Santos

NARRABRI GAS PROJECT

Irrigation Management Plan

PHASE 1

0041-150-PLA-0020

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Prepared by:

Title	Name	Signature	Date
Senior Environmental Manager	S. van der Meulen Onward Consulting		24 October 2022
Director	Mark Vile Onward Consulting		24 October 2022

Reviewed by:

Title	Name	Signature	Date
Principal Environmental Advisor - Hydrogeologist	David Gornall		24 October 2022

Approved by:

Title	Name	Signature	Date
Development Manager NSW	Todd Dunn		24 October 2022

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Document review history

In accordance with consent condition D4, this document has been reviewed as follows:

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Acronyms and abbreviations

Acronym	Description
µg/L	micrograms per litre
AHD	Australian height datum
ANZECC	Australia and New Zealand Environment and Conservation Council
BOD	biological oxygen demand
$CaCO_3$	calcium carbonate
$CaSO_4$	calcium sulfate (gypsum)
cm	centimetre
CoC	Conditions of consent for the NGP SSD 6456
cm	centimetre
CSG	coal seam gas
DEC	The former NSW Department of Environment and Conservation
DISRD	Department of Industry Skills and Regional Development
DPE	NSW Department of Planning and Environment
DPE Water	The Water Group within DPE
DPI	The former NSW Department of Primary Industries
DPIE	The former NSW Department of Planning, Industry and Environment
dS	deciSiemens
dS/m	deciSiemens per metre
EC	electrical conductivity
EHS	environmental health and safety
EIS	environmental impact statement
EMI	electromagnetic induction
EMP	environmental management plan
EMS	Environmental Management Strategy
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979* (NSW)
EP&A Regulation	Environmental Planning and Assessment Regulation 2021
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
EPL	environment protection licence under the POEO Act
EQuIS	Environmental Quality Information System
ET	evapotranspiration
ha	hectare
IEA	Independent Environmental Audit
IMP	Irrigation Management Plan (this document)
L	litre
LNG	liquefied natural gas

Acronym	Description
m	metre
m^2	square metre
m^3	cubic metre
mbTOC	metres below top of casing
ML	megalitre
ML/day	megalitre per day
ML/y	megalitre per year
mm	millimetre
NRAR	Natural Resources Access Regulator
NSWIC	NSW Irrigators Council
PAL	petroleum assessment lease under the PO Act
PEL	petroleum exploration licence under the PO Act
PO Act	*Petroleum (Onshore) Act 1991* (NSW)
POEO Act	*Protection of the Environment Operations Act 1997* (NSW)
POEO Regulation	Protection of the Environment Operations (General) Regulation 2022
PPL	petroleum production lease under the PO Act
PPLA	petroleum production lease application under the PO Act
PWMP	Produced Water Management Plan
RO	reverse osmosis
RREO	Resource Recovery Exemption and Order
SAR	sodium adsorption ratio
SEPP	State Environmental Planning Policy
SSD	State significant development
SWB	Site Water Balance
SWD	soil water deficit
SWL	standing water level
TDS	total dissolved solids
WAL	water access licence
WBTP	Leewood Water and Brine Treatment Plant
WM Act	*Water Management Act 2000* (NSW)
WMP	Water Management Plan
WTAG	Water Technical Advisory Group

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1. Introduction

1.1 Narrabri Gas Project

1.1.1 Background

Resource exploration has been occurring in the north-western area of NSW since the 1960s; initially for oil, but more recently for coal and gas. Santos NSW Pty Ltd began exploring for natural gas from coal seams in north-western NSW in 2008 and is currently conducting coal seam gas (**CSG**) exploration and appraisal activities within Petroleum Exploration Licence (**PEL**) 238, Petroleum Assessment Lease (**PAL**) 2 and Petroleum Production Lease (**PPL**) 3, located in the Gunnedah Basin about 20 kilometres (**km**) south-west of the town of Narrabri. Activities in PAL 2 have focussed on the Bibblewindi and Bohena CSG pilots, whilst recent activities in PEL 238 have focussed on the Dewhurst and Tintsfield CSG pilots.

The Narrabri Coal Seam Gas Utilisation Project (Wilga Park Power Station and associated infrastructure) operates under an existing Part 3A approval under the *Environmental Planning and Assessment Act 1979* (NSW) (**EP&A Act**). It was originally approved in 2008, with various modifications approved between 2011 and 2019. It encompasses a gas gathering system, a compressor and associated flare, a gas flow line from Bibblewindi to Wilga Park within a 10 metre (**m**) corridor with a riser at Leewood and an expansion of the existing Wilga Park Power Station from 12 to 40 megawatts.

1.1.2 Current Project

On 30 September 2020, Santos NSW (Eastern) Pty Ltd (**Santos**) obtained consent for State significant development (**SSD**) 6456 to develop the Narrabri Gas Project (**NGP**) (**the Project**). Approval EPBC 2014/7376 under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (**EPBC Act**) was granted on 24 November 2020.

The Project includes the progressive installation of up to 850 new gas wells on up to 425 new well pads over approximately 20 years and the construction and operation of gas processing and water treatment facilities. The Project area covers about 950 square kilometres (95,000 hectares) in size and the Project footprint will only directly impact about 1% of that area.

Four phases of development are defined under the consent, including:

- Phase 1 - exploration and appraisal;
- Phase 2 - construction activities for production wells and related infrastructure;
- Phase 3 - gas production operations; and
- Phase 4 - gas well and infrastructure decommissioning, rehabilitation and closure.

Phase 1 of the Project is defined in the consent as the phase of the development comprising ongoing exploration and appraisal activities in the Project area, including:

- seismic surveys;
- core and chip holes;
- construction and operation of pilot wells (up to 25 wells on up to 25 well pads across the project area); and
- pilot well ancillary infrastructure, including access tracks, gas and water gathering lines, water balance tanks, safety flaring infrastructure, utilities and services, and environmental monitoring equipment including groundwater monitoring bores.

Santos plans to continue exploration and appraisal of the resource in the near term until a final investment decision can be made. The exploration and appraisal activities will include continued operation of Santos' existing wells, infrastructure and facilities in PEL 238 and PAL 2, and construction and operation of new core holes, pilot wells and supporting infrastructure permitted under Phase 1.

Santos' existing exploration and appraisal activities in PEL 238 and PAL 2 include:

- Tintsfield Pilot;
- Bibblewindi East Pilot;
- Bibblewindi West Pilot;
- Dewhurst North Pilot;
- Dewhurst South Pilot;
- Dewhurst northern and southern flow lines;
- Leewood Water Management Facility including ponds, water treatment plant and irrigation area;
- Bibblewindi Facility including gathering system, water balance tank, compressor and flare; and
- Bibblewindi to Leewood buried gas pipeline.

These exploration and appraisal activities will continue as part of the NGP. The initial, new-appraisal Phase 1 scope is a relatively minor extension to these existing exploration and appraisal activities.

The Phase 1 scope is planned to include the construction and operation of:

- 4 coreholes;
- 6 pilot wells;
- 2 deep reservoir monitoring bores (converted coreholes);
- new shallow water monitoring bores;
- associated linear infrastructure;
- seismic surveys (length and location to be determined); and
- continued operation of Santos' existing exploration and appraisal activities, including workover activities.

The full definitions of the approved activities for Phases 2, 3 and 4 of the Project are provided in the consent. Santos is not prevented from carrying out any or all of the phases concurrently, subject to the conditions of this consent.

Further details regarding the NGP, including a full overview of the regulatory framework and statutory provisions of the NGP and the current approvals, leases and licences related to the management of water, are provided in the overarching NGP Water Management Plan (**WMP**). Details regarding the staging of the works and the exact scope for each phase are as per the approved Field Development Plan.

1.2 Purpose and scope of the IMP - Phase 1

Santos has developed this Irrigation Management Plan (**IMP** or the **Plan**) in accordance with the requirements of PAL 2; compliance conditions of Environment Protection Licence (**EPL**) 20350; the SSD 6456 conditions of consent (**CoC**) and with the NSW *Environmental guidelines - Use of effluent by irrigation* (DEC, 2004) (**Effluent Irrigation Guidelines**). It details how Santos manages irrigation associated with its CSG activities for the NGP during Phase 1 of the Project and will be reviewed annually and in accordance with the consent conditions. Santos will implement all reasonable and

feasible measures to prevent, and if prevention is not reasonable and feasible, minimise any harm to the environment that may result from the irrigation activities.

This Plan supersedes the IMP that was approved by the Secretary of the then Department of Industry Skills and Regional Development (**DISRD**) on 26 June 2017. That plan was prepared to satisfy condition 6 of the approval for the Leewood Produced Water Treatment and Beneficial Reuse Project under Part 5 of the EP&A Act by the then NSW Department of Industry - Division of Resources and Energy on 18 August 2015.

This Plan forms part of a suite of documents prepared as part of the WMP under Condition B41, which consist of the following:

(i) An Erosion and Sediment Control Plan, prepared in accordance with the Blue Book[1] and identifying details including but not limited to activities that could cause soil erosion, generate sediment or affect flooding; the location, function, and capacity of erosion and sediment control structures and flood management structures; and measures to manage any effects of soil erosion, sediment transport and flooding;

(ii) A Site Water Balance, which includes but is not limited to details of the inflows and outflows in the Project area; sources and security of water supply for the life of the Project; water storage and treatment capacity; water use and management, including sharing and transfers; licenced discharge points; and reporting procedures, including the annual preparation of an updated site water balance;

(iii) A Surface Water Management Plan, which includes but is not limited to specific details on baseline data on surface water flows and quality of watercourses; the surface water management system; detailed plans, design objectives and performance criteria for water infrastructure; performance criteria; a program and procedures for monitoring, evaluation and reporting; and plan to respond to any exceedances of the performance measures or performance criteria, and repair, mitigate and/or offset any adverse surface water impacts of the development;

(iv) A Groundwater Management Plan (**GMP**), which provides details including but not limited to baseline data of hydrogeology and groundwater levels, formation parameters and quality for groundwater resources; a description of the groundwater management and monitoring system; performance criteria, trigger and response levels; a program and procedures for monitoring, evaluation and reporting; and a plan to respond to any exceedances of the groundwater performance criteria, and repair, mitigate and/or offset any adverse groundwater impacts of the Project;

(v) A Produced Water Management Plan (**PWMP**) that provides detailed baseline data on produced water yield and quality, and includes but is not limited to details regarding the produced water management system; performance criteria, including trigger levels; and a program and procedures for monitoring, evaluation and reporting;

(vi) An Irrigation Management Plan (this Plan);

(vii) A Dust Suppression Protocol for managing beneficial reuse of treated water for dust suppression and construction activities including but not limited to details of site selection and assessment; baseline soil and groundwater conditions and quality; a protocol for operation of the dust suppression system; and measures to manage any effects on soils structure, erosion, surface water runoff, groundwater quality and groundwater levels;

(viii) A Managed Release Protocol for managing disposal of treated water to Bohena Creek, that includes but is not limited to details of water flows, quality and health; predicted plume dispersal; a protocol and detailed procedures for managed release; and measures to manage any effects of water quality, stream and riparian health, erosion and sedimentation and

[1] The 2004 Landcom publication *Managing Urban Stormwater: Soils and Construction - Volume 1* is commonly known as the 'Blue Book'. This is not part of the publication title.

downstream flooding. There will be no managed release to Bohena Creek during Phase 1 of the Project and as such this protocol will be developed for Phase 2 of the Project. A summary of the managed release is provided in section 6 of the PWMP;

(ix) A Salt Management Plan, which includes but is not limited to details of salt and other waste volumes and composition generated by the produced water management system; a program for investigating and implementing beneficial reuse options for the salt product; and a protocol and procedures for the full-cycle management of salt and salt-related waste products; and measures to ensure appropriate storage and disposal of any salt waste. There will be no salt generated during Phase 1 of the Project (only brine will be produced) and there is adequate storage in the existing facilities to manage this brine for Phase 1. Section 7 of the PWMP describes this proposed approach to salt management for the Project for Phase 1. A stand-alone Salt Management Plan will be developed prior to Phase 2 of the Project, based on the findings of the Produced Salt Beneficial Reuse and Disposal Study required by condition B65;

(x) A Pollution Incident Response Management Plan, prepared in accordance with the Protection of the Environment Operations (General) Regulation 2022 (POEO Regulation) and which includes detailed procedures for responding to incidents, spills and leaks associated with the produced water management system; and a Dam Safety Emergency Plan for managing potential incidents and emergencies associated with produced water storages, and

(xi) A protocol to report on the measures, monitoring results and performance criteria identified above, in the Annual Review referred to in consent condition D8.

A full list of the conditions applicable to the IMP is presented in section 3.1.3. A copy of the consent conditions relevant to each of the other sub-plans listed above is provided in each of the individual documents.

As required by CoC B42, Santos will implement the latest revision of the WMP (including this IMP) once approved by the Planning Secretary.

1.3 Objectives

The objectives of this IMP are to provide the following:

- details of the relevant statutory requirements (including any relevant approval, licence or lease conditions);
- details of any relevant commitments or recommendations identified in the EIS for the Project;
- a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria;
- to provide context regarding the landscape where the irrigation system operates, in particular the climate, soils and topography;
- to provide details on the operational instructions for the irrigation system that comply with the NSW *Environmental guidelines- Use of effluent by irrigation* (DEC, 2004);
- to detail the monitoring program for irrigation water, soil and groundwater;
- to identify triggers from monitoring that will be used to modify the irrigation systems operation;
- to outline reporting protocols for activities relating to water treatment, irrigation system operations, maintenance and monitoring; and
- to provide treated and amended treated water quality criteria.

1.4 Performance measures

As required by consent condition B37, Santos will ensure that the development complies with the following management performance measures related to irrigation and beneficial reuse management:

- negligible change to soil quality and groundwater quality and levels in irrigation areas and other areas subject to treated water application;
- only amended treated water to be used for reuse activities (except for firefighting), unless other use of treated water has been approved as part of the WMP; and
- no irrigation (no application of treated water) in forested area, apart from construction activities on operational areas and access roads;
- only bore water will be used for dust suppression during Phase 1.

The management measures to be implemented to comply with the relevant statutory requirements, limits and performance measures and criteria are listed in Appendix D and Appendix E. Section 5 of the PWMP also describes the management of produced water.

1.5 Consultation

Extensive consultation was undertaken during the preparation and finalisation of each previous version of this IMP. The outcomes of consultation undertaken with the Department of Primary Industries (**DPI**) and the EPA in April 2017 during the development of the previous version of the plan have been incorporated in the finalisation of this IMP.

For Phase 1, this IMP has been prepared by a suitably qualified and experienced person in consultation with the Water group within the NSW Department of Planning and Environment (**DPE**) (generally referred to as DPE Water), the NSW Environment Protection Authority (**EPA**) and the Water Technical Advisory Group (WTAG).

No comments were received from the Natural Resources Access Regulator (**NRAR**) [on behalf of DPE Water] on the draft IMP (Revision C) and the attachments, and no comments were received from the EPA.

The comments provided by the WTAG predominantly focussed on the volume of treated water that could be applied to land at the Leewood irrigation area; the soil types present across the irrigation area and the details of the soil and groundwater monitoring regime. The comments also identified a number of discrepancies and opportunities for improvement.

All consultation correspondence and the responses to comments are provided in Appendix A.

1.6 Structure of this Plan

Together with the suite of documents listed in section 1.2, this Plan is a supporting management plan (sub-plan) to the WMP. The WMP sets out the overall details how the documents are related and where information or details are located in the event of any overlap or commonality. The structure of this Plan is as follows:

Section 1	Provides an introduction to the Project and the context, scope, purpose and objectives of this Plan. It further provides the performance measures related to irrigation and the management of effluent
Section 2	Defines the roles and responsibilities of personnel involved with the irrigation of treated produced water generated through NGP activities, including staff, consultants, contractors and service providers
Section 3	Outlines the statutory provisions relevant to the beneficial use through irrigation of produced water generated by development of the NGP
Section 4	Provides a description of the irrigation site, including details about the topography, soil types, climate and vegetation crops
Section 5	Provides details of the water supply and irrigation system
Section 6	Outlines the monitoring program associated with irrigation, including groundwater, soil, native vegetation and crop monitoring
Section 7	Describes the trigger, action and response plan developed to assess and respond to abnormal conditions and to manage irrigation risks to operations and the environment
Section 8	Provides details on the process that is implemented to manage data and records in a consistent, efficient and effective manner
Section 9	Details the actions required for incidents and non-compliances related to the irrigation at Leewood
Section 10	Describes the reporting, evaluation and review process of this IMP, including the annual review, independent audits and environmental improvement measures
Section 11	References
Section 12	Glossary

Appendix A	Consultation records
Appendix B	Conditions directly relevant to the IMP
Appendix C	Treated water quality
Appendix D	Inspection and maintenance of irrigation operations
Appendix E	Irrigation TARPs

1.7 Distribution

A copy of the approved IMP is available to all Santos personnel via the Santos intranet. In accordance with consent condition D13, the latest copy of the Plan including all associated appendices, audits and reports, and summaries of all monitoring data (where relevant), will be placed on the Project website, once these have been approved by the Planning Secretary. This information will be kept up to date.

