

The Permanent Peoples’ Tribunal Session on Human Rights, Fracking and Climate Change

APPENDIX 1 to Violations of Nature’s Rights

Evidence of environmental and climate harm caused by unconventional oil and gas extraction

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Water contamination

Australia

- Methane seepage and bubbling within river in Condamine River, Queensland.¹
- Fresh water being drawn from bores, in a bucket, bubbling with methane gas and producing a bad smell. Sudden impacts of this included: Dying vegetable plants, wasting pigs (stock needed to be euthanized) and dying chickens in Tara, Qld.²
- The Australian Commonwealth Scientific and Industrial Research Organisation declared in a report that “Methane in water bores is a major concern in areas of coal seam gas (CSG) development. There are risks associated with ignition and asphyxiation in closed spaces around bores that create real concern. There are also other risks, such as gas lock in pumps, colour and odour impacts from water quality changes, toxicity due to other gases and build-up of gases affecting the integrity of the bores.”³
- Waterways with algal blooms and or/oily sheens visible in Nine Mile Creek, Chinchilla district, Qld. Ephemeral creeks have been described to appear to sit at ‘high tide’ with a pea-soup like flow 365 days a year.⁴
- A flood event in 2011 caused an unlined evaporation pond to traverse into neighbouring property to overflow into the residential dam.⁵
- Santos coal seam gas project contaminated an aquifer with uranium levels 20 times higher than safe drinking water guidelines in Pilliga, NSW.⁶
- Creek testing on property revealed high mercury, aluminium and sodium.⁷
- Creek and storage tank testing confirmed higher than usual aluminium, sodium and iron. There was also lead and cadmium present.⁸

¹ MSN. (2017, 17 April). ‘CSG could increase methane emission near bubbling Condamine River’. Retrieved from <http://au.pressfrom.com/news/australia/-18035-csg-could-increase-methane-emissions-near-bubbling-condamine-river-report-finds>.

² Jang family testimony. (2017). Australian Tribunal into the Human Rights Impacts of Unconventional Gas, Session 5 – Cultural and Social Impacts (“Australian Tribunal – Session 5”). Retrieved from <https://www.peopletribunalongas.org/wp-content/uploads/2017/11/Jang-Testimony-1.pdf>.

³ Walker, G.R. & Mallants, D. (2014, September). *Methodologies for Investigating Gas in Water Bores and Links to Coal Seam Gas Development*. CSIRO. Retrieved from <https://publications.csiro.au/rpr/pub?pid=csiro:EP147897>.

⁴ Sharon Lohse testimony, Australian Tribunal – Session 5: <https://www.peopletribunalongas.org/session-five/>.

⁵ Kylie H testimony, Australian Tribunal – Session 5: <https://www.peopletribunalongas.org/session-five/>.

⁶ Nicholls, S. (2018, 8 March). ‘Santos coal seam gas project contaminates aquifer’. The Sydney Morning Herald. <https://www.smh.com.au/environment/santos-coal-seam-gas-project-contaminates-aquifer-20140307-34csb.html>.

⁷ Sharon Lohse testimony, Australian Tribunal - Session 5: <https://www.peopletribunalongas.org/session-five/>.

⁸ Sharon Lohse testimony, Australian Tribunal - Session 5: <https://www.peopletribunalongas.org/session-five/>.

- Repeated spraying of toxic waste water from UGE onto roads from ‘beneficial use’ trucks in Kogan, Qld. Nugrow Waste Disposal facility in Kogan also accepting contaminated water, transferred into toxic sump pit. This waste includes CSG drill muds, brine sludges, oily water, septic tank waste and food waste, which is recycled into land additives and compost.⁹

North America

- Massive amounts of fresh water are used in the tar sands industry in Canada and elsewhere. In 2011 alone, companies mining the tar sands siphoned approximately 370 million cubic meters of water from the Athabasca River alone, exceeding the amount of water that the city of Toronto, with a population of 2.8 million, uses in one year.¹⁰ The timing and sheer scale of the water use is drying up wetlands, disrupting water flows, and potentially threatening riparian habitats thousands of miles downstream along the Mackenzie River basin.¹¹
- In Northern Alberta, 340 billion gallons of toxic tar sands extraction wastewater lies in tailings ponds covering 251 square kilometres (97 square miles).¹²
- Three billion gallons fracking wastewater illegally dumped into central California aquifers that supply drinking water and farming irrigation.¹³
- Study of more than 1021 chemicals used or created during fracking process found that 781 lacked basic toxicity data, and of 240 remaining, 157 were reproductive or developmental toxicants.¹⁴
- PSE statistical analysis of scientific literature from 2009-2015 (685 peer-reviewed papers) shows 69% original research studies on water quality found potential for, or actual evidence of water contamination.¹⁵
- Methane found in 42 water wells in Denver-Julesburg Basin from well failures.¹⁶

⁹ Brian Monk Testimony. (2017). Australian Tribunal - Session 5: <https://www.peopletribunalongas.org/session-five/>.

¹⁰ YaleEnvironment360 report (5 August 2013) *With Tar Sands Development, Growing Concern on Water Use*. Retrieved from: https://e360.yale.edu/features/with_tar_sands_development_growing_concern_on_water_use.

¹¹ Rosenberg International Forum on Water Policy report (2013), Potentially ‘catastrophic’ changes underway in Canada’s northern Mackenzie River Basin. Retrieved from: <https://phys.org/news/2013-06-potentially-catastrophic-underway-canada-northern.html>.

¹² See: <http://business.financialpost.com/commodities/energy/340-billion-gallons-of-sludge-spur-environmental-fears-in-canada>.

