Supporting Information Report

Amendment Application for Environmental Authority EPPG00651513

Reference:	18 October 2023
Document:	SENEX-ROMN-EN-REP-009
Revision:	0

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Document Status

Revision History

Revision	Release Date	Document Status	Revision Comments	Author
A	29/09/2023	Issue for review		
0	18/10/2023	Final		
1				

Document Approval

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1. Introduction

1.1. Background

Stuart Petroleum Cooper Basin Gas Pty Ltd ACN (130 588 055) (Stuart Petroleum) a wholly owned subsidiary of Senex Energy Pty Ltd (ACN 008 942 827) (Senex) has prepared this supporting information report to accompany its application under the *Environmental Protection Act 1994* (EP Act) to amend Environmental Authority (EA) EPPG00651513 which covers its Western Surat Gas Project (WSGP). The WSGP comprises Authority to Prospect (ATP) 767 and Petroleum Leases (PL) 1022, 1023 and 1024 and is located approximately 30 kilometres northeast of Roma.

The application seeks to amend existing EA conditions to enable Senex to undertake planned development activities and to manage its activities in a way that:

- appropriately reflects the scale, scope and nature of current petroleum activities over WSGP; and
- enhances the operational efficiency and reduces regulatory uncertainty for the purpose of complying with EA EPPG00651513.

Specifically, it is proposed to:

- amend the schedule of disturbance (Schedule A, Table 1) to provide greater clarity on authorised activities;
- enable an alternative methodology to authorise pipeline wastewater releases if an alternative assessment is undertaken;
- amend the way in which air emissions monitoring will be undertaken for the compression facilities authorised under the EA;
- amend EA conditions to authorise disturbance within the Primary Protection Zone (PPZ) of a Category C Environmentally Sensitive Area (ESA) (Of Concern Regional Ecosystem) for the purpose of conducting a petroleum activity; and
- amend the definition of essential petroleum activities.

Proposed amended EA conditions are discussed in detail in Section 4 and **Appendix B**.

No additional activities are sought under this amendment. On this basis, the relevant third-party assessment of potential impacts on environmental values is that previously undertaken by Boobook Ecological Consulting. Notably, Senex considers that impacts to environmental values as a result of the proposed amendments will be negligible.

1.2. Purpose

The purpose of this report is to:

- support the EA amendment application for EPPG00651513 to enhance operational efficiency and reduce regulatory uncertainty for the WSGP.
- provide the administering authority with a high level of certainty that there are no additional environmental values impacted by the proposed amendment of EA EPPG00651513.
- assist in demonstrating that the proposed EA amendments achieve improved environmental outcomes through continued regulatory compliance.

2. Application Requirements

2.1. Key Requirements

Chapter 5, Part 7, Division 2 of the *Environmental Protection Act 1994* (EP Act) prescribes the requirements for a properly made application to amend an EA. Each requirement is outlined below with specific references to where the requirements are addressed in the application.

Standard criteria, as defined in Schedule 4 of the EP Act and relevant EPP's have been comprehensively addressed and considered throughout the application and supporting documents.

Table 1: Legislative Requirements for Application

EP Act Section	Requirement	Reference
224	EA may be amended by the holder	Stuart Petroleum (a wholly owned subsidiary of Senex) is the holder of EA00651513
225	Application cannot be made in certain circumstances	Not applicable
226(1)(a)	Application must be made to the administering authority	This amendment application is made to the Department of Environment and Science as the administering authority
226(1)(b)	Application must be made in the approved form	Form ESR/2015/1792 is lodged as part of this application
226(1)(c)	Application must be accompanied by the prescribed fee	Contact details for payment of the application fee are included in the application form
226(1)(d)	Application must describe the proposed amendment	Refer to Section 6
226(1)(e)	Application must describe the land affected by the proposed amendment	Refer to Section 3
226(1)(f)	Application must describe any development permits or approvals required under the *Planning Act* or *State Development Act* for the carrying out of the relevant activity for the authority	Not applicable–no development permits or approvals are required
226(2)	Subsection (1)(d) and (e) do not apply to an application for a condition conversion	Not applicable–this application does not relate to any condition conversions
226AA	Requirement for amendment application to ensure consistency between EA and PRCP schedule	Not applicable
226A(1)(a)	Application must describe any development permits in effect under the *Planning Act* for carrying out the relevant activity for the authority	Not applicable–no development permits are in effect under the *Planning Act* for the activities, which are the subject of this amendment application
226A(1)(b)	Application must state whether each relevant activity will, if the amendment is made, comply with the eligibility criteria for the activity	Not applicable–this application is not a standard or variation application

226A(1)(c)	If the application states that each relevant activity will, if the amendment is made, comply with the eligibility criteria for the activity–include a declaration that the statement is correct	Not applicable–this application is not a standard or variation application
226A(1)(d)	Application must state whether the application seeks to change a condition identified in the authority as a standard condition	Not applicable–this application does not seek to change a standard condition
226A(1)(e)	If the application relates to a new relevant resource tenure for the authority that is an exploration permit or GHG permit–state whether the applicant seeks an amended environmental authority that is subject to the standard conditions for the relevant activity or authority, to the extent it relates to the permit	Not applicable–this application is not for a new relevant resource tenure
226A(1)(f)	Application must include an assessment of the likely impact of the proposed amendment on the environmental values, including–	Refer to Section 5-7
226A(1)(f)(i)	A description of the environmental values likely to be affected	Refer to Section 3.3 and Section 5-7
226A(1)(f)(ii)	Details of emissions or releases likely to be generated	Refer to Section 5-7
226A(1)(f)(iii)	A description of the risk and likely magnitude of impacts on the environmental values	Refer to Section 4-7
226A(1)(f)(iv)	Details of the management practices proposed to be implemented to prevent or minimise adverse impacts	Refer to Section 4-7
226A(1)(f)(v)	If a PRCP schedule does not apply for each relevant activity—details of how the land the subject of the application will be rehabilitated after each relevant activity ends	Refer to Section 5
226A(1)(g)	Application must include a description of the proposed measures for minimising and managing waste generated by amendments to the relevant activity	Refer to Section 5
226A(2)	Subsection (1)(f) does not apply if an EIS process have been completed or the Coordinator-General has evaluated an EIS and there are Coordinator-General's conditions that relate to the proposed amendment	Not applicable
226A(3)	Certain subsections do not apply for a condition conversion	Not applicable
226A(4)	Despite subsections (1)(f), (g) and (h), certain subsections do not apply for an application for a prescribed Environmentally Relevant Activity (ERA) mentioned in the Environmental Protection Regulation 2019, Schedule 2, section 13A (commercial cropping and horticulture in Great Barrier Reef catchment)	Not applicable
226A(1)(h)	Application must include details of any site management plan or environmental protection order that relates to the land the subject of the application	Not applicable
226B	Requirements for amendment applications for PRCP schedules	Not applicable

227	Requirements for amendment applications–CSG activities where amendment results in the change to management of CSG Water	Proposed amendments do not seek to change existing CSG water management practices.
227AA	Requirements for amendment application–underground water rights	Proposed amendments do not seek to change the exercise of underground water rights.

2.2. Environmentally Relevant Activities

No changes to the ERAs already authorised under EPPG00651513 are proposed as part of this amendment application.

2.3. Assessment Level Decision

Section 223 of the EP Act defines the requirements that must be satisfied for an assessment level decision for an amendment application under section 228, to be decided as a minor amendment. Senex considers this EA amendment application to be a minor amendment, as outlined in Table 2 below.

Table 2: Criteria for Assessment Level

s. 223 EP Act	Minor Amendment Threshold	Justification
(a)	Amendment is not a change to a condition identified in the authority as a standard condition	It is not proposed to change a standard condition
(b)	Amendment does not significantly increase the level of environmental harm caused by the relevant activity	The proposed amendments are not expected to increase the level of environmental harm. Further detail to support this is provided in sections 4 to 7 and appendices C to E.
©	Amendment does not change any rehabilitation objectives stated in the authority in a way likely to result in significantly different impacts on environmental values than the impacts previously permitted under the authority	It is not proposed to change the rehabilitation objectives
(d)	Amendment does not significantly increase the scale or intensity of the relevant activity	The proposed amendments are not expected to increase the level of environmental harm. Refer to sections 4 to 7 and appendices C to E.
(e)	Amendment does not relate to a new relevant resource tenure for the authority that is (i) a new mining lease; or (ii) a new petroleum lease; or (iii) a new geothermal lease under the Geothermal Energy Act; or (iv) a new Greenhouse Gas (GHG) injection and storage lease under the GHG storage Act	The amendment does not relate to a new relevant resource authority
(f)	Amendment involves an addition to the surface area for the relevant activity of no more than 10% of the existing area	Not applicable
(g)	For an environmental authority for a petroleum activity— (i) if the amendment involves constructing a new pipeline—the new pipeline does not exceed 150 km; and (ii) if the amendment involves extending an	It is not proposed to construct a new pipeline

	existing pipeline—the extension does not exceed 10% of the existing length of the pipeline	
(h)	If the amendment relates to a new relevant resource tenure for the authority that is an exploration permit or GHG permit—the amendment application under section 224 seeks an amended environmental authority that is subject to the standard conditions for the relevant activity or authority, to the extent it relates to the permit.	Not applicable

3. Project Details

3.1. Location

The WSGP is located approximately 30 km north-east of Roma over a combined area of about 76,250 ha (Figure 1) and is wholly located within the Maranoa Regional Council Local Government Area.

3.2. Real Property Locations

Lot / plan details for the WSGP are provided in **Appendix A**. No WSGP properties are listed in the EMR or CLR.

Lot 10 on WV406 is the proposed location for the already authorised gas compression facility (GCF).

3.3. General Site Setting

In overall terms, the location of the proposed disturbance is rural, remote agricultural land with limited to no industrial activity and sparsely distributed dwellings.

Due to the nature and character of the location, ambient noise levels are low and typical of rural areas. Ambient air quality is typical of rural airsheds and exhibits no exceedances of the relevant EPP Air criteria.

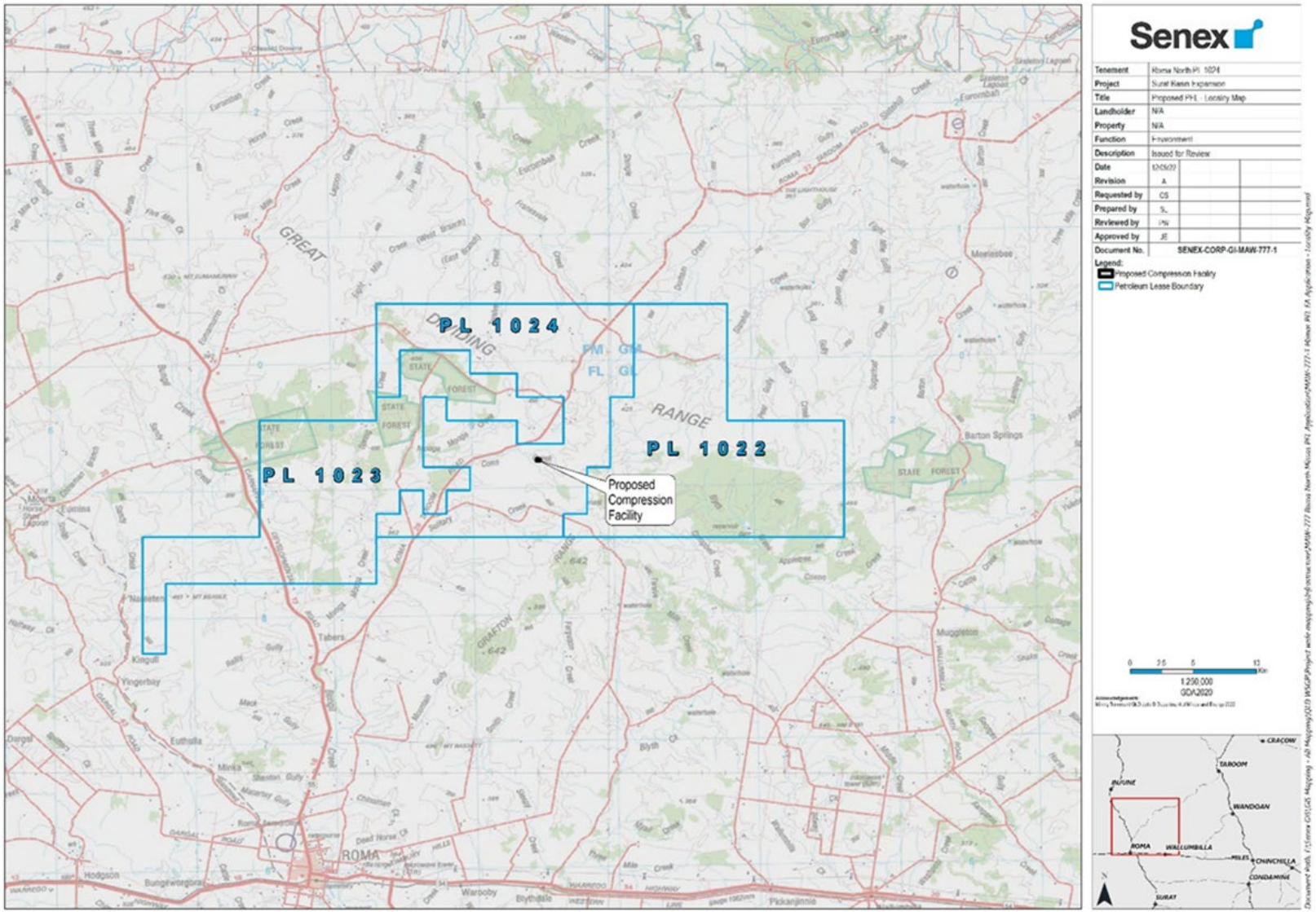

Figure 1: WSGP Location Overview

3.3.1. Bioregion and Terrestrial Ecology

The WSGP is located in Subregion 26 (Southern Downs) of the Brigalow Belt bioregion. Native vegetation of the bioregion is characterised by woodland and forest communities of *Acacia harpophylla* (Brigalow) with scattered ecosystems dominated by saltmarshes, eucalypt species, cypress pine, acacia species and grassland. Scattered areas of regional and locally significant biodiversity are located on all WSGP tenures (Figure 2).

At the planned location of the compression facility, the landscape has been largely cleared for livestock grazing and agriculture with scattered small, isolated fragments of remnant vegetation, and discontinuous narrow corridors of woodland along watercourses and within road reserves (Refer also section 7 and Appendix E). The landscape comprises non-remnant pasture dominated by Buffel Grass on a gentle rise derived from fine-grained sedimentary rocks.

3.3.2. Topography, Geology and Soils

The area is at an elevation around 430 m above sea level, within an undulating landscape of rolling rises. The area is drained by headwater tributaries of Conn Creek, an intermittent watercourse within the Maranoa-Balonne system of the Murray-Darling Basin.

The predominant land use within the WSGP is agriculture (cattle grazing), with some areas of State Forest. The WSGP is located on land predominantly cleared of remnant vegetation, with the remaining remnant vegetation being associated with waterway riparian areas, isolated patches that have remained uncleared and state forest areas located on PL1023. The landscape ranges from gentle to moderately undulating or rolling lands, to strongly undulating or low hilly lands, dissected with small stream floodplains that rise gradually to moderately undulating marginal valley slopes.

Acid sulfate soils are not mapped within the tenures in question.

Soils in the area of the planned compression facility area are deep, brown clay-loams. The area is situated on sediments derived from the Orallo formation (Kyo) which consists of early-Cretaceous medium to fine-grained sandstones, mudstones and conglomerates, with coal seams. The area is entirely on land zone 9 (fine-grained sedimentary rocks).

3.3.3. Climate

Based on Bureau of Meteorology data recorded at the Roma Airport weather station, the WSGP area is subject to a semi-arid climate with very hot summers and warm, dry winters. Maximum temperatures range from 20.4°C in winter to 34.6°C in summer, while minimum temperatures range from 3.8°C in winter to 21.1°C in summer. Extremes of recorded temperatures have ranged from 0°C to 40°C.

Rainfall is relatively high during the summer months, reducing over autumn into winter with the lowest average of 21.3 mm recorded in the month of July. The highest recorded monthly rainfall between 1985 and 2021 was approximately 278 mm in February 2020.

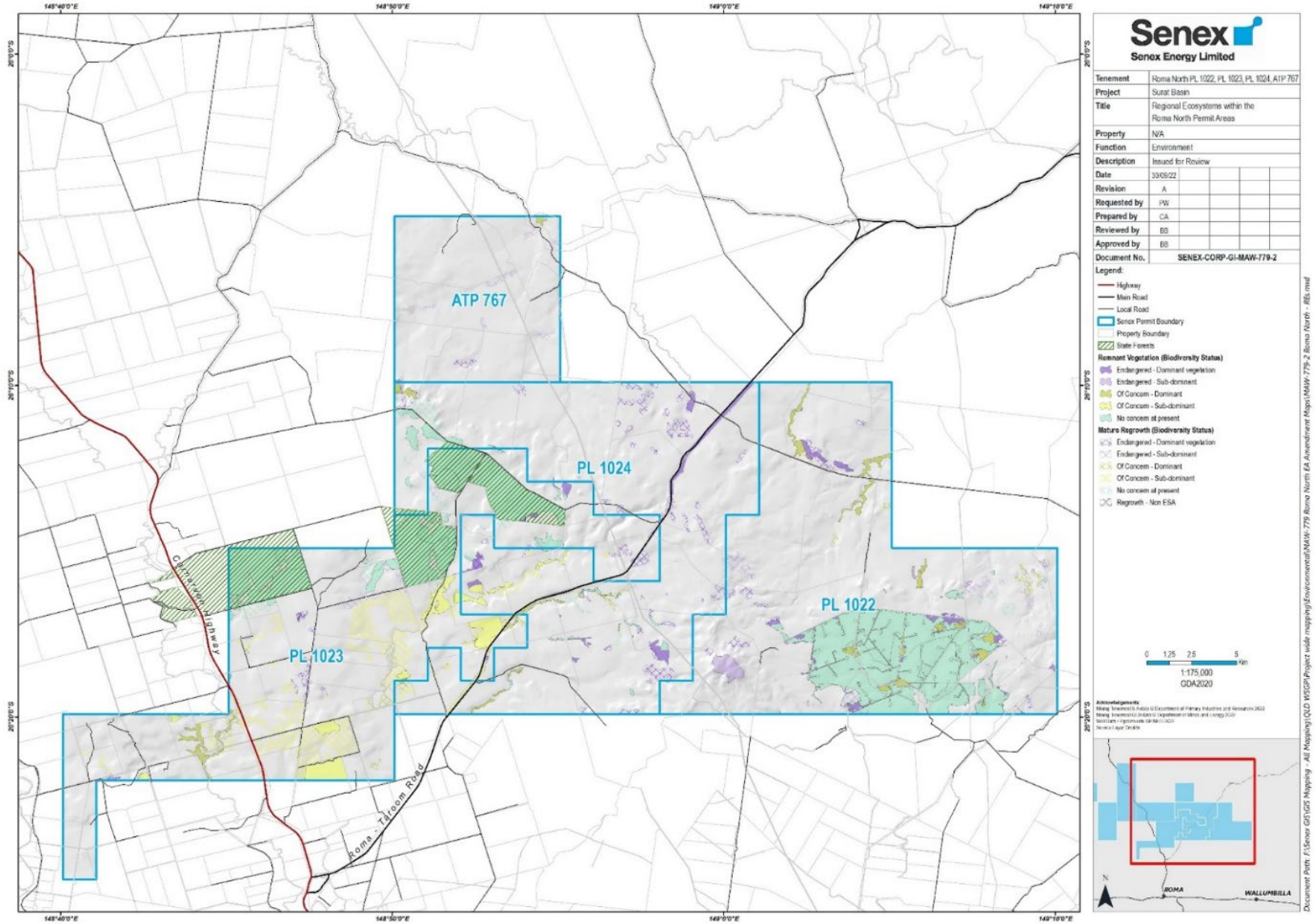

Figure 2: WSGP Mapped Biodiversity Values

4. Proposed Amendments

4.1. Proposed Activities to be Authorised

Senex is seeking the inclusion of the following amendments to EA00651513:

- Amend Schedule A, Table 1 – Authorised Activities to:
  - separately specify the number of regulated and low consequence structures; and
  - amalgamate “field compressor facility” and “central processing facility”.
- Amend Schedule B – Waste to include additional conditions regulating the release of Pipeline Wastewater.
- Amend Schedule D – Air to replace the requirement for an Air Receiving Environment Monitoring Plan (AREMP) with a requirement for point source emissions monitoring for authorised point sources.
- Amend Schedule F - Biodiversity to authorise disturbance within the PPZ of a Category C ESA (Of Concern Regional Ecosystem) to authorise the proposed location of temporary laydown areas and a site office during the construction of the ‘Mimas' compression facility, and installation of a sediment basin for the duration of project life.
- Amend the definition of “essential petroleum activities” to clarify:
  - how produced water is managed; and
  - the installation and use of water monitoring bores and equipment.

These proposed amendments are described in further detail in the following subsections and a full draft of the proposed amendments is provided as **Appendix B**. Please note that proposed deletions have been marked as strikethrough text and proposed amendments / additions are in red text.

4.2. Amending Schedule A – Table 1 – Authorised Activities

Senex proposes to amend the schedule of disturbance to provide greater clarity to Senex and to the regulator over authorised activities.

4.2.1. Proposed Amendment

Currently, Schedule A – Table 1 authorises:

Tenure Numbers	Authorised Petroleum Activity	Scale	Intensity (Maximum Size)
ATP767, PL1022, 1023 and 1024	Wells	442	442 ha
	Historic well pads	47	38 ha
	Regulated / Low Consequence Structures	11	110 ha
	Sewage Treatment Plants	3	>21 EP ≤100EP
ATP767, PL1022, 1023 and 1024	Field Compressor Facility	3	11 ha
	Central Processing Facility	1	6.25 ha
	Water Management Facility	1	4 ha

Senex proposes to amend this table to read as follows:

Tenure Numbers	Authorised Petroleum Activity	Scale	Intensity (Maximum Size)
ATP767, PL1022, 1023 and 1024	Wells	442	442 ha
	Historic well pads	47	38 ha
	Regulated Structures	8	80 ha
	Low Consequence Structures	3	30 ha
	Sewage Treatment Plants	3	>21 EP ≤100EP
ATP767, PL1022, 1023 and 1024	Field Compressor Facility	4	17.25 ha
	~~Central Processing Facility~~	~~1~~	~~6.25 ha~~
	Water Management Facility	1	4 ha

4.2.2. Justification

Senex is seeking to improve clarity and certainty in relation to the specific number and type of activities authorised. In this regard, while regulated / low consequence structures have been split into two rows, and compression facilities has amalgamated two rows, no additional activities or disturbance beyond that already authorised is proposed.

4.2.3. Impacts to Environmental Values

Senex views the proposed change as administrative in nature and considers that as the proposed amendment does not seek to increase disturbance limits or the intensity of petroleum activities it will not result in any impacts to environmental values.

4.3. Addition of Pipeline Wastewater Conditions

Under its EA for Project Atlas (PL 1037) (EA0001207) Senex is able to release pipeline wastewater[1] to land where it does not meet the acceptable standards for release to land, providing that a Receiving Environment Report (RER) has been prepared by a suitably qualified person and such a release will not cause visible scouring or erosion; pooling or ponding; vegetation die-off; or visible salting.

Senex commissioned an RER for Project Atlas (Appendix C) which also considers the release of pipeline wastewater to soils in the WSGP area. Senex are seeking to amend EA00651513 to authorize the release of LPD water in accordance with the RER.

4.3.1. Proposed Amendment

To promote consistency across its tenure areas and associated EA's, Senex is seeking to include conditions (B7) to (B9) from EA0001207 into EPPG000651513.

(B6) Pipeline waste water, may be released to land provided that it:

a) can be demonstrated it meets the acceptable standards for release to land; and
b) is released in a way that does not result in visible scouring or erosion or pooling or run-off or vegetation die-off.

[1] means hydrostatic testing water, flush water or water from low point drains (LPDs).

(B7) Pipeline waste water must not be directly or indirectly released to waters.

(B8) Despite condition (B6), where the acceptable standards for release to land cannot be met, release of pipeline waste water must not occur until:

a) a suitably qualified person has prepared a written Receiving Environment Report;
b) does not result in visible scouring or erosion;
c) does not cause pooling or ponding;
d) does not cause vegetation die off;
e) does not cause visible salting.

(B9) The Receiving Environment Report in (B8)(a) must at minimum address water quality criteria, which has been determined in accordance with assessment procedures outlined in Schedule B, Table 1 – Assessment procedures for water quality criteria and must include:

a) a water monitoring program to monitor that the outcomes of B8 are being achieved; and
b) the frequency of water quality monitoring.

4.3.2. Justification

The Senex Project Atlas area has an EA condition allowing for the release of LPD water where a RER has been prepared by a suitably qualified person and demonstrates that the associated criteria can be met. This RER also covers the potential release of LPD water across the WSGP area and identifies that LPD water can be released across the WSGP in compliance with the criteria in proposed conditions (B7) to (B9). Senex proposes to align the two EAs to create a consistent operational environment across its producing tenures.

4.3.3. Impact to Environmental Values

In CSG projects, gas and water flow to the surface through the bore and/or annulus of CSG wells. At the wellhead the gas enters the gathering network as a water-saturated gas (or "wet gas"). As the gas is transported, changes in temperature and pressure cause the water vapour to condense, which then precipitates and accumulates within the network.

Any free water within the gas gathering network (condensation or produced water) flows downgradient and tends to accumulate at topographic low points within the network. Although the quantities of water are relatively small, the water must be periodically removed to prevent blockages (or water locking) and allow for the free flow of gas. To cater for this, during the design phase, considerations are made for the removal of this water through the installation of LPDs.

Estimated LPD water volumes for the WSGP are provided in Table 3 below.

Table 3: Estimated Total Water Volume from LPDs under Various Operating Scenarios

Field	Operating Scenario	Volumes Based on Operations Advice (L/fortnight)
WSGP	Typical	2,000
	High duty	5,000
	Abnormal	7,500

Available monitoring data from the WSGP generally aligns with the typical operating scenario volumes (Table 3), and this scenario has been used for the calculations detailed in the RER (Appendix C).

A detailed water quality assessment of LPD water (pipeline wastewater) is provided in the RER and indicates that water quality is variable across the network, with one or more criteria in the acceptable standards for release to land being exceeded at any of the sampled WSGP LPDs.

The Atlas EA condition, and the conditions proposed as part of this amendment application state that:

> *where the acceptable standards for release to land cannot be met, release of pipeline waste water must not occur until:*
>
> *a) a suitably qualified person has prepared a written Receiving Environment Report;*

b) does not result in visible scouring or erosion;

c) does not cause pooling or ponding;

d) does not cause vegetation die off;

e) does not cause visible salting'

and

The Receiving Environment Report in B8(a) must at minimum address water quality criteria, which has been determined in accordance with assessment procedures outlined in Schedule B, Table 1 – Assessment procedures for water quality criteria and must include:

a) a water monitoring program to monitor that the outcomes of B8 are being achieved; and

b) the frequency of water quality monitoring.

The Atlas EA water quality criteria are based on short-term (20 year) trigger values (STV) for irrigation established in the Australian and New Zealand guidelines for fresh and marine water quality (Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand (ANZECC & ARMCANZ, 2000) (the ANZECC guidelines)) and the same approach has been applied to the WSGP assessment.

The proposed criteria for the discharge of pipeline wastewater in the Atlas and WSGP EAs incorporate generic trigger concentration levels for irrigation, which are based on the presumption of routine application of large volumes of water to cropping land over extended time periods. However, LPDs typically generate relatively small volumes of low-salinity water and are in locations where discharges to areas used for crops can be largely avoided.

The assessment procedures used in the RER (Appendix C) are commensurate with the EA criteria and are detailed below in Table 4.

Table 4: Assessment Procedures for Water Quality Criteria

Water Quality Criteria	Assessment Procedure
Electrical conductivity **Sodium adsorption ratio** **pH**	Salinity Management Handbook, with reference to Chapter 11; and/or the ANZECC Guidelines with reference to Volume 1 Chapter 4 and Volume 3 Chapter 9. The assessment should consider: · soil properties within the root zone to be irrigated (e.g., clay content, cation exchange capacity, exchangeable sodium percentage) · water quality of the proposed resource (e.g., salinity, sodicity) · climate conditions (e.g., rainfall) · leaching fractions · average root zone salinity (calculated) · crop salt tolerance (e.g., impact threshold and yield decline) · management practices and objectives (e.g., irrigation application rate, amelioration techniques) · broader landscape issues (e.g., land use, depth to groundwater) · any additional modelling and tests undertaken to support the varied water quality parameters
Heavy metals	The ANZECC Guidelines, with reference to Volume 1 Chapters 3 and 4 and Volume 3 Chapter 9. The assessment should aim to derive site specific trigger values (e.g., cumulative contaminant loading limit) based on the methodology provided in the abovementioned procedure

LPDs are predominantly located within disturbed areas associated with pipeline ROWs and access tracks. Therefore, the potential for any increased soil salinity impacts on crops is limited. However, impacts to plant growth (primarily grasses) along RoWs include the following mechanisms:

- Foliar stress when sodium accumulates in or on leaves
- Development of poor soil structure
- Calcium and magnesium deficiency through reduced availability and imbalance with respect to sodium

- Toxicity to root systems

To assess risks associated with salinity, an assessment was completed in accordance with the ANZECC Guidelines to predict the root zone salinity based on the range of pipeline water quality and release volumes. Considering the generally small volumes of water that is generated by LPDs as compared to that applied to land under an irrigation scenario, the use of irrigation guidelines for LPD water provides a conservative approach.

Soil types within the WSGP area are identified in Figure 3. Currently, all existing WSGP LPDs are within the Merivale and Brigalow Uplands soil types, for which soil chemistry data is available. Modelling of the impacts to crop root zone salinities has been undertaken using available soil chemistry and water quality data from the WSGP area, and the estimated typical LPD volume.

Modelling results are summarized in Table 5, and indicate that soils (excluding the Maranoa soil type) are relatively tolerant of salinity and LPD water of between 5 and 16dS/m can be applied at rates of up to 1,000 mm/yr without exceeding the root zone salinity threshold. These parameters are expected to cover a range of abnormal operating conditions, but where abnormal operating conditions occur LPD water will be sampled prior to release and only released where EC is equal to or less than the value in the 'maximum concentration and application rate (no exceedance of root zone salinity)' column in Table 5. The same approach is recommended for those soils not yet impacted by development.

In the Maranoa Land unit where no soils data was available[2], the RER recommends that:

- LPD water should be captured and not released to land where EC is greater than 3 dS/m.
- Soil sampling and analysis is recommended, but is not required prior to discharge providing that LPD water is:

  o is tested prior to release; and
  o only released where EC is less than 3 dS/m.

Table 5: Suggested LPD Water Application Limits

Soil	Available Data	Impacted if release authorised (Y/N)	Max Observed EC (normal operating conditions)	Max application rate at max observed EC (mm/yr)	Max Concentration and application rate (No exceedance of root zone salinity threshold)
Merivale	Site-specific	Y	1.S/m	1000	16 dS/m at 1000mm/yr
Limewood	Desktop	N			5 dS/m at 1000mm/yr
Eumomurrin	Desktop	N			
Glenorden	Desktop	N			
Nimitybelle	Desktop	N			
Pamaroo	Desktop	N			12 dS/m at 1000mm/yr
Wondolin	Desktop	N			
Maranoa	Nil[2]	N			3 dS/m max concentration

4.3.3.1. Monitoring and Management Measures

The RER includes comprehensive measures designed to monitor water and soil parameters to ensure that threshold criteria are not exceeded. These are summarised in Table 6 and Table 7.

[2] Senex has no current activity in the Maranoa soil type and activities in these areas are not planned until post 2025.

Table 6: Monitoring Program

Monitoring to be Completed	Details
LPD discharge volumes	**Data Objectives:** To confirm the range and variability of water volumes produced from LPDs. **How Often/When:** The discharge volume per discharge event should be monitored at least once a year (e.g. drain, recharge for 2 weeks, measure subsequent volume when released). **Monitoring Locations:** 25% of LPDs in Atlas and 25% of LPDs in WSGP on a rotational basis. **Monitoring/Analysis Requirements**: Discharge volumes to be metered, except in cases where discharge volumes are too small to be practicably metered, in which case a visual estimate (e.g., bucket test) is acceptable. **Assessment Requirements**: To be reviewed periodically in conjunction with water quality data to confirm whether loading rates remain within acceptable limits. Comprehensive review of all volume data is required after a period of two years of discharging from LPDs.
Characterisation of LPD water quality	**Data Objectives:** Confirmation of water quality based on a representative number of wells across each operating field to determine outliers and potential issues with water quality. In addition, assess temporal variations and determine representative water quality values. **How Often/When:** Annually for existing LPDs and prior to commencement of discharges for new LPDs and annually thereafter on a rotational basis. LPDs that return elevated results will be resampled. **Monitoring Locations:** Sample 25% of LPDs in Atlas and 25% of LDPs in WSGP for laboratory analysis parameters on a rotational basis and all LPDs for field parameters for each 12 month period (except LPDs that produce negligible volumes of water at the time of monitoring). LPDs that have produced the greatest volumes of water historically (i.e., greater than 1,000 L/month) should be prioritised for sampling and analysis. **Analysis Requirements**: Laboratory samples to be analysed for EC, SAR and total metals as per **Table 8-2**. Field samples to be analysed for pH and EC. **Assessment Requirements**: As data is collected, as per the site-specific trigger levels listed in **Table 8-2**. The majority of trigger levels will be assessed based on the average of the most recent two to three results (where multiple results are available), although a threshold approach will be applied for assessment of salinity. Further assessment on a case-by-case basis is required for LPDs exceeding the site-specific trigger values. Comprehensive review of all analysis data is required after a period of two years of discharging from LPDs. **Comments:** • If an exceedance of the site-specific discharge limits occurs, further review must be undertaken in accordance with ANZACC/ARMCANZ (2000) to determine if continued discharges from the LPD can proceed. • A comprehensive review of analysis data is necessary from time to time to confirm that long-term risks are mitigated. Conversely, this review may determine that reduced monitoring and control measures may be implemented. • Prior to discharge from new LPDs, monitoring of water quality must be conducted to confirm that the water quality meets the required water quality limits. • LPDs should be sampled and analysed when there is an observed spike in water volume, as determined by recorded discharge volumes above or as identified during operations. • Where the volumes produced are sufficient, the LPD should be purged of stagnant water prior to sample collection, taking care to minimise flow rates and associated turbidity.
Visual monitoring of	**Data Objectives:** Identify potential land and vegetation issues that require corrective action.

erosion and vegetation	**How Often/When:** Annually at a minimum, and during LPD discharge events. **Monitoring Locations:** All LPDs from which water is discharged. **Monitoring/Analysis Requirements**: Visual inspection for indicators of erosion, compaction (e.g., water logging/poor drainage), impaired vegetation, fouling or other landscape issues. **Assessment Requirements**: Observations to be recorded and processed through the Senex HAZOB (or similar) system. **Comments:** Nil

Table 7: Specific Management Measures

Management Measure	Details
Soil treatment to mitigate SAR impacts	Based on monitoring of indicators of erosion or compaction, gypsum treatment will be used, where required, to control the effects of SAR on soil.

Monitoring changes in water volume and quality due to changes in infrastructure / abnormal operating conditions	During the operation of the gas gathering network, there may be sudden changes in the quantity and quality of water generated from individual LPDs as a result of workovers or changes in infrastructure, such as the connection of new wells or additional segments of gathering lines to the gas gathering network. When such operational changes occur, increased monitoring of the water volumes and quality from affected segments of the gas gathering network will be conducted. Water quality will be measured in either or both of two ways, including:
	• A campaign approach involving monthly monitoring of EC for potentially affected LPDs, and analysis of pH, SAR, and metals parameters where there has been a marked increase in salinity as compared to historical levels. Where increases in salinity have been observed, screening will be conducted against the site-specific trigger levels.
	• Screening of EC levels in individual LPDs prior to each discharge. In this case,
	  ○ a value of 3 dS/m will be used for all soil types where no chemistry data was available and where this value is exceeded, the LPD will not be discharged until sampling, analysis and screening of pH, SAR and metals is conducted.
	  ○ when experiencing abnormal operating conditions, the values listed in the 'max concentration at max application rate' value in **Table 6-8** will be used. Where this value is exceeded, the LPD will not be discharged until sampling, analysis and screening of pH, SAR and metals is conducted.
	• Based on the results to date, salinity can be used as a surrogate parameter to provide a general indication of whether metals concentrations may exceed site specific trigger levels.

Soils analysis to enable tailored discharge criteria	Soil chemistry data is required for the Maranoa land units in the WSGP to allow for assessment and determination of appropriate discharge criteria. Site-specific soils data for other identified soil types should also be gathered and dependent on results may require updates to the analysis and discharge criteria (n.b. this has already been provided for the Juandah, Mundell, Narran, Wandoan and Merivale soils).

Table Notes:
dS/m = decisiemen per metre
* 8 dS/m selected as it is anticipated abnormal operating conditions will be infrequent and one-off applications of higher salinity water are unlikely to impact root zone salinities.

Based on the above, and the application of management controls specified in the RER, it is not expected that the limited discharge from LPDs and typically low salinity values would cause any impact to vegetation or soils.

With the inclusion of proposed condition (B7), releases of pipeline wase water directly or indirectly to waters would not be authorised, and as a result impacts to waters are not expected.

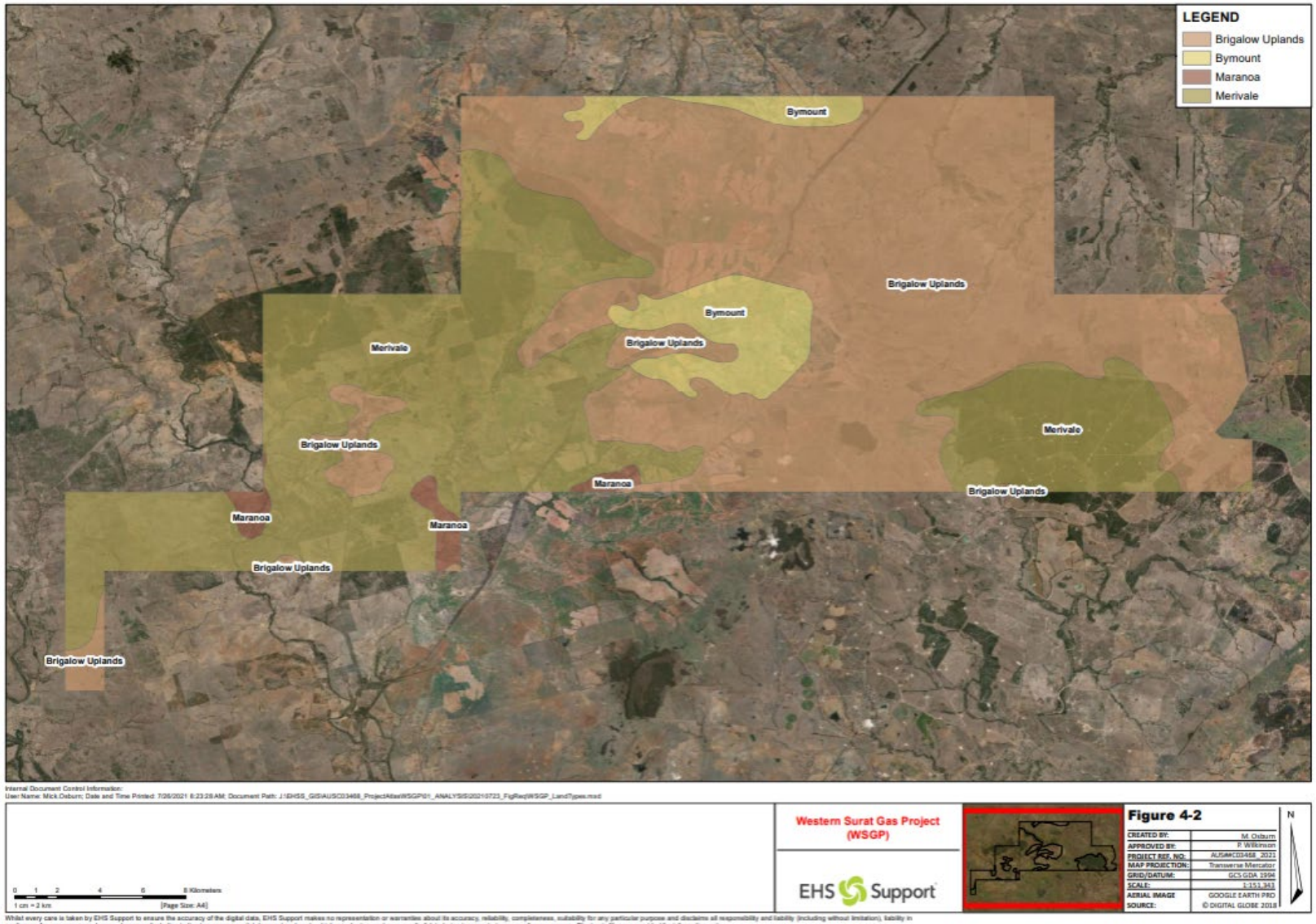

Figure 3: WSGP Soil Types

4.4. Amending air emissions monitoring methodology

Currently the WSGP EA authorises the construction and operation of four compression facilities and one water treatment plant, all of which are likely to require power generation equipment which would trigger the fuel burning ERA (capable of burning >500kg/hr fuel). Conditions D3 to D9 of the existing EA detail the requirements for Senex to undertake monitoring activities in accordance with an Air Receiving Environment Monitoring Report (AREMP). To date, Senex has not constructed any plant under the EA which would trigger the fuel burning ERA.

To align with its more recent EA for the Atlas East Gas Compression Facility (PFL 31), Senex is seeking to amend its EA to switch to the default monitoring methodology provided for in the streamlined model conditions – namely point source emissions monitoring (SMCs Air 2A to Air 3).

4.4.1. Proposed Amendment

Currently EA EPPG00651513 includes conditions D3 to D9 which specify the requirements of an AREMP.

(D2) The operation of fuel burning or combustion facilities must not result in ground level concentrations of contaminants exceeding the maximum limits specified in Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

Contaminant	EPP Air Quality Objective / Maximum ground level concentration at 0°C	Units	Averaging Time
Nitrogen Dioxide	250	µg/m³	1 hour
Nitrogen Dioxide	33	µg/m³	1 year
Carbon Monoxide	11	mg/m³	8 hours

(D3) An air receiving environment monitoring program (AREMP) must be developed to demonstrate compliance with the limits in Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

Air receiving environment monitoring program

(D4) An air receiving environment monitoring program (AREMP) must be developed to demonstrate compliance with the limits in Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

(D5) The AREMP must include, but not necessarily be limited to:

(a) the delineation of the relevant air shed(s)

(b) the identification of background reference sites and impact monitoring sites within the relevant air shed(s), including sensitive places

(c) a monitoring program to be carried out annually that:

i. includes background reference and impact monitoring sites

ii. includes an assessment of meteorological conditions (wind speed and direction)

iii. is sufficient to determine compliance with the limits listed in Schedule D, Table 1—Maximum ground level concentration of contaminants to air v. identifies the effects of the authorised contaminants released to air in the relevant air shed(s)

vi. is representative of when the fuel burning or combustion facilities are operating under maximum operating conditions for the annual period

(d) an assessment of the condition of each fuel burning or combustion facility; and

(e) a description of other significant point sources in the air shed and surrounding land use including sensitive places.

(D6) A AREMP report must be written annually which includes the information required by condition (D5) and an assessment of the extent to which monitoring data for ground level concentrations complies with the air contaminant limits listed in Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

(D7) Where monitoring data indicates that ground level concentrations listed in Schedule D, Table 1—Maximum ground level concentration of contaminants to air have not been met, the AREMP report required by condition (D6) must also include an assessment of:

(a) the extent to which the values of the air environment in the relevant air shed(s) are being protected

(b) an assessment of whether contaminant releases to the air environment are consistent with the air management hierarchy in the Environmental Protection (Air) Policy 2008, and

(c) any corrective actions that have been implemented or proposed to be implemented to become consistent with the air management hierarchy and achieve compliance with Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

(D8) A statement of compliance prepared by a suitably qualified person must accompany each AREMP report required by condition (D6) and if applicable, condition (D7) stating:

(a) whether the AREMP as most recently implemented complies with the requirements of conditions (A4), condition (A8(d)), (D4) and (D5)

(b) that, to the best of the suitably qualified person's knowledge, the assessment required by condition (D6) and if applicable, condition (D8) is true, correct and complete, and

(c) that, to the best of the suitably qualified person's knowledge, all information provided as part of the statement of compliance, including attachments, is true, correct and complete.

(D9) Where condition (D7) applies, the documents required by conditions (D6), (D7) and (D8) must be given to the administering authority within 5 business days after the AREMP report is written.

Senex proposes to replace existing conditions (D2) to (D9) (above) with the following default methodology from the Streamlined Model Conditions Air 2A to Air 3.

Air 2A.
A fuel burning or combustion facility must not be operated unless it is listed in **Protecting air values, Table 1–Authorised point sources**.

Schedule D Table 1 – Authorised point Sources

Release Point Reference	Facility	Equipment Description	Minimum Release Height (m)	Minimum Efflux Velocity (m/sec)	Maximum Mass Emission Rate (g/sec)	
					NO_x as NO_2	Carbon Monoxide
1	Mimas	Gas Generator 1	12.45	30	2.0	1.0
2	Mimas	Gas Generator 2	12.45	30	2.0	1.0
3	Mimas	Gas Generator 3	12.45	30	2.0	1.0
4	Mimas	Gas Generator 4	12.45	30	2.0	1.0
5	Mimas	Gas Generator 5	12.45	30	2.0	1.0
6	Mimas	Gas Generator 6	12.45	30	2.0	1.0
7	Mimas	Gas Generator 7	12.45	30	2.0	1.0

Air 2B.

If a fuel burning or combustion facility is listed in **Protecting air values, Table 1—Authorised point sources**, the fuel burning or combustion facility must be operated so that the releases to air do not exceed the limits specified in **Protecting air values, Table 1—Authorised point sources** at the specified release point reference.

Point source air monitoring

Air 3.

Point source air monitoring for each fuel burning or combustion facility listed in Protecting air values, Table 1—Authorised point sources must:

(a) be undertaken once:

i. in the first three months after each facility is first commissioned, and then

ii. every year thereafter

(b) be carried out when the facility the subject of the sampling is operating under maximum operating conditions for the annual period; and

(c) demonstrate compliance with the limits listed in Protecting air values, Table 1—Authorised point sources at each release point reference.

4.4.2. Justification

As per the explanatory notes in the Streamlined Model Conditions:

'*Conditions (Air 2A), (Air 2B) and (Air 3) are required when an applicant seeks stack emission limits on their EA and / or air dispersion modelling shows there are negative cumulative impacts from surrounding industry to ambient air quality. These conditions are the default EA conditions*.'

And also:

'*Annual monitoring is an acceptable standard in keeping with the intent of the administering authority's Regulatory Strategy which is to move away from high levels of prescription and paperwork for low risk activities and move towards focusing on the department's core business of protecting environmental values. Enhancing compliance is the proposed means to measure environmental performance. It is reasonable for the operator to have annual data on point source emissions to air as this will allow for a yearly compliance assessment by the holder, and if required, the administering authority. It will ensure that the assessment can effectively establish whether each facility is operating efficiently and air quality objectives in the Environmental Protection (Air) Policy 2008 are being met, or whether unexpected impacts are occurring.*'

The proposed conditions are in effect for Senex's PFL 31, and the plant and equipment proposed for use in the WSGP area are identical to that being installed for PFL 31.

4.4.3. Impacts to Environmental Values

Impacts associated with the construction and operation of compression facilities have already been assessed and authorised under EPPG00651513 and do not form part of this application.

The proposed change in monitoring methodology is entirely consistent with the approach outlined in the streamlined model conditions and is considered appropriate to confirm that authorised facilities are operating within design parameters and meeting the air quality objectives in the EPP Air.

Based on the above, impacts to environmental values associated with the proposed change in monitoring methodology are not expected.

4.5. Authorising Disturbance within Category C PPZ

Senex is currently planning for an expansion of its WSGP gas processing capacity to enable Senex to meet its gas sales commitments. The construction and operation of up to four Gas Compression Facilities

is already authorised under the existing EA. The first of these is currently going through the detailed design phase and its location means that some of the temporary workspaces and part of the proposed site office location would be within the Primary Protection Zone (PPZ) of a Category C ESA. In addition, a very small part of the operational footprint also encroaches into the PPZ (Figure 4). The current EA does not authorise this type of impact.