In accordance with specific licence, approval or code of practice conditions, a copy of this IMP is available at the Santos' Operations Centre located at 300 Yarrie Lake Road in Narrabri. This is where operational and field staff commence and finish each workday.

Note that any printed copies of this IMP are uncontrolled.

2. Roles and responsibilities

All Santos employees and contractors involved in the Narrabri Gas Project are responsible for the environmental performance of their activities and for complying with all legal requirements and obligations. Project personnel will be required to comply with approval requirements of the activities they undertake and potential environmental impacts from all activities will be managed in accordance with the Project's relevant management plan(s).

In accordance with consent condition D1(d), the Environmental Management Strategy (**EMS**) sets out the roles, responsibilities, authorities and accountabilities of all key personnel involved in the environmental management of the Project. The requirements and obligations from this IMP that are assigned to specific personnel are listed below in Table 2.1, including the Agricultural Supervisor and the Irrigation Operator. All roles, responsibilities and accountabilities have been assigned in accordance with Santos Management System *SMS-MS_14 People Management Standard*.

Table 2.1 - Roles and responsibilities

Position	Responsibility
Agricultural Supervisor	• Before commencing irrigation, checks the soil water deficit to ensure it has reached 30 mm. • Determines the suitability for irrigation commencement taking into account soil moisture deficit, wind direction. Review against available observations and data such as from past irrigation, weather station data, calculated evapotranspiration and weather forecasts. • Monitors the infiltration and moisture in soil, consistent with typical irrigation practices. Perform annual hand auger soil cores near moisture probes to allow correlation to be determined between probes and actual measured soil moisture. This will assist in calibrating the probes for future use to reduce management. • Decides any changes to daily irrigation practice based on advice from the Irrigation Operator, and soil moisture deficit, expected rainfall events and wind direction. • Ensures digital watering maps match up with the soil variation and crop grown. Ensure CP travel speed and nozzle cycle time change as per the watering map when observing pivot operation in field. • Checks GPS functionality. Check results with an emission uniformity catch can test. • Provides notification to the Team Leader Narrabri Operations of any Trigger Level 1 or 2 event as defined in the TARP for known crop decline in health and water logging -surface ponding and run-off.
Irrigation Operator	• Completes daily pre-start reports, including all equipment and pipelines inspected prior to irrigation activity, visual inspections of sprinkler nozzle plugging, track erosion or run-off, cables for damage from wildlife. • Conducts a site inspection to determine site conditions for signs of erosion, cracking, surface sealing, ponding or run-off. • Checks the pivot area for signs of water run-off (see above). No water is to exit the pivot area – this must be monitored during operation. • Checks pivot area for signs of water pooling – any pooling must be consistent with what is occurring outside the pivot area. This includes during / after rainfall events. • Monitors wind direction and strength to ensure water mist is not travelling off the centre pivot area. This is especially important during southerly and westerly winds. • Inspects the crop weekly for health (crop yellowing).

Position	Responsibility
	• Conducts random weekly testing of the variable rate solenoids controlling nozzle output. This includes flushing of mainlines, secondary filters, submains, laterals, centre pivot and flushing manifolds. Flushing events may be required periodically due to build-up of sediments in lines coming from suspended solids in water, suction of soil particles, chemical precipitation (scaling) and biological activity. • Completes the daily operational report.
Environmental Advisor	• Arranges water and soil monitoring in accordance with EPL 20350 requirements. • Arranges for two transects of the surface 10 cm of topsoil to be sampled annually and the soil analysed for nutrients, SARe, pH and EC. • Annual reporting of irrigation activity. • Assesses TARP Level 1 & 2 triggers and provides notification to the Team Leader Narrabri Operations on: ▪ excessive salinity in groundwater ▪ health of native vegetation communities on northern boundary ▪ excessive salinity in soil ▪ excessive sodicity in soil • Provides notification to DPE and any other relevant agency after becoming aware of an incident, in accordance with the incident and non-compliance reporting requirements.

3. Regulatory requirements

The Project is permissible with development consent under the *State Environmental Planning Policy (Resources and Energy) 2021*, and is identified as a 'State significant development' under section 4.38 of the EP&A Act and the *State Environmental Planning Policy (Planning Systems) 2021*.

The Project was subject to the State significant development assessment and approval provisions of Division 4.1 of Part 4 of the EP&A Act and was approved as a State significant development under the EP&A Act and the EPBC Act.

The Project will be carried out in accordance with the:

- relevant existing development consents and activity approvals;
- the conditions associated with PAL 2, the provisions of the *Petroleum (Onshore) Act 1991* (NSW) (**PO Act**) and relevant codes of practice and guidelines;
- Environment Protection Licence (**EPL**) 20350 issued by the EPA and the provisions of the *Protection of the Environment Operations Act 1997* (**POEO Act**); and the
- conditions of consent for the NGP SSD 6456.

3.1 Compliance conditions

Compliance conditions associated with the following licence(s), lease(s) and consent(s) are relevant to this IMP:

- PAL 2, granted on 30 October 2007;
- PPLs 13, 14, 15 and 16, once issued;
- EPL 20350, as varied; and
- SSD 6456.

3.1.1 PAL 2

Environmental management condition 2 in Schedule 2 of PAL 2 states that activities must only be carried out in accordance with a Petroleum Operations Plan (**POP**) which has been approved by the Director-General of the Department of Primary Industries. Further, the POP must (i) identify how operations will be carried out on site in order to prevent and or minimise harm to the environment; and (ii) reflect conditions of approval under the EP&A Act, the POEO Act, and any other relevant approvals.

The most recent POP, including the Leewood Produced Water Treatment and Beneficial Use Project, was approved on 18 September 2020 subject to number of conditions as provided in Table B1 in Appendix B. This IMP supports the POP and satisfies condition 2 of PAL 2 by providing information about how Santos manages its irrigation system as part of the operation of its activities within PAL 2.

3.1.2 EPL 20350

'Petroleum exploration, assessment and production' is a scheduled activity listed in Schedule 1 of the POEO Act. Under section 48 of this Act, all scheduled activities are required to hold an environment protection licence. EPL 20350 is held for CSG activities in PEL 238, PAL 2 and PPL 3. There are several specific conditions related to irrigation in EPL 20350, presented in Table B2 in Appendix B.

Santos will at all times fully comply with the requirement and obligations of the EPL conditions and the relevant provisions of the POEO Act..

3.1.3 Development Consent SSD 6456

There are a number of SSD 6456 consent conditions directly relevant to this IMP for Phase 1, with the key conditions CoC B36, B37 and B41(d)(vi) outlined below. Table B3 in Appendix B specifies where each of the requirements of all the relevant SSD 6456 consent conditions are addressed in this Plan.

Consent condition B36 states that Santos must ensure that all surface discharges from the development comply with:

(a) discharge limits (both volume and quality) set for the development in any EPL or Resource Recovery Exemption and Order (**RREO**); and

(b) relevant provisions of the POEO Act.

Consent condition B37 states that Santos must ensure that the development complies with the following management performance measures related to irrigation and beneficial reuse management:

- negligible change to soil quality and groundwater quality and levels in irrigation areas and other areas subject to treated water application;
- only amended treated water to be used for reuse activities (except for firefighting), unless other use of treated water has been approved as part of the WMP; and
- no irrigation in forested areas, apart from dust suppression and construction activities on operational areas and access roads.

Consent condition B41 states that prior to the commencement of Phase 1, Santos must prepare a Water Management Plan for the Project to the satisfaction of the Planning Secretary and that this plan must include an:

(vi) Irrigation Management Plan for managing beneficial reuse of treated water for crop irrigation and stock watering, that includes details of:

- site selection and assessment in accordance with applicable guidelines including the *Environmental Guidelines: Use of Effluent by Irrigation* (DEC 2004);
- irrigation areas and off-site storage capacity, including provisions for ensuring sustainable irrigation before, during and after peak water production;
- agreements with third parties receiving treated water (excluding any commercial in confidence material);
- baseline soil and groundwater conditions and quality, based on additional assessment by a suitably qualified agricultural expert/s;
- a protocol for operation of the irrigation management system, including any irrigation subject to a RREO; and
- measures to:
    - maintain soil structure, stability and agricultural productive capacity;
    - minimise erosion and sedimentation, ponding and waterlogging;
    - ensure effective surface water and stormwater runoff controls;
    - maintain groundwater quality and minimise changes to groundwater levels;
    - coordinate optimal cropping regimes to maintain water balance throughout the year; and
    - provide contingency areas for irrigation and storage.

3.2 Relevant codes, standards, policies and guidelines

3.2.1 Effluent Irrigation Guidelines

As per CoC B41(d)(vi), the site selection and assessment must be conducted in accordance with the Effluent Irrigation Guidelines. These Guidelines provide information for planners, designers, installers and operators of irrigation systems that use effluent from a wide range of rural and industrial sources. It is educational and advisory in nature. It is not a mandatory or regulatory tool and it does not introduce new environmental requirements. The emphasis is on best management practices related to the management of effluent by irrigation, to be used to design and operate effluent irrigation systems, with the goal of reducing risks to the environment, public health and agricultural productivity. The Effluent Irrigation Guidelines will assist decision-makers and industry members in achieving the best environmental outcome for each site at least cost.

The Guidelines reflects the idea that a sustainable effluent irrigation system will be a function of the interactions between the site, soil, agronomic system and effluent characteristics, and diligent operational practices. These interactions require effective management to maximise the resources available in effluent and ensure that the environment is protected. The guideline also outlines a number of environmental performance objectives that apply to the use of effluent for irrigation. These performance objectives, and details of how the proposed activity meets them, are outlined in Table 3.1.

Table 3.1 - Environmental performance objectives - Effluent Irrigation Guidelines

Environmental performance objective	Summary of how irrigation meets the performance objective
Protection of surface waters	The irrigation system is located, designed, constructed and operated to protect surface waters. The irrigation area is located approximately 450 m from the nearest natural water body (Bohena Creek). The Leewood irrigation system has been designed so that any runoff will be caused by rainfall and will not be highly altered from conditions under a dryland pasture regime.
Protection of groundwater	The irrigation area is located, designed, constructed and operated so that groundwater quality and levels are not impacted by the irrigation activities. The Leewood irrigation system has been designed so that any runoff will be caused by rainfall, and will not be highly altered from conditions under a dryland pasture regime.
Protection of lands	The irrigation system improves the capacity of the land to grow plants and does not result in deterioration of land quality through soil structure degradation, salinisation, waterlogging, chemical contamination or soil erosion. The irrigation area has had extensive amelioration by deep ripping, cultivation, fertiliser, lime and gypsum to improve production in 2017. Additional treatment would be undertaken as needed.
Protection of plant and animal health	Design and management of the irrigation system does not compromise the health and productivity of plants, domestic animals, wildlife and the aquatic ecosystem. The IMP will ensure the ongoing protection of plant and animal health. The treated water for irrigation is low in nutrients.
Prevention of public health risk	The irrigation scheme is sited, designed, constructed and operated so as not to impact public health. The closest residence is approximately 360 m to the east of the irrigation area. The Newell Highway is approximately 25 m to the east of the spray irrigation area. The treated water for irrigation sources is low in nutrients. It also does not contain heavy metals as these are removed by membranes during treatment, and no organic compounds are expected to be found in the treated water. Therefore, there is minimal risk to public health, beyond those associated with standard fertiliser and chemical application.

Environmental performance objective	Summary of how irrigation meets the performance objective
Resource use	Water balance modelling indicates that the irrigation system at Leewood can beneficially reuse at least 90 % of the available treated water from the Leewood Water and Brine Treatment Plant (**WBTP**), the remainder being used for construction, dust management, drilling & completions and firefighting. Any use of the treated water by another user would also be a beneficial use of this water resource. Further, this approach minimises the use of other sources of water for these purposes, e.g. bore water and town water.
Community amenity	The irrigation system is located, designed, constructed and operated to avoid unreasonable interference with any commercial activity or the comfortable enjoyment of life and property offsite. The closest sensitive receiver to the irrigation area is approximately 360 m to the east. Potential impacts of the proposed irrigation activity relating to odour, dust, insects and noise are considered to be negligible and manageable.

3.3 EIS commitments

In the EIS Chapter 31, and updated in Appendix B to the Response to Submissions, Santos committed to implement a number of measures pending Project approval and a final investment decision. Where the EIS commitments relevant to irrigation of treated produced water have not already been translated into consent conditions, these have been reproduced below in Table 3.2. Note that in some instances a commitment may be no longer relevant due to the management plan structure required by the SSD 6456 consent conditions, rather than the environmental management plan structure proposed in the EIS.

Table 3.2 - EIS commitments relevant to irrigation

Number	EIS Commitment relevant to Irrigation
3.1 / 5.6	Irrigation of treated water during production will be undertaken in accordance with an irrigation framework, included under the Produced Water Management Plan [Note: Irrigation of treated water is fully described in this Plan, and not in the PWMP]

As described in section 10 of this Plan and section 8 of the EMS, this Plan will be subject to regular evaluation and review. This will include the EIS commitments to ensure they remain current, applicable, and generally improve the environmental performance of the Project.

4. Site selection and baseline information

To assess the viability of utilising treated water for irrigation in the vicinity of the Project area, an irrigable land survey was undertaken in 2015 across an area within a 20 km radius of the Leewood water treatment plant and subsequently a concept irrigation design was developed (BenaTerra, 2015). Full details on the irrigable land survey and the general concept irrigation design are presented in the Concept Irrigation Design, included in the EIS as Appendix G2.

Soils of the survey area comprise deep, uniformly textured cracking clays, dominated by Vertosol soils, and non-clayey surfaced soils, dominated by Sodosol soils. The survey identified 9,000 ha within a 20 km radius of the Leewood water treatment plant that were classified as suitable for irrigated crop development.

A number of crops were identified as possible candidates for irrigation in the region including cotton, wheat, grain sorghum, forage sorghum, oats and lucerne. Computer modelling using the HowLeaky® modelling software was employed first to evaluate the different crop water demands, secondly to predict the storage capacity requirements and thirdly the surplus water volumes at the peak treated water rate.

Based on the outcomes of the scenario modelling, lucerne (as a perennial crop) was recommended for the Project irrigation strategy. Several annual crop rotations were also investigated as comparative options. The annual cropping options were all inferior to the perennial lucerne regarding water use capacity.

4.1 Tenure

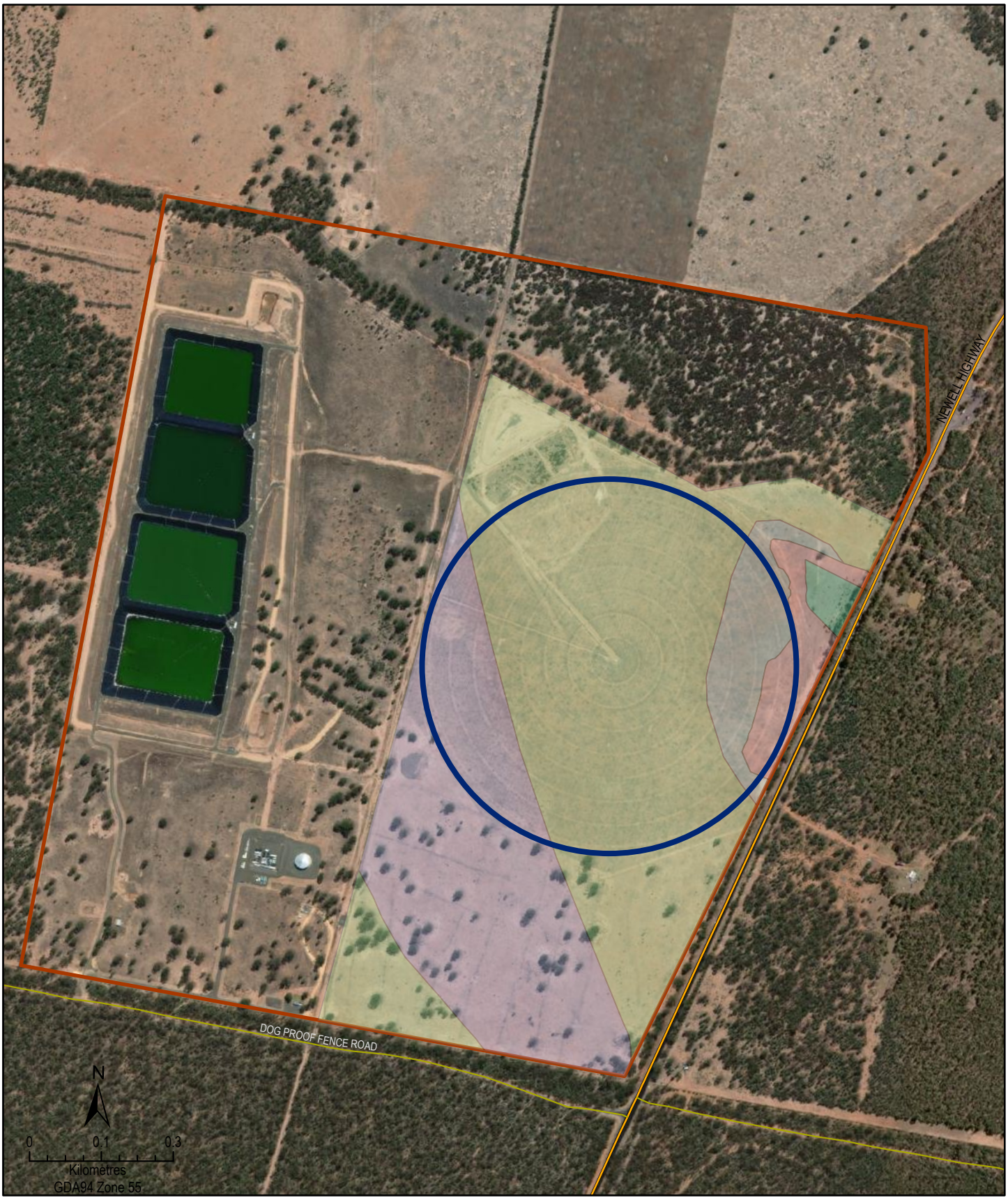
The Leewood irrigation site is owned and operated by Santos and is located within PAL 2. It is located adjacent to and to the east of the Leewood water treatment plant and approximately 49 hectares (**ha**) in size, on a parcel of land of approximately 100 ha. Prior to an irrigation trial in August 2017, the site was dryland unimproved pasture, with scattered native trees.

