Vimy Resources Limited

Groundwater Monitoring and Management Plan

(Management-based Condition Environmental Management Plan)

Mulga Rock Uranium Project

EHS-EMP-004

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Summary

Title of proposal	Mulga Rock Uranium Project (MRUP)
Proponent name	Vimy Resources Limited
Ministerial Statement number	1046
Purpose of this EMP	The Groundwater Monitoring and Management Plan is submitted to fulfil the requirements of Conditions 7 and 12 of the above Statement
EPA's environmental objective for the key environmental factor/s	Inland Waters Environmental Quality To maintain the quality of groundwater and surface water so that environmental values are protected.
Condition environmental objective	1) Minimise impacts to groundwater quality as far as practicable.
Key provisions	**Management target 1**: Reinjection of no more than 1.5GL/a within the associated water licence year. **Management target 2**: Reinjection water quality is similar to or better than background groundwater quality. **Management target 3**: Dewatering of no more than 2.5GL/a within the associated water licence year. **Management target 4**: Groundwater quality remains within background concentrations at the M39/1080 (now M39/1104) mining lease boundary.

1. Context, scope and rationale

1.1 Proposal

Vimy Resources Limited (Vimy) proposes to develop the Mulga Rock Uranium Project (MRUP; the Project) which lies approximately 240km east-north-east of Kalgoorlie-Boulder in the Shire of Menzies. The area is remote, located on the western flank of the Great Victoria Desert, comprising series of large, generally parallel sand dunes, with inter-dunal swales and broad flat plains.

The MRUP covers approximately 102,000 hectares on granted mining tenure (primarily M39/1104 and M39/1105) within Unallocated Crown Land (UCL). It includes two distinct mining centres, Mulga Rock East (MRE) comprising the Princess and Ambassador resources and Mulga Rock West (MRW) comprising the Emperor and Shogun resources, which are approximately 20km apart. The deposits will be mined using large-scale open pits to produce an annualised peak capacity of 2,180 t/a (4.8 Mlbs) U_3O_8.

The anticipated Life-of-Mine (LOM) is up to 16 years, based on the current identified resource.

This Condition Environment Management Plan (CEMP) has been written in accordance with the *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans* (EPA, 2016).

1.2 Key environmental factors

This Management-based CEMP specifically addresses the Inland Waters Environmental Quality environmental factor, which is part of the overall Water theme.

The MRUP occurs within an Eocene-aged oxbow palaeodrainage channel that drains the eastern Yilgarn Craton, eventually discharging into the Eucla Basin. The uranium deposit to be mined at the MRUP is hosted within a carbonaceous Eocene sediment, located at and immediately below the groundwater level (i.e. at the redox boundary). As the eastern margin of the Yilgarn Craton has been slowly uplifted, the carbonaceous sediments have been oxidised resulting in significant generation of Acid and Metalliferous Drainage (AMD); hence the MRUP environment represents a contemporary natural Acid Sulphate Soil (ASS) system, which has strongly degraded the quality of the groundwater aquifer. The natural groundwater is therefore generally highly acidic, hypersaline and contains elevated metals.

Although the groundwater system already exists in a degraded condition the MRUP may have the following impacts on its quality:

Potential direct impacts to groundwater quality include:

- Reinjection – reinjection of surplus water into the aquifer may have an impact on groundwater quality if the volumes reinjected are significant and the quality of the reinjection water is appreciably different from the baseline groundwater quality.

Potential indirect impacts to groundwater quality include:

- AMD – dewatering of groundwater levels to facilitate mining may result in exposure and / or oxidation of Potential Acid Forming (PAF) materials, either within the cone of groundwater depression or exposed on the pit surfaces (i.e. walls and floor), leading to the generation and mobilisation of AMD.

Potential impacts on groundwater quality from surface contamination, including spills and AMD, are unlikely to occur as groundwater levels are 29 to 49m below the land surface, separated by a vadose zone that exists at below field capacity. The thickness of the vadose zone and the low permeability of the unsaturated sediments, at moisture contents below field capacity, mean that the risk of any surface contamination reaching the aquifer by recharge is extremely low; thus no management actions or targets are needed to protect against this risk.

It is important also to emphasise that the nearest potential environmental receptor of conservational significance is Queen Victoria Springs, located approximately 14km south of the proposed reinjection borefield and 24km south of the Mulga Rock East deposits. The spring however, is a seasonal surface perched feature that is not connected to the paleochannel aquifer from which groundwater will be abstracted and reinjected (i.e. it is a non-phreatophytic system). In addition, there are no downstream beneficial users of the groundwater and baseline studies conducted for the Public Environmental Review (PER) have indicated that there are no stygofauna or other macroinvertebrates of significance within the groundwater aquifer to be disturbed by the MRUP.

1.3 Condition requirements

Condition	Section in CEMP
12-1 The proponent shall manage the abstraction of groundwater for dewatering and the reinjection to meet the following environmental objective: (1) Minimise impacts to groundwater quality as far as practicable.	Whole document
12-2 The proponent shall consult with the Department of Mines and Petroleum and prepare and submit a Groundwater Monitoring and Management Plan required by Condition 7-1 that satisfies the requirements of Condition 7-2, to meet the objectives required by Condition 12-1.	Section 4
12-3 The Groundwater Monitoring and Management Plan required by Condition 7-1 shall include provisions required by Condition 7-2 to manage impacts on water quality including, but not limited to Acid and Metalliferous Drainage from seepage into groundwater and the reinjection of surplus water into the aquifer.	Section 2
12-4 The proponent shall continue to implement the version of the Groundwater Monitoring and Management Plan most recently approved by the CEO until the CEO has confirmed by notice in writing that the Groundwater Monitoring and Management Plan required by condition 7-1 satisfies the requirements of condition 7-2 to meet the objectives required by condition 12-1.	Whole document

Table 1: List of conditions

Condition 12-1 addresses only groundwater quality impacts (not quantity) associated with "*abstraction of groundwater for dewatering and the reinjection*". Impacts on groundwater quality associated with the Tailings Storage Facilities are covered in the Tailings Storage Facility Monitoring and Management Plan (satisfying Condition 15). Given the above scope (as defined in Condition 12-1), this CEMP therefore does not consider potential impacts from groundwater abstraction from the Kakarook North Borefield, as this is not associated with dewatering activities.

1.4 Rational and approach

1.4.1 Survey and study findings

Numerous groundwater related studies and modelling investigations have been conducted during the PER process (Vimy, 2015) to assess the potential environmental impacts associated with the proposed operation on groundwater quality and identify potential management strategies to minimise the risk of impact on the groundwater system.

