SCIENTIFIC INQUIRY INTO
HYDRAULIC FRACTURING
IN THE NORTHERN TERRITORY

STRATEGIC REGIONAL ENVIRONMENTAL AND BASELINE ASSESSMENT

15

Chapter 15 Strategic regional environmental and baseline assessment

15.1 Introduction

The lack of adequate pre-development assessment and environmental baseline data is routinely cited as being one of the biggest environmental regulation and management-related issues associated with the shale gas industry in the US and with the CSG industry in Queensland.[1]

The need for robust baseline data has been emphasised and echoed in many of the submissions received by the Panel, during the community forums, and in various publications on hydraulic fracturing and extraction of shale gas.[2] Recommendation 4 from the 2012 Hunter Report specifically referred to the need for baseline water data,[3] and recommendation 15 from the 2015 Hawke Report referred to the need to "*strengthen long-term strategic land use planning so that environmental considerations and constraints - including threatened species impacts - are considered when strategic land use decisions are being made.*"[4]

Without adequate pre-development baseline information, the magnitude of any post-development change cannot be effectively predicted, or its impact assessed. Comprehensive regional baseline datasets are essential to underpin modelling of the possible impacts of any new industry and to inform the site-specific quantitative risk assessments that are being conducted by industry and being submitted to regulators for assessment.[5] The absence of robust baseline information not only negatively affects the ability of the industry, the Government, the community, and affected landholders to be able to strategically plan for the rollout of any onshore shale gas industry, it also impedes identification of key sensitivities in the regional context and to openly and constructively investigate and resolve issues that may arise as a result.[6]

The lack of an integrated strategic and coordinated approach to data collection over large geographic regions in which multiple industry players are involved can further result in inconsistencies between datasets, and therefore, prejudice the subsequent usefulness of such data for developing region-wide assessment and management models. An Australian example of where this has been effectively addressed for water-related data is provided by OGIA in Queensland, which was established to develop and house an integrated groundwater model for the Surat Basin and to provide an independent assessment of likely impacts. [7]

It has also been noted by the Panel (see Chapters 7 and 8) that there is generally poor spatial coverage of data on surface and groundwater characteristics and of both aquatic and terrestrial biodiversity in the regions of the NT most likely to be affected by any onshore shale gas industry. Based on evidence provided to the Panel, there is very limited understanding of the attributes and behaviour of surface waters and groundwater, or their relationship with aquatic or groundwater-dependent, or groundwater-influenced, ecosystems. Distributions of most species are known only in general terms, and there is very limited knowledge of geographic patterns of diversity and endemism and the dependence of that biodiversity on specific surface and groundwater resources. Such limited information on biodiversity assets and their location in prospective onshore shale gas development regions represents a significant knowledge gap, impeding the ability to properly assess the risks of any shale gas development (especially cumulative risks over large areas). It also reduces the ability to plan the location of infrastructure to avoid, or minimise, the risk of unacceptable impacts to local flora and fauna (both aquatic and terrestrial).

The Panel considers that it is essential that the key knowledge gaps identified in this Report be addressed prior to the granting of any further production approvals (see Chapter 16 and the Glossary). This knowledge is required before many of the required key risk assessments can be completed. The overarching framework for these assessments has been described by the Panel

1 US EPA 2016a; Jackson et al. 2013b; ACOLA Report; Queensland Gasfields Commission 2017a.
2 See, for example, Newfoundland and Labrador Report.
3 2012 Hunter Report.
4 2015 Hawke Report
5 Australian Department of the Environment and Energy 2017c.
6 Queensland Gasfields Commission 2017a.
7 Queensland Gasfields Commission 2017a, p 52.

as a 'strategic regional environmental and baseline assessment', or 'SREBA'. The purpose of a SREBA is to provide the information necessary for appropriate decisions to be made about the development of any onshore shale gas industry in the NT, including assessment of water and biodiversity resources, to inform land-use planning, and the collection of baseline data to provide a reference point for ongoing monitoring. In this Chapter, the scope of a SREBA is outlined, along with recommendations for its commencement and completion.

Recommendation 15.1

That a strategic regional environmental and baseline assessment (SREBA) be undertaken prior to the granting of any further production approvals.

15.2 Scope of strategic regional environmental and baseline assessment

The inclusion of the term 'regional' to describe the assessment is deliberate. This is because onshore shale gas plays typically extend over large areas that often include whole aquifer systems and large sections of river catchments, together with multiple social and cultural contexts. Only a regional assessment will provide the foundation for a planning framework for any development that gives certainty to both the gas industry and local and play-based communities, and which will achieve better environmental outcomes by addressing the potential for cumulative impacts across broad areas (for a discussion of area-based regulation, see Section 14.8.2 and ***Recommendations 14.21*** and ***14.22***).