A compression facility is required to be able to meet the following technical and economic design parameters in order for it to operate efficiently and effectively drain its (gas) catchment area:

a) Location must be central to the development area – lowering back-pressure on wells and increasing gas recovery per well for a given gathering system size.
b) Location must be optimal location for civils / earthworks
c) Internal Project conditions precedent requiring access to the proposed location property as a pre-requisite for Stage 2 development.

Primary consideration was also given to the landholder's preference for the location of compression facilities to avoid infrastructure on the eastern boundary, as this is used as a cattle corridor.

Potential alternative options were considered early in the process and were not pursued further as they had the potential to adversely impact the operation of the existing Jemena compression facility in the Eos block of the WSGP (PFL 29) and adversely impacting the economics of Senex's current production profile.

Table 8 and Figure 4 detail the proposed disturbances within the PPZ. The site offices and laydown area will be a short-term temporary disturbance within the PPZ as they are required for construction purposes only. These disturbed areas will be reinstated following construction completion. The southwest corner of the compression facility will also overlap the PPZ. This small area of disturbance will exist for the operational life of the project. However, it will be rehabilitated in accordance with the relevant EA conditions at end of project life.

Site topography means that surface / storm water would drain across the site from northeast to southwest and necessitates the positioning of a sediment basin in the southwestern corner of the operational footprint. It is this sediment basin that forms the 0.15 ha of disturbance within the PPZ of the ESA which would remain for the duration of the compression facility lifespan.

The facility footprint cannot be moved to avoid this encroachment due to the landholder requiring that the cattle corridor to the immediate east of the facility not be impacted by the proposed works.

Table 8: ESA PPZ Disturbance Areas

Description	Total Area (ha)	ESA PPZ Impact Area (ha)
Compression Facility	9.43	0.15
Site Offices	1.12	1.09
Laydown	1.35	1

A full ecological assessment of the proposed location has been completed by Boobook (2021) and the findings of this assessment are detailed in section 7 of this report. Please note that the Boobook survey was undertaken prior to the landholder raising concerns about the impact to the cattle corridor, and as such mapping in this report shows temporary workspaces and site offices to the west of the compression facility. Despite this, the survey covered the areas in question and the findings are directly applicable to this application.

4.5.1. Proposed Amendment

(F7) Where petroleum activities are to be carried out in environmentally sensitive areas or their protection zones, the petroleum activities must be carried out in accordance with Schedule F, Table 1— Authorised petroleum activities in environmentally sensitive areas and their protection zones.

Schedule F, Table 1 – Authorised petroleum activities in environmentally sensitive areas and their protection zones

Environmentally Sensitive Area	Within the Environmentally Sensitive Area	Primary Protection Zone of the Environmentally Sensitive Area	Secondary Protection Zone of the Environmentally Sensitive Area
Category A environmentally sensitive areas	No petroleum activities permitted.	Only low impact petroleum activities permitted.	Only essential petroleum activities permitted.
Category B environmentally sensitive areas that are other than 'endangered' regional ecosystems	Only low impact petroleum activities permitted.	Only low impact petroleum activities permitted.	Only essential petroleum activities permitted.
Category B environmentally sensitive areas that are 'endangered' regional ecosystems	Only low impact petroleum activities permitted.	Only essential petroleum activities permitted.	Only essential petroleum activities permitted.
Category C environmentally sensitive areas that are 'nature refuges' or 'koala habitat'	Only low impact petroleum activities permitted.	Only low impact petroleum activities permitted.	N/A
Category C environmentally sensitive areas that are 'essential habitat', 'essential regrowth habitat' or 'of concern' regional ecosystems	Only low impact petroleum activities permitted.	Only essential petroleum activities permitted.	N/A
Category C environmentally sensitive areas that are 'regional parks' (previously known as 'resources reserves')	Only essential petroleum activities permitted.	Only essential petroleum activities permitted.	N/A
Category C environmentally sensitive areas that are 'state forests' or 'timber reserves'	Only essential petroleum activities permitted.	Petroleum activities permitted.	N/A

(F8) Despite condition (F7) of this environmental authority, activities specified in Schedule F, Table 2 – Authorised petroleum activities in ESAs and protection zones are authorised under this approval:

Schedule F, Table 2 – Authorised petroleum activities in ESAs and protection zones

ESA	Description of Permitted Activities	Extent Disturbance Authorised within the PPZ of the ESA	Corner Points (Lat / Long)
Category C environmentally sensitive areas that are 'essential habitat', 'essential regrowth habitat' or 'of concern' regional ecosystems	Compression Facility	0.15	-26.276666; 148.948178 -26.277223; 148.948319 -26.277163; 148.948045
	Site Offices	1.09	-26.27508; 148.945387 -26.275233; 148.946118 -26.275893; 148.945949 -26.275739; 148.945217
			-26.275253; 148.946217 -26.275476; 148.946932 -26.276059; 148.94679 -26.275914; 148.946056
	Laydown	1	-26.275522; 148.947035; -26.276208; 148.947881; -26.276799; 148.947723; -26.276587; 148.94675

4.5.2. Justification

In selecting the location for the compression facility Senex first refined the general areas based on technical and operational requirements. It then applied its Constraints Protocol (**Appendix D**) to further refine location, and on identifying a potential site was able to avoid all environmental constraints in the area. However, subsequent negotiations with the landholder meant that Senex had to relocate the temporary areas required during construction and move the facility location slightly to the west in order to avoid landholder infrastructure (cattle corridor). In accommodating landholder requirements (a pre-requisite in being able to maintain its social license to operate) impacts within the PPZ of a Category C ESA became unavoidable.

These impacts are limited spatially and temporally, with a long-term impact of 0.15 ha associated with the necessity of locating a sediment basin at the lowest point of the proposed CPF disturbance footprint.

4.5.3. Impacts to Environmental Values

As described in section 7 and Appendix E of this report, the proposed location of the compression facility is devoid of any MSES or MNES values and is comprised of extensively grazed exotic pasture (buffel grass) with no patches of remnant or regrowth vegetation present.

While up to 2.24 ha of disturbance will occur within the PPZ of a category C ESA (Of Concern RE), a number of factors mean that impacts to environmental values as a result of the proposed disturbance are expected to be negligible:

- the lack of MSES, MNES, habitat or other environmental values within the disturbance area
- 2.09 ha out of a total of 2.24 ha of disturbance will be temporary and short term.
- The 0.15 ha of long-term disturbance will comprise a stormwater sediment basin, which may conversely provide a degree of habitat which is not currently present on site.

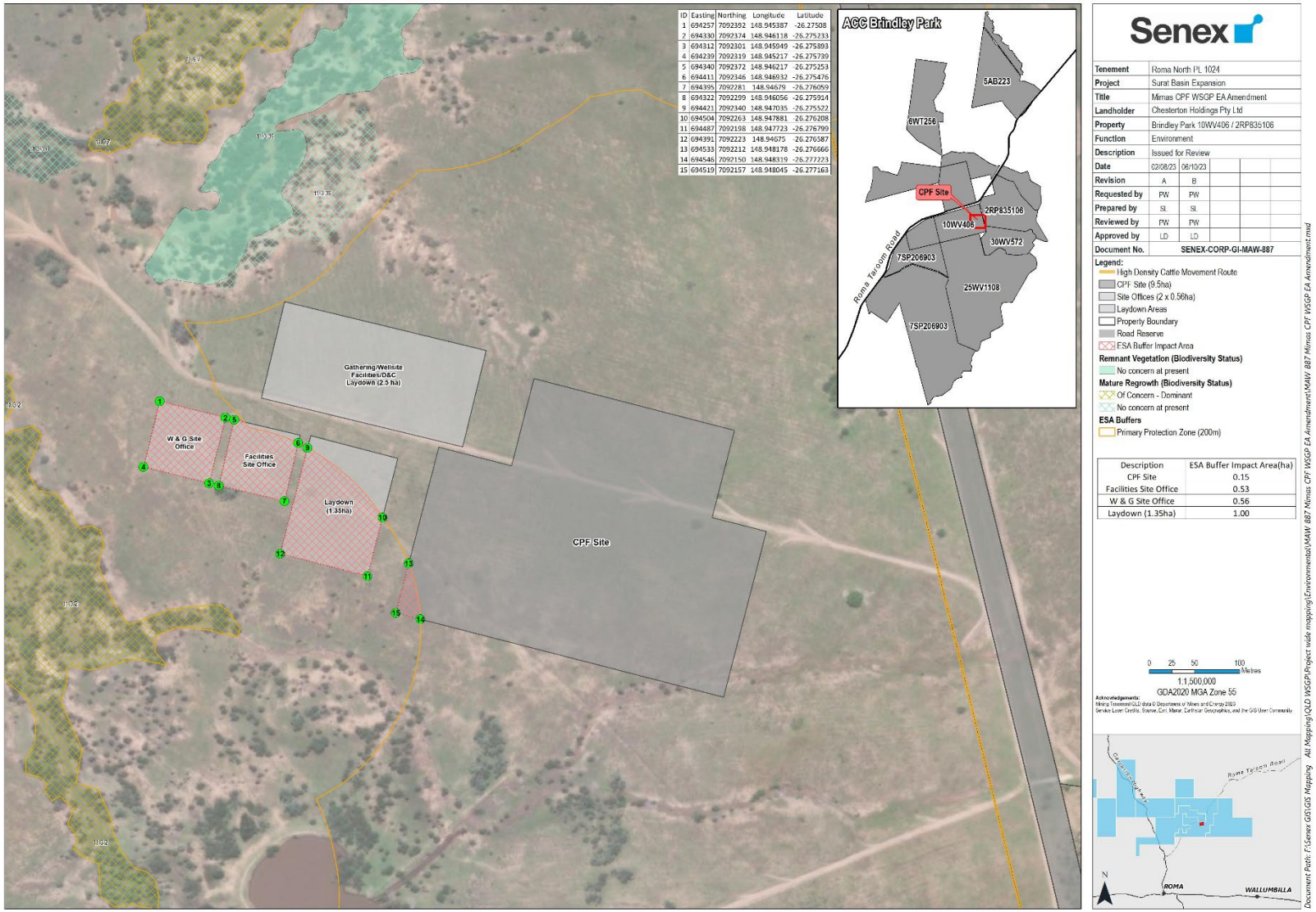

Figure 4: Site Location and Configuration Relative to the PPZ

4.6. Amending the Definition of Essential Petroleum Activities

Senex proposes to amend the definition of essential petroleum activities to better reflect activities that are essential to the daily operation of a CSG project. The proposed definitions have appeared in other resource Eas such as EPPG00935413 (PL196).

The development of CSG resources necessarily involves the 30ecognizes30ation of coal seams through the extraction of water to reduce pore pressures and allow gas to desorb from the coals and be extracted via wells. The ability to manage produced water effectively and in accordance with the relevant EA conditions, is an essential part of CSG activities.

Management of produced water is usually via dams or other storages (including tanks). The ability to interlink water storages to balance water flows across producing gas fields is essential to the safe and effective operation of the storages, and subsequently the efficient and ongoing production of gas. The ability to manage water balances across the field also allows dams to remain within operating envelopes as required by other EA conditions and in accordance with the required Consequence Category Assessments (CCAs). Therefore, it is proposed to amend the definition of "essential petroleum activities" to expand "gathering / flow pipelines from a well head to the initial compression facility" to incorporate pipeline between water storages and/or compression facilities and water storages.

In addition to managing produced water, Senex may be directed under State and Commonwealth environmental approvals to install monitoring bores/surface water flow gauges or sampling points to support seepage monitoring, groundwater impact monitoring or gauge impacts of activities on existing hydraulic regimes. In some instances, the location of the bore is determined at the discretion of the relevant administering authority and rarely takes into account on-ground constraints.

The current definition of "essential petroleum activity" only includes monitoring bores that are incidental to well sites, i.e., "well sites with monitoring equipment". The installation and use of monitoring bores/surface water flow gauges or sampling points of water on their own is not contemplated despite otherwise being an essential petroleum activity. It is proposed to specify monitoring bores as a standalone as an explicit "essential petroleum activity".

4.6.1. Proposed Amendment

Proposed additional text is included (in red) in the below definition taken from EPPG00651513

"**essential petroleum activities**" means activities that are essential to bringing the resource to the surface and are only the following:

- low impact petroleum activities
- geophysical, geotechnical, geological, topographic and cadastral surveys (including seismic, sample /test / geotechnical pits, core holes)
- single well sites not exceeding 1 hectare disturbance and multi-well sites not exceeding 1.5 hectare disturbance
- well sites with monitoring equipment (including monitoring bores):
    - for single well sites, not exceeding 1.25 hectares disturbance
    - for multi-well sites, not exceeding 1.75 hectares disturbance
- well sites with monitoring equipment (including monitoring bores) and tanks (minimum 1 ML) for above ground fluid storage:
    - for single well sites, not exceeding 1.5 hectares disturbance
    - for multi-well sites, not exceeding 2.0 hectares disturbance
- associated infrastructure located on a well site necessary for the construction and operations of wells:
    - water pumps and generators
    - flare pits
    - chemical / fuel storages
    - sumps for residual drilling material and drilling fluids

- tanks, or dams which are not significant or high consequence dams to contain wastewater (e.g. stimulation flow back waters, produced water)
- pipe laydown areas
- soil and vegetation stockpile areas
- a temporary camp associated with a drilling rig that may involve sewage treatment works that are no release works
- temporary administration sites and warehouses
- dust suppression activities using water that meets the quality and operational standards approved under the environmental authority

- Monitoring bores and/or equipment required to monitor activities or potential impacts associated with activities authorised under an environmental authority
- communication and power lines that are necessary for the undertaking of petroleum activities and that are located within well sites, well pads and pipeline right of ways without increasing the disturbance area of petroleum activities
- supporting access tracks
- gathering / flow pipelines from a well head to, or between, any one or more of the following:
  - the initial compression facility;
  - water storage facility
  - the initial compression facility and/or to, or between, water storage facilities
- activities necessary to achieve compliance with the conditions of the environmental authority in relation to another essential petroleum activity (e.g. sediment and erosion control measures, rehabilitation).

4.6.2. Justification

This amendment 31ecognizes the essential nature of managing produced water, in particular the need to balance water flows across producing gas fields as part of safe and effective operation of the storages.

Similarly, the amendment as it relates to monitoring bores 31ecognizes it as an essential petroleum activity and that they are periodically required to be installed and used in compliance with State and Commonwealth environmental approvals.

4.6.3. Impact to Environmental Values

With regard to gathering / flow pipeline, Condition (F5) of EPPG00651513 limits the width of linear infrastructure corridors to 40m. Senex commits to meeting this limit even with the inclusion of water transfer pipelines. As a result, the proposed amendment doesn't result in any increase in disturbance beyond that which is already authorised under the EA.

The inclusion of water monitoring bores / equipment (e.g. surface water flow gauges or sampling points) allows Senex the flexibility to meet its obligations under both State and Commonwealth environmental approvals. Any disturbance areas associated with monitoring equipment will be minimal and the purpose of any monitoring related disturbance is to better inform the regulator about either baseline conditions, or real time impacts as a result of petroleum activities. The benefit of being able to provide this data outweighs any potential impact from the minimal disturbance required.

5. Existing Management Practices

Potential impacts as a result of the proposed amendments will further be minimized through the application of Senex's internal management plans and procedures which are designed to ensure compliance its EA conditions of approval.

Those directly relevant to the amendments proposed are summarized in the following sub-sections.

5.1. Reinstatement and Rehabilitation

Rehabilitation will be undertaken in accordance with Senex's Rehabilitation Plan Atlas Stage 3 Gas Project (SENEX-ATLS-EN-PLN-018) which addresses the requirements of the rehabilitation SMCs.

The objectives of rehabilitation are to achieve agreed final land uses that are:

- Safe to humans and wildlife
- Stable and non-polluting
- Re-profiled to contours consistent with the surrounding landform.

Proposed rehabilitation measures are summarised in the following sections.

5.1.1. Transitional Rehabilitation

Transitional rehabilitation (also known as reinstatement or partial rehabilitation) will be undertaken on disturbance associated with ongoing operational activities where part of the disturbed area is no longer required.

The aim of transitional rehabilitation is to stabilise disturbed land during the operational phase, thereby minimising potential impacts on surrounding EVs (e.g. minimising erosion and potential for weed establishment). Transitional rehabilitation will generally involve re-contouring the land surface if required, replacing topsoil, and direct seeding groundcover species (pasture or native grasses depending on the final post-disturbance land use) or allowing natural recruitment of plant species, with ongoing maintenance where required.

5.1.2. Final Rehabilitation

Final rehabilitation will be undertaken once the site is no longer required for operational activities and may involve:

- Remediating any contamination;
- Re-contouring the landform;
- Replacing subsoil and topsoil;
- Ripping as required; and
- Direct seeding pasture grass or native grass, or allowing natural recruitment of plant species.

5.2. Waste Management

The proposed amendment will not result in any changes to how waste is managed while carrying out authorised petroleum activities, or rehabilitation objectives. Waste will continue to be managed in accordance with existing waste management practices under the Waste Management Procedure (SENEX-QLDS-EN-PRC-022), and the proposed EA conditions which are consistent with waste SMCs.

Waste management measures generally implemented by Senex are summarised in the following sections.

5.2.1. Emissions and Releases

Wastes likely to be associated with the use of the temporary laydown area and site office include:

- General waste–those wastes not defined as regulated waste under legislation. General wastes comprise putrescible wastes (easily decomposed, recyclable by composting) and non-putrescible wastes (not easily decomposed, may be recyclable);
- Recyclable waste–this waste type is able to be reconditioned, reprocessed or reused; and
- Regulated waste–regulated wastes are those that require specific controls or actions as defined by legislation. Listed, hazardous, regulated, controlled or trackable wastes typically have unique handling and disposal requirements in order to manage specific associated hazards.

Potential waste streams along with the activity likely to generate that waste and the proposed waste minimisation/management measures to be implemented where practicable are detailed in Table 9 below.

Table 9: Waste minimisation measures

Waste Name	Description	Activity	Management Measures
General Wastes			
Domestic wastes	Food scraps, tea bags, coffee grounds etc. Food wrappers and packaging Textile materials Plastic wrapping films, plastic bags Facial tissues, ear plugs Pens and pencils Polystyrene Aluminium foil, waxed paper or cardboard Non-recyclable plastics No recyclables, hazardous wastes, liquids, chemicals or batteries.	All activities	Disposal to licensed landfill
Pipeline tape wrap	Pipeline tape wrap protects pipelines against corrosion	Construction and operational activities	Disposal to landfill
Timber	Untreated timber derived from packaging and uses that cannot be reused or recycled	All activities	In order of preference: reuse or recycle or licensed landfill
Treatment filters and membranes	Cartridge filters generated from the water treatment process	Water treatment	Recycled/reused where practical otherwise disposed to landfill
Uncontaminated scrap metals and wiring	Uncontaminated scrap metals and wiring. No pressurised cylinders or drums with chemical or oily residue	All activities	Recycled where practical otherwise disposed to landfill
Recyclable Wastes			

General Recycling	Plastic bottles and clean food containers Glass bottles and jars, milk cartons, aluminium bottles and cans, metal lids from jars, tin cans, plastic and paper cups. Cardboard and paper packaging Folders, phone books, envelopes, office paper, magazines, cereal boxes, clean paper towels. Scrap metals (uncontaminated) No plastic food wrap or general waste.	All activities	Recycled at local facilities wherever practicable
Intermediate bulk containers	Containers used for transport of fluids and bulk materials	All activities	Returned to supplier once no longer required
Scrap Metals	Uncontaminated scrap metals and wiring No pressurised cylinders or drums with chemical or oily residue	All activities	Recycled at scrap metal recycler
Regulated Wastes			
Asbestos and Synthetic Mineral Fibre Insulation (SMF)	Asbestos can be found in materials such as lagging, insulation, gaskets and brake pads. Examples of SMF include waste insulation and rock wool.	All activities	Transported by an appropriately licensed transporter to an appropriately licensed disposal / recycling facility
Batteries	Lead, gel, nickel-cadmium and alkaline type batteries generated from equipment, vehicles, generators and electronics.	All activities	Recycling facility
Chemical waste and chemical containers (including plastic fuel, and lubricant containers)	Chemical wastes may include herbicides, pesticides, water treatment chemicals (biocides), paint and solvents. Regulated chemical containers are those containing any volume of free chemical that is regulated. These may include waste oil containers, and aerosol cans containing solvent or paint.	All activities	Recycle
Contaminated soil	Contaminated soils are generated where local spills of hydrocarbons and other contaminants may occur.	All activities	Regulate –Treated or regulated landfill General–reuse
Cooking oil	Waste cooking oil is generated from kitchen facilities.	Incidental activities	Recycle
Grease trap waste	Grease trap waste is generated from kitchen facilities.	Incidental activities	Treated at licensed facility

Medical and clinical waste	Sharps and biohazard wastes are generated at camps during routine medical care and treatment.	Incidental activities	Treated at licensed facility
Oily filters, rags, absorbents	Oily filters, rags and absorbents are generated from routine equipment and vehicle servicing, repair and filter changes.	All activities	Recycle
Triethylene Glycol / Glycol / coolant	Waste Triethylene Glycol / Glycol / coolant are generated from vehicle and equipment fluid changes, and as part of the gas dehydration process.	Construction and operational activities	Treated at licensed facility
Tyres	Tyres and tubes are generated from tyre changes on work vehicles and equipment.	All activities	Licensed facility - recycle
Used spill kits	Used spill kits are generated from spill clean-up of chemicals and hydrocarbons.	All activities	Regulated landfill
Waste oil (clean waste oil)	Small quantities of waste oil are generated routinely from vehicle and equipment oil changes.	All activities	Recycle

5.2.2 Potential Impacts and Management Practices

Waste will be managed in accordance with the waste management hierarchy as required by the *Waste Reduction and Recycling Act 2011*:

a) Source Reduction – by eliminating, changing or reducing practices that generates wastes;
b) Reuse – reusing waste materials;
c) Recycling – converting waste into other useable materials;
d) Treatment and Disposal – the rendering of wastes safe by neutralisation of other methods and finally depositing of the waste products which can no longer be reused or recycled.

Application of the waste management hierarchy will avoid or minimise the potential for:

- release of waste to land or waters either through inappropriate waste disposal or accidental release;
- inadequate waste management leading to inappropriate disposal or inadequate re-use and recycling; and/or
- impacts to the environment, land use or well-being of people resulting from inappropriate waste disposal.

6. Environmental Values

Section 9 of the EP Act defines Environmental Value as:

(a) a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or
(b) another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.

The following Environment Protection Policies (EPP) prescribe environmental values as per section (9)(b) of the EP Act:

1. Environmental Protection (Air) Policy 2019
2. Environmental Protection (Noise) Policy 2019
3. Environmental Protection (Water and Wetland Biodiversity) Policy 2019

6.1. EPP Air

The environmental values prescribed by the EPP Air are:

(a) the qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and
(b) the qualities of the air environment that are conducive to human health and wellbeing; and
(c) the qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and
(d) the qualities of the air environment that are conducive to protecting agricultural use of the environment.

The EPP Air is designed to achieve the objectives of the EP Act in relation to the air environment. The air quality goals prescribed for the key pollutants of concern in this study (particulate matter) are shown in Table 6-1.

Table 6-1: EPP (Air) 2019 Ambient Air Quality Objectives for Particulate Matter (SLR, 2023)

Indicator	Environmental Value	Air Quality Objectives µg/m³ at 0°C	Averaging Period	Source
PM_{10}	Health and wellbeing	50	24 Hours	(Qld Gov, 2019), (NEPC, 2021)
		25	Annual	(Qld Gov, 2019), (NEPC, 2021)
$PM_{2.5}$	Health and wellbeing	25	24 Hours	(Qld Gov, 2019), (NEPC, 2021)
		8	Annual	(Qld Gov, 2019), (NEPC, 2021)
TSP	Health and wellbeing	90	Annual	(Qld Gov, 2019)

None of the proposed amendments will result in the generation of emissions to air that are additional to those already assessed and authorized under the existing EA (refer also section 4.4.3).

Senex is confident that it can comply with proposed conditions (D2) to (D4) and impacts to the air environment have not been discussed further.

6.2. EPP Noise

The environmental values prescribed by the EPP Noise are:

(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following—
    (i) sleep;
    (ii) study or learn;
    (iii) be involved in recreation, including relaxation and conversation; and
(c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

The EPP Noise also defines acoustic quality objectives (Table 6-2), and where these are met noise levels are deemed to achieve the environmental values.

Table 6-2: Acoustic Quality Objectives (SLR, 2023)

Sensitive Receptors	Time of Day	Acoustic Quality Objectives (Measured at the Receptor, dBA)			Environmental Value
		$L_{Aeq, adj, 1 hr}$	$L_{A10, adj, 1 hr}$	$L_{A1, adj, 1 hr}$	
Dwelling (for outdoors)	Daytime and Evening	50	55	65	Health and wellbeing
Dwelling (for indoors)	Daytime and Evening	35	40	45	Health and wellbeing
	Night time	30	35	40	Health and wellbeing, in relation to the ability to sleep

Source Schedule 1 Environmental Protection Policy (noise).

None of the proposed amendments will result in the generation of noise emissions that are additional to those already assessed and authorised under the existing EA.

Senex considers it can comply with the requirements of the current EA conditions (C1) to (C6). As a result, potential impacts to the noise environment are not discussed further.

6.3. EPP (Water and Wetlands Biodiversity)

Environmental values for surface waters in the project area are defined in:

- Condamine River Basin Environmental Values and Water Quality Objectives; and
- Dawson River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Dawson River Sub-basin except the Callide Creek Catchment

Under the EPP (Water and Wetland Biodiversity, Environmental Values are also defined as:

(a) for high ecological value waters—the biological integrity of an aquatic ecosystem that is effectively unmodified or highly valued; or

(b) for slightly disturbed waters—the biological integrity of an aquatic ecosystem that has effectively unmodified biological indicators, but slightly modified physical, chemical or other indicators; or

(c) for moderately disturbed waters—the biological integrity of an aquatic ecosystem that is adversely affected by human activity to a relatively small but measurable degree; or

(d) for highly disturbed waters—the biological integrity of an aquatic ecosystem that is measurably degraded and of lower ecological value than waters mentioned in paragraphs (a) to (c); or

(e) for waters that may be used to produce, or from which may be taken, aquatic foods for human consumption—the suitability of the water for—

(i) producing aquatic foods that are safe and suitable for human consumption; and

(ii) having aquatic foods that are safe and suitable for human consumption taken from the water; or

(f) for waters that may be used for aquaculture—the suitability of the water for aquacultural use; or

(g) for waters that may be used for agricultural purposes—the suitability of the water for agricultural purposes; or

(h) for waters that may be used for recreation or aesthetic purposes—the suitability of the water for—

(i) primary recreational use; or

(ii) secondary recreational use; or (iii) visual recreational use; or

(i) for waters that may be used for drinking water—the suitability of the water for supply as drinking water having regard to the level of treatment of the water; or

(j) for waters that may be used for industrial purposes—the suitability of the water for industrial use; or

(k) the cultural and spiritual values of the water.

The proposed amendment to authorise the release of low point drain water (section) has the potential to impact waters. However, the inclusion of proposed condition (B7) means that direct or indict release of pipeline wastewater to waters would not be authorised. As a result, impacts to water and wetland biodiversity as a result of the proposed release of pipeline wastewater are not expected.

The remaining proposed amendments do not propose any disturbance or emissions in addition to those already authorised under the existing and their adoption will not result in any impacts to water or wetland biodiversity.

7. Ecological Assessment

In regard to the potential impacts associated with proposed disturbances within the PPZ of a category C ESA an ecological assessment of the proposed site was undertaken by Boobook ecological consulting (Boobook) in June and August 2021 (**Appendix E**) and the methodology and findings are summarised in the following subsections.

As stated previously, this assessment was undertaken prior to the landholder raising concerns about the impact to the cattle corridor, and as such mapping in this report shows temporary work spaces and site offices to the west of the compression facility. Despite this, the survey covered the areas in question and the findings are directly applicable to this application.

7.1. Environmental Values

The area is located in the Maranoa region. Maranoa has traditionally depended on agriculture for its primary source of economic growth, which has been complemented by developments in the energy and tourism industries. Biodiversity values within the area, reflects the intention for the land to be used for livestock grazing and agriculture.

The area is located in a highly modified area devoid of any mapped remnant ecosystems or regrowth vegetation, and comprising pastures dominated by Buffel Grass. As a result, the area has limited environmental values.

7.2. Methodology

The Ecological assessment used a combination of desktop and field surveys to identify and map notable ecological features as detailed in the following subsections.

7.2.1. Desktop Assessment

To provide baseline data for the field survey, a desktop assessment interrogated the following datasets:

- EPBC Act Protected Matters Search Tool (PMST) (DAWE 2021a)
- WildNet Queensland fauna and flora records (DES 2021a)
- Atlas of Living Australia fauna and flora records (ALA 2021)
- Protected Plants Flora Survey Trigger Map (DES 2021b)
- Referable Wetlands mapping (DES 2021c)
- Environmentally Sensitive Area mapping (DES 2021d)
- Matters of State Environmental Significance (DES 2021e)
- State terrestrial biodiversity and aquatic conservation values (DES 2021f)
- Regulated vegetation mapping (DoR 2021)
- Remnant vegetation RE: Regional Ecosystems – biodiversity status (DES 2021g)
- Mature Regrowth mapping (DES 2020)
- Essential Habitat mapping (DES 2019)
- Ordered stream mapping (DNRM 2010)
- Previous survey data (ERM 2017).

7.2.2. Field Survey

The field ecological survey was conducted via foot and vehicle traverses. Location and other data for all notable features encountered were recorded using a Zebra tablet device, a hand-held GPS unit and written notes.

Baseline surveys and ground-truthing were undertaken with data (fauna habitat features and vegetation community) collected within 50m x 10m plots within representative locations in all identified Regional

Ecosystems and regrowth types within the area. The results of microhabitat assessments were used to predict habitat suitability for EPBC Act and NC Act listed threatened fauna species. The survey area and mapped biodiversity values are shown in Figure 5.

7.2.3. Limitations

During the survey and in the preceding weeks the weather was dry and cool to mild. Total rainfall was close to the median winter rainfall of 53.2 mm at this weather station (BOM 2021). The lack of plant growth may have precluded detection and identification of some herbaceous plant species that may potentially occur within the area.

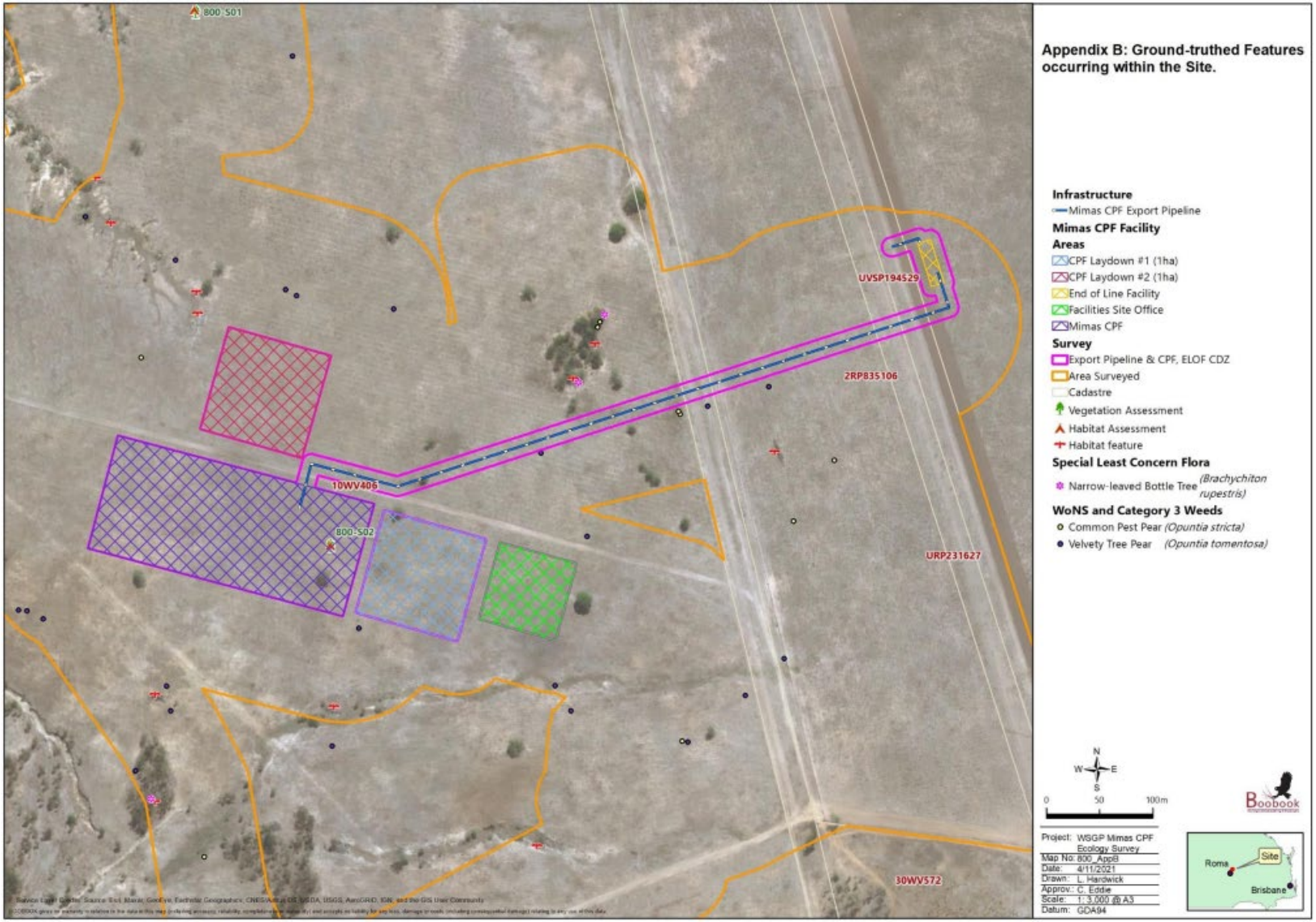

Figure 5: Survey Location and Mapped Biodiversity Values

7.2.4. Findings

The ecological assessment identified the following ecological values/potential constraints:

Matters of National Environmental Significance

- No Threatened Ecological Communities (TEC) were detected within the site
- No EPBC Act listed threatened flora species were detected within the site
- Two species of WoNS were detected within the site:
    - Common Pest Pear (*Opuntia stricta*); and,
    - Velvety Tree Pear (*O. tomentosa*)
- No EPBC Act listed threatened fauna species were detected within the site
- One EPBC Act listed threatened fauna species was assessed as likely to occur within the site:
    - White-throated Needletail (*Hirundapus caudacutus*)
- Five EPBC Act listed migratory and marine fauna species were assessed as potentially occurring within the site.
- No Wetlands of International or National Significance occur within the site.

Queensland Biodiversity Values and Constraints

- There is no remnant or regrowth vegetation within the site
- No NC Act listed threatened flora species were detected within the site
- One selected SLC flora species (*Brachychiton rupestris*) was present within the site
- Two Biosecurity Act Category 3 Restricted Matter invasive plants were present within the site, these being the two WoNS species (above): Common Pest Pear (*O. stricta*) and Velvety Tree Pear (*O. tomentosa*)
- No NC Act listed threatened fauna species were detected within the site
- There is no suitable habitat for NC Act listed threatened fauna species within the site
- There were few potential fauna breeding and/or shelter places within the site
- No referable wetlands occur within the site
- No lakes, springs or GDE occur within the site
- No mapped streams occur within the site.

Project Impacts

- No significant residual impacts of the proposed works are expected on MNES or MSES.

8. Conclusions

The proposed amendments seek to authorise disturbances within the PPZ of a Category C ESA and the inclusion of conditions that allow for the release of pipeline waste water from Low Point drains.

The disturbances within the PPZ of a Category C ESA are necessary for a temporary lay down area and office sites (during construction phase), and the southwest corner of the operational compression facility footprint by virtue of site topography (this is the low point of the site) and its preferred and optimal location (taking into account the associated cost, configuration and landholder preferences).

The temporary disturbances will be remediated once construction of the compression facility is complete. While 0.15ha of impact will exist for the life of the compression facility, remediation at the end of project life will be in accordance with Senex's Rehabilitation Management Plan and conditions of the EA at that time. Notwithstanding, the site being largely been cleared of native remnant vegetation means that potential impacts associated with the proposed amendments are considered limited / negligible.

Releases of pipeline wastewater undertaken in accordance with the proposed EA conditions contained within this document and the RER (Appendix C) will not result in any impacts to environmental values.

The remainder of the proposed amendments are largely administrative in nature and seek only to clarify existing authorised activities, or those which are essential.

Therefore, Senex considers that the proposed amendments to EA EPPG00651513 will enhance operational efficiency, regulatory clarity and continued environmental compliance for Senex's WSGP with minimal potential impact to environmental values.

Appendix A: WSGP Lot / Plan Details

Lot/Plan	Tenure	Lot/Plan	Tenure	Lot/Plan	Tenure	Lot/Plan	Tenure	Lot/Plan	Tenure
6WV282	Freehold	BJSP204333	Easement	BWV803395	Easement	2SP309882	Freehold	66WV762	Freehold
52WV1661	Lands Lease	492FTY894	State Forest	069WV758	Profit à Prendre	36WAL53461	Freehold	12WV1572	Reserve
24WV420	Freehold	1RP173977	Freehold	5AB223	Freehold	25WV283	Freehold	20SP253620	Freehold
481WV895	Freehold	3RP173978	Freehold	4RP887916	Freehold	9AB191	Lands Lease	2AB233	Freehold
2SP309882	Freehold	7SP253624	Freehold	12SP166538	Freehold	CBSP284872	Easement	1WAL53280	Freehold
9WV284	Freehold	29SP252074	Freehold	12AB233	Freehold	41WV1782	Freehold	1SP309882	Freehold
91WV803395	Lands Lease	53WV30	Freehold	AWV1688	Lands Lease	3WV406	Freehold	SWV1949	Easement
4WAL53493	Freehold	3SP180954	Freehold	11RP839475	Freehold	5AB223	Freehold	1SP166548	Freehold
34WV503	Freehold	2CP835110	Freehold	CSP287707	Easement	68WV758	Freehold	5WV406	Freehold
2WV1931	Freehold	HWT355	Easement	1RL7687	Lands Lease	481WV895	Freehold	11WV1275	Reserve
48WAL53470	Freehold	5WV1609	Freehold	1SP309882	Freehold	8WV1578	Freehold	51SP203117	Freehold
17WAL53461	Freehold	3WAL53282	Freehold	2RP835106	Freehold	ASP208671	Easement	16WV1249	Reserve
2CP835110	Freehold	AASP222871	Easement	7SP206903	Freehold	ASP182520	Easement	PRSP270628	Easement
2SP309882	Freehold	31SP178386	Freehold	482WV1655	Freehold	2RP173977	Freehold	066WV762	Profit à Prendre
4WV406	Freehold	14WAL53497	Freehold	2WT299	Lands Lease	69WV758	Freehold	2WAL53666	Freehold
UVSP194529	Easement	8AB223	Freehold	AAP21190	Lands Lease	RWV1948	Easement	37WAL53461	Freehold
37WAL53470	Freehold	2WV1345	Freehold	135WAL53277	Freehold	39WAL53470	Freehold	11WAL53496	Freehold
4WV588	Freehold	5AB137	Freehold	SSSP194529	Easement	BGSP225703	Easement	10AB211	State Land
53WV30	Freehold	28WAL53467	Freehold	15WV1398	Freehold	71WV758	Freehold	BRP234078	Easement
2SP309882	Freehold	ASP166548	Easement	2WV1931	Freehold	26WAL53469	Freehold	64WAL53470	Freehold
27WV523	Freehold	083WV763	Profit à Prendre	11WV1275	Reserve	503WV493	Freehold	62WAL53470	Freehold
3SP180954	Freehold	29SP178386	Freehold	9AB191	Lands Lease	BESP225702	Easement	3RP887916	Freehold
31SP178386	Freehold	16WV1249	Reserve	3AB232	Freehold	10WV406	Freehold	2CP835110	Freehold

068WV758	Profit à Prendre	13WV1398	Freehold	27WV284	Freehold	6WT256	Freehold	BSP182519	Easement
1RP118459	Freehold	13WAL53470	Freehold	DWT352	Easement	BSP287707	Easement	482WV1655	Freehold
4AB209	Freehold	32WAL53493	Freehold	URP231627	Easement	7SP206903	Freehold	21SP253620	Freehold
35WAL53461	Freehold	1WV1661	Freehold	FWT354	Easement	16RP228502	Freehold	70WV758	Freehold
EWT353	Easement	18WAL53461	Freehold	66WV1253	Freehold	389FTY1024	State Forest	8AB223	Freehold
492FTY894	State Forest	1WV1661	Freehold	AWV1953	Easement	28WV1825	Freehold	67WV758	Freehold
CBSP284872	Easement	10WV1554	Freehold	73WV759	Freehold	GRP234082	Easement	BLSP204335	Easement
067WV758	Profit à Prendre	5RP228502	Freehold	AWV1950	Easement	31SP178386	Freehold	30SP252074	Freehold
4WT256	Freehold	CAB251	Easement	488FTY874	State Forest	83WV763	Freehold	TRP231626	Easement
3SP180954	Freehold	37WV1315	Lands Lease	63WAL53541	Freehold	BAP22542	Lands Lease	2SP166548	Freehold
1RP80479	Freehold	72WV758	Freehold	30WV572	Freehold	25WV1108	Freehold	50WV1643	Lands Lease
TTSP194529	Easement	52WV1661	Lands Lease	BHSP204331	Easement	91WV803395	Lands Lease	3WAL53494	Freehold
VRP231627	Easement	1AP14259	Lands Lease	481WV895	Freehold	BISP204332	Easement	1SP203117	Freehold
1WV803395	Lands Lease	9WV1653	Freehold	51SP203117	Freehold	BKSP225704	Easement		

Appendix B: Details of Proposed Amendments

<table>
<tr><th>Schedule</th><th>#</th><th>Condition Text</th><th>Proposed Amendment</th></tr>
<tr><td>A—General</td><td>A1</td><td>
Schedule A, Table 1 - Authorised Petroleum Activities
<table>
<tr><th>Tenure Numbers</th><th>Authorised Petroleum Activity</th><th>Scale</th><th>Intensity (Maximum Size)</th></tr>
<tr><td rowspan="4">ATP767, PL1022, 1023 and 1024</td><td>wells</td><td>442</td><td>442 ha</td></tr>
<tr><td>Historic well pads</td><td>47</td><td>38 ha</td></tr>
<tr><td>Regulated / Low Consequence structures</td><td>11</td><td>110 ha</td></tr>
<tr><td>Sewage Treatment Plants</td><td>3</td><td>>21 EP ≤100EP</td></tr>
<tr><td rowspan="3">ATP767, PL1022, 1023 and 1024</td><td>Field Compressor facility</td><td>3</td><td>11 ha</td></tr>
<tr><td>Central Compression Facility</td><td>1</td><td>6.25</td></tr>
<tr><td>Water Management Facility</td><td>1</td><td>4 ha</td></tr>
</table>
</td><td>
Schedule A, Table 1 - Authorised Petroleum Activities
<table>
<tr><th>Tenure Numbers</th><th>Authorised Petroleum Activity</th><th>Scale</th><th>Intensity (Maximum Size)</th></tr>
<tr><td rowspan="4">ATP767, PL1022, 1023 and 1024</td><td>wells</td><td>442</td><td>442 ha</td></tr>
<tr><td>Historic well pads</td><td>47</td><td>38 ha</td></tr>
<tr><td>Regulated structures</td><td>8</td><td>80 ha</td></tr>
<tr><td>Low Consequence Structures</td><td>3</td><td>30 ha</td></tr>
<tr><td rowspan="2">ATP767, PL1022, 1023 and 1024</td><td>Sewage Treatment Plants</td><td>3</td><td>>21 EP ≤100EP</td></tr>
<tr><td>Field Compressor facility</td><td>4</td><td>17.25 ha</td></tr>
<tr><td>Water Management Facility</td><td>1</td><td>4 ha</td></tr>
</table>
</td></tr>
</table>

B – Waste	B6	**Pipeline waste water, may be released to land provided that it:** **(a) can be demonstrated it meets the acceptable standards for release to land; and** **(b) is released in a way that does not result in visible scouring or erosion or pooling or run-off or vegetation die-off.**	**Insert:** **(B7) Despite condition (B6), where the acceptable standards for release to land cannot be met, release of pipeline wastewater must not occur until:** **a) a suitably qualified person has prepared a written Receiving Environment Report;** **b) does not result in visible scouring or erosion;** **c) does not cause pooling or ponding;** **d) does not cause vegetation die off;** **e) does not cause visible salting.** **(B8) The Receiving Environment Report in B8(a) must at minimum address water quality criteria, which has been determined in accordance with assessment procedures outlined in Schedule B, Table 1 – Assessment procedures for water quality criteria and must include:** **a) a water monitoring program to monitor that the outcomes of B8 are being achieved; and** **b) the frequency of water quality monitoring.**

D – Air

D2–D9

(D2) The operation of fuel burning or combustion facilities must not result in ground level concentrations of contaminants exceeding the maximum limits specified in Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

Schedule D, Table 1—Maximum ground level concentration of contar

Contaminant	EPP Air Quality Objective / Maximum ground level concentration at 0°C	Units	Ave
Nitrogen Dioxide	250	µg/m³	
Nitrogen Dioxide	33	µg/m³	
Carbon Monoxide	11	mg/m³	

(D3) An air receiving environment monitoring program (AREMP) must be developed to demonstrate compliance with the limits in Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

Air receiving environment monitoring program

(D4) An air receiving environment monitoring program (AREMP) must be developed to demonstrate compliance with the limits in Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

(D5) The AREMP must include, but not necessarily be limited to:

(a) the delineation of the relevant air shed(s)

(b) the identification of background reference sites and impact monitoring sites within the relevant air shed(s), including sensitive places

(c) a monitoring program to be carried out annually that:

i. includes background reference and impact monitoring sites

ii. includes an assessment of meteorological conditions (wind speed and direction)

~~**(D2)** *The operation of fuel burning or combustion facilities must not result in ground level concentrations of contaminants exceeding the maximum limits specified in Schedule D, Table 1—Maximum ground level concentration of contaminants to air.*~~

(D2)
A fuel burning or combustion facility must not be operated unless it is listed in **Protecting air values, Table 1–Authorised point sources**.

Schedule D Table 1 – Authorised point Sources

Release Point Reference	Equipment Description	Minimum Release Height (m)	Minimum Efflux Velocity (m/sec)	Maximum Mass Emission Rate (g/sec)	
				NO_x as NO_2	Carbon Monoxide
1	Gas Generator 1	12.45	30	2.0	1.0
2	Gas Generator 2	12.45	30	2.0	1.0
3	Gas Generator 3	12.45	30	2.0	1.0
4	Gas Generator 4	12.45	30	2.0	1.0

iii. is sufficient to determine compliance with the limits listed in Schedule D, Table 1—Maximum ground level concentration of contaminants to air v. identifies the effects of the authorised contaminants released to air in the relevant air shed(s)

vi. is representative of when the fuel burning or combustion facilities are operating under maximum operating conditions for the annual period

(d) an assessment of the condition of each fuel burning or combustion facility; and

(e) a description of other significant point sources in the air shed and surrounding land use including sensitive places.

(D6) A AREMP report must be written annually which includes the information required by condition (D5) and an assessment of the extent to which monitoring data for ground level concentrations complies with the air contaminant limits listed in Schedule D, Table 1—Maximum ground level concentration of contaminants to air.

(D7) Where monitoring data indicates that ground level concentrations listed in Schedule D, Table 1— Maximum ground level concentration of contaminants to air have not been met, the AREMP report required by condition (D6) must also include an assessment of:

(a) the extent to which the values of the air environment in the relevant air shed(s) are being protected

(b) an assessment of whether contaminant releases to the air environment are consistent with the air management hierarchy in the Environmental Protection (Air) Policy 2008, and

(c) any corrective actions that have been implemented or proposed to be implemented to become consistent with the air management hierarchy and achieve compliance with Schedule D, Table 1— Maximum ground level concentration of contaminants to air.

5	Gas Generator 5	12.45	30	2.0	1.0
6	Gas Generator 6	12.45	30	2.0	1.0
7	Gas Generator 7	12.45	30	2.0	1.0

(D3).