Groundwater throughout the project area is generally unconfined with the phreatic surface (or water table) lying around 29 to 49m below ground level (bgl) and coinciding with the top of the orebody. The groundwater system extends throughout the Eocene sediments, 50 to 70m below the watertable. The hydraulic gradient through the paleodrainage channel is very flat (~0.002), maintaining an elevation of around 285 to 290m Australian Height Datum (AHD) throughout the system. This low hydraulic gradient results in sluggish groundwater movement, with modelling showing that it will take between 1,000 and 3,000 years to reach the Project Boundary (depending on the starting location – i.e. from the Reinjection Borefield or the southern margin of the Ambassador Pit, respectively; Rockwater, 2015).

As discussed above, the quality of the groundwater in the paleodrainage channel is naturally degraded due to contemporaneous ASS oxidation. The upper portion of the Eocene sediments was deposited under lacustrine conditions, forming a thick (30 to 50m) lignitic / carbonaceous layer overlying the more permeable channel sands. With the continual uplift of the eastern margin of the Yilgarn Craton and drying of the climate, groundwater levels have gradually receded exposing and oxidising the lignitic / carbonaceous Eocene sediments. Oxidation of these sulphidic-rich sediments has resulted in significant and widespread Acid and Metalliferous Drainage (AMD), which has impacted on groundwater quality. At present, groundwater within the paleodrainage channel, where mining is to occur, has a pH in the range of 4.43.

There are no downstream beneficial users and no downstream environmental receptors that could be impacted by this project.

Dewatering – Mining areas

In order mine the orebody, which coincides with the groundwater level, it necessary to dewater the water table to safely and effectively operate the mining fleet. Dewatering will principally use sacrificial dewatering bores installed ahead of the mining front to lower the water level to below the base of the ore. As mining advances these bores are removed and new bores installed to maintain the required dewatering status.

In addition to these in-pit sacrificial bores, permanent bores will also likely be located adjacent to the pit walls, at various distances, to prevent influx from the side walls. These bores will remain in place after the mining front advances to monitor water level recovery and groundwater quality, so that any environmental impact can be identified and quantified.

The estimated dewatering volume for the life-of-mine (LOM) is provided below (Rockwater 2015; Advisian, 2017). Dewatered groundwater will be used for in-pit processing activities (beneficiation; approximately 0.65GL/y) and for dust suppression (0.20GL/y). When the amount of water extracted exceeds these uses, the surplus will be reinjected. Groundwater levels will recover to within 95% of the pre-mine levels approximately 35 years after active dewatering ceases (Advisian, 2017).

It is important to acknowledge that under Ministerial Statement 1046 the dewatering volume is currently capped at no more than 2.5GL/yr, and reinjection of excess dewater is capped at 1.5GL/yr.

Year	Estimated dewatering volume per annum (GL)	Estimated reinjection volume per annum (GL)
0	1.29	0.44
1	1.06	0.21
2	2.09	1.24
3	0.38	0.00
4	0.32	0.00
5	0.06	0.00
6	2.5	1.50
7	2.28	1.43
8	2.5	1.50
9	1.65	0.80
10	0.24	0.00
11	2.5	1.50
12	1.65	0.80
13	0.06	0.00
14	2.24	1.39
15	1.29	0.44

Table 2: Estimated water extraction and rejection rates

Reinjection Borefield

Reinjection of excess water (from dewatered groundwater from the mine pit not subsequently used for mining purposes) into the palaeochannel aquifer will take place about 12 km south of the initial mining area. Reinjection will only occur in years when the amount extracted exceeds the operational demand. Current modelling shows that maximum reinjection rates will occur in Years 6, 8 and 11 where the current Ministerial approval volume limit of 1.50GL/a will be achieved.

Reinjection of excess water will be into the same aquifer that underlies the mining area. However, as the water moves south down gradient, the quality deteriorates along the length of the palaeochannel and thus it is expected that the reinjected water from the active mining area will be of better quality than the *in situ* groundwater at the downstream Reinjection Borefield.

Two production bores (NWB01 and NWB02) that are located in the reinjection borefield area were pump tested in 2015 (each for 48 hours) the pH of the water extracted varied between pH 3.9 and 4.1 and the salinity as measured by Total Dissolved Solids (TDS) varied between 59g/L and 71g/L. It is likely that these two bores will be used for reinjection purposes together with additional bores that would be constructed to the west (but within the Development Envelope) where acidity and salinity are known to be higher.

Baseline groundwater quality will be determined by extraction and testing from the exact area and depth where reinjection will occur at the time when the reinjection borefield is established. A submersible pump will be used to extract water from each bore that is established for use for reinjection purposes and this data will be used as the baseline groundwater quality for each bore when in operation. The proposed location of these bores and proximal monitoring bore locations is shown in Figure 1 below

where the green rectangles represent possible reinjection bore sites and the blue diamond shapes represent locations of bores that could be used as monitoring bores:

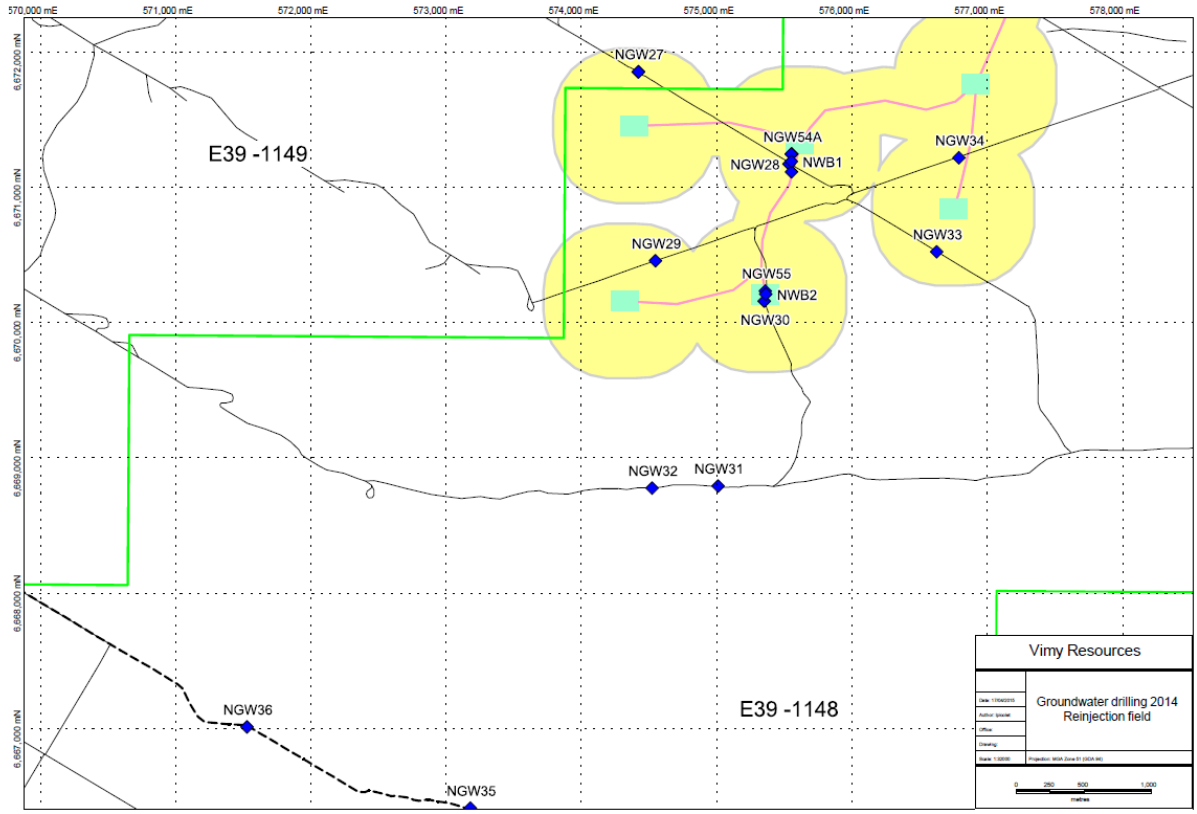

Figure 1 Showing location of proposed reinjection bores

It is likely that only the most westerly 4 sites will be used for reinjection purposes as both acidity and TDS increase in a westerly direction and therefore the groundwater is capable of accommodating lower quality surplus water whilst complying with Management Target 2 in support of Condition 12-1(1).

The most recent baseline data collection from the relevant area concerned was taken during reinjection pump test work undertaken in August/September 2016 when NWB02 was pumped continuously for about 5 days to fill a turkeys nest in preparation for a reinjection trial and water quality readings were taken directly from the water during pumping. Two readings were taken per day making a total of 10 readings in total. The pH recorded in the groundwater over this period of testing (during which around 3,200kL of groundwater was extracted) was on average pH 4.3. Subsequent testing of the water stored in the turkeys nest before being reinjected confirms that a baseline data value of pH 4.3 is appropriate to use for the reinjection borefield until better baseline data becomes available on establishment of the location of all the reinjection bores. Similarly, the average value for TDS over the same period of pumping was 55.2 g/L and subsequent testing of the contents of the turkeys nest also confirms the appropriateness of this value.

Although these values recorded in 2016 are slightly different from the values recorded in 2015 – pH4.3 versus pH3.9 to 4.1 and TDS 55.2 g/L versus between 59 and 71 g/L they are considerably more acidic and considerably more saline than the groundwater expected to be extracted from the Princess and Ambassador mining areas where TDS typically ranges between 20 to 30g/L and pH is generally in the range pH5.5 to 6.6.

For baseline data purposes the reinjection bore located at NWB02 would use the following values:

	Baseline	Typical Princess/Ambassador
pH	4.3	5.5 – 6.6
TDS (g/L)	55.2	20 - 30

These values will be checked again prior to using NWB02 and the additional reinjection bores will also be tested to establish baseline data prior to use.

Pumping tests in the reinjection borefield showed that the aquifer is highly permeable, with hydraulic conductivity values ranging from 9 to 140m/day. Numerical modelling suggests that temporary mounding would not exceed 2m.

The location of the reinjection borefield in relation to proposed mine elements is shown in Figure 2 below:

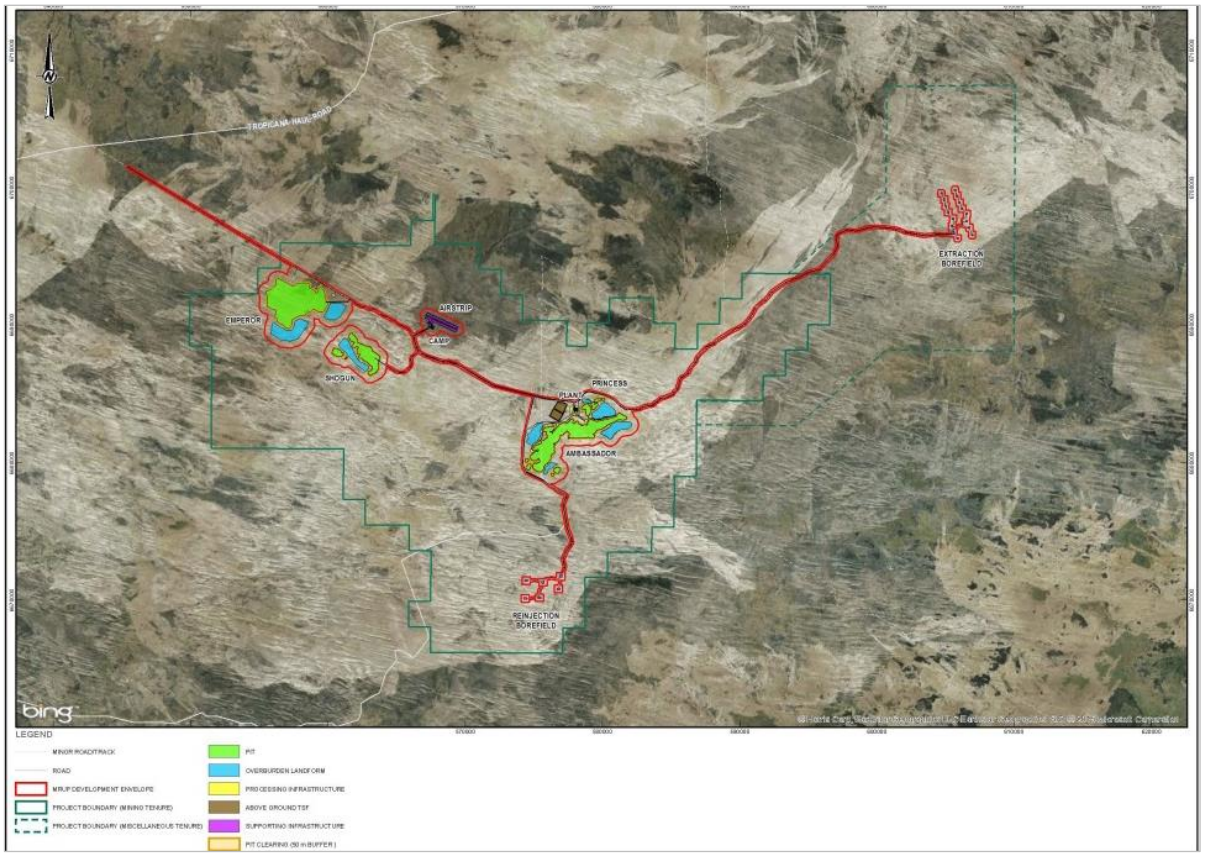

Figure 2 Location of reinjection borefield in relation the rest of the mining infrastructure

The relationship between the reinjection borefield and mining infrastructure can also be seen in Figure 3, which shows an outline of the paleochannel (in red) and 10m groundwater level contours in blue. The groundwater level to the north east of the reinjection borefield is at 290m AHD (as shown by contour) and groundwater flow is in a south westerly direction confined by the paleochannel margin

and towards the lower level as shown by the 280m AHD contour.