4.2 Location

The irrigation site is located on the eastern half of Santos' Leewood block, approximately 24 km southwest of Narrabri on the Newell Highway. The property borders the Pilliga State Forest on the south and west boundaries. It is bounded on the southwest corner at MGA 55, 751072 E, 6622328 S and on the northeast corner at MGA 55, 752849 E, 6623255 S. The location of the irrigation area relative to the existing Leewood infrastructure is presented in Figure 4.1.

4.3 Climate

Australian Bureau of Meteorology records from January 1963 to April 2013, Narrabri post office [station 053030] were utilised to develop the climate statistics for the Project. The climatic regime is characterised by a slightly summer-dominated rainfall pattern, with almost half the annual rainfall (46%) falling between November and February. Over the 50-year period, mean annual rainfall at nearby Narrabri was 644 mm whereas annual mean pan evaporation was 1,966 mm. Evaporation exceeded rainfall in all months.



Santos

ONWARD CONSULTING

LEGEND

- Leewood
- Central pivot
- Highway
- Roads

Soil Type

- Brown Chromosol
- Brown Sodosol
- Brown Sodosol-transitional
- Grey/Brown Sodosol
- Red Chromosol

NARRABRI GAS PROJECT

Figure 4.1

Soil Type Distribution across Centre Pivot Irrigation Area

4.4 Geologic setting

The surficial geological layer of the majority of the site is described as being Quaternary colluvium and/or residual deposits, and comprise talus, scree and sheet wash. The southwest corner of the parcel is mapped as a Cainozoic sand plain and may include some residual alluvium. It is sand dominant, also containing gravel and clay. Siliceous sands are dominant components of the parent material forming the soils, and consequently all the soils described at the site presented coarse sand fragments that were easily distinguishable by feel in most horizons.

4.5 Topography

The site is relatively flat, with elevations ranging from 245 m to 249 m Australian Height Datum (**AHD**). The median slope for the irrigation area is 0.4 %. The minimum slope for the area is 0.2 % and maximum slope is 1.2 %. The steepest slope drains a small catchment northeast toward the Newell highway and Bohena Creek. This corner also presents the best drained soils. The land rises away slightly from this corner towards the southwest, then slopes down toward a minor depression forming the drainage line that flows across the parcel from the southeast corner to the middle of the western boundary. Most of the property drains toward the northwest and overland flow enters from the southeast corner of the parcel. The topography and drainage patterns of the prospective irrigation are shown in Figure 4.2.

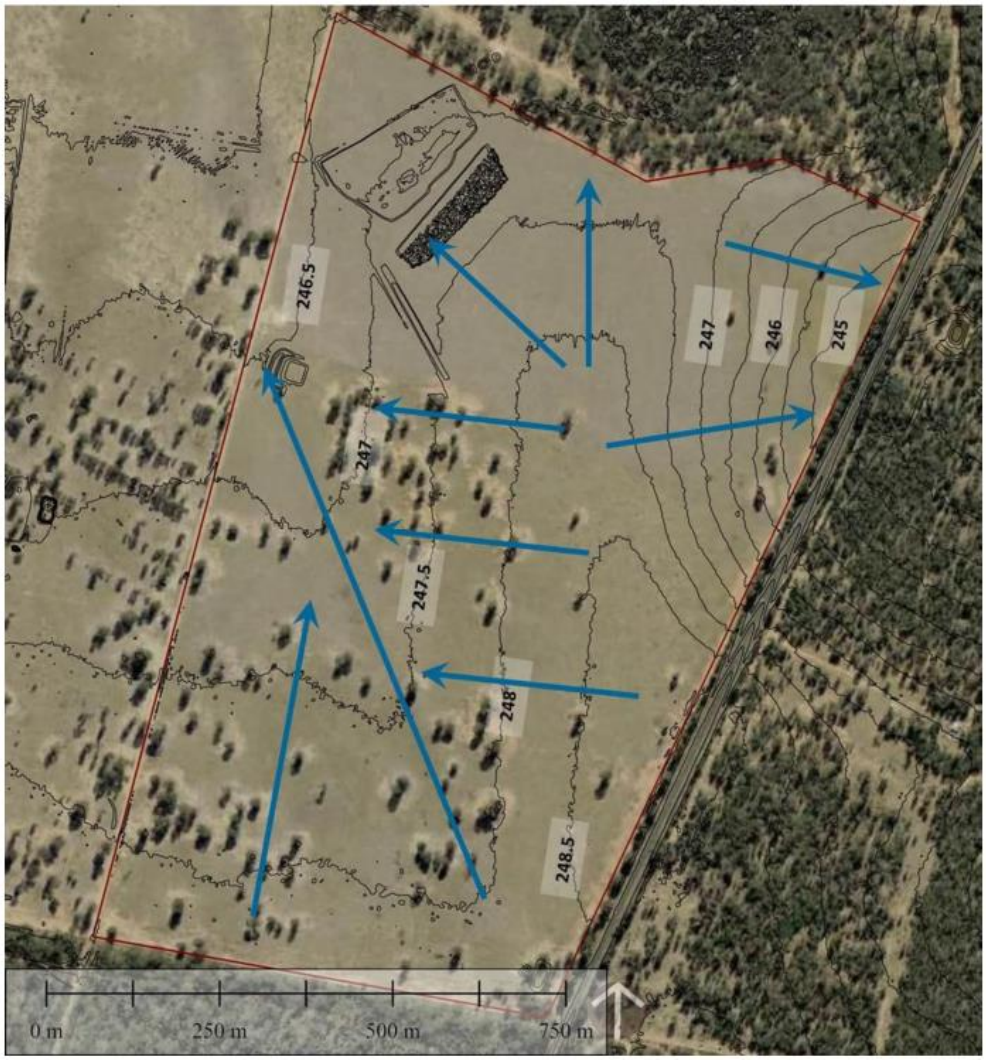


Figure 4.2 - Topography and drainage patterns of the prospective irrigation area

4.6 Limitations of landscape

The Leewood irrigation site has been assessed for irrigation in accordance with the Effluent Irrigation Guidelines. Table 4.1 is reproduced from the Effluent Irrigation Guidelines. The slopes on this site present no limitations for irrigation whilst occasional flooding or inundation of the lower elevations present a moderate limitation. The minor drainage line is considered a severe landform limitation according to the Effluent Irrigation Guidelines because of the potential for erosion and waterlogging. Monitoring of the irrigation area will occur to manage quantities applied in order to mitigate inundation and water logging. There are no surface outcrops of rock to interfere with irrigation of this property.

Table 4.1 - Landscape limitations for irrigation technologies

Property [1]	Limitation			Restrictive feature
	Nil or slight	Moderate	Severe [2]	
Slope (%) (for the following irrigation methods)				
• flood / surface / underground	<1	1-3	>3	excess run-off and erosion risk
• sprinkler	<6	6-12 [3]	>12 [3]	
• trickle / micro-spray	<10	10-20 [3]	>20 [3]	
Flooding	none or rare	occasional	frequent	limited irrigation opportunities
Landform	crests, convex slopes and plains	Concave slopes and foot-slopes	drainage lines and incised channels	erosion and seasonal water- logging risk
Surface rock outcrop (%)	Nil	0-5	>5	interferes with irrigation and/or cultivation equipment; risk of run-off

Source: Table 2.1 from the NSW *Environmental Guidelines – Use of Effluent by Irrigation* (DEC, 2004)

Notes:
1. Careful consideration should also be given to potential impacts on groundwater
2. Sites with these properties are generally not suitable for irrigation.
3. Slopes over 12 % may be acceptable provided run-off and erosion risks are identified in the site selection process.
4. The Leewood site limitation are nil or slight, apart from flooding (moderate) and the drainage line (severe).

4.7 Vegetative cover

Prior to irrigation commencing, the property was primarily covered with low-quality pasture grasses. Approximately 150 medium to large scattered woodland trees were identified on the eastern land parcel. Ninety of these trees were cleared from the 49 ha irrigation area in late November 2016, in accordance with the activity approval, to prepare the site for irrigation. The remaining trees outside of the 49 ha irrigation area have been retained. The area has since been cropped with barley and lucerne with the intention to establish a perennial pasture for grazing or hay production. The site is currently fallow land.

4.8 Soil descriptions

The soils were initially grouped into "soil units" based on similarities in morphology, chemistry and management requirements. The following five soil units are present across the 49 ha centre pivot irrigation area at the Leewood property (refer to Figure 4.1), with the area approximations below applying to the approximately 100 ha total land parcel:

Red Chromosol soil unit is a friable brown loam over a friable red clay loam, well drained, and chemically and physically amenable to root growth. It covers approximately 1 ha in area.

Brown Chromosol soil unit is a friable brown loam over a hard brown clay, moderately drained, and moderately chemically and physically amenable to root growth. It covers approximately 4 ha in area.

Transitional Brown Sodosol soil unit is very similar to the Brown Sodosol unit for most of its properties (see description below). The soils of this unit were shallower than the other Sodosol units, with a sandstone parent material encountered at around 1.2 m. It covers approximately 6 ha in area.

Brown Sodosol soil unit is a hardsetting brown sandy clay loam (or clay loam, sandy) over a very hard columnar brown clay, well drained in the 0.15 m or so of loam at the surface, changing sharply to much lower porosity clay upon which water perches for extended periods following heavy rainfall (remaining saturated for several days to a week). Root growth often extends to 1-1.5 m, but is restricted by the coarse soil structure and moderate salinity of the subsoil, particularly below 1 m. It comprises approximately 58 ha in area.

Grey/Brown Sodosol soil unit is similar to Brown Sodosol unit, but with the following distinctions: often a thicker surface soil, possibly built up from erosion off the up-slope soils, usually with a distinctly bleached subsurface horizon above the coarsely structured subsoil. The subsoil is grey or grey brown, indicating poorer drainage than the other soil units. However, it appears this is due just to landscape induced inundation i.e. due to drainage line flooding, rather than to lower internal permeability of the soil. Root development and clay structure are similar to the other Sodosols, indicating that the landscape effect is more important than differences in soil morphology. These cover approximately 31 ha in area.

All five soil units shared the characteristics of being loamy and acidic in the surface grading to less acidic below the surface horizon with most becoming near neutral in the subsoil. Plant nutrients phosphorus, potassium and sulphur are marginal to deficient. Phosphorus buffering, estimated from soil type and surface texture, were moderate in the soil surface and high in the subsoil. The majority of the soils were identified as "Magnesic Mesonatric Grey or Brown Sodosols; medium, non-gravelly, clay loamy/clayey, deep" according to the Australian Soil Classification.

The soils in the northwest corner of the property tended to be shallower with most presenting a sandstone parent material within 1.2 m. Only about 11 ha consisted of these soils, with 6 ha of Brown Sodosols, and the remaining 5 ha being Red or Brown Chromosols – "Mottled, Mesotrophic Brown or Red Chromosol; medium or thick, non-gravelly, loamy/clay loamy, deep".

For the purposes of the irrigation design, the soils on this site were further grouped into two irrigation management classes – A and B. These were differentiated primarily due to their landscape position and susceptibility to inundation:

- Class A soils: Chromosols and Brown Sodosols – more upland soils
- Class B soils: Grey/Brown Sodosols – lower lying soils

The maximum irrigation application rates are calculated to ensure there will be no run-off and the area is continually monitored for any run-off. Soil moisture data is also used to understand the condition of the soil to check if the soil is saturated and therefore is used to manage the likelihood of inducing run-

off. There are a range of monitoring methods and triggers outlined in the IMP that ensure there is no over-irrigation which could create run-off. The irrigation will be appropriately managed through a combination of visual field inspections, rainfall monitoring, and soil moisture probes in order to meet the requirements of EPL 20350.

4.9 Soil amelioration

The majority of the landscape to be irrigated is located on Sodosol soils. The soils have been ameliorated using a combination of deep ripping and gypsum to improve soil permeability and surface condition. Additionally, agricultural lime has been applied to neutralise surface acidity and to supply supplementary calcium, and fertiliser has been added to improve crop vigour. Further soil amelioration and fertiliser applications will be based on the results of crop growth, agronomic advice and soil monitoring.

4.10 Groundwater

Groundwater depth beneath much of the Leewood irrigation area is in the region of 20 m below ground surface. For the proposed perennial lucerne crop scenario, it would take approximately 500 years for applied treated water to reach the groundwater table and for the alternative wheat-cotton double crop rotation, approximately 50 years.

Three sets of nested groundwater monitoring bores, (LWDMW 1, LWDMW 2 and LWDMW 3) were drilled to about 36 metres below ground level (**mBGL**) on the Leewood property. Static water levels ranged from 20.7 to 29.5 mBGL. This translates to water levels of 216.72 m AHD to 227.47 m AHD. Excavations for geotechnical test pits (up to 5 m deep) and the produced water and brine ponds (up to 1.5 m deep) near the proposed treated water storage tank did not encounter groundwater.

Groundwater flow is to the north and no evidence of dryland salinity is present within the study area.

Further groundwater baseline data is provided in the Groundwater Management Plan and sub-plans, provided as attachment 4 to the WMP.

5. Water supply and irrigation protocol

5.1 Water volume

Produced water from pilot wells will be collected in holding ponds at Leewood and treated by reverse osmosis (**RO**) technologies. Using 1.5 megalitre (**ML**) produced water the RO plant will produce approximately 1 ML per day (**ML/day**) (365 ML/yr) of permeate water (treated water) which will be available for irrigation. The irrigation system has the maximum capacity to utilise up to 6.5 ML/day, with this volume incorporating approximately 49 ha of irrigation at a maximum of 12 mm on the ground per day, with a 90 % irrigation system application efficiency. Actual maximum daily application rates will be determined by daily evaporation rates i.e. the average daily rates averaged over a month can vary between 2 and 10 mm/day. The average water balance for Phase 1 indicates irrigation between 115 and 225 ML/year, which would equate to approximately 0.6 ML/day or less.

It should be noted that variables like temperature and evaporation will be taken into account to determine the actual daily application rate, since irrigation on a hot and windy day in summer generally results in a different actual applied volume on the ground than on a cold, still winter day. Treated water availability will be limited to 6 ML per day based on plant capacity and storage volumes, with treated water to be stored in the 5 ML tank during periods when irrigation is not being conducted. There is also additional system buffer capacity in the Leewood ponds in the event that irrigation is precluded, as detailed in section 6 of the Site Water Balance. Water level monitoring is addressed in section 9.1 of the PWMP.

There is no off-site treated water storage capacity during Phase 1.

5.2 Water quality

All produced water is treated to meet the treated water quality criteria in Table C1 in Appendix C, unless otherwise authorised in the EPL. As stated in section 9.5 of the PWMP, monitoring of treated water from this tank is conducted in accordance with condition M2.2, M2.3 and M2.11 of EPL 20350 prior to irrigation recommencing. Further details on the monitoring requirements are provide in Table B2 in Appendix B.

5.3 Suitability for irrigation

In accordance with Table 3.1 of the Effluent Irrigation Guidelines, the amended treated water is classified as ‘low-strength effluent’ according to its concentrations of nitrogen, phosphorus, biological oxygen demand (**BOD_5**), total dissolved solids (**TDS**) and other potential contaminants. The amended treated water is unlikely to contain heavy metals or organic compounds as these are either not present or present in very low concentrations only. Considering the actual concentrations of the various parameters, the amended treated water meets all the relevant ANZECC 2000 irrigation guideline values in Table C1 in Appendix C, making it suitable for long term irrigation (more than 20 years). Note that the ANZECC guidelines for irrigation provide operational limits, and that these may be crop-specific, as Santos may not necessarily always crop lucerne.

5.4 Irrigation design

The irrigation system infrastructure consists of a storage tank, pump, generator, filter, pipelines, valves, and a centre pivot distribution network. The approved concept irrigation design combined centre pivot to irrigate up to 41 ha of Class A soils and 8 ha of Class B soils. The centre pivot system allows irrigation to occur across the entire irrigation area or on specific sections (units) at a time depending on crop requirements, localised soil conditions and water availability. The rate of irrigation can also be varied across the irrigation area to coordinate optimal cropping regimes to maintain water balance throughout the year. There is no irrigation (no application of treated water) in forested areas, apart from construction activities on operational areas and access roads. Only bore water will be used for dust suppression during Phase 1.

