INDEPENDENT EXPERT REPORT BY DR. KARL MALLON

IN THE MATTER OF ANJALI SHARMA & ORS V MINISTER FOR THE ENVIRONMENT (COMMONWEALTH) FEDERAL COURT OF AUSTRALIA, VID 607/2020

1.1 My name is Dr Karl Mallon of 43 Bolton St, Newcastle East, 2300.

1.2 I have read and complied with the Expert Evidence Practice Note (GPN-EXPT) including the Harmonised Expert Witness Code of Conduct ("Code") and agree to be bound by the Code. These documents were together included as Annexure 11 to the original letter of instruction provided by Equity Generation Lawyers and received via email by me on Thursday 19 November 2020.

Karl Mallon, 9 . 12 . 2020

1.3 I currently hold the position of Director at Climate Risk Pty Ltd and XDI Pty Ltd.

1.4 I am a member of the following organisations;

- Founding board member of the Climate Bonds Initiative (London);
- Chair of the University of Newcastle Undergraduate Science Program External Reference Group;
- Board member of Newcastle Business Improvement Association;

1.5 My qualifications include;

- 1st Class Honours in Physics from the University of Liverpool;
- PhD in Mechanical Engineering, University of Melbourne; and
- International Commonwealth Postgraduate Scholarship.

1.6 Since 1997 I have worked in the field of both energy and emissions modelling and climate change physical impact analysis. I endeavour to provide scientifically accurate and independent analysis which can be trusted by governments, the private sector, non-government organisations alike. My work in climate impacts analysis has received awards from the German Government and the Australian climate adaptation profession.

1.7 In these fields I have contracts with, and provided consultation and reports to, a large range of private sector companies, infrastructure utilities, federal, state and local governments and national and international non-government organisations.

1.8 The work of my company XDI is considered in the top 4 providers of physical risk analysis on the world (Murphy et al. 2020)

1.9 I acknowledge that the opinions I provide throughout this report are based upon my specialised knowledge in the fields of both climate emissions and physical impact modelling. I have gained specialised knowledge in these fields from my training, study and work in this field which is referenced above.

1.10 Some of the opinions and analysis presented in this result is based on previous work conducted by either Climate Risk or XDI. I acknowledge the contribution of the following people to the work referenced : Max McKinlay, Ned Haughton, Mike Bojko, Stephen Haynes, Anastasia Martinez, Riley Cooper, Zafi Bachar, Rohan Hamden, Ruth Tedder, Tika Wright, Michela Skipp, Isaac Leonard, Joni Gear, Jackie Lamb and Tamara Dorrington.

1.11 All documents and correspondence containing any instructions regarding this report have been attached to this report. These attachments include; correspondence with Equity Generation Lawyers, the letter of instruction, all annexures to the letter of instruction and accompanying emails.

1.12 In writing this report, I acknowledge that I have made all the inquiries which I believe are desirable, and that no matters of significance which I regard as relevant have, to the best of my knowledge, been withheld from the Court.

1.13 This report addresses the following five questions as included in the letter of instruction;

1.13.1 **Question 1:** Please describe your academic qualifications, professional background and experience in the field of climate change risk assessment and adaptation, and any other training, study or experience that is relevant to this brief (you may wish to do so by reference to a current curriculum vitae).

1.13.2 **Question 2**: Please describe with respect to the field of climate change risk assessment and adaptation:

(a) the types of services you provide (particularly in respect of property, settlements, infrastructure and/or industries, communities and/or human populations more broadly); and

(b) the types of organisations and entities that engage you to perform those services.

1.13.3 **Question 3:** Can you assess possible future impacts (either of the type/s referred to in paragraph 16 of the Concise Statement, or any other type of impact which you may identify as a result of your specialised knowledge) of any one or more of the drivers described in paragraph 15.1 to 15.3 of the Concise Statement on property, settlements, infrastructure, industries, communities and human populations more broadly? Please explain any assumptions and refer to any material upon which you rely to reach your answer.

1.13.4 **Question 4:** If you have identified one or more future impacts of such drivers in response to question 3 above, are you able to assess the likely effect of such impact/s specifically on individuals who are currently under 18 years of age? Please explain any assumptions and refer to any material upon which you rely to reach your answer.

1.13.5 **Question 5:** If the occurrence of any of the drivers described in paragraph 15.1 to 15.3 of the Concise Statement become more severe and/or more frequent in future, how (if at all) would this affect your responses to questions 3 and 4 above? Please explain any assumptions and refer to any material upon which you rely to reach your answer.

1.14 Question 1 has been addressed so far throughout this report. The subsequent questions will be addressed throughout the remainder of this report. Headings will be used to indicate which question is being addressed. Sub-headings will be used to indicate the key issues raised in answering the question.

1.15 Questions 4 and 5 have been addressed together as they include both increased emissions, the resultant changing physical impacts and the consequences thereof.

REPORT SUMMARY (PER CONCLUSIONS)

2.1 I have been asked to offer an opinion regarding the impacts of climate change in a case brought on behalf of a cohort of children and with respect to the approval of a new coal mine and harm that may be done.

2.2 I have chosen to confine my opinion to the impacts on people in Australia between the age of zero and 18 in the year 2020 and to quantify the impacts on this cohort at major stages in their lives.

2.3 I have based my opinion on a set of Global Circulation Models which in my opinion best accord with the matter being considered, namely a policy context which allows for expanding coal mine numbers and therefore significant increased coal exploitation beyond existing mines. In my opinion, Representative Concentration Pathway (RCP8.5) model is the most applicable selection. RCP 8.5 also the most consistent with current global emissions and well-studied in the academic literature and data-sets.

2.4 I have sought to quantify the impacts where possible into financial harm and physical harm. While the range of possible mechanisms of harm is wide and complex, I have confined my opinion to losses of family wealth in housing, losses of income due to worker productivity and economic impairment, and the health impact of increased heat-stress. Thus, I do not suggest that this is the only harm that will be caused by climate change, but it provide a set of examples for which I have access to detailed modelling upon which to form an opinion. I have assumed that if there is adaptation, it will be at equivalent net present cost to the impacts, so the financial quantities will remain valid.

2.5 The results provided suggest that the cohort of today's children can on average expect to lose between $41,000 and $85,000 of family wealth due to climate driven corrections in the property market. These will account for the elevated and increasing risk of about 750,000 dwellings exposed to flooding, coastal inundation, forest fire and subsidence. The figures do not include the southerly movement of cyclones and should therefore be considered conservative.

2.6 Of the cohort of today's children, approximately 30% will be in jobs where rising temperatures will decrease their productivity because, per workplace health and safety expectations, they will need to take more breaks or work more limited hours to avoid heat exhaustion. As a result, these people will on average forego about $75,000 in income over their working lives.

2.7 Those with air-conditioned places of work will be vulnerable to increased disruptions of critical infrastructure like power, telecommunications and supply chain stability. Based on the fraction of infrastructure sites exposed to extreme weather, in my opinion increased extreme weather will place a drag on the economy through supply chain and business continuity disruption over the course of the century. The associated cumulative impact will be $25,000 per year over the working life of a cohort member (with no economic growth, and no discounting).

2.8 I have estimated the cumulative impact of reduced agricultural productivity on the national economy based on the work of Professor Tom Kompass (Steffen et al. 2019)), to be at least $60,000 per capita over the life of a member of the cohort.

2.9 Thus, my constrained estimate of financial impacts due to the chosen climate change scenario is that today's children will each forego between $125,000 and $245,000, with a best estimate of about $170,000 in lost income (in today's dollars) through the specific impacts of revaluation of hazard exposed property, heat related productivity losses, supply chain disruption and agricultural output impairment.

2.10 It should be noted that there are many other forms of economic losses that have not been addressed including specific impacts to the resources and tourism sectors, nor the impacts to the international and regional economy. These may be of equal or larger importance, but for which I cannot provide fully quantified opinion at this time.

