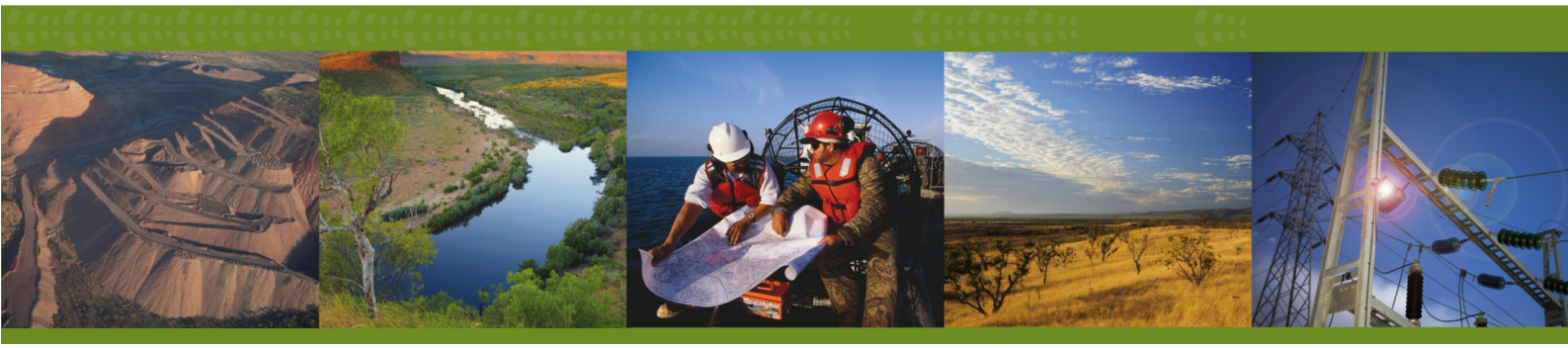

Ord River Irrigation Area Weaber Plain Development Project

Groundwater Management Plan

Approved by DSEWPaC on 16 January 2013

Prepared for
LandCorp
by Strategen

December 2012

STRATEGEN
environmental consultants

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December 2012

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1. Introduction

1.1 Project background

The Western Australian Minister for State Development intends to develop an area of land on the Weaber Plain for irrigated agriculture, approximately 30 km north-northeast of Kununurra and adjoining the existing Ord River Irrigation Area, in the Kimberley region of Western Australia. Key components or environmental aspects of the Proposal relevant to groundwater management include:

- application of 80 – 120 GL/yr of irrigation water which would increase recharge over the Weaber Plain and add to any rise in the watertable
- vegetation clearing of approximately 9260 ha of land for farms and infrastructure which would increase groundwater recharge and result in a rise to the watertable
- installation of infrastructure (including roads, channel, power supply, drainage and flood protection infrastructure, groundwater management) which would affect the pattern of surface flows and ponding therefore potentially increase recharge to groundwater
- groundwater management that could (but unlikely) require periodic discharge to the Keep River system in the wet season depending on the extent of watertable rise and soil salinity increases in the Proposal area.

State approval

The WA Minister for the Environment approved implementation of the above Proposal (as part of the M2 Proposal) in February 2002 subject to a number of conditions outlined in Statement 585. Some changes to Statement 585 were subsequently made, resulting in the issue of Statement 830 on 7 May 2010, this does not materially affect the content of this Groundwater Management Plan (GMP).

Commonwealth approval

The Australian Government Minister determined in June 2010 that the Project required approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as the Proposed Action was considered to have the potential to impact significantly on a number of Matters of National Environmental Significance (NES). The Proposed Action was approved, subject to a number of conditions, on 13 September 2011 (EPBC 2010/5491).

1.2 Purpose and scope

This GMP describes the processes for monitoring and management of groundwater within the Weaber Plain Development Project Area (Proposal area, Figure 1). This plan does not detail the methodology of monitoring programs or design characteristics; these will be continuously refined based on future monitoring and modelling results in consultation with the **Independent Review Group** (**IRG**).

This document has been prepared to address conditions and commitments of WA EPA Statement 830 and EPBC Act Approval Condition 12 (EPBC 2010/5491).

State conditions

Condition 7 of Statement 830 requires that the proponent prepare, prior to commencement of ground disturbing activities, a series of sub-plans, including a GMP, as listed in Condition 7 and Schedule 2 in the Statement.

This GMP also addresses Proponent Environmental Management Commitments 30–37 of Statement 830 which state:

> ***Commitment 30**: "Engineering design standards for all irrigation channels and regulating storage's intended to convey or store water for prolonged periods will be adopted to restrict seepage to a maximum of 2 mm/d."*
>
> ***Commitment 31**: "Incorporate wider, shallower drains than were built in ORIA Stage 1. Where deeper drains are required, the excavated surface of the drain will be compacted to minimise seepage."*
>
> ***Commitment 32**: "Groundwater delineation drilling across the interpreted position of the palaeochannel aquifers will be implemented in order to define the position of aquifers beneath the irrigation area.*
>
> *An extensive network of groundwater monitoring bores will be installed within and adjacent to the irrigation area prior to the commencement of irrigation. This network will include bore transects aligned perpendicular to the Keep River and Sandy Creek to acquire additional data in relation to the river—groundwater interactions, as well as the establishment of monitoring bores adjacent to Milligan Lagoon.*
>
> *Groundwater samples will be collected during the delineation drilling to quantify the vertical and horizontal water quality distribution."*
>
> ***Commitment 33**: "Groundwater levels will be controlled via the utilisation of bores and subsoil drains if necessary."*
>
> ***Commitment 34**: "A comprehensive monitoring programme for groundwater levels and quality, and use of the collected data to modify management practices will be practiced."*
>
> ***Commitment 35**: "Test dewatering bores will be installed to confirm aquifer yields and the response of the aquifers to pumping. The data collected from the groundwater monitoring programme will be used to continually update the groundwater model and to optimise the extent and timing of installation of the groundwater management system."*
>
> ***Commitment 36**: "Groundwater will be tested on a regular basis for all chemicals used in the Project Area to ensure compliance with national drinking water quality guidelines."*
>
> ***Commitment 37**: "The quality of groundwater adjacent to watercourses will be monitored. The groundwater pumping strategy will include provision for the capture of additional groundwater adjacent to the watercourses if considered necessary."*

Groundwater quality, in terms of chemicals and nutrients for irrigation, will be assessed against site specific triggers, determined in accordance with the ANZECC & ARMCANZ (2000) guidelines. Site specific triggers are considered a more appropriate standard than the Australian Drinking Water Guidelines (NHMRC & NRMMC 2004), referenced in Commitment 36, to assess the groundwater quality within the Proposal area. Sufficient baseline data will be available prior to irrigation to determine site specific triggers. The Proponent will seek an amendment to Commitment 36 under section 46 of the *Environmental Protection Act 1986* (EP Act) to refer to site-specific trigger values determined in accordance with ANZECC & ARMCANZ (2000) guidelines.

A previous version of this plan was incorporated in the Environmental Management Programme required under Condition 7 of Statement 830 and was prepared on the advice of the WA Environmental Protection Authority (EPA) and other agencies in 2011.

EPBC conditions

Condition 12 of the EPBC decision statement (EPBC 2010/5491) requires the preparation of a GMP in order to protect listed threatened species in the Keep River. This plan addresses aspects that may potentially impact EPBC listed species in the Keep River, specifically:

- the critically endangered speartooth shark (G*lyphis glyphis*)
- the endangered northern river shark (*Glyphis garricki)*
- the vulnerable dwarf sawfish (*Pristis clavata*)
- the vulnerable freshwater sawfish (*Pristis microdon).*

The Gouldian Finch is the subject of a separate plan required by Condition 6 of EPBC approval 2010/5491.

Table 1 outlines the requirements of the EPBC approval conditions and where the requirements have been addressed in this Plan.

Table 1 Correlation between Groundwater Management Plan and EPBC 2010/5491 Condition 12

Item	EPBC requirements	Section
A	Expansion of the existing groundwater monitoring bore network for the collection of baseline and ongoing groundwater data. The expanded bore network must be installed prior to commencing clearing of farm lots and at least 18 months before the commencement of irrigation and must include: i. at least 20 high intensity regional bores, and ii. at least 30 low intensity regional bores. The management plan must indicate the locations for the expanded bore network;	This is addressed in Table 2, Item 1.
B	Monitoring of the bores established under condition 12.A to collect baseline and ongoing groundwater data. Baseline monitoring must commence at least 18 months prior to commencement of irrigation. Sampling parameters must be determined in consultation with the **Independent Review Group** and must include: i. High intensity bores: Daily groundwater levels and temperature monitoring; Seasonal monitoring of Electrical Conductivity (EC), pH, Total Dissolved Solids (TDS), major cations and anions, nutrients and pesticides; ii. Low intensity bores: Seasonal monitoring of EC, pH, groundwater levels, TDS, nutrients and pesticides;	This is addressed in Section 2.3.3 and Table 2, Item 2 and 3.
C	The establishment of at least one on-farm bore per farm. The on-farm bore network must be installed prior to commencement of irrigation;	This is addressed in Table 2, Item 4.
D	Monitoring of the on-farm bores established under condition 12.C to collect baseline and ongoing groundwater data. Parameters for monitoring must be determined in consultation with the **Independent Review Group** and must include seasonal monitoring of groundwater levels, EC, and pH;	This is addressed in Table 2, Item 5 and 6.
E	Updates of the groundwater model and operation of the groundwater management system with monitoring data derived from conditions 12.B and 12.D to assist in determining an optimal dewatering strategy. Numerical groundwater modelling must be updated prior to commencement of irrigation and in consultation with the **Independent Review Group**. Subsequent updates must be conducted every 2-4 years depending on monitoring in Condition 12.D (if worse case scenario indicates a breach in trigger levels, modelling must be updated every 2 years, otherwise every 4 years);	This is addressed in Table 2, item 12 .