Bioregional planning based on strategic assessment is widely recognised, including by the EPA,[8] as the most appropriate basis for limiting the impacts of regional development on biodiversity. It is formally recognised under the EPBC Act, especially for *"large-scale industrial development and associated infrastructure"* (see likewise the discussion in Section 8.4.1).[9]

But a SREBA framework as recommended by the Panel is much broader than the scope of the bioregional assessment process that has been developed and applied by the Australian Government for the assessment of regions affected, or potentially affected, by large coal mines or by the extraction of CSG.[10] Those bioregional assessments are limited to the assessment of water assets and water-dependent ecosystems by virtue of constraints imposed by the 'water trigger' provision of the EPBC Act. Water related aspects of the extraction of onshore shale gas are not included within the ambit of the EPBC Act (see Section 7.2.4.4), and only MNES that might be at risk of a significant impact (for example, rare and endangered species, or Ramsar wetlands) by a development are required to be assessed under that Act. Areas of high conservation significance by virtue of special local assemblages of plants and animals are not specifically addressed by the provisions of the EPBC Act unless they constitute habitat for rare and endangered species. In addition, the bioregional assessments completed to date have largely relied on existing datasets. This approach is especially problematic in the NT where, as noted in Chapters 7 and 8, there is generally poor survey coverage of aquatic and terrestrial biological assets.

As proposed by the Panel, a SREBA would consist of the physical, biological, public health, social and cultural elements outlined below to address the key knowledge gaps identified in this Report.

8 EPA submission 417, p 3.
9 Australian Government 2011.
10 Barrett et al. 2013.

15.2.1 Water quality and quantity

A SREBA should address the following objectives with respect to water quality and water quantity, namely, to:

- establish a baseline for groundwater and surface water hydrology over a period that is representative of the climatic cycles of the area and of the geological and geomorphological variation across the region;
- characterise the hydrostratigraphy of the region sufficient to identify and characterise the aquifer systems and any interconnectivity that could be affected by the extraction of water for any onshore shale gas development;
- quantify recharge rates (and where possible, recharge zones) and to establish the sustainable yield for potentially affected aquifer systems;
- develop a suitably calibrated groundwater-surface water flow model(s) to quantify the connectivity between groundwater and surface water systems to predict the likely impacts of hydrological perturbation as the result of any potential onshore shale gas development and production;
- establish a baseline for water quality, including measuring vertical profiles of water quality parameters through potentially affected aquifers and surface waters, noting that this will need to be done at a number of locations across a region to inform the lateral variations in quality. In semi-arid and arid regions, particular attention should be paid to the water quality of perennial to near-perennial water bodies that are likely to provide dry season refugia for aquatic biota and drinking water sources for wildlife; and
- define, using baseline water quality data, a staged operational regime (that is, response trigger levels) for remedial action in the event of upward trending key water quality indicators, such as dissolved methane and/or electrical conductivity.

15.2.2 Surface aquatic and groundwater dependent ecosystems

A SREBA should address the following objectives with respect to surface aquatic ecosystems and GDEs, namely, to:

- determine locations of ecologically important perennial and temporary waterbodies and dry season aquatic refugia;
- characterise the wet season surface water flow regime (including overland flow);
- characterise the dependency or degree of influence on ecosystems by groundwater, and their likely sensitivity to shale gas-related water extraction; and
- characterise inter-annual and seasonal water quality variability, with particular focus on dry season aquatic refugia (see above).

15.2.3 Terrestrial ecosystems

A SREBA should address the following objectives with respect to terrestrial ecosystems, namely, to:

- identify locations of high conservation value within affected IBRA bioregions[11] through systematic survey of vascular plants, vertebrates and selected invertebrate taxa;
- establish current distribution and densities of occurrence of weed species throughout the region; and
- determine if any threatened species are likely to be seriously affected by the cumulative effects of habitat loss and fragmentation that could accompany any onshore shale gas development.

15.2.4 Greenhouse gas emissions

A SREBA should address the following objectives with respect to GHG, namely, to:

- establish a regional baseline for methane concentrations and fluxes; and
- identify any locations that have substantively higher emissions than the regional average and to determine, where possible, the reasons for these anomalies.

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11 Thackway and Cresswell 1995.

15.2.5 Public health

A SREBA should collect baseline data on the frequency and duration of the occurrence of symptoms commonly associated with irritant substances (for example, sore eyes, respiratory irritation and asthma).

15.2.6 Social impacts

A SREBA should address the social impacts of any onshore shale gas industry in accordance with the SIA framework discussed in detail in Chapter 12.

15.2.7 Aboriginal people and their culture

A SREBA should consider cultural impacts and should:

- be designed in consultation with Land Councils and AAPA; and
- engage traditional Aboriginal owners, native title holders and affected Aboriginal communities, and be conducted in accordance with world leading practice, as discussed in Chapter 11 (see ***Recommendation 11.8***).