2.11 In terms of health impacts, I have confined my opinion to the impacts of heat and heat stress alone. I have not considered the impacts of range changes in disease vectors, injury and death from extreme weather events, nor impacts of climate change on food security.

2.12 I have specifically considered the impacts on the cohort of children when they pass 75 years of age, when statistically speaking they are at a significantly heightened risk from heat-stress related health impacts. Climate change will cause an eight-fold increase in the probability of an average person having a heat-stress related presentation to a doctor or hospital. On the balance of probabilities, it's likely that 1 in 5 of the cohort will be hospitalised due to heat stress during the senior years. Some of these people will die due to exacerbated underlying health conditions.

2.13 I have sought to provide a scientifically sound, balanced and unbiased quantification of the impacts to the cohort of people in question within my areas of expertise, the data available to my team and I and the time available to prepare this report. I am happy to explain or clarify any of the calculations, data sets and assumptions used. I provide this report in good faith to the court to assist with its deliberations.

QUESTION 2

PART A: THE TYPES OF SERVICES YOU PROVIDE (PARTICULARLY IN RESPECT OF PROPERTY, SETTLEMENTS, INFRASTRUCTURE AND/OR INDUSTRIES, COMMUNITIES AND/OR HUMAN POPULATIONS MORE BROADLY); AND

3.1 Climate Risk assesses how extreme weather and climate change might cause harm to built assets and to communities. Climate Risk analyses the physical mechanisms that undermine the ability of an asset, system or person to function, computing a range of hazards such as riverine flood, coastal inundation, forest fire, extreme heat, windstorms and subsidence due to drought.

3.2 The Climate Risk Engines overlay specific asset information with hazard-specific local context data and climate change projections to analyse the impacts of climate change and extreme weather on key damage, failure and productivity-related indicators in order to inform asset investment and resilience decisions.

3.3 The Climate Risk Engines are inherently probabilistic in nature. The main vehicle by which climate change impacts are evaluated and quantified is the changing probability of events capable of breaching the design threshold of a given asset or the coping capacity of the materials of its component 'elements' (such as foundations, cladding or roof).

3.4 Failure and strain thresholds can also be applied to cohorts of people in the Climate Risk Engines, which means that the number of people affected by extreme events can be quantified going forward. This can include impacts such as flooding and forest fires, but the most widespread impact is usually heat stress through the increased probability of heatwaves. The system uses metrics specifically designed to capture the circumstances which cause heat stress - currently used as warnings by CSIRO and BOM - and applies them to detailed climate change modelling data. In this way it is possible to forward compute the annual projected numbers of people likely to suffer discomfort, heat stress, call a doctor or attend hospital.

3.5 Having identified the most at-risk assets, Climate Risk assists many of its clients in planning, costing and prioritising appropriate adaptation actions to address those risks. Climate Risk's analytical platform deals with adaptation by re-running the analysis with the same climate and context data, allowing the asset with and without adaptation to be directly comparable for climate risk metrics.

3.6 Many assets are more exposed to climate risks through dependence on critical infrastructure than through direct vulnerability to weather hazards such as flood, forest fire or extreme winds. In recognition of this fact, the company XDI was established. Its analytical systems have been programmed to identify the most likely supply chain nodes that provide power, water, telecommunications, gas or (road/rail) access to any analysed asset.

3.7 XDI also provides services into the financial markets to enable the climate change impacts to directly-owned investments and equities to be quantified and the work is used to re-value share prices, bond values and investment return expectations.

PART B: THE TYPES OF ORGANISATIONS AND ENTITIES THAT ENGAGE YOU TO PERFORM THOSE SERVICES.

4.1 Climate Risk, XDI and Climate Valuation provide the services identified above to the following types of organisations;

- 4.1.1 Utilities (water, power, transport and telecommunication utilities)
- 4.1.2 Banks;
- 4.1.3 Insurers;
- 4.1.4 Local Government;
- 4.1.5 State Government (including health, environment, education, justice, strategic development, treasury and transport agencies);
- 4.1.6 Federal Government;
- 4.1.7 Non-government Organisations (including environment groups);
- 4.1.8 Social Services Peak Bodies;
- 4.1.9 Community Service Organisations;
- 4.1.10 Multi-lateral development Banks

4.2 These are or have been provided in the following countries:

- 4.2.1 Australia
- 4.2.2 New Zealand
- 4.2.3 United Kingdom
- 4.2.4 Canada
- 4.2.5 USA
- 4.2.6 Fiji
- 4.2.7 Samoa

QUESTION 3

CAN YOU ASSESS POSSIBLE FUTURE IMPACTS (EITHER OF THE TYPE/S REFERRED TO IN PARAGRAPH 16 OF THE CONCISE STATEMENT, OR ANY OTHER TYPE OF IMPACT WHICH YOU MAY IDENTIFY AS A RESULT OF YOUR SPECIALISED KNOWLEDGE) OF ANY ONE OR MORE OF THE DRIVERS DESCRIBED IN PARAGRAPH 15.1 TO 15.3 OF THE CONCISE STATEMENT ON PROPERTY, SETTLEMENTS, INFRASTRUCTURE, INDUSTRIES, COMMUNITIES AND HUMAN POPULATIONS MORE BROADLY? PLEASE EXPLAIN ANY ASSUMPTIONS AND REFER TO ANY MATERIAL UPON WHICH YOU RELY TO REACH YOUR ANSWER.

5.1 To answer this question it is necessary for me to decide which forward looking climate change model is most appropriate. Global Circulation Models (GCM) are computer simulations of the atmosphere which run using different and evolving mixes of gases - including greenhouse gas emissions.

5.2 The climate modelling community, led by the Intergovernmental Panel on Climate Change (IPCC), provide a number of Representative Concentration Pathways as possible futures which the impact modelling community use to generate results that can be compared to one another.

5.3 The RCPs can be separated in terms of the extent to which they see a world in which emissions are curbed and, if so, how quickly. CSIRO describes RCP2.6 as "the most ambitious mitigation scenario, with emissions peaking early in the century (around 2020), then rapidly declining". RCPs 4.5 and 6 have varying degrees of low emissions cuts, while RCP8.5 assumes "a future with little curbing of emissions" (Climate Chane in Australia n.d.).

5.4 Since the emission pathways that result in emissions reduction almost all require either reduction in coal use or, at least, rapid flattening of production (which one might assume would come from exploitation of existing coal supplies if stranded assets are to be avoided), then, in my opinion RCP 8.5 is the most appropriate pathway consistent with a policy environment in which new coal mines are developed and exploited.

5.5 A range of modelling teams from around the world have modelled the effects of RCP8.5 on Australia including the CSIRO, UK Hadley Centre, UNSW, and the University of Queensland. These groups 'downscale' Global Circulation Models to create high resolution projections for parameters such as temperatures, precipitation, fire weather and sea-level rise. My team and I specialise in quantifying the effects of these changes on hazards such as flooding, coastal inundation, forest fires, subsidence and wind extremes, and their effects on property, infrastructure and people. We are considered amongst the world's leading physical risk analysis teams (Murphy et al. 2020).

5.6 We find that the impacts are not shared equally across Australia, and some of the risks are highly concentrated. Whilst risk from subsidence and bushfire can be broadly distributed, the risk from flooding and coastal inundation is highly concentrated, thus presenting an acute social and economic risk for affected areas.

5.7 Climate Change Risk to the Australian Built Environment: A Second Pass National Risk Assessment (Mallon et al. 2019) provides a comprehensive overview of the impacts under RCP8.5. The study was undertaken by assessing weather and climate hazards on a standard property placed at every address in Australia, providing;

5.7.1 **General Warming -** The rise in mean temperatures has a range of direct effects but underpins a wider range of other impacts like flooding, fire seasons and drought discussed below. According to the CSIRO, Australia has already warmed over 1.44°C (CSIRO (Australia) 2020). Aside from extreme weather impacts, the more chronic and incremental impacts will be on agriculture where it has been estimated that agricultural productivity will be reduced substantially, especially in Queensland. This is discussed in more detail in question 4.

