Western Surat Gas Project

Water Monitoring and Management Plan

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Position	Name	(tick one column only)		Signature	Date
		Approve	Review		
Environment Manager	T. Jensen	☒	☐	[signature]	20/ 7 / 2018

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REVISION HISTORY

Revision	Revision Date	Document Status	Revision Comments	Author	Approved By
A	May 2017	Issued for Review	Document creation	CK (KCB)	CS, CD (KCB)
B	June 2017	Issued for Approval	Revised following Senex comments	CK	CS (KCB)
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1. INTRODUCTION

Senex Energy Limited (Senex) (ACN 008 942827), on behalf of its wholly-owned subsidiary Stuart Petroleum Cooper Basin Gas Pty Ltd, is proposing to produce and supply raw or treated gas to domestic markets and neighbouring operators (third parties) and distribute gas via existing pipelines and LNG processing facilities through its Western Surat Gas Project (WSGP).

The Production Area within the WSGP covers an area of ~686 km^2 and is located approximately 30 km northeast of Roma, in Queensland's Surat Basin. Gas field production activities are planned to commence in 2018, subject to approvals, and will include the following activities:

- Drilling, installation, operation and maintenance of up to 425 coal seam gas (CSG) production wells (all vertical), targeting the Walloon Coal Measures (WCM) of the Surat Basin, over an estimated 47-year project life;
- Installation, operation and maintenance of gas and water gathering flowlines;
- Installation, operation and maintenance of associated supporting infrastructure (e.g. temporary workforce accommodation, access roads, field compression facilities, pipelines, power and communication systems, laydowns, stockpiles and storage areas);
- Decommissioning and rehabilitation of infrastructure and disturbed areas; and
- Installation, operation and maintenance of water storage and water management facilities.

1.1. Aim and Objectives of the CSG WMMP

CSG water production is required as part of the CSG extraction process. Groundwater is removed (pumped) from CSG production wells to depressurise the CSG target production coal seams. This depressurisation generates gas flow, and sustains a groundwater flow to maintain the target producing operational pressure of each production well.

The removal of groundwater for this purpose is regulated under the *Petroleum and Gas (Production and Safety) Act 2004* (State of Queensland 2017a), where petroleum tenure holders can exercise underground water rights. The Act identifies underground water rights for petroleum tenures, and states that the holder of a petroleum tenure may take or interfere with underground water in the area of the tenure if the taking or interference happens during the course of, or results from, the carrying out of another authorised activity for the tenure.

Abstraction of groundwater as part of CSG production may cause a drawdown in groundwater levels / pressure and therefore may impact existing water-dependent assets within the vicinity of the WSGP, such as groundwater bores, or groundwater dependent ecosystems.

This CSG Water Monitoring and Management Plan (WMMP) has been prepared to outline Senex's proposed monitoring, management and mitigation measures to specifically address impacts to groundwater from the WSGP.

1.2. Regulatory and Policy Framework

1.2.1 WSGP Approval Status

Key State and Commonwealth legislation relevant to the WSGP include:

- *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Commonwealth of Australia 2016)
- *Petroleum and Gas (Production and Safety) Act 2004* (State of Queensland 2017a)
- *Environmental Protection Act 1994* (State of Queensland 2016)
- *Water Act 2000* (State of Queensland 2017b)

A summary of the WSGP's current approval status under these Acts is provided in Table 1-1.

Table 1-1: Summary of the WSGP Approval Status under State and Commonwealth Legislation

Act / Policy	Approval Status
Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act) (Commonwealth of Australia 2016)	The DoEE have determined that the proposed action (WSGP) will be assessed by Public Environment Report (PER) under the *EPBC Act*. The draft PER is due to be submitted to DoEE in July, 2017.
Petroleum and Gas (Production and Safety) Act 2004 (State of Queensland 2017a)	Applications for Petroleum Lease were submitted to the Queensland Department of Natural Resources and Mines (DNRM) in December, 2016.
Environmental Protection Act 1994 (State of Queensland 2016)	Exploration activities are authorised under Environmental Authority (EA) EPPG00651513. Senex have applied for a major amendment of this EA (EPPG00651513) to authorise production activities, which was approved in December, 2017.
Water Act 2000 (State of Queensland 2017b)	WSGP is included within the Surat Cumulative Management Area (CMA) Underground Water Impact Report (UWIR), published in September 2016 (OGIA 2016b). The Office of Groundwater Assessment (OGIA) has provided Senex with obligations required to comply with the Surat CMA UWIR.

1.2.2 Surat Cumulative Management Area Underground Water Impact Report

Under the *Water Act 2000* (State of Queensland 2017b), where there is an area of concentrated development, a cumulative management area (CMA) can be declared. The WSGP is located within the Surat CMA, which was declared in 2011.

The Office of Groundwater Impact Assessment (OGIA) was established under the *Water Act 2000* and is responsible for predicting regional impacts on water pressures in aquifers; developing water monitoring and spring management strategies; and assigning responsibility to individual petroleum tenure holders for implementing specific parts of the strategies within CMAs. These predictions, strategies and responsibilities are set out in the Surat CMA Underground Water Impact Report (UWIR), prepared and maintained by OGIA.

The Surat CMA UWIR was first published by Queensland Water Commission (QWC) in 2012 (QWC 2012) to assess the cumulative impacts to the Surat and southern Bowen Basin, as a result of the expansion of CSG production by multiple, adjacent developers. An updated UWIR was published by the OGIA in September 2016 (OGIA 2016b).

OGIA has provided Senex with obligations to comply with the Surat CMA UWIR Water Monitoring Strategy (WMS). These include:

- For groundwater monitoring: the location, type of facilities, target aquifer and frequency of monitoring required;

- For baseline assessment: details of bores that are required to be included in a baseline assessment; and
- For springs: the complex to be surveyed and monitored by Senex and the frequency of monitoring required.

OGIA has also provided Senex with groundwater modelling predictions to assist with the development of a monitoring and mitigation strategy to address the predicted groundwater impacts.

2. PROJECT DESCRIPTION

2.1. General Description

The WSGP Production area covers an area of ~686 km^2 and is located approximately 30 km northeast of Roma, in Queensland's Surat Basin. The location of the WSGP is presented in Figure 2-1.

The WSGP Production area consists of nine individual development blocks (Glenora, Eos, Mimas, Tethys, Phoebe, Pandora, Rhea, Dione and Titan). The CSG production target for the WSGP is the Walloon Coal Measures (WCM).

The WSGP is located adjacent to other CSG tenure holders targeting the WCM, including Santos' Roma Gas Field, located immediately to the south, and Origin's Combabula Development Area located to the east of the WSGP. Origin's Spring Gully Development Area is located to the northeast of the WSGP and targets the Bandanna Formation of the Bowen Basin.

WSGP production activities, scheduled to commence in 2018, will include the following activities:

- Drilling, installation, operation and maintenance of up to 425 CSG production wells (all vertical), targeting the WCM of the Surat Basin, with an operation duration over an estimated 47-year project life;
- Installation, operation and maintenance of gas and water gathering flowlines;
- Installation, operation and maintenance of associated supporting infrastructure (e.g. temporary workforce accommodation, access roads, power and communication systems, laydowns, stockpiles and storage areas);
- Decommissioning and rehabilitation of infrastructure and disturbed areas;
- Installation, operation and maintenance of field compressor facilities, medium pressure infield pipelines, and a central processing facility; and
- Installation, operation and maintenance of water storage and water management facilities.

Details of the WSGP components, including location and size, will be identified progressively over the life of the WSGP.

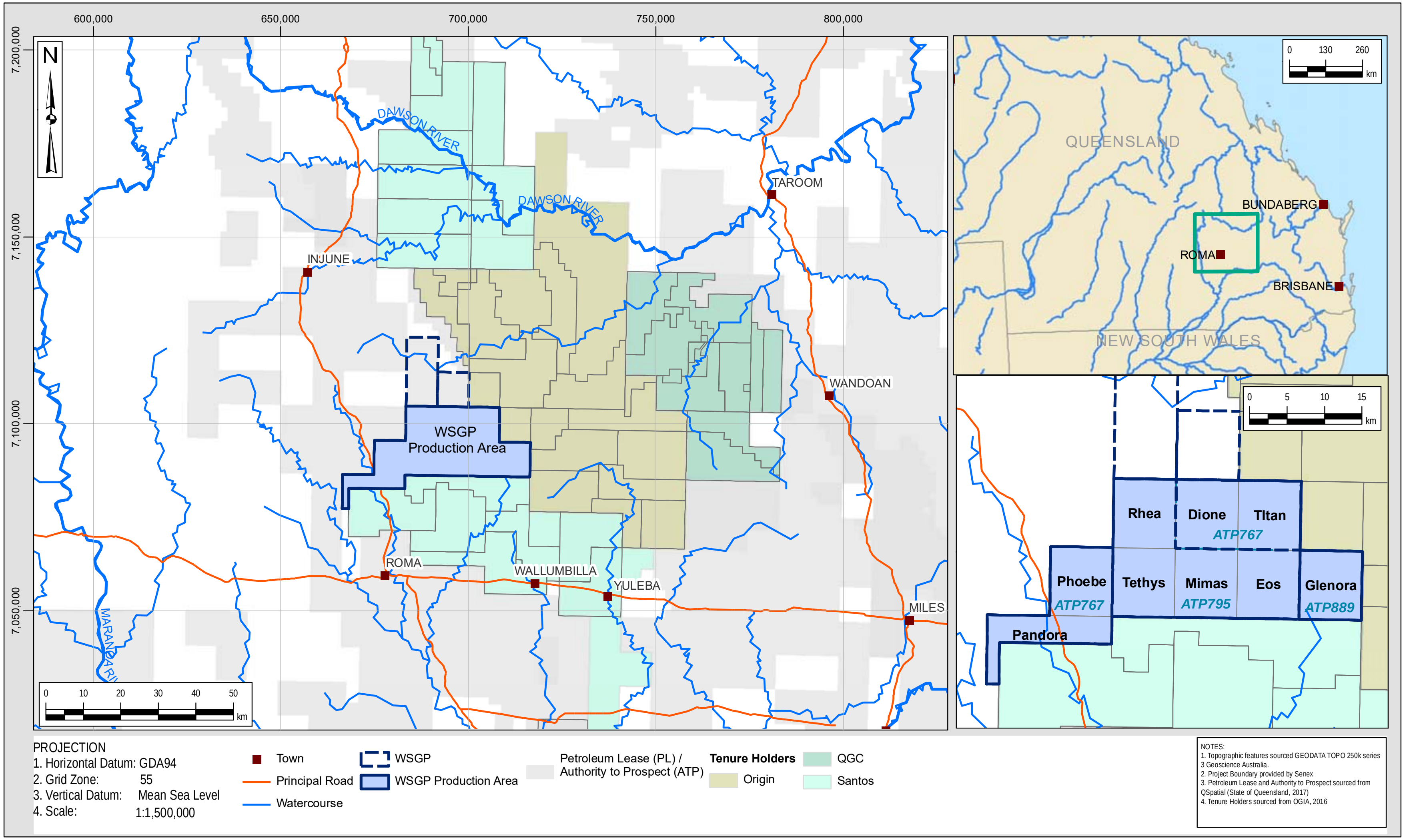

Figure 2-1: Location of the WSGP

2.2. CSG Water Production

CSG water production is required as part of the CSG extraction process. Groundwater is removed (pumped) from CSG production wells to depressurise the CSG target production coal seams. This depressurisation generates gas flow, and sustains a groundwater flow to maintain the target producing operational pressure of each production well. As part of the WSGP, up to 425 CSG production wells are proposed. The operating life of a CSG production well is expected to be approximately 25-30 years. Gas field development will commence in the southern sections of the tenure and generally progress from east to west across the WSGP. The anticipated future production scenario or well commissioning sequencing is presented in Figure 2-2, which is based on the June 2016 future plan[1]. The operating life of a CSG production well is expected to be approximately 25-30 years. CSG production (water and gas) is planned to cease by 2065.