15.3 Guidance for undertaking a SREBA

While it is not the intention of the Panel to be overly prescriptive in relation to the content of any SREBA, there are a number of overarching issues that must be addressed when designing and developing scopes of work for any SREBA to ensure a proper outcome.

In particular, it must be recognised that much of the work that has been undertaken to date has been opportunistic (that is, the use of existing data collected for other purposes), or spatially restricted, rather than being regionally strategic for the purposes of providing the pre-development data required to underpin effective land use planning and to properly inform the environmental performance of any onshore shale gas industry. This situation is aptly described, using groundwater as an example, by the quotation below from a recent paper describing the status of monitoring (baseline and otherwise) for methane and other contaminants in relation to the industry in the US:

"Present-day monitoring efforts do not consider the groundwater resource in its entirety and involve only periodic sampling from existing sparsely located domestic wells, which serve as receptors at risk, rather than adequate monitors for groundwater impact evaluation." [12]

While this example relates to the US, the situation is similar in Australia.

15.3.1 Water

The data collected for the regional assessment must be sufficient to inform the water supply, surface and groundwater interactions, and water quality components of the baseline assessment. Further, the data must add to the knowledge base of these systems in the NT. Useful guidance for this process has been developed by the Victorian EPA[13] and the IESC[14].

15.3.1.1 Water supply

The key groundwater parameters are recharge rate, recharge mechanism, sustainable yield and flow velocity. As noted in Chapter 7, these four components are not well defined over much of the NT. Even for the most well characterised groundwater system in the Beetaloo Sub-basin, there is still missing data, especially in the southern part of the Sub-basin.

Recharge can be inferred from water balance models, but this is a relatively unsophisticated approach that is subject to considerable uncertainty,[15] especially in the case of stratified aquifer systems. Leading practice for measuring these parameters uses a combination of geochemical fingerprinting and stable isotope measurements.[16] Work of this type needs to be done regionally to determine the extent of heterogeneity in aquifer systems because sustainable yield in one part of a shale basin may be very different to other (lower rainfall) parts. Santos and Origin have

12 Cahill et al. 2017, p 293.
13 Victorian EPA 2006.
14 IESC 2015.
15 Crosbie et al. 2010; Suckow et al. 2016.
16 Suckow et al. 2016; Suckow et al. 2017.

recently commissioned CSIRO to undertake these measurements across their lease areas in the Beetaloo Sub-basin, including the southern Beetaloo area.[17]

15.3.1.2 Surface and groundwater interactions

The regional assessment should identify locations where groundwater aquifers intersect with surface waters, and the extent and importance of any ecosystems dependent on, or influenced by, groundwater. In particular, the locations of groundwater-fed springs and dry season aquatic refugia must be identified and characterised, and the sensitivity of these assets to the extraction of groundwater should be assessed.

For all relevant water resources and water dependent assets, a description of baseline conditions, and conceptual and numerical computer models of potential impacts of any onshore shale gas industry need to be developed. Numerical modelling should be undertaken to inform an understanding of potential impacts to a particular water resource. Such models should be constructed in accordance with the conceptual model, be calibrated and verified with appropriate baseline data, and should explore the probability of a range of possible outcomes based on uncertainty analysis.[18]

For a Beetaloo Sub-basin SREBA, one particular focus should be a better understanding of the importance of the CLA in sustaining the Mataranka Springs and the Roper and Daly rivers, and the potential for any onshore shale gas industry to adversely affect this aquifer system.

15.3.1.3 Water quality

The standard set of water quality parameters that have been measured throughout the NT by the Power and Water Corporation have focussed on the inorganic (salts and metals) and microbiological indicators most relevant to assessing near-surface systems for human drinking, stock watering, or agricultural uses.[19] There are no extended time series baseline datasets for these parameters that can assist in diagnosing potentially contaminated groundwater with natural inorganic (including NORM) and organic chemicals (methane and hydrocarbons) that originate from depth as a result of hydraulic fracturing activity for onshore shale gas in the NT.[20]

It is only recently that a more comprehensive range of water quality measurements have been obtained for the Beetaloo Sub-basin from samples collected by consultants engaged by the gas industry.[21] These measurements will need to be extended regionally and seasonally over several years to provide a robust baseline dataset.[22] The analytical detection limits (**DLs**) that are specified will also need to be fit-for-purpose. The lowest DLs appropriate for water quality assessments must be used, noting that the DLs needed for environmental baseline assessments are generally lower than those required for human drinking water.