Item	EPBC requirements	Section
F	Monitoring of the bores established under Condition 12.C for physical, chemical and nutrient parameters, if high or low intensity bores exceed groundwater quality or groundwater level triggers. Sampling must include groundwater levels, EC, TDS, major cations and anions, nutrients, pesticides and pH and must be undertaken on a seasonal basis for five years following the exceedance of trigger levels.	This is addressed in Table 2, Item 7.
G	Establishment of groundwater quality trigger levels for chemicals and nutrients through the use of baseline groundwater quality monitoring in accordance with ANZECC guidelines (2000). ANZECC guidelines trigger values for a 'high conservation/ecological value system" must be adopted for the initial 3 year period. Site specific trigger levels may be determined following this period based on ANZECC guidelines protocols.	This is addressed in Section 2.3.3 and Table 2, Item 14.
H	Establishment of groundwater management infrastructure, including a network of groundwater abstraction bores in the Development Area and Buffer Area and discharge infrastructure at the K1 pool or downstream in the Keep River estuary designed in consultation with the **Independent Review Group**. Forecasting of trigger level exceedance must be projected 10 years into the future. Abstraction wells and groundwater discharge infrastructure must be installed and operational prior to any expected breach of trigger levels based on forecasting (incorporating the accuracy of the model into installation timings).	Groundwater management infrastructure is addressed in Section 2.3.3 and Table 2, Item 1 - 12, Figure 4 and Figure 5. Stormwater and groundwater discharge and associated infrastructure is addressed in the Stormwater and Groundwater Discharge Management Plan and therefore is not discussed in this Plan.
I	Establishment of a series of high intensity reference bores, at locations agreed to by the **Independent Review Group**, to define a groundwater reference condition. The reference bores must be installed at least 18 months prior to commencement of irrigation.	This is addressed in Table 2, Item 8 and Figure 5.
J	Monitoring of the bores established under Condition 12.I to collect reference baseline and ongoing groundwater data. Sampling must include daily groundwater levels and temperature and seasonal EC and pH levels.	This is addressed in Table 2, Item 9.
K	Details of contingency measures should groundwater levels, soil salinity, chemicals or nutrients exceed trigger levels. This must include details of increased monitoring, implementation of a groundwater control program and changes to farm practices such as reducing or ceasing the use of fertiliser and chemicals.	This is addressed in Table 4.
L	Details of contingency measures to be implemented should trend analysis of groundwater levels exceed the trend at reference bores by a rate determined in consultation with the **Independent Review Group**. This must include details of increased monitoring and implementation of a groundwater control program.	This is addressed in Table 4.
M	Protocols and timelines for review and reporting to the Department.	This is addressed in Section 2.5 and 3

1.3 Relationship to other management plans

Relevant management plans that contribute to protection of groundwater quantity and quality (e.g. storage and application of chemicals) within the Proposal area and surrounding environment or are influenced by mitigation measures as detailed in this plan include:

- Chemicals Management Sub-plan - to ensure that chemical storage and application is being undertaken in the appropriate manner (Strategen 2011a)
- Soil Management Sub-plan - describes procedures for the prevention of soil erosion and details soil monitoring and management measures including the management of sodic soil; soil conservation; repair and restoration[1] and, soil chemical status (Strategen 2011a)
- Buffer Management Sub-plan - outlines the requirement for vegetation condition monitoring, which may identify any potential vegetation health issues associated with groundwater accretion and salinity (Strategen 2011a)
- Stormwater and Groundwater Discharge Management Plan (SGDMP) – should groundwater abstraction be required to control watertables and salinity within the Proposal area, it will be discharged to the Keep River during high river flow periods and M2 Channels during low river flow periods. The management of groundwater discharge is discussed in this plan (Strategen 2012a)
- Aquatic Fauna Management Plan - outlines specific management and monitoring measures that will be implemented for the protection of the EPBC listed species. The plan includes the framework for an outcome-based risk assessment to identify the likely risk and consequences of the impacts to threatened species (Strategen 2012b).

1.4 Description of groundwater

Groundwater flow across the Weaber Plain is from west to east and takes place principally within a palaeochannel (ancestral river bed aquifer) of the Ord River (Kinhill 2000). The palaeochannel contains highly transmissive gravels that control the direction and rate of groundwater flow across the Weaber Plain (Lawrie et al. 2010; George et al. 2011). The depth to groundwater throughout the plain is generally 5 – 15 m below ground level (mbgl) (Figure 2). Water levels in the area have risen in recent years as a result of irrigation development in the ORIA Stage 1 and the onset of much wetter conditions (30% higher than the long-term average) since 1993 – 1994 (KBR 2010; Lawrie et al. 2010).

The depth to groundwater in the northwest of the development is closer to the surface (< 4 m) than surrounding areas as it has relatively shallow bedrock and sandy soils recharged by the nearby creeks (Figure 2; Kinhill 2000; George et al. 2011). In the southwest corner of the Proposal area, groundwater is within 5 m of the surface due to irrigation activities in the existing ORIA Stage 1. The groundwater levels associated with Point Springs Nature Reserve occur in the bedrock and are therefore not connected to the alluvial aquifer of the Weaber Plain (Figure 2; Kinhill 2000; George et al. 2011).

The groundwater quality of the Weaber, Keep River and Knox Creek Plains varies from fresh to saline, with salinity ranging from < 500 mg/L to > 10 000 mg/L TDS (Figure 3; Lawrie et al. 2010; Lillicrap et al. in prep). Groundwater salinities are generally lowest in the south of the Development area (Cununurra soils and palaeochannel), where salinity ranges from 120 – 1300 mg/L TDS (Figure 3). Groundwater salinity within the Buffer area is generally less than 1000 mg/L, except in the northern Buffer area west of Point Springs Nature Reserve, where salinity ranges from 1000 – 3000 mg/L TDS (Aquitaine soils, limited aquifer development) (Figure 3).

[1] The requirement for a sub-plan for soil conservation, repair and restoration is addressed partly in the Rehabilitation Management Plan and partly in the Soil Management Plan.

Groundwater accession is expected to occur as a consequence of irrigation and increased recharge from rainfall over the cleared Proposal area. Rises in groundwater levels may potentially result in waterlogging and possible land salinisation if not adequately managed. Modelling by KBR (2011) has been undertaken to facilitate predictions of where groundwater rise is expected to occur within the Proposal area. This work was supervised by a Technical Review Group, which included experts from CSIRO, Geoscience Australia and state agencies (including the Northern Territory Department of Natural Resources, Environment, the Arts and Sport [NRETAS]).

Because baseflow to the Keep River at the K4 pool is primarily controlled by the groundwater gradient, a change in the height of the watertable under the Weaber Plain may also have an additional effect on baseflow rates. The rate of groundwater baseflow to Keep River at the K4 Pool has been increasing naturally since 2000 and is currently estimated to be about 25 L/s during the dry season. Groundwater baseflow to the K4 Pool from the Weaber Plain has been modelled under baseline and several development scenarios (KBR 2011). The baseflow rate is expected to further increase by approximately 63%, as a result of recent climate-forced groundwater level rise (KBR 2011). Under these natural conditions the baseflow salinity at the K4 Pool is likely to increase to 900 mg/L TDS. The modelled change in the future baseflow into K4 Pool is expected to be between approximately 43% for development with no groundwater management (Scenario 2), and 8% for development with groundwater management (Scenario 3) (KBR 2011). In the unlikely event that increases in baseflow to K4 pool (under Scenario 3), are having a detrimental impact on the environment of the Keep River, the groundwater pumping strategy will be reviewed to increase the abstraction rates at the eastern bores within the Development area (as described in the Aquatic Fauna Management Plan).

To ensure groundwater rise does not have a significant detrimental environmental effect to Matters of NES the Proposed Action involves enhanced management of groundwater through a combination of implementing project design specification, maintaining leasehold tenure on blocks with a defined risk, deferring clearing of some lots pending future groundwater level trends and a range of contingency measures (Section 2.4). The modelling indicates that implementation of the groundwater management and contingency measures will be successful in controlling groundwater levels. If groundwater rise due to the development is likely to cause unacceptable impacts that would not have occurred under the no development situation, Section 2.3.3 and Figure 4 outlines the triggers that would apply for the commencement of contingency actions to prevent unacceptable impacts on the K4 pool and EPBC listed species. The trigger values will be continuously reassessed based on baseline survey results and ongoing aquatic fauna and water quality monitoring.

