NOTICE OF FILING

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Details of Filing

Document Lodged:	Affidavit - Form 59 - Rule 29.02(1)
File Number:	NSD758/2021
File Title:	THE ENVIRONMENT CENTRE NT INC v MINISTER FOR RESOURCES AND WATER & ANOR
Registry:	NEW SOUTH WALES REGISTRY - FEDERAL COURT OF AUSTRALIA

Dated: 10/09/2021 9:14:28 PM AEST Registrar

Important Information

As required by the Court's Rules, this Notice has been inserted as the first page of the document which has been accepted for electronic filing. It is now taken to be part of that document for the purposes of the proceeding in the Court and contains important information for all parties to that proceeding. It must be included in the document served on each of those parties.

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Form 59
Rule 29.02(1)

Affidavit

No. NSD758 of 2021

Federal Court of Australia

District Registry: New South Wales

Division: General

The Environment Centre NT Inc

Applicant

The Minister for Resources and Water and another

Respondents

Affidavit of: **Professor Nerilie Abram**

Address: Research School of Earth Sciences, Australian National University, Acton ACT 2601

Occupation: Professor of Australian National University

Date: 10 September 2020

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Filed on behalf of (name & role of party) The Environment Centre NT Inc
Prepared by (name of person/lawyer) Anna Gudkov
Law firm (if applicable) Environmental Defenders Office Ltd (our ref: S1952)
Tel (02) 9262 6989 Fax (02) 9264 2414
Email Anna.Gudkov@edo.org.au
Address for service (include state and postcode) Level 5, 263 Clarence Street Sydney NSW 2000

I, Professor Nerilie Abram, of Research School of Earth Sciences, Australian National University, Acton ACT 2601, affirm:

1. I am an expert witness retained by the Applicant in these Federal Court proceedings to prepare an expert report regarding the causes of and impacts arising from anthropogenic climate change and the impacts of potential greenhouse gas emissions arising from the exploration and exploitation of gas fields in the Beetaloo sub-basin.

2. All of the information in this affidavit is true and correct to the best of my knowledge or belief. Where information is not within my direct knowledge, I have stated the source of that information.

Training, experience and qualifications

3. I am a Professor of Climate Science at the Australian National University.

4. I graduated with a Bachelor of Science (Advanced; Honours first class with university medal) from the University of Sydney in 2000, majoring in Geology and Marine Science. I was awarded a PhD from the Australian National University in 2004 in climate research carried out at the Research School of Earth Sciences (Australian National University).

5. I have worked as a researcher in this field since this time, at the British Antarctic Survey (2004-2011) and the Australian National University (2011-present).

6. I currently hold the following research leadership roles:

   (a) Associated Director of Research for the Research School of Earth Sciences

   (b) chief investigator for the ARC Centre of Excellence for Climate Extremes; and

   (c) Deputy Director for the Australian Centre for Excellence in Antarctic Science.

7. I am also a current member of the international Climate Crisis Advisory Group chaired by Sir David King (University of Cambridge).

8. Previously I have served as a Coordinating Lead Author for the Intergovernmental Panel on Climate Change (IPCC).

Engagement as an expert in these Proceedings

9. On 27 August 2021, I was briefed by the solicitors for the Applicant, the Environmental Defenders Office Ltd, to prepare a written report addressing the following questions:

   (a) Provide a brief description of the causes and effects of anthropogenic climate change.

   (b) Provide a brief description of any impacts of anthropogenic climate change already being experienced in Australia and the world.

(c) *In your opinion what, if any, is the amount of future temperature rise above pre-industrial levels caused by anthropogenic climate change that is already committed as a consequence of GHG emissions to date?*

(d) *Provide a brief description of Australian and global targets for limiting climate change impacts.*

(e) *What is the relationship between the amount of further emissions of greenhouse gas (GHG) from human industrial activity, including the combustion of liquified natural gas, and future GHG concentration and temperatures above pre-industrial levels?*

(f) *In your opinion, what are the likely future impacts of anthropogenic climate change at a national and global level? In providing your response, please consider:*

   i. *warming scenarios that are consistent with meeting the goals of the Paris Agreement; and*

   ii. *warming scenarios that are consistent with the current trajectory of greenhouse gas emissions.*

(g) *What is the relationship between GHG emissions from the extraction and consumption of gas from the Beetaloo sub-basin and the remaining carbon budget for limiting global temperature rise to:*

   i. *approximately 1.5^{o}C above pre-industrial levels;*

   ii. *1.8^{o}C above pre-industrial levels;*

   iii. *2^{o}C above pre-industrial levels;*

(h) *What is the relationship between the total GHG emissions from the extraction and consumption of gas from the Beetaloo sub-basin and:*

   i. *Australia's current annual GHG emissions; and*

   ii. *Australia's share of the remaining carbon budget for limiting global temperature rise to:*

      1. *approximately 1.5^{o}C above pre-industrial levels;*

      2. *1.8^{o}C above pre-industrial levels; and*

      3. *2^{o}C above pre-industrial levels.*

(i) *In your opinion is the exploration of the three wells for which grants have been made (namely 2D Seismic & Carpentaria 2, Carpentaria 3 and Carpentaria 4 & 3D Seismic) (the Three Wells); and/or extraction and use of gas from those areas; and/or the extraction and use of gas from the Beetaloo sub-basin more broadly; consistent with Australian and global targets for limiting climate change impacts?*

(j) In your opinion, will the exploration of the Three Wells and/or extraction and use of gas from those areas and/or the extraction and use of gas from the Beetaloo sub-basin more broadly, have any impact on the risks associated with climate change? If so, please set out your reasoning in relation to the nature and extent of that impact.

10. Annexed to this Affidavit and marked "**NA-1**" is a true copy of that Letter of Instruction.

11. I have prepared a short report in response to the questions asked of me. Annexed to this Affidavit and marked "**NA-2**" is a true copy of that report.

12. In preparing this Affidavit, I acknowledge that I have read and complied with the Federal Court of Australia Expert Evidence Practice Note (GPN-EXPT) General Practice Note and agree to be bound by it.

13. Annexed to this Affidavit and marked "**NA-3**" is a true copy of my curriculum vitae.

Affirmed in counterpart and witnessed over audio visual link in accordance with section 14G of the Electronic Transactions Act 2000 (NSW))

Signature of deponent .....

Before me:

.....
Signature of witness

Name: Anna Gudkov
Date: 10 September 2021

Qualification: Solicitor

Certificate of Annexure NA-1

No. NSD758 of 2021

Federal Court of Australia

District Registry: New South Wales

Division: General

Environment Centre NT Inc

Applicant

Minister for Resources and Water and another

Respondents

This and the following 26 pages form Annexure NA-1 to the Affidavit of Nerilie Abram affirmed on 10 September 2021 before me.

_____

Signature of witness

Name: Anna Gudkov
Qualification: Solicitor

Environmental Defenders Office

27 August 2021

Professor Nerilie Abram
Research School of Earth Sciences
Australian National University

By email: nerilie.abram@anu.edu.au

CONFIDENTIAL AND SUBJECT TO LEGAL PROFESSIONAL PRIVILEGE

Dear Professor Abram

Environment Centre NT Inc v Minister for Resources and Water & Anor
Federal Court of Australia Proceedings no. NSD758/2021

1. We act for the Environmental Centre NT Inc (**ECNT**), who is the peak community sector environmental organisation in the Northern Territory. ECNT engages in activities aimed at protecting and conserving the environment of the NT, including in relation to climate change.

2. Our client, ECNT, has commenced proceedings in the Federal Court of Australia (**Proceedings**) against the Minister for Resources and Water (**Minister)** and the Commonwealth of Australia (**Commonwealth**) alleging that:

    a. the Minister's making of the *Industry Research and Development (Beetaloo Cooperative Drilling Program) Instrument 2021* (Cth) (the **Instrument**); and

    b. the Minister's decision to award up to $21 million in grants to Imperial Oil and Gas (**Imperial**) pursuant to the Beetaloo Cooperative Drilling Program (**the Program**) (the **Decision**)

    were unlawful in circumstances where the Minister:

    a. breached s 71 (1) of the *Public Governance, Performance and Accountability Act 2013 (Cth)* (**the PGPA Act**) by failing to make reasonable inquiries in respect of climate change risks. S 71(1) requires that the Minister must not approve a proposed expenditure of relevant money unless the Minister is satisfied, after making reasonable inquiries, that the expenditure is a "proper use" of relevant money, where "proper" is defined as a use that is "efficient, effective, economical and ethical"; and

    b. acted in a way that was legally unreasonable and/or illogical and/or irrational, by failing to have regard to and/or failing to have adequate regard to, climate change risks.

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ABN: 72002 880 864

3. We are instructed to engage you to act as an expert witness under Part 23 (rules 23.01-23.15) of the *Federal Court Rules 2011* (Cth) (**FC Rules**) and the Expert Evidence Practice Note (GPN-EXPT) (**Expert Evidence Practice Note**), including the Harmonised Expert Witness Code of Conduct (**Code of Conduct**)). Part 23 of the FC Rules and the Expert Evidence Practice Note is set out in **Annexure A** to this letter.

4. Your role as an expert witness is to assist the Court impartially on matters relevant to your area of expertise. You are not to act as an advocate for our clients and any opinion expressed must be genuinely held by you based on your professional training, knowledge, or experience.

5. Please read those documents carefully before you commence the work requested. **Your expert report must contain an acknowledgment that you have read the Code of Conduct and that you agree to be bound by it.** Otherwise your report will be inadmissible as evidence. Your role as an expert witness is to assist the Court impartially on matters relevant to your area of expertise. You are not to act as an advocate for our clients and any opinion expressed must be genuinely held by you based on your professional training, knowledge, or experience.

Overview of the Work Required

6. The work we require involves the following:

    a. reviewing the relevant documentation;

    b. preparing a written expert report that conforms with the Code of Conduct and addresses our questions (questions located at **Annexure B**);

    c. reviewing the Respondent's expert report(s) (if necessary);

    d. conferring with the Respondent's expert(s) at a joint conference(s) and prepare a joint report, which sets out the matters agreed, matters disagreed, and the reasons for agreement and disagreement as a result of the joint conference(s) (if necessary); and

    e. appearance as an expert witness in the Court (if required).

7. We request that you provide us with a draft of your expert report for review before finalising it. The purpose of this is not to influence the conclusions or recommendations you make but to ensure that the report is clear and addresses the issues adequately to inform the Court.

Background

8. The following information is provided to assist your consideration of the matters on which are you asked to provide expert advice. Please note that you are not permitted to express an opinion on any question of law in your report and your report should confine itself to the relevant issues of fact within your area of expertise.

9. The independent *Scientific Inquiry into Hydraulic Fracturing of Onshore Unconventional Reservoirs in the Northern Territory* (**Fracking Inquiry**) was commissioned by the Northern Territory Government under the *Inquires Act 1945* (NT) and its Terms of Reference required it to investigate the environmental, social and economic risks and impacts of hydraulic fracturing (commonly known as fracking) of onshore unconventional gas reservoirs and associated activities in the Northern Territory.

10. The Fracking Inquiry handed down its Final Report to the Northern Territory Government on Tuesday 27 March 2018. Amongst other things, the Fracking Inquiry identified that a best estimate indicative later development scenario for the exploitation of a new shale gasfield or gasfields in the Beetaloo sub-basin would equate to gas production of 1,240 petajoules per year (**PJ/y**).[1]

11. The Fracking Inquiry further noted that in this later development scenario, it is assumed that 2,740 TJ/day is used for liquid natural gas (**LNG**) export and 660 terajoules per day (**TJ/day**) is used for domestic gas consumption.[2]

12. On 15 September 2020, the Prime Minister of Australia, the Minister for Energy and Emissions Reduction, and the Minister for Resources and Water (**Minister**) announced that Australia will be pursuing a "Gas-led recovery." [3]One of the elements of the Gas-led Recovery was the unlocking of five key gas basins, starting with the Beetaloo basin in the Northern Territory.[4]

13. On 17 December 2020, the Minister announced a $50 million subsidy program for Beetaloo exploration to "fast-track drilling by providing grants to cover 25% of eligible exploration costs, capped at $7.5 million per well and 3 wells per exploration venture."[5] The Minister further announced that it was estimated that the Beetaloo sub-basin could hold more than 200,000 petajoules of gas.[6]

14. In or about January 2021, the Minister issued the Beetaloo Strategic Basin Plan entitled 'Unlocking the Beetaloo,' which set out some details of the Program.

15. On 22 February 2021, Empire Energy Group Ltd (**Empire**), the Australian Stock Exchange (**ASX**) listed parent company of Imperial, published an announcement to the ASX relating to a Material Beetaloo Resource Upgrade. This statement included, amongst other things, the information that Empire has:

    a. a best estimate prospective gas resource of 3,446 billion cubic feet (**BCF**); and

    b. a best estimate of prospective condensate resource of 27 million barrels of petroleum liquids (**MMBL**).

16. On 18 March 2021, the Department of Industry, Science, Energy and Resources (**DISER**) issued the 'Beetaloo Cooperative Drilling Program – Grant Opportunity Guidelines' (**Guidelines**) and a standard Grant Agreement (**Standard Grant Agreement**). The Guidelines govern the provision of grants under the Program.

17. On 7 April 2021, Imperial submitted three applications seeking a total of $21,806,453 of funding under the Program, comprising of:

    a. Application BCD000001, seeking $7,314,081 in funding in respect of a project entitled 'Carpentaria-2 Horizontal Well';

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[1] Fracking Inquiry, p 227.
[2] Fracking Inquiry, p 227.
[3] https://www.pm.gov.au/media/gas-fired-recovery
[4] Ibid.
[5] https://www.minister.industry.gov.au/ministers/pitt/media-releases/beetaloo-strategic-plan-will-unlock-gas-jobs-and-development
[6] Ibid.

b. Application BCDP000002, seeking $6,992,372 in funding in respect of a project entitled 'Carpentaria-3 Horizontal Well'; and

c. Application BCDP000003, seeking $7,500,0000 in funding in respect of a project entitled 'Carpentaria-4 and 3D Seismic'

(together, **the Applications**).

18. Between 7 May and 8 May 2021, the Applications were the subject of DISER review.

19. On 11 May 2021, the Minister made the Instrument and purported to prescribe the Program as a program under s 33 of the *Industry Research and Development Act 1986* (Cth) (the **IRD Act**).

20. On 28 May 2021 and 1 June 2021 an Assessment Committee in respect of the Program (**Assessment Committee**) met to consider the Applications.

21. On 1 June 2012 the Assessment Committee resolved that the Applications were satisfactory (subject to some limitations/conditions [7]) and resolved to recommend to the Minister that they be approved for funding under the Program.

22. On 17 June 2021, following receipt of a DISER brief recommending that the Minister approve the three Applications (subject to the conditions set out by the Assessment Committee[8]), the Minister approved the Applications. On 7 July 2021, the Minister announced the Decision, by way of publication of a Media Release (**Announcement**).

23. On 8 July 2021, Empire Energy Group Ltd, the Australian Stock Exchange (**ASX**) listed parent company of Imperial, published an announcement to the ASX relating to the Decision and Announcement.

Expert Brief

24. We will provide, by way of separate email, a link to an electronic a brief of documents for your review. **Annexure C** contains an index to these documents.

Timeframe

25. Under the current Court orders, your expert report will be due to be filed and served by 10 September 2021. We therefore request a draft of your advice by no later than Monday **6 September 2021**.

26. We will notify you of further relevant dates in the Proceedings as they become available.

Fees and Terms

27. Thank you for agreeing to provide this advice at a capped amount of $1,000 (plus GST).

28. Please note the following terms:
    a. Your work will only be used by EDO in relation to this matter;

[7] Conditions set out on page 5 to 7 of the Meeting Minutes of the Beetaloo Cooperative Drilling Program Assessment Committee (**Assessment Committee**) Meeting on 1 June 2021 – At tab 19 of the Brief.
[8] See Annexure A to Ministerial Recommendation – BCDP Recommended Projects – At tab 29 of the Brief.

b. EDO will take all reasonable steps to prevent your work being used for purposes other than that mentioned above, but we accept no responsibility for the actions of third parties;

c. Regardless of the above points, EDO may choose not to use your work;

d. You will not be covered by EDO's insurance while undertaking the above tasks.

Duty of Confidentiality

29. Please treat your work as strictly confidential, unless authorised by us.

If you would like to discuss this retainer further, please contact us at anna.gudkov@edo.org.au.

Yours sincerely,
Environmental Defenders Office

Anna Gudkov
Senior Lawyer (Gas/Corporate)

Ref: s1952

Part 23—Experts

Division 23.1—Court experts

23.01 Appointment of Court expert

(1) A party may apply to the Court for an order:

(a) that an expert be appointed (a ***Court expert***) to inquire into and report on any question or on any facts relevant to any question arising in a proceeding; and

(b) fixing the Court expert's remuneration, including the cost of preparing the expert's report; and

(c) for the Court expert's attendance before the Court; and

(d) terminating the liability to pay the Court expert's remuneration.

Note 1: ***Expert*** is defined in the Dictionary.

Note 2: The Court may give instructions relating to the inquiry and report including the carrying out of an experiment or test.

Note 3: The Court may make an order of its own motion—see rule 1.40.

(2) If the Court makes an order under paragraph (1)(b), the expert's remuneration is payable jointly and severally by the parties.

23.02 Court expert's report

(1) The Court expert must provide the report to the Court within the time fixed by the Court.

Note: A Registrar will provide a copy of the report to any party interested in the question.

(2) The Court expert's report must:

(a) be signed by the Court expert; and

(b) contain particulars of the training, study or experience by which the Court expert has acquired specialised knowledge; and

(c) identify the questions that the Court expert was asked to address; and

(d) set out separately each of the factual findings or assumptions on which the Court expert's opinion is based; and

(e) set out separately from the factual findings or assumptions each of the Court expert's opinions; and

(f) set out the reasons for those opinions; and

(g) contain an acknowledgement that the opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (b).

23.03 Court expert's report—use at trial

(1) A report that complies with rule 23.02 will be admissible at trial as the evidence of the Court expert.

Note: Section 177 of the *Evidence Act 1995* deals with the tender of an expert's report.

(2) A party may apply to the Court for an order:

(a) to cross-examine a Court expert before or at trial; and

(b) if the cross-examination is to take place before trial—that the cross-examination take place before a Registrar or an examiner.

Note: ***Examiner*** is defined in the Dictionary.

23.04 Other expert's reports on the question

A party who has delivered to another party interested in the question a copy of another expert's report that complies with Division 23.2 may apply to the Court for leave to adduce the evidence of the other expert on the question.

Note: The question is referred to in rule 23.02.

Rules 23.05–23.10 left blank

Division 23.2—Parties' expert witnesses and expert reports

23.11 Calling expert evidence at trial

A party may call an expert to give expert evidence at a trial only if the party has:

(a) delivered an expert report that complies with rule 23.13 to all other parties; and

(b) otherwise complied with this Division.

Note: ***Expert*** and ***expert report*** are defined in the Dictionary.

23.12 Provision of guidelines to an expert

If a party intends to retain an expert to give an expert report or to give expert evidence, the party must first give the expert any practice note dealing with guidelines for expert witnesses in proceedings in the Court (the ***Practice Note***).

Note: A copy of any practice notes may be obtained from the District Registry or downloaded from the Court's website at http://www.fedcourt.gov.au.

23.13 Contents of an expert report

(1) An expert report must:

(a) be signed by the expert who prepared the report; and

(b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and

(c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and

(d) identify the questions that the expert was asked to address; and

(e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and

(f) set out separately from the factual findings or assumptions each of the expert's opinions; and

(g) set out the reasons for each of the expert's opinions; and

(ga) contain an acknowledgement that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c); and

(h) comply with the Practice Note.

(2) Any subsequent expert report of the same expert on the same question need not contain the information in paragraphs (1)(b) and (c).

23.14 Application for expert report

A party may apply to the Court for an order that another party provide copies of that other party's expert report.

23.15 Evidence of experts

If 2 or more parties to a proceeding intend to call experts to give opinion evidence about a similar question, any of those parties may apply to the Court for one or more of the following orders:

(a) that the experts confer, either before or after writing their expert reports;

(b) that the experts produce to the Court a document identifying where the expert opinions agree or differ;

(c) that the expert's evidence in chief be limited to the contents of the expert's expert report;

(d) that all factual evidence relevant to any expert's opinions be adduced before the expert is called to give evidence;

(e) that on the completion of the factual evidence mentioned in paragraph (d), each expert swear an affidavit stating:

(i) whether the expert adheres to the previously expressed opinion; or

(ii) if the expert holds a different opinion;

(A) the opinion; and

(B) the factual evidence on which the opinion is based.

(f) that the experts give evidence one after another;

(g) that each expert be sworn at the same time and that the cross-examination and re-examination be conducted by putting to each expert in turn each question relevant to one subject or issue at a time, until the cross-examination or re-examination is completed;

(h) that each expert gives an opinion about the other expert's opinion;

(i) that the experts be cross-examined and re-examined in any particular manner or sequence.

Note 1: For the directions a Court may make before trial about expert reports and expert evidence, see rule 5.04 (items 14 to 19).

Note 2: The Court may dispense with compliance with the Rules and may make orders inconsistent with the Rules—see rules 1.34 and 1.35.

FEDERAL COURT OF AUSTRALIA

EXPERT EVIDENCE PRACTICE NOTE (GPN-EXPT)

General Practice Note

1. INTRODUCTION

1.1 This practice note, including the *Harmonised Expert Witness Code of Conduct* ("**Code**") (see **Annexure A**) and the *Concurrent Expert Evidence Guidelines* ("**Concurrent Evidence Guidelines**") (see **Annexure B**), applies to any proceeding involving the use of expert evidence and must be read together with:

(a) the Central Practice Note (CPN-1), which sets out the fundamental principles concerning the National Court Framework ("**NCF**") of the Federal Court and key principles of case management procedure;

(b) the Federal Court of Australia Act 1976 (Cth) ("**Federal Court Act**");

(c) the *Evidence Act 1995* (Cth) ("**Evidence Act**"), including Part 3.3 of the Evidence Act;

(d) Part 23 of the *Federal Court Rules 2011* (Cth) ("**Federal Court Rules**"); and

(e) where applicable, the Survey Evidence Practice Note (GPN-SURV).

1.2 This practice note takes effect from the date it is issued and, to the extent practicable, applies to proceedings whether filed before, or after, the date of issuing.

2. APPROACH TO EXPERT EVIDENCE

2.1 An expert witness may be retained to give opinion evidence in the proceeding, or, in certain circumstances, to express an opinion that may be relied upon in alternative dispute resolution procedures such as mediation or a conference of experts. In some circumstances an expert may be appointed as an independent adviser to the Court.

2.2 The purpose of the use of expert evidence in proceedings, often in relation to complex subject matter, is for the Court to receive the benefit of the objective and impartial assessment of an issue from a witness with specialised knowledge (based on training, study or experience - see generally s 79 of the Evidence Act).

2.3 However, the use or admissibility of expert evidence remains subject to the overriding requirements that:

(a) to be admissible in a proceeding, any such evidence must be relevant (s 56 of the Evidence Act); and

(b) even if relevant, any such evidence, may be refused to be admitted by the Court if its probative value is outweighed by other considerations such as the evidence

being unfairly prejudicial, misleading or will result in an undue waste of time (s 135 of the Evidence Act).

2.4 An expert witness' opinion evidence may have little or no value unless the assumptions adopted by the expert (ie. the facts or grounds relied upon) and his or her reasoning are expressly stated in any written report or oral evidence given.

2.5 The Court will ensure that, in the interests of justice, parties are given a reasonable opportunity to adduce and test relevant expert opinion evidence. However, the Court expects parties and any legal representatives acting on their behalf, when dealing with expert witnesses and expert evidence, to at all times comply with their duties associated with the overarching purpose in the Federal Court Act (see ss 37M and 37N).

3. INTERACTION WITH EXPERT WITNESSES

3.1 Parties and their legal representatives should never view an expert witness retained (or partly retained) by them as that party's advocate or "hired gun". Equally, they should never attempt to pressure or influence an expert into conforming his or her views with the party's interests.

3.2 A party or legal representative should be cautious not to have inappropriate communications when retaining or instructing an independent expert, or assisting an independent expert in the preparation of his or her evidence. However, it is important to note that there is no principle of law or practice and there is nothing in this practice note that obliges a party to embark on the costly task of engaging a "consulting expert" in order to avoid "contamination" of the expert who will give evidence. Indeed the Court would generally discourage such costly duplication.

3.3 Any witness retained by a party for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based in the specialised knowledge of the witness[1] should, at the earliest opportunity, be provided with:

(a) a copy of this practice note, including the Code (see Annexure A); and

(b) all relevant information (whether helpful or harmful to that party's case) so as to enable the expert to prepare a report of a truly independent nature.

3.4 Any questions or assumptions provided to an expert should be provided in an unbiased manner and in such a way that the expert is not confined to addressing selective, irrelevant or immaterial issues.

[1] Such a witness includes a "Court expert" as defined in r 23.01 of the Federal Court Rules. For the definition of "expert", "expert evidence" and "expert report" see the Dictionary, in Schedule 1 of the Federal Court Rules.

4. ROLE AND DUTIES OF THE EXPERT WITNESS

4.1 The role of the expert witness is to provide relevant and impartial evidence in his or her area of expertise. An expert should never mislead the Court or become an advocate for the cause of the party that has retained the expert.

