Surat Gas Project Water Resource Monitoring and Management Plan

Flood Risk Assessment

SGP Water Resource Monitoring and Management Plan

Flood Risk Assessment

Revision history

Revision	Revision Date	Revision Summary
1	26 June 2025	Initial Issue

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1 Introduction

This document has been prepared to provide flood risk management information supporting the Surat Gas Project (SGP) Water Resource Monitoring and Management Plan (WRMMP). In particular, this document summarises information addressing EPBC 2010/5344 (as varied 27 February 2025) approval condition:

- **17A(j):** *A flood risk assessment for processing facilities and any raw co-produced water and brine dams, which addresses flood risks to the environment from the action in the case of a 1:1000 ARI event. The risk assessment should estimate the consequences if major project infrastructure was subject to such an event, including release of brine and chemicals into the environment.*

This document includes:

- An overview of the flood risk assessment requirements.
- Arrow's proposed gas processing and produced water infrastructure footprints and approximate locations.
- Arrow's overall approach to flood risk assessment and management.
- Flood risk characterisation and model predictions of land inundation based on a 1,000 year average recurrence interval (ARI) event.
- A flood risk assessment and statement of Arrow's commitment to risk elimination.
- An outline of further risk assessment steps (such as the assessment of brine and chemical release) that may be taken where the preferred approach of risk elimination cannot be achieved.

The document includes relevant information from the SGP Stage 1 Coal Seam Gas (CSG) Water Monitoring and Management Plan (WMMP) (Arrow Energy, 2018), the SGP Updated WMMP (Arrow Energy, 2019), and information / data collected since the SGP Updated WMMP was approved (22 November 2019).

2 Arrow Development Plans

The SGP is initially expected to comprise eight gas drainage areas (DAs) with each DA incorporating wells, a water gathering network, a gas gathering network and a central gas processing facility (CGPF). Four properties have been identified for gas processing and produced water infrastructure for the initial development comprising DAs 2, 7, 8 and 9. The properties have been identified as CGPF2, CGPF7, CGPF8 and CGPF9 (Figure 2-1). Further properties may be identified for the remaining DAs, as planning progresses.

Three types of production facilities may be required for each DA:

- Field compression facilities (FCF) will provide between 30 and 60 TJ/day of gas compressed to 1,000 kPa for production wells that are located within a 12-km radius of the facility. Field compression facilities may be located between wells and larger production facilities where wellhead pressure is not sufficient to transport to the larger production facilities. If required, the approximate footprint of a field compression facility is 100 m x 50 m.
- Central gas processing facilities (CGPF) will receive gas from both low and medium-pressure gathering systems. These facilities will dehydrate and compress between 30 and 150 TJ/d of gas to 10,200 kPa using electrically driven compressors before transporting the gas to market. A water transfer station comprising a water transfer dam and pumping station will be located at each central gas processing facility. The water will be transferred to a water treatment and storage facility located at or near an integrated processing facility (see below). The approximate footprint of a central gas processing facility is 600 m x 250 m.

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- Integrated processing facilities are central gas processing facilities (gas dehydration and compression, and power generation) and coal seam gas water treatment and storage facilities. The approximate footprint of an integrated processing facility is 800 m x 250 m for plant and associated buildings, and between 1 km^2 and 2 km^2 for water storage.

