NSW GOVERNMENT | Chief Scientist & Engineer

Independent Review of Coal Seam Gas Activities in NSW

Information paper: On managing the interface between coal seam gas activities and other land uses (Setbacks)

September 2014

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EXECUTIVE SUMMARY

There is a tension between the CSG industry and the communities in which it operates. Industry looks to maximise its access to methane-bearing coal, with the potential for increased revenues for industry, increased royalties for the state, and increased employment opportunities. But closer proximity between industry and communities may result in a higher perceived potential for adverse impacts. Conversely, increased distance between industry and communities can decrease the perceived potential for adverse impacts but increase the areas of methane-bearing coal that must be foregone by industry.

Every industry has potential risks and impacts. The way in which these risks are assessed and understood is fundamental to the management of the interface between potentially conflicting land uses. Each location and industry presents unique and complex challenges; for the most effective assessment, key considerations should be carefully measured on a site-by-site basis to ensure risks are appropriately addressed.

Setbacks or exclusion zones are typically defined by planning or zoning laws, and are designed to act as spatial barriers between two or more otherwise conflicting land uses or activities. Setbacks or separation distances are regulated distances that 'set back' oil and gas activities from entities that have been judged to merit additional protection, like human and animal inhabited spaces – including residences, urban areas, schools, hospitals – and surface and subsurface water resources. Setbacks exist to separate these protected spaces from potential harm related to resource extraction activities in the event of natural disasters, technological or procedural failures, or other incidents.

A clearly delineated interface such as a setback is easily understood and readily legislated, but should not detract from the need to understand the complex interaction and interdependency of social, environmental, legal and economic factors. The process of how setbacks are determined, whether they apply across the board or on a site-by-site basis, should be transparent, as should conditions under which operators will be required to implement further mitigation measures and monitoring.

It is normal practice to impose conservative control measures, such as standardised setbacks, on emerging industries, until ongoing monitoring and experience of local and regional impacts of a specific activity are obtained, and evidence-based controls can be adopted. Control measures should be modified and adapted over time to reflect improved knowledge and understanding based on robust data from monitoring and improved predictive modelling.

While setbacks are likely to be most effective in managing the interface with conflicting land uses when determined on a scientific basis, oil and gas activities that occur near iconic social and cultural locations may still be, for some, perceptually 'too close' and conflict with social values. However, opportunities exist for NSW to learn from examples provided by other jurisdictions and industries, and take a lead in establishing a transparent, data-based method for determining setbacks that also incorporates stakeholder concerns.

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1 INTRODUCTION

Term of Reference 3 for the Independent Review of Coal Seam Gas Activities in NSW (the Review) required the Chief Scientist and Engineer to:

> *"identify best practice in relation to the management of CSG or similar unconventional gas projects in close proximity to residential properties and urban areas and consider appropriate ways to manage the interface between residences and CSG activity"* (CSE, 2013).

This paper examines strategies for managing the interface between proposed CSG activities and residential, industrial, urban and environmental areas, with a focus on setbacks. The strategies have been drawn from a range of industries, as the impact potential is similar no matter from which industry it arises.

1.1 CONTEXT

There is a tension between the CSG industry and the communities in which it operates. The industry looks to maximise its access to methane-bearing coal, with the potential for increased revenues for industry, increased royalties for the state, and increased employment opportunities. But the closer an industry moves to existing communities and activities, the higher the potential for perceived negative impact on those communities. Conversely, the greater the distance between industry and communities, the less the potential for these impacts and others such as visual, noise, vibration and traffic but the greater the areas of methane-bearing coal that must be foregone.

This paper investigates approaches to managing this tension, including improvements in industry design and performance, emission reduction, restriction of operating times and spatial barriers. However, spatial barriers such as setbacks, exclusion or buffer zones, and the methods for their calculation, form a primary focus.

In 2013 'CSG exclusion zones' and 2km 'buffer zones' came into effect across NSW on existing and future residential land, and subsequently for critical industry clusters, through changes to the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*.

During the course of the Review community and industry stakeholders expressed frustration about the lack of transparency involved in determining the scale of the exclusion zones, and have continued to advocate for data-based research to inform where, when or how oil and gas activities should occur to best minimise risk, harm and other impacts on humans and the environment. At the same time, the apparent inflexibility of the setback has been viewed by some, including those in the resources sector, as problematic, especially as technology advances and the industry broadens exploration activities.

1.2 APPROACH

To gain insight into how risks and impacts from industry are considered and controlled, information was sought from a range of sources, including Government agencies that regulate the extractive industries in NSW (including the Office of Coal Seam Gas [OCSG], Division of Resources and Energy [DRE] and NSW Office of Water [NOW] in NSW Trade & Investment; the Environmental Protection Agency [EPA], and the Department of Planning and Environment [DP&E]) and a selection of experts with differing backgrounds. Commentary regarding the use of setbacks was also sought from the NSW Ombudsman, the Ministry of Health and the Dam Safety Committee.

Research was also conducted into current practices adopted by both national and international jurisdictions across various industries, including where setbacks were deemed necessary, the reasoning behind these decisions, and how the distances were calculated.

2 APPROACH TO MANAGING THE INTERFACE

The term ‘sensitive receptors’ is commonly used to refer to entities that have been judged to be most susceptible to the adverse effects of exposure to pollutants and to merit protection from the risks and impacts associated with industry. Though the specific entities that this term encompasses differ in terms of the impacting factors or jurisdiction, sensitive receptors may comprise human, animal and ecological inhabited spaces, including residences, urban areas, schools, hospitals, ecosystems; surface and subsurface water resources; or neighbouring, yet competing, industrial and agricultural activities. Impacts can occur as a result of normal operations of the industry (e.g., noise and light) and also as the result of an incident or event, and the level of sensitivity will vary between receptors. Some industries impacts will be confined to the surface; however others like CSG will incorporate subsurface activities, where the reach extends beyond the surface footprint.

Many industries are required to proceed through some form of regulatory development application process requiring assessment and consultation in order to ensure impacts and risks on sensitive receptors are addressed appropriately. For example, formal self-assessment processes involving environmental impact assessments are required in NSW to help quantify potential impacts.

During this process the company documents the specific impacts of the proposed activity and typically identifies how these impacts will be managed. If plans to address these are determined to be inadequate, project characteristics can be changed commensurate with the severity of the risk or impact, e.g. by altering the location, scale, orientation or industrial design, or instituting mitigation measures.

A better understanding of a project’s impacts over time can be achieved by taking the entire life-cycle into account when assessing its scale and reach. A CSG production project can remain current for up to 21 years and therefore changes in technology and the local environment could potentially alter the impact of the project during its lifetime and beyond. Assessments therefore need updating and review based on factors such as a change in the nature or scale of the project, or improvements in technical approaches and knowledge. To protect sensitive receptors and achieve industry best practice, this may require consideration on a case-by-case basis, and over a potentially extended timeframe.

As the project evolves, mitigation measures through all stages of development and operation are designed to ensure accidents, failures and other impacts are avoided or diminished at the source. Ongoing monitoring activities are critical to inform whether established setbacks and mitigation are effective, or whether they should be adjusted. Modelling and monitoring are vital in the assessment process for any project.