If a fuel burning or combustion facility is listed in **Protecting air values, Table 1—Authorised point sources**, the fuel burning or combustion facility must be operated so that the releases to air do not exceed the limits specified in **Protecting air values, Table 1—Authorised point sources** at the specified release point reference.

Point source air monitoring

(D4)

Point source air monitoring for each fuel burning or combustion facility listed in Protecting air values, Table 1—Authorised point sources must:

(a) be undertaken once:

i. in the first three months after each facility is first commissioned, and then

ii. every year thereafter

(b) be carried out when the facility the subject of the sampling is operating under maximum operating conditions for the annual period; and

		(D8) A statement of compliance prepared by a suitably qualified person must accompany each AREMP report required by condition (D6) and if applicable, condition (D7) stating: *(a) whether the AREMP as most recently implemented complies with the requirements of conditions (A4), condition (A8(d)), (D4) and (D5)* *(b) that, to the best of the suitably qualified person's knowledge, the assessment required by condition (D6) and if applicable, condition (D8) is true, correct and complete, and* *(c) that, to the best of the suitably qualified person's knowledge, all information provided as part of the statement of compliance, including attachments, is true, correct and complete.* *(D9) Where condition (D7) applies, the documents required by conditions (D6), (D7) and (D8) must be given to the administering authority within 5 business days after the AREMP report is written.*	(c) demonstrate compliance with the limits listed in Protecting air values, Table 1—Authorised point sources at each release point reference.

<table>
<tr>
<td>F— Biodiversity</td>
<td>-</td>
<td>Not applicable – condition does not exist.</td>
<td>
<table>
<tr><th>ESA</th><th>Description of Permitted Activities</th><th>Extent Disturbance Authorised within the PPZ of the ESA</th><th>Corner Points (Lat / Long)</th></tr>
<tr><td rowspan="3">Category C environmentally sensitive areas that are ‘essential habitat’, ‘essential regrowth habitat’ or ‘of concern’ regional ecosystems</td><td>Compression Facility</td><td>0.15</td><td>-26.276666; 148.948178
-26.277223; 148.948319
-26.277163; 148.948045</td></tr>
<tr><td>Site Offices</td><td>1.09</td><td>-26.27508; 148.945387
-26.275233; 148.946118
-26.275893; 148.945949
-26.275739; 148.945217</td></tr>
<tr><td>Laydown</td><td>1</td><td>-26.275522; 148.947035;
-26.276208; 148.947881;
-26.276799; 148.947723;
-26.276587; 148.94675</td></tr>
</table>
</td>
</tr>
</table>

Definitions	-	**"essential petroleum activities"** means activities that are essential to bringing the resource to the surface and are only the following:
		• low impact petroleum activities
		• geophysical, geotechnical, geological, topographic and cadastral surveys (including seismic, sample / test / geotechnical pits, core holes)
		• single well sites not exceeding 1 hectare disturbance and multi-well sites not exceeding 1.5 hectare disturbance
		• well sites with monitoring equipment (including monitoring bores):
		  ○ for single well sites, not exceeding 1.25 hectares disturbance
		  ○ for multi-well sites, not exceeding 1.75 hectares disturbance
		• well sites with monitoring equipment (including monitoring bores) and tanks (minimum 1 ML) for above ground fluid storage:
		  ○ for single well sites, not exceeding 1.5 hectares disturbance
		  ○ for multi-well sites, not exceeding 2.0 hectares disturbance
		• associated infrastructure located on a well site necessary for the construction and operations of wells:
		  ○ water pumps and generators
		  ○ flare pits
		  ○ chemical / fuel storages
		  ○ sumps for residual drilling material and drilling fluids
		  ○ tanks, or dams which are not significant or high consequence dams to contain wastewater (e.g.stimulation flow back waters, produced water)
		  ○ pipe laydown areas
		  ○ soil and vegetation stockpile areas
		  ○ a temporary camp associated with a drilling rig that may involve sewage treatment works that are no release works
		  ○ temporary administration sites and warehouses
		  ○ dust suppression activities using water that meets the quality and operational standards approved under the environmental authority
		• communication and power lines that are necessary for the undertaking of petroleum activities and that are located within well sites, well pads and pipeline right of ways without increasing the disturbance area of petroleum activities
		• supporting access tracks
		• gathering / flow pipelines from a well head to the initial compression facility
		• activities necessary to achieve compliance with the conditions of the environmental authority in relation to another essential petroleum activity (e.g. sediment and erosion control measures, rehabilitation).
			• **"essential petroleum activities"** means activities that are essential to bringing the resource to the surface and are only the following:
			• low impact petroleum activities
			• geophysical, geotechnical, geological, topographic and cadastral surveys (including seismic, sample /test / geotechnical pits, core holes)
			• single well sites not exceeding 1 hectare disturbance and multi-well sites not exceeding 1.5 hectare disturbance
			• well sites with monitoring equipment (including monitoring bores):
			  ○ for single well sites, not exceeding 1.25 hectares disturbance
			  ○ for multi-well sites, not exceeding 1.75 hectares disturbance
			• well sites with monitoring equipment (including monitoring bores) and tanks (minimum 1 ML) for above ground fluid storage:
			  ○ for single well sites, not exceeding 1.5 hectares disturbance
			  ○ for multi-well sites, not exceeding 2.0 hectares disturbance
			• associated infrastructure located on a well site necessary for the construction and operations of wells:
			  ○ water pumps and generators
			  ○ flare pits
			  ○ chemical / fuel storages
			  ○ sumps for residual drilling material and drilling fluids
			  ○ tanks, or dams which are not significant or high consequence dams to contain wastewater (e.g. stimulation flow back waters, produced water)
			  ○ pipe laydown areas
			  ○ soil and vegetation stockpile areas
			  ○ a temporary camp associated with a drilling rig that may involve sewage treatment works that are no release works
			  ○ temporary administration sites and warehouses
			  ○ dust suppression activities using water that meets the quality and operational standards approved under the environmental authority
			• Monitoring bores and/or equipment required to monitor activities or potential impacts associated with activities authorised under an environmental authority
			• communication and power lines that are necessary for the undertaking of petroleum activities and that are located within well sites, well pads and pipeline right of ways without increasing the disturbance area of petroleum activities
			• supporting access tracks
			• gathering / flow pipelines from a well head to, or between, any one or more of the following:
			  ○ the initial compression facility;
			  ○ water storage facility
			  ○ the initial compression facility and/or to, or between, water storage facilities

			activities necessary to achieve compliance with the conditions of the environmental authority in relation to another essential petroleum activity (e.g. sediment and erosion control measures, rehabilitation).

Appendix C: Receiving Environment Report

Receiving Environment Report for Low Point Drain Water

Senex Energy Gas Gathering Networks

Project Atlas and Western Surat Gas Project

Prepared for:

Senex Energy Limited

Prepared by:

EHS Support

November 2021

Document Control

PROJECT DETAILS

Project No.	AUS##C03468_2021
Report Revision No.	2
Date of Issue	24/11/2021
Project Manager	Joe Hayes

REPORT DETAILS

Title	Receiving Environment Report for Low Point Drain Water
Main Author(s)	Joe Hayes; Phill Wilkinson
Approved By	Kevin Simpson
Client	Senex Energy Limited
Client Contact	Byron Brooks

DISTRIBUTION LIST

Date	No. of Copies	Company/Organisation	Name	Issue Type
29/07/21	1	Senex Energy Limited	Byron Brooks	(e)
08/09/21	1	Senex Energy Limited	Byron Brooks	(e)
24/11/21	1	Senex Energy Limited	Byron Brooks	(e)

Note:
(e) electronic file
(h) hardcopy

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Acronyms

ANZECC	Australian and New Zealand Environment Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
EA	environmental authority
CSG	coal seam gas
DES	Department of Environment and Science
RER	Receiving Environment Report
LPD	low point drain
SMC	Streamline Model Conditions

1 Introduction

EHS Support Pty Ltd (EHS Support) has been retained by Senex Energy Ltd (Senex) to undertake an impact assessment and to develop a receiving environmental report (RER) for releases of water from low point drains (LPD) within the Western Surat Gas Project (WSGP) and project Atlas areas. This report presents the result of the impact assessment, and an RER detailing monitoring requirements and other control measures that would be required to be undertaken to manage potential impacts.

1.1 Background and Context

The WSGP area includes a group of three petroleum leases (PLs) and two authorities to prospect tenures (ATPs)[1]. These tenures are located between 20 and 55 km north-northeast of Roma, Queensland, and are administered under Environmental Authority (EA) EPPG00651513. The Atlas area includes PL1037 and ATP 2059, which are located about 20 km southwest of Wandoan and are administered under EA EA0001207 and EA0002524 respectively. Each of the tenements and respective EAs are identified in **Table 1-1**.

Table 1-1 Senex Surat Basin Tenements and Environmental Authorities

EA Reference	Project Area Reference	Tenements (Field Names)
EPPG00651513	WSGP	PL1022, PL1023, PL1024, ATP767, ATP795* and ATP889
EA0001207	Atlas	PL1037
EA0002524	Atlas	ATP 2059

Table Notes:
PL1023 and PL1024 have been granted over the entire area of ATP795, and therefore this ATP has terminated, but is still listed on the EA.

The WSGP currently comprises approximately 65 gas production wells. Gas is gathered from this field and sent directly to the Roma North Gas Processing Facility, which is owned and operated by Jemena. Atlas comprises approximately 44 gas production wells, with gas sent to the Atlas Gas Processing Facility, which is also owned and operated by Jemena.

The process of CSG production involves the extraction of gas and water through production wells. The gas and water are separated at the well head and routed to processing facilities through separate gas and water gathering networks. Water can enter the gas gathering system through carryover at the wellhead, which then condenses and precipitates within the pipeline. These small quantities of water tend to accumulate within the gathering lines at topographic lows, and although the quantities of water are relatively small, the water must be periodically removed to prevent blockages and allow for the free flow of gas. LPDs are installed at low points in the networks as a means to evacuate this water from the gas gathering lines.

The Atlas and WSGP EAs both include conditions governing releases of contaminants to land, including the potential release of contaminants via pipeline wastewater, which is defined in the EAs as:

[1] ATPs are exploration tenure and unlikely to have gas gathering networks and LPDs. As such assessment of the WSGP has been limited to the area of the PLs.

*"**pipeline waste water**" means hydrostatic testing water, flush water or water from low point drains*

The EA conditions allow pipeline wastewater to be released to land if it meets specified water quality criteria. However, crucially, the Atlas EA also allows for pipeline wastewater to be released to land even where water quality criteria are exceeded, providing that a RER has been prepared. The EA for ATP 2059 does not specifically authorise the release of pipeline wastewater.

Currently, if the water quality does not meet the criteria (or if the water quality is insufficiently characterised to determine if the criteria are met), the water cannot be released. Instead, the water is required to be collected and either disposed of at a suitable waste receiving facility or treated to a quality that allows for the water to be supplied for a beneficial use[2]. Typically, LPD water that cannot be released to land is managed by transferring the water into the water management system (e.g., into an aggregation pond or feed pond). It is not common for LPD water to be disposed of off-site.

The process of collecting LPD water that cannot be released to land is labour and cost-intensive, requiring operators to manually recover the water into a tank or tanker, and then to transport and transfer the water into the water gathering network. This must be done on a routine basis to keep the gas gathering network free of accumulated water.

From a cost and efficiency perspective, the discharge of LPD water directly to ground is preferred over the practice of manual recovery. Notwithstanding, it is recognised there is a potential for environmental harm by discharging to ground and that this must be managed responsibly and done in a manner that does not cause environmental harm. For cases where the LPD water does not meet the current water quality criteria, an application-specific and site-specific assessment of impacts and control measures is necessary as part of an RER, but also to support the potential approval of alternative EA criteria and conditions for the WSGP to further minimise the requirement for manual recovery.

Currently, the criteria in the Atlas and WSGP EAs for the discharge of pipeline wastewater incorporate generic trigger concentration levels for irrigation, which are based on the presumption of routine application of large volumes of water to cropping land over extended time periods. However, LPDs typically generate relatively small volumes of low-salinity water and are in locations where discharges to areas used for crops can be largely avoided. For Atlas, a site-specific assessment (the RER) enables water of different quality to be used. However, for the WSGP the generic trigger levels adopted are not necessarily commensurate with the potential risk of impacts associated with the discharge of LPD water to land and are overly-conservative.

1.2 Purpose and Objectives

The purpose of the impact assessment and associated RER is to determine if the discharge of water from LPDs will pose unacceptable risks to soils, and to develop a program identifying monitoring requirements and other proposed control measures and operational constraints to ensure that proposed future releases of LPD water do not cause environmental harm.

For Atlas, this document is intended to meet the requirements for an RER required by the EA. The WSGP EA does not currently authorise the release of pipeline wastewater to land that does not meet the generic criteria specified in the EA. However, this RER has been developed in anticipation that

[2] For petroleum activities, supply for beneficial reuse is governed under a combination of EA conditions and the Queensland End of Waste (EoW) Framework, which is established under Chapter 8 and Chapter 8A of the *Waste Reduction and Recycling Act 2011*.

the EA will be amended in a manner similar to the Atlas EA regarding discharges of pipeline wastewater to ground and can be used as supporting evidence for such an amendment.

1.3 Scope

The scope of works completed included the following:

- Compilation and review of Senex-provided LPD data for the volumes of water produced from low point drains.
- Compilation and review of Senex-provided LPD water quality data.
- Completion of a screening-level assessment based on the water quality data provided.
- For constituents that did not meet generic trigger levels, further assessment to evaluate potential risks to soils, taking into consideration application-specific and project-specific factors (e.g., volumes discharged, soil contaminant loading, etc.).
- Development of monitoring and other proposed control measures and operational constraints to manage future proposed releases of LPD water.

The scope of this assessment is limited to gas gathering networks within the WSGP and Atlas tenure identified in **Table 1-1**. Whilst this assessment is intended to apply broadly to the Atlas and WSGP areas, further monitoring will be periodically required to confirm that discharges from the current and future LPDs will meet the associated assumptions, constraints and control measures as set out in this document.

The EA water quality criteria are based on short-term (20 year) trigger values (STV) for irrigation established in the *Australian and New Zealand guidelines for fresh and marine water quality. Australian and New Zealand Environment and Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand* (ANZECC & ARMCANZ, 2000) (the ANZECC guidelines). In line with the basis of this criteria, this assessment focused on soils impacts from application of water to land, and largely relies on these guidelines. Considering the generally small volumes of water that is generated by LPDs as compared to that applied to land under an irrigation scenario, the use of irrigation guidelines for LPD water provides a conservative approach.

2 Regulatory Context

The management of wastewater generated from gas gathering networks is regulated under the EAs for each project area refer to **Table 1-1**. The EAs are based on the Queensland guideline *Streamlined model conditions for petroleum activities* (DES, 2016) and contain the following conditions (or very similar conditions) relating to the release of pipeline wastewater to land:

> *Pipeline wastewater may be released to land provided that it:*
> *a) Can be demonstrated it meets the acceptable standards for release to land; and*
> *b) Is released in a way that does not result in visible scouring or erosion of pooling of run-off or vegetation die-off.*

Pipeline wastewater is defined as:

> *hydrostatic testing water, flush water, or water from low point drains.*

Acceptable standards for release to land is defined as:

> *wastewater of the following quality as determined by monitoring results or by characterisation:*
> *a) electrical conductivity (EC) not exceeding 3000 µS/cm*
> *b) sodium adsorption ratio (SAR) not exceeding 8*
> *c) pH between 6.0 and 9.0*
> *d) heavy metals (measured as total) meet the respective short term trigger value in section 4.2.6, Table 4.2.10—Heavy metals and metalloids in Australian and New Zealand Guidelines for Fresh and Marine Water Quality*
> *e) does not contain biocides.*

With the exception of biocides, the water quality criteria are based on generic short-term trigger values (STV) and other guideline criteria for irrigation established in the ANZECC Guidelines. Any water generated from LPDs is considered pipeline wastewater. Therefore, under the current EA conditions, any discharge to land is required to meet these criteria (despite the conservative nature of the criteria as applied to the LPD water discharge scenario).

The Atlas EA contains the following additional conditions authorising the release of pipeline wastewater in cases where the water does not meet the *acceptable standards for release to land.* In such cases, the supplemental conditions require an assessment to be undertaken in accordance with relevant guidelines and an RER to be prepared to ensure that the discharge meets certain outcome-based criteria.

> *Despite condition (B6), where acceptable standards for release to land cannot be met, release of pipeline wastewater must not occur until:*
> *a) A suitably qualified person has prepared a written Receiving Environment Report (RER)*
> *b) Does not result in visible scouring or erosion*
> *c) Does not cause pooling or ponding*
> *d) Does not cause vegetation die off*
> *e) Does not cause visible salting*
>
> *The Receiving Environment Report must at a minimum address water quality criteria, which have been determined in accordance with procedures outlined in Table 1 and must include:*
> *a) A water monitoring program to monitor the outcomes of [Supplemental Condition 1]*
> *b) The frequency of water quality monitoring*

Table 2-1 Assessment procedures for water quality criteria

Water quality criteria	Assessment Procedure
Electrical Conductivity Sodium Absorption Ratio pH	Salinity Management Handbook, with reference to chapter 11; and/ or Australian and New Zealand Guidelines for Fresh and Marine Water Quality, with reference to Volume 1, Chapter 4, and Volume 3 Chapter 9. The assessment should consider: • Soil properties within the root zone to be irrigates (e.g., clay content, cation exchange capacity, exchangeable sodium percentage) • Water quality of the proposed resource (e.g., salinity, sodicity) • Climate conditions (e.g., rainfall) • Leaching fractions • Average root zone salinity (calculated) • Crop salt tolerance (e.g., impact threshold and yield decline) • Management practices and objectives (e.g., irrigation application rate, amelioration techniques) • Broader landscape issues (e.g., land use, depth to groundwater) • Any additional modelling and tests undertaken to support the varied water quality parameters.
Heavy Metals	Salinity Management Handbook, with reference to chapter 11; and/ or Australian and New Zealand Guidelines for Fresh and Marine Water Quality, with reference to Volume 1, Chapter 4, and Volume 3 Chapter 9, The assessment should aim to derive site specific trigger values (e.g., cumulative contaminant limit) based on the methodology provided in the above-mentioned procedure.

As noted in Section 1, the WSGP EA does not contain these same provisions, but it is anticipated that the EA will be amended to include similar conditions in the future.

3 Gas Gathering Water Generation

The following describes the general processes of wastewater generation in CSG gas gathering networks and characteristics of LPD water. This information forms the basis for the impact assessment and control measures detailed in subsequent sections of this document.

3.1 Process Description

The process of CSG production involves the extraction of gas and water through a large network of individual production wells that are screened within target coal seam formations. The Walloon Coal Measures is the principal target formation in the Surat Basin for the production of CSG. Typical target depths range from 400 m to 450 m below ground level for the WSGP and from 675 m to 775 m below ground level for Project Atlas.

To produce gas, water is extracted from the well, which depressurises the formation and allows gas to flow. The gas and water are separated at the well head and routed to processing facilities through separate gas and water gathering networks. The configuration of CSG wells and associated infrastructure can vary due to site and field-specific requirements. The general configurations of a CSG well, which may or may not include an auxiliary gas-water separator, are illustrated in **Figure 3-1.**

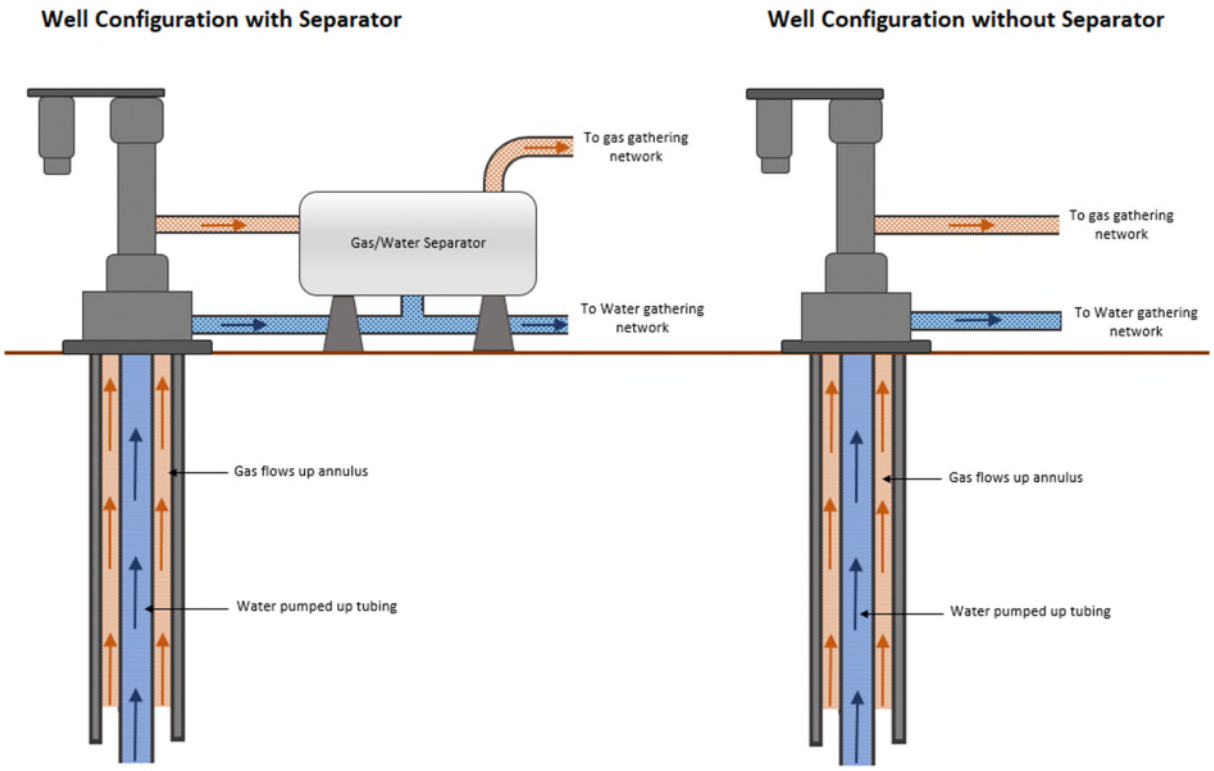


Figure 3-1 Typical well infrastructure

The groundwater is extracted by pumping to surface through production tubing and into the water gathering network. From there, the water is transferred into the water storage system, which comprises one or more aggregation ponds. The water is then treated at a water treatment facility, from where the treated water can then be beneficially re-used under the End of Waste framework, and brine is transferred to a brine storage pond.

The gas flows to the surface under pressure through the well annulus and is then either passed through a gas-water separator (if required) or directly piped into the gas gathering network. From there, the gas is transported to downstream gas processing facilities, where the gas is dried, compressed and transferred into a transport pipeline. Any liquids captured within the separator (if used) are directed into the water gathering network.

At the wellhead, the gas enters the gathering network as a water-saturated gas (or "wet gas"). As the gas is transported, changes in temperature and pressure cause the water vapour to condense, which then precipitates and accumulates within the network. A significant factor in the amount of water generated is the gas pressure and temperature differential between the well head and the gathering network. Wellhead pressures are higher than that of the gathering line, and so as the gas leaves the wellhead, there is a pressure drop. The drop in pressure and associated expansion of gas will tend to decrease the temperatures within the pipeline. In turn, the drop in temperature will cause water in the gas to condense and then precipitate. This is a simplified explanation, but in general, the greater the drop in pressure and temperature, the greater the volume of water that will tend to be generated.

Under certain abnormal operating circumstances, produced water (as distinguished from condensate water from wet gas) can also enter the gas gathering network through the carryover of free water and/or water droplets from the gas-water separator or well annulus into the gas gathering network. Carryover can happen under a few conditions, including the following:

- Unusually high gas velocities
- Slugging of water within the well
- Temporary blockages within the separator

Carryover of produced water is undesirable from an operational perspective. The gathering network is designed and operated to minimise the potential for this to occur, and when it does occur, it is a temporary condition.

Any free water within the gas gathering network (condensation or produced water) flows downgradient and tends to accumulate at topographic low points within the network. Although the quantities of water are relatively small, the water must be periodically removed to prevent blockages (or water locking) and allow for the free flow of gas. To cater for this, during the design phase, considerations are made for the removal of this water through the installation of LPDs. LPDs are placed at topographic low points and provide a means for removal of water at these locations. For the purposes of this report, 28 LPDs in the Atlas gathering network and 4 LPDs in the WSGP gathering network were sampled. At the time of sampling these LPDs were considered representative of those LPDs producing water.

Nearly all of the LPDs within the Atlas and WSGP gathering networks are manually operated, meaning that an operator must open a valve to release the water. There is one automatic drain installed in the WSGP network, which is designed to pump LPD water directly into the adjacent water gathering lines and does not discharge water to grade (and therefore is not considered for this assessment). Senex will continue to consider the installation of additional automatic LPD systems across the identified fields at those LPD locations which typically generate the highest volumes of pipeline wastewater.

LPDs are constructed as an off take from the main subsurface flow line. For manual LPDs, field operators routinely check the LPDs by manually opening a valve which releases any accumulated water. The frequency of checking and opening the drains depends on operational requirements.

However, each LPD is typically opened to remove and recover water about once every two weeks. More frequent drainage of water may be required at LPDs that tend to generate larger volumes of water, or in cases where significant carryover of produced is occurring.

3.2 LPD Water Volumes

As discussed in **Section 3.1**, the volume of water generated within the gas gathering network is related to water condensation from wet gas resulting from pressure and temperature differentials between the wellhead and gas gathering network. In addition, carryover of produced water contributes to the volume of water generated. Other factors that can influence the volume of water generated at individual LPDs include:

- **Topography and Pipe Drainage Area** - LPDs that receive the greatest area of drainage within the gathering network will tend to produce more water than those that capture a relatively small area of drainage.
- **Proximity to production wells** - LPDs within segments of the network that are more proximal to production wells may tend to generate more water, as this is where the greatest pressure differential, temperature differential and capacity for water generation is likely to occur.
- **Gas velocity** - increased gas velocity will increase the potential for the carryover of water from the wellhead.
- **Abnormal operating conditions** - events such as a blockage within the gas-water separator or the slugging of water within the well annulus.
- **Cooler ambient temperatures** - cool temperatures during winter months can increase the potential for condensation and precipitation within the network.
- **New Well Connections** – wells that have recently started operating may increase the risk of carryover.

Senex has provided records of LPD volumes from mid-2020 (**Table 3-1**) and has also provided estimates (based on operational advice) of LPD volumes under three operating scenarios (**Table 3-2**).

The LPD's which have been sampled within the Atlas area were the only drains that produced any significant volume of water (i.e., over 100 L) during the 2020 sampling program. All other drains in the Atlas area were either not producing any volume or a very small amount (approximately 20 L). Any LPDs drains which did not meet the WQ criteria were re-sampled in the second round of monitoring.

In general, Atlas LPD's produce lower volumes than WSGP LPDs (20 to 500 L).

Table 3-1 Monthly Water Volumes from Low Point Drains

Field	LPD	Sample Date	Volume (L)
WSGP	LPD 201 - 1	02/12/2019	No data
		16/01/2020	No data
		10/06/2020	1,000
		28/07/2020	1,250
	LPD 201 - 11	02/12/2019	No data
		28/01/2020	No data
		11/03/2020	2,000
		10/06/2020	1,750
		28/07/2020	2,000
	LPD 207-1	28/07/2020	1,500
	LPD 201-2	28/07/2020	5,000
Atlas	LPD A005	17/06/2020	<100
	LPD A006	17/06/2020	<100
		30/07/2020	<100
	LPD A008	17/06/2020	<100
	LPD A013	17/06/2020	150
		30/07/2020	200
	LPD A016	17/06/2020	<100
	LPD A022	17/06/2020	<100
	LPD A023-1	17/06/2020	600
		30/07/2020	500
	LPD A023-2	17/06/2020	500
		30/07/2020	500
	LPD A202	17/06/2020	250
		30/07/2020	350
	LPD A205	17/06/2020	<100
		30/07/2020	<100
	LPD A207-02	17/06/2020	<100
	LPD A207-4	17/06/2020	<100
	LPD A207-5	17/06/2020	<100
	LPD A208	17/06/2020	<100
		30/07/2020	<100
	LPD A210	17/06/2020	500
		30/07/2020	500
	LPD A212	17/06/2020	200
		30/07/2020	250
	LPD A063	17/06/2020	<100

Field	LPD	Sample Date	Volume (L)
	LPD A035	17/06/2020	<100
	LPD A025	17/06/2020	<100
		30/07/2020	<100
	LPD A026	17/06/2020	<100
	LPD A027-01	17/06/2020	<100
	LPD A027-03	17/06/2020	<100
	LPD A027-04	17/06/2020	<100
	LPD A031	17/06/2020	<100
	LPD A036	17/06/2020	<100
		30/07/2020	<100
	LPD A041	17/06/2020	<100
	LPD A022	17/06/2020	<100
	LPD A009	17/06/2020	<100

Table Notes:
L= litres

Table 3-2 Estimated Total Water Volumes from Low Point Drains Under Various Operating Scenarios

Field	Operating Scenario	Volumes Based on Operations Advice (L/fortnight)
WSGP	Typical	2,000
	High duty	5,000
	Abnormal	7,500
Atlas	Typical	<500
	High duty	2,500
	Abnormal	5,000

Table Notes:
L= litres

Based on the data available, actual volumes generally align with the estimated typical operating scenario volumes and this volume has been used for the calculations detailed later in this report (**Section 6**).

3.3 Water Quality

Water originating from wet gas is, by its nature, very low in dissolved solids, and therefore low in salinity and metals content. In addition, this water is generally at a near neutral pH. However, free water that has originated from wet gas can become commingled with other water present in pipelines, and/or can potentially pick up sediment or dissolved constituents as it travels through the pipeline. Therefore, water from LPDs will typically have some degree of salinity, dissolved solids, major ions, and metals, albeit such concentrations are typically very low.

Water originating from coal formations (i.e., produced water) typically has a moderate salinity, depending on the source. In the Surat Basin, produced water tends to have elevated sodium

absorption ration (SAR) and slightly alkaline pH. The produced water may also exhibit elevated metals concentrations from suspended solids if the water contains significant fines from the formation or drill cuttings. Suspended solids can show as elevated metals in analysis where total metals analysis is used (and if present in significant concentration can sometimes result in elevated dissolved metals in the analysis due to carryover of particles during the filtration process). Therefore, the quality of water from LPDs is typically of low dissolved solids, low salinity, and low metals, but can vary depending on the above variables and the proportion of water derived from wet gas relative to produced water and other materials present within the gathering lines.

Water quality sampling was undertaken by Senex from mid-2020 (Atlas) for 28 LPDs and late 2019 – mid 2020 (WSGP) for 4 LPDs, with the majority of the LPDs sampled on two separate occasions. Samples were analysed for the parameters established in the EAs for *acceptable standards for release to land*, including:

- EC
- SAR
- pH
- heavy metals, including metals species listed in Table 4.2.10 of the ANZECC Guidelines.

The analysis results are provided in **Appendix A**. A statistical summary of the range of results for each area is provided in **Table 3-3** and **Table 3-4**. In compiling this analysis, it should be noted that for some samples, analytes were not detected above the Limit of Reporting (LOR). In some instances (boron, molybdenum and selenium) the LOR was greater than the STV. In order to present a conservative analysis, where this occurred the sample was counted as if it had returned a value equal to the LOR.

In addition, **Appendix B** includes a series of graphs for SAR and metals that compares these results with the corresponding EC value. As discussed in the foregoing, a number of these parameters are correlated with salinity, and therefore, it is useful to understand these relationships.

The following sections provide *general* observations of the water quality of the LPD water based on the results provided by Senex (screening results and the results of assessment of water quality against relevant water quality criteria are detailed in **Section 5** and **Section 6**.

Table 3-3 Summary of LPD Water Quality (Atlas)

Analyte	Units	EA Criteria		No.	Min	10th Pct.	25th Pct.	Median	75th Pct.	90th Pct.	Max.
		Lower Limit	Upper Limit								
PHYSICO-CHEMICAL											
Electrical Conductivity @ 25°C	µS/cm	n/a	3000	38	46	101	209	382	873	4047	202000
pH Value	pH Unit	6	9	38	6.3	6.5	6.7	7.1	7.5	8.1	9.2
Sodium Adsorption Ratio		n/a	8	38	1	1	4	8	23	68	1310
MAJOR AND MINOR IONS											
Fluoride	mg/L	n/a	2	38	0.1	0.1	0.1	0.1	0.3	0.9	11
TOTAL METALS											
Aluminium (total)	mg/L	n/a	20	11	0.014	0.014	0.024	0.279	2	36	44
Arsenic (total)	mg/L	n/a	2	11	0.0003	0.0003	0.0004	0.0011	0.2000	0.2000	0.2000
Beryllium (total)	mg/L	n/a	0.5	11	0.0001	0.0001	0.0002	0.1000	0.1000	0.1000	0.1000
Boron (total)	mg/L	n/a	0.5	11	0.011	0.012	0.024	5	5	5	5
Cadmium (total)	mg/L	n/a	0.05	11	0.0006	0.0105	0.0500	0.0500	0.0500	0.0500	0.0500
Chromium (total)	mg/L	n/a	1	11	0.0009	0.0009	0.0011	0.0021	0.0065	0.0321	0.0382
Cobalt (total)	mg/L	n/a	0.1	11	0.0002	0.0002	0.0008	0.0014	0.0030	0.0911	0.1000
Copper (total)	mg/L	n/a	5	11	0.0005	0.0005	0.0011	0.0059	0.0188	0.4656	0.5000
Iron (total)	mg/L	n/a	10	11	4	4	5	14	19	143	172
Lead (total)	mg/L	n/a	5	11	0.0001	0.0001	0.0004	0.0020	0.1000	0.1832	0.2040
Lithium (total)	mg/L	n/a	2.5	11	0.0017	0.0018	0.0024	0.0035	0.0104	0.0296	0.0322
Manganese (total)	mg/L	n/a	10	11	0.077	0.080	0.186	0.352	0.577	4.473	5.350
Mercury (total)	mg/L	n/a	0.002	11	0.00004	0.00004	0.00004	0.00004	0.00004	0.00046	0.00056
Molybdenum (total)	mg/L	n/a	0.05	11	0.0001	0.0001	0.0003	0.0005	0.0007	0.0806	0.1
Nickel (total)	mg/L	n/a	2	11	0.0006	0.0007	0.0010	0.0018	0.0074	0.4108	0.5000

Analyte	Units	EA Criteria		No.	Min	10th Pct.	25th Pct.	Median	75th Pct.	90th Pct.	Max.
		Lower Limit	Upper Limit								
Selenium (total)	mg/L	n/a	0.05	11	0.0013	0.0410	0.2	0.2	0.2	0.2	0.2
Uranium (total)	mg/L	n/a	0.1	11	0.00007	0.00008	0.00014	0.05	0.05	0.05	0.05
Vanadium (total)	mg/L	n/a	0.5	11	0.0003	0.0003	0.0011	0.0045	0.2000	0.2000	0.2000
Zinc (total)	mg/L	n/a	5	11	0.002	0.002	0.003	0.016	0.033	0.916	1

Table Notes:
µS/cm= microsiemen per centimetre
mg/L= milligram per litre
Cells highlighted pink are those where values exceed the STV

Table 3-4 Summary of LPD Water Quality (WSGP)

Analyte	Units	EA Criteria		No.	Min	10th Pct.	25th Pct.	Median	75th Pct.	90th Pct.	Max.
		Lower Limit	Upper Limit								
PHYSICO-CHEMICAL											
Electrical Conductivity @ 25°C	µS/cm	n/a	3000	6	213	237	305	530	**75400.0**	**187200.0**	**191000.0**
pH	pH Unit	6	9	6	7.2	7	7.4	7.9	**9.2**	**9.3**	8.3
Sodium Adsorption Ratio		n/a	8	6	0.6	2	7.0	**18.1**	**40.1**	**21315.2**	**23600.0**
MAJOR AND MINOR IONS											
Fluoride	mg/L	n/a	2	9	0.1	0.1000	0.2	0.2	**65.2**	**332.0**	**332.00**
TOTAL METALS											
Aluminium (total)	mg/L	n/a	20	4	0.073	ID	0.0923	0.3025	0.7618	ID	0.8640
Arsenic (total)	mg/L	n/a	2	4	0.0004	ID	0.0004	0.1003	0.2000	ID	0.2000
Beryllium (total)	mg/L	n/a	0.5	4	0.1	ID	0.1000	0.1000	0.1000	ID	0.1000
Boron (total)	mg/L	n/a	0.5	4	5	ID	**5.0000**	**5.0000**	**5.0000**	ID	**5.0000**
Cadmium (total)	mg/L	n/a	0.05	4	0.05	ID	0.0500	0.0500	0.0500	ID	0.0500
Chromium (total)	mg/L	n/a	1	4	0.0005	ID	0.0006	0.0010	0.0014	ID	0.0015

Cobalt (total)	mg/L	n/a	0.1	4	0.0002	ID	0.0003	0.0006	0.0013	ID	0.0015
Copper (total)	mg/L	n/a	5	4	0.0006	ID	0.1255	0.5000	0.5000	ID	0.5000
Iron (total)	mg/L	n/a	10	4	0.9	ID	1.0260	1.6400	3.0850	ID	2.0200
Lead (total)	mg/L	n/a	5	4	0.0001	ID	0.0001	0.0004	0.0752	ID	0.0006
Lithium (total)	mg/L	n/a	2.5	4	0.0024	ID	0.0025	0.0031	0.0036	ID	0.0037
Manganese (total)	mg/L	n/a	10	4	0.037	ID	0.0467	0.0821	0.1779	ID	0.2080
Mercury (total)	mg/L	n/a	0.002	4	0.00004	ID	0.00004	0.00004	0.00004	ID	0.00004
Molybdenum (total)	mg/L	n/a	0.05	4	0.0002	ID	0.0002	**0.0501**	**0.1000**	ID	**0.1000**
Nickel (total)	mg/L	n/a	2	4	0.0008	ID	0.0008	0.2504	0.5000	ID	0.5000
Selenium (total)	mg/L	n/a	0.05	4	0.2	ID	**0.2000**	**0.2000**	**0.2000**	ID	**0.2000**
Uranium (total)	mg/L	n/a	0.1	4	0.05	ID	0.0500	0.0500	0.0500	ID	0.0500
Vanadium (total)	mg/L	n/a	0.5	4	0.0003	ID	0.0004	0.0013	0.1505	ID	0.0018
Zinc (total)	mg/L	n/a	5	4	0.002	ID	0.0028	0.0095	0.7535	ID	0.0140

Table Notes:
µS/cm= microsiemen per centimetre
mg/L= milligram per litre
ID – insufficient data to calculate percentile value
Cells highlighted pink are those where values exceed the STV

3.3.1 Electrical Conductivity

The salinity of the Walloon Coal Measures averages approximately 3,000 mg/L total dissolved solids (TDS) (4,700 µS/cm) but can range from 150 mg/L (230 µS/cm) to 18,000 mg/L (28,000 µS/cm) (OGIA, 2019).

The water from the majority of WSGP and Atlas LPDs had a low EC value (typically below about 2,000 µS/cm). The water from these drains is interpreted to be derived from a combination of wet gas and a relatively small proportion of produced water.

Two Atlas LPDs had a moderate EC value, between approximately 2,000 µS/cm and 5,000 µS/cm, which likely reflects a mixture of water derived from wet gas and a more significant proportion of produced water.

One Atlas LPD had a moderately high EC value of over 6,000 µS/cm and two Atlas LDPs had high EC values of 18,300 µS/cm and 202,000 µS/cm, respectively. Subsequent samples taken 6 weeks later from these two LPDs showed EC returning to significantly lower levels of about 1,000 µS/cm. Similarly, one LPD in the WSGP area returned two readings three months apart that were greater than 172,000 µS/cm. Again, a further reading six weeks later showed that EC had dropped significantly to 411 µS/cm. Therefore, these high ECs have been attributed to abnormal operating conditions (carryover of produced water) and measures proposed in **Section 8-2** to mitigate potential risks.

Regarding the above discussion about EC values, note that it is not possible from the data to define precise EC thresholds for characterisation of the water from LPDs, or to determine the precise origin of the water, whether that be from wet gas condensate or produced water.

3.3.2 pH

The pH values of the LPD water ranged from 6.3 to slightly over 9, although the majority of values ranged from 7 (near neutral) to 8 (slightly alkaline).

3.3.3 Sodium Absorption Ratio

The SAR values of the LPD water ranged from less than 1 to 23,600 (WSGP) and less than 1 to 1,300 (Atlas)[3]. The SAR graph in **Appendix B** shows that the SAR values are correlated with salinity. This is likely associated with the presence of produced water (refer to **Section 1-1**), which, from the Walloon Coal Measures in the Senex Surat Basin area contains proportionally high levels of sodium as a major component of the overall salinity.

3.3.4 Metals

The following observations have been made with respect to the metals analysis data presented in **Section 6** and **Appendix A**:

[3] the two highest SAR readings from both Atlas and WSGP are from the same samples that returned elevated EC readings and are assumed to be from abnormal operating conditions. Results from subsequent samples taken six weeks later dropped to between 9 and 16.

- Boron, cadmium, selenium, and uranium were not detected at levels above the LOR in the majority of samples. However, the LoR for selenium and boron was significantly greater than the STV.
- The majority of results for arsenic, beryllium, chromium, cobalt, copper, lead, lithium, manganese, mercury, molybdenum, nickel, vanadium and zinc were detected above the LOR, although concentrations of these species were generally low and below relevant STV criteria.
- Iron and aluminium were detected in every sample, with concentrations generally low although a small number of results were elevated above relevant STV.

Based on the graphs of metals and EC in **Appendix B**, most results that exceeded the STVs were a result of the LOR being greater than the STV. In these instances, further sampling and analysis should be conducted to determine if values exceed the STVs (**Section 7** and **Section 8**). Further assessment to determine suitable screening thresholds or applications rates may be required if the results indicate an exceedance of the STV.

3.4 Abnormal Operating Conditions

Data provided by Senex for Atlas LPD volumes is limited to single samples only and indicates a maximum actual LDP volume of 600 L. For WSGP, more data is available but is based over 6 weeks to 3-month intervals between samples. The largest volume discharged by a WSGP LPD was 5,000 L (201-2).

Senex has provided an estimate for abnormal operating conditions of 5,000 L/fortnight (10,000 L month) and 7,500 L/fortnight (15,000 L/fortnight) for Atlas and WSGP, respectively.

Abnormal operating conditions generally occur when there is carryover of water from wells into the gas gathering network and are usually short-term infrequent events. Two Atlas samples and one WSGP LPD (3 samples) showed very high EC and SAR results and are considered indicative of a carryover event and therefore abnormal operating conditions. This is supported by subsequent readings which showed EC and SAR returning to about the relevant STV.

4 Receiving Environment

The following summarise relevant aspects of the receiving environment for assessment of potential impacts associated with discharges of LPD water to ground.

4.1 Climate

The project development area is temperate, with a warm to hot summer. The mean annual rainfall is 667 mm for Atlas and 563mm for WSGP, with both areas having annual evaporation of approximately 2,000 mm - indicating a water deficit. Most of the rain falls during the summer months.

Climate monitoring data collected by the Bureau of Meteorology (BoM) is available for the Taroom Post Office (Station No. 035070) located about 55km to the northeast of Atlas, and for Roma Airport (Station No. 043091) located about 20km to the south of WSGP. This data is summarised in **Table 4-1** and **Table 4-2**.

Table 4-1 Temperature, Rainfall and Evaporation Statistical Averages for Taroom, Queensland (1952 to 2021)

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temp (°C)	Max	33.9	33	32	29	25	22	21	23	27	30	32	34	28
	Min	21	20	18	14	10	7	5	7	11	15	18	20	14
Rainfall (mm)	Mean	97	88	64	35	39	37	33	28	32	55	72	89	667
	10th pct.	28.1	10	8	0.3	2.7	1.2	0.8	1.2	0.5	7.6	13	19	458
	Med.	88	62	50	22	25	27	22	19	21	46	59	78	635
	90th pct.	193.1	195	136	82	82	82	74	72	76	114	148	150	922
Mean days of rain >=1 mm		6	5	4	3	3	3	3	3	3	5	5	6	47.3
Approx. Pan Evaporation (mm)														2000

Table Notes
°C = Celsius
mm = millimetre
Temp. = Temperature
Pct. = percentile
Data from Australia Bureau of Meteorology (http://www.bom.gov.au). Rainfall and temperature based on site number 035070 (Taroom Post Office).

Table 4-2 Temperature, Rainfall and Evaporation Statistical Averages for Roma, Queensland (1995 to 2021)

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temp (°C)	Max	35	33	32	28	24	21	20	23	27	30	32	34	28
	Min	21	20	18	12	7.6	5.2	3.8	4.7	9.3	14	17	20	13
Rainfall (mm)	Mean	68	90	59	32	30	29	21	23	25	50	57	77	563
	10th pct.	4	24	5	0.1	6	3	2	0.2	1	7	14	25	366

Month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Med.	61	69	40	10	21	23	13	18	16	46	50	56	555
	90th pct.	154	185	150	107	66	59	53	52	71	95	103	165	733
Mean days of rain >=1 mm		5	6	4	2	3	3	3	3	3	5	6	7	48
Approx. Pan Evaporation (mm)														2000

Table Notes
°C = Celsius
mm = millimetre
Temp. = Temperature
Pct. = percentile
Data from Australia Bureau of Meteorology (http://www.bom.gov.au). Rainfall and temperature based on site number 043091 (Roma Airport).

4.2 Soils

Site-specific soils analysis was available for one land type in the Atlas area (Mundell) and additional site-specific soil sampling was undertaken by Senex on 23 September 2021. For all other land types the data presented below is based on desktop review and information provided by Horizon Soils (2021) (**Appendix C**). A summary of the identified land and soil types is provided in **Figure 4-1** and **Figure 4-2** with summary soils analysis data presented in **Table 4-3** and **Table 4-4**.