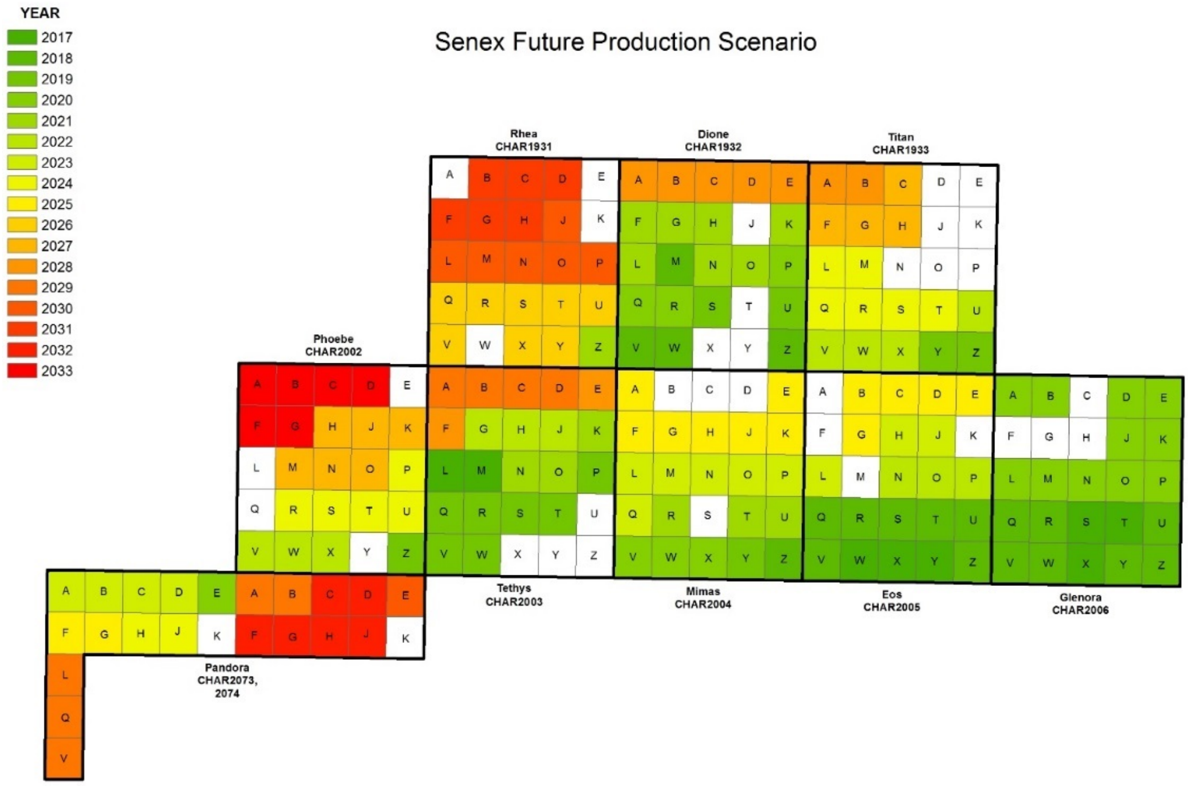

Figure 2-2: Proposed WSGP Future Production Scenario (June 2016 Future Plan)

Produced water volumes and rates from the WSGP are predicted using Senex's analytical modelling tool or reservoir model with probabilistic distributions applied to several key reservoir parameters (i.e. permeability, porosity and net coal). Predictions from these models generate production profiles (type curves). These production profiles are used in field development planning to provide a water forecast. Some uncertainty is inherent in these analytical models, with a tendency for the reservoir models to initially over-predict water production, due to factors including sensitivity to assumed porosity. A key method for reducing uncertainty is to historically match the model results, by modifying model input parameters, with actual production data. Senex's predicted water volumes have a very good match with the actual water production for the adjacent proponent's 74 CSG wells that are located within 5 km of

[1] Note that field development planning and water production rates may change as new information becomes available during the life of the Project.

the project area. As Senex acquires more production data, the model is enhanced with additional historical matching, and revised production forecasts are produced. These revised production forecasts will be incorporated into the water balance model (along with the actual observations of water disposal volumes, rainfall and dam levels). Senex has confidence this integrated and iterative approach will ensure that produced water is managed responsibly, and beneficial use will be optimised. Type curves are updated during the life of the project as more information becomes available.

Figure 2-3 presents the predicted total water extraction rate for the WSGP. Peak CSG water production is predicted to occur in 2022 at a rate of 6.5 ML/d. The estimated annual total CSG water production for the life of the WSGP, as well as the cumulative water production volume, is presented in Figure 2-4. It is estimated that 34,540 ML will be extracted during the 47-year WSGP life.

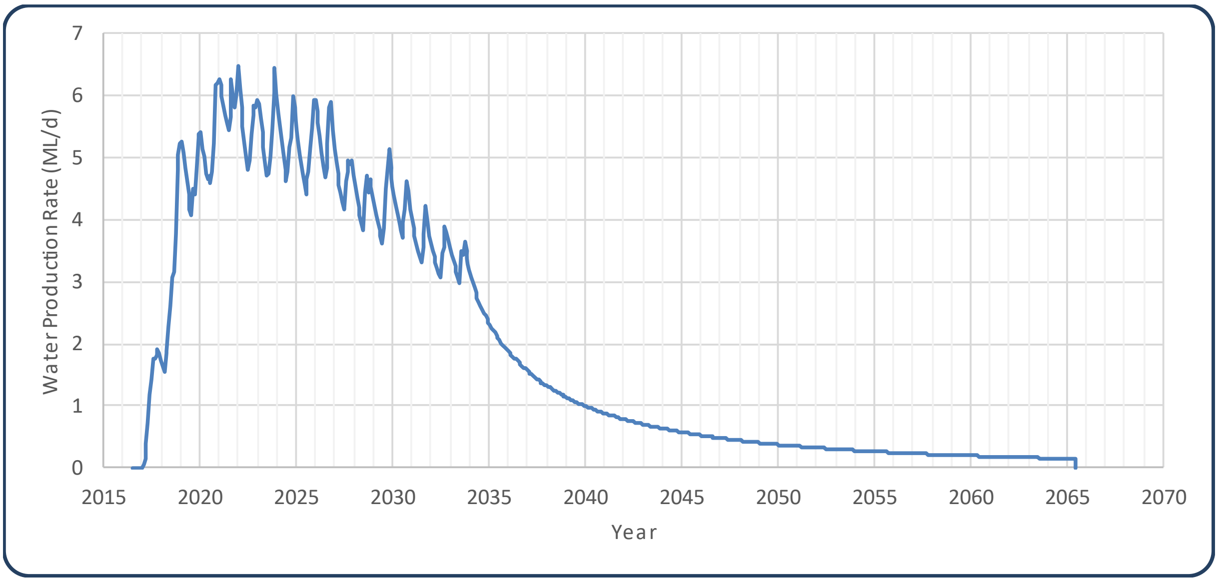

Figure 2-3: Total Proposed CSG Water Production Rate for the WSGP (2018 to 2065)

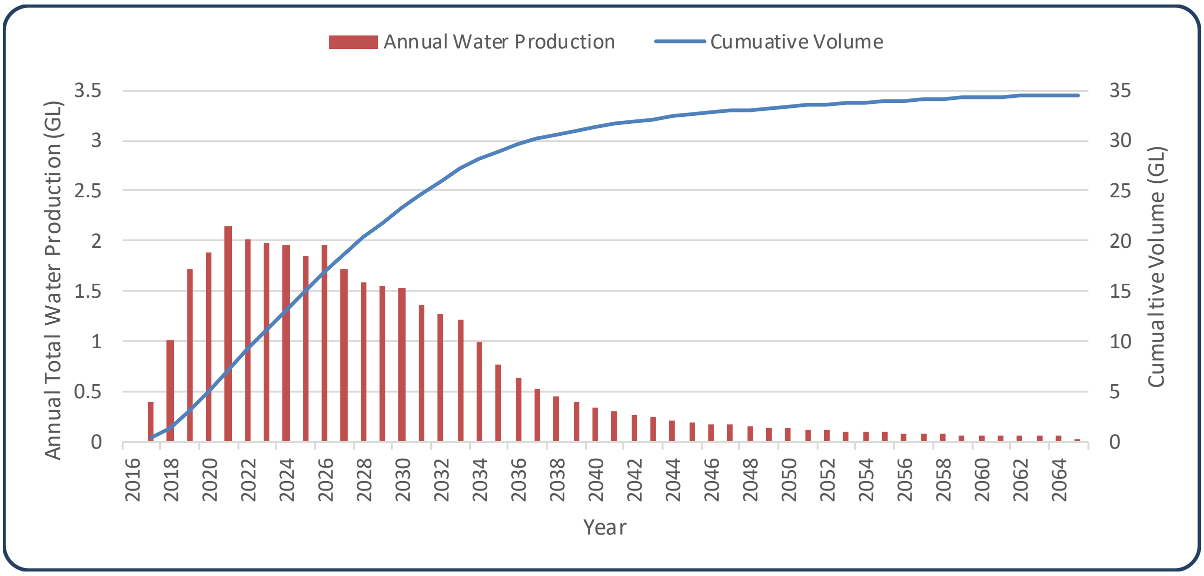

Figure 2-4: Annual Total Proposed CSG Water Production for the WSGP (2018 to 2065)

2.3. CSG Water Management

CSG produced water for the WSGP will be collected via water gathering systems. The WSGP will include water storage facilities that include:

- dams for aggregating untreated CSG produced water;
- temporary tanks or dams for pilot production;
- dams for blending treated water; and
- dams for storage of brine[2].

The infrastructure and process associated with water management is provided in Figure 2-5.

Senex's strategy for CSG water management at the WSGP has been developed based on the DEHP Prioritisation Hierarchy (DEHP 2012). The water management options have been developed to maximise beneficial use of water, which includes use for WSGP activities and Landowner Water Supply Agreements (WSA).

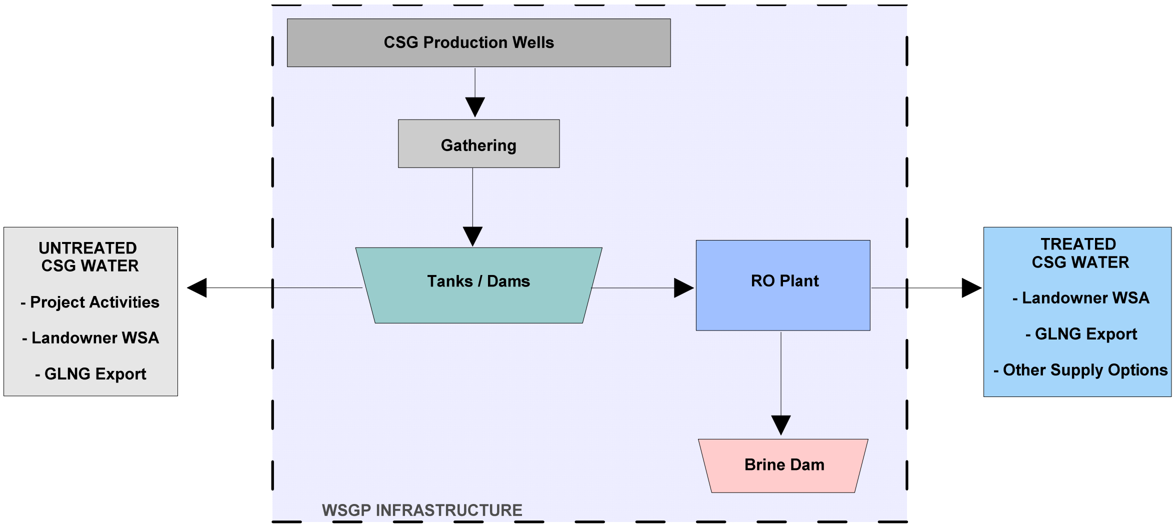

Figure 2-5: Water Management Infrastructure Schematic

The CSG Water Management Plan (SENEX-WSGP-EN-PLN-008) provides further information related to the management of CSG water and associated water storage.