2.1 KEY CONSIDERATIONS

The potential impacts of a project will depend on the particular development’s location, scale and operational factors; timeframe of activities and resilience of the environment. The impacts of a proposed development need to be considered against a range of factors including health, safety, environment, community (social) and economic criteria. The more transparent and open the decision-making process, the greater the level of acceptance there is of its outcomes. This extends to decisions on how the activity’s impact will be assessed at the proposed location and other relevant sites, and how this will occur on an ongoing basis, with consideration given to any uncertainties within predictions. It also extends to the reasoning behind the adoption and adequacy of mitigating measures that may result, such as engineering or technical controls. Table 2.1 presents criteria that could be considered when managing the interface between land uses in NSW, but is by no means exhaustive.

Table 2.1: Key issues to consider when determining whether a development proposal appropriately addresses risks and impacts

Note: some of the considerations may overlap into other categories or may apply cumulatively or not at all.

Category	Impact to be managed
Health	o Air emissions (dust, particulates, vent/flare events, leakages) o Surface water interference (Chemical spills to water sources) o Mental Health
Safety	o Risk of explosion or blow out o Seismicity o General worksite safety (traffic) o Proximity of other industries o Fire o Flood o Natural hazards o Worker health and safety
Environment	o Groundwater (connected aquifers, fractured aquifers) o Vibration o Greenhouse gases o Waste management (solid and liquid) o Biodiversity (threatened species, endangered ecological communities)
Community	o Aesthetics o Noise o Light o Community acceptance o Aboriginal archaeology and cultural heritage o Additional stress on infrastructure (roads, schools, hospitals, amenities)
Economic	o Existing or alternative land use (agriculture, viticulture, tourism) over various time scales o Property value o Subsidence

2.2 STRATEGIES TO MANAGE THE INTERFACE

Regulators use a number of strategies to manage the interface between industry and sensitive receptors. Any one strategy is rarely used in isolation, as different approaches may be used for different risks – e.g. noise, water, safety – and strategies may change over time as site operations and new technologies evolve. If management of this interface is configured on a site-by-site basis, accounting for localised geology and topography, different strategies may be used in each location, even within the same industry.

Many strategies are mandated at the approvals stage of a project or an activity. For example the EPA sets outcomes for specific potential impacts on the environment, e.g. for noise, with the onus on the proponent to indicate how the outcomes will be met.

In addition to increasing the spatial distance between an industry and any nearby sensitive receptors (discussed in Chapter 3), mitigative strategies already employed or available in NSW include technical controls, physical barriers, time restrictions, land acquisition and alternative siting.

2.2.1 Employing technical controls

An array of engineering and technical controls is available to industry for use onsite to reduce or eliminate the release of chemicals, improve safety, etc. The judicious employment of these can substantially reduce both risks and the scale of any impacts.

Controls are imposed on CSG operators by way of legislation, e.g. the *Petroleum (Onshore) Act 1991* and related regulations, schedules and codes. For example, CSG titleholders are required to fit blowout preventers to well heads in order to prevent the uncontrolled release

of gas from a well (blowout) which presents a significant safety risk to personnel at the site. This is mandated by the *Schedule of Onshore Petroleum Exploration and Production Safety Requirements* Clause 507 which is a requirement of all petroleum exploration and production licences (DMR, 1992).

2.2.2 Barriers and time restrictions

Time and locational factors can also be used to reduce impacts. For example, restrictions on operating hours can help reduce the impact of noise and light on nearby residents, whilst choice of plant equipment and site landscaping may also be effective. Physical barriers such as those used to block noise can be employed as a mitigation strategy to manage conflicting land uses when they arise. As new technologies evolve and industry practice improves, it may be possible to review mitigative strategies that have become redundant.

For example, an environment protection licence (EPL 12003) issued by the Environment Protection Authority (EPA) to a CSG operator under the *Protection of the Environment Operations Act 1997* includes a condition titled “Hours of operation”. It restricts planned maintenance activities to 7am to 6pm on weekdays and 8am to 1pm on Saturdays (excluding public holidays) in order to minimise impacts to nearby residents.

2.2.3 Land acquisition and alternative siting

In some cases land acquisition from residents is the best option to avoid unavoidable impacts to neighbouring properties.

For example, the Ashton Coal Project, 4km northwest of Singleton, NSW, includes an underground coal mine and the construction and operation of associated surface facilities. The Development Consent for the project by the Department of Planning includes conditions titled “*Area of Affectation – Land Acquisition”* (Department of Planning, 2002). These stipulate how the titleholder must purchase a particular property if requested by the owner, including responsibilities such as paying the current market value, compensation and costs for obtaining legal advice.

In other cases an industry may not be considered compatible with the proposed location and consent is conditional on its being located elsewhere.

The *State Environmental Planning Policy (Infrastructure) 2007* requires that authorities approving landfills take into consideration “whether the development is located so as to avoid land use conflicts” and refers to the *EIS Guideline: Landfilling* document. These guidelines outline principles for site selection including several trigger points that would require alternative site selection (DUAP, 1996). These include proximity to environmentally sensitive areas, compatibility with local zoning requirements, as well as the results of initial geological, soil, hydrological, topographical, meteorological, flora and fauna assessments. If any of these trigger points show the site to be unsuitable alternative siting would be required.

3 SETBACKS: EXCLUSION AND BUFFER ZONES

Establishing setbacks acknowledges the risks involved in resource extraction and that unforeseen incidents may affect development activities. However, there are few international standards for doing so that are promulgated by peak industry bodies. The Review could not find any standard by the International Organization for Standards that mentioned setbacks, nor one by the International Energy Agency. While the American Petroleum Institute (API) and the International Risk Governance Council both mention setbacks, no consistent position is held to be applicable across jurisdictions.

The API states that where feasible, exploration or production activities should be located away from sensitive or high-exposure areas such as churches, schools, hospitals, residential areas, surface waters, freshwater wells, flood zones, active fault areas, threatened and endangered plants and animals (including habitat), protected bird habitat, wetlands, archaeological, recreational, biological or scenic areas (API, 2011). The API also suggests that impacts from accidents, spills and leaks should be considered, along with noise, and notes that in most jurisdictions, these risks and issues are considered during a statement of environmental objectives process in which preventative and mitigative controls and/or setbacks are imposed to reduce risk to an acceptable level.

The International Risk Governance Council suggests a 'proper process' for unconventional gas development involves community participation in deciding setbacks and outlining projects but gives no further guidance (IRGC, 2013).

3.1 SETBACK DEFINITIONS

Setbacks are regulated distances that separate activities from entities that have been judged to merit protection, like human and animal inhabited spaces – including residences, urban areas, schools, hospitals – and surface and subsurface water resources (see Appendix 1).

Setbacks are designed to reduce potential harm due to normal industry operations as well as potential technological or procedural failures or other incidents. Typically two types of setbacks are employed to ensure accidents, failures and other impacts are avoided or diminished:

- an exclusion zone, in which no activity may take place
- a buffer zone, where activity may be allowed, but adherence to additional requirements and mitigation measures is required.

In NSW the *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) defines CSG exclusion and buffer zones as detailed in Table 3.1 below. Each of the specified areas of land is also defined in the Mining SEPP.

Table 3.1: Setback definitions (NSW Mining SEPP 2007)

Term	Definition
CSG exclusion zone	Any of the following areas of land: a) land within a residential zone b) future residential growth area land c) additional rural village land d) critical industry cluster land
Buffer zone	Land that is not within a CSG exclusion zone but is within 2km of the following land: a) land within a residential zone b) future residential growth area land c) additional rural village land

Setbacks and mitigation measures used varies between jurisdictions and each jurisdiction may use slightly different terminology for setback measures – commonly used terms are described in Table 3.2. However whilst the terminology used for describing setbacks varies across jurisdictions, the principle behind them remains reasonably constant- an imposed geospatial barrier within which an activity or industry is either prohibited or restricted. A setback could potentially describe a horizontal or vertical separation of activities.