¹³ Concerned Health Professionals of New York & Physicians for Social Responsibility. (2016, November 17). *Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction)* (4th ed.). <http://concernedhealthny.org/compendium>. At page 133 (“*Compendium*”); Dechert, S. (2014, October 14). *Fracking wastewater spoils California drinking, farm supplies*. Clean Technica. Retrieved from <http://cleantechnica.com/2014/10/14/fracking-wastewater-spoils-california-drinking-farm-supplies>.

¹⁴ *Compendium*, above n 10, at page 42; Elliot, E. G., Ettinger, A. S., Leaderer, B. P., Bracken, M. B., Deziel, N. (2016). A systematic evaluation of chemicals in hydraulic-fracturing fluids and wastewater for reproductive and developmental toxicity. Advance online publication. *Journal of Exposure Science & Environmental Epidemiology*. doi: 10.1038/jes.2015.81.

¹⁵ *Compendium*, above n 10, at page 4.

¹⁶ *Compendium*, above n 10, at page 38; Sherwood, O. A., Rogers, J. D., Lackey, G., Burke, T. L., Osborn, S. G. & Ryan, J. N. (2016). Groundwater methane in relation to oil and gas development and shallow coal seams in the Denver-Julesburg Basin of Colorado. *Proceedings of the National Academy of Sciences* 113(30). doi: 10.1073/pnas.1523267113.

- Fracking waste found in water and sediment samples from creek downstream of a fracking wastewater disposal facility in West Virginia.¹⁷
- Contaminated surface water and soil throughout North Dakota found to be caused by accidental spills of fracking wastewater. Contaminants included salts, lead, selenium and vanadium. Levels often exceeded federal drinking water guidelines.¹⁸
- Contaminated drinking water found in town of Pavillion, Wyoming. Substances found match those used in local fracking operations or in disposal pits used to dispose of drilling waste. Chemicals included benzene (known carcinogen) and toluene (neurotoxicant).¹⁹
- Three private drinking water wells were contaminated when Antero Resources mistakenly drilled into one of its own gas wells causing Benzene (carcinogen) and toluene (reproductive toxicant) to be detected in the drinking water at four times the legal maximum limit.²⁰
- Four thousand gallons of liquid fracking waste dumped into Waynesburg sewer system was discovered by sewage treatment plant workers in Greene County, Pennsylvania. The sewage treatment plant discharges into a creek that feeds the Monongahela River which provides drinking water to more than 800,000 people.²¹
- Operator of six leaking pits in Washington County that each held millions of gallons of fracking wastewater, Range Resources, was fined \$4.5mil by Pennsylvania Department of Environmental Protection.²²
- A spill into a creek in Monroe County, Ohio, which is an important supply of drinking water for downstream communities, caused mass die-off of fish and other aquatic wildlife. Operator, Halliburton, delayed disclosure to EPA agencies for five full days.²³

¹⁷ *Compendium*, above n 10, at page 39; Akob, D. M., Mumford, A. C., Orem, W. H., Engle, M. A., Klinges, J. G., Kent, D. B., & Cozzarelli, I. M. (2016). Wastewater disposal from unconventional oil and gas development degrades stream quality at a West Virginia injection facility. *Environmental Science and Technology*, 50(11). doi: 10.1021/acs.est.6b00428.

¹⁸ *Compendium*, above n 10, at page 39-40; Lauer, N. E., Harkness, J. S., & Vengosh A. (2016). Brine spills associated with unconventional oil development in North Dakota. *Environmental Science & Technology*, 50(10). doi: 10.1021/acs.est.5b06349.

¹⁹ *Compendium*, above n 10, at page 40; DiGiulio, D. C. & Jackson, R. B. (2016). Impact to underground sources of drinking water and domestic wells from production well stimulation and completion practices in the Pavillion, Wyoming, Field. *Environmental Science & Technology*, 50(8). doi: 10.1021/acs.est.5b04970.

²⁰ *Compendium*, above n 10, at page 53; Board, G. (2014, November 3). September drilling accident contaminated water in Doddridge County. West Virginia Public Broadcasting. Retrieved from <http://wvpublic.org/post/dep-september-drilling-accidentcontaminated-water-doddridge-county>.

²¹ *Compendium*, above n 10, at page 54; Hopey, D. (2014, October 15). Waynesburg officials investigate dumping of fracking wastewater. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/news/environment/2014/10/15/Waynesburginvestigates-dumping-of-fracking-wastewater/stories/201410150056>.

²² *Compendium*, above n 10, at page 55; Hopey, D. (2014, September 18). Range resources to pay \$4.15M penalty. *Pittsburgh Post-Gazette*. Retrieved from <http://www.post-gazette.com/local/2014/09/18/DEP-orders-Range-Resources-to-pay-4-millionfine/stories/201409180293>.

²³ *Compendium*, above n 10, at page 57; Arenschield, L. (2014, July 21). Halliburton delayed releasing details on fracking chemicals after Monroe County spill. *The Columbus Dispatch*. Retrieved from <http://www.dispatch.com/content/stories/local/2014/07/21/details-on-chemicals-trickle-in-after-spill.html>.

- Pennsylvania court found gas corporation guilty of contaminating a woman’s drinking water well in Bradford County.²⁴
- Criminal charges filed against Exxon Mobil Corporation’s subsidiary, XTO Energy Corporation, for a 50,000 gallon spill of toxic drilling wastewater in 2010 that contaminated a spring and tributary of the Susquehanna River.²⁵
- Causal link documented between fracking wastewater spill and widespread death of fish in Acorn Fork, a creek in Kentucky.²⁶

Europe

- The mayor of Isovoarele, Romania, where drilling has been occurring for decades, stated that almost half of the village’s water sources were poisonous, with allegations of physical abuse to those who had spoken out about the contamination.²⁷
- Underground water contamination problems have been reported in Beba Veche and surrounding areas in Romania since 2011, including instances of flammable water and the presence of arsenic in the water, well above recommended maximum levels.²⁸

Air pollution and climate change

Australia

- A report prepared for the Queensland Department of Natural Resources and Mines found that “free gas migrating from CSG development can occur in water bores that do not experience a water level decline from CSG development. Presence of free gas in a water bore is more than just nuisance. It directly affects the bore’s capacity to provide water supply for the intended purpose”.²⁹

²⁴ *Compendium*, above n 10, at page 60; Gibbons, B. (2014, February 19). Woman wins case against Chesapeake Jaqueline Place of Terry Township to receive compensation for well contamination. *TheDailyReview.com*. Retrieved from <http://thedailyreview.com/news/woman-wins-case-against-chesapeake-jaqueline-place-of-terry-township-to-receive-compensation-for-well-contamination-1.1636832>.