5.5 Irrigation schedule

The irrigation schedule is driven by crop water demand and availability of treated water. Irrigation will be managed in such manner as to ensure the capacity of the utilisation area to effectively utilise the water is not exceeded. Together with the run-off monitoring detailed in section 6.5 this will ensure that no surface run-off occurs from the irrigation area resulting from the irrigation. A minimum of two moisture probes are utilised to help assess the area's ability to effectively utilise the water. Irrigation of the Class B soils between October and May is prioritised, allowing the Class A soils to increase their soil water deficit, improving their ability to receive water when the Class B soils may be too wet to irrigate. Irrigation may be reduced on the Class B soils between June and September when evapotranspiration (**ET**) is low, and the soils are most susceptible to overland flow from high rainfall events.

The irrigation schedule and the actual daily application rate will be determined by the Agricultural Supervisor based on the soil moisture monitoring equipment, the crop demands and routine site inspections to check there is no run-off and to minimise erosion and sedimentation, ponding and waterlogging. The monitoring regime is described in section 6.

6. Monitoring and reporting

6.1 Groundwater monitoring

Seven groundwater monitoring bores at three locations (LWDMW1-3) were in place on the Leewood property prior to the initial irrigation trial that commenced in 2017. In order to monitor for any changes during the irrigation activities, three additional monitoring bores (LWDMW4-6) were installed on the property. These three new bores are indicatively located as set out in Figure 6.1 and were screened in the first groundwater encountered. The details for all groundwater monitoring bores, including total depth and screen intervals, are provided in Table 6.1.

All bores monitor standing water levels and groundwater quality in accordance with the conditions of EPL 20350. As per condition M2.2, quarterly in situ monitoring of the dissolved oxygen, electrical conductivity (**EC**), pH and standing water level (**SWL**) is undertaken, whilst groundwater samples are collected and analysed for a broad spectrum of water quality parameters on an annual basis, in accordance with EPL 20350 condition M2.4. An additional representative sample for a full suite of analytes will be taken at quarterly in situ monitoring should trigger values for electrical conductivity, pH or standing water level at the monitoring point be exceeded, with trigger values set as specified in condition M2.5.

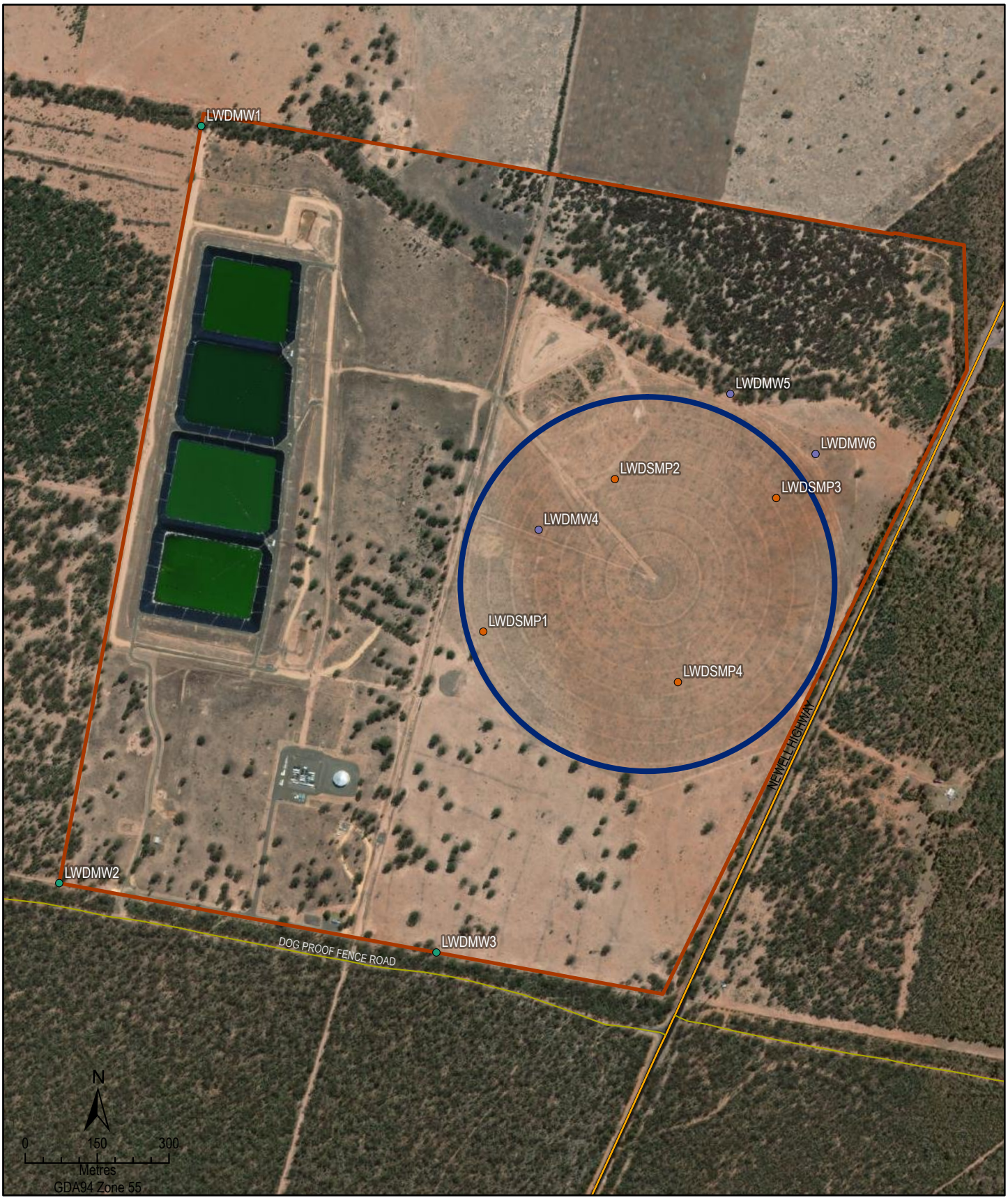
Table 6.1 - Total depth and screened interval of groundwater monitoring bores

Groundwater monitoring bore ID	Total depth (m)	Screened interval (m)	Date range (mm/yy)	SWL (mbTOC)	TDS (mg/L)	EC (µS/cm)
LWDMW1 (nested, one deep one shallow)	35	10-13 / 29-35	07/14 - 09/21	29.75-30.04	551-1440	1871-2382
LWDMW2 (nested, one deep one shallow)	35	10-13 / 29-35	07/14 - 09/21	25.93-26.27	952-2310	1301-2167
LWDMW3 (nested, one deep one shallow)	35	10-13 / 29-35	07/14 - 09/21	20.95-21.4	499-1260	844-1142
LWDMW4 (single piezometer)	35	28-35	03/17 - 03/20	N/A	696-971	1206-1696
LWDMW5 (single piezometer)	35	29-35	03/17 - 03/20	N/A	760-1110	1196-1575
LWDMW6 (single piezometer)	34	26-34	03/17 - 03/20	N/A	657-847	1200-1368

Notes: The depth of bores is in metres below ground level. There is no groundwater encountered in the shallow wells. SWL, TDS and EC are available on the Santos water portal (https://waterportal.santos.com/).

mbTOC – metres below top of casing

Monitoring will be undertaken consistent with the existing groundwater monitoring at the site, as described above. Section 7 provides details on groundwater monitoring in the event of changes to groundwater salinity outside of the expected range.



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LEGEND

- Leewood
- Central pivot
- Highway
- Roads

Groundwater and soil monitoring points

- New groundwater monitoring bore
- Original groundwater monitoring bore
- Soil monitoring point / soil sensor

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Figure 6.1

Groundwater and Soil Monitoring Points

6.2 Soil moisture and vadose zone monitoring

Soil moisture and EC sensors which provide continuous monitoring have been installed across the irrigation area. The locations where the sensors are located are representative of the soil types and landform and are spaced to assess a range of points along the pivot span. The soil monitoring locations provide adequate coverage for the centre pivot irrigation activity and reflect the original number of bores proposed for the centre pivot area. The soil moisture probes provide regular measurements of soil moisture, salinity, and temperature in order to maintain soil structure, stability and agricultural productive capacity. The sensors utilise capacitance-based technology to provide near-continuous measurements within the soil profile. By creating a high frequency electrical field around the sensor, extending through the access tube into the surrounding soil, the sensors detect the changes in dielectric constant, or permittivity, of the soil over time. The power to each of the sensors and its data collector is supplied by a small solar panel system integrated on a pole with its data collector. The data collected is sent to a base server which can be accessed remotely via telemetry.

The sensors measure moisture content and salinity of the rootzone and into the vadose zone, from the soil surface to 200 centimetres (**cm**) below the surface. The derived data is used to estimate the volume and rate of water moving through the soil and vadose zone. Based upon monitoring bore log data describing the vadose zone beneath the rootzone, potential impacts to groundwater could then be estimated by hydrogeological modelling. For this modelling, the available bore log data will provide the soil structure to depth, and together with the monitoring data the groundwater transport will be estimated using specific groundwater models. If the irrigation area is operational, this modelling will be completed prior to Phase 2.

6.3 Soil quality monitoring

The soil monitoring program at the four dedicated soil monitoring points (LWDSMPT 1 to 4) with approximate locations provided in Figure 6.1 is conducted in accordance with EPL 20350 condition M2.2, M2.3 and M2.4. As required by condition M2.3, three soil cores to a depth of 3 m will be taken within a 25 m radius of each of the four soil monitoring points. From these soil cores, samples will be taken from depths of 0-25 cm, 25-50 cm, 50-75 cm, 75-100 cm, 100-200 cm and 200-300 cm. Samples of the same depth from the three soil cores will be composited and analysed.

As required by EPL 20350 condition M2.2, the six composite soil samples will be analysed for a suite of pollutants. As per condition M2.4, soil samples will be taken prior to irrigation of treated water occurring and then yearly thereafter. Note that in accordance with EPL 20350 condition M2.11, since the Leewood water treatment plant is not operating and irrigation is not occurring on the irrigation utilisation area, monitoring is not required in the period since the last monitoring event. However, monitoring will be undertaken prior to the recommencement of irrigation, as per condition M2.2 and M2.3. All observations are recorded for reporting purposes, as described in section 6.10.

6.4 Electromagnetic induction monitoring

Electromagnetic induction (**EMI**) surveys are often used in practice to estimate field-scale soil salinity patterns, and to infer changing salinity conditions with time. EMI soil surveying can recognise areas of differing moisture conditions and/or salt loading, allowing areas requiring additional attention to receive early investigation or rehabilitation. An EMI survey design will be developed, including the choice of conductivity instrument and GPS, and a baseline EMI survey of the irrigation site will be conducted prior to irrigation recommencing. The data will be used to compare subsequent EMI surveys conducted in subsequent years, with the frequency for regular EMI surveys to be included in the IMP when this is updated and revised prior to Phase 2.

6.5 Run-off, erosion and waterlogging monitoring

As detailed in section 4.5, the irrigation site is relatively flat, with a median slope of 0.4 % and a maximum slope of 1.2 %. Run-off will only be caused by rainfall events and may carry small amounts of sediment and nutrients. Losses of sediment and nutrients from the irrigation area will be monitored by placing stormwater sampling devices upstream of the paddocks where run-on might occur, and downstream of where run-off due to rainfall might occur. This monitoring will only be undertaken when periods of high rainfall (>10 mm in 24 hours) are forecast within 24 hours of active irrigation, with the locations for the stormwater sampling devices to be determined based on topography and soil surface conditions. These locations will change over time as the irrigation area is actively managed and potentially reshaped over time (refer to Table D2). The contribution from the irrigation area will be calculated as a portion of the micro-catchment feeding the sampling device.

Visual inspections of the landscape by the Irrigation Operator are made daily during irrigation to assess irrigation evenness, and to identify and to minimise any areas of erosion and sedimentation, waterlogging or ponding.

6.6 Native vegetation monitoring

The Brigalow woodland and Pilliga Box-White Cypress grassy open woodland native vegetation communities located on the northern boundary of the site will be monitored to ensure no adverse impacts occur as a result of irrigation activities (refer to Table E6 in Appendix E). A baseline condition survey will be undertaken prior to recommencement of irrigation, and visual monitoring of vegetation will be undertaken on a quarterly basis. The monitoring point will be located adjacent to LWDMW5, in a 25 m radius.

As a part of the irrigation design to protect the native vegetation, a 10 m buffer has been implemented between the irrigated land and the native vegetation. Potential for sprinkler mist to affect the native vegetation is minimised by using low-pressure drop nozzles. When necessary, spans or individual nozzles can be shut down in susceptible areas. Regular visual inspections along the boundary of the sprinkler system will be undertaken. The quality of the treated water is such that there will be negligible impact on this vegetation community, and the pivot is managed to avoid spray drift to this area.

6.7 Weather monitoring

A meteorological station installed and operating at Leewood records rainfall, temperature, solar radiation and wind speed. The collected data will be used to calculate ET for that location. Soil moisture monitoring devices will be set out as shown in Figure 6.1 and reviewed regularly against the weather station data. Irrigation rates will be adjusted by soil and crop type to optimise crop health and water use. The soil moisture monitoring devices will be placed at least 200 cm below ground level to estimate root uptake of moisture and deep drainage. The irrigation schedule will utilise soil water sensor data along with irrigation, ET and rainfall data to develop a water balance record.

Daily and weekly weather forecasts together with the collected data from the meteorological station will be used to provide a look-ahead for the suitability for irrigation.

6.8 Crop health

A healthy, actively growing crop is required to utilise the treated water. Monitoring and reporting requirements for the crop are found in Table D2 of Appendix D.

The crop will be inspected for weeds, pests and diseases, health and vigour by the Agricultural Supervisor, with assistance from an agronomist or soil scientist when needed. This will include making recommendations for harvest timing or for grazing, which should optimise forage quality and minimise soil compaction and weed distribution. The suitably experienced person will also make recommendations for the crop rotation sequences suitable to the goals of the Project. Two transects of the surface 10 cm of topsoil will be sampled annually and the soil analysed for nutrients, soil adsorption ratio (**SAR**), pH and $EC_{1:5}$. One transect will be across the Class A soil area, and the other will be across the Class B soil area. For each transect, 20 to 30 cores will be collected then mixed together (composited) into a single sample for analysis. This data will provide the basis for ongoing fertiliser and amendment applications.

6.9 Operations, maintenance and monitoring schedules

A set of inspection and maintenance schedules have been developed for the operation of the irrigation system. Tables D1 and D2 in Appendix D summarise the inspections and maintenance required under this IMP, including equipment calibration, water quality, application rates and schedules, crop health and soil conditions. Irrigation plant and equipment will at all times be operated and maintained in a proper and efficient manner.

6.10 Annual report on irrigation operations

On an annual basis from the commencement of irrigation operations an Annual Irrigation Summary Report will be prepared. The report will contain summary information on:

- weather conditions at the site, including rainfall and evapotranspiration;
- volume of water irrigated;
- irrigation system operations and maintenance;
- treated water dosing;
- soil amelioration activities;
- groundwater monitoring;
- soil moisture and soil sample monitoring;
- native vegetation monitoring;
- crop health, yield, and associated agronomic activities; and
- review and refinement of a water balance for the activity.

The inspection and monitoring activities tabled in Appendix D will provide the data upon which the above reports will be based.

7. Trigger action response plans

Trigger Action Response Plans (**TARPs**) are developed to identify, assess and respond to abnormal conditions and are implemented to manage risk to operations, personnel and the environment. A TARP consisting of six separate aspects has been developed to address the management and consent conditions associated with the operation and management of the irrigation system. Monitoring of the crop, soil, landscape, native vegetation and groundwater have been related to measurement thresholds that will trigger a change in monitoring intensity and/or operational actions.

The TARPs outline the threshold triggers for measurements of the following aspects:

- crop heath,
- waterlogging (surface ponding and run-off),
- soil salinity;
- soil sodicity;
- salinity in groundwater; and
- native vegetation health.

It is the responsibility of the Environmental Advisor to assess the TARP triggers and provide the relevant notification to the Team Leader Narrabri Operations, and provide any notification to DPE and any other relevant agency in the event of an incident..

The Irrigation TARPs are presented in Tables E1 to E6 in Appendix E.

8. Record keeping

Santos has a data management plan for the NGP that outlines the policies and procedures that will be implemented to ensure that data is managed in a consistent, efficient and effective manner in order to provide accurate records of activity operations and enhance the value of the data collected. An overview of Santos' data management plan is presented in Figure C1 of Appendix C of the WMP, in the form of a data-management flow chart.

Santos uses a number of systems and platforms to manage the documentation and data associated with the activities under this Plan. These include Sharepoint for management plans, procedures and laboratory reports; Santos' EHS Toolbox for capturing inspections and field assessments; and EquIS[2], an advanced environmental data management and decision support system, for capturing all data and any laboratory results.

Details of data collection, inspection and maintenance key records associated with this IMP that are stored and managed include:

- inspection and monitoring records;
- records of any review of the IMP;
- operational monitoring and performance data for treatment systems;
- water sampling and laboratory analytical reports;
- calibration records for field instruments and continuous water quality monitoring systems; and
- annual inspection reports and/or certifications.