As stated in Chapter 7, methane will be a key water quality parameter because 'fugitive' methane is the most likely substance to be found in groundwater close to shale gas extraction wells. The baseline needs to determine both the concentrations and geologic origin ('thermogenic' - deep shale gas, and 'biogenic' - near-surface microbiological origin) of measured methane.[23] Determining the origin of methane can be established using a combination of isotopic ratio measurements and gas compositions. Establishing a reliable baseline for methane in water requires specialist expertise.[24]

A fundamental limitation on the rigour and usefulness of the water data acquired to date (and this is likely to include the current CSIRO work) is that it has mainly come from bores constructed for the purpose of domestic supply or stock watering, with variable bore depths and screened intervals. While the groundwater quality data from these bores is adequate for a preliminary assessment, the data obtained to date are not sufficient to properly inform the development of a regionally extensive industry that has the potential to contaminate groundwater by salts or gas for three principal reasons:

- first, aquifer systems can be vertically stratified, with overlying younger water flowing

17 Santos submission 420, pp 10-11; Origin submission 469, Attachment 1, p 12.
18 Barnett et al. 2012.
19 Power and Water Corporation 2016.
20 For example, Appendix A in Australian Department of the Environment and Energy 2017c.
21 Origin submission 153, Appendix 4.
22 See Jackson et al. 2013b for a comprehensive discussion of the issues and the extent of the monitoring required.
23 Currell et al. 2017.
24 Currell et al. 2017; Walker and Mallants 2014.

across the top of the aquifer profile and much older water residing below it. Therefore, measurements of groundwater age that do not specifically address this issue can yield estimates of recharge (and therefore sustainable yield) that are incorrect and;[25]

- second, the concentrations of dissolved oxygen through the aquifer need to be determined to inform the potential for degradation of fugitive methane in groundwater by aerobic or anaerobic microbial pathways (see Section 7.6.1), and the potential for the occurrence of stygofauna; and
- third, the baseline concentrations of major ions must be established through the aquifer profile to provide a reference condition against which leakage of flowback water from a well, or from a surface spill contaminating the groundwater, can be assessed.

Obtaining this information will require the targeted installation of multilevel piezometer arrays screened across a number of discrete vertical intervals to permit sampling through time and conducted reliably and reproducibly at each horizon. In this context, the Panel has recommended that multilevel bores be used for performance monitoring of installed shale gas extraction wells (see ***Recommendation 7.11***).

15.3.1.4 Collation of data and quality control of data-collection process

A central issue regarding the integrity of regional baseline assessments is the quality of the data being collected. Typically, multiple entities collect water samples and submit them for analysis to different commercial laboratories. This is currently the case in the Beetaloo Sub-basin where different consultants are engaged by different gas companies to do their baseline work.

All data being collected for a SREBA must be collated into a single repository database. Ideally, this collation should be performed regularly to ensure that any identified issues are addressed as expeditiously as possible, including inconsistencies in analysis quality and achieved quantification limits. Adequate resourcing must be provided to ensure that the data is uploaded regularly and any problems immediately identified and rectified.

Ongoing attention to quality control is critical because variances in sampling methods, sample processing, and laboratory analysis procedures, can lead to significant systematic variation between datasets consisting of the same set of measured parameters.

To minimise the potential for problems, there should be an annual field and laboratory evaluation component built into the work program for any consultants involved in the assessment program. Specifically, this should comprise samples collected (annually, at minimum) from several bores nominated by the regulator, with the resultant field and laboratory data being compared and assessed by the regulator, or by an independent consultant engaged by the regulator. In this way, any bias or systemic issue can be identified at the earliest opportunity and corrective action taken. If this does not occur, unexplained discrepancies between datasets being obtained across the same region may result.

The Panel recommends that the regulator play a central role in auditing the data and the data-collection process, not only to avoid discrepancies, but to give the community confidence in the scientific independence and rigour of the process.

This control of data quality and review by the regulator must apply to all components of any SREBA.

Recommendation 15.2

That the regulator oversees the auditing and the data-collection processes and provides a central repository for all data informing any SREBA.

25 Suckow et al. 2017.

15.3.2 Aquatic and stygofauna biodiversity

For surface water ecosystems, there are few generic protocols for assessment of biodiversity that will be equally applicable to all NT waters. The Australian River Assessment System (**AusRivAS**) models have been developed for parts of the NT, and can be used to obtain generic river health biodiversity data for some systems in the Top End.[26] However, it only provides information on higher taxonomic level biodiversity of macroinvertebrates, which is one component of biodiversity in the waters of the NT. More recently, Townsend et al. provided more general commentary on approaches to river health assessment in the wet-dry tropics,[27] but again, this was focussed on stream health assessment, and not on the development of a biodiversity baseline. For a SREBA a broader range of taxonomic groups should be considered, including fish and other vertebrates, macroinvertebrates, macrophytes and algae, and microcrustaceans that can play dominant roles in the aquatic biodiversity of some NT waters.

The NT straddles a number of major Australian drainage divisions, including the Lake Eyre Basin, Tanami-Timor Sea, North Western Plateau and Carpentaria Coast,[28] and some spring systems associated with the Great Artesian Basin. The Carpentaria Coast drainage division is the current remnant of a previously much more extensive Lake Carpentaria catchment at lower sea level[29] that connected what are current drainage divisions of the NT, Queensland and southern Papua New Guinea. Inundation of that catchment by sea level rise has resulted in patchy remnant populations of aquatic organisms that were formerly more widespread, with an example being the Finniss River Grunter,[30] which is only known to occur in one NT river, its nearest relative found in Papua New Guinea.