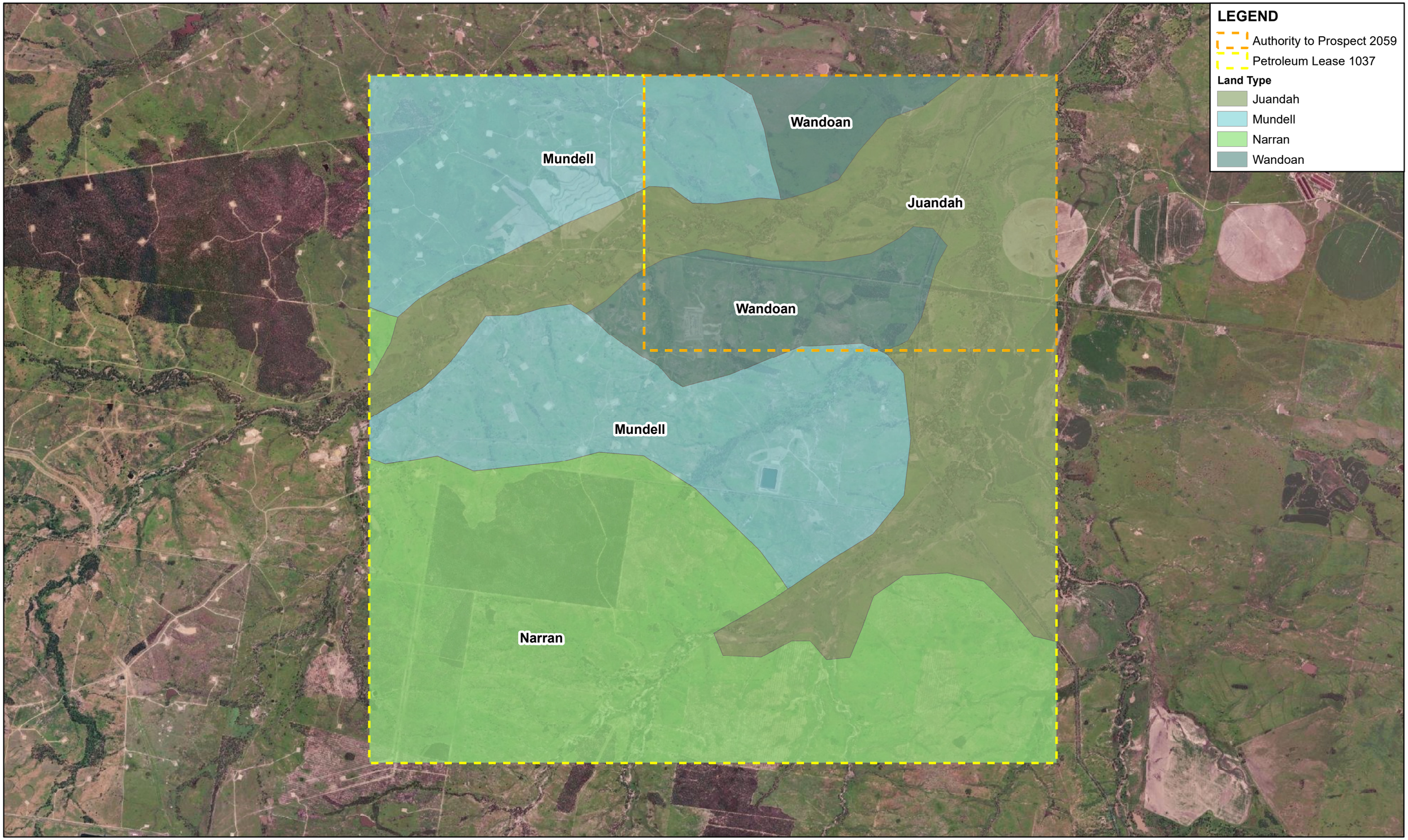
Table 4-3 Project Atlas Summary Soils Analysis

Land Type	Soil type / SALI code	Depth (m)	Clay%	ESP	CEC	CCR	a	b
Juandah	FSE281	0 - 0.1	31	0.8	24	0.77	0.772	-0.98
		0.5 - 0.6	36	5.0	17	0.48	0.706	-1.141
		1 - 1.1	45	5.4	33	0.73	0.802	-0.971
		1.5 - 1.6	27	5.3	24	0.89	0.772	-0.98
Juandah (Senex data)	n/a	0 – 0.1	39	4.1	19.5	0.5	0.706	-1.141
Mundell	n/a	Topsoil 1	47	4.0	31.5	0.67	0.802	-0.971
		Topsoil 2	50	2.2	36.8	0.74	0.802	-0.971
		Topsoil 3	42	7.3	30.8	0.73	0.827	-1.087
		Topsoil 4	45	5.4	33.4	0.74	0.802	-0.971
		Subsoil	48	4.0	41.4	0.86	0.794	-1.105
Mundell (Senex data)	n/a	0 – 0.1	22	0.2	6.1	0.28	-0.011	-0.598
Narran	FSE290	0 - 0.07	21	20.6	16	0.76	0.479	-1.195
		0.1 - 0.2	45	1.5	25	0.56	0.802	-0.971
		0.8 - 0.9	37	22.6	24	0.65	0.827	-1.087
		1 - 1.1	35	23.4	24	0.69	0.827	-1.087
Narran (Senex data)	n/a	0 – 0.1	31	0.2	6.3	0.20	0.147	-0.672
Wandoan	FSE342	0 - 0.05	no data	8.4	32	n.a		
		0.2 - 0.4		33.3	27			
		0.9 - 1.1		49.3	27			

Land Type	Soil type / SALI code	Depth (m)	Clay%	ESP	CEC	CCR	a	b
Wandoan (Senex data)	n/a	0 – 0.1	56	16.4	25.6	0.46	0.812	-1.317

Table 4-4 WSGP Summary Soils Analysis

WSGP Land type	Soil type / SALI code	Depth	Clay%	ESP	CEC	CCR	a	b
Brigalow Uplands	Limewood	0-10	23	1.7	22	0.96	0.295	-0.671
		20-30	41	6.8	38	0.93	0.831	-0.962
		50-60	37	15	34	0.92	0.831	-0.962
		80-90	23	21	29	1.26	0.295	-0.671
Brigalow Uplands	Wondolin	0-10	11	3.4	38	3.45	-0.559	-0.067
		23-30	11	10.3	36	3.27	-0.559	-0.067
		50-60	10	18.1	37	3.70	-0.559	-0.067
		80-90	14	18.6	37	2.64	-0.559	-0.067
		110-120	16	17.3	40	2.50	0.295	-0.671
		140-150	18	10.7	38	2.11	0.295	-0.671
	Eumomurrin	0-10	35	2.1	33	0.94	0.831	-0.962
		23-30	45	6.9	39	0.87	0.794	-1.105
		50-60	45	20	37	0.82	0.794	-1.105
	Glenorden	0-10	27	1.8	24	0.89	0.772	-0.098
		20-30	45	12	31	0.69	0.802	-0.971
		50-60	50	25	35	0.70	0.802	-0.971
		80-90	41	7	30	0.73	0.827	-1.087
Bymount	Nimitybelle	0-10	34	1.1	29	0.85	0.831	-0.962
		23-30	45	2.9	33	0.73	0.802	-0.971
		50-60	45	1.1	32	0.71	0.802	-0.971
		80-90	45	22	28	0.62	0.802	-0.971
		110-120	49	23	34	0.69	0.802	-0.971
	Pamaroo	0-10	15	0.7	14	0.93	0.479	-1.19
		23-30	41	3.3	29	0.71	0.827	-1.087
		50-60	34	8	20	0.59	0.633	-1.032
		80-90	29	8.9	19	0.66	0.633	-1.032
		110-120	21	10	16	0.76	0.479	-1.195
Merivale (Senex data)	Merivale	0 – 0.1	21	0.4	7	0.31	-0.011	-0.593
Maranoa	No data (but not impacted by any WSGP activities yet)							



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Project Atlas

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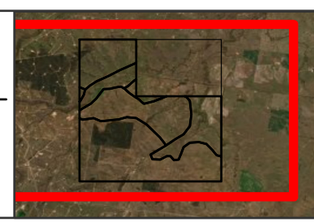
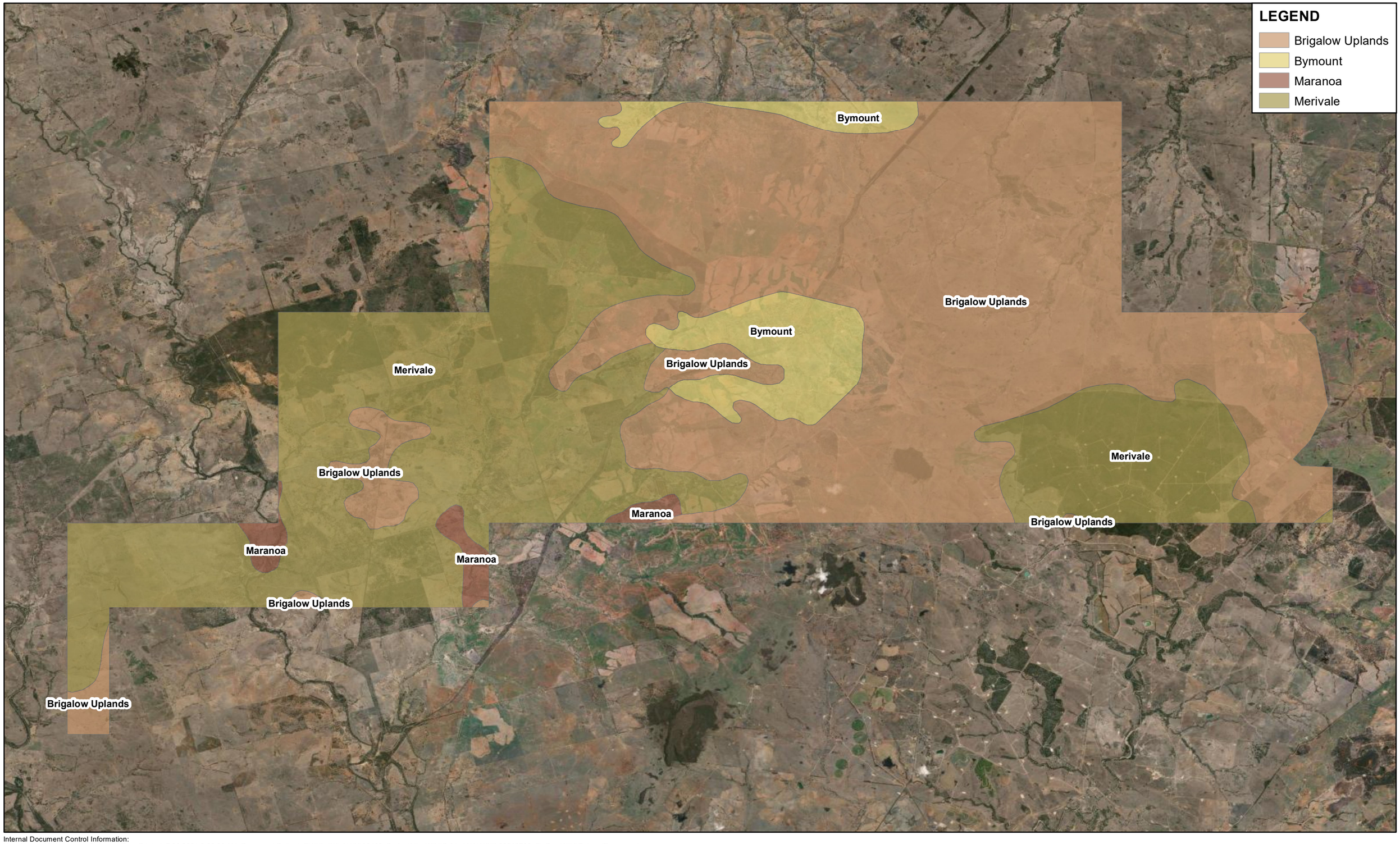


Figure 2

N

CREATED BY:	M. Osburn
APPROVED BY:	P. Wilkinson
PROJECT REF. NO:	AUS##C03468_2021
MAP PROJECTION:	Transverse Mercator
GRID/DATUM:	GCS GDA 1994
SCALE:	1:46,675
AERIAL IMAGE SOURCE:	GOOGLE EARTH PRO © DIGITAL GLOBE 2018



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1 cm = 2 km [Page Size: A4]

Western Surat Gas Project (WSGP)

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Figure 4-2

CREATED BY:	M. Osburn
APPROVED BY:	P. Wilkinson
PROJECT REF. NO:	AUS#C03468_2021
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GRID/DATUM:	GCS GDA 1994
SCALE:	1:151,343
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N

4.3 Vegetation

Regional ecosystem (RE) mapping has been used to determine the plant species which are known to occur within Senex's tenures. Where salinity tolerance values are available for these species, they are included in **Table 4-5.**

Within the right-of-way (RoW) for the gathering network, the majority of the alignment is typically cleared, and part of the RoW is then revegetated, primarily with pasture species. Tree and shrub species are unlikely to be present within gas gathering RoWs due the requirement to keep them clear of roots which have the potential to cause pipeline damage. The most likely species to be present within the current gathering line RoWs are grass and pasture species. Satellite imagery shows that the predominant land use in both areas is grazing and forestry. Notwithstanding, due to potential for gathering networks to be installed in cropping areas in the future, salinity thresholds for common cropping species are considered.

Table 4-5 Summary of Vegetation

Common Name	Scientific Name	Associated RE within Project Area*
Pasture Species		
Buffel grass, Gayndah	Cenchrus ciliaris var. Gayndah	n/a
Buffel grass, Nunbank	Cenchrus ciliaris var. Nunbank	n/a
Rhodes grass, Pioneer	Chloris gayana	n/a
Couch grass	Cynodon dactylon	RE 11.3.25
Green panic, Petri	Panicum maximum	-
Trees/Shrubs		
Black oak, Belah	Casuarina cristata	11.3.2, 11.3.25, 11.9.4a, 11.9.5, 11.9.5a, 11.9.10,
River red gum	Eucalyptus camaldulensis	11.3.2, 11.3.25
Forest red gum	Eucalyptus tereticornis*	11.3.2, 11.3.25 and 11.5.1
Lemon scented gum	Corymbia citriodora* subsp. variegata	-
Coolabah	Eucalyptus coolabah	11.3.25
Crops		
Barley – grain	Hordeum vulgare	n/a
Barley – Forage	Hordeum vulgare	n/a
Barley – hay	Hordeum vulgare	n/a
Cotton	Gossypium hirsutum	n/a
Oats	Avena sativa	n/a
Sorghum	Sorghum bicolor	n/a
Sorghum, crooble	Sorghum alum	n/a
Sunflower	Helianthus annuus	n/a
Wheat	Triticum aestivum	n/a
Wheat, durum	Triticum turgidum	n/a

*Sourced from Re mapping and technical RE descriptions (DES, 2018)

4.4 Groundwater

Due to the generally low volumes of water generated from LPDs, the controlled manner in which water would be applied to land (i.e., surficial wetting only and no ponding) and the clay content of natural soils (which have a low permeability), infiltration into groundwater is minimised, and the risk of impacts to groundwater resulting from application of LPD water are minimal.

As a result, the groundwater receiving environment has not been defined and impacts to groundwater have not been assessed.

4.5 Discharge Area and Potential Application Rates

Applying the typical operating scenario LPD discharge volumes of 1,000 L/month and 4,000 L/month for Atlas and WSGP gives annual discharge volumes of 12,000 L and 48,000 L, respectively.

The discharge area can be adjusted to maintain application rates below a specified threshold. Based on the volumes generated, the application rates for both areas can be managed to 200 mm/year or less, whilst maintaining a reasonably small discharge area. Although this value is somewhat arbitrary, maintaining an application rate below this level would mitigate most potential water quality criteria issues associated with salinity or metals. In comparison, the STVs are based on an irrigation rate of 1,000 mm/year (or 5 times this amount) as per Section 9.2.5.2 of ANZACC/ARMCANZ (2000).

For 12,000 L/year an application rate of 200 mm/yr can be maintained with a discharge area of 60m^2 (7.5m by 8m) while for 48,000 L/year a discharge area of 240m^2 (15m by 16m) would be required.

The above calculations are based on extrapolation of the estimated amount discharged per fortnight to a yearly rate and assumes that this rate is sustained. However, the limited data available for actual discharges indicates that volumes are likely to be significantly less than the estimated normal operating scenario for the majority of LPDs. Time-series monitoring of discharge volumes would confirm this and may mean the assessments in this report can be revisited on the basis of lower discharge volumes (**Section 7** and **Section 8**).

Whilst noting that 200 mm/yr would mitigate potential water quality criteria issues, the analysis undertaken has modelled application rates of up to 1000 mm/yr.

5 Screening Results

Table 5-1 provides a summary of the water quality analysis results compared with the STV for irrigation (as specified in the various EAs for the Senex Surat Basin Tenements). Analysis results that exceed the upper limit in the EA are highlighted red. Individual results are compared with the STVs in **Appendix A**.

Table 5-1 Summary of LPD Water Quality Screening Results (Atlas)

Analyte	Units	EA Criteria		No. Samples	Max	LPD Locations Exceeding EA Criteria
		Lower Limit	Upper Limit			
PHYSICO-CHEMICAL						
EC (lab)	µS/cm	n/a	**3000**	36	**202000**	A005, A036, A202, A205
pH (lab)	pH Unit	6	**9**	38	**9.2**	A205
SAR	SAR unit	n/a	**8**	36	**1310**	A005, A006, A013, A023-2, A025, A035, A036, A202, A205, A208, A210, A212
TOTAL METALS						
Aluminium	mg/L	n/a	**20**	38	**44**	A205
Arsenic	mg/L	n/a	2		0.2000	
Beryllium	mg/L	n/a	0.5	11	0.1000	
Boron	mg/L	n/a	**0.5**	11	**5**	A203-1, A203-2, A025, A036, A208, A210, A212*
Cadmium	mg/L	n/a	0.05	11	0.0500	
Chromium	mg/L	n/a	1	11	0.0382	
Cobalt	mg/L	n/a	0.1	11	0.1000	
Copper	mg/L	n/a	5	11	0.5000	
Iron	mg/L	n/a	**10**	11	**172**	A006, A013, A025, A202, A205, A208, A210, A212
Lead	mg/L	n/a	5	11	0.2040	
Lithium	mg/L	n/a	2.5	11	0.0322	
Manganese	mg/L	n/a	10	11	5.350	
Mercury	mg/L	n/a	0.002	11	0.00056	
Molybdenum	mg/L	n/a	**0.05**	11	**0.1**	A212*
Nickel	mg/L	n/a	2	11	0.5000	
Selenium	mg/L	n/a	**0.05**	11	**0.2**	A023-1, A005, A006, A013, A023-2, A025, A036, A202, A205, A208, A210, A212*
Uranium	mg/L	n/a	0.1	11	0.05	
Vanadium	mg/L	n/a	0.5	11	0.2000	
Zinc	mg/L	n/a	5	11	1	

Notes:
Max= Maximum result
mg/L = milligram per litre
Cells highlighted pink are the where the STV was exceeded by any sample from the area
*Analyte not detected, but LOR greater than STV

Table 5-2 Summary of LPD Water Quality Screening Results (WSGP)

Analyte	Unit	EA Criteria		No. samples	Max.	LPD Locations Exceeding EA Criteria
		Lower Limit	Upper Limit			
PHYSICO-CHEMICAL						
EC (lab)	µS/cm	n/a	**3000**	11	**191000**	201-11
pH (lab)	pH Unit	6	**9**	11	**9.3**	201-11
SAR	SAR unit	n/a	**8**	11	**23600**	201-1, 201-2, 207-1
TOTAL METALS						
Aluminium	mg/L	n/a	20	3	0.864	
Arsenic	mg/L	n/a	2	3	0.2	
Beryllium	mg/L	n/a	0.5	3	0.1	
Boron	mg/L	n/a	**0.5**	3	**5**	201-1. 201-11. 201-2, 207-1*
Cadmium	mg/L	n/a	0.05	3	0.05	
Chromium	mg/L	n/a	1	3	0.0015	
Cobalt	mg/L	n/a	0.1	3	0.0015	
Copper	mg/L	n/a	5	3	0.5	
Iron	mg/L	n/a	10	3	3.4	
Lead	mg/L	n/a	5	3	0.1	
Lithium	mg/L	n/a	2.5	3	0.0037	
Manganese	mg/L	n/a	10	3	0.208	
Mercury	mg/L	n/a	0.002	3	0.00004	
Molybdenum	mg/L	n/a	**0.05**	3	**0.1**	207-1*
Nickel	mg/L	n/a	2	3	0.5	
Selenium	mg/L	n/a	**0.05**	3	**0.2**	201-1, 201-2, 207-1*
Uranium	mg/L	n/a	0.1	3	0.05	
Vanadium	mg/L	n/a	0.5	3	0.2	
Zinc	mg/L	n/a	5	3	1	

Notes:
Max= Maximum result
mg/L = milligram per litre
Cells highlighted pink are the here the STV was exceeded by any sample from the area
* Analyte not detected, but LOR greater than STV

Key comments in relation to the statistical summaries in Tables 5-1 and 5-2 are:

- EC exceeded the STVs at a total of four locations, as discussed in Section 3.3.
- The pH field results exceeded the upper pH STV of 9 at two LPDs, but only by a marginal amount (i.e., the maximum pH recorded was 9.3 as compared to the STV of 9).
- SAR exceeded the STVs at seventeen locations.
- Of the metal species analysed, aluminium, boron, iron, molybdenum, and selenium exceeded STVs at one or more locations. The exceedance of the aluminium STV was from a single LPD in the Atlas area and represents an anomaly with other results from Atlas being in

the range of 0.016 – 1.87 mg/L. Iron exceeded the STV at eight locations in the Atlas area, but samples from the WSGP area did not exceed the STV. For boron and selenium, the LOR was generally greater than the STV, so while these metals were not detected in samples, further sampling is required to determine if the relevant STVs will be exceeded.

- The concentrations of the remaining metals were significantly less (up to an order of magnitude less) than the respective STV's. The concentrations of these metals in the LPD water are not expected to pose a risk of environmental harm to soils and further consideration of these metals is not warranted.

By way of comparison, the EC, pH and SAR associated with normal operating conditions only are presented in **Table 5-3**. The analysis shows the following:

- maximum ECs of about 6.6 dS/m and 1.3dS/m for Atlas and WSGP respectively.
- Maximum SAR of 73 and 40 for Atlas and WSGP respectively

Table 5-2: Summary of Atlas and WSGP physico-chemical data under normal operating conditions only

Analyte	Unit	EA Criteria		No. samples	Max.	LPD Locations Exceeding EA Criteria
		Lower Limit	Upper Limit			
Atlas						
EC (lab)	µS/cm	n/a	**3000**	11	**6630**	A005, A036
pH (lab)	pH Unit	6	9	11	8.2	
SAR	SAR unit	n/a	**8**	11	**73**	A005, A006, A013, A023-2, A025, A035, A036, A208, A210, A212
WSGP						
EC (lab)	µS/cm	n/a	3000	11	1300	
pH (lab)	pH Unit	6	9	11	8.3	
SAR	SAR unit	n/a	**8**	11	**40.1**	201-1,

Table Notes:
Max= Maximum result
Cells highlighted pink are the here the STV was exceeded by any sample from the area

6 Assessment of Water Quality Results

The following provides an assessment of water quality results for constituents that did not meet the acceptable standards for release to land (i.e., STVs) in one or more of the water quality samples, as per the screening results presented in **Section 5**.

The EA conditions proposed in **Section 2** that provide for the release of pipeline waste water that doesn't meet the acceptable standards for release to land states that, 'the RER must at minimum address water quality criteria, which has [sic] been determined in accordance with assessment procedures outlined in schedule B (**Table 2-1** -Assessment procedures for water quality criteria)'.

These procedures have been developed for assessment of impacts from the irrigation of produced water. Due to the difference in scale between normal irrigation rates (i.e., 1,000 mm/year, as per the ANZECC Guidelines and that which would be required for LPDs, which are a fraction of this amount, the application of these procedures to LPD discharges is a highly conservative approach.

Table 6-1 Assessment Procedures for Water Quality Criteria

Water Quality Criteria	Assessment Procedure
electrical conductivity sodium adsorption ratio pH	Salinity Management Handbook, with reference to Chapter 11; and/or the ANZECC Guidelines with reference to Volume 1 Chapter 4 and Volume 3 Chapter 9. The assessment should consider: • soil properties within the root zone to be irrigated (e.g., clay content, cation exchange capacity, exchangeable sodium percentage) • water quality of the proposed resource (e.g., salinity, sodicity) • climate conditions (e.g., rainfall) • leaching fractions • average root zone salinity (calculated) • crop salt tolerance (e.g., impact threshold and yield decline) • management practices and objectives (e.g., irrigation application rate, amelioration techniques) • broader landscape issues (e.g., land use, depth to groundwater) • any additional modelling and tests undertaken to support the varied water quality parameters
Heavy metals	The ANZECC Guidelines, with reference to Volume 1 Chapters 3 and 4 and Volume 3 Chapter 9. The assessment should aim to derive site specific trigger values (e.g., cumulative contaminant loading limit) based on the methodology provided in the above-mentioned procedure.

6.1 pH

Sections 4.2.10.1 and 9.2.9.1 of the ANZECC Guidelines discuss the effects of pH on soil health. This document states that soil (and animal) health will not generally be affected by water with pH in the range of 4 to 9. In addition, for irrigation water, minor deviations from the guideline values will not significantly affect soil quality owing to the fact that soils tend to be well-buffered.

Based on the sampling that has been undertaken to date, the majority of laboratory pH results were within the acceptable standards for release to land. However, pH results from one LPD showed a marginal exceedance of the upper pH STV (pH 9.3).

Considering that the water application rates from LPDs will be a fraction of the 1,000 mm/year application rate assumed in the calculation of the STVs (refer to **Section 4.3**), that the exceedance was marginal and at a single locations, the pH of the LPD water is not considered to pose a risk to soils or the greater environment. Additional monitoring as recommended in **Section 8** will provide a more detailed picture of general pH levels in both the WSGP and Atlas areas. Further assessment to determine suitable screening thresholds or applications rates may be required dependent on the results.

6.2 Salinity and Sodicity

Application of water with elevated salinity to soil has the potential to increase soil and root zone salinity and also the sodicity of soils. Typically, assessments of root zone salinity are undertaken for irrigation projects to identify the potential for impacts on crops. Root zone salinity calculations have been undertaken for this assessment to provide an indication of the potential for increased salinity that could impact vegetation within the vicinity of LPDs. Notwithstanding, in this setting, the area of discharge around LPDs would be small, with the LPDs requiring a discharge area of between 60m^2 (a 7.5m by 8m area) and 240m^2 (a 15m by 16m area) to achieve an application rate of 200mm/year. Therefore, the potential area of saline impacts to soils would be localised.

LPDs are predominantly located within disturbed areas associated with pipeline ROWs and access tracks. Therefore, the potential for any increased soil salinity impacts on crops is limited. Impacts to plant growth (primarily grasses) along RoWs include the following mechanisms:

- Foliar stress when sodium accumulates in or on leaves
- Development of poor soil structure
- Calcium and magnesium deficiency through reduced availability and imbalance with respect to sodium
- Toxicity to root systems

It is not expected that the limited discharge from LPDs, and typically low salinity values would cause visible salting. This aspect can be effectively managed through routine monitoring (and re-evaluation of discharges if and where potential visible salting occurs).

To assess risks associated with salinity, an assessment was completed in accordance with the ANZECC Guidelines to predict the root zone salinity based on the range of pipeline water quality and release volumes. Again, this is a very conservative approach considering the differences in application rates between a normal irrigation scenario as compared to discharge rates required to manage LPD water.

6.2.1 Methodology for Assessing Salinity and Sodicity Impacts

Consistent with the framework for developing site and application specific criteria, the ANZECC Guidelines include a framework for evaluating salinity and sodicity impacts from irrigation water. Key inputs into the assessment include soil properties, crop salt tolerance and management practices.

The process for development of site-specific criteria is outlined below and in **Figure 6-1**:

- Step 1: Identify the soil properties, water quality, climate (rainfall) and management practices (including irrigation application rates).
- Step 2: Estimate the leaching fraction under the proposed irrigation regime.

- Step 3: Estimate the new average root zone salinity.
- Step 4: Assess the crop salt tolerance appropriate management practices and potential impacts on yield (management practices are discussed in **Section 7** and **Section 8**.
- Step 5: Consider salinity and sodicity problems within the framework of broader catchment issues such as regional water tables, groundwater pollution and surface water quality.

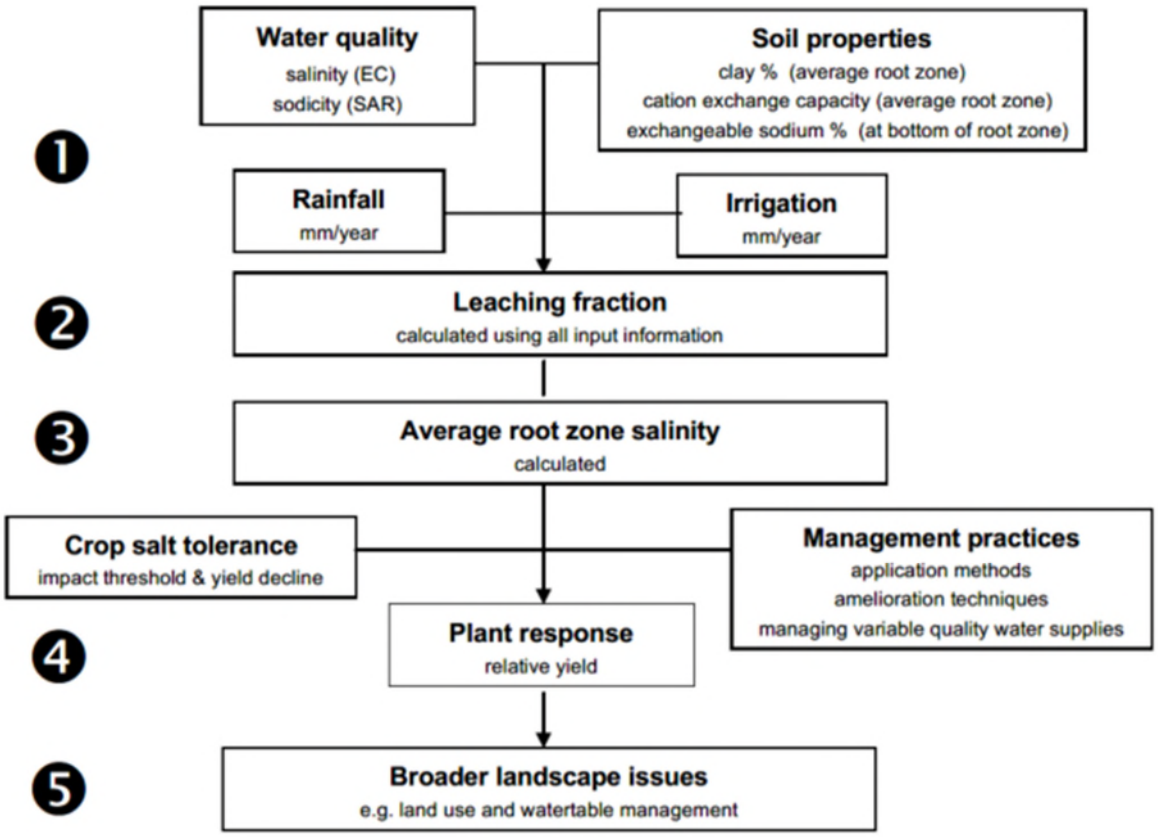

Figure 6-1 Flow Diagram for Evaluating Salinity and Sodicity Impacts of Irrigation Water (from Figure 4.2.1 of ANZACC/ARMCANZ (2000))

A key component of the assessment is consideration of potential management practices (including modification of irrigation methods and rates and soil amendment). Exceedances of generic standards or derived site-specific standards after Step 3 do not preclude the use of pipeline wastewater from LPDs for irrigation under certain conditions. Rather, consistent with the philosophy contained within the ANZECC Guidelines, management practices can be employed to allow use of lower quality water and management or mitigation of harm. These practices (for example land amendment) which are undertaken to ensure that harm is not caused or more importantly, fertility is improved under good irrigation systems agronomic practice, do not inherently contravene the principles contained within the *Environmental Protection Act 1994* (EP Act) or the ANZECC Guidelines.

the ANZECC Guidelines supports this management approach by stating:

> *The effects of salinity and sodicity in irrigation waters are very situation-specific, making it inappropriate to set water quality trigger values for general application. Factors which need to be considered include: the type of crop being cultivated and its*

salt tolerance, the characteristics of the soil under irrigation, soil management and water management practices, climate and rainfall' (refer to Chapter 4, page 4.2-4).

Methodologies for assessment of these potential exposure pathways are contained within Chapter 9 of the ANZECC Guidelines and no additional risk assessment methodologies were required to complete the site and application specific evaluation.

The ANZECC Guidelines assesses each constituent of potential concern (COPC) independent of one another and do not consider cumulative or synergistic effects. The assessment of Electrical Conductivity is considered in the ANZECC Guidelines to provide a broad assessment of the suitability of water for irrigation (including these cumulative effects), with cation and anion specific assessments focused on specific modes of impact to soil structure and quality, plant growth and suitability of crops for feed or human consumption.

For each COPC, the ANZECC Guidelines describe the mode of impact and site or application specific modifiers that could affect this mode of impact. The assessment below mirrors the structure contained within the ANZECC Guidelines with Steps 4 and 5 in the assessment structure on a COPC by COPC basis. The sections for each COPC provide a description of the mode of impact (as described in ANZECC Guidelines), site and application specific modifiers and assesses the relevance to the proposed application. Where calculation methodologies are provided in the ANZECC Guidelines, these are completed to support the assessment.

6.2.2 Evaluation of Salinity and Sodicity

Leaching fraction (LF) and EC form the basis of predicting soil root zone salinity (EC_{se}) and plant response, from which a sustainable irrigation management strategy can be determined. (**Figure 6-2**) shows the general concept for the calculations described below.

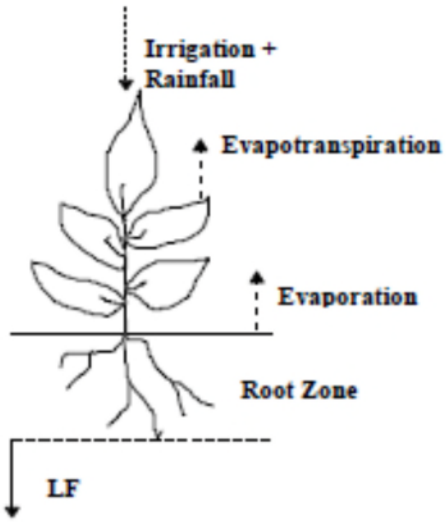

Figure 6-2 Concept for Estimation of Root Zone Salinity

6.2.2.1 Step 1: Calculation of water EC entering the Soil (EC_i)

An initial evaluation of potential impacts to crops can be undertaken by direct comparison of the EC of the water to be applied to the water salinity ratings from Table 9.2.5 of the ANZECC Guidelines. These values are shown in **Table 6-2**.

Based on the LPD water analysis to date, the majority of Atlas LPD water ranges between the "very low" and" low" water salinity ratings (based on the 75th percentile), which can support sensitive to moderately sensitive crops. However, there was one result in the very high category (LPD A005) and two results in the extreme category (LPD A202 and LPD A205). LPD A005 was only sampled once but the high EC reading is considered to be a result of carryover of produced water during abnormal operating conditions.

For the WSGP LPDs, EC ranged between very low and the low end of medium.

Table 6-2 Water Salinity and Crop Tolerances (refer to Table 9.2.5 (ANZECC & ARMCANZ, 2000))

Electrical conductivity (dS/m) of Applied Water	Water salinity rating	Plant suitability
<0.65	Very low	Sensitive crops
0.65-1.3	Low	Moderately sensitive crops
1.3-2.9	Medium	Moderately tolerant crops
2.9-5.2	High	Tolerant crops
5.2-8.1	Very high	Very tolerant crops
>8.1	Extreme	Generally, too saline

To further assess the suitability of the associated water for irrigation of crops, the ANZECC method can be used. The first step is to calculate the combined effect of irrigation water (EC_{iw}) and rainfall (EC_r) entering the soil (EC_i):

$$EC_i = \frac{(EC_r \times D_r) + (EC_{iw} \times D_{iw})}{D_r + D_{iw}}$$

where:

EC_i = electrical conductivity of water entering the soil (rainfall + irrigation), dS/m
EC_r = electrical conductivity of rainfall, taken to be 0.03 dS/m (unless measured locally)
EC_{iw} = electrical conductivity of irrigation water, dS/m
D_r = rainfall depth, mm/year
D_{iw} = depth of irrigation water applied to the soil profile, mm/year

The calculation above considers the ameliorating effect of rainfall on the EC of combined rainfall and irrigation water entering the soil.

Table 6-3 shows the estimated EC of water entering the soil based on the potential range of LPD water application rates and the median annual rainfall for the region (667 mm/yr for Atlas and 563mm/yr for WSGP).

Table 6-3 Calculated Electrical Conductivity of Water entering the Soil (EC_i) (Atlas)

EC of LPD Water (dS/m)		1	2	4	6	8	10	12	14	16
Amount of LPD Water Applied (mm/yr)	50	0.1	0.2	0.3	0.4	0.6	0.7	0.9	1.00	1.14
	100	0.2	0.3	0.5	0.8	1.1	1.3	1.6	1.85	2.11
	200	0.3	0.5	0.9	1.4	1.9	2.3	2.8	3.25	3.71
	300	0.3	0.6	1.3	1.9	2.5	3.1	3.7	4.36	4.98
	400	0.4	0.8	1.5	2.3	3.0	3.8	4.5	5.27	6.02
	500	0.4	0.9	1.7	2.6	3.4	4.3	5.2	6.0	6.9

Table Notes:
ds/m= decisiemen per metre
mm= millimetres

Table 6-4 Calculated Electrical Conductivity of Water entering the Soil (ECi) (WSGP)

EC of LPD Water (dS/m)		1	2	4	6	8	10	12	14	16
Amount of LPD Water Applied (mm/yr)	50	0.1	0.2	0.4	0.5	0.7	0.8	1.0	1.17	1.33
	100	0.2	0.3	0.6	0.9	1.2	1.5	1.8	2.14	2.44
	200	0.3	0.5	1.1	1.6	2.1	2.6	3.2	3.69	4.22
	300	0.4	0.7	1.4	2.1	2.8	3.5	4.2	4.89	5.58
	400	0.4	0.8	1.7	2.5	3.3	4.2	5.0	5.83	6.66
	500	0.5	1.0	1.9	2.8	3.8	4.7	5.7	6.6	7.5

Table Notes:
ds/m= decisiemen per metre
mm= millimetres

The ECi from **Table 6-3** and **Table 6-4 i**s used (in conjunction with other site-specific parameters) to calculate the leaching zone fraction and the average root zone salinity. Root zone salinity is used evaluate plant salt tolerance.

6.2.2.2 Step 2: Calculation of leaching fraction

Soil properties are used to predict soil salinity from the relationship between rainfall, leaching and clay mineralogy. The leaching fraction can be estimated by using measured or estimated values of EC within LPD water and soil zone water and by using known volumes and soil drainage water.

Background soils data was sourced by Horizon Soils from the Land resource areas - Roma district land management field manual (WSGP) and Land resource areas - evaluation of agricultural land in the Taroom Shire (Atlas) and the Soil and Land Information (SALI) database. Laboratory analysis for the Mundell, Narran, Juandah, Wandoan and Merivale Soil Types was provided by Senex. Land type, soils type and SALI sites are detailed in **Table 6-5**.

Application rates of up to 1000mm/yr were modelled for all soils where data was available. Data was unavailable for the Maranoa Land Unit in the WSGP area, but this Land unit is not yet impacted by any WSGP development activities.

Table 6-5 Background Soils Assessment (Horizon Soils, 2021)

Project Atlas Soil type	SALI sites	WSGP Land Unit	WSGP – Soil types (Roma Land Management Field Manual)
Juandah	FSE281	Brigalow Uplands	Limewood Wondolin Eumomurrin Glenorden
Mundell	n/a	Bymount	Nimitybelle Pamaroo
Narran	FSE290	Maranoa	no data
Wandoan	FSE342	Merivale	Merivale

Available soil chemistry data were used for the calculations required for this step refer to **Section 4.2**, **Table 4-2**, with the most conservative values used to create a worst-case scenario. The input parameters for soils properties used for the respective operating fields are summarised in **Table 6-6**.

Table 6-6 Soil Property Parameters Used for Calculation of Leaching Fraction

Soil Type	ESP	Clay (%)	CCR (mmolec/kg)	Coefficient*	
				a	b
Juandah	4.1	35-45%	0.5	0.706	-1.141
Mundell	0.2	15-25%	0.28	-0.011	-0.593
Narran	0.2	25-35%	0.02	0.147	-0.672
Wandoan	16.4	55-65%	0.46	0.812	-1.317
Limewood	15	35-45%	1.26	0.831	-0.962
Wondolin	17.3	15-25%	2.50	0.295	-0.671
Eumomurrin	20	45-55%	0.82	0.794	-1.105
Glenorden	25	45-55%	0.70	0.802	-0.971
Nimitybelle	22	45-55%	0.62	0.802	-0.971
Pamaroo	8.9	25-35%	0.66	0.633	-1.032
Merivale	1.6	15-25%	0.31	-0.011	-0.593

Table Notes:
ESP = Exchangeable Sodium Percentage
CCR = Cation Exchange Capacity to Clay Ratio
*Refer to Table 9.2.8 of the ANZECC Guidelines for calculation coefficients

The leaching fraction that occurs under rainfall is estimated using:

$$LF_r = \frac{EC_r}{2.2 \times 10^{\left[a+blog\left(\frac{EC_r \times (D_r + D_{iw})}{ESP}\right)\right]}}$$

Where:

The total quantity of water applied to the soil[4] is the sum of the depth of rainfall and depth of irrigation water.

Thereafter, the leaching fraction under future irrigation conditions is calculated and used to estimate the average leaching fraction of the root zone (LF_{av}):

$$LF_f = LF_r \left[2.65 \left(\frac{EC_i}{EC_r} \right)^{0.5} - 1.35 \right]$$

$$LF_{av} = \left(0.976 LF_f + 0.022 \right)^{0.625}$$

Where:

LF_f = future leaching fraction predicted after allowing for irrigation water quality and depth.

EC_i = electrical conductivity of water entering the soil, dS/m

EC_r =electrical conductivity of rain = 0.03 dS/m (default value)

6.2.2.3 Step 3: Estimation of Root Zone Salinity

The average leaching fraction is used to estimate the root zone salinity:

$$EC_{se} = \frac{EC_{iw}}{2.2 \times LF_{av}}$$

Where:

EC_{se} = average root zone salinity, dS/m

ECiw = electrical conductivity of irrigation water, dS/m

The calculated root zone salinities for varying LPD water application rates and salinity based on soil properties for the Atlas and WSGP fields are shown in (**Figure 6-3**) to (**Figure 6-12**).

[4] Confirmed by communication with one of the authors (Shaw pers com 2014).