[2] The treatment of CSG produced water using desalination technologies results in brine.

3. GROUNDWATER AND THE WSGP

3.1. Hydrogeological Overview

The WSGP is located within the geographical extent of the Surat Basin, a basin of Jurassic-Cretaceous age, which is underlain by the Permo-Triassic Bowen Basin. Cenozoic-age formations are present overlying the Surat Basin formations.

The Surat Basin forms part of the Great Artesian Basin (GAB), which is comprised of several aquifers and confining aquitards. Aquifers of the Surat Basin are a significant source for water used for stock, public water and domestic supply. OGIA (2016b) presents the hydrostratigraphy of the Surat and Bowen Basin, included as Figure 3-1.

The main aquifers within the GAB, from the deepest to the shallowest, are the Precipice Sandstone, Hutton Sandstone, Springbok Sandstone, Gubberamunda Sandstone, Mooga Sandstone and Bungil Formation. These aquifers are typically laterally continuous, have significant water storage, are permeable and are extensively developed for water supply. However, in some areas, they have more of the character of aquitards than aquifers (OGIA 2016b). Minor discontinuous aquifers include the Wallumbilla Formation and Orallo Formation. The major aquitards are the Evergreen Formation, Eurombah Formation, Westbourne Formation, Surat Siltstone and Griman Creek Formation (Figure 3-1). WCM is the target formation for CSG production for the WSGP.

Many of these Surat Basin units outcrop within the vicinity of the WSGP. Figure 3-2 presents the local basinal hydrostratigraphy sourced from the OGIA Surat CMA geological model surfaces (OGIA 2017) and indicates the outcrop areas associated with the WSGP, including the Springbok Sandstone, Westbourne Formation, Gubberamunda Sandstone, Orallo Formation and Mooga Sandstone. The WCM outcrop is located immediately to the north of the WSGP.

North-south and west-east oriented cross sections through the WSGP are presented in Figure 3-3, with the section locations provided on Figure 3-2. The sections show the units dipping from outcrop towards the south. Generally, all units are laterally extensive and continuous across the WSGP area, except for the Precipice Sandstone, which is thin or absent across much of the area.

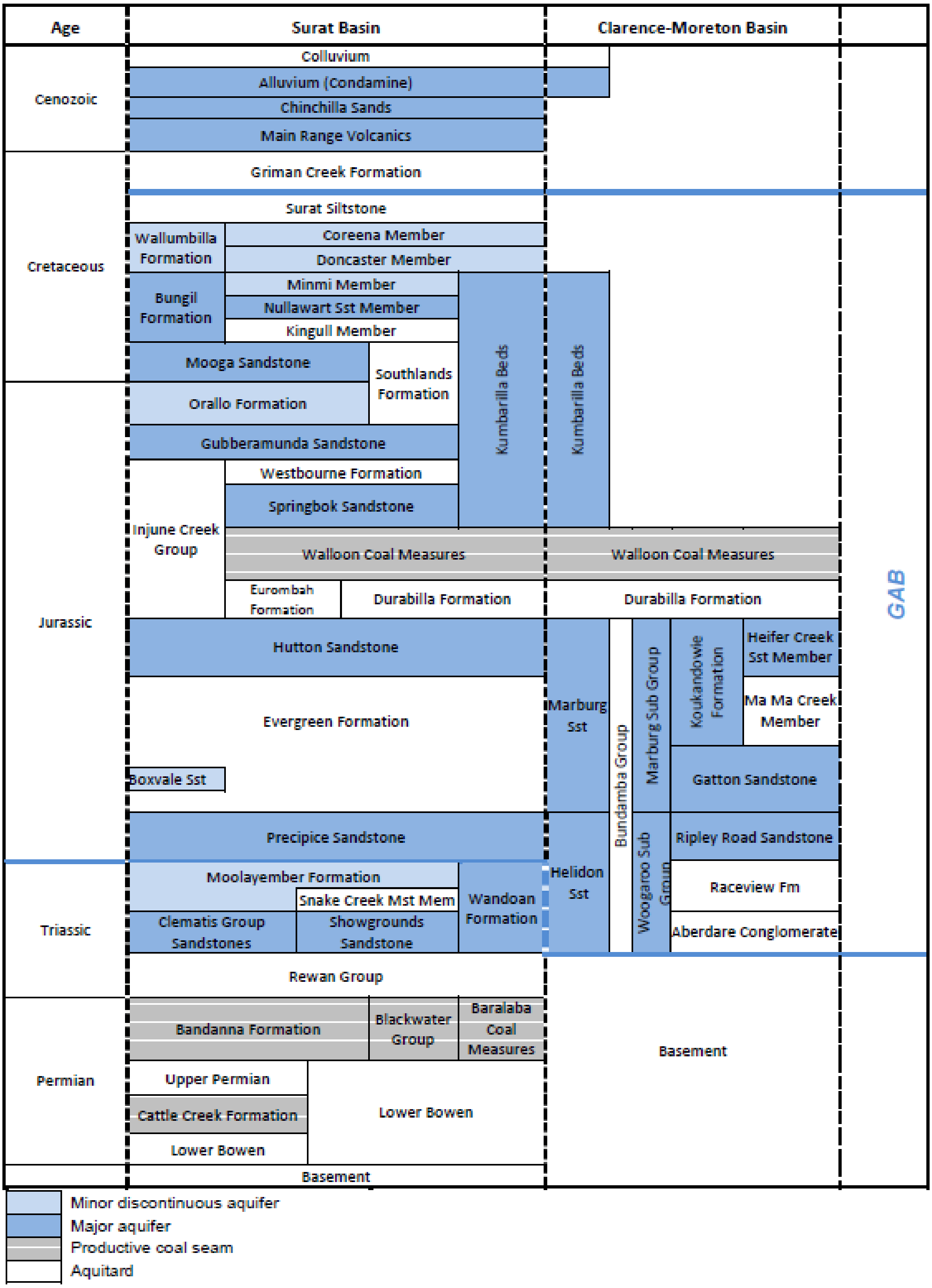

Figure 3-1: Regional Hydrostratigraphy (OGIA 2016b)

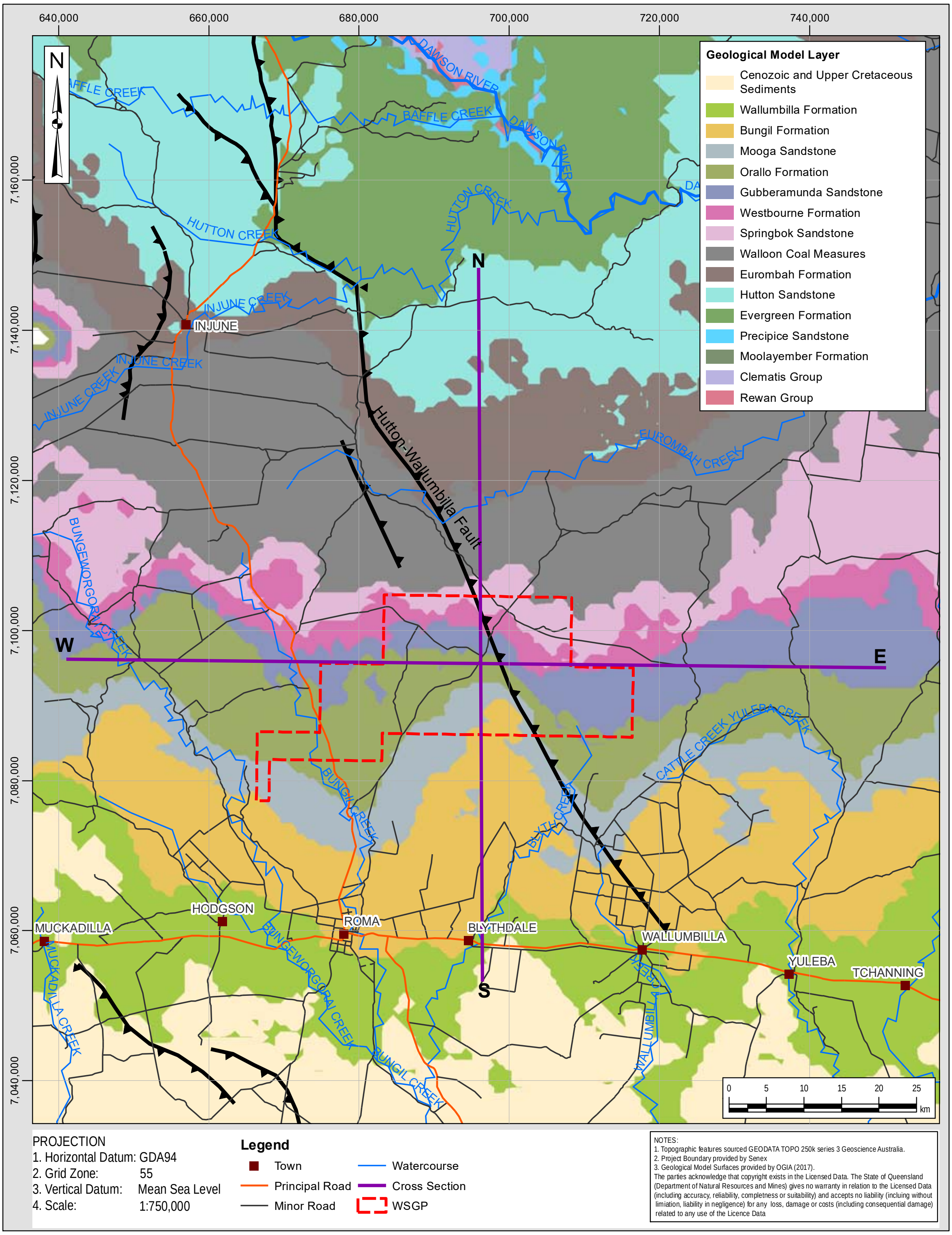

Figure 3-2: Local Geology and Cross Section Locations (after OGIA 2017)