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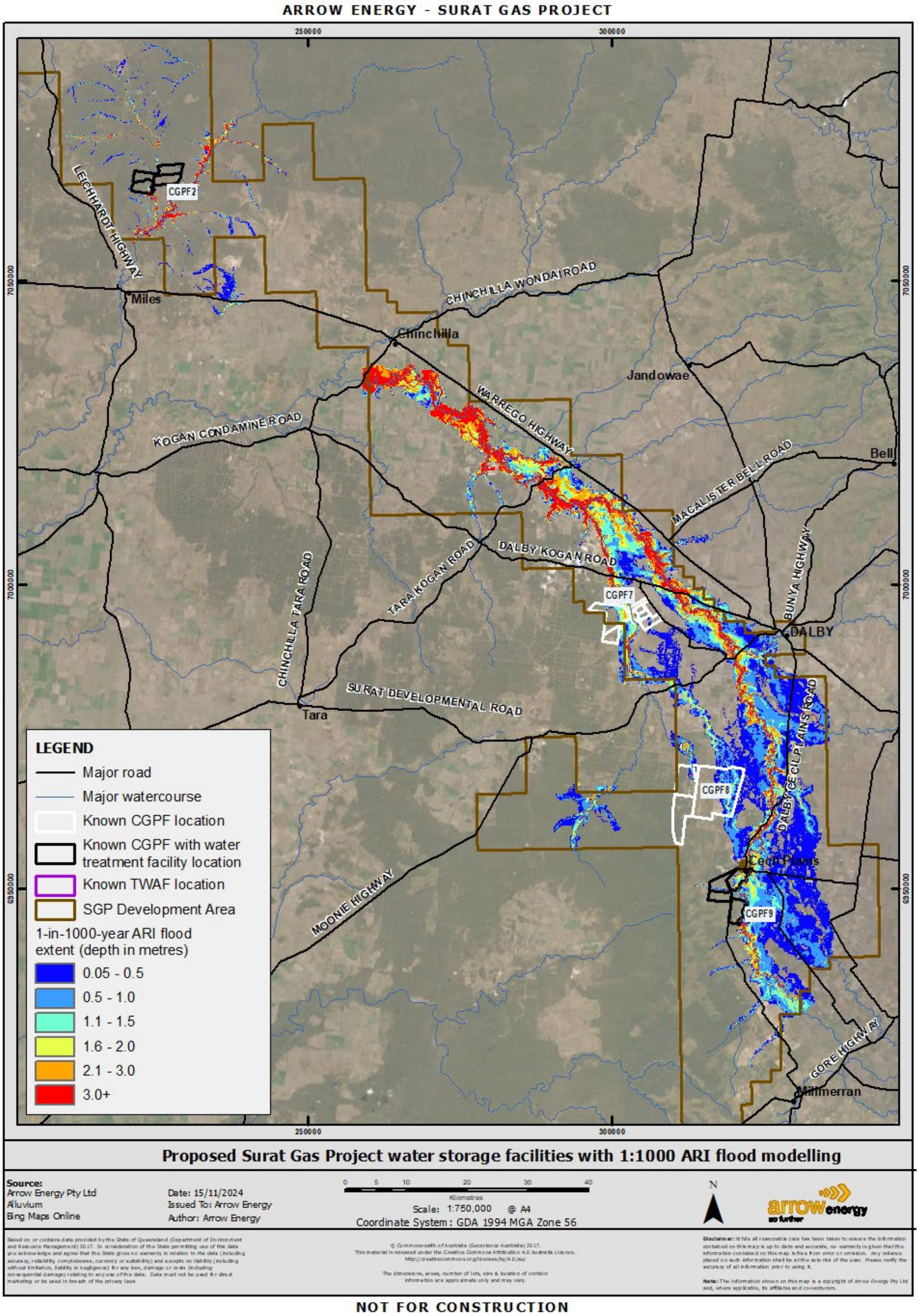

Figure 2-1 Overview of Arrow Energy's SGP with 1:1000 ARI flood modelling

3 Flood Risk Assessment

3.1 Risk assessment methodology

Arrow will apply a hierarchy of controls when managing flood risks posed to major gas and produced water infrastructure (Figure 3-1). This section presents the hierarchy of controls and the risk assessment approach.

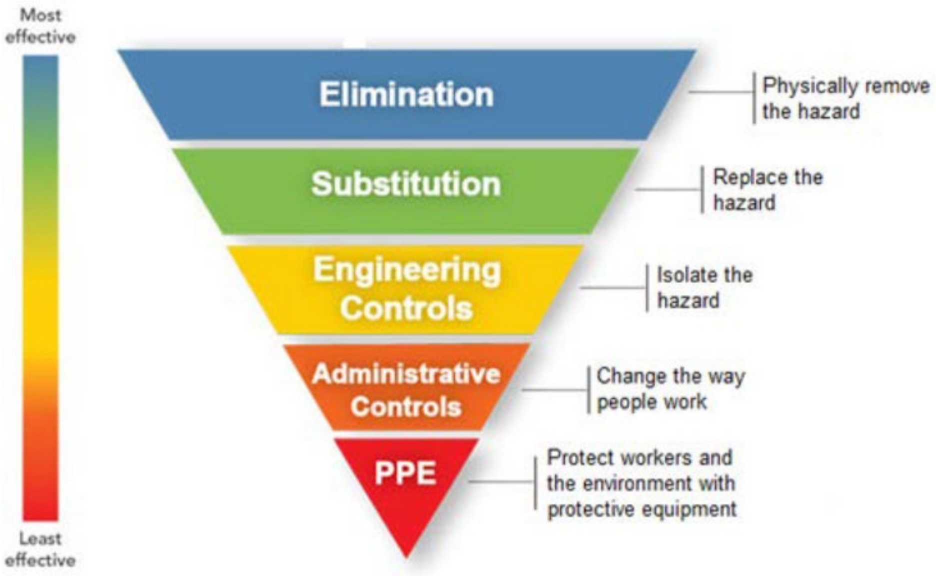

Figure 3-1 Hierarchy of controls

Arrow's approach to the management of flood risks within their tenement areas is based on:

1. **Hazard elimination**: Model the 1,000 year ARI event and seek to locate infrastructure outside of the mapped inundation area. Where major infrastructure is located outside of the mapped inundation area the hazard is deemed to have been eliminated and no further risk assessment is required.
2. **Substitution**: There are currently no alternatives to the gas processing and co-produced water infrastructure and gasfield layout proposed by Arrow. Substitution is not currently a feasible control option.
3. **Engineering controls**: Where gas processing and co-produced water infrastructure cannot be located outside the 1,000 year ARI flood extent:
   a. Demonstrate, using modelling, that infrastructure siting will minimise the potential for changes to overland flow paths resulting in adverse impacts to neighbouring properties;
   b. Design and operate the structures to withstand, as far as practicable, bank erosion and failure caused by flood waters eroding structure embankments;
   c. Design and operate the structure to the relevant standards with sufficient freeboard to minimise the potential for overtopping, causing bank erosion and failure from within;
   d. Model dam failure including brine fate and transport in the event of failure during a flood event; and
   e. If required, identify appropriate mitigation informed by additional impact assessment which identifies the consequences of brine/chemical release to the environment.
4. **Administrative controls**: Where engineering controls do not provide sufficient mitigation of flood risks additional administrative controls may be applied. Administrative controls may include

monitoring of storm warning systems and adopting management controls that reduce the risk of infrastructure failing or malfunctioning in major storm events.

3.2 Data inputs

The flood risk assessment relies on a range of inputs and third party studies which were reviewed in the development of this memorandum. Key documents that supported the flood risk assessment are summarised in Table 3-1.

Table 3-1 Documents reviewed

Reference	Title / Comment
Worley Parsons, 2013	Surat Gas Project – Concept Select Studies. Surat Basin Design Flood Modelling. Report prepared for Arrow Energy, September 2013, by Worley Parsons detailing flood modelling work undertaken for the Arrow tenement areas including 1,000 year ARI modelling. Report serves currently as the basis for assessing flood risk in development areas.
Coffey Environments, 2013.	Supplementary Groundwater Assessment. Appendix 4 to the Arrow Energy Surat Gas Project Supplementary Report to the EIS. Appendix 4 to the Arrow Energy Surat Gas Project Supplementary Report to the EIS, June 2013. Report provides updated summary of Arrow's infrastructure development plans.
Alluvium, 2013	Surat Gas Project – Supplementary Report to the Environmental Impact Statement. Appendix 5: Supplementary Surface Water Assessment Part A – Geomorphology and Hydrology. Report presents findings of previous flood modelling work completed for the development areas.
Arrow, 2012	Surat Gas Project – Environmental Impact Statement. Surface water chapters provide baseline assessment of surface water environment and potential project impacts.
Department of the Environment, 2013	Approval - Surat Gas Expansion Project (EPBC 2010/5344). Sets out project approval conditions including the requirement for flood risk assessment.

3.3 Flood risk characterisation

Flood modelling was completed by Worley Parsons (2013) and this forms the basis of flood risk characterisation across the Arrow tenements. This section presents a summary of the Worley Parsons (2013) flood modelling results and provides commentary on their suitability to address the requirements of Condition 17A(j).

3.3.1 Simulation of flood events

WorleyParsons (2013) details the hydraulic and hydrologic modelling work undertaken to produce a series of flood maps across Arrow's development areas in the Surat Basin. Flood levels, extents of inundation, maximum depths and velocities of floodwaters for the 50, 100, 500 and 1,000 years ARI flood events were simulated along prominent drainage lines within Arrow tenements.

Flood modelling comprised the following key elements:

- Flood frequency analysis using Department of Natural Resource Management (DNRM) streamflow data to derive regional flood frequency relationship for ungauged locations.
- Watershed bounded network model (WBNM) rainfall-runoff models for the Condamine River catchment and other prominent tributary creek catchments in the lower Condamine River basin to generate flood flows.
- TUFLOW (two-dimensional unsteady flow) hydraulic models to determine flood levels, extents, depths and flood water velocities.

Recent recorded flood events in 2010, 2011 and 2013 were simulated in the WBNM and TUFLOW model. These events correlated with 50 year ARI and 100 year ARI events. Model outputs were compared to the actual measured DNRM level and flow data. Worley Parsons (2013) concluded that the modelled and measured flood events showed relatively good correlation and were considered to validate the models reliability. Worley Parsons identified that there was significant overestimation of the peak water level at Chinchilla. The reason for this level difference was not resolved, but may be associated with the level of refinement of the terrain data in the area. It is considered that the overestimation of water level adds a conservative bias to the modelled predictions.

It is noted that some smaller tributaries have not had specific flows estimated for storm events which may add uncertainty to the modelled flood extent in these less significant drainage features.

3.3.2 Results

The TUFLOW hydraulic modelling predicted extents of inundation on the Arrow tenements for 1,000 year ARI flood events, as well as floodwater depth and maximum velocity.