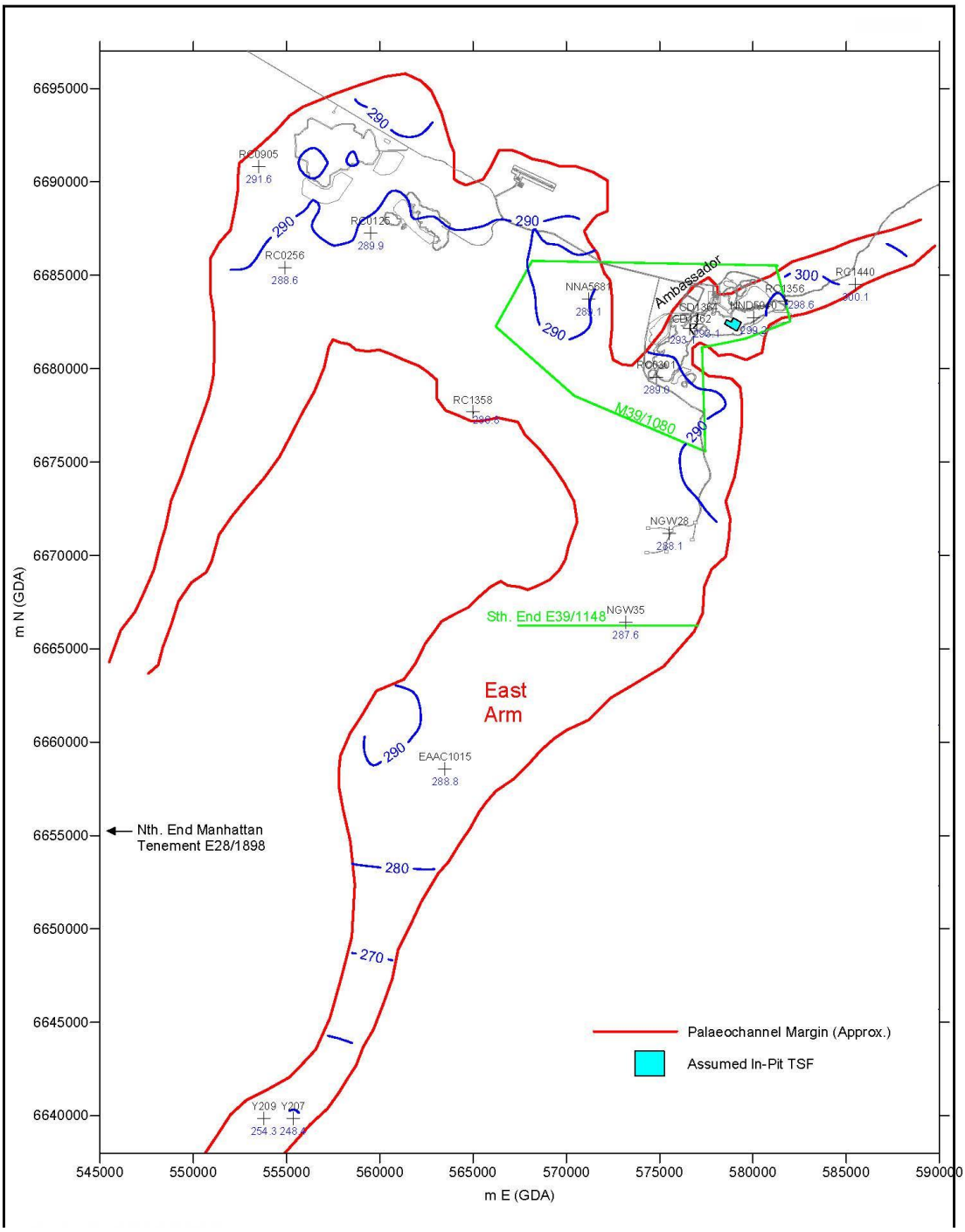

Figure 3 Mining and Infrastructure locations and groundwater contours

Potential Acid Forming Material - AMD

Geochemical characterisation of the Overburden and Ore materials has been undertaken by ANSTO (2015), SWC (2015a, b), and assayed during geological drilling. In this work, the multi-elemental composition of the solid-phase has been quantified, either using ICP-OES/MS or XRF and standard Acid Rock Drainage (ARD) techniques (i.e. AMIRA, 2002), whilst the potential for mobilisation of metals and metalloids were determined using the Australian Standard Leach Procedure (ASLP) with site water as the extractant. The results of this geochemical characterisation are summarised below:

- Overburden materials to within 2 – 5 m of the water table (i.e. associated with the capillary fringe) classified as Non-Acid Forming (NAF), with negligible Acid and Metalliferous Drainage (AMD) potential.
- The basal 2 – 5 m of the Oxidised Eocene sediments (Overburden) likely contains residual sulphides and elevated mobile metals.
- The overburden materials are inherently moderately acidic (pH 4 – 6) and have low salinities (EC < 100 mS/m) in response to the extensive weathering and leaching.
- The Ore material is classified as Potential Acid Forming (PAF); recent studies have recorded average Total S contents of 1.64% across the orebody and an associated sulphide-S content (80 – 90% of the Total S) of 1.3 – 1.5%. This equates to a Maximum Potential Acidity of around 43 kg H_2SO_4/t. Given the ore material also exists in an acidic condition, due to previous (and possibly contemporaneous) sulphide oxidation, it contains no effective or readily available Acid Neutralising Capacity (ANC), and thus the MPA is equivalent to the Net Acid Producing Potential (NAPP). The corresponding Net Acid Generation (NAG) of the orebody therefore varies from 15 to 57 H_2SO_4/t.
- ASLP testing of the Ore material demonstrated that Cd, Co, Fe, Se and Zn may be mobile from the ore (lignite) materials, whilst all other metals assessed were found to be immobile under current groundwater conditions.

1.4.2 Key assumptions and uncertainties

It is assumed that the desktop and field investigations and surveys undertaken for the MRUP have sufficiently identified the groundwater characteristics of the project and surrounding areas.

Groundwater modelling has been based on the predicted mining activities, a change in mining process may affect modelling outcomes.

The mineralogy and geochemistry of the proposed area is well understood, with the bulk of the uranium minerals laterally diffused through the rich organic carboniferous sediments. A review of the physiochemical characterisation of the MRUP investigation conducted by Soil Water Group (SWC, 2015b) indicates the major base minerals which coincide with the uranium deposit and are within the proposed mining domain include: cobalt (Co), copper (Cu), nickel (Ni), scandium (Sc) and zinc (Zn).

