a new bore to the west (GSMB20) adjacent GSMB04 and screen across the upper 5m of the water table so that samples representative of the chemistry of groundwater (bore GSMB04 is over 18m below the water table) are obtained for assessing possible GSF impact.

- Installation of a new bore to east of GSMB15A (e.g. Bore GSMB21) in order to assess water chemistry and obtain hydraulic detail to ascertain whether leakage mounding is occurring, quantify major cation and anion concentrations and use in future base modelling considerations.

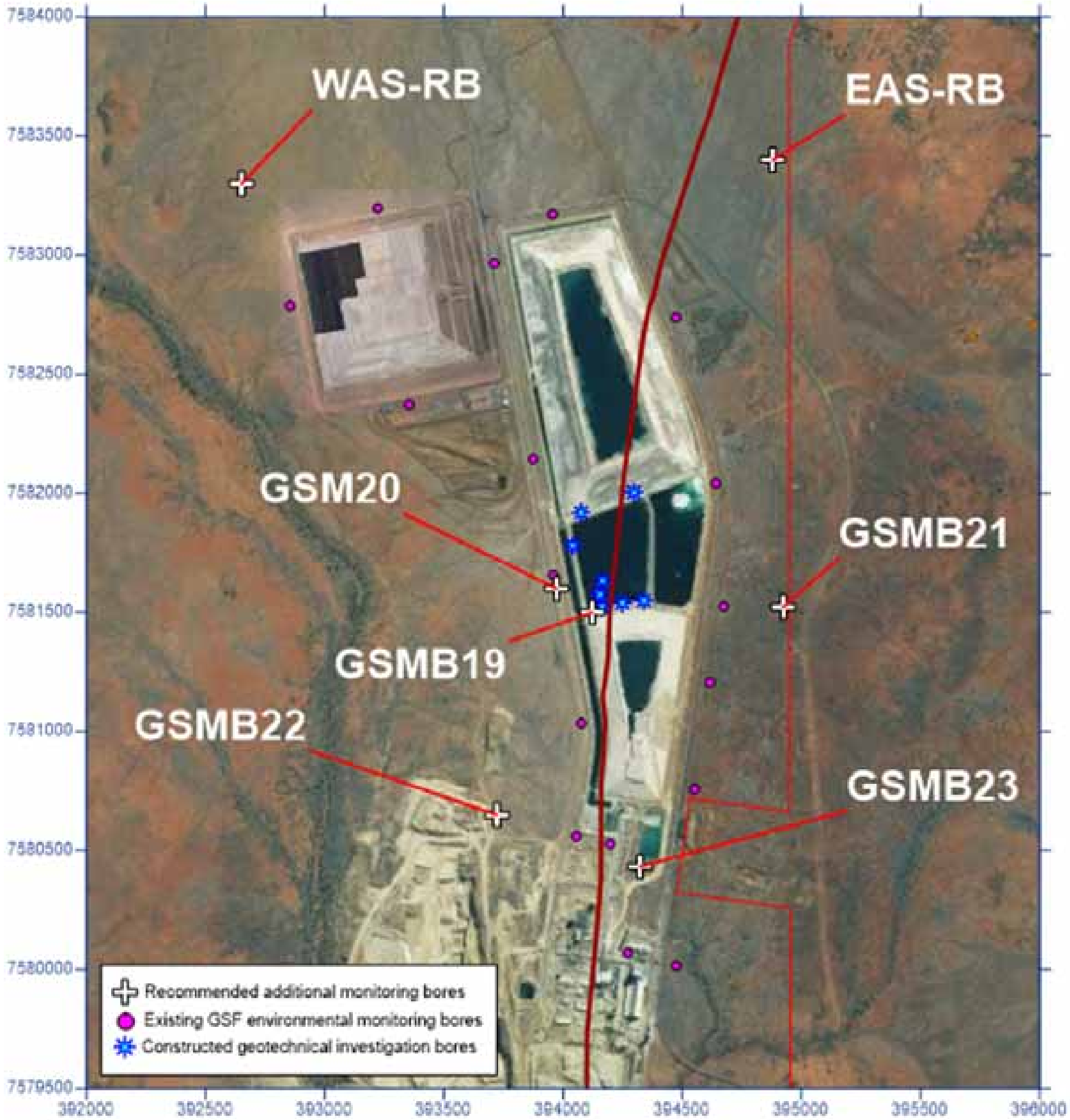


Figure E6 Indicative locations of additional monitoring bores

- Construction of a new bore (GSMB22) to the southwest of the GSF (between the GSF and the Galah Pit). Flow system analysis indicates that pit dewatering and evaporation of groundwater exposed in deeper parts of the pits and/or just below the pit floor could cause flow towards the pits. Monitoring near the pit would enable more accurate mapping of the water table and movement of potentially contaminated groundwater during both mining and post mining phases.
- Installation of a new bore (GSMB23) to the south of the evaporation pond to monitor down-hydraulic gradient groundwater flowing beneath the GSF. [Monitoring bore GW05A is located about 400m down hydraulic gradient from the evaporation pond, however, the groundwater chemistry in this bore differs from surrounding bores suggesting it could be impacted from an historic plant based spill, meaning that distinguishing impact from the GSF is difficult to ascertain].
- Assessment of the feasibility of establishing shallow (e.g. 8-10m) inclined monitoring bores adjacent each operational stack and pond extending below the membrane as an under-liner integrity checking method. These bores would be expected to remain dry unless the liner integrity is compromised. Initially a single bore is scheduled to be installed to the east of Cell 3B to gauge the feasibility and value of this approach.
- Installation of 3x additional bores to the south-west of Cell 3A to permit further evaluation of whether a perched groundwater table exists in this area or whether saturated conditions are sourced from cell and/or localized surge drain leakage.
- Post construction works, undertake a complete round of groundwater gauging, and monitoring for all bores (existing and new) surrounding the GSF. During this monitoring event, groundwater levels in other bores at the mine site should be measured concurrently (i.e. the same week) with the new monitoring of the GSF bores to aid flow system analysis and pathway impact assessment.
- Undertake a semi-quantitative Hydrogeological Risk Assessment to identify transportation pathways for impact, should leakage occur, and what its significance is likely to be to the environmental values both on and beyond the mine lease.

Table E1: Impact Assessment Results

Contaminant Indicator	Units	Leachate water from evaporation pond & dyke storage[1]	Eastern aquifer groundwater quality[2]	Western aquifer groundwater quality[2]	Environmental Value – Livestock Drinking Water	Historic Background G'water Quality[3]
Acidity/ Alkalinity	pH	0.9 – 2.5	7.24 – 8.14	7.33 – 8.20	*6-9*[~]	7.5
TDS (Conductivity)	mg/L (*uS/cm*)	(11,500 –55,800)	1247 - 1673 (*2441*) Ave: 1421 (*2210*)	856 – 1105 (*1716*)	5000 (*7500*) <4,000 no effects	867 (*1171*)
Bicarbonate	mg/L	No Data	268 – 460 Ave: 297	250 – 318 Ave: 265	-	234
Calcium[+]	mg/L	No Data	86 – 184 **Ave: 119**	81 – 182 **Ave: 106**	<1000	49
Fluoride	mg/L	142 – 5220	0.4 – 0.9	0.6 – 0.9	1.0	0.64
Chloride	mg/L	280-320	218 – 494 **Ave: 332**	250 – 375 **Ave: 345**	-	108
Sodium	mg/L	1600 - 2000	114 – 242 **Ave: 169**	120 – 229 **Ave: 175**	-	69
Sulphate	mg/L	2380 – 6830	80 – 186 Ave: 93	96 – 149 Ave: 106	1000	56
Total Nitrogen	mg/L	ND – 0.85	0.1 – 1.6	0.005 – 0.4	90 (as nitrate)	0.71
Phosphorus	mg/L	ND - 6.800	0.005 – 0.13	0.005 – 0.1	10	61[!]
Arsenic[^]	mg/L	0.600 – 2.560	ND – 0.003	ND – 0.002	0.5	0.002
Cadmium[^]	mg/L	0.103 - 1.010	ND – 0.001	ND – 0.0001	0.01	0.002
Copper[^]	mg/L	7.210 – 13.400	ND – 0.007	ND – 0.010	0.5	0.019
Lead[^]	mg/L	ND – 0.213	ND – 0.003	ND – 0.002	0.1	0.016
Uranium[^]	mg/L	2.820 – 24.800	0.008 - 0.011	0.009 – 0.011	0.2	No Data

Legend:

ND = non detect; ^ = Dissolved metals; + = Calcium data not obtained between 2012-2014

Ave = Average of most impacted bore within east and west aquifer (as applicable); **Bold** results are averages that exceed historic reported concentrations by >200%.

NOTES:

1= Leachate data provided from site monitoring March, October 2014 and March 2016: ALS EB1443542, EB 1407258 and EB1605387.

2= General concentration range over past 4 years (excluding possible outliers/ anomalies) {Source: C&R, 2015}.

3 = Historic concentrations as reported in Dippel, 2004 Water quality within Duchess Embayment Aquifer (pre mining) (Likely to be from western aquifer system).

! = Total P reported seems very high and possibly an error in the historical reporting units. In all likelihood it is 0.061mg/L.

1.0 INTRODUCTION

Incitec Pivot Limited (IPL), trading as Southern Cross Fertilisers, operates a phosphate manufacturing facility adjacent their mine site at Phosphate Hill, Queensland.

IPL operate a number of waste storage facilities on their mine lease. In May 2014 an incident involving a D6 dozer resulted in a potential compromise of a pond liner containing acidic process related wastewaters. Other liner integrity issues were noted surrounding the adjacent waste gypsum storage cells and a new cell under construction. Integrity issues were reported to the Department of Environment and Heritage Protection (EHP).

In March 2015, EHP issued IPL with a notice to conduct an '*Environmental Evaluation'* based on '*reasonable grounds that the activity is causing, of is likely to cause environmental harm*'. The Environmental Evaluation (EE) related to all of the Gypsum Storage Facility (GSF).

EnviroRisk was engaged by IPL to assist in responding to the requirements within the Environmental Evaluation(EE). This report discusses the outcome of the initial phases of the evaluation. As a result of rain events over the wet season, some investigative work has had to be postponed into the second quarter of 2016.

A comprehensive response to the EE notice requirements will be prepared following the attainment of information to address knowledge gaps.

2.0 SCOPE OF WORKS

The scope of work for this report including:

1. Establishing the source, cause and extent of the release of contaminants from the Gypsum stockpile facility (GSF).
2. Based on reports provided by others (i.e. C&R Consulting and AECOM), prepare a conceptual site model that focusses only on the Gypsum Stockpile Facility (GSF).
3. Report on the actual, and any reasonably deduced potential impact, of the release of contaminants upon the groundwater of the receiving environment.
4. Evaluate the works required to progress a risk assessment and bridge data gaps, if necessary, as to pathways into the environment and likely impact should pathways be realized.

2.1 Information

Information to support the findings made in this report was obtained from:

- Physical inspections of the process areas, storage practices, catchments areas and mine site over the period 7- 9 July 2015 and again 16 March 2016;
- Review of historic background reports on cell structural design, hydrogeological modelling and monitoring of groundwater;
- Interrogation of monitoring and inspection data provided by environmental and process engineering advisors;
- Aerial photographs of the site, surrounds and catchments;

- Geotechnical and environmental quality compartment reports by AECOM;
- Regional groundwater investigation reporting provided by C&R Consulting; and
- Interviews and discussions with environmental and process engineering advisors, projects personnel, site management, site supervisors and operators.

3.0 REGULATORY SETTING

In March 2015 the Department of Environment and Heritage Protection (EHP) issued two notices to conduct an '*Environmental Evaluation'* based on '*reasonable grounds that the activity is causing, of is likely to cause environmental harm*'.

The Environmental Evaluation (EE) related to the entire Gypsum Storage Facility (GSF) (i.e. Cells 1, 2, 3A (stormwater and acid storage pond), 3B (acid storage and evaporation pond), 4A & 4B, 5A, the 'evaporation pond' and associated toe drains, surge ditch(s) and containment structures.

Section B of the Environmental Evaluation (EE) contains the following requirements:

1. Establish the source, cause and extent of the release of contaminants from the Gypsum Storage facility.
2. Based on the established source, cause and extent of the release of contaminants, report on the actual and potential impact of the release of contaminants in the groundwater of the receiving environment. At a minimum, the report must consider:
   a) The relevant environmental values in accordance with ANZECC methodology;
   b) The impacts on the environmental values.
3. Based on the established source, cause and extent of the release of contaminants, describe all relevant remediation options including the works, cost and timeframes before recommending a preferred option. Remediation options must ensure the ongoing protection of the environmental values of the receiving environment.
4. Determine the adequacy of the current leak detection monitoring for the Gypsum Storage Facility and identify current best practice and areas of improvement.
5. Conduct an investigation of the regional groundwater system which, at a minimum:
   a) identified the type, location and hydrology of groundwater aquifers in the area;
   b) Established background reference water quality of each aquifer and determines appropriate trigger values and limits;
   c) establishes appropriate reference bore locations for each aquifer;
   d) Compares the results from the reference bores to current and historical monitoring results and considers the impact of mining activities at the premises.

4.0 METHODOLOGY

The following methodology was progressed to respond to specific requirements of the Environmental Evaluation (EE):

4.1 EE Requirement 1

Establish the source, cause and extent of the release of contaminants from the Gypsum Storage facility.

The process to respond to this requirement included:

- Obtaining the incident report on dozer entry into Cell3A and any other incidents (such as ditch and/or infrastructure e.g., surge ditch, integrity issues warranting repair and heaving). Review of the geotechnical and environmental investigations into Cell 3A [AECOM, 2016a&b] which aims to summarize the cause of a release from Cell 3A and its environmental impact.
- Review findings of 2015 installed bores within and surrounding Cell 3A [AECOM 2016a&b] and integrate into the determinations made on the overall groundwater monitoring of the GSF.
- Assessment of advice and determinations from EE support investigations [C&R Consulting, 2015; AECOM, 2016a&b].
- Based on supporting studies and available data, prepare a conceptual site model (CSM) with a primary focus on the Gypsum Stockpile Facility (GSF).
- Attaining and reviewing the adequacy of monitoring reports on the underdrain system integrity inspections, as available.
- Attaining and reviewing the adequacy of routine inspection reports on the liner.
- Further investigation into heaving causes and potential impact on pond integrity.
- Water quality and flows around the GSF and suitability of the existing bore network to reveal same.
- Connectivity of water systems at the GSF and the production bores, the mine pit water table and any stock bores in reasonable proximity beyond the site.
- Interpretation of available downhole geophysical logs and integration of interpretations into the CSM.
- Specifying data requirements to enable progression of a risk assessment, including practicability of inclined shallow bores and/or need for additional monitoring bores and their locations.
- Evaluation of any reasonable leak detection methods available.
- Compilation of data into a report including recommendations to:
  i. progress a response to the EE item 1;
  ii. bridge data gaps if necessary as to pathways into the environment and likely impact should pathways be realized; and
  iii. progress an environmental risk assessment against the environmental values on, and beyond the mine lease.

4.2 EE Requirement 2

Based on the established source, cause and extent of the release of contaminants, report on the actual and potential impact of the release of contaminants in the groundwater of the receiving environment.

At a minimum, the report must consider:
a) The relevant environmental values in accordance with ANZECC methodology;
b) The impacts on the environmental values.

Based on determinations arising from EE Requirement 1, EnviroRisk was to specify additional bores and/or sampling to bridge data gaps and enable a qualified opinion as to the potential impact arising as a consequence of the release of contaminants. The extent of additional works will be dictated by the significance of any plausible environmental release identified during the initial impact assessment stage.

Following attainment of relevant data, this stage was to progress to a review that identifies likely pathways and potential receptors and summarizes relevant information from these hydraulic stresses. A risk assessment on pathways and receptors will then need to be progressed.

4.3 EE Requirement 3

Based on the established source, cause and extent of the release of contaminants, describe all relevant remediation options including the works, cost and timeframes before recommending a preferred option. Remediation options must ensure the ongoing protection of the environmental values of the receiving environment.

The need for remediation will depend on impact, pathways and receptors. During this stage, a risk assessment on pathways and receptors will be progressed. The extent of this assessment will be dictated by the significance of any environmental release identified during the impact investigation processes.

A remediation options matrix will be progressed, and indeed be of value, once all available information attained. It is likely predictive analysis, based on a site specific derived hydro-geological chemical fate and transport model, will be required to support remediation considerations.

4.4 EE Requirement 4

Determine the adequacy of the current leak detection monitoring for the Gypsum Storage Facility and identify current best practice and areas of improvement.

A determination on the adequacy of current leak detection monitoring was to include:

- an assessment of groundwater and soil quality from existing monitoring programs and the identification of any trends, if present;
- a review of the outcome and value of physical inspections of the liner integrity and repair program made against design 'maintenance' specifications.
- an evaluation of data gaps and recommendation to bridge same via additional monitoring bores and/or risk management measures.

4.5 EE Requirement 5

Conduct an investigation of the regional groundwater system which, at a minimum:
a) identified the type, location and hydrology of groundwater aquifers in the area;
b) Established background reference water quality of each aquifer and determines appropriate trigger values and limits;
c) establishes appropriate reference bore locations for each aquifer;
d) Compares the results from the reference bores to current and historical monitoring results and considers the impact of mining activities at the premises.

EnviroRisk's role was to interpret the determinations provided in the overall regional groundwater investigation [C&R Consulting, 2015] and summarize into a conceptual site model specifically for the GSF.

5.0 SITE SETTING, PROCESSES & ENVIRONMENTAL RISK – GSF

The Phosphate Hill mine site is situated approximately 140km south southeast from Mt Isa and 950km due west of Mackay. The GSF forms part of the northern aspect of the mine lease area and is located immediately adjacent Durimbil Drive just prior to entry to the mine site office. The GSF covers an area of approximately 110 ha and has a height of about 30-40 above the surrounding ground at its highest point (Cell 4). The spatial layout of the GSF is illustrated in Figure 1 below.

The geological setting has been outlined in detail by others [C&R Consulting, 2015; Dippel, 2004]. A summary relevant to this assessment with a focus purely on the GSF is further discussed within Section 6: Conceptual Site Model.

The main components within the GSF includes gypsum in the forms:

- Dihydrate gypsum ($CaSO_4.2H_2O$); Bassinite – hemihydrate gypsum - ($CaSO_4.0.5H_2O$); Anhydrite gypsum ($CaSO_4$); and
- Quartz (SiO_2) at levels of over 20%, which is derived from the comparatively high level of chert and silicified siltstone and shale in the parent phosphorite ore body.

Principal chemical indicators of contamination have been identified as:

- pH, TDS (Conductivity), Calcium, Fluoride, Sulphate, Nitrate, Phosphate, Chloride[1], Arsenic, Cadmium, Uranium and Lead.

There are many other components within the GSF leachate but the aforementioned chemicals are considered to represent the best lead indicators of environmental impact.

There are also radionuclides that could be used as integrity markers in the future (i.e. U-238).

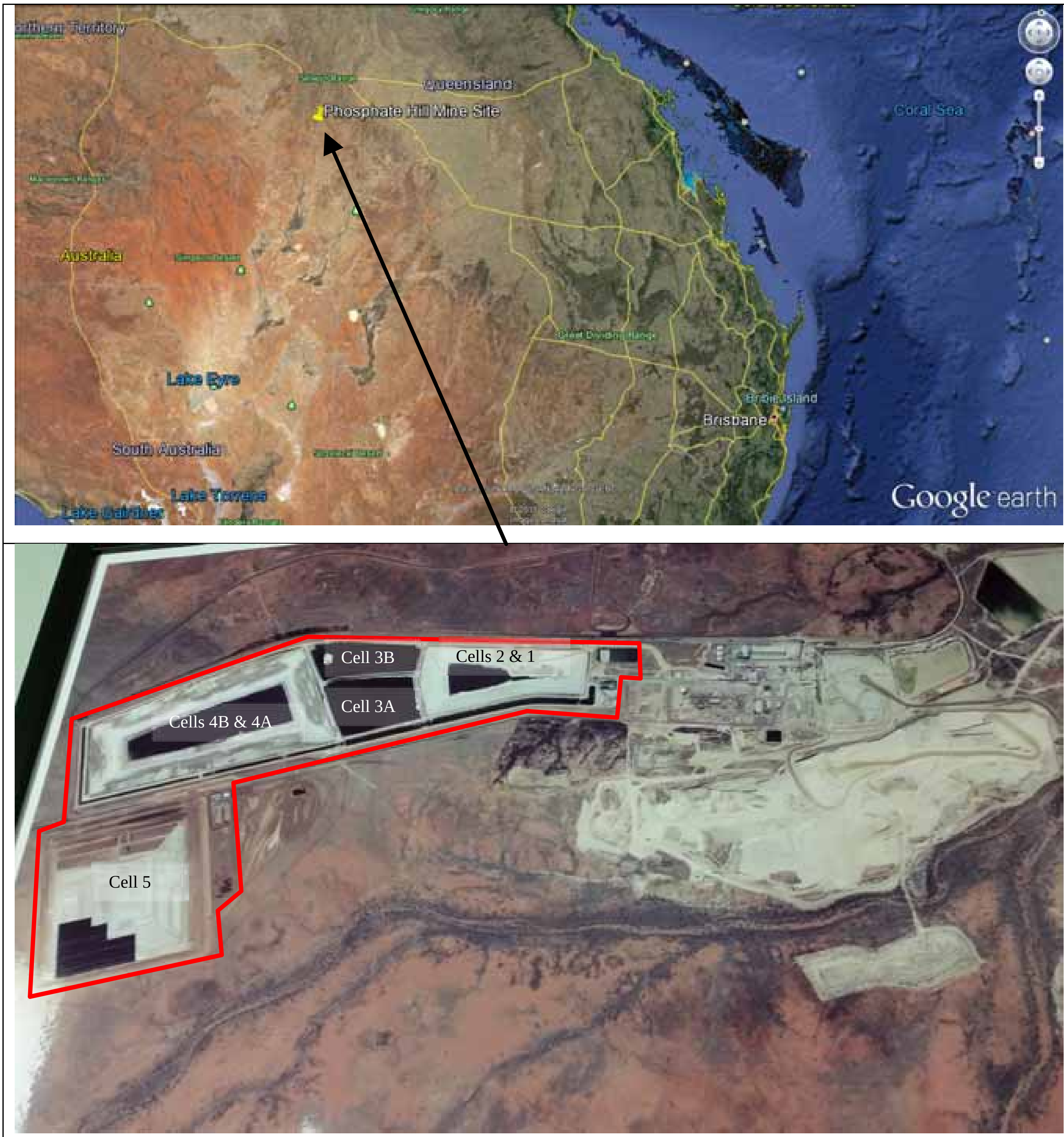
5.1 Gypsum Stockpile Facility Layout

IPL's phosphate fertilizer manufacture process produces a phosphogypsum (PG) by-product. This by-product has no current commercial value and is managed on the mine site in permanent stockpiles.

Dihydrate phosphogypsum ($CaSO_4.2H_2O$) is the predominant form of the by-product produced from the re-slurry and transfer facility at the north of the manufacturing site. The slurry is pumped for de-watering where, over time, it precipitates to form a solid stockpile.

Approximately seven(7) tonne of PG is produced for every ten (10) tonne of ore processed through the phosphoric acid plant.

[1] Chloride was previously reported as not being a contaminant generated from the facility [C&R, 2008 Phosphate Hill Wider Aquifer Study]. However, 2016 testing has identified it is present at concentrations of approximately 190 mg/L in 'wet' PG, and less than 10mg/L in dry PG. Its ability to readily leach from the PG, coupled with its solubility renders it as a lead indicator chemical for GSF integrity inspection purposes.



North. ***Figure 1: Location and general layout of the north aspects of IPL's Phosphate Hill Mine site. GSF area (indicative) is within the red border.*** (GSF map Scale 1 = 22,000 approx.)

As of March 2016 there are:

- five(5) active gypsum waste management cells, labelled 'Cell 1, 2, 4A, 4B & 5A' (Note: Cells 1 and 2 have been combined into the one stockpile, as have Cells 4A and 4B – leaving three distinct PG stockpiles – refer image 1); and
- one (1) empty water storage cell ' Cell 3A'; and
- two(2) evaporation pond cells namely 'Cell 3B' and the southern 'Evaporation Pond'.

Cell 1&2 is also currently used for water evaporation.

The entire area containing phosphosgypsum stockpiles and associated waste liquor surge ditches, toe drains, boundary dykes, evaporation and storage ponds is approximately 110 Ha in size and is termed the Gypsum Stockpile Facility (GSF).

Image 1: GSF Aerial revealing liquor (dark) & PG (white).

Image 2: North end of Cell 4B gypsum stockpile revealing a lined surge ditch.

5.2 Gypsum Stockpile Cells

Each cell has been engineer designed as a permanent impervious containment facility. Details held by IPL suggest Ardaman & Associates have been the principal designer and project lead for all constructed cells other than Cell 3A where Golder Associates were also involved with construction aspects in the year 2000. Ardaman & Associates, and also Golders Associates, are recognised world leaders in the design and project management of liner systems for phosphogypsum stockpiles. As such the facility was designed, and approved, according to best practice techniques at the time. The following description of the Gypsum Stockpile Cells and stacks was summarized from the engineering design report for the most recent cell (5A) prepared by Ardaman (2012)[2].

A schematic of the layout of the gypsum stack and process water storage facility showing basic design information (e.g., dyke crest elevation, etc.) is presented in Figure 2. The location of the various cells and ancillary works is shown in Figure 3 which is an aerial image of the gypsum stacks and immediate surrounding area draped over a Digital Elevation Model (DEM).

[2] The description provided by Ardaman & Associates dates back to 2012. Since this date Cells 4a/4b no longer receive gypsum and likewise cells 1/2 are used for water evaporation only.

"*The gypsum storage facility consists of a five cells designated as Cell1, Cell 2, Cell 3 (A and B), Cell 4 (A and B) and Cell 5A. The cells are surrounded by earthen dykes and incorporate a return water/surge ditch system (water/surge ditches are located on the north side of Cell 4 and west sides Cell 1/2/ 3A and 4, and on the eastern and southern sides of Cell 5A). A lined evaporation pond and the emergency dry staking area is located immediately south of Cells 1 and 2.*

All of the process water storage ponds and the entire base area of the gypsum stack storage cells compartments are provided with an impervious high density polyethylene (HDPE) bottom liner for seepage control and containment of the acidic process waters in the gypsum slurry.

The gypsum storage facility commenced operation in September 1999. The initial gypsum storage area consisted of two lined compartments (Cells 1 and 2) and a lined process return water/surge ditch along the west side of the stack. A lined process water storage compartment (Cell 3A) and northerly extension of the return water/surge ditch was added in late 2000. Cell 3A was originally intended to be converted to a gypsum storage area, but it was subsequently decided to construct a larger gypsum stack expansion to the north (Cell 4) and to use Cell 3A for water storage and stormwater surge. In late 2002, the construction of the first phase of a lined gypsum stack expansion (Cell 4A) was completed to the north of Cell 3A, and the stack expansion commenced operation in early 2003. In November 2005, a lined evaporation pond (Cell 3B) was added on the east side of Cell 3A. The second phase of the lined gypsum stack expansion (Cell 4B) and return ditch system was constructed north of Cell 4A and commissioned in late 2007 (Ardaman, 2012). Cell 5A has been constructed to the west of Cell4.