The predicted 1,000 year ARI flood extent and depths produced by Worley Parsons (2013) have been applied by Coffey to the Arrow tenements and are presented in Figure 2-1. Detailed flood extent and depth maps are provided in Figure 3-2 and Figure 3-3. The Worley Parsons (2013) assessment concluded:

- Extents of inundation are typically less than 300 m wide along minor drainage lines, up to 1 km wide along major tributary streams and up to 15 km wide along the Condamine River in the 1,000 year ARI flood event.
- Modelled inundation extents in the upper and middle reaches of the Condamine River were noted to be less expansive than previously determined by Alluvium (2013). Earlier flood extents were derived from a coarse model that yielded peak flood levels 0.6-1.1 m higher than the recorded peak levels.
- The 100 year ARI modelled flood extents were compared to recorded historical flood events in recent years for the modelled watershed areas of the lower Condamine River, Charleys Creek, Dogwood Creek and Juandah Creek catchment areas. Worley Parsons (2013) concluded that results showed good correlation in these areas.
- The sensitivity analysis completed as part of the Worley Parsons (2013) study found that the model was not overly sensitive to floodplain roughness and tailwater boundary conditions (the two model parameters assessed). Sensitivity analysis found that variation of these modelling parameters led to a 0.1 m to 0.2 m rise in peak 1,000 year ARI flood levels.

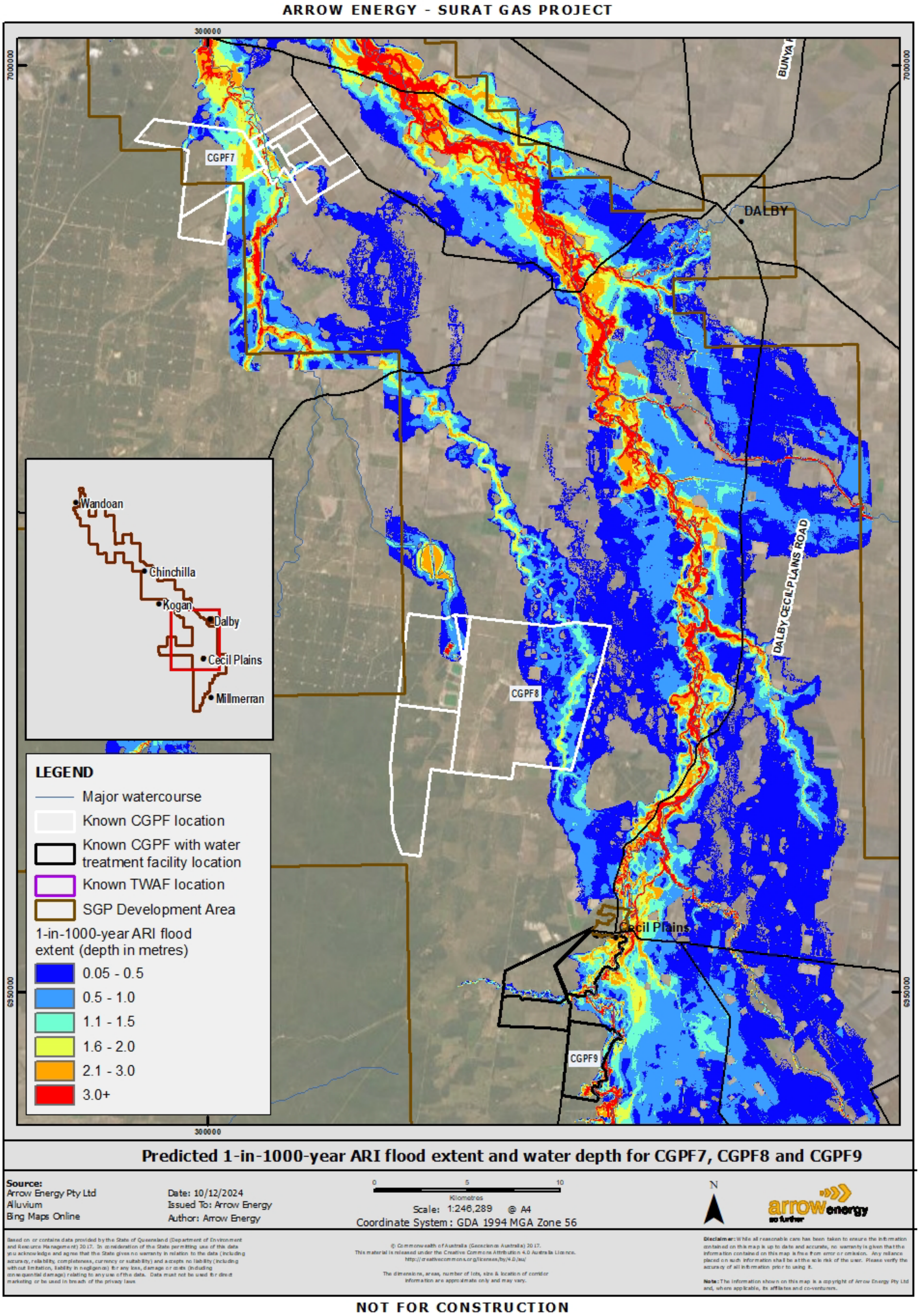

Figure 3-2 Predicted 1-in-1000-year ARI flood extent and water depth for CGPF7, CGPF8 and CGPF9