²⁵ *Compendium*, above n 10, at page 62; Maykuth, A. (2013, September 13). Shale criminal charges stun drilling industry. *Philly.com*. Retrieved from http://articles.philly.com/2013-09-13/news/42012429_1_xto-energy-inc-criminal-charges-attorney-general.

²⁶ Papoulias, D., & MacKenzie, T. (2013, August 28). Hydraulic fracturing fluids likely harmed threatened Kentucky fish species. *USGS Newsroom*. Retrieved from <http://www.usgs.gov/newsroom/article.asp?ID=3677>

²⁷ O’Brien, P. (2014, February 18) Romania – a Peasants Revolt against Fracking. *TheEcologist.org*. Retrieved from <https://theecologist.org/2014/feb/18/romania-peasants-revolt-against-fracking>.

²⁸ Olteanu, M. (2015, February 16). Romanian NGOs worried about water contamination in Beba Veche village and surrounding areas. English version retrieved from <https://frackoffromania.wordpress.com/2015/02/24/romanian-ngos-worried-about-water-contamination-in-beba-veche-village-and-surrounding-areas/#more-458>.

²⁹ Klohn Crippen Berger. (2016, March). *Potential effects of free gas on bore waters supply from CSG development – final report*. Retrieved from <http://notatanycost.com.au/wp-content/uploads/2014/02/KCB-Gassy-Bore-Final-Report.pdf>.

- During rainfall events, Cadmium forms as a white coat over everything as a result of the air pollution, killing the plants – dead toads were also recorded after rainfall events.³⁰
- “The amount of methane and other emissions will cause the quality of the air to be diminished and contribute to climate change. Of methane – “It is a powerful greenhouse gas; up to 80 times more powerful than carbon dioxide emissions that are causing most concerns about climate change”³¹

North America

- Recent research shows that the levels of methane being emitted into the atmosphere in Alberta as a result of oil sands extraction are far worse than originally thought.³²
- A new federal inventory of greenhouse gases documented that methane leaks from U.S. oil and gas operations are higher than previously estimated, as are total U.S. methane emissions, which increased by more than 30 per cent between 2002 and 2014.³³
- PSE statistical analysis of scientific literature from 2009-2015 (685 peer-reviewed papers) shows 87% original research studies on air quality found elevated air pollutant emissions.³⁴
- Aliso Canyon gas storage leak in California: a 3,600 acre underground natural gas storage facility. The blowout began 23 October 2015 and the leak was uncontrolled for 4 months, releasing over 100,000 metric tons of methane. 8,300 households were evacuated at cost of \$500 million.³⁵ Largest ever natural gas leak in US history - so large the methane plume could be seen from space.³⁶
- 2016 study found that since 2009 North American ethane emissions have increased by 5% per year. Ethane is a volatile organic compound (VOC) that reacts with nitrogen oxides in sunlight to create ground-level ozone (smog). It is also a potent greenhouse gas (GHG), co-released with methane

³⁰ John Jenkyns Testimony, Australian Tribunal – Session 5. Retrieved from <https://docs.google.com/viewerng/viewer?url=https://www.peopletribunalongas.org/wp-content/uploads/2018/01/JJ-Committee-Secretary-Senate-Select-Committee-on-Unconventional-Gas-Mining-4.pdf&hl=en>.

³¹ Forcey, T. (2017, 3 August). ‘Methane emission from coal seam gas development raise climate change concern’, ABC News. Retrieved from <http://www.abc.net.au/news/2017-02-28/methane-emissions-from-coal-seam-gas-climate-change/8310932>.

³² Johnson, M.R, et al (2017) Comparisons of Airborne Measurements and Industry Estimates of Methane Emissions in the Alberta Upstream Oil and Gas Sector, *Environ. Sci. Technol.*, 2017, 51 (21), pp 13008–13017. Retrieved from: <https://pubs.acs.org/doi/full/10.1021/acs.est.7b03525>. See also The Guardian news report, retrieved from: <https://www.theguardian.com/world/2017/oct/17/study-methane-emissions-from-alberta-oil-and-gas-wells-are-worse-than-thought>.

³³ *Compendium*, above n 10, at page 3.

³⁴ *Compendium*, above n 10, at page 4.

³⁵ *Compendium*, above n 10, at pages 3-4, 169-176; Conley, S., Franco, G., Faloona, I., Blake, D. R., Peischl, J. & Ryerson, T. B. (2016). Methane emissions from the 2015 Aliso Canyon blowout in Los Angeles, CA. *Science*. Advance online publication. doi: 10.1126/science.aaf2348.