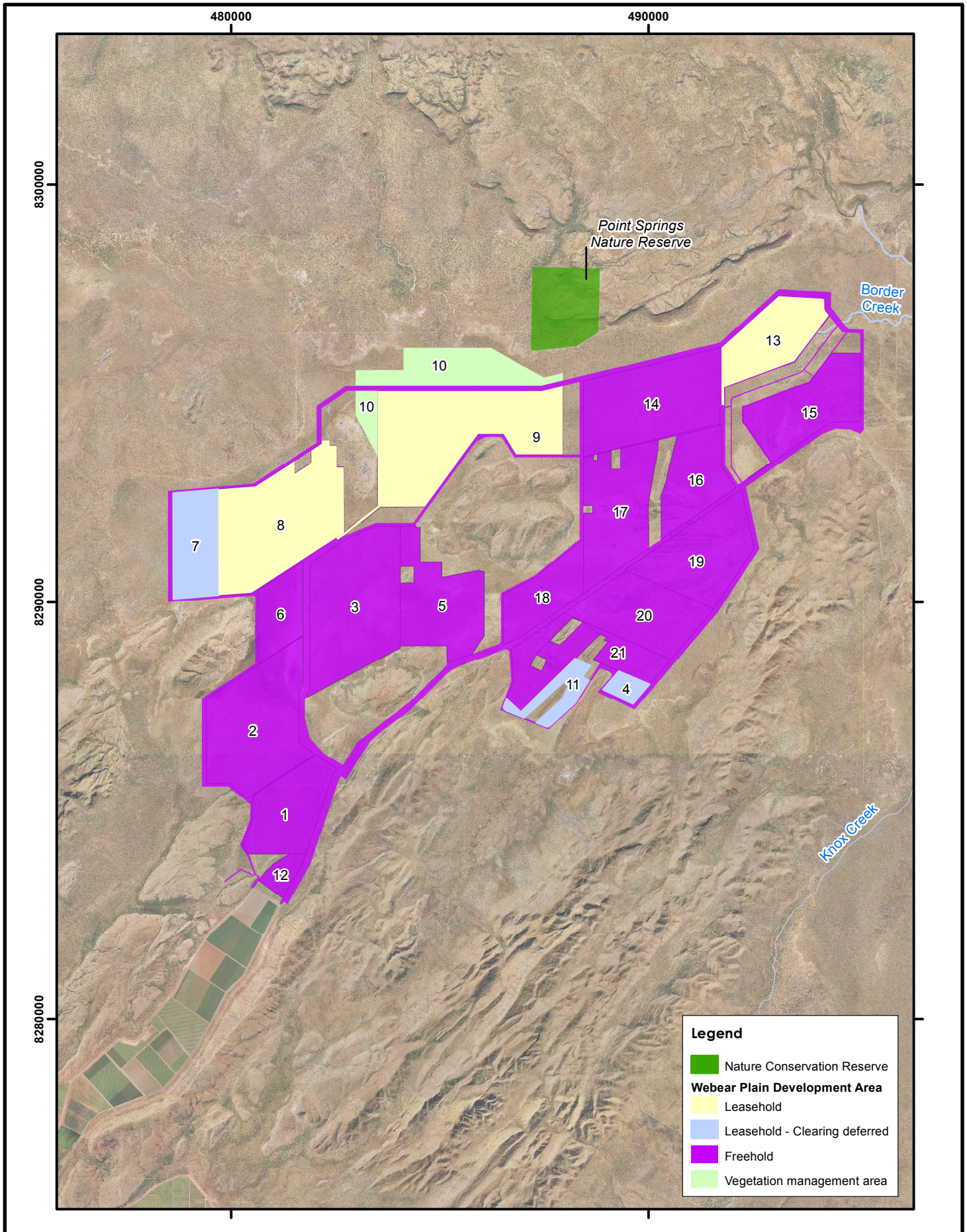


Figure 1 Weaber Plain Development Area

STRATEGEN
info@strategen.com.au
www.strategen.com.au

Scale
0 1 2
Kilometres

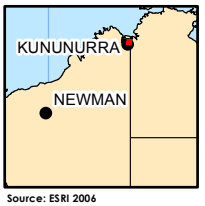
N

1:120,000
at A4

Coordinate System: GDA 1994 MGA Zone 52
Date: 30/11/2011
User: awelker

Source: Geoscience Australia 2006,
McMullenNolan 03/11/2011, S. Pryke 2010 and 2011.
Note that positional errors may occur in some areas

Regional



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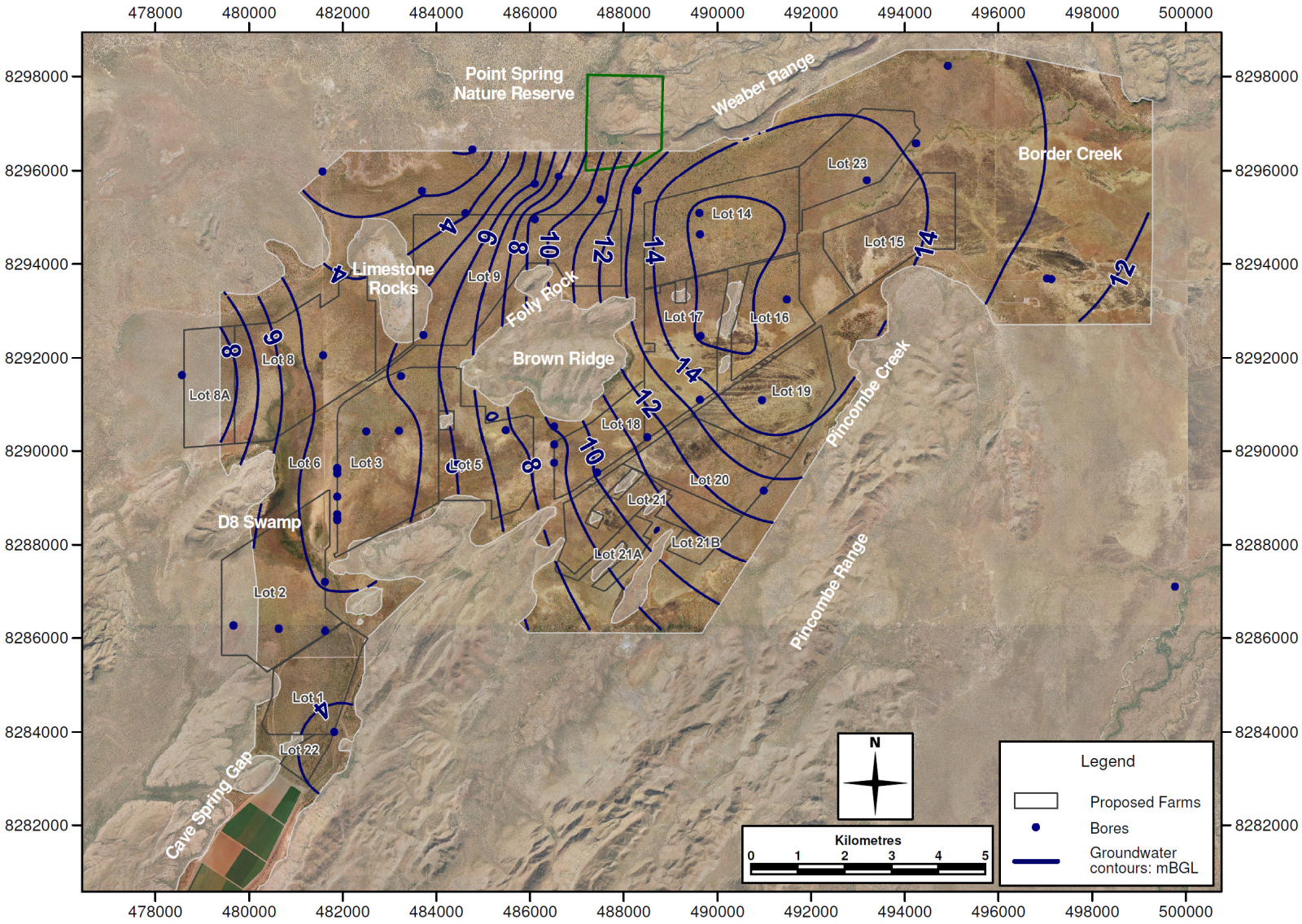