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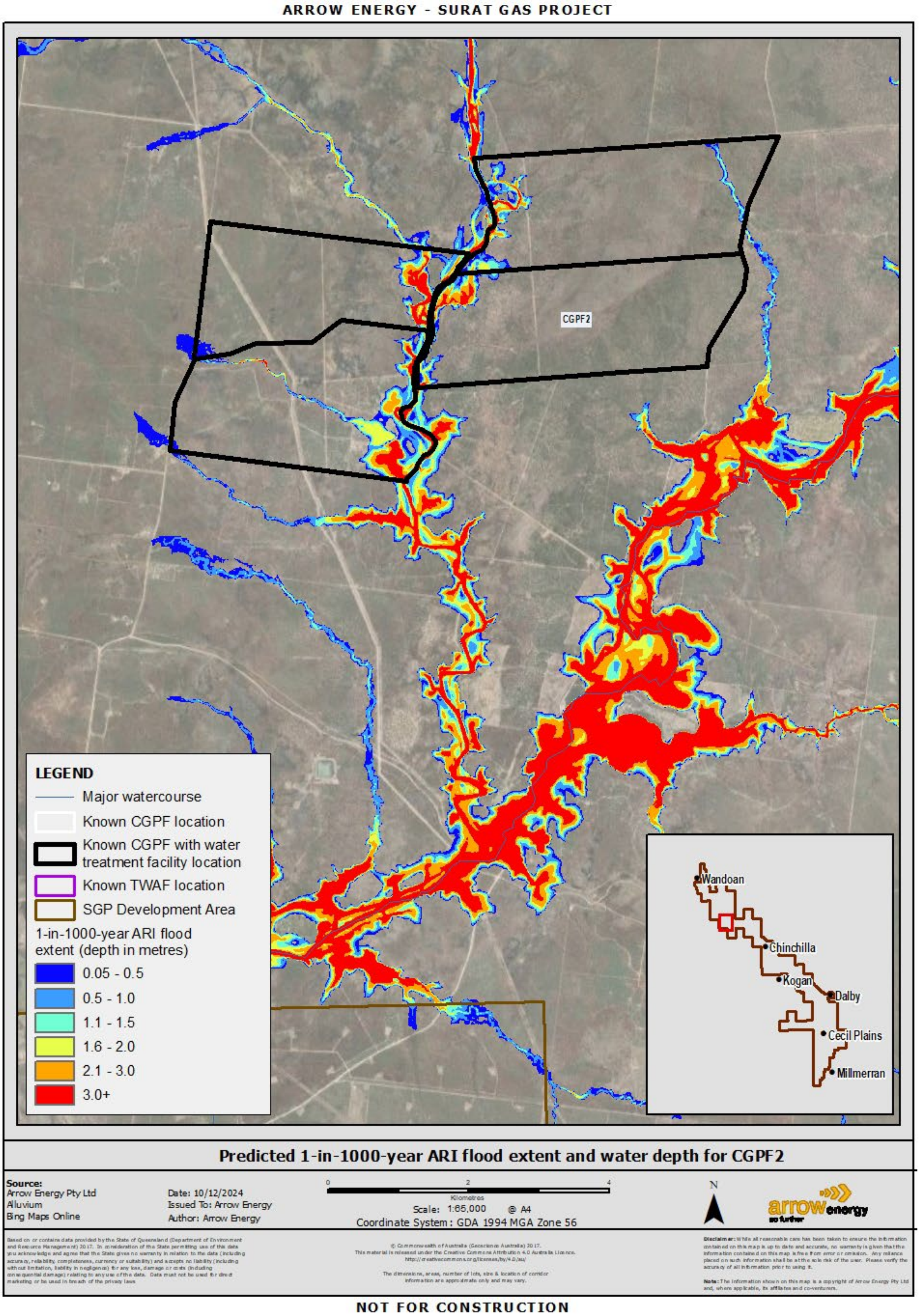

Figure 3-3 Predicted 1-in-1000-year ARI flood extent and water depth for CGPF2

3.3.3 Model considerations

Flood design event

Buildings and structures susceptible to inundation, or which might impede or change overland flow behaviour. The default flood level adopted is typically a 100 year ARI event, and Western Downs Regional Council (which encompasses the SGP) publishes 100 year ARI flood maps. Council notes that higher flood levels have occurred and may occur. The Chinchilla Shire Planning Scheme of the Western Downs Regional Council nominates the maximum recorded flood as the reference flood level for siting and designing buildings and structures in the rural zone. Due to uncertainty in hydraulic models, Australian best practice also recommends a 500 mm freeboard for planning purposes[1].