5.7.2 **Riverine and Surface Flooding** - Flood water causes major damage to any property to which it gains access. It is also highly disruptive to infrastructure both directly and indirectly, with power companies at liberty during flooding to turn off power to avoid electrocution risk. The analysis suggests that flood risk is already a major problem in many Local Government Areas (LGAs). In many areas, the impact is dominated by a small number of properties that have very high annual average losses. In general, the results suggest that flood risk is material for about 5% of addresses. The degree of risk then depends on the vulnerability of the property at that address.

5.7.3 **Coastal Inundation (including Sea Level Rise)** - Coastal inundation - or actions of the sea - are another form of flooding. Similarly, coastal inundation has a high impact when it occurs. The total proportion of addresses at risk is starting at a low level today but is projected to increase exponentially through the century. due to Sea Level Rise which is driven by warming oceans and melting on-land ice deposits. Therefore, it can be expected to rival the scale of flood risk in a number of addresses and volume on infrastructure over time. Whilst this affects a small proportion of all addresses, the financial impacts will be severe, and most insurance policies do not cover 'actions-of-the-sea'.

5.7.4 **Forest Fire** - Forest fires are generally major or total property loss once they reach an unprotected property or infrastructure asset - and cause injury or harm to anyone present. Forest Fire has a relatively low probability of causing damage to any individual property in a given year but has broad-scale implications due to the large number of properties exposed to bushfire. As forest fire events in recent years have shown, the increases in severity and duration of forest fire events are leading to longer fire seasons and loss of life and property. Looking forward, the analysis suggests that probability of fire conditions will increase in many areas and, more worrying still, penetrate into areas not normally associated with forest fire.

5.7.5 **Subsidence** - Subsidence occurs when clay soils contract and move the foundations of a property causing cracking in floors, walls and ceilings. Subsidence is a problem for any construction on reactive soils, which are widely distributed across Australia. While the amount of damage from subsidence can be modest and non-catastrophic for a single building, the probability of droughts combined with the large number of exposed properties makes this a potentially large source of damage and financial loss, as has been seen in Europe and the USA. Unlike in those countries, it is not generally insurable in Australia.

5.7.6 **Wind, Cyclones (including the effect of warming oceans)** - Wind storms can cause damage to roofs and cladding if gusts exceed their coping capacity. In cyclones, more extensive damage is possible, including total loss. So far, from Global Circulation Models (GCMs), changes in wind profiles are found to be generally modest and winds may even decrease in speed in many areas. This model result is largely considered to be due to the inadequate resolution of the models to calculate small scale convective storms - such GCM models are not yet available in Australia. However, because ocean temperatures are warming, the range of the 'cyclone belt' moving southward and which means cyclones of various severities can be expected to reach areas where properties are not designed for such conditions leading to a very large increase in damage, losses and harm (Bruyere et al. 2020).

5.7.7 **Heatwaves** - Heatwaves cause discomfort and heat-stress in human beings and can also disrupt critical infrastructure through electronic and electrical systems. Physical systems tend to be vulnerable to temperatures in the 40s Celsius. Outside workers are vulnerable to a combination of temperatures and humidity that starts in the 30s Celsius and gradually gets worse as temperatures increase. Human heat stress is a function of 'thermal shock' based on how acclimatised people are, and also whether people get night time respite. (Goldie et al. 2017)

5.7.8 **Coastal Erosion (including sea level risk)** - Coastal erosion in a climate change context is caused by rising seas and changing wave directions gradually converting coastal land area into areas accessed by the high tide. While affecting a smaller number of properties than Coastal Inundation, it leaves few options for adaptation and property protection and in many cases will ultimately require exposed properties or communities to be abandoned.

5.8 Rather than address general impacts to Australia and its people and economy from these changing hazards I will confine my opinion to specific impacts to a specific cohort as set out in the subsequent questions.

QUESTION 4

IF YOU HAVE IDENTIFIED ONE OR MORE FUTURE IMPACTS OF SUCH DRIVERS IN RESPONSE TO QUESTION 3 ABOVE, ARE YOU ABLE TO ASSESS THE LIKELY EFFECT OF SUCH IMPACT/S SPECIFICALLY ON INDIVIDUALS WHO ARE CURRENTLY UNDER 18 YEARS OF AGE? PLEASE EXPLAIN ANY ASSUMPTIONS AND REFER TO ANY MATERIAL UPON WHICH YOU RELY TO REACH YOUR ANSWER.

QUESTION 5

IF THE OCCURRENCE OF ANY OF THE DRIVERS DESCRIBED IN PARAGRAPH 15.1 TO 15.3 OF THE CONCISE STATEMENT BECOME MORE SEVERE AND/OR MORE FREQUENT IN FUTURE, HOW (IF AT ALL) WOULD THIS AFFECT YOUR RESPONSES TO QUESTIONS 3 AND 4 ABOVE? PLEASE EXPLAIN ANY ASSUMPTIONS AND REFER TO ANY MATERIAL UPON WHICH YOU RELY TO REACH YOUR ANSWER.

6.1 In this section I address questions 4 and 5 in a combined response as I am drawing on analysis that covers present day impacts and projected future impacts based on a considered selection of an appropriate emissions scenario for the context of the questions.

6.2 The following paragraphs consider the future impacts of the climate change drivers on individuals who are currently under 18 years of age, being the children of today.

6.3 In assessing the future impacts on children, this report specifically examines impacts in the following areas;

6.3.1 **Wealth -** with a focus on loss of family property wealth; and
6.3.2 **Prosperity -** with a focus on loss of income and economic retardation.
6.3.3 **Health -** with a focus on heat-stress driven acute and none-acute events;

6.4 When considering the future impacts on children in these areas, I have presented the opinion in terms of the following three epochs:

6.4.1 Impacts in the **near future** (approximately 2020-2030);
6.4.2 Impacts in the **middle of cohort's working lives** (approximately 2040-2060); and
6.4.3 Impacts at the **end of the cohort's lives** (approximately 2070-2100).

6.5 Current scientific research covers a wide range of impacts with complex manifestations. My area of specialisation is the quantification of human and financial impacts from climate change, and cost-benefit-analysis of adaptation. This generally assists in determining whether risk mitigation action is warranted. For the purpose of this report, I have sought to put some level of quantification around these time points and impact areas identified above.

Wealth: Impacts on housing wealth during the first epoch (2020-2030)

7.1 A major direct impact will be on housing in high-risk areas and a correction in property values which will affect the family wealth of approximately 5% of families. Based on my work with banks and insurance companies, it is my opinion that this correction is likely to commence within the next 5 years.

7.2 To provide more insight, according to internal Climate Risk company analysis and consistent with the results released by XDI (Mallon et al. 2019))

- 7.2.1 9% of properties are exposed to fluvial or pluvial flooding
- 7.2.2 4% of properties are exposed to forest-fire
- 7.2.3 48% of properties are exposed to subsidence
- 7.2.4 2% of properties are exposed to Coastal inundation

7.3 Most houses are designed to cope with a certain level of impact. Most roofs do not blow off in storms every summer, however, every few decades a very severe storm may do lots of damage. This is because buildings are designed in accordance with certain thresholds that strike a balance between safety and cost. For example, in general, planners around the developed world do not allow housing development on land that has more than a 1% chance of flooding each year. Put another way, planners accept that statistically houses in such a location may still get flooded, but rarely. This is seen as an acceptable level of risk. It's also an acceptable level of risk for insurance companies. This is also a risk level commonly used by the insurance industry and considered acceptable for insuring a property (FEMA).