1.4.3 Management approach

To minimise direct and indirect impacts, as far as practicable, on groundwater quality, Vimy will:

- reduce, as far as practicable, the volume of groundwater dewatered from the mining areas and the volume of water reinjected in the Reinjection Borefield, by reducing as far as practicable:
  - the area opened for mining at any one time;
  - the depth to which dewatering will lower the water table in the areas where mining is occurring;

  - the time in advance of when mining activity will take place that dewatering activity will commence; and
  - the distance from where mining activity is occurring and the location of the dewatering infrastructure.
- ensure that the dewatering volume is not projected to exceed 2.5GL/yr and that the reinjection volume is not projected to exceed 1.5GL/yr within the associated water licencing year; thus satisfying Ministerial Statement 1046.
- ensure that the quality of reinjected water is of similar, or better, quality than the groundwater within the Reinjection Borefield, by:
  - Monitoring the mine dewatering water at the Processing Water Dam(s) located at the Processing Plant where it will initially be pumped to, in order to allow silts to settle out.
  - The water in the Processing Plant Dam(s) will be continuously monitored for quality purposes to ensure suitability for use in processing. This will be via a water quality probe assessing pH, temperature, TDS and Eh (redox potential) and communicating results via Wi-Fi to the process plant controller.
  - Note that in the highly unlikely event of there being significant oxidation of lignite having the potential to lower the pH in the groundwater and mobilise heavy metals there would be early indications of a developing problem indicated by an increase in the redox potential which would be captured by this monitoring.
  - Water from the Processing Water Dam(s) at the Processing Plant will only be pumped to the Holding Dam(s) at the Reinjection Borefield if the quality is suitable for reinjection purposes.
  - Water held in the Processing Water Dam will be continually blended with mine dewatering water (which comes from different areas) and the fresher water extracted from the Kakarook North borefield.
  - The same ability to blend water for production purposes will also be used to blend water to ensure that it is suitable for reinjection in the Reinjection Borefield based upon the quality threshold established for groundwater in the reinjection area established during commissioning of the Reinjection Borefields.
- monitor groundwater bores around the mine pits to detect any change in groundwater quality in response to AMD.
- ensure that groundwater quality at the M39/1080 (now M39/1104) mining lease is within background groundwater concentrations.

In the event that groundwater quality monitoring (of mine dewater water) at the Processing Water Dam at the Process Plant indicates that the water quality is unsuitable for reinjection because it is worse than the baseline quality within the Reinjection Borefield area, the water will either be improved until it passes the quality test by blending with better quality water, or it will be disposed of by utilising it for mining purposes (particularly in-pit dust suppression) or it will be transferred for disposal into available in-pit tailings facilities.

In addition to the above management approaches, further protection of groundwater quality will be achieved by:

- Environmental Inductions – to ensure that all new personnel entering the MRUP are aware of the environmental qualities within the MRUP and how their actions may impact on these qualities.
- Environmental Training – this will ensure that all personnel undertaking works that may have either a direct or indirect impact on groundwater quality are properly trained, are competent to perform the task, and that fit-for-purpose equipment is used to minimise the environmental impacts.

- Contributing Factors – identification and implementation of management actions to minimise and prevent the contributing factors that may cause either a direct or indirect impact on groundwater quality.

If direct or indirect impacts are reported on groundwater quality then investigations will be undertaken to determine the contributing factors and re-evaluate the appropriateness of existing management actions, establishing new management actions if required, to achieve the management targets and overall environmental objectives.

1.4.4 Rationale for choice of provisions

A management target has been established for each contributing factor listed in Section 1.2 that may cause either a direct or indirect impact on groundwater quality. It is expected that by implementing the identified management actions, then the management targets will be achieved which will ensure that the environmental objectives are met.

Further protection of groundwater quality is achieved by Condition 15-1 which ensures that:

- The tailings plume from the Tailings Storage Facility (TSF) is within background concentrations at the M39/1080 (now M39/1104).
- All in-pit TSFs have at least 2 metres of carbonaceous material beneath them.
- The above-ground TSF has a 1 metre clay liner beneath it.
- All TSFs are covered with a 1m capillary break.

In addition, the risk of impact on groundwater quality from surface contamination is considered very low, due to the considerable depth of the groundwater (29 to 49m bgl) and the very low permeability of the unsaturated sediments at *in situ* moisture contents at or below field capacity. It is therefore considered that this risk does not need to be managed.

It is also important to understand that indirect impacts on groundwater quality from dewatering activities, and associated potential AMD, will be further minimised by the following:

- High Carbon content of the sulphidic carbonaceous material – this material contains around 20 to 40% Total Carbon, with the majority of this, given its pH, being organic C. Continued microbial decomposition of this organic material will result in a consumption of available oxygen favouring reducing (Eh) conditions below the approximate ~600 to 700 mV (SHE) needed to oxidise Ferrous (Fe^{2+}) to Ferric (Fe^{3+}), which has the potential to oxidise sulphides.
- Inherent buffering capacity – although the pH of the tailings would suggest no readily available acid neutralisation capacity (ANC) is present (i.e. no carbonates present), microbial decomposition of the organic matter, under depleted oxygen and sulphur reducing conditions, will produce biogenic alkalinity which will assist in neutralising the released acidity.
- Dewatering operations – dewatering of an aquifer to facilitate mining will result in hydraulic gradients towards the mine pit. Groundwater flow will therefore be towards the operation, and not away from it, which will prevent the release of any AMD generated by dewatering activities from being released into the surrounding environment. As groundwater flows are towards the mine pits, any impacted groundwater in the vicinity of the pits will be 'recharged' with natural groundwater, facilitating its dilution.
- Limited oxygen diffusion at field capacity – Dewatering activities can only decrease the moisture content of the *in situ* aquifer materials to field capacity. The field capacity of the sulphidic carbonaceous material is around 30% (SWC, 2015b), with a corresponding air-filled porosity of only 10%, due to its high water holding capacity. At this field capacity value oxygen diffusion is very low and thus the potential for oxidation of *in situ* PAF materials is limited.

2. EMP provisions

This section of the EMP identifies the legal provisions that Vimy proposes to implement to minimise impacts to groundwater quality as far as practicable. It identifies the management actions that Vimy will implement and how they will be monitored and reported, to achieve the management target; thus ensuring that the environmental objectives of Condition 12-1 are met. Table 1 provides a detailed list of these provisions.

This section also identifies how Vimy will review and revise management actions if the management targets are exceeded.

2.1 Objective

As specified in Ministerial Statement No. 1046 the environmental objectives for Condition 12 are:

- Condition 12-1(1): Minimise impacts to groundwater quality as far as practicable.