Table 3.2: Setback/exclusion zone definitions

Term	Definition
Setback or separation distance	A defined distance separating incompatible land uses in order to avoid potential conflict
Exclusion zone	A defined geographic area within which specific activities are prohibited
Buffer zone/ restrictive area	A defined geographic area within which additional mitigation must occur to defuse potential conflict with neighbouring or sensitive receivers
Emergency planning zone	A defined geographic area surrounding a facility where people and the environment could be affected by a potential worst-case incident and which require mitigation

3.2 APPROACHES TO IMPOSING SETBACKS

There are typically two approaches available to regulators when imposing setback distances:

- prescriptive – setback distances are prescribed in legislation or codes to an industry, so the setback distance will be the same no matter what the location or conditions
- outcomes-based – specific risks and impacts of an individual project and/or site are assessed and setback distances applied according to research and evidence, so that different sites could have different setbacks based on their characteristics.

These two approaches do not have to be used in isolation. A hybrid of the two approaches may be adopted.

A prescriptive approach is mandated by legislation or mandatory codes, and imposes fixed rules for an industry or activity unrelated to any site or project-specific circumstances. It may rely on precedents, i.e., where a similar industry already has a similar distance imposed. A site-specific, outcomes-based approach assesses the risks and impacts project-by-project, and allows for localised flexibility in the controls to be used.

The primary advantage of a prescriptive approach is that it is more straightforward to mandate at the planning or approval stage, as extensive site-by-site testing is not required. The main disadvantage is the ‘one size fits all’ nature of the decision. This could mean, depending on the setback size chosen, that the setback may be unnecessarily large leading to significant resources being ‘sterilised’ and their value to society and CSG operators lost. Also theoretically possible is that the ‘one size fits all’ approach is too small.

Often with a prescriptive approach, the rationale behind how the setback size was calculated is not evident.

For an outcomes-based approach, numerical modelling can be a useful tool in assessing the potential scale and range of impacts of a project. Essentially a numerical model is a representation of reality which can be used to estimate the predicted impacts in a given environment (e.g., air, water or soil). Good quality data is essential for modelling, as the output (i.e., predictions of impacts in this case) from any model will only be as good as the input (data going in).

In NSW, the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* outlines the methods for modelling and assessing emissions of air pollutants from stationary

sources (DEC, 2005). An example of how this has been used for a major development project can be observed in the EIS for the recently announced NorthConnex road tunnel project. Modelling was utilised to predict impacts on ambient air quality anticipated during the construction and operational phases of the project (AECOM Australia, 2014). This information allows the estimation of exposure concentrations and likely intakes by any population potentially at risk which can then be compared to relevant exposure guidelines to determine and characterise any risks to health. Numerical modelling is also routinely done for noise and traffic impacts.

The two approaches represent the extremities of a scale. A hybrid of the two may be used, whereby an outcomes-based assessment of a particular operator's likely impacts may be utilised to create a generic setback which is then prescribed to an industry as a whole. Alternatively, an outcomes-based approach may be used to modify a prescribed setback on a case-by-case basis. Both these approaches are highlighted in the South Australian *Guidelines for Separation Distances* (SA EPA, 2007) which provide recommended setback distances based on the "best available information", the "experience and knowledge of EPA officers" and "the assumption that Best Available Technology Economically Achievable (BATEA) is implemented". The guidelines contain a mechanism for a proponent to demonstrate that a setback, other than the recommended distance, is appropriate. However setback distances are determined, its acceptance within the community is linked to the openness and transparency of the decision.

3.3 ROLE OF MONITORING

The imposition of a setback does not negate the need for monitoring. Effective monitoring surrounding a project provides a method for testing the predicted impacts, whilst also providing an early warning system if any unforeseen circumstances arise. Monitoring a project also presents a way in which to gain further knowledge of an industry or industries, not only at the specific location, but also in general terms. Data acquired through on-the-ground monitoring can be used to improve the degree of certainty in predictions in subsequent models and also assist in moving from a prescriptive to outcomes-based approach for setbacks. This is particularly relevant to subsurface operations, where causality issues are mired by uncertainties.

However, monitoring *per se* does not prevent unacceptable harm. The use of monitoring is most effective when tied to strict licensing and reporting conditions with clear repercussions for any breaches.

3.4 CSG SETBACKS IN NSW

As mentioned in Section 3.1, in 2013 the Mining SEPP was amended to prohibit CSG development in NSW residential areas and future residential growth areas, defined as 'CSG exclusion zones' (DP&E, 2014). CSG development was also prohibited within a 2km 'buffer zone' around any 'CSG exclusion zone'.

In January 2014, 'CSG exclusion zones' were expanded to include seven village areas, future residential growth areas and critical industry clusters in the Upper Hunter (NSW Government, 2014b). However, critical industry clusters do not have a 2km 'buffer zone' surrounding them.

In July 2014, the Department of Planning & Environment proposed further amendments to the Mining SEPP which included adding more properties to the critical industry cluster and clarifying the application of State Significant Development criteria for CSG exploration wells (NSW Government, 2014a). Currently, CSG is the only industry that has a setback applied through a State Environmental Planning Policy (SEPP) in NSW.

The methodology that was used for determining the size of the CSG setback in NSW is not available. In addition the setback only applies to new CSG activity (with some exceptions for related infrastructure, such as pipelines); approval for any proposed urban developments within 2km of an existing or approved CSG well or infrastructure are determined by the relevant consent authority (local government etc.). This allows for new residences to be located within 2km of CSG wells and infrastructure.

Additionally, the CSG setback is not consistent with comparative industries with potentially similar impacts. The NSW CSG setback only applies to the CSG industry, with setbacks for similar petroleum industries such as conventional, shale and tight gas, not currently considered.

3.5 GAS INDUSTRY SETBACKS IN OTHER JURISDICTIONS

An investigation into the jurisdictions of Queensland, South Australia, Western Australia, Alberta (Canada), England, and Colorado (USA), found that while all bar England mandate the application of setback distances to buildings and/or water, the exact principles, reasoning and calculations used by jurisdictions to underpin setbacks and exclusion zones remain largely unclear. Of the separation distances and/or conditions established, most all are unique to the jurisdiction, reflecting individual regimes and/or case by case analyses. Across the examined jurisdictions, distances between oil and gas operations and buildings, water sources or designated special areas vary from 50 metres to two kilometres.

A 2km buffer/exclusion zone is not without precedent. Queensland's *Resources Amendment Bill 2011*, which would have put in place a 2km exclusion zone around towns with more than 1,000 people, lapsed in February 2012 and was never enforced (Queensland Government, 2014). Rather than mandate development exclusion zones, in Western Australia, a 2km buffer in effect around declared occupied town sites triggers the referral of a development proposal from the Department of Mines and Petroleum to the EPA to assess impact (DMP & EPA (WA), 2009).

However, two examples, where the development of a setback distance informed by research, employed to ascertain the setback size of CSG developments in Queensland and Alberta are included below. Additionally, stakeholder input is an essential component of developing a policy acceptable to all stakeholders; this is considered in South Australia, England and Colorado.