7.4 Even though many houses are in forested areas, the probability of a damaging fire has hitherto been low and insurable. Risks have been similarly low for wind, subsidence and coastal inundation, though not all are included in Australian insurance policies.

7.5 Even for very damaging extreme events, engineering expectations have been adjusted to accommodate for acceptable levels of risk tolerance. For example, in the Northern Territory in 1974, cyclone Tracy destroyed 70% of houses https://www.nma.gov.au/defining-moments/resources/cyclone-tracy). But new design standards mean that buildings in Darwin are now reasonably well adapted to cyclones, and consequently insurance is readily available and affordable.

7.6 However, a warming atmosphere is changing the statistical probabilities behind extreme weather events. For example, most floodplain analysis is based on long term rainfall data for catchments. At best, a few decades of data is available in specific locations (flood depth gauges), with a lot of weather data available since the satellite era. Considering this, most flood maps used today are based on rainfall data collected between 1960 and 2020. Similar stories apply to other hazard data, such as temperature and wind measurement. Therefore, this flood data does not, strictly speaking apply to today, rather it is 'centred' on a historical weather, say 1990. But the world has changed since then.

7.7 Using this 1990 reference point, it is possible to examine how much change our global climate models suggest has occurred over the past 30 years. For example, if we look at the appended briefing provided regarding the Townsville flooding event in 2019 (Climate Risk 2019) our model shows very high levels of correspondence between what we expect a flooding river to do and what actually happened. This gives us confidence that it is possible to predict which houses would flood and which would not in other similar events.

7.8 Using my organisation's climate risk models, it is also possible to estimate the extent to which the probability of such an event has increased since the 1990 reference point. So in Townsville, for example, our simulations suggest that the probability of such flooding has already increased by a little over 20% due to climate change.

7.9 Similarly, in Nymboida, where 150 homes were destroyed by fire last summer, our models suggest that the probability of fire weather has increased by 17% since 1990. That could be much worse if we were to include the combined impact of increasing drought probability which has increased by 8% (internal climate risk data).

7.10 When the probability of extreme weather events increases, the probability of loss related to those events also increases, and the cost of insurance in that location should increase proportionally. Insurers sometimes react stochastically to the change in actuarial data - i.e. they change in response to events. However, the companies I am involved in (Climate Risk, XDI and Climate Valuation) have introduced technology to market that allows pre-emptive adjustment for risk. This technology is used by a number of financial market banks and insurers in Australia, the United Kingdom and New Zealand. Consequently, we are aware that adjustments are likely to flow through to the market in the next two years. Moreover, regulators like the Australian Prudential Regulatory Authority (APRA)(REF) are strongly urging companies to quantify and disclose such risks under the rules of the Task Force for Climate Related Financial Disclosure (TCFD) (TCFD 2020).

7.11 In the short term, I expect that insurance premiums will go up for families exposed to the various hazards mentioned above. This means that for a family paying $2,000 for house and contents insurance per year in Townsville, a 20% increase would mean that there is $400 less available for the household budget.

7.12 However, others have produced evidence demonstrating much more severe corrections. For example, I participated in an interview with the ABC on 12 November 2020, in which a fellow interviewee revealed that the strata insurance on her building had increased from $18,000 per year in 2010 to $174,000 per year today. This interviewee said this was a figure the residents simply could not afford (Mangan 2020).

7.13 This raises the next issue regarding unaffordable and unavailable insurance. My work has found that approximately 380,000 addresses today rising to 736,000 of Australian addresses in 2100 are at sufficient levels of risk to make the insurance unaffordable and therefore uninsurable for extreme weather hazards for all practical purposes.

7.14 This is especially true for flood risk, and this analysis is supported by industry statistics that suggest 6% of all insurance policies do not have flood cover (ICA 2019). This means that the people that are most likely to need flood cover may not actually have it because they cannot afford it.

7.15 My organisations' work follows the U.S government's FEMA system for defining low-, moderate-, and high-risk property (REF FEMA). This system uses the 1% flood exposure reference point as the threshold for high risk. However, our work also accounts for property resilience. Consequently, a "Queenslander" style house, with raised floor level, would not likely be considered high risk in our models even if it is located in a flood zone.

7.16 In a review of all addresses in Australia, the report which I co-authored states:

> *"The scale of extreme weather and climate change related risk (since 1990 baseline) is already significant. Across Australia, the results find that there are 383,300 addresses in 2020 which would be classified as High Risk Properties. This number is projected to increase to 735,654 in 2100 for existing development only. This figure does not account for new development occurring in high hazard areas, or continued use of inadequate building standards, which unabated will substantially increase this number."* This equates to approximately 5.3% of properties being or becoming high risk.

7.17 The implications of families not having insurance are extremely serious. According to the Insurance Council of Australia, (Tooth and Barker 2007) about 4% of homeowners do not have building cover, and 12% don't have contents insurance. If we assume that even those with general cover are waiving flood cover because it is unaffordable then there are still a significant number of families taking a risk every year that their home will suffer major uninsured damage. Even for those with cover most policies do not cover "actions of the sea" such as flooding by coastal high tide events, nor subsidence land-slip or erosion.

7.18 While this problem is a low probability, high consequence risk, which may affect a small number of unfortunate people from time to time, wider scale wealth impacts will manifest via corrections in the residential property market.

7.19 When issuing mortgages, lending institutions need to ensure that the homeowner can afford the repayments and where default occurs, the property should be able to be sold at a price sufficient to pay off the remaining mortgage.

7.20 In an era of climate change, banks now need to consider these risks not just at the time the mortgage is contracted, but throughout the duration of the mortgage. Therefore, when assessing the affordability of the mortgage for the borrower they will need to consider whether increasing insurance costs will undermine the serviceability of the mortgage. For example, if the bank had assumed that the cost of insurance was $2,000 per year but it is rising toward $10,000 per year, this may mean that the borrower falls short of the income needed. Significant insurance costs may make high-risk properties non-mortgageable or undesirable for a large proportion of home buyers.

7.21 This effect can be expected to flow through to property values. If there are two identical properties and one is high risk with high insurance costs, the value of such a property is likely to be reduced compared to the other with no such exposure. There are various ways to compute such impacts, and such 'Climate Adjusted Values' are currently being supplied to banks for consideration. This will plausibly lead to a couple of outcomes:

7.21.1 One possibility is that that banks will require much higher deposits to cope with possible decreases in value relative to the general market; and

7.21.2 A second possibility is that banks may turn away borrowers who cannot manage the serviceability pressures of projected insurance costs over the life of the mortgages.

7.22 It is rational to expect a correction in the value of properties exposed to a range of climate-exacerbated hazards as insurers bring premiums up to date and banks forward project risks to the end of a mortgage. In my opinion it is most likely that there will be an abrupt correction in property pricing in the next few years, to accommodate 60 years of climate change impacts, from the 1990 reference point to the end of a current mortgage in 2050.

7.23 Our estimates are that over 1 in 10 addresses will need to be price corrected and of these, about 1 in 20 will suffer a severe correction in value - with a consequent loss of value (quantified below). In practice, this will result in a loss of family wealth for those involved. Some will be at risk of negative equity – where the outstanding loan exceeds the value of the property.

7.24 The Climate Risk Engines include algorithms to compute the effect of increased insurance costs of property value which include data such as market value, replacement costs, Technical Insurance Premium and mortgage interest rates. These are based on the increase in risk from 1990 only and an average property value of $530,000.

7.25 Based on an interest rate of 5.2% under RCP 8.5 (the IPCC's unabated greenhouse gas emissions trajectory) there will be a 4% of lost value due to climate change, which equates to $41,000 per child.

7.26 The situation is heightened with current lower interest rates (the relative size of the insurance payments is higher compared to mortgage repayments). At current 2.5% interest rates the lost value due to climate change is 8.23%, or $642 billion. This equates to $85,000 loss per child.