Cells 1 and 2 of the initial gypsum storage area have reached the final design top elevations and are currently used only for process water storage and evaporation. Cells 3A and 3B are not configured for gypsum storage and likewise used only for purposes of process water storage and evaporation. The combined Cells 4A and 4B top area and the newly commissioned Cell5A, therefore, are the only compartments actively receiving gypsum slurry[3].

The active gypsum stack is operated using the wet stacking disposal method. Gypsum slurry, at about 25 to 30 percent solids, is pumped through HDPE pipelines to the top of the gypsum stack and discharged into an elevated rim ditch system that distributes the gypsum slurry around the perimeter of the stack. Precipitated gypsum is subsequently excavated from the perimeter rim ditch and used as a borrow material for raising the perimeter dike of the gypsum stack by the upstream method of construction.

Clarified water can be decanted and/or siphoned from the clarification pond on top of the gypsum stack and discharged into the return water/surge ditch on the west side of the stack. A pump station in the return water ditch on the south side of Cell 1 of the original stack returns decanted water back to the gypsum slurry tank and to the phosphoric acid plant for makeup water as needed. The Phosphate Hill facility has a design production capacity of approximately 525,000 metric tons per year, with an associated gypsum by-product production rate of approximately 2.99 million metric tons per year.

[3] The description provided by Ardaman & Associates dates back to 2012. Since this date Cells 4a/4b no longer receive gypsum and like cells 1/2 are used for water evaporation only.

Cells 3A and 3B were constructed as part of a proposed northerly expansion in late 2000, Cell 3A was originally designated for future conversion to a gypsum storage area. Cell 3A was used only for process water storage and as a surge pond for surface water runoff from the side slopes of gypsum Cell 2 and Cells 4A and 4B. The surge pond, Cell 3A, is not equipped with a gravity flow outfall structure, requiring that a portable diesel pump be used to recover make-up water from the pond when needed.

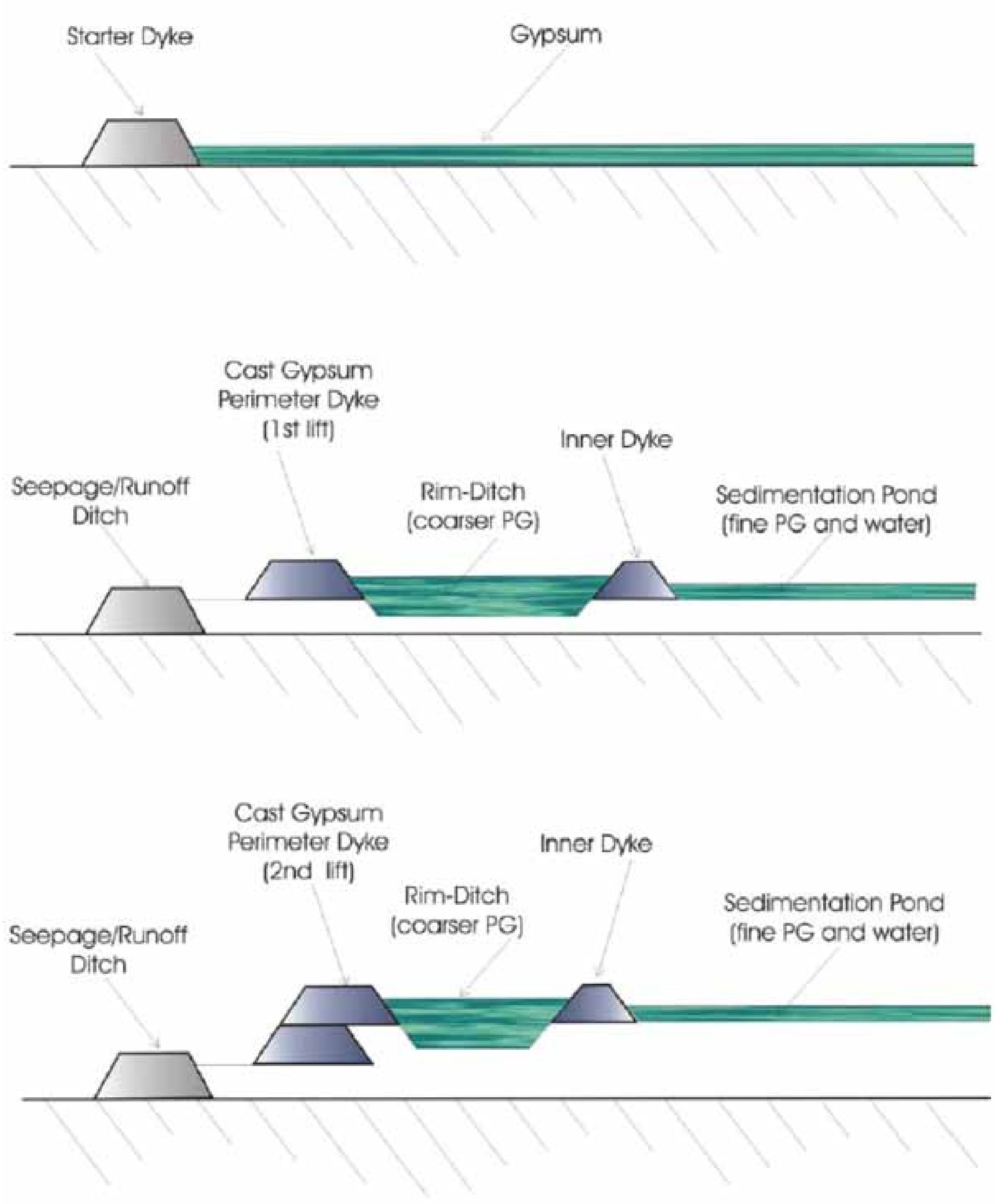


Figure 2.18. Schematic of PG wet-stack construction method as used at Phosphate Hill (adapted from Ardaman 1999).

(Adopted from Dippel, 2004).

Until its decommissioning in 2015, a siphon was used to transfer water from Cell 3A to Cell 3B. The combined watershed (catchment area) for Cell 3A, prior to the completion of expansion Cell 5A, is on the order of 61.9 hectares for the existing stack geometry (including the side slopes of gypsum Cells 2 and 4A/4B and the direct watershed for Cell 3A).

Cell 3B was added in November 2005 as a lined evaporation pond. Cell 3B is provided with a smooth 1.5mm HDPE bottom liner and is currently used for water storage and evaporation purposes. Cell 3B was not previously configured to receive stormwater runoff from the gypsum stack side slopes.

Cell 5a is the most recent cell and is located west of the plant access road and west of existing Cells 4A and 4B. Cell 5A encompass a base area of about 50 hectares, which includes the perimeter earthen dyke, a lined return water ditch on the south and east sides of the gypsum stack, a lined earthen starter dyke adjacent to the return water ditch, the lined return water transfer ditch bringing return water under the plant access road and the lined gypsum stacking area. Just over 46 hectares of the total base area is provided with a 1.5mm thick HDPE liner, with the base of the gypsum stack inside the starter dykes covering a footprint area of approximately 42 hectares.

The return water/surge ditches collect seepage from the gypsum stack stabilization underdrains, rainfall runoff from the ditch direct watershed and portions of the gypsum stack side slopes, and gypsum slurry water siphoned or decanted from the top of the active gypsum cell. The return water ditch on the west side of Cell 4A is higher than the rest of the return water ditch system to the south (i.e. original ditch adjacent to Cells 1, 2 and 3A). The return water ditch that abuts Cell 4B is, in turn, higher than the ditch along the west side of Cell 4A to the south. These ditches are hydraulically connected, with no flow control structures provided at the ditch junctures.

The return ditches abutting Cells 4A and 4B, therefore, have no surge storage capacity. Operational surge in the return water ditch, therefore, is provided in the lowermost sections of the ditch, west of Cells 1, 2 and 3A."

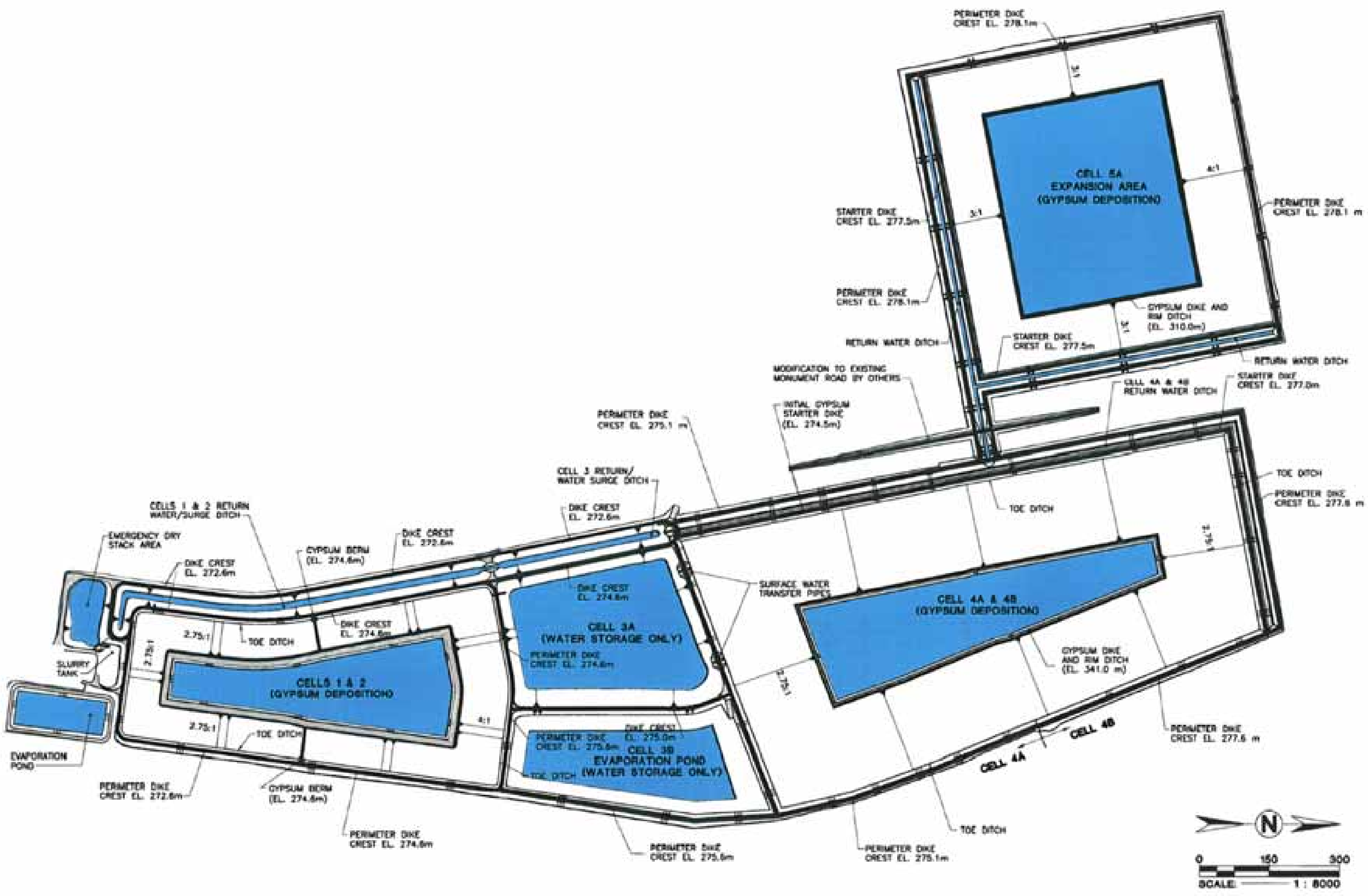


FIGURE 2. Gypsum Cell Layout (modified after Ardaman (2012)

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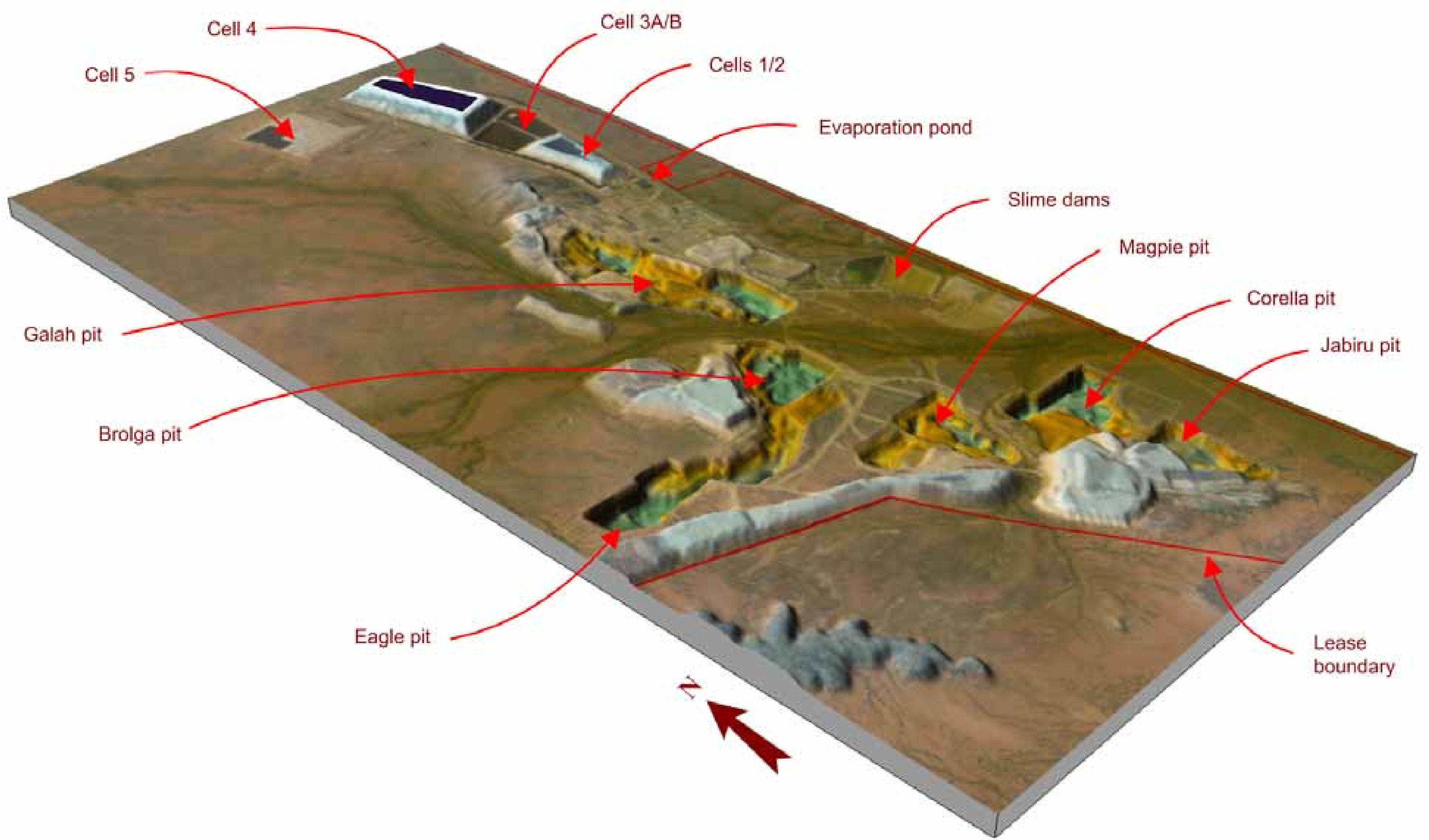

FIGURE 3. Aerial Image of Gypsum Cells Draped Over Digital Elevation Model

5.3 Evaporation Ponds

Waters draining through and from the stacks following slurry application, and also surface waters captured during rains, are directed into boundary ditches that surround the stockpiles. These facilities form part of the HDPE liner control area with the liner integrated with the main HDPE liner beneath the PG stack.

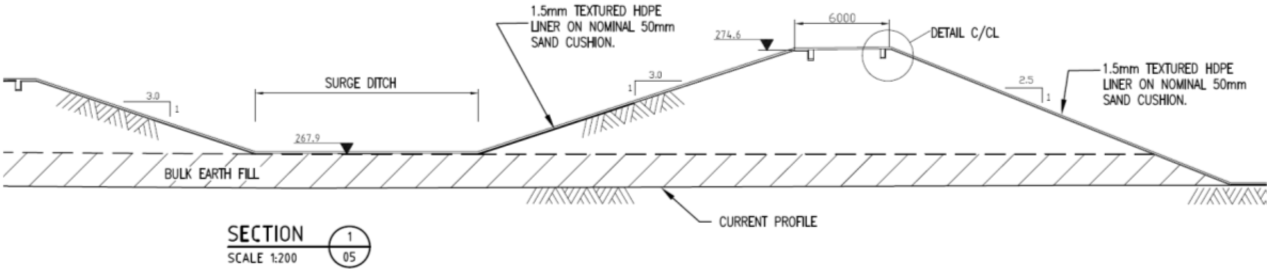

Figure 4: Surge Ditch Cross Section and HDPE design

Ditch channels direct waters back towards the evaporation ponds where the water is lost to evaporation of recirculated back into the re-slurry process.

Image 3: Evaporation & Re-slurry Recirculation Pond 3B

Image 4: Pond 3A dewatered in preparation for geotechnical investigation

5.4 Chemical Constituents

The chemical constituents likely to be contained within water draining through and off the GSF have been identified based on process chemical inputs and the trace chemical components that can become concentrated during the refining and waste water recirculation process.

Table 1. Contaminant Concentrations within GSF Leachate

Contaminant Indicator	Units	Leachate water within 3B evaporation pond and ditches[1]
Acidity/ Alkalinity	pH	0.7 – 1.1
TDS (Conductivity)	mg/L	(11,500 –158,000)
Bicarbonate	mg/L	<1
Calcium	mg/L	1700- 2890
Fluoride	mg/L	142 – 9400
Chloride[!]	mg/L	280 – 327
Sodium	mg/L	1600- 1870
Sulphate	mg/L	2380 – 11,200
Total Nitrogen	mg/L	ND – 0.85
Phosphorus (reactive)	mg/L	ND – 28,500
Arsenic[^]	mg/L	0.60 – 5.38
Cadmium[^]	mg/L	0.10 – 2.10
Copper[^]	mg/L	7.21 – 25.20
Lead[^]	mg/L	ND – 0.53
Zinc[^]	mg/L	51.10- 103.00
Uranium[^]	mg/L	2.82 – 57.00

1. Includes March 2016, surge ditch tests results.
! – Recent (2016) monitoring results indicate chloride is present in wet gypsum and surge waters. Its high solubility and leachability make it a good lead indicator chemical for transportation from the stacks.
^ - reported as dissolved metals.

Image 5: Phosphorite resource extraction intersects the groundwater table (Brolga Pit, 2015)

5.5 Reported incidents at the GSF

In May 2014 an incident involving a D6 dozer which inadvertently entered the north-west corner of the evaporation pond at Cell 3A resulted in a potential compromise of the pond liner. Over the following months Cell 3A was emptied and liner tears were identified to the southern edge. It was not clear whether the liner tears were created by the gypsum shrinkage as it dried out.

Considerable disruption to the flatness of the liner was noted across the south-east aspect of pond 3A (refer image 6). An investigation program involving soil drilling, and the establishment of a groundwater monitoring bore within the upper horizon to confirm or otherwise the existence of a perched groundwater was initiated. The results of this investigation [AECOM 2016a&b], reveal variable perch acidic water at various depths both at the north and south ends of the cell, but interesting not to the west between Cell 3A and the surge ditch. This suggests the acid water is variable, localized and possibly sourced from seepage through the Cell 3A liner when it was damaged. Further investigation into the variance in perch water presence is proposed.


Image 6: Liner impairment

Routine integrity inspections of the liner have previously identified tears around the extremities, including on the elevated areas of the outer ditch (refer Image 6). Repairs have been initiated when structural deficiencies have been identified. Deficiencies are noted in daily checks as exemption reporting only. If, during inspections, impairment is not observed, no records are registered.

6.0 CONCEPTUAL HYDROGEOLOGICAL SITE MODEL – GSF

6.1 Physical Location

Phosphate Hill Mine (PHM), is an open cut phosphate mine located about 140 km south south-east of Mount Isa and approximately 51 km east south-east of Dajarra. The mine is situated in the northeast of the Lake Eyre Basin, in the mid-catchment of the Burke River (C&R, 2015).

The Phosphate Hill Mine and associate plant and waste storage facilities were developed on a low relief plain disrupted by a number of higher elevated mesa-like ridges. The area is drained by a number of ephemeral drainage systems often with ill-defined channels forming dendritic drainage patterns (Figure 5). The main local systems are Dead Horse Gully which enters the PHM from the west and a Galah Creeek entering from the north with their confluence between the Galah and Brolga pits; downstream the system becomes the Kolar Creek.

The topography across the mine site slopes gently to the south from elevation of 275-280 m AHD in the area north of cells 4 and 5 to less than 260 m AHD around Kolar Creek. The topography has been extensively modified by mining operations and on-site gypsum storage cell constructions. The site topography is illustrated as a Digital Elevation Model in Figure 3 above.

6.2 Geological Setting

The geology of the Phosphate Hill site is complex due to faulting and folding which has deformed the rocks, formed local dome and basin structures and juxtaposed different stratigraphic units.

The major local structural element is the north-south aligned fault, the Mehaffey Fault (downthrown to the west) which has caused the juxtaposition of Ordovician rocks (east) against older Cambrian rocks (west).

A number of different stratigraphic units have been identified in the local area. The local stratigraphy is summarised in Table 2. The outcrop geology of the GSF and surround area is shown in Figure 6.

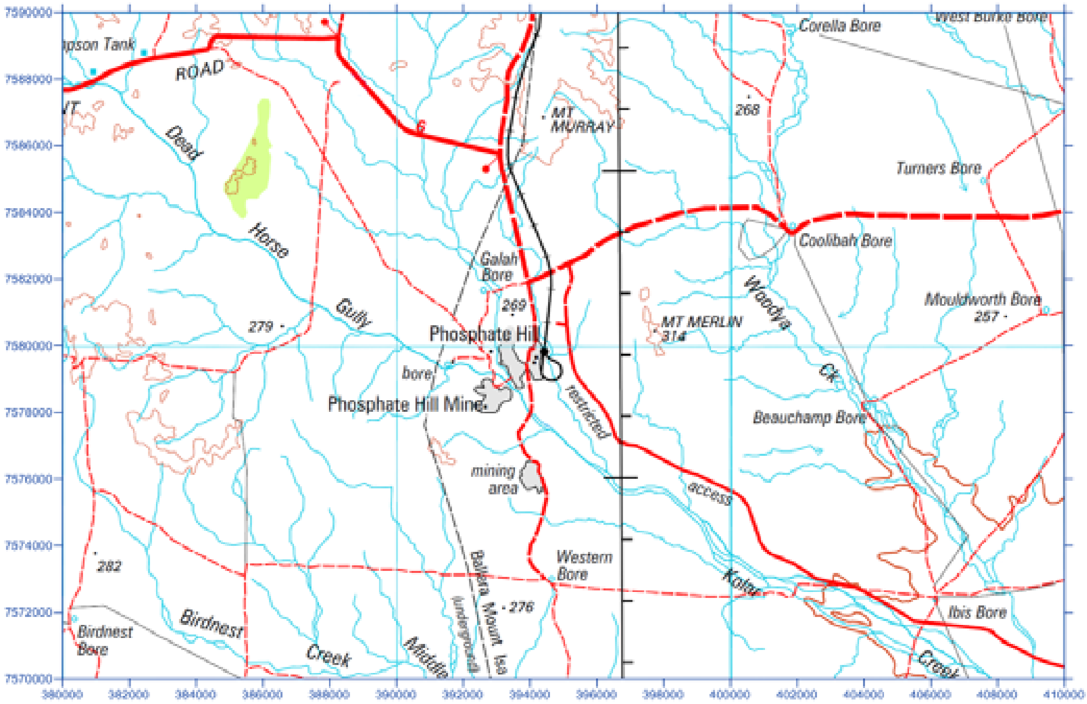

FIGURE 5: PHM Location and Local Drainage Features

Neither the Swift Formation nor the Ninmaroo Formation outcrop in the vicinity of the PH mine site. The Beetle Creek Formation outcrops less than 150 southwest of Cell3 and the Inca Formation more than 2.5 km to the southwest (Figure 6).

TABLE 2. PH Mine Site Stratigraphic Column

Age	Stratigraphic Unit	Lithology	Occurrence
Caino-zoic	Quaternary sediment & soil	Alluvial clay, silt, sand, gravel, conglomerate.	Widespread
	Tertiary laterite	Ferricrete.	Widespread
Early Ordovician	**Swift Formation**	Sandstone, siltstone with limestone and chert.	East of M F
	Ninmaroo Formation	Sandy calcarenite, calcilutite, oolitic limestone, dolomitic limestone and marl.	East of MF
Middle Cambrian	**Inca Formation** • Limestone Member • Shale Member	Fetid, cherty dolomitic limestone with minor calcareous shale. Shale, cherty shale and siltstone, minor chert.	West of M F
	Beetle Ck Formation (BCF) • Monastery Ck Phosphorite Member (MCPM) • Lower Siltstone Member (LSM)	Phosphorite, phosphatic cherty siltstone, chert and fetid phosphatic limestone. Calcareous and cherty phosphatic ^siltstone, chert, fetid dolomitic phosphatic limestone and minor phosphorite.	West of M F
	Thorntonia Limestone • Chert Member • Carbonate Member	Silicified carbonate rock and coquina. Dolomitic limestone and dolomite, minor chert.	West of M F
Early Cambrian	**Mt. Birnie Beds (MBB)**	Ferruginous silty mudstone & sandstone, orthoquartzite and conglomerate, dolomite, marly dolomite, siltstone & chert, unsorted boulder clay of silty mudstone and polymictic fragments, pebbles and boulders.	West of M F
Pre-Cam-brian	**Kalkadoon Gneissic Granite**	Coarse-grained porphyritic granite and granodiorite (some amphibolite).	Widespread

Modified after Russell and Trueman 1971; Dippel, 2004; and C&R Consulting, 2015.