2.2 Management targets

The following management targets have been identified to ensure that the above environmental objective is met:

- **Management Target 1**: Reinjection of no more than 1.5GL/a within the associated water licence year.
- **Management Target 2**: Reinjection water quality is similar to or better than background groundwater quality.
- **Management Target 3**: Dewatering of no more than 2.5GL/a within the associated water licence year.
- **Management Target 4**: Groundwater quality remains within background concentrations at the M39/1080 (now M39/1104) mining lease boundary.

No management targets have been established to protect against surface contamination impacting on groundwater quality as the likelihood for this to occur is very low to unlikely.

2.3 Management actions

The following specific management actions will be implemented to achieve the above management targets. They are prioritised such that the greatest management effort will be placed on the Project activities that have the highest risk of causing environmental impact.

2.3.1 Direct Risks / Impacts

Reinjection of surplus water

Risk Rating: High

Corresponding Management Targets:

- **Management Target 1**: Reinjection of no more than 1.5GL/a within the associated water licence year.
- **Management Target 2**: Reinjection water quality is similar to or better than background groundwater quality.

Management Actions to be implemented to achieve Management Targets 1 and 2:

- **Management Action 1** (Volume) – Analysis of monitoring of reinjection volumes; if monitoring of volumes suggests that Management Target 1 is on course to be exceeded in the near future then either dewatering will be reduced or disposal of surplus dewatering water through use for mining purposes (such as dust suppression) will be increased or a combination of both such that the surplus water needing reinjection is reduced down to levels consistent with management Target 1 not being exceeded.
- **Management Action 2** (Quality) – Analysis of monitoring of reinjection water quality will be undertaken, prior to water being reinjected. This analysis will take place along the length of the process from the monitoring of individual dewatering bores through to the water holding areas located at both the Process Plant and at the Reinjection Borefield. The key monitoring area will be where the water is initially held at the Process Plant prior to determining its use. If there is surplus mine dewatering water that is of too poor a quality to be reinjected, it will be directed towards use in mine processing and dust suppression activities, or blended with better quality water to achieve a standard acceptable for reinjection or failing any of these options it will be sent for co-disposal with tailings.

2.3.2 Indirect Risks / Impacts

AMD

Risk Rating: Moderate

Corresponding Management Targets:

- **Management Target 3**: Dewatering of no more than 2.5GL/a within the associated water licence year.
- **Management Target 4**: Groundwater quality remains within background concentrations at the M39/1080 (now M39/1104) mining lease boundary.

Management Actions to be implemented to achieve Management Targets 3 and 4:

- **Management Action 3** (Volume) – Analysis of monitoring of dewatering volumes; if monitoring of volumes suggests that Management Target 3 is on course to be exceeded in near future then dewatering flow rates will be selectively decreased (most likely by reducing advanced dewatering) to ensure that volumes remain consistent with Management Target 3.
- **Management Action 4** (Quality) – Analysis of monitoring of groundwater quality at what was mining lease boundary M39/1080 (now M39/1104) will occur under the Tailings Storage Facility Monitoring and Management Plan. The same management actions will be implemented regardless of whether a deterioration in groundwater quality is caused by a tailings plume or AMD consequent on mine dewatering. If AMD caused by mine dewatering resulted in a deterioration of groundwater quality at the mining lease boundary, either intercept bores would be used to extract the plume and transfer to the tailings facility, or better quality water would be used to dilute away the problem.

2.4 Monitoring

For each management action listed above, a specific monitoring program or task will be undertaken to ensure that the management action is implemented and its requirements met. If monitoring identifies that the requirements of the management action has not been met, then there is a risk that the management target will not be achieved and that the environmental objectives are not attained.

The specific monitoring tasks to be undertaken for each management action are outlined below.

Management Action	Monitoring
Reinjection of surplus water (Management Target 1 & 2)	
1. Quarterly analysis of the monitoring of reinjection volumes to ensure Management Target 1 will be met. Adjustment made to dewatering volumes and the use of surplus water for mining purposes if analysis suggests that Management Target 1 could be exceeded.	Reinjection bores will have flow meters located at the point of reinjection, recording both instantaneous and cumulative flows. A constant record of the data will be kept. Annual audit of reinjection volumes will be undertaken to ensure that metering is accurate.
2. Quarterly analysis of monitoring of reinjection water quality to ensure that it is similar or better than background water quality. If water quality is too poor for reinjection it will be redirected to other acceptable uses or diluted to acceptable levels or failing those it will be sent to tailings. In the final analysis if no immediate solution is available then reinjection will be suspended until the situation is rectified.	Initial monitoring for metals will be undertaken when dewatering first commences and repeated at 3-monthly intervals over the two years. Analysis will take place at the Process Plant holding pond. Thereafter testing for metals will be undertaken annually. The metals tested for in solution will be Zinc, Nickel, Manganese, Copper and Cobalt. Reinjection water quality will be monitored along the chain from mine dewatering bores all the way to reinjection bores to ensure that it is similar to or better than background groundwater quality. The main place where quality assessment will take place will be at the Process Plant where a dam holding processing water will be located. Water quality (relevantly pH, TDS and Eh) will be continuously recorded using a multiparameter probe and a constant record of the data will be kept. In the event that pH and Eh monitoring detects acidity or oxidation levels outside the range of normal variability (> 2 standard deviations from rolling three-month average) then water quality monitoring will include additional checks for metals. Metal ions in solution will be considered unusually high if recorded levels exceed the highest levels found in past sampling in mining area: • Zinc – 12.9 mg/L • Nickel – 3.8 mg/L • Copper – 1.9 mg/L • Cobalt – 3.1 mg/L These limits will be reviewed once sufficient data has been collected and revised if necessary. An annual audit to ensure probe accuracy will be undertaken.

Management Action	Monitoring
Acid and Metalliferous Drainage (AMD) (Management Target 3 & 4)	
3. Quarterly analysis of the monitoring of dewatering volumes to ensure Management Target 3 will be met. Adjustments made to advance dewatering volumes if developments suggest Management Target 3 will be exceeded.	Extraction bores will have flow meters located at the point of extraction, recording both instantaneous and cumulative flows. A constant record of the data will be kept. Annual audit of dewatering volumes will be undertaken to ensure that metering is accurate.
4. An investigation of the cause of the problem would be undertaken and appropriate measures implemented with poor quality water extracted and pumped back for disposal upstream (to allow carbonaceous material to sequester metals), diluted to acceptability or transferred to tailings facilities.	Monitoring will take place under Tailings Storage Facility Management and Monitoring Plan. In order to ensure that groundwater flow, in the areas around where mining activity takes place, both during and after dewatering activities, behaves in a manner similar to that modelled, groundwater levels will be monitored to ensure that any AMD that might have been generated will flow towards the cone of depression created by the dewatering activity as expected.