4.2 It should be emphasised that there is nothing inherently wrong with experts disagreeing or failing to reach the same conclusion. The Court will, with the assistance of the evidence of the experts, reach its own conclusion.

4.3 However, experts should willingly be prepared to change their opinion or make concessions when it is necessary or appropriate to do so, even if doing so would be contrary to any previously held or expressed view of that expert.

Harmonised Expert Witness Code of Conduct

4.4 Every expert witness giving evidence in this Court must read the *Harmonised Expert Witness Code of Conduct* (attached in Annexure A) and agree to be bound by it.

4.5 The Code is not intended to address all aspects of an expert witness' duties, but is intended to facilitate the admission of opinion evidence, and to assist experts to understand in general terms what the Court expects of them. Additionally, it is expected that compliance with the Code will assist individual expert witnesses to avoid criticism (rightly or wrongly) that they lack objectivity or are partisan.

5. CONTENTS OF AN EXPERT'S REPORT AND RELATED MATERIAL

5.1 The contents of an expert's report must conform with the requirements set out in the Code (including clauses 3 to 5 of the Code).

5.2 In addition, the contents of such a report must also comply with r 23.13 of the Federal Court Rules. Given that the requirements of that rule significantly overlap with the requirements in the Code, an expert, unless otherwise directed by the Court, will be taken to have complied with the requirements of r 23.13 if that expert has complied with the requirements in the Code and has complied with the additional following requirements. The expert shall:

(a) acknowledge in the report that:

(i) the expert has read and complied with this practice note and agrees to be bound by it; and

(ii) the expert's opinions are based wholly or substantially on specialised knowledge arising from the expert's training, study or experience;

(b) identify in the report the questions that the expert was asked to address;

(c) sign the report and attach or exhibit to it copies of:

(i) documents that record any instructions given to the expert; and

(ii) documents and other materials that the expert has been instructed to consider.

5.3 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the other parties at the same time as the expert's report.

6. CASE MANAGEMENT CONSIDERATIONS

6.1 Parties intending to rely on expert evidence at trial are expected to consider between them and inform the Court at the earliest opportunity of their views on the following:

(a) whether a party should adduce evidence from more than one expert in any single discipline;

(b) whether a common expert is appropriate for all or any part of the evidence;

(c) the nature and extent of expert reports, including any in reply;

(d) the identity of each expert witness that a party intends to call, their area(s) of expertise and availability during the proposed hearing;

(e) the issues that it is proposed each expert will address;

(f) the arrangements for a conference of experts to prepare a joint-report (see Part 7 of this practice note);

(g) whether the evidence is to be given concurrently and, if so, how (see Part 8 of this practice note); and

(h) whether any of the evidence in chief can be given orally.

6.2 It will often be desirable, before any expert is retained, for the parties to attempt to agree on the question or questions proposed to be the subject of expert evidence as well as the relevant facts and assumptions. The Court may make orders to that effect where it considers it appropriate to do so.

7. CONFERENCE OF EXPERTS AND JOINT-REPORT

7.1 Parties, their legal representatives and experts should be familiar with aspects of the Code relating to conferences of experts and joint-reports (see clauses 6 and 7 of the Code attached in Annexure A).

7.2 In order to facilitate the proper understanding of issues arising in expert evidence and to manage expert evidence in accordance with the overarching purpose, the Court may require experts who are to give evidence or who have produced reports to meet for the purpose of identifying and addressing the issues not agreed between them with a view to reaching agreement where this is possible ("**conference of experts**"). In an appropriate case, the Court may appoint a registrar of the Court or some other suitably qualified person ("**Conference Facilitator**") to act as a facilitator at the conference of experts.

7.3 It is expected that where expert evidence may be relied on in any proceeding, at the earliest opportunity, parties will discuss and then inform the Court whether a conference of experts and/or a joint-report by the experts may be desirable to assist with or simplify the giving of expert evidence in the proceeding. The parties should discuss the necessary arrangements for any conference and/or joint-report. The arrangements discussed between the parties should address:

(a) who should prepare any joint-report;

(b) whether a list of issues is needed to assist the experts in the conference and, if so, whether the Court, the parties o r the experts should assist in preparing such a list;

(c) **t**he agenda for the conference of experts; and

(d) arrangements for the provision, to the parties and the Court, of any joint-report or any other report as to the outcomes of the conference ("**conference report**").

Conference of Experts

7.4 The purpose of the conference of experts is for the experts to have a comprehensive discussion of issues relating to their field of expertise, with a view to identifying matters and issues in a proceeding about which the experts agree, partly agree or disagree and why. For this reason the conference is attended only by the experts and any Conference Facilitator. Unless the Court orders otherwise, the parties' lawyers will not attend the conference but will be provided with a copy of any conference report.

7.5 The Court may order that a conference of experts occur in a variety of circumstances, depending on the views of the judge and the parties and the needs of the case, including:

(a) while a case is in mediation. When this occurs the Court may also order that the outcome of the conference or any document disclosing or summarising the experts' opinions be confidential to the parties while the mediation is occurring;

(b) before the experts have reached a final opinion on a relevant question or the facts involved in a case. When this occurs the Court may order that the parties exchange draft expert reports and that a conference report be prepared for the use of the experts in finalising their reports;

(c) after the experts' reports have been provided to the Court but before the hearing of the experts' evidence. When this occurs the Court may also order that a conference report be prepared (jointly or otherwise) to ensure the efficient hearing of the experts' evidence.

7.6 Subject to any other order or direction of the Court, the parties and their lawyers must not involve themselves in the conference of experts process. In particular, they must not seek to encourage an expert not to agree with another expert or otherwise seek to influence the outcome of the conference of experts. The experts should raise any queries they may have in relation to the process with the Conference Facilitator (if one has been appointed) or in

accordance with a protocol agreed between the lawyers prior to the conference of experts taking place (if no Conference Facilitator has been appointed).

7.7 Any list of issues prepared for the consideration of the experts as part of the conference of experts process should be prepared using non-tendentious language.

7.8 The timing and location of the conference of experts will be decided by the judge or a registrar who will take into account the location and availability of the experts and the Court's case management timetable. The conference may take place at the Court and will usually be conducted in-person. However, if not considered a hindrance to the process, the conference may also be conducted with the assistance of visual or audio technology (such as via the internet, video link and/or by telephone).

7.9 Experts should prepare for a conference of experts by ensuring that they are familiar with all of the material upon which they base their opinions. Where expert reports in draft or final form have been exchanged prior to the conference, experts should attend the conference familiar with the reports of the other experts. Prior to the conference, experts should also consider where they believe the differences of opinion lie between them and what processes and discussions may assist to identify and refine those areas of difference.

Joint-report

7.10 At the conclusion of the conference of experts, unless the Court considers it unnecessary to do so, it is expected that the experts will have narrowed the issues in respect of which they agree, partly agree or disagree in a joint-report. The joint-report should be clear, plain and concise and should summarise the views of the experts on the identified issues, including a succinct explanation for any differences of opinion, and otherwise be structured in the manner requested by the judge or registrar.

7.11 In some cases (and most particularly in some native title cases), depending on the nature, volume and complexity of the expert evidence a judge may direct a registrar to draft part, or all, of a conference report. If so, the registrar will usually provide the draft conference report to the relevant experts and seek their confirmation that the conference report accurately reflects the opinions of the experts expressed at the conference. Once that confirmation has been received the registrar will finalise the conference report and provide it to the intended recipient(s).

8. CONCURRENT EXPERT EVIDENCE

8.1 The Court may determine that it is appropriate, depending on the nature of the expert evidence and the proceeding generally, for experts to give some or all of their evidence concurrently at the final (or other) hearing.

8.2 Parties should familiarise themselves with the *Concurrent Expert Evidence Guidelines* (attached in Annexure B). The Concurrent Evidence Guidelines are not intended to be exhaustive but indicate the circumstances when the Court might consider it appropriate for

concurrent expert evidence to take place, outline how that process may be undertaken, and assist experts to understand in general terms what the Court expects of them.

8.3 If an order is made for concurrent expert evidence to be given at a hearing, any expert to give such evidence should be provided with the Concurrent Evidence Guidelines well in advance of the hearing and should be familiar with those guidelines before giving evidence.

9. FURTHER PRACTICE INFORMATION AND RESOURCES

9.1 Further information regarding Expert Evidence and Expert Witnesses is available on the Court's website.

9.2 Further information to assist litigants, including a range of helpful guides, is also available on the Court's website. This information may be particularly helpful for litigants who are representing themselves.

J L B ALLSOP
Chief Justice
25 October 2016

Annexure A

HARMONISED EXPERT WITNESS CODE OF CONDUCT[2]

APPLICATION OF CODE

1. This Code of Conduct applies to any expert witness engaged or appointed:

   (a) to provide an expert's report for use as evidence in proceedings or proposed proceedings; or

   (b) to give opinion evidence in proceedings or proposed proceedings.

GENERAL DUTIES TO THE COURT

2. An expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person retaining the expert witness, to assist the Court impartially on matters relevant to the area of expertise of the witness.

CONTENT OF REPORT

3. Every report prepared by an expert witness for use in Court shall clearly state the opinion or opinions of the expert and shall state, specify or provide:

   (a) the name and address of the expert;

   (b) an acknowledgment that the expert has read this code and agrees to be bound by it;

   (c) the qualifications of the expert to prepare the report;

   (d) the assumptions and material facts on which each opinion expressed in the report is based [a letter of instructions may be annexed];

   (e) the reasons for and any literature or other materials utilised in support of such opinion;

   (f) (if applicable) that a particular question, issue or matter falls outside the expert's field of expertise;

   (g) any examinations, tests or other investigations on which the expert has relied, identifying the person who carried them out and that person's qualifications;

   (h) the extent to which any opinion which the expert has expressed involves the acceptance of another person's opinion, the identification of that other person and the opinion expressed by that other person;

   (i) a declaration that the expert has made all the inquiries which the expert believes are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which the expert regards as relevant have, to the

[2] Approved by the Council of Chief Justices' Rules Harmonisation Committee

knowledge of the expert, been withheld from the Court;

(j) any qualifications on an opinion expressed in the report without which the report is or may be incomplete or inaccurate;

(k) whether any opinion expressed in the report is not a concluded opinion because of insufficient research or insufficient data or for any other reason; and

(l) where the report is lengthy or complex, a brief summary of the report at the beginning of the report.

SUPPLEMENTARY REPORT FOLLOWING CHANGE OF OPINION

4. Where an expert witness has provided to a party (or that party's legal representative) a report for use in Court, and the expert thereafter changes his or her opinion on a material matter, the expert shall forthwith provide to the party (or that party's legal representative) a supplementary report which shall state, specify or provide the information referred to in paragraphs (a), (d), (e), (g), (h), (i), (j), (k) and (l) of clause 3 of this code and, if applicable, paragraph (f) of that clause.

5. In any subsequent report (whether prepared in accordance with clause 4 or not) the expert may refer to material contained in the earlier report without repeating it.

DUTY TO COMPLY WITH THE COURT'S DIRECTIONS

6. If directed to do so by the Court, an expert witness shall:

(a) confer with any other expert witness;

(b) provide the Court with a joint-report specifying (as the case requires) matters agreed and matters not agreed and the reasons for the experts not agreeing; and

(c) abide in a timely way by any direction of the Court.

CONFERENCE OF EXPERTS

7. Each expert witness shall:

(a) exercise his or her independent judgment in relation to every conference in which the expert participates pursuant to a direction of the Court and in relation to each report thereafter provided, and shall not act on any instruction or request to withhold or avoid agreement; and

(b) endeavour to reach agreement with the other expert witness (or witnesses) on any issue in dispute between them, or failing agreement, endeavour to identify and clarify the basis of disagreement on the issues which are in dispute.

ANNEXURE B

CONCURRENT EXPERT EVIDENCE GUIDELINES

APPLICATION OF THE COURT'S GUIDELINES

1. The Court's Concurrent Expert Evidence Guidelines ("**Concurrent Evidence Guidelines**") are intended to inform parties, practitioners and experts of the Court's general approach to concurrent expert evidence, the circumstances in which the Court might consider expert witnesses giving evidence concurrently and, if so, the procedures by which their evidence may be taken.

OBJECTIVES OF CONCURRENT EXPERT EVIDENCE TECHNIQUE

2. The use of concurrent evidence for the giving of expert evidence at hearings as a case management technique[3] will be utilised by the Court in appropriate circumstances (see r 23.15 of the *Federal Court Rules 2011* (Cth)). Not all cases will suit the process. For instance, in some patent cases, where the entire case revolves around conflicts within fields of expertise, concurrent evidence may not assist a judge. However, patent cases should not be excluded from concurrent expert evidence processes.

3. In many cases the use of concurrent expert evidence is a technique that can reduce the partisan or confrontational nature of conventional hearing processes and minimises the risk that experts become "opposing experts" rather than independent experts assisting the Court. It can elicit more precise and accurate expert evidence with greater input and assistance from the experts themselves.

4. When properly and flexibly applied, with efficiency and discipline during the hearing process, the technique may also allow the experts to more effectively focus on the critical points of disagreement between them, identify or resolve those issues more quickly, and narrow the issues in dispute. This can also allow for the key evidence to be given at the same time (rather than being spread across many days of hearing); permit the judge to assess an expert more readily, whilst allowing each party a genuine opportunity to put and test expert evidence. This can reduce the chance of the experts, lawyers and the judge misunderstanding the opinions being expressed by the experts.

5. It is essential that such a process has the full cooperation and support of all of the individuals involved, including the experts and counsel involved in the questioning process. Without that cooperation and support the process may fail in its objectives and even hinder the case management process.

[3] Also known as the "hot tub" or as "expert panels".

CASE MANAGEMENT

6. Parties should expect that, the Court will give careful consideration to whether concurrent evidence is appropriate in circumstances where there is more than one expert witness having the same expertise who is to give evidence on the same or related topics. Whether experts should give evidence concurrently is a matter for the Court, and will depend on the circumstances of each individual case, including the character of the proceeding, the nature of the expert evidence, and the views of the parties.

7. Although this consideration may take place at any time, including the commencement of the hearing, if not raised earlier, parties should raise the issue of concurrent evidence at the first appropriate case management hearing, and no later than any pre-trial case management hearing, so that orders can be made in advance, if necessary. To that end, prior to the hearing at which expert evidence may be given concurrently, parties and their lawyers should confer and give general consideration as to:

   (a) the agenda;

   (b) the order and manner in which questions will be asked; and

   (c) whether cross-examination will take place within the context of the concurrent evidence or after its conclusion.

8. At the same time, and before any hearing date is fixed, the identity of all experts proposed to be called and their areas of expertise is to be notified to the Court by all parties.

9. The lack of any concurrent evidence orders does not mean that the Court will not consider using concurrent evidence without prior notice to the parties, if appropriate.

CONFERENCE OF EXPERTS & JOINT-REPORT OR LIST OF ISSUES

10. The process of giving concurrent evidence at hearings may be assisted by the preparation of a joint-report or list of issues prepared as part of a conference of experts.

11. Parties should expect that, where concurrent evidence is appropriate, the Court may make orders requiring a conference of experts to take place or for documents such as a joint-report to be prepared to facilitate the concurrent expert evidence process at a hearing (see Part 7 of the Expert Evidence Practice Note).

PROCEDURE AT HEARING

12. Concurrent expert evidence may be taken at any convenient time during the hearing, although it will often occur at the conclusion of both parties' lay evidence.

13. At the hearing itself, the way in which concurrent expert evidence is taken must be applied flexibly and having regard to the characteristics of the case and the nature of the evidence to be given.

14. Without intending to be prescriptive of the procedure, parties should expect that, when evidence is given by experts in concurrent session:

(a) the judge will explain to the experts the procedure that will be followed and that the nature of the process may be different to their previous experiences of giving expert evidence;

(b) the experts will be grouped and called to give evidence together in their respective fields of expertise;

(c) the experts will take the oath or affirmation together, as appropriate;

(d) the experts will sit together with convenient access to their materials for their ease of reference, either in the witness box or in some other location in the courtroom, including (if necessary) at the bar table;

(e) each expert may be given the opportunity to provide a summary overview of their current opinions and explain what they consider to be the principal issues of disagreement between the experts, as they see them, in their own words;

(f) the judge will guide the process by which evidence is given, including, where appropriate:

(i) using any joint-report or list of issues as a guide for all the experts to be asked questions by the judge and counsel, about each issue on an issue-by-issue basis;

(ii) ensuring that each expert is given an adequate opportunity to deal with each issue and the exposition given by other experts including, where considered appropriate, each expert asking questions of other experts or supplementing the evidence given by other experts;

(iii) inviting legal representatives to identify the topics upon which they will cross-examine;

(iv) ensuring that legal representatives have an adequate opportunity to ask all experts questions about each issue. Legal representatives may also seek responses or contributions from one or more experts in response to the evidence given by a different expert; and

(v) allowing the experts an opportunity to summarise their views at the end of the process where opinions may have been changed or clarifications are needed.

15. The fact that the experts may have been provided with a list of issues for consideration does not confine the scope of any cross-examination of any expert. The process of cross-examination remains subject to the overall control of the judge.

16. The concurrent session should allow for a sensible and orderly series of exchanges between expert and expert, and between expert and lawyer. Where appropriate, the judge may allow for more traditional cross-examination to be pursued by a legal representative on a particular issue exclusively with one expert. Where that occurs, other experts may be asked to comment on the evidence given.

17. Where any issue involves only one expert, the party wishing to ask questions about that issue should let the judge know in advance so that consideration can be given to whether

arrangements should be made for that issue to be dealt with after the completion of the concurrent session. Otherwise, as far as practicable, questions (including in the form of cross-examination) will usually be dealt with in the concurrent session.

18. Throughout the concurrent evidence process the judge will ensure that the process is fair and effective (for the parties and the experts), balanced (including not permitting one expert to overwhelm or overshadow any other expert), and does not become a protracted or inefficient process.

ANNEXURE B– QUESTIONS TO EXPERT

In providing your response to the following questions, please consider information that was in the public domain as at 17 June 2021:

1. Provide a brief description of the causes and effects of anthropogenic climate change.
2. Provide a brief description of any impacts of anthropogenic climate change already being experienced in Australia and the world.
3. In your opinion what, if any, is the amount of future temperature rise above pre-industrial levels caused by anthropogenic climate change that is already committed as a consequence of GHG emissions to date?
4. Provide a brief description of Australian and global targets for limiting climate change impacts.
5. What is the relationship between the amount of further emissions of greenhouse gas (**GHG**) from human industrial activity, including the combustion of liquified natural gas, and future GHG concentration and temperatures above pre-industrial levels?
6. In your opinion, what are the likely future impacts of anthropogenic climate change at a national and global level? In providing your response, please consider:
    a. warming scenarios that are consistent with meeting the goals of the Paris Agreement; and
    b. warming scenarios that are consistent with the current trajectory of greenhouse gas emissions.
7. What is the relationship between GHG emissions from the extraction and consumption of gas from the Beetaloo sub-basin and the remaining carbon budget for limiting global temperature rise to (i) approximately 1.5°C above pre-industrial levels; (ii) 1.8°C above pre-industrial levels; (iii) 2°C above pre-industrial levels;
8. What is the relationship between the total GHG emissions from the extraction and consumption of gas from the Beetaloo sub-basin and:
    a. Australia's current annual GHG emissions; and
    b. Australia's share of the remaining carbon budget for limiting global temperature rise to (i) approximately 1.5°C above pre-industrial levels; (ii) 1.8°C above pre-industrial levels; and (iii) 2°C above pre-industrial levels.
9. In your opinion is the exploration of the three wells for which grants have been made (namely 2D Seismic & Carpentaria 2, Carpentaria 3 and Carpentaria 4 & 3D Seismic) (the **Three Wells**); and/or extraction and use of gas from those areas; and/or the extraction and use of gas from the Beetaloo sub-basin more broadly; consistent with Australian and global targets for limiting climate change impacts?
10. In your opinion, will the exploration of the Three Wells and/or extraction and use of gas from those areas and/or the extraction and use of gas from the Beetaloo sub-basin more broadly, have any impact on the risks associated with climate change? If so, please set out your reasoning in relation to the nature and extent of that impact.

ANNEXURE C – INDEX TO BRIEF

No.	Document	Date
	PLEADINGS	
1.	Originating Application	28 July 2021
2.	Concise Statement	16 August 2021
	LEGISLATION	
3.	*Industry Research and Development (Beetaloo Cooperative Drilling Program) Instrument 2021* (**the Instrument**)	11 May 2021
4.	Explanatory Statement to the Instrument	13 May 2021
	DOCUMENTS BEFORE THE MINISTER WHEN MAKING THE INSTRUMENT	
5.	Ministerial Submission issued by the Department of Industry of Industry, Science, Energy and Resources to the Minister for Resources, Water and Northern Australia making recommendations in respect of the making of the Instrument (**Ministerial Recommendation**)– MLO version	23 April 2021
6.	Attachment A to the Ministerial Recommendation – *Industry Research and Development (Beetaloo Cooperative Drilling Program) Instrument 2021* (Draft)	23 April 2021
7.	Attachment B to the Ministerial Recommendation – Explanatory Statement	23 April 2021
8.	Attachment C to the Ministerial Recommendation – Background Brief	23 April 2021
9.	Signed Ministerial Recommendation approving the making of the Instrument	11 May 2021
	EMPIRE APPLICATION FOR FUNDING	
10.	Imperial Application for Beetaloo Grant – Empire Beetaloo Acceleration Program Carpentaria-2 Horizontal Well (**BCP00001**)	7 April 2021
11.	BCP00001 Application Annexure A – Project Budget	7 April 2021
12.	Imperial Application for Beetaloo Grant – Empire Beetaloo Acceleration Program Carpentaria-3 Horizontal Well' (**BCP00002**)	7 April 2021
13.	BCP00002 Application Annexure A – Project Budget	7 April 2021
14.	Imperial Application for Beetaloo Grant – Empire Beetaloo Acceleration Program Carpentaria-4 and 3D Seismic (**BCP00003**)	7 April 2021
15.	BCP00003 Application Annexure A – Project Budget	7 April 2021
	DOCUMENTS RELATING TO APPROVAL OF THE APPLICATIONS	
16.	DISER Eligibility and Completeness Checklist for BCP00001 completed by Mario Pricone (Assessor) and Janet Lau (QA Officer)	7 -8 May 2021
17.	DISER Eligibility and Completeness Checklist for BCP00002 completed by Mario Pricone (Assessor) and Janet Lau (QA Officer)	7 -8 May 2021

18.	DISER Eligibility and Completeness Checklist for BCP00003 completed by Mario Pricone (Assessor) and Janet Lau (QA Officer)	7 -8 May 2021
19.	Meeting Minutes of the Beetaloo Cooperative Drilling Program Assessment Committee (**Assessment Committee**) Meeting on 27 May 2021 and 1 June 2021	1 June 2021 and 7 June 2021
20.	Attachment A to the Meeting Minutes of Assessment Committee Meeting– Excel spreadsheet of all Program applications	27 May 2021
21.	Attachment C to the Meeting Minutes of the Assessment Committee Meeting – Questions from Committee to Imperial and Imperial's responses	1 June 2021
22.	Scorecard (Summary)- Assessment Committee member Daniel Quin	
23.	Scorecard (Summary)- Assessment Committee member Merrie-Ellen Gunning	
24.	Scorecard for BCDP000001 - Assessment Committee member Louis Gomatos	
25.	Scorecard for BCDP000002 - Assessment Committee member Louis Gomatos	
26.	Scorecard for BCDP000003 - Assessment Committee member Louis Gomatos	
DOCUMENTS BEFORE THE MINISTER WHEN MAKING THE DECISION		
27.	Ministerial Submission issued by the Department of Industry of Industry, Science, Energy and Resources to the Minister for Resources, Water and Northern Australia making recommendations in respect of the Decision (**Ministerial Recommendation**)– MLO version	16 June 2021
28.	Minister's signed Decision approving Ministerial Recommendation	17 June 2021
29.	Annexure A to Ministerial Recommendation – BCDP Recommended Projects	17 June 2021
30.	Annexure B to Ministerial Recommendation - Program Guidelines	17 June 2021
31.	Annexure C to Ministerial Recommendation – Governance and Program Background	17 June 2021
32.	Annexure D to Ministerial Recommendation – Legal Advice (Redacted – Subject to LPP)	17 June 2021
DECISION ANNOUNCEMENTS		
33.	Minister's Media Release on the Decision	7 July 2021
34.	Empire Energy ASX Announcement on the Decision	8 July 2021
RELEVANT OTHER DOCUMENTS		
35.	'Unlocking the Beetaloo – The Beetaloo Strategic Basin Plan'	Jan 2021
36.	Commonwealth Grants Rules and Guidelines 2017	Current

37.	Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory	April 2018
RELEVANT IMPERIAL DOCUMENTS		
38.	Empire Energy ASX announcement entitled "Material Beetaloo Resource Upgrade"	22 February 2021
39.	Morgans report entitled "Backing the Beetaloo" published on Empire Energy's 'Investors' section of website	26 November 2020
ENVIRONMENTAL MANAGEMENT PLANS (EMPS) FOR EP187		
IMP2-04 – Imperial 2019 Drilling Program NT Exploration Permit 187 - APPROVED		
40.	Imperial Environmental Management Plan IMP2-04	Submitted 22 August 2019
41.	Attachment to Imperial EMP IMP2-04 – Emergency Response Plan	Submitted 22 August 2019
42.	NT Government EPA advice in respect of IMP2-04	6 January 2020
43.	NT Government – Approval Notice and Statement of Reasons	2 March 2020
IMP2-6.1 – Imperial 2020-21 Drilling Program NT Exploration Permit 187 - APPROVED		
44.	Imperial Environmental Management Plan IMP2-6.1	Submitted 30 June 2020
45.	Attachments to EMP IMP2-6.1	Submitted 30 June 2020
46.	NT Government EPA advice in respect of IMP2-6.1	9 September 2020
47.	NT Government – Approval Notice and Statement of Reasons	30 September 2020
48.	EP187 Groundwater monitoring results	25 March - 22 October 2020
49.	Imperial Drilling Fluid waste water analysis from the Carpentaria-1 Well site	28 October 2020
IMP3-4 – Hydraulic fracturing and extended production testing of the existing Carpentaria-1 Vertical exploration well on EP187 – APPROVED		
50.	Imperial Environmental Management Plan IMP3-4	Submitted 17 November 2020
51.	Appendices to IMP3-4	Submitted 17 November 2020
52.	NT Government EPA advice in respect of IMP3-4	5 February 2021
53.	NT Government – Approval Notice and Statement of Reasons	15 February 2021

Certificate of Annexure NA-2

No. NSD758 of 2021

Federal Court of Australia

District Registry: New South Wales

Division: General

Environment Centre NT Inc

Applicant

Minister for Resources and Water and another

Respondents

This and the following 65 pages form Annexure NA-2 to the Affidavit of Nerilie Abram affirmed on 10 September 2021 before me.