The fact that most surface waters of the NT have been poorly studied highlights the need for detailed surveys before the production phase of a regionally extensive industry, such as onshore shale gas, commences. Specifically, the aquatic biodiversity of the NT is not well known, the distributions of its species is uncertain, even for fish, and the locations of key refugia, sensitive assemblages, and isolated populations are poorly documented. The Panel finds that, without detailed baseline data, it is not possible to understand the key sensitivities in any region proposed for any onshore shale gas industry. Planning to manage possible impacts on aquatic ecosystems must therefore be guided by the application of the precautionary principle. Accordingly, assessing the risk to surface water aquatic ecosystems from the accidental release of shale gas wastewaters will need to be based on expert opinion. This is correct for not only Top End ecosystems, but also for the much less studied semi-arid and arid ecosystems.

In the less reliably inundated semi-arid and arid systems, baseline data collection is made especially difficult because planning for sampling is exacerbated by unpredictability. It is further complicated by the fact that in any one period of inundation, only part of the biodiversity may be apparent because of high variability in the development of assemblages of organisms between wetting-drying cycles and geographically within temporary water networks due to:

- stochastic recruitment effects on assemblage development;[31]
- in-built genetic variability in timing and triggers for ending aestivation within populations ('spreading the risk') and among different species;[32]
- physical and chemical constraints on assemblage successions and variability among years, which require different benchmarking between inundation events. For example, the initial assemblage composition (and therefore process of ecosystem successional development) in salt lakes is contingent upon the amount of inflow in the initial re-wetting of the ecosystem, with different taxa favoured by different salinities;[33]
- changes in the relative input of surface and groundwater flows (particularly to pools/refugia) at different phases of the wetting-drying cycle, with implications for water persistence and water quality; and

26 See https://ausrivas.ewater.org.au/.
27 Townsend et al. 2012.
28 BOM River Regions.
29 Reeves et al. 2008.
30 DENR 2006.
31 Vanschoenwinkel et al. 2010.
32 Simovich and Hathaway 1997.
33 Suter et al. 1995; Halse et al. 1998; Cale et al. 2004.

- the extent of connectivity between refugia and newly inundated habitats, geographically and temporally, strongly affecting recruitment opportunities and sequences, and therefore, the resultant biological interactions.[34]

Accordingly, it is essential that any SREBA is designed to include multiple-year sampling of aquatic ecosystems. As a general rule in the Top End two to five years of baseline data will be required to achieve adequate coverage of inter-annual variability,[35] while in drier zones a longer timeframe is required.

The timing of sampling will be dependent on the hydrological cycle of the water bodies of interest. For example, King et al. identified three phases of the seasonal flow regime for perennial and intermittent rivers in tropical savannah climates: the wet-dry transition; the dry season; and the dry-wet season transition.[36] They identified each hydrological phase as ecologically important, albeit in different ways. However, Humphrey and Pigeon[37] identified the recessional flow phase in the wet-dry transition as the best period for sampling the macroinvertebrate assemblage in these seasonal tropics, because it represents the period of maximum biodiversity in an established assemblage. In systems with different inundation patterns and durations, the timing of sampling in each inundation cycle will need to be adapted, and optimal timing may differ for different taxonomic groups.

There is no specific guidance on measuring the biodiversity of stygofauna in the NT, but policies have been developed for WA, NSW and Queensland that are generally applicable to the NT.[38] The comments above concerning the limitations of using existing bores for characterising the groundwater quality baseline are equally applicable to establishing a baseline for stygofauna biodiversity, but bores developed for a regional assessment of groundwater quality can also be designed to be appropriate for stygofauna assessment.

Timing may be less critical for the assessment of surface GDEs than for non-groundwater dependent surface water ecosystems. However, access may be more difficult in the wet season in the wet-dry tropics, or immediately after the less predictable rainfall further south. Again, for these systems, a broad range of taxonomic groups should be considered, including fish and other vertebrates, macrophytes and algae. Microcrustaceans and terrestrial vegetation and associated fauna should also be considered.

Bameranji Waterhole, Hayfield Station 2017.

34 Sheldon et al. 2003; Sheldon et al. 2010.
35 Humphrey et al. 1995.
36 King et al. 2015, pp 747-753.
37 Humphrey and Pidgeon 2001.
38 WA EPA 2007; WA EPA 2016; Serov et al. 2012; Queensland DSITI 2015.