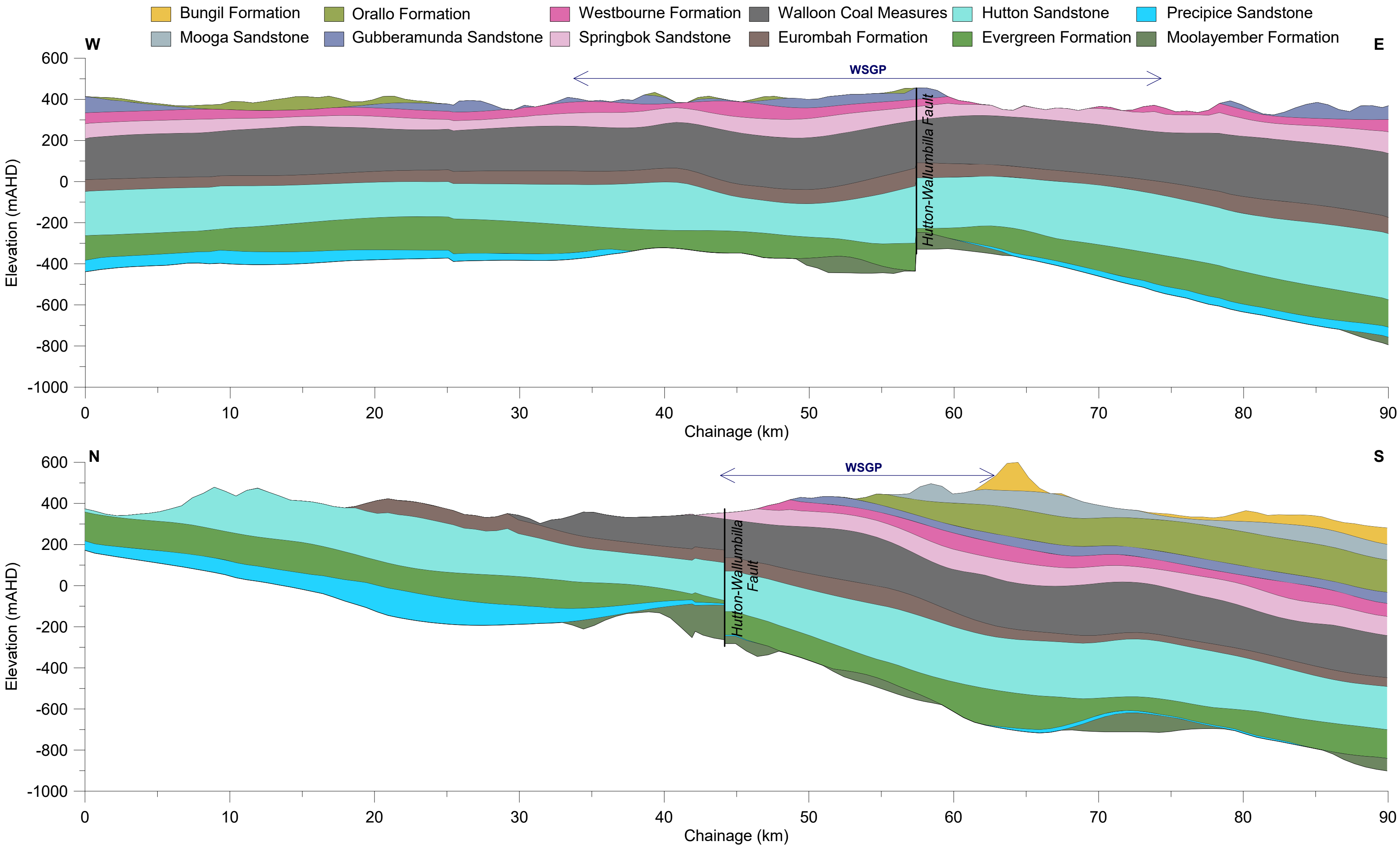

Figure 3-3: West-East and North-South Geological Cross Section (after OGIA 2017)

3.2. Groundwater-Dependent Assets

3.2.1 Groundwater Bores

In the vicinity of the WSGP (within the WSGP tenure and a 25 km buffer of the WSGP extent), there are an estimated 1,015 bores which access water from Surat Basin units, with a combined water use estimate of 1,790 ML/yr (KCB 2017). The location of these bores is presented in Figure 3-4. The highest water usage is attributed to the Orallo Formation, Gubberamunda Sandstone, Walloon Coal Measures and Hutton Sandstone. Stock and Domestic use is the most common groundwater abstraction purpose within the vicinity of the WSGP. There are 30 bores that are utilised for an alternative purpose, including three bores licensed for agricultural purposes within the WSGP boundary.

Senex are required as part of the Surat CMA UWIR WMS (under the *Water Act 2000*) to undertake baseline assessments for 126 bores within the WSGP area. To date, baseline assessments have been carried out for 89 bores during 2015 and 2016. Following several attempts, Senex were unable to secure land access to assess the remaining 37 bores. The location of bores which have been surveyed as part of the baseline assessment program are shown on Figure 3-4.

The baseline assessments were undertaken by Cardno, with details of the assessments provided in the 'Bore Baseline Assessment Summary Report' (Cardno 2017). Baseline assessments were carried out in accordance with the 'Baseline Assessment Guideline' (DEHP 2017), Australian Standard for water quality sampling (AS/NZS 5667.11 1998) and other relevant guidelines. The field assessments included an interview with the bore owner, bore inspection, water level measurement (where possible) and water quality sampling (where possible).

Following field data collection, an assessment of the baseline results was undertaken. This included collation of the available data to estimate the screened interval for each landholder bore. This was also cross-checked against Senex's geological model. Data from the baseline assessment, including the estimated screened interval, was provided to OGIA for incorporation into their aquifer attribution dataset.

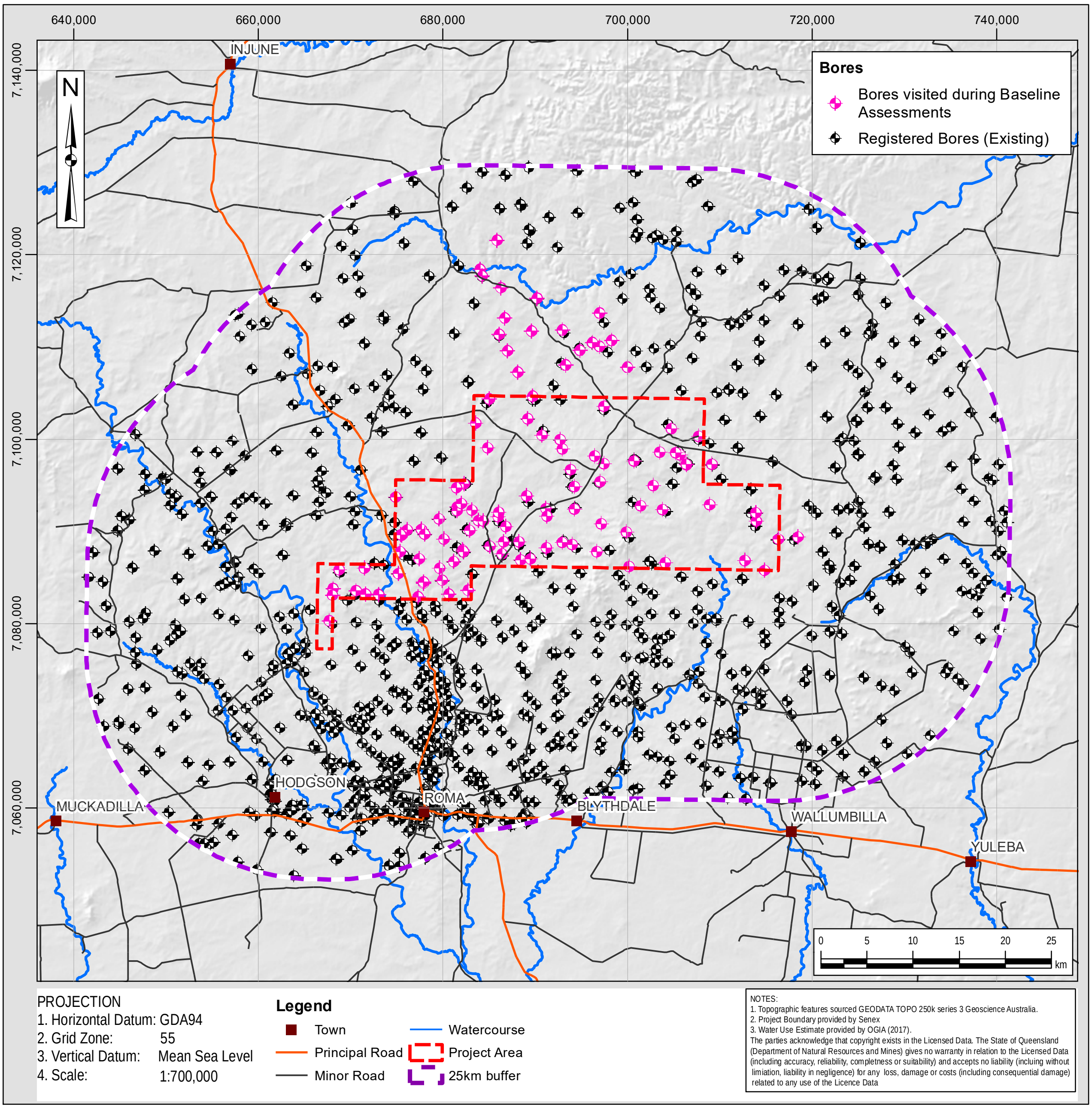

Figure 3-4: Location of Registered Groundwater Bores within the vicinity of the WSGP

3.2.2 Groundwater Dependent Ecosystems

Surface expression Groundwater Dependent Ecosystems (GDEs) are defined as:

> *'ecosystems dependent on the discharge of groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services. Surface expression GDEs include drainage lines, spring wetlands and regional ecosystems that have some groundwater dependency' (DSITI 2015).*

In the GAB, these are referred to as Spring Vents / Complexes and Watercourse Springs. Table 3.1 presents a summary of springs and watercourse springs within the vicinity of the WSGP, with their locations presented on Figure 3-5.

Table 3.1: Surface expression GDEs within the vicinity of the Project

GDE Type	Complex / Site Number	Name	Vent	Source Aquifer	Distance from the Project Boundary
Spring Vents	506	Spring Ridge	184.1, 185.1, 186.1	Gubberamunda Sandstone	Within Project (Rhea Block)
	283	Barton	702.1, 703.1	Gubberamunda Sandstone	6.7 km east
	358	Gubberamunda (VI Mile)	187.1, 679.1, 680.1, 680.1.1	Gubberamunda Sandstone	5.0 km west
Watercourse Springs	W10	Blyth Creek	N/A	Mooga Sandstone, Orallo Formation	10 km south
	W16	Bungeworgorai Creek		Gubberamunda Sandstone	22.6 km
	W17	Bungeworgorai Creek		Mooga Sandstone	1.6 km west
	W18	Bungil Creek		Gubberamunda Sandstone	1.6 km west
	W19	Bungil Creek		Mooga Sandstone	6.3 km south
	W59	Eurombah Creek		Upper Hutton Sandstone	22.8 km

Recent work by OGIA (2017b), published since the UWIR, to re-map gaining streams (or baseflow-fed reaches, watercourse springs) has identified three further reaches of creeks, within the vicinity of the WSGP, as potentially gaining streams. Details of the three further reaches are provided in Table 3-2 with their location shown on Figure 3-5. Blyth Creek (W10) and Eurombah Creek (W59) were also included in the assessment.

Table 3-2: Details of Potentially Gaining Streams (Watercourse Springs) from OGIA (2017b)

Name	Potential Source Aquifer	Distance from WSGP Boundary	Information Source
Sugarloaf Creek	Alluvium / Westbourne Formation / Springbok Sandstone / WCM	4.2 km	OGIA (2017b)
Barton Creek	Alluvium / Springbok Sandstone	10.6 km	OGIA (2017b)
Kangaroo Creek	Gubberamunda Sandstone / Westbourne Formation / Springbok Sandstone	23.8 km	OGIA (2017b)

The Spring Ridge complex is located centrally within the WSGP boundary, inside the Rhea development block. Senex commissioned a spring survey of this complex in 2015. OGIA (2016a) identifies groundwater discharge at this spring as being controlled by the outcrop geology of the Gubberamunda Sandstone and is associated with a perched aquifer. The spring is described as a 'Type 4b wetland', which is a semi-permanent fresh riverine-to-palustrine wetland with minor wetland soils and moderate vegetation cover, mainly connected to local groundwater systems. These wetlands are located within riverine-to-palustrine environments with shallow-to-nil consolidated material. These wetlands can form in areas of significant topography. The Spring Ridge complex does not support an EPBC groundwater community[3].