_____

Signature of witness

Name: Anna Gudkov
Qualification: Solicitor

Environment Centre NT Inc v Minister for Resources and Water & Anor
Federal Court of Australia Proceedings no. NSD758/2021

EXPERT REPORT OF PROFESSOR NERILIE ABRAM - 10 September 2021

INTRODUCTION

1. This report has been prepared by Professor Nerilie Abram.

2. I have read the Federal Court of Australia expert evidence practice note and associated code of conduct and agree to be bound by their contents.

3. I am a Professor of Climate Science at the Australian National University. I graduated with a Bachelor of Science (Advanced; Honours first class with university medal) from the University of Sydney in 2000, majoring in Geology and Marine Science. I was awarded a PhD from the Australian National University in 2004 in climate research carried out at the Research School of Earth Sciences. I have worked as a researcher in this field since this time, at the British Antarctic Survey (2004-2011) and the Australian National University (2011-present).

4. I currently hold the following research leadership roles: Associated Director of Research for the Research School of Earth Sciences, a chief investigator for the ARC Centre of Excellence for Climate Extremes, and Deputy Director for the Australian Centre for Excellence in Antarctic Science. I have previously served as a Coordinating Lead Author for the Intergovernmental Panel on Climate Change, and I am a member of the international Climate Crisis Advisory Group chaired by Sir David King (University of Cambridge).

5. A copy of my curriculum vitae is set out in **Appendix 1** to this report.

6. The expert opinions I provide here are based wholly or substantially on specialised knowledge arising from my training, study and professional experience as a climate scientist.

7. **Appendix 2** to this report is a copy of my letter of instruction and the questions I have been requested to provide expert comment on.

RESPONSES TO QUESTIONS

The evidence I draw upon in providing these responses was available in the public domain as at 17 June 2021.

Question 1: Provide a brief description of the causes and effects of anthropogenic climate change

8. Anthropogenic (or human-caused) climate change refers to the ways in which human activities are altering our climate system. Typically, we assess anthropogenic climate change relative to a pre-industrial baseline[1], most commonly defined as the average climate over the 1850-1900 interval[2]. Prior to this time climate changes were primarily caused by natural factors (volcanic eruptions, solar fluctuations, and variability internal to the climate system such as the El Niño-Southern Oscillation).

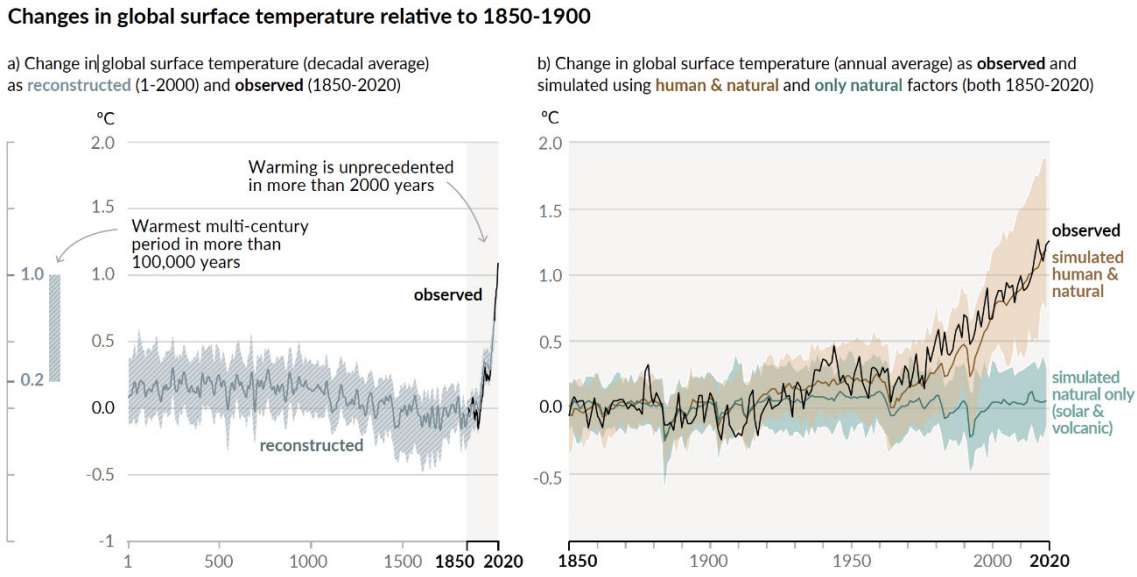
9. Human activities have caused our climate system to begin changing rapidly since the pre-industrial (1850-1900). Observed warming since this time is only consistent human factors, and cannot be reproduced in climate model simulations that include only natural factors[3],[4].

10. **Figure 1 below** illustrates that observed warming (black line on right side panel) is only consistent with human forcing (brown shading on right side panel). This figure is from the IPCC 6th Assessment Report of working group 1 (released in August 2021), but equivalent figures are also available in the references in footnotes 3 and 4.

11. The human-caused factors that are causing climate change include: the release to the atmosphere of aerosols (e.g. sulphur dioxide particles) that have a net cooling effect by blocking solar energy from reaching the Earth surface; ozone-depleting substances (CFCs) that alter southern hemisphere atmospheric circulation; and greenhouse gases including carbon dioxide (CO_2) and methane (CH_4) that warm the climate by trapping infrared radiation that would have otherwise been radiated out to space.

[1] Paris Agreement, Article 2. https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[2] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (2019). Cross-chapter Box 1 in chapter 1. https://www.ipcc.ch/srocc/chapter/chapter-1-framing-and-context-of-the-report/
[3] Gillett et al., 2021, Nature Climate Change. https://www.nature.com/articles/s41558-020-00965-9.pdf
[4] IPCC 5th Assessment Report of Working Group 1. Summary for Policymakers. Section D.3 and Figure SPM.6. https://www.ipcc.ch/report/ar5/wg1/summary-for-policymakers/

Figure 1 (https://www.ipcc.ch/report/ar6/wg1/#SPM)



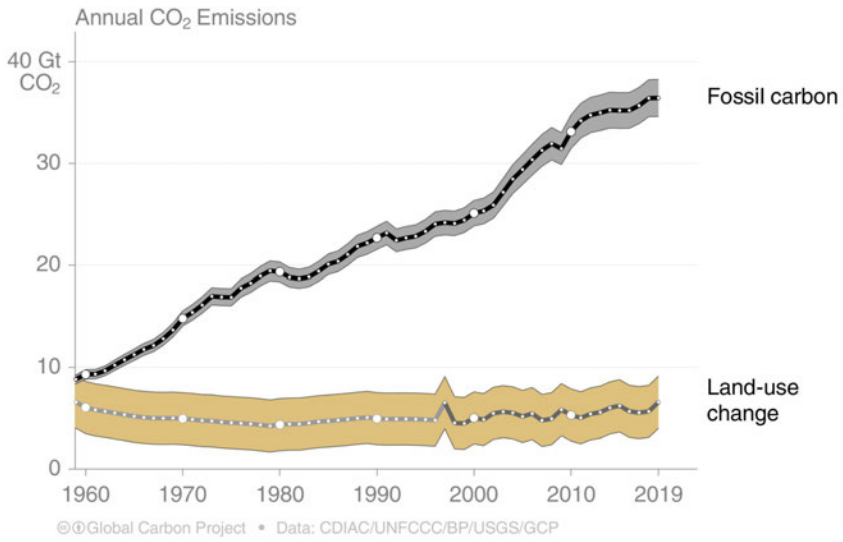
12. Assessments of the contributions of these different factors have concluded that human activities are responsible for approximately 100% (i.e. all) of the observed global warming since pre-industrial times. The Earth's climate has warmed by +1.1°C (2010-2019 average) since the pre-industrial (1850-1900). Human activities are responsible for +1.1 ± 0.2 °C of this warming. This is comprised of +1.5 ± 0.4 °C of warming from human-caused increases in atmospheric greenhouse gas concentrations, and –0.4 ± 0.3 °C of cooling from human-caused changes in atmospheric aerosols. There has been a negligible contribution to observed climate warming since the pre-industrial from natural factors[5].

13. By far the largest contributor to human-caused increases in atmospheric greenhouse gases is the burning of fossil fuels. Over the past decade (2011-2019), fossil carbon accounted for 86% of CO_2 emissions (34 Billion tonnes of CO_2 per year). In 2019 the share of CO_2 emissions to these fossil carbon sources was comprised of coal (39%), oil (33%), gas (21%), cement (4%), and flaring (1%). Land use changes (e.g. deforestation, wildfires) accounted for 14% of CO_2 emissions (5.7 Billion tonnes of CO_2 per year) over the last decade (2011-2019)[6],[7].

[5] Gillett et al., 2021, Nature Climate Change. https://www.nature.com/articles/s41558-020-00965-9.pdf
[6] Friedlingstein, P. et al., (2020), Global Carbon Budget 2020, Earth Syst. Sci. Data, 12, 3269–3340, https://doi.org/10.5194/essd-12-3269-2020
[7] Global Carbon Budget 2020, slides 30 and 51. https://www.globalcarbonproject.org/carbonbudget/20/files/GCP_CarbonBudget_2020.pdf

14. Annual emissions of CO_2 from land-use change have stayed relatively constant since the 1960s, while annual emissions from fossil carbon have increased strongly since this time, as shown in **Figure 2 below**[8]:

Figure 2.



15. The recent 'Net Zero by 2050' report from the International Energy Agency (**IEA**) (**IEA Net Zero Report**) stated: *"The energy sector is the source of around three-quarters of greenhouse gas emissions today and holds the key to averting the worst effects of climate change, perhaps the greatest challenge humankind has faced.*"[9]

[8] Global Carbon Budget 2020, slide 47. https://www.globalcarbonproject.org/carbonbudget/20/files/GCP_CarbonBudget_2020.pdf

[9] Net Zero by 2050 A Roadmap for the Global Energy Sector. International Energy Agency, May 2021. https://www.iea.org/reports/net-zero-by-2050

Question 2: Provide a brief description of any impacts of anthropogenic climate change already being experienced in Australia and the world

16. Human-caused climate change is already causing damaging impacts for all inhabited parts of the planet.

17. **Globally**, these impacts include:

    a) more frequent and intense heatwaves over most land areas[10],
    b) increases in the intensity of heavy rainfall globally with implications for flood risk[11],
    c) increases in the occurrences and intensity of drought, dust storms, desertification and wildfire risk in some regions[12],
    d) loss of snow and ice with impacts on water security in high mountains and downstream areas[13],
    e) warming and destabilisation of permafrost, with potential amplifying effects on climate change through greenhouse gas release[14],
    f) rapid loss of Arctic sea ice, with amplifying effects on climate change through accelerated temperature rise in the Arctic[15],
    g) intensification of wind and rainfall associated with tropical cyclones[16],
    h) oceans becoming hotter, more acidic and losing oxygen with implications for marine ecosystems and fisheries[17], and
    i) rising sea levels (from ice sheet and glacier mass loss and expansion of the warming oceans) leading to an increasing frequency of extreme sea level events, and risks for coastal retreat in some places as well as inundation and loss of low-lying coasts and islands[18].

[10] IPCC Special Report on Climate Change and Land, 2019. Summary for Policymakers A.2. https://www.ipcc.ch/srccl/
[11] IPCC Special Report on Climate Change and Land, 2019. Summary for Policymakers A.2. https://www.ipcc.ch/srccl/
[12] IPCC Special Report on Climate Change and Land, 2019. Summary for Policymakers A.2. https://www.ipcc.ch/srccl/
[13] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers A.1, A.4 and A.7. https://www.ipcc.ch/srocc/
[14] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers A.1, A.4, A.7 and A.9. https://www.ipcc.ch/srocc/
[15] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers A.1, A.4 and A.7. https://www.ipcc.ch/srocc/
[16] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers A.3 and A.9. https://www.ipcc.ch/srocc/
[17] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers A.2, A.5, A.6 and A.8. https://www.ipcc.ch/srocc/
[18] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers A.3, A.6 and A.9. https://www.ipcc.ch/srocc/

18. **Within Australia**, major climate risks already being experienced include:

a) a decline in cool season rainfall across southern parts of Australia. In southwest Australia there has been a 16% loss of rainfall April-October rainfall since 1970, and in southeast Australia there has been a 12% loss in April-October rainfall since the late 1970s. This is decreasing streamflow across the majority of southern Australia[19];

b) increases in the intensity of heavy rainfall events in Australia. The intensity of extreme rainfall events has increased by around 10% in some regions over recent decades, resulting in increased flood risk to communities[20];

c) rising sea levels that are increasing the risk of inundation and damage to low-lying coastal communities and infrastructure[21];

d) increasing frequency and intensity of extreme heat that is a deadly natural hazard for people and animals. In 2019 there were more than 33 days that exceeded 39°C, more than the total observed number (24) from 1960-2018 combined[22].

e) longer and more frequent marine heatwaves that are damaging marine ecosystems including coral reefs, kelp forests and sea grasses and damaging coastal fisheries and aquaculture[23];

f) and increases in the length of the fire season and the number of dangerous fire weather days since the 1950s[24].

19. All of the global and Australian climate change impacts summarised in paragraphs 18 and 19 will continue to worsen if human-caused climate warming is allowed to continue. Impacts observed so far are the result of 1.1°C of human-caused warming. These trends will continue with further warming, with high greenhouse gas emission futures seeing larger future changes than low emission futures[25].

20. Some of the changes in the climate system that have already been set in motion are irreversible, building in long-term commitments for loss and damage. In particular, sea level will continue to rise for centuries to millennia in all future climate scenarios, even those where global

[19] State of the Climate 2020, Bureau of Meteorology and CSIRO. http://www.bom.gov.au/state-of-the-climate/
[20] State of the Climate 2020, Bureau of Meteorology and CSIRO. http://www.bom.gov.au/state-of-the-climate/
[21] State of the Climate 2020, Bureau of Meteorology and CSIRO. http://www.bom.gov.au/state-of-the-climate/
[22] State of the Climate 2020, Bureau of Meteorology and CSIRO. http://www.bom.gov.au/state-of-the-climate/
[23] State of the Climate 2020, Bureau of Meteorology and CSIRO. http://www.bom.gov.au/state-of-the-climate/; IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers A.2, A.5, A.6 and A.8; and Chapter 6 Tasmanian 2015/16 marine heatwave case study https://www.ipcc.ch/srocc/
[24] State of the Climate 2020, Bureau of Meteorology and CSIRO. http://www.bom.gov.au/state-of-the-climate/
[25] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers Figures SPM.1., SPM.3 and SPM.4 https://www.ipcc.ch/srocc/; IPCC Special Report on Climate Change and Land, 2019. Summary for Policymakers Figure SPM.2 https://www.ipcc.ch/srccl/

temperature is stabilised. The observed acceleration of ice loss from West Antarctica may already represent the onset of an irreversible ice sheet instability[26].

21. The risk of passing other irreversible tipping points also increases as global warming worsen. Tipping points are rapid and sudden changes in parts of the Earth system, that if triggered, will have extreme consequences for climate change impacts. They include loss of Arctic sea ice, coral reef die off, shutdown of Atlantic deep ocean circulation, forest dieback and large-scale increases in fire risks. At current levels of human-caused climate warming there are already indications of changes developing in each of these climate tipping points[27].

22. The information set out in paragraphs 16-21 above means that every fraction of a degree of additional climate warming increases the damage done to the Earth's system, and elevates the risks and costs placed on people, including future generations.

[26] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers A.3, B.3 and Figure SPM.1. https://www.ipcc.ch/srocc/

[27] The risks to Australia of a 3°C warmer world, Australian Academy of Science, March 2021. Section 2.2. https://www.science.org.au/supporting-science/science-policy-and-analysis/reports-and-publications/risks-australia-three-degrees-c-warmer-world

Question 3: In your opinion what, if any, is the amount of future temperature rise above pre-industrial levels caused by anthropogenic climate change that is already committed as a consequence of GHG emissions to date?

23. To respond to this question, I first present information on the current level of climate warming (paragraphs 24–25 below), and the current level of greenhouse gases in the atmosphere (paragraphs 26–28 below). I then look at 3 independent ways of assessing the committed warming expected from current greenhouse gas concentrations in the atmosphere (i.e. from GHG emissions to date) (paragraphs 29–34 below).

24. In 2020 the global average temperature was around 1.2 degrees Celsius (°C) above pre-industrial levels[28], and the last decade (2011–2020) was the warmest decade on record at 1.1°C above pre-industrial[29].

25. Warming of the Australian continent is occurring faster than the global average, and across Australia the climate has now warmed on average by 1.44°C since the national record began in 1910[30].

26. Pre-industrial levels of greenhouse gases in the atmosphere were stable at around 280 parts per million. Human activities have caused atmospheric carbon dioxide (CO_2) levels to rise to 410 parts per million in 2019, and over the past decade atmospheric CO_2 concentration has been increasing by 2.37 parts per million each year on average[31].

27. The combined effect of all greenhouse gases in the atmosphere can be expressed as a CO_2-equivalent value. CO_2-equivalent converts amounts of other greenhouse gases to the equivalent amount of carbon dioxide on the basis of their global warming potential[32].

28. Taking into account human-caused increases in other major greenhouse gases (including methane and nitrous oxide), the total CO_2-equivalent concentration in the atmosphere was 508 parts per million in 2019[33].

[28] The State of the Global Climate, World Meteorological Organisation, April 2021. https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate
[29] Gillett et al., 2021, Nature Climate Change. https://www.nature.com/articles/s41558-020-00965-9.pdf
[30] State of the Climate 2020, Bureau of Meteorology and CSIRO. http://www.bom.gov.au/state-of-the-climate/
[31] State of the Climate 2020, Bureau of Meteorology and CSIRO: See section titled "Greenhouse gases", pages 18-20. http://www.bom.gov.au/state-of-the-climate/
[32] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Carbon_dioxide_equivalent
[33] State of the Climate 2020, Bureau of Meteorology and CSIRO: See section titled "Greenhouse gases", pages 18-20. http://www.bom.gov.au/state-of-the-climate/

Short-term temperature commitment of current GHG levels

29. It is estimated that the warming effect of greenhouse gas emissions since the pre-industrial is already around 1.5°C. That is more than the total observed warming (1.1°C averaged over 2010-2019) because other factors – mostly sulphur dioxide aerosol emissions as a by-product from fossil fuel combustion – have contributed a total cooling effect of around 0.4°C (see paragraph 12 above)[34]. Continued efforts to improve air quality (and reduce associated health impacts) by reducing aerosol emissions, would therefore result in further climate warming in the short-term (being, years to decades) to around 1.5°C even with no further emissions of greenhouse gases.

Long-term temperature commitment of current GHG levels

30. The warming effect of greenhouse gases is also not fully felt until the earth system has time to adjust over the long-term (being, centuries to millennia). Equilibrium climate sensitivity (**ECS**) estimates the amount of warming expected for a doubling of atmospheric CO_2 from 280 parts per million (the pre-industrial level) to 560 parts per million once the climate system has been able to equilibrate to these changes[35]. As a simple estimate, a CO_2-equivalent of 508 parts per million represents a level around 180% of preindustrial levels (i.e. an 80% increase).

31. ECS is estimated to be between 2.6 to 4.1°C (with a 2 in 3 chance of lying between these values)[36]. So, 80% of this warming implies current greenhouse gas levels in the atmosphere would ultimately result in around 2.1 to 3.3°C given enough time (centuries to millennia) for the climate system to equilibrate.

32. Paleoclimate data supports this ECS estimate of long-term warming commitment. The mid-Pliocene, around 3-3.3 Million years ago, was the last time that the Earth had atmospheric carbon dioxide levels similar to today (around 400 parts per million). At this time average global temperatures are estimated to have been 1.8 to 3.6°C warmer than pre-industrial temperatures[37].

[34] Gillett et al., 2021, Nature Climate Change. https://www.nature.com/articles/s41558-020-00965-9.pdf
[35] Briefing Note 12: How sensitive is the Earth's temperature to the amount of carbon dioxide in the atmosphere? November 2020. https://climateextremes.org.au/briefing-note-12-how-sensitive-is-the-earths-temperature-to-the-amount-of-carbon-dioxide-in-the-atmosphere/
[36] Briefing Note 12: How sensitive is the Earth's temperature to the amount of carbon dioxide in the atmosphere? November 2020. https://climateextremes.org.au/briefing-note-12-how-sensitive-is-the-earths-temperature-to-the-amount-of-carbon-dioxide-in-the-atmosphere/
[37] Burke et al., 2018, PNAS. https://www.pnas.org/content/115/52/13288

GHG levels compatible with meeting the 1.5°C Paris Agreement target[38]

33. Future greenhouse gas emission scenarios compatible with limiting warming to 1.5°C require atmospheric CO_2 concentrations to peak and start declining this century. This can only be achieved through immediate and rapid emission reductions to reach net zero emissions by the middle of this century, and thereafter also drawing more CO_2 out of the atmosphere than is emitted (i.e. net negative emissions)[39] (see paragraphs 40–44 below).

34. The shared socio-economic pathways (**SSPs**) are narratives of possible future pathways of development used for climate change research and to aid climate change mitigation and adaptation planning. There are five SSP narratives (SSP1 to SSP5)[40], and each SSP has a set of plausible greenhouse gas forcing scenarios for emission pathways that different socioeconomic decisions could result in[41]. Below I discuss the SSP narrative (SSP1), and associated greenhouse gas forcing scenarios (SSP1-2.6 and SSP1-1.9) that could meet the Paris Agreement targets. I note the following:

    a. **SSP1** is a "sustainability" narrative for future socioeconomic development and is compatible with low greenhouse gas emission pathways that would meet the Paris Agreement targets for limiting human-caused climate warming42.

    b. **SSP1-2.6** is a greenhouse gas forcing scenario within the SSP1 socio-economic family that is consistent with a roughly 2°C warming scenario. SSP1-2.6 approximately corresponds to the previously used Representative Concentration Pathway RCP2.6 scenario43. The SSP1-2.6 scenario sees atmospheric CO2 concentrations in the atmosphere of 445 parts per million by 2100 (i.e. 35ppm more than today). This level of atmospheric CO2 is compatible with around 2°C of warming in 2100, so may be too high to limit warming to "well below" 2°C in 2100.

[38] Article 2 of the Paris Agreement. https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[39] IPCC Special Report on Warming of 1.5°C, 2018. Section C of Summary for Policymakers https://www.ipcc.ch/sr15/
[40] https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change
[41] Meinshausen, M. et al., 2020. The shared socio-economic pathway (SSP) greenhouse gas concentrations and their extensions to 2500, Geosci. Model Dev., 13, 3571–3605, https://doi.org/10.5194/gmd-13-3571-2020
[42] https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change
[43] Meinshausen, M. et al., 2020. The shared socio-economic pathway (SSP) greenhouse gas concentrations and their extensions to 2500, Geosci. Model Dev., 13, 3571–3605, https://doi.org/10.5194/gmd-13-3571-2020

c. **SSP1-1.9** is the future greenhouse gas emission scenario that reflects most closely the 1.5°C target under the Paris Agreement[44]. SSP1-1.9 sees atmospheric CO2 concentrations in the atmosphere of 394 parts per million by 2100[45] (i.e. 20ppm less than today). This implies that the current level of atmospheric greenhouse gases in the atmosphere are already too high to limit warming to 1.5°C in 2100.

[44] Meinshausen, M. et al., 2020. The shared socio-economic pathway (SSP) greenhouse gas concentrations and their extensions to 2500, Geosci. Model Dev., 13, 3571–3605, https://doi.org/10.5194/gmd-13-3571-2020
[45] Ibid.

Question 4: Provide a brief description of Australian and global targets for limiting climate change impacts

35. The Paris Agreement includes a commitment to limit warming to well below 2°C above pre-industrial levels and to pursue efforts to limit warming to 1.5°C[46]. Australia is a signatory to this agreement.