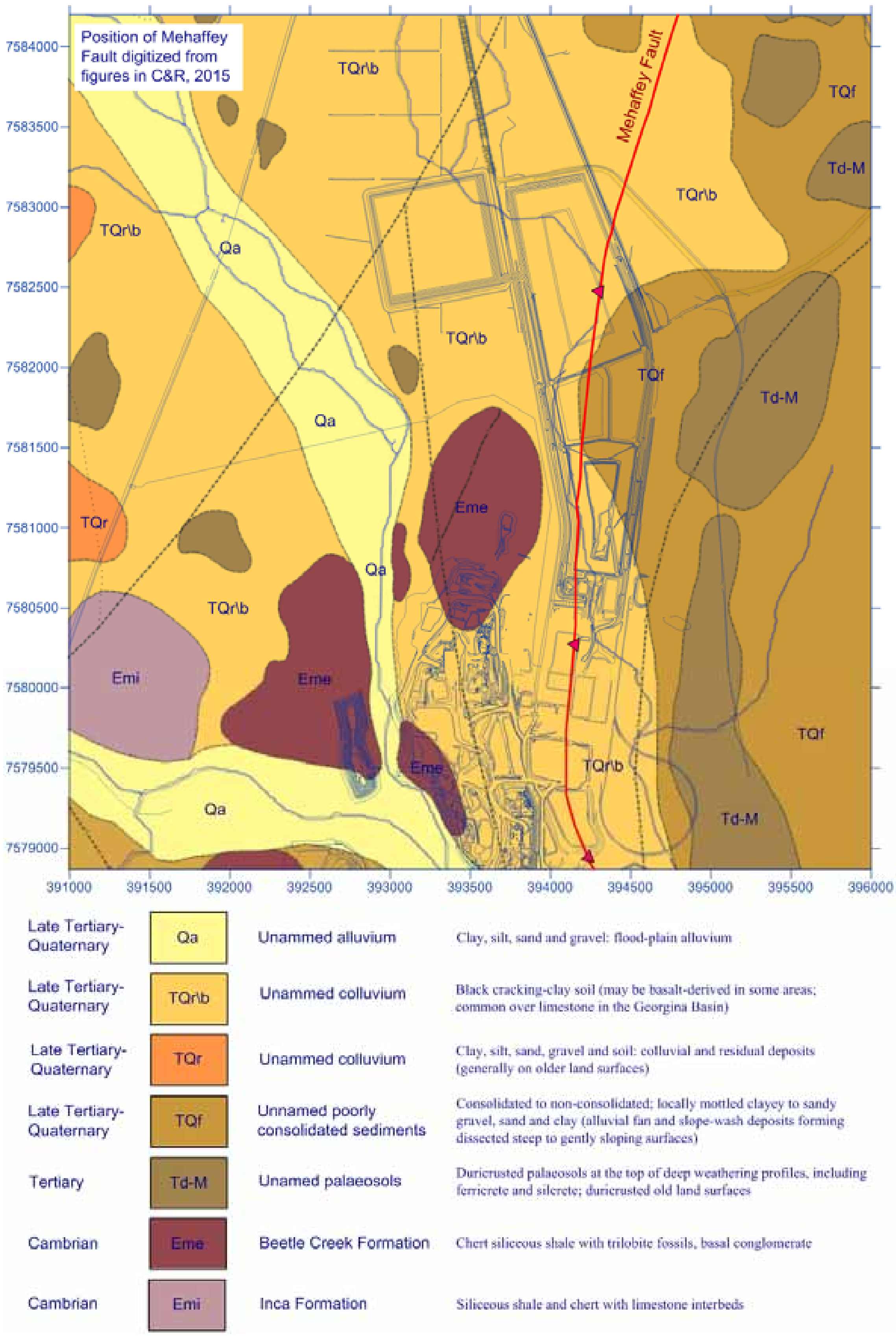

FIGURE 6. Geological Outcrop Map (geology downloaded from https://minesonlinemaps.business.qld.gov.au/)

6.3 GSF Monitoring Bores

There are seventeen(17) bores in the general area of the GSF which have been intermittently monitored for water level and groundwater chemistry. Details of these bores are summarised in Table 3 below. The stratigraphic units monitored at each of site as interpreted by C&R Consulting, 2015 are shown in Figure 7.

TABLE 3. GSF Bores Monitored Stratigraphic Units

Bore	MGA E	MGA E	RLMP	RLGL	Drilled	Cased	Screens	Stratigraphi Units	Aquifer System
EPMB1	394621.7	7581195.1	272.783	272.164	69.8	2.5	48.5 - 69.8	Ninmaroo Fm.	EAS
EPMB2	394555.7	7580754.1	269.928	269.338	64.1	2.5	47.2 - 64.1	Ninmaroo Fm.	
EPMB4	394478.7	7580015.1	265.54	265.140	60	59.2	47.2 - 59.2	Ninmaroo Fm.	
GSMB07A	394644.5	7582038.0	273.245	272.690	84	84	72 - 84	Ninmaroo Fm.	
GSMB9	394204.7	7580521.1	266.631	266.631	64	64	49 - 55, 58 - 63	Ninmaroo Fm.	
GSMB14	394471.0	7582732.0	274.68	274.250	88	87.9	55.0 - 87.9	Ninmaroo Fm.	
GSMB15A	394674.2	7581521.2	273.511	272.940	102	90	72 - 90	Ninmaroo Fm.	
GW05A!	394275.2	7580067.8	267.659	267.680	88	88	51 - 57, 81 - 87	Ninmaroo Fm.	
GSMB01A	394053.1	7580562.1	268.519	268.050	89	89	68 - 74, 83 - 89	Inca Fm.	WAS
GSMB02A	394078.3	7581030.8	269.962	269.490	90	81	69 - 81	Thorntonia Fm.	
GSMB04B!	393968.3	7581660.0	270.899	270.270	84	84	78 - 84	Thorntonia Fm.	
GSMB11	393874.6	7582145.5	272.98	272.510	94	87.9	34.5 - 82.5	Inca Fm.	
GSMB12	393714.1	7582963.2	274.77	274.420	106	105.9	45.9 - 102.9	Inca/MCPM Fm.	
GSMB13	393963.7	7583175.8	276.26	275.850	100	99.5	49.5 - 97.5	Inca Fm.	
GSMB16	393221.2	7583198.0	277.223	276.000	95	95	65-95	LSM	
GSMB17	392851.8	7582790.7	274.077	272.900	95	95	65-95	LSM	
GSMB18	393353.3	7582378.2	275.274	274.100	95	95	65-95	LSM	

Notes: 1) Reduced levels (RL) in m AHDD,
2) MP, Measuring Point,
3) GL, Ground Level, and
4) Drilled depth, cased depth and screened intervals in meters below GL.

! – This bore may be influenced by production activities.

6.4 CSM Description

A conceptual hydrogeological model of the GSF was developed using multiple lines of evidence including:

- Geological maps showing outcrops and structures.
- Groundwater elevation and trend analysis.
- Hydraulic theory.

The mine site stratigraphy and aquifer system components are indicated in Table 2. Two multilayered, leaky aquifer system separated by the Mehaffey Fault are present at the mine site:

1. The aquifer system to the east of the fault includes the Swift Formation and the Ninmaroo Formation and is here referred to as the Eastern Aquifer System (EAS).
2. The aquifer system west of the fault is referred to as the Western Aquifer System (WAS) which includes three stratigraphic units namely the Inca Formation, Beetle Creek Formation and Thortonia Limestone. [The WAS has been referred to as the "Western Aquifer" or the "Duchess Embayment Aquifer' (DAE) in various reports by others.]

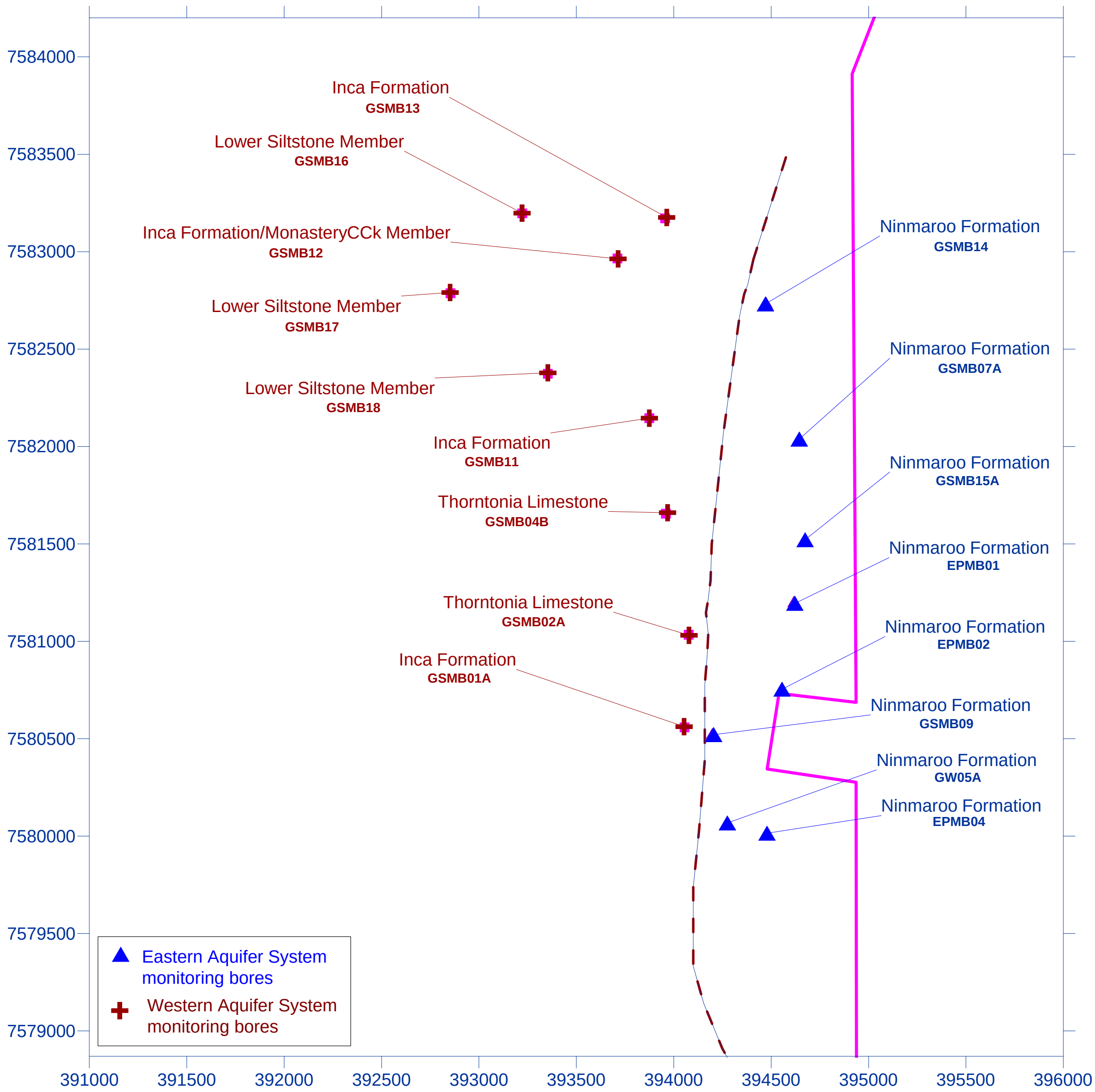

FIGURE 7. GSF bores and monitored stratigraphic units

Groundwater in both aquifer systems is considered to be unconfined to semi-unconfined. Aquifer hydraulic characteristics have not been evaluated except for transmissivities determined from pumping tests mainly carried out in the 1990s on bores west of the Mehaffey Fault for dewatering system design. Transmissivity values derived from these tests are very likely not representative of the regional aquifer mass as the test bores were constructed in higher permeability zones (in order to maximise drawdown). No aquifer tests have been reported for the EAS.

The water table in the EAS occurs in the Ninmaroo Formation. On the western side of the Mehaffey Fault, the water table is located in the Inca Formation in the vicinity of the GSF but is within Beetle Creek Formation further to the west where the Inca formation is absent and to south where the water table has been lowered by mine dewatering and extraction of groundwater for use in the ore processing plant.

The groundwater table in both aquifer systems in the vicinity of the mine site flows in general southerly direction. The hydraulic gradients on both sides of the Mehaffey Fault are very flat in both aquifer systems. Dewatering and extraction for water has created a cone of depression on the western side of Mehaffey Fault to the south of the processing plant. However, the water table in this area on the eastern side of the fault has not been drawn down indicating a high degree of hydraulic separation between the WAS and the EAS.

Hydrograph analysis shows that the water levels in monitoring bores in the WAS to the west of the Mehaffey Fault (including the southerly SDMB bores down hydraulic gradient from the GSF) all exhibit declining water level trends in response to local groundwater extraction whereas the water level trends in bores in the EAS east of the fault are relatively static to slightly rising. The trend directions in the GSF monitoring bores are mapped in Figure 8.

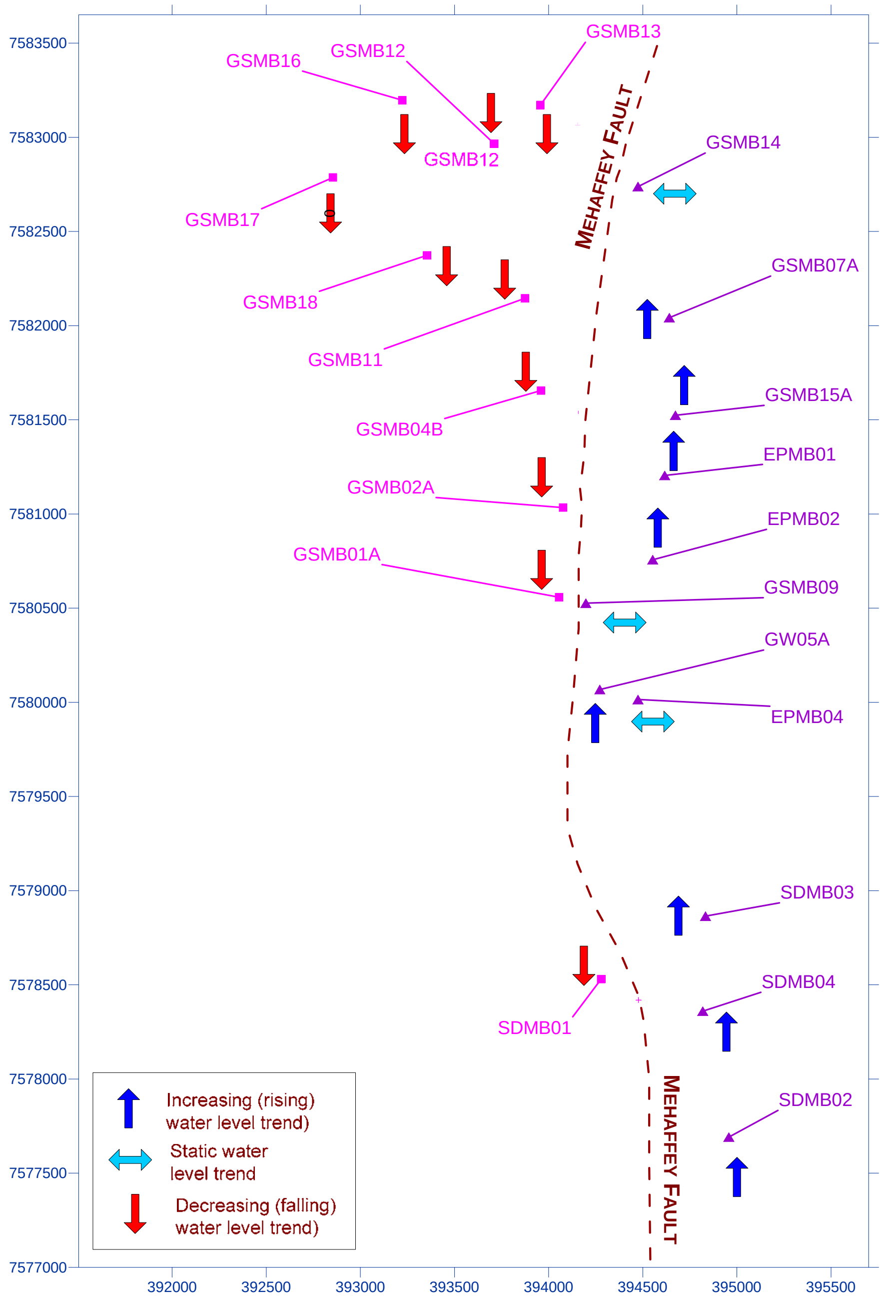

FIGURE 8. GSF Monitoring Bores Water Level Trend Directions

The water level in bores on the eastern side of the Mehaffey Fault is about 5.5 to 6.5 m higher than that in nearby bores on the western side (Figure 9). The large difference in hydraulic head even between closely spaced bores on opposite sides of the fault (e.g. bore GSMB01A (west) and bore GSMB09 (east)), indicate that the fault is locally at least a hydrogeological barrier boundary. The head differential is illustrated as a 3-Dimensional model generated using the September 2014 monitoring data is presented in Figure 9.

The fault was "modelled" as a no-flow hydrogeological barrier boundary. In reality, some flow is likely to occur at least in places along the fault but the available evidence including little or no induced drawdown on the eastern side of the fault in response to the pumping groundwater from the production and/or dewatering bores immediately west of the fault indicates that the flux is small despite the large head differential.

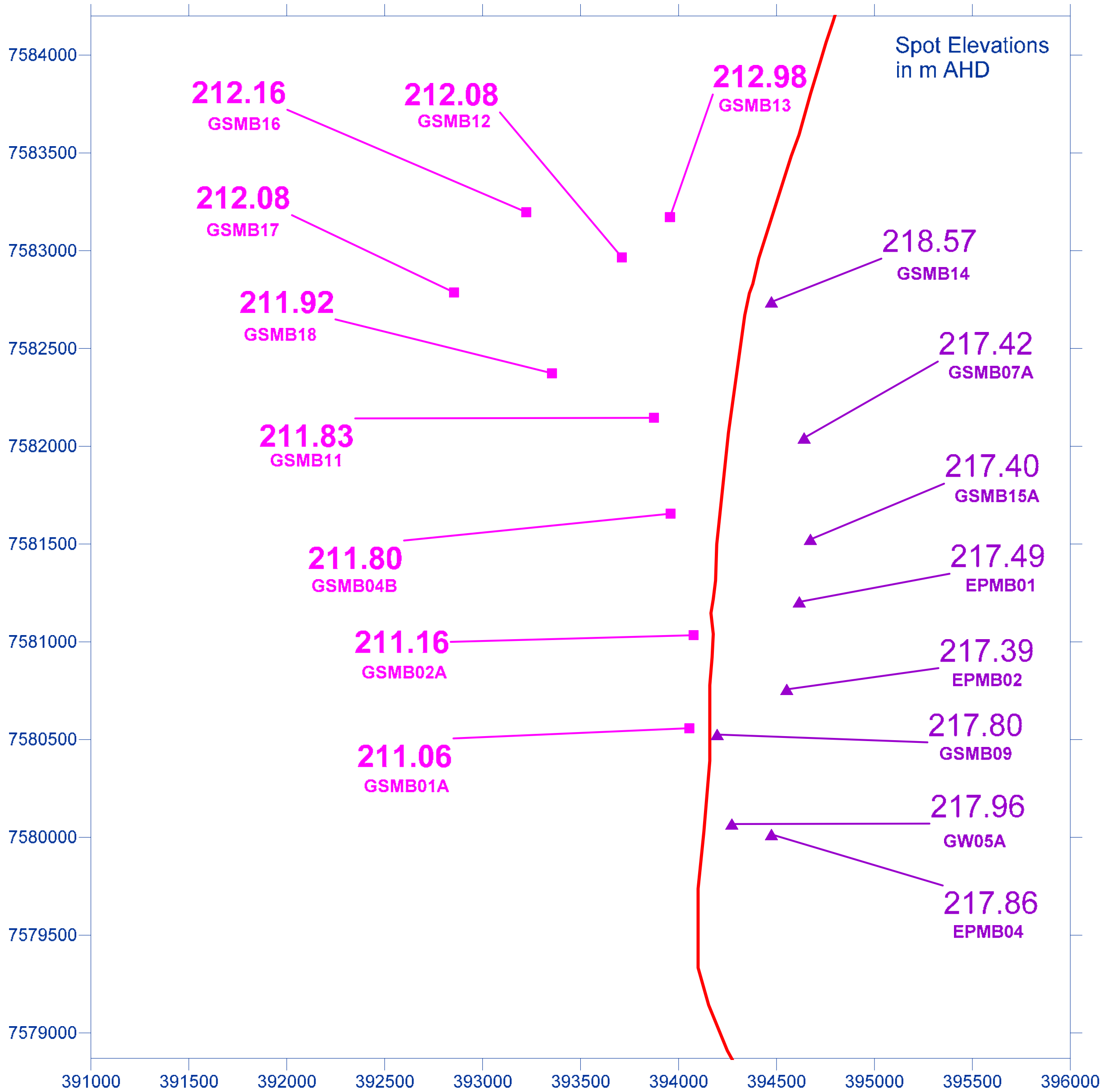

FIGURE 9. Spot Groundwater Elevations- September 2014

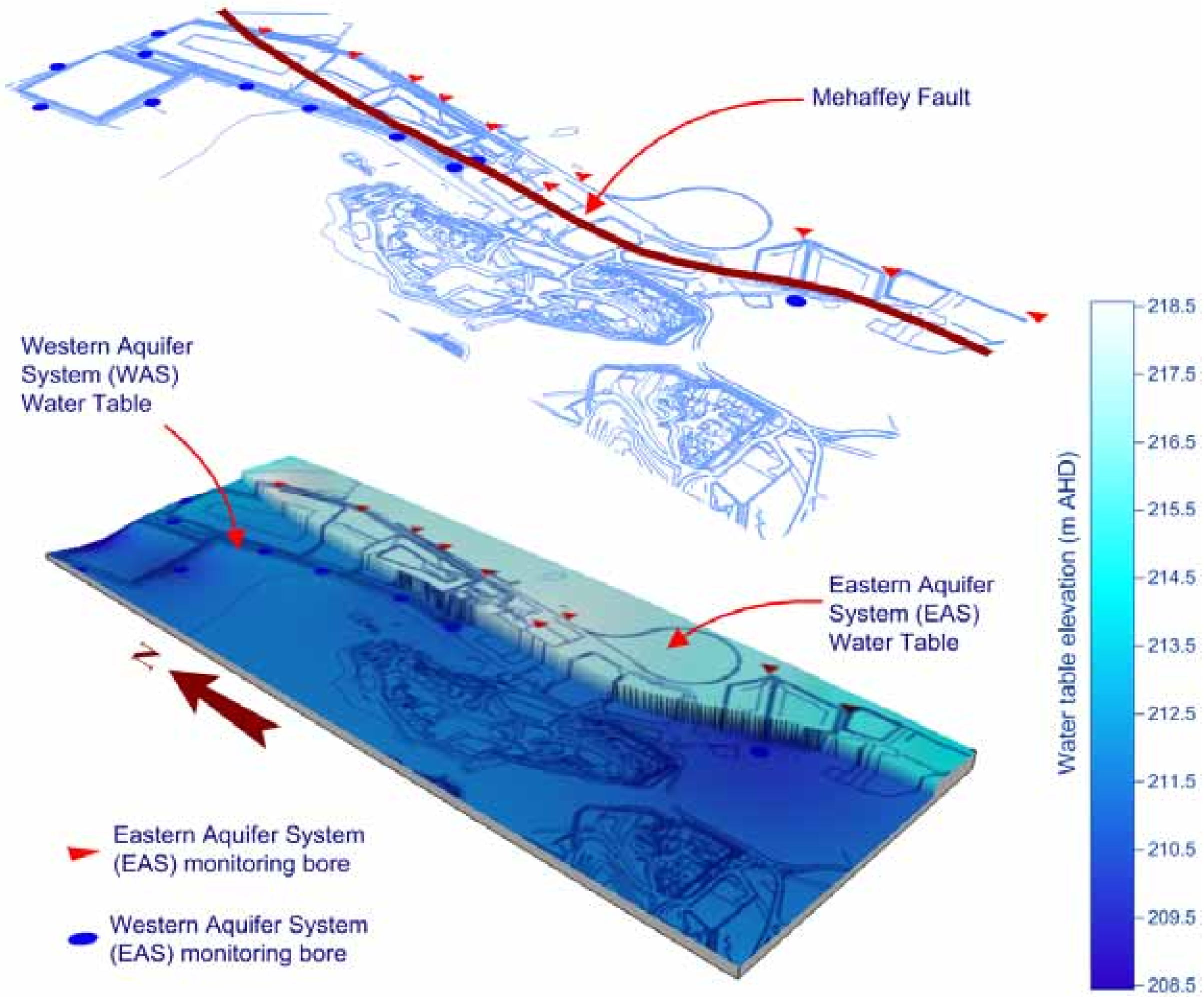

FIGURE 10. Three-dimensional representation of the water table on both sides of the Mehaffey Fault with the fault acting as a hydrogeological barrier boundary

The hydrogeological data specifically the large hydraulic head differential across the Mehaffey Fault and the significantly different water level trends indicates the Mehaffey Fault forms a reasonably effective hydrogeological barrier boundary that provides a high degree of hydraulic separation between the groundwater flow systems on either of the fault, at least in the vicinity of the Phosphate Hill mine.

The Mehaffey fault has juxtaposed stratigraphic units having different hydraulic properties. The fault-parallel groundwater flow is indicative of highly contrasting hydraulic conductivities in rocks on the different sides of the fault

6.5 Adequacy of GSF Monitoring Bore Network

<u>*6.5.1 Screen intervals*</u>

The water levels reduced to meter AHD elevations were compared to the elevations of the screened intervals in the respective monitoring bores in order to assess whether the measured hydraulic heads were indicative of the elevation of the water table and whether the determined groundwater chemistry was representative of the groundwater near the top of the saturated zone.

The water levels in 13 of the 17 bores were within the screened interval but groundwater was significantly above the top of the screened interval in three bores, namely GSMB07A, GSMB02A and GSMB04B. Example plots for bores were the standing water level was within the screened interval and where the water level was significantly above the top of the screened interval are shown in Figure 11.

Plots showing the relationship of the water level to the screened interval for all 17 GSF monitoring bores are included in the Appendix 1.

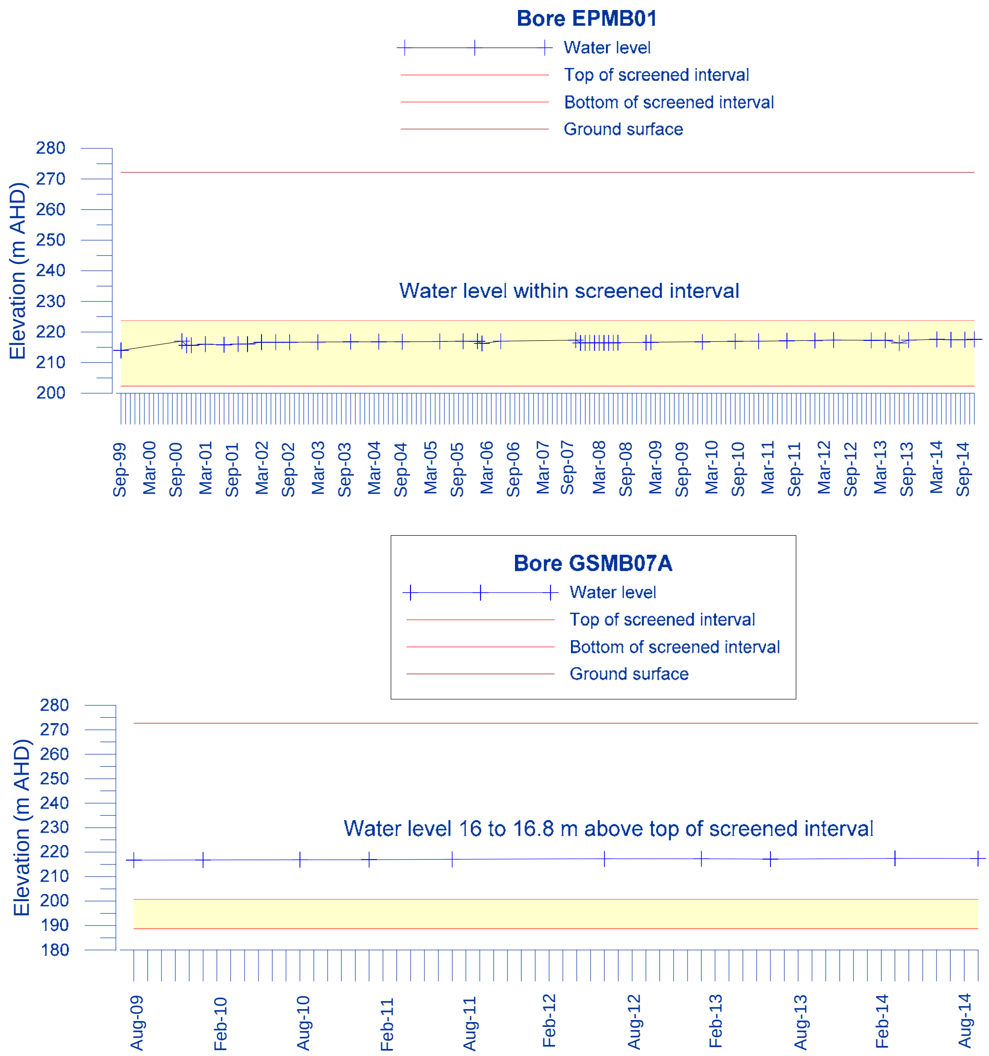

Figure 11. Example bore hydrographs with water table within and above screened intervals

6.5.2 Information gaps within the network

Given that groundwater flow direction is to the south, there is a gap in the monitoring of the GSF liner integrity bore network between bore GSMB09 and bore GW5A.