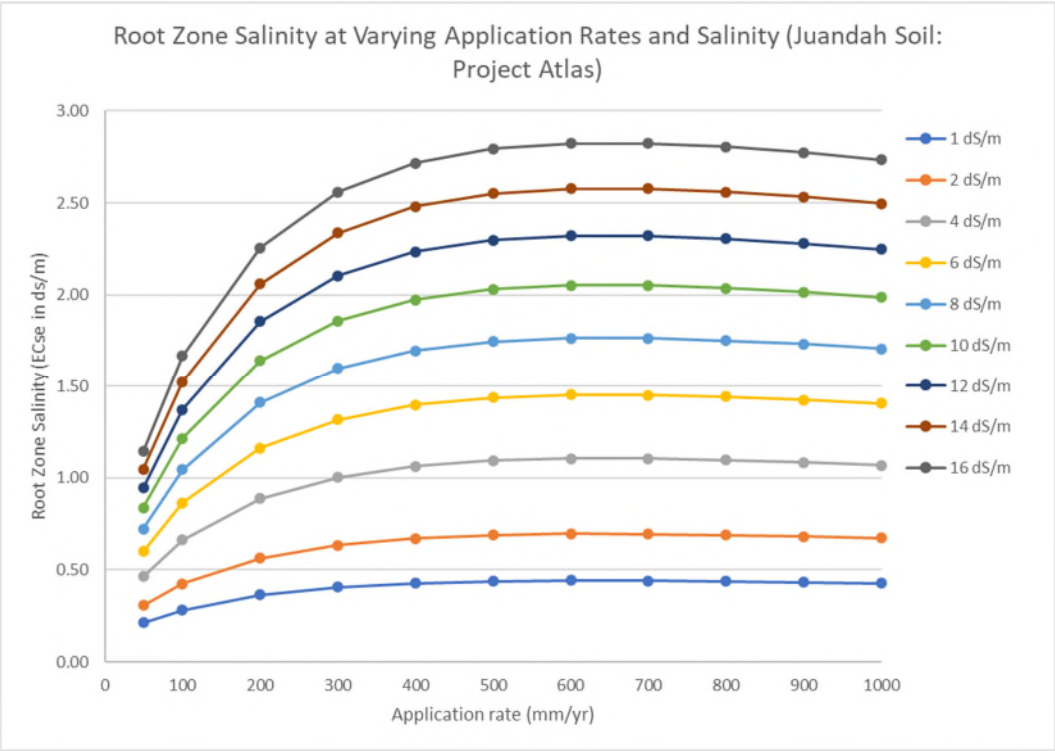

Figure 6-3 Root Zone Salinity Calculations – Juandah Soil: Atlas Field

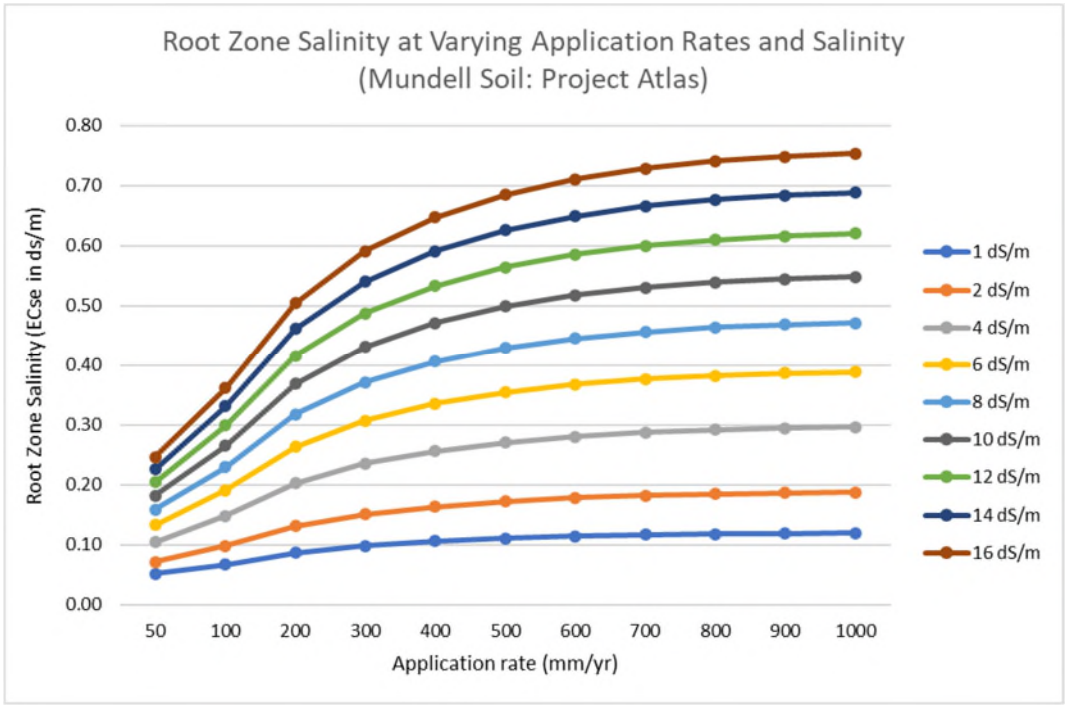

Figure 6-4 Root Zone Salinity Calculations – Mundell Soil: Atlas Field

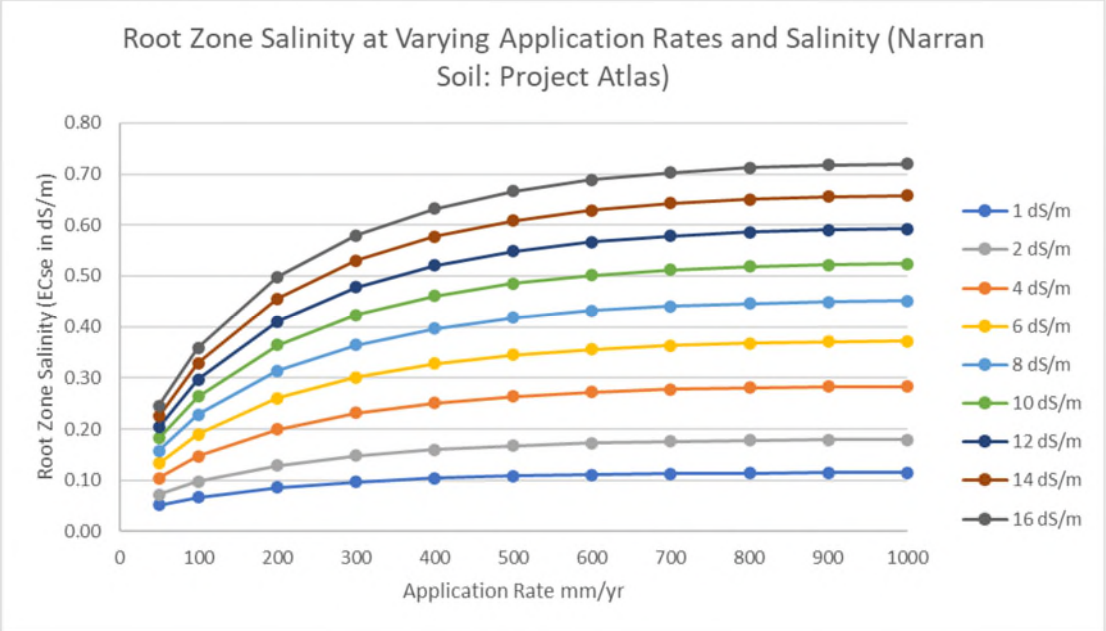

Figure 6-5 Root Zone Salinity Calculations – Narran Soil: Atlas Field

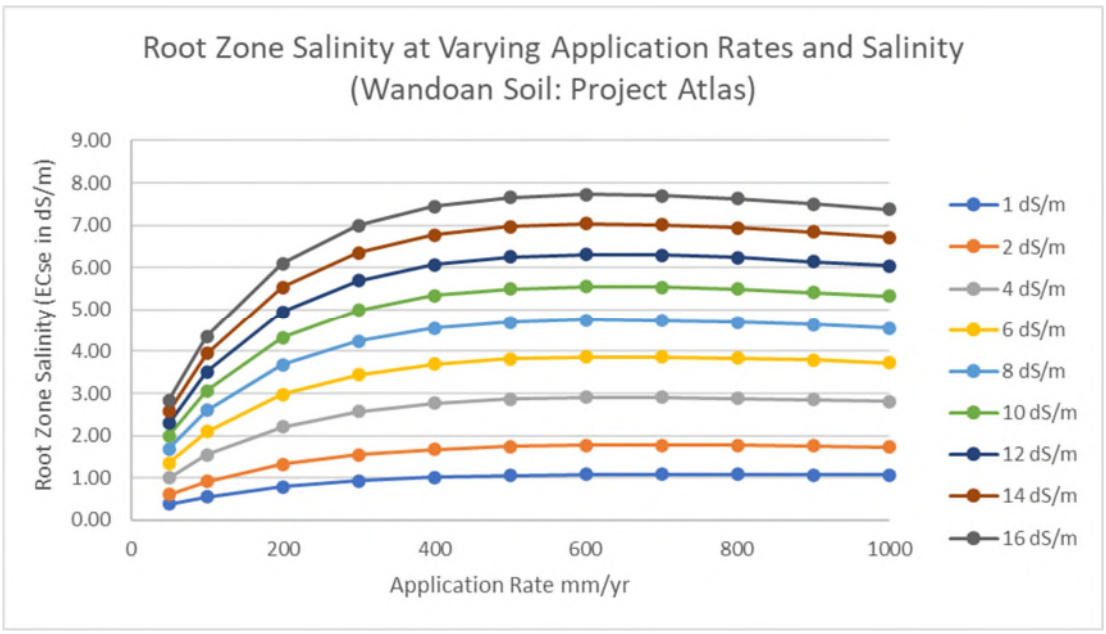

Figure 6-6 Root Zone Salinity Calculations – Wandoan Soil: Atlas Field

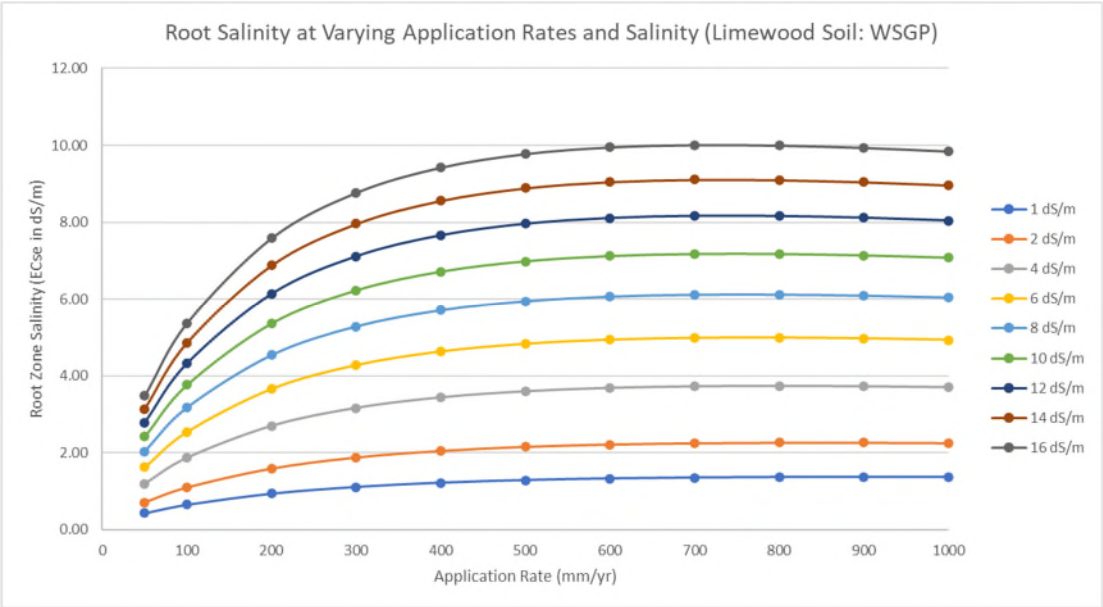

Figure 6-7 Root Zone Salinity Calculations – Limewood Soil: WSGP Field

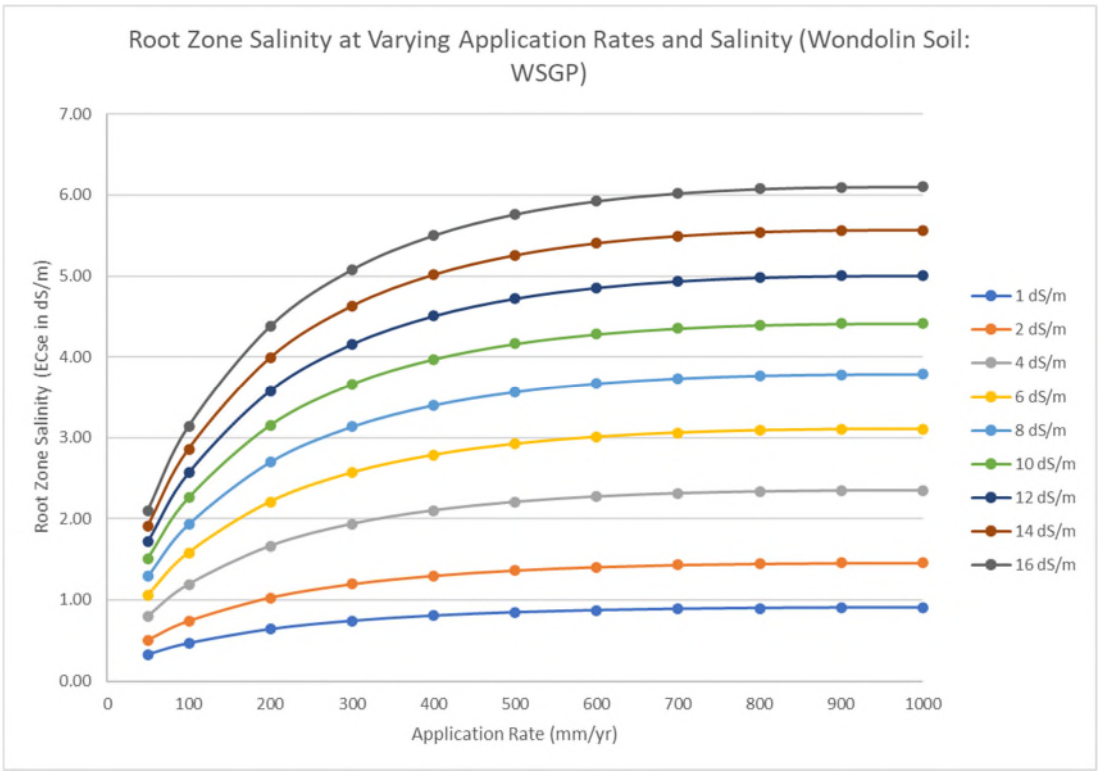

Figure 6-8 Root Zone Salinity Calculations – Wondolin Soil: WSGP Field

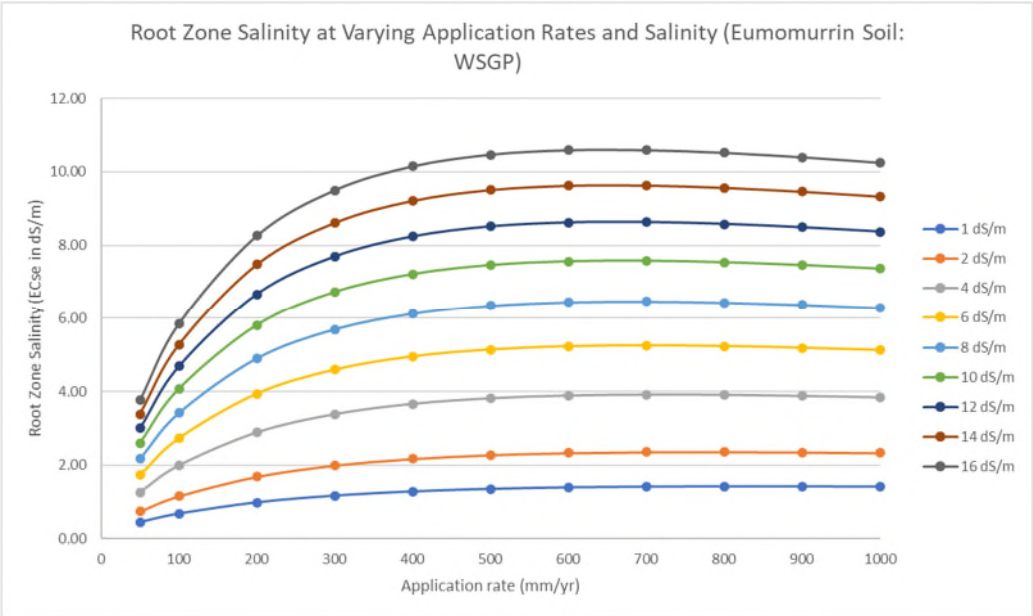

Figure 6-9 Root Zone Salinity Calculations – Eumomurrin Soil: WSGP Field

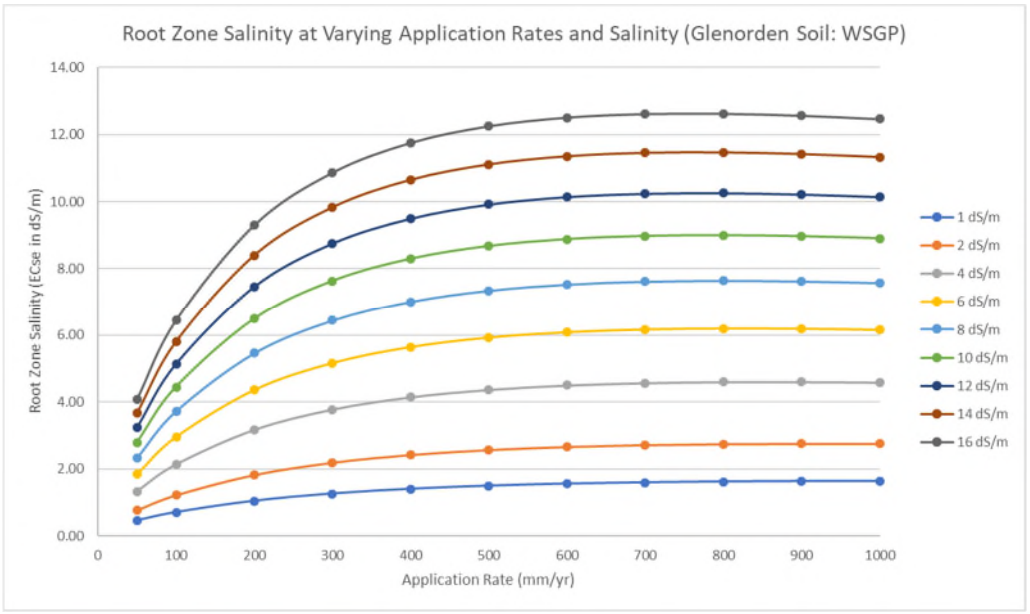

Figure 6-10 Root Zone Salinity Calculations – Glenorden Soil: WSGP Field

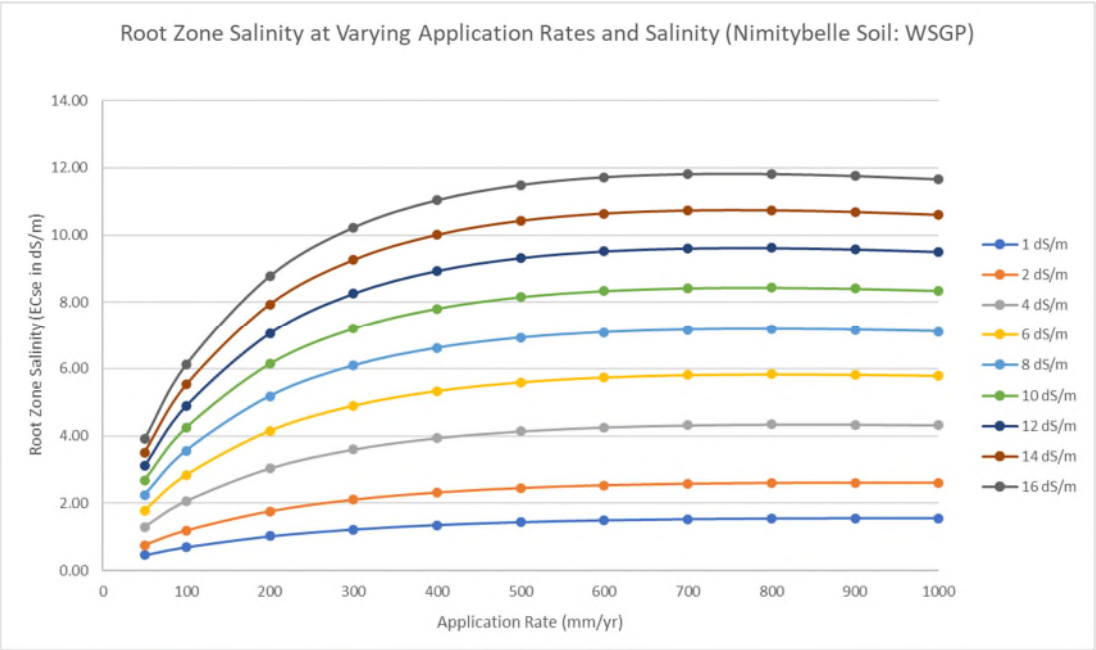

Figure 6-11 Root Zone Salinity Calculations – Nimitybelle Soil: WSGP Field

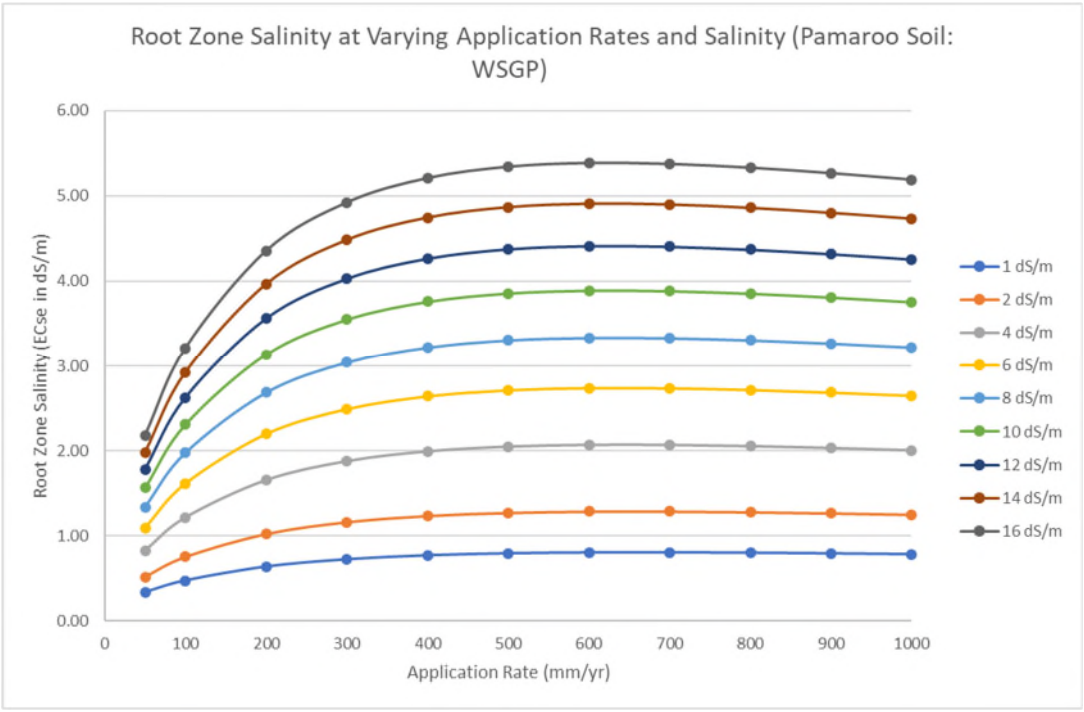

Figure 6-12 Root Zone Salinity Calculations – Pamaroo Soil: WSGP Field

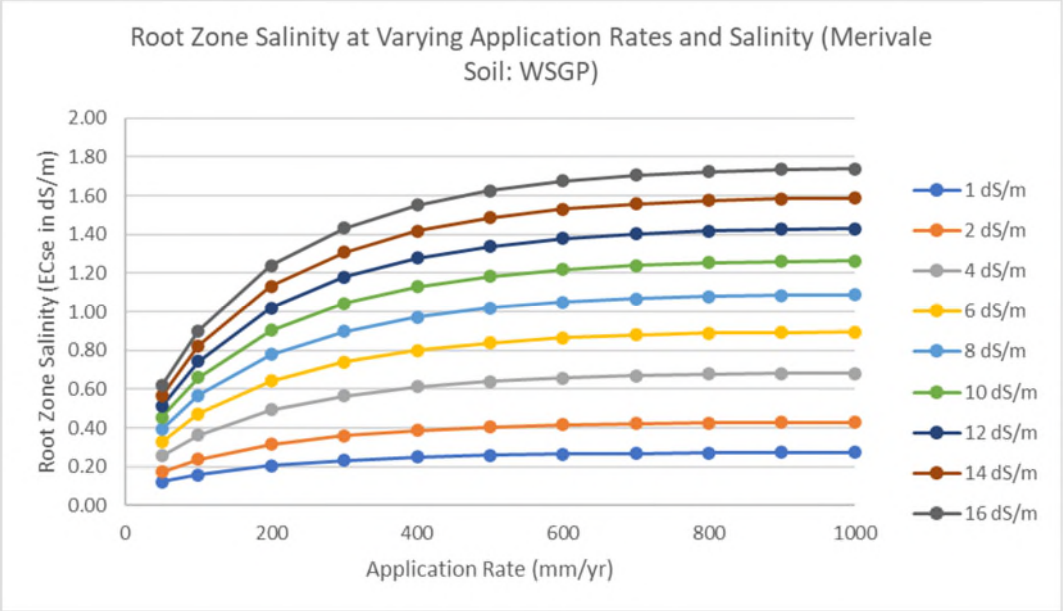

Figure 6-13 Root Zone Salinity Calculations – Merivale Soil: WSGP Field

6.2.2.4 Step 4: Assess the crop salt tolerance and potential impacts on yield

Table 6-7 shows the tolerance to salinity in pore water for a selection of plant species and crops that may be present in the region. While this table is not inclusive of all plant species, it provides guidance for the development of soil salinity values above which there is a higher potential for salinity issues. RE mapping and technical RE descriptions (DES, 2018) were used to determine the plant species which are known to occur within Senex's tenure.

As discussed in **Section 4**, tree and shrub species are unlikely to be present within gas gathering RoWs due the requirement to keep pipeline RoWs clear of trees and shrubs, which have the potential to cause damage to pipelines from roots. The most likely species to be present within the current gathering line RoWs are grass and pasture species, which function to provide protection from erosion. Satellite imagery shows limited cropping activity within the Atlas and WSGP areas. However, due to potential for gathering networks to be installed in cropping areas in the future, salinity thresholds for common cropping species have been considered.

Table 6-7 Plant Tolerances to Root Zone Salinity

Common Name	Scientific Name	Associated RE within Project Area (DES 2018)	Salinity Threshold (EC_{se})	Productivity decreases per dS/m increase (%)	Soil Salinity EC_{se} (dS/m)		
					90 % yield	75 % yield	50 % yield
Pasture Species							
Buffel grass, Gayndah	*Cenchrus ciliaris var. Gayndah*	-	5.5	10.3	6.5	7.9	10.4
Buffel grass, Nunbank	*Cenchrus ciliaris var. Nunbank*	-	6.0	6.8	7.0	9.3	13.4
Rhodes grass, Pioneer	*Chloris gayana*	-	7.0	3.2	10.1	14.8	22.6
Couch grass	*Cynodon dactylon*	RE 11.3.25	6.9	6.4	8.5	10.8	14.7
Green panic, Petri	*Panicum maximum*	-	3	6.9	4.4	6.6	10.2
Trees/Shrubs							
Black oak, Belah	*Casuarina cristata*	11.3.2, 11.3.25, 11.9.4a, 11.9.5, 11.9.5a, 11.9.10,	4 to 8*				
River red gum	*Eucalyptus camaldulensis*	11.3.2, 11.3.25	4 to 8*				
Forest red gum	*Eucalyptus tereticornis**	11.3.2, 11.3.25 and 11.5.1	4 to 8*				
Lemon scented gum	*Corymbia citriodora* subsp. variegata*	-	2 to 4*				
Coolabah	*Eucalyptus coolabah*	11.3.25	2 to 4*				
Crops							
Barley – grain	*Hordeum vulgare*	n/a	8.0	5.0	10	13	18
Barley – Forage	*Hordeum vulgare*	n/a	6.0	7.0	7.4	9.6	13.1
Barley – hay	*Hordeum vulgare*	n/a	6.0	7.1	7.4	9.5	13
Cotton	*Gossypium hirsutum*	n/a	7.7	5.2	9.6	12.5	17.3
Oats	*Avena sativa*	n/a	5.0	20	5.5	6.3	7.5
Sorghum	*Sorghum bicolor*	n/a	6.8	15.9	7.4	8.4	9.9
Sorghum, crooble	*Sorghum alum*	n/a	8.3	11.2	9.2	10.5	12.8
Sunflower	*Helianthus annuus*	n/a	5.5	25	5.9	6.5	7.5
Wheat	*Triticum aestivum*	n/a	6.0	7.1	7.4	9.5	13
Wheat, durum	*Triticum turgidum*	n/a	5.7	5.4	7.6	10.3	15

Table Notes:
dS/m = decisiemen per metre
n/a = data not available
EC_{se} = average root zone salinity Values are from the [Salinity] Management Handbook – Second Edition, except as otherwise noted
* Values are from the Western Australia Department of Primary Industries and Regional Development (https://www.agric.wa.gov.au/soil-salinity/salinity-tolerance-plants-agriculture-and-revegetation)

During normal operating conditions, the 75th and 90th percentiles for EC in the Atlas area are approximately 0.7 dS/m and 1.9 dS/m respectively, while the maximum observed EC was 6.6 dS/m (**Table 3-2**). For the WSGP area, the 75th percentile for EC is approximately 1 dS/m and the maximum observed EC was 1.3 dS/m (**Table 3-3**) [5]. However, further sampling is required to verify available water quality data.

Table 6-8 Suggested LPD water application limits

Soil	Project area	Available data	Impacted (Y/N)	Max observed EC (normal operating conditions)	Max application rate at max observed EC (mm/yr)*	Max concentration and application rate (no exceedance of root zone salinity threshold)
Juandah	Atlas	Site-specific	Y	6.6 dS/m	1000	16dS/m at 1000mm/yr
Mundell	Atlas	Site-specific	Y		1000	16dS/m at 1000mm/yr
Narran	Atlas	Site-specific	Y		1000	16dS/m at 1000mm/yr
Wandoan	Atlas	Site-specific	Y		1000	8dS/m at 1000mm/yr or 12dS/m at 200mm/yr
Merivale	WSGP	Site-specific	Y	1.3dS/m	1000	16dS/m at 1000mm/yr
Limewood	WSGP	Desktop	N	1.3dS/m	1000	5dS/m at 1000mm/yr
Eumomurrin	WSGP	Desktop	N		1000	5dS/m at 1000mm/yr
Glenorden	WSGP	Desktop	N		1000	5dS/m at 1000mm/yr
Nimitybelle	WSGP	Desktop	N		1000	5dS/m at 1000mm/yr
Pamaroo	WSGP	Desktop	N		1000	12dS/m at 1000mm/yr
Wondolin	WSGP	Desktop	N		1000	12dS/m at 500mm/yr
Maranoa	WSGP	Nil	N		n/a	3dS/m max concentration

Table Notes:
*normal operating conditions,
n/a = data not available
dS/m = decisiemen per metre

Based on the LPD water quality to date, it is not expected that discharges from LPDs under normal operating conditions within current operational areas will cause root zone salinity issues, although periodic monitoring should be conducted to ensure that the LPD water quality remains within acceptable levels. Salinity impacts, if observed, are likely to be localised and easily monitored and managed. However, further sampling is required to verify available water quality data.

As can be seen from **Table 6-8**, impacted soils are relatively tolerant of salinity and with the exception of the Wandoan soil, LPD water of up to 16 dS/m can be applied without exceeding the root zone salinity threshold. For the Wandoan soil, water of up to 8 dS/m can be applied without exceeding the root zone salinity threshold. These parameters are expected to cover a range of abnormal operating conditions, but where abnormal operating conditions occur LPD water should be sampled prior to release and only released where EC is equal to or less than the value in the

[5] the two highest EC readings from Atlas and the three highest EC reading from WSGP were excluded from this analysis because readings returned levels below the STV in subsequent samples taken about 6 weeks later.

'maximum concentration and application rate (no exceedance of root zone salinity)' column in **Table 6-8**. The same approach is recommended for those soils not yet impacted by development.

In the Maranoa Land unit where no soils data is available[6]:

- LPD water should be captured and not released to land where EC is greater than 3 dS/m.
- Soil sampling and analysis is recommended, but is not required prior to discharge providing that:
  - LPD water is tested prior to release; and
  - only released where EC is less than 3 dS/m.

Once soils chemistry data is available, detailed analysis can be undertaken to provide a soil-specific discharge threshold for EC.

The salinity thresholds for various plants presented in **Table 6-7** are also calculated based on long-term irrigation (20years) of significantly higher volumes of water. As shown in **Table 6-8**, LPD water with elevated salinity can be applied to soils in operational areas with limited risk of exceeding the root zone salinity threshold (5 dS/m).

A potential exception to this is green panic grass. However, it may be sown as a pasture species where rainfall exceeds 600mm annually. As shown in **Figures 6-3 to 6-11,** during normal operating conditions, LPD water with the maximum observed EC (6.6 dS/m) could be applied to the Juandah, Mundell and Narran soils in the Atlas area at rates of 1000mm/yr without exceeding the root zone salinity of 3 EC_{se}. For the Wandoan soil in the Atlas area the application rate drops to about 150 mm/yr. For WSGP soils, LPD water with the maximum observed EC (1.3 dS/m) can be applied at rates of 1000 mm/yr without exceeding the root zone salinity of 3 EC_{se}.

Green panic is not likely to be commonly encountered in the WSGP area as annual rainfall is below 600mm. The Atlas area has an annual rainfall of over 600mm, and green panic may be present in improved pastures. However, if green panic grass were to be present within a RoW, impacts to growth would likely be limited, as irrigating to maintain a root zone ECse of 5 dS/m or less would limit the predicted decline in yield for this species to less than 25%. Notwithstanding, reductions in yield due to LPD water discharges would be highly localised.

6.2.2.5 Step 5: Consider salinity and sodicity problems

Sodicity is the presence of a high proportion of sodium (Na+) ions relative to other cations in soil (in exchangeable and/or soluble form) or water. Effectively this can be described as an ionic imbalance that impacts soil structure. High levels of sodicity (i.e., high SAR) can impair the structure of soils by causing compaction and reduction in permeability, which can reduce water infiltration, leading to reduced plant growth. High sodicity also increases soil dispersivity, which can lead to erosion.

[6] EHS-Support understands that to date the WSGP development has only occurred on the Merivale land type.

For the Atlas area the SAR values for LPD water range from less than 1 to 73[7], with half the results being below the STV of 8. For the WSGP area the SAR values for LDP water range from less than 1 to 40.

As discussed in **Section 3.3.3**, and as shown in the SAR-EC graph presented in **Appendix B**, the SAR of the LPD water increases with salinity. **Figure 6-14** shows the impact on soil structure at varying EC and SAR conditions for an average soil. As indicated, where critical SAR/EC balance is not maintained for any soil solution EC, structural instability and soil dispersion can occur.

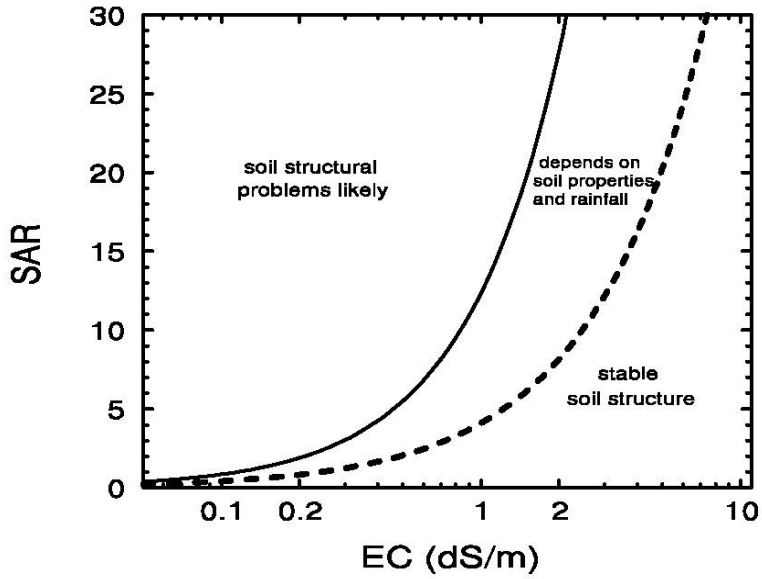

Figure 6-14 Relationship between SAR and EC and impacts on soil structure

Based on the range of SAR values in the LPD water, **Figure 6-14** predicts that the discharge of LPD water at some locations would be likely to introduce degradation of soil structure, potentially requiring corrective management (e.g., application of gypsum).

However, it is stressed this chart has been developed for a theoretical soil and is based on an assumed irrigation scheme (e.g., application of 1,000 mm/year over periods of 20 or 100 years). In practice, discharges from LPDs are periodic, and the application rates would be much less than that of a common irrigation scheme. Therefore, the chart should not be construed as predicting that appreciable degradation of soil structure will occur as a result of discharges from LPDs. Rather, this indicates that the LPD water could promote impairment of soil and that monitoring is required to determine any resulting effects and if treatment is required.

Notwithstanding, maintenance of stable SAR/EC balance for optimum soil structural stability can be achieved by amendment of soil prior to release of LPD water with gypsum or another calcium source.

[7] the highest SAR readings corresponded to the highest EC readings and have been excluded from this analysis as representative of abnormal operating conditions. Subsequent readings returned to about the STV in samples taken 6 weeks later.

6.3 Metals

The following provides an assessment of total metals contained in the LPD water that exceeded the STVs in one or more samples. The assessment is based on analysis of total metals (unfiltered samples).

The Project Atlas and WSGP EAs require that metals are measured as total metals (refer **section 2**) and must *meet the respective short term trigger value in section 4.2.6, Table 4.2.10—Heavy metals and metalloids in Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

The ANZECC Guidelines do not expressly state whether the STVs are based on dissolved or total metals. However, the relevant EA conditions appropriateness of either of the methods may depend on the specific parameter and the basis of the STV development as detailed in Section 9.2.5 of the guidelines. For example, the STVs for iron are based on fouling associated with precipitation of the most soluble form of iron (i.e., ferrous iron). However, total metals samples often contain solid particulates of oxidised and non-soluble forms of iron, which can significantly increase the concentration of iron detected in the sample but will not have an impact on plant growth (oxidised forms of iron are a major component of soils). In any case, the use of total metals for this analysis will provide the most conservative approach.

All of the following metal species were below the STVs for irrigation in all samples to date:

- Arsenic
- Beryllium
- Cadmium[8]
- Chromium
- Cobalt[7]
- Copper
- Lead
- Lithium
- Manganese
- Mercury
- Nickel
- Uranium
- Vanadium
- Zinc.

The majority of the concentrations for these metals were only a fraction of the respective screening levels / STVs. Subject to further monitoring to confirm concentrations over time, these constituents are not expected to pose a risk of impairment to soils, and further assessment is not warranted.

6.3.1 Aluminium

There was one anomalously high result of aluminium at 44.1 mg/L in A205, which is more than double the STV. The next highest result for aluminium was 1.84 mg/L in A202, which is less than one tenth of the STV, and the majority of values were less than 1 mg/L.

[8] One or more sample where the LOR was equal to STV, bit nothing detected in the sample.

It is not appropriate to establish a cumulative contaminant loading limit (CCL) for aluminium because it is a major constituent of soils. Therefore, as no CCL is available, contaminant loading for aluminium has not been calculated.

As the exceedance of the aluminium STV is from a single result, the presence of aluminium in this case does not necessarily indicate a risk to soils. However, prior to implementing a discharge from this LPD, additional sampling and analysis of aluminium in A205 is warranted to determine whether the elevated aluminium concentration is sustained for this LPD, or whether this was a unique occurrence.

6.3.2 Boron

Boron was detected in four samples from the Atlas area at concentrations significantly lower than the STV. It was not detected in any other sample, although the LOR for all remaining samples of <5 was an order of magnitude greater than the STV. Boron is essential to the normal growth of all plants but can be toxic when present in excessive concentrations. Crop species vary both in their boron requirement and in their tolerance to excess boron. The STVs for boron are crop-dependent, and the ANZECC Guidelines provide a range of STVs based on crop sensitivity to boron, as per Table 9.2.18 of the guidelines). These values are shown in **Figure 6-15**.

Tolerance	Concentration of boron in soil water (mg/L)	Crop
Very sensitive	<0.5	Blackberry, lemon
Sensitive	0.5–1.0	Peach, cherry, plum, grape, cowpea, onion, garlic, sweet potato, wheat, barley, sunflower, mung bean, sesame, lupin, strawberry, Jerusalem artichoke, kidney beans, lime beans
Moderately sensitive	1.0–2.0	Capsicum, pea, carrot, radish, potato, cucumber
Moderately tolerant	2.0–4.0	Lettuce, cabbage, celery, turnip, bluegrass, oat, corn, artichoke, tobacco, mustard, clover, squash, musk melon
Tolerant	4.0–6.0	Sorghum, tomato, alfalfa, purple, vetch, parsley, red beet, sugar-beet
Very tolerant	6.0–15.0	Asparagus

a From Westcot & Ayers (1984), cited by ANZECC (1992)

Figure 6-15 Relative Tolerance of Agricultural crops to Boron (Table 9.2.18 (ANZECC & ARMCANZ, 2000))

Land use in the Atlas and WSGP areas is predominantly forestry and grazing, and there are currently no LPDs in cropping areas. Therefore, the boron values in **Figure 6-15** are not yet applicable but are included should areas be cropped in future. For future cropping areas, the STV for sensitive crops may apply where the gathering lines traverse wheat, barley, or sunflower crop areas, or the STV for tolerant crops may apply where sorghum is grown. Based on Error! Reference source not found. and the potential crops in the area, a screening level of 1.0 mg/L for boron would be a more appropriate value to use for boron than the value for very sensitive crops.

The LOR for boron exceeded the STV for many of the samples. Further analysis is warranted to confirm that concentrations are below STVs (this should use analysis methods that achieve an LoR less than or equal to the STV). Further assessment to determine suitable screening thresholds or applications rates for boron may be required dependent on the results.

6.3.3 Iron

Iron exceeded the STVs in approximately half of the Atlas samples, but none of the WSGP samples.

Although iron is above the STV in a number of samples, the STV is based on application of water containing the most soluble form of iron (i.e., ferrous iron) onto plant leaves and subsequent precipitation and fouling, resulting in inhibition of plant growth. The ANZECC Guidelines indicate that there is insufficient data to determine a toxicity threshold of iron for plants growing in soils, and that there are no known direct negative effects of iron in soil (iron is a major component of soils).

It is possible that the samples, which were not filtered and represent total metals, may have contained a significant amount of iron as suspended solids containing oxidised (and less soluble) forms of iron. This can significantly increase the concentration of iron detected in the sample yet will not have an impact on plant growth as it is dissolved iron that is the predominant concern for this STV.

The effects of precipitation of dissolved iron onto plant leaves is visually evident, making it easy to monitor and manage any impacts to plant productivity. Where such conditions occur, the application of water can be distributed in a manner that does not result in spraying of droplets onto leaves. However, Senex currently release LPD water close to the ground and directly from the valve – limiting spray onto plant leaves and minimising the likelihood of any foliar impacts from high iron concentrations.

In addition, further monitoring of iron should include analysis of dissolved iron to determine whether dissolved forms present such risks. It may be the case that once the solids component is removed from samples, that the iron content in the samples will be substantially lower than the samples collected to date.

6.3.4 Molybdenum

Molybdenum was generally detected at levels significantly below the STV. However, the LOR for two samples from the WSGP area (201-1 and 207-1) and one sample from the Atlas area (A212) was 0.1 mg/L, higher than the STV (0.05 mg/L).

As the LOR for molybdenum exceeded the STV for these three samples, further analysis is warranted to confirm that concentrations are below STVs (this should use analysis methods that achieve an LoR less than or equal to the STV). Further assessment to determine suitable screening thresholds or applications rates may be required if the results indicate an exceedance of the STV.

As discussed in the ANZECC Guidelines, there is limited evidence of the phytotoxic impacts of molybdenum in soil or irrigation water, and the LTV and STV are designed to prevent the build-up of levels in soils that could result in uptake by crops at concentrations that could impact grazing stock.

Any added molybdenum from LPDs to soils would affect a very small proportion of the area available to livestock in any given scenario (e.g., LPD water application areas up to 240m^2 as compared to grazing areas of typically hundreds or potentially thousands of hectares). Therefore, even if molybdenum were to exceed the STV at some LPDs on a long-term basis and accumulate in soils, it is improbable that cattle would be affected by intermittent grazing in these limited areas.

A CCL has not been established for molybdenum due to a lack of data on molybdenum concentrations or toxicity thresholds in soils. Therefore, as no CCL is available, contaminant loading for molybdenum has not been calculated.

6.3.5 Selenium

Selenium was detected in one LPD sample below the STV. However, the LOR for the remainder of the samples of <0.2 exceeded the STV (0.05).

Because the LOR for selenium exceeded the STV for many of the samples, further analysis is warranted to confirm that concentrations are below STVs (this should use analysis methods that achieve an LoR less than or equal to the STV). Further assessment to determine suitable screening thresholds or applications rates may be required if the results indicate an exceedance of the STV.

A CCL for selenium has been set at 10 kg/ha and therefore potential contaminant loading can be calculated based on the LOR and STV of 0.2 mg/L and the typical operating scenario discharge volumes of 500 L/fortnight for Atlas and 2000L/fortnight for WSGP. A discharge area of approximately 60m^2 was assumed for Atlas and 240m^2 for WSGP. Using these values, the total selenium loading over a 20-year period would be approximately 8kg/ha for both areas. Based on this scenario, it is unlikely that selenium would exceed the CCL under these worst-case assumptions.

Applying the above CCL calculation (set at the LOR for selenium) the loading limits are unlikely to be exceeded. Therefore, selenium concentrations in the LPD water are not considered to present a risk of impacts to soils and does not warrant further consideration.

7 Potential Issues Requiring Monitoring and Management

Error! Reference source not found. provides a summary of potential issues that require further monitoring or management to mitigate potential issues associated with discharges of LPD water to ground, and associated risks to soils or plant health.

Table 7-1 Summary of Potential Issues Requiring Further Monitoring and/or Management

Potential Issue	Description
Characterisation of LPD discharge volumes	Data on actual LPD volumes is limited, so the assessment has been based on the 'Typical' operating volumes provided by Senex. Additional monitoring of LPD discharge volumes will be needed to confirm that the discharge volumes remain within the range of volumes that form the basis of this assessment. Note that further LPD volume data is not required to commence discharges from LPDs, as a short-term increase in volume (e.g., over a period of less than two years) is not likely to impair soils. Rather, it will enable more accurate assessment and evaluation of potential longer-term impacts.
Time-series LPD water quality data	With the exception of EC, pH and SAR (in the Atlas area), time series data is not available to assess temporal trends in water quality. Collection of time-series data from select LPDs (i.e., LPDs that produce the largest volumes of water, or where high salinity or concentrations of other constituents have been recorded) is warranted to ensure that the concentrations remain within the range of concentrations that for the basis of this assessment and to assess the frequency / occurrence of spikes in EC. Time series data is not required to commence discharges from existing LPDs, as short-term increases in concentrations are not likely to impair soils or vegetation. Rather, periodic (e.g., annual) collection of samples from select LPDs and analysis of the results should be undertaken.
Soil sampling and analysis	Site-specific soils chemistry data was not available for all soils for this assessment. A soil sample and associated analysis should be undertaken for each discrete soil type in Atlas and WSGP areas – prioritising the Maranoa land unit in the WSGP area. Further assessment of other soil types and discharge criteria may be required dependant on results.
Effects of the salinity of LPD water on root zone salinity	The application rates of the water discharged from LPDs must be managed to ensure that root zone salinity does not exceed plant salt tolerances within the gathering network RoW. During normal operating conditions, LPD water with the maximum observed EC can be released at rates of up to1,000 mm/yr without exceeding the root zone salinity threshold. Based on the LPD water quality to date, it is not expected that discharges from LPDs under normal operating conditions will cause root zone salinity issues, although periodic monitoring should be conducted to ensure that the LPD water quality remains within acceptable levels. **Soils with no data** To date there is no development within the Maranoa soils / Land Units (WSGP). However, should development occur in these areas and where no soils chemistry data has been collected LPD water should be tested prior to discharge and not released if salinity is greater than 3 dS/m.
Abnormal operating conditions	LPD water with high EC (>17dS/m) has been observed during abnormal operating conditions. To minimise the risk of exceeding the root zone salinity threshold (5 dS/m ECse), during abnormal operating conditions LPD water should be: • Manually tested; and • Not released if EC greater than the value specified in the 'maximum concentration at maximum application rate' column, **Table 6-8**. For impacted soils this means LPD water with an EC of up to 16 dS/m can be applied at rates of up to 1000mm/yr to the Juandah, Mundell, Narran and Merivale soils without exceeding the root zone salinity threshold (5 dS/m). For the Wandoan Soil, LPD water with an EC of up to 8dS/m can be applied at rates of up to 1000mm/yr without exceeding the root zone salinity threshold.

Potential Issue	Description
	Non-impacted soils • During abnormal operating conditions, LPD water of 12 dS/m can be applied to the Pamaroo and Wondolin soils and water of 5 dS/m can be applied to remaining soils as detailed in **Table 6-8**. **Soils with no data** To date there is no development within the Maranoa soils / Land Units (WSGP). However, should development occur in these areas and where no soils chemistry data has been collected LPD water should be tested prior to discharge and not released if salinity is greater than 3 dS/m.
Effects of sodicity of LPD water on soils	The LPD water in some cases has a high sodicity (i.e., high SAR), which can theoretically impact the structure of soils, potentially causing compaction and preventing the infiltration of water. This can also affect the stability of soils, potentially causing soils to become dispersive, which can lead to greater rates of erosion. The effects of sodicity in the LPD water can be effectively managed and mitigated through visual monitoring for evidence of impact and treatment of soils with gypsum (or other source of calcium ions).
Boron concentrations in the LPD water	Boron was not detected at concentrations above the STV, but the LOR was an order of magnitude greater than the STV for many samples. Boron concentrations and loading can potentially exceed crop tolerance levels. This can be managed by limiting application rates, but in the absence of WQ data suggested rates have not been proposed. Further analysis is warranted to confirm that concentrations are below STVs (this should use analysis methods that achieve an LoR less than or equal to the STV).
General metals impact to soils	Periodic monitoring and assessment of metals concentrations in the LPD water will be required to ensure that metals concentrations and loading to soils remain within acceptable limits.
Broader landscape issues	Potential issues associated with discharges from LPDs that warrant consideration include the following: • Localised erosion around LPDs where greater volumes of water are generated. • Potential run-off of LPD water to surface water. • Potential impacts to foliage due to iron / SAR. Impacts to groundwater are not considered to be a plausible risk due to the volumes of water being very small (as compared to volumes applied under an irrigation scheme) and the low permeability of soils in the region. Largely, the chemistry of produced water (i.e., the component of water in gas gathering networks that is the predominant source of salinity, sodicity and some metals) is not very different to that of local groundwater. Erosion around LPDs due to the discharge can be readily monitored, controlled, and mitigated. Due to the small volumes generated by the majority of LPDs, this is not considered a significant risk. Where soils are particularly susceptible to erosion, soils can be effectively treated with gypsum to minimise the potential for soil dispersion and erosion. Similarly, run-off of LPD water to surface water can be effectively controlled through simple measures. All of the LPDs proposed to be discharged to land are operated manually, and so an operator can directly control the amount of water applied to ensure that there is no ponding, and discharges during periods of rainfall or potential rainfall can be avoided entirely. Monitoring of vegetation in proximity to LPDs for signs of stressed or dying vegetation is warranted. Where impacts are identified, the cause of the impacts should be investigated.

Table Notes:
dS/m= decisiemen per metre
µS/cm= microsiemen per centimetre
mm= millimetres

8 Monitoring and Management Measures

The following monitoring and management measures have been designed to be implemented over a two-year period, after which a comprehensive assessment should be conducted to confirm the acceptability of the water for continued discharge to land. A period of two years was selected on the basis that this will provide a representative basis for further assessment without causing a significant risk of impact to soils and allows for monitoring to potentially be reduced within a reasonable period of time. Based on the LPD volume and water quality data to date, proceeding with discharge from LPDs over a two-year period with the proposed controls described below presents a very low risk of impact to soils or vegetation. Additional data gathered over this period will be used to refine the assessment, and to determine if additional controls are required for continuation on a long-term basis. This data will also be used to assess whether the level of monitoring or controls can be reduced based on the greater confidence that can be derived from a larger and longer-term dataset.

8.1 Monitoring Program

Monitoring program requirements are detailed in **Table 8-1**. Monitoring analytes for water quality monitoring and associated site-specific trigger values and method of comparison are described in (**Table 8-2)**. Representative sampling will be conducted for comparison to trigger values.

Table 8-1 Monitoring Program

Monitoring to be Completed	Details
LPD discharge volumes	**Data Objectives:** To confirm the range and variability of water volumes produced from LPDs. **How Often/When:** The discharge volume per discharge event should be monitored at least once a year (e.g. drain, recharge for 2 weeks, measure subsequent volume when released). **Monitoring Locations:** 25% of LPDs in Atlas and 25% of LPDs in WSGP on a rotational basis. **Monitoring/Analysis Requirements**: Discharge volumes to be metered, except in cases where discharge volumes are too small to be practicably metered, in which case a visual estimate (e.g., bucket test) is acceptable. **Assessment Requirements**: To be reviewed periodically in conjunction with water quality data to confirm whether loading rates remain within acceptable limits. Comprehensive review of all volume data is required after a period of two years of discharging from LPDs.
Characterisation of LPD water quality	**Data Objectives:** Confirmation of water quality based on a representative number of wells across each operating field to determine outliers and potential issues with water quality. In addition, assess temporal variations and determine representative water quality values. **How Often/When:** Annually for existing LPDs and prior to commencement of discharges for new LPDs and annually thereafter on a rotational basis. LPDs that return elevated results will be resampled. **Monitoring Locations:** Sample 25% of LPDs in Atlas and 25% of LDPs in WSGP for laboratory analysis parameters on a rotational basis and all LPDs for field parameters for each 12 month period (except LPDs that produce negligible volumes of water at the time of monitoring). LPDs that have produced the greatest volumes of water historically (i.e., greater than 1,000 L/month) should be prioritised for sampling and analysis. **Analysis Requirements**: Laboratory samples to be analysed for EC, SAR and total metals as per **Table 8-2**. Field samples to be analysed for pH and EC. **Assessment Requirements**: As data is collected, as per the site-specific trigger levels listed in **Table 8-2**. The majority of trigger levels will be assessed based on the average of the most recent two to three results (where multiple results are available), although a threshold approach will be applied for assessment of salinity. Further assessment on a case-by-case basis is required for LPDs exceeding the site-specific trigger values. Comprehensive review of all analysis data is required after a period of two years of discharging from LPDs.