36. The magnitude of human-caused climate warming will be determined by cumulative global greenhouse gas emissions since the pre-industrial[47]. That is – there is a **global carbon budget** that cannot be exceeded if the goals of the Paris Agreement are to be met.

37. The following responses examine first the global carbon budgets remaining for limiting warming in line with the Paris Agreement targets (paragraphs 38–44 below), and then Australia's remaining share of the carbon budget and required emission reductions within these budgets (paragraphs 45–54 below).

Carbon Budget analysis

38. Cumulative carbon dioxide emissions from 1850 to 2017 amounted to around 2,200 Billion tonnes of CO_2[48]. Since 2017, global CO_2 emissions have been 42 Billion tonnes of CO_2 in 2018, 43 Billion tonnes of CO_2 in 2019, and an estimated 40 Billion tonnes of CO_2 in 2020[49]. The decline in global emissions in 2020 is related to restrictions from the COVID-19 pandemic and as such is thought to be temporary[50].

39. There is no evidence to suggest that annual greenhouse gas emissions have peaked yet. In 2021 global energy-related CO_2 emissions are projected to grow by 4.8%, rebounding to near 2019 emission levels[51].

40. Emission pathways to limit warming to 1.5°C with little or no temperature overshoot require global CO_2 emissions to peak by 2020, decline by about 45% from 2010 levels by 2030, and reach net zero around 2050[52]. Reductions in CO_2 emissions to net zero need to be matched by

[46] Article 2 of the Paris Agreement. https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[47] IPCC 2014 Synthesis Report. Figure SPM.5. https://www.ipcc.ch/report/ar5/syr/
[48] IPCC Special Report on warming of 1.5°C, 2018. Summary for Policymakers C.1.3. https://www.ipcc.ch/sr15/
[49] Global Carbon Project 2020. https://www.icos-cp.eu/science-and-impact/global-carbon-budget/2020
[50] Le Quere et al 2021, Nature Climate Change. https://www.nature.com/articles/s41558-021-01001-0
[51] International Energy Agency, April 2021. https://www.iea.org/reports/global-energy-review-2021/co2-emissions
[52] IPCC Special Report on warming of 1.5°C, 2018. Summary for Policymakers C.1. https://www.ipcc.ch/sr15/

deep reductions in emissions of methane (estimated by the IEA at a 75% reduction over the next 10 years)[53].

41. Every year of delay in reaching peak CO_2 emissions requires the emission reductions pathway to become steeper (i.e. more difficult to achieve) and brings forward the time when net zero emissions must be reached to limit warming to the targets set out in the Paris Agreement.

42. The remaining global carbon budget for a 50% chance of limiting warming to 1.5°C was assessed to be 580 Billion tonnes of CO_2[54] at the end of 2017. Global emissions in 2018–2020 amount to 125 Billion tonnes of CO_2 (see paragraph 38), leaving a remaining global CO_2 emissions budget of 455 Billion tonnes as of the start of 2021. Without global emission reductions, the current global CO_2 emission rates of approximately 42 Billion tonnes per year leaves roughly 11 years until the carbon budget for 1.5°C will be fully used.

43. The remaining global carbon budget for a 67% chance (i.e. a 2 in 3 chance) of limiting warming to 2.0°C was assessed to be 1,170 Billion tonnes of CO_2[55] at the end of 2017. Global emissions in 2018–2020 amount to 125 Billion tonnes of CO_2 (see paragraph 38), leaving a remaining global CO_2 emissions budget of 1,045 Billion tonnes as of the start of 2021. Without global emission reductions, the current global CO_2 emission rates of approximately 42 Billion tonnes per year leaves roughly 24 years until the carbon budget for 2°C will be fully used.

44. Global carbon budgets to limit warming to "well below" 2.0°C, as stated in the Paris Agreement, would lie between the remaining budgets for 1.5°C and 2°C described in paragraphs 42 and 43 (above).

Application of carbon budget analysis to Australia

45. Australia's 'fair share' of the remaining global carbon budgets for limiting warming has been assessed as **0.97%** of the global budget (over the 2013-2050 period)[56].

46. The equity factors guiding sharing of the global budget between countries are based upon equality, capability and responsibility. Under different burden-sharing approaches Australia's share could be as high as 1.27% (constant emissions ratio determined) or as low as 0.52%

[53] Net Zero by 2050 A Roadmap for the Global Energy Sector. International Energy Agency, May 2021. https://www.iea.org/reports/net-zero-by-2050
[54] IPCC Special Report on warming of 1.5°C. Summary for Policymakers, C.1.3. https://www.ipcc.ch/sr15/
[55] IPCC Special Report on warming of 1.5°C. Chapter 2, Table 2.2. https://www.ipcc.ch/sr15/
[56] Australia's Paris Agreement Pathways: Updating the Climate Change Authority's 2014 emission reduction targets. Climate Targets Panel, January 2021. https://www.climatecollege.unimelb.edu.au/australias-paris-agreement-pathways

(capability determined)[57]. In my opinion, the use of a 0.97% share for Australia's proportion of global emission is reasonable and maintains consistency across previous Australian government and expert reports, including the Garnaut Climate Change Review (2008) and Climate Change Authority, Targets and Progress Review (2014).

47. To have a 67% chance of not exceeding 2°C of global warming, Australia's remaining carbon budget from 2021 onwards is now only 6,161 Million tonnes CO_2-equivalent. This budget equates to a 2030 emissions target that is 50% below 2005 emission levels, and reaching net zero by 2045[58].

48. This 2°C compliant Australian emissions trajectory is shown in **Figure 3** below:

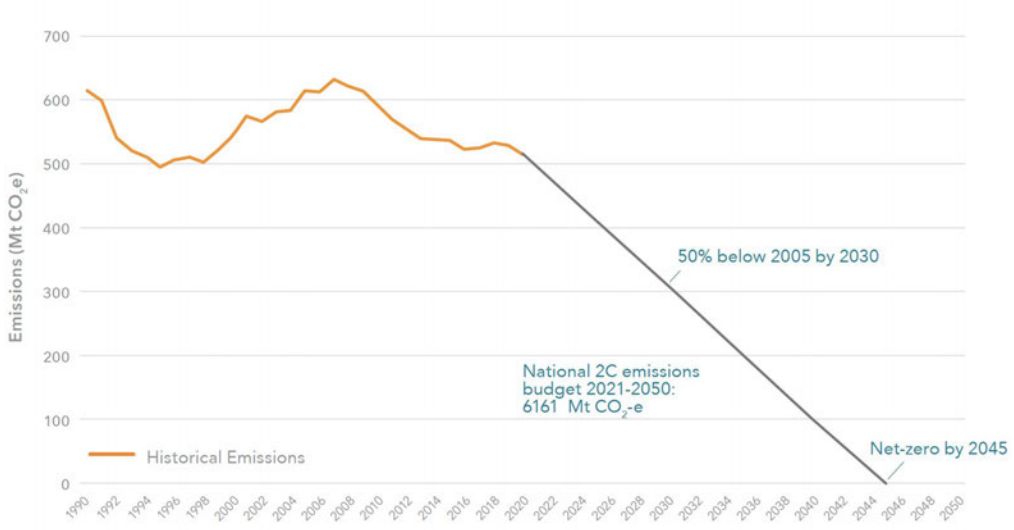


Figure 3 – Australian greenhouse gas emission trajectory compatible with limiting warming to 2°C
Source: Australia's Paris Agreement Pathways: Updating the Climate Change Authority's 2014 emission reduction targets. Climate Targets Panel, January 2021.

49. To have a 50% chance of limiting warming to 1.5°C, Australia's remaining carbon budget from 2021 onwards is now only 3,521 Million tonnes CO_2-equivalent. **This budget equates to a 2030 emissions target that is 74% below 2005 emission levels, and reaching net zero by 2035.**[59]

[57] Meinshausen et al., Section 2.8 and Table 3. https://www.climatechange.vic.gov.au/__data/assets/pdf_file/0016/421702/Greenhouse-Gas-Emissions-Budgets-for-Victoria.pdf
[58] Australia's Paris Agreement Pathways: Updating the Climate Change Authority's 2014 emission reduction targets. Climate Targets Panel, January 2021. https://www.climatecollege.unimelb.edu.au/australias-paris-agreement-pathways
[59] Australia's Paris Agreement Pathways: Updating the Climate Change Authority's 2014 emission reduction targets. Climate Targets Panel, January 2021. https://www.climatecollege.unimelb.edu.au/australias-paris-agreement-pathways

50. This 1.5°C compliant Australian emissions trajectory is shown in **Figure 4** below.

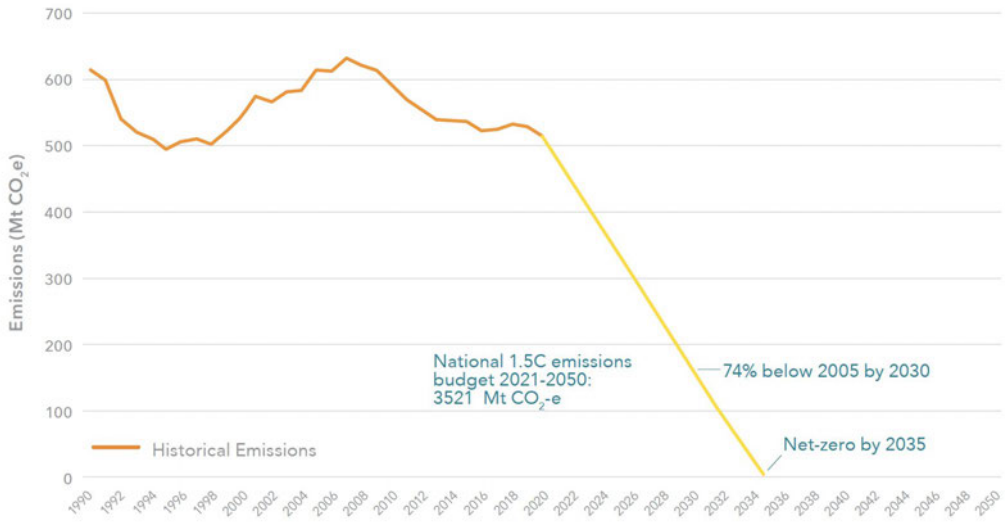


Figure 4 – Australian greenhouse gas emission trajectory compatible with limiting warming to 1.5°C
Source: Australia's Paris Agreement Pathways: Updating the Climate Change Authority's 2014 emission reduction targets. Climate Targets Panel, January 2021.

Australia's Nationally Determined Contribution (NDC) and the carbon budget

51. Australia's existing Nationally Determined Contribution (**NDC**) for 2030 is an emissions reductions target is 26-28% on 2005 levels[60].

52. If this target is achieved, it has been estimated that Australia will emit 4,832 – 4,764 Million tonnes of CO_2-equivalent across the decade from 2021-2030 [61]. **This would have exceeded our total available budget for limiting warming to 1.5°C by 2028** [62] (i.e. before the end of the 2030 NDC period).

53. If Australia's current NDC to 2030 is kept, then limiting warming to 2°C would then require net zero emissions to be reached in 2037. This requires an emission reduction of 12.9% every year from 2030 to 2037 to limit warming to 2°C, which is unfeasibly steep [63]. This 2°C compliant

[60] Australia's Nationally Determined Contribution, 2020. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Australia%20First/Australia%20NDC%20recommunication%20FINAL.PDF
[61] Australia's Nationally Determined Contribution, 2020. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Australia%20First/Australia%20NDC%20recommunication%20FINAL.PDF
[62] Shifting the Burden: Australia's emissions reduction tasks over coming decades. Climate Targets Panel, March 2021. https://www.climatecollege.unimelb.edu.au/australias-paris-agreement-pathways
[63] Shifting the Burden: Australia's emissions reduction tasks over coming decades. Climate Targets Panel, March 2021. https://www.climatecollege.unimelb.edu.au/australias-paris-agreement-pathways

Australian emissions trajectory if Australia does not increase its 2030 NDC commitment is shown in **Figure 5** below.

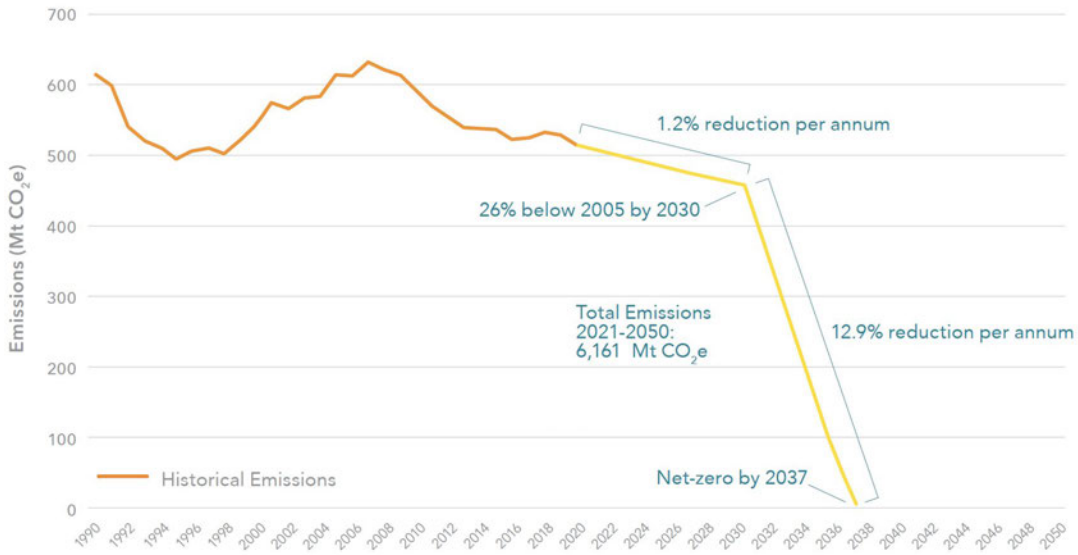


Figure 5 – *Australia's greenhouse gas emissions trajectory for limiting warming to 2°C if the current 2030 NDC is maintained.*
Source: Shifting the Burden: Australia's emissions reduction tasks over coming decades. Climate Targets Panel, March 2021.

54. There is no scientific evidence or government modelling to support the NDC target Australia currently holds as being compatible with our responsibilities for limiting global warming to well below 2°C under the Paris Agreement[64].

[64] Shifting the Burden: Australia's emissions reduction tasks over coming decades. Climate Targets Panel, March 2021. https://www.climatecollege.unimelb.edu.au/australias-paris-agreement-pathways

Question 5: What is the relationship between the amount of further emissions of greenhouse gas (GHG) from human industrial activity, including the combustion of liquified natural gas, and future GHG concentration and temperatures above pre-industrial levels?

55. The physical relationship between atmospheric greenhouse gas levels and global temperature is clear and unambiguous, with agreement across multiple lines of evidence including theoretical understanding, observations, paleoclimate evidence and climate model simulations[65].

56. Every additional tonne of greenhouse gas emissions will cause further climate warming[66]. This is illustrated for historical and future emissions in **Figure 6** below. This figure is from the IPCC 6th Assessment Report of working group 1 (released in August 2021), but equivalent figures are also available in the IPCC Special Report on warming of 1.5°C[67] and the IPCC 5th Assessment Synthesis Report,[68] both of which were available on 17 June 2021.

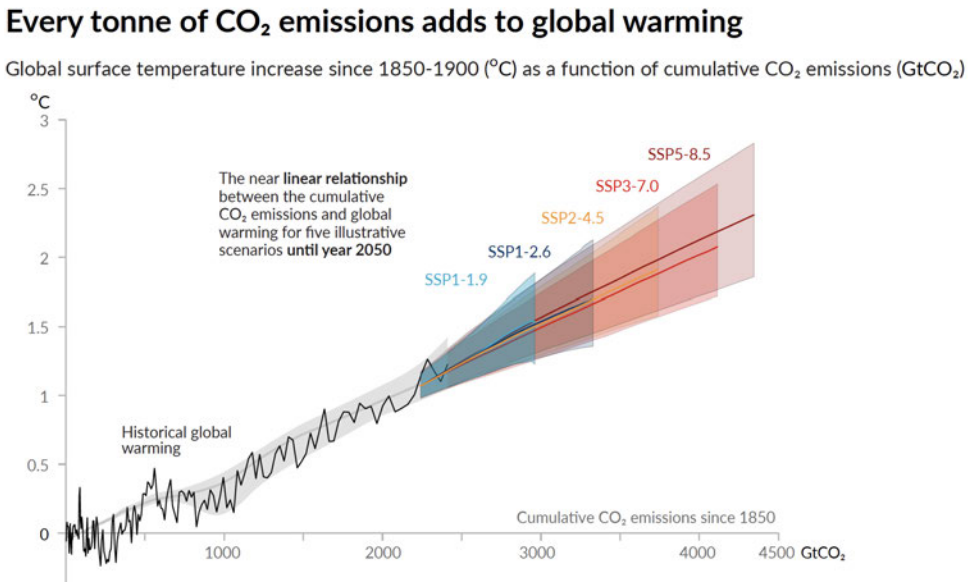


Figure 6 – Near linear relationship between cumulative CO2 emissions and global temperature rise, shown for historical data and future scenarios out to 2050.
Source: IPCC 6th Assessment Report, Working Group I, Summary for Policymakers

57. There are total (cumulative) amounts of greenhouse gas emissions that cannot be exceeded if global average temperature rise is to be limited to 1.5 or 2.0°C. To keep warming to "well below" 2°C, as stated in the Paris Agreement, implies cumulative emissions between those consistent with limiting warming to 1.5°C or 2°C (see paragraphs 42–44 above).

[65] IPCC 5th Assessment Synthesis Report, including SPM 2. https://www.ipcc.ch/report/ar5/syr/
[66] IPCC Special Report on warming of 1.5°C. Figure 2.3. https://www.ipcc.ch/sr15/chapter/chapter-2/
[67] IPCC Special Report on warming of 1.5°C. Figure 2.3. https://www.ipcc.ch/sr15/chapter/chapter-2/
[68] IPCC 5th Assessment Synthesis Report. Figure SPM.5. https://www.ipcc.ch/report/ar5/syr/

58. Modelling by the International Energy Agency of the energy transition consistent with reaching global net zero emissions by 2050, has determined that fossil fuels are required to fall from 4/5^{ths} of the total energy supply in 2021 to around 1/5th by 2050. This net zero pathway requires that from 2021 there are no new oil or gas fields approved for development, and no new coal mines or mine extensions[69].

59. Australia's current greenhouse gas emissions are also mostly due to the burning of fossil fuels (coal, gas and oil). Australia's emissions from the burning of fossil fuels were 404 Million tonnes of CO_2-equivalent in 2019[70], which was 76% of the total national emissions of 533 Million tonnes of CO_2-equivalent for 2019[71]. This implies that emission reductions consistent with Australia's commitments under the Paris Agreement must involve large and rapid reductions in fossil fuel use.

[69] Net Zero by 2050 A Roadmap for the Global Energy Sector. International Energy Agency, May 2021. https://www.iea.org/reports/net-zero-by-2050

[70] Global Carbon Project 2020. https://folk.universitetetioslo.no/roberan/GCB2020.shtml

[71] Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2019. https://www.industry.gov.au/sites/default/files/2020-05/nggi-quarterly-update-dec-2019.pdf

Question 6: In your opinion, what are the likely future impacts of anthropogenic climate change at a national and global level? In providing your response, please consider:

a. **warming scenarios that are consistent with meeting the goals of the Paris Agreement; and**
b. **warming scenarios that are consistent with the current trajectory of greenhouse gas emissions.**

60. All of the impacts of climate change (see paragraphs 16–22 above) worsen with elevated levels of anthropogenic climate warming. Warming of 2°C will be more dangerous and costly than warming of 1.5°C[72]; warming of 3°C will be more dangerous and costly than warming of 2°C[73].

61. Current policies for emission reductions globally are estimated to cause around 2.9°C of global warming by 2100.[74]

62. Where explicit evidence is not available comparing the impacts of warming at 2°C to warming of 3°C, these can instead be estimated by using a comparison of the end-of-century (2018–2100) impact of the Representative Concentration Pathway RCP2.6 scenario (estimated mean warming of 0.9 to 2.4°C) with the lower end of outcomes from the RCP8.5 scenario (estimated mean warming of 3.2 to 5.4°C)[75,76].

Future impacts of climate change consistent with the current trajectory of GHG emissions (3°C warming or more)

63. Some specific but not exhaustive examples of the impacts in Australia of a 3°C warmer world (i.e. the warming scenario consistent with the currently committed trajectories of greenhouse gas emissions) include:[77]

[72] IPCC Special Report on Warming of 1.5°C, 2018. Summary for Policymakers Section B, FAQ3.1 https://www.ipcc.ch/sr15/

[73] The risks to Australia of a 3°C warmer world, Australian Academy of Science, March 2021. https://www.science.org.au/supporting-science/science-policy-and-analysis/reports-and-publications/risks-australia-three-degrees-c-warmer-world

[74] Climate Action Tracker, April 2021. https://climateactiontracker.org/global/temperatures/

[75] The risks to Australia of a 3°C warmer world, Australian Academy of Science, March 2021. https://www.science.org.au/supporting-science/science-policy-and-analysis/reports-and-publications/risks-australia-three-degrees-c-warmer-world

[76] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers Table SPM.1. https://www.ipcc.ch/srocc/

[77] The risks to Australia of a 3°C warmer world, Australian Academy of Science, March 2021. Section 6, Table 2 and Table 3. https://www.science.org.au/supporting-science/science-policy-and-analysis/reports-and-publications/risks-australia-three-degrees-c-warmer-world

a. **Heatwaves** become more frequent, more intense and last longer as global warming continues, with significant implications for infrastructure and the health of people and ecosystems.

   i. At a warming of 2°C, days above 50°C in Sydney and Melbourne would be rare; but at a warming of 3°C days exceeding 50°C would be a regular occurrence.

   ii. Heatwave impacts for Queensland at different levels of warming have been quantified as follows:

      1. Under 1.5°C of global warming, heatwaves would occur three times a year with each event lasting on average 7.5 days.

      2. With global warming of 2°C, heatwaves would occur at least four times a year, on average lasting 10 days.

      3. At 3°C of global warming, heatwaves would happen as often as seven times a year, with events lasting 16 days on average.

b. At 3°C of warming there would be 100-300% **more extreme fire days** in southern Australia, compared with a 15-65% increase for 1°C of warming.

c. Already at 1.1°C of **warming coral reefs** are at high risk, as evidenced by mass bleaching of the Great Barrier Reef (**GBR**) 3-times since 2016. The level of ocean heat that caused GBR bleaching in 2016 will occur every 2 years in 3 when warming reaches 1.5°C, and at 2°C of warming this level of heat will be met or exceeded in 9 years out of 10. At and beyond 2°C of warming, coral reefs globally are expected to have been effectively lost all together.

d. Under high emissions (3°C warming or more) winter/spring **season rainfall** over southern Australia is projected to change by –2 to –44% (i.e. rainfall declines) by the end of this century, whereas under low emissions the projected change in winter/spring rainfall is between +4 and –23%.

Differences in outcomes between scenarios consistent with meeting Paris (2°C warming or less) v. scenarios consistent with current trajectories (3°C warming or more)

64. Globally, there are large differences by the end of this century in the scale of climate change impacts for a low emission future where warming is limited to 2°C or less (**RCP2.6**), compared with a high emission future with warming of 3°C or more (**RCP8.5**). These include[78]:

    a. 0.42 m of global sea level rise rising at 4 mm each year under RCP2.6 at 2100 compared with 0.84 m and rising at 15 mm each year under RCP8.5 at 2100, relative to 1986–2005 levels.

    b. A 50-times increase in the frequency of marine heatwaves under RCP8.5, compared with a 20-times increase under RCP2.6, by 2081–2100 compared with 1850–1900.

    c. A 24% decrease in near-surface permafrost area under RCP2.6 compared with 69% decrease under RCP8.5 by 2100.

65. A tipping point in the West Antarctic ice sheet will likely be exceeded if warming exceeds 2°C, leading to a rapid acceleration of sea level rise. Scenarios consistent with 3°C of warming by the end of this century see a rapid increase in ice loss from West Antarctica after 2060 as this tipping point activates[79].

66. Higher levels of warming also increase the risk of passing other high-impact tipping points in the climate system. In general, as scientific understanding has developed the risk of passing abrupt and irreversible tipping points has been assessed to lie at lower levels of global temperature rise[80].

67. Climate change impacts, particularly at warming levels beyond the Paris Agreement targets, have the potential to push societies and ecosystems beyond the capacity for adaptation[81].

68. Adaptation needs and costs will be lower for global warming of 1.5°C compared to 2°C or more of warming[82].

[78] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers including Figure SPM.1. https://www.ipcc.ch/srocc/
[79] DeConto et al 2021, Nature. https://doi.org/10.1038/s41586-021-03427-0
[80] Lenton et al., 2019, Nature. https://www.nature.com/articles/d41586-019-03595-0
[81] IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, 2019, Summary for Policymakers Section C. https://www.ipcc.ch/srocc/
[82] IPCC Special Report on Warming of 1.5°C, 2018. Summary for Policymakers Section B.6 https://www.ipcc.ch/sr15/

Question 7: What is the relationship between GHG emissions from the extraction and consumption of gas from the Beetaloo sub-basin and the remaining carbon budget for limiting global temperature rise to:

(i) approximately 1.5ºC above pre-industrial levels;

(ii) 1.8ºC above pre-industrial levels; and

(iii) 2ºC above pre-industrial levels.