15.3.3 Terrestrial biodiversity

The Panel's assessment is that the risk of inappropriate location of any onshore shale gas development would be both 'low' and acceptable, provided that a SREBA of terrestrial biodiversity values is undertaken to ensure that the development is excluded from any identified areas of high conservation value. These regional assessments should be comprehensive,[39] both in terms of space (covering all major vegetation types across the region) and biota (including all groups of vascular plants and terrestrial vertebrates, and representative terrestrial invertebrates).[40] The data should be assessed for patterns of species richness and endemism, and for the occurrence of threatened species.

The EPA has developed guidelines for assessing impacts on terrestrial biodiversity. [41] The recommended assessment methodology utilises a combination of desktop assessments and field verification to identify and map vegetation communities, the presence of threatened flora and fauna under the TPWC Act, critical habitat, MNES, and the presence of weed and pest species.

While the EPA guidelines provides a good starting point for what is required, it should be noted that across much of the NT, there is insufficient coverage of survey data to be able to place a strong degree of reliance on existing mapping datasets. This applies especially to the coverage of ground data that will be required for a regional assessment of an industry with a potentially large footprint and a potentially significant cumulative impact, as distinct from an individual project assessment with a smaller total footprint (for example, a medium sized mine). Significant on-ground work will therefore be needed to comprehensively map the occurrence and distribution of terrestrial biodiversity assets of regions likely to be affected by the extraction of any onshore shale gas.

As discussed above for water, it will be critical to ensure that verifiably consistent methods are being used by the different consultants engaged to undertake the baseline assessment for the gas companies that hold permits in prospective shale gas basins. If not, the integrity and usefulness of any SREBA may be compromised.

15.3.4 Greenhouse gas emissions

Establishing an appropriate methane baseline is important to provide an understanding of pre-existing pollutant sources, which is necessary to predict cumulative impacts from any proposed onshore shale gas development. In the Beetaloo Sub-basin, for example, there are a range of natural GHG emission sources likely to contribute to the regional GHG (including methane) budget. These include biomass burning, temporary wetlands, termites, and agricultural and pastoral activities. These emission sources will vary significantly both temporally and spatially, and therefore, a robust GHG baseline program is required.

Many of the technical issues involved with estimating fluxes of methane to the atmosphere have been addressed in Chapter 9 (Section 9.5), noting that such measurements are complex and require well developed expertise and specialist equipment. GISERA has undertaken detailed measurements of methane concentrations in the Surat Basin in Queensland over the last three years, which provide a good reference for future monitoring programs.[42] It is noted that both Origin and Santos are in the planning phase of a baseline methane assessment in the Beetaloo Sub-basin.[43]

15.3.5 Public health

Chapter 10 (Section 10.2) references the community demand for adequate baseline data on public and environmental health to be collected ahead of any onshore shale gas development, so that future impacts of the industry can be reliably assessed. The Panel has recommended the need for a completed SREBA that includes baseline human health data prior to the granting of any production approvals (see the Glossary and Chapter 16) in any of the prospective onshore shale gas regions in the NT.

39 EDO submission 456, p 27.
40 ALEC submission 88, p 16; ALEC submission 238, p 12.
41 NT EPA 2013.
42 Day et al. 2013; Day et al. 2015; Etheridge et al. 2017.
43 Santos submission 168, p 110; Origin submission 433, p 58.

The Panel does not underestimate the difficulties of compiling this public health data. It is not known by the Panel what type of health data is held by regional hospitals or community health centres. Nor is it clear how accessible this data is, given the privacy issues surrounding its collation. Collection of public health data through community surveys of self-reported symptoms and health status may be one way of collecting the information, but the utility and reliability of this survey data is problematic. Section 10.3.3.1 discusses some of the limitations of self-reported public health data in assessing the impacts of airborne pollutants sourced from any onshore shale gas industry.

The sample size is likely to be small for people living in close proximity to any onshore shale gasfield development in the NT, and this is likely to compromise baseline health comparisons with larger regional and Territory wide surveys. However, the Panel suggests that existing models for the assessment of this data, such as that used by the Menzies School of Health Research, may be useful. Such methods have been successfully applied to the prospective assessment of birth outcomes in a relatively small Aboriginal birth cohort.[44]

While supporting the need for collation of baseline regional health data, one industry submission suggests that some of these data already exist in State and Territory health departments and that their collation should not be the responsibility of the gas industry but a responsibility of the Government or an independent agency.[45] It was noted that baseline health statistics were used in an analysis of the impact of CSG activities in Queensland.[46]

Another issue is drawing the boundaries for the public health component of a SREBA. The proximity of humans and livestock ('receptors' in HHRA methodology) to the sources of emissions is an important factor in determining health risks. In the HHRA reports commissioned by the gas industry (see Section 10.1.1.4), a finding that credible exposure pathways leading to nearby residents or people other than onsite workers were 'incomplete' led to the discounting of any potential health impacts on local communities.