Monitoring data is subject to quality assurance (**QA**) and quality control (**QC**) protocols and procedures that ensure that data is accurate and usable. Data is subjected to consistent validation and verification procedures. Any data that fails QA and QC procedures is rejected for future use.

The records required to be kept and maintained according to the Produced Water Code should be kept from the time the Code applies as a term imposed on an activity approval. Records are to be kept in a legible form for production to any inspector for a period of four years following the expiry or termination of a prospecting title (refer to sections 97D and 97E of the PO Act).

[2] EQuIS (Environmental Quality Information System) is a proprietary software application.

9. Incidents, non-compliances and complaints

9.1 Incidents and non-compliances

Incident reporting and non-compliance notification will be in accordance with CoC D6 and D7 respectively, as described in section 6 of the EMS. Santos will notify the DPE and any other relevant agency via the Major Projects Portal immediately after becoming aware of an incident.

Within 7 days of becoming aware of a non-compliance with the CoC, Santos will notify the Department of the non-compliance via the Major Projects Portal. This notice will set out the non-compliance, the reasons for the non-compliance (if known) and what actions have been taken, or will be taken, to address the non-compliance. A non-compliance which has been notified as an incident will not be notified as a non-compliance.

Where incidents or non-compliances associated with this IMP are identified, Santos will:

- take all reasonable and feasible steps to ensure that the incident or non-compliance ceases and does not reoccur;
- consider all reasonable and feasible options for remediation (where relevant) and submit a report to the relevant department(s) describing options and any preferred remediation measures or other courses of action; and
- implement remediation measures as directed by the relevant department(s).

9.2 Unpredicted impact protocol

It is considered unlikely that the activities during Phase 1 will result in any unpredicted or unforeseen impacts in relation to the irrigation of amended treated water. However, in accordance with CoC D3(f), the following strategy outlined in Table 9.1 will be adopted in the event where the management and trigger response measures do not lead to the required outcomes and conditions for the irrigation process.

Table 9.1 - Unpredicted impact protocol

Step	Strategy
1	Stop the irrigation process and implement immediate corrective actions to minimise the unpredicted impact
2	Review the unpredicted effect or impact and consider the following: • activities that may have triggered this event; and • relevant monitoring data.
3	Notify the relevant agencies and departments
4	If appropriate, commission an investigation by an appropriate specialist.
5	Based on the results of the investigation, develop the appropriate amendment and amelioration methods for the irrigation process.

Step	Strategy
6	Implement the information from the investigation to review, and if necessary, update this IMP which will include any or all of the following: • a review and where required, revision of the amended treated water application process; • a review and where required, revision of the treated water storage facilities and monitoring regime; • a review the actions that may have been taken prior to event; and • implement any relevant training based on the findings of the investigation to avoid any recurrence of the unpredicted impact.

9.3 Complaint management

Santos has a documented *Complaint Management Procedure* that is communicated to all relevant staff members. Complaints can be directed to Santos via phone or email 24 hours a day, 7 days a week. Contact details are publicly available on the Project website and are presented in Appendix D of the EMS.

All complaints are logged on a complaint form which includes the following details:

- date and time of the complaint;
- complainant details;
- details of the issue or complaint;
- actions taken to remediate the issue, if any;
- follow up actions required, if any;
- details of further liaison with complainant, if any; and
- closure date and time of the issue.

As per CoC D13, Santos maintains a complaint register which is updated as required and available on the Project website.

10. Reporting, evaluation and review

10.1 Annual Review

In accordance with condition D8 and as further described in section 6 of the EMS, Santos will review the performance of its irrigation management for the previous calendar year and report the relevant results within the Annual Review, to the satisfaction of the Planning Secretary. The Annual Review will be submitted to the DPE via the Major Projects Portal by the end of March each year, and will at minimum provide the following information regarding:

- the effectiveness of the management measures to prevent, and if prevention is not reasonable and feasible, to minimise any impact from irrigation of treated water; and
- any irrigation incidents or non-compliances at the Leewood irrigation area.

Further, the annual review under consent condition D8 requires a number of items to be reviewed or assessed. In summary these are:

- monitoring results and complaints;
- non-compliances and incidents;
- compliance with performance measures;
- discrepancies between predicted and actual impacts; and
- measures to be implemented to improve environmental performance.

The Annual Review may also make recommendations for any additions, changes or improvements to the irrigation strategy and processes.

10.2 Independent environmental audits

Within one year of commencement of Phase 1 and every three years thereafter, Santos will commission an Independent Environmental Audit (**IEA**) of the operation, to be conducted in accordance with CoC D9. The audit team will be led by a suitably qualified auditor and include experts in groundwater, well integrity, hazards, and any other fields specified by the Planning Secretary.

The IEA process is further described in section 8.3 of the EMS.

10.3 Management Plan review and evaluation

As required by CoC D4, Santos will review the suitability of existing strategies, plans and programs required under this consent, within two months of:

(a) the submission of an incident report;
(b) the submission of an Annual Review;
(c) the submission of an Independent Environmental Audit;
(d) the submission of a Field Development Plan;
(e) the submission of a Groundwater Model Update; or
(f) the approval of any modification of the conditions of SSD 6456.

This is to ensure the IMP is updated on a regular basis and to incorporate any recommended measures to improve the environmental performance of the Project.

In view of the various conditions requiring annual reviews, suitability assessments and performance evaluations, this IMP will also be reviewed and, if necessary, updated in at least the following circumstances:

- in accordance with any direction from the NSW EPA or the Minister administering the PO Act;
- due to any significant change to the design or operation of the irrigation management system as described herein; and
- based on the findings of a technical review panel that meets once per year, or more often if an issue occurs.

The review history table in the front of this Plan provides the details of each review, conducted in accordance with condition D4.

As required by CoC D5, if the review under condition D4 determines that the IMP requires revision – to either improve the environmental performance of the development, cater for a modification or comply with a direction – then Santos will submit the revised document to the Planning Secretary for approval within 6 weeks of the review.

Further details on the reporting, evaluation and review of the IMP are provided in section 8 of the EMS.

10.4 Improvement measures

Santos will conduct a program to investigate and implement ways to improve the environmental performance regarding irrigation over time, and implement a protocol for the periodic review of the IMP, in accordance with CoC D3(g) and (i) respectively.

Measures to improve the environmental performance of the Project that will be implemented following review and evaluation include the following:

- audit of the irrigation management system, reviewing the water treatment plant operation and the management measures;
- implementation of modifications to the IMP; and
- additional monitoring and inspections.

The protocol for review is set out by consent conditions D8, D4 and D5, which have been addressed in sections 10.1 and 10.3 above.

In accordance with CoC D13 and as described in section 6 of the EMS, all relevant monitoring data and associated reports will be made available on the Project website, for the duration of the Project. This information will be kept up to date.

11. References

BeneTerra P/L (2015). *Irrigation General Concept Design – Report*. Prepared for Santos as Appendix G2 of the Narrabri Gas Project Environmental Impact Statement.

DEC (2004). *Environmental Guidelines - Use of Effluent by Irrigation*. Department of Environment and Conservation (NSW)

Department of Environment & Climate Change (2008). *Managing Urban Stormwater: Soils and Construction, Volume 2C, Unsealed Roads*.

Department of Environment & Climate Change (2008). *Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and Quarries*.

GHD (2017). *Narrabri Gas Project Environmental Impact Statement*. Prepared for Santos Ltd.

Landcom (2004) *Managing Urban Stormwater - Soils and Construction: Volume 1*.

OEH (2012). *Erosion and Sediment Control of Unsealed Roads - A Field Guide for Erosion and Sediment Control Maintenance Practices*

12. Glossary

Term	Definition[3]
Access track	Cleared and graded track constructed where existing tracks are not available
Alignment	The line or lines that describe a linear-infrastructure route; it defines how linear infrastructure (such as a road, access track or pipeline) will be located in relation to the features encountered along the route
Alluvial	Sediments deposited following a decrease in velocity of flowing water
Alluvium	General term for unconsolidated fluvio-lacustrine deposits of inorganic materials (clay, silt, sand, gravel, and boulders) deposited following a decrease in velocity of flowing water
Amended treated water	Produced water that has undergone treatment and amendment, as generally described in the EIS, to enable it to be used for beneficial reuse purposes including irrigation, stock watering, drilling[4], construction and dust suppression
Aquatic ecosystems	The physical and chemical environment that contains a community of organisms (plants, animals, and microbes), and ecological processes within rivers and their riparian zones and reservoirs, lakes, wetlands and their fringing vegetation
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
Aquifer	A saturated permeable geologic unit that can transmit useful quantities of water
Baseline	A starting point used for future comparisons. Water baselines in context of the Narrabri Gas Project have been derived from long term water level and quality data presented in the Narrabri Gas Project Water Baseline Report.
Beneficial use	Beneficial use refers to the use of waters, including produced water from an oil or gas well, for a secondary purpose that has a positive value. Potential beneficial use options for produced water include domestic and livestock supply, industrial supply, irrigation supply, dust suppression and recreation.
BOD_5	BOD (biological oxygen demand) is a measure of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a certain period. It is usually expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C (and referred to as BOD_5).
Brine	Saline water with a total dissolved solid concentration of greater than 40,000 milligrams per litre. May be a wastewater produced by the desalination of coal seam water (e.g., by reverse osmosis)
Bund (or bunding)	Wall of a secondary containment system, usually in the form of an embankment, used to prevent sediment and liquids from entering the environment
Catchment	The area of land that collects and transfers rainwater into a watercourse
Cation exchange capacity	The number cations (positively charged ions) available in a soil. Cation exchange capacity can be used as a measure of soil fertility
Council	Narrabri Shire Council
Department	NSW Department of Planning and Environment (DPE)
Depressurisation	The extraction of coal seam water to facilitate gas production causes depressurisation of the target coal seams, which has the potential to

[3] The majority of the definitions are as provided in the Development Consent for SSD 6456.

[4] Note that when 'drilling' is stated in consent conditions, where relevant this has been interpreted to mean 'drilling and completions'.

Term	Definition[3]
	propagate into surrounding formations.
Drilling fluid	A fluid (sometimes referred to as a mud) made up of 70 to 80 per cent water that is pumped into wells during drilling to cool and lubricate the drill bit and carry drill cuttings to the surface
Ecosystem	An interconnected biological community of organisms that interact with each other and their physical environment.
EIS	The Environmental Impact Statement titled Narrabri Gas Project Environmental Impact Statement, dated 31 January 2017, submitted with the development application, including the Applicant's response to submissions and supplementary response to submissions, and the additional information provided by the Applicant to the Department in support of the application
Erosion	Wearing away of rock or soil caused by physical or chemical processes
Gas compression facility	A facility that houses multiple compressor units, either nodal or hub compressors or a mixture of both used to increase the pressure of gas for the purpose of transmission; may be collocated with a gas treatment facility and/or water management facility
Gas field infrastructure	All Project-related infrastructure, excluding the Leewood facility, Bibblewindi facility and the road upgrades required under SSD 6456
Gas well	Pilot wells and production wells
Gathering lines	Pipelines used to transfer gas and produced water from wells
Groundwater	Water contained in the interconnected pore spaces and voids of the saturated zone of sediments and rocks.
Groundwater level (or static / standing water level)	The depth to groundwater from some reference point (usually the natural surface)
Groundwater monitoring network	An arrangement of groundwater monitoring bores that is usually installed to monitor groundwater quantity and quality to inform how a groundwater system is responding to some applied stress, such as irrigation pumping and application, coal seam gas development, municipal water supply and climate variability
Groundwater quality	A measure of groundwater value expressed in physio-chemical terms, such as acidity / alkalinity, dissolved oxygen, dissolved salts, ions and contaminants like hydrocarbons
Groundwater quantity	A measure of the amount of groundwater held within a groundwater system, usually expressed as groundwater head (elevation or pressure) and flux
Incident	An occurrence or set of circumstances that causes or threatens to cause material harm and which may or may not be or cause a non-compliance
Irrigation scheme	The use of water for agricultural production. In the case of the Narrabri Gas Project, treated water is proposed to be used for irrigation as part of the overall Produced Water Management Plan
Linear infrastructure	Project related infrastructure of a linear nature including gas and water gathering lines, gas and water pipelines, access tracks, power lines, communication lines and other service lines
Losing stream	Streams that lose water by outflow through the streambed. This can occur permanently or seasonally
Major facilities	Leewood facility and Bibblewindi facility
Material harm	Material harm to the environment is defined in Section 147 of the POEO Act
Minimise	Implement all reasonable and feasible mitigation measures to reduce the impacts of the Project
Mitigation	Activities associated with reducing the impacts of the development

Term	Definition[3]
Namoi Alluvium	The Upper Namoi Alluvium, an aquifer made of coarse-grained river gravels and sands. The Lower Namoi Alluvium, a hydrostratigraphic unit made of shallow alluvial fan deposits associated with the Namoi River. These units contain a significant resource of readily accessible, good quality groundwater that is heavily utilised for irrigation, public water supply, private water supply and livestock
Non-compliance	An occurrence, set of circumstances or development that is a breach of the SSD 6456 consent
Petroleum Assessment Lease 2 (PAL 2)	A PAL is required to hold the exclusive right to prospect for petroleum and to assess any petroleum deposit over a specified area of land in NSW. A lease allows the holder to maintain a title over a potential area, without having to commit to further exploration. The holder can, however, continue prospecting operations and to recover petroleum in the course of assessing the viability of commercial mining. PAL 2 is held by Santos NSW Pty Ltd.
Petroleum Exploration Licence 238 (PEL 238)	Before exploring for minerals or petroleum in NSW, an explorer must first obtain a Petroleum Exploration Licence (PEL) under the Petroleum (Onshore) Act 1991. An exploration licence gives the licence holder exclusive rights to explore for petroleum or specific minerals within a designated area but it does not permit mining, nor does it guarantee a mining or production lease will be granted. PEL 238 is held by Santos NSW Pty Ltd.
Petroleum Production Lease 3 (PPL 3)	A petroleum production lease gives the holder the exclusive right to extract petroleum within the production lease area during the term of the lease. PPL 3 is held by the following titleholders: • Santos QNT Pty Ltd; • Santos NSW (Hillgrove) Pty Ltd; and • Santos NSW (Eastern) Pty Ltd.
Petroleum production lease application (PPLA)	A petroleum production lease gives the holder the exclusive right to extract petroleum within the production lease area during the term of the lease. Development consent under the Environmental Planning and Assessment Act 1979 must be in place before a petroleum production lease can be granted. Santos, on behalf of its joint venture partner lodged four petroleum production lease applications under the PO Act in May 2014 for the Project area, being PPLAs 13, 14, 15 and 16. The ownership of the application is now held by Santos NSW Pty Ltd.
Pilot well	A well for gas and water extraction, for the purpose of exploration, appraisal and assessment of the gas field potential
Planning Secretary	Planning Secretary under the EP&A Act, or nominee
Pollution incident	Has the same meaning as in the POEO Act
Produced water	Any form of groundwater that is actively extracted from a borehole, well or excavation, excluding incidental groundwater mixed with drilling fluids
Production well	A well for gas and water extraction, for the purpose of commercial gas production and/or use
Project area	The area of approximately 95,000 hectares that encompasses the Project
Project footprint	The area of surface expression being about 1,000 hectares occupied by the infrastructure components of the Narrabri Gas Project
Project-related infrastructure	All infrastructure and other structures associated with the development. This includes linear infrastructure and non-linear infrastructure, surface infrastructure and subsurface infrastructure, major facilities, wells and well pads and other gas field infrastructure
Public infrastructure	Linear and related infrastructure that provides services to the general public,

Term	Definition[3]
	such as roads, railways, water supply, drainage, sewerage, gas supply, electricity, telephone, telecommunications, etc.
Reasonable	Means applying judgement in arriving at a decision, considering mitigation benefits, cost of mitigation versus benefits provided, community views and the nature and extent of potential improvements
Recharge spring	A spring supported by water that recharges sandstone sediments that outcrop on the margins of the Great Artesian Basin and discharge locally after relatively short residence times.
Red-brown Clays	A type of soil described as gradational brown to red-brown cracking sandy clays
Red-brown Earths	A type of soil described as gradational red-brown clay loams
Registered bore	A water bore whose presence has been notified to the Water NSW and included in its registered groundwater bore database. The database typically includes details on bore location, construction and where possible, the source aquifer.
RREO	Resource Recovery Exemption under clauses 91 and 92, and/or Resource Recovery Order under clause 93, of the Protection of the Environment (Waste) Regulation 2014
Spring	A naturally occurring discharge of groundwater flowing out of the ground, often forming a small stream or pool of water. Typically, it represents the point at which the water table intersects the ground level.
Sedimentation	Deposition or accumulation of mineral or organic matter deposited by air or water
Transmissivity	Rate in which water of a given density and viscosity is transmitted through a unit width of aquifer or aquitard under a unit hydraulic gradient.
Treated water	Produced water that has undergone treatment to enable it to be used for beneficial reuse purposes including irrigation, stock watering, drilling[5], construction and dust suppression, and/or for managed release to Bohena Creek[6]
Unacceptable risk	The level of risk at which mitigation actions are deemed to be warranted.
Well	Pilot wells and production wells
Well pad	An area of up to 1 hectare in size upon which the gas wells are to be located, with the area decreasing to no more than 0.25 hectares following rehabilitation[7], or other area as may be approved in the Field Development Plan

[5] Note that when 'drilling' is stated in consent conditions, where relevant this has been interpreted to mean 'drilling and completions'.