Further detail on setbacks in the different jurisdictions studied is discussed in Appendix 2.

3.5.1 Hydraulic fracture treatments

Both Alberta and Queensland have 'vertical depth restrictions' for fracture treatments near water wells to prevent potential contamination or interference. In 2008, the Alberta regulator commissioned a third party review of their existing rules for shallow depth fracture stimulation, particularly concerning CSG (TAURUS Reservoir Solutions, 2008). The report analysed existing fracture data for nitrogen fractures in CSG wells and simulated fracture propagation in coals. It found that fracture lengths could be longer than predicted, prompting an increase in the setback distance (AER, 2013). New vertical setbacks were recommended and subsequently adopted by the regulator. These setbacks include: for gas wells within 200m (horizontally) of a water well, a 100m vertical setback for hydraulic fractures and a 50m vertical setback for nitrogen fractures in coals.

Alberta also instituted a 100m setback from the top of the bedrock for hydraulic fractures. Operators fracturing within 100m of the Base of Groundwater Protection[1] must produce additional risk assessments with their applications and are subject to additional regulation (AER, 2013).

Queensland's setback is much larger, stipulating a 200m vertical setback for fracture activities within 2,000m (horizontally) of a water well (DEHP, 2013). However it is uncertain how this separation distance was determined.

3.5.2 Hydrogen sulphide in Alberta

Unlike NSW, some methane gas reserves in Alberta contain hydrogen sulphide (H_2S), which is referred to as 'sour' gas. H_2S is a highly toxic gas with well-documented health effects and safety precautions in place for exposure. In Alberta, sour gas wells, pipelines and facilities containing high levels of sour gas, are subject to setbacks based on their potential release rate and the type of residential or public facility that could be affected. The setback distances range from 100m (low H_2S content, single dwelling) to 1,500m (high H_2S content, urban centre), with the potential for even greater setbacks at the regulator's discretion (AER, 2014). These varying setback levels are ascribed to the ease of notification and evacuation during an emergency (AER, 2014).

In addition to setbacks, which are set to protect people from day-to-day operations, sour gas facilities must meet additional requirements in Emergency Planning Zones (EPZs), which are areas affected in worst-case scenarios that require specific emergency response planning. The EPZ is determined using a software program developed by the regulator, which uses thermodynamics, fluid mechanics, atmospheric dispersion, and toxicology modelling (AER, 2009).

3.5.3 Stakeholder consultation

A stakeholder comment and consultation period allows stakeholders on all sides to present their opposition or support for a proposed development application or setback rule. These inputs usually occur early in the process to inform the project's development.

Community consultation is undertaken as part of determining setbacks in most jurisdictions studied. In jurisdictions such as South Australia, England or Colorado (and as required in the NSW *Environmental Planning and Assessment Act 1979*), this may include accepting comment on site-by-site planning applications or approvals processes, environmental permit applications, or during rulemaking hearings. Although the weight of stakeholder commentary is not expressed in these jurisdictions, the comments are considered alongside project plans that outline site characteristics, technological competencies, as well as existing data and regulation to determine the proximity of proposed projects to certain locations.

3.5.4 Proximity to sensitive land use

Some jurisdictions identify particular land uses as sensitive and impose additional setbacks around those uses. Western Australia, for example, places setbacks around uses including residential developments, schools, hospitals, hotels, nursing homes, shopping centres, child care centres and some public buildings; Colorado includes outdoor recreational areas. While site-specific studies are preferred as a way to set the distance, generic separation distances have also been devised (WA EPA, 2005).

Queensland identifies Environmentally Sensitive Areas (ESAs) and assigns protection zones within which petroleum activities are restricted. ESAs include a large variety of areas

[1] BGWP is "A modelled depth at which saline groundwater is likely to occur. It is calculated as the base of the deepest protected (nonsaline groundwater-bearing) formation plus a 15m buffer" (AER, 2013).

protected under various acts, including national parks, marine parks, aboriginal cultural heritage areas, heritage sites, resource reserves, and threatened ecosystems.

3.5.5 Noise considerations

While some jurisdictions including Queensland, Alberta, and Colorado regulate noise through permissible sound levels measured at specified distances, both South Australia and Western Australia mitigate noise through setback distances.

South Australia specifies separation distances for both air and noise considerations. For most activities, including petroleum production, only an air distance is specified as the noise distance is expected to fall within that (SA EPA (2007). Western Australia's separation distance guidelines indicate that gaseous emissions, noise, odour and risk are the impacts used to determine the petroleum production separation distances, however no further details are provided.

3.5.6 Consequence estimations, risk assessments and modelling

Examined jurisdictions require risks throughout the development process to be reduced to a defined level.

In South Australia, regulating agencies assessing these risks usually consider the natural, social and economic factors of the site's specific environment, as well as preventive and mitigative controls. This is set out in the *Petroleum and Geothermal Energy Act 2000* (South Australia) and includes engineering capabilities, monitoring requirements, maintenance and emergency plans and/or operating procedures proposed by the operator. This may also include assessing the day-to-day operational impacts and the probability of worst-case hazardous events, both individually and cumulatively, as well as the potential consequence of such events on the environmental factors listed above by commissioning relevant modelling.

If modelling shows that a potential consequence is unacceptable and mitigation measures do not raise the impacts to an acceptable level, then setbacks or separation distances may be established (as advised to the Review by South Australia DSD).

3.5.7 What is usually not considered in determining setbacks

Many of the setback policies investigated did not have clearly articulated rationales underpinning them. Frequently, guidance documents fail to provide any calculations or sources for how different setbacks were determined. Conversely, these guidance documents do often explain what was not considered when determining distances.

For the most part, human health concerns are one of the factors that are not considered. All the examined jurisdictions commonly acknowledge this omission (COGCC, 2013; SA EPA, 2007; WA EPA, 2005). The API only mentions health impacts regarding the training of employees, which they suggest should be overseen by employers, manufacturers or suppliers (API, 2011).

In addition to not considering occupational health and welfare issues, South Australia also does not address major hazards such as fire or explosion in their guidelines (SA EPA, 2007). For Western Australia, the guidelines also do not take into account cumulative impacts, non-typical emissions and the protection of natural resources (WA EPA, 2005).

In justifying the exclusion of human health impacts from consideration when making the new setback rules, Colorado stated that there were numerous data gaps related to oil and gas development's potential effect on humans health that warranted further study (COGCC, 2013).

4 SETBACK EXAMPLES FROM OTHER INDUSTRIES

To understand how other industries address their impacts and risks through setbacks, research was conducted into a range of other fields that may share similar hazards – fugitive emissions, chemical use, subsidence or groundwater interaction – or that have an entirely different set of risks, such as radioactivity.

The examples outlined in this section use both prescriptive and outcomes-based methodologies to determine setbacks. Industries operating in locations where preferred setbacks are not achievable apply additional protection measures to compensate for geographic space.

4.1.1 Wind turbines

For wind turbines in NSW, the EPA sets noise limits for the closest residential receptors and the proponent meets these through turbine selection and location.

In Victoria, residents have the power to ban any wind turbines within 2km of their residence, with development only proceeding if there is a written agreement with the relevant landowners (DPCD, 2012). In NSW, there is a current proposal to adopt this 2km setback distance, which is based on wind turbines' visual amenity, physical proximity and noise levels. The "*Draft NSW Planning Guidelines: Wind farms*" states that the gateway process in NSW may allow wind turbines to be developed within the 2km distance if they can prove that noise levels, visual impacts and land value remain at acceptable levels (DP&I, 2011).