Condition 17A(j) requires that flood risks posed to Arrow's processing facilities and raw co-produced water and brine dams be assessed based on a 1 in 1,000 year ARI event. It is recognised that a 1 in 1,000 year ARI event is significantly more conservative than the Council's general planning and construction approach. Consistent with this, Worley Parsons (2013) also recommended adopting a 500 mm freeboard for siting major SGP infrastructure.

The Australian Rainfall and Runoff (ARR) Guidelines categorise frequency of occurrence of flood events based on design rainfalls (Figure 3-4). A 1,000 year ARI (0.1% probability) is a rare event, approaching Probable Maximum Flood. It typically results in substantially higher flood levels than in a 100 year ARI event. Worley Parsons (2013) noted that 100 year ARI flood levels were up to 300 mm higher than 50 year ARI levels, and 1,000 year ARI levels were 750 mm to 1,000 mm higher than 100 year ARI levels.

The adoption of the 1,000 year ARI event flood level (without additional freeboard) for siting major infrastructure is intrinsically conservative, when compared with the standard Council planning approach (100 year ARI level plus 500 mm freeboard). Accordingly, it is considered an appropriate level for siting infrastructure where elimination of the hazards posed by flooding.

Flood frequency analysis

Typically, streamflow data can be used to estimate flood quantiles within the range of approximately twice the length of the available record. Based on the maximum available 92 year record of streamflow data at the Chinchilla station, at-site flood frequency analysis of an ARI event greater than 1 in 200 years would typically be beyond the statistical reach of the dataset. Worley Parsons' flood model was calibrated with the same 92 year record and used to predict flood inundation extents for a 1 in 1,000 year ARI event. Therefore, Worley Parsons' (2013) flood modelling predictions, while highly conservative compared to typical planning guidelines, contain a degree of calibration uncertainty which cannot be avoided when meeting the requirements of Condition 17A(j).

[1] As defined in Appendix K, Floodplain Development Manual, NSW Department of Infrastructure, Planning and Natural Resources, June 2005; as cited in Section 3.2 of Queensland Flood Commission of Inquiry, Brisbane River 2011 Flood Event - Flood Frequency Analysis, Final Report, September 2011.

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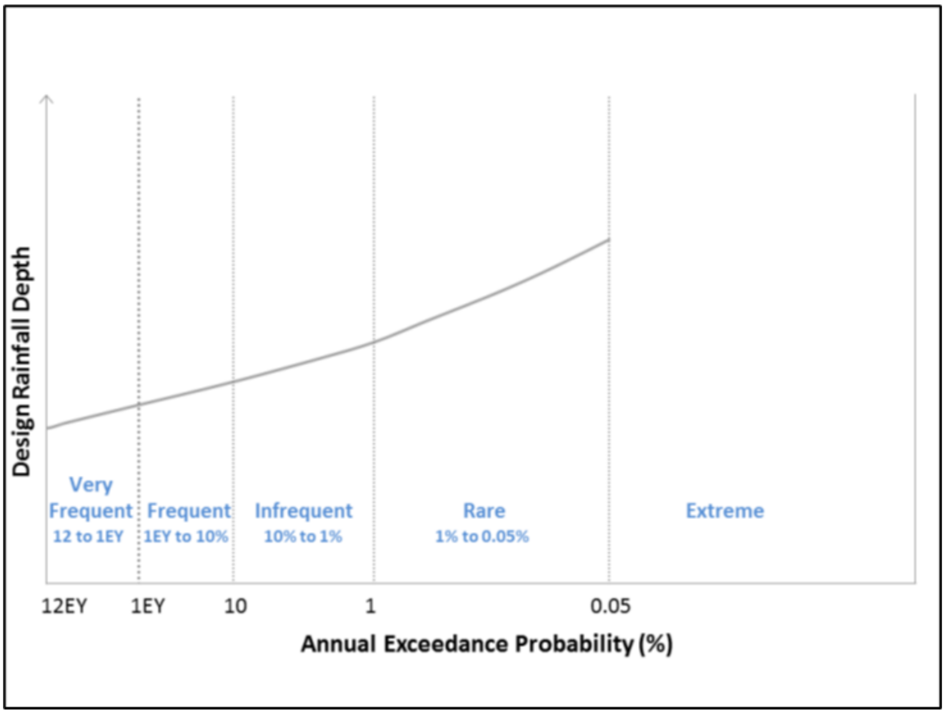

Figure 3-4 Classes of design rainfalls (source: Ball et al, 2016[2])

Baseflow and model calibration

It is noted that the Worley Parsons (2013) flood model report does not describe the consideration of baseflow contributions to the gauged data record during model calibration. Because the WBNM flood hydrograph model does not account for baseflow, typically the baseflow component is removed from the observed hydrograph record in order to make a valid comparison with model predictions, and a reliable calibration.