[3] Community of species dependent on natural discharge from groundwater from the GAB.

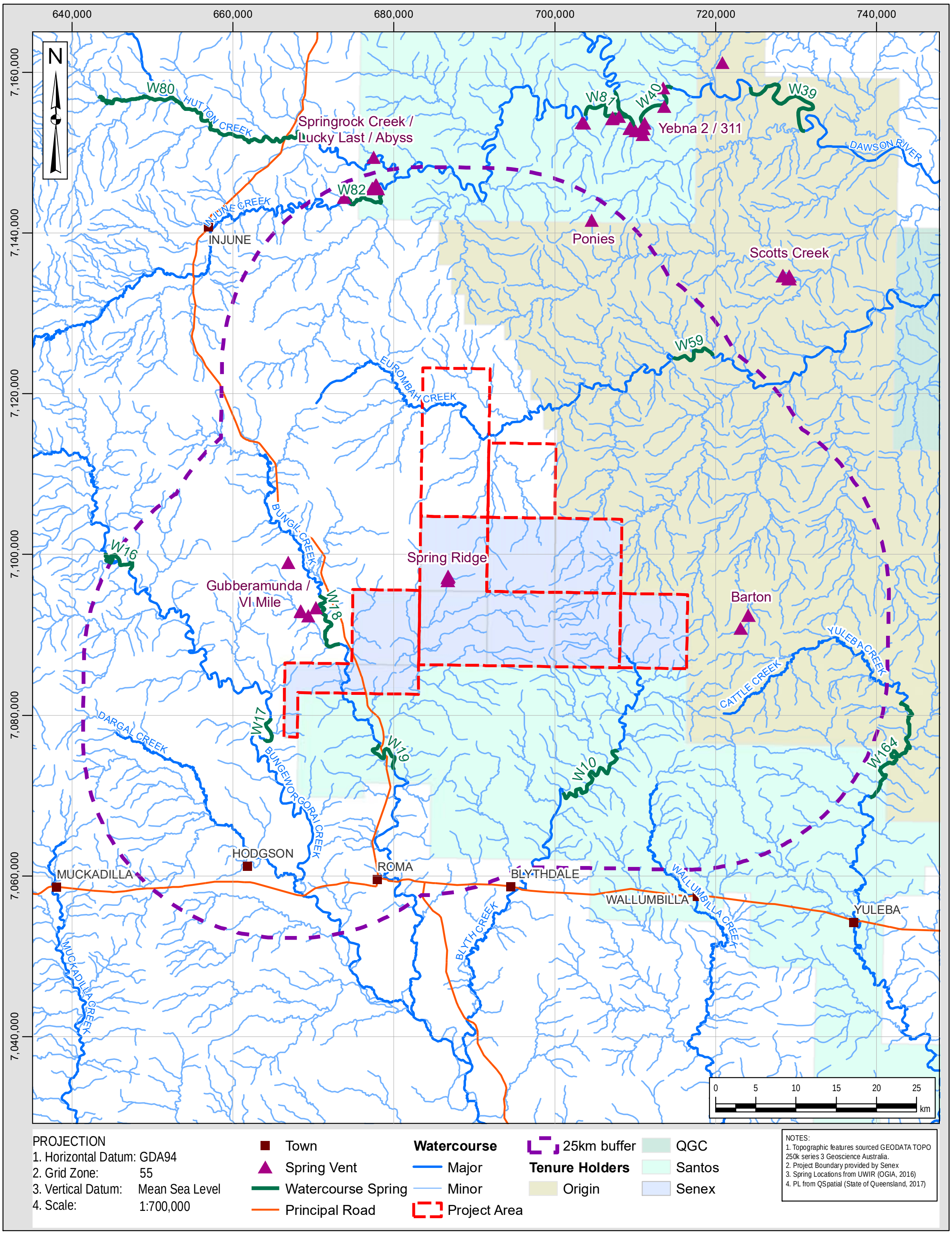

Figure 3-5: Location of Spring Complexes / Vents and Watercourse Springs

3.3. Predicted Impacts

As part of the Surat CMA UWIR (OGIA 2016b), a regional numerical groundwater flow model was developed to predict groundwater pressure impacts resulting from activities from multiple petroleum and gas tenure holders. The model was first developed and utilised as part of the 2012 UWIR (QWC 2012). An updated UWIR and updated numerical groundwater model was published by OGIA in September, 2016 (OGIA 2016b).

The primary purpose of the model is to predict regional water pressure or water level changes in aquifers within the Surat CMA footprint in response to extraction / production of water from the various producing coal seams. In particular, the OGIA numerical groundwater model is used to assess potential impacts to landholder groundwater bores and springs relative to the *Water Act 2000* trigger thresholds.

CSG water production from the WSGP was included as part of the UWIR (2016) groundwater model, however the scenario published within the UWIR included a 1,000 CSG production well scenario within the WSGP. The WSGP CSG production well count has since been revised to 425, and as a result, Senex requested OGIA to undertake additional modelling on their behalf to simulate the revised CSG production well count within the cumulative scenario. The extent of drawdown at 2042 for the cumulative scenario from the UWIR model is presented in Figure 3-6.

Potential impacts to groundwater bores were assessed against the *Water Act 2000* bore trigger threshold of 5 m for a consolidated aquifer using these drawdown predictions.

3.3.1 Immediately Affected Bores

An ‘Immediately Affected Area’ is defined by *Water Act 2000* as an aquifer in the area within which water pressures are predicted to fall by more than the trigger threshold within three years. Bores within immediately affected areas are subject to make good arrangements under the *Water Act 2000*, as assigned by OGIA.

3.3.2 Long-Term Affected Bores

Results of the cumulative impact assessment (KCB 2017) indicate that 57 bores, attributed to the WCM, are predicted to experience a drawdown greater than the bore trigger threshold by 2042. This is as a result of the WSGP and other proposed and existing CSG developments in the area.

This includes 55 bores which are triggered as a result of the WSGP and two additional bores where the WSGP has greater than 50% contribution to drawdown at the bore. Thirty-seven (37) bores are located within the WSGP, with 20 bores located beyond the WSGP extent.

3.3.3 GDE Impacts

There are no impacts predicted as a result of the WSGP to GDEs.

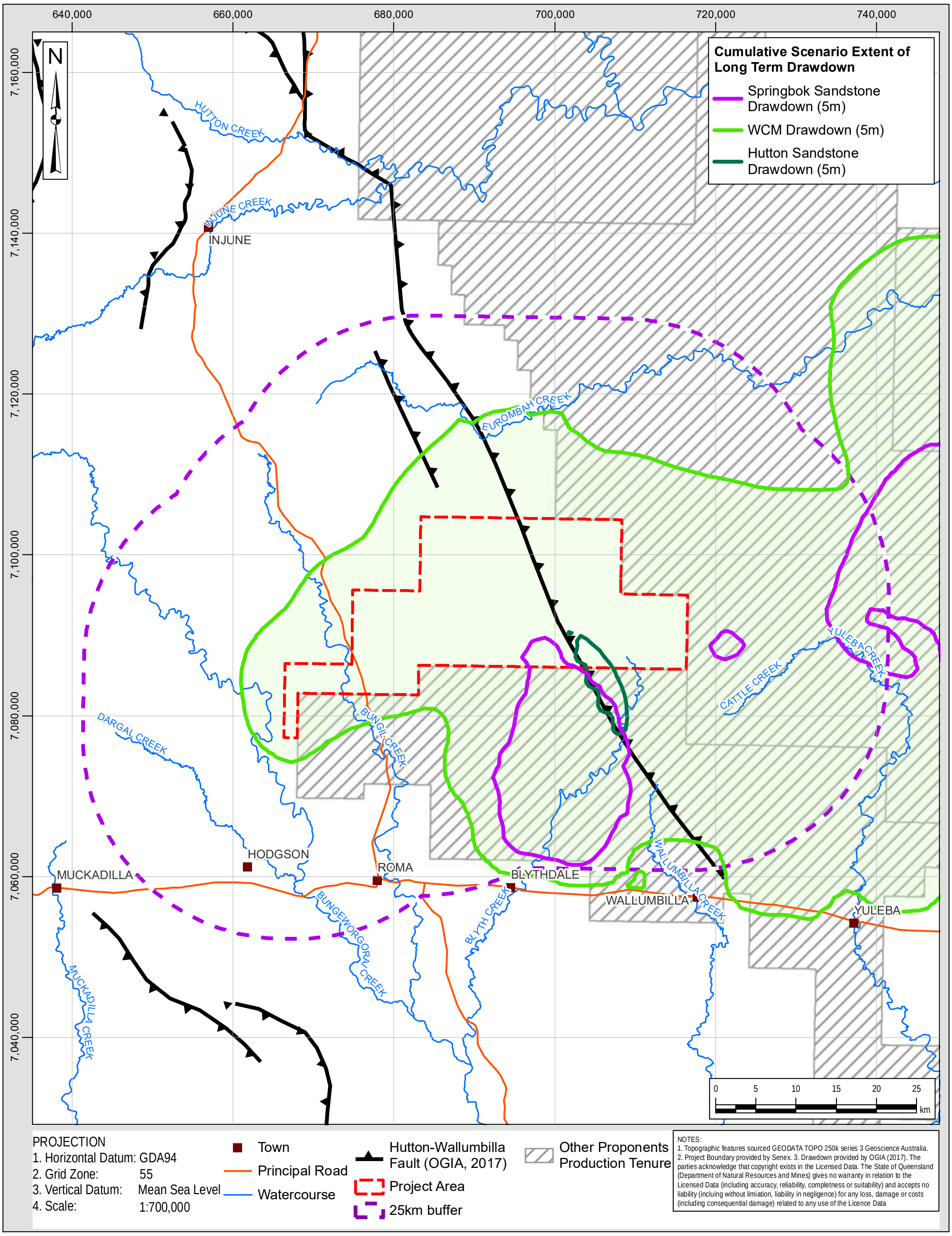

Figure 3-6: Predicted Cumulative Drawdown Impacts

4. GROUNDWATER MONITORING PROGRAM

4.1. Overview

The WSGP groundwater monitoring program has been designed with consideration to key legislation, policies, guidelines and standards. These are outlined in Table 4-1.

The WSGP groundwater monitoring network includes both existing and proposed facilities.

Table 4-1: Key legislation, policies and standards applicable to groundwater monitoring

Type	Name
Legislation	*Water Act 2000* (State of Queensland 2017b) *Environment Protection Act 1994* (State of Queensland 2016) *Petroleum and Gas (Production and Safety) Act 2004* (State of Queensland 2017a) *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia 2016)
Guidelines and Policies	Baseline Assessments: Guideline (DEHP 2017a) Queensland Water Quality Guidelines 2009 (DEHP 2013) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000)
Standards	Minimum Construction Requirements for Water Bores in Australia (NUDLC 2012) Minimum standards for the construction and reconditioning of water bores that intersect the sediments of artesian basins in Queensland (DNRM 2014)
Reports	Underground Water Impact Report for the Surat Cumulative Management Area (OGIA 2016b) Groundwater Sampling and Analysis – A Field Guide (Sundaram et al. 2009)

4.2. Regional Groundwater Monitoring Program

Groundwater monitoring forms a key mechanism for the early identification of the response to CSG water production, within the WCM and other formations where groundwater receptors exist.