In several European countries, the distance between wind turbines and residents is determined by noise limits or a multiple of the turbine's height or rotor diameter of the turbine. In Sweden and Germany, the setback distance is based upon the noise level produced by the wind turbine (Minnesota Government & Haugen, 2011). Denmark has setback limits based on turbine height because of nuisance factors of shadows and "flickers" of shadow as the turbine blades turn. There, wind turbines must be set back from residential dwellings a distance of four times the total turbine height. For a large turbine, the setback distance is about 600m (Danish Energy Agency, 2009).

4.1.2 Nuclear reactors

The NSW Lucas Heights Research Reactor established a 1.6km setback, where no permanent residential areas were permitted. The setback was based on an International Atomic Energy Agency assessment of the area at the highest risk in an emergency (NSW Health, 2003, citing IAEA, 1996). The assessment also notes examples of international nuclear reactors setbacks, ranging from no stated buffer zones (in Boston and Munich) to a radius of 500m (near Berlin). Most nuclear reactors take into account the surrounding population density and the feasibility of an emergency evacuation when developing setbacks (NSW Health, 2003).

4.1.3 Mining, demolition and explosives

Impacts and risks considered in mining include blasting debris, fugitive emissions from coal mines, subsidence and proximity to water. In NSW, management controls such as setbacks are specific to the activity and location of any sensitive receptors. Specific underground mining activities require minimum setbacks from sensitive receptors (e.g., dams). These setbacks are determined by assessing the 'angle of draw' or maximum theoretical extent of subsidence impacts (as advised to the Review by DRE). For mines in Queensland, a mandated risk assessment identifies the location and size of setbacks on a site-by-site basis. The recommendations that set the distances are based on mine activities, absolute levels of methane and foreseeable events and failure modes (DEEDI & Kabel, 2010).

The Kalgoorlie gold mines in Western Australia have a 400m safety exclusion zone. This area acts as a buffer between the mining activities and the urban residents. It excludes residential development inside the zone in order to reduce the level of risk associated with open cut mining activity (City of Kalgoorlie-Boulder, 2005).

4.1.4 Dams

The basic setback requirements for large dams are strongly dependent on local factors, such as the intended use of the particular dam, its relationship with other water bodies, existing uses of surrounding land and whether or not the dam is a prescribed dam[2]. Distances are calculated based on risk factors inherent in constructing and operating the dam. For example, the requirements and consequences of failure of a mine tailings dam contrast starkly with reservoirs supplying drinking water.

As a rule, setbacks for dams are applied on a case-by-case basis, usually on the recommendation of peak bodies such as the Australian National Committee on Large Dams and the NSW Dam Safety Committee (DSC). However, some rudimentary setbacks have widespread application. For example, dam spillway structures must incorporate a minimum 5m setback from any property boundary (The Hills Shire Council, n.d.).

The NSW DSC mandates a setback of up to 1.5km for mining operations around the Sydney Catchment and other water supply dams. The setback does not prohibit mining, but any proposed mining within it, requires the DSC's approval, when convinced that the safety of the dam is not impacted (CSE, 2014b).

4.1.5 Power stations

To ensure residential developments do not constrain the operation of power plants, the Western Australian EPA recommended that a large setback of over 4km be established around Collie Power Station to exclude residential development. This setback also serves to protect residents from air quality and noise issues (Griffin Energy, 2003).

4.1.6 Radio telescopes

In 2009, CSIRO established the Murchison Radio-astronomy Observatory (MRO) in Western Australia. The MRO is a purpose built radio astronomy observatory that offers operators a fully-equipped telescope site which is protected from the impacts of growing human settlement. In 2007 a Radio Quiet Zone extending 260km from the MRO was introduced to limit sources of radio interference from intentional radio communications (TV, radio stations, mobile phones) and unintentional radio emissions (electrical devices) (SKA Australia, 2014).

[2] "Prescribed" dams are those listed in Schedule 1 of the Dams Safety Act 1978. The Dams Safety Committee (DSC) can require owners of prescribed dams to do things to ensure the safety of their dams

5 CONCLUSION

The way in which risks and impacts are assessed and understood is fundamental to the management of the interface between potentially conflicting land uses, as appropriate controls can then be implemented to mitigate any perceived complexities. Setbacks have a role to play in the mitigation of risks. However, as with any industry, there will always be a degree of uncertainty in the predictions which underpin the determination of any setbacks.

Surface impacts of CSG activities on water, air and noise decrease with increasing distance from the well pad (CSE, 2014a). Therefore it is logical that, at some distance from the site, the potential stressor/pollutant will be at a level that is tolerable in terms of its impact, whether this is where it reaches background levels or where it comes within a threshold set by relevant guidelines such as Australian Drinking Water Guidelines, or National Environment Protection Measures ambient air quality guidelines. Subsurface impacts (e.g., connected aquifers and groundwater resources) need to be assessed separately. Should NSW move to a more outcomes-based approach in determining CSG setbacks, these dilution or dispersion factors could be used in their calculation.

Spatial barriers, such as setbacks, are commonly used (along with other approaches and technical controls) when addressing the interface between potentially conflicting land uses, be they industry wide setbacks prescribed by planning or zoning regulation, or distances proposed by an operator and approved by a regulator. If the potential impacts of an activity or project are assessed and understood, then perhaps increased regulation or more stringent design specifications could be adopted at the source to control risks. As stated in the South Australian EPA's *Guidelines for separation distances*:

> *Buffers or separation distances are not an alternative to source control and cleaner production methods. They are a means of reducing the effects of residual emissions and, in exceptional circumstances, the emissions from an enterprise operating under less than optimum conditions. It is important that the application of separation distances is not seen as a substitute for Best Available Technology Economically Achievable* (SA EPA, 2007).

In addition to any onsite controls, an outcomes-based approach to calculating setbacks could be adopted in NSW, similar to the hybrid approach taken in the South Australian EPA guidelines. The guidelines provide recommended setback distances based on experience and analysis, with mechanisms for a proponent to demonstrate that an alternative setback is appropriate, based on the inclusion of stronger controls or specific environmental barriers.

Technologies are changing the way in which we interact with the subsurface, such as horizontal drilling allowing the subsurface "footprint" to greatly exceed that at the surface. This ability to access underground resources while having little to no surface impact (directly above) means there may be scope for the development of dynamic setback provisions for subsurface separations.

However the interface between different land uses is managed, appropriate monitoring programs will be required to observe the predicted impacts, and to provide notification if the predicted impact thresholds are exceeded. For example, some noise impacts are managed through the imposition of specified noise limits with monitoring at the nearest residence, rather than by imposition of a set distance between the activity and the residential zone. Monitoring, however, does not prevent unacceptable impacts from occurring, and is only effective when coupled with strict regulatory conditions with clear repercussions for any departures from the agreed limits of operation.

Monitoring is also a useful tool to increase the level of understanding of the impacts of a particular activity on a particular receptor, thus providing knowledge from experience that

can be utilised in the approval of subsequent relevant projects. It is preferable to ensure the controls imposed on an activity or project are adaptable as knowledge increases. A sensible approach could be to impose conservative controls on an emerging industry and then monitor the predicted impacts against the actual impacts of the project, and later amend levels of constraint if appropriate.