Prosperity: impacts on prosperity during the second epoch (2040-2060)

8.1 In the second epoch, consideration can be given to today's children in the middle of their working life. In doing so we attempt to estimate the impact of climate change on their ability to work as individuals (their productivity), the ability of the businesses they work for to operate (business continuity) and the impacts on various parts of the economy.

8.2 For this epoch, the two decades centred on 2050 will be examined. At this point, the children of today will be between 20 and 58 years old.

Productivity

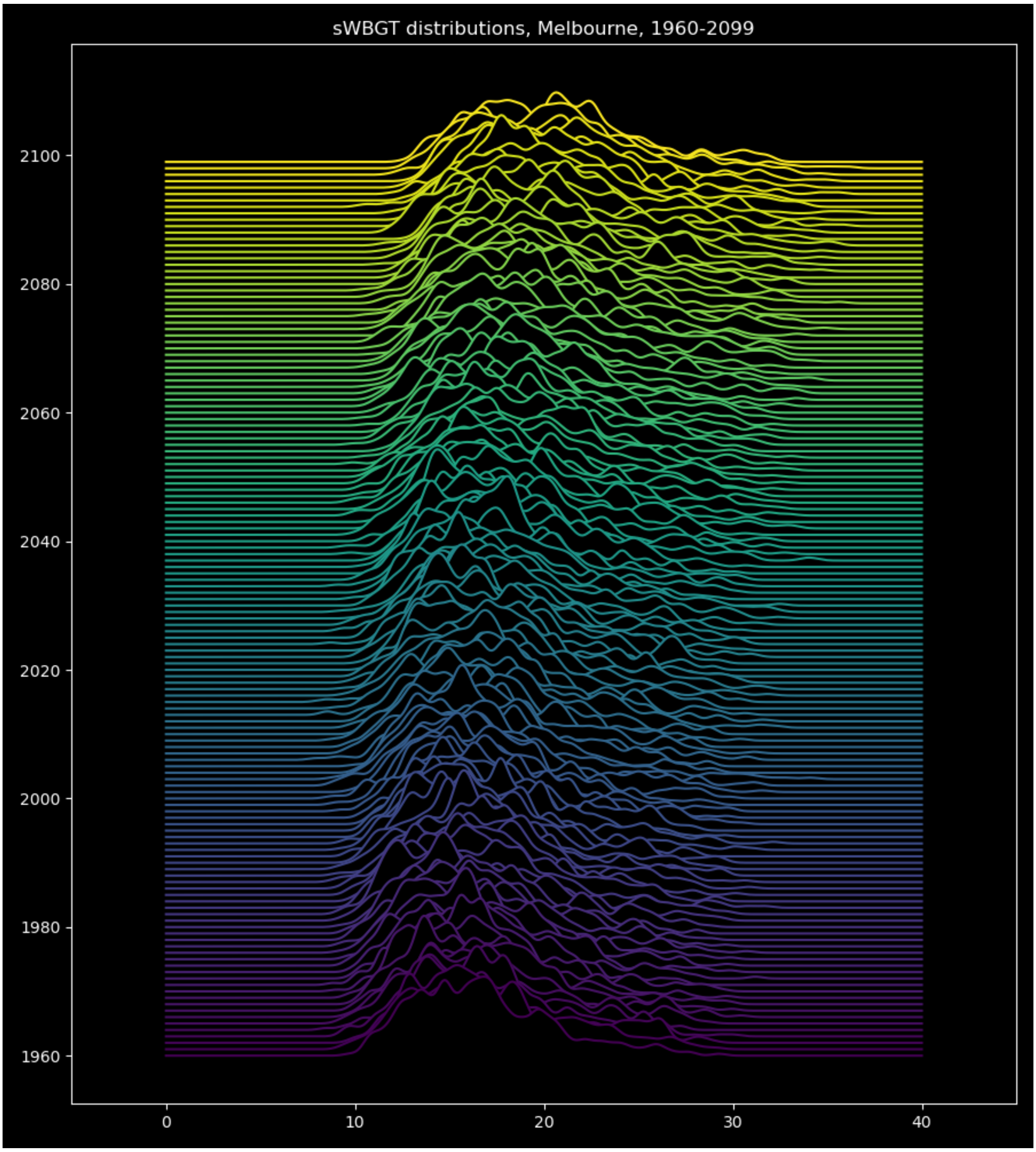
8.3.1 There will be a divide between those working in air-conditioned spaces and those not. Using Australia Bureau of Statistics (ABS) information, a number of occupations are relevant, one is considered to be fully exposed to outdoor temperatures (Labourers), with a further 3 occupations being exposed to a lesser extent, either through shading or part time air-conditioning (e.g. Machinery Operators and Drivers, Technicians and Trade Workers). All together these groups account for about 30% of the national workforce (ABS 2016).

8.3.2 When the ambient temperature is above the core human body temperature of 37°C, the body has to expend energy dissipating heat. The body normally does this through sweating. On humid days, and days without wind, this process becomes less efficient. If a person is also physically exerting themselves even more thermal energy has to be dissipated.

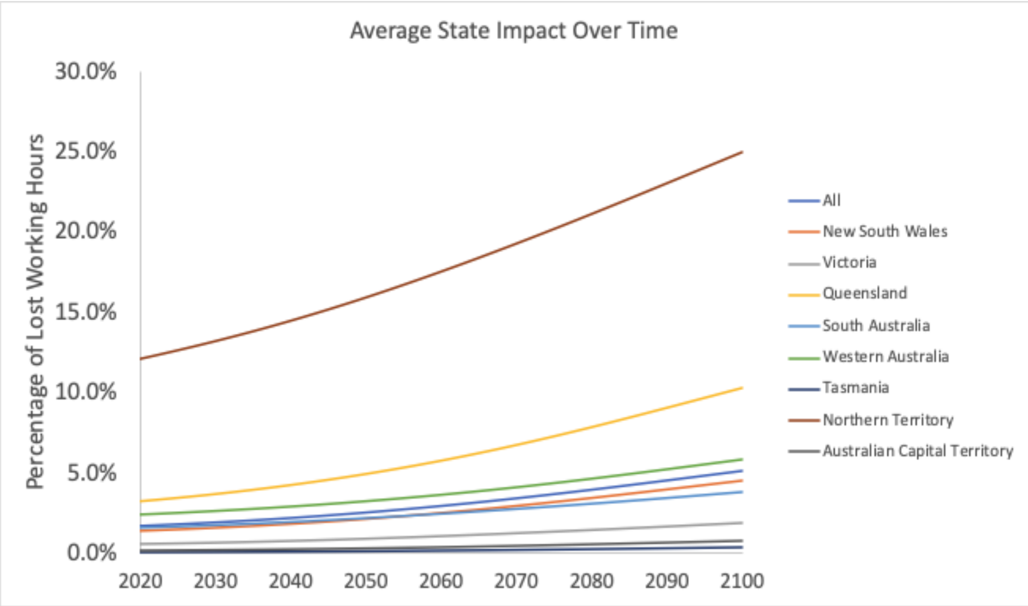
8.3.3 Under such circumstances people are intrinsically less efficient – more of their energy is spent on cooling and they have to minimise exertion to avoid dangerous overheating, therefore they will need to take more breaks to cool down and take on fluids - resulting in less work done. If a person does not manage excess heat, they will become fatigued and ultimately suffer various levels of heat stress.