³⁶ Thompson, D. R., Thorpe, A. K., Frankenberg, C., Green, R. O., Duren, R., Guanter, L., ...Ungar, S. (2016). Space-based remote imaging spectroscopy of the Aliso Canyon CH₄ superemitter. *Geophysical Research Letters* 43(12). doi: 10.1002/2016GL069079.

from drilling and fracking. Two thirds of ethane in earth's atmosphere is leakage from natural gas wells and pipelines.³⁷

- A 2016 study estimates that methane emissions in US have increased by more than 30% over the last 12 years.³⁸
- Major study in Science found that methane leaks negate any climate benefits of natural gas as a fuel for vehicles and EPA is significantly underestimating methane in the atmosphere.³⁹
- In 2013 the IPCC determined methane is even worse for climate than previously thought; it is 34 times more potent as a greenhouse gas than carbon dioxide over 100 years and 86 times more potent over 20 years.⁴⁰
- New Scientist review of science suggests that fracking could accelerate climate change rather than slow it.⁴¹
- Fugitive emissions from urban natural gas pipeline systems found to be largest anthropogenic source of GHG methane in US.⁴²
- Eight highly toxic chemicals in air samples were found near fracking and associated infrastructure in five states.⁴³
- Increased smog has been found to be related to increased ethane in numerous studies:⁴⁴
Ethane affects climate and decreases air quality. It is the third largest GHG contributor to human-caused climate change. Ethane contributes to creation of ground-level ozone pollution (smog).⁴⁵

³⁷ *Compendium*, above n 10, at page 139; Franco, B., Mahieu, E., Emmons, L. K., Tzompa-Sosa, Z. A., Fischer, E. V., Sudo, K., ... Walker, K. A. (2016). Evaluating ethane and methane emissions associated with the development of oil and natural gas extraction in North America. *Environmental Research Letters*, 11. doi: 10.1088/1748-9326/11/4/044010.

³⁸ *Compendium*, above n 10, at page 140; Turner, A. J., Jacob, D. J., Benmergui, J., Wofsy, S. C., Maasackers, J. D., Butz, A., . . . Biraud, S. C. (2016). A large increase in U.S. methane emissions over the past decade inferred from satellite data and surface observations. *Geophysical Research Letters*, 43. doi: 10.1002/2016GL067987.

³⁹ *Compendium*, above n 10, at page 150; Brandt, A. R., Heath, G. A., Kort, E. A., O'Sullivan, F., Petron, G., Jordaan, S. M., . . . Harriss, R. (2014). Methane leaks from North American natural gas systems. *Energy and Environment*, 343(6172), 733-735. doi: 10.1126/science.1247045.

⁴⁰ *Compendium*, above n 10, at page 152; IPCC. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T. F., D. Qin, G.-K. Plattner, M. Tignor, S. K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex & P. M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Retrieved from <http://www.ipcc.ch/report/ar5/wg1/>

⁴¹ *Compendium*, above n 10, at page 152; Pearce, F. (2013, August 12). Fracking could accelerate global warming. *New Scientist*. Retrieved from <http://www.newscientist.com/article/dn24029-fracking-could-accelerate-global-warming.html#.UpEWqsQ3uSo>

⁴² *Compendium*, above n 10, at page 160; Hendrick, M. F., Ackley, R., Sanaie-Movahed, B., Tang, X., & Phillips, N.G. (2016). Fugitive methane emissions from leak-prone natural gas distribution infrastructure in urban environments. *Environmental Pollution*, 213, 710– 716. doi:10.1016/j.envpol.2016.01.094

⁴³ *Compendium*, above n 10, at page 28-29; Macey, G. P., Breech, R., Chernaik, M., Cox, C., Larson, D., Thomas, D., & Carpenter, D. O. (2014). Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study. *Environmental Health*, 13(82). doi: 10.1186/1476-069X-13-82.

⁴⁴ See Concerned Health Professionals of New York & Physicians for Social Responsibility. (2016, November 17). *Compendium of scientific, medical, and media findings demonstrating risks and harms of fracking (unconventional gas and oil extraction)* (4th ed.). <http://concernedhealthny.org/compendium>. At pages 22-37.

⁴⁵ *Compendium*, above n 10, at page 24.

- Extreme wintertime ozone (smog) events in Utah:
 - A research team studied air pollution from drilling and fracking operations in Utah’s Uinta Basin and found that they emit exceptional amounts of volatile organic air pollutants, including benzene, toluene and methane, all of which are precursors for ground-level ozone (smog). The sources were found to be multiple pieces of equipment on and off the well pad, including condensate tanks, compressors, dehydrators, and pumps.⁴⁶
 - A major paper published in *Nature* demonstrated that exceptionally high emissions of VOCs explain how drilling and fracking in Utah’s Uinta Basin create extreme smog even in absence of abundant UV light and water vapour, which are normally required.⁴⁷
 - VOCs emitted in Utah Uinta Basin led to 39 winter days exceeding EPA’s 8-hr National Ambient Air Quality Standards level for ozone pollutants in winter of 2013.⁴⁸
- 17% of locally created summertime ozone in Colorado’s Front Range was found to be created by VOCs from drilling and fracking operations.⁴⁹
- Ethane emissions in the northern hemisphere increased by approximately 400,000 tonnes annually between 2009 and 2014 – with the majority from North American oil and gas activity. Ethane emissions peaked in 1970s and began declining but since 2009 they have increased.⁵⁰
- 2% of global ethane emissions originate from Bakken shale oil and gas field, which emits 250,000 tons of ethane per year.⁵¹
- 2012 study linked a single well pad in Colorado to more than 50 airborne chemicals (44 of which have known health effects).⁵²

Earthquakes & seismic activity

Australia/Asia

- In 2006 mud began erupting from the ground in volcano-like fashion in an urban area of Java, Indonesia. As at 2015, the Lusi mudflow had caused 39,700 people to be displaced and nearly

⁴⁶ Warneke, C., Geiger, F., Edwards, P. M., Dube, W., Pétron, G., Kofler, J., . . . Roberts, J. M. (2014). Volatile organic compound emissions from the oil and natural gas industry in the Uinta Basin, Utah: oil and gas well pad emissions compared to ambient air composition. *Atmospheric Chemistry and Physics*, 14, 10977-10988. doi: 10.5194/acp-14-10977-2014.