If baseflow was not removed during calibration the loss rates adopted to achieve calibration may have been underestimated. This, in turn, has resulted in very low design loss rates adopted during the flood modelling. While the overall effect of adopting very low loss rates cannot be quantified by Coffey, it is expected to have resulted in conservative (higher) peak flood levels.

Critical storm duration

Flood characteristics vary under different intensity-frequency-duration conditions. The current modelling approach was based on a 72 hour storm duration with design rainfall data estimated using statistical approaches including the Bureau of Meteorology (BOM) design rainfall calculator.

It is recognised that variability associated with storm duration has not been assessed and is a noted uncertainty, however the approach is consistent with the Australian Rainfall and Runoff (ARR) guidance, and the CRC-FORGE method.

[2] Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors) (2016). Australian Rainfall and Runoff: A Guide to Flood Estimation, (Geoscience Australia), 2016

Flood modelling of smaller tributaries

We note that some smaller tributaries have not had specific flows estimated for storm events which may have some influence on actual flood extents in some locations.

Whilst large areas of Arrow's tenements are unlikely to be unaffected by a 1 in 1,000 year ARI event, flood characteristics of minor tributaries have not been specifically addressed and is a recognised uncertainty that requires further consideration.

3.4 Flood risk assessment results

3.4.1 Hazard elimination

An assessment of available land within Arrow tenements that is outside of the mapped 1,000 year ARI flood extent was made and compared with water and gas processing infrastructure footprints (where known/currently proposed). Results of this assessment are presented in Table 3-2.

As the proposed infrastructure is yet to be confirmed, this assessment conservatively assumes that each drainage area location is capable of hosting an integrated processing facility. The final development concept is not, however, expected to include an integrated processing facilities in each area.

In the hierarchy of risk management, the preferred approach is to eliminate the hazard, and this assessment indicates that there is sufficient land available outside the predicted 1,000 year ARI flood extents for major project infrastructure.

Arrow plans to locate all major infrastructure outside of the flood inundation zone, and accordingly the hazards associated with the 1,000 year ARI will be eliminated. Therefore further assessment to meet Condition 17A(j) will not be required.

Where major infrastructure is to be located in close proximity to the 1,000 year ARI flood inundation zone, and also in close proximity to smaller drainage features with no mapped flood inundation risk, Arrow will conduct further investigations that may include site-based flood modelling. This approach seeks to address any local scale uncertainty that may exist in the regional modelling.

Table 3-2 Estimated land outside flood extent compared to proposed infrastructure footprint

Drainage area and property	Proposed infrastructure and footprint	Available land outside inundation zone	Assessment against flood mapping
2 / CGPF2	Integrated processing facility 800 m x 250 m, plus up to 2 km2 for water storage 20 ha plus 200 ha; 220 ha in total	2,208 ha	The property identified as CGPF2 has limited exposure to mapped flooding extents. Three large areas of land are located outside of the flood inundation extents: south-west (300 ha), north-west (630 ha) and east (1,164 ha). All three areas present feasible options for the integrated processing facility.
7 / CGPF7	Integrated processing facility	2,700 ha	The property identified as CGPF7 straddles Wilkie Creek. The parcels of land on the west side of the creek experience significant inundation in the area

Drainage area and property	Proposed infrastructure and footprint	Available land outside inundation zone	Assessment against flood mapping
	800 m x 250 m, plus up to 2 km2 for water storage 20 ha plus 200 ha; 220 ha in total		immediately adjacent to the creek, and the smaller tributary. Overall, a significant area of land (2,700 ha) lies outside the flood extent, towards the eastern and western boundaries of the property. Flood extents divide the available land into five parcels, all of which are of sufficient size for the integrated processing facility.
8 / CGPF8	Integrated processing facility 800 m x 250 m, plus up to 2 km2 for water storage 20 ha plus 200 ha; 220 ha in total	8,175 ha	The property identified as CGPF8 experiences shallow flooding across the eastern third of the land from a flood runner that connects the Condamine River and Wilkie Creek. 6,600 ha of land across the remaining property is outside of the 1,000 year ARI flood extent. This land comprises three contiguous parcels that offer several options for the integrated processing facility.
9 / CGPF9	Integrated processing facility 800 m x 250 m, plus up to 2 km2 for water storage 20 ha plus 200 ha; 220 ha in total	2,367 ha	The eastern sections of the property identified as CGPF9 are predicted to be inundated up to depths of 2 to 3 m. Channel flow bisects the north-east parcel of the property which drains localised rainfall runoff. Land west of Millmerran-Cecil Plains Road is bisected by Crawlers Creek with a 300 m wide flood inundation area. Unaffected land to the north totals 620 ha and unaffected land to the south totals 586 ha. The shapes of both areas of unaffected land are likely to be suitable options for the integrated processing facility. Land east of Millmerran-Cecil Plains Road comprises two separate properties; north and south of Crawlers Creek. The southern property has approximately 690 ha of non-flood inundated land that is likely to provide a suitable option for the infrastructure. The northern property has approximately 300 ha of non-flood inundated land. The irregular shape of the land may not be suitable for the proposed integrated processing facility.
Unconfirmed	Field Compression Facility (FCF) 100 m x 50 m	Unconfirmed	While the need for FCFs has not been confirmed, this infrastructure may be required depending on wellhead pressures realised across the gas field. Unlike other gas processing infrastructure, FCFs may have less flexibility in their location.