8.3.4 For these people the key indicator of productivity will be the Wet Bulb Globe Temperature (WBGT), which captures both temperature and humidity. WBGT is commonly used as a heat stress risk indicator by sporting organisations and the US military. Exposure to WBGT above 25-28°C (depending on regional acclimatisation) for extended periods is considered risky, and regular breaks and water are required, and exercise is not recommended at WBGT above 30-33°C (Grundstein et al. 2015)

8.3.5 The Bureau of Meteorology's (BOM) Simplified Wet Bulb Globe Temperature (Bureau of Meteorology n.d.) is a metric that captures most of the variation in WBGT, but is easier to calculate. The figure below (internal Climate Risk data) shows the changes in the distribution of sWBGT in Melbourne from 1960 to 2100, as modelled by CSIRO for the VCP-19 project, using CSIRO's CCAM Regional Climate Model, based on a global simulation by the UK Met Office Hadley Centre's HadGEM2 Global Climate Model. These have been prepared by Dr Haughton of the Climate Risk modelling team. In these models, the gradual shift of the distribution toward hotter temperatures and an extension of the tail of extreme events is clear, and indicates a strong increase in days where the ability to work outside safely will be significantly reduced.



8.3.6 Overall productivity losses for the affected workers from extreme heat are estimated to currently be around 1.7% in Australia, varying from almost zero in Tasmania to 12.2% in the Northern Territory. The figure below shows the regional variation, and the much higher impact to be expected on workers in Queensland and the Northern Territory. By 2050 the productivity losses are projected to rise nearly 1.5 times to 2.6% for all of Australia and by 2100 it will be at 5.1%.



8.3.7 Of the 5 million children in Australia, 1.5 million may have jobs which will expose them to heat and humidity that will reduce their productivity. The productivity losses will increase by 3.4% over their working lives due to climate change driven temperature changes. Clearly this impact will initially go to the employer, but that must be assumed to be passed through to wages. On average this is equivalent to $1,500 per year in lost income based on the average Australian wage of $89,000 (ABS, 2020). Over their 50-year working life, this will be a total $75,000 in lost income.

Business Continuity

8.4.1 There will be retardation to the general economy. This will include;

8.4.1.1 General business continuity effects;
8.4.1.2 Loss of critical infrastructure supplies like power and tele-communications;
8.4.1.3 The costs of increased insurance premiums;
8.4.1.4 More frequent situations where staff cannot get to work;
8.4.1.5 Disruption of logistical networks such as road and rail; and
8.4.1.6 More frequent loss of supply chain continuity.

8.4.2 Taken individually, each of these are examples of low probability events with different levels of consequence, ranging from one person calling in to say they can't get to work to the inability of primary industries to get their commodities to ports (Melik 2011).

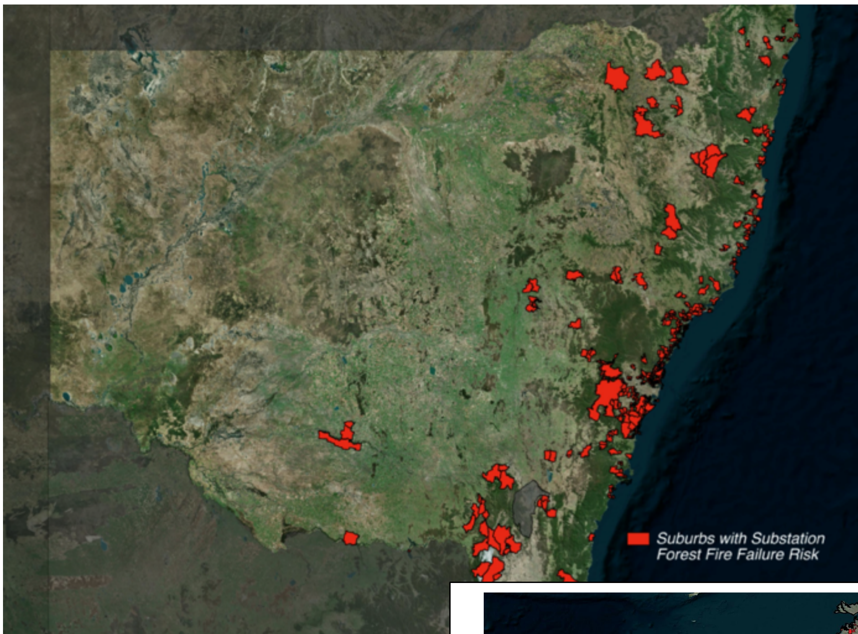
8.4.3 With highly dependent just-in-time global supply chains, I and my colleagues are of the view that business disruption through the loss of critical infrastructure and supply chain could be amongst the largest of the climate impacts to the economy.

8.4.4 To provide a practical example, if an individual owns 100 premises and builds these premises expecting a 1 in 100 probability of failure, then in general, the individuals will have one premise impacted every year. This is no longer an unlucky event, rather a normality.

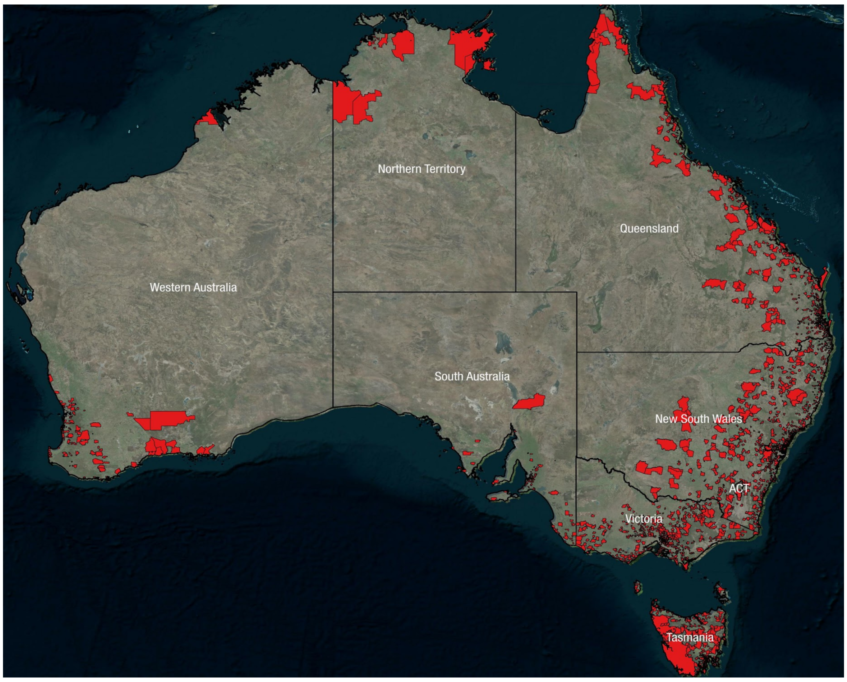
8.4.5 More extreme weather will lead to increased damage to business premises. However, by far the more disruptive impact will be disruptions to critical infrastructure that businesses require to operate, this includes power, water, telecommunications and transport.

8.4.6 The maps below show the numerous suburbs which have electrical substations or telecommunication towers at risk from bushfires.

Australian states with electrical substation at risk from forest fire.



NSW Suburbs with electrical substation at risk from forest fire.



Suburbs with mobile telecommunication towers at risk from forest fire.

8.4.7 Based on internal analysis we have conducted on various projects, about 0.6% of the asset replacement values are at risk per year (Value-at-Risk) roughly tripling over the century with climate change. The probability of disruption from extreme events is generally several times higher than the Value-At Risk percentage.

8.4.8 For a business that depends on multiple critical infrastructure supplies each of which has a small probability of failure, the probability of disruption is approximately the sum of the individual failure probabilities.

8.4.9 A simple estimate therefore would be that the probability of disruptive events occurring is approximately 3% rising to 12% (due to the highly coastal bias of Australian infrastructure). We can conservatively assume such extreme events cause an outage of 7 days. For a reality check, this suggests that today, an average business might suffer a week's outage every 30 years due to an extreme event like flooding, bushfires or heat-wave causing a 1 week disruption to its essential services supply chain. The modelling suggests this will rise to a frequency of once in 8 years with un-adapted climate change. The resulting productivity loss caused would be about 0.4% today, rising to 1.6% by the end of the century.