⁴⁷ Edwards, P. M., Brown, S. S., et. al. (2014). High winter ozone pollution from carbonyl photolysis in an oil and gas basin. *Nature*, 514(7522), 351-354. doi: 10.1038/nature13767.

⁴⁸ Helmig, D., Thompson, C. R., et. al. (2014). Highly elevated atmospheric levels of volatile organic compounds in the Uinta Basin, Utah [Abstract]. *Environmental Science & Technology*, 48(9), 4707-4715. doi: 10.1021/es405046r.

⁴⁹ McDuffie, E.E., Edwards, et. al. (2016). Influence of oil and gas emissions on summertime ozone in the Colorado Northern Front Range. *Journal of Geophysical Research: Atmospheres*. doi: 10.1002/2016JD025265.

⁵⁰ Helmig, D. & Scott, J. (2016, June 13). Global ethane concentrations rising again, says study. *News Center University of Colorado Boulder*. Retrieved from <http://www.colorado.edu/news/releases/2016/06/13/global-ethaneconcentrations-rising-again-says-study>.

⁵¹ Kort, E. A., Smith, M. L., et. al. (2016). Fugitive emissions from the Bakken shale illustrate role of shale production in global ethane shift. *Geophysical Research Letters*, 43, 4617–4623. doi: 10.1002/2016GL068703.

⁵² Colborn, T., Schultz, K., et. al. (2014). An exploratory study of air quality near natural gas operations. *Human and Ecological Risk Assessment: An International Journal*, 20(1), 86-105. doi: 10.1080/10807039.2012.749447.

\$3 billion in damages and disaster management. A study in 2015 concluded that the likely cause was nearby gas drilling which forced fluid into clay layer via the open well.⁵³

- In 2017 shaking and exploding of a bore was reported at Hopewell This bore was reported as empty and now filling with explosive levels of methane.⁵⁴

North America

- Hydraulic fracturing (as opposed to wastewater injection) has been linked to earthquake swarms in Western Canada.⁵⁵
- Five small earthquakes in 24 hours in Lawrence County, Pennsylvania originated near a fracking operation that was drilling into the deep Utica Shale.⁵⁶
- A study summarising the evidence linking drilling and fracking activities to earthquakes suggests that pressure changes caused by fracking wastewater injection can migrate for years before encountering a geological fault and altering stresses in ways that cause slippage.⁵⁷
- A Study of a swarm of earthquakes in California's Central Valley in 2005 concluded that underground injection of wastewater from oil drilling operations had contributed to seismicity via changes in localised pressures along an active fault.⁵⁸
- A Canadian regulatory agency ordered a drilling and fracking operation in North West Alberta to shut down after a magnitude 4.8 earthquake struck nearby at the time fracking was occurring.⁵⁹
- Kansas recorded more than 200 earthquakes between 2013 and October 2015. Before that, the average was one earthquake every two years.⁶⁰

⁵³ Tingay, M. R. P., Rudolph, M. L., Manga, M., Davies, R. J., & Wang, C-Y. (2015). Initiation of the Lusi mudflow disaster. *Nature Geoscience*, 8. doi:10.1038/ngeo2472.

⁵⁴ George Bender testimony, Australian Tribunals, session 5:
<https://docs.google.com/viewerng/viewer?url=https://www.peopletribunalongas.org/wp-content/uploads/2018/01/Pam-Bender-Testimony-1.pdf&hl=en>.

⁵⁵ *Compendium*, above n 10, at page 105; Atkinson, G. M., Eaton, D. W., Ghofrani, H., Walker, D., Cheadle, B., Schultz, R. ... Kao, H. (2016). Hydraulic fracturing and seismicity in the Western Canada Sedimentary Basin. *Seismological Research Letters*, 87(3). doi: 10.1785/0220150263.

⁵⁶ Legere, L. (2016, April 29). State studying link between fracking, Lawrence County earthquakes. *Pittsburgh Post-Gazette*. Retrieved from <http://powersource.post-gazette.com/powersource/companies/2016/04/29/Statestudying-link-between-fracking-and-Lawrence-County-earthquakes/stories/201604290099>

⁵⁷ Kuchment, A. (2016, March 28). Drilling for earthquakes. *Scientific American*. Retrieved from <https://www.scientificamerican.com/article/drilling-for-earthquakes>.

⁵⁸ Goebel, T. H. W., Hosseini, S. M., Cappa, F., Hauksson, E., Ampuero, J. P., Aminzadeh, F. & Saleeby J. B. (2016). Wastewater disposal and earthquake swarm activity at the southern end of the Central Valley, California. *Geophysical Research Letters*, 43. doi: 10.1002/2015GL066948

⁵⁹ CBC News. (2016, January 12). Fox Creek fracking operation closed indefinitely after earthquake. Retrieved from <http://www.cbc.ca/news/canada/edmonton/fox-creek-fracking-operation-closed-indefinitely-after-earthquake-1.3400605>

⁶⁰ *Compendium*, above n 10, at page 106.

- Causality for a 5.3 magnitude earthquake in Colorado in 2011 has been ascribed to wastewater injection wells from coal-bed methane production. As at 2014, it was the second largest earthquake for which there was clear evidence that the earthquake sequence was induced by fluid injection.⁶¹
- A giant sinkhole that formed in August 2012 near Bayou Corne in southeast Louisiana has been linked to tremors caused by high-pressure pulses of either natural gas or water charged with natural gas.⁶²
- Oklahoma's damaging magnitude 5.7 earthquake in 2011 was confirmed by a study to be caused by fracking wastewater injection.⁶³

Europe

- In 2011, two earth tremors were triggered by shale gas test drilling in the Bowland Basin in Lancashire, Northwest England.⁶⁴ The integrity of at least one well in the area was damaged by the resulting earthquakes.⁶⁵
- In the village of Isovoarele, Romania there has been an increase in reports of earthquakes and sinkholes near fracking sites. In September 2013, 280 earthquakes were recorded and in one house a sinkhole appeared in the living room.⁶⁶
- Conventional gas extraction at the Netherland's Groningen gas field, which commenced in the 1960s, has been causing increased earthquakes as the gas reservoir is depleted.⁶⁷ Most recently, a 3.4 magnitude earthquake occurred on 8 January 2018.⁶⁸

⁶¹ Rubinstein, J. L., Ellsworth, W. L., McGarr, A. & Benz, H. M. (2014). The 2001-present induced earthquake sequence in the Raton Basin of Northern New Mexico and Southern Colorado [abstract]. *Bulletin of the Seismological Society of America*. Retrieved from <http://www.bssaonline.org/content/104/5/2162.abstract?stoc>.