Monitoring to be Completed	Details
	Comments: • If an exceedance of the site-specific discharge limits occurs, further review must be undertaken in accordance with ANZACC/ARMCANZ (2000) to determine if continued discharges from the LPD can proceed. • A comprehensive review of analysis data is necessary from time to time to confirm that long-term risks are mitigated. Conversely, this review may determine that reduced monitoring and control measures may be implemented. • Prior to discharge from new LPDs, monitoring of water quality must be conducted to confirm that the water quality meets the required water quality limits. • LPDs should be sampled and analysed when there is an observed spike in water volume, as determined by recorded discharge volumes above or as identified during operations. • Where the volumes produced are sufficient, the LPD should be purged of stagnant water prior to sample collection, taking care to minimise flow rates and associated turbidity.
Visual monitoring of erosion and vegetation	**Data Objectives:** Identify potential land and vegetation issues that require corrective action. **How Often/When:** Annually at a minimum, and during LPD discharge events. **Monitoring Locations:** All LPDs from which water is discharged. **Monitoring/Analysis Requirements**: Visual inspection for indicators of erosion, compaction (e.g., water logging/poor drainage), impaired vegetation, fouling or other landscape issues. **Assessment Requirements**: Observations to be recorded and processed through the Senex HAZOB (or similar) system. **Comments:** Nil

Table Notes:
L= litres

Table 8-2 Water Monitoring Analytes and Site-Specific Trigger Values

Analyte	Site-Specific Trigger Values and Assessment Approach
PHYSICO-CHEMICAL	
EC (field)	Discharges will be limited to a trigger value threshold per soil unit (Error! Reference source not found.).
EC (lab)	
pH (field)	pH will be assessed based on field instrumentation using the STV value of 6 to 9 as a guideline. pH values will be assessed based on the average of up to the most recent three water quality monitoring results for individual LPDs. Minor deviations from the assessment criteria will not be considered a trigger parameter exceedance unless the deviation is greater than 1 pH unit or where three or more time-series results are available, the average of the results falls outside the trigger values.
SAR	A site-specific trigger value has not been established for SAR, as controls are in place to monitor for and mitigate the effects of SAR (**Table 8-3**).
METALS	
Aluminium	Site-specific trigger values for these metals will default to the STVs listed in Table 4.2.10 of the ANZECC Guidelines. Assessment against the trigger values will be based on the average of the most recent three water quality monitoring results for individual LPDs where multiple results are available. LOR should be confirmed to ensure that it is equal to or less than the STV.
Arsenic	
Beryllium	
Cadmium	
Chromium	
Cobalt	
Copper	
Lead	
Lithium	
Manganese	

Analyte	Site-Specific Trigger Values and Assessment Approach
Mercury	
Molybdenum	
Nickel	
Selenium	
Uranium	
Vanadium	
Zinc	
Iron	A site-specific trigger value has not been established for iron, as controls are in place to monitor for and mitigate the effects of iron fouling.
Boron	A site-specific trigger value of 2 mg/L will be used for boron (based on the STV for sensitive crops). As for the other metals, assessment against the trigger values will be based on the average of the most recent three water quality monitoring results for individual LPDs where multiple results are available.

Table Notes:
mg/L= milligram per litre

8.2 Management Measures

Table 8-3 describes management measures that will be undertaken in specific situations to mitigate the risk of unacceptable impacts associated with discharges from low point drains. These are in addition to the monitoring program measures described in (**Section 8.1**), which cover most aspects of normal operation.

Table 8-3 Specific Management Measures

Management Measure	Details
Soil treatment to mitigate SAR impacts	Based on monitoring of indicators of erosion or compaction, gypsum treatment will be used, where required, to control the effects of SAR on soil.
Monitoring changes in water volume and quality due to changes in infrastructure / abnormal operating conditions	During the operation of the gas gathering network, there may be sudden changes in the quantity and quality of water generated from individual LPDs as a result of workovers or changes in infrastructure, such as the connection of new wells or additional segments of gathering lines to the gas gathering network. When such operational changes occur, increased monitoring of the water volumes and quality from affected segments of the gas gathering network will be conducted. Water quality will be measured in either or both of two ways, including: • A campaign approach involving monthly monitoring of EC for potentially affected LPDs, and analysis of pH, SAR, and metals parameters where there has been a marked increase in salinity as compared to historical levels. Where increases in salinity have been observed, screening will be conducted against the site-specific trigger levels. • Screening of EC levels in individual LPDs prior to each discharge. In this case, o a value of 3 dS/m will be used for all soil types where no chemistry data was available and where this value is exceeded, the LPD will not be discharged until sampling, analysis and screening of pH, SAR and metals is conducted. o when experiencing abnormal operating conditions, the values listed in the 'max concentration at max application rate' value in **Table 6-8** will be used. Where this value is exceeded, the LPD will not be discharged until sampling, analysis and screening of pH, SAR and metals is conducted.

Management Measure	Details
	• Based on the results to date, salinity can be used as a surrogate parameter to provide a general indication of whether metals concentrations may exceed site-specific trigger levels.
Soils analysis to enable tailored discharge criteria	Soil chemistry data is required for the Maranoa land units in the WSGP to allow for assessment and determination of appropriate discharge criteria. Site-specific soils data for other identified soil types should also be gathered and dependent on results may require updates to the analysis and discharge criteria (n.b. this has already been provided for the Juandah, Mundell, Narran, Wandoan and Merivale soils).

Table Notes:
dS/m = decisiemen per metre
* 8 dS/m selected as it is anticipated abnormal operating conditions will be infrequent and one-off applications of higher salinity water are unlikely to impact root zone salinities.

9 Conclusion

Based on the assessment of LPD water under the framework set out in the ANZECC Guidelines and as described in this RER, potential environmental risks and impacts associated with discharges of LPD water can be effectively managed to acceptable levels. This is contingent upon the implementation of the practical monitoring and control measures as described in **Section 8** of this document.

It is noted that while the RER analysis is based on application of water during normal operating conditions, further data is required to support the assumptions made in this report.

This assessment was conducted in a manner consistent with the Atlas EA conditions described in **Section 2** of this document, which incorporates the framework in the ANZECC Guidelines, and the Queensland Salinity Management Handbook (Queensland Government, 2011). Compared with the current WSGP EA conditions, this would provide a practical and flexible means to manage LPD water, whilst ensuring that the risk of environmental harm is effectively managed. Therefore, a WSGP EA amendment as proposed in **Section 2** of this document is recommended.

10 Limitations

EHS Support Pty Ltd ("EHS Support") has prepared this report in accordance with the usual care and thoroughness of the consulting profession for the use of Senex Energy Ltd and only those third parties who have been authorised in writing by EHS Support to rely on the report. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this report. It is prepared in accordance with the scope of work and for the purpose outlined in the Proposal dated 29th July 2021.

The methodology adopted and sources of information used by EHS Support are outlined in this report. EHS Support has made no independent verification of this information beyond the agreed scope of works and EHS Support assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information contained in this report as provided to EHS Support was false.

This report was prepared between June 2021 and November 2021 and is based on the information reviewed at the time of preparation. EHS Support disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

This report contains information obtained by inspection, sampling, testing, or other means of investigation. This information is directly relevant only to the points in the ground where they were obtained at the time of the assessment.

Where conditions encountered at the site are subsequently found to differ significantly from those anticipated in this report, EHS Support must be notified of any such findings and be provided with an opportunity to review the recommendations of this report.

Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels can change in a limited time. Therefore, this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

11 References

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Appendix A Analysis Results Tables

Analyte grouping/Analyte	Unit	EPPG00651513	LPD A005 EB2016042001 17/06/2020	LPD A006 EB2016042002 17/06/2020	EB2020178002 30/07/2020	LPD A008 EB2016042003 17/06/2020	LPD A013 EB2016042004 17/06/2020	EB2020178005 30/07/2020	LPD A016 EB2016042005 17/06/2020	LPD A022 EB2016042006 17/06/2020	KLPD A023-1 EB2016042007 17/06/2020
EA005P: pH by PC Titrator											
pH Value	pH Unit	**6.0-9.0**	8.21	7.52	6.85	6.32	6.82	6.35	7.22	6.53	7.65
EA010P: Conductivity by PC Titrator											
Electrical Conductivity @ 25°C	µS/cm	**3000**	**6630**	1500	1040	46	198	184	240	39	1880
ED093F: SAR and Hardness Calculations											
Sodium Adsorption Ratio		**8**	**73.2**	**37.3**	**35.5**	0.72	**8.37**	7.65	6.39	0.72	**25.4**
EG020T: Total Metals by ICP-MS											
Aluminium	mg/L	**20**			0.093			0.016			
Arsenic	mg/L	**2**			<0.2			0.0004			
Beryllium	mg/L	**0.5**			<0.1			<0.1			
Boron	mg/L	**15**			0.016			0.024			
Cadmium	mg/L	**0.05**			<0.05			<0.05			
Chromium	mg/L	**1**			0.0012			0.005			
Cobalt	mg/L	**0.1**			0.0003			0.001			
Copper	mg/L	**5**			0.0011			0.0058			
Iron	mg/L	**10**			**18.3**			**27**			
Lead	mg/L	**5**			0.0004			<0.1			
Lithium	mg/L	**2.5**			0.0104			0.0017			
Manganese	mg/L	**10**			0.352			0.388			
Molybdenum	mg/L	**0.05**			0.0001			0.0003			
Nickel	mg/L	**2**			0.0016			0.0058			
Selenium	mg/L	**0.05**			<0.2			<0.2			
Uranium	mg/L	**0.1**			<0.05			<0.05			
Vanadium	mg/L	**0.5**			0.0003			0.2			
Zinc	mg/L	**5**			0.003			0.014			
EG035T: Total Recoverable Mercury by FIMS											
Mercury	mg/L	**0.002**			<0.00004			<0.00004			

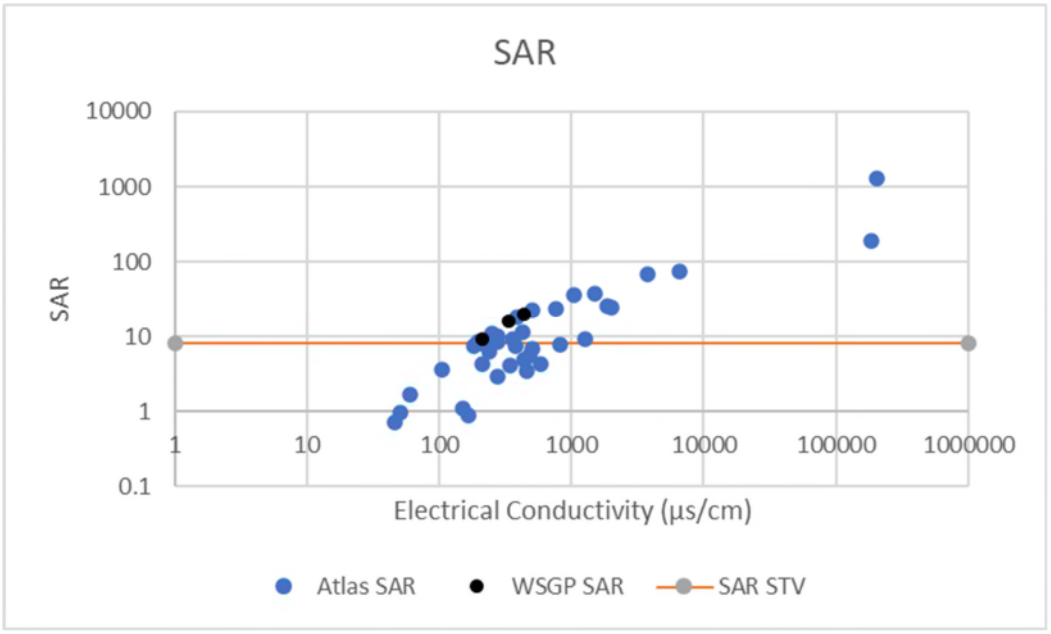
	LPD A023-2		LPD A202		LPD A205		LPD A207-02	LPD A207-4	LPD A207-5	LPD A208		LPD A210	
EB2020178006	EB2016042008	EB2020178007	EB2016042009	EB2020178011	EB2016042010	EB2020178001	EB2016042011	EB2016042012	EB2016042013	EB2016042014	EB2020178003	EB2016042015	EB2020178008
30/07/2020	17/06/2020	30/07/2020	17/06/2020	30/07/2020	17/06/2020	30/07/2020	17/06/2020	17/06/2020	17/06/2020	17/06/2020	30/07/2020	17/06/2020	30/07/2020
7	7.75	7.02	8.94	7.55	**9.2**	7.2	7.25	7.07	7.23	7.07	**6.53**	7.4	6.66
209	2000	364	**202000**	1270	**18300**	817	505	482	434	208	106	428	279
4.36	**24.8**	**9.15**	**1310**	**9.12**	**188**	7.87	6.83	5.62	4.95	**8.13**	3.59	**11.3**	**10.2**
0.069	0.279			1.84	**44.1**						1.77		1.68
0.0004	0.0005			0.0012	0.0108						0.0011		0.0008
<0.1	<0.1			0.0001	0.0027						0.0002		0.0001
<5	<5			0.072	0.011						<5		<5
<0.05	<0.05			<0.05	0.00061						<0.05		<0.05
0.0011	0.001			0.0023	0.0382						0.0075		0.0065
0.0008	0.0014			0.0025	0.0553						0.0028		0.003
0.0006	0.0005			0.0059	0.328						0.0188		0.0138
3.58	3.71			**14.3**	**172**						**18.8**		**14**
0.0001	0.0003			0.0042	0.204						0.0017		0.002
0.0022	0.0037			0.0191	0.0322						0.0024		0.0035
0.34	0.577			0.964	5.35						0.331		0.376
0.0004	0.0001			0.0006	0.003						0.0003		0.0005
0.0009	0.0006			0.0018	0.0538						0.0074		0.0063
<0.2	<0.2			<0.2	0.0013						<0.2		<0.2
<0.05	<0.05			0.00007	0.00284						0.00014		0.00011
0.2	0.0005			0.0032	0.0839						0.0045		0.0036
0.002	0.002			0.019	0.579						0.018		0.016
<0.00004	<0.00004			<0.00004	0.00056						<0.00004		<0.00004

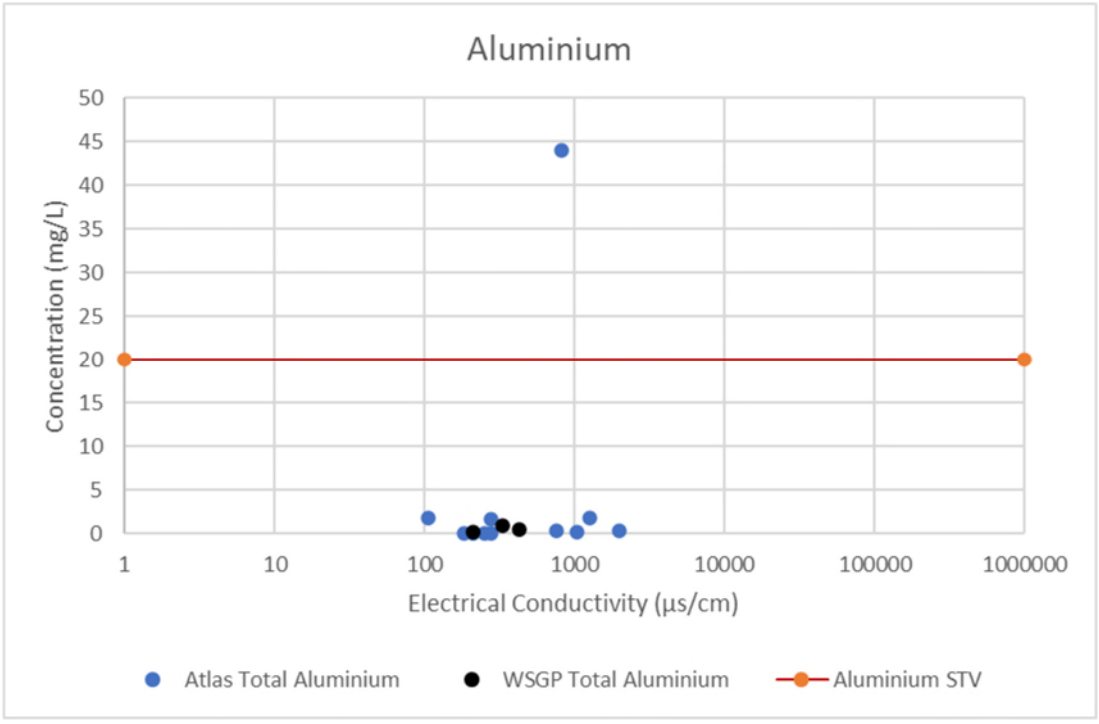
LPD A212		**LPD A063**	**LPD A035**	**LPD A025**		**LPD A026**	**LPD A027-01**	**LPD A027-03**	**LPD A027-04**	**LPD A031**	**LPD A036**		**LPD A041**
EB2016042016	EB2020178004	EB2016042017	EB2016042018	EB2016042019	EB2020178009	EB2016042020	EB2016042021	EB2016042022	EB2016042023	EB2016042024	EB2016042025	EB2020178010	EB2016042026
17/06/2020	30/07/2020	17/06/2020	17/06/2020	17/06/2020	30/07/2020	17/06/2020	17/06/2020	17/06/2020	17/06/2020	17/06/2020	17/06/2020	30/07/2020	17/06/2020
7.23	6.63	7.19	7.45	6.87	7.05	6.48	7.07	7.35	7.57	6.6	8.06	7.04	6.51
387	**251**	376	511	219	762	152	341	579	167	277	**3760**	276	457
18.2	**10.8**	7.46	**22.5**	**8.13**	**23.8**	1.12	4.08	4.4	0.9	2.96	**67.1**	**8.56**	3.51
	0.014				0.283							0.024	
	<0.2				0.0003							<0.2	
	<0.1				<0.1							<0.1	
	<5				<5							<5	
	<0.05				<0.05							<0.05	
	0.0009				0.0021							0.0015	
	<0.1				0.001							0.0002	
	<0.5				0.0144							0.002	
	11.2				**11.6**							5.17	
	<0.1				0.0171							0.0004	
	0.0024				0.0088							0.003	
	0.0907				0.186							0.0774	
	<0.1				0.0005							0.0007	
	<0.5				0.0014							0.001	
	<0.2				<0.2							<0.2	
	<0.05				<0.05							<0.05	
	<0.2				0.0011							<0.2	
	<1				0.033							0.008	
	<0.00004				<0.00004							<0.00004	

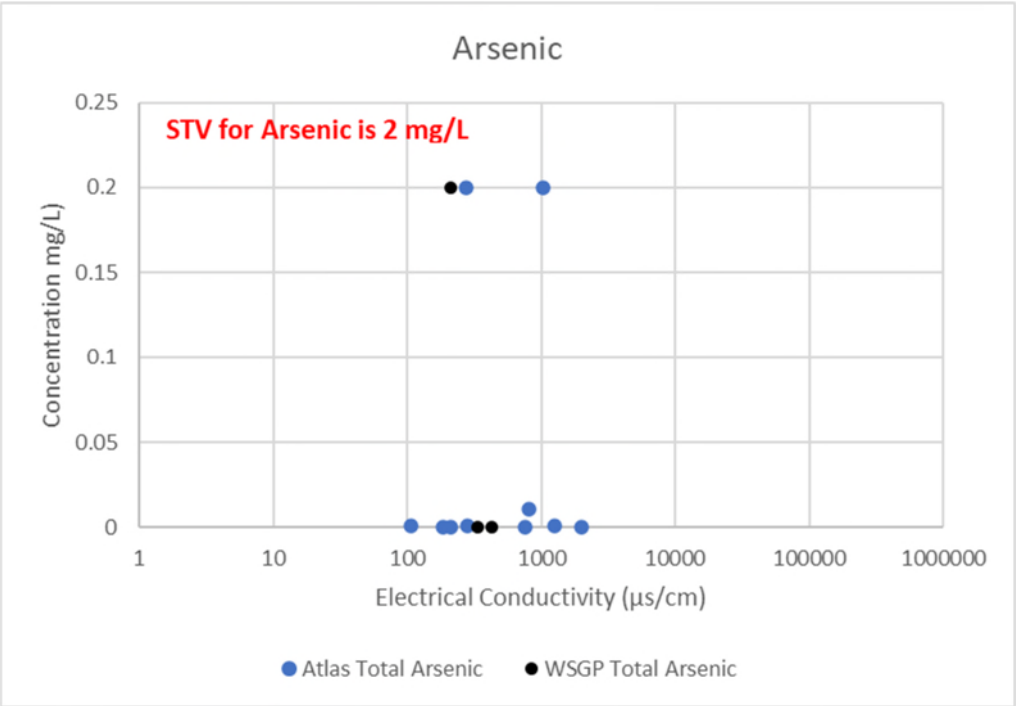
LPD A022	**LPD A009**
EB2016042027	EB2016042028
17/06/2020	17/06/2020
6.56	6.3
51	60
0.96	1.67

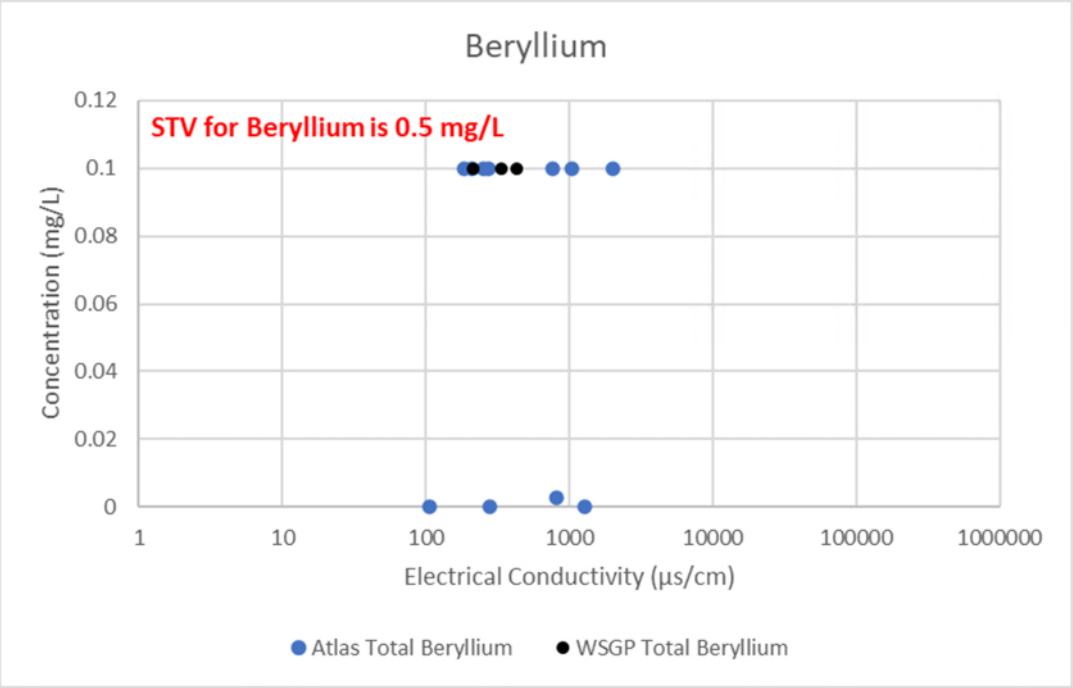
Analyte grouping/Analyte	Unit	EPPG00651513	LPD 201 - 1				LPD 201 - 11					LPD 207-1	LPD 201-2
			EB1932581002	EB2001648002	EB2016038001	EB2019943004	EB1932581001	EB2002415002	EB2006927001	EB2016038002	EB2019943001	EB2019943002	EB2019943003
			02/12/2019	16/01/2020	10/06/2020	28/07/2020	02/12/2019	28/01/2020	11/03/2020	10/06/2020	28/07/2020	28/07/2020	28/07/2020
EA005P: pH by PC Titrator													
pH Value	pH Unit	6.0-9.0	7.98	8.25	7.95	7.75	**9.23**	**9.19**	**9.27**	7.87	7.41	7.22	7.52
EA010P: Conductivity by PC Titrator													
Electrical Conductivity @ 25°C	µS/cm	3000	1300	1130	627	432	**75400**	**191000**	**172000**	726	411	213	335
ED093F: SAR and Hardness Calculations													
Sodium Adsorption Ratio		8	0.6	**40.1**	**22.8**	**20.3**	**35.5**	**23600**	**12176**	**15.4**	**15.5**	**9.09**	**15.8**
EG020T: Total Metals by ICP-MS													
Aluminium	mg/L	20				0.455					0.073	0.15	0.864
Arsenic	mg/L	2				0.0004					<0.2	<0.2	0.0005
Beryllium	mg/L	0.5				<0.1					<0.1	<0.1	<0.1
Boron	mg/L	15				<5					<5	<5	<5
Cadmium	mg/L	0.05				<0.05					<0.05	<0.05	<0.05
Chromium	mg/L	1				0.0012					0.0007	0.0005	0.0015
Cobalt	mg/L	0.1				0.0008					0.0002	0.0004	0.0015
Copper	mg/L	5				<0.5					<0.5	<0.5	0.0006
Iron	mg/L	10				0.948					3.44	1.26	2.02
Lead	mg/L	5				0.0002					<0.1	0.0001	0.0006
Lithium	mg/L	2.5				0.0037					0.0029	0.0024	0.0033
Manganese	mg/L	10				0.0877					0.0765	0.0368	0.208
Molybdenum	mg/L	0.05				<0.1					0.0002	<0.1	0.0002
Nickel	mg/L	2				0.0008					<0.5	<0.5	0.0008
Selenium	mg/L	0.05				<0.2					<0.2	<0.2	<0.2
Uranium	mg/L	0.1				<0.05					<0.05	<0.05	<0.05
Vanadium	mg/L	0.5				0.0008					<0.2	0.0003	0.0018
Zinc	mg/L	5				0.002					<1	0.014	0.005
EG035T: Total Recoverable Mercury by FIMS													
Mercury	mg/L	0.002				0.00004			0.001		0.00004	0.00004	0.00004
EG020F: Dissolved Metals by ICP-MS													
Arsenic	mg/L								0.051				
Beryllium	mg/L								0.02				
Barium	mg/L								0.431				
Cadmium	mg/L								0.002				
Chromium	mg/L								0.02				
Cobalt	mg/L								0.02				
Copper	mg/L								0.02				
Lead	mg/L								0.02				
Manganese	mg/L								0.055				
Nickel	mg/L								0.02				
Selenium	mg/L								0.2				
Vanadium	mg/L								0.2				
Zinc	mg/L								0.1				
Boron	mg/L								11.1				
EG035F: Dissolved Mercury by FIMS													
Mercury	mg/L								0.001				

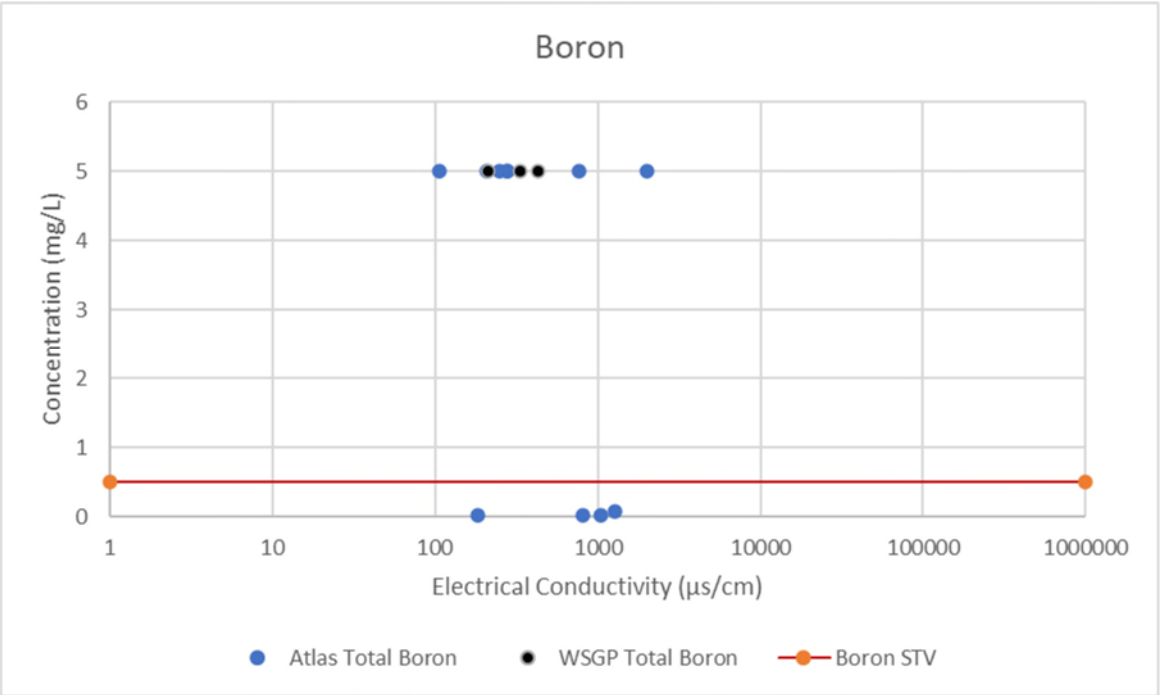
Appendix B Analysis Results Graphs

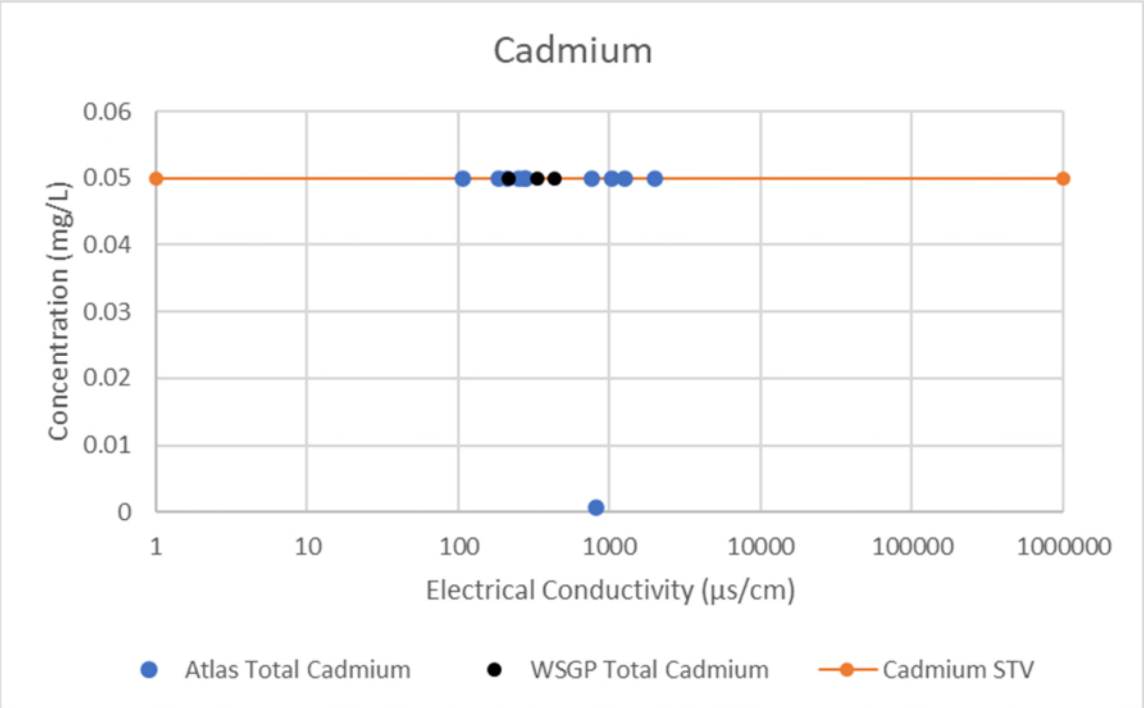


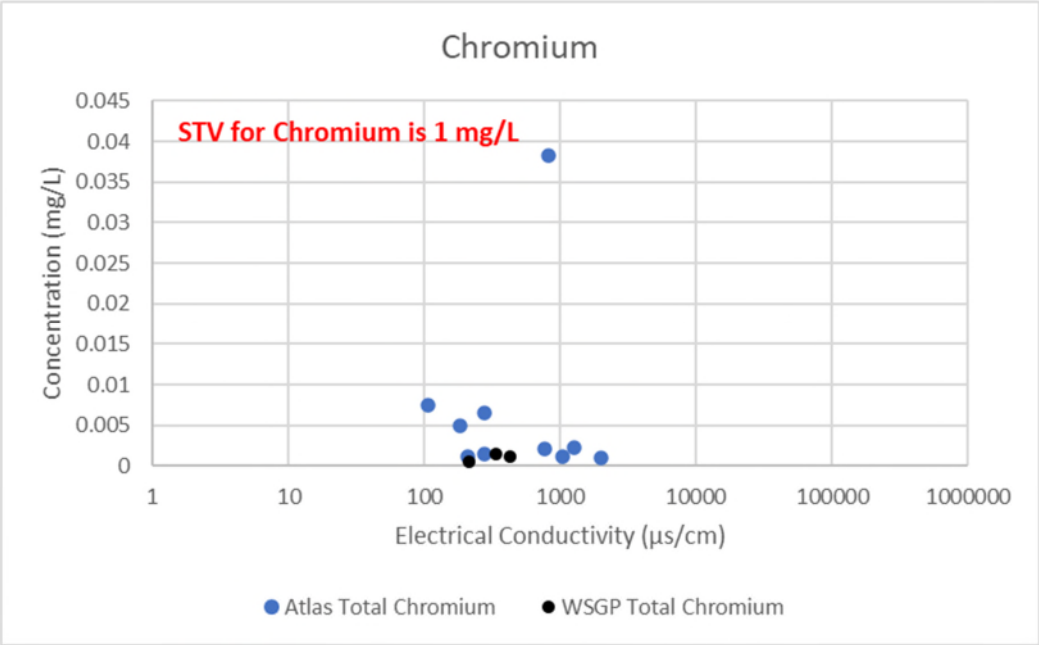


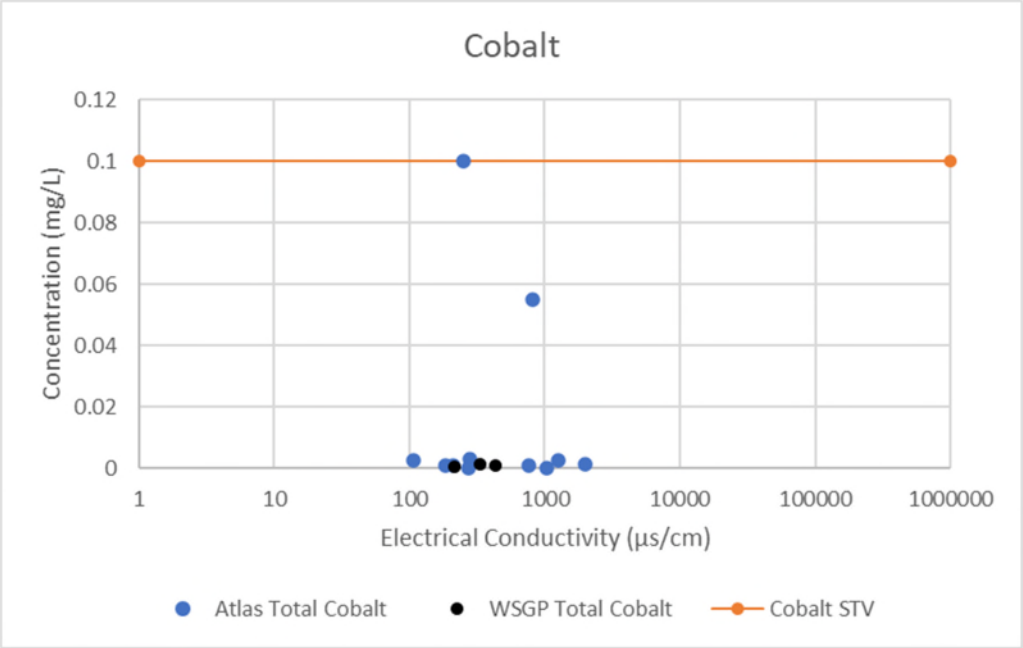

Arsenic
STV for Arsenic is 2 mg/L
Concentration mg/L)
0.25
0.2
0.15
0.1
0.05
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Arsenic
WSGP Total Arsenic

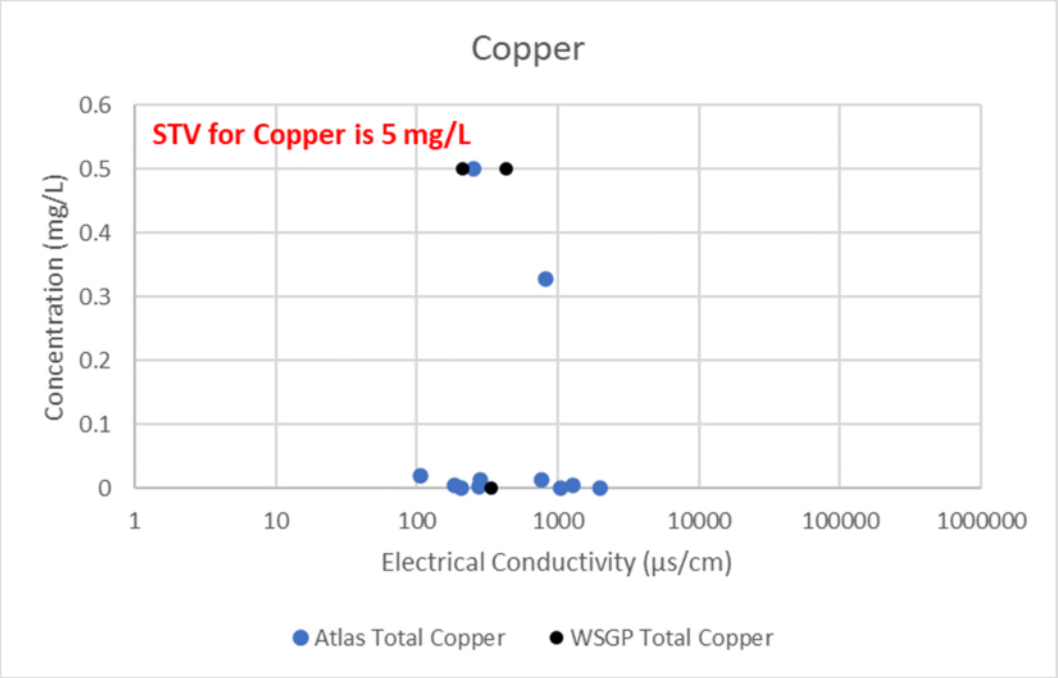

Beryllium
STV for Beryllium is 0.5 mg/L
Concentration (mg/L)
0.12
0.1
0.08
0.06
0.04
0.02
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Beryllium
WSGP Total Beryllium

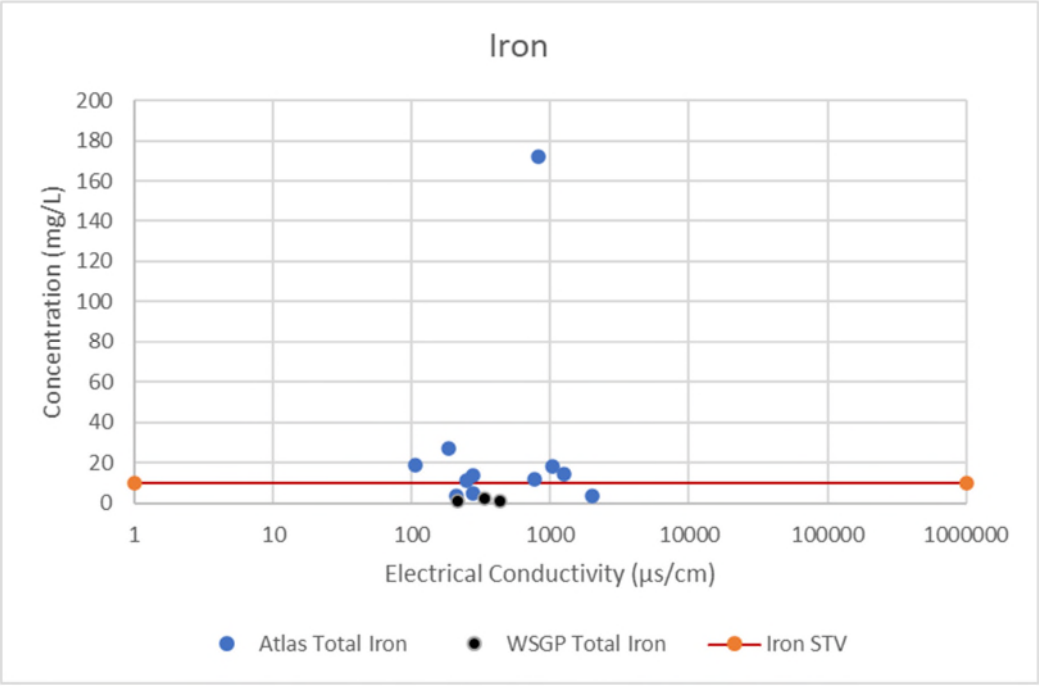

Boron
Concentration (mg/L)
6
5
4
3
2
1
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Boron
WSGP Total Boron
Boron STV

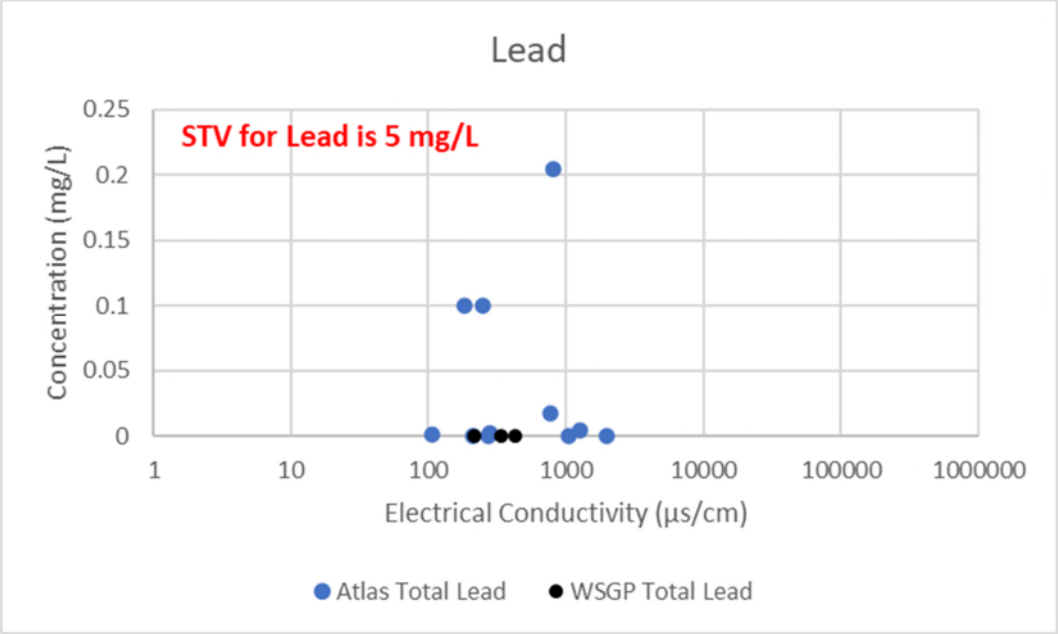

Cadmium
Concentration (mg/L)
0.06
0.05
0.04
0.03
0.02
0.01
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Cadmium
WSGP Total Cadmium
Cadmium STV

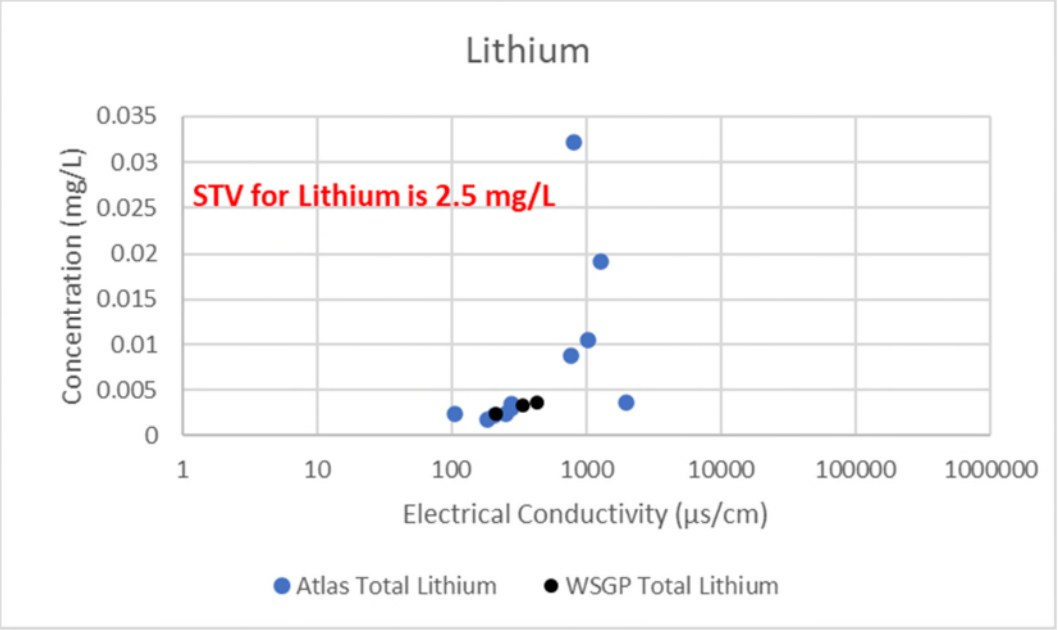

Chromium
STV for Chromium is 1 mg/L
Concentration (mg/L)
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Chromium
WSGP Total Chromium

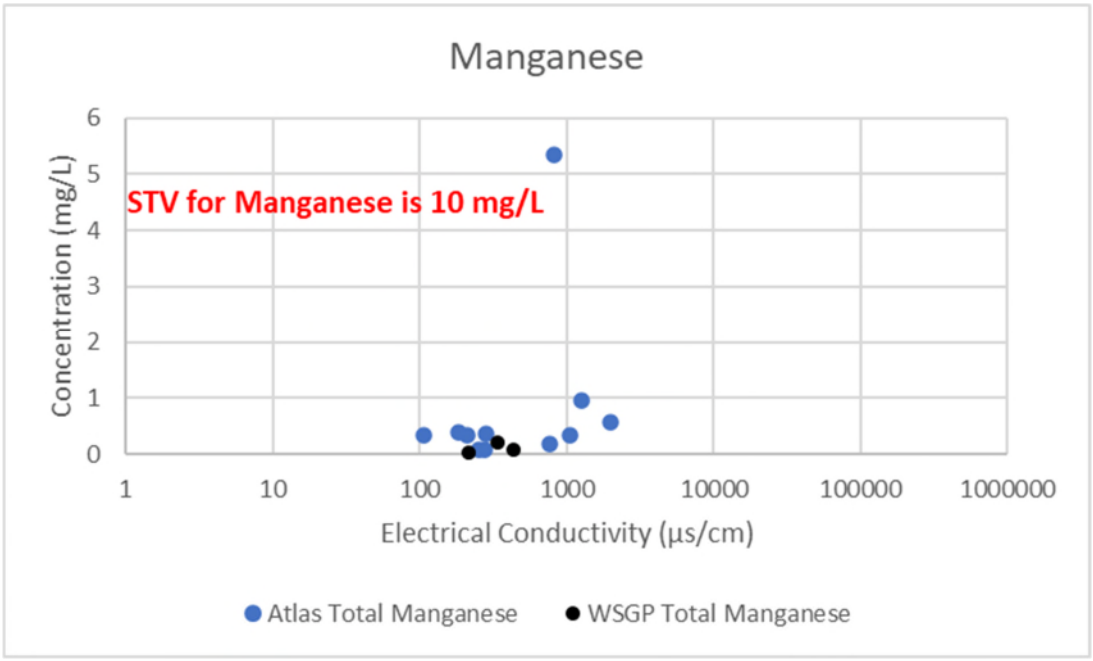

Cobalt
Concentration (mg/L)
0.12
0.1
0.08
0.06
0.04
0.02
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Cobalt
WSGP Total Cobalt
Cobalt STV