69. To answer this question, I use estimates of GHG emissions expected from extraction and consumption of gas from the Beetaloo sub-basin (paragraph 70 below), and the global carbon budget for limiting global warming to 1.5°C, 1.8°C and 2°C above pre-industrial levels (paragraphs 71–73 below). These are then used to quantify the relationship between GHG emissions from the basin and remaining global carbon budgets (paragraph 74 below).

70. I have been provided with a copy of the expert report of Dr Hugh Saddler, entitled *Potential Greenhouse Gas Emissions From Estimated Gas Resources In The Beetaloo Basin* and dated 4 September 2021. That report estimated that greenhouse gas emissions from fossil fuel extraction and consumption from the Beetaloo sub-basin would be between a total of 200 to 10,000 Million tonnes of CO_2-equivalent (a-c), or 64 Million tonnes of CO_2-equivalent per year (d).

71. The remaining global carbon budget remaining from the start of 2021 for a 50% chance of limiting warming to 1.5°C is 455 Billion tonnes CO_2 (see paragraph 42 above).

72. The remaining carbon budget from the start of 2021 for a 67% chance of limiting warming to 2.0°C is 1,045 Billion tonnes CO_2 (see paragraph 43 above).

73. I note that as at 17 June 2021, carbon budgets carbon budgets were not readily available for a 1.8°C warming target. It was only when the IPCC released its 6th Assessment Report in August 2021, when such analysis became readily available. However, based on the linear relationship between cumulative emissions and global temperature increase (see paragraphs 56–57 above), I interpolate an approximate global budget of 809 Billion tonnes CO_2 (noting also that the likelihood for this budget would be between a 50% and 67% chance of meeting this target).

74. Based on the information above I estimate that extraction and consumption of gas from the Beetaloo sub-basin amounts to between:

(i) 0.044 to 2.2% of the remaining global carbon budget for limiting warming to 1.5°C

(ii) 0.025 to 1.2% of the remaining global carbon budget for limiting warming to 1.8°C

(iii) 0.019 to 0.96% of the remaining global carbon budget for limiting warming to 2.0°C

<u>Question 8: What</u> is the relationship between the total GHG emissions from the extraction and consumption of gas from the Beetaloo sub-basin and:

a. Australia's current annual GHG emissions; and

b. Australia's share of the remaining carbon budget for limiting global temperature rise to:

(i) approximately 1.5°C above pre-industrial levels;

(ii) 1.8°C above pre-industrial levels; and

(iii) 2°C above pre-industrial levels.

75. To answer this question, I follow a similar approach as described in paragraph 69 above, but applying Australian annual GHG emissions and Australia's remaining carbon budgets.

76. It is estimated in the expert report by Dr Hugh Saddler[83] that greenhouse gas emissions from fossil fuel extraction and consumption from the Beetaloo sub-basin would be between a total of 200 to 10,000 Million tonnes of CO_2-equivalent (a-c), or 64 Million tonnes of CO_2-equivalent per year (d) (see paragraph 70 above).

77. Australia's current (2020) annual greenhouse gas emissions are currently 499 Million tonnes of CO_2-equivalent[84].

78. For Australian carbon budgets I follow the approach of previous Australian assessments[85] and assuming Australia's fair share of the remaining global budget is 0.97% (see paragraphs 45–46 above).

79. The remaining Australian carbon budget at the start of 2021 for a 50% chance of limiting warming to 1.5°C is 3,521 Million tonnes CO_2-equivalent (see paragraph 49 above).

80. Australia's remaining carbon budget at the start of 2021 for a 67% chance of limiting warming to 2.0°C is 6,161 Million tonnes CO_2-equivalent (see paragraph 47 above).

81. Interpolation between the remaining 1.5°C and 2.0°C budgets implies an Australian budget for limiting warming to 1.8°C of 5,105 Million tonnes CO_2-equivalent.

[83] Expert report of Dr Hugh Saddler, entitled *Potential Greenhouse Gas Emissions From Estimated Gas Resources In The Beetaloo Basin,* dated 4 September 2021.

[84] National Greenhouse Gas Inventory, December 2020. https://www.industry.gov.au/sites/default/files/2021-05/nggi-quarterly-update-december-2020.pdf

[85] Australia's Paris Agreement Pathways: Updating the Climate Change Authority's 2014 emission reduction targets. Climate Targets Panel, January 2021. https://www.climatecollege.unimelb.edu.au/australias-paris-agreement-pathways

82. Combustion of gas from a new Beetaloo Basin shale gas field would result in annual emissions of approximately 64 Million tonnes CO_2-equivalent (see paragraph 76 above). This equates to a 13% increase on Australia's 2020 greenhouse gas emissions of 499 Million tonnes CO_2-equivalent (see paragraph 77 above).

83. Based on the information I set out paragraphs 76 and 79–81 above, I estimate that extraction and consumption of gas from the Beetaloo sub-basin amounts to:

(i) 5.7 to 284% of Australia's remaining carbon budget for limiting warming to 1.5°C
(ii) 3.9 to 196% of Australia's remaining carbon budget for limiting warming to 1.8°C
(iii) 3.2 to 162% of Australia's remaining carbon budget for limiting warming to 2.0°C

Question 9: In your opinion is the exploration of the three wells for which grants have been made (namely 2D Seismic & Carpentaria 2, Carpentaria 3 and Carpentaria 4 & 3D Seismic) (the Three Wells); and/or extraction and use of gas from those areas; and/or the extraction and use of gas from the Beetaloo sub-basin more broadly; consistent with Australian and global targets for limiting climate change impacts?

84. In my opinion, exploration, extraction and use of gas from the Three Wells, and more broadly from the Beetaloo sub-basin, is inconsistent with Australian and global targets for limiting climate change impacts.

85. Commitments made under the Paris Agreement require limiting warming to well below 2°C, and the remaining carbon budget for meeting these obligations (as set out in paragraphs 35–54 above) is exceedingly small, particularly relative to current annual emission levels. Meeting the targets of the Paris Agreement requires immediate and rapid reductions in greenhouse gas emissions. As 76% (Australian) / 80% (Global) of current emissions are from burning of fossil fuels the emission reductions required to meet the Paris Agreement imply strong transitions away from fossil fuel use.

86. **Annual greenhouse gas emissions from gas extracted from the Beetaloo sub-basin could equate to a 13% increase on Australia's 2020 emission levels**. This is inconsistent with the progressive year-on-year emission reductions required to reach a 50% reduction (on 2005 levels) by 2030 and net zero by 2045 if global warming is to be limited to 2°C (see paragraphs 47–48 above). Emission reductions required to limit warming to "well below" 2°C or to 1.5°C require even more ambitious Australian emission reductions (see paragraphs 49–50 and 44 above).

87. **Total greenhouse gas emissions from the Beetaloo sub-basin could account for between 3.2% and 284% of Australia's remaining carbon budget**, depending on the level between 1.5 and 2°C that warming is to be limited to and the amount of gas extracted from the basin (paragraph 86). Percentages greater than 100% are clearly impossible to accommodate within the context of Australia's remaining carbon budget. Percentages far less than 100% are also unfeasible in the context of Australia's existing emissions base and the need for rapid emission reductions (by between 50-74%) by 2030.

88. Globally, whilst it could be argued that the extraction and consumption of gas from the Beetaloo sub-basin is technically able to be accommodated within the remaining global carbon budget (i.e. it would produce greenhouse gas emissions of between 0.019 to 2.2% of the remaining global carbon budget; see paragraph 74 above), the development of this new gas field is inconsistent with assessment of the global energy transition required to meet net zero emissions by 2050 which finds no space for development of any new gas fields globally from 2021 onwards

(see paragraph 61 above). The Minister's forward in the Beetaloo Strategic Basin Plan specifies that the basin has the potential to "supply a variety of gas markets, including downstream gas industries in the NT, the east coast domestic gas market and potentially LNG exports"[86]. Use to the gas resources primarily in Australia means that emissions from the burning of gas from the Beetaloo sub-basin need to be evaluated in the context of Australia's remaining carbon budget (paragraph 83) rather than the global carbon budget of all nations.

89. In my opinion the exploration, extraction and use of gas from the Beetaloo sub-basin becomes even less consistent with Australian and global targets for limiting climate change when considering the timeframe for development. The Beetaloo development plan is based upon development decisions being made in 2025, with production running for 20–40 years after that[87] (i.e. from 2025 to 2045–2065).

90. **Production of gas from the Beetaloo sub-basin through to 2045 or 2065 cannot be accommodated within emission reduction frameworks consistent with commitments under the Paris Agreement**. Limiting warming to 1.5°C requires strong emission reductions from 2020 that globally reach a 45% reduction by 2030 and net zero global emissions by 2050. For Australia's share of the remaining carbon budget, net zero emissions need be achieved even earlier – between 2035 to 2045 depending on the emission pathway and warming level taken (see paragraphs 47–50 above).

91. Hence, while potential annual emissions of approximately 64 Million tonnes CO_2-equivalent from combustion of gas from development of the Beetaloo sub-basin would equate to a 13% increase on Australia's 2020 greenhouse gas emissions (see paragraph 82 above), this would form a much higher proportion of Australia's allowable emissions by the time gas production from the Beetaloo sub-basin started as large emission reductions are required this decade to begin meeting our Paris Agreement commitments. This includes emissions from combustion of gas from the Beetaloo sub-basin after the time when net zero emissions need to have been achieved, based on the estimated lifetime of production from this gas field.

[86] Unlocking the Beetaloo. The Beetaloo Strategic Basin Plan.
[87] Unlocking the Beetaloo. The Beetaloo Strategic Basin Plan, Figure 4.

Question 10: In your opinion, will the exploration of the Three Wells and/or extraction and use of gas from those areas and/or the extraction and use of gas from the Beetaloo sub-basin more broadly, have any impact on the risks associated with climate change? If so, please set out your reasoning in relation to the nature and extent of that impact.

92. In my opinion there is no doubt that extraction and use of gas from the Three Wells, and more broadly from the Beetaloo sub-basin, will increase the risks associated with climate change. These risks, globally and to Australia, are summarised in paragraphs 16–22 and 60–68 above.

93. I base my opinion on well-established scientific evidence that every additional tonne of greenhouse gases emitted to the atmosphere contributes to further climate warming (see paragraph 56 above). Existing human-caused climate warming of 1.1°C above pre-industrial is already having damaging impacts on all inhabited parts of the Earth (see paragraphs 16–22 above), and future risks worsen with every fraction of a degree of additional warming (see paragraphs 60–68 above).

94. The temperature goals within Article 2 of the Paris Agreement are to hold

> "*the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change"*[88].

95. To meet the goals of the Paris Agreement, and in turn reduce the risks and impacts of climate change, requires immediate, large-scale and rapid emission reductions globally and in Australia (see paragraphs 35–54 above). Exploration and development of new gas fields, including the Beetaloo sub-basin, is inconsistent with the emission reductions needed to meet the commitments of the Paris Agreement (see paragraphs 55–59 and 69–83 above).

96. The Beetaloo Strategic Basin Plan[89] specifies that the purpose of the Beetaloo Cooperative Drilling Program is to facilitate accelerated gas exploration that will *"support the development of the Northern Territory gas industry while building on the Australian Government's commitment to unlocking gas supply"* [90], and contains proposed timelines from exploration to production[91].

[88] Article 2 of the Paris Agreement. https://unfccc.int/sites/default/files/english_paris_agreement.pdf
[89] Unlocking the Beetaloo. The Beetaloo Strategic Basin Plan.
[90] LEGISLATION APPROVAL PACKAGE - INDUSTRY RESEARCH AND DEVELOPMENT (BEETALOO COOPERATIVE DRILLING PROGRAM) INSTRUMENT 2021. Ministerial Submission issued by DISER to Minister, April 2021.
[91] Unlocking the Beetaloo. The Beetaloo Strategic Basin Plan, Figure 4.

97. Hence, it is my opinion that exploration of the Three Wells and the Beetaloo sub-basin under this Beetaloo Cooperative Drilling Program will also increase the risks in Australia and globally (see paragraphs 16–22 and 60–68 above) that are associated with climate change.

Signed: Nerilie Abram, 10th September 2021

Curriculum Vitae of Professor Nerilie Abram

August 2021

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Formal Qualifications

Doctor of Philosophy (2000-2004), The Australian National University.
Awarded the Robert Hill Memorial Prize.

Bachelor of Science (Advanced) with first class Honours (1996-1999), The University of Sydney.
Awarded the University Medal.

Appointments

2021– Associate Director (Research), Research School of Earth Sciences, ANU.

2020– Professor, The Australian National University

2017–21 Future Fellow (Australian Research Council), The Australian National University.

2016–19 Associate Professor, The Australian National University.

2015 Permanent academic appointment, Research Fellow, The Australian National University.

2011–16 QEII Research Fellow (Australian Research Council), The Australian National University.

2009–11 Group Manager (ice cores), British Antarctic Survey, Cambridge, UK.

2004–09 Palaeoclimatologist (ice cores), British Antarctic Survey, Cambridge, UK.

Maternity leave career breaks in 2003, 2005 and 2008. Maternity leave and intervals of part-time work during return-to-work periods are equivalent to ~2.5 years out of my research career.

Honours and Awards

- College of Science Dean's Commendation for Teaching Excellence, 2020.
- Priestly Medal, Australian Meteorological and Oceanographic Association, 2019.
- Vice Chancellor's Award for Impact and Engagement, 2019.
- Vice Chancellor's Award for Advancing the Reputation of the University through Media, 2016.
- ANU Media and Outreach Awards, 2016. Highly commended for "*Impact award for reach and influence*".
- Dorothy Hill Award, Australian Academy of Science, 2015.
- Finalist for Malcolm McIntosh Prize for Physical Scientist of the Year, 2015 and 2016 Prime Minister's Prizes.
- ANU Media and Outreach Awards, 2014. Highly commended for "*Close up award for best talent on film*".
- Finalist for Eureka Prize for Environmental Research, 2007.
- Robert Hill Memorial Prize, ANU, 2003.
- University Medal, University of Sydney, 2000.
- Elliston Medal, Earth Resources Foundation, 2000.

Academic and Research Leadership

- Deputy Director, Australian Centre for Excellence in Antarctic Science (2021–present). This is a $25M research centre with 39 chief investigators across 7 universities, with further extensive national and international partnerships.

- Leader of Drought Program (2021–present) and member of Impact and Engagement Committee (2017–present), ARC Centre of Excellence for Climate Extremes. This is a $35M research centre with 16 chief investigators across 5 universities, with further extensive national and international partnerships.

- Co-lead of CoralHydro2k working group, PAGES 2k network (2017–present).

- Coordinating Lead Author, IPCC Special Report for the Ocean and Cryosphere in a Changing Climate (2017–2019). Involved co-leading a chapter team of 15 scientists spanning a diversity of career stages, geographic location, and expertise. Successfully delivered the chapter milestones to a tight-time frame, working with the leadership of the IPCC and negotiating the summary for policymakers through the government approval process.

- Coordinators team for PAGES 2k Network (2016–2021; Phases 2 and 3 of program). The longest running community project of the Past Global Changes program, with numerous project groups across a community of more than 1000 researchers.

- Member of Advisory Board for the ANU Climate Change Institute (2017–2020).

- Chair of Faculty, Research School of Earth Sciences (2018–2020).

- RSES Marketing and Outreach coordinator, and chair of committee (2012–2016).

Professional Service

- Chair of National Committee for Antarctic Research, Australian Academy of Science (2021–present).
- Co-Editor-in-Chief for peer-review journal, *Climate of the Past,* (2015–2017 and 2020–present).
- Member of the Australian Antarctic Science Council (2021–present).
- Selection committee for Dorothy Hill Medal, Australian Academy of Science (2019–2021).
- Member of National Committee for Antarctic Research, Australian Academy of Science (2016–2020).
- Member of the science sub-committee to the board of the Antarctic Science Foundation (2018–2020).
- Member of National Committee for Earth System Science, Australian Academy of Science (2015–2018).
- Editor for peer-review journal, *Climate of the Past* (2010–2015).
- I have been a frequent guest speaker for public events of the ANU Climate Change Institute
- I am a frequent science communicator, including writing for The Conversation where my articles have reached a readership of more than 788,000 people.

Research Funding

National Environmental Science Program 2 – Climate Systems Hub. Marsland, S., et al., including Abram as ANU lead-CI. $38M for 2021-2027 (Department of Agriculture, Water and Environment).

ARC Special Research Initiative for Excellence in Antarctic Science. King, M., and 39 other CIs, including 6 ANU CIs (Armand, Abram, Ellwood, Morrison, Rohling, Tregoning). *The Australian Centre for Excellence in Antarctic Science*. $20M for 2021-2025 (SE200100008).

ANU Major Equipment Grants: Ellwood, Abram, Fallon, Eggins, Opdyke. *Renewing ANU capabilities in trace element analysis for environmental studies*. $80,000 in 2019 for a new trace element ICP-OES system (19MEC18).

Department of Environment and Energy: Howden, M., Abram, N., Bai, X., *IPCC AR6 Authors*, $33,000 for 2019-2021.

Australian Antarctic Science Program: Vance, T., Abram, N.J., Curran, M., Gallant, A., Moy, A., Roberts, J., Vallelonga, P., Plummer, C., Favier, V. *IPICS 2k ice core array: Filling the climatological gap of the Indian Ocean sector from Wilhelm II Land.* 2017-2021 (AASP4414).

ARC Centres of Excellence: Pitman et al., and 16 other CIs (including Abram) from UNSW, ANU, Melbourne, Monash and University of Tasmania, *Centre of Excellence for Climate Extremes*, $30M for 2017-2023 (CE170100023).

ARC Future Fellowships: Abram (CI), *Quantifying and mitigating changes in Australia's rainfall belts*, $933,000 for 2017-2021 (FT160100029).

ANU Major Equipment Grants: Abram, Farquhar and Rohling, *ANU water isotope capabilities for climate, environmental and biological research*, $210,000 in 2016 for 2 new Picarro water isotope systems (16MEC11).

ANU Computational Merit Allocation Scheme: Abram, N. (lead CI), Ackerley, D., Lewis, S.E., Phipps, S.J., Dommenget, D. *An ensemble of simulations for Australasian palaeoclimate data-model assessments*, 320 kSU in 2016 (~$32,000 equivalent).

ANU Computational Merit Allocation Scheme: Abram, N.J. (lead CI), Lewis, S.E. and Phipps, S.J. *Testing the drivers of Southern Annular Mode changes over the last millennium*. 100 kSU in 2015 (~AUD$10,000 equivalent).

ARC Discovery Projects Abram, N.J. (CI), Mulvaney, R. (PI), Curran, M.A.J. (PI), Treble, P.C. (PI) and Vance, T. (PI). *Equator to Pole: reconstructing tropical and Antarctic climate variability over the last millennium and their impacts on southern Australian rainfall*. AUD$480,000 for 2014-2016 (DP140102059).

ARC Discovery Projects (**including QEII Fellowship)** Gagan, M.K. (CI), Abram, N.J. (QEII), Hantoro, W.S. (PI), Natawidjaja, D.H. (PI), Shen, C.-C. (PI), Sieh, K. (PI), Edwards, R.L. (PI), Cheng, H. (PI) and Schmidt, G. (PI). Climate and natural hazards in Australasia: a comprehensive impact analysis of prehistoric droughts, great earthquakes, and the Toba super-eruption. AUD$835,000 for 2011-2016 (DP110101161).

NERC PhD studentships Abram, N.J. (CI), Blackwell, P. (CI), Wolff, EW. (PI) and Sime, L.C. (PI). *Annual layer counting in ice cores: developing an objective statistical tool. GBP£46,000 (approx.) for 2010-2013.*

Plenary, Keynote and Invited Lectures (selected examples since 2014)

2021 CLIVAR Tropical Basin Interactions workshop. **Invited**: *Paleoclimate perspectives on the Indian Ocean Dipole.*

2020 SCAR Open Science Conference. **David Walton Memorial Lecture**: *Discovering Antarctica's climate secrets.*

2020 Bureau of Meteorology Research and Development workshop. **Invited**: *Connections of climate change and variability to large and extreme forest fires in southeast Australia.*

2020 Celebrating Antarctica: climate change, biodiversity, and science, Climate Change Institute public event, co-hosted by Italian, French and British embassies. **Guest speaker**: *Antarctica in a warming world.*

2019 The IPCC ocean and cryosphere report, Climate Change Institute public event. **Guest speaker**: *The Ocean and Cryosphere in a Changing Climate.* Also delivered separately to the Department of Environment.

2019 Asia Oceania Geosciences Society, Singapore. **Distinguished lecture**: *Tight coupling of tropical Indian and Pacific variability through the last millennium.*

2019 ANU Climate Update 2019, Climate Change Institute public event. **Guest speaker**: *Climate Impacts: oceans and coral reefs.*

2018 AGU Fall Meeting, Washington DC. **Invited**: *Indian Ocean Dipole variability during the last millennium*

2018 Monash University. **Invited**: *Indian Ocean Dipole variability during the last millennium*.

2018 AntClim21 workshop, Davos. **Invited**: *Causes and impacts of pre-instrumental variations in the Southern Annular Mode.*

2017 Ice Core Analysis Techniques, Copenhagen (PhD and ECR training course). **Invited**: *Climate reconstructions.*

2017 PAGES Open Science meeting, Zaragoza. **Plenary**: *The onset of Industrial-era warming across the oceans and continents*.

2017 Time, Technologies and the Anthropocene symposium, ANU. **Invited**: *The onset of Industrial-era warming across the oceans and continents*.

2017 Lessons learnt from paleoscience on a possible 1.5 – 2^{o}C warmer world in the future, Bern. **Invited**: *The onset of Industrial-era warming across the oceans and continents*.

2017 Australian Meteorological and Oceanographic Society annual meeting, Canberra. **Plenary**: *The onset of Industrial-era warming across the oceans and continents*.

2015 Antarctica2k workshop (September 2015, Venice), Ocean2k workshop (October 2015, Barcelona), and Australasia2k workshop (October 2015, Auckland). **Invited**: *The onset of Industrial-era warming across the oceans and continents*.

2015 Large-scale climate variability in Antarctica and the Southern Ocean over decades to centuries, and links to extra-polar climate, San Diego. **Invited**: *Evolution of the Southern Annular Mode over the past millennium.*

2015 Invited seminars at Cambridge University, the British Antarctic Survey, and University of Copenhagen (April 2015).

2014 AGU Fall Meeting, San Francisco. **Invited**: *What can sea ice reconstructions tell us about recent regional trends in sea ice around Antarctic?* Sea Ice in Earth history session.

2014 ARC Centre of Excellence for Climate System Science Annual Workshop, Hunter Valley. **Invited**: *Evolution of the Southern Annular Mode over the past millennium.*

2014 International Symposium on Sea Ice in a Changing Environment, Hobart. **Keynote**: *Before satellites: reconstructing past sea-ice changes using proxy records.*

Conference organisation

- Organising committee member for *Paleo-ENSO workshop*, Belitung, Indonesia (August 2019).
- Organising committee member for *2018 Negative Emissions conference*, Shine Dome (October 2018).
- Co-chair of organising committee for 2017 Theo Murphy Australian Frontiers of Science conference on *The Antarctic Frontier: Developing research in an extreme environment*, Hobart (September 2017).

Publications

- Scopus statistics: H-index = 28, G-index = 55, Field-weighted citation impact = 3.1 (ID: 22633807400)
- Google Scholar statistics: H-index = 33 (last 5-years = 27), i10-index = 51 (last 5 years = 47)
- ORCID: 0000-0003-1246-2344

Scholarly Book Sections and Theses

B11. **IPCC** (2019) Summary for Policymakers. In: *Special Report on the Ocean and Cryosphere in a Changing Climate*.

B10. **Abram, N.J.**, Gattuso, J.-P., Prakash, A., Chidichimo, M.P., Crate, S., Enomoto, H., Garschagen, M., Gruber, N., Harper, S., Holland, E., Kudela, R.M., Rice, J., Steffen, K., and von Schuckmann, K. (2019). Framing and Context (Chapter 1). In: *Special Report on the Ocean and Cryosphere in a Changing Climate*.

B9. **Abram, N.J.**, Cheung, W., Cheng, L., Frolicher, T., Hauser, M., He, S., Hollowed, A., Marzeion, B., Morin, S., Pirani, A., and Swingedouw, D. (2019). Scenarios, pathways and reference periods (Cross-Chapter Box 1). In: *Special Report on the Ocean and Cryosphere in a Changing Climate*.

B8. Adler, C., Oppenheimer, M., **Abram, N.J.**, McInnes, K., and Schuur, E. (2019). Confidence and Deep Uncertainty (Cross-Chapter Box 5). In: *Special Report on the Ocean and Cryosphere in a Changing Climate*.

B7. **Abram, N.J.** (2018). FactCheck Q&A: Was it four degrees hotter 110,000 years ago? In: Watson, J. *The Conversation Yearbook 2017: 50 articles that informed public debate*. Melbourne University Press, ISBN: 9780522872668.

B6. **Abram, N.J.** (2014) Antarctic Ice: Going, going,…. In: Hay, A. (ed.) 2014 *Best Australian Science Writing*. UNSW Press

B5. **Abram, N.J.** (2013) Antarctic Ice: Going, going, going? In: Dayton, L. (ed.) The Curious Country. ANU Press, for the Office of the Chief Scientist.