⁶² Nayak, A. & Dreger, D. S. (2014). Moment tensor inversion of seismic events associated with the sinkhole at Napoleonville Salt Dome, Louisiana. *Bulletin of Seismological Society of America* 104(4), 1763-1776. doi: 10.1785/0120130260.

⁶³ Sumy, D. F., Cochran, E. S., Keranen, K. M., Wei, M., & Abers, G. A. (2013). Observations of static Coulomb stress triggering of the November 2011 M5.7 Oklahoma earthquake sequence [Abstract]. *Journal of Geophysical Research: Solid Earth*, 119(3), 1904-1923. doi: 10.1002/2013JB010612.

⁶⁴ Marshall, M. (2011, 2 November). How fracking caused earthquakes in the UK. *New Scientist*. Retrieved from <https://www.newscientist.com/article/dn21120-how-fracking-caused-earthquakes-in-the-uk>.

⁶⁵ Harvey, F. (2012, 17 April). Gas 'fracking' gets green light. *TheGuardian.com*. Retrieved from <https://www.theguardian.com/environment/2012/apr/17/gas-fracking-gets-green-light>.

⁶⁶ O'Brien, P. (2014, February 18) Romania – a Peasants Revolt against Fracking. *TheEcologist.org*. Retrieved from <https://theecologist.org/2014/feb/18/romania-peasants-revolt-against-fracking>.

⁶⁷ Amin, L. (2015, 10 October). Shell and Exxon's €5bn problem: gas drilling that sets off earthquakes and wrecks homes. *The Guardian*. Retrieved from <https://www.theguardian.com/environment/2015/oct/10/shell-exxon-gas-drilling-sets-off-earthquakes-wrecks-homes>.

⁶⁸ Staatstoezicht op de Mijnen (Netherland's State Supervision of Mines). Aardbevingen Groningen (Earthquakes Groningen). Retrieved from <https://www.sodm.nl/onderwerpen/aardbevingen-groningen>.

Biodiversity loss & soil contamination

Australia/Asia

Soil contamination:

- The QCLNG Project and GLNG projects in the Surat Basin QLD, have released associated water. Analysis of this by-product has shown a toxic mixture of hydro-carbons, salts, metals and naturally occurring radioactive material (NORMs) (National Toxic Network 2013).
 - Much is 'treated' in osmosis plants and re-used for domestic, municipal and agricultural water users;
 - Concentrated brine is stored in above ground-containers or used in land-fill and subject to leakage and groundwater contamination;
 - Raw by-product water is often held in dams and allowed to evaporate;
 - Much is sprayed onto roads as 'dust suppression', finding its way into waterways and water tables;
 - 'Treated' or 'de-salinated' water is discharged into natural waterways. These treatments do not remove all toxic components of associated water.⁶⁹
- Residents in Chinchilla district have reported numerous enormous toxic brine and waste water evaporation ponds; reverse osmosis plants and associated infrastructure; turbines, generators, wells, open air human effluent dumps and lay-down storage yards, pollution/smog close to the property.⁷⁰ The same testimony provides that the residential sprinklers had been turned on – sourced from their dam – and found that after a week of watering, it had killed almost everything.
- Disposal of the 'salts' from the produced toxic water is proving problematic. Residents face the prospect of Dry Tombs to house many tonnes of salt (salt storage cells) going into landfill some 2.5km from residential area sometime later this year. Due to the hazardous nature of these enormous amounts of salts, the 'dry tombs' will have to be re-mined in the not too distant future.⁷¹
- Pond liners, pipes, plastic and other rubbish from QGC (a Shell-operated venture) dumped on a property near Montrose Rd, Western Queensland.⁷²

Livestock and native animals

- The GLNG gas field alone will directly and indirectly affect thousands of square kilometres of suitable habitat for all five of Australia's lizard families, four of the six snake families who are

⁶⁹David C. Paull, 'Review of ecological impact of current unconventional gas operations in the Surat Basin Queensland', Ethical Ecology. January 2018.

⁷⁰ John Jenkyns Testimony, Australian Tribunals session 5:
<https://docs.google.com/viewerng/viewer?url=https://www.peopletribunalongas.org/wp-content/uploads/2018/01/JJ-Committee-Secretary-Senate-Select-Committee-on-Unconventional-Gas-Mining-4.pdf&hl=en>.

⁷¹ Ibid.