Stakeholder considerations are also important in the determination of setbacks if a harmonious relationship between industry and community is to occur. While scientific evaluation may be an effective method for calculating an appropriate distance between industry and residential zones, this report acknowledges that social and cultural considerations also need to be taken into account. Despite sound scientific evidence supporting a determination, for some people the proposed distance from an unfamiliar industry may still be perceptually 'too close' and they would prefer the imposition of 'comfort distances', despite the lack of rationale, to protect such amenities as visual impacts, heritage and privacy. Requirements for compensation, or even land acquisition in extreme cases, similar to those seen for the mining industry, could be considered by the NSW Government for the CSG industry, to help ease the tension between community and industry. This provides added incentive to the developer to minimise impacts, whilst taking in to account any impacts incurred by neighbouring residences as well as land owners.

The management of future developments encroaching on any project also needs to be considered. As urban growth areas expand, new residential areas can creep up to historical industrial facilities, eroding original setback distances imposed. Although the project may have a legal right to continue to operate, over time residents may begin to resent it (even if the project may have been the original reason for the town's development). The use of a setback around the project could help to address this issue.

For any determination made regarding the interface between conflicting land uses, it is imperative that the rationale behind the decision be open and transparent to help assure residents that their concerns, along with any potential risks, have been assessed and appropriately addressed.

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Acronyms

AER	Alberta Energy Regulator
ALARP	As Low as Reasonably Practicable
API	American Petroleum Institute
BGWP	Base of Ground Water Protection (Alberta)
CSG	Coal Seam Gas
COGCC	Colorado Oil and Gas Conservation Commission
DCPS	Drilling, Completion, Production and Storage
DMP	Department of Mines and Petroleum (Western Australia)
DP&E	Department of Planning and Environment
DRE	Division of Resources and Energy
DSC	Dam Safety Committee
DSD	Department of State Development (South Australia)
EA	Environmental Agency (England)
EPZ	Emergency Planning Zone (Alberta)
EPA	Environmental Protection Authority
EPL	Environmental Protection Licence
ESA	Environmentally Sensitive Area (Queensland)
MPA	Mineral Planning Authority (England)
H_2S	Hydrogen Sulphide
SA EPA	South Australia Environmental Protection Authority
MRO	Murchison Radio-astronomy Observatory
NOW	NSW Office of Water
OCSG	Office of Coal Seam Gas
PAL	Petroleum Assessment Lease
PEL	Petroleum Exploration Licence
PPL	Petroleum Production Lease
SEPP	State Environmental Planning Policy
SPZ	Source Protection Zones (England)
WA EPA	Western Australia Environmental Protection Authority

APPENDIX 1 – FURTHER INFORMATION ON SETBACKS IN OTHER JURISTICTIONS

Across the examined jurisdictions, distances between oil and gas operations and buildings, water sources or designated special areas vary from 50 metres to two kilometres.

A1.1 SETBACK CENTRE POINTS AND BOUNDARIES

Setback distances usually surround the gas well bore, but the centre point may also be the 'production facility' (equipment directly associated with oil, gas or injection wells) including waste water or produced water pits, or between surface equipment. These centre points extend radially to the location determined to merit additional protection, which may include:

- buildings, property lines, residential or urban boundaries
- water sources, including surface and subsurface
- other sensitive land use areas including wildlife habitat, heritage or social landmarks, outdoor recreational facilities, or agricultural land.

By contrast, in Western Australia, 'separation distances' are more broadly defined as "*the shortest distance between the boundary of the area that may potentially be used by an industrial land use*" and the sensitive land use boundary, rather than from an oil or gas wellhead (WA EPA, 2005). England also determines the required distances for above-ground setbacks from the boundary of the minerals site and the adjacent development (DCLG, 2013).

Colorado recently modified its setback rules concerning the measurement of distances. In the Oil and Gas Location Assessment, operators must provide the shortest distances between any well or production facility and "*the edge or corner of the nearest building, Building Unit, High Occupancy Building Unit, the nearest boundary of a Designated Outside Activity Area, and the nearest public road, above ground utility, railroad, and property line*" (Rule 303.b.(3)A, COGCC, n.d.). This clarification was made "*to ensure any piece of permanent production equipment located within a Designated Setback Location triggers appropriate requirements*" (COGCC, 2014).

Setbacks do not always place a moratorium on oil and gas activity – instead, setbacks may allow oil and gas operations to proceed within buffer zones, but only after or while operators adhere to additional restrictions and employ required mitigation measures.

A1.2 BUILDINGS, PROPERTY LINES, RESIDENTIAL OR URBAN BOUNDARIES

Most of the examined jurisdictions have setbacks surrounding buildings where people live and gather. The definitions and classifications of buildings and dwelling types vary from region to region along with the associated separation distances.

South Australia, Western Australia, and Colorado have additional setback conditions around urban or higher-density areas than around single dwellings however, exemptions may apply. For example, Colorado companies must have a public hearing before a well may be approved within the 305m buffer zone of 'high occupancy' buildings (Rule 604a, COGCC, n.d.).

Western Australia also currently has a 2km buffer in effect around declared occupied town sites, which triggers the referral of a development proposal from the DMP to the EPA (DMP & EPA (WA), 2009). Queensland's *Resources Legislation (Balance, Certainty and Efficiency)*

Amendment Bill 2011, which would have enabled a 2km exclusion zone to have been declared around towns with more than 1,000 people, lapsed in February 2012 (Queensland Government, 2014).

In Alberta, a standard setback of 100m applies to surface improvements, which include dwellings, industrial plants, farm buildings, schools, and churches. While exceptions may be granted, applications then become 'non-routine' and are subject to additional conditions and reviews. Additional setbacks are applied to sour gas facilities based on the potential H_2S release. As outlined in Table A.1, these setbacks range from 100m to 1,500m with an additional level left to the discretion of the AER.

Table A.1: Alberta setback requirements for Category C, D, or E facilities with pipelines and wells containing H_2S

Level	H_2S release volume (m^3)	Minimum distance
1	< 300	• Lease boundary (for pipelines); 0.1km to any surface improvement other than a surveyed roadway or road allowance (for wells). Specified by the *Oil and Gas Conservation Act 2000 (Alberta)*
2	≥ 300 to <2000 (for pipelines and wells)	• 0.1km to individual permanent dwellings and unrestricted country developments • 0.5km to urban centres or public facilities
3	≥ 2000 to <6000 (for pipelines and wells)	• 0.1km to individual permanent dwellings up to 8 dwellings per quarter section • 0.5km to unrestricted country developments. • 1.5km to urban centres or public facilities
4	≥ 6000	• As specified by the AER but not less than Level 3

(Adapted from tables 5.5 and 7.5 in AER Directive 56, 2011)

Alberta also utilises Emergency Planning Zones (EPZs) for sour gas wells, pipelines and facilities. A regulator-developed software program called ERCBH_2S is used to determine the size of these zones, which then act as a buffer zone with additional notification, safety and emergency response requirements (AER, 2009; ERCB, 2010).