B4. Gagan, M.K. and **Abram, N.J.** (2011). Stable isotopes and trace elements. In: Hopley, D. (ed) *Encyclopedia of modern coral reefs: structure, form and process*. Encyclopedia of Earth Science Series, Springer-Verlag.

B3. Hodgson, D.A., **Abram, N.J.**, Anderson, J., Bargelloni L., Barrett P., Bentley M.J., Bertler N.A.N., Chown S., Clarke A., Convey P., Crame A., Crosta X., Curran M., di Prisco G., Francis J.E., Goodwin I., Gutt J., Masse G., Masson-Delmotte V., Mayewski P.A., Mulvaney R., Peck L., Portner H.-O., Rothlisberger R., Stevens M.I., Summerhayes C.P., van Ommen T., Verde C., Verleyen E., Vyverman W., Wiencke C. and Zane L. (2009) *Antarctic climate and environmental history in the pre-instrumental period*. In: Turner, J. Convey P., di Prisco G., Mayewski P.A., Hodgson D.A., Fahrbach E, Bindschadler R. and Gutt J. (eds) *Antarctic Climate Change and the Environment*. Scientific Committee for Antarctic Research, Cambridge.

B2. **Abram N.J**. (2004). Multi-proxy coral reconstruction of Holocene climate and reef growth in the eastern Indian Ocean. *PhD thesis, Research School of Earth Sciences, The Australian National University*, 262pp.

B1. **Abram N.J.** (1999). High resolution record of Holocene environmental variations at Kikai-jima, Japan. *BSc Advanced Honours thesis, School of Geosciences, The University of Sydney*, 84 pp.

Refereed Journal Articles

* Indicates publication led by a PhD student
† Indicates Scopus 90th to 99th percentile for citations (40% of my publications are in top 10% of citations worldwide)
‡ Indicates Scopus 99th percentile for citations
§ Indicates Web of Science "Highly Cited Paper" (top 1% of field) in last 5 years
84% of my publications are published in the top 10% of journals (Scopus SciVal)

J54. **Abram, N.J.**, Henley, B.J., Sen Gupta, A. Lippmann, T.J.R., Clarke, H., Dowdy, A.J., Sharples, J.J., Nolan, R.H., Zhang, T., Wooster, M.J., Wurtzel, J.B., Meissner, K.J., Pitman, A.J., Ukkola, A.M., Murphy, B.P., Tapper, N.J., Boer, M.M. (2021). Connections of climate change and variability to large and extreme forest fires in southeast Australia. *Communications Earth and Environment* 2, 8, doi: 10.1038/s43247-020-00065-8.

J53. McConnell, J.R., Chelman, N.J., Mulvaney, R., Eckhardt, S., Stohl, A., Plunket, G., Kipfstuhl, S., Freitag, J., Isakssan, E., Gleason, K.E., Brugger, S., McWethy, D.B., **Abram, N.J.**, Liu, P. and Aristarain, A.J. (2021). Hemispheric black carbon increase after 13th C Māori arrival in New Zealand. *Nature.* (in press, accepted 27/07/2021).

J52. Ummenhofer, C.C., Murty, S.A., Sprintall, J., Lee, T., and **Abram, N.J.** (2021). Heat and freshwater changes in the Indian Ocean region. *Nature Reviews Earth and Environment* 2, 525–541.

J51.* Crockart, C.K., Vance, T.R., Fraser, A.D., **Abram, N.J**., Criscitiello, A.S., Curran, M.A.J., Favier, V., Gallant, A.J.E., Kjær, H.A., Klekociuk, A.R., Jong, L.M., Moy, A.D., Plummer, C.T., Vallelonga, P.T., Wille, J., and

Zhang, L. (2021). El Niño Southern Oscillation signal in a new East Antarctic ice core, Mount Brown South, *Climate of the Past*.

J50.†§ **Abram, N.J.,** Wright, N.M., Ellis, B., Dixon, B.C., Wurtzel, J.B., England, M.E., Ummenhofer, C.C., Philibosian, B., Cahyarini, S.Y., Yu, T.-L., Shen, C.-C., Cheng, H., Edwards, R.L., Heslop, D. (2020). Coupling of Indo-Pacific climate variability through the last millennium. *Nature.* 579, 385-392

J49.† **Abram, N.J.,** Hargreaves, J.A., Wright, N.M., Thirumalai, K., Ummenhofer, C.C. and England, M.H. (2020). Palaeoclimate perspectives on the Indian Ocean Dipole. *Quaternary Science Reviews* 237, 106302.

J48. Konecky, B.L., McKay, N.P., Churakova (Sidorova), O.V., Comas-Bru, L., Dassié, E.P., DeLong, K.L., Falster, G.M., Fischer, M.J., Jones, M.D., Jonkers, L., Kaufman, D.S., Leduc, G., Managave, S.R., Martrat, B., Opel, T., Orsi, A.J., Partin, J.W., Sayani, H.R., Thomas, E.K., Thompson, D.M., Tyler, J.J., **Abram, N.J.**, Atwood, A.R., Cartapanis, O., Conroy, J.L., Curran, M.A., Dee, S.G., Deininger, M., Divine, D.V., Kern, Z., Porter, T.J., Stevenson, S.L., von Gunten, L., and Iso2k Project Members (2020). The Iso2k database: a global compilation of paleo-$\delta^{18}O$ and $\delta^{2}H$ records to aid understanding of Common Era climate, *Earth Syst. Sci. Data*, 12, 2261–2288

J47.*†§Freund, M.B., Henley, B.J., Karoly, D.J., McGregor, H.V., **Abram, N.J.**, and Dommenget, D. (2019). Higher frequency of Central Pacific El Niño events in recent decades. *Nature Geoscience*. doi: 10.1038/s41561-019-0353-3

J46. Bracegirdle, T.J., Colleoni, F., **Abram, N.J.**, Bertler, N., Dixon, D.A., England, M., Favier, V., Fogwill, C., Fyfe, J.C., Goodwin, I., Goosse, H., Hobbs, W., Jones, J.M., Keller, E.D., Khan, A., Phipps, S.J., Raphael, M., Russell, J., Sime, L., Thomas, E.R., van den Broeke, M., Wainer, I. (2019). Back to the Future: Using long-term observational and paleo-proxy reconstructions to improve model projections of Antarctic climate. *Geosciences* 9 (6), 255. doi:10.3390/geosciences9060255

J45.* Datwyler, C., **Abram, N.J.**, Grosjean, M., Wahl, E., Neukom, R. (2019). ENSO variability, teleconnection changes and response to large volcanic eruptions since AD 1000. *International Journal of Climatology*. doi: 10.1002/joc.5983

J44.* Dey, R., Lewis, S., and **Abram, N.J.** (2019). Investigating observed northwest Australian rainfall trends in CMIP5 detection and attribution experiments. *International Journal of Climatology*, 39 (1), 112-127, doi: 10.1002/joc.5788

J43.*†§Dey, R., Lewis, S., Arblaster, J., and **Abram, N.J.** (2019). A Review of Past and Projected Changes in Australia's Precipitation: Trends, Means and Extremes. *WIRES Climate Change*, https://doi.org/10.1002/wcc.577

J42.* Ellis, B., Grant, K., Mallela, J., **Abram, N.J.** (2019). Is XRF core scanning a viable method of coral palaeoclimate temperature reconstructions? *Quaternary International*. doi: 10.1016/j.quaint.2018.11.044

J41.* Krause, C.E., Gagan, M.K., Dunbar, G.B., Helstrom, J.C., Cheng, H., Edwards, R.L., Hantoro, W.S., **Abram, N.J.**, and Rifai, H. (2019). Meridional and zonal drivers of Australasian monsoon hydroclimate over the last 40,000 years. *Earth and Planetary Science Letters*, 513, 103-112, doi: 10.1016/j/epsl.2019.01.045

J40.* Klein, F., **Abram, N.J.**, Curran, M.A.J., Goosse, H., Goursaud, S., Masson-Delmotte, V., Moy, A., Neukom, R., Orsi, A., Sjolte, J., Steiger, N., Stenni, B., and Werner, M. (2019). Assessing the robustness of Antarctic temperature reconstructions over the past two millennia using pseudoproxy and data assimilation experiments. *Climate of the Past*. 15, 661-684, doi: 10.5194/cp-15-661-2019

J39. Turney, C.S.M, McGregor, H.V., Francus, P., **Abram, N.**, Evans, M.N., Goosse, H., von Gunten, L., Kaufman, D., Linderholm, H., Loutre, M.F. and Neukom, R. (2019). Introduction to the Special Issue on Climate of the Past 2000 Years: Global and Regional Syntheses. *Climate of the Past*, 16, 611-615, doi: 10.5194/cp-15-611-2019

J38.†§ Fischer, H., Meissner, K., Mix, A., et al., including **Abram N.J.** (2018), Palaeoclimate constraints on the impact of 2°C anthropogenic warming and beyond. *Nature Geoscience*. doi: 10.1038/s41561-018-0146-0

J37. Kaufman, D. and PAGES 2k special-issue editorial team, including **Abram, N.J.** (2018), Technical Note: Open-paleo-data implementation pilot – The PAGES 2k special issue, *Climate of the Past*, https://doi.org/10.5194/cp-14-593-2018

J36.† NEEM Aerosol Community, led by Fischer, H. and including **Abram, N.J.** (2018), Greenland records of aerosol source and atmospheric lifetime changes from the Eemian to the Holocene. *Nature Communications*, 9:1476, doi: 10.1038/s41467-018-03924-3

J35. Sigl, M., **Abram, N.J.**, Gabrieli, J., Jenk, T.M., Osmont, D., and Schwikowski, M. (2018), 19th century glacier retreat in the Alps preceded the emergence of industrial black carbon deposition on high-alpine glaciers, *The Cryosphere*, https://doi.org/10.5194/tc-12-3311-2018

J34.* Wurtzel, J.B., **Abram, N.J.**, Lewis, S.E., Bajo, P., Helstrom, J.C., Troitzsch, U. and Heslop, D. (2018). Tropical Indo-Pacific hydroclimate response to North Atlantic forcing during the last deglaciation as recorded by a speleothem from Sumatra, Indonesia. *Earth and Planetary Science Letters*, 492, 264-278, https://doi.org/10.1016/j.epsl.2018.04.001

J33.*† Datwyler, C., Neukom, R., **Abram, N.J.**, Gallant, A., Grosjean, M., Jacques-Coper, M., Karoly, D., and Villalba, R. (2017). Teleconnection stationarity, variability and trends of the Southern Annular Mode (SAM) during the last millennium. *Climate Dynamics*, doi:10.1007/s00382-017-4015-0.

J32. Hessl, A., Allen, K., Vance, T., Abram, N.J. and Saunders, K. (2017). Reconstructions of the Southern Annular Mode (SAM) during the Last Millennium. *Progress in Physical Geography*. doi:10.1177/0309133317743165

J31.‡§ PAGES 2k Consortium, led by Emile-Geay, J. and including **Abram, N.J.** (2017). A global multiproxy database for temperature reconstructions of the Common Era. *Nature Scientific Data*, doi: 10.1038/sdata.2017.88

J30.† Stenni, B., Curran, M., **Abram, N.J.**, Orsi, A., and 14 others from the Antarctica 2k working group (2017). Antarctic climate variability at regional and continental scales over the last 2,000 years, *Climate of the Past*, doi:10.5194/cp-13-1609-2017

J29.‡§ **Abram, N.J.,** McGregor, H.V., Tierney, J.E., Evans, M.N., McKay, N.P., Kaufman, D.S. and the PAGES 2k Consortium^ (2016). The onset of Industrial-era warming across the continents and oceans. *Nature.*
^PAGES 2k Consortium name includes an additional 21 authors.

J28.†§ Jones, J.M., Gille, S.T., Goosse, H., **Abram, N.J.**, and 21 other co-authors (2016). Assessing recent trends in high-latitude Southern Hemisphere surface climate. Nature Climate Change, 6, 917-926, doi:10.1038/nclimate3103

J27. Hobbs, W., Curran, M.A.J., **Abram, N.J.** and Thomas, E.R. (2016). Century-scale perspectives on observed and simulated Southern Ocean sea ice trends. Journal of Geophysical Research, 121, 7804-7818, doi: 10.1002/2016JC012111

J26. Thomas, E.R. and **Abram, N.J.** (2016). Ice core reconstruction of sea ice change in the Amundsen-Ross Seas since 1702AD. *Geophysical Research Letters*, 43, 5309-5317, doi: 10.1002/2016GL068130

J25. Vance, T., Roberts, J., Moy, A., Curran, M., Tozer, C., Gallant, A., **Abram, N.J.**, van Ommen, T., Young, D., Blankenship, D., Siegert, M., and Grima, C. (2016). Optimal site selection for a high resolution ice core record in East Antarctica. *Climate of the Past*, 12, 595-610, doi:10.5194/cp-12-595-2016

J24. **Abram, N.J.,** Dixon, B.C., Rosevear, M.G., Plunkett, B., Gagan, M.K., Hantoro, W.S. and Phipps, S.J. (2015). Optimised coral records of the Indian Ocean Dipole: an assessment of location and length considerations. *Paleoceanography*, 30, 1391-1405, doi: 10.1002/2015PA002810

J23.‡ Tierney, J.E., **Abram, N.J.**, Anchukitas, K.J., Evans, M.N., Giry, C., Kilbourne, K.H., Saenger, C.P., Wu, H.C., Zinke, J. (2015). Tropical sea-surface temperatures for the past four centuries reconstructed from coral archives. *Paleoceanography* 30, 226-252, doi: 10.1002/2014PA002717.

J22.‡ **Abram, N.J.**, Mulvaney, R., Vimeux, F., Phipps, S.J., Turner, J., England, M.E. (2014). Evolution of the Southern Annular Mode during the last millennium. *Nature Climate Change* 4, 564-569, doi:10.1038/nclimate2235.

J21. Murphy, E.J., Clarke, A., **Abram, N.J.** & Turner, J. (2014). Variability of sea-ice in the northern Weddell Sea during the 20th century. *Journal of Geophysical Research*, 119, doi:10.1002/2013JC009511.

J20.† **Abram, N.J.**, Mulvaney, R., Wolff, E.W., Triest, J., Kipfstuhl, S., Trusel, L.D., Vimeux, F., Fleet, L. & Arrowsmith, C. (2013). Acceleration of snowmelt in an Antarctic Peninsula ice core during the twentieth century. *Nature Geoscience,* 6, 404-411. doi:10.1038/ngeo1787.

J19.† **Abram, N.J.**, Wolff, E.W. & Curran, M.A.J. (2013). A review of sea ice proxy information from polar ice cores. *Quaternary Science Reviews* 79, 168-183. doi:10.1016/j.quascirev.2013.01.011.

J18.† Mulvaney, R^., **Abram, N.J^**., Hindmarsh, R.C.A., Arrowsmith, C., Fleet, L., Triest, J., Sime, L.C., Alemany, O. & Foord, S. (2012). Recent Antarctic Peninsula warming relative to Holocene climate and ice-shelf history. *Nature* 489, 141-144, doi:10.1038/nature11391. ^equal contributions.

J17.* Wheatley, J.J., Blackwell, P.G., **Abram, N.J**., McConnell, J.R., Thomas, E.R. and Wolff, E.W. (2012). Automated ice-core layer-counting with strong univariate signals. *Climate of the Past,* 8, 1869-1879, doi:10.5194/cp-8-1869-2012.

J16. **Abram, N.J.,** Mulvaney, R. & Arrowsmith, C. (2011). Environmental signals in a highly resolved ice core from James Ross Island, Antarctica. *Journal of Geophysical Research,* 116, D20116, doi:10.1029/2011jd016147.

J15. D'Arrigo R., **Abram N.J**., Ummenhoffer C., Palmer J. and Mudelsee M. (2011). Reconstructed streamflow for Citarum River, Java, Indonesia: linkages to tropical climate dynamics. *Climate Dynamics* 36, 451-462.

J14. **Abram, N.J.**, Thomas, E.R, McConnell, J.R., Mulvaney, R., Bracegirdle, T.J., Sime, L.C., and Aristarain, A.J. (2010). Ice core evidence for a 20th century decline of sea ice in the Bellingshausen Sea, Antarctica. *Journal of Geophysical Research* 115, D23101, doi:10.1029/2010JD014644.

J13.† Rothlisberger R., Crosta X., **Abram N.J**., Armand L. and Wolff E.W. (2010). Potential and limitations of marine and ice core sea-ice proxies: An example from the Indian Ocean sector. *Quaternary Science Reviews* 29, 296-302.

J12.† **Abram N.J**., McGregor H.V., Gagan M.K. Hantoro W.S. and Suwargadi B.W. (2009). Oscillations in the southern extent of the Indo-Pacific Warm Pool during the mid-Holocene. *Quaternary Science Reviews* 28, 2794-2803.

J11.† Convey, P., Bindschadler, R., Di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D.A., Mayewski, P.A., Summerhayes, C.P., Turner, J., and the ACCE Consortium incl. **Abram N.J.** (2009). Antarctic Climate Change and the Environment. *Antarctic Science*, 21(6), 541-563.

J10.* Ault T.R., Cole J.E., Evans M.N., Barnett H., **Abram N.J**., Tudhope A.W. and Linsley B.K. (2009). Intensified decadal variability in tropical climate during the late 19th century, *Geophysical Research Letters* 36, L08602, doi:10.1029/2008GL036924.

J9.† **Abram N.J**., Gagan M.K., Cole J.E., Hantoro W.S., and Mudelsee M. (2008). Recent intensification of tropical climate variability in the Indian Ocean, *Nature Geoscience* 1, 849-853.

J8. McGregor H.V. and **Abram N.J**. (2008). Images of diagenetic textures in *Porites* corals from Papua New Guinea and Indonesia, *Geochemistry Geophysics Geosystems* 9, Q10013, doi:10.1029/2008GC002093.

J7.† Reda T., Plugge C.M., **Abram N.J.** and Hirst J. (2008). Reversible interconversion of carbon dioxide and formate by an electroactive enzyme. *Proceedings of the National Academy of Sciences* 105, 10654-10658, doi:10.1073/pnas0801290105.

J6. **Abram N.J.,** Curran M.A.J., Mulvaney R. and Vance T. (2008). The preservation of methanesulphonic acid in frozen ice-core samples. *Journal of Glaciology* 54 (187), 680-684.

J5. **Abram N.J**., Mulvaney R. Wolff E.W. and Mudelsee M. (2007). Ice core records as sea ice proxies: An evaluation from the Weddell Sea region of Antarctica. *Journal of Geophysical Research* 112, D15101, doi:10.1029/2006JD008139.

J4. **Abram N.J**., Gagan M.K., Liu, Z., Hantoro W.S., McCulloch M.T. and Suwargadi B.W. (2007). Seasonal characteristics of the Indian Ocean Dipole during the Holocene epoch, *Nature* 445, 299-302.

J3.* Grumet N.S., **Abram N.J**., Beck J.W., Dunbar R.B., Gagan M.K. Guilderson T.P., Hantoro W.S. and Suwargadi B.W. (2004). Coral radiocarbon records of Indian Ocean water mass mixing and wind-induced upwelling along the coast of Sumatra, Indonesia, *Journal of Geophysical Research* 109, C05003.

J2.*† **Abram N.J**., Gagan M.K., McCulloch M.T., Chappell J. and Hantoro W.S. (2003). Coral reef death during the 1997 Indian Ocean Dipole linked to Indonesian wildfires, *Science* 301, 952-955.

J1.* **Abram N.J**., Webster J.M., Davies P.J. and Dullo W-C. (2001). Biological response of coral reefs to sea surface temperature variation: Evidence from the raised Holocene reefs at Kikai-jima (Ryukyu Islands, Japan), *Coral Reefs*, 20, 221-234.

Other Publications

The following publications demonstrate my commitment to communicating scientific information with a broad audience, including policy makers and the public. I am a frequent publisher with The Conversation, where my articles have reached a readership of more than 788,000 people.

O28. King, A., **Abram, N.J.,** Perkins-Kirkpatrick, S. (2021). Climate Change – how bad could it get? *The Conversation*.

O27. McGregor, S., Reef, R., and **Abram, N.J.** (2021) 'How high above sea level am I?' If you've googled this, you're likely asking the wrong question — an expert explains. *The Conversation*.

O26. Pitman, A., **Abram, N.J.,** Alexander, L., Arblaster, J., King, A., Macadam, I., McGregor, S., Perkins-Kirkpatirck, S., Sherwood, S., and Stone, A. (2021) The Intergovernmental Panel on Climate Change 6th Assessment Report. *Special Briefing from the ARC Centre of Excellence for Climate Extremes*.

O25. **Abram, N.J.,** King, A., Pitman, A., Jacob, C., Arblaster, J., Alexander, L., Perkins-Kirkpatrick, S., McGregor, S and Sherwood, S. (2021) Yes, a few climate models give unexpected predictions – but the technology remains a powerful tool. *The Conversation*.

O24. Pitman, A., Macadam, I., **Abram, N.**, Sherwood, S., and De Kauwe M. (2021) Can we limit global warming to 1.5ºC? *ARC Centre of Excellence for Climate Extremes, Briefing Note 15*.

O23. **Abram, N.J.,** De Kauwe, M. and Perkins-Kirkpatrick, S. (2021) Matt Canavan suggested the cold snap means global warming isn't real. We bust this and 2 other climate myths. *The Conversation*.

O22. Wright, N., Ellis, B. and **Abram, N.J.** (2020) A rare natural phenomenon brings severe drought to Australia. Climate change is making it more common. *The Conversation*.

O21. Melbourne-Thomas, J., McIness, K., Bindoff, N. and **Abram, N.J.** (2019) A landmark report confirms Australia is girt by hotter, higher seas. But there's still time to act. *The Conversation*.

O20. **Abram, N.J.,** England, M.H., and King, M. (2019) Arctic ice loss is worrying, but the giant stirring in the South could be even worse. *The Conversation*.

O19. **Abram, N.J.** (2019) Time will tell is this is a record summer for Greenland ice melt, but the patterns of the past 20 years is clear. *The Conversation*.

O18. Freund, M.B., Henley, B.J., Karoly, D.J., McGregor, H.V., and **Abram, N.J.**, (2019). El Niño has rapidly become stronger and stranger, according to coral records. *The Conversation.*

O17. **Abram, N.J.** (2018). Past warming events in the Arctic linked to shifting winds in the Antarctic. *Nature*, 563, 630-631

O16. **Abram, N.J.** (2017). FactCheck Q&A: Was it four degrees hotter 110,000 years ago? *The Conversation*.

O15. Dasse, E., and 37 others including **Abram, N.J.** (2017). Saving our marine archives. *Eos*, 98, https://doi.org/10.1029/2017EO068159

O14. Henley, B, and **Abram, N.J.** (2017). The three-minute story of 800,000 years of climate change with a sting in the tail. *The Conversation.*

O13. Turner, J., Comiso, J., and 20 co-signatories including **Abram, N.J.** (2017). Solve Antarctica's sea-ice puzzle. *Nature*, 547, 275–277, doi:10.1038/547275a

O12. McGregor, H.V., **Abram, N.J.**, Gergis, J. and Phipps, S. (2016). The Industrial Revolution kick-started global warming much earlier than we realised. *The Conversation.*

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O8. King, P.L., Edwards, A., and **Abram, N.J.** (2015) Recognising biases that affect women geoscientists in the workplace. *Elements Magazine*, 11 (April), 88-89.

O7. **Abram, N.**, Armand, L., Chase, Z., De Decker, P., Ellwood, M., Exon, N., Gagan, M., Goodwin, I., Howard, W., Lough, J., McCulloch, M., McGregor, H., Meissner, K., Moy, A., O'Leary, M., Phipps, S., Skilbeck, G., Webster, J., Welsh, K. and Zinke, J. (2014), Dealing with Climate Change: Palaeoclimate Research in Australia. White paper for the National Marine Science Plan. *Quaternary Australasia.*

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O5. Hope, P., Gergis, J., **Abram, N.**, Brown, J., Phipps, S.J., Drysdale, R., Henley, B.J., Lorrey, A.M., Roop, H., and Tyler, J. (2014). Australasia's past climate variability – strengths drawn from palaeoclimate and model data over the last 2,000 years. *Bulletin of the Australian Meteorological and Oceanographic Society*, 27 (5), 92-95.

O4. Hope, P., Gergis, J., **Abram, N.**, Henley, B. (2014). Australasia's climate variability: clues drawn from paleoclimate and model data over the last 2000 years. *PAGES Magazine*, 22 (2), 101.

O3. **Abram N**, (2009). Corals predict rainfall decline, *Australasian Science*, April, 25-27 (invited).

O2. Rothlisberger, R. and **Abram N.** (2009) Sea-ice proxies in Antarctic ice cores. *PAGES News*, **17** (1), 24-26.

O1. **Abram N.** (2004). Fire threat to coral reefs, *Australasian Science*, March, 21-23 (invited).

Open-Access Data and Code Publications

I am committed to the principles of FAIR data (Findable, Accessible, Interoperable, Reusable) as a way to accelerate scientific discovery and safeguard scientific integrity and investment. Through the PAGES 2k Network I have worked to improve data archiving practices within the paleoclimate community (e.g. see publications J37 and J31).