⁷² Anonymous testimony, Australian Tribunals, session 5:
<https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww%2Epeopletribunalongas%2Eorg%3A443%2Fwp-content%2Fuploads%2F2018%2F01%2FTribunal%2Edoc%26wdAccPdf=0>.

represented in the highly fragmented bioregion and several are regarded as regional endemics (only occurs in the Southern Brigalow Belt).⁷³

- Examples of contamination of cattle in the Kingaroy and Moura areas.⁷⁴ The case at Kingaroy was gasification—Cougar Energy, it got into the groundwater, and there was at least one herd of cattle there that was quarantined for a certain amount of time, until they found out whether they were contaminated or not. The case at Moura came from a stockpile of chemicals for the mine, which was reported in the Queensland Country Life in Mid-2017.
- For a period of two years, prior to and during the construction phase of the Kenya Reverse Osmosis plant, tankers were dumping (raw, untreated coal seam gas water) on the bitumen road outside a residential house – this was done under the guise of ‘dust suppressant’.⁷⁵
- Run off from Chinchilla Tara Rd feeds into residential dams. After a high rain event a few years back, the yabbies (freshwater crayfish) were observed leaving the dam, so resident put them back in. They all died.⁷⁶ Yellow coloured yabbies and yellow cane toads were found in and next to a nearby dam.⁷⁷
- Pigs out of breath and random deaths.⁷⁸

Vegetation

- Forest fragmentation in Chinchilla/Dalby area: Approximately 900 km² (90 000 ha) of remnant vegetation in this area is fragmented by unconventional gas development by a grid-work of wells, pipelines and connecting roads. The affected area amounts to about 25% of all remnant vegetation within 50 km of the two towns.
- Fragmentation and habitat loss occurring in NSW State forest.⁷⁹ Total of 95,000 hectares subdivided by roads, well pads and gas processing infrastructure, most of it in the State forest.⁸⁰

⁷³ Santos GLNG (2016, a) ‘Santos GLNG Significant Species Management Plan’ – GFD Project Document Number: 0007-650-PLA-0006 and (b) ‘Santos GLNG Gas Fields Development Project Stage 1 Offset Plan 2016 – 2021’, Document Number: 0007-650-PLA-0008.

⁷⁴ Joe Hill testimony, Australian Tribunals: <https://www.peopletribunalongas.org/session-three/>.

⁷⁵ John Jenkyns Testimony, Australian Tribunals session 5: <https://docs.google.com/viewerng/viewer?url=https://www.peopletribunalongas.org/wp-content/uploads/2018/01/JJ-Committee-Secretary-Senate-Select-Committee-on-Unconventional-Gas-Mining-4.pdf&hl=en>.

⁷⁶ Ibid.

⁷⁷ Ibid.

⁷⁸ George Bender testimony, Australian Tribunals, session 5: <https://docs.google.com/viewerng/viewer?url=https://www.peopletribunalongas.org/wp-content/uploads/2018/01/Pam-Bender-Testimony-1.pdf&hl=en>.

⁷⁹ John Williams Scientific Services Pty Ltd; Ann Milligan ENRi: Environment and Natural Resources in Text; and Tim Stubbs, Yellow and Blue Pty Ltd: Environmental and Natural Resource Consulting1 ‘Coal Seam Gas Production: Challenges and Opportunities’ 2013: http://wentworthgroup.org/wp-content/uploads/2013/12/BREE_Coal-seam-gas-production_WILLIAMS-et-al-.pdf.

⁸⁰ Dr Hugh Barret testimony:

<https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww%2Epeopletribunalongas%2Eorg%3A443%2Fwp-content%2Fuploads%2F2018%2F02%2FDr-H-Barrett-Permanent-Peoples-Tribunal-submission-Feb2018%2Edocx&wdAccPdf=0>.

- “For brigalow, and semi-evergreen vine thicket (endangered native Australian plant species), the GLNG and QCLNG projects are claimed to account for clearing of 0.03 per cent and 0.16 per cent respectively of these communities in the bioregion. APLNG indicates that its total clearing footprint will only take about 0.5 per cent of the vegetated area in its potential gas field, but that (it) ... may cause fragmentation of some vegetation types.” (C-G Report for GLNG Project).⁸¹
- Even though impacts from the CSG industry is predicted to be smaller than the historical impacts from agriculture and / or urban development, further use of an already highly transformed region can have significant impacts on biodiversity and will add to existing threatening processes in the region, such as clearing and fragmentation of native vegetation, increased invasive species and fire risk and changes to the hydrology of groundwater-dependent ecosystems.⁸²
- Existing declines in the density and distribution of amphibians, reptiles, birds and medium to large mammals are likely to be exacerbated by indirect impacts arising from CSG development.⁸³
- It has been declared that water extraction and treatment processes may impact on threatened ecological communities.⁸⁴
- The vast degradation stemming from the rise of the gas industry upon the land, air, water and fauna around a property is prevalent throughout the region – and covers hundreds of kilometres.⁸⁵
- Huge tracts of vegetation have been cleared throughout residential area – wiping out valuable habitat around Montrose Rd, Queensland Western Downs.⁸⁶

North America

Soil contamination:

- From 2009-2014 more than 180 million gallons of wastewater from oil and gas operations has spilled in the U.S.⁸⁷
- 19,000 gallons of hydrochloric acid spilled during completion of fracking well on alfalfa farm in Kingfisher Country, Oklahoma. It was feared that rain had washed chemical runoff into a nearby creek that flows into town of Hennessey’s water system.⁸⁸

⁸¹ Ponce Reyes, R, Firn, J, Nicol, S, Chadès, I, Stratford, DS, Martin, TG, Whitten, S, Carwardine, J (2016) ‘Priority Threat Management for Imperilled Species of the Queensland Brigalow Belt.’ CSIRO, Brisbane.

⁸² Ponce Reyes, R, Firn, J, Nicol, S, Chadès, I, Stratford, DS, Martin, TG, Whitten, S, Carwardine, J (2016) ‘Priority Threat Management for Imperilled Species of the Queensland Brigalow Belt.’ CSIRO, Brisbane.

⁸³ Ibid.

⁸⁴ Ibid.

⁸⁵ John Jenkyns testimony.

⁸⁶ Anonymous testimony, Australian Tribunals, session 5:

<https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww%2Epeopletribunalongas%2Eorg%3A443%2Fwp-content%2Fuploads%2F2018%2F01%2FTribunal%2Edoc&wdAccPdf=0>.