The groundwater monitoring requirements for CSG tenure holders within the Surat CMA are provided as part of the UWIR WMS (OGIA 2016b), which provides for establishment of baseline trends, identification of any changes within or near CSG development areas or locations of interest and information to inform future improvement of groundwater modelling.

4.2.1 Monitoring Locations

Senex's groundwater monitoring locations were selected and agreed upon through consultation with OGIA, to complement the existing UWIR monitoring network and monitoring of drawdown associated with the WSGP.

Senex have currently installed one of the three monitoring sites required (Glenora-4M, Glenora-6M), with the remaining two sites (Tethys-6M, Tethys-7M and Pegasus-2M) scheduled for installation in 2018. Senex also continue to monitor Glenora-24M, which was installed by the previous tenure holder, QGC, in 2013, however there is limited confidence in the pressure readings for a number of the sensors, and Glenora-4M has been installed to replace this facility.

Table 4-2 provides details on each of the monitoring sites, including facility type, status and formations to be monitored, with the location of the facilities presented in Figure 4-1. The location of other UWIR monitoring sites, assigned to neighbouring proponents are also shown.

It should be noted that Tethys-7M, to be installed in the Gubberamunda Sandstone, has been sited in a location to act as an early-warning monitoring site for the Spring Ridge complex, discussed further in Section 4.2.3.

Table 4-2: WSGP Proposed and Installed Groundwater Monitoring Sites

UWIR Site No	Site ID	Easting (m)	Northing (m)	Facility Type	Monitoring Formation	Status
163	Glenora-4M	710543	7089038	Multi-Level Gauge	Springbok Sandstone Upper Juandah CM Lower Juandah CM Taroom CM Hutton Sandstone	Drilled Dec-16
163	Glenora- 6M	710473	7089038	Monitoring Bore	Gubberamunda Sandstone	Drilled Feb-17
164	Tethys-6M	Proposed	Proposed	Multi-Level Gauge	Springbok Sandstone Upper Juandah CM Lower Juandah CM Taroom CM Hutton Sandstone	Proposed, to be drilled in 2018
164	Tethys-7M	Proposed	Proposed	Monitoring Bore	Gubberamunda Sandstone	Proposed, to be drilled in 2018
165	Pegasus-2M	Proposed	Proposed	Monitoring Bore	Hutton Sandstone	Proposed, to be drilled in 2018

Additional monitoring bores are proposed to be established during the development of the WSGP field over the duration of the project life and in areas where the project will be expanding into. These monitoring facilities will be established in key hydrostratigraphic units (i.e. Hutton Sandstone, WCM, Springbok Sandstone, Gubberamunda Sandstone) to establish baseline conditions and to identify whether pressure effects have transmitted from the WCM to surrounding hydrostratigraphic units. A schedule for groundwater monitoring well installation over the duration of the project life will be established as the project development schedule is confirmed. Once established these monitoring facilities will be incorporated into the regional groundwater monitoring plan, including the installation of automated water-level monitoring equipment.

4.2.2 Monitoring Facility Types

Two types of facilities are installed as part of Senex's groundwater monitoring network:

- Multi-level gauge system, installed within a single drill-hole. This system insolates each hydrostratigraphic unit and monitors the head pressure associated with the individual units on an hourly-frequency. Data is planned to be downloaded on a bi-monthly frequency, with the intention of moving towards a telemetry system as the production field progresses.
- Groundwater monitoring bore, installed with a screened interval within the target formation for monitoring. These sites are installed and constructed according to the *'Minimum Construction Requirements for Water Bores in Australia'* (NUDLC 2012). These facilities will be installed, where possible, with a pressure transducer to monitor groundwater elevation on at least twelve-hour frequency, with manual measurements taken to confirm

pressure readings on a bi-annual frequency. Pressure data will also be downloaded on a bi-monthly frequency initially, with the intention of moving towards a telemetry system as the production field progresses.

A schematic of the facility types is presented in Figure 4-2.

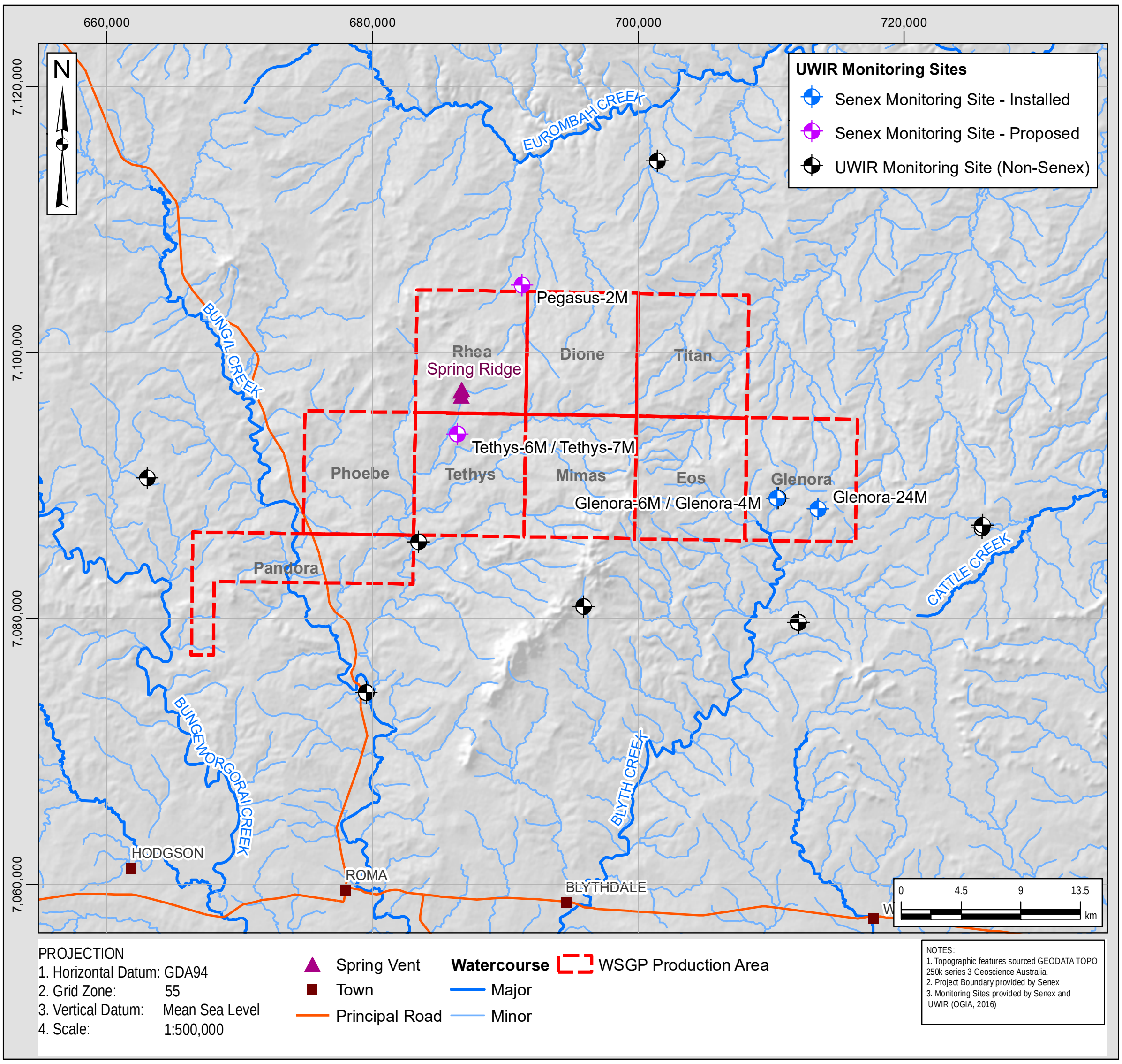

Figure 4-1: Location of Existing and Proposed Monitoring Sites

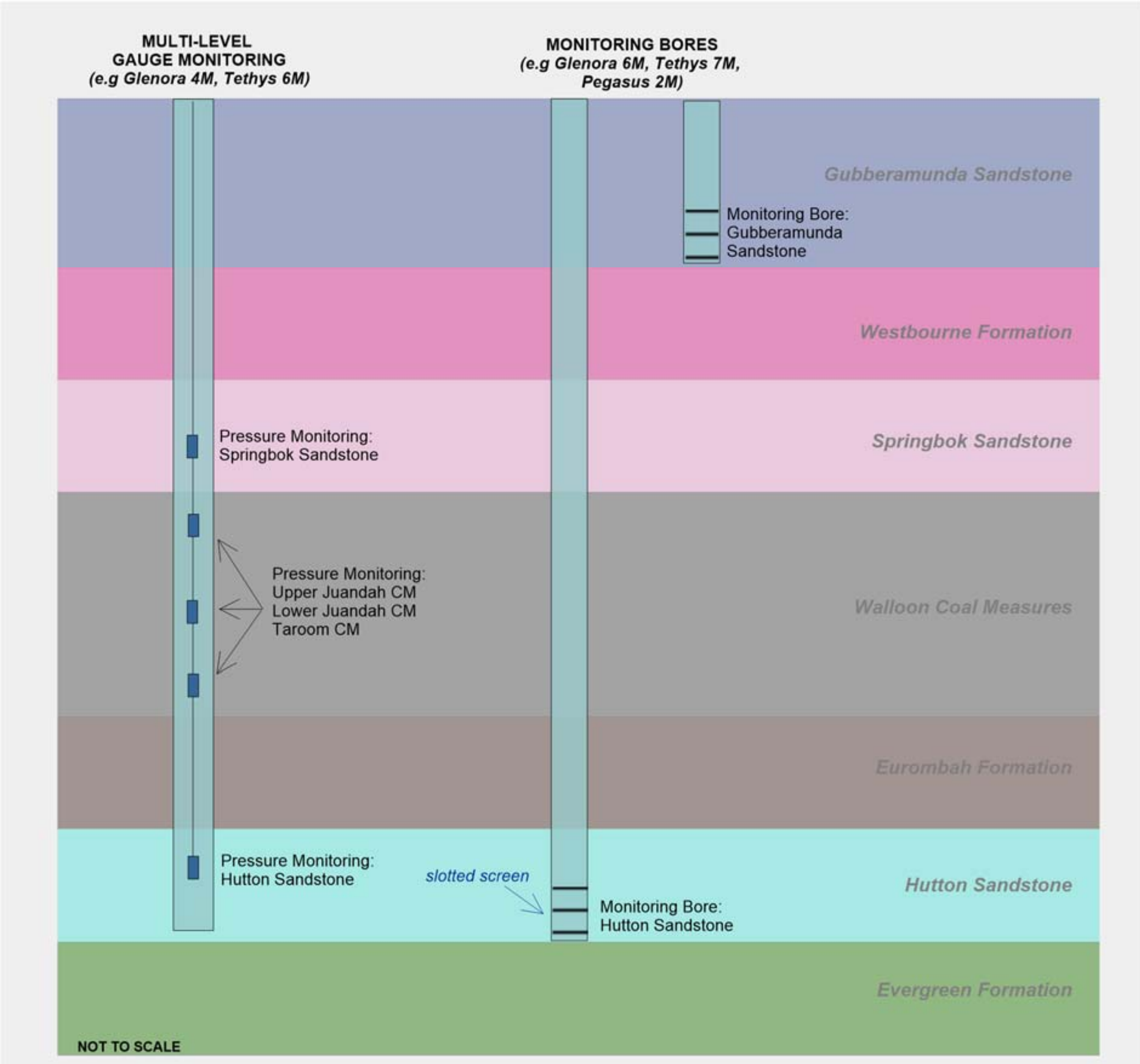

Figure 4-2: Schematic of Monitoring Facility Types

4.2.3 Spring Monitoring

The Spring Ridge Complex is located within the Rhea development block of the WSGP. The spring is considered to be associated with a perched aquifer within the Gubberamunda Sandstone. There are no impacts predicted at this spring complex, however to verify the groundwater model predictions, monitoring bore Tethys-7M will be installed in the Gubberamunda Sandstone, to the south of the complex (see Figure 4-1).