D17. Data archive for Abram et al., 2020 (*Nature*) Southern Mentawai Islands d18O and d13C Data and Indian Ocean Dipole reconstruction over the last millennium: https://www.ncdc.noaa.gov/paleo-search/study/28451

D16. Data archive for Konecky et al., 2020 (*ESSD*) Iso2k Database Global Common Era Paleo-d18O and d2H Records: https://www.ncdc.noaa.gov/paleo/study/29593

D15. Data archive for Freund et al., 2019 (*Nature Geoscience*) 400 year El Nino event type reconstruction: https://www.ncdc.noaa.gov/paleo/study/26270

D14. Data archive for Datwyler et al., 2019 (*International Journal of Climatology*) 1000-year ENSO reconstructions: https://www.ncdc.noaa.gov/paleo/study/25891

D13. Data archive for Sigl et al., 2018 (*Cryosphere*) Colle Gnifetti ice core black carbon data: https://doi.org/10.1594/PANGAEA.894788

D12. Data archive for Wurtzel et al, 2018 (*Earth and Planetary Science Letters*) 16,000-year speleothem $\delta^{18}O$ data: https://www.ncdc.noaa.gov/paleo/study/23790

D11. Data archive for Datwyler et al., 2017 (*Climate Dynamics*) Southern Annular Mode reconstructions: https://www.ncdc.noaa.gov/paleo/study/23130

D10. Data archive for PAGES2k Consortium, 2017 (*Nature Scientific Data*) Global temperature database: https://www.ncdc.noaa.gov/paleo/study/21171

D9. Data archive for Stenni et al., 2017 (*Climate of the Past*) Antarctica 2k database: https://www.ncdc.noaa.gov/paleo/study/22589

D8. Code and data archive for Abram et al., 2016 (*Nature*) Onset of industrial-era warming: https://www.ncdc.noaa.gov/paleo/study/20083

D7. Data archive for Tierney et al., 2015 (*Paleoceanography*) Ocean 2k high-resolution database: https://www.ncdc.noaa.gov/paleo/study/17955

D6. Data archive for Abram et al., 2015 (*Paleoceanography*) Sunda Strait and South Pagai coral $\delta^{18}O$ data: https://www.ncdc.noaa.gov/paleo/study/18895

D5. Data archive for Abram et al., 2014 (*Nature Climate Change*) 1000-year Southern Annular Mode reconstruction: https://www.ncdc.noaa.gov/paleo/study/16197

D4. Data archive for Abram et al., 2013 (*Nature Geoscience*) 1000-year James Ross Island ice core melt and $\delta^{18}O$ data: https://www.ncdc.noaa.gov/paleo/study/14201

D3. Data archive for Mulvaney et al., 2012 (*Nature*) Holocene ice core $\delta^{18}O$ data from the James Ross Island ice core: https://www.ncdc.noaa.gov/paleo/study/13954

D2. Data archive for Abram et al., 2009 (*Quaternary Science Reviews*) Holocene Sr/Ca SST reconstructions for the Indo-Pacific Warm Pool: https://www.ncdc.noaa.gov/paleo/study/9819

D1. Data archive for Abram et al., 2008 (*Nature Geoscience*) Dipole Mode Index reconstruction: https://www.ncdc.noaa.gov/paleo/study/8607

Environmental Defenders Office

Appendix 2

27 August 2021

Professor Nerilie Abram
Research School of Earth Sciences
Australian National University

By email: nerilie.abram@anu.edu.au

CONFIDENTIAL AND SUBJECT TO LEGAL PROFESSIONAL PRIVILEGE

Dear Professor Abram

Environment Centre NT Inc v Minister for Resources and Water & Anor
Federal Court of Australia Proceedings no. NSD758/2021

1. We act for the Environmental Centre NT Inc (**ECNT**), who is the peak community sector environmental organisation in the Northern Territory. ECNT engages in activities aimed at protecting and conserving the environment of the NT, including in relation to climate change.

2. Our client, ECNT, has commenced proceedings in the Federal Court of Australia (**Proceedings**) against the Minister for Resources and Water (**Minister)** and the Commonwealth of Australia (**Commonwealth**) alleging that:

    a. the Minister's making of the *Industry Research and Development (Beetaloo Cooperative Drilling Program) Instrument 2021* (Cth) (the **Instrument**); and

    b. the Minister's decision to award up to $21 million in grants to Imperial Oil and Gas (**Imperial**) pursuant to the Beetaloo Cooperative Drilling Program (**the Program**) (the **Decision**)

    were unlawful in circumstances where the Minister:

    a. breached s 71 (1) of the *Public Governance, Performance and Accountability Act 2013 (Cth)* (**the PGPA Act**) by failing to make reasonable inquiries in respect of climate change risks. S 71(1) requires that the Minister must not approve a proposed expenditure of relevant money unless the Minister is satisfied, after making reasonable inquiries, that the expenditure is a "proper use" of relevant money, where "proper" is defined as a use that is "efficient, effective, economical and ethical"; and

    b. acted in a way that was legally unreasonable and/or illogical and/or irrational, by failing to have regard to and/or failing to have adequate regard to, climate change risks.

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ABN: 72002 880 864

3. We are instructed to engage you to act as an expert witness under Part 23 (rules 23.01-23.15) of the *Federal Court Rules 2011* (Cth) (**FC Rules**) and the Expert Evidence Practice Note (GPN-EXPT) (**Expert Evidence Practice Note**), including the Harmonised Expert Witness Code of Conduct (**Code of Conduct**)). Part 23 of the FC Rules and the Expert Evidence Practice Note is set out in **Annexure A** to this letter.

4. Your role as an expert witness is to assist the Court impartially on matters relevant to your area of expertise. You are not to act as an advocate for our clients and any opinion expressed must be genuinely held by you based on your professional training, knowledge, or experience.

5. Please read those documents carefully before you commence the work requested. **Your expert report must contain an acknowledgment that you have read the Code of Conduct and that you agree to be bound by it.** Otherwise your report will be inadmissible as evidence. Your role as an expert witness is to assist the Court impartially on matters relevant to your area of expertise. You are not to act as an advocate for our clients and any opinion expressed must be genuinely held by you based on your professional training, knowledge, or experience.

Overview of the Work Required

6. The work we require involves the following:

    a. reviewing the relevant documentation;

    b. preparing a written expert report that conforms with the Code of Conduct and addresses our questions (questions located at **Annexure B**);

    c. reviewing the Respondent's expert report(s) (if necessary);

    d. conferring with the Respondent's expert(s) at a joint conference(s) and prepare a joint report, which sets out the matters agreed, matters disagreed, and the reasons for agreement and disagreement as a result of the joint conference(s) (if necessary); and

    e. appearance as an expert witness in the Court (if required).

7. We request that you provide us with a draft of your expert report for review before finalising it. The purpose of this is not to influence the conclusions or recommendations you make but to ensure that the report is clear and addresses the issues adequately to inform the Court.

Background

8. The following information is provided to assist your consideration of the matters on which are you asked to provide expert advice. Please note that you are not permitted to express an opinion on any question of law in your report and your report should confine itself to the relevant issues of fact within your area of expertise.

9. The independent *Scientific Inquiry into Hydraulic Fracturing of Onshore Unconventional Reservoirs in the Northern Territory* (**Fracking Inquiry**) was commissioned by the Northern Territory Government under the *Inquires Act 1945* (NT) and its Terms of Reference required it to investigate the environmental, social and economic risks and impacts of hydraulic fracturing (commonly known as fracking) of onshore unconventional gas reservoirs and associated activities in the Northern Territory.

10. The Fracking Inquiry handed down its Final Report to the Northern Territory Government on Tuesday 27 March 2018. Amongst other things, the Fracking Inquiry identified that a best estimate indicative later development scenario for the exploitation of a new shale gasfield or gasfields in the Beetaloo sub-basin would equate to gas production of 1,240 petajoules per year (**PJ/y**).[1]

11. The Fracking Inquiry further noted that in this later development scenario, it is assumed that 2,740 TJ/day is used for liquid natural gas (**LNG**) export and 660 terajoules per day (**TJ/day**) is used for domestic gas consumption.[2]

12. On 15 September 2020, the Prime Minister of Australia, the Minister for Energy and Emissions Reduction, and the Minister for Resources and Water (**Minister**) announced that Australia will be pursuing a "Gas-led recovery." [3]One of the elements of the Gas-led Recovery was the unlocking of five key gas basins, starting with the Beetaloo basin in the Northern Territory.[4]

13. On 17 December 2020, the Minister announced a $50 million subsidy program for Beetaloo exploration to "fast-track drilling by providing grants to cover 25% of eligible exploration costs, capped at $7.5 million per well and 3 wells per exploration venture."[5] The Minister further announced that it was estimated that the Beetaloo sub-basin could hold more than 200,000 petajoules of gas.[6]

14. In or about January 2021, the Minister issued the Beetaloo Strategic Basin Plan entitled 'Unlocking the Beetaloo,' which set out some details of the Program.

15. On 22 February 2021, Empire Energy Group Ltd (**Empire**), the Australian Stock Exchange (**ASX**) listed parent company of Imperial, published an announcement to the ASX relating to a Material Beetaloo Resource Upgrade. This statement included, amongst other things, the information that Empire has:

    a. a best estimate prospective gas resource of 3,446 billion cubic feet (**BCF**); and

    b. a best estimate of prospective condensate resource of 27 million barrels of petroleum liquids (**MMBL**).

16. On 18 March 2021, the Department of Industry, Science, Energy and Resources (**DISER**) issued the 'Beetaloo Cooperative Drilling Program – Grant Opportunity Guidelines' (**Guidelines**) and a standard Grant Agreement (**Standard Grant Agreement**). The Guidelines govern the provision of grants under the Program.

17. On 7 April 2021, Imperial submitted three applications seeking a total of $21,806,453 of funding under the Program, comprising of:

    a. Application BCD000001, seeking $7,314,081 in funding in respect of a project entitled 'Carpentaria-2 Horizontal Well';

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[1] Fracking Inquiry, p 227.
[2] Fracking Inquiry, p 227.
[3] https://www.pm.gov.au/media/gas-fired-recovery
[4] Ibid.
[5] https://www.minister.industry.gov.au/ministers/pitt/media-releases/beetaloo-strategic-plan-will-unlock-gas-jobs-and-development
[6] Ibid.

b. Application BCDP000002, seeking $6,992,372 in funding in respect of a project entitled 'Carpentaria-3 Horizontal Well'; and

c. Application BCDP000003, seeking $7,500,0000 in funding in respect of a project entitled 'Carpentaria-4 and 3D Seismic'

(together, **the Applications**).

18. Between 7 May and 8 May 2021, the Applications were the subject of DISER review.

19. On 11 May 2021, the Minister made the Instrument and purported to prescribe the Program as a program under s 33 of the *Industry Research and Development Act 1986* (Cth) (the **IRD Act**).

20. On 28 May 2021 and 1 June 2021 an Assessment Committee in respect of the Program (**Assessment Committee**) met to consider the Applications.

21. On 1 June 2012 the Assessment Committee resolved that the Applications were satisfactory (subject to some limitations/conditions [7]) and resolved to recommend to the Minister that they be approved for funding under the Program.

22. On 17 June 2021, following receipt of a DISER brief recommending that the Minister approve the three Applications (subject to the conditions set out by the Assessment Committee[8]), the Minister approved the Applications. On 7 July 2021, the Minister announced the Decision, by way of publication of a Media Release (**Announcement**).

23. On 8 July 2021, Empire Energy Group Ltd, the Australian Stock Exchange (**ASX**) listed parent company of Imperial, published an announcement to the ASX relating to the Decision and Announcement.

Expert Brief

24. We will provide, by way of separate email, a link to an electronic a brief of documents for your review. **Annexure C** contains an index to these documents.

Timeframe

25. Under the current Court orders, your expert report will be due to be filed and served by 10 September 2021. We therefore request a draft of your advice by no later than Monday **6 September 2021**.

26. We will notify you of further relevant dates in the Proceedings as they become available.

Fees and Terms

27. Thank you for agreeing to provide this advice at a capped amount of $1,000 (plus GST).

28. Please note the following terms:
    a. Your work will only be used by EDO in relation to this matter;

[7] Conditions set out on page 5 to 7 of the Meeting Minutes of the Beetaloo Cooperative Drilling Program Assessment Committee (**Assessment Committee**) Meeting on 1 June 2021 – At tab 19 of the Brief.
[8] See Annexure A to Ministerial Recommendation – BCDP Recommended Projects – At tab 29 of the Brief.

b. EDO will take all reasonable steps to prevent your work being used for purposes other than that mentioned above, but we accept no responsibility for the actions of third parties;

c. Regardless of the above points, EDO may choose not to use your work;

d. You will not be covered by EDO's insurance while undertaking the above tasks.

Duty of Confidentiality

29. Please treat your work as strictly confidential, unless authorised by us.

If you would like to discuss this retainer further, please contact us at anna.gudkov@edo.org.au.

Yours sincerely,
Environmental Defenders Office

Anna Gudkov
Senior Lawyer (Gas/Corporate)

Ref: s1952

Part 23—Experts

Division 23.1—Court experts

23.01 Appointment of Court expert

(1) A party may apply to the Court for an order:

(a) that an expert be appointed (a ***Court expert***) to inquire into and report on any question or on any facts relevant to any question arising in a proceeding; and

(b) fixing the Court expert's remuneration, including the cost of preparing the expert's report; and

(c) for the Court expert's attendance before the Court; and

(d) terminating the liability to pay the Court expert's remuneration.

Note 1: ***Expert*** is defined in the Dictionary.

Note 2: The Court may give instructions relating to the inquiry and report including the carrying out of an experiment or test.

Note 3: The Court may make an order of its own motion—see rule 1.40.

(2) If the Court makes an order under paragraph (1)(b), the expert's remuneration is payable jointly and severally by the parties.

23.02 Court expert's report

(1) The Court expert must provide the report to the Court within the time fixed by the Court.

Note: A Registrar will provide a copy of the report to any party interested in the question.

(2) The Court expert's report must:

(a) be signed by the Court expert; and

(b) contain particulars of the training, study or experience by which the Court expert has acquired specialised knowledge; and

(c) identify the questions that the Court expert was asked to address; and

(d) set out separately each of the factual findings or assumptions on which the Court expert's opinion is based; and

(e) set out separately from the factual findings or assumptions each of the Court expert's opinions; and

(f) set out the reasons for those opinions; and

(g) contain an acknowledgement that the opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (b).

23.03 Court expert's report—use at trial

(1) A report that complies with rule 23.02 will be admissible at trial as the evidence of the Court expert.

Note: Section 177 of the *Evidence Act 1995* deals with the tender of an expert's report.

(2) A party may apply to the Court for an order:

(a) to cross-examine a Court expert before or at trial; and

(b) if the cross-examination is to take place before trial—that the cross-examination take place before a Registrar or an examiner.

Note: ***Examiner*** is defined in the Dictionary.

23.04 Other expert's reports on the question

A party who has delivered to another party interested in the question a copy of another expert's report that complies with Division 23.2 may apply to the Court for leave to adduce the evidence of the other expert on the question.

Note: The question is referred to in rule 23.02.

Rules 23.05–23.10 left blank

Division 23.2—Parties' expert witnesses and expert reports

23.11 Calling expert evidence at trial

A party may call an expert to give expert evidence at a trial only if the party has:

(a) delivered an expert report that complies with rule 23.13 to all other parties; and

(b) otherwise complied with this Division.

Note: ***Expert*** and ***expert report*** are defined in the Dictionary.

23.12 Provision of guidelines to an expert

If a party intends to retain an expert to give an expert report or to give expert evidence, the party must first give the expert any practice note dealing with guidelines for expert witnesses in proceedings in the Court (the ***Practice Note***).

Note: A copy of any practice notes may be obtained from the District Registry or downloaded from the Court's website at http://www.fedcourt.gov.au.

23.13 Contents of an expert report

(1) An expert report must:

(a) be signed by the expert who prepared the report; and

(b) contain an acknowledgement at the beginning of the report that the expert has read, understood and complied with the Practice Note; and

(c) contain particulars of the training, study or experience by which the expert has acquired specialised knowledge; and

(d) identify the questions that the expert was asked to address; and

(e) set out separately each of the factual findings or assumptions on which the expert's opinion is based; and

(f) set out separately from the factual findings or assumptions each of the expert's opinions; and

(g) set out the reasons for each of the expert's opinions; and

(ga) contain an acknowledgement that the expert's opinions are based wholly or substantially on the specialised knowledge mentioned in paragraph (c); and

(h) comply with the Practice Note.

(2) Any subsequent expert report of the same expert on the same question need not contain the information in paragraphs (1)(b) and (c).

23.14 Application for expert report

A party may apply to the Court for an order that another party provide copies of that other party's expert report.

23.15 Evidence of experts

If 2 or more parties to a proceeding intend to call experts to give opinion evidence about a similar question, any of those parties may apply to the Court for one or more of the following orders:

(a) that the experts confer, either before or after writing their expert reports;

(b) that the experts produce to the Court a document identifying where the expert opinions agree or differ;

(c) that the expert's evidence in chief be limited to the contents of the expert's expert report;

(d) that all factual evidence relevant to any expert's opinions be adduced before the expert is called to give evidence;

(e) that on the completion of the factual evidence mentioned in paragraph (d), each expert swear an affidavit stating:

(i) whether the expert adheres to the previously expressed opinion; or

(ii) if the expert holds a different opinion;

(A) the opinion; and

(B) the factual evidence on which the opinion is based.

(f) that the experts give evidence one after another;

(g) that each expert be sworn at the same time and that the cross-examination and re-examination be conducted by putting to each expert in turn each question relevant to one subject or issue at a time, until the cross-examination or re-examination is completed;

(h) that each expert gives an opinion about the other expert's opinion;

(i) that the experts be cross-examined and re-examined in any particular manner or sequence.

Note 1: For the directions a Court may make before trial about expert reports and expert evidence, see rule 5.04 (items 14 to 19).

Note 2: The Court may dispense with compliance with the Rules and may make orders inconsistent with the Rules—see rules 1.34 and 1.35.

FEDERAL COURT OF AUSTRALIA

EXPERT EVIDENCE PRACTICE NOTE (GPN-EXPT)

General Practice Note

1. INTRODUCTION

1.1 This practice note, including the *Harmonised Expert Witness Code of Conduct* ("**Code**") (see **Annexure A**) and the *Concurrent Expert Evidence Guidelines* ("**Concurrent Evidence Guidelines**") (see **Annexure B**), applies to any proceeding involving the use of expert evidence and must be read together with:

(a) the Central Practice Note (CPN-1), which sets out the fundamental principles concerning the National Court Framework ("**NCF**") of the Federal Court and key principles of case management procedure;

(b) the Federal Court of Australia Act 1976 (Cth) ("**Federal Court Act**");

(c) the *Evidence Act 1995* (Cth) ("**Evidence Act**"), including Part 3.3 of the Evidence Act;

(d) Part 23 of the *Federal Court Rules 2011* (Cth) ("**Federal Court Rules**"); and

(e) where applicable, the Survey Evidence Practice Note (GPN-SURV).

1.2 This practice note takes effect from the date it is issued and, to the extent practicable, applies to proceedings whether filed before, or after, the date of issuing.

2. APPROACH TO EXPERT EVIDENCE

2.1 An expert witness may be retained to give opinion evidence in the proceeding, or, in certain circumstances, to express an opinion that may be relied upon in alternative dispute resolution procedures such as mediation or a conference of experts. In some circumstances an expert may be appointed as an independent adviser to the Court.

2.2 The purpose of the use of expert evidence in proceedings, often in relation to complex subject matter, is for the Court to receive the benefit of the objective and impartial assessment of an issue from a witness with specialised knowledge (based on training, study or experience - see generally s 79 of the Evidence Act).

2.3 However, the use or admissibility of expert evidence remains subject to the overriding requirements that:

(a) to be admissible in a proceeding, any such evidence must be relevant (s 56 of the Evidence Act); and

(b) even if relevant, any such evidence, may be refused to be admitted by the Court if its probative value is outweighed by other considerations such as the evidence

being unfairly prejudicial, misleading or will result in an undue waste of time (s 135 of the Evidence Act).

2.4 An expert witness' opinion evidence may have little or no value unless the assumptions adopted by the expert (ie. the facts or grounds relied upon) and his or her reasoning are expressly stated in any written report or oral evidence given.

2.5 The Court will ensure that, in the interests of justice, parties are given a reasonable opportunity to adduce and test relevant expert opinion evidence. However, the Court expects parties and any legal representatives acting on their behalf, when dealing with expert witnesses and expert evidence, to at all times comply with their duties associated with the overarching purpose in the Federal Court Act (see ss 37M and 37N).

3. INTERACTION WITH EXPERT WITNESSES

3.1 Parties and their legal representatives should never view an expert witness retained (or partly retained) by them as that party's advocate or "hired gun". Equally, they should never attempt to pressure or influence an expert into conforming his or her views with the party's interests.

3.2 A party or legal representative should be cautious not to have inappropriate communications when retaining or instructing an independent expert, or assisting an independent expert in the preparation of his or her evidence. However, it is important to note that there is no principle of law or practice and there is nothing in this practice note that obliges a party to embark on the costly task of engaging a "consulting expert" in order to avoid "contamination" of the expert who will give evidence. Indeed the Court would generally discourage such costly duplication.

3.3 Any witness retained by a party for the purpose of preparing a report or giving evidence in a proceeding as to an opinion held by the witness that is wholly or substantially based in the specialised knowledge of the witness[1] should, at the earliest opportunity, be provided with:

(a) a copy of this practice note, including the Code (see Annexure A); and

(b) all relevant information (whether helpful or harmful to that party's case) so as to enable the expert to prepare a report of a truly independent nature.

3.4 Any questions or assumptions provided to an expert should be provided in an unbiased manner and in such a way that the expert is not confined to addressing selective, irrelevant or immaterial issues.

[1] Such a witness includes a "Court expert" as defined in r 23.01 of the Federal Court Rules. For the definition of "expert", "expert evidence" and "expert report" see the Dictionary, in Schedule 1 of the Federal Court Rules.

4. ROLE AND DUTIES OF THE EXPERT WITNESS

4.1 The role of the expert witness is to provide relevant and impartial evidence in his or her area of expertise. An expert should never mislead the Court or become an advocate for the cause of the party that has retained the expert.

4.2 It should be emphasised that there is nothing inherently wrong with experts disagreeing or failing to reach the same conclusion. The Court will, with the assistance of the evidence of the experts, reach its own conclusion.

4.3 However, experts should willingly be prepared to change their opinion or make concessions when it is necessary or appropriate to do so, even if doing so would be contrary to any previously held or expressed view of that expert.

Harmonised Expert Witness Code of Conduct

4.4 Every expert witness giving evidence in this Court must read the *Harmonised Expert Witness Code of Conduct* (attached in Annexure A) and agree to be bound by it.

4.5 The Code is not intended to address all aspects of an expert witness' duties, but is intended to facilitate the admission of opinion evidence, and to assist experts to understand in general terms what the Court expects of them. Additionally, it is expected that compliance with the Code will assist individual expert witnesses to avoid criticism (rightly or wrongly) that they lack objectivity or are partisan.

5. CONTENTS OF AN EXPERT'S REPORT AND RELATED MATERIAL

5.1 The contents of an expert's report must conform with the requirements set out in the Code (including clauses 3 to 5 of the Code).

5.2 In addition, the contents of such a report must also comply with r 23.13 of the Federal Court Rules. Given that the requirements of that rule significantly overlap with the requirements in the Code, an expert, unless otherwise directed by the Court, will be taken to have complied with the requirements of r 23.13 if that expert has complied with the requirements in the Code and has complied with the additional following requirements. The expert shall:

(a) acknowledge in the report that:

(i) the expert has read and complied with this practice note and agrees to be bound by it; and

(ii) the expert's opinions are based wholly or substantially on specialised knowledge arising from the expert's training, study or experience;

(b) identify in the report the questions that the expert was asked to address;

(c) sign the report and attach or exhibit to it copies of:

(i) documents that record any instructions given to the expert; and

(ii) documents and other materials that the expert has been instructed to consider.

5.3 Where an expert's report refers to photographs, plans, calculations, analyses, measurements, survey reports or other extrinsic matter, these must be provided to the other parties at the same time as the expert's report.

6. CASE MANAGEMENT CONSIDERATIONS

6.1 Parties intending to rely on expert evidence at trial are expected to consider between them and inform the Court at the earliest opportunity of their views on the following:

(a) whether a party should adduce evidence from more than one expert in any single discipline;

(b) whether a common expert is appropriate for all or any part of the evidence;

(c) the nature and extent of expert reports, including any in reply;

(d) the identity of each expert witness that a party intends to call, their area(s) of expertise and availability during the proposed hearing;

(e) the issues that it is proposed each expert will address;

(f) the arrangements for a conference of experts to prepare a joint-report (see Part 7 of this practice note);

(g) whether the evidence is to be given concurrently and, if so, how (see Part 8 of this practice note); and

(h) whether any of the evidence in chief can be given orally.

6.2 It will often be desirable, before any expert is retained, for the parties to attempt to agree on the question or questions proposed to be the subject of expert evidence as well as the relevant facts and assumptions. The Court may make orders to that effect where it considers it appropriate to do so.

7. CONFERENCE OF EXPERTS AND JOINT-REPORT

7.1 Parties, their legal representatives and experts should be familiar with aspects of the Code relating to conferences of experts and joint-reports (see clauses 6 and 7 of the Code attached in Annexure A).