In analysing all of the data on airborne and water-borne exposure pathways, the Panel has had difficulty in recommending suitable 'setback' distances between wells, processing facilities, pipelines, and local communities. If any onshore shale gas industry in the NT occurs in areas remote from established towns or local communities, the gathering of public health data from distant sites of habitation may be less useful. If there are isolated pockets of people living in closer proximity to any onshore shale gas development (for example, pastoral homesteads or Aboriginal communities), the small numbers of people may compromise the meaningfulness of any data.

15.3.6 Social impacts

As discussed in Chapter 12, developing a baseline assessment of social and economic data for individual communities and regions has been deemed essential for monitoring and evaluating the effect of any onshore shale gas industry on the NT. Leading SIA practice suggests that such baseline data become a critical reference, along with other benchmark values, against which potential social impacts can be anticipated and change measured. Leading practice for SIA requires that the assessment is not undertaken as a component of an EIS, but rather as a standalone measurement that also anticipates the monitoring of any cumulative impacts that may occur as a result of intersecting and co-occurring industries.

To be successful, any SIA must include participation from a range of stakeholders and communities that are likely to be affected by the industry. On-ground consultation means that each community or region should develop its own framework based on the natural, cultural, social, human, political, financial, built and institutional capitals of that community or region. From this, key indicators can be developed that will take into account both historic trends and any regional aspirations for growth.

In the CSRM Report it is recommended that SIA baseline studies independent of any specific project be carried out based on an adaptive participatory management approach (see the report at Appendix 16). The strategic assessment will provide the framework for project-level assessments, with project-level monitoring providing information to facilitate review and update

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44 Menzies 2013.
45 Origin submission 433, p 63.
46 Werner et al. 2017.

of the strategic assessment. It identifies the phases and activities of an SIA, and states how they relate to an adaptive participatory management approach. These will typically take several years and involve extensive community and stakeholder engagement to understand social values, identify and explain potential impacts, and develop, explain, refine and reach agreement on appropriate responses, management measures and initiatives.

Significant disparity exists between the regional service centres and remote Aboriginal communities, affecting access to services, the state of housing, access to a labour market, and differences in health and education status. Any SIA will accordingly need to be mindful of these local considerations.

Based on other Australian and international experiences, it will be critical to monitor the cumulative social impacts that may develop if multiple onshore shale gas projects exist and operate across a common region. Any data gathered by individual gas companies must be shared openly and be made available to the community to ensure that the greatest degree of transparency is afforded to any development. There must be a participatory regional monitoring and an evaluation framework that includes an online open access database of all information arising from any monitoring.

15.3.7 Aboriginal people and their culture

The SREBA should include an assessment of the cultural impacts of any onshore shale gas development and, as discussed in Chapter 11, must:

- be undertaken by a suitably qualified and independent party;
- be designed to engage traditional Aboriginal owners and affected Aboriginal communities to enable Aboriginal people to understand the risks and opportunities associated with the development of any onshore shale gas industry, including the risks to the maintenance of culture and to community cohesion;
- utilise the expertise and knowledge held within the Land Councils and AAPA for both the design and implementation of the assessment;
- be conducted in accordance with world leading practice; and
- be completed and their findings made public before any production approvals are granted.

15.4 Timeframe for a SREBA

During the final round of community consultations, and in many of the recent submissions received by the Panel, many people and stakeholders argued cogently that all elements of a SREBA must be completed before any further exploration activity takes place in the NT for onshore shale gas. It was argued that if exploration activity was allowed to occur prior to the completion of a SREBA (as proposed by the Panel in the Draft Final Report), then:

- the baseline studies obtained as part of a SREBA will not properly form part of any pre-development data (see Section 15.1);
- exploration activity may occur in areas that a SREBA may subsequently identify as inappropriate for any shale gas activity, for example, a no go zone (see ***Recommendation 8.2*** and ***Recommendation 14.4***); and
- exploration activity may occur to such an extent (by reason of exploration creep) that the utility of a SREBA in designing appropriate mitigation measures will have been seriously undermined.

The Panel has considered the timing of any SREBA carefully in light of the community's concerns about exploration activities occurring in the absence of its completion, but ultimately it has not resiled from its original position for the following reasons:

- first, the Panel has proposed that many of the recommendations contained in this Report must be implemented prior to the grant of any further exploration approvals (see **Table 16.1** in Chapter 16). This means that the key risks associated with any drilling and hydraulic fracturing for onshore shale gas will be mitigated from the outset;
- second, the Panel considers that the footprint associated with exploration (up to and including the 'appraisal' phase described in **Table 15.1**) in the Beetaloo Sub-basin is unlikely to have a significant regional impact for three to five years. While the time taken

to complete a SREBA will depend on the specific climatic, biophysical, ecosystem, social and cultural conditions of the region where it is being conducted, the Panel estimates that it will take the same period of time (three to five years) to complete the data acquisition, interpretation and reporting stages of a SREBA for that Sub-basin;