8.4.10 To consider the impacts of this on the cohort of children whose future work will be affected, I have applied this as a generalised retardation to today's economy (with no growth or population expansion). The result is an average of $25,000 in economic losses per capita per year due to climate change.

THE ECONOMY

8.5.1 Climate change will have more specific and/or concentrated impacts on particular sectors such as mining, agriculture and tourism. Mining will be affected due to the exposure to very severe temperatures and long-distance logistic chains which we have discussed above.

8.5.2 In agriculture, the impacts of climate change will be driven by both general changes in climate such as increasing temperatures and changes in rainfall patterns, as well as damage from extreme events.

8.5.3 Based on the research work with Professor Tom Kompas of the University of Melbourne, it is my view that the best current estimates for the accumulated loss of wealth due to reduced agricultural productivity and labour productivity as a result of climate change are $19 billion by 2030, $211 billion by 2050 and $4.2 trillion by 2100 (Steffen et al. 2019).

8.5.4 Based on an assumption that arable land use is maximised as is in Australia, then this loss cannot be displaced by a shift in overall production; i.e., as conditions become too hot or too dry we may be able to move production, but only by displacing what we grow already.

8.5.5 To quantify this impact to the child cohort under consideration, Kompas (Steffen et al. 2019), calculates the per capita impact as $60,000 per year (with population growth included, a much higher figure if current population were to be applied).

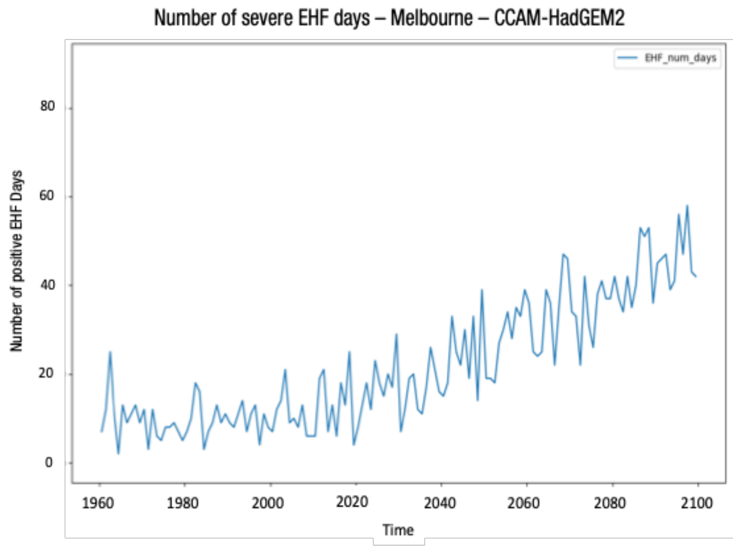
Health: impacts on health during the third epoch (2070-2100)

9.1 In this epoch, consideration is given to the impacts of climate change on the health of the child cohort which, statistically speaking, will have all passed the average Australian life expectancy between 2078 and 2098. This is about as far as current climate change models extend.

9.2 There are many climate change impacts that could affect the health of the cohort. These impacts range from injury in extreme events such as cyclones to the long term impacts of smoke inhalation during bushfires. However, all Australians will be affected by increases in temperatures and especially extreme temperatures.

9.3 There is an emerging body of research to suggest that the health impacts of heat are not solely dependent on temperature, but on 'thermal shock' or the inability to acclimatise to heatwaves and also the inability to cool down or get respite from severe temperature (Goldie et al, 2017). The Climate Risk science team has adopted the CSIRO developed metric Excess Heat Factor (EHF) to interpret the climate change modelling data in terms of ill health. These are used for quantification of heat-stress related doctor, ambulance and hospital presentation.

9.4 The figure below shows the trends in Excess Heat Factor in Melbourne over time for one of the climate models considered. EHF includes the degree to which people are able to acclimatise to increasing temperatures ahead of a heat wave and uses an average daily temperature which captures both the daily extreme and the night time minimum.



9.5 Using EHF to predict the days where a heat wave is likely to cause ill health combined with elevated presentation rate data during actual heat waves (Nitschke, Tucker, and Bi 2007, Department of Health & Human Services 2014, Jegasothy et al. 2017) enables forward looking projections of presentations to doctor, ambulance or hospital due to heat-stress under RCP8.5, see the table below.

Year	Ambulance	Hospital	Doctor
1990	6,650	10,300	1,130,000
2020	14,000	21,900	2,390,000
2050	24,900	38,900	4,240,000
2100	56,300	88,000	9,600,000

9.6 Based on the sample of 1% of all addresses and assuming average occupancy levels, my team has estimated the thermal shock of heat waves. In Southern states like Victoria heat stress presentations to doctors, paramedics and hospitals will more than double. But for Australia as a whole the incidents will increase by 850% or an eight fold increase.

9.7 In practical terms that means that 8 million doctor visits will be attributable to climate change driven warming, equivalent to an average 38% of the population attending the doctor due to a heat stress event. There are also expected to be 50,000 of additional hospitalisations due to heat stress.

9.8 However, the burden of heat stress will not fall as equally on the population as these averages suggest. Today's cohort of children will all be over 80 years old by 2100 and heat stress hits the elderly particularly hard. For example in the 2003 French heatwave, of the 14,729 excess deaths, 11,731 were over the age of 75. (Fouillet et al. 2006). So we can assume that the doctor visits and hospitalisations will be heavily represented by today's children. If such ratios play out for the cohort in question, then every year, 1% of the group will be hospitalised with heat-stress exacerbated illness - an estimated tenth of that figure today. Put another way, it would imply that in the last 20 years of these children's lives, on average one if five will suffer at least one heat-stress episode serious enough to require acute care in a hospital.

9.9 Some of those heat-stress events will be fatal, but as my team has not undertaken these statistical calculations or projections I am unable to offer an opinion.

CONCLUSIVE SUMMARY

10.1 In conclusion, I have been asked to offer an opinion regarding the impacts of climate change in a case brought on behalf of a cohort of children and with respect to the approval of a new coal mine and harm that may be done.

10.2 I have chosen to confine my opinion to the impacts on people in Australia between the age of zero and 18 in the year 2020 and to quantify the impacts on this cohort at major stages in their lives.

10.3 I have based my opinion on a set of Global Circulation Models which in my opinion best accord with the matter being considered, namely a policy context which allows for expanding coal mine numbers and therefore significant increased coal exploitation beyond existing mines. In my opinion, Representative Concentration Pathway (RCP8.5) model. It is also the most consistent with current global emissions and well studied in the academic literature and data-sets.

10.4 I have sought to quantify the impacts where possible into financial harm and physical harm. While the range of possible mechanisms of harm is wide and complex, I have confined my opinion to losses of family wealth in housing, losses of income due to worker productivity and economic impairment, and the health impact of increased heat-stress. Thus, I do not suggest that this is the only harm that will be caused by climate change, but provide a set of examples for which I have access to detailed modelling upon which to form an opinion. I have assumed that if there is adaptation, it will be at equivalent net present cost to the impacts, so the financial quantities will remain valid.

10.5 The results provided suggest that the cohort of today's children can on average expect to lose between $41,000 and $85,000 of family wealth due to climate driven corrections in the property market. These will account for the elevated and increasing risk of about 750,000 dwellings exposed to flooding, coastal inundation, forest fire and subsidence. The figures do not include the southerly movement of cyclones, and should therefore be considered conservative.

10.6 Of the cohort of today's children, approximately 30% will be in jobs where rising temperatures will decrease their productivity because, per workplace health and safety expectations, they will need to take more breaks or work more limited hours to avoid heat exhaustion. As a result, these people will on average forego about $75,000 in income over their working lives.