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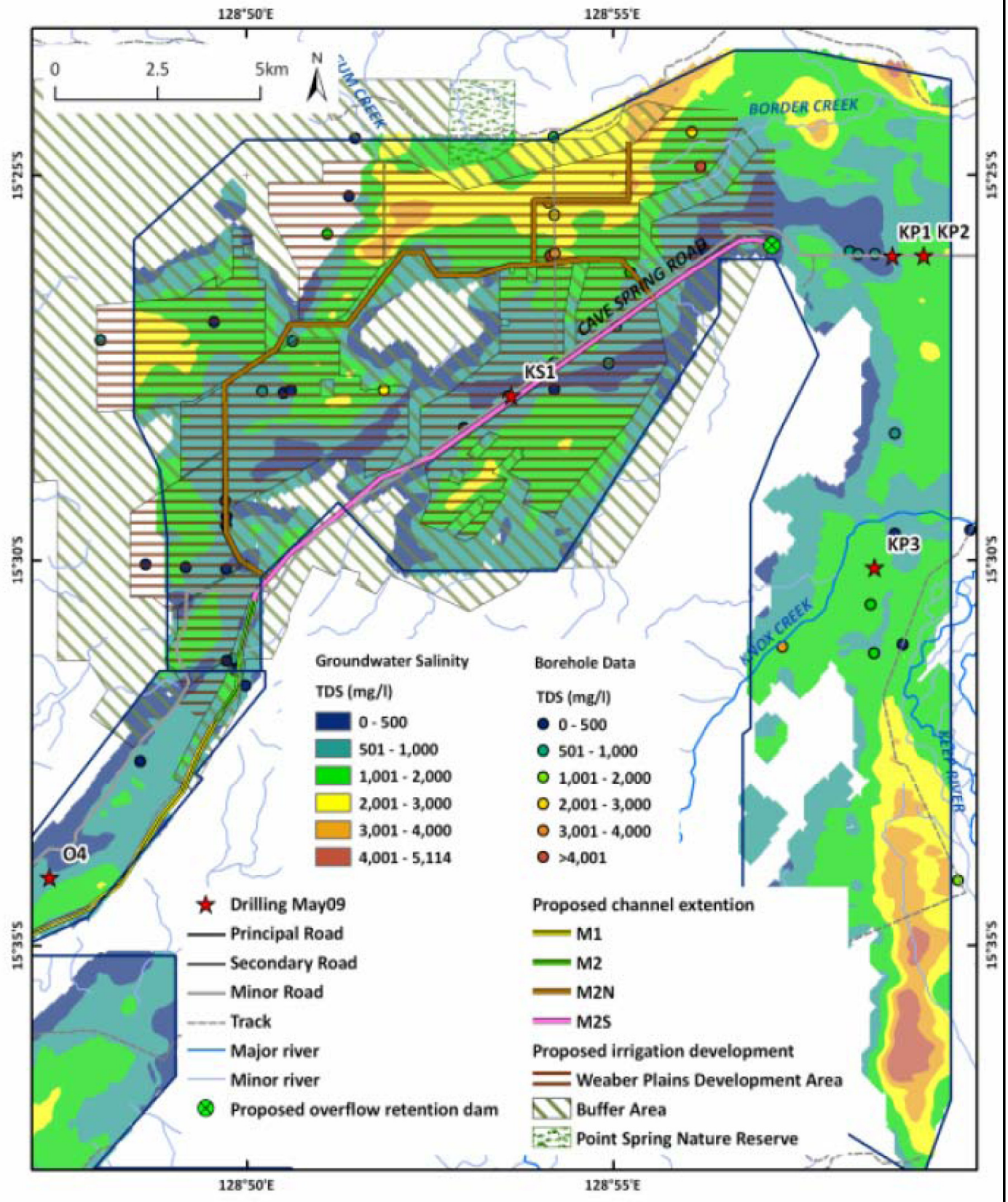
EXISTING GROUNDWATER LEVELS UNDER THE WEABER PLAIN

Source: George et al. 2011 (APPENDIX H1: KBR 2011)

FIGURE
2



Source: Lawrie et al. 2010

STRATEGEN	Groundwater salinity mapping derived from AEM of the Weaber Plain, Keep River and Knox Creek	Figure 3

2. Management

2.1 Environmental aspects to be managed

An environmental aspect is an element of a proposal that has the potential to impact the environment. The following aspects of the Proposal could potentially affect groundwater:

- **clearing and irrigation of agricultural lots** will increase groundwater accession leading to a rise in groundwater levels, potentially resulting in waterlogging of soils and an increase in base flow into the K4 pool (Figure 1)
- **application of agricultural fertilisers and agrochemicals** may lead to a change and/or contamination of surface and groundwater
- **spills of hydrocarbons** may lead to contamination of groundwater.

2.2 Environmental objectives

The environmental objective for the management of groundwater is to ensure changes to the groundwater regime (quantity and quality) resulting from the Proposal does not significantly adversely affect:

- vegetation (including crops) or fauna habitat within the Development area or adjacent Buffer areas which supports EPBC listed species, in particular the Gouldian Finch (management of impacts to Gouldian Finch are also discussed in the Gouldian Finch Management Plan)
- downstream riverine environment and its flora and fauna
- EPBC listed threatened aquatic fauna species in the Keep River, specifically:
- the critically endangered speartooth shark (G*lyphis glyphis*)
- the endangered northern river shark (*Glyphis garricki)*
- the vulnerable dwarf sawfish (*Pristis clavata*)
- the vulnerable freshwater sawfish (*Pristis microdon).*

2.3 Management actions and monitoring regime

2.3.1 Management actions commenced and/or implemented

In order to build upon current knowledge and assist future management the following actions/studies to manage, monitor and understand groundwater with respect to the Proposal have either commenced or already been undertaken:

- delineation Airborne Electromagnetic (AEM) surveys and drilling within the Proposal area to determine the position of the palaeochannel and related aquifers (relates to Commitment 32 of Statement 830) (Lawrie et al. 2010; George et al. 2011)
- determination of the hydraulic characteristics of the palaeochannel (Paul et al. 2011)
- a trial dewatering program to model the effects of dewatering within the palaeochannel (related to Commitment 35 of Statement 830) (Paul et al. 2011)
- development of a refined groundwater model for the Weaber Plain and utilisation of the model to run a number of development and management scenarios determined with guidance and feedback from a Technical Review Group (TRG) (KBR 2011)
- investigation of methods to reduce channel leakage (e.g. clay lining)
- expansion and intensification of the monitoring bore network, including baseline sampling
- detailed water quality and aquatic fauna sampling of the downstream receiving environment (Border Creek and Keep River).

2.3.2 Management measures/strategy

In addition to the above, a number of design and Best Management Practice measures will be implemented to mitigate potential impacts to groundwater which will minimise risk to EPBC threatened species (See Aquatic Fauna Management Plan), including:

- establishment of Vegetation Management Area (where no broad-scale clearing of vegetation will occur) in the north of the Proposal area to reduce salinity risk (Lot 10; Figure 1). Retention of vegetation will provide additional habitat for Matters of NES, as well as reducing the groundwater accretion and potential pumping requirements associated with this area.
- deferment of clearing in some areas where salinity (Lot 7), bedrock or groundwater conditions (Lot 4, 11) are considered a higher risk. Interim vegetation retention areas will be designated as leasehold land and clearing will be deferred until it can be demonstrated (from up to ten years of operation and monitoring) that there will be no groundwater and soil salinity impacts after applying the above measures (Figure 1).
- leasing Lot 8, 9 and 13, rather than the properties being freehold, to provide more control over land use (Figure 1)
- requiring cropping on Lots 8 and 9 of deep-rooted perennial species or revegetating the areas with commercial tree crops (e.g. mahogany), or similar, to manage recharge (Figure 1)
- seepage rates from supply channel to be specified to engineering standards as below 2 mm/day
- recycling irrigation tailwater on farm (see SGDMP)
- designing tailwater systems to capture runoff events (volume equivalent of up to 25 mm runoff; see SGDMP)
- managing water delivery and allocation standards by the Department of Water (DoW)/Water Service Provider on farmers
- implementation of pumping in the event that groundwater level and quality risks cannot be appropriately managed through the application of the above measures (Section 2.4).

2.3.3 Monitoring framework

The flow chart in Figure 4 provides a framework that addresses the risks of salinity, shallow groundwater and the requirement for effective management of these risks. It addresses this by understanding that there are several related elements of risk reflected by the soils and their associated groundwater systems and impacts of overlying vegetation and the downstream environment. Rather than separating the monitoring strategy based on one aspect such as soil type (e.g. Aquitaine and Cununurra), it looks at factors common to both soils such as:

- depth to watertable and watertable trend
- groundwater salinity and trend
- soil salinity; severity and extent of impact on crops/native vegetation.

Groundwater level and salinity trigger levels

Interim trigger levels for groundwater management are presented in Figure 4, which are to apply after the commencement of irrigation. The combination of the monitored parameters define risk, as depth to watertable alone is not a sufficient indicator of impact ,as identified at the ORIA Stage 1 (Lawrie et al. 2010); therefore other factors such as groundwater electrical conductivity (EC) and soil ECe (extract of soil water solute) are also considered (Lawrie et al. 2010). Interim triggers based on annual average values will be reassessed and replaced by site-specific triggers (probabilistic/exceedance measures) as baseline and on-going monitoring data become available, determined in consultation with **IRG**.

For areas of native vegetation (i.e. Buffer area), risk is initially indicated by depth to watertable, and an interim trigger level of 5 mbgl is assumed based on the average depth across the region of interest. Where the baseline groundwater level in the Buffer area is already less than 5 mbgl, an interim trigger level of 2 mbgl is assumed. An interim trigger level of 2 mbgl is assumed for farming areas (DNR 1997).

Initial interim trigger values of groundwater EC have been defined that will apply after the commencement of irrigation, to match experience of impact from southern Australia. Insufficient data exists in northern Australia to make a more site-specific recommendation. The groundwater EC interim trigger level of 500 mS/m is conservative as it is at the low end of the threshold regarding impact on plants (George et al. 1999; DNR 1997).

A soil ECe interim trigger level of 400 mS/m is defined as the threshold for impact on typical irrigation crops (DNR 1997) causing a yield suppression of approximately 20%. Interim triggers will be replaced by specific triggers as crops are established and may utilise both direct and remote sensing measures.

The triggers will also be continually re-assessed and refined using experience gained from ORIA to prevent unacceptable impacts on the receiving environment and EPBC listed species. Proponent or farm owners will be responsible for conducting investigations to identify the cause of any trigger level exceedance and for developing and implementing a soil and/or groundwater control program (if necessary).