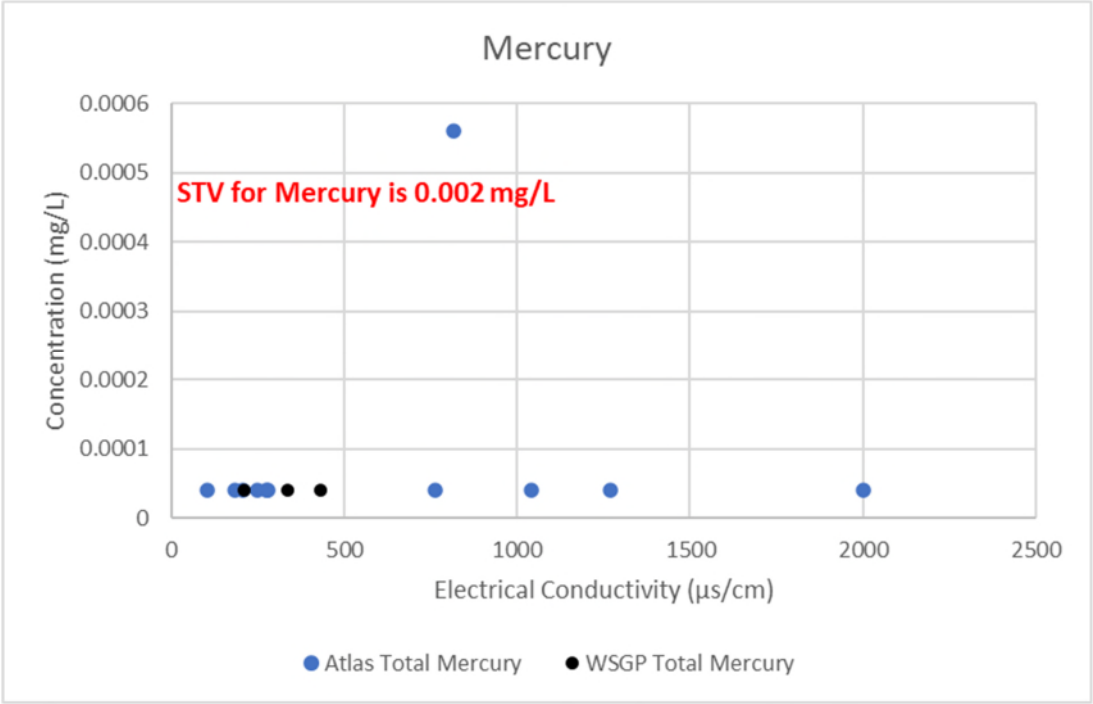

Copper
STV for Copper is 5 mg/L
Concentration (mg/L)
0.6
0.5
0.4
0.3
0.2
0.1
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Copper
WSGP Total Copper

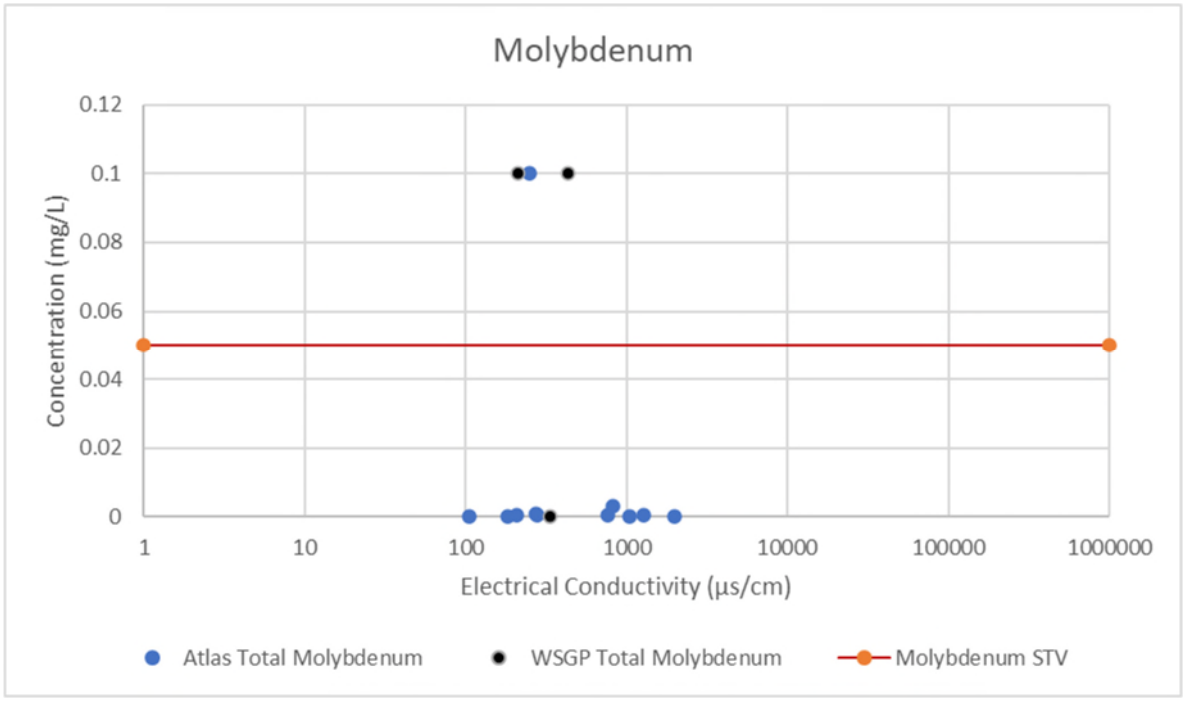

Iron
Concentration (mg/L)
200
180
160
140
120
100
80
60
40
20
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Iron
WSGP Total Iron
Iron STV

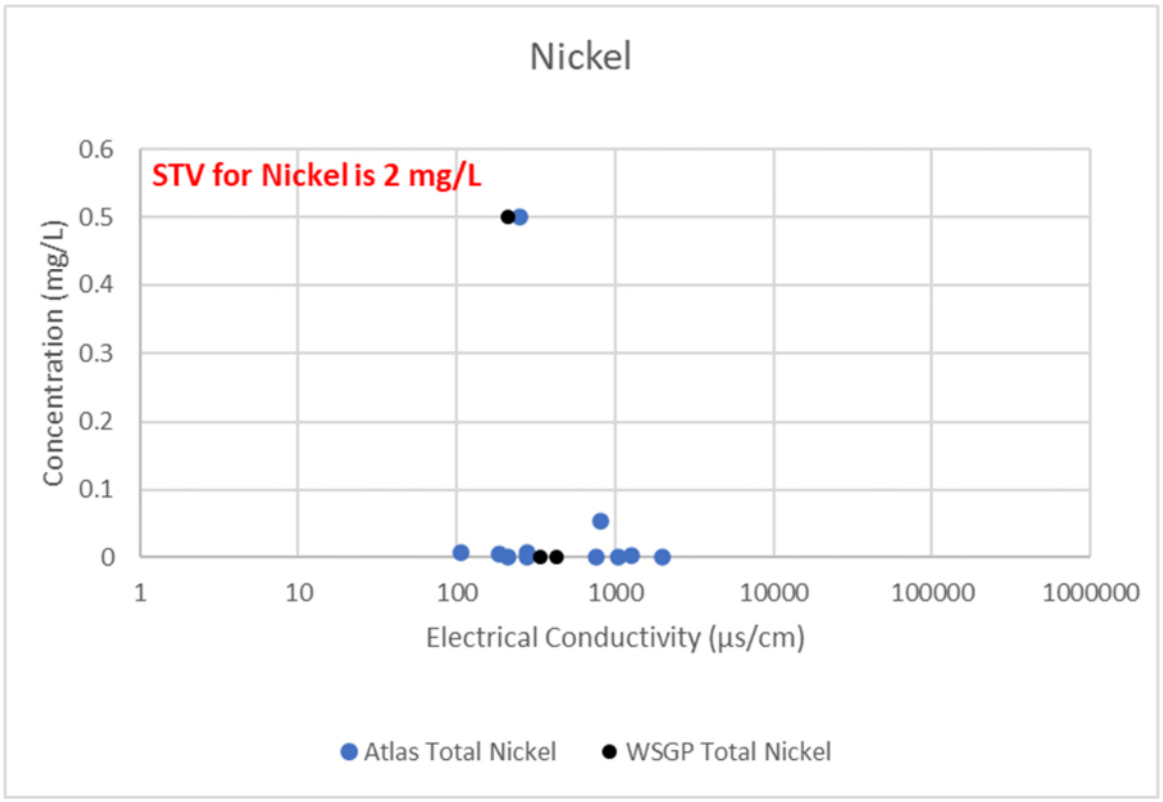

Lead
STV for Lead is 5 mg/L
Concentration (mg/L)
0.25
0.2
0.15
0.1
0.05
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Lead
WSGP Total Lead

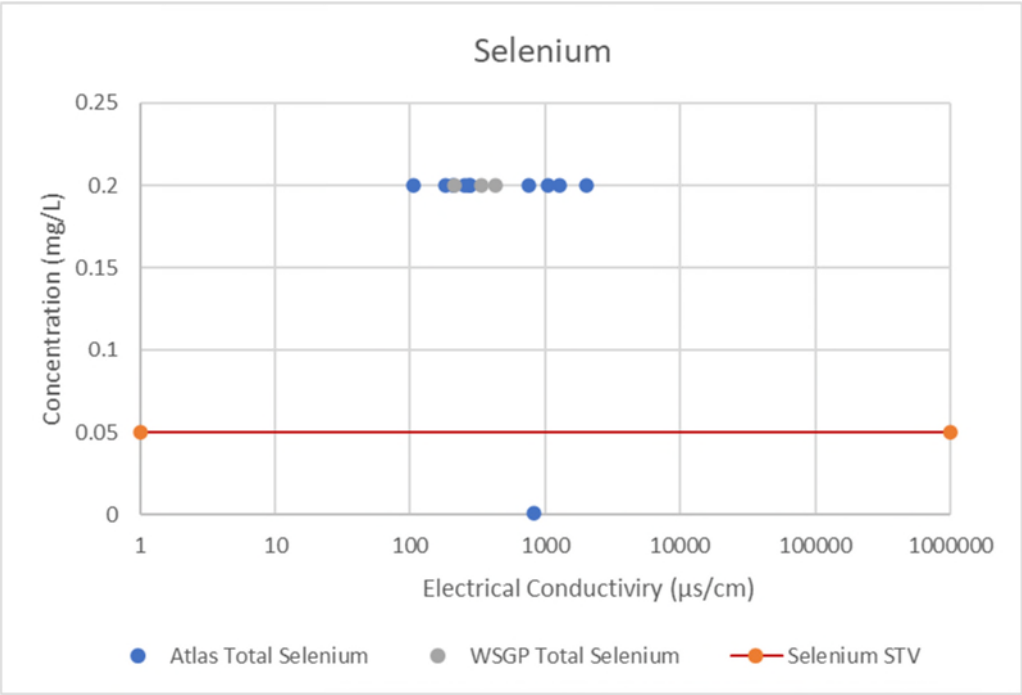

Lithium
STV for Lithium is 2.5 mg/L
Concentration (mg/L)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Lithium
WSGP Total Lithium

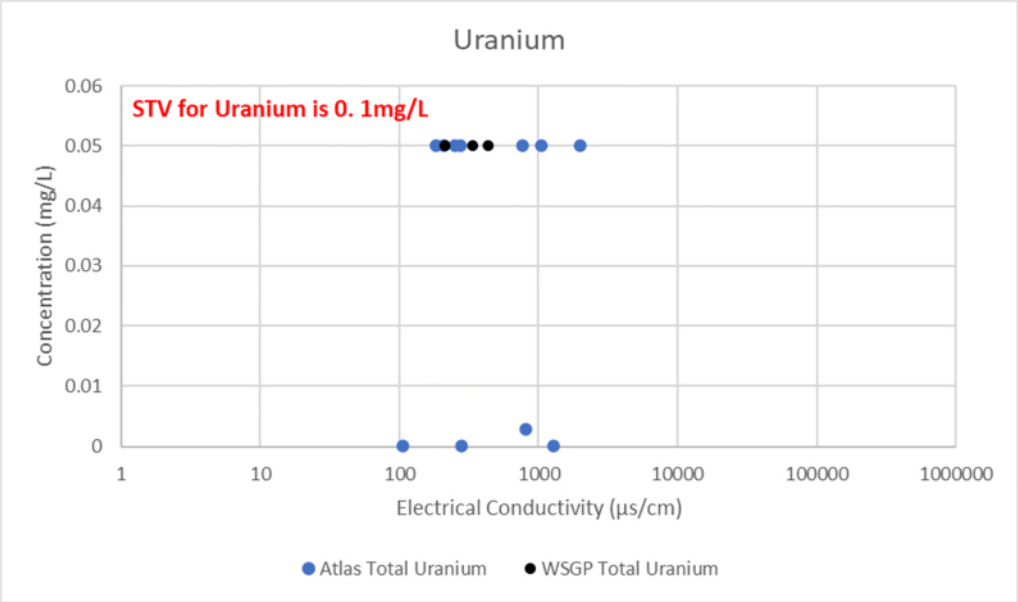

Manganese
STV for Manganese is 10 mg/L
Concentration (mg/L)
0
1
2
3
4
5
6
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Manganese
WSGP Total Manganese

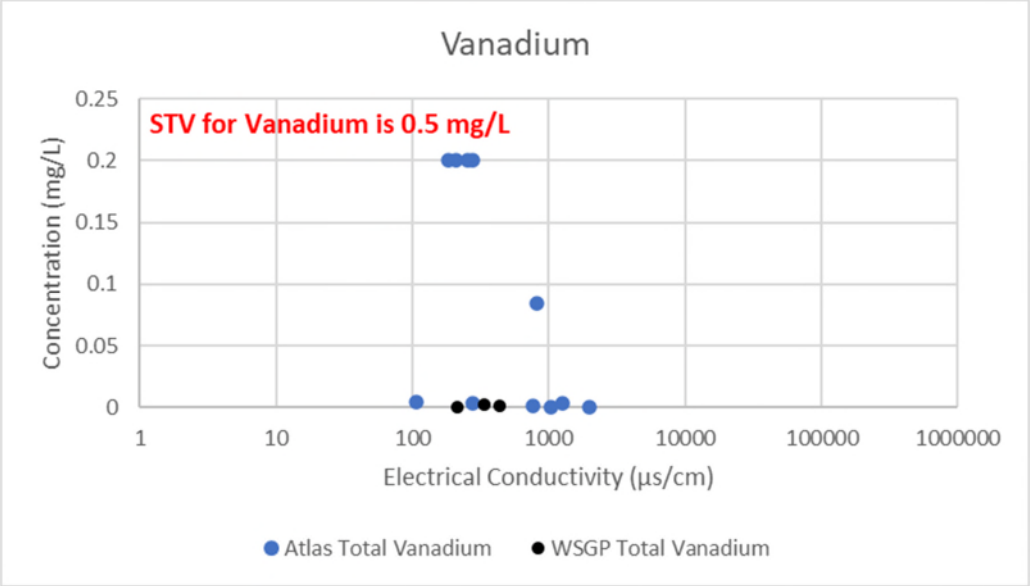

Mercury
STV for Mercury is 0.002 mg/L
Concentration (mg/L)
0
0.0001
0.0002
0.0003
0.0004
0.0005
0.0006
0
500
1000
1500
2000
2500
Electrical Conductivity (µs/cm)
Atlas Total Mercury
WSGP Total Mercury

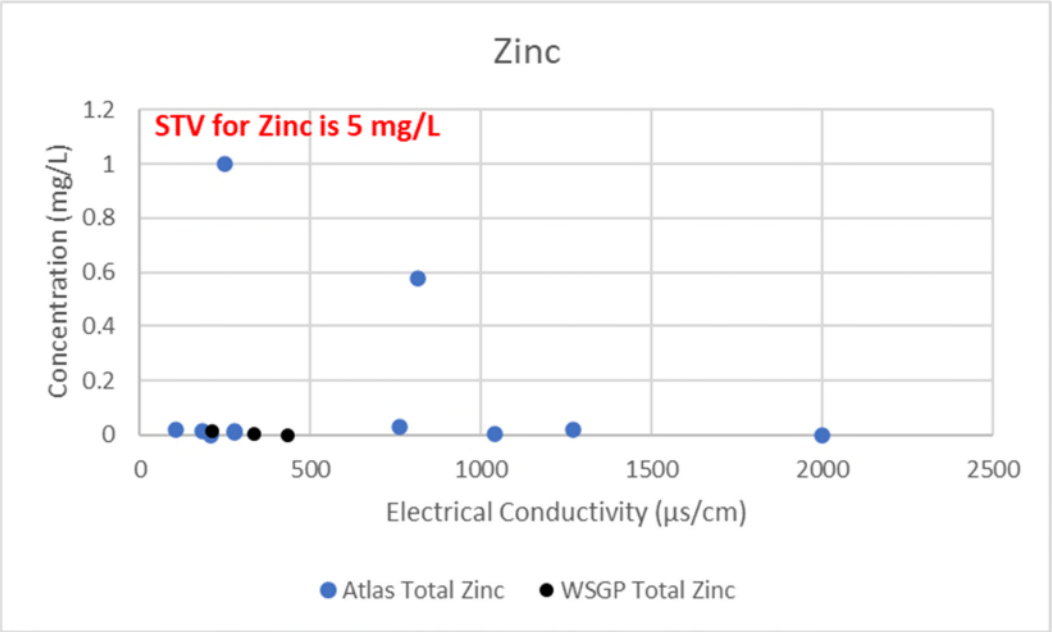

Molybdenum
0.12
0.1
0.08
0.06
0.04
0.02
0
Concentration (mg/L)
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Molybdenum
WSGP Total Molybdenum
Molybdenum STV


Nickel
STV for Nickel is 2 mg/L
0.6
0.5
0.4
0.3
0.2
0.1
0
Concentration (mg/L)
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Nickel
WSGP Total Nickel


Selenium
0.25
0.2
0.15
0.1
0.05
0
Concentration (mg/L)
1
10
100
1000
10000
100000
1000000
Electrical Conductiviry (µs/cm)
Atlas Total Selenium
WSGP Total Selenium
Selenium STV


Uranium
STV for Uranium is 0. 1mg/L
0.06
0.05
0.04
0.03
0.02
0.01
0
Concentration (mg/L)
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Uranium
WSGP Total Uranium


Vanadium
STV for Vanadium is 0.5 mg/L
Concentration (mg/L)
0.25
0.2
0.15
0.1
0.05
0
1
10
100
1000
10000
100000
1000000
Electrical Conductivity (µs/cm)
Atlas Total Vanadium
WSGP Total Vanadium


Zinc
STV for Zinc is 5 mg/L
Concentration (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
0
500
1000
1500
2000
2500
Electrical Conductivity (µs/cm)
Atlas Total Zinc
WSGP Total Zinc

Appendix C Soil Analysis Data

Land types	PL1037	SALI sites	PL 1022 / PL 1023 / PL 1024	Roma Land Management Field Manual
	Juandah	FSE281	Brigalow Uplands	x 4 soil types
	Mundell	no data	Bymount	x 2 soil types
	Narran	FSE290	Maranoa	no data
	Wandoan	FSE342	Merivale	no data

Land type	Soil type / SALI code	Depth	Clay%	ESP	CEC	CCR	a	b	
PL1037									
Junandah	FSE281	0 - 0.1		31	0.8	24	0.77	0.772	-0.98
		0.5 - 0.6		36	5.0	17	0.48	0.706	-1.141
		1 - 1.1		45	5.4	33	0.73	0.802	-0.971
		1.5 - 1.6		27	5.3	24	0.89	0.772	-0.98
Narran	FSE290	0 - 0.07		21	20.6	16	0.76	0.479	-1.195
		0.1 - 0.2		45	1.5	25	0.56	0.802	-0.971
		0.8 - 0.9		37	22.6	24	0.65	0.827	-1.087
		1 - 1.1		35	23.4	24	0.69	0.827	-1.087
Wandoan	FSE342	0 - 0.05	no data		8.4	32	n.a		
		0.2 - 0.4			33.3	27	n.a		
		0.9 - 1.1			49.3	27	n.a		
PL 1022 / PL 1023 / PL 1024									
Brigalow Uplands	Limewood	0-10		23	1.7	22	0.96	0.295	-0.671
		20-30		41	6.8	38	0.93	0.831	-0.962
		50-60		37	15	34	0.92	0.831	-0.962
		80-90		23	21	29	1.26	0.295	-0.671
Brigalow Uplands	Wondolin	0-10		11	3.4	38	3.45	-0.559	-0.067
		23-30		11	10.3	36	3.27	-0.559	-0.067
		50-60		10	18.1	37	3.70	-0.559	-0.067
		80-90		14	18.6	37	2.64	-0.559	-0.067
		110-120		16	17.3	40	2.50	0.295	-0.671
		140-150		18	10.7	38	2.11	0.295	-0.671
Brigalow Uplands	Eumomurrin	0-10		35	2.1	33	0.94	0.831	-0.962
		23-30		45	6.9	39	0.87	0.794	-1.105
		50-60		45	20	37	0.82	0.794	-1.105
Brigalow Uplands	Glenorden	0-10		27	1.8	24	0.89	0.772	-0.098
		20-30		45	12	31	0.69	0.802	-0.971
		50-60		50	25	35	0.70	0.802	-0.971
		80-90		41	7	30	0.73	0.827	-1.087
Bymount	Nimitybelle	0-10		34	1.1	29	0.85	0.831	-0.962
		23-30		45	2.9	33	0.73	0.802	-0.971
		50-60		45	1.1	32	0.71	0.802	-0.971
		80-90		45	22	28	0.62	0.802	-0.971
		110-120		49	23	34	0.69	0.802	-0.971
	Pamaroo	0-10		15	0.7	14	0.93	0.479	-1.19
		23-30		41	3.3	29	0.71	0.827	-1.087
		50-60		34	8	20	0.59	0.633	-1.032
		80-90		29	8.9	19	0.66	0.633	-1.032
		110-120		21	10	16	0.76	0.479	-1.195

Table 9.2.8 Parameters used in equation 9.5 to estimate LF under irrigation[a]

Clay content range	Parameter	CCR <0.35	CCR 0.35 0.55	CCR 0.55 0.75	CCR 0.75 0.95	CCR >0.95
(%)		($mmole_c$/kg)	($mmole_c$/kg)	($mmole_c$/kg)	($mmole_c$/kg)	($mmole_c$/kg)
5 15	a	-0.653	-0.240	-0.124	-0.115	-0.559
	b	-0.098	-0.521	-0.562	-0.506	-0.067
15 25	a	-0.011	0.330	0.440	0.479	0.295
	b	-0.593	-0.857	-0.934	-1.195	-0.671
25 35	a	0.147	0.411	0.633	0.772	0.457
	b	-0.672	-0.936	-1.032	-0.980	-0.750
35 45	a	0.438	0.706	0.827	0.831	0.663
	b	-1.036	-1.141	-1.087	-0.962	-0.897
45 55	a	0.602	0.831	0.802	0.794	0.570
	b	-1.161	-1.047	-0.971	-1.105	-0.807
55 65	a	0.802	0.812	0.870	0.783	0.613
	b	-0.888	-1.317	-1.006	-0.888	-0.588
65 75	a		0.722	0.663	0.684	0.394
	b		-0.826	-0.840	-1.109	-0.583
75 85	a			0.660	0.690	0.248
	b			-0.751	-0.872	-0.777

a From Shaw (1996)

Method code	Method name	Sample	1	2	3	4	5
		Sample de	0 - 0.15	0 - 0.1	0.5 - 0.6	1 - 1.1	1.5 - 1.6
		Bulk	Y	N	N	N	N
		Units					
15A1_Ca	Exchangeable bases (Ca2+) - 1M ammonium chloride at pH 7.0, no pretreatment for soluble salts	cmol_c/kg		16.1	11.9		
15A1_K	Exchangeable bases (K+) - 1M ammonium chloride at pH 7.0, no pretreatment for soluble salts	cmol_c/kg		2.01	0.733		
15A1_Mg	Exchangeable bases (Mg2+) - 1M ammonium chloride at pH 7.0, no pretreatment for soluble salts	cmol_c/kg		5.42	3.8		
15A1_Na	Exchangeable bases (Na+) - 1M ammonium chloride at pH 7.0, no pretreatment for soluble salts	cmol_c/kg		0.199	0.874		
15A3_Na	Exchangeable bases- 1M ammonium chloride at pH 7.0, adjusted for soluble sodium - Na	cmol_c/kg		0.129	0.72		
15C1_Ca	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - Ca	cmol_c/kg				23.3	14.7
15C1_CEC	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - CEC	cmol_c/kg				33	24
15C1_K	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - K	cmol_c/kg				0.933	0.755
15C1_Mg	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - Mg	cmol_c/kg				6.26	4.09
15C1_Na	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - Na	cmol_c/kg				1.77	1.26
15G1_Al	Exchangeable aluminium, Al3+ (exchange acidity by 1M potassium chloride)	cmol_c/kg			<0.03		
15G1_H	Exchange acidity (hydrogen plus aluminium) by 1M potassium chloride	cmol_c/kg			0.07		
15J1	Effective CEC	cmol_c/kg			17.2		
15L1	Base saturation percentage (BSP)	%				99	86
15M1_Ca/CEC	Calcium to cation exchange capacity ratio					0.713	0.608
15M1_Ca/Mg	Cation ratio Ca/Mg					3.71	3.59
15M1_K/CEC	Potassium to cation exchange capacity ratio					0.0286	0.0313
15M1_Mg/Ca	Magnesium to calcium ratio					0.269	0.279
15M1_Mg/CEC	Magnesium to cation exchange capacity ratio					0.192	0.169
15M1_Mg/K	Cation ratio Mg/K					6.71	5.42
15M1_Na/K	Cation ratio Na/K					1.89	1.67
15N1	Exchangeable sodium percentage (ESP)	%			4.18	5.4	5.2
15Z1_CEC/clay	Cation exchange capacity:clay					0.7	0.9
2A1	Air-dry moisture content	%		3	2.9	3.4	1.9
2Z1_R1	Aqu. Silt+Clay/Total Silt+Clay			0.52	0.59	0.63	0.71
2Z1_R2	Dispersion ratio			0.13	0.2	0.23	0.23
2Z2_Clay	Clay fraction (%) QG method	%		31	36	45	27
2Z2_CS	Coarse sand fraction (%) QG method	%		4	4	2	<1
2Z2_FS	Fine sand (%) QG method	%		45	39	35	60
2Z2_Silt	Silt fraction (%) QG method	%		25	25	20	13
2Z2_sum	Sum of PSA (%)			105	104	102	100
3A1	EC of 1:5 soil/water extract	dS/m		0.11	0.06	0.27	0.26
4A1	pH of 1:5 soil/water suspension			6.7	5.8	8.2	8.6
5A2	Chloride - 1:5 soil/water extract, automated colour	mg/kg		25	54	275	222
6A1	Organic carbon - Walkley and Black	%	1.76				
7B1	Water soluble nitrate - automated colour	mg/kg		19	1	1	<1

Depth	**Clay%**	**ESP**	**CEC**
0 - 0.1	31	0.8	23.729
0.5 - 0.6	36	5.0	17.307
1 - 1.1	45	5.4	33
1.5 - 1.6	27	5.3	24

		Sample	1	2	3	4	5
		Sample de	0 - 0.1	0 - 0.07	0.1 - 0.2	0.8 - 0.9	1 - 1.1
		Bulk	Y	N	N	N	N
Method co	Method name	Units					
15A1_Ca	Exchangeable bases (Ca2+) - 1M ammonium chloride at pH 7.0, no pretreatment for soluble salts	cmol_c/kg			12.3	19.7	
15A1_K	Exchangeable bases (K+) - 1M ammonium chloride at pH 7.0, no pretreatment for soluble salts	cmol_c/kg			0.341	0.294	
15A1_Mg	Exchangeable bases (Mg2+) - 1M ammonium chloride at pH 7.0, no pretreatment for soluble salts	cmol_c/kg			9.1	9.93	
15A1_Na	Exchangeable bases (Na+) - 1M ammonium chloride at pH 7.0, no pretreatment for soluble salts	cmol_c/kg			3.3	6.67	
15A3_Na	Exchangeable bases- 1M ammonium chloride at pH 7.0, adjusted for soluble sodium - Na	cmol_c/kg			3.22	6.31	
15C1_Ca	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - Ca	cmol_c/kg		9.39		12.4	12.3
15C1_CEC	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - CEC	cmol_c/kg		16		24	24
15C1_K	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - K	cmol_c/kg		0.397		0.191	0.218
15C1_Mg	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - Mg	cmol_c/kg		3.18		9.62	10.2
15C1_Na	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - Na	cmol_c/kg		0.375		5.43	5.61
15L1	Base saturation percentage (BSP)	%		84		113	120
15M1_Ca/(	Calcium to cation exchange capacity ratio			0.591		0.506	0.52
15M1_Ca/I	Cation ratio Ca/Mg			2.95		1.29	1.21
15M1_K/CI	Potassium to cation exchange capacity ratio			0.025		0.00782	0.00921
15M1_Mg/	Magnesium to calcium ratio			0.339		0.777	0.828
15M1_Mg/	Magnesium to cation exchange capacity ratio			0.2		0.393	0.431
15M1_Mg/	Cation ratio Mg/K			8.02		50.3	46.8
15M1_Na/	Cation ratio Na/K			0.945		28.4	25.7
15N1	Exchangeable sodium percentage (ESP)	%		2.4		22.2	23.7
15Z1_CEC/	Cation exchange capacity:clay			0.8		0.7	0.7
2A1	Air-dry moisture content	%		1.7	3.6	3.4	3.2
2Z1_R1	Aqu. Silt+Clay/Total Silt+Clay			0.55	0.87	0.94	1
2Z1_R2	Dispersion ratio			0.21	0.53	0.62	0.84
2Z2_Clay	Clay fraction (%) QG method	%		21	45	37	35
2Z2_CS	Coarse sand fraction (%) QG method	%		43	32	34	36
2Z2_FS	Fine sand (%) QG method	%		29	17	22	22
2Z2_Silt	Silt fraction (%) QG method	%		12	9	11	9
2Z2_sum	Sum of PSA (%)			105	103	104	102
3A1	EC of 1:5 soil/water extract	dS/m		0.11	0.06	0.13	0.7
4A1	pH of 1:5 soil/water suspension			7.4	6.9	6.4	8.7
5A2	Chloride - 1:5 soil/water extract, automated colour	mg/kg		33	29	130	893
6A1	Organic carbon - Walkley and Black	%	2.13				
7B1	Water soluble nitrate - automated colour	mg/kg		5	4	<1	<1

Depth	Clay%	ESP	CEC
0 - 0.07	21	20.6	16
0.1 - 0.2	45	1.5	25
0.8 - 0.9	37	22.6	24
1 - 1.1	35	23.4	24

		Sample	1	2	3
		Sample depth range (m)	0 - 0.05	0.2 - 0.4	0.9 - 1.1
		Bulk	N	N	N
Method code	Method name	Units			
15C1_Ca	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - Ca	cmol_c/kg	27	16.7	11.9
15C1_CEC	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - CEC	cmol_c/kg	32	27	27
15C1_K	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - K	cmol_c/kg	0.79	0.34	0.35
15C1_Mg	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - Mg	cmol_c/kg	2.96	2.98	3.15
15C1_Na	Exchangeable bases and CEC - alcoholic 1M ammonium chloride at pH 8.5, pretreatment for soluble salts - Na	cmol_c/kg	2.7	9	13.3
15L1	Base saturation percentage (BSP)	%	104	107	104
15M1_Ca/CEC	Calcium to cation exchange capacity ratio		0.838	0.613	0.434
15M1_Ca/Mg	Cation ratio Ca/Mg		9.14	5.6	3.79
15M1_K/CEC	Potassium to cation exchange capacity ratio		0.0242	0.0125	0.0127
15M1_Mg/Ca	Magnesium to calcium ratio		0.109	0.179	0.264
15M1_Mg/CEC	Magnesium to cation exchange capacity ratio		0.0917	0.11	0.115
15M1_Mg/K	Cation ratio Mg/K		3.78	8.77	9.02
15M1_Na/K	Cation ratio Na/K		3.45	26.5	38
15N1	Exchangeable sodium percentage (ESP)	%	8.4	33.1	48.3
3A1	EC of 1:5 soil/water extract	dS/m	0.15	0.84	1.2
4A1	pH of 1:5 soil/water suspension		7.7	8.9	8.2

Depth	**Clay%**	**ESP**	**CEC**
0 - 0.05	**no data**	8.4	**32**
0.2 - 0.4		33.3	27
0.9 - 1.1		49.3	27

Land type	Soil type / SALI code	Depth	Clay%	ESP	CEC	CCR	a	b
Mundell	n/a	Topsoil 1	47	4.0	31.5	0.67	0.802	-0.971
	n/a	Topsoil 2	50	2.2	36.8	0.74	0.802	-0.971
	n/a	Topsoil 3	42	7.3	30.8	0.73	0.827	-1.087
	n/a	Topsoil 4	45	5.4	33.4	0.74	0.802	-0.971
	n/a	Subsoil	48	4.0	41.4	0.86	0.794	-1.105

Table 9.2.8 Parameters used in equation 9.5 to estimate LF under irrigation[a]

Clay content range (%)	Parameter	CCR <0.35 ($mmole_c$/kg)	CCR 0.35 0.55 ($mmole_c$/kg)	CCR 0.55 0.75 ($mmole_c$/kg)	CCR 0.75 0.95 ($mmole_c$/kg)	CCR >0.95 ($mmole_c$/kg)
5 15	a	-0.653	-0.240	-0.124	-0.115	-0.559
	b	-0.098	-0.521	-0.562	-0.506	-0.067
15 25	a	-0.011	0.330	0.440	0.479	0.295
	b	-0.593	-0.857	-0.934	-1.195	-0.671
25 35	a	0.147	0.411	0.633	0.772	0.457
	b	-0.672	-0.936	-1.032	-0.980	-0.750
35 45	a	0.438	0.706	0.827	0.831	0.663
	b	-1.036	-1.141	-1.087	-0.962	-0.897
45 55	a	0.602	0.831	0.802	0.794	0.570
	b	-1.161	-1.047	-0.971	-1.105	-0.807
55 65	a	0.802	0.812	0.870	0.783	0.613
	b	-0.888	-1.317	-1.006	-0.888	-0.588
65 75	a		0.722	0.663	0.684	0.394
	b		-0.826	-0.840	-1.109	-0.583
75 85	a			0.660	0.690	0.248
	b			-0.751	-0.872	-0.777

a From Shaw (1996)

Appendix D: Constraints Protocol

Senex

Queensland Environmental Protocol for Field Development and Constraints Analysis

Date:	24/08/2022
Document:	SENEX-CORP-EN-PRC-019
Revision:	1

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Document Status

Revision History

Revision	Release Date	Document Status	Revision Comments	Author
0	10/10/2017	Issued for Use	New document	H. Wood
1	11/1/2/2019	Issued for Use	Incorporating Project Atlas Dulacca snail requirements	H.Wood

Document Approval

Originator	Name and role	**Signed**	Date
Reviewed by			
Approved by			

1 Definitions

Biodiversity values – environmentally sensitive areas, prescribed environmental matters and wetlands.

Constraints checklist – used for quality assurance purposes to ensure all relevant environmental constraints are considered as early in the infrastructure siting process as possible.

Constraints maps – created and updated by the WSGP Technical Officer, the maps will assist in initial environmental desktop constraints analysis for proposed infrastructure locations. Information includes (as required):

- Aerial imagery;
- Flood plains;
- Elevation data (Lidar and/or contours);
- Ecological and watercourse/wetland constraints;
- Areas of Regional Planning Interest (e.g. Strategic Cropping Land);
- Existing infrastructure;
- Native title;
- Cultural heritage;
- Sensitive receptors; and
- Landholder status.

Ecology Survey Report – report detailing the findings of the ecological surveys undertaken as part of the environmental site assessment.

Invasive plant – as defined under the *Biosecurity Act 2014*.

MNES – matter of national environmental significance under the *Environmental Protection and Biodiversity Protection Act 1999*.

MSES – matter of state environmental significance under the *Environmental Offset Act 2014*.

Significant disturbance to land – defined in Schedule 12 of the Environmental Protection Regulation 2008 as land that has been disturbed and human intervention is needed to rehabilitate it to a condition required under the relevant environmental authority, or to the condition it was in immediately before the disturbance.

Site-specific environmental conditions and maps – conditions and restrictions (and associated maps) governing how construction activities on site should be carried out to ensure compliance with Environmental Authority conditions and regulatory requirements.

Strategic cropping area – an area of regional interest defined under the Regional Planning Interests Act 2014.

2 Purpose

The Environmental Protocol for Field Development and Constraints Analysis (the Protocol) aims to ensure that infrastructure siting:

- Considers biodiversity values and environmental constraints when selecting preferential locations, aligning with planning principles to avoid, minimise, mitigate and then manage potential environmental impacts
- Is compliant with Environmental Authority (EA) conditions and State and Federal regulatory requirements
- Identifies any additional external environmental approvals required and that those are secured prior to the commencement of construction activities

- Avoids important populations of the threatened Dulacca Woodland snail (Adclarkia dulacca), if it is found to occur within Project Atlas, and limits the potential to fragment or isolate populations should they occur within the disturbance area or adjacent areas.

The Protocol also recognises that, in addition to environmental constraints, landholder, engineering and cultural heritage constraints must be considered during infrastructure siting. These constraints are assessed through processes aligned with this Protocol.

3 Scope

This Protocol applies to site selection and approvals for across all Senex's infrastructure projects where construction will involve significant disturbance to land. This includes but is not limited to:

- Well lease pads;
- Access tracks;
- Compression facilities;
- Dams and water management facilities;
- Pipelines;
- Seismic surveys;
- Camps and associated laydowns and hardstand areas; and
- Borrow pits.

The Protocol is triggered by the initiation of a work program by the Project Infrastructure Development Team and involves the steps described in Section 5 and as shown in Figure 5-1.

4 Protocol steps

4.1 Desktop environmental constraints analysis

Upon development of a work program a desktop constraints analysis will be completed. This analysis involves review of GIS mapping layers relating to the proposed infrastructure location(s). The GIS mapping layers generally comprise publicly available State and Federal Government data supplemented by site-specific GIS data gathered during survey activities.

The desktop constraints analysis results in the production of constraints map(s) for internal review.

Depending on the specific nature of any environmental or other constraint(s) identified during the desktop assessment, the proposed infrastructure location may be revised and the new location selected to avoid or minimise the impacts on the constraining environmental values where possible. The constraints maps and associated analysis checklist are retained on file for quality assurance purposes.

4.2 Site surveys

Once a preferred infrastructure location is defined through the desktop constraints analysis and consultative process, site surveys are undertaken to confirm the suitability of the location. This includes, in general chronological order:

- Discussions with landholders to identify on-ground constraints (e.g. stock routes) and to confirm preferred location(s);
- Survey of infrastructure locations by engineering staff to confirm constructability;
- Environmental surveys of infrastructure locations to ground-truth mapped constraints including protected vegetation, fauna habitat, watercourses, prescribed environmental matters to trigger environmental offsets, invasive weeds, areas of regional interest etc.

- Cultural heritage clearance of infrastructure locations.

Outcomes of 1 and 2 above refine the scope of the environmental survey. The primary environmental survey undertaken is ecological ground-truthing to confirm the likelihood of habitat for protected fauna, the occurrence of protected flora, regional ecosystems and ecological communities, prescribed environmental matters, and validation of mapped watercourses. The survey will be based on field methods to collect data using the Queensland Biodiversity Values Field Assessment Form (SENEX-CORP-EN-FRM-008).

Where required, additional species specific targeted field based surveys will be undertaken by suitably experienced ecologists within areas identified as potential habitat to further understand the impact of the project on a species, Surveys will be required for Nature Conservation Act Flora trigger plants in a trigger area or where disturbance is proposed within or adjacent to potential Dulacca snail habitat in Project Atlas. Species specific surveys for species such as Koala or Yakka skink may also be undertaken to assist managing the site for a particular species.

The results are documented in a report based on the report template (SENEX-CORP-EN-TEM-001 Biodiversity Values Report Template).

Should site surveys locate constraints not identified through the desktop environmental constraints analysis, infrastructure locations may be modified or revised, returning to step 1 above.

4.3 Post-survey environmental constraints analysis

The results of the site surveys are used to further refine the proposed infrastructure locations. The environmental survey results and in particular the content of the Ecological Survey Report is used to:

- Identify areas within the disturbance footprint or directly adjacent supporting potential habitat for threatened species or significant species and avoid the field validated habitat where possible.
- Where there is evidence of threatened or significant species occurrence, identify if there is flexibility in the design to avoid important populations, and limit the potential for fragmentation and isolation of populations, should they occur within the disturbance area or adjacent areas. Important populations of the Dulacca snail will be avoided within Project Atlas, where they occur.
- Define limited or no-access areas (e.g. to protect mature habitat trees, areas of declared weed infestation etc);
- Determine whether any secondary approvals (e.g. protected plant clearing permits) need to be secured prior to commencing construction activities;
- Determine whether any environmental offsets at the State or Federal level will be triggered against environmental offset approvals;
- Determine other construction-related environmental requirements such as design considerations for watercourse crossings that constitute waterway barrier works and requirements to address strategic cropping areas.

Key environmental restrictions for infrastructure siting or construction activities arising from the environmental surveys and desktop constraints analysis feed into the Preliminary Access to Work documentation to allow Conduct and Compensation Agreements to be negotiated with relevant landholder(s). Any additional approvals required are then sought.

4.4 Environmental constraints reporting

Once any additional approvals are secured, an Environmental Constraints Report is prepared formally documenting:

- That infrastructure siting complies with relevant environmental approval conditions including planning considerations and disturbance/clearing limits;

- That infrastructure siting complies with requirements of relevant regulations and secondary approvals;
- The estimated disturbance area for any MNES or MSES to be debited from the approved disturbance limit in the relevant approval;
- Identifies where environmental offsets will be triggered and the estimated disturbance area to be debited from the relevant offset plan; and
- Site-specific or construction-related environmental considerations.

The report includes a list of Site-specific Environmental Conditions and associated maps that are included in the final Access to Work documentation, issued upon sign-off by the Project Manager to relevant staff and contractors prior to commencing construction. The Environmental Constraints Report is used to demonstrate compliance with relevant regulations, as part of the overarching Senex Environmental Compliance Management System. The disturbance data in the report is used to update the land disturbance GIS layer that manages aspects for total disturbed area and environmental offsets required for external environmental annual reporting.

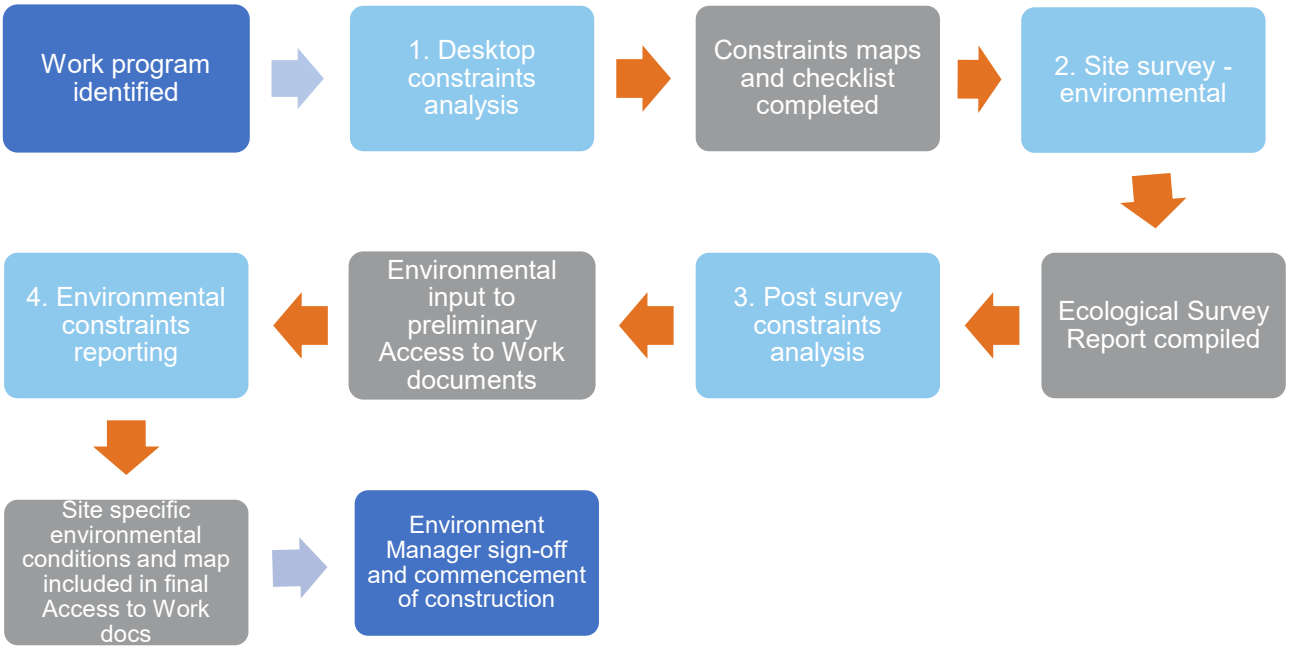

Figure 5-1 Key steps in the Protocol

5 Delivery

Key deliverables, timing and roles and responsibilities are detailed in Table 6-1 below.

Table 6-1 Deliverables, roles and responsibilities

Step	Deliverable	Timing (estimate)	Role (WSGP)
1. Desktop environmental constraints analysis	Constraints mapping and completed checklist.	2 weeks	Senex Environmental Adviser
2. Site surveys - environmental	Ecology Survey Report (or similar for other environmental considerations.	4 weeks (from completion of landholder discussions and constructability surveys)	Undertaken by Senex and/ or third party ecologist (consultant)

3. Post-survey environmental constraints analysis	Key environmental restrictions included in preliminary Access to Work documentation for CCA negotiation.	2 weeks	Senex Environmental Advisor
4. Environmental constraints reporting	Environmental Constraints Report. Site-specific Environmental Conditions and associated maps for inclusion into final Access to Work documentation.	2 weeks	Senex Environmental Advisor and approved by the Environment Manager

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Appendix E: Ecological Assessment Report (Boobook, 2021)

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Ecological Assessment Report

WSGP Mimas export pipeline and facilities ecology survey.

Compiled by BOOBOOK for Senex

Revision	Date	Description	Author/s	Verifier	Approved
A	9/11/2021	Draft issued to client for review	M. Cunningham	C. Eddie	C. Eddie
0	15/11/2021	Revised report addressing client comments	M. Cunningham	C. Eddie	C. Eddie

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List of Abbreviations

ACC	Australian Country Choice
Biosecurity Act	*Biosecurity Act 2014* (Qld)
CE/CR	Critically Endangered
CDZ	Construction Disturbance Zone/s
DAFF	Department of Agriculture, Forestry and Fisheries (Qld).
DAWE	Department of Agriculture, Water and the Environment (Australia)
DEHP	Department of Environment and Heritage Protection (Qld)
DES	Department of Environment and Science. Queensland (Qld)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Australia)
DNRM	Department of Natural Resources and Mines. Queensland (Qld)
DoR	Department of Resources (Qld).
E	Endangered
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Australia)
ESA	Environmentally Sensitive Area
GDE	Groundwater Dependent Ecosystem/s
GIS	Geographic Information System
GPS	Global Positioning System
C	Least Concern
MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
NC Act	*Nature Conservation Act 1992* (Qld)
NT	Near Threatened
PMST	Protected Matters Search Tool
Qld	Queensland
RE	Regional Ecosystem/s
REDD	Regional Ecosystem Description Database
SLC	Special Least Concern
TEC	Threatened Ecological Community/ies
V	Vulnerable
VMA	*Vegetation Management Act 1999* (Qld)
WoNS	Weeds of National Significance
WSGP	Senex Western Surat Basin Gas Project

Executive Summary

This report provides a description of an ecology survey undertaken for the Senex Western Surat Basin Gas Project (WSGP) on the Australian Country Choice (ACC) property 'Brindley Park' approximately 36 km north-northeast of Roma, southern inland Queensland. The 'Site' includes the proposed disturbance footprint and associated buffer areas for the proposed Mimas gas export pipeline and associated facilities. The ecology survey was conducted by BOOBOOK between June and August 2021.

Field assessment included identification and mapping of remnant and regrowth Regional Ecosystems (RE) and assessment of potential Threatened Ecological Communities (TEC). Vegetation structure and faunal habitat assessments were made at a representative location within the Site.

The Site is in an extensively cleared landscape with most remnant and regrowth vegetation in the vicinity occurring as narrow corridors and small fragments, mainly along streamlines. The Site is entirely cleared, with no remnant or regrowth native vegetation within the Site. There are no streams, waterbodies, springs or wetlands within the Site.

Field survey of flora species was limited to incidental observations and active searches for threatened plants around vegetation structure points. No *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or Queensland *Nature Conservation Act 1992* (NC Act) listed threatened flora species were found. Six threatened flora species, listed under federal and/or state legislation, were identified as potentially present at the Site based on desktop searches. These six species were assessed as unlikely to occur within the Site due to the lack of suitable habitat in and around the Site, and the absence of records of these species in the vicinity.