In Colorado, COGCC Rules and Regulations have authority under the *Oil and Gas Conservation Act 1951 (Colorado)*. Series 600 on safety addresses setbacks and mitigation measures. Colorado setbacks include:

- Exception Zone Setback – prohibits any Well or Oil and Gas Location within 500ft (~152m) of a Building Unit unless, among other requirements, protective measures are put in place sufficient to eliminate, minimise or mitigate potential adverse impacts to public health, safety, welfare, the environment to the maximum extent technically feasible and economically practicable (COGCC, 2013) (Rule 604, COGCC, n.d.)
- Buffer Zone Setbacks – imposes heightened mitigation, notice, and communication requirements on Operators where a Well or Production Facility is proposed to be located within 1,000ft (~305m) of a Building Unit (Rule 604.a.(2), COGCC, n.d.) (COGCC, 2013)
- High Occupancy Buildings – no Well or Production Facility will be located within 1,000ft (~305m) of a High Occupancy Building (Rule 604.a.(3), COGCC, n.d.)
- Designated Outside Activity Areas – no Well or Production Facility within 350ft (~107m) or less from the boundary of a Designated Outside Activity Area Rule (604.a.(4), COGCC, n.d.)

Finally, in Colorado, for seismic operations, exploration involving shothole drilling or recording operations requires blasting safety setbacks from building units, water wells or springs. Minimum setbacks of 200-1,320ft (~402m) are based on the weight of charges, from zero to more than 20lbs (~9kg) (Rule 333c, COGCC, n.d.).

In Western Australia buffer distances are one trigger by which the DMP is required to liaise with the WA EPA; they do not dictate a fixed setback. This liaison subjects the project to additional environmental review and may result in the WA EPA recommending further conditions on the project. Trigger criteria for liaising with the WA EPA is outlined in a memorandum of understanding between the organisations but includes when oil or gas extraction and production is within 2,000m of a town site (DMP, 2012).

A1.3 AIR EMISSIONS, NOISE AND AESTHETICS

Other regulated mitigation measures regarding noise, light, and other aesthetics exist in most jurisdictions to minimise nuisance impacts on neighbouring entities, be they private residences or sensitive areas, at the source.

The API states that "when feasible, the wellsite and access road should be located as far as practical from occupied structures and places of assembly" to protect "non-lease holders from noise impacts that conflict with their property use" (API, 2011).

South Australia's Guidelines for Separation Distances were designed as a planning tool for new developments; however they are considered indicative and are subject to adjustment (SA EPA, 2007). These guidelines apply airborne and noise separation distances of 1,500m from petroleum production, storage or processing works or facilities to residential or other sensitive land uses, taking into account topographical features including metropolitan areas, heavy timber or undulating hills (SA EPA, 2007).

Colorado mandates that site lighting be managed so as to avoid glare on public roads and building units within approximately 300m of the development (Rule 803, COGCC, n.d.). They also require operators to control fugitive dust and comply with Department of Public Health and Environment Air Quality Control Commission for odour and emissions (Rules 805.c, 805.b,) ("*5 CCR 1001-9*," 2013; "*5 CCR 1001-5*," 2014; "*5 CCR 1001-9*," 2014). Further conditions are placed on the presence of certain production equipment and operations, involving crude oil, condensate and produced water tanks, glycol dehydrators, or pits within ~400m of a 'Building Unit' or 'Designated Outside Activity Area' (like a sporting field).

Colorado, Queensland and Alberta all address noise concerns, not with setbacks but through regulated allowable sound levels. Queensland has a maximum allowable decibel and peak particle velocity for blasting activities as measured at sensitive places including dwellings, public buildings, parks and protected areas (DEHP, 2013). Alberta uses 'permissible sound levels' determined from an equation taking into account baseline sound level, seasonal considerations, and the duration of the sound, measured at the nearest dwelling or 1.5km from the facility (AER, 2007). Colorado applies a maximum decibel level as measured ~107m from the source. Colorado's allowable sound levels are summarized in Table A.2 below.

Table A.2: Maximum permissible noise levels for oil and gas operations at any Colorado well site, production facility or gas facility, measured ~107m from the noise source

Zone	7:00am to next 7:00pm	7:00pm to next 7:00am
Residential/ Agricultural/ Rural	55db(A)	50db(A)
Commercial	60db(A)	55db(A)
Light industrial	70db(A)	65db(A)
Industrial	80db(A)	75db(A)

(Rule 802, COGCC, n.d.)

A1.4 WATER

Water-related setbacks vary greatly between jurisdictions. Differences include the distance between wellbores or produced water pits and surface or subsurface water sources, mitigation requirements, and what is and is not considered a protected water source.

The API states that sites for all exploration and production activities warrant careful evaluation and planning should consider the potential for soil and surface water impacts in the event of a spill, especially where hydraulic fracturing operations will be carried out (API, 2011). They also state that ponds used for fluid storages should be sited away from surface water due to the danger of overflows (API, 2010).

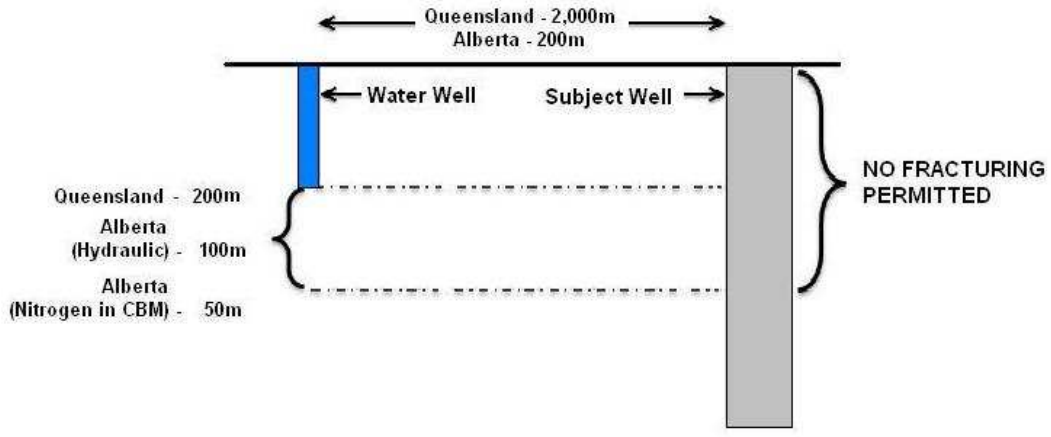
In Queensland, a 200m distance from any wetland, lake or spring and a 100m distance from the out bank of any watercourse must be maintained for any petroleum activities that require earthworks, vegetation clearing and/or placing fill (DEHP, 2013). In Western Australia, oil or gas extraction activities within 500m of an environmentally sensitive or priority one water area or within 2,000m of a coastline or water resource area are an additional trigger criteria for the DMP liaising with the Western Australia EPA (DMP, 2012). In this case, the EPA will have final sign off on the project.

In Alberta, wells must be set back 100m from any water bodies in order to submit a routine application. Proposed well locations within this setback must submit a non-routine application which is subject to greater scrutiny (AER (2011).

While not strictly a setback, Alberta has developed what is referred to as the Base of Ground Water Protection (BGWP). This depth marker varies across the province, and represents the deepest non-saline aquifer plus a buffer zone; an online query tool is available to identify the BGWP for an area. Many directives reference the BGWP, with more stringent regulations applying to activities occurring above or near it. One example of this is additional produced water testing required for wells operating above the BGWP.

Specific to fracturing near water wells, Alberta and Queensland have both implemented setbacks for fracture activities. Queensland stipulates a 200m vertical setback for fracture activities within 2,000m of a water well (DEHP, 2013). Alberta has similar stipulations, albeit significantly smaller. For wells within 200m of a water well there is a 100m vertical setback for hydraulic fractures and a 50m vertical setback for nitrogen fractures in coals. In addition Alberta has instituted a 100m setback from the top of the bedrock for hydraulic fractures and fractures occurring within 100m of the BGWP must produce additional risk assessments with their applications and are subject to additional regulation (AER, 2013). See Figure A.1.