Groundwater quality trigger levels for nutrients and chemicals

Groundwater samples from bores will be monitored within the Development area to forecast potential on-site and downstream impacts, and to trigger contingency actions, as required. Until water quality data from the groundwater discharge pipeline is available (when abstraction occurs), groundwater samples in reference bores will be used in conjunction with the Operational Surface Water Model to predict water quality downstream of the Development area. Groundwater quality in bores downstream of the Development area and adjacent to the K4 pool will also be monitored to determine potential water quality impacts on the K4 pool and the downstream environment as a result of changed groundwater baseflow. Changes to K4 pool water quality from increased baseflow will also be determined through ongoing monitoring and modelling of water level and water quality at the K4 pool.

The groundwater pumping strategy will be reviewed if increases in baseflow to K4 pool arising from the development are shown to have a detrimental impact (based on future modelling and water quality data) on the downstream environment. Potential adverse effects could be managed by increasing the pumping rates at the eastern bores within the Development area.

An interim list of analytes to be sampled during the baseline period for groundwater is provided in Table 3. A register of all chemicals applied on farms in the Development area will be maintained as described in the Chemicals Management Sub-plan. The list will be updated taking into consideration on-farm practices and ongoing monitoring of analytes in consultation with the **IRG**.

Groundwater quality will be assessed against site-specific triggers, determined in accordance with the ANZECC & ARMCANZ (2000) guidelines. ANZECC guideline trigger values for a 'high conservation/ecological value system' will be adopted for the initial three year period until site specific trigger values are established.

Water quality triggers and monitoring of abstracted groundwater are addressed in detail in the SGDMP.

Monitoring regime

Monitoring of groundwater levels and quality will be conducted at both regional and local scales. The proposed monitoring bore network is identified in Figure 5. There are three types of monitoring bores:

- 'high intensity' regional bores
- 'low intensity' regional bores
- 'on-farm' bores.

'High intensity' regional bores are defined as monitoring bores that are equipped with automated data loggers. The data loggers will record groundwater levels and temperature on a sub-daily time-step. This data will be managed and evaluated by the Proponent (Table 2, Item 10). 'Low intensity' regional bores are defined as bores that do not have data loggers and are currently monitored seasonally for groundwater level by DAFWA. A minimum of 20 'high intensity' and 30 'low intensity' regional bores across the Proposal area will be monitored as part of the monitoring bore network (Table 2, Items 1 and 3).

Each farm will have an 'on-farm' bore installed post-clearing and layout of farm infrastructure, but prior to the commencement of irrigation (Table 2, Item 4 and 6). The site of each 'on-farm' bore will be selected within the operation and not near the head ditches/sumps (water storages). Each site will comprise a minimum of 50 mm PVC cased bore and will monitor groundwater within the superficial aquifer. 'On-farm' bores will be monitored seasonally for groundwater level, EC and pH by land owners and/or the Proponent. Existing bores on farms can be used if they conform to the above criteria.

Monitoring data will be collected (Table 2, Item 3, 6, and 9) and a database of groundwater level and quality established and maintained for the duration of the Proposal following the establishment of the bore network (Table 2, Item 10 and 11). A list of proposed interim analytes for baseline assessment and post-clearing is presented in Table 3. The list was based on water quality monitoring results from Ord Stage 1 and will be updated annually based on ongoing monitoring, and will be changed in accordance with farm practices (as advised by the Chemicals Management Sub plan) and in consultation with the **IRG**.

The Proponent will be responsible for the collection and analysis of all data related to the regional bores such as physical parameters (water levels, pH and EC) and submitting water samples for chemical analysis by a National Association of Testing Authorities (NATA) accredited analytical laboratory. The chemical analysis will include measurement of elements determined by the licence condition imposed by DoW and required by Condition 12B of EPBC approval 2010/5491, and may include pH, EC, TDS, metals, nutrients, pesticides and a suite of major ionic species (Table 2, Item 2, 4 and 7). Physical and chemical parameter sampling and analysis may also be undertaken of all or part of the 'on-farm' bore network if required (Table 4). Any proposed changes to the sampling and analysis of parameters will be determined in consultation with the **IRG** following the preparation of the Annual Environmental Report (Section 2.5).

Soil monitoring will also be undertaken and results used to inform groundwater management where appropriate. Physical and remote sensing systems (where appropriate) will be used in conjunction to monitor changes in agricultural production and natural vegetation. Soil monitoring is detailed in the Soil Management Sub-Plan (Strategen 2011a).

2.3.4 Management and monitoring actions

The management and monitoring actions required to meet the environmental objectives are described in Table 2.

Table 2 Groundwater management and monitoring actions

Item	Action	Purpose	Timing	Responsibility
Groundwater levels and quality (as it relates to salinity management)				
1.	Expand the groundwater monitoring bore network to include: • at least 20 'high intensity'† regional bores • at least 30 'low intensity'† regional bores. Regional bore locations shown in Figure 5.	To allow the collection of baseline and ongoing groundwater data to guide management.	Install prior to commencement of clearing of farm lots and at least 18 months before the commencement of irrigation.	Proponent

Item	Action	Purpose	Timing	Responsibility
2.	Determine sampling parameters for groundwater monitoring bores in consultation with the **IRG** including: • 'high intensity' bores: groundwater levels, temperature EC and pH, TDS, major cations and anions, nutrients and pesticides (as defined in Table 3) • 'low intensity' bores: groundwater levels, EC and pH, groundwater levels, TDS, nutrients and pesticides (as defined in Table 3).	To inform management.	18 months prior to commencement of irrigation.	Proponent
3.	Undertake monitoring of the parameters determined under Item 2 in bores established under Item 1.	To collect baseline and ongoing groundwater data to determine any adverse effects to the receiving environment as a result of the Proposal.	Commencing 18 months prior to operation of irrigation infrastructure. High intensity bores: • groundwater levels and temperature (automatic, daily) • EC, pH, TDS, major cations and anions, nutrients and pesticides seasonally[S]. Low intensity bores: • groundwater levels, EC, pH, TDS, nutrients and pesticides seasonally.	Proponent
4.	Expand the groundwater monitoring bore network with the establishment of: • at least one 'on-farm' bore per farm.	To allow the collection of baseline and ongoing groundwater data to inform management.	Install post-clearing but prior to irrigation commencing.	Farm owner/ manager
5.	Determine sampling parameters for 'on farm' bores in consultation with the **IRG** including: • groundwater levels, EC and pH.	To inform management.	Prior to commencement of irrigation and annually after the commencement of irrigation.	Proponent
6.	Undertake monitoring of the parameters determined under Item 5 in 'on-farm' bores, established under Item 4.	To collect baseline and ongoing groundwater data to determine any adverse effects to the receiving environment as a result of the Proposal.	Seasonally at the start of the dry season (prior to irrigation) and at the start of the wet season (prior to wet season rains) commencing the first year after clearance of farm lots.	Proponent /Farm owner/ manager
7.	Undertake monitoring of the 'on-farm' bores established under Item 4 for EC, TDS and pH if farm bore exceeds triggers as determined Condition 12D of EPBC 2010/5491.	To increase the monitoring spatial intensity to help determine location and reasons for exceedance. To assist with development of appropriate contingency action.	Annually for five years at commencement of dry season if triggers have been exceeded for each bore.	Proponent
8.	Establishment of a series of high and low intensity reference bores, at locations agreed to by the **IRG**.	To define a groundwater reference condition to inform management.	18 months prior to commencement of irrigation.	Proponent