10.7 Those with air-conditioned places of work will be vulnerable to increased disruptions of critical infrastructure like power, telecommunications and supply chain stability. Based on the fraction of infrastructure sites exposed to extreme weather, in my opinion increased extreme weather will place a drag on the economy through supply chain and business continuity disruption over the course of the century. The associated cumulative impact will be $25,000 per year over the working life of a cohort member (with no economic growth, and no discounting).

10.8 I have estimated the cumulative impact of reduced agricultural productivity on the national economy based on the work of Professor Tom Komapss (Steffen et al. 2019), to be at least $60,000 per capita over the life of a member of the cohort.

10.9 Thus my constrained estimate of financial impacts due to the chosen climate change scenario is that today's children will each forego between $125,000 and $245,000, with a best estimate of about $170,000 in lost income (in today's dollars) through the specific impacts of revaluation of hazard exposed property, heat related productivity losses, supply chain disruption and agricultural output impairment.

10.10 It should be noted that there are many other forms of economic losses that have not been addressed including specific impacts to the resources and tourism sectors, nor the impacts to the international and regional economy. These may be of equal or larger importance, but for which I cannot provide fully quantified opinion at this time.

10.11 In terms of health impacts, I have confined my opinion to the impacts of heat and heat stress alone. I have not considered the impacts of range changes in disease vectors, injury and death from extreme weather events, nor impacts of climate change on food security.

10.12 I have specifically considered the impacts on the cohort of children when they pass 75 years of age, when statistically speaking they are at a significantly heightened risk from heat-stress related health impacts. Climate change will cause an 8.5 fold increase in the probability of an average person having a heat-stress related presentation to a doctor or hospital. On the balance of probabilities it's likely that 1 in 5 of the cohort will be hospitalised due to heat stress during the senior years. Some of these people will die due to exacerbated underlying health conditions.

10.13 I have sought to provide a scientifically sound, balanced and unbiased quantification of the impacts to the cohort of people in question within my areas of expertise, the data available to my team and I team and the time available to prepare this report. I am happy to explain or clarify any of the calculations, data sets and assumptions used. I provide this report in good faith to the court to assist with its deliberations.

BIBLIOGRAPHY

ABS. 2016. “Census 2016, G53 Industry of Employment by Occupation (SA2+).” Data Set. ABS. http://stat.data.abs.gov.au/Index.aspx?DataSetCode=ABS_C16_G53_SA#.

Bruyere, Cindy, Bruce Buckley, Andreas Prein, Gregory Holland, Mark Leplastrier, David Henderson, Peter Chan, James Done, and Andrew Dyer. 2020. “Severe Weather in a Changing Climate (2nd Edition).” https://doi.org/10.5065/B64X-E729.

Bruyère, Cindy, Greg Holland, Andreas Prein, James Done, Bruce Buckley, Peter Chan, Mark Leplastrier, and Andrew Dyer. n.d. “Severe Weather in a Changing Climate,” 67.

Bureau of Meteorology. n.d. “Understanding Heatwaves.” corporateName=Bureau of Meteorology. Accessed December 8, 2020. http://www.bom.gov.au/australia/heatwave/knowledge-centre/understanding.shtml.

Climate Chane in Australia. n.d. “Greenhouse Gas Scenarios.” Climate Change in Australia. Accessed December 9, 2020. https://www.climatechangeinaustralia.gov.au/en/climate-campus/modelling-and-projections/projecting-future-climate/greenhouse-gas-scenarios/.

Climate Risk. 2019. “Climate Risk Media Release: Townsville Floods.”

CSIRO (Australia). 2020. “State of the Climate 2020.” https://www.csiro.au/en/Showcase/state-of-the-climate.

Department of Health & Human Services. n.d. “The Health Impacts of the January 2014 Heatwave in Victoria.” Melbourne: State Government of Victoria. Accessed December 8, 2020. https://www2.health.vic.gov.au:443/about/publications/researchandreports/health-impacts-january-2014-heatwave.

Fouillet, Anne, Grégoire Rey, Françoise Laurent, Gérard Pavillon, Stéphanie Bellec, Chantal Ghihenneuc-Jouyaux, Jacqueline Clavel, Eric Jougla, and Denis Hémon. 2006. “Excess Mortality Related to the August 2003 Heat Wave in France.” *International Archives of Occupational and Environmental Health* 80 (1): 16–24. https://doi.org/10.1007/s00420-006-0089-4.

Goldie, James, Lisa Alexander, Sophie C. Lewis, and Steven Sherwood. 2017. “Comparative Evaluation of Human Heat Stress Indices on Selected Hospital Admissions in Sydney, Australia.” *Australian and New Zealand Journal of Public Health* 41 (4): 381–87. https://doi.org/10.1111/1753-6405.12692.

Grundstein, Andrew, Castle Williams, Minh Phan, and Earl Cooper. 2015. “Regional Heat Safety Thresholds for Athletics in the Contiguous United States.” *Applied Geography* 56 (January): 55–60. https://doi.org/10.1016/j.apgeog.2014.10.014.

ICA. 2019. “Townsville Catastrophe Insurance Claims Rising by the Hour.” Insurance Council of Australia. February 5, 2019. https://www.insurancecouncil.com.au/media_release/plain/498.

Jegasothy, Edward, Rhydwyn McGuire, John Nairn, Robert Fawcett, and Benjamin Scalley. 2017. “Extreme Climatic Conditions and Health Service Utilisation across Rural and Metropolitan New South Wales.” *International Journal of Biometeorology* 61 (8): 1359–70. https://doi.org/10.1007/s00484-017-1313-5.

Mallon, Karl, Maxwell McKinlay, Ned Haughton, Rohan Hamden, Ruth Tedder, and Jacquelyn Lamb. 2019. “Climate Change Risk to Australia’s Built Environment: A Second Pass National Assessment.” Sydney, Australia: XDI. https://xdi.systems/wp-content/uploads/2019/10/Climate-Change-Risk-to-Australia%E2%80%99s-Built-Environment-V4-final-reduced-2.pdf.

Melik, James. 2011. “Australia’s Floods Disrupt Commodity Supplies.” BBC News. January 5, 2011. https://www.bbc.com/news/business-12111175.

Murphy, Renee, Salvatore Schiano, Amy DeMartine, and Kate Pesa. 2020. “The Forrester New Wave™: Climate Risk Analytics, Q3 2020. The Eight Providers That Matter Most And How They Stack Up.” https://www.forrester.com/report/The+Forrester+New+Wave+Climate+Risk+Analytics+Q3+2020/-/E-RES157308#.

Nitschke, Monika, Graeme R. Tucker, and Peng Bi. 2007. “Morbidity and Mortality during Heatwaves in Metropolitan Adelaide.” *The Medical Journal of Australia* 187 (11): 662–65. https://doi.org/10.5694/j.1326-5377.2007.tb01466.x.

Sinead Mangan. 2020. “Can Australians Continue to Safely (and Affordably) Live amongst the Trees, or by the Sea?” Sound. ABC Radio. Australian Broadcasting Corporation. November 6, 2020. https://www.abc.net.au/radio/programs/australia-wide/australia-wide/12854582.

Steffen, Will, Karl Mallon, Annika Dean, Martin Rice, and Tom Kompas. 2019. “Compound Costs: How Climate Change Is Damaging Australia’s Economy.” Australia: Climate Council. https://www.climatecouncil.org.au/wp-content/uploads/2019/05/costs-of-climate-change-report-v3.pdf.

TCFD. 2020. “Task Force on Climate-Related Financial Disclosures.” Task Force on Climate-Related Financial Disclosures. 2020. https://www.fsb-tcfd.org/.
Tooth, Richard, and George Barker. 2007. “The Non-Insured: Who, Why and Trends.” Sydney, Australia: Centre of Law and Economics, Insurance Council of Australia. https://www.insurancecouncil.com.au/assets/report/the%20non%20insured%20-%20report.pdf.