Figure A.1: Setback requirements for fracture stimulations near water wells in Queensland and Alberta
(Figure based on information from DEHP, 2013; TAURUS Reservoir Solutions, 2008)



England designates Source Protection Zones (SPZs) for 2,000 groundwater sources such as wells, boreholes and springs used for public drinking water supply (Environment Agency, 2014). The Environmental Agency states they will object to hydrocarbon exploration, extraction infrastructure or activity within SPZ1 (Environment Agency, 2013b). Outside of SPZ1, they will also object if the activity will have unacceptable effect on groundwater.

SPZ1s are inner source protection zones with the extent defined by a 50-day travel time of groundwater to the borehole (drinking water) with a minimum radius of 50m (Environment Agency, 2013b). An SPZ2 is defined by a 400-day travel time, and an SPZ3 encompasses the full catchment. While the Environment Agency says there should be no drilling within SPZ1s, horizontal drilling deep below the base of the aquifer may be acceptable (Environment Agency, 2013b).

England applies progressively more stringent controls as the sensitivity of the location increases and applies the precautionary principle when the potential consequences of a risk are high (Environment Agency, 2013b). If an activity is deemed to pose too great a risk to water supplies, the Environment Agency will object to the activity through either the planning process or its own permitting controls; however raising an objection does not signal the end for a proposal. Rather, after an objection is given, more information will be requested and solutions for the developer to consider will be suggested (Environment Agency, 2013b).

Colorado's complex arrangement requires setback from approximately 257 designated public water sources (COGCC, n.d.). Drilling-related activities are more heavily restricted closer to the body of water (Richardson, Gottlieb, Krupnick, & Wiseman, 2013).

Table A.3: Buffer zones associated with Colorado drilling, completion, production and storage operations

Zone	Classified Water Supply Segments in feet (& metres)
Internal Buffer	0-300ft (~0-91m)
Intermediate Buffer	301-500ft (~92-152m)
External Buffer	501-2640ft (~153 – 805m)

(Rule 317B, Table 1, COGCC, n.d.)

Drilling, Completion, Production and Storage (DCPS) operations and roads or pipelines within a Surface Water Supply Area – or within five miles (~8.05km) upstream of a surface water intake – may not occur in whole or in part within 300ft (~91.44m) of a classified drinking water source unless a variance is granted (Table A.3). Again, this applies only to classified water supply segments. Mitigation, reporting and notification requirements apply to DCPS operations within Intermediate and External Buffer zones.

Lessons learned about setbacks after flooding near oil and gas development

In September 2013, Colorado experienced dramatic flooding along its Front Range, where a large amount of oil and gas activity occurs. In its March 2014 a Lessons Learned report on the flooding was released (COGCC & Lepore, 2014).

The report cited three circumstances that led to operators locating oil and gas wells and equipment near waterways. These include:

1. surface owners who farm or ranch negotiate with operators to locate wells and production equipment and pads away from valuable agricultural land, defaulting to locations near waterways that cannot otherwise be used for agriculture
2. sometimes building setback requirements leave operators with little practical choice but to build in undeveloped flood plains
3. the topography of steep slopes and few flat locations cause operators to locate wells and equipment near waterways (COGCC & Lepore, 2014).

During the course of fact-finding for the report some suggested that setback restrictions should be adopted for wells and facilities near streams (COGCC & Lepore, 2014). However, the resulting recommendations did not suggest statutory changes, but primarily involved early emergency response procedures for COGCC staff, including training, fact finding and information distribution, and communications with relevant agencies.

The report did recommend that no pit should be allowed within a designated distance from the ordinary high water mark of a waterway and that any existing pit within these areas near waterways should be removed and reclaimed (COGCC & Lepore, 2014).

A1.5 OTHER LAND USE AREAS

Western Australia has a 2km separation distance in place between oil and gas operations and sensitive land use areas (WA EPA, 2005). Queensland's *Environmental Protection Regulation 2008* outlines a series of setbacks from Environmentally Sensitive Areas (ESAs) (Table A.4). These areas include national parks, wet tropics, marine parks, conservation areas, state forest parks, endangered regional ecosystems, registered heritage places, registered aboriginal culture areas, resource reserves, and various other habitats and ecosystems (DEHP, 2013; "Environmental Protection Regulation 2008 (Qld)," 2014).

Table A.4: Petroleum setbacks for Queensland Environmentally Sensitive Areas

ESA Category	ESA Area	Primary Protection Zone (200m from the area boundary)	Secondary Protection Zone (100m from the Primary Protection Zone boundary)
A	No petroleum activities	Low impact petroleum activities only	Essential petroleum activities only
B	Low impact petroleum activities only	Essential petroleum activities only	Essential petroleum activities only
C –excl. state forests or timber reserves	Low impact petroleum activities only	Essential petroleum activities only	
C - state forests or timber reserves	Essential petroleum activities only		

*Low Impact Petroleum Activity – does not result in significant disturbance to land which cannot be rehabilitated immediately using hand tools after the activity is completed.
*Essential Petroleum Activities – includes well sites not exceeding 1.5Ha disturbance, necessary onsite infrastructure, pipelines, and access tracks, with communication and power lines restricted to well pad and pipeline right-of-ways.
(DEHP, 2013)

Alberta's Environment and Sustainable Resource Development (ESRD) is currently developing a comprehensive Land Use Framework to manage growth, in part by continuing to identify sensitive lands where development, including oil and gas development, will be

restricted or prohibited (Government of Alberta, 2008). As part of each regional plan, sub-regional plans and air, land and water frameworks will be undertaken.

Further, in Alberta, the standard 100m setback applies to ‘surface improvements’ which, in addition to the buildings and dwellings mentioned previously, includes railways, pipelines, canals, road allowances, and surveyed roads. Buffer zones of up to 5km exist around airports that impose additional requirement notifications before drilling can occur. Also, well licence applications within 3km of coal mines are subject to additional requirements and may need to submit non-routine applications (AER, 2011).

In 2012, Alberta introduced additional development regulation, mandating that development proposals identify and locate abandoned wells onsite and that a 5m setback from the abandoned well be maintained (AER, 2012).

In England, the Environment Agency considers the location of the site and distances in relation to biodiversity, heritage, residential areas, nearest water course and groundwater zones, landscape and nature conservation in order to set suitable limits and conditions in the permits for waste, water and/or radioactive materials (Environment Agency, 2013a). In addition to residences, schools, and water resources according to the nearest SPZ (Section A2.4), the proximity of proposed oil and gas development to protected species, wildlife sites or habitats, Sites of Special Scientific Interest and other sensitive ‘receptors’ is considered (DCLG, 2013).

Though these factors are considered in the planning application, proximity to these sensitive areas is not always reason enough for rejecting an application. Further, while no set minimum distance is specified for these activities, except the SPZs, applications are considered on a case-by-case basis.

In Colorado, operators must implement additional mitigation measures, within a Sensitive Wildlife Habitat or Restricted Surface Occupancy area to minimise adverse impacts to wildlife resources. Maps defining these areas, with spatial data, are updated by and kept on the COGCC website. Additionally, oil and gas wells in Colorado are not allowed within 200ft (~70m) of a coal shaft or coal mine that is not abandoned (Rule 318.e, COGCC, 2013)

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