As specified in Condition 7-5, if the above monitoring indicates that one or more management actions specified in this CEMP have not been implemented, then:

(1) A report will be issued to the CEO of DWER, in writing, within 7 days of identification of the failure to implement the management action/s;

(2) An investigation will be undertaken to determine the cause of the management action/s not being implemented;

(3) The potential environmental harm or alteration that may have occurred due to the failure to implement the management action/s will be determined;

(4) A written report will be issued to the CEO of DWER within 21 days of the reporting required by Condition 7-5(1), with the report containing:

  (a) the cause for the failure to implement the management action/s;

  (b) the findings of the investigation required by Conditions 7-5(2) and 7-5(3);

  (c) the relevant changes being implemented to activities to rectify the situation; and

  (d) the measures to be undertaken to prevent, control or abate the environmental harm which may have occurred.

As specified in Condition 7-4, if the above monitoring indicates that one or more management targets specified in this CEMP have not been met, then:

(1) A report will be issued to the CEO of DWER, in writing, within 21 days of identification of the management target/s not being met.

(2) An investigation will be undertaken to determine the cause of the management target/s not being met.

(3) A written report will be issued to the CEO of DWER within 90 days of the reporting required by Condition 7-4(1), with the report containing:

(a) the cause of the management target/s not being met;

(b) the findings of the investigation required by Condition 7-4(2);

(c) details of the revised and / or additional management actions to be implemented to ensure that the management target/s are met; and

(d) relevant changes to the proposal activities.

2.5 Reporting

Reporting of the above monitoring results, and achievement of the management actions and management targets that satisfy the environmental objectives, will occur in the Compliance Assessment Report (CAR) to be submitted annually (in March; starting in 2018) to the CEO of DWER. In the event of an exceedance occurring it will be reported to the CEO of DWER within 7 days.

In accordance with Condition 4-6, the CAR shall:

(1) be endorsed by Vimy's CEO or other person delegated to sign on the CEO's behalf;

(2) include a statement as to whether Vimy has complied with the conditions;

(3) identify all potential non-compliances and describe corrective and preventative actions taken;

(4) be made publicly available in accordance with the approved Compliance Assessment Plan (CAP); and

(5) indicate any proposed changes to the Compliance Assessment Plan (CAP) required by Condition 4-1.

The CAR will also include:

- Monitoring of results and trends against management targets.
- Any exceedance of management targets.
- A review of the management actions and their appropriateness in achieving the management targets and the overall environmental objectives.
- Proposed revision of the management actions, if required, to obtain formal approval from DWER to amend the CEMP.

In addition to the CAR, all dewatering and reinjection water volumes and quality will be presented in the Annual Environmental Report (AER).

3. Adaptive management and review of the EMP

3.1 Review and revision of management actions

In the event that a management target is not met or is exceeded, Vimy will review and revise the risk assessment, review and revise management actions and identify additional management actions where necessary.

Risks and key impacts with associated management actions and priorities will be reviewed and revised and, if necessary, implement the following adaptive management procedure:

- Investigate the potential cause of failing to meet the management target and identify any impacts to groundwater quality resulting from this failing.
- If the causes of failing to meet the management target or any impacts identified are a result of the MRUP, the risk assessment will be reviewed and revised risk based management actions will be implemented, following formal approval from DWER, so that the MRUP environmental objective is met.

In accordance with Conditions 7-2(5) and 7-6, the management actions will be reviewed annually (or as directed by the CEO) and revised so that the management targets, and the overall environmental objectives, are met.

Vimy will also implement adaptive management to learn from the implementation of mitigation measures, monitoring and evaluation against management target/s, to more effectively meet the environmental objectives. The following approach will be followed:

- Monitoring data will be systematically evaluated and compared to baseline and reference site data in a process of adaptive management to verify whether responses to the impact are the same or similar to predictions.
- Re-evaluate the risk assessment and revision of risk-based priorities on the basis of monitored information.
- Review management actions when existing actions are shown not to be as effective as predicted.
- Update management actions when external changes during the life of the proposal occur (e.g. changes to the sensitivity of the key environmental factor, implementation of other activities in the area, etc.).
- Review of CEMP – changes to CEMP provisions required by a condition, timeframe, etc.

3.2 Corrective Actions

If the results of monitoring show that the management targets are not being met (or more likely are on track to not being met in the near future), then the corrective actions outlined below will be implemented.

Performance Indicator	Corrective Action	Responsibility
Volume of reinjection water is projected to exceed 1.5GL/yr within the associated water licence year.	• Decrease the reinjection rate so that the projected yearly total (for the current associated water licence year) is restored to below 1.5GL/yr. • Conduct an investigation to determine specific cause of the forecast exceedance and adjust the use of water to bring the amount of surplus water requiring disposal back into line with the required limit. • Identify and implement appropriate control measures to reduce or rectify any impact that may have been caused. • Review and revise management actions so that management targets and environmental objectives are met.	Mine Manager and Environmental Manager
Quality of reinjection water is worse than baseline groundwater quality and could potentially cause an adverse impact on the groundwater aquifer or downstream environmental receptors	• Identify the location of the bores where the poor-quality water is coming from and redirect sufficient quantity of this water to use in processing or to disposal with tailings whilst the problem persists. • Conduct investigation to determine why the reinjection water quality from the identified offending bores is so different. • If water quality is too poor to allow reinjection and it cannot be remedied by dilution with better quality water, it will either be disposed of by utilising for mining purposes (if safe to do so) or will be disposed of into in-pit tailings facilities, or some combination of these approaches. • Identify and implement appropriate control measures to reduce or rectify any impact that may have been caused. • Review and revise management actions so that management targets and environmental objectives are met.	Mine Manager and Environmental Manager
Volume of dewatered groundwater is projected to exceed 2.5GL/yr within the associated water licence year.	• Decrease the extraction rate so that the projected yearly total (for the current associated water licence year) is restored to below 2.5GL/yr. • Conduct investigation to determine specific cause of the forecast exceedance. • Make adjustments to mine dewatering schedule (particularly advanced dewatering activities) and infrastructure (location and emphasis given to different bores) to reduce dewatering volumes consistent with achieving the required local reduction in the water level whilst simultaneously reducing extraction volumes overall.	Mine Manager and Environmental Manager