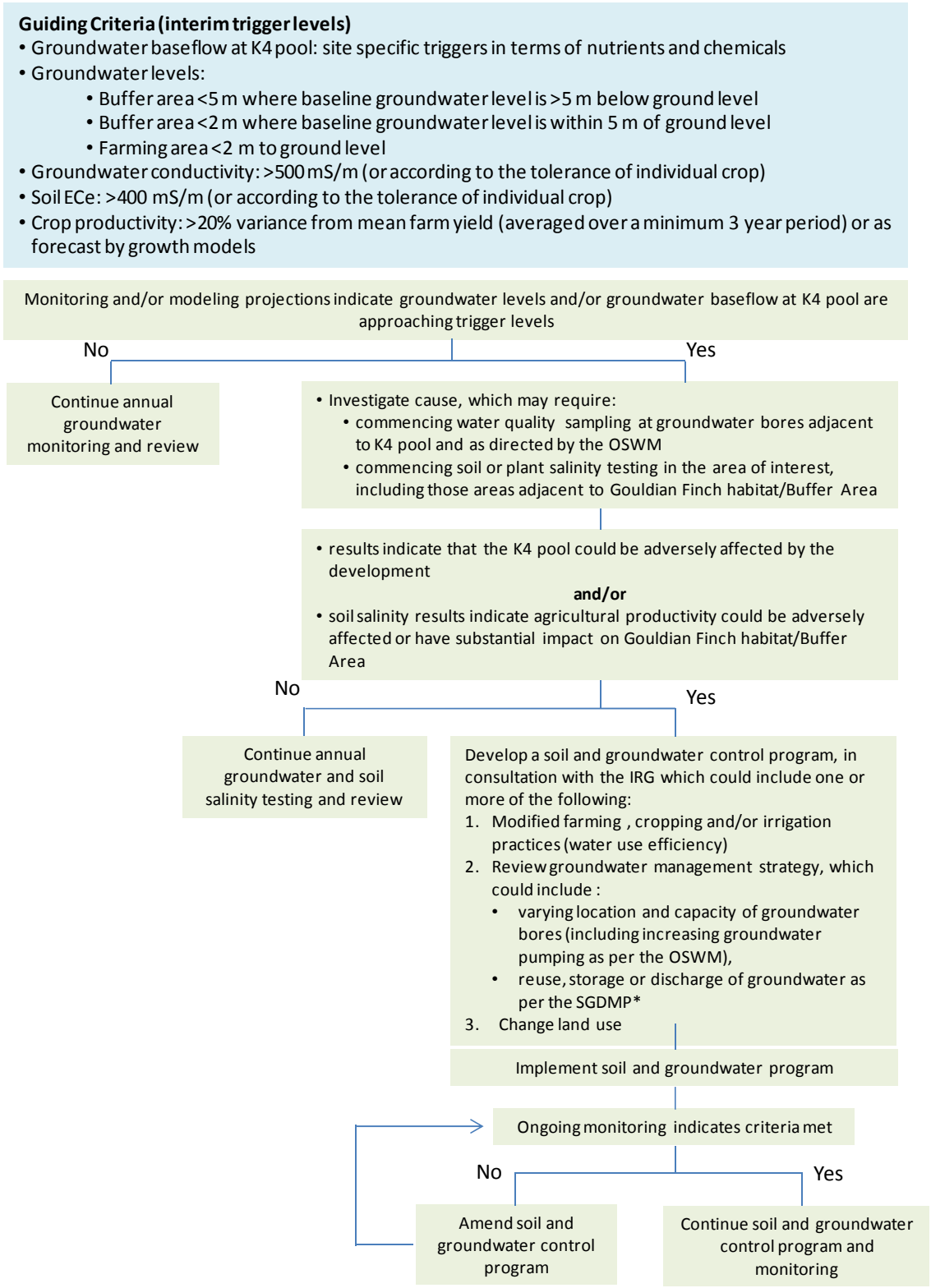
Item	Action	Purpose	Timing	Responsibility
9.	Undertake monitoring of reference bores determined in Item 8 for groundwater levels, temperature, EC and pH.	To collect baseline and ongoing groundwater data to determine any adverse effects to the receiving environment as a result of the Proposal.	Seasonally at the start of the dry season (prior to irrigation) and at the start of the wet season (prior to wet season rains) commencing the first year after clearance of farm lots.	Proponent
10.	Maintain a database of groundwater levels and groundwater quality data based on monitoring results.	To provide data to inform management. To be used in combination with high and low intensity bores where exceedances of triggers are defined.	Ongoing – database to be updated at least every six months with the database to be established prior to June 2013.	Proponent
11.	Establish and maintain a database of groundwater chemical and nutrient parameters.	To provide data to inform management.	Ongoing – database to be updated annually.	Proponent
12.	Update groundwater model and operation of groundwater management system with monitoring data derived from Item 3, 6, 9, 10 and 11, in consultation with the **IRG**.	To assist in determining an optimal dewatering strategy, to forecast potential breaches of trigger values within a ten year period, and to ensure compliance with Commitment 35 of Statement 830.	Prior to commencement of irrigation and subsequently every 2–4 years depending on monitoring trends. If worst case scenario indicated a breach in trigger levels, modelling must be updated every two years.	Proponent
13.	Define the conditions at which various irrigation methods can be utilised for the leased farms on the Weaber Plain development, based on the outcomes of future modelling undertaken.	To maximise water use efficiency and minimise potential environmental impacts of shallow groundwater levels by managing irrigated agriculture and/or cropping systems where required, e.g. on leased farms.	Review every five years in association with modelling from the commencement of irrigation.	Proponent in consultation with WSP*
14.	Adopt ANZECC guidelines trigger values for a 'high conservation/ecological value system' for three years then adopt appropriate site-specific trigger levels for chemicals and nutrients in accordance with ANZECC & ARMCANZ guidelines (2000).	To ensure monitoring and management responses relate to appropriate trigger levels.	For the initial three years, after which site-specific triggers will be adopted.	Proponent
15.	Establish a network of groundwater abstraction bores and discharge infrastructure in consultation with the **IRG.**	To assist with development of appropriate contingency action.	If monitoring and/or modelling undertaken in Item 12 predicts trigger values will be exceeded.	Proponent

† 'High intensity' bores – equipped with automatic data loggers which record groundwater levels and temperature; 'Low intensity bores' – not equipped with data loggers- sampled manually. * **IRG** – **Independent Review Group**; DoW – Department of Water, WSP – Water Service Provider. #EC – electrical conductivity, Pesticides – indicator of multiple herbicides, insecticides, fungicides, Chemicals – includes hydrocarbons. S '

Table 3 Proposed interim groundwater analytes for baseline assessment and post irrigation

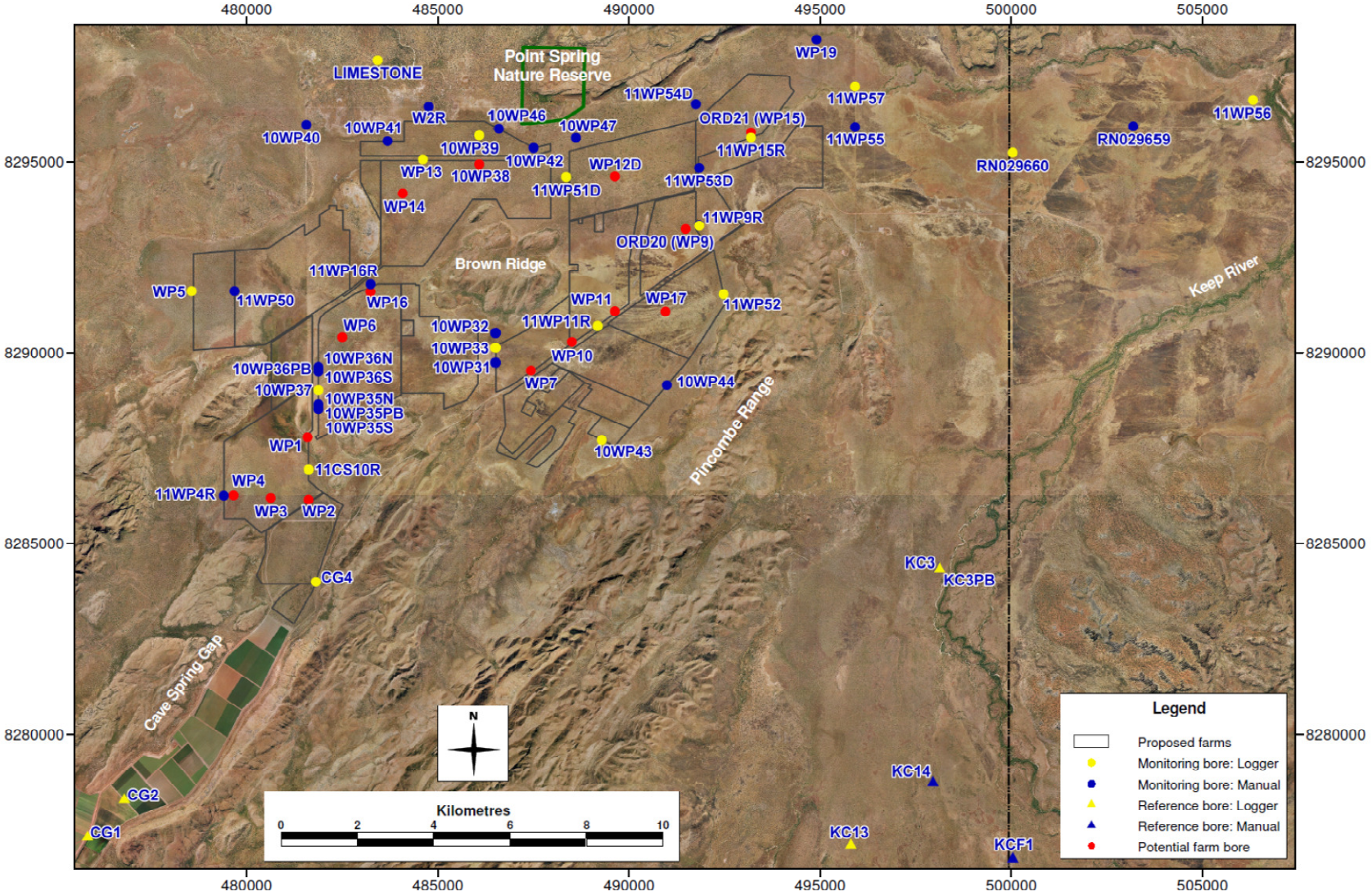
Analyte ID*	Method Code	Limit of Reporting	High Intensity Seasonal	Low Intensity Seasonal	Reference & Farm Bores Seasonal	Units
Al	iMET1WCICP	*0.005*	Y			mg/L
Alkalin	iALK1WATI	*1*	Y			mg/L $CaCO_3$
As	iMET1WCMS	*0.001*	Y			mg/L
B	iMET1WCICP	*0.02*	Y			mg/L
Ba	iMET1WCICP	*0.002*	Y			mg/L
Be	iMET1WCICP	*0.001*	Y			mg/L
Bi	iMET1WCMS	*0.0001*	Y			mg/L
Ca	iMET1WCICP	*0.1*	Y			mg/L
Cd	iMET1WCMS	*0.0001*	Y			mg/L
Cl	iCO1WCDA	*1*	Y	Y		mg/L
Co	iMET1WCICP	*0.005*	Y			mg/L
CO_3	iALK1WATI	*1*	Y			mg/L
Cr	iMET1WCICP	*0.001*	Y			mg/L
Cu	iMET1WCICP	*0.002*	Y			mg/L
ECond	iEC1WZSE	*0.2*	Y	Y	Y	mS/m
Fe	iMET1WCICP	*0.005*	Y			mg/L
Hardness	iHTOT2WACA	*1*	Y			mg/L
HCO_3	iALK1WATI	*1*	Y			mg/L
K	iMET1WCICP	*0.1*	Y			mg/L
La	iMET1WCICP	*0.005*	Y			mg/L
Li	iMET1WCICP	*0.005*	Y			mg/L
Mg	iMET1WCICP	*0.1*	Y			mg/L
Mn	iMET1WCICP	*0.001*	Y			mg/L
Mo	iMET1WCMS	*0.001*	Y			mg/L
N_NH_3	iAMMN1WFIA	*0.01*	Y			mg/L
N_NO_3	iNTAN1WFIA	*0.01*	Y			mg/L
N_total	iNP1WTFIA	*0.02*	Y	Y		mg/L
Na	iMET1WCICP	*0.1*	Y			mg/L
Ni	iMET1WCMS	*0.001*	Y			mg/L
P_SR	iP1WTFIA	*0.01*	Y			mg/L
P_total	iPP1WTFIA	*0.01*	Y	Y		mg/L
Pb	iMET1WCMS	*0.0001*	Y			mg/L
pH	iPH1WASE	*0.1*	Y	Y	Y	
Sb	iMET1WCMS	*0.0001*	Y			mg/L
Se	iMET1WCMS	*0.001*	Y			mg/L
Si	iMET1WCICP	*0.05*	Y			mg/L
Sn	iMET1WCICP	*0.02*	Y			mg/L
SO_4	iCO1WCDA	*0.5*	Y			mg/L
TDS_Calc	iSOL1WDCA	*5*	Y	Y		mg/L
U	iMET1WCMS	*0.0001*	Y			mg/L
V	iMET1WCICP	*0.005*	Y			mg/L
Zn	iMET1WCICP	*0.005*	Y			mg/L
Fluoride	TBA		Y			mg/L
Mercury	TBA		Y			mg/L
Atrazine	TBA	*0.1*	Y	Y		ug/L