GW5A is located within the manufacturing area and may be influenced by activities other than the GSF. As such it does not appear to represent potential impact purely associated with the GSF and has limited use as being part of the integrity monitoring bore network.

The water level in the eastern aquifer system (EAS) in close proximity to Cells 1, 2 and 3B appears to be increasing. Bores further north and south within the EAS are stable. This potentially indicates a source entering the groundwater.

Additional bores, one to the south and one east, are required to enable a determination to be made of the significance of water level changes.

6.5.3 Variations in groundwater elevations

The findings of the groundwater flow systems analysis indicate that vertical hydraulic gradients within the aquifer systems on both the west and east sides of the Mehaffey Fault are small to negligible. Consequently the stabilised water levels in the monitored bore including those where the water levels were significantly above the screened intervals would be reasonably indicative of the position of the water table. However, analysis of groundwater sampled from the three bores where the standing water level is above the screens is uncertain as the samples are not representative of the concentrations of introduced contaminants near the water table. Consequently, less reliance should be placed on the results of contamination testing of groundwater samples from these bores.

Additionally hydrograph information on file reveals some discrepancies (e.g. refer Figure 12) that require consolidation to facilitate the accuracy of future predictive modelling.

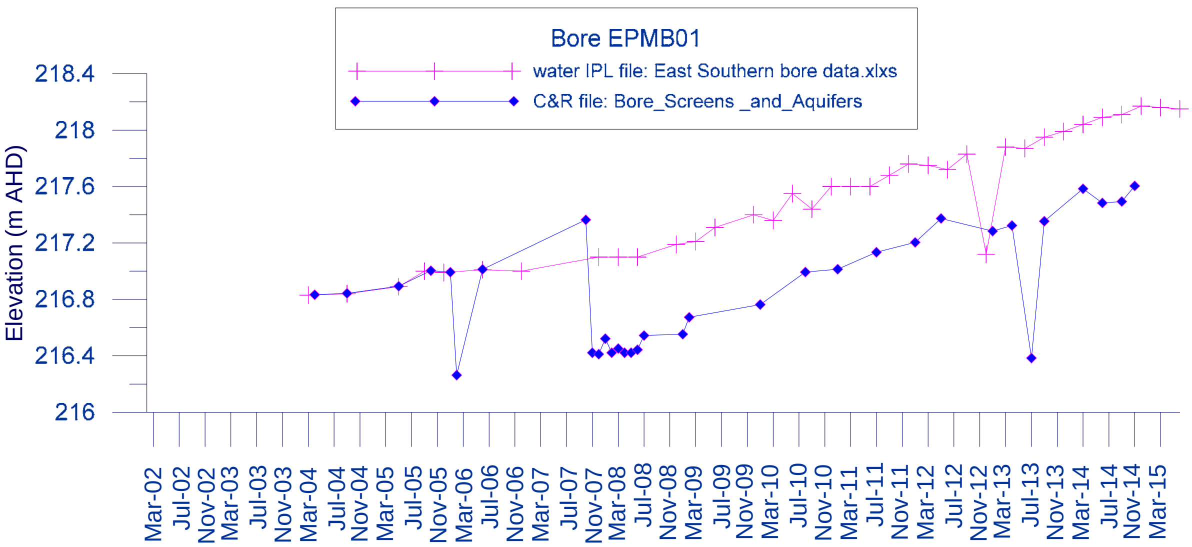

FIGURE 12. Hydrographs for Bore EPMB01 Compiled From Different Datasets

7.0 EXPOSURE PATHWAYS

In a risk assessment, exposure pathways are means by which contaminants move through the environment from a source to a point of contact with people or environmental values. A complete exposure pathway must have four parts:
(1) a source of contamination,
(2) a mechanism for transport of a substance from the source to the air, surface water, groundwater and/or soil,
(3) a point where contact is made with contaminated air, surface water, groundwater or soil, and
(4) a route of entry into the compartment (eg body). Routes of entry can be eating or drinking contaminated materials, breathing contaminated air, or absorbing contaminants through the skin or root systems.

Risks can be assessed when an exposure pathway is complete. If any part of an exposure pathway is absent, the pathway is said to be incomplete and no exposure or risk is possible. In some cases, although a pathway is complete, the likelihood that significant exposure will occur is very small.

Risk assessments include a "pathways analysis" to identify those pathways that are complete and most likely to produce significant exposure.

7.1 Groundwater

The GSF represents a potential source of groundwater contamination if the liner membrane fails. If the liner fails, any escaping liquor would move vertically downward under gravitational forces.

If downward flow of contaminated leakage water is inhibited by lower permeability zones the water would become perched above the lower permeability material and not reach the deeper underlying water table. Under these physical conditions, the pathway beyond the mining lease would be incomplete.

If the contaminated leakage water reaches the regional water table if would move in the hydraulic gradient direction towards natural or induced (pits below the water table, groundwater extraction by pumping bores) discharge areas and/or points. Once contaminants enter the groundwater flow regime their concentration is reduced by dilution and dispersion. In addition, natural attenuation mechanisms can markedly alter their characteristics. The rate of attenuation is a function of the type of contaminant and the local hydrogeological framework (type of flow, and the composition of the soil and aquifer materials and the size and shape of their particles). Attenuation processes are time-dependent; residence time is increased by low flow rates which increases the opportunity for natural attenuation.

Under mining conditions, groundwater flow from the GSF area west of the Mehaffey Fault either discharges into the mine pits, is captured by groundwater pumping from the production/ dewatering bores (effectively being recycled), flows further south towards distant discharge points (e.g., station bores) or into the surface water drainage system (receiving waters) at a considerable distance away from the site.

The environmental value of the groundwater has been reported as stock watering [C&R Consulting, 2015]. To-date there is no definitive evidence that impairment of groundwater has occurred that would render it unsuitable for stock water purposes. However, a risk assessment is required to better quantify impact potential.

7.2 Surface Water

Phosphate Hill is located in a low rainfall area, with an annual average of just under 300mm occurring predominantly during the wet season (November – March). Mean rainfall occurring outside the wet season is generally less than 20mm per month.

The ephemeral streams and rivers flow only after storm events. Cell design is such that stormwaters falling on the stacks are contained within the GSF ditches and transferred to the evaporation ponds.

A tributary of Galah Creek has been diverted around Cell 5A. Dykes divert surface flows around the facility so as not to contact gypsum or process waters. An illustration of flow diversion associated with Cell 5A against original flow channels is provided in Figure 13.

Historically, release of groundwater pumped to dewater mine pits into Kolar Creek provided a pathway for potentially contaminated groundwater to impact local surface water. Discharge of dewatering or process waters ceased in 2015 and therefore this exposure pathway between groundwater and surface water is no longer relevant. IPL continues to monitor surface water quality within creeks, including Galah and Kolar Creek and it is understood no impact has been evidenced to-date.

Erosion from the stockpiles is controlled by a dyke that surrounds the GSF. Sediment movement is contained within the bunding created by the outer dyke walls. There is no evidence of release from the GSF into surface waters. Engineering design, coupled with integrity inspections of the GSF and liner system, are considered satisfactory to mitigate the risk to surface waters based on all reasonable foreseeable events that may relate to a release likely to impact surface waters.

An environmental investigation into soil impact beneath Cell 3A [AECOM, 2016], reports no significant impact other than localised areas of acidity.

7.3 Air

Upon exposure to air and drying, the gypsum becomes solidified with minimal wind borne dust generated. Contaminant transportation via wind-blown dust off the mine site is rated a low environmental contamination risk based on low transportation and low hazard potential of the remnant gypsum to soil quality.

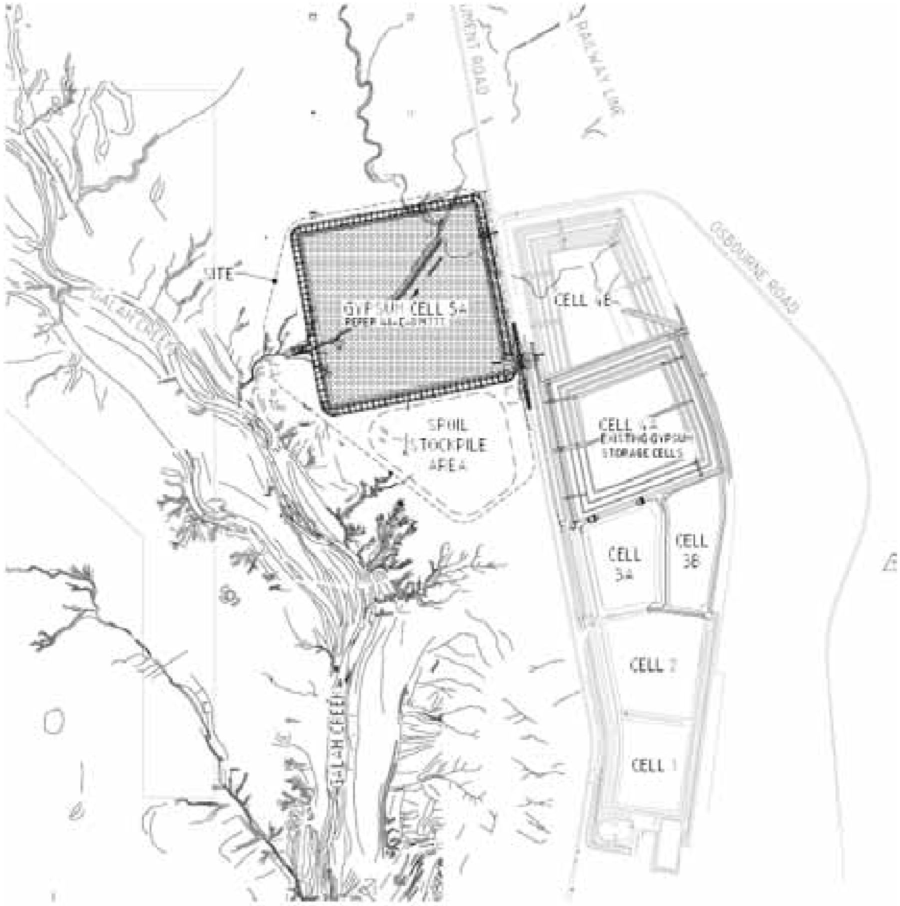

Figure 13. Surface water flows diverted around Cells 4B and 5A (from Drawing 48-C-019776)

8.0 CONCLUSION

A reasonable network of groundwater monitoring bores exists to assess potential impact associated with monitoring the integrity of GSF cell liners, as evidenced in Figure 7.

Groundwater data interpretation is complicated by the positioning of the GSF above the north-south running Mehaffey Fault(s) system. Two separate aquifer systems exist; one to the west and the other east. The precise boundary of the fault (or fault zone) has not been well defined. Given the size of the facilities that now overlie the fault, the precise identification is not feasible nor practical.

Monitoring reveals the fault(s) is providing a barrier for groundwater flow with groundwater in the eastern aquifer system is currently about 6 meters higher than that in the western aquifer system.

Prior to 2005, the groundwater elevation in the west aquifer system was significantly higher. Dewatering of pits and use of groundwater for production has lowered the water table in the western aquifer system by approximately 24m. This would be expected to rebound back to its normal state over time following cessation of groundwater extraction.

Flow system analysis indicates that groundwater flow within both the aquifer systems is to the south i.e. towards the manufacturing facility and possibly towards the pit voids. The depth to groundwater suggests there is no local connectivity with surface waters with the water table most likely intersecting the ground surface a long way, possibly hundreds of kilometers down hydraulic gradient from the PHM site.

Increasing trends were noted for TDS concentrations (predominantly a result of increasing calcium, sodium and chloride ions) in bores EPMB1 and GSMB15A (to the south east of cell 3B) and therefore what is likely to be down hydraulic gradient of the cell 1&2 and pond 3B). No other indicators of contamination were noted. Chemical analysis surrounding the GSF has identified no definitive impact above the groundwater's environment value of stock drinking water.

Charts of a number of water quality indicator chemicals illustrate trends and are provided within Appendix 5.

Liner integrity monitoring presently involves physical maintenance checks of the surge ditch liner and other liners but only where visual checks are possible. This visual integrity check is coupled with twice yearly to quarterly groundwater monitoring. The inclusion of some form of leakage detection within the porous cushioning sands, gypsum and/or associated soil fill beneath the liner, if at all feasible, would assist in demonstrating a best practice approach to liner integrity.

The outcome against each requirement of the EE is presented below:

<u>EE Requirement 1.</u>
Establish the source, cause and extent of the release of contaminants from the GSF.

Each stockpile and water storage cell has been designed to be watertight to prevent migration of contaminants into the soils, and groundwater systems, beneath and beyond the GSF. Each cell contains its own HDPE liner and relief vents to drain the stockpile of water and enable a solid gypsum material to remain within the stack. Some liners (i.e. cells 1&2 and cells 4A&4B have a joined liner system).

The phosphogypsum contains a number of potential contaminants that could impair environmental conditions if released in sufficient quantities beyond the GSF. Main contaminants of concern are:

- pH (acidity), TDS (Conductivity), Calcium, Fluoride, Sulphate, Phosphate, Sodium, Chloride, Arsenic, Cadmium, Lead and Uranium.

Investigations have identified impact within the soil beneath cell 3A, within bores BH01 and BH02 (south-west end of cell) and BH12 (north-west end where dozer entered cell). Acidic soil conditions were noted down to at least 3m. Detail of the investigation is provided within AECOM geotechnical and environmental reports [AECOM 2016a, 2016b].

No saturated conditions with potential to migrate to surface waters were identified. One area to the south-west contained standing water. This was not uniformly encountered across the pond (i.e. cell 3A) area.

No impact of groundwater quality indicators at a level above the livestock drinking water environmental value criteria has been identified in monitoring done to-date.

The cause of the impact observed to the southern end of cell 3A may have resulted from liner tears in cell 3A caused during the heaving experienced in recent years. A liner tear was also reported in the surge ditch west of cell 3A that has since been repaired.

Based on the current integrity monitoring program, no other release of contaminants has been reported to have occurred from other cells.

Pathway risks have been identified from historic resource investigation reports (geotechnical bores) that suggest bores were constructed in locations that are now beneath the GSF (i.e. cell 3B). There is no record as to how the majority of these bores were decommissioned, and as such they may represent a preferential flow path to the groundwater table that cannot be discounted should the liner leak.

<u>EE Requirement 2.</u>

Report on the actual and potential impact of the release of contaminants on the groundwater of the receiving environment. At a minimum, the report must consider:
a. The relevant environmental values in accordance with the ANZECC methodology;
b. The impacts on the environmental values.

Assessment of groundwater chemistry within monitoring bores surrounding the GSF reveals that no bore contains contaminants that impede the environmental value of the relevant groundwater quality use (i.e. livestock drinking water).

Increasing trends were noted in bores EPMB1 and GSMB15A for TDS (predominantly a result of increasing calcium and chloride ions) (to the south east of cell 3B and therefore likely to be down hydraulic gradient). A summary of analytical results is provided within Table E1 contained within Appendix 3. Further detail against ANZECC is provided in reference reports [C&R Consulting, 2015].

<u>EE Requirement 3</u>

Based on the established source, cause and extent of the release of contaminants, describe all relevant remediation options including the works, cost and timeframes before recommending a preferred option. Remediation options must ensure the ongoing protection of the environmental values of the receiving environment.

Based on the current bore network, chemical impact has not been identified in any aquifer warranting remedial action. Works are however, underway to obtain the further detail necessary to describe remediation options and timeframes; particularly associated with cell 3A. Kelly Drilling has been engaged to construct the additional monitoring bores, which have had to be postponed due to inclement weather. A list of the works that are being finalized is outlined in Section 8.1.

EE Requirement 4.

Determine the adequacy of the current leak detection monitoring for the Gypsum Storage Facility and identify current best practice and areas of improvement.

Leak detection monitoring comprises a series of liner inspections that are occurring daily following a maintenance inspection program recommended by the cell designers. This is coupled with groundwater monitoring at selected bores surrounding the GSF on a twice yearly to quarterly basis.

For an established liner system, the leak detection monitoring program being implemented by IPL represents close to best practice. Ardaman & Associates, recognized world leaders in phosphogypsum stockpile management, were responsible for the design of each cell and pond in the GSF to best practice standards of the time. Any future cell should consider the option to have an integrated leak monitoring system added beneath the liner with electrical leak detection to flag issues prior to bulk application, . However, such systems would have needed to be established prior to waste storage progressing, which isn't the case at Phosphate Hill. Retrofit of such integrity systems is not feasible post phosphogypsum stockpiling.

To improve leak detection, IPL were advised to, and are now progressing a feasibility investigation by installing a below liner monitoring bore (e.g. inclined bore to around 8-10m depth) designed to identified water seepage from any liner integrity breaches, should it occur. This bore aims to intersect or come in close proximity to the permeable sand cushioning beneath the liner. A single 'tangential' bore is being constructed to the east of cell 3B. If successful, further bores warrant consideration to monitor each cell and pond.

EE Requirement 5.

Conduct an investigation of the regional groundwater system which, at a minimum:
a) identified the type, location and hydrology of groundwater aquifers in the area;
b) Established background reference water quality of each aquifer and determines appropriate trigger values and limits;
c) establishes appropriate reference bore locations for each aquifer;
d) Compares the results from the reference bores to current and historical monitoring results and considers the impact of mining activities at the premises.

C&R Consulting has reviewed and reported on the regional groundwater system [C&R, 2015]. Recommendations that have come out of their review relate to establishment of two 'reference bores' to the north of the GSF. This is supported.

C&R Consulting also recommend a statistical analysis of groundwater quality and calculation of 80th and 95th percentiles as trigger levels for missing values until new reference bores can be established.

Reference bores are to be used to gauge water quality changes and enable action to identify and control a source prior to chemicals encroaching upon the environmental value of the groundwater (i.e. a stock drinking water standard).

Based on our conceptual hydrogeological model and data gap analysis, five(5) new bores are necessary in order to monitor the potential for impact from the GSF on local groundwater and for use in hydrogeological risk assessment. We also support that two new references bores be established. Tentative locations of the seven(7) new monitoring bores are plotted in Figure 14. The background, objective, site location and constraints are summarized in Appendix 6.

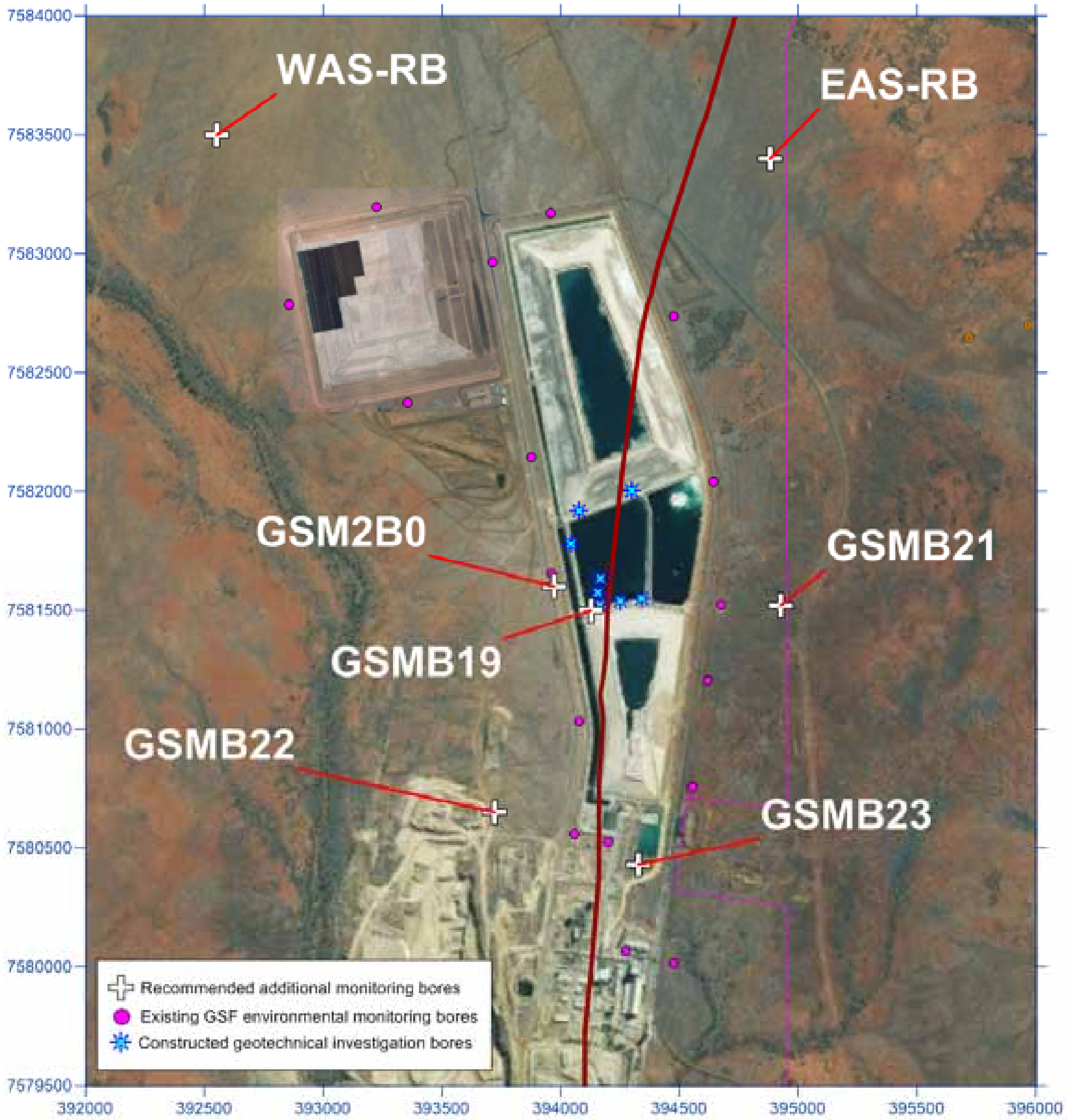

Figure 14. Indicative locations of new monitoring bores

Additional bores south of cell 3A to better gauge the extent of any perch water table, and a trial 'tangential' bore to the east of cell 3B, will also be required for risk assessment purposes.

8.1 Works underway and rationale for the works

The following works are being progressed. These works were delayed by inclement weather and are essential to evaluating the the 'potential for impact' and remediation options:

Table 4: Works underway and rationale for same

No.	Assessment Works	Rationale
16-1	Construction of an additional bore to east of GSMB15A.	Water table immediate east of GSF is increasing. An easterly bore aims to establish: 1. Whether water table height is regional and not localised (and therefore not sourced from the GSF); 2. Water chemistry (TDS) representative of the east aquifer; and 3. Confirm groundwater flow direction.
16-2	Construction of reference bores up-hydraulic gradient and distant from the GSF potential contamination source on both sides of Mehaffey Fault (i.e. within EAS & WAS).	Existing bores are too close to the GSF and may be impacted if the liner integrity were to be compromised. New bore on west side of fault should be NW of the GSF and that on the east should be to the NE.
16-3	Construction of a new bore adjacent GSMB04B and screen across the water table so that representative water associated with possible GSF impact is sampled and analysed.	Bore screen intervals in the western bores are well below the water table (refer Appendix 1 hydrographs). (Note: these represent replacement bores as original bores are now 'dry' due to a drop in the groundwater water level)
16-4	As the new perched water bore established in 2015 near SW corner of Cell 3A (Bore labelled 'Pond3A_BH8') contains water, a new bore adjacent to it screened across same interval as GSMB15A is being constructed.	Comparison of groundwater chemistry from two depths at the one site would enable better assessment of leakage from the GSF. Side-by-side bores would enable vertical hydraulic gradient determination. A deep bore at the SE corner of Cell 3A would provide a W-E line of bores (i.e., proposed deep Cell3A bore to GSMB14a to proposed bore further east) which would provide information (groundwater level and chemistry) and identify any mounding due to leakage from the GSF.
16-5	Construction of a new bore south of the southern evaporation pond between bores GSMB09 and GW5A.	Production bore GW5A reveals impact but this impact may not be a result of the GSF. A bore up-hydraulic gradient of the production facility, but within the southerly flow path of the groundwater would enable assessment of the GSF's impact.
16-6	Construction of 3x additional perch water presence monitoring bores to south and south-east of cell 3A.	Assist with risk assessment and remediation requirements around cell 3A.

No.	Assessment Works	Rationale
16-7	Construction of a shallow tangential monitoring bore as a trial to gauge i) whether it can be drilled and ii) whether it is of value for integrity monitoring purposes. If proven feasible and then functional over a 12 month period, repeat beneath each operational stack and pond to improve on the geo-membrane liner integrity monitoring regime.	Liner integrity checks by IPL are restricted to physical checks along the external area of the GSF. Once stockpiles increase in size the integrity of the liner is not able to be verified by visual inspection at locations other than the outer dyke/ditches.
16-8	Following construction, progress a complete round of groundwater gauging, and monitoring for all bores surrounding the GSF, and monitor groundwater levels in other bores at the mine site and exposed within the mine pits concurrently (same week) to aid flow calculations and pathway impact assessment and obtain groundwater chemistry data from GSMB17 (adjacent Cell 5A)	Data indicates a varying gauge point. Sampling was not always taken from the upper 3m of the aquifer (most likely to reveal impact). Concurrent monitoring of water levels in other bores at the mine site would enable more accurate water table mapping including better assessment of flow away from the GSF and identification of pathways and receptors for a Hydrogeological Risk Assessment and any groundwater flow modelling. Installed in 2014, due to slow recharge, water chemistry has not been compiled previously for bore GSMB17. Groundwater depth is however available, as is chemistry for nearby Bores 16 & 18.
16-9	Better quantify the contaminant concentrations within water within the slurry, the evaporation ponds and surge ditches.	Progress a review of water quality based on recent testing of gypsum, the surge ditch and the toe drain.
16-10	Undertake a semi-quantitative Hydrogeological Risk Assessment.	The outcome of risk assessment could enable rationalization of ongoing groundwater monitoring program and provide an informed response should a change be detected with the groundwater chemistry.