[6] Note that there will be no discharge to Bohena Creek during Phase 1.

[7] Workover activities will be contained within the operational area of the well pad area of around 0.2 ha, with an additional laydown area that could be approximately 0.2 ha in size.

Appendix A - Consultation records

NSW GOVERNMENT | Natural Resources Access Regulator

Contact: Tim Baker
Phone: 0428 162 097
Email : Tim.Baker@nrar.nsw.gov.au

Our ref: V15/3875-5#53
File No:
Your Ref:

27 September 2021

Dave Gornall
Santos Limited
email: David.Gornall@santos.com

Dear Dave

Re: Narrabri Gas Project - Water Management Plans second batch

Thank you for the opportunity to provide comment on the second set of plans under the Water Management Plan requirement for Phase 1 of the Narrabri Gas Project. It is understood this consultation is in accordance with the Condition B41 of Project Approval SSD 6456. The plans reviewed include the Water Management Plan, Erosion and Sediment Control Plan, Produced Water Management Plan, Irrigation Management Plan and the Pollution Incident Response Management Plan. NRAR is satisfied the consultation requirements have been met in respect to the plan preparation and provides the following comments.

- It is recommended the Water Management Plan include a map that depicts the location of the existing and proposed infrastructure for the Phase 1 activities.
- In Section 4.2 of the Produced Water Management Plan it is noted 1.26ML/d of produced water is predicted from operation of the existing and proposed pilot wells. It is recommended a reference be included to how this water take is to be accounted for by inclusion of relevant Water Access Licence numbers and entitlement, and relevant linked Work Approval/Miscellaneous Work numbers.
- The Erosion and Sediment Control Plan refers to water needed for dust suppression, but no details are provided on the volumes/water source and any relevant water license details. It is recommended this information be included in this plan or the separate Dust Suppression Protocol.
- It is recommended Section 5.9 of the Erosion and Sediment Control Plan include a reference to the need to design works in watercourses in accordance with the *"Guidelines for Controlled Activities on Waterfront Land* (NRAR 2018)". It is also recommended that these guidelines are reviewed against the proposed design for works within waterfront land such as Appendix D and E. The guidelines are accessible at the following link: https://www.nrar.nsw.gov.au/how-to-apply/controlled-activities/guidelines-for-controlled-activities

For further information please contact Tim Baker, Senior Water Regulation Officer on 0428162097 or **e:** Tim.Baker@nrar.nsw.gov.au

Yours sincerely

Tim Baker
for
Shavaun Tasker
A/Manager Licensing and Approvals – Water Regulatory Operations - West
Natural Resources Access Regulator
Department of Planning, Industry and Environment

Santos

Management Plan Consultation Feedback Form

DOCUMENT TITLE:	**Irrigation Management Plan**
STAKEHOLDER:	**NSW Environment Protection Authority**
CONSULTATION RELEASE DATE:	**3 August 2021**
COMMENTS DUE DATE:	**11 October 2021**

General Feedback	
Key Issues	No significant issues identified.
Suggestions for improvement	Nil

Section	**Type**	**Specific Feedback** *Detail specific issues with certain sections in the document*
eg Section 2	*Legislative + Regulatory reqs./ Readability / Usability /*	*Further detail is required about when a report is required and how the report is to be submitted.*

Irrigation Management Plan – WTAG comments received on Revision C (draft)

Comments received from Randall Cox, Jack Warnock and Michael Williams

Item	Section #	Section heading	Existing text	Comment	Final response
1	1.2	Purpose and scope of the IMP - Phase 1	This Plan forms part of a suite of documents prepared as part of the WMP under Condition B41, which consist of the following: (i) An Erosion and Sediment Control Plan, prepared in accordance with the Blue Book' and….	**[Randall Cox]** It states… '*This Plan forms part of a suite of documents prepared as part of the WMP under Condition B41, which consist of the following:* *(i) An Erosion and Sediment Control Plan, prepared in accordance with the Blue Book'* 'Blue Book' is defined in the overarching Water Management Plan but not the Irrigation Management Plan. There could be an entry in the glossary for the irrigation referring to the Water Management Plan.	The sentence referring to the Blue Book is a direct extract from the Project Approval condition B41. Although the Blue Book is not directly relevant to the Irrigation Management Plan, the following footnote has been added for clarification: *The 2004 Landcom publication Managing Urban Stormwater: Soils and Construction - Volume 1 is commonly known as the 'Blue Book'. This is not part of the publication title.*
2	1.4	Performance measures	• no irrigation in forested area, apart from dust suppression and construction activities on operational areas and access roads.	**[Jack Warnock]** Page 11: second paragraph: Refer to: "no irrigation in forested areas…". Is it appropriate to use the word "irrigation" in this context? "Water use" might be more appropriate.	This is verbatim from Condition B37 Table 7 of the Project Approval. However, a global review has been completed to apply most appropriate wording in each instance when referring to 'irrigation'. Generally reworded as '*no application of treated water*'.
3	3.1.3	Development consent	• no irrigation in forested area, apart from dust suppression and construction activities on operational areas and access roads.	**[Jack Warnock]** Page 15: Last dot point: same reference as above to "no irrigation in forested area	This is verbatim from Condition B37 Table 7 of the Project Approval. However, a global review has been completed to apply most appropriate wording in each instance when referring to 'irrigation'. Generally reworded as '*no application of treated water*'.
4	3.2	Table 3.1 Protection of groundwater	The irrigation area is located, designed, constructed and operated so that groundwater quality and levels are not ~~affected~~ by the irrigation activities.	**[Michael Williams]** Recast sentence 1, as irrigation will impact on groundwater even if only minimal root zone drainage.	The sentence has been amended as follows: The irrigation area is located, designed, constructed and operated so that groundwater quality and levels are not *impacted* by the irrigation activities.
5	3.2.1	Effluent Irrigation Guidelines	No specific text reference	**[Jack Warnock]** Page 18: Table 3.1: Reference is made to "The Leewood irrigation system has been designed so that runoff will be predominately driven by rainfall and will not be highly altered from conditions under a dryland pasture regime". It is expected that up to 1.26ML/day will be produced in Phase 1 (Refer to Section 4.2 Produced water quantity – Produced Water Management Plan). It is anticipated that 90% of the treated water will be used for irrigation. This would mean that on average in Phase 1 up to 365 ML/year will need to be utilised on the 49 hectare irrigation area. This will definitely alter the nature of this area and will increase the run-off from this area. I believe provision should be made to manage run-off by preventing it leaving the irrigation area. This would require the construction of "tail water drains" and lift pumps and storage facilities, together with re-use plans for this water. This is standard practice on irrigation farms in the Namoi Valley and elsewhere. Consideration should be given to the movement of sediment, nutrients and pesticides moving off the irrigation area following rainfall events.	The provided calculation in the comment assumes that irrigation will occur 365 days per year. This assumption is not correct. Section 5.2.1 of the Site Water Balance states the following: *The irrigation system has the maximum capacity to utilise up to 6.5 ML/day, with this volume incorporating approximately 49 ha of irrigation at a maximum of 12 mm on the ground per day, with a 90 % irrigation system application efficiency. Actual maximum daily application rates will be determined by daily evaporation rates i.e. the average daily rates averaged over a month can vary between 2 and 10 mm/day.* The average water balance for Phase 1 indicates irrigation between 115 and 225 ML/year, which would equate to approximately 0.6 ML/day or less. Section 5.2.1 of the Site Water Balance also states that: *The irrigation schedule is driven by crop water demand and availability of amended treated water. Irrigation is managed in such manner as to ensure the capacity of the utilisation area to effectively utilise the water is not exceeded.* Together with the run-off monitoring detailed in section 6.4 this will ensure that no surface run-off occurs from the irrigation area resulting from the irrigation.
6	4.6	Limitations of landscape	Table 4.1 Landscape limitations for irrigation technologies	**[Randall Cox]** I think 'Property 1' should be 'Property[1]	The correction has been made.

Item	Section #	Section heading	Existing text	Comment	Final response
7	4.8	Soil descriptions	Five soil units were defined for the 49 ha centre pivot irrigation area across the eastern land parcel of the Leewood property	**[Randall Cox]** Second sentence states … 'Five soil units were defined for the 49ha centre pivot irrigation area'. However, the areas for the individual soils must relate to the soil area within the larger 'eastern land parcel' rather than irrigated part. Initially I thought the soil areas were the areas of the soil type within the irrigation area, until it became clear on reading further that that could not be the case. Perhaps worth clarifying for readability.	Agreed that this may be confusing. The text has been amended to: *The following five soil units are present across the 49 ha centre pivot irrigation area at the Leewood property:* A new figure will be inserted to add clarity. This figure will be similar to Figure 2 in the current approved Irrigation Management Plan (https://narrabrigasproject.com.au/wp-content/uploads/2019/09/Santos-Irrigation-Management-Plan.pdf)
8	4.8	Soil descriptions	No specific text reference	**[Jack Warnock]** All five soil types described represent a total area of approximately 100 hectares. It is not clear what soil types are represented in the 49-hectare irrigation area. The Brown Sodosol soil represent 58 hectares. These soils are described as hard setting, changing sharply to much lower porosity clay upon which water perches for extended periods following heavy rainfall (remaining saturated for several days to a week). This would suggest that this area would prove unsuitable for normal root development and growth in an irrigation/rainfall environment. Would these conditions limit long-term utilisation of this area for treated effluent water reuse. A more suitable site may need to be considered for the long-term use of treated effluent water for irrigation as part of this project. Is it possible to consider making treated effluent water available for use by established irrigators where more suitable soils are available for irrigation. I believe this needs to be given serious consideration in light of the difficulties involved with the Leewood soils.	Agreed that the existing text may be confusing. The text has been amended to: *The following five soil units are present across the 49 ha centre pivot irrigation area at the Leewood property:* A new figure will be inserted to add clarity. This figure will be similar to Figure 2 in the current approved Irrigation Management Plan (https://narrabrigasproject.com.au/wp-content/uploads/2019/09/Santos-Irrigation-Management-Plan.pdf) . It shows that Brown Sodosol is the most common soil the irrigation area across the 49-ha irrigation area. The maximum irrigation application rates are calculated to ensure there is no run-off and the area is continually monitored for any run-off. Soil moisture data is also used to understand the condition of the soil to check if the soil is saturated and therefore manage the likelihood of inducing run-off. There are a range of monitoring methods and triggers outlined in the IMP that ensure there is no over-irrigation which could create run-off. Making treated effluent water available for use by established irrigators is an option that is under consideration for Phase 2, but would be subject to approval from the EPA. This is consistent with the general water management performance criteria outlined in Condition B37 Table 7, which require Santos to '*maximise water recycling, reuse and sharing opportunities*'.
9	4.10	Groundwater	No specific text reference	**[Michael Williams]** The Gunnedah and Cubbaroo Formations do not subcrop in the area of the Irrigation site. Apart from the Namoi Upper and Lower Water Sources in the north, the alluvium is a Narrabri Formation equivalent which is assigned to the NSW GAB Southern Recharge Water Source.	Section 4.10 is a general statement regarding the groundwater in the Project area (extracted from section 2.6 of Appendix G2 of the EIS) with a brief link to the groundwater for the irrigation site. Section 4.10 has been rewritten specific to the irrigation area and local scale geology.
10	4.10	Groundwater	Static water levels ranged from 20.7 to 29.5 mBGL.	**[Michael Williams]** Are the water levels quoted for the new or old observation bores?	These levels are for the new monitoring bores, LWDMW4-6.
11	4.10	Groundwater	Three sets of nested groundwater monitoring bores were drilled to about 36 m below ground level (mBGL) on the Leewood property.	**[Randall Cox]** Third paragraph states: '*Three sets of nested groundwater monitoring bores were drilled to about 36 m below ground level (mBGL) on the Leewood property*' Presume these are the 'new groundwater monitoring bores' in Figure 6.1. Section 4.10 refers to 'nested' which I presume means multiple depth piezometers, but there are no details of the nesting. Table 6.1 is presented as being details of the new bores but the bore numbers suggest they are the original monitoring bores.	Table 6.1 has been expanded to include the details for the original groundwater monitoring bores LWDMW1-3 (deep) which are nested. There are two monitoring bores at each site, with the last character (*D* or *S*) denoting 'deep' or 'shallow'. For example, LWDMW1D is deep, and LWDMW1S is shallow. The shallow (~10m deep) holes are dry, with no groundwater present. The deep holes (~35m deep) encounter groundwater. LWDMW4-6 are single piezometers (~35m deep holes) that encounter groundwater.

Item	Section #	Section heading	Existing text	Comment	Final response
12	5.3	Suitability for irrigation	In accordance with Table 3.1 of the Effluent Irrigation Guidelines, the amended treated irrigation water is classified as 'low-strength effluent' according to its concentrations of nitrogen, phosphorus, BOD_5, TDS and other potential contaminants.	**[Jack Warnock]** Could "BOD_5" be explained?	BOD (biological oxygen demand) is a measure of dissolved oxygen needed by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a certain period. It is usually expressed in milligrams of oxygen consumed per litre of sample during 5 days of incubation at 20 °C (and referred to as BOD_5). A definition has been added to the glossary and to the list of abbreviations and acronyms, and the text has been amended as follows: *In accordance with Table 3.1 of the Effluent Irrigation Guidelines, the amended treated irrigation water is classified as 'low-strength effluent' according to its concentrations of nitrogen, phosphorus, biological oxygen demand (**BOD_5**), total dissolved solids (**TDS**) and other potential contaminants.*
13	6.1	Groundwater monitoring	No specific text reference	**[Michael Williams]** What are details of old observation bores? Or is this irrelevant.	Table 6.1 has been expanded to include the details for the original groundwater monitoring bores LWDMW1-3 (deep) which are nested. Refer also to item #11.
14	6.1	Groundwater monitoring	Table 6.1	**[Michael Williams]** Could SWL and salinity (TDS) be included? Table D5 provides change in salinity measures and caveat of vadose leaching but not what the range will be. When will that be resolved?	The standing water level (SWL) and TDS has been added to Table 6.1 for a particular date/range. Adding a value range to Table D5 can only occur once a statistically appropriate set of monitoring data is available.
15	6.2	Soil and vadose monitoring	Soil moisture and EC sensors which provide continuous monitoring have been installed across the irrigation area,	**[Randall Cox]** Second line - the comma should be a full stop	Correction made. Comma has been replaced by full stop.
16	6.2	Soil and vadose monitoring	Based upon monitoring bore log data describing the vadose beneath the rootzone, potential impacts to groundwater could then be estimated by hydrogeological modelling.	**[Randall Cox]** 2nd para 4th line '…..potential impacts to groundwater could then be estimated by hydrogeological modelling.' Is the modelling intended? what would be the circumstances under which modelling would be carried out?	Correct - the modelling is intended. The bore log data is available which will provide the soil structure to depth, and together with monitoring data the groundwater transport will be estimated using specific groundwater models. If the irrigation area is operational, this will be completed prior to Phase 2.
17	6.2	Soil and vadose monitoring	The soil monitoring program at the four dedicated soil monitoring points (*LWD*SMPT 1 to 4) with approximate locations provided in Figure 6.1 is conducted in accordance with condition M2.2 and M2.3 of EPL 20350	**[Randall Cox]** 2nd para 5th line refers to '(SMPT 1 to 4)' However the numbers on Figure 6.1 refer to 'LWDSMP 1-4'	Correct. The abbreviation SMPT was used initially to denote a 'soil monitoring point', however this was changed to Leewood (LWD) SMPT. The text has been updated: *The soil monitoring program at the four dedicated soil monitoring points (LWDSMPT 1 to 4) with….*
18	6.3	EM induction monitoring	A baseline EMI survey of the irrigation site will be conducted prior to irrigation recommencing and the data will be used to compare subsequent EMI surveys conducted in subsequent years.	**[Michael Williams]** There are various EM methods which was used? If to be used as a monitoring tool then the site will need to have been surveyed for GPS sites. Should say so?	The choice of EMI to be used is still to be determined, depending on the survey objectives. The EMI survey design will identify these objectives, the choice of conductivity instrument and the choice of GPS. The text has been amended to include reference to this: *An EMI survey design will be developed, including the choice of conductivity instrument and GPS, and a baseline EMI survey of the irrigation site will be conducted prior to irrigation recommencing and the data will be used to compare subsequent EMI surveys conducted in subsequent years.*
19	6.4	Runoff monitoring		**[Jack Warnock]** See earlier comments about possible runoff following rainfall events.	Refer to responses at Item #8.
20	6.7	Crop health	The crop ~~should~~ be inspected for weeds, pests and diseases, health and vigour by the Agricultural Supervisor, with assistance from an agronomist or soil scientist when needed.	**[Randall Cox]** Para 2 states 'The crop should be inspected for weeds…' . Is it a 'should be' or a 'will be'. that is, it is not clear if it a guide or a commitment. A global check to this type of issue would be useful.	Correction made. 'Should' has been replaced by 'will': The crop *will* be inspected for weeds, pests and diseases, health and vigour by the Agricultural Supervisor, with assistance from an agronomist or soil scientist when needed. A global review has also been completed and 'would' has been replaced with 'will' where appropriate, to confirm intent.