⁸⁷ *Compendium*, above n 10, at page 132; Flesher, J. (2015, October 24). Fatal flow: Brine from oil, gas drilling fouls land, kills wildlife at alarming rate. *Dallas Morning News*. Retrieved from <http://www.dallasnews.com/news/local-news/20151024-fatal-flow-brinefrom-oil-gas-drilling-fouls-land-kills-wildlife-at-alarming-rate.ece>.

⁸⁸ *Compendium*, above n 10, at page 134; Passoth, K. (2014, August 1). Major oil field spill in Kingfisher Co. *KOCO.com Oklahoma City*. Retrieved from <http://www.koco.com/news/major-oil-field-spill-in-kingfisher-county/27236612>.

- An analysis of Colorado state data shows that 578 spills were reported in 2013, equivalent to a gallon of toxic liquid penetrating the ground every eight minutes.⁸⁹

Livestock and native animals:

- In 2008, 1,600 ducks died in a Syncrude Canada Ltd tailing pond in the Athabasca tar sands, resulting in a C\$ 3 million penalty for the company.⁹⁰ In 2010, around 550 migratory ducks died or had to be euthanized after having to land during freezing rain and high winds in tailings ponds containing toxic bitumen.⁹¹
- A study examined 24 cases in six states where animals and owners were potentially affected by gas drilling. In one instance a farmer put 60 cattle in a field with access to a contaminated creek resulting in 21 cattle dying and 16 failing to reproduce, whereas the other cattle with no access to the creek reported no adverse effects. In another case, of 140 cattle exposed to fracking wastewater, approximately 70 died, and there was a high incidence of stillborn and stunted calves in the remaining cattle.⁹²
- 28 cows were quarantined after they wandered through a drilling wastewater spill. Of the 17 calves born to the quarantined cows, 11 died (either as stillborn or later due to weakness).⁹³

Vegetation:

- Between 2000 and 2012, forest loss in the Alberta tar sands region amounted to 5.5 per cent of total land area (14 million hectares), surpassing forest loss in Russia (2.2 per cent), the United States (2.9 per cent), Brazil (4.3 per cent) and Canada as a whole (3.1 per cent). In the surface mineable area of the tar sands region (a 475,000 hectare area where developers clear all vegetation from the land in order to extract bitumen) forest loss reached 20 per cent.⁹⁴
- An average of 50,000 new fractured wells were drilled per year in North America over the last 15 years (prior to 2015). The land area occupied by all the infrastructure during this period is

⁸⁹ *Compendium*, above n 10, at page 134; Finley, B. (2014, May 4). Colorado faces oil boom “death sentence” for soil, eyes microbe fix. *Denver Post*. Retrieved from http://www.denverpost.com/environment/ci_25692049/colorado-faces-oil-boom-death-sentencesoil-eyes.

⁹⁰ Reuters report (26 June 2010) Syncrude guilty of 1600 duck deaths in toxic pond. Retrieved from: <https://www.reuters.com/article/us-syncrude-ducks/syncrude-guilty-in-1600-duck-deaths-in-toxic-pond-idUSTRE65O68520100625>.

⁹¹ National Post Report (4 October 2012). Oil sands death of hundreds of ducks in 2010 blamed on weather. Retrieved from: <http://nationalpost.com/news/canada/oil-sands-death-of-hundreds-of-ducks-in-2010-blamed-on-weather-no-charges-laid>.

⁹² *Compendium*, above n 10, at page 135; Ramanujan, K. (2012, March 7). Study suggests hydrofracking is killing farm animals, pets. *Cornell Chronicle*. Retrieved from <http://www.news.cornell.edu/stories/2012/03/reproductive-problems-death-animals-exposed-fracking>.

⁹³ *Compendium*, above n 10, at page 136; Phillips, S. (2011, September 27). Burning questions: Quarantined cows give birth to dead calves. *StateImpact*. Retrieved from <http://stateimpact.npr.org/pennsylvania/2011/09/27/burning-questions-quarantined-cows-give-birth-to-dead-calves/>.

⁹⁴ World Resources Report (15 July 2014), Petersen R., Sizer, N. and Lee, P. Retrieved from: <http://www.wri.org/blog/2014/07/tar-sands-threaten-world%E2%80%99s-largest-boreal-forest>.

approximately three million hectares (roughly three times the size of the Yellowstone National Park).⁹⁵

- U.S. Forest Service researchers reported damage to vegetation near well pad and where wastewater had been sprayed.⁹⁶
- A study of vegetation at well pads in Colorado found disturbance of plant and soil systems linked to contemporary oil and gas well pad construction and found none of the study sites returned to pre-drilling conditions even after 20 to 50 years.⁹⁷

⁹⁵ *Compendium*, above n 10, at page 133; Allred, B. W., Kolby Smith, W., Tridwell, D., Haggerty, J. H., Running, S. W., Naugle, D. E., & Fuhlendorf, S. D. (2015). Ecosystem services lost to oil and gas in North America. *Science*, 348 (6233), 401-402. 573 Minnick, T. J. & Alward, R. D. (2015). Plant–soil feedbacks and the partial recovery of soil spatial patterns on abandoned well pads in a sagebrush shrubland. *Ecological Applications*, 25(1), 3-10.

⁹⁶ *Compendium*, above n 10, at page 135; Adams, M., Edwards, P. J., Ford, W. M., Johnson, J. B., Schuler, T. M., Thomas-Van Gundy, M., & Wood, F. (2011, January). Effects of development of a natural gas well and associated pipeline on the natural and scientific resources of the Fernow experimental forest (Rep.). Retrieved from United States Department of Agriculture website: http://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs76.pdf. (11-15, Rep.).

⁹⁷ *Compendium*, above n 10, at page 133; Minnick, T. J. & Alward, R. D. (2015). Plant–soil feedbacks and the partial recovery of soil spatial patterns on abandoned well pads in a sagebrush shrubland. *Ecological Applications*, 25(1), 3-10.