4.2.4 Landowner Bore Monitoring

Senex are required as part of the Surat CMA UWIR WMS (under the *Water Act 2000*) to undertake baseline assessments for 126 bores within the WSGP area. To date, baseline assessments have been carried out for 89 bores during 2015 and 2016. Following several attempts, Senex were unable to secure land access to assess the remaining 37 bores.

Should impacts to landowner bores be identified during the groundwater monitoring program (in accordance with the UWIR), Senex will negotiate a "make good" arrangement with the landowner of the impacted bore. Further details of this impact mitigation is provided in Section 4.5.1.

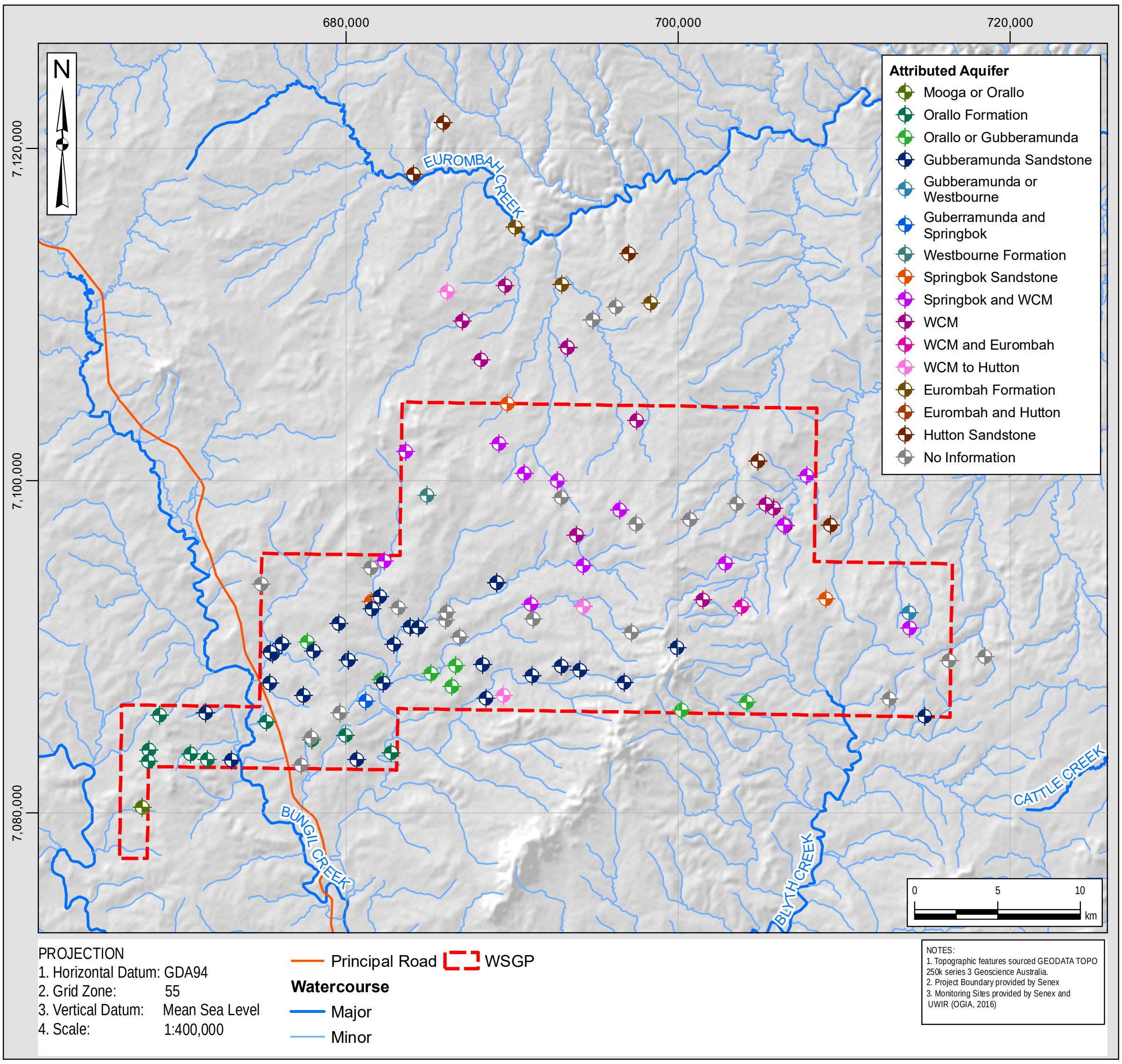

Figure 4-3: Baseline Assessment of Landowner Bores by Aquifer

4.3. Data Management and Analysis

4.3.1 Data Management

Data collected as part of the groundwater monitoring program is intended to be collated and stored in a database. The database may include but not limited to the following information:

- Monitoring facility location details, aquifer and construction information;
- Landowner bore monitoring information from baseline assessments and the landowner bore monitoring program;
- Groundwater elevation monitoring data, as metres below ground level (mbGL) and metres above the datum (mAHD);
- Groundwater quality sampling results, including field measurements and laboratory analysis;
- Stratigraphic information;
- Relevant CSG production data; and
- Climate data, including barometric pressure and rainfall.

4.3.2 Analysis of Monitoring Data

Senex have developed a procedure for review and analysis of groundwater monitoring data. Figure 4-4 presents the flow chart for the data review process which will be undertaken on receipt of the data.

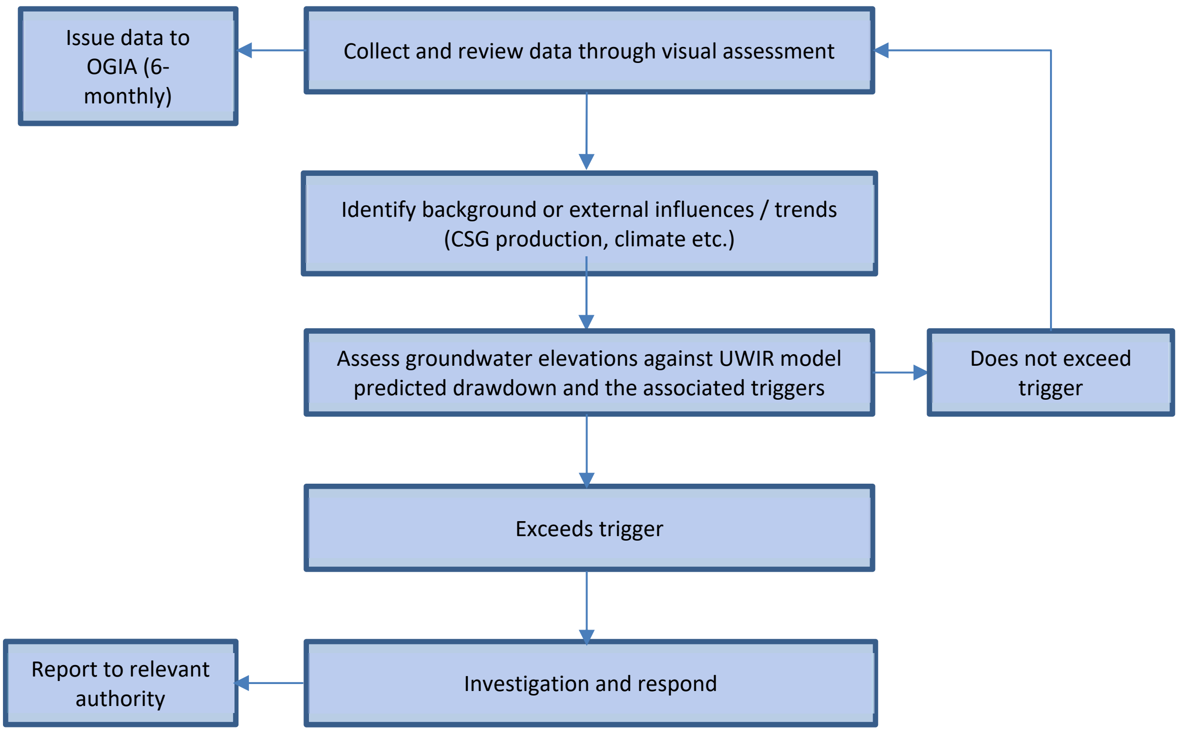

Figure 4-4: Groundwater Monitoring Data Analysis Procedure

A summary of each of the stages in the flow diagram is provided in the following:

- **Collect and review data**

  Data will be collected / downloaded and reviewed by a hydrogeologist. Data will be reviewed through a visual assessment of the groundwater elevation hydrographs and any data quality issues will be identified.

- **Identify background or external influences / trends**

  Groundwater elevations can be influenced by several factors, which can cause fluctuations and trends in groundwater elevations, both on a short-term (daily) or long-term (years or decades) scale. These can include:

  - Changes in barometric pressure;
  - Recharge following large precipitation events (short term);
  - Longer term climatic response, such as wet / dry seasons as well as periods of drought or consecutive years of above average rainfall which overprint on season to season conditions;
  - Response to groundwater pumping; and
  - Response to aquifer repressurisation.

  These potential influences will be considered in conjunction with CSG water production volumes and CSG production well commissioning, when reviewing groundwater monitoring data to determine trends associated with CSG production.

- **Review and access groundwater elevations against UWIR model predictions and determine if trigger limit has been exceeded**

  Review groundwater elevations against the UWIR model predictions and WSGP trigger limits, which have determined the impacts to groundwater-dependent assets within the vicinity of WSGP. Further discussion related to this part of the process is provided in Section 4.4.

- **Initiate investigation and response procedure and reporting**

  If the groundwater monitoring data indicates that the trigger has been exceeded, Senex will initiate their investigation and response procedure and report to the relevant authority (e.g. DEHP or DoEE). Further discussion is provided in Section 4.5.

4.4. Groundwater Monitoring Triggers

Triggers have been developed to provide for the early-warning of unpredicted impacts to groundwater dependent assets in the vicinity of the WSGP. The early-warning of impacts specifically relates to a deviation from the groundwater level decline predicted as part of the UWIR model.

Drawdown predictions at the monitoring locations from the UWIR model are presented in Figure 4-5 and Figure 4-6.