Performance Indicator	Corrective Action	Responsibility
	• Identify and implement appropriate control measures to reduce or rectify any impact that may have been caused. • Review and revise management actions so that management targets and environmental objectives are met.	
Quality of groundwater at what was mining lease boundary M39/1080 deteriorates below established background levels.	• Conduct investigation to determine the specific cause/s of the change in groundwater quality. • If it is determined that an observed deterioration in groundwater quality in the reinjection borefield (from monitoring bores) poses a potential risk that the water quality at the lease boundary may be adversely impacted in future when the water migrates there, install intercept bores and recycle sufficient quantity of the poor quality water back to the mining area (processing use or tailings) to reduce the forecast plume back to acceptable levels (i.e. within background variation). • Determine the potential environmental impact that may result from this change in groundwater quality. If no impact is predicted then dewatering operations can continue. If an adverse environmental impact is predicted, in response to the change in groundwater quality as a result of the dewatering operations, then suspend dewatering operations and identify and implement appropriate control measures to reduce or rectify any impact that may have been caused. • Identify and implement appropriate control measures to reduce or rectify any impact that may have been caused. • Review and revise management actions so that management targets and environmental objectives are met.	Mine Manager and Environmental Manager

4. Stakeholder Consultation

Extensive consultation regarding groundwater quality, and the potential impacts that the MRUP may have on background levels, occurred during the Public Environmental Review (PER; Section 3). Specific consultation with regards to this CEMP with the Department of Mines, Industry Regulation and Safety (DMIRS; formerly the Department of Mines and Petroleum - DMP) is outlined below.

Date	Stakeholder	Topic	Issues Raised	Vimy Response
22/02/2017	DMP	Meet with DMP EOs to discuss the Condition EMP and its fulfilment of Ministerial Statement 1046	Consistency with the Mining Proposal and Mine Closure Plan	Vimy ensured that all three documents were prepared together and in collaboration to provide alignment

Table 1: CEMP Provisions (management-based) table

Purpose of EMP	**To meet the legal requirements of Condition 12 of Ministerial Statement 1046**
EPA Factor	**Inland Waters Environmental Quality**
EPA Objective	**To maintain the quality of groundwater and surface water so that environmental values are protected**
MS 1046 Condition 12-1 Environmental Objectives:	**(1) minimise impacts to groundwater quality as far as practicable**

Management-based provisions

Risk / Impact (Risk Ranking)	Management Actions	Management Targets	Monitoring	Reporting
Direct Risks / Impacts				
Reinjection of surplus water (High)	Quarterly analysis of the monitoring of reinjection volumes to ensure Management Target 1 will be met. Adjustment made to dewatering volumes and the use of surplus water for mining purposes if analysis suggests that Management Target 1 could be exceeded.	Reinjection of no more than 1.5GL/a within the associated water licence year.	Reinjection bores will have flow meters located at the point of reinjection, recording both instantaneous and cumulative flows. A constant record of the data will be kept. Annual audit of reinjection volumes will be undertaken to ensure that metering is accurate.	CAR AER
	Quarterly analysis of monitoring of reinjection water quality to ensure that it is similar or better than background water quality. If water quality is too poor for reinjection it will be redirected to other acceptable uses or diluted to acceptable levels or failing those it will be sent to tailings. In the final analysis if no immediate solution is available then reinjection will be	Reinjection water quality is similar to or better than background groundwater quality.	Initial monitoring for metals will be undertaken when dewatering first commences and repeated at 3-monthly intervals over the two years. Analysis will take place at the Process Plant holding pond. Thereafter testing for metals will be undertaken annually. The metals tested for in solution will be Zinc, Nickel,	CAR AER

Risk / Impact (Risk Ranking)	Management Actions	Management Targets	Monitoring	Reporting
	suspended until the situation is rectified.		Manganese, Copper and Cobalt. Reinjection water quality will be monitored along the chain from mine dewatering bores all the way to reinjection bores to ensure that it is similar to or better than background groundwater quality. The main place where quality assessment will take place will be at the Process Plant where a dam holding processing water will be located. Water quality (relevantly pH, TDS and Eh) will be continuously recorded using a multiparameter probe and a constant record of the data will be kept. In the event that pH and Eh monitoring detects acidity or oxidation levels outside the range of normal variability (> 2 standard deviations from rolling three-month average) then water quality monitoring will include additional checks for metals. Metal ions in solution will be considered unusually high if recorded levels exceed the	

Risk / Impact (Risk Ranking)	Management Actions	Management Targets	Monitoring	Reporting
			highest levels found in past sampling in mining area: • Zinc – 12.9 mg/L • Nickel – 3.8 mg/L • Copper – 1.9 mg/L • Cobalt – 3.1 mg/L These limits will be reviewed once sufficient data has been collected and revised if necessary. An annual audit to ensure probe accuracy will be undertaken.	
Indirect Risks / Impacts				
Acid and Metalliferous Drainage (AMD) (Moderate)	Quarterly analysis of the monitoring of dewatering volumes to ensure Management Target 3 will be met. Adjustments made to advance dewatering volumes and other bores, if developments suggest Management Target 3 will be exceeded.	Dewatering of no more than 2.5GL/a within the associated water licence year.	Extraction bores will have flow meters located at the point of extraction, recording both instantaneous and cumulative flows. A constant record of the data will be kept. Annual audit of dewatering volumes will be undertaken to ensure that metering is accurate.	CAR AER
	Analysis of monitoring of groundwater quality; appropriate remedial action if indicated to be required.	Groundwater quality remains within background concentrations at the M39/1080 (now M39/1104) mining lease boundary.	Monitoring will take place under Tailings Storage Facility MMP.	CAR AER

Risk / Impact (Risk Ranking)	Management Actions	Management Targets	Monitoring	Reporting
			Annual audit of groundwater quality. In order to ensure that groundwater flows, in the areas around where mining activity takes place, both during and after dewatering activities, behaves in a manner similar to that modelled, groundwater levels will be monitored to ensure that any AMD that might have been generated will flow towards the cone of depression created by the dewatering activity as expected.	
Surface contamination (spills, AMD) (Low)	Not Applicable – groundwater levels are 29 to 49m below the land surface, separated by a vadose zone that exists at below field capacity. The thickness of the vadose zone and the low permeability of the unsaturated sediments, at moisture contents below field capacity, mean that the risk of any surface contamination reaching the aquifer by recharge is extremely low; thus no management actions or targets are needed to protect against this risk.			

5. References

Advisian (2017). Modelled dewatering volumes for the MRUP. Unpublished report prepared for Vimy Resources Limited, December 2017.

EPA (2016). *Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans*, Environmental Protection Authority (EPA), Perth, Western Australia.

SWC (2015a), *Physicochemical Characterisation of Ore and Tailings from the Mulga Rock Uranium Project.* Unpublished report prepared for Vimy Resources Limited, October 2015.

SWC (2015b), *Mulga Rock Uranium Project Tailings Storage Facility Seepage Analysis*. Unpublished report prepared for Vimy Resources Limited, October 2015.

Rockwater (2015), *Results of Hydrogeological Investigations and Numerical Modelling, Mulga Rock Uranium Project*, unpublished report prepared for Vimy Resources Limited, October 2015.

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