- third, further approvals are required before any exploration activity can occur in the Beetaloo Sub-basin (or any other region). The holding of an exploration permit does not grant a gas company the right to immediately commence drilling or hydraulic fracturing for onshore shale gas. The company must submit a draft EMP for Ministerial approval (which the Panel has recommended be subject to prior public scrutiny: see ***Recommendation 14.15***)) and the Minister must be satisfied that the EMP has identified and reduced all of the risks to a level that is acceptable and ALARP, prior to granting the approval;
- fourth, the implementation of the mitigation measures relating to well integrity, monitoring and public reporting regimes recommended by the Panel in this Report must occur prior to any further exploration approvals being granted (see Chapter 16 and **Table 16.1**). Assuming their implementation, the risk to the environment has been assessed by the Panel as 'low' and acceptable, notwithstanding that a SREBA will not have been completed at this stage;
- fifth, the Panel has made a specific recommendation that the Minister must be satisfied that the cumulative impacts of a proposed activity are thoroughly dealt with in an EMP to mitigate the risk of exploration creep (see ***Recommendation 14.19***); and
- sixth, there is considerable technical merit in any SREBA proceeding in parallel with exploration activity because the activity will provide essential data, such as critical hydrogeological information on groundwater from deep shale drilling, that will form part of the SREBA.

As **Table 15.1** indicates, there are some elements of a SREBA that must commence immediately, while others can proceed in parallel with the relatively small (and controlled) activity footprint of exploration. **Table 15.1** sets out a suggested timeline for any onshore shale gas industry and indicates when various components of a SREBA should commence and be completed. The terms, 'exploration', 'appraisal', and 'delineation', while not necessarily statutorily defined, are terms used by the gas industry to describe the sequential process that is required to prove up a gas resource to a commercially viable stage.[47] This project management is recognised in reporting requirements for the ASX.[48]

The Panel's opinion is that the timeframes shown in **Table 15.1** are reasonable given the availability of the required specialist equipment in Australia and the time needed to interpret the data produced from any early to mid-stage exploration activities.

47 Origin submission 153, p 38; Pangaea submission 1147, pp 5-6.
48 RISC 2013.

Table 15.1: Development timeline and SREBA Implementation.

Stage[1]	Description[2]	Number of wells/size of development	Timeframe for SREBA component to be completed
Exploration	2-5 years	Small number of widely spaced wells to investigate and confirm lateral extent of any onshore shale gas resource.	Prior to the grant of any further exploration approvals. • baseline acquisition of methane concentrations to be undertaken for a six month period (***Recommendation 9.3***); • local groundwater quality data to be acquired using multi-level wells installed adjacent to, and six months prior to the drilling of, any new shale gas exploration wells, (***Recommendation 7.11***); and • other elements of SREBA commence, including: regional surface and groundwater studies (***Recommendation 7.5***); terrestrial bioassessments (***Recommendations 8.2***, ***8.4***, ***8.5***, and ***8.6***); aquatic biodiversity assessments (Section 15.3.2); and social (***Recommendation 12.13***), cultural (***Recommendation 11.8***) and human health (Section 15.3.5) baseline studies.
Appraisal	1 year	Increased number (small) of wells to prove the technical viability of the extraction technology in the target shale formation.	Prior to the grant of any production approvals: • the bulk of the data acquisition required by a SREBA must be completed by the end of appraisal; • key SREBA elements (for example, sustainable yield of groundwater: ***Recommendation 7.16***) must be completed by the end of the delineation phase because the results could have major implications for the location and scale of any onshore shale gas industry and could impact upon the commercial decision to proceed to production; and • full social, cultural, environmental and human health risk assessments must be completed prior to commercial production commencing. These assessments can only be finalised at this late stage because the scale and location(s) of any development will not have been known earlier.
Delineation	2 years	Several multi-well pads constructed to assess economic viability of any commercial scale production. Could potentially produce a marketable quantity of gas.	
Commercial production	6-10 years	Staged construction of successive multi-well pads, increasing to required scale for commercial production.	

1 These descriptions are consistent with accepted gas industry terminology.

2 Theses are indicative only but are based on information provided to the Panel by the gas industry.

A SREBA must be completed by the time any production approvals for production activity are granted (the 'delineation' phase). It is intended that the results from a SREBA form the basis of any decision to grant production approvals on a production licence.

Having said this, the Panel recognises the need for any SREBA to be completed in a timely and efficient manner. The assessment process cannot be open-ended. Communities (local, regional and Territory wide), the Government and gas companies require certainty and finality to the SREBA process.

Recommendation 15.3

That a SREBA:

- ***should be completed within five years from the first grant of exploration approvals; and***
- ***must be completed prior to the grant of any production approvals.***

The acquisition of regional data will not, however, cease with the completion a SREBA. Ongoing work will be required by both the regulator and the gas industry to progressively transition the information obtained from a SREBA into the operational performance and monitoring regimes recommended by the Panel throughout this Report.