Item	Section #	Section heading	Existing text	Comment	Final response
21	8	Record keeping	These include Sharepoint for management plans, procedures and laboratory reports; Santos' EHS Toolbox for capturing inspections and field assessments; and EQuIS, an advanced environmental data management and decision support system, for capturing all data and any laboratory results.	**[Jack Warnock]** 2nd paragraph: Please explain "EQuIS"	EQuIS (Environmental Quality Information System) is a proprietary software application. A footnote with this information has been added to the text, and the acronym has been added to the Acronyms and abbreviations table.
22	Appendix C	Inspection and maintenance of irrigation operations	Table C1 and C2 Review recorded daily total flow to the CP.	**[Jack Warnock]** What does "CP" mean?	CP was an acronym for 'centre pivot'. It has been removed and replaced by 'centre pivot' to remove any misunderstanding.
23	Appendix D	Irrigation TARPs	Table D4 Sodicity in soil TARP. The SAR in the surface 40 cm remains at amended levels of below 8	**[Jack Warnock]** Explain "SAR". It is helpful to have acronyms listed in the "Acronyms and abbreviations" or in a footer on the bottom of the page.	SAR is the sodium adsorption ratio. It has been added to the list of abbreviations and acronyms, and the text has been amended as follows: *The (SAR) in the surface 40 cm remains at amended levels of below 8.*

Note:
The numbering of the sections and appendices between the draft and final version of the document may have changed.

Appendix B - Conditions relevant to the IMP

Table B1 - PAL 2 conditions directly relevant to this IMP

PAL 2 conditions directly relevant to this IMP	Section reference
PAL 2 Approval to Leewood Produced Water Treatment and Beneficial Reuse Project **Condition 6** An Irrigation Management Plan (IMP) must be submitted to and approved by the Secretary DISRD prior to undertaking the irrigation. This plan is to be developed in accordance with the EPA's *Use of Effluent by Irrigation Guidelines* (2003)[8]. The DPI and the EPA must be consulted in the development of the IMP. The IMP must set-out the following:	
a) Detailed design of the soil and groundwater monitoring program showing monitoring locations and sampling frequency	Section 6 Section 7
a) Specification for the unamended and amended quality of the irrigation water and the circumstances, under which the amendment might be varied, linked to soil and groundwater monitoring	Section 5 Table C1 Appendix C
b) Identification of operational triggers (such as 'trigger action response plans') to ensure that the irrigation program is being managed in a sustainable manner and to prevent unacceptable impacts to the environment. Triggers for commencement and cessation of irrigation must be clearly articulated and supported by assessment data. Triggers and associated responses must be provided for, but not limited to the following	Section 7 Irrigation TARPs in Appendix E
▪ crop failure	
▪ excessive saturation of the soil profile (waterlogging) - to ensure no surface runoff occurs from the irrigation area resulting from the irrigation	
▪ excessive salinity in the soil profile or groundwater - ensuring that salinity levels (EC/TDS) remain consistent with baseline monitoring	
▪ Impacts to the Brigalow Woodland and Pilliga box-white cypress grassy open woodland on the northern boundary of the site – ensuring no adverse impacts occur to the vegetation in this area associated with the irrigation	
c) A program for reporting on the treatment process and irrigation operations, including further development and review of a detailed water balance.	Section 5 Refer also to the Site Water Balance

[8] Note that this is the exact wording of Condition 6 of the approval to undertake the Leewood Produced Water Treatment and Beneficial Reuse Project. The guidelines referred to are the (former) NSW Department of Environment and Conservation Environmental Guidelines – *Use of Effluent by Irrigation* (2004).

Table B2 - EPL 20350 conditions directly relevant to this IMP

	EPL 20350 conditions directly relevant to this IMP	Section reference
O6.4	The SWMP must be updated to reflect the proposed irrigation of treated water at the premises, prior to irrigation occurring.	Refer to the WMP, and the Erosion and Sediment Control Plan section 10
O6.6	The quantity of treated water applied to the utilisation area(s) must not exceed the capacity of the utilisation area(s) to effectively utilise the water. For the purpose of this condition, "effectively utilise" includes the use of the water for pasture or crop production, as well as the ability of the soil to absorb the nutrient, salt, hydraulic loads and the applied organic material without causing harm to the environment.	Section 5.1 and section 5.5
O6.7	Treated water application to the utilisation area(s) must not occur in a manner that causes surface run-off from the utilisation area(s)	Section 5
M2.4	For the purposes of Condition M2 the following definitions apply to the required frequency specified in the tables:	Section 6.3

Frequency	Definition
Special Frequency 1	Samples must be taken prior to irrigation of treated water occurring and then yearly thereafter
Special Frequency 2	Samples must be taken annually. An additional representative sample for a full suite of analytes is to be taken at quarterly in situ monitoring should trigger values for electrical conductivity, pH or standing water level at the monitoring point be exceeded

M2.5	For the purposes of Condition M2 the following trigger values apply for quarterly in situ sampling at points 37,38,39,40,41,42,43	Section 6.1

Pollutant	Units of measure	Trigger value for additional sampling
Electrical conductivity	microsiemens per centimetre	>95th percentile of baseline data
pH	pH	<5th percentile of baseline data or >95th percentile of baseline data
Standing Water Level	metres	<5th percentile of baseline data

M2.6	For the purposes of the table(s) above, Special Frequency 1 means that samples must be taken prior to irrigation of treated water occurring, and then yearly thereafter.	
M2.7	The monitoring frequency specified for monitoring point 77 (LWWTPDM1) commences upon the completion of the commissioning stage for the Water and Brine Treatment Plant as outlined in document titled "Energy NSW - Leewood Phase 2 - Water Treatment Plan" dated 19 November 2015.	Refer to section 9.5 of the PWMP

EPL 20350 conditions directly relevant to this IMP	Section reference
M2.11 If the Leewood Water Treatment Plant is not operating and irrigation is not occurring on the irrigation utilisation area, the following applies (refer to EPL 20350 for details): 1. Monitoring in accordance with condition M2.2 of treated water (point 77) groundwater (points 80-82) and soil (points 83-86) in irrigation utilisation area is not required if irrigation did not occur in the period since the last monitoring event; and 2. Prior to recommencement of irrigation after a period in which a monitoring event did not occur for the relevant monitoring point in accordance with the above, monitoring of the point 77, 80-82 and 83-86 will occur and then as per the frequency as set out in condition M2.2.	Sections 6.1, 6.2 and 6.3

Table B3 - SSD 6456 consent conditions directly relevant to this IMP

SSD 6456 consent conditions directly relevant to this IMP	Section reference
Consent condition A1 In meeting the conditions of this consent, the Applicant must implement all reasonable and feasible measures to prevent and, if prevention is not reasonable and feasible, minimise any material harm to the environment that may result from the construction, operation or rehabilitation of the development.	Section 1.2
Consent condition A5 The Applicant may only undertake the development in the following stages:	Section 1.1.2 Section 1.2
a) Phase 1, comprising ongoing exploration and appraisal activities;	
b) Phase 2, comprising construction activities for production wells and related infrastructure;	
c) Phase 3, comprising gas production operations; and	
d) Phase 4, comprising gas well and infrastructure decommissioning, rehabilitation and mine closure.	
Consent condition A23 With the approval of the Planning Secretary, the Applicant may:	
a) prepare and submit any strategy, plan or program required by this consent on a staged basis (if a clear description is provided as to the specific stage and scope of the development to which the strategy, plan or program applies, the relationship of the stage to any future stages and the trigger for updating the strategy, plan or program	Section 1.2
b) combine any strategy, plan or program required by this consent (if a clear relationship is demonstrated between the strategies, plans or programs that are proposed to be combined);	No combination proposed as part of this Plan
c) update any strategy, plan or program required by this consent (to ensure the strategies, plans and programs required under this consent are updated on a regular basis and incorporate additional measures or amendments to improve the environmental performance of the development); and	Section 1.2 Section 10.4
d) combine any strategy, plan or program required by this consent with any similar strategy, plan or program required by a consent	No combination proposed as part of this Plan
Consent condition B36 The Applicant must ensure that all surface discharges from the development comply with:	
a) discharge limits (both volume and quality) set for the development in any EPL or Resource Recovery Exemption and Order (**RREO**); and	Section 3.1.2 Site Water Balance MP
b) relevant provisions of the POEO Act.	Section 3.1.2
Consent condition B37 The Applicant must ensure that the development complies with the water management performance measures in Table 7 [of the CoC]:	Section 1.4
• Irrigation and beneficial reuse management	
▪ negligible change to soil quality and groundwater quality and levels in irrigation areas and other areas subject to treated water application;	Section 5.3

SSD 6456 consent conditions directly relevant to this IMP	Section reference
▪ only amended treated water to be used for reuse activities (except for firefighting), unless other use of treated water has been approved as part of the Water Management Plan; and	Refer to the Dust Suppression Protocol
▪ no irrigation [no application of treated water] in forested areas, apart from dust suppression and construction activities on operational areas and access roads.	Refer to the Dust Suppression Protocol
Consent condition B41 Prior to the commencement of Phase 1, the Applicant must prepare a Water Management Plan for the development to the satisfaction of the Planning Secretary. This plan must:	
(d) include a	
(vi) Irrigation Management Plan for managing beneficial reuse of treated water for crop irrigation and stock watering, that includes details of	
• site selection and assessment in accordance with applicable guidelines including the *Environmental Guidelines: Use of Effluent by Irrigation* (DEC, 2004);	Section 3.2.1 and 4.6
• irrigation areas and off-site storage capacity, including provisions for ensuring sustainable irrigation before, during and after peak water production;	Section 5.1
• agreements with third parties receiving treated water (excluding any commercial in confidence material);	Not applicable for Phase 1. There are no agreements to share treated water with other users.
• baseline soil and groundwater conditions and quality, based on additional assessment by a suitably qualified agricultural expert/s;	Section 4.6 and 4.8
• protocol for operation of the irrigation management system, including any irrigation subject to a RREO; and	Section 5
• measures to:	Section 7 Irrigation TARP Appendix E
▪ maintain soil structure, stability and agricultural productive capacity;	
▪ minimise erosion and sedimentation, ponding and waterlogging;	
▪ ensure effective surface water and stormwater runoff controls;	
▪ maintain groundwater quality and minimise changes to groundwater levels;	
▪ coordinate optimal cropping regimes to maintain water balance throughout the year; and	
▪ provide contingency areas for irrigation and storage.	
Consent condition D3 The Applicant must ensure that (where relevant) the management plans required under this consent include:	
a) summary of relevant background or baseline data;	Refer to the PWMP
b) details of:	
(i) the relevant statutory requirements (including any relevant approval, licence or lease conditions);	Section 3
(ii) any relevant limits or performance measures and criteria; and	Appendix C

SSD 6456 consent conditions directly relevant to this IMP	Section reference
(iii) the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the development or any management measures;	Section 1.4
c) any relevant commitments or recommendations identified in the documents that together comprise the NGP EIS;	Section 3.3
d) a description of the measures to be implemented to comply with the relevant statutory requirements, limits, or performance measures and criteria	Section 6.1
e) a program to monitor and report on the:	
(i) impacts and environmental performance of the development; and	Section 6 Section 10.1
(ii) effectiveness of the management measures set out pursuant to paragraph (d);	Section 6 Section 10.1
f) a contingency plan to manage any unpredicted impacts and their consequences and to ensure that ongoing impacts reduce to levels below relevant impact assessment criteria as quickly as possible;	Section 9.2
g) a program to investigate and implement ways to improve the environmental performance of the development over time	Section 10.4
h) a protocol for managing and reporting any:	
(i) incident, non-compliance or exceedance of any impact assessment criterion and performance criterion	Section 9.1
(ii) complaint; or	Section 9.3
(iii) failure to comply with other statutory requirements; and	Section 9.1
i) a protocol for periodic review of the plan.	Section 10.3
Consent condition D4 Within 2 months of: (a) the submission of an incident report; (b) the submission of an Annual Review; (c) the submission of an Independent Environmental Audit; (d) the submission of a Field Development Plan; (e) the submission of a Groundwater Model Update; or (f) the approval of any modification of the conditions of this consent, the Applicant must review the suitability of existing strategies, plans and programs required under this consent.:	Section 10.3
Consent condition D5 If the review determines that the strategies, plans and programs required under this consent require revision – to either improve the environmental performance of the development, cater for a modification or comply with a direction - then the Applicant must submit the revised document to the Secretary for approval within 6 weeks of the review. **Note**: *This is to ensure strategies, plans and programs are updated on a regular basis and to incorporate any recommended measures to improve the environmental performance of the development.*	Section 10.3

SSD 6456 consent conditions directly relevant to this IMP	Section reference
Consent condition D6 The Applicant must notify the Department and any other relevant agencies via the Major Projects Portal immediately after it becomes aware of the incident. This notice must describe the location and nature of the incident.	Section 9.1
Consent condition D7 Within 7 days of becoming aware of a non-compliance with the conditions of this consent, the Applicant must notify the Department of the non-compliance via the Major Projects Portal. This notice must set out the non-compliance, the reasons for the non-compliance (if known) and what actions have been taken, or will be taken, to address the non-compliance. **Note**: *A non-compliance which has been notified as an incident does not need to also be notified as a non-compliance*	Section 9.1
Consent condition D8 By the end of March each year, unless the Planning Secretary agrees otherwise, the Applicant must submit an Annual Review of the environmental performance of the development to the Department via the Major Projects Portal.	Section 10.1
Consent condition D9 Within one year of commencement of Phase 1 and every 3 years thereafter, unless the Planning Secretary directs otherwise, the Applicant must commission and pay the full cost of an Independent Environmental Audit of the development.	Section 10.2
Consent condition D13 From the commencement of Phase 1, until the completion of all rehabilitation required under this consent, the Applicant must:	
a) make copies of the following information publicly available on its website: (i) the document/s listed in condition A2(c); (ii) current statutory approvals for the development; (iii) approved strategies, plans and programs; (iv) detailed plans for the Phases of the development; (v) minutes of CCC and Advisory Group meetings; (vi) regular reporting on the environmental performance of the development in accordance with the reporting requirements in any plans or programs approved under the conditions of this consent; (vii) a comprehensive summary of the monitoring results of the development, reported in accordance with the specifications in any conditions of this consent, or any approved plans and programs; (viii) a summary of the current phase/s and progress of the development; (ix) contact details to enquire about the development or to make a complaint; (x) a complaint register, updated monthly; (xi) a record of all incidents and non-compliances; (xii) the Annual Reviews of the development; (xiii) audit reports prepared as part of any Independent Environmental Audit of the development and the Applicant's response to the recommendations in any audit report; and any other matter required by the Planning Secretary; and	Section 1.7 Section 10.4
b) keep such information up to date.	Section 1.7 Section 10.4

Appendix C - Treated water quality

Table C1 – Treated water quality

Parameter	Australian Drinking Water and Recreational Guidelines (NHMRC, NRMMC 2008; 2011, 2017)	ANZECC / ARMCANZ (2000) Irrigation Guidelines (long term > 20 years)	ANZECC / ARMCANZ (2000) Stock watering	Treated water [a]	Treated and amended water [b]	Treated water [c] (Leewood WBTP)	Treated and amended water [d] (Leewood WBTP)	RO brine [e] (Leewood WBTP)
	(mg/L)			Target (mg/L)			Actual (mg/L)	
pH (pH units)	6.5 – 8.5	6.0 -9.0	Not referenced	7.1	7.1	7.9	7.1	(Lab) 9.3
Electrical conductivity (laboratory) (µS/cm)	Not referenced	Crop specific -Lucerne (2,700 in loamy soils)	Not referenced	357	566	n/a	107	76,000
Total dissolved solids	Health: Not referenced Aesthetic as follows: <600 good quality 600-900 fair quality 900-1200 poor quality >1,200 Unacceptable	Crop specific – Lucerne (1,273 – 3,015)	No adverse effects to: Beef cattle, pigs and horses 4,000 Sheep 5,000	232	368	56	71	N/A
Sodium Adsorption Ratio	Not referenced	<1 excellent 1-2 Good 2-4 Fair 4-8 Poor 8-15 Very poor >15 Unacceptable	Not referenced	130	3.3	29	3.7	1,046
Sodium (filtered)	Health: Not referenced Aesthetic: 180	Crop specific – Lucerne (230 – 460)	Not referenced	77	77	17	18	41,600
Magnesium (filtered	Not referenced	Not referenced	Not referenced	<0.01	<0.01	<1	<1	55
Aluminium	Health: Not ref Aesthetics: 2	5	5	<0.001	<0.001	<0.01	<0.01	<0.05
Silica (SiO2) (µg/L)	80	Not referenced	Not referenced	23	0.15	<0.1	<0.1	135
Potassium (filtered)	Not referenced	Not referenced	Not referenced	0.8	0.8	<1	<1	387
Calcium (filtered)	Health: Not referenced Aesthetic as follows: <60 Soft 60-200 Good quality >200 Increased scaling	Not referenced	1,000	0.01	40.01	<1	6	28
Chromium (III+VI)	0.05	0.1 (Cr^{IV})	1	<0.001	<0.001	<0.001 (Cr^{IV})	<0.001 (Cr^{IV})	<0.01
Manganese	0.5	0.2	Not sufficiently toxic	<0.001	<0.001	<0.001	<0.001	0.014
Iron	<1	0.2	Not sufficiently toxic	<0.001	<0.001	<0.05	<0.05	0.27
Boron	4	Crop specific: 0.5 (sensitive) to 15 (very tolerant)	5	0.12	0.12	0.11	0.09	5.57
Cobalt	Not referenced	0.05	1	<0.001	<0.001	<0.001	<0.001	<0.005
Nickel	0.02	0.2	1	<0.001	<0.001	<0.001	<0.001	<0.005
Copper	2	0.2	0.4 (sheep) 1 (cattle)	<0.001	<0.001	<0.001	<0.001	<0.005