9.0 REFERENCES

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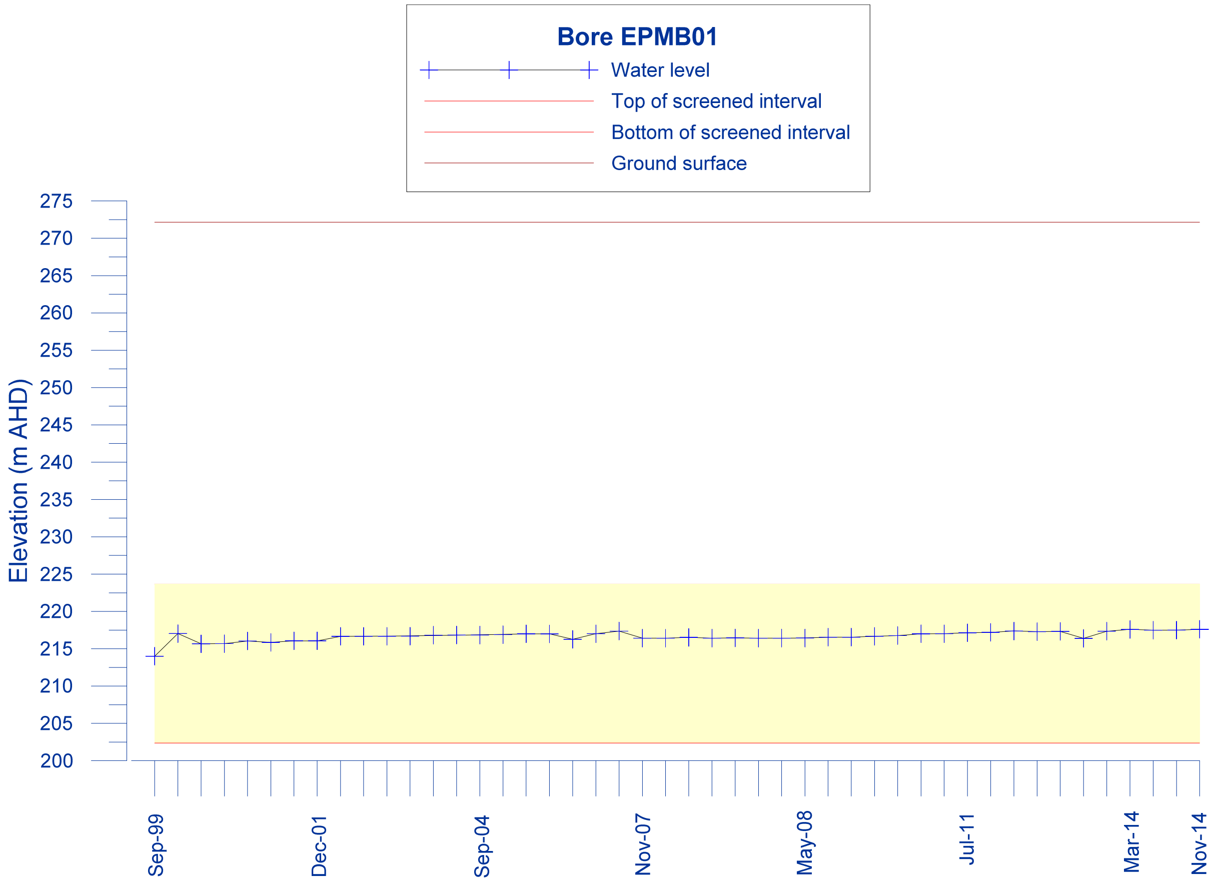
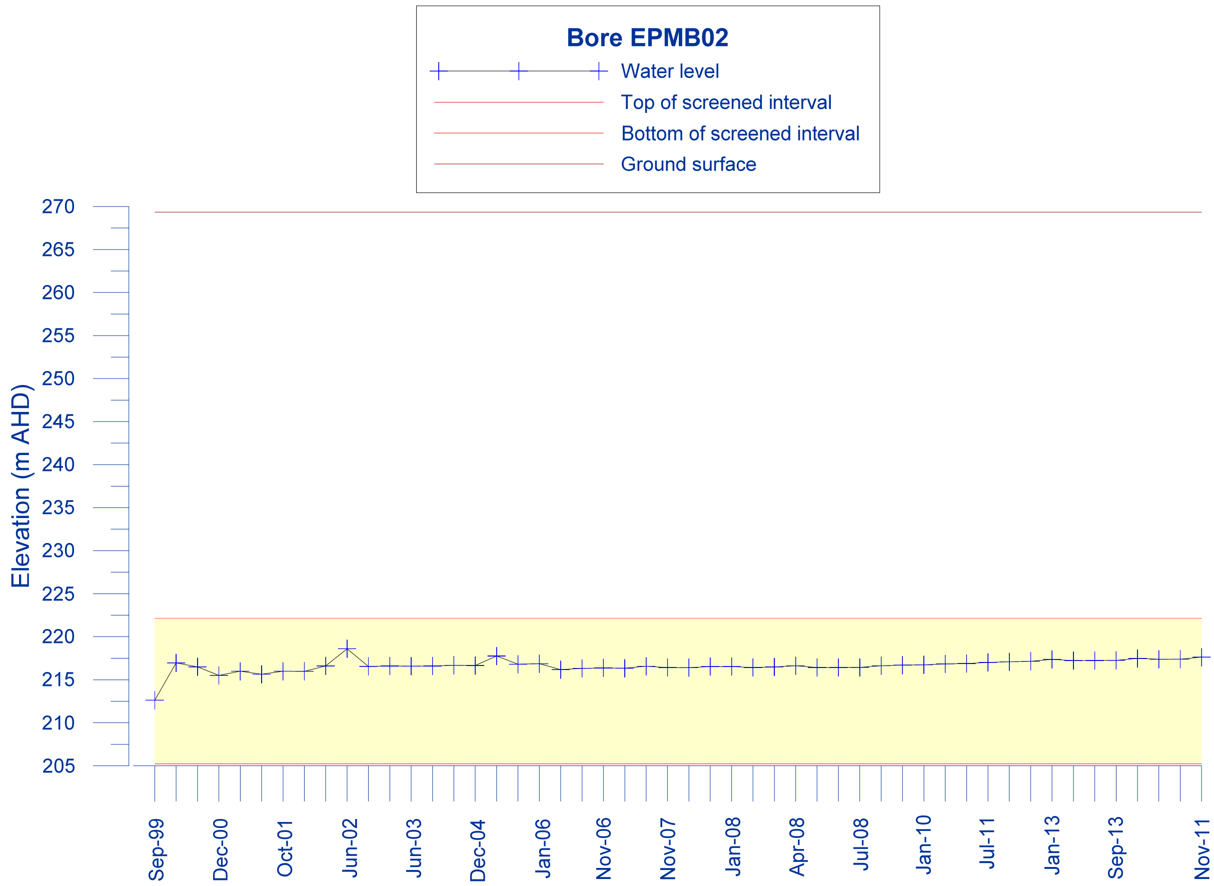
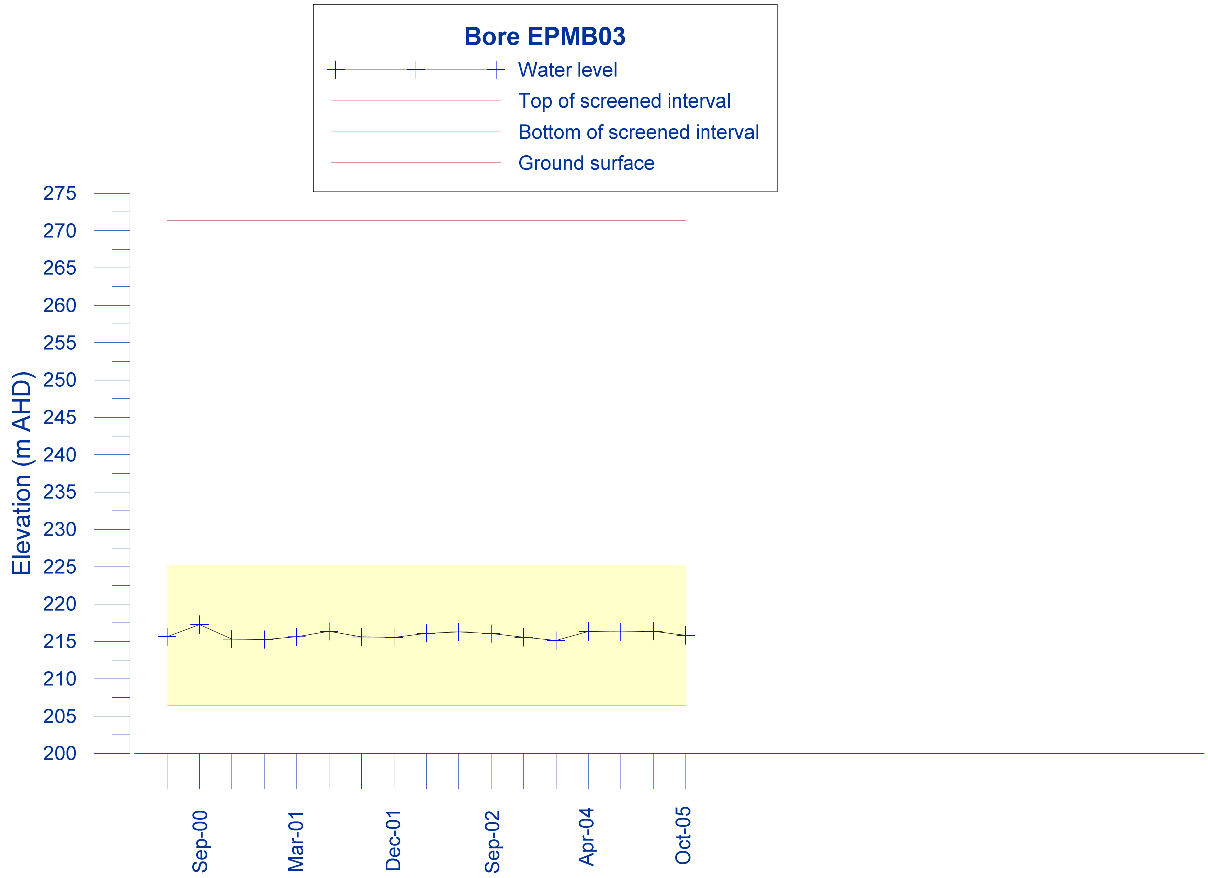
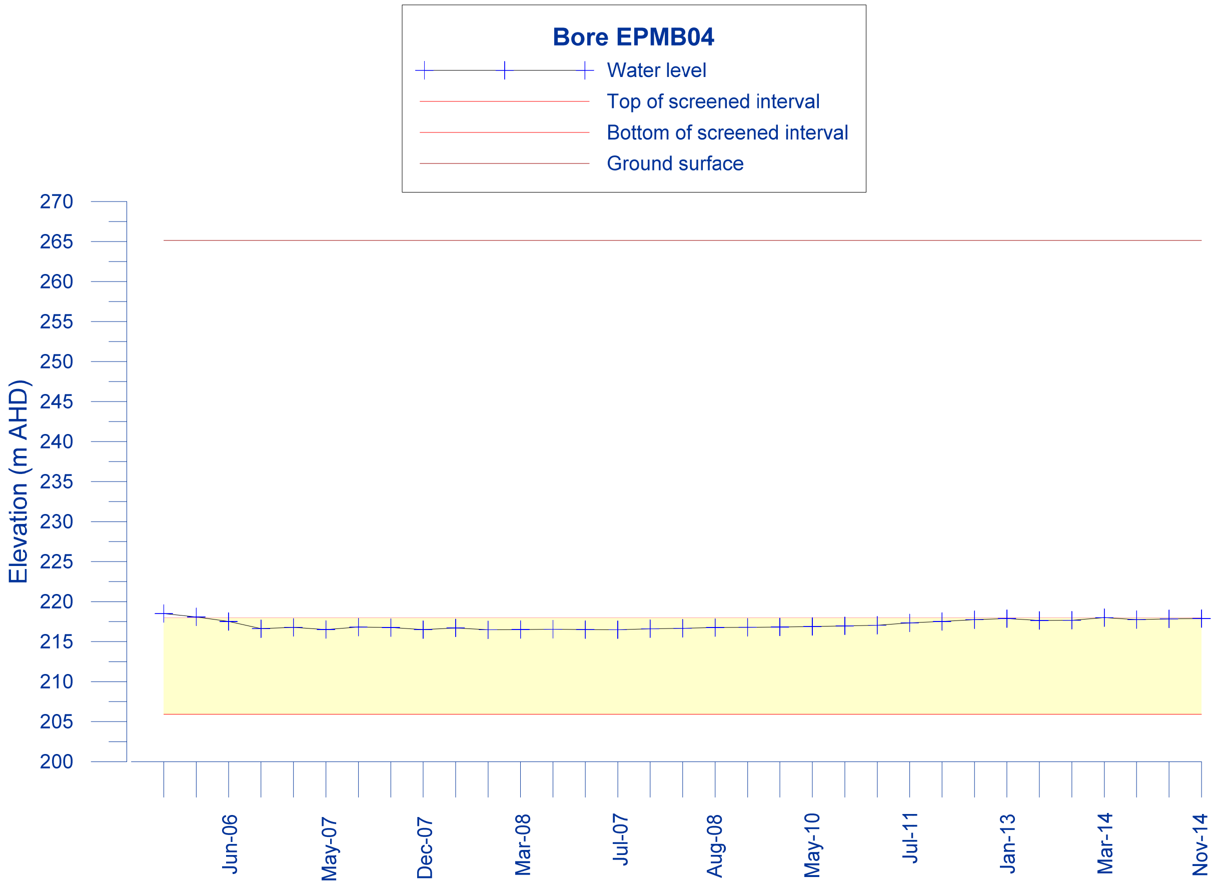
APPENDICES


Bore EPMB01
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
275
270
265
260
255
250
245
240
235
230
225
220
215
210
205
200
Sep-99
Dec-01
Sep-04
Nov-07
May-08
Jul-11
Mar-14
Nov-14

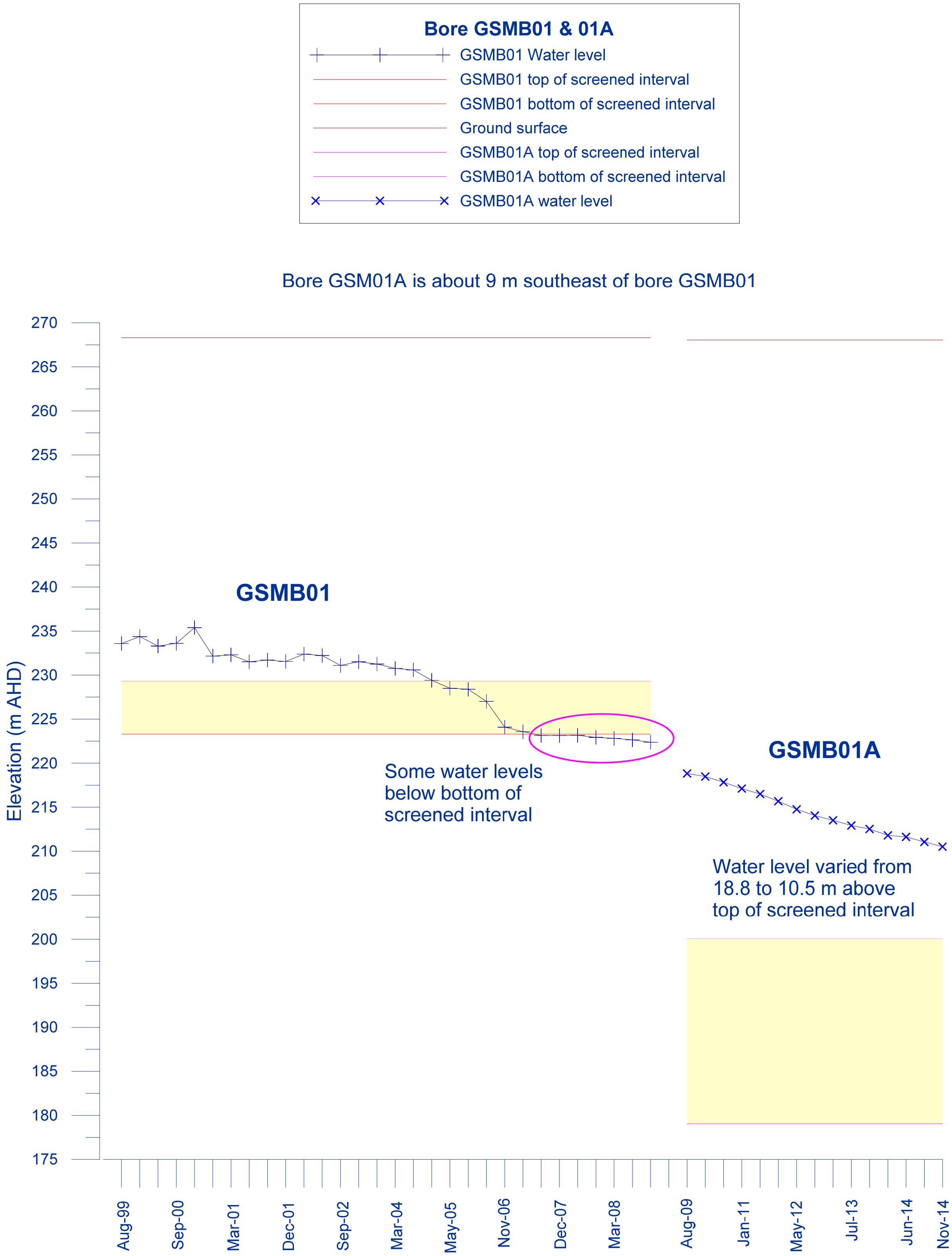

Bore EPMB02
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
270
265
260
255
250
245
240
235
230
225
220
215
210
205
Sep-99
Dec-00
Oct-01
Jun-02
Jun-03
Dec-04
Jan-06
Nov-06
Nov-07
Jan-08
Apr-08
Jul-08
Jan-10
Jul-11
Jan-13
Sep-13
Nov-11



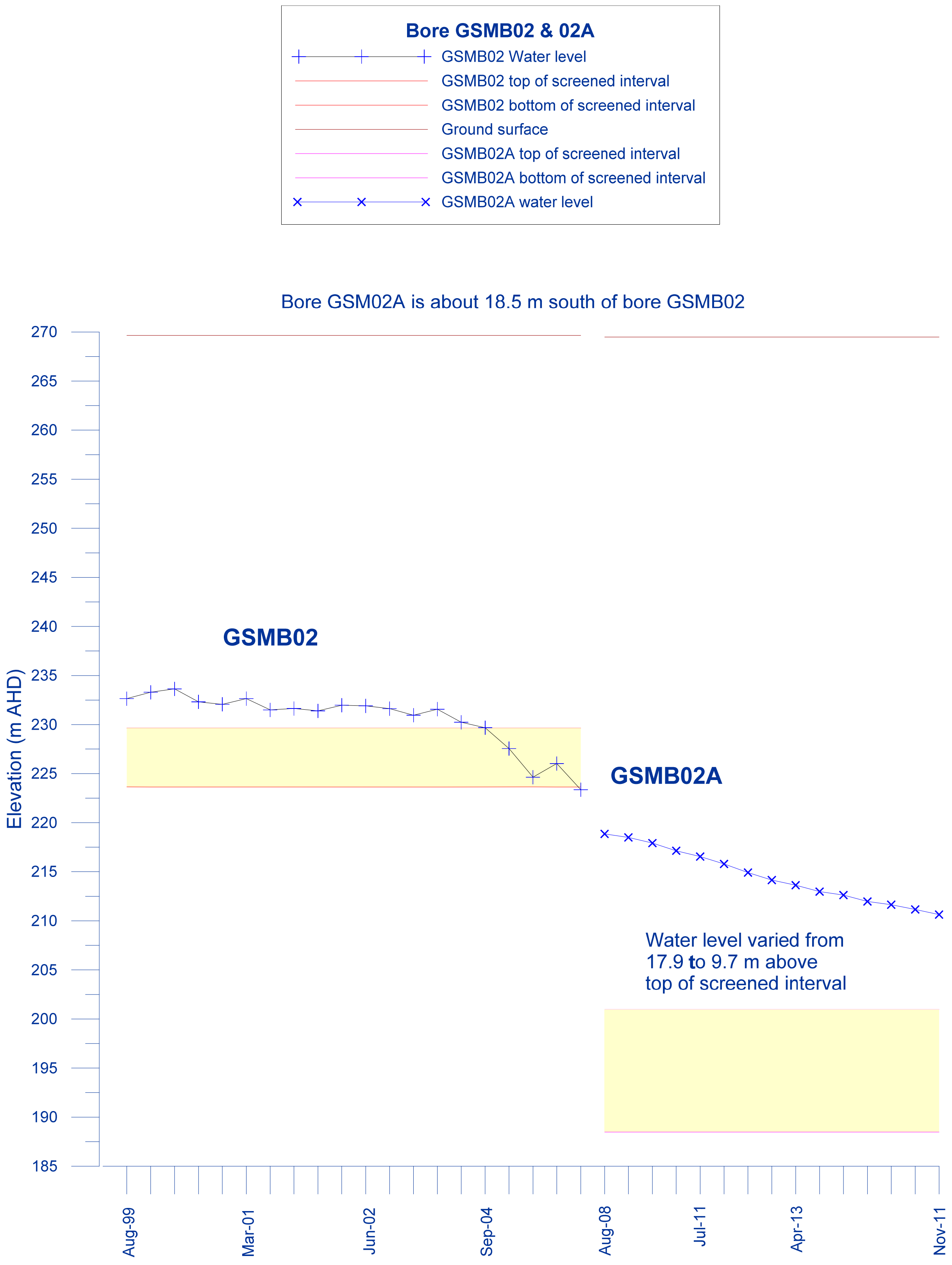
Bore EPMB03
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
275
270
265
260
255
250
245
240
235
230
225
220
215
210
205
200
Sep-00
Mar-01
Dec-01
Sep-02
Apr-04
Oct-05



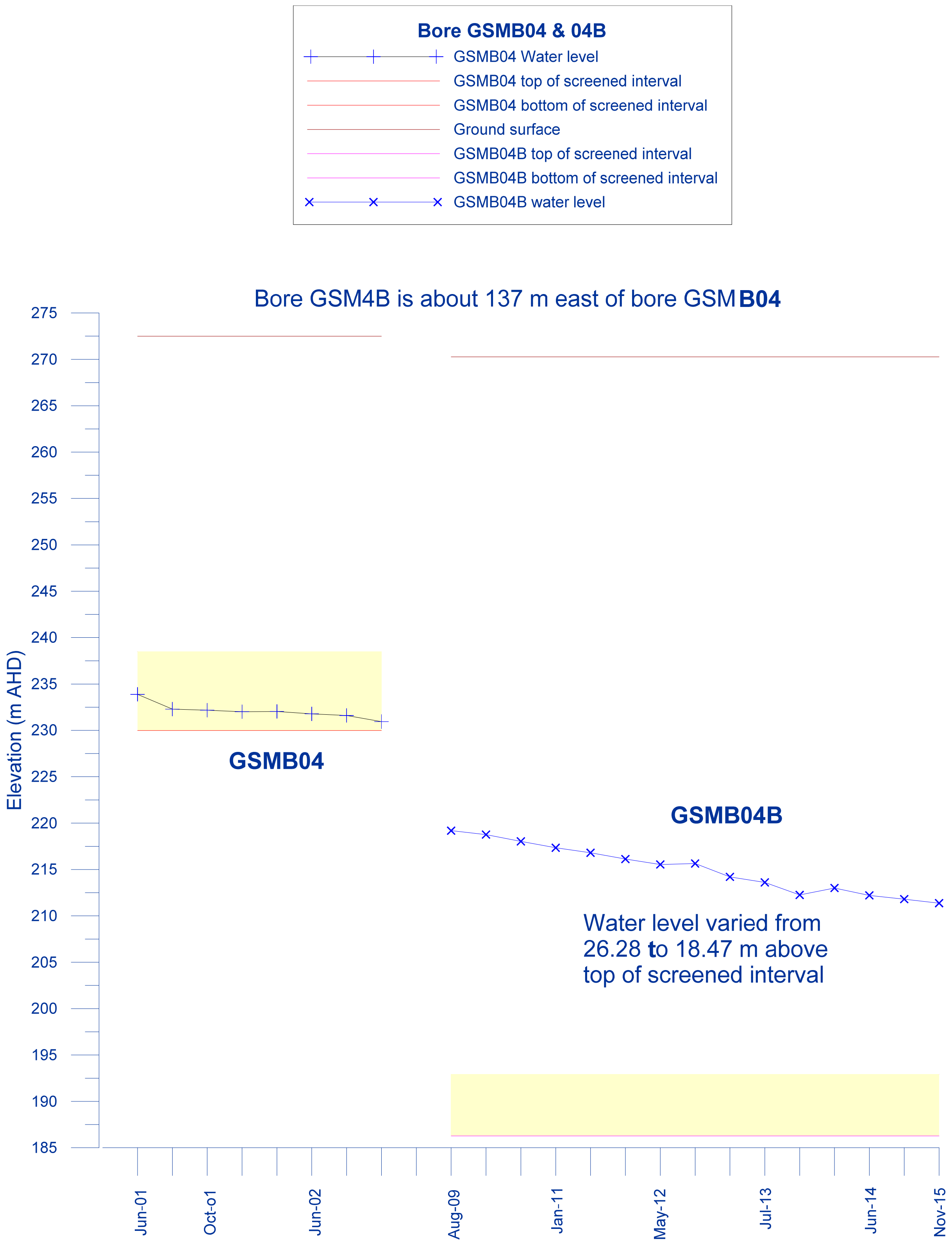
Bore EPMB04
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
270
265
260
255
250
245
240
235
230
225
220
215
210
205
200
Jun-06
May-07
Dec-07
Mar-08
Jul-07
Aug-08
May-10
Jul-11
Jan-13
Mar-14
Nov-14