*The list was based on water quality data from Ord Stage 1. The only chemicals recorded above the detection limits in Ord Stage 1 were endosulfan and atrazine. Endosulfan has now been banned and will not be utilised in the Proposal area and therefore not included in the interim list. As per the Chemicals Management Sub-plan, a register of all chemicals applied on farms in the Development area will be maintained. This list will be updated based on these on farm practices and on ongoing monitoring in consultation with the **IRG**.



Note: the existing groundwater model will be updated every 2 – 4 years based on monitoring results
*contingency action assumes continuous groundwater pumping will be able to be conducted

Figure 4 Decision flow chart for the management of groundwater rise in the Development and Buffer areas and changes to groundwater baseflow to K4 Pool



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Ord River Irrigation Area Weaber Plain Development Project

Indicative location of regional groundwater monitoring bores associated with the Weaber Plain Development Project

Figure 5

2.4 Contingency Framework

Should the groundwater monitoring regime indicate that the overall objective or trigger values for groundwater are not being met, or are not likely to be met, the relevant corrective actions shall be implemented. These may include the modification of irrigation and agricultural practices, reducing or ceasing the use of specified fertilisers and/or chemicals, initiating groundwater abstraction or a combination of these measures (Table 4).

Modification of land use

If site-specific trigger levels for nutrients or chemicals are exceeded then the exceedance levels will be mapped and the cause investigated. If investigations determine that a spill has caused the exceedance, this will be addressed by the Chemical Management Sub-plan (Strategen 2011a). If the exceedance is caused by irrigation/agricultural practices, farmers will be required to modify their practices; for example, by modifying the method of chemical application. On leasehold land, lease conditions can be changed to modify practices.

The Proponent can require the lessee(s) of Lots 8, 9 and/or 13 to modify irrigation practices and/or crop systems and then continue to monitor, or withdraw the Lease under the appropriate terms if monitoring identifies that groundwater level and quality risks cannot be appropriately managed by Best Management Practice irrigation (Figure 1). If this occurs, the Government will consider cropping deep rooted perennial species or revegetating the areas with a commercial tree crop and managing the land as a Vegetation Management Area to manage recharge. Under such conditions, as experienced at the Ivanhoe Plain of the ORIA, water tables were drawn down by revegetation with a commercial tree crop (e.g. mahogany) and existing/potential salinity managed (Lawrie et al. 2010).

If, as a result of the development, monitoring identifies increasing groundwater level trends and subsequent risks in the Vegetation Management Area and also threatens conservation areas in the Buffer area and EBPC listed species, additional bores may be used to dewater (if required) and management measures identified below would then apply to these bores.

Groundwater abstraction

Groundwater abstraction after the commencement of irrigation can be used as a contingency measure to reduce the risk of groundwater and/or soil salinity in the Proposal area (in accordance with the monitoring framework in Figure 4). This method can also be used if increased baseflow at K4 due to the development is found to have a detrimental impact on the environment of the Keep River (as described in the Aquatic Fauna Management Plan). High yield pumps will be established at appropriate locations to manage measured impacts (Figure 6). Abstraction rates will be re-evaluated when the management model defines that the risk has been abated and the groundwater trigger values are no longer being exceeded.

Groundwater will be discharged in accordance with the indicative groundwater discharge framework in Figure 7 and per the Operational Surface Water Model (OSWM) contained within the SGDMP. Based on current groundwater and hydrodynamic modelling, the main contingency strategy for groundwater is to discharge groundwater to the M2 Channels during low Keep River flow periods, where it will be mixed with the irrigation water supplied to farms to meet Australian and New Zealand Guidelines for water quality for both irrigation and general use (ANZECC & ARMCANZ 2000; Lillicrap et al. in prep). The duration of the low river flow period and period of irrigation has been conservatively estimated at approximately 200 days/year on average. The volumes of water indicated in Figure 7 are for a worst case or 'wet-wet' scenario (KBR 2011). The total volume of water to be abstracted in the worst case scenario is 7.2 GL/yr, whereas the predicted median volume is expected to be 5.7 GL/yr.

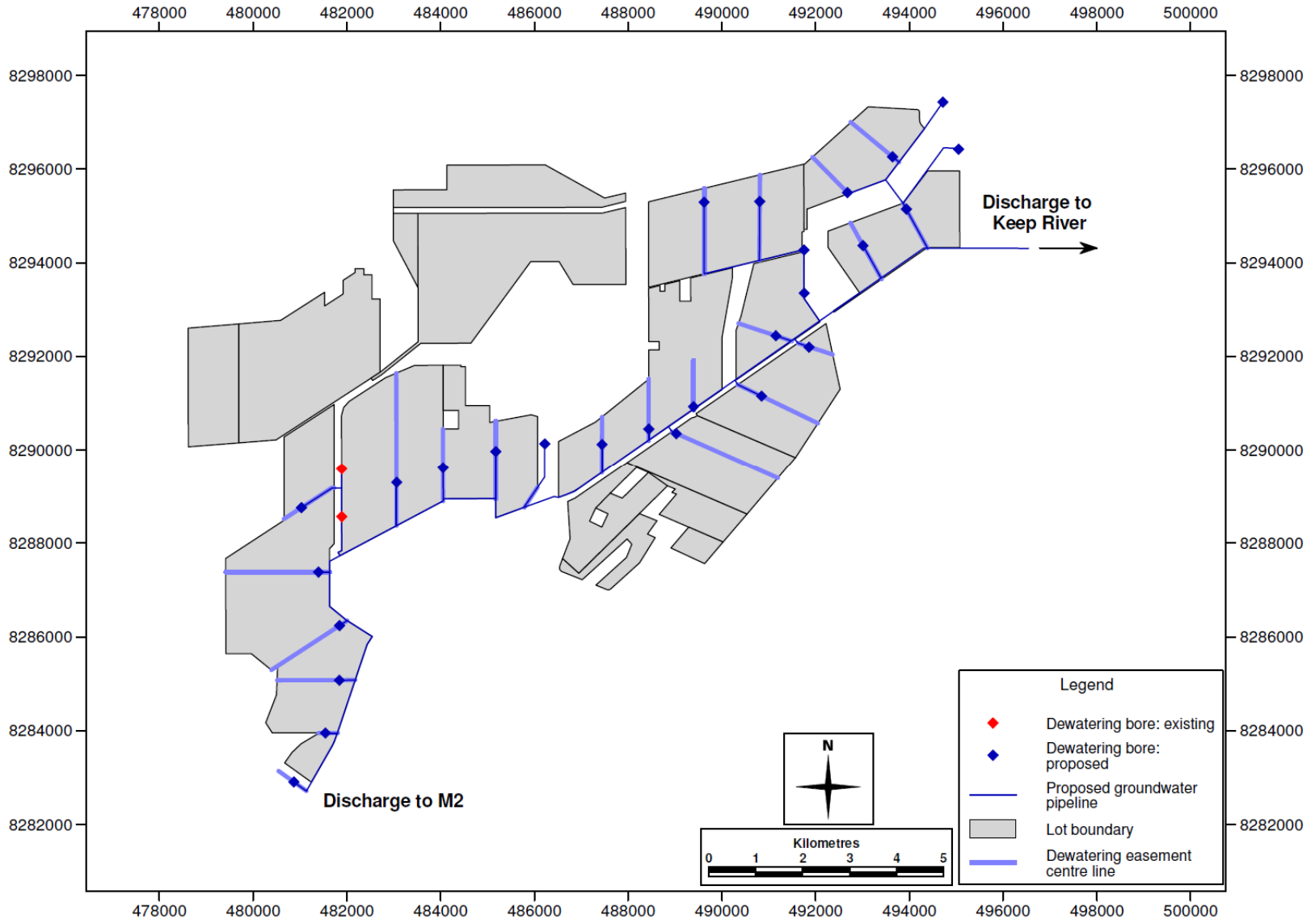
The discharge of groundwater into the Keep River at the K1 pool would only occur when flows in the Keep River are sufficient to ensure adequate flushing of the system and the rules for discharging groundwater to Keep River are defined in the OSWM contained in the SGDMP. These rules will be refined following results from ongoing monitoring and baseline water quality monitoring of the Border Creek and Keep River system.