Parameter	Australian Drinking Water and Recreational Guidelines (NHMRC, NRMMC 2008; 2011, 2017)	ANZECC / ARMCANZ (2000) Irrigation Guidelines (long term > 20 years)	ANZECC / ARMCANZ (2000) Stock watering	Treated water [a]	Treated and amended water [b]	Treated water [c] (Leewood WBTP)	Treated and amended water [d] (Leewood WBTP)	RO brine [e] (Leewood WBTP)
	(mg/L)			Target (mg/L)			Actual (mg/L)	
			5 (pigs)					
Zinc	Health: Not referenced Aesthetic: 3	2	20	<0.001	<0.001	<0.005	<0.005	<0.025
Arsenic	0.01	0.1	0.5 – 5	<0.001	<0.001	<0.001	<0.001	0.018
Selenium	0.01	0.02	0.02	<0.001	<0.001	<0.01	<0.01	<0.05
Molybdenum	0.05	0.01	0.15	<0.001	<0.001	<0.001	<0.001	0.006
Cadmium	0.002	0.01	0.01	<0.001	<0.001	<0.0001	<0.0001	0.0012
Barium	2	Not referenced	Not referenced	<0.001	<0.001	<0.001	<0.001	12.3
Mercury	0.001	0.002	0.002	0.0000067	<0.001	<0.0001	<0.0001	<0.0005
Lead	0.017	2	0.1	<0.001	<0.001	<0.001	<0.001	<0.005
Uranium	0.017	0.01	0.2	<0.0028	<0.0028	<0.001	<0.001	<0.005
Alkalinity (total as CaCO3)	Not referenced	Not referenced	Not referenced	139	139	34	28	73,500
Ammonia (as N)	Health: Not referenced Aesthetic: 0.5	Crop specific as N (25 – 125)	Not referenced	0.005	0.005	0.25	0.24	N/A
Nitrate (as N)	50	Crop specific as N (25 – 125)	400	0.005	0.005	0.04	0.25	N/A
Total N	Not referenced	25 – 125	Not referenced	0.005	0.005	0.23	0.42	N/A
Sulfate	500	Not referenced	1,000	0.003	95.9	<1	<1	58
Chloride	Health: Not referenced Aesthetics: 250	Crop specific –Lucerne (350 –700)	Not referenced	15	15	10	19	7030
Fluoride	0.5	1	2 (1 if livestock feed contains fluoride)	0.08	0.08	<0.1	<0.1	47
Total phosphorous	Not referenced	0.05 [g]	Not referenced	0.01	0.01	<0.01	<0.01	N/A

N/A – not analysed.
a – Theoretical composition based on manufacturers' specifications.
b – Calculated composition based on theoretical treated water and amendment with 1 mol gypsum.
c – All values reported as maximum recorded values, except pH reported as average.
d – Treated water amended with calcium chloride.
e – Laboratory limits raised due to high salinity.
f – To minimise blocking of irrigation equipment only.

Appendix D - Inspection and maintenance of irrigation operations

Table D1 - Irrigation plant and equipment - Data collection, inspection and maintenance

Item	Description
Irrigation plant and equipment - general	All Irrigation plant and equipment will be operated and maintained in a proper and efficient manner.
Flow rates	Review recorded daily total flow to the centre pivot. Water flow meters should be checked for accuracy against the design flow rate.
Pipe work leaks	All pipe work must be inspected for any signs of leakage.
Chemical usage	Record volume of each chemical amendment injected.
Sensor feedback	Review electronic record of in-line sensors used to control inputs (EC, pH). Note in record average values and abnormal flux.
Sensor calibration	Clean and calibrate in-line sensors. This varies depending upon amount of fouling encountered and can vary seasonally with biological blooms.
Water quality analysis	Collect water sample post treatment from sampling port (EPL 20350 monitoring point 77) when irrigation system operating normally in accordance with EPL 20350.
Application rate	In systems without variable rate irrigation, determine the volume applied per irrigation event by using the water meter reading and hours run. Check the application rate (mm) against the scheduled amount as per the speed application chart.

Table D2 - Agronomic and environmental - Data collection, inspection and maintenance

Item	Description
Crop stage	Inspect paddocks for growth stage of each species. Predict harvest dates.
Irrigation schedule	Electronically collect soil moisture and salinity data throughout the profile from five in-field sensors placed within and beneath the active rootzone. Schedule irrigations after the soil water deficit (SWD) trigger is reached. Review against available observations and data such as from past irrigation, weather station data, calculated ET and weather forecasts.
Infiltration and moisture assessment	Monitor infiltration and moisture in soil, consistent with typical irrigation practices. Perform hand auger soil cores near moisture probes to allow correlation to be determined between probes and actual measured soil moisture. This will assist in calibrating the probes for future use to reduce management. Also core more generally before and after an irrigation event (in front and behind the centre pivot) to assess the irrigation schedule.
Pests	Scout for insects, weeds and plant diseases.
Soil surface	Inspect soil surface for signs of cracking, surface sealing, ponding or run-off. Use findings to assist in scheduling irrigation.
Soil sampling	Sampling conducted in accordance with EPL 20350 requirements.
Groundwater	Sample groundwater monitoring bores and analyse for standing water level, on-site analysis of Redox potential, pH, dissolved oxygen and electrical conductivity.
Groundwater chemistry	Laboratory analysis for a broad water quality suite of chemical analyses.
Erosion, ponding & run-off	Observe and note patterns of erosion, ponding and run-off during weekly agronomic inspections. Adjust irrigation schedules if necessary. Assess the potential to reshape the irrigation area, possibly during ploughing.
Native vegetation	Visual inspections of condition of native vegetation communities on the northern boundary.

Appendix E - Irrigation TARPs

Table E1 - Crop health TARP

Trigger Level	Trigger	Action	Cause	Response	Notes
NORMAL	>70% vegetative cover	Regular field inspection.	N/A	No response necessary	Pasture health should be assessed by a suitably experienced person. Some seasonal variations in pasture performance and cover do not necessarily reflect a problem with the irrigation system. Green cover may be assessed using a quadrant or defined area assessment approach, or other method consistent with that used in operations of a similar size and nature.
LEVEL 1	40-70% vegetative cover	• Inspect crop for cause of decline. • Investigate potential causes. • Adjust irrigation schedule commensurate with reduced ET	Disease	Seek agronomic advice. This may require alteration of cultural practices, varietal selection, crop rotation or chemical treatment	
			Drought	Assess whether recovery will occur once irrigation commences	
			Waterlogging	Refer to Waterlogging TARP	
			Salinity	Refer to Salinity TARP	
			Species suitability	Monitor for further decline. Plan rotation to more suitable variety or species	
LEVEL 2	<40% vegetative cover	• Inspect crop for cause of decline. Investigate potential causes. Adjust irrigation schedule commensurate with reduced ET	Disease	Seek agronomic advice and respond as above.	
			Drought	Irrigate if water is available	
			Waterlogging	Refer to Waterlogging TARP	
			Salinity	Refer to Salinity TARP	
			Species suitability	Renovate with more suitable crop	

Table E2 - Waterlogging TARP (surface ponding and runoff)

Trigger Level	Trigger	Action	Cause	Response	Notes
NORMAL	Surface ponding is similar to conditions outside of the irrigation site.	Regular field inspection.	Normal landscape response to rainfall.	No response necessary.	The irrigation schedule is set so that under normal conditions no irrigation occurs until at least a 30 mm SWD is achieved. This means that the soil is unlikely to become waterlogged unless rainfall also occurs, or instantaneous application rates are too high. Some irrigation above a 30 mm SWD may be required for rare events, such as applying a leaching fraction.
LEVEL 1	Surface ponding as a result of irrigation activities is noticeably higher than outside of the irrigation site, with individual ponding greater than 1 m^2. Run-off occurring as a result of irrigation.	Assess infiltration rates and instantaneous application rates of emitters / sprinklers. Check soil moisture status of soils to 0.6 m.	Application rate exceeds infiltration rate.	Alter the instantaneous application rate of the emitters/sprinklers.	
				Use minimum till ripper on sprinkler irrigated land to improve infiltration.	
			Water applied exceeds water holding capacity of soil.	Cease irrigating all units above SWD trigger.	
			Off site and on-site flows into drainage line.	Cease irrigating Class B soils.	
LEVEL 2	Persistent surface ponding as a result of irrigation activities, lasting more than one week, are several times higher than outside of the irrigation site, with individual ponding greater than 2 m^2. Persistent run-off occurring as a result of irrigation.	Cease irrigating until SWD is reached across the entire irrigation unit.	Soil surface waterlogged from a combination of rainfall and irrigation.	Review irrigation schedule. Use soil water monitoring data to identify potential perched water layers within the soil profile.	

Table E3 - Salinity in soil TARP

Trigger Level	Trigger	Action	Cause	Response	Notes
NORMAL	Weighted average rootzone (to 60 cm below surface) EC_e remains similar to target salinity threshold of 2-3 mS/cm above background levels (see Note 1).	Soil monitoring program (refer to section 6.3).	N/A	No response necessary.	The irrigation schedule is set so that under normal conditions no irrigation occurs until at least a 30 mm SWD is achieved. This means that the soil is unlikely to become waterlogged unless rainfall also occurs, or instantaneous application rates are too high. Some irrigation above a 30 mm SWD may be required for rare events, such as applying a leaching fraction.
LEVEL 1	Weighted average rootzone (to 60 cm) EC_e is 4-5 mS/cm above background level.	• Carry out additional hand auger sampling to depths of 60 cm in areas where crop appears affected. 60 cm represents the rootzone area with the highest concentration of roots. Sample each horizon encountered and test for ECe and pH	• Insufficient leaching of salts. • Non-representative field sampling. • Laboratory error.	Observe crop health. Resample and /or retest soil. If a period of high rainfall/low ET occurs, consider applying a leaching fraction irrigation event.	
LEVEL 2	Weighted average rootzone (to 100 cm) EC_e greater than 8 mS/cm.	• Carry out additional hand auger sampling to depths of 100 cm in areas where crop appears affected. 100 cm represents the major rootzone of the crop. Sample each horizon encountered and test for ECe and pH	• Insufficient leaching of salts. • Non-representative field sampling. • Laboratory error.	Resample and /or retest soil. Cease irrigation until a period of low ET, then apply a leaching fraction calculated to remove excess salt. Resample soil following leach.	

Note 1: As detailed in section 6.3 and in accordance with EPL 2035 condition M2.11, monitoring will be undertaken prior to the recommencement of irrigation, as per condition M2.2 and M2.3. These values will be used as the background levels.

Table E4 - Sodicity in soil TARP

Trigger Level	Trigger	Action	Cause	Response	Notes
NORMAL	The sodium adsorption ratio (SAR) in the surface 40 cm remains at amended levels of below 8.	Soil monitoring program (refer to section 6.3).	n/a	No response necessary	The irrigation schedule is set so that under normal conditions no irrigation occurs until at least a 30 mm SWD is achieved. This means that the soil is unlikely to become waterlogged unless rainfall also occurs, or instantaneous application rates are too high. Some irrigation above a 30 mm SWD may be required for rare events, such as applying a leaching fraction.
LEVEL 1	SAR in surface 40 cm between 8 and 15.	Carry out additional hand auger sampling to depths of 100 cm in areas where crop appears affected.	• Insufficient / ineffective calcium amendment. • Non-representative field sampling. • Laboratory error.	Resample and /or retest soil. Apply gypsum to the soil at a rate calculated to reduce soil SAR to <6, as advised by the Agricultural Supervisor. Irrigation may continue in order to assist gypsum incorporation into soil profile.	
LEVEL 2	SAR in surface 40 cm >15.	Carry out additional hand auger sampling to depths of 100 cm in areas where crop appears affected.	• Insufficient / ineffective calcium amendment. • Non-representative field sampling. • Laboratory error.	Resample and /or retest soil. Apply gypsum to the soil at a rate calculated to reduce soil SAR to <6. Irrigation may continue in order to assist gypsum incorporation into soil profile. Apply additional gypsum to soil to further offset sodium in irrigation water.	

Table E5 - Salinity in groundwater TARP

Trigger Level	Trigger	Action	Cause	Response	Notes
NORMAL	Groundwater salinity (TDS/EC) remains consistent with range of natural variation (Note 1)	Normal monitoring (refer to section 9 of the Groundwater Management Plan)	n/a	No response necessary.	It is possible to cease or reduce water production by varying output or shutting down the reverse osmosis plant, with the treatment plant remaining shut down until there is capacity available for irrigation to recommence. Pre-existing salts held within the vadose zone may be a source of high salt loads available to ground water. The increased deep drainage from the irrigation system may hasten the rate of vadose zone salts entering groundwater.
LEVEL 1	Groundwater salinity (TDS/EC) level outside expected range based on regional groundwater salinity levels for a single monitoring event.	• Analyse and evaluate local regional groundwater data. • Undertake additional review (over next two monitoring events) to determine whether possible adverse trend developing.	Sampling or analysis error or anomaly Regional variation in groundwater salinity caused by natural / seasonal fluctuation Increased localised recharge from an unknown high permeability zone within the irrigation area.	Continue monitoring. If adverse trend (min. three monitoring events) develops, trigger level 2.	
LEVEL 2	Groundwater salinity (TDS/EC) levels trending adversely in comparison to regional groundwater levels.	• Analyse and evaluate local and regional data. • Undertake additional monitoring to confirm adverse trend is localised in nature. • Investigate source of the elevated salinity and any potential effects.	Regional variation in groundwater salinity caused by natural / seasonal fluctuation.	• Assess irrigation management strategy and identify contributing factor/s to adverse localised trend in groundwater salinity. • Implement any change to irrigation management strategy to reduce effects of adverse trend. • Undertake a risk assessment to determine physical extent of adverse salinity trend in groundwater and determine whether increased salinity will have a negative effect on surrounding beneficial groundwater uses. • Undertake notification in accordance with regulatory requirements. • Continue monitoring.	

Note 1: Refer to Table 6.1 for the range of natural variation of TDS and EC values, monitored between 2014 and 2021.

Table E6 - Native vegetation community health TARP

Trigger Level	Trigger	Action	Cause	Response	Notes
NORMAL	Vegetation health stable	Quarterly monitoring, including potential for sprinkler mist from the irrigation system to impact vegetation.	N/A	No response necessary	Pasture health should be assessed by a suitably experienced person. Some seasonal variations in pasture performance and cover do not necessarily reflect a problem with the irrigation system. Green cover may be assessed using a quadrant or defined area assessment approach, or other method consistent with that used in operations of a similar size and nature.
LEVEL 1	By comparison with baseline conditions, reduced growth of vegetation or visible signs of stress, such as: • wilting • yellowing leaves • crown thinning • defoliation • epicormic growth • dead patches on leaves (particularly at margins and tips) • increase in presence of salt tolerant species • salt crystal accumulation on vegetation or soils	• Assess cause of stress/damage. • Assess sprinkler mist from pivot. • Inspect foliage for salt scalding. • Hand auger soil to determine moisture content, pH and ECe in the A and B21 horizons.	Natural/seasonal event such as drought, above average rainfall, insect pressure, etc.	Continue monitoring and visual assessment of vegetation.	
			Excessive sprinkler mist affecting foliage.	Adjust sprinkler nozzle parameters as required.	
			Subsurface and above ground run-off introducing excess soil water and salts.	Alter irrigation schedule in the irrigation units adjacent to the vegetation. Build a low diversion bund to redirect any run-on.	
LEVEL 2	By comparison with baseline conditions, death of dominant trees and/or understory	• Assess cause of vegetation death. Assess sprinkler mist from pivot.	Natural/seasonal event such as drought, above average rainfall, insect pressure, etc.	Continue monitoring and visual assessment of vegetation.	

Trigger Level	Trigger	Action	Cause	Response	Notes
		• Inspect foliage for salt scalding • Hand auger soil to determine moisture content, pH and ECe in the A and B21 horizons.	Excessive sprinkler mist affecting foliage	Adjust sprinkler nozzle parameters as required. . Consider using drop tubes to bring irrigation closer to the ground.	
			Subsurface and above ground run-off introducing excess soil water and salts.	Cease irrigation in the adjacent area until soil dries back to background levels. Once this has occurred, alter irrigation schedule in the irrigation units adjacent to the vegetation prior to recommencement of irrigation in the adjacent area	