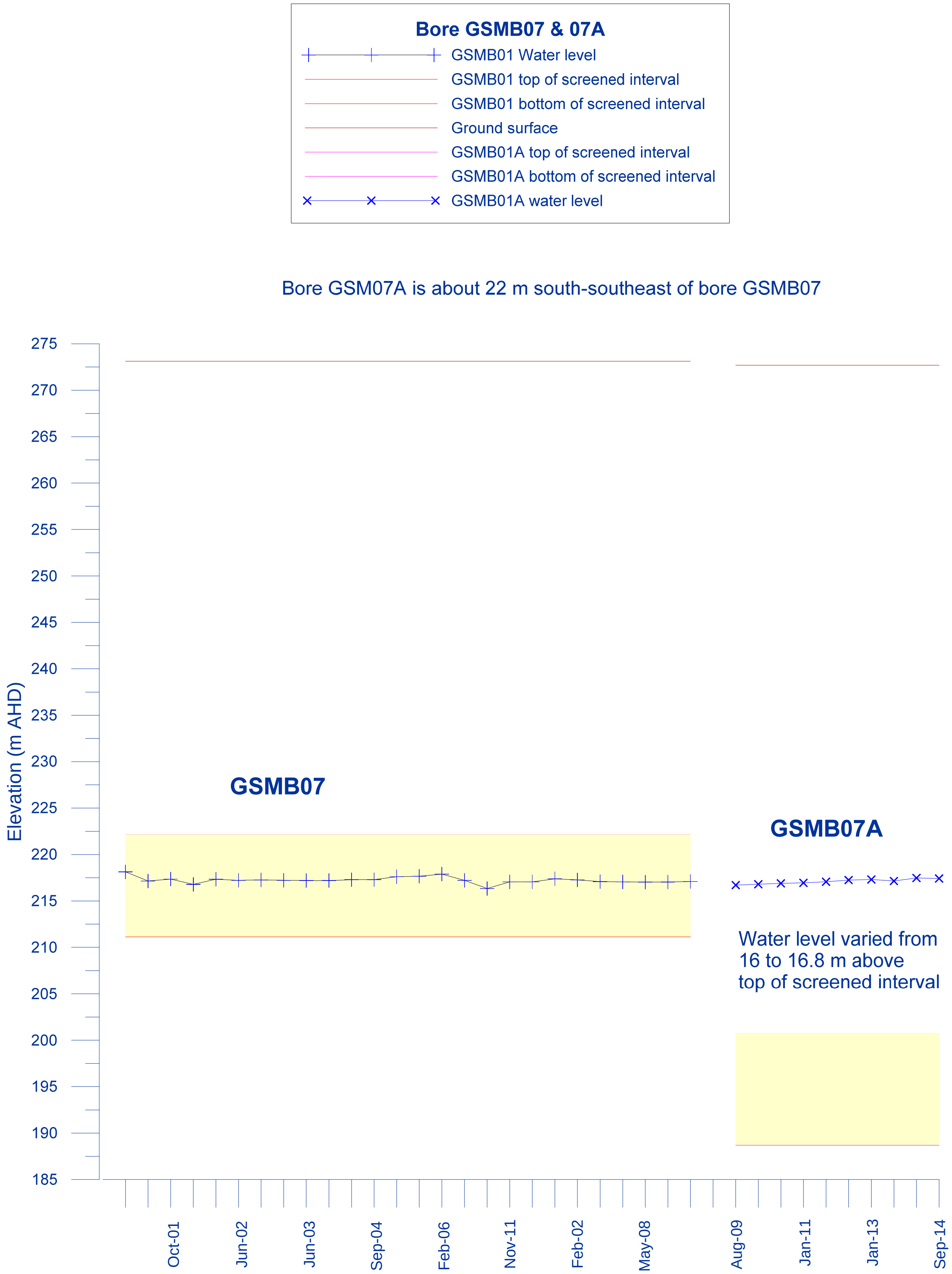
Bore GSMB01 & 01A
GSMB01 Water level
GSMB01 top of screened interval
GSMB01 bottom of screened interval
Ground surface
GSMB01A top of screened interval
GSMB01A bottom of screened interval
GSMB01A water level
Bore GSM01A is about 9 m southeast of bore GSMB01
Elevation (m AHD)
270
265
260
255
250
245
240
235
230
225
220
215
210
205
200
195
190
185
180
175
GSMB01
Some water levels
below bottom of
screened interval
GSMB01A
Water level varied from
18.8 to 10.5 m above
top of screened interval
Aug-99
Sep-00
Mar-01
Dec-01
Sep-02
Mar-04
May-05
Nov-06
Dec-07
Mar-08
Aug-09
Jan-11
May-12
Jul-13
Jun-14
Nov-14

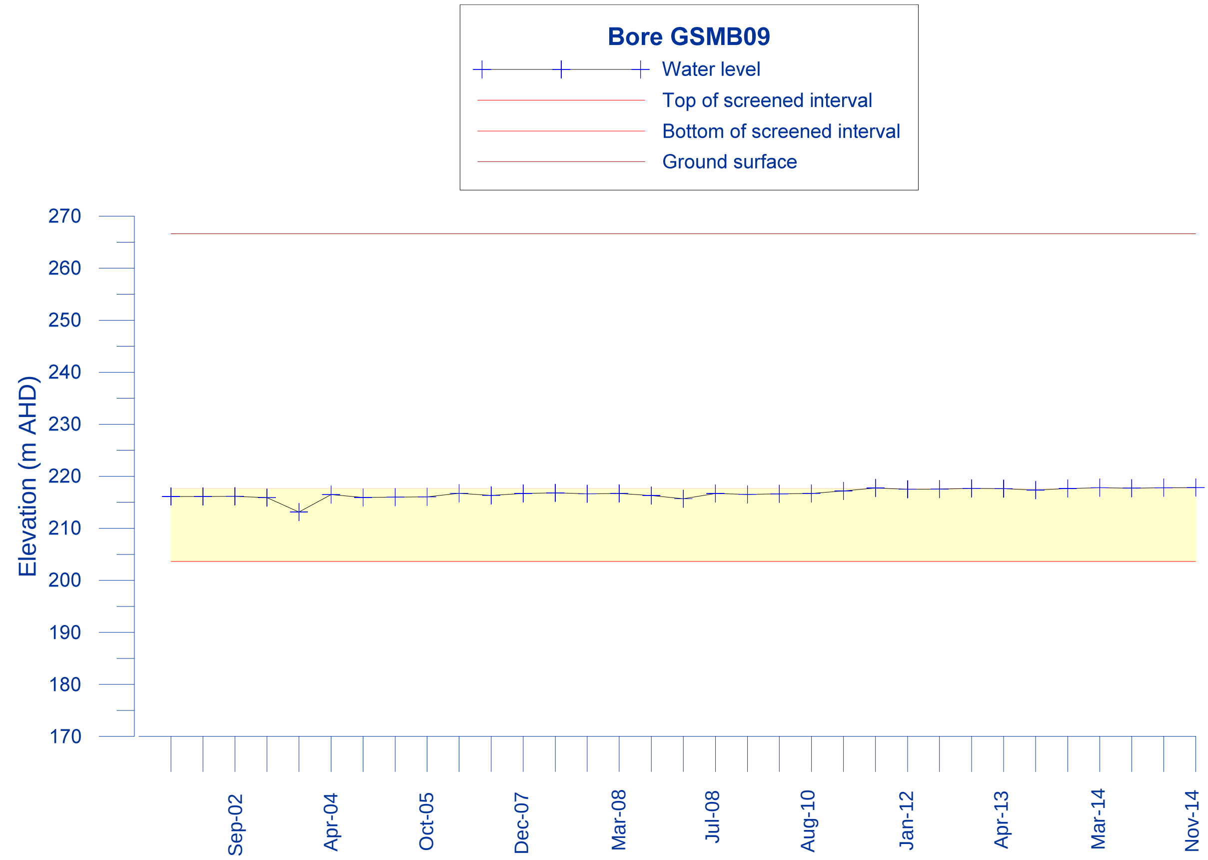


Bore GSMB02 & 02A
GSMB02 Water level
GSMB02 top of screened interval
GSMB02 bottom of screened interval
Ground surface
GSMB02A top of screened interval
GSMB02A bottom of screened interval
GSMB02A water level
Bore GSM02A is about 18.5 m south of bore GSMB02
Elevation (m AHD)
270
265
260
255
250
245
240
235
230
225
220
215
210
205
200
195
190
185
GSMB02
GSMB02A
Water level varied from
17.9 to 9.7 m above
top of screened interval
Aug-99
Mar-01
Jun-02
Sep-04
Aug-08
Jul-11
Apr-13
Nov-11

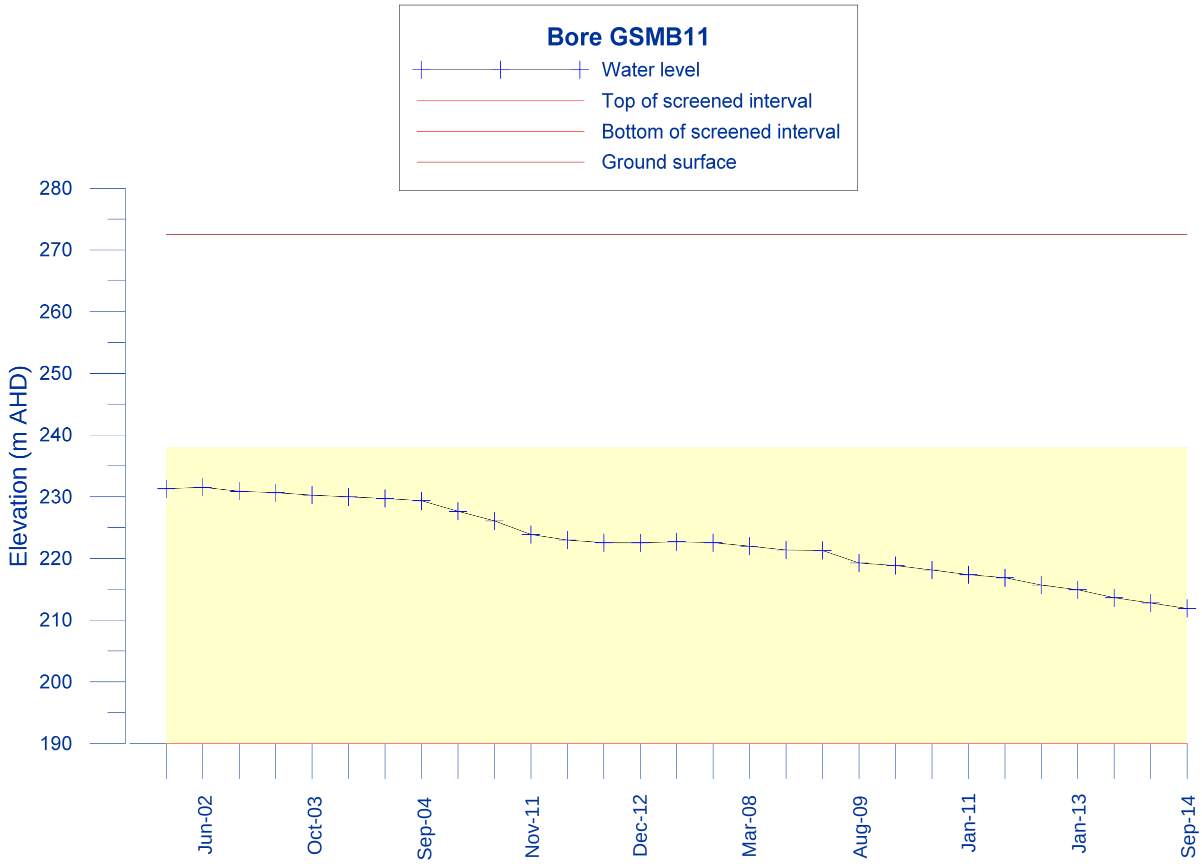


Bore GSMB04 & 04B
GSMB04 Water level
GSMB04 top of screened interval
GSMB04 bottom of screened interval
Ground surface
GSMB04B top of screened interval
GSMB04B bottom of screened interval
GSMB04B water level
Bore GSM4B is about 137 m east of bore GSMB04
Elevation (m AHD)
275
270
265
260
255
250
245
240
235
230
225
220
215
210
205
200
195
190
185
GSMB04
GSMB04B
Water level varied from
26.28 to 18.47 m above
top of screened interval
Jun-01
Oct-o1
Jun-02
Aug-09
Jan-11
May-12
Jul-13
Jun-14
Nov-15

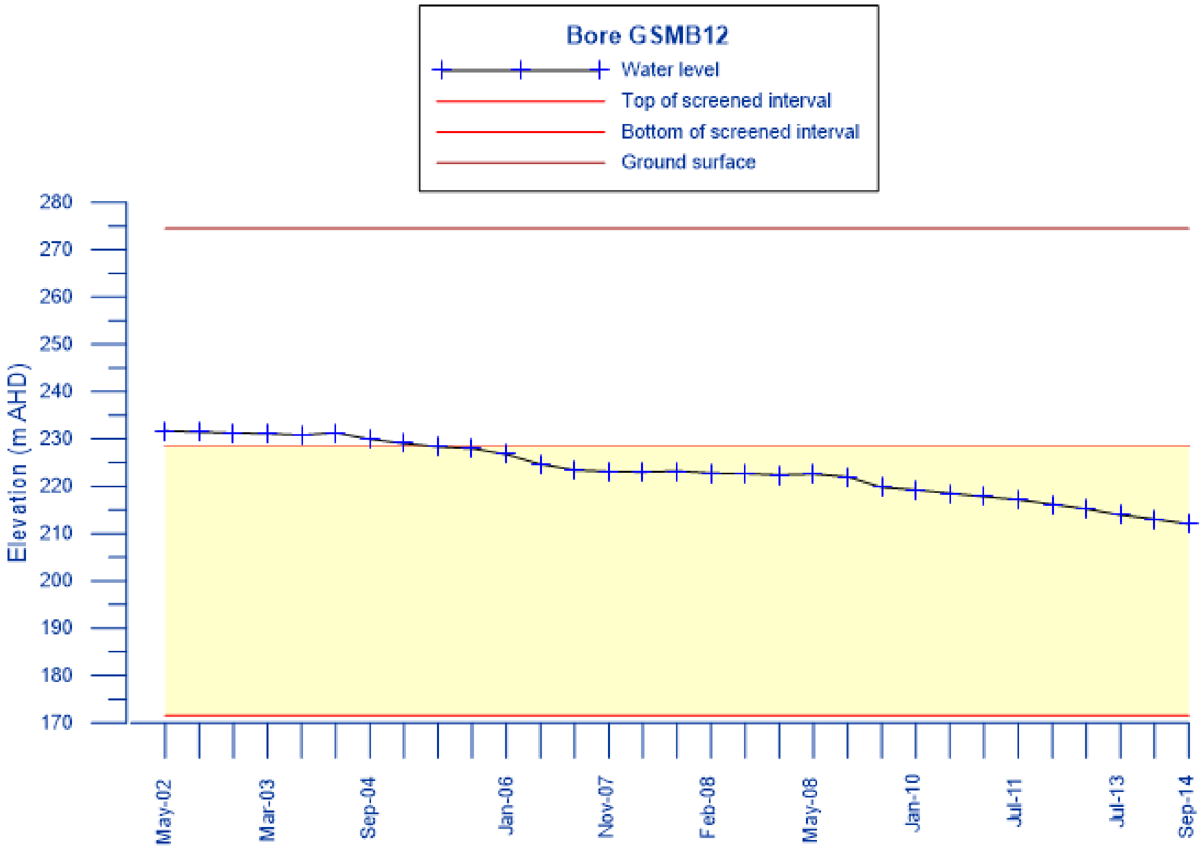

Bore GSMB07 & 07A
GSMB01 Water level
GSMB01 top of screened interval
GSMB01 bottom of screened interval
Ground surface
GSMB01A top of screened interval
GSMB01A bottom of screened interval
GSMB01A water level
Bore GSM07A is about 22 m south-southeast of bore GSMB07
Elevation (m AHD)
275
270
265
260
255
250
245
240
235
230
225
220
215
210
205
200
195
190
185
GSMB07
GSMB07A
Water level varied from
16 to 16.8 m above
top of screened interval
Oct-01
Jun-02
Jun-03
Sep-04
Feb-06
Nov-11
Feb-02
May-08
Aug-09
Jan-11
Jan-13
Sep-14

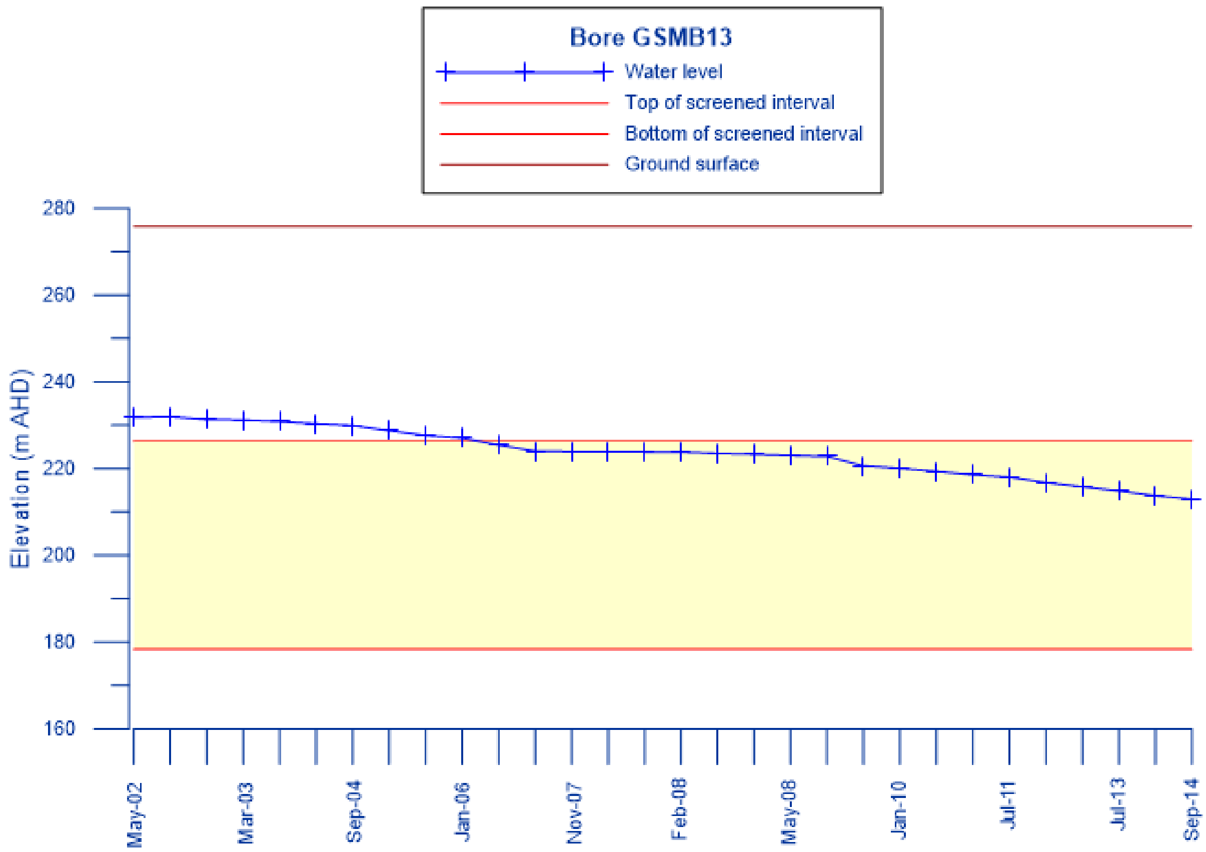


Bore GSMB09
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
270
260
250
240
230
220
210
200
190
180
170
Sep-02
Apr-04
Oct-05
Dec-07
Mar-08
Jul-08
Aug-10
Jan-12
Apr-13
Mar-14
Nov-14



Bore GSMB11
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
280
270
260
250
240
230
220
210
200
190
Jun-02
Oct-03
Sep-04
Nov-11
Dec-12
Mar-08
Aug-09
Jan-11
Jan-13
Sep-14


Bore GSMB12
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
280
270
260
250
240
230
220
210
200
190
180
170
May-02
Mar-03
Sep-04
Jan-06
Nov-07
Feb-08
May-08
Jan-10
Jul-11
Jul-13
Sep-14


Bore GSMB13
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
280
260
240
220
200
180
160
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Mar-03
Sep-04
Jan-06
Nov-07
Feb-08
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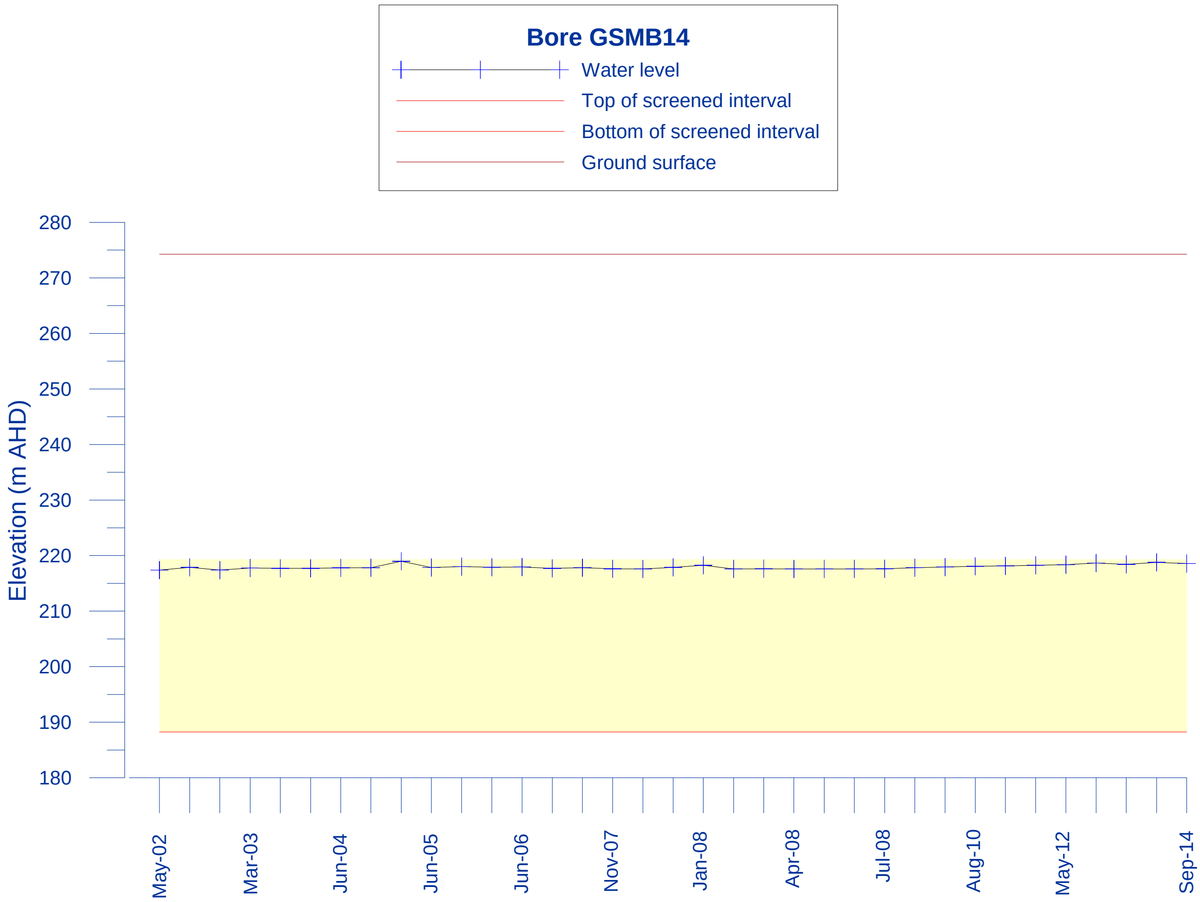
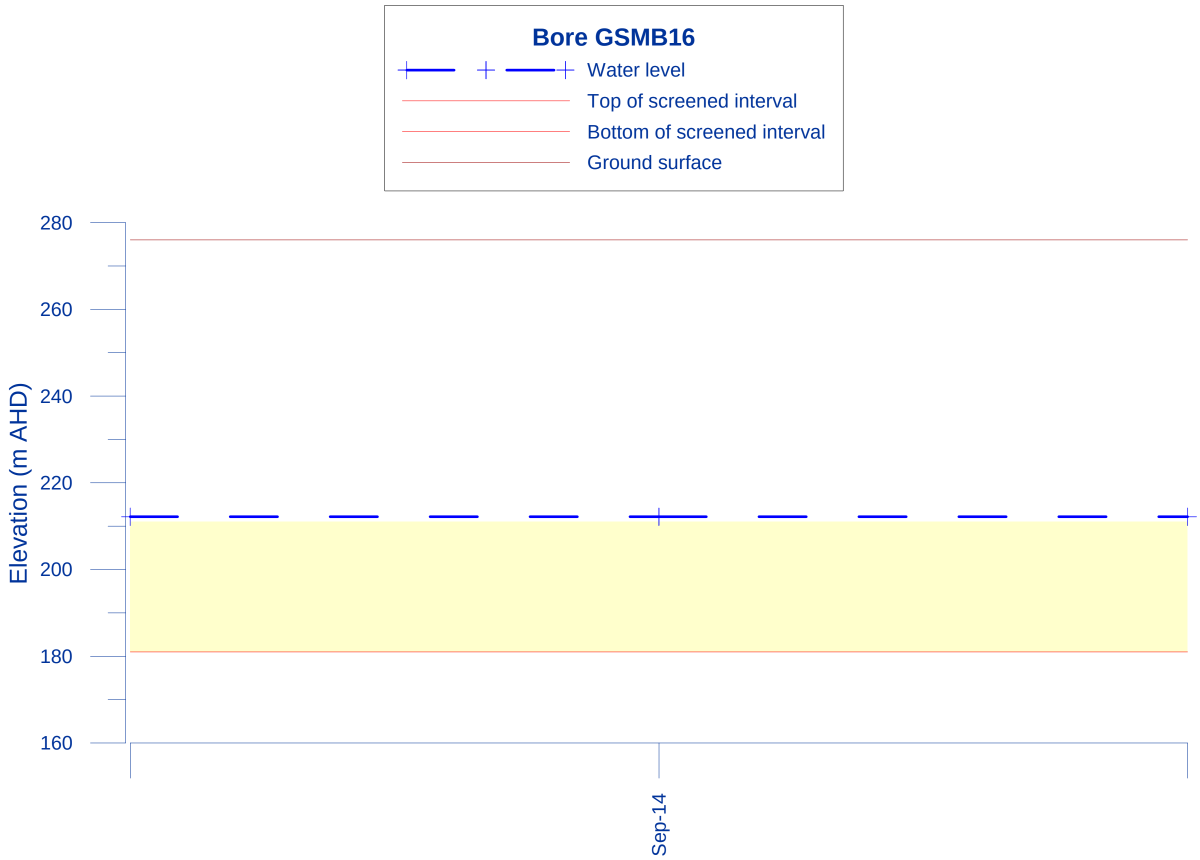
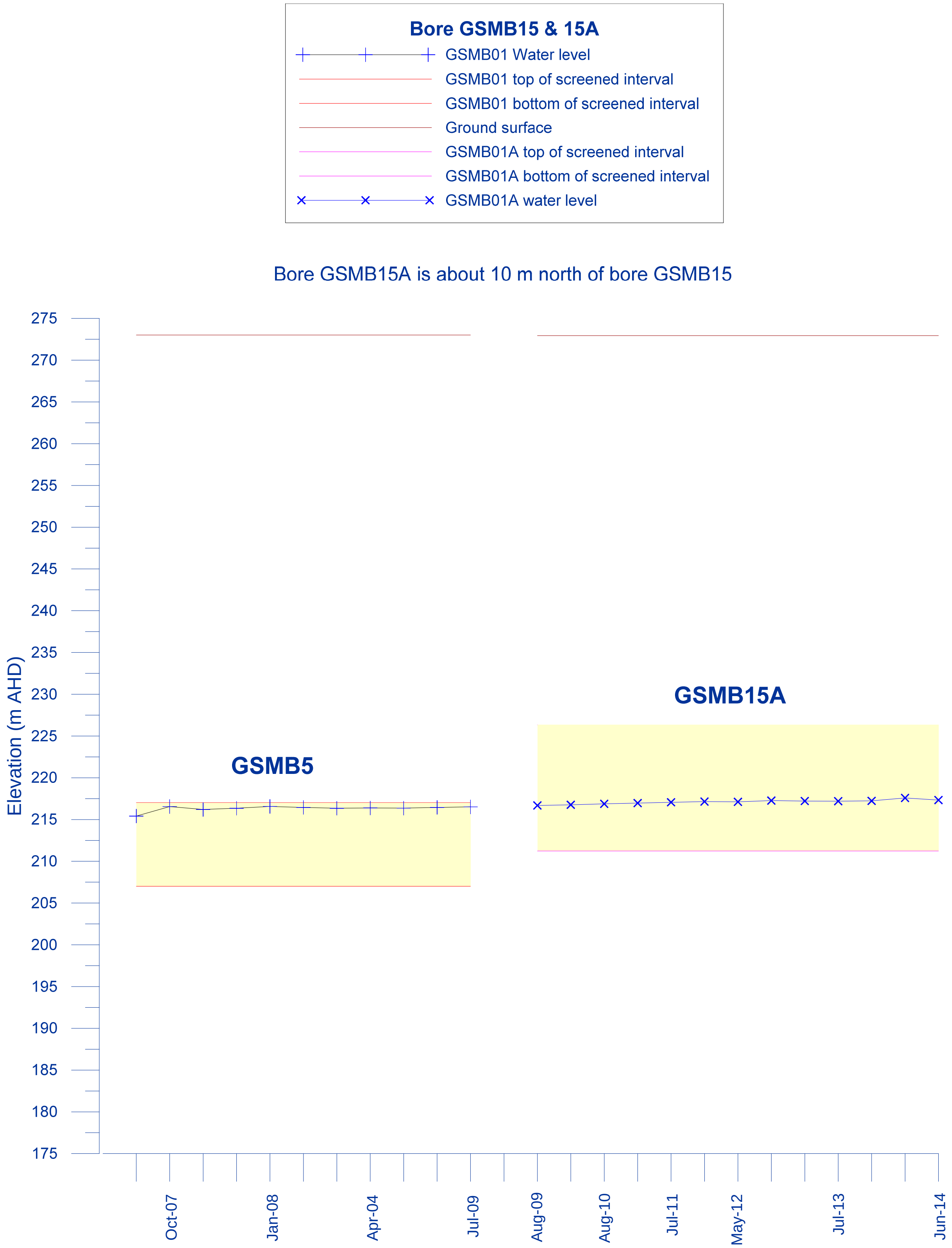
Jul-11
Jul-13
Sep-14