No comprehensive fauna surveys were performed under this Scope of Works. Fauna surveys were limited to incidental observations and active searches at habitat quality assessment sites. No threatened fauna species listed under the EPBC Act and/or the NC Act, were detected during the field survey. One threatened fauna species, White-throated Needletail (*Hirundapus caudacutus*), was assessed as potentially present within the Site. This aerial feeding species is not dependent on specific resources within the Site. Five EPBC Act listed Migratory and/or Marine fauna species were assessed as potentially present or likely to be present at the Site. These species may occasionally pass through the Site but there were no specific resources that would attract these species to the Site. Few faunal habitat features were detected at the Site and these consisted of scattered timber and windrowed timber piles in non-remnant vegetation.

This development is unlikely to have any significant impact on Matters of National Environmental Significance (MNES) or Matters of State Environmental Significance (MSES), including vegetation, flora and fauna, or aquatic habitats.

1. Introduction

1.1 Purpose & Scope

This report provides the results from an ecological assessment undertaken for Senex Energy Ltd. (Senex) for the Mimas gas export pipeline and associated facilities (the Project) on the Australian Country Choice (ACC) property 'Brindley Park'. The survey area (hereafter termed 'the Site') defined by Senex, comprises a buffered area around the proposed Mimas gas compression and processing facility, a power station, a gas export pipeline, an end-of-line facility, and associated construction infrastructure. The Site is located approximately 36 km north-northeast of Roma, southern inland Queensland, and is accessed via the Roma-Taroom Road. The Site includes areas within Lot 10 on Plan WV406 and Lot 2 on Plan RP835106 including areas within associated pipeline easements UVSP194529 and URP231627.

The purpose of this report is to provide a description of potential ecological values and constraints within the Site. Results presented here are based on an initial desktop assessment combined with a field survey to confirm vegetation communities, flora and fauna species and habitat values present within the Site. This report builds on previous assessments of potential ecological constraints at the Site (BOOBOOK 2021).

BOOBOOK was requested to undertake the following assessments for Matters of National Environmental Significance (MNES) and Matters of State Environmental Significance (MSES) within the buffered alignment of the Site:

- Assess ground-truthed ecological values, including validating:
  - regional ecosystems (RE) and identifying their *Vegetation Management Act 1999* (VMA) and biodiversity status;
  - remnant / endangered regrowth constituting an Environmentally Sensitive Area (ESA) / non-remnant status of vegetation.
- Assess and ground-truth watercourses, groundwater dependent ecosystems (GDEs) , wetlands and springs
  - Assess the status of watercourses in relation to the *Water Act 2000* and the *Environmental Protection Act 1994* as per the Environmental Authority -No. EPPG00651513.
  - Provide information to determine whether a DAFF Waterway Barrier Works permit is required.
  - Identify regulated vegetation associated with watercourses to be impacted.
- Provide an assessment of any potential significant impacts on MNES or MSES fauna species known, or potentially present, at the Site, including:
  - Glossy Black-Cockatoo;
  - South-eastern Long-eared Bat;
  - Yakka Skink;
  - Collared Delma; and
  - Dunmall's Snake.
- Provide predictive habitat mapping for *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Nature Conservation Act 1992* (NC Act) listed threatened fauna and flora species;
- Identify potential constraints within the project area, relating to significant habitat values, breeding places as defined by the *Nature Conservation Act 1992* (NC Act), of concern and endangered regional ecosystems (biodiversity status) contributing to environmentally sensitive areas within or adjacent to the disturbance footprint;
- Provide co-ordinates and description for selected breeding places (as defined by the NC Act);
- Record the location and abundance of non-native plants constituting Weeds of National Significance (WoNS) and/or Restricted Matter scheduled under the *Biosecurity Act 2014* (Biosecurity Act); and
- Identify any significant existing erosion that may impact project construction and operations.

1.3 Survey Team

The field survey component assessing environmental values and constraints within the proposed infrastructure footprint was conducted by Michael Cunningham (Senior Ecologist) between 1st – 8th of June 2021 and 24th – 31st August 2021.

1.4 Site Description

1.1.1 Location

The Site comprises nominated parts of the ACC 'Brindley Park' property complex accessed via the Roma – Taroom Road, approximately 36 km north-northeast of Roma. The site is entirely within the boundary of Maranoa Regional Council, southern inland Queensland.

1.4.3 Site Definition

The Site was identified in spatial data supplied by Senex (email of 4th November 2021 from Byron Brooks, Environmental Advisor, Senex). Proposed infrastructure to be constructed within the Site includes a gas compression and processing facility, a power station, a gas export pipeline, and an end-of-line facility, along with associated access tracks, site offices, construction laydowns and workspaces. The extent of the Site is shown within Appendix A.

1.4.4 Bioregion, Topography and Vegetation

The Site is located in Subregion 26 (Southern Downs) of the Brigalow Belt bioregion. The Site is at an elevation around 430 m above sea level, within an undulating landscape of rolling rises. The Site is drained by headwater tributaries of Conn Creek, an intermittent watercourse within the Maranoa-Balonne system of the Murray-Darling Basin. Vegetation at the Site comprises a derived grassland dominated by introduced Buffel Grass (*Cenchrus ciliaris*). There are no patches of remnant or regrowth native vegetation within the Site.

1.4.5 Soils & Geology

Soils within the Site are deep, brown clay-loams. The Site is situated on sediments derived from the Orallo formation (Kyo) which consists of early-Cretaceous medium to fine-grained sandstones, mudstones and conglomerates, with coal seams. The Site is entirely on land zone 9 (fine-grained sedimentary rocks) as defined within Sattler and Williams (1999).

1.4.6 Current Land Use

The landscape within and around the Site has been largely cleared for livestock grazing and agriculture with scattered small, isolated fragments of remnant vegetation, and discontinuous narrow corridors of woodland along watercourses and within road reserves. Representative images of landscapes within the Site are shown in Figure 1 (a-b).

2. Methodology

2.1 Desktop & Literature Review

A desktop assessment was performed prior to the field survey which included interrogation of the following datasets:

- EPBC Act Protected Matters Search Tool (PMST) (DAWE 2021a);
- WildNet Queensland fauna and flora records (DES 2021a);
- Atlas of Living Australia fauna and flora records (ALA 2021);
- Protected Plants Flora Survey Trigger Map (DES 2021b);
- Referable Wetlands mapping (DES 2021c);
- Environmentally Sensitive Area mapping (DES 2021d);
- Matters of State Environmental Significance (DES 2021e);
- State terrestrial biodiversity and aquatic conservation values (DES 2021f);
- Regulated vegetation mapping (DoR 2021);
- Remnant vegetation RE: Regional Ecosystems – biodiversity status (DES 2021g);
- Mature Regrowth mapping (DES 2020);
- Essential Habitat mapping (DES 2019);
- Ordered stream mapping (DNRM 2010); and
- Previous survey data (ERM 2017).

The searches were conducted using online spatial layers, and/or searches using lot/plan details as a reference or the coordinates 26.2762°S, 148.9514°E (datum GDA94), which correspond to the approximate centre point of the Site, with a 10 km buffer. These datasets provided a baseline for subsequent field assessment.

2.2 Field Survey

The field ecological survey was conducted via foot and vehicle traverses of the entire Site with a focus on the buffered CDZ which includes the proposed disturbance footprint and a surrounding buffer area. Location and other data for all notable features encountered were recorded using a Zebra tablet device, a hand-held GPS unit and written notes.

Baseline botanical surveys were undertaken to describe dominant flora and vegetation community structure within the Site. Ground-truthing of the Regional Ecosystem (RE) designation (DES 2021g) within the Site was undertaken using the quaternary level of data collection as described by Neldner *et al.* (2020).

The vegetation community assessments were undertaken within 50 m x 10 m plots within representative locations in all identified REs and regrowth types within the Site. The locations of the vegetation community survey sites are shown in Appendix B.

Vegetation community polygons were verified in accordance with Queensland RE description and biodiversity status as per the latest updates of the Regional Ecosystem Description Database (REDD) (DES 2021h) and TEC criteria (DAWE 2021b, TSSC 2019, TSSC 2013).

RE polygons were assigned to remnant or non-remnant status as defined by the *Vegetation Management Act 1999*. Remnant vegetation was that which had achieved a canopy layer covering more than 50% of that of the undisturbed canopy and a height more than 70% of the undisturbed height of the vegetation. Minimum size thresholds for remnant vegetation follow the Queensland Herbarium (Neldner *et al*. 2020) definition which delineates a minimum area of 5 ha and 75 m width limit for linear features at a scale of 1: 100,000.

For regrowth (i.e. vegetation not meeting the 50/70 rule cited above) that was floristically equivalent to RE with a biodiversity status of Endangered, ecosystem functionality criteria as supplied by Senex were applied to confirm ESA equivalence. Minimum mappable areas for regrowth vegetation follow the minimum size thresholds for remnant vegetation.

A search was made for EPBC Act and NC Act listed threatened flora and selected Special Least Concern flora within the Site. Where found, the species, location and number of individuals were recorded. Flora species names follow Brown and Bostock (2020).

Significant weed species, WoNS and Biosecurity Act Restricted Matters, were recorded as representative examples to indicate the presence and abundance of the species within a given part of the Site.

Data were collected for fauna habitat features to inform likelihood of occurrence and significant impact assessments for threatened fauna. These data were collected within the same 50 m x 10 m plot used for vegetation assessments, and additionally on well lease pads where non-remnant vegetation was present. Features were assessed semi-quantitatively and included the presence and abundance of:

- hollow-bearing live trees, stags and logs;
- logs by size class;
- leaf and woody litter stone/rock and grassy ground cover;
- rock outcrops, gilgais, termite mounds and burrows; and
- mistletoe and other potential food plants.

Active or potential fauna breeding places were also recorded where found. Such places included:

- Decorticating trees and logs; and
- Hollow-bearing logs, live trees and stags.

The results of microhabitat assessments, combined with published information and ecologist knowledge of fauna distribution and habitat use, were used to predict habitat suitability for EPBC Act and NC Act listed threatened fauna species. These results were used to develop GIS-based mapping of potential habitat for threatened species assessed as potentially occurring within the Site.

Incidental searches were conducted to detect the presence of threatened vertebrate fauna. These were confined to active searches of suitable habitat while traversing the site. No detailed fauna surveys were undertaken.

Any mapped ordered streams occurring within the Site were assessed at representative survey locations to determine whether these were watercourses or drainage features as defined by the *Water Act 2000*. Ordered stream assessments included assessment of the presence/absence of a defined channel with bed and banks, riparian vegetation, evidence of extended flow and hydrophytes. Bank height and slope, and bed widths, were also recorded where these features were present.

Where potential wetlands (including springs) were encountered these were assessed against the hydrological and biotic criteria of the Queensland Wetland Program wetland definition (DERM 2011).

2.3 Limitations

During the survey and in the preceding weeks the weather was dry and cool to mild. Total rainfall of 64.2 mm recorded over June, July and August 2021 at Roma Airport was close to the median winter rainfall of 53.2 mm at this weather station (BOM 2021). Much of the grass and many forbs had withered with repeated frost. There was limited plant growth evident and few species had produced flowers or fruit. The lack of plant growth may have precluded detection and identification of some herbaceous plant species that may potentially occur within the Site.

3. Results & Discussion

3.1 Matters of National Environmental Significance

3.1.1 Threatened Ecological Communities

PMST search results (DAWE 2021a) indicated the potential presence of five TECs within the Site these being:

- Brigalow (*Acacia harpophylla* dominant and co-dominant);
- Coolibah – Black Box woodlands of the Darling Riverine Plains and the Brigalow Belt South Bioregions;
- Poplar Box grassy woodland on alluvial plains;
- Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions; and,
- Weeping Myall woodlands.

There are no significant areas of native vegetation remaining within the Site and no areas of potential TEC were detected during field surveys of the Site.

3.1.2 Threatened Flora

PMST search results indicated the potential occurrence of six EPBC Act-listed threatened flora, these being Hairy-joint Grass (*Arthraxon hispidus*), Ooline (*Cadellia pentastylis*), a Bluegrass (*Dichanthium setosum*), Winged Pepper-cress (*Lepidium monoplocoides*), Slender Darling-pea (*Swainsona murrayana*) and Slender Tylophora (*Tylophora linearis*). No records of threatened flora listed under the EPBC Act were identified within searches of Wildlife Online (DES 2021a) and ALA (ALA 2021) databases.

No species of EPBC Act listed threatened flora were detected during field surveys of the Site. The Site is highly modified being entirely non-remnant vegetation of introduced pasture grasses. It is unlikely any threatened plant species occur within the Site.

3.1.3 Weeds of National Significance

Weeds of National Significance (WoNS) detected within the Site are listed in Table 1. Representative locations of these species are shown within Appendix B. Representative images of these species are shown in Section 7 (Figure 2a-b). The weeds listed in Table 1 are also subject to State legislation, being Category 3 restricted matter under the Queensland *Biosecurity Act 2014.*

Table 1. WoNS and Biosecurity Act invasive plants recorded within the Site.

Family	Scientific Name	Common Name	WoNS/ Biosecurity Act Status	Comments
Cactaceae	*Opuntia stricta*	Common Pest Pear	WoNS, Cat. 3 Restricted Matter	Occurs throughout the Site at low densities.
Cactaceae	*Opuntia tomentosa*	Velvety Tree Pear	WoNS, Cat. 3 Restricted Matter	Occurs throughout the Site at low to moderate densities.

3.1.4 Threatened Fauna

A PMST search (DAWE 2021a) combined with a previous WSGP project assessment (ERM 2017) and local ecological knowledge suggested seventeen species of EPBC Act listed threatened fauna that may possibly occur within the Site. Desktop searches of the Queensland Government WildNet database (DES 2021a) revealed a record of one EPBC Act listed threatened species, Eastern Long-eared Bat (*Nyctophilus corbeni*) within 10 km of the Site. Searches of public databases (DES 2021a, ALA 2021) did not find any other publicly available records of EPBC Act listed threatened species within 10 km of the Site. No EPBC Act listed threatened species were detected during the current survey, however, searches for threatened fauna were opportunistic and no systematic fauna surveys were made. An updated likelihood of occurrence assessment for EPBC Act and NC Act threatened fauna within the Site is presented in Table 2.

Table 2: Likelihood of occurrence assessment for EPBC Act and NC Act listed threatened fauna within the Site.

Key to Status: CE/CR = Critically Endangered; E = Endangered; V = Vulnerable; NT = Near Threatened; C = Least Concern.

Family	Scientific & Common Name	EPBC Act Status	NC Act Status	General Habitat Requirements	Likelihood of Occurrence
Birds	*Calidris ferruginea* Curlew Sandpiper	CE	CR	A migratory wader species usually encountered on coastal and near-coastal saline and freshwater tidal and palustrine wetlands (DAWE 2021b). Passage migrants are occasionally present on inland wetlands but the species is sparsely recorded across inland Queensland (ALA 2021).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.
Birds	*Calyptorhynchus lathami* Glossy Black-Cockatoo	-	V	A specialised feeder dependent on seeds of Casuarinaceae trees. Nests in large hollows generally high up in large eucalypt trees or stags (Pavey *et al.* 2016). This species is capable of moving among isolated trees and small habitat patches within fragmented landscapes (Pavey *et al*. 2016, Holmes 2012). There are few records of this species in the region but small feeding groups are periodically observed in and around Roma (Craig Eddie, pers. obs).	**Unlikely to be present.** There are no suitable feed or nest trees within the Site.

Family	Scientific & Common Name	EPBC Act Status	NC Act Status	General Habitat Requirements	Likelihood of Occurrence
Birds	*Erythrotriorchis radiatus* Red Goshawk	V	E	A highly mobile species with a large home range. Breeding habitat is in intact tall forest around major drainage lines, especially near permanent water bodies where there is high avian prey diversity, but the species could potentially forage much further away from these areas (Marchant and Higgins 1993). The species is sensitive to landscape level clearing and may now be extinct in NSW and Southeast Queensland (DERM 2012, Seaton 2014). There are no recent published records from the Southern Brigalow Belt.	**Unlikely to be present.** There are no recent confirmed records from the region and the landscape is largely cleared.
Birds	*Falco hypoleucos* Grey Falcon	V	V	A rarely seen species, occurring at low densities throughout much of the semi-arid interior of Australia (TSSC 2020). This is a pursuit predator that hunts birds and other small prey in open woodland plains. The species nests in large trees along stream lines (TSSC 2020). The species is occasionally recorded in more mesic areas such as the Brigalow Belt (ALA 2021).	**Unlikely to be present.** The Site is far from the preferred habitat of this species, *Acacia* shrubland plains traversed by tree-lined watercourses (TSSC 2020).
Birds	*Geophaps scripta scripta* Squatter Pigeon (southern subspecies)	V	V	The Site is within the historical range of the species (Birdlife Australia 2021). Inhabits grassy woodlands with open areas for foraging habitat usually within 3 km of a water source (Higgins and Davies 1996).	**Unlikely to be present.** There is no suitable grassy woodland habitat within the Site. Squatter Pigeon may forage in open non-remnant grassland, however, there are no recent records of this species from the Roma North gas-field (ALA 2021).
Birds	*Grantiella picta* Painted Honeyeater	V	V	In Queensland the species has been recorded from a wide area extending from the southern inland to the north-west (ALA 2021). Breeding range extends from about Roma southward, while northern records represent the winter range. Lives and breeds in woodlands and open forests with high densities of suitable food plants (i.e. mistletoes, family Loranthaceae) (Higgins *et al*. 2001, Watson 2012).	**Unlikely to be present.** There are few or no suitable mistletoe food plants occurring within the Site.
Birds	*Hirundapus caudacutus* White-throated Needletail	V	V	Aerial spring/summer migrant and insectivore, present over most habitat types including disturbed areas (DAWE 2021b).	**Likely to be present.** May potentially occur overhead throughout the Site.
Birds	*Rostratula australis* Australian Painted Snipe	E	E	The Site is within the species' known range (ALA 2021); forages at shallow edges and adjacent vegetated margins of freshwater wetlands (DAWE 2021b).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.

Family	Scientific & Common Name	EPBC Act Status	NC Act Status	General Habitat Requirements	Likelihood of Occurrence
Insects	*Jalmenus eubulus* Pale Imperial Hairstreak (butterfly)	-	V	This butterfly is essentially limited to the Brigalow Belt: its range extends from inland of Eungella, central Qld southward to the Carnarvon Range and Darling Downs, extending into far northern NSW (ALA 2021). Usually associated with mature Brigalow (*Acacia harpophylla*) open forests and woodlands (Eastwood et al. 2008; Valentine and Johnson 2012). The species has a naturally fragmented habitat and is capable of dispersal over moderate distances, with vagrant individuals found far from patches of Brigalow habitat (Eastwood *et al*. 2008).	**Unlikely to be present.** There are no areas of suitable Brigalow habitat within the Site.
Mammals	*Chalinolobus dwyeri* Large-eared Pied Bat	V	V	This species occurs from coastal to inland areas of New South Wales and Queensland (ALA 2021). All known occurrences of this species are within or near forested landscapes with relatively high relief (DAWE 2021b). The species roosts and breeds in deep fissures in large rocky outcrops and cliffs.	**Unlikely to be present.** The Site is not close to any areas with suitable roost sites in cliffs or rocky outcrops with deep fissures. The landscape is entirely cleared.
Mammals	*Dasyurus hallucatus* Northern Quoll	E	C	Formerly widespread in south-central Queensland this species has declined markedly and is now confined to rugged and remote areas throughout its distribution (Burnett 2012). Forested uplands with high relief and/or containing abundant rock outcrops may support the species (Oakwood 2008). The nearest recent records are from the Carnarvon Range (ALA 2021).	**Unlikely to be present.** The landscape is largely cleared and there are no suitable rocky areas for dens in the vicinity of the Site.
Mammals	*Nyctophilus corbeni* South-eastern Long-eared Bat	V	V	The Site is within the species' known range, which comprises woodlands of the Murray-Darling Basin and some adjacent areas (Churchill 2008). Inhabits woodlands with a shrubby understorey, roosting in tree hollows and crevices and under loose bark (Reardon 2012, DAWE 2021b).	**Unlikely to be present.** This species has been recorded from remnant woodland in the vicinity, however, there is no suitable habitat within the Site.
Mammals	*Petauroides volans* Greater Glider	V	V	Occurs from central Victoria to northern Queensland, living in eucalypt woodlands and open forest particularly those with mature trees containing large hollows (TSSC 2016). It is frequently reported from forested uplands of the Great Dividing Range in Qld (ALA 2021) and has been recorded in riparian vegetation along Bungil Creek, near the Site (ALA 2021).	**Unlikely to be present.** There is no eucalypt woodland within the Site.
Mammals	*Phascolarctos cinereus* Koala	V	V	Requires eucalypt woodland and forest habitat with suitable food trees (primarily *Eucalyptus* spp.) (DAWE 2021b). Favoured habitat is *E. tereticornis* along streamlines. The Site is within the species' known range (ALA 2021).	**Unlikely to be present.** There is no eucalypt woodland within the Site.
Reptiles	*Acanthophis antarcticus* Common Death Adder	-	V	A widespread but patchily distributed snake (ALA 2021, DES 2021h). Lives in woodlands, open forests and heathlands; requires abundant shelter/ambush predation cover e.g. low shrubs, rocks, logs and dense leaf litter (Wilson 2015).	**Unlikely to be present.** There is no suitable woodland habitat and insufficient potential shelter features within the Site.

Family	Scientific & Common Name	EPBC Act Status	NC Act Status	General Habitat Requirements	Likelihood of Occurrence
Reptiles	*Delma torquata* Collared Delma	V	V	The species lives under surface rock or large woody debris in eucalypt woodlands and open forests (Peck 2012, Wilson 2015). The Site is within species known range (DSEWPaC 2011, ALA 2021) although occupancy of this range is very patchy.	**Unlikely to be present.** There is no suitable woodland habitat and insufficient potential shelter features within the Site.
Reptiles	*Egernia rugosa* Yakka Skink	V	V	This species lives in woodland and open forests, also grassland with regrowth trees; requires suitable soils for burrows, sinkholes, abandoned rabbit warrens, large hollow logs, or piles of woody debris for shelter (Wilson 2015, Eddie 2012). The species has been recorded in previous BOOBOOK surveys of the Eos and Glenora gas fields (BOOBOOK 2018).	**Unlikely to be present.** There is no suitable woodland habitat and insufficient potential shelter features within the Site.
Reptiles	*Elseya albagula* Southern Snapping Turtle	CR	CE	The species is confined to perennial rivers in the Fitzroy Basin of Queensland (Limpus *et al*. 2011).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.
Reptiles	*Furina dunmalli* Dunmall's Snake	V	V	The Site is within the species' known range (ALA 2021, DSEWPaC 2011). Occupies woodlands and open forests, may be reliant on presence of abundant fallen woody debris (Hobson 2012).	**Unlikely to be present.** There is no suitable woodland habitat and insufficient potential shelter features within the Site.
Reptiles	*Rheodytes leukops* Fitzroy Turtle	V	V	The species is confined to perennial rivers in the Fitzroy Basin of Queensland (Limpus *et al*. 2011).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.
Reptiles	*Strophurus taenicauda* Golden-tailed Gecko	-	NT	This gecko is endemic to inland southern and central Queensland, where it inhabits a variety of dry woodland and open forest habitats in the Brigalow Belt (DES 2021h). Within these habitats it lives in tree hollows and splits, and under loose bark on live and dead trees (DES 2021h, Wilson 2015)	**Unlikely to be present.** There is no suitable woodland habitat and insufficient potential shelter features (loose bark) within the Site.

3.1.5 Migratory & Marine Fauna

PMST search results indicated the possible occurrence of 10 migratory and 14 marine species listed under the EPBC Act. Previous likelihood of occurrence assessments of EPBC Act listed migratory and marine species were conducted for the WSGP project area (ERM 2017) and the Eos-Glenora Phase 3 development (BOOBOOK 2018). Table 3 provides an update of these assessments.

Table 3: Likelihood of occurrence assessment for EPBC Act listed migratory and marine fauna within the Site.

Key to EPBC Status: Mi = Migratory; Ma = Marine; CE = Critically Endangered; E = Endangered; V = Vulnerable

Family	Scientific Name	Common Name	EPBC Act Status	General Habitat Requirements	Likelihood of Occurrence
Birds	*Actitis hypoleucos*	Common Sandpiper	Mi, Ma	Spring-summer migrant to Australia usually found in coastal environments (muddy, sandy or rocky stream banks, mangrove margins) but may occur on any inland freshwater or saline wetland during passage, including artificial habitats (Pizzey and Knight 2010). Less commonly reported from the inland (ALA 2021).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.
Birds	*Apus pacificus*	Fork-tailed Swift	Mi, Ma	Aerial spring/summer migrant and insectivore, present over most habitat types including disturbed areas (DAWE 2021b).	**Likely to be present**. May potentially occur overhead throughout the Site. The species has been recorded in the Roma North area on the Eos-Glenora gas fields (BOOBOOK 2018).
Birds	*Ardea ibis*	Cattle Egret	Ma	Widely distributed in northern and eastern Australia, also SW Australia. Inhabits a wide range of dryland and wetland habitats and notably associates with livestock (Pizzey and Knight 2010). Nests colonially in flooded or swamp forests.	**Potentially present**. There is no aquatic habitat or inundated grassland within the Site. The species may occasionally occur within the Site as a casual visitor.
Birds	*Calidris acuminata*	Sharp-tailed Sandpiper	Mi, Ma	A widespread spring-summer migrant to Australia, utilizing both inland and coastal wetlands such as tidal mudflats, saltmarshes and saline and freshwater inland swamps (Pizzey and Knight 2010). There are numerous records in inland southern Queensland (ALA 2021).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.
Birds	*Calidris ferruginea*	Curlew Sandpiper	Mi, Ma, CE	A migratory species usually encountered on coastal and near-coastal saline and freshwater tidal and palustrine wetlands (DAWE 2021b). Passage migrants are occasionally present on inland wetlands but the species is sparsely recorded across inland Queensland (ALA 2021).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.
Birds	*Calidris melanotos*	Pectoral Sandpiper	Mi, Ma	Spring-summer migrant preferring freshwater wetlands, both inland and sub-coastally (Pizzey and Knight 2010). Much less common than the related Sharp-tailed Sandpiper in Australia, there are few records in inland southern Queensland (ALA 2021).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.

Family	Scientific Name	Common Name	EPBC Act Status	General Habitat Requirements	Likelihood of Occurrence
Birds	*Chrysococcyx osculans*	Black-eared Cuckoo	Ma	The Site is within the range of the species and it is commonly recorded from this area (ALA 2021). Breeding migrant to inland Australia, inhabiting dry woodlands and shrublands (Pizzey and Knight 2010). The species is a brood parasite that lays its egg in nests of Speckled Warbler and Thornbills (Pizzey and Knight 2010).	**Potentially present**. The species may occasionally occur within the Site as a casual visitor, however, there is no suitable woodland habitat for its host species.
Birds	*Cuculus optatus*	Oriental Cuckoo	Mi	Migrant to coastal and near-inland northern and eastern Australia, inhabiting denser forest types but may occur in other habitats on passage (Pizzey and Knight 2010).	**Unlikely to be present**. No suitable forest or woodland habitat is present within the Site.
Birds	*Gallinago hardwickii*	Latham's Snipe	Mi, Ma	Spring-summer migrant, preferring wet pastures, boggy margins of vegetated wetlands and similar habitat at a range of elevations (Pizzey and Knight 2010). It occurs throughout eastern Australia including southern inland Queensland (ALA 2021).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.
Birds	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	Ma	Occurs around the entire Australian coast but also penetrates far inland on larger rivers (Pizzey and Knight 2010). Feeds on a variety of vertebrates and will take carrion. There are numerous records of the species in the Dawson catchment (ALA 2019).	**Unlikely to be present**. May overfly the Site but there is no suitable lacustrine or riverine habitat to support foraging by the species.
Birds	*Hirundapus caudacutus*	White-throated Needletail	Mi, Ma, V	Aerial spring/summer migrant and insectivore, present over most habitat types including disturbed areas (DAWE 2021b).	**Likely to be present**. Likely to forage over the Site seasonally, following low-pressure fronts.
Birds	*Merops ornatus*	Rainbow Bee-eater	Ma	Widespread and abundant species frequently present in southern inland Queensland during spring and summer (ALA 2021, Barrett *et al*. 2003). Feeds on aerial insects and nests in burrows in sandy soils (Pizzey and Knight 2010).	**Likely to be present**. Spring – Summer breeding groups are likely to occur regularly at the Site and breeding may potentially occur within the Site.
Birds	*Motacilla flava*	Yellow Wagtail	Mi, Ma	Summer migrant in small numbers to mostly coastal northern Australia but birds often sighted in southern Australia: it prefers open grassed areas such as wetland margins, pasture and parks (Pizzey and Knight 2010).	**Unlikely to be present**. There are no existing records for southern inland Queensland (ALA 2021).
Birds	*Myiagra cyanoleuca*	Satin Flycatcher	Mi, Ma	The Site is within the species known range (ALA 2021). A passage migrant in southern Queensland, with birds recorded in a variety of woodland types as well as parks and gardens, but breeding in south-east Australia in more closed forest types (Pizzey and Knight 2010).	**Unlikely to be present.** There is no suitable woodland habitat within the Site. Sparse records of this species within the region probably represent occasional passage migrants. The closest record is from Roma (ALA 2021).

Family	Scientific Name	Common Name	EPBC Act Status	General Habitat Requirements	Likelihood of Occurrence
Birds	*Rostratula australis* Listed as *R. benghalensis* (*sensu lato*)	Australian Painted Snipe	Ma, E	The Site is within the species' known range (ALA 2021); forages at shallow edges and adjacent vegetated margins of freshwater wetlands (DAWE 2021b).	**Unlikely to be present.** There is no suitable aquatic habitat within the Site.

3.1.6 Internationally & Nationally Important Wetlands

No internationally or nationally significant wetlands are present within or in close proximity to the Site. All Wetlands of International Significance identified within the PMST search are at least 300-400 km downstream of the Site.

3.2 State Biodiversity Values & Constraints

3.2.1 Regional Ecosystems & Other Regulated Vegetation

Areas of Queensland state government mapped remnant and regrowth vegetation in the vicinity of the Site are shown in Appendix A. There are no mapped patches of remnant or regrowth vegetation within the Site and no areas of regulated vegetation mapped within the Site. Ground-truthing during field surveys confirmed that there is no remnant or regrowth vegetation within the Site.

3.2.2 Threatened Flora & Essential Habitat

No records of threatened flora species listed under the NC Act were found in searches of Wildlife Online (DES 2021a) and ALA (2021) databases. The proposed infrastructure disturbance footprint and buffer is not located within a High-Risk Area as shown on a Protected Plants Flora Survey Trigger Map (DES 2021b). No threatened flora species were detected during field surveys of the Site.

3.2.3 Special Least Concern Flora

One species of selected Special Least Concern (SLC) flora, Narrow-leaved Bottle Tree (*Brachychiton rupestris*), was recorded within the Site. This comprised two individual trees occurring within a buffer area, outside the proposed Construction Disturbance Zone (CDZ). The locations of SLC flora species are shown in Appendix B.

3.2.4 Biosecurity Act Weeds and other Weeds of Management Concern

Two species of weeds (invasive plants) proscribed as Category 3 restricted matter under the Queensland *Biosecurity Act 2014* were detected within the Site, these being Velvety Tree Pear (*Opuntia tomentosa*) and Common Pest Pear (*O. stricta*). These species are also WoNS as described at Section 3.1.3, Table 1. Representative images of these species shown in Section 7 (Figure 2a-b). The locations of invasive plant species detected within the Site are shown in Appendix B.

3.2.5 Pest fauna and invasive species

No evidence of pest animal species was detected during field surveys within the Site. Evidence of dog and pig was observed elsewhere in the vicinity. These species may pass through the Site but there are few shelter, food or other habitat features that would attract these species to the Site.

3.2.6 Threatened Fauna & Essential Habitat

Desktop searches of public databases (DES 2021a, ALA 2021) found records of South-eastern Long-eared Bat (*Nyctophilus corbeni*) (EPBC: Vulnerable, NC Act: Vulnerable) within 10 km of the Site but there is no suitable woodland habitat for that species within the Site. No threatened species were found during the field survey; however, fauna

searches were conducted opportunistically during the field survey and no detailed fauna surveys were undertaken. A likelihood of occurrence assessment for twenty NC Act listed threatened fauna that may occur in the region is included in Table 2.

3.2.7 Special Least Concern Fauna

No Special Least Concern fauna species were detected within the Site. Echidna (*Tachyglossus aculeata*) occur within the vicinity and these may occasionally pass through the Site. However, there are few habitat features such as woodland, windrowed timber or logs that would attract this species to the Site.

3.2.8 Fauna Habitat Features & Potential Breeding Places

The results of fauna habitat assessments conducted within the Site are included with the associated spatial data. Fauna habitat features occurred sparsely within the Site, comprising scattered timber and small piles of windrowed timber. These features were restricted to buffer areas; no fauna habitat features were detected within the proposed CDZ. No other potential fauna breeding sites were recorded within the Site. Location of fauna habitat features and assessment sites are shown in Appendix B.

3.2.9 Wetlands, Lakes, Springs & Groundwater Dependent Ecosystems

No springs, lakes or wetlands of High Ecological Significance or wetlands of General Ecological Significance, as shown on a Map of Referable Wetlands (DES 2021c), were mapped as present within the Site. No other wetland areas were detected within or adjacent to the Site. No GDE were detected within the Site.

3.2.10 Watercourses & Drainage Features

No mapped streams occur within or adjacent to the Site.

3.3 Project Impacts

3.3.1 Threatened Ecological Communities

There are no Threatened Ecological Communities within or adjacent to the Site.

3.3.2 Threatened Flora

The project will not impact upon any known populations of EPBC or NC Act listed threatened flora.

3.3.3 MNES & MSES Threatened Fauna

3.3.3.1 Predictive Habitat Mapping

There is no habitat for threatened fauna species within the Site. The Site is cleared of native vegetation with only a few scattered trees remaining within and adjacent to the proposed disturbance area. The few habitat features within the Site consist of scattered timber and windrowed wood piles along minor gullies in buffer areas. The single threatened fauna species likely to occur within the Site, White-throated Needletail (*Hirundapus caudacutus*), is an aerial foraging bird that does not depend on features within the Site and which would not be impacted by this development.

3.3.3.2 Potential Fauna Habitat Impacts

DoE (2013) documents a number of potential impacts on Matters of National Environmental Significance (MNES) that may result from an action (e.g. construction, operation and decommissioning of gas-field infrastructure). Threatened fauna are at risk of significant impact if an action results in, or has a real possibility of resulting in, any of a series of adverse outcomes. Assessment of these potential impacts is also consistent with the Queensland Environmental Offsets Policy (DEHP 2014). The following potential adverse impacts of a development on threatened fauna are listed by DoE (2013):

- Lead to a long-term decrease in the size of a population (including declines due to loss or modification of habitat);
- Reduce the Area of Occupancy (AoO), or the Extent of Occurrence (EoO) of the specie;
- Fragment an existing population into two or more populations; or, result in genetically distinct populations forming;
- Adversely affect habitat critical to the survival of a species (including disruption to breeding, feeding, nesting, migration or resting sites);
- Result in invasive species that are harmful to a species becoming established in the threatened species' habitat;
- Introduce disease that may cause the population to decline; and,
- Interfere with the recovery of the species.

The proposed development is unlikely to have any of these impacts on threatened fauna species. There are no suitable habitat or essential resources for threatened fauna species within the Site, consequently threatened fauna are unlikely to occur within the Site. The development is unlikely to affect populations of invasive species within the area or to result in the introduction of disease affecting fauna species.

4. Conclusions

An ecological assessment within the Site identified the following ecological values/potential constraints:

Matters of National Environmental Significance:

- No Threatened Ecological Communities (TEC) were detected within the Site.
- No EPBC Act listed threatened flora species were detected within the Site.
- Two species of WoNS were detected within the Site:
    - Common Pest Pear (*Opuntia stricta*); and,
    - Velvety Tree Pear (*O. tomentosa*).
- No EPBC Act listed threatened fauna species were detected within the Site:
- One EPBC Act listed threatened fauna species was assessed as likely to occur within the Site:
    - White-throated Needletail (*Hirundapus caudacutus*).
- Five EPBC Act listed migratory and marine fauna species were assessed as potentially occurring within the Site:
- No Wetlands of International or National Significance occur within the Site.

Queensland Biodiversity Values and Constraints:

- There is no remnant or regrowth vegetation within the Site.
- No NC Act listed threatened flora species were detected within the Site
- One selected SLC flora species (*Brachychiton rupestris*) was present within the Site.
- Two Biosecurity Act Category 3 Restricted Matter invasive plants were present within the Site, these being the two WoNS species (above): Common Pest Pear (*O. stricta*) and Velvety Tree Pear (*O. tomentosa*).
- No NC Act listed threatened fauna species were detected within the Site
- There is no suitable habitat for NC Act listed threatened fauna species within the Site.
- There were few potential fauna breeding and/or shelter places within the Site.
- No referable wetlands occur within the Site.
- No lakes, springs or GDE occur within the Site.

- No mapped streams occur within the Site.

Project Impacts:

- No significant residual impacts of the proposed works are expected on MNES or MSES.

5. Recommendations

It is recommended that the findings in this report are considered during detailed development planning such that disturbance to the ecological values within the Site may be avoided wherever practical. Where disturbance is unavoidable, impact mitigation measures should be implemented in accordance with the approved site environmental management plan and regulatory approval conditions.

Clearing of fauna habitat features should be avoided wherever possible. A qualified fauna spotters should be engaged to assist with the relocation of fauna during proposed clearing within the Site.

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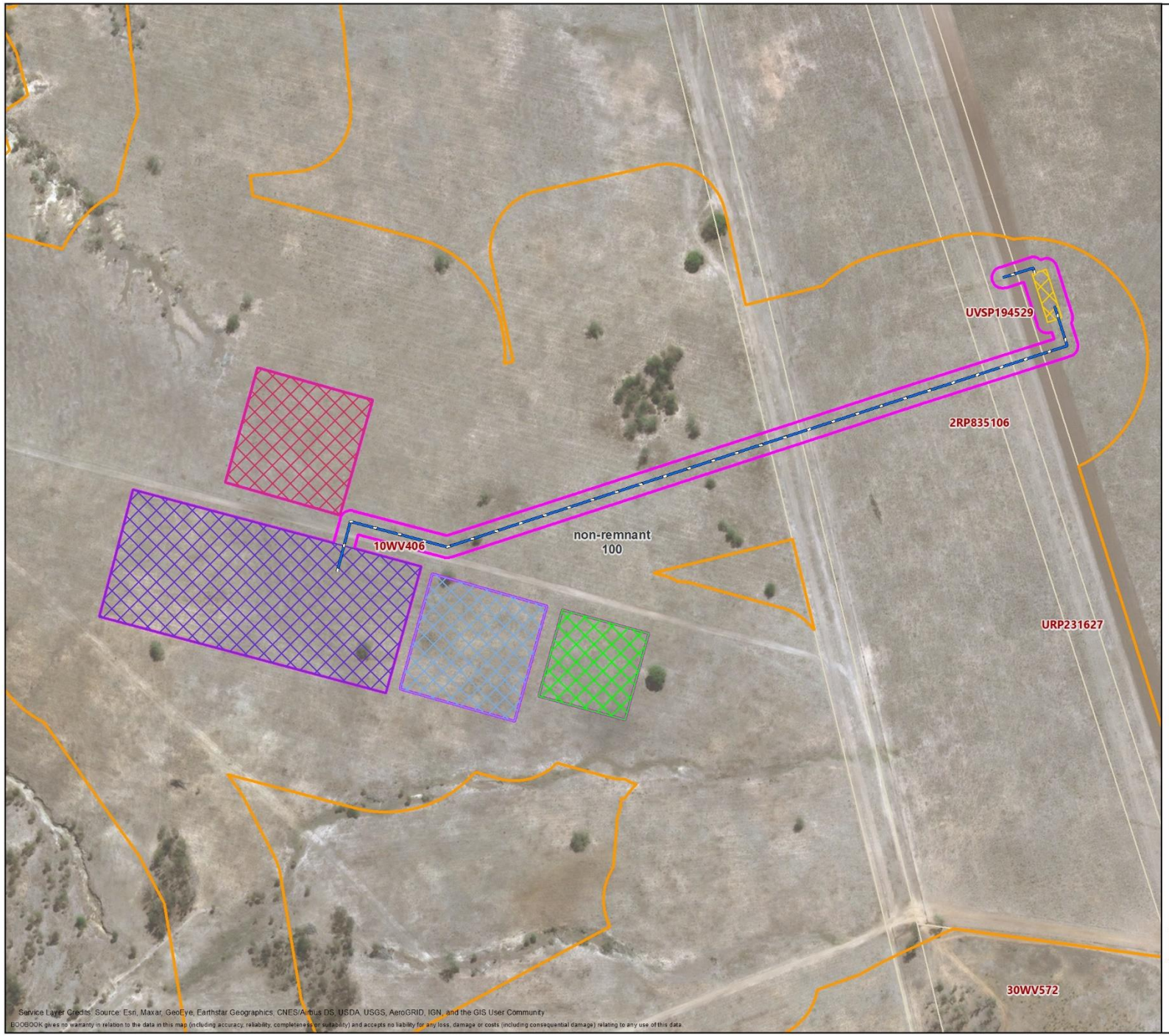
7. Figures

Figure 1a-b: Representative images of the Site: view north from survey point 800-S02 with riparian vegetation along Conn Creek visible in the distant background beyond the Site (left), and view east from the same point showing sparsely scattered trees (right). The landscape comprises non-remnant pasture dominated by Buffel Grass (*Cenchrus ciliaris*) on a gentle rise derived from fine-grained sedimentary rocks. There is no significant native vegetation within the Site.

Figure 2a-b: Weeds of National Significance (WoNS) detected at the Site included Common Pest Pear (*Opuntia stricta*) (left) and Velvety Tree Pear (*Opuntia tomentosa*) (right). Both species are Class 3 Restricted Matter under the Biosecurity Act. These pest species were present at low densities in and around the Site.

Appendix A. Desktop Biodiversity Values Mapped on Site.



Appendix A: Desktop Biodiversity Values mapped on Site.

Infrastructure
- Mimas CPF Export Pipeline

Mimas CPF Facility Areas
- CPF Laydown #1 (1ha)
- CPF Laydown #2 (1ha)
- End of Line Facility
- Facilities Site Office
- Mimas CPF

Survey
- Export Pipeline & CPF, ELOF CDZ
- Area Surveyed
- Cadastre

Remnant Regional Ecosystems (Biodiversity Status)
- Endangered, Dominant
- Endangered, Sub-dominant
- Of Concern, Dominant
- Of Concern, Sub-dominant
- No concern At Present
- Plantation
- Water

Mature Regrowth (Biodiversity Status)
- Endangered, Dominant
- Endangered, Sub-dominant
- Of Concern, Dominant
- Of Concern, Sub-dominant
- No concern At Present

MSES Essential Habitat
- MSES Essential Habitat

Protected Plants Flora Trigger
- High Risk Area

Wetland Management Areas
- General Ecological Significance Wetland

Wetland Mgt Trigger Areas
- Wetland Mgt Trigger Areas (GES)

N
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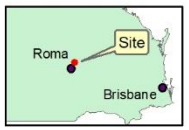
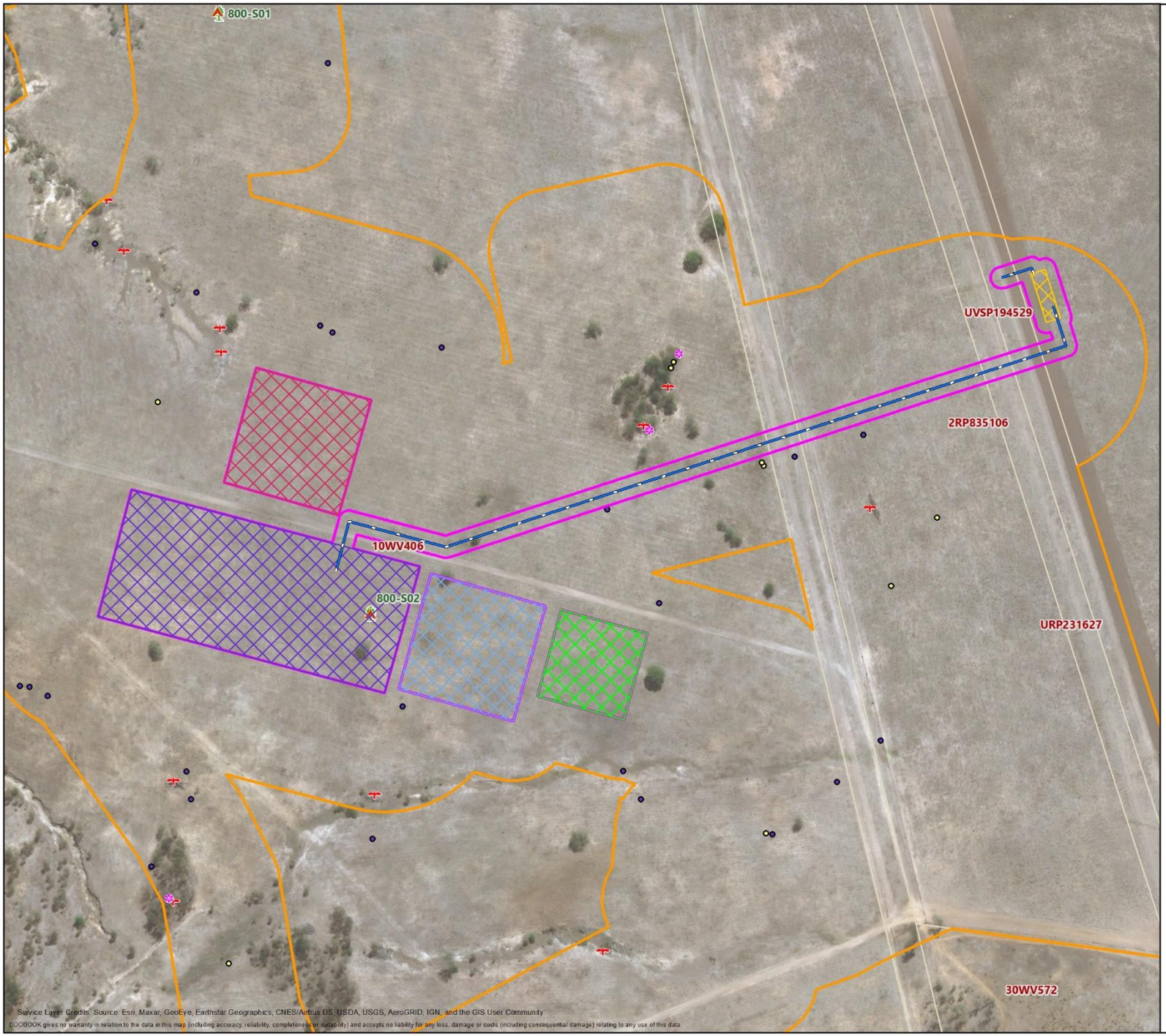
0 50 100m

Project:	WSGP Mimas CPF Ecology Survey
Map No:	800_AppB
Date:	4/11/2021
Drawn:	L. Hardwick
Approv.:	C. Eddie
Scale:	1: 3,000 @ A3
Datum:	GDA94



Appendix B. Ground-truthed Features Occurring within the Site



Appendix B: Ground-truthed Features occurring within the Site.

Infrastructure
- Mimas CPF Export Pipeline

Mimas CPF Facility

Areas
- CPF Laydown #1 (1ha)
- CPF Laydown #2 (1ha)
- End of Line Facility
- Facilities Site Office
- Mimas CPF

Survey
- Export Pipeline & CPF, ELOF CDZ
- Area Surveyed
- Cadastre
- Vegetation Assessment
- Habitat Assessment
- Habitat feature

Special Least Concern Flora
- Narrow-leaved Bottle Tree *(Brachychiton rupestris)*

WoNS and Category 3 Weeds
- Common Pest Pear *(Opuntia stricta)*
- Velvety Tree Pear *(Opuntia tomentosa)*

N
W E
S

0 50 100m

Project:	WSGP Mimas CPF Ecology Survey
Map No:	800_AppB
Date:	4/11/2021
Drawn:	L. Hardwick
Approv.:	C. Eddie
Scale:	1: 3,000 @ A3
Datum:	GDA94

WSGP_EA Amendment_Supporting Information Report_Rev0_compiled

Final Audit Report 2023-10-18

Created:	2023-10-18
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