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Drainage area and property	Proposed infrastructure and footprint	Available land outside inundation zone	Assessment against flood mapping
	0.5 ha		In the case where FCFs are required, and fall within the 1,000 year ARI event flood inundation zone, flood risks will be assessed further on a case by case basis applying the hierarchy of controls.

3.4.2 Engineering and administrative controls

Under the current development plan, no further controls are required as the flood risk hazards have been eliminated. Should final development plans change from the current, assessed approach, and identify that some infrastructure cannot be located outside the modelled 1,000 year ARI extent, further risk assessment will be conducted to develop suitable engineering and administrative controls.

This risk assessment process will be tailored to the specific scenario being assessed and may include one or more of the following elements:

- Additional flood modelling to determine potential impacts, inform design of the facilities and develop management measures for operation of the facilities;
- Demonstration, using numerical models, of the likely changes to overland flow paths and assessment of impacts to neighbouring properties; and
- Assessment of consequences if major project infrastructure was subject to a 1,000 year ARI event, including release of brine and chemicals into the environment.

The risk assessment process will drive the development of a range of specific engineering controls to mitigate the flood risks. Engineering controls may include:

- Development of infrastructure design and operating guidelines so that the potential for bank erosion and failure caused by flood waters eroding structure embankments is minimised;
- Design and operation of structures to relevant engineering standards with sufficient freeboard to minimise the potential for overtopping, causing bank erosion and failure from within; and
- Modelling of dam failure during a 1,000 year ARI flood event, including brine fate and transport. Where adverse impacts are indicated, further design elements/controls will be considered to provide adequate mitigation to reduce the impact of brine/chemical release to the environment.

Administrative controls may also be specified to supplement engineering controls. Administrative controls may include monitoring of storm warning systems and adopting management controls that reduce the risk of infrastructure failing or malfunctioning in major storm events.

Arrow will develop and implement site-specific stormwater management plans, as required by any Environmental Authority, around major infrastructure.

4 Conclusions

A condition of the Australian Government's approval for the SGP requires a WRMMP to be developed that addresses, amongst other things, the flood risk posed to gas processing and water treatment and storage facilities.

Flood Risk Assessment

This memorandum provides a risk assessment to address Condition 17A(j) of the Australian Government's approval of the SGP (EPBC 2010/5344).

A hierarchy of controls has been adopted when assessing and managing flood risks. In accordance with the hierarchy, elimination of flood risks by locating infrastructure outside of the 1,000 year ARI extent underpins Arrow's strategy to address Condition 17A(j).

Flood risk was characterised by modelling the 1,000 year ARI flood extent across the proposed development areas, and assessing whether major water treatment and storage infrastructure could be located outside of these extents. The risk assessment verified that Arrow's approach of hazard elimination can be achieved based on the currently proposed infrastructure and properties. As the hazard has been eliminated, no further risk assessment or controls are required. Should additional properties be identified for infrastructure siting, or infrastructure design refinement result in the need for additional footprint on the properties assessed as part of this study, Arrow will review and revise the hazard elimination assessment accordingly.

As flood risk is eliminated by siting dams and major infrastructure outside of the 1,000 year ARI flood extents, the risk associated with brine or chemical release caused by such an event is effectively mitigated.

Where final development plans determine that some infrastructure, including FCF's (if required), cannot be located outside the modelled 1,000 year ARI extent, further risk assessment will be carried out to develop suitable engineering controls and the WRMMP updated in accordance with the approval conditions. Key elements of the risk assessment include the assessment of impacts to overland flow regimes, and risks associated with dam failure including impact assessments based on modelling of raw water and brine release in the event of failure.

5 References

Arrow Energy, 2018. *Surat Gas Project Stage 1 Water Monitoring and Management Plan*, December 2018

Arrow Energy, 2019. *Surat Gas Project Updated Water Monitoring and Management Plan*, October 2019