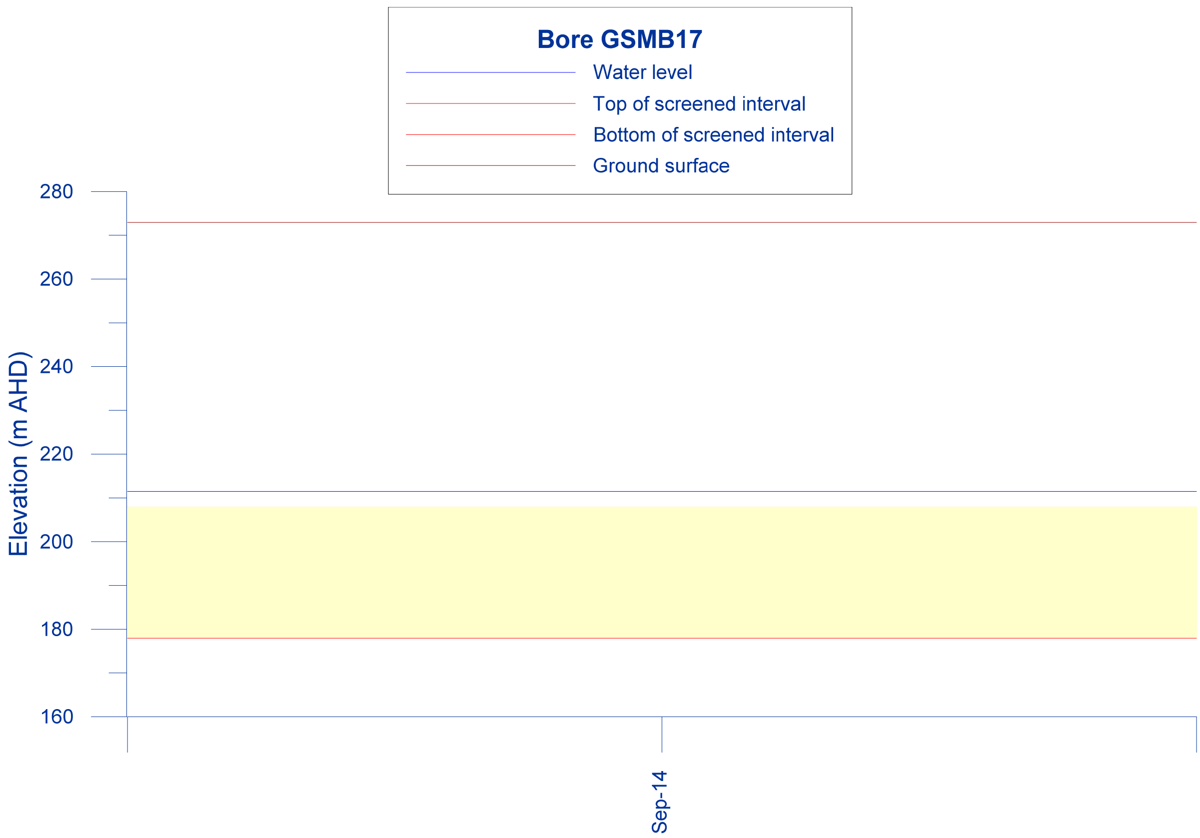
Bore GSMB14
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
280
270
260
250
240
230
220
210
200
190
180
May-02
Mar-03
Jun-04
Jun-05
Jun-06
Nov-07
Jan-08
Apr-08
Jul-08
Aug-10
May-12
Sep-14

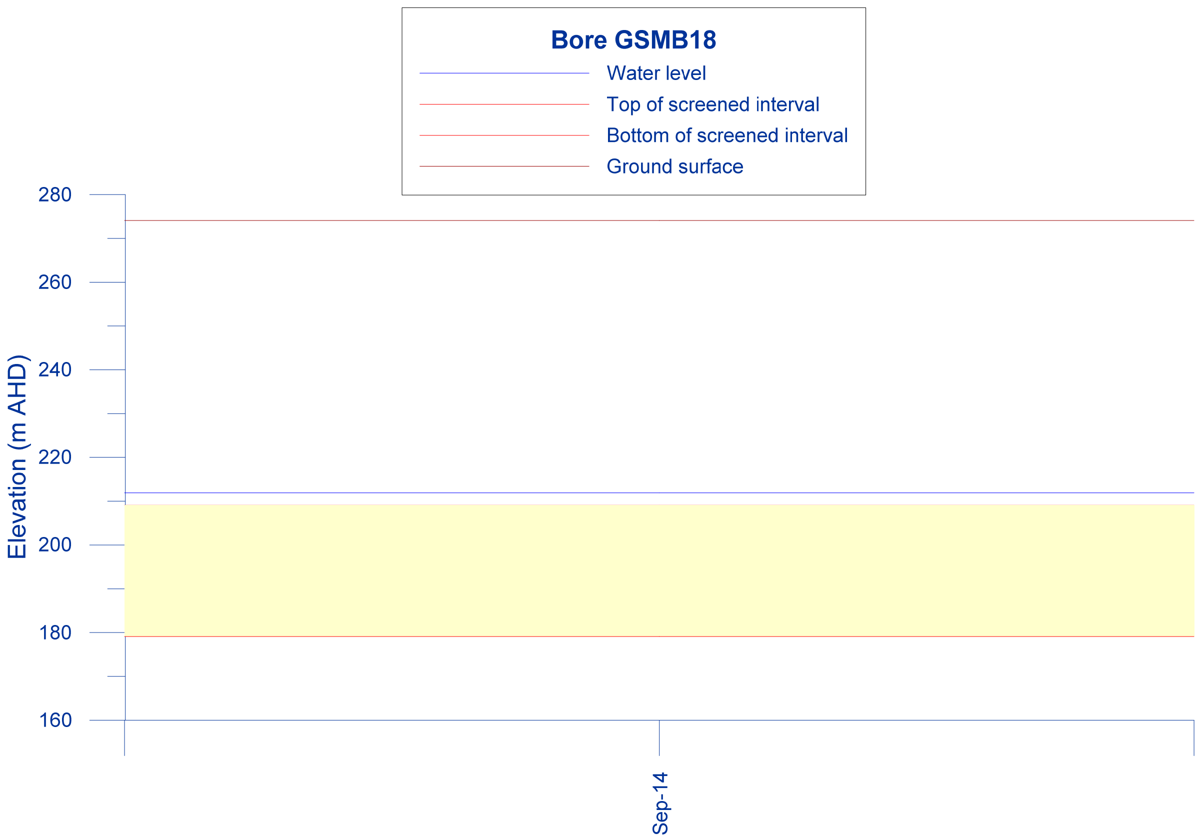


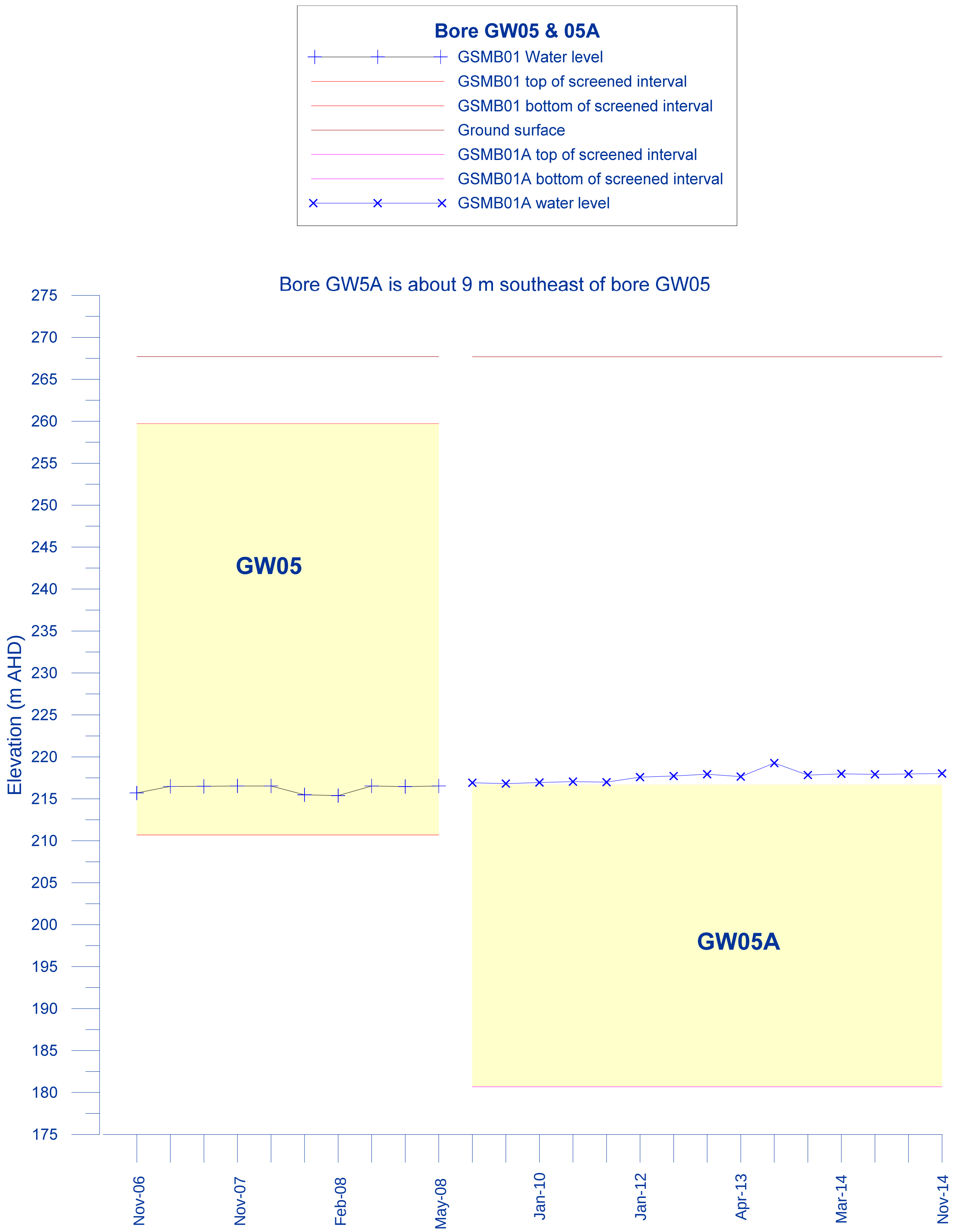
Bore GSMB16
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
280
260
240
220
200
180
160
Sep-14



Bore GSMB15 & 15A
GSMB01 Water level
GSMB01 top of screened interval
GSMB01 bottom of screened interval
Ground surface
GSMB01A top of screened interval
GSMB01A bottom of screened interval
GSMB01A water level
Bore GSMB15A is about 10 m north of bore GSMB15
Elevation (m AHD)
275
270
265
260
255
250
245
240
235
230
225
220
215
210
205
200
195
190
185
180
175
GSMB5
GSMB15A
Oct-07
Jan-08
Apr-04
Jul-09
Aug-09
Aug-10
Jul-11
May-12
Jul-13
Jun-14


Bore GSMB17
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
280
260
240
220
200
180
160
Sep-14


Bore GSMB18
Water level
Top of screened interval
Bottom of screened interval
Ground surface
Elevation (m AHD)
280
260
240
220
200
180
160
Sep-14


Bore GW05 & 05A
GSMB01 Water level
GSMB01 top of screened interval
GSMB01 bottom of screened interval
Ground surface
GSMB01A top of screened interval
GSMB01A bottom of screened interval
GSMB01A water level
Bore GW5A is about 9 m southeast of bore GW05
Elevation (m AHD)
275
270
265
260
255
250
245
240
235
230
225
220
215
210
205
200
195
190
185
180
175
GW05
GW05A
Nov-06
Nov-07
Feb-08
May-08
Jan-10
Jan-12
Apr-13
Mar-14
Nov-14

Appendix - ***TABLE E1. Summary of Analytical Results***

Contaminant Indicator	Units	Leachate Water from stockpiles and evaporation pond storage[1]	Eastern Aquifer Groundwater quality[2]	Western Aquifer Groundwater quality[2]	Environmental Value – Livestock Drinking Water	Historic Background G'water Quality[3]
Acidity/ Alkalinity	**pH**	**0.9 – 2.5**	**7.24 – 8.14**	**7.33 – 8.20**		**7.5**
DS (Conductivity)	**mg/L**	**(11,500 –55,800)**	**1660 - 2160 (2640)** **Ave: 1421 (2210)**	**820 – 1000 (1450)**	**5000 (7500)** **<4,000 no effects**	**867 (1171)**
Bicarbonate	mg/L	No Data	268 – 460 Ave: 297	250 – 318 Ave: 265	-	234
Calcium	mg/L	No Data	86 – 184 **Ave: 119**	81 – 182 **Ave: 106**	<1000	49
Fluoride	mg/L	142 – 5220	0.4 – 0.9	0.6 – 0.9	1.0	0.64
Chloride	mg/L	No Data	218 – 494 **Ave: 332**	250 – 375 **Ave: 345**	-	108
Sodium	mg/L	No Data	114 – 242 **Ave: 169**	120 – 229 **Ave: 175**	-	69
Sulphate	mg/L	2380 – 6830	80 – 186 Ave: 93	96 – 149 Ave: 106	1000	56
Total Nitrogen	mg/L	ND – 0.85	0.1 – 1.6	0.005 – 0.4	90 (as nitrate)	0.71
Phosphorus	mg/L	ND - 6.800	0.005 – 0.13	0.005 – 0.1	10	61[!]
Arsenic^	mg/L	0.600 – 2.560	ND – 0.003	ND – 0.002	0.5	0.002
Cadmium^	mg/L	0.103 - 1.010	ND – 0.001	ND – 0.0001	0.01	0.002
Copper^	mg/L	7.210 – 13.400	ND – 0.007	ND – 0.010	0.5	0.019
Lead^	mg/L	ND – 0.213	ND – 0.003	ND – 0.002	0.1	0.016
Uranium^	mg/L	2.820 – 24.800	0.008 - 0.011	0.009 – 0.011	0.2	No Data

Legend:

ND = non detect; ^ = Dissolved metals.

Ave = Average of most impacted bore within east and west aquifer (as applicable); **Bold** results are averages that exceed historic reported concentrations by >200%.

NOTES:

1= Leachate data provided from site monitoring March & October 2014: ALS EB1443542, EB 1407258.

2= General concentration range over past 4 years (excluding possible outliers/ anomalies) {Source: C&R, 2015}.

3 = Historic concentrations as reported in Dippel(2004) Water quality within Duchess Embayment Aquifer (pre mining).

! = Total P reported seems very high and possibly an error in the historical reporting units. In all likelihood it is 0.061mg/L.

Section 6

GYPSUM STACK INSPECTION AND MONITORING PROGRAM

The inspection and monitoring program that should be conducted by operations personnel for the gypsum stack includes: (i) daily inspection for obvious signs of abnormal conditions and monitoring of any critical defects requiring maintenance; (ii) a weekly inspection of all dike and ditch surfaces, all drain outlets and the pump station; and (iii) monthly inspection and reading of the piezometers. The inspection and performance monitoring program for the gypsum stack area, therefore, includes:

- Daily Inspection. An inspection by operations personnel of the hydraulic structures and outlets, ditch water levels, containment dikes, and gypsum stack for proper operation, freeboard adequacy and any abnormal conditions, as well as inspection of previously documented defective areas deemed to represent a critical condition requiring maintenance. Water level in ditches should be recorded daily.

- Weekly Inspection. A thorough visual inspection by operations personnel of the general condition and performance of the hydraulic structures and outlets, stack drain outlets and outlet structure, containment dike and ditch surfaces, and gypsum stack surfaces and estimate of percent area covered by water on top of the stack.

- Monthly Inspection. The same as the weekly inspection with the addition of reading the gypsum stack piezometers.

In addition to inspections by operations personnel, a detailed annual inspection of the drain outlets, pump station, containment dike and ditch surfaces, and gypsum stack surfaces should be conducted by an independent engineer knowledgeable in earthen dam and gypsum stack construction and operation.

Specific items to observe during the inspections are listed in Table 6.1, which should be used as a guide by operations personnel for performing the inspections. The maintenance requirements for the various features of the gypsum stack (listed in detail in Sections 1, 2 and 3) are summarized in Table 6.2. This list can be used as a guide by operations personnel for properly maintaining the gypsum stack and perimeter dikes. The performance monitoring tasks included as part of the inspections are summarized in Table 6.3.

6.1 Daily Inspection

The daily inspection should be performed by operations personnel familiar with the features and operation of the gypsum stack area. The daily inspection should be performed by making observations from a slow moving vehicle while: (i) driving completely around the gypsum stack on the crest road of the perimeter earthen dike to inspect the conditions of the drain outlets, ditch and pond bottoms, pump station, dike surfaces and toe of slope of the stack; and (ii) by driving around the crest road atop the stack to inspect the condition of the ponded areas, slurry discharge and rim ditches, return water decant, and freeboard adequacy. Items that should be observed during the daily inspection include the following:

- Ditch and Pond Water Levels. Verify that the water levels in the runoff collection and return water/surge ditches and surge ponds are acceptable. Record water levels in ditches and ponds.

- Stack Drain Outlet Pipes. Verify that the lower, normal operating outlet pipes are flowing, and that abnormal flow conditions do not exist. Also verify that the upper, overflow outlet pipes are not flowing, unless the lower outlets are capped. The visual inspection may be accomplished by observing the outlet pipes from the crest of the perimeter earthen dike. The designation of each drain outlet should be used to identify any outlet with an abnormal condition requiring attention.

- Pump Station. Verify that the openings at the pump station are not blocked and are properly functioning.

- Containment Dikes and Ditches. Verify freeboard adequacy and that no abnormal conditions exist (e.g., obvious signs of concentrated seepage, leakage of pond water through the perimeter earthen dike, blockage of ditch bottoms or culverts seriously obstructing flow, or obvious signs of slope or ditch bottom instability or movement).

- Gypsum Stack Slopes and Top Area. Verify that the gypsum stack is being properly operated with adequate freeboard and that no abnormal conditions exist (e.g., obvious signs of concentrated seepage with piping/erosion of gypsum, obvious signs of slope instability or movement, significant leakage from the gypsum slurry launder or pipelines, inadequate freeboard, or improper decanting from the top of the stack).

- Evaporation Pond and Emergency Dry Stack Area. Verify that water levels are acceptable and that no abnormal conditions exist.

- Defective Areas. If a defect is discovered during any inspection, the defective area should be inspected daily until corrective maintenance is undertaken. Defects indicative of a critical condition warranting immediate investigation and potential emergency maintenance are noted in Table 6.1.

The daily inspection should consist of regularly spaced inspections (e.g., once per shift) during daylight hours of the gypsum stack starter dike and any rim ditch being actively used, the decant area and decant structure, and the discharge from the gypsum slurry pipeline. The other inspection items (i.e., pump station, ditch and pond water levels, stack drain outlets and dikes and ditches) can be inspected just once per day.

Any abnormal or suspect conditions should be immediately reported to the gypsum stack supervisor. The Daily Inspection Report (Table 6.4) should be used to record observations during the daily inspections. The plan on Figure 6.1 can be used to record the location of defective conditions. The stack drain system plans on Figures 6.2 and 6.3 can be used as a guide for the location and number of drain outlets.

6.2 Weekly Inspection

The weekly inspection should be performed by operations personnel familiar with the features and operation of the gypsum stack area. The inspection should be performed by walking along the perimeter earthen dike crest road, the toe of slope of the perimeter earthen dike, return water/surge ditch earthen dike crest road, and crest road around the top of the stack and making observations. The inspection should be supplemented with a more thorough examinations at: (i) the stack underdrain outlet pipes by walking down to the outlets if a more thorough inspection is required at any outlet; (ii) previously identified or new defective areas; and (iii) the pump station. The inspector should have a supply of spray paint to mark locations requiring maintenance or repair.

The entire weekly inspection does not have to be performed all in on one day provided all of the observations are made over the course of each week. The Weekly Inspection Report (Table 6.5) should be used to record the inspection observations.

6.2.1 Perimeter Earthen Dikes

A visual inspection should be made of the upstream and downstream slopes and crest of the perimeter earthen dikes. The inspection of the perimeter earthen dike should consist of checking for the following items:

- Evidence of any leakage or seepage of water from the gypsum stack (i.e., general seepage or concentrated seepage that may have created a boil and/or soil cone, spring or delta). Note that because the gypsum stack is lined, seepage should not normally be observed, and any seepage could be indicative of a leak in the HDPE liner. Testing should be performed to measure the pH of suspected pond water seepage that may be identified by a pH less than 5;

- General condition of the earthen surfaces on the crest, downstream slope, access ramps, and on any earthen roads around the toe of slope of the perimeter dike with particular attention given to areas of any condition that could be indicative of pond water seepage or severely eroded or gullied areas requiring refilling.

- Evidence of sloughing, bulging or heaving of the downstream slope of the dike, or any form of slope instability;

- Evidence of lateral movement, settlement, subsidence or cracking of the dike crest and slopes;

- Animal burrows;

- General condition and trafficability of the dike crest, and grading of the dike crest to maintain the uniform flow of runoff across the dike crest;

- General condition of drainage ditches along the toe of slope of the perimeter earthen dike with particular attention to accumulated sediment that needs to be removed or cleared so as not to hinder the flow of rainfall runoff in the ditches; and

- Evidence of sloughing or erosion of the gypsum slope cover (to be placed after startup) on the upstream slope of the dike and exposure of the HDPE liner.

Any evidence of slope instability, lateral movement or subsidence, and leakage and/or seepage of acidic water from the gypsum stack should be considered critical conditions potentially requiring emergency maintenance, and should immediately be reported to the gypsum stack supervisor.

Surface erosion and gullying of the earthen surfaces on the downstream slope and crest, and gypsum cover on the HDPE liner on the upstream slope should be considered indicative of potential trouble areas requiring maintenance because they could result in more serious slope stability problems if allowed to progress without repair.

6.2.2 Return Water/Surge Ditches and Surge Pond

The bottom and side slopes of the return water/surge ditches and surge pond should be visually inspected for: (i) accumulations of gypsum sediment restricting flow and requiring removal; (ii) punctures, tears, missing sections or significant abrasion marks in the HDPE liner; and (iii) any objects driven into the liner or into the dike that may penetrate the liner.

Because the return water/surge ditches and surge pond are lined, seepage should not normally be observed, and any seepage could be indicative of a leak in the HDPE liner. Evidence of damage to the liner or any abnormal condition should be considered critical conditions potentially requiring emergency maintenance, and should be immediately reported to the gypsum stack supervisor.

6.2.3 Runoff Collection Ditches

The surfaces of the runoff collection ditch should be visually inspected for: (i) accumulations of gypsum sediment or debris filling the ditch and/or restricting flow and requiring removal (noting that any gypsum removal must be undertaken with care to avoid damaging the underlying HDPE liner); (ii) erosion gullies or scouring of the ditch side slopes requiring repair; (iii) gypsum sediment, scaling or debris restricting the flow of water through pipe culverts and requiring removal; and (iv) evidence of concentrated seepage.

Concentrated seepage with evidence of piping (movement of gypsum particles) or plugged pipe culverts should be considered critical conditions potentially requiring emergency maintenance, and immediately reported to the gypsum stack supervisor.

6.2.4 HDPE Liner

The HDPE liner within the stack compartments will eventually be completely covered with gypsum, and after which time it will no longer be able to be inspected. Items affecting the liner that should be checked include: (i) the existence of exposed or near exposed HDPE liner by erosion gullies in the gypsum slope cover on the upstream slope of the perimeter earthen dike; (ii) damaged or inoperable flap vents (if installed); (iii) subsidence, cracking or bulging in the gypsum slope cover over the HDPE liner on the upstream slope of the perimeter earthen dike; (iv) the existence of any object driven into the gypsum slope cover on the upstream slope of the perimeter earthen dike; and (v) the existence of any pieces of HDPE liner in gypsum excavated from the runoff collection ditch or the gypsum stack.

The presence of objects driven into the gypsum slope cover in the seepage collection ditch or existence of pieces of HDPE liner in any excavated gypsum should be immediately reported to the gypsum stack supervisor to investigate potential damage to the HDPE liner.

6.2.5 Underdrain System Outlet Pipes

The gypsum stack underdrain outlet pipes should be inspected for the following items:

- Damaged or broken outlets;
- Blockage of the ends of the outlet pipes by accumulated gypsum sediment;
- Encrustation of pipe surfaces;
- Abnormally low (or no) flow, or abnormally high flow, relative to other similar drain outlets;
- Flow from any upper, overflow outlet (unless lower outlet is capped);
- Visual appearance and clarity of the water exiting the outlets; and
- Presence of an end cap on each outlet clean-out.

Damaged or broken outlets, plugged outlets, outlets displaying no flow that are on a section of drain without a redundant flowing outlet, discharge from overflow outlets, and outlets discharging turbid water should be considered critical conditions potentially requiring emergency maintenance, and immediately reported to the gypsum stack supervisor.

Scaling in pipes (or encrustation) should be removed on a regular basis to prevent plugging of the outlets. Missing clean-out end caps should be replaced.