The indicative discharge location would be at the K1 pool or downstream in the Keep River Estuary; however, it is not expected that discharge will be required for at least 10 years. Other potential contingency actions, pending analysis prior to groundwater discharge, could include increased groundwater discharge to Ord Stage 1 or 2 channels as well as discharge to the lower Keep River Estuary. These contingency actions also assume that groundwater can be discharged at these locations as required.

The objective of the contingency actions with respect to groundwater level and salinity is to ensure that changes to groundwater quantity and quality resulting from the Proposal do not significantly adversely affect vegetation (including crops); fauna habitat in the Development area or adjacent Buffer area (particularly EPBC listed species such as the Gouldian Finch); or, the downstream riverine environment. In terms of chemicals and nutrients, the objective is not to exceed site-specific trigger levels relevant to the discharge environment, hence preventing unacceptable impacts on EPBC listed species.

Table 4 Contingency actions

Item	Trigger	Corrective action	Timing	Responsibility
1.	Groundwater levels, soil salinity and quality exceed or are likely to exceed trigger levels (refer Figure 4).	1. Investigate cause. 2. Implement actions consistent with Figure 4 and Figure 7 (e.g. modify land use/irrigation strategies, groundwater extraction). 3. Document changes in Annual Environmental Report (AER).	Refer to Figure 4	Proponent
2.	Levels of chemicals and nutrients exceed scenarios that show: • an increasing trend in the concentration of any chemical (at statistical confidence levels) • an exceedance of the site-specific triggers for a particular chemical over two consecutive years.	1. Implement Item 7 (Table 2) to better map the distribution of groundwater exceeding target levels. 2. Investigate cause. 3. In consultation with the IRG, identify remedial action required, which could include the modification of irrigation and agricultural practices, reducing or ceasing the use of fertiliser and/or chemicals, groundwater abstraction or a combination of these measures. 4. Implement remedial action immediately after trigger levels are exceeded or, in consultation with the IRG, at an appropriate time. 5. Monitor success of remedy quarterly for 12 months or, following consultation with the IRG and in accordance with the advice from the IRG. 6. Document changes in Annual Environmental Report (AER).	Refer to Figure 4	Proponent



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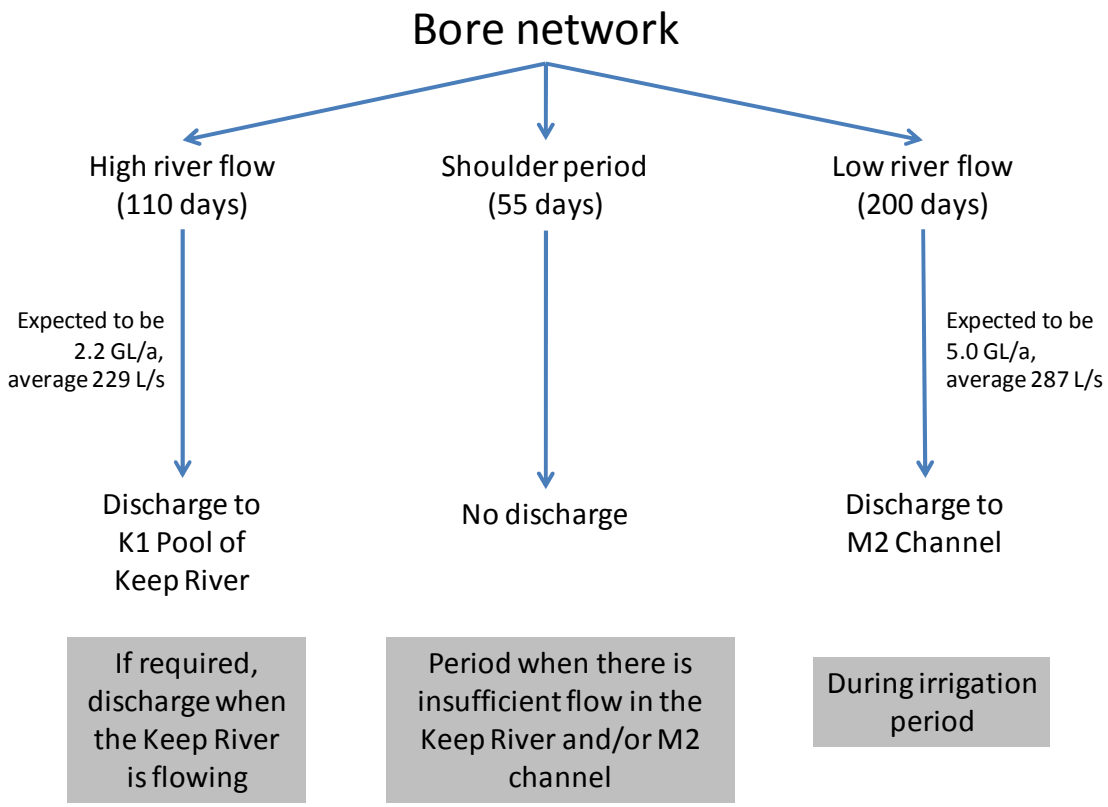
Ord River Irrigation Area Weaber Plain Development Project

Proposed Weaber Plain Development Project dewatering bores for the management of groundwater

Figure 6



Source: KBR 2011

Figure 7 Indicative groundwater discharge framework, with figures shown for modelled worst case scenario

2.5 Performance reporting

Performance reporting of this Groundwater Management Plan will be implemented consistent with the reporting requirements set out in the Ord River Irrigation Area – Weaber Plain Development Project Environmental Management Plan (Ord EMP), which includes systematic, comprehensive and informative reports on environmental management and monitoring for the Proposal area (Strategen 2011a). Under this regime, performance will be reported in:

- an Annual Environmental Report (AER)
- a Triennial Performance Review Report.

Both the AER and triennial Performance Review Report will be prepared by the Proponent. The reports will be provided to the relevant regulatory authorities and made publically available.

2.5.1 Annual Environmental Report

The AER will:

- describe the status of work activities and environmental management
- outline the status of implementation of Procedure 14 of Statement 830 (relates to the creation of conservation reserves)
- outline the achievement of targets
- identify any contingencies triggered over the previous 12 months
- provide interpretations and trend analysis of monitoring results from the previous 12 months
- outline developments scheduled to occur in the next 12 months
- outline the effectiveness of the environmental management measures currently implemented.

2.5.2 Triennial Performance Review Report

A triennial Performance Review Report will be prepared and will address the above AER items over the three year period, in addition to:

- outline the status of implementation of Procedure 14 of Statement 830 (State approval)
- outline the effectiveness of the environmental management measures currently implemented and detail actual environmental performance against:
  - targets
  - achievement of environmental objectives reported on by the WA Environmental Protection Authority (EPA) (2000, 2001); DLPE (2000); and DIPE (2002); and, the objective of this plan
  - commitments documented in Schedule 2 of Statement 830 (State approval).

2.5.3 Audit

Consistent with Condition 19 of the EPBC approval, an independent audit of compliance with conditions will be conducted and the resultant report will be submitted to the Australian Government Minister. The same audit report will be submitted to address compliance reporting required by Statement 830 (State approval).

Where there is an exceedance in trigger levels or any non conformances this will be reported to the Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) and the **IRG** in the first instance, from where further action and reporting will commence.

3. Review and revision

Consistent with the Ord EMP, the Groundwater Management Plan will be reviewed by the Proponent as part of the annual and triennial environmental reporting process. The plan will be revised as required based on assessment of monitoring results and assessment of performance, which may include updating the dilution and flushing characteristics, sampling frequency and water quality parameters sampled.

Construction personnel will be notified of revisions to the plan at a site briefing or using other suitable methods as required. In addition, the Proponent will ensure that adaptive improvement of the plan occurs in response to environmental incident resolutions, audit findings, monitoring results, and changes in regulatory requirements.

The Department of Agriculture and Food (DAFWA), Department of Environment and Conservation (DEC), Department of Water (DoW), **IRG** and DSEWPaC will be advised of any changes to the management actions and will be provided with the revised Groundwater Management Plan as required. Major changes as determined by the Proponent or the **IRG** will be undertaken only in consultation with DAFWA, DEC, DoW, **IRG** and submitted to DSEWPaC for approval based on the advice of these agencies.

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