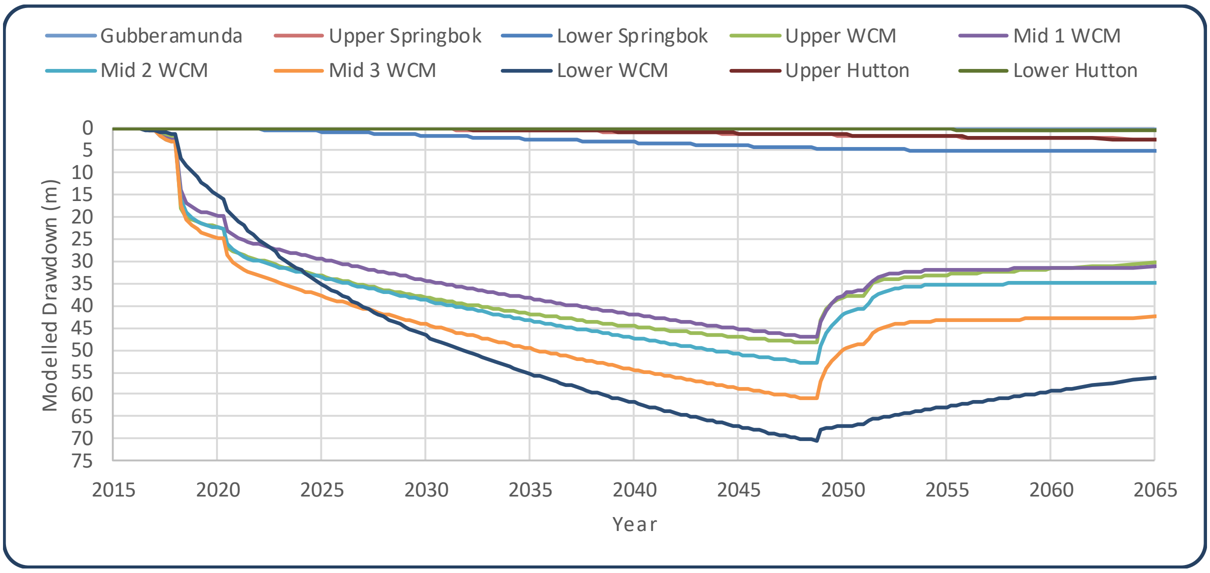

Figure 4-5: Predicted Drawdown at Glenora-4M/6M

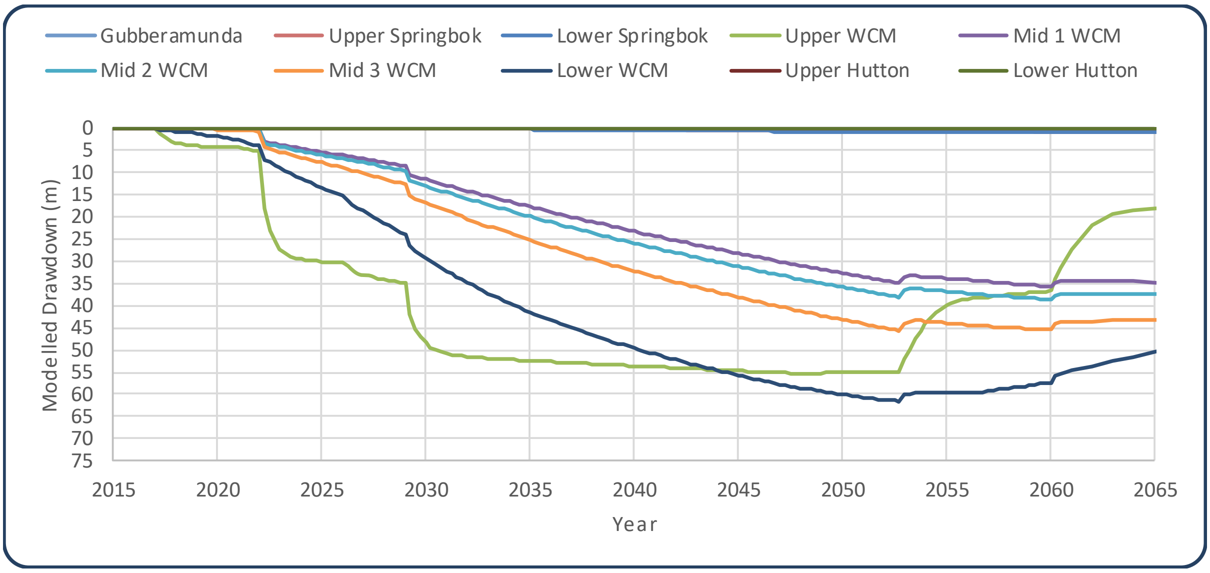

Figure 4-6: Predicted Drawdown at Tethys-6M/7M

A comparison of modelled drawdown versus actual drawdown will be undertaken by the Senex Hydrogeologist, and based on a review of the results the following triggers will be assessed; and if triggered further investigation will be undertaken.

- Where the monitored groundwater level drawdown at the monitoring site exceeds the UWIR modelled drawdown.
- Where the rate of drawdown at the monitoring site is greater than the rate of the modelled drawdown.
- Where there is change in the rate of drawdown from the previous year.

Modelled drawdown used for comparison will be updated as new predictions become available from OGIA.

4.5. Investigation and Response

Where the groundwater monitoring data indicates that a defined trigger has been exceeded, an investigation will be undertaken.

The investigation will involve determining the cause of the deviation and assessing both the significance and consequence in relation to water-dependent assets. This may include the following:

- Hydrogeological characterisation of the area, including identification of information and knowledge gaps;
- Identification of the potential impacts; and
- Risk assessment.

The investigation outcome will determine the appropriate course of action, which may include:

- Continue with monitoring at the current frequency;
- Continue with monitoring at an increased frequency;
- Modification of operations;
- Stakeholder consultation; and
- Make good arrangements.

4.5.1 Make Good Arrangements

The *Water Act 2000* outlines requirements for make good obligations of a resource tenure holder for a bore located in immediately affected areas. Tenure holders must carry out a bore assessment and enter into a make good agreement with the bore owner if the bores are located within an immediately affected area. The UWIR assigns bores to tenure holders located within immediately affected areas.

As indicated in Section 3.3, Senex do not currently have any make good obligations under the UWIR. Senex will comply with any updates to the make good agreements required in future updates of the UWIR, and undertake bore assessments as required as a result of make good obligations.

Senex will also respond to any complaints made from landowners in relation to potential unanticipated impacts. This will be undertaken through a bore assessment to establish whether a water bore has an impaired capacity, or is likely to have an impaired capacity, as a result of the WSGP. The bore assessments will be undertaken in accordance with the DEHP *'Bore Assessments Guideline'* (DEHP 2017b) as presented in Figure 4-7.

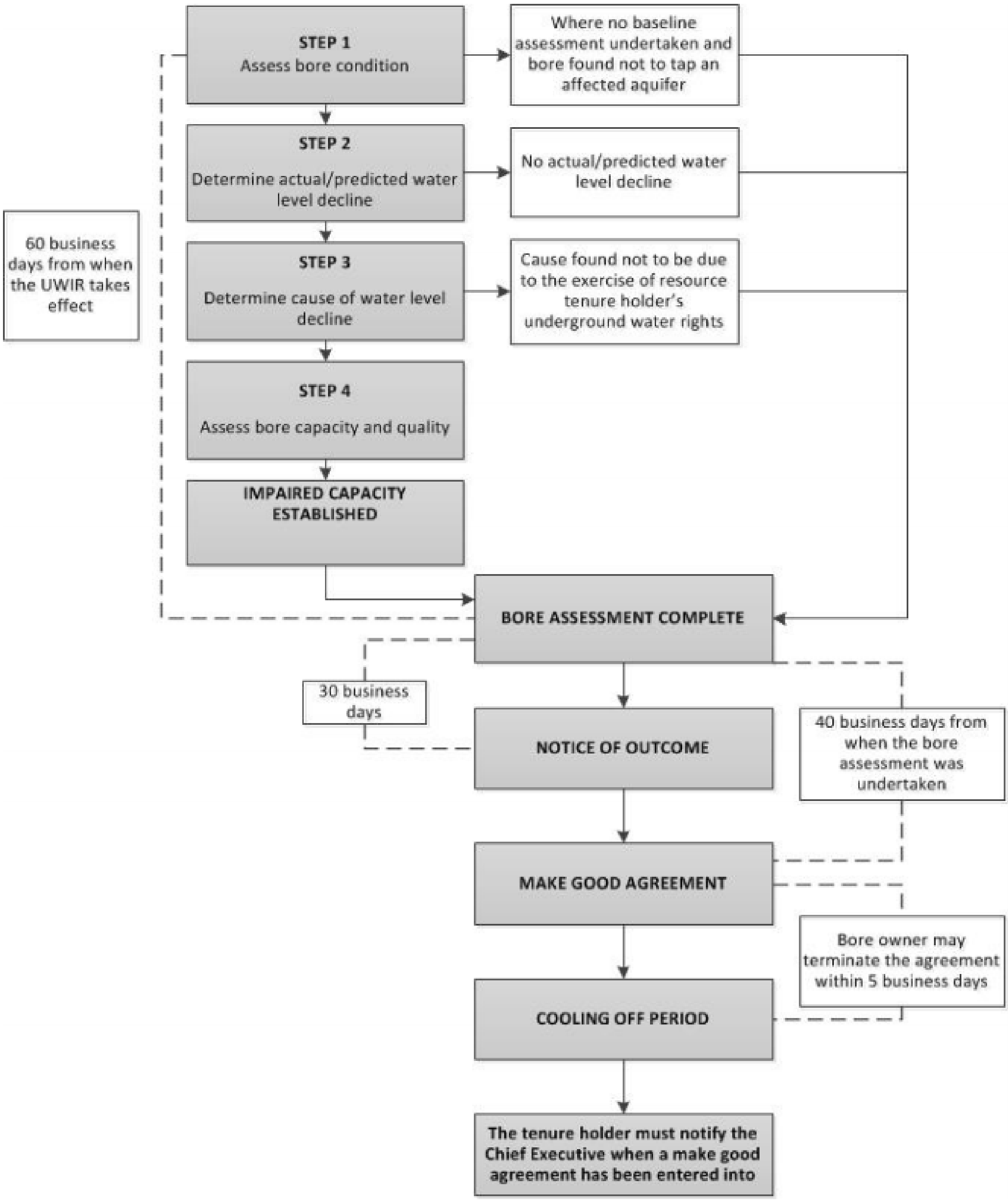

Figure 4-7: Process for Undertaking a Bore Assessment for Water Level Decline (after DEHP 2017b)

5. PETROLEUM HYDROCARBON MONITORING

A hydrocarbon monitoring program will be developed and implemented to identify and measure total petroleum hydrocarbons[4] in pre-treated produced water. The monitoring program will commence from the commencement of the production well drilling program and include:

- monthly monitoring of pre-treated produced water
- details (including GPS coordinates) of the monitoring locations for collecting representative samples
- details of the methods used to identify and analyse total petroleum hydrocarbons
- determining water quality criteria (trigger levels) for total petroleum hydrocarbons for authorised uses using treated produced water, and the justification for the water quality criteria. This will include a risk assessment undertaken with regards the proposed beneficial use.
- measures for addressing exceedances to ensure that beneficial re-use of aggregated produced water is fit for purpose.

Data collected during the monitoring program will be analysed and provided to the DoEE. The first round of monitoring will be provided once analysed, with subsequent data provided as part of the annual compliance reporting.

6. FUTURE RESEARCH AND REPORTING

6.1. Future Research

To develop further understanding of the hydrogeological conditions within the tenure, Senex will remain involved in any further assessment of the available geological information and may be updated as more geological information becomes available through drilling of CSG production wells.

Senex will provide the findings of relevant research to OGIA for incorporation into the next revision of the Surat CMA UWIR, which is due for publication in 2019.

6.2. Reporting

Senex will report to the government in accordance with:

- Relevant conditions and approvals issued by DoEE and DEHP; and
- UWIR requirements, related to the WMS, including monitoring network implementation and required data on a six-monthly basis.

Additionally, Senex will undertake groundwater assessments, and other hydrogeological studies to enhance knowledge, and make them available as required.

[4] means C10 – C14 fraction, C15 – C28 fraction and C29 – C36 fraction

This CWMMP will be reviewed and updated as new information becomes available. This will include an update based on the next revision of the Surat CMA UWIR and any modelled drawdown predictions.

7. REFERENCES

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