The flow from each of the gypsum stack underdrain outlet pipes should be qualitatively measured weekly (i.e., none, low, medium, high) and be compared to the flow observed during the previous inspection. Any unusual flow condition (i.e., relatively too little or too much flow in comparison to other drains) should be reported to the gypsum stack supervisor. The Stack Drain Outlet Inspection Data Collection Sheet (Tables 6.7 and 6.8) should be used to record the qualitative flow measurements.

6.2.6 Pump Station

The inspection of the pump station should include checking the following items:

- General condition of the opening of the pump station into the ditch and any scaling, gypsum sediment or other blockage requiring removal;
- General structural condition of the concrete floor and walls and any evidence of cracking or structural deterioration requiring maintenance or repair;

6.2.8 Performance Monitoring

At a minimum, the estimated percentage of stack ponded with water should be performed on a weekly basis.

Record data on Table 6.5 data collection sheet.

6.3 Monthly Inspection

The monthly inspection should be performed by operations personnel familiar with the features and operation of the gypsum stack area. The inspection should be performed by slowly driving (i.e., at about 10-15 km/hour) along the various dike crest roads and toe roads and making observations from the vehicle, supplemented with inspections on-foot at: (i) previously identified or new defective areas; (ii) the outlet structure; and (iii) the gypsum stack piezometers. The inspector should have a supply of flagged stakes to mark any locations requiring maintenance or repair.

The monthly inspection includes the weekly inspection items (Section 6.2) with the addition of the items presented below. The Monthly Inspection Report (Table 6.6) should be used as a guide to obtain the required supplemental observations.

6.3.1 Piezometers

Inspection of the piezometers should include checking that the piezometers are accessible and have not been damaged. Damaged piezometers should be reported to the gypsum stack supervisor.

The piezometers should be read monthly and the data recorded. A data sheet for recording the instrument readings is presented in Section 5.

6.3.2 Surface Water Diversion

The inspection of the surface water diversion ditches at the downstream toe of slope of the perimeter earthen dike should be performed monthly and following a significant rainfall event. The inspection should consist of checking for the following items:

- Evidence of any leakage of water from the gypsum stack particularly concentrated seepage that may have created a boil and/or soil cone, spring or delta (Note that because the gypsum stack is lined, seepage should not be normally observed and any seepage could be indicative of a leak in the HDPE liner. Testing should be performed to measure the pH of suspected pond water seepage that may be identified by a pH less than 5);

- Significant accumulations of sediment, debris or thick vegetation requiring removal to restore hydraulic capacity and allow visual inspection;

- Plugged or partially plugged culverts with sediment or debris requiring removal to restore hydraulic capacity; and

- General condition of the earthen surfaces with particular attention given to any condition that could be indicative of pond water seepage, and eroded or gullied areas requiring refilling.

Evidence of leakage and/or seepage of water from the gypsum stack, and complete plugging of culverts should be considered critical conditions potentially requiring emergency maintenance, and immediately reported to the gypsum stack supervisor. Significant accumulations of sediment, debris or thick vegetation in the ditches, partially plugged culverts, and eroded or gullied surfaces in the ditches are not as critical, but should be scheduled for maintenance to maintain the hydraulic capacity of the ditches.

6.4 Annual Inspection

A thorough and detailed annual inspection of the gypsum stack and earthen dams should be undertaken in October of each year by a qualified geotechnical engineer experienced in the field of construction and maintenance of gypsum stacks and earthen dams, and knowledgeable of the specific design features incorporated into the facility. The annual inspection should preferably be performed by foot.

The annual inspection should include a review of inspection reports completed by operations personnel to evaluate the history of the facility and the effectiveness of maintenance during the period since the last annual inspection. It should also include the examination and interpretation of water level data from the ultrasonic level detector and/or staff gages and piezometers, and flow measurement data from the outlet pipes.

An aerial photograph and topographic map of the gypsum stack, including an estimate of the volume of gypsum in the stack, should be obtained annually to monitor stack growth with time and allow updated forecasts of storage life. Concurrent with the aerial survey, it is desirable to perform pond soundings to estimate the quantity of water stored atop the stack. The water balance prediction should be reevaluated and, if necessary, revised.

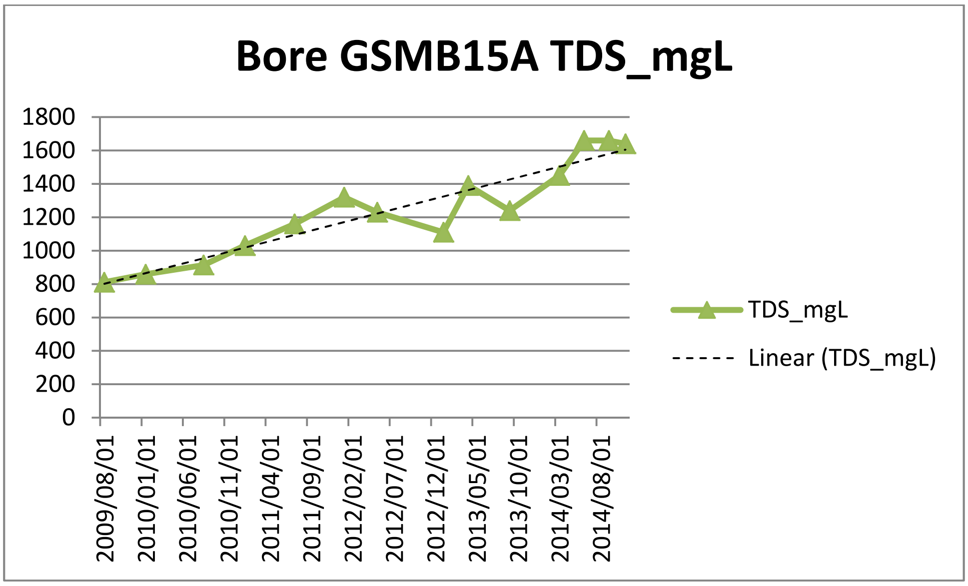
Table 6.3

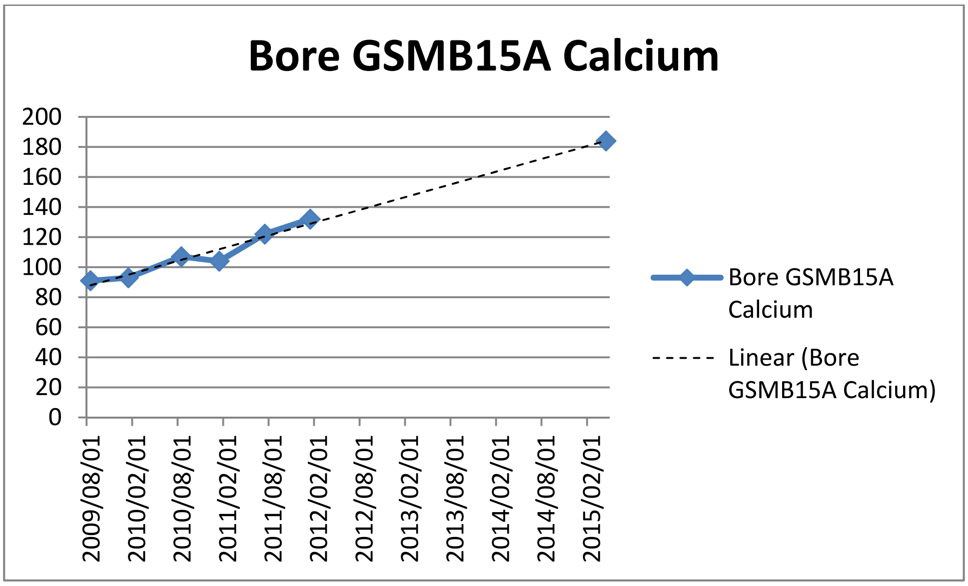
GYPSUM STACK MONITORING REQUIREMENTS

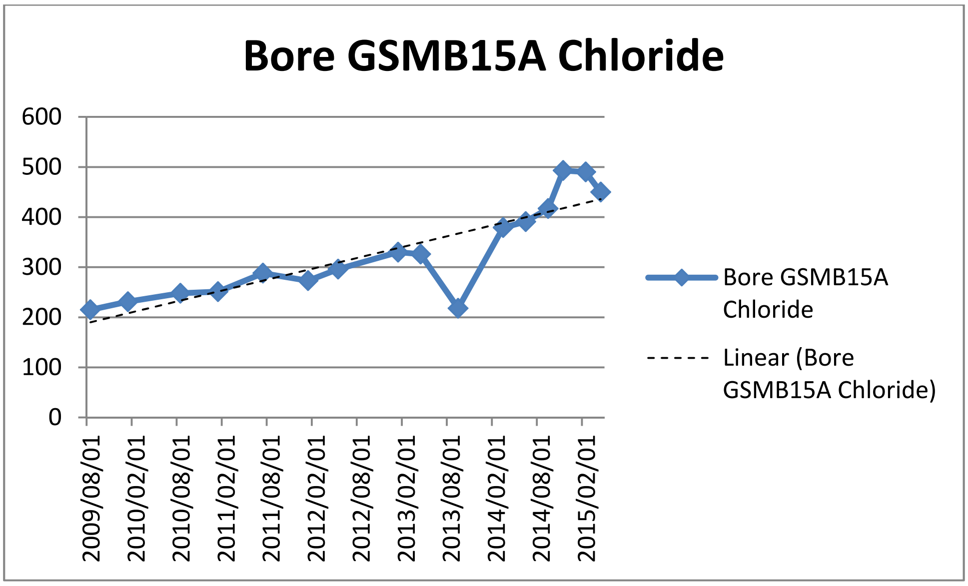
Inspection	Monitoring Requirement
Daily	• Record return water/surge ditch and surge pond water levels.
Weekly	• Record cumulative weekly rainfall. • Record cumulative weekly volume of water pumped to the stack system. • Estimate percentage of stack ponded with water. Record measurements on Table 6.5 data collection sheet. • Rate the flow from each stack drain outlet. Record measurements on Tables 6.7 and 6.8 data collection sheets.
Monthly	• Measure water pressures in the gypsum stack piezometers. Record measurements on Tables 5.1 and 5.2 data collection sheets.

Appendix- Charts of Analytical Results

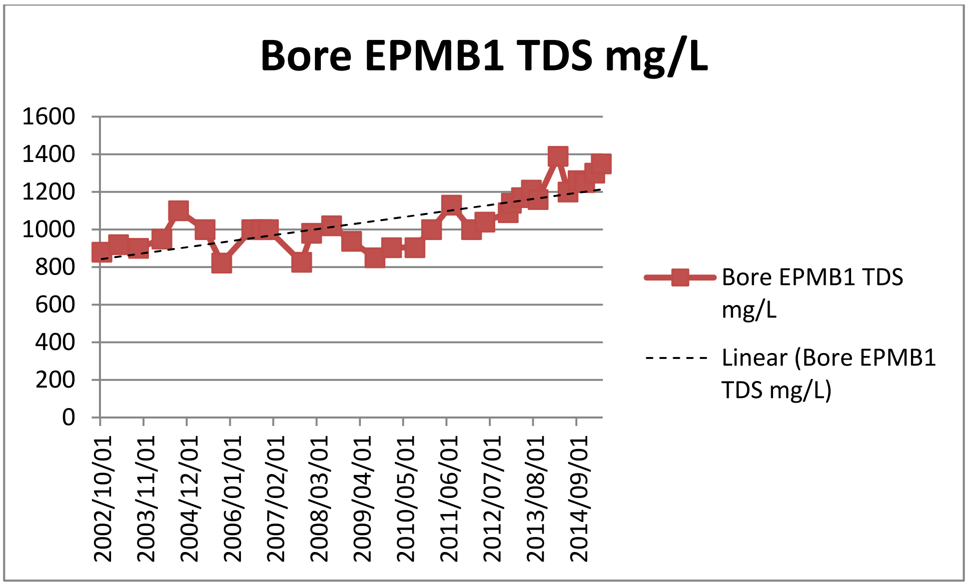
EAST Aquifer Bores – Trends evident in two bores south- east of Cell 3B



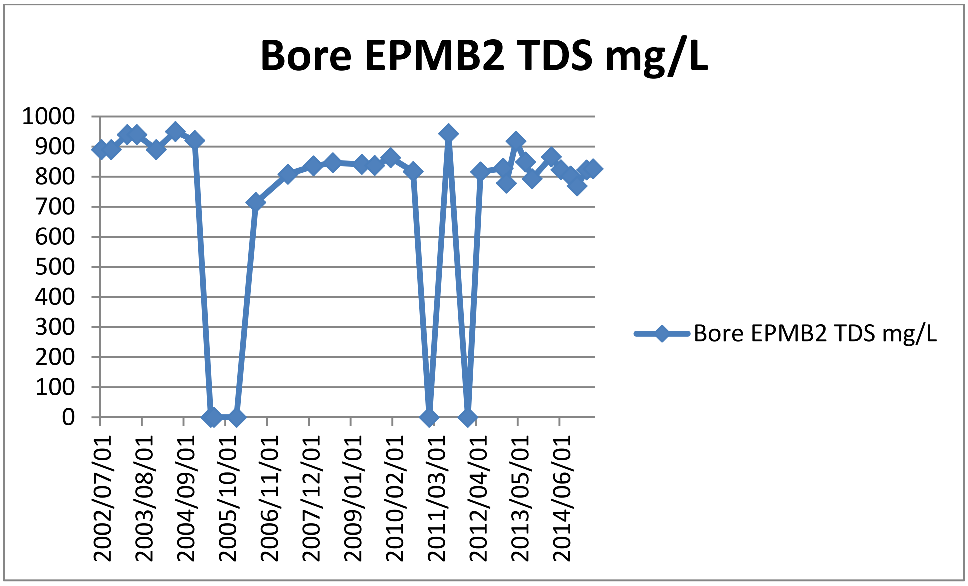




Appendix- Charts of Analytical Results

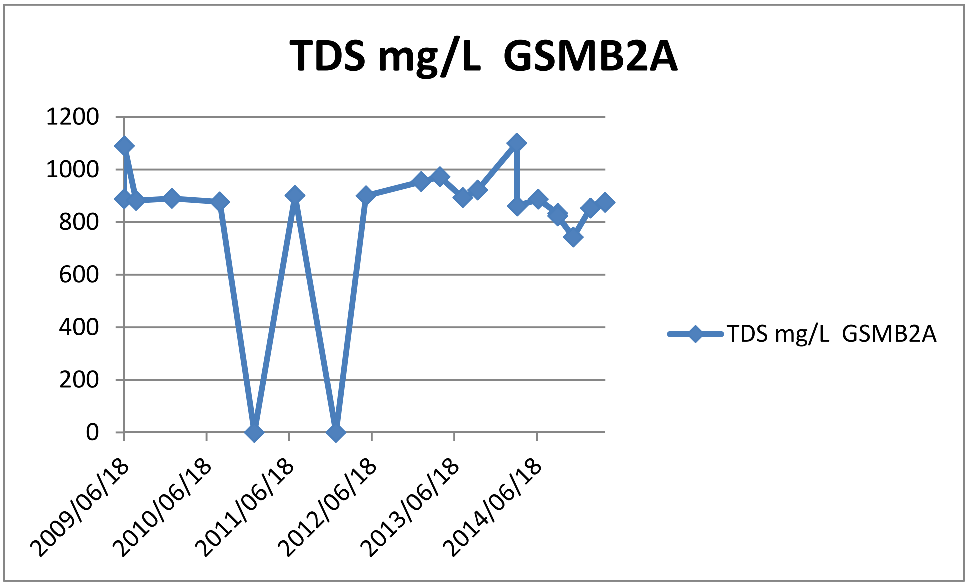


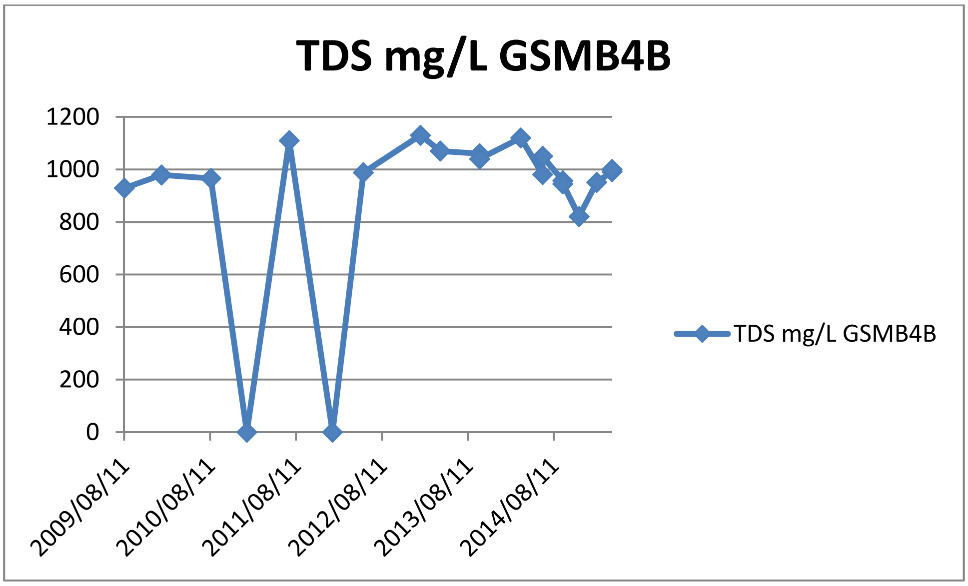
Further south-east of Gypsum Stockpile Facility (NO trend evident)

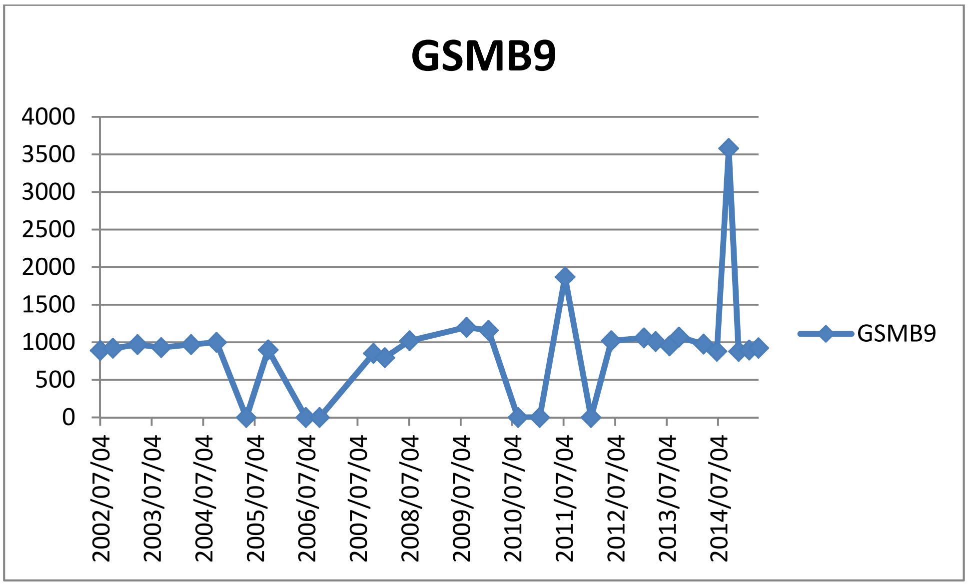


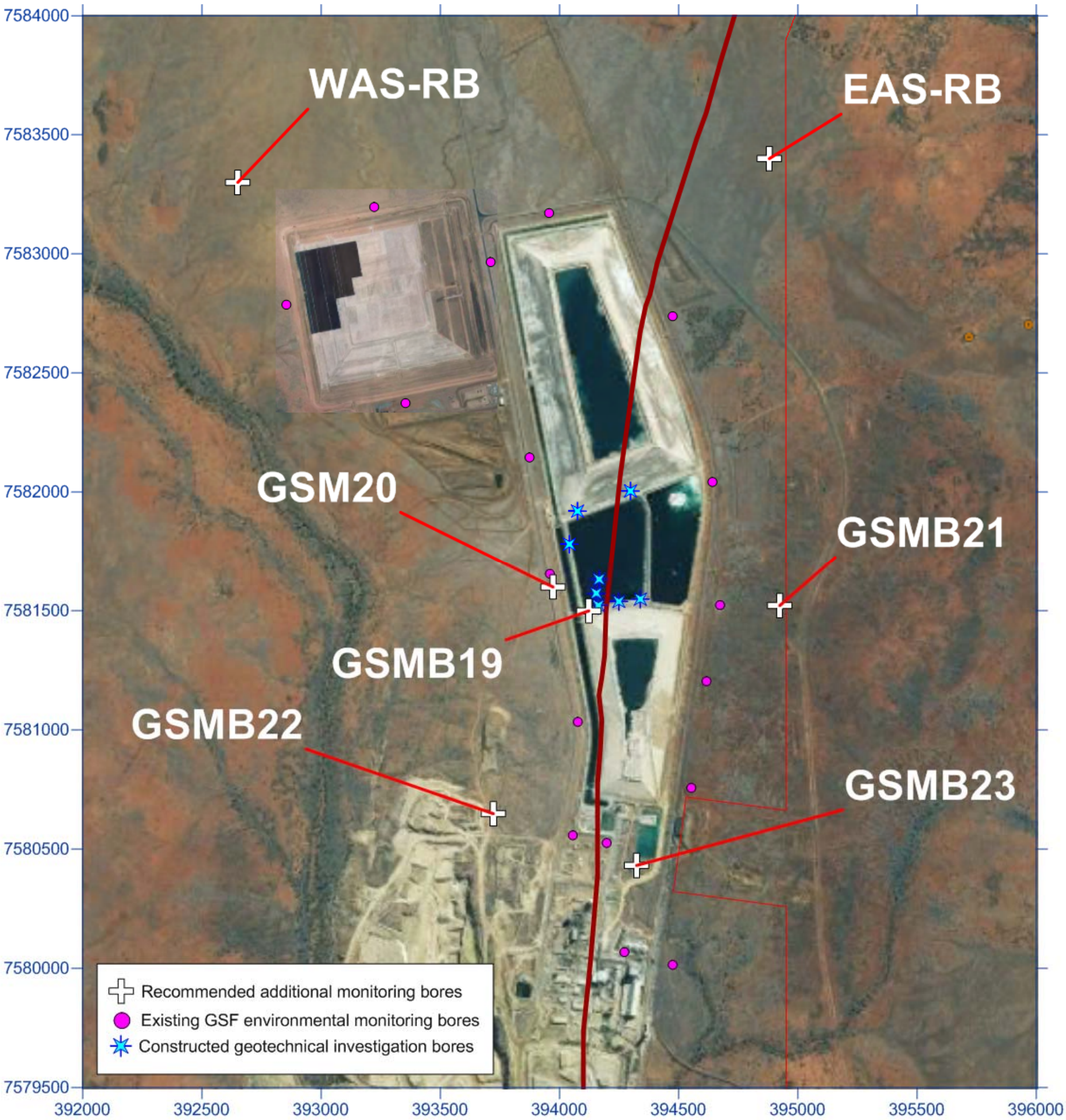
Appendix- Charts of Analytical Results

WEST Aquifer System Bores (NO Trends Evident)









<u>EAS-RB Eastern Aquifer System Reference Bore</u>

Background: Need for a EAS reference bore up-hydraulic gradient from GSF identified by C&R (2015) and supported by our review.

Objective: Monitor ambient groundwater quality in the EAS

Tentative site: About 700 m ENE from NE corner of Cell 4.

Constraints:

- North of GSF Cells
- East of Mehaffey Fault
- Sufficiently east of GSF Cell so as not to be in general N-S alignment with existing EAS monitoring bores
- Within lease boundary?

Proposed New Groundwater Monitoring Bores Objectives and Constraints

<u>WAS_RB Western Aquifer System Reference Bore</u>
Background: Need for a WAS reference bore up-hydraulic gradient from GSF identified by C&R (2015) and supported by our review.

Objective: Monitor ambient groundwater quality in the WAS
Tentative site: About 350 m ENE from NE corner of Cell 4.
Constraints:
- North of GSF Cells
- West of Mehaffey Fault
- Sufficiently west of GSF Cell so as not to be in general N-S alignment with existing WAS monitoring bores

<u>GSMB19: Deep Monitoring Bore adjacent geotechnical investigation bore BH9</u>

Background: Geotechnical Investigation at Cell 3A identified shallow groundwater beneath Cell 3A and between Cell3A and Cell 2.

Objective: Determine deep groundwater elevation and chemistry and will also enable determination of vertical hydraulic gradient.
Tentative site: Within about a metre from BH9.
Constraints:
- None know

<u>GSMB20: Bore next to GSMB04B</u>

Background: Hydrograph analysis showed that the water level in a number of replacement monitoring bores is significantly above the top of the screened interval (18 – 26 m) which means that the tested chemistry may not be indicative of the chemistry at the water table.

Objective: To obtain groundwater samples from bore screen across the water table
Measurements of water levels in both bores at this site would enable hydraulic gradient determinations.
Tentative site: Within a couple of metres from bore GSMB04B.
Constraints:
- None known

<u>GSMB21: Bore East of GSMB15A</u>

Background: Hydrographs exhibit increasing groundwater elevations (decreasing depths) in bores on the eastern side of the Mehaffey Fault monitoring the EAS. It is not known whether these trends relate to regional groundwater recharge or to leakages from the GSF.

Objective: Monitor ambient groundwater elevation and quality in the EAS and analysis mounding potential. – An E-W hydrogeologic cross-section could be constructed from this bore to GSMB15A and to recommended new deep bore next to BH9 as part of flow system analysis.

Tentative site: About 350 m E of bore GSMB15A.

Constraints:

- North of GSF Cells
- East of Mehaffey Fault
- Sufficiently east of GSF Cell so as not to be in general N-S alignment with existing EAS monitoring bores
- Within lease boundary?

GSMB22: Bore between GSF and Galah Pit

Background: Groundwater flow system analysis indicates the groundwater would flow into mine pit(s) that extend below the water table.

Objective: A bore between the GSF and the Galah Pit to the west of GSMB01A would enable improved water table mapping and enable construction of an approximate W-E hydrogeological cross-section this recommended bore to GSMB01A across the Mehaffey Fault to bore GSMB09. The recommended bore would provide additional information of Hydrogeological Risk Assessment and for mine site groundwater modelling under mining and post mining conditions.
Tentative site: About 330 m west of bore GSMB01A (near northeast corner of the Galah Pit).
Constraints:

- Need to consider extent of ore and future mining plans.

GSMB23: Bore south of the evaporation pond

Background: Groundwater flow system analysis indicates the groundwater in the EAS flows in a general southerly direction towards the plant facility. Bore to the south of the evaporation pond the monitor down-hydraulic movement of potentially groundwater bore flowing beneath the GSF. [Monitoring bore GW05A is located about 400m down hydraulic gradient from the evaporation pond, however, the groundwater in this bore could be impacted by nearby potential contamination making distinguishing impact from the GSF difficult to ascertain.

Objective: A bore to the south of the evaporation pond would enable improved water table mapping and enable construction of an approximate W-E hydrogeological cross-section this recommended bore to GSMB01A across the Mehaffey Fault to bore GSMB09. The recommended bore would provide additional information of Hydrogeological Risk Assessment and for mine site groundwater modelling under mining and post mining conditions.
Tentative site: Between evaporation pond and access road.
Constraints:

- None known.