7.2 In order to facilitate the proper understanding of issues arising in expert evidence and to manage expert evidence in accordance with the overarching purpose, the Court may require experts who are to give evidence or who have produced reports to meet for the purpose of identifying and addressing the issues not agreed between them with a view to reaching agreement where this is possible ("**conference of experts**"). In an appropriate case, the Court may appoint a registrar of the Court or some other suitably qualified person ("**Conference Facilitator**") to act as a facilitator at the conference of experts.

7.3 It is expected that where expert evidence may be relied on in any proceeding, at the earliest opportunity, parties will discuss and then inform the Court whether a conference of experts and/or a joint-report by the experts may be desirable to assist with or simplify the giving of expert evidence in the proceeding. The parties should discuss the necessary arrangements for any conference and/or joint-report. The arrangements discussed between the parties should address:

(a) who should prepare any joint-report;

(b) whether a list of issues is needed to assist the experts in the conference and, if so, whether the Court, the parties o r the experts should assist in preparing such a list;

(c) **t**he agenda for the conference of experts; and

(d) arrangements for the provision, to the parties and the Court, of any joint-report or any other report as to the outcomes of the conference ("**conference report**").

Conference of Experts

7.4 The purpose of the conference of experts is for the experts to have a comprehensive discussion of issues relating to their field of expertise, with a view to identifying matters and issues in a proceeding about which the experts agree, partly agree or disagree and why. For this reason the conference is attended only by the experts and any Conference Facilitator. Unless the Court orders otherwise, the parties' lawyers will not attend the conference but will be provided with a copy of any conference report.

7.5 The Court may order that a conference of experts occur in a variety of circumstances, depending on the views of the judge and the parties and the needs of the case, including:

(a) while a case is in mediation. When this occurs the Court may also order that the outcome of the conference or any document disclosing or summarising the experts' opinions be confidential to the parties while the mediation is occurring;

(b) before the experts have reached a final opinion on a relevant question or the facts involved in a case. When this occurs the Court may order that the parties exchange draft expert reports and that a conference report be prepared for the use of the experts in finalising their reports;

(c) after the experts' reports have been provided to the Court but before the hearing of the experts' evidence. When this occurs the Court may also order that a conference report be prepared (jointly or otherwise) to ensure the efficient hearing of the experts' evidence.

7.6 Subject to any other order or direction of the Court, the parties and their lawyers must not involve themselves in the conference of experts process. In particular, they must not seek to encourage an expert not to agree with another expert or otherwise seek to influence the outcome of the conference of experts. The experts should raise any queries they may have in relation to the process with the Conference Facilitator (if one has been appointed) or in

accordance with a protocol agreed between the lawyers prior to the conference of experts taking place (if no Conference Facilitator has been appointed).

7.7 Any list of issues prepared for the consideration of the experts as part of the conference of experts process should be prepared using non-tendentious language.

7.8 The timing and location of the conference of experts will be decided by the judge or a registrar who will take into account the location and availability of the experts and the Court's case management timetable. The conference may take place at the Court and will usually be conducted in-person. However, if not considered a hindrance to the process, the conference may also be conducted with the assistance of visual or audio technology (such as via the internet, video link and/or by telephone).

7.9 Experts should prepare for a conference of experts by ensuring that they are familiar with all of the material upon which they base their opinions. Where expert reports in draft or final form have been exchanged prior to the conference, experts should attend the conference familiar with the reports of the other experts. Prior to the conference, experts should also consider where they believe the differences of opinion lie between them and what processes and discussions may assist to identify and refine those areas of difference.

Joint-report

7.10 At the conclusion of the conference of experts, unless the Court considers it unnecessary to do so, it is expected that the experts will have narrowed the issues in respect of which they agree, partly agree or disagree in a joint-report. The joint-report should be clear, plain and concise and should summarise the views of the experts on the identified issues, including a succinct explanation for any differences of opinion, and otherwise be structured in the manner requested by the judge or registrar.

7.11 In some cases (and most particularly in some native title cases), depending on the nature, volume and complexity of the expert evidence a judge may direct a registrar to draft part, or all, of a conference report. If so, the registrar will usually provide the draft conference report to the relevant experts and seek their confirmation that the conference report accurately reflects the opinions of the experts expressed at the conference. Once that confirmation has been received the registrar will finalise the conference report and provide it to the intended recipient(s).

8. CONCURRENT EXPERT EVIDENCE

8.1 The Court may determine that it is appropriate, depending on the nature of the expert evidence and the proceeding generally, for experts to give some or all of their evidence concurrently at the final (or other) hearing.

8.2 Parties should familiarise themselves with the *Concurrent Expert Evidence Guidelines* (attached in Annexure B). The Concurrent Evidence Guidelines are not intended to be exhaustive but indicate the circumstances when the Court might consider it appropriate for

concurrent expert evidence to take place, outline how that process may be undertaken, and assist experts to understand in general terms what the Court expects of them.

8.3 If an order is made for concurrent expert evidence to be given at a hearing, any expert to give such evidence should be provided with the Concurrent Evidence Guidelines well in advance of the hearing and should be familiar with those guidelines before giving evidence.

9. FURTHER PRACTICE INFORMATION AND RESOURCES

9.1 Further information regarding Expert Evidence and Expert Witnesses is available on the Court's website.

9.2 Further information to assist litigants, including a range of helpful guides, is also available on the Court's website. This information may be particularly helpful for litigants who are representing themselves.

J L B ALLSOP
Chief Justice
25 October 2016

Annexure A

HARMONISED EXPERT WITNESS CODE OF CONDUCT[2]

APPLICATION OF CODE

1. This Code of Conduct applies to any expert witness engaged or appointed:

   (a) to provide an expert's report for use as evidence in proceedings or proposed proceedings; or

   (b) to give opinion evidence in proceedings or proposed proceedings.

GENERAL DUTIES TO THE COURT

2. An expert witness is not an advocate for a party and has a paramount duty, overriding any duty to the party to the proceedings or other person retaining the expert witness, to assist the Court impartially on matters relevant to the area of expertise of the witness.

CONTENT OF REPORT

3. Every report prepared by an expert witness for use in Court shall clearly state the opinion or opinions of the expert and shall state, specify or provide:

   (a) the name and address of the expert;

   (b) an acknowledgment that the expert has read this code and agrees to be bound by it;

   (c) the qualifications of the expert to prepare the report;

   (d) the assumptions and material facts on which each opinion expressed in the report is based [a letter of instructions may be annexed];

   (e) the reasons for and any literature or other materials utilised in support of such opinion;

   (f) (if applicable) that a particular question, issue or matter falls outside the expert's field of expertise;

   (g) any examinations, tests or other investigations on which the expert has relied, identifying the person who carried them out and that person's qualifications;

   (h) the extent to which any opinion which the expert has expressed involves the acceptance of another person's opinion, the identification of that other person and the opinion expressed by that other person;

   (i) a declaration that the expert has made all the inquiries which the expert believes are desirable and appropriate (save for any matters identified explicitly in the report), and that no matters of significance which the expert regards as relevant have, to the

[2] Approved by the Council of Chief Justices' Rules Harmonisation Committee

knowledge of the expert, been withheld from the Court;

(j) any qualifications on an opinion expressed in the report without which the report is or may be incomplete or inaccurate;

(k) whether any opinion expressed in the report is not a concluded opinion because of insufficient research or insufficient data or for any other reason; and

(l) where the report is lengthy or complex, a brief summary of the report at the beginning of the report.

SUPPLEMENTARY REPORT FOLLOWING CHANGE OF OPINION

4. Where an expert witness has provided to a party (or that party's legal representative) a report for use in Court, and the expert thereafter changes his or her opinion on a material matter, the expert shall forthwith provide to the party (or that party's legal representative) a supplementary report which shall state, specify or provide the information referred to in paragraphs (a), (d), (e), (g), (h), (i), (j), (k) and (l) of clause 3 of this code and, if applicable, paragraph (f) of that clause.

5. In any subsequent report (whether prepared in accordance with clause 4 or not) the expert may refer to material contained in the earlier report without repeating it.

DUTY TO COMPLY WITH THE COURT'S DIRECTIONS

6. If directed to do so by the Court, an expert witness shall:

(a) confer with any other expert witness;

(b) provide the Court with a joint-report specifying (as the case requires) matters agreed and matters not agreed and the reasons for the experts not agreeing; and

(c) abide in a timely way by any direction of the Court.

CONFERENCE OF EXPERTS

7. Each expert witness shall:

(a) exercise his or her independent judgment in relation to every conference in which the expert participates pursuant to a direction of the Court and in relation to each report thereafter provided, and shall not act on any instruction or request to withhold or avoid agreement; and

(b) endeavour to reach agreement with the other expert witness (or witnesses) on any issue in dispute between them, or failing agreement, endeavour to identify and clarify the basis of disagreement on the issues which are in dispute.

ANNEXURE B

CONCURRENT EXPERT EVIDENCE GUIDELINES

APPLICATION OF THE COURT'S GUIDELINES

1. The Court's Concurrent Expert Evidence Guidelines ("**Concurrent Evidence Guidelines**") are intended to inform parties, practitioners and experts of the Court's general approach to concurrent expert evidence, the circumstances in which the Court might consider expert witnesses giving evidence concurrently and, if so, the procedures by which their evidence may be taken.

OBJECTIVES OF CONCURRENT EXPERT EVIDENCE TECHNIQUE

2. The use of concurrent evidence for the giving of expert evidence at hearings as a case management technique[3] will be utilised by the Court in appropriate circumstances (see r 23.15 of the *Federal Court Rules 2011* (Cth)). Not all cases will suit the process. For instance, in some patent cases, where the entire case revolves around conflicts within fields of expertise, concurrent evidence may not assist a judge. However, patent cases should not be excluded from concurrent expert evidence processes.

3. In many cases the use of concurrent expert evidence is a technique that can reduce the partisan or confrontational nature of conventional hearing processes and minimises the risk that experts become "opposing experts" rather than independent experts assisting the Court. It can elicit more precise and accurate expert evidence with greater input and assistance from the experts themselves.

4. When properly and flexibly applied, with efficiency and discipline during the hearing process, the technique may also allow the experts to more effectively focus on the critical points of disagreement between them, identify or resolve those issues more quickly, and narrow the issues in dispute. This can also allow for the key evidence to be given at the same time (rather than being spread across many days of hearing); permit the judge to assess an expert more readily, whilst allowing each party a genuine opportunity to put and test expert evidence. This can reduce the chance of the experts, lawyers and the judge misunderstanding the opinions being expressed by the experts.

5. It is essential that such a process has the full cooperation and support of all of the individuals involved, including the experts and counsel involved in the questioning process. Without that cooperation and support the process may fail in its objectives and even hinder the case management process.

[3] Also known as the "hot tub" or as "expert panels".

CASE MANAGEMENT

6. Parties should expect that, the Court will give careful consideration to whether concurrent evidence is appropriate in circumstances where there is more than one expert witness having the same expertise who is to give evidence on the same or related topics. Whether experts should give evidence concurrently is a matter for the Court, and will depend on the circumstances of each individual case, including the character of the proceeding, the nature of the expert evidence, and the views of the parties.

7. Although this consideration may take place at any time, including the commencement of the hearing, if not raised earlier, parties should raise the issue of concurrent evidence at the first appropriate case management hearing, and no later than any pre-trial case management hearing, so that orders can be made in advance, if necessary. To that end, prior to the hearing at which expert evidence may be given concurrently, parties and their lawyers should confer and give general consideration as to:

   (a) the agenda;

   (b) the order and manner in which questions will be asked; and

   (c) whether cross-examination will take place within the context of the concurrent evidence or after its conclusion.

8. At the same time, and before any hearing date is fixed, the identity of all experts proposed to be called and their areas of expertise is to be notified to the Court by all parties.

9. The lack of any concurrent evidence orders does not mean that the Court will not consider using concurrent evidence without prior notice to the parties, if appropriate.

CONFERENCE OF EXPERTS & JOINT-REPORT OR LIST OF ISSUES

10. The process of giving concurrent evidence at hearings may be assisted by the preparation of a joint-report or list of issues prepared as part of a conference of experts.

11. Parties should expect that, where concurrent evidence is appropriate, the Court may make orders requiring a conference of experts to take place or for documents such as a joint-report to be prepared to facilitate the concurrent expert evidence process at a hearing (see Part 7 of the Expert Evidence Practice Note).

PROCEDURE AT HEARING

12. Concurrent expert evidence may be taken at any convenient time during the hearing, although it will often occur at the conclusion of both parties' lay evidence.

13. At the hearing itself, the way in which concurrent expert evidence is taken must be applied flexibly and having regard to the characteristics of the case and the nature of the evidence to be given.

14. Without intending to be prescriptive of the procedure, parties should expect that, when evidence is given by experts in concurrent session:

(a) the judge will explain to the experts the procedure that will be followed and that the nature of the process may be different to their previous experiences of giving expert evidence;

(b) the experts will be grouped and called to give evidence together in their respective fields of expertise;

(c) the experts will take the oath or affirmation together, as appropriate;

(d) the experts will sit together with convenient access to their materials for their ease of reference, either in the witness box or in some other location in the courtroom, including (if necessary) at the bar table;

(e) each expert may be given the opportunity to provide a summary overview of their current opinions and explain what they consider to be the principal issues of disagreement between the experts, as they see them, in their own words;

(f) the judge will guide the process by which evidence is given, including, where appropriate:

(i) using any joint-report or list of issues as a guide for all the experts to be asked questions by the judge and counsel, about each issue on an issue-by-issue basis;

(ii) ensuring that each expert is given an adequate opportunity to deal with each issue and the exposition given by other experts including, where considered appropriate, each expert asking questions of other experts or supplementing the evidence given by other experts;

(iii) inviting legal representatives to identify the topics upon which they will cross-examine;

(iv) ensuring that legal representatives have an adequate opportunity to ask all experts questions about each issue. Legal representatives may also seek responses or contributions from one or more experts in response to the evidence given by a different expert; and

(v) allowing the experts an opportunity to summarise their views at the end of the process where opinions may have been changed or clarifications are needed.

15. The fact that the experts may have been provided with a list of issues for consideration does not confine the scope of any cross-examination of any expert. The process of cross-examination remains subject to the overall control of the judge.

16. The concurrent session should allow for a sensible and orderly series of exchanges between expert and expert, and between expert and lawyer. Where appropriate, the judge may allow for more traditional cross-examination to be pursued by a legal representative on a particular issue exclusively with one expert. Where that occurs, other experts may be asked to comment on the evidence given.

17. Where any issue involves only one expert, the party wishing to ask questions about that issue should let the judge know in advance so that consideration can be given to whether

arrangements should be made for that issue to be dealt with after the completion of the concurrent session. Otherwise, as far as practicable, questions (including in the form of cross-examination) will usually be dealt with in the concurrent session.

18. Throughout the concurrent evidence process the judge will ensure that the process is fair and effective (for the parties and the experts), balanced (including not permitting one expert to overwhelm or overshadow any other expert), and does not become a protracted or inefficient process.

ANNEXURE B– QUESTIONS TO EXPERT

In providing your response to the following questions, please consider information that was in the public domain as at 17 June 2021:

1. Provide a brief description of the causes and effects of anthropogenic climate change.
2. Provide a brief description of any impacts of anthropogenic climate change already being experienced in Australia and the world.
3. In your opinion what, if any, is the amount of future temperature rise above pre-industrial levels caused by anthropogenic climate change that is already committed as a consequence of GHG emissions to date?
4. Provide a brief description of Australian and global targets for limiting climate change impacts.
5. What is the relationship between the amount of further emissions of greenhouse gas (**GHG**) from human industrial activity, including the combustion of liquified natural gas, and future GHG concentration and temperatures above pre-industrial levels?
6. In your opinion, what are the likely future impacts of anthropogenic climate change at a national and global level? In providing your response, please consider:
    a. warming scenarios that are consistent with meeting the goals of the Paris Agreement; and
    b. warming scenarios that are consistent with the current trajectory of greenhouse gas emissions.
7. What is the relationship between GHG emissions from the extraction and consumption of gas from the Beetaloo sub-basin and the remaining carbon budget for limiting global temperature rise to (i) approximately 1.5°C above pre-industrial levels; (ii) 1.8°C above pre-industrial levels; (iii) 2°C above pre-industrial levels;
8. What is the relationship between the total GHG emissions from the extraction and consumption of gas from the Beetaloo sub-basin and:
    a. Australia's current annual GHG emissions; and
    b. Australia's share of the remaining carbon budget for limiting global temperature rise to (i) approximately 1.5°C above pre-industrial levels; (ii) 1.8°C above pre-industrial levels; and (iii) 2°C above pre-industrial levels.
9. In your opinion is the exploration of the three wells for which grants have been made (namely 2D Seismic & Carpentaria 2, Carpentaria 3 and Carpentaria 4 & 3D Seismic) (the **Three Wells**); and/or extraction and use of gas from those areas; and/or the extraction and use of gas from the Beetaloo sub-basin more broadly; consistent with Australian and global targets for limiting climate change impacts?
10. In your opinion, will the exploration of the Three Wells and/or extraction and use of gas from those areas and/or the extraction and use of gas from the Beetaloo sub-basin more broadly, have any impact on the risks associated with climate change? If so, please set out your reasoning in relation to the nature and extent of that impact.

ANNEXURE C – INDEX TO BRIEF

No.	Document	Date
	PLEADINGS	
1.	Originating Application	28 July 2021
2.	Concise Statement	16 August 2021
	LEGISLATION	
3.	*Industry Research and Development (Beetaloo Cooperative Drilling Program) Instrument 2021* (**the Instrument**)	11 May 2021
4.	Explanatory Statement to the Instrument	13 May 2021
	DOCUMENTS BEFORE THE MINISTER WHEN MAKING THE INSTRUMENT	
5.	Ministerial Submission issued by the Department of Industry of Industry, Science, Energy and Resources to the Minister for Resources, Water and Northern Australia making recommendations in respect of the making of the Instrument (**Ministerial Recommendation**)– MLO version	23 April 2021
6.	Attachment A to the Ministerial Recommendation – *Industry Research and Development (Beetaloo Cooperative Drilling Program) Instrument 2021* (Draft)	23 April 2021
7.	Attachment B to the Ministerial Recommendation – Explanatory Statement	23 April 2021
8.	Attachment C to the Ministerial Recommendation – Background Brief	23 April 2021
9.	Signed Ministerial Recommendation approving the making of the Instrument	11 May 2021
	EMPIRE APPLICATION FOR FUNDING	
10.	Imperial Application for Beetaloo Grant – Empire Beetaloo Acceleration Program Carpentaria-2 Horizontal Well (**BCP00001**)	7 April 2021
11.	BCP00001 Application Annexure A – Project Budget	7 April 2021
12.	Imperial Application for Beetaloo Grant – Empire Beetaloo Acceleration Program Carpentaria-3 Horizontal Well' (**BCP00002**)	7 April 2021
13.	BCP00002 Application Annexure A – Project Budget	7 April 2021
14.	Imperial Application for Beetaloo Grant – Empire Beetaloo Acceleration Program Carpentaria-4 and 3D Seismic (**BCP00003**)	7 April 2021
15.	BCP00003 Application Annexure A – Project Budget	7 April 2021
	DOCUMENTS RELATING TO APPROVAL OF THE APPLICATIONS	
16.	DISER Eligibility and Completeness Checklist for BCP00001 completed by Mario Pricone (Assessor) and Janet Lau (QA Officer)	7 -8 May 2021
17.	DISER Eligibility and Completeness Checklist for BCP00002 completed by Mario Pricone (Assessor) and Janet Lau (QA Officer)	7 -8 May 2021

18.	DISER Eligibility and Completeness Checklist for BCP00003 completed by Mario Pricone (Assessor) and Janet Lau (QA Officer)	7 -8 May 2021
19.	Meeting Minutes of the Beetaloo Cooperative Drilling Program Assessment Committee (**Assessment Committee**) Meeting on 27 May 2021 and 1 June 2021	1 June 2021 and 7 June 2021
20.	Attachment A to the Meeting Minutes of Assessment Committee Meeting– Excel spreadsheet of all Program applications	27 May 2021
21.	Attachment C to the Meeting Minutes of the Assessment Committee Meeting – Questions from Committee to Imperial and Imperial's responses	1 June 2021
22.	Scorecard (Summary)- Assessment Committee member Daniel Quin	
23.	Scorecard (Summary)- Assessment Committee member Merrie-Ellen Gunning	
24.	Scorecard for BCDP000001 - Assessment Committee member Louis Gomatos	
25.	Scorecard for BCDP000002 - Assessment Committee member Louis Gomatos	
26.	Scorecard for BCDP000003 - Assessment Committee member Louis Gomatos	
DOCUMENTS BEFORE THE MINISTER WHEN MAKING THE DECISION		
27.	Ministerial Submission issued by the Department of Industry of Industry, Science, Energy and Resources to the Minister for Resources, Water and Northern Australia making recommendations in respect of the Decision (**Ministerial Recommendation**)– MLO version	16 June 2021
28.	Minister's signed Decision approving Ministerial Recommendation	17 June 2021
29.	Annexure A to Ministerial Recommendation – BCDP Recommended Projects	17 June 2021
30.	Annexure B to Ministerial Recommendation - Program Guidelines	17 June 2021
31.	Annexure C to Ministerial Recommendation – Governance and Program Background	17 June 2021
32.	Annexure D to Ministerial Recommendation – Legal Advice (Redacted – Subject to LPP)	17 June 2021
DECISION ANNOUNCEMENTS		
33.	Minister's Media Release on the Decision	7 July 2021
34.	Empire Energy ASX Announcement on the Decision	8 July 2021
RELEVANT OTHER DOCUMENTS		
35.	'Unlocking the Beetaloo – The Beetaloo Strategic Basin Plan'	Jan 2021
36.	Commonwealth Grants Rules and Guidelines 2017	Current

37.	Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory	April 2018
RELEVANT IMPERIAL DOCUMENTS		
38.	Empire Energy ASX announcement entitled "Material Beetaloo Resource Upgrade"	22 February 2021
39.	Morgans report entitled "Backing the Beetaloo" published on Empire Energy's 'Investors' section of website	26 November 2020
ENVIRONMENTAL MANAGEMENT PLANS (EMPS) FOR EP187		
IMP2-04 – Imperial 2019 Drilling Program NT Exploration Permit 187 - APPROVED		
40.	Imperial Environmental Management Plan IMP2-04	Submitted 22 August 2019
41.	Attachment to Imperial EMP IMP2-04 – Emergency Response Plan	Submitted 22 August 2019
42.	NT Government EPA advice in respect of IMP2-04	6 January 2020
43.	NT Government – Approval Notice and Statement of Reasons	2 March 2020
IMP2-6.1 – Imperial 2020-21 Drilling Program NT Exploration Permit 187 - APPROVED		
44.	Imperial Environmental Management Plan IMP2-6.1	Submitted 30 June 2020
45.	Attachments to EMP IMP2-6.1	Submitted 30 June 2020
46.	NT Government EPA advice in respect of IMP2-6.1	9 September 2020
47.	NT Government – Approval Notice and Statement of Reasons	30 September 2020
48.	EP187 Groundwater monitoring results	25 March - 22 October 2020
49.	Imperial Drilling Fluid waste water analysis from the Carpentaria-1 Well site	28 October 2020
IMP3-4 – Hydraulic fracturing and extended production testing of the existing Carpentaria-1 Vertical exploration well on EP187 – APPROVED		
50.	Imperial Environmental Management Plan IMP3-4	Submitted 17 November 2020
51.	Appendices to IMP3-4	Submitted 17 November 2020
52.	NT Government EPA advice in respect of IMP3-4	5 February 2021
53.	NT Government – Approval Notice and Statement of Reasons	15 February 2021

Certificate of Annexure NA-3

No. NSD758 of 2021

Federal Court of Australia

District Registry: New South Wales

Division: General

Environment Centre NT Inc

Applicant

Minister for Resources and Water and another

Respondents

This and the following 11 pages form Annexure NA-3 to the Affidavit of Nerilie Abram affirmed on 10 September 2021 before me.

_____

Signature of witness

Name: Anna Gudkov
Qualification: Solicitor

Curriculum Vitae of Professor Nerilie Abram

August 2021

Address: Research School of Earth Sciences, The Australian National University, Acton 2601, ACT
Phone: (02) 6125 1978
Email: nerilie.abram@anu.edu.au
Citizenship: Australian and British

Formal Qualifications

Doctor of Philosophy (2000-2004), The Australian National University.
Awarded the Robert Hill Memorial Prize.

Bachelor of Science (Advanced) with first class Honours (1996-1999), The University of Sydney.
Awarded the University Medal.

Appointments

2021– Associate Director (Research), Research School of Earth Sciences, ANU.

2020– Professor, The Australian National University

2017–21 Future Fellow (Australian Research Council), The Australian National University.

2016–19 Associate Professor, The Australian National University.

2015 Permanent academic appointment, Research Fellow, The Australian National University.

2011–16 QEII Research Fellow (Australian Research Council), The Australian National University.

2009–11 Group Manager (ice cores), British Antarctic Survey, Cambridge, UK.

2004–09 Palaeoclimatologist (ice cores), British Antarctic Survey, Cambridge, UK.

Maternity leave career breaks in 2003, 2005 and 2008. Maternity leave and intervals of part-time work during return-to-work periods are equivalent to ~2.5 years out of my research career.

Honours and Awards

- College of Science Dean's Commendation for Teaching Excellence, 2020.
- Priestly Medal, Australian Meteorological and Oceanographic Association, 2019.
- Vice Chancellor's Award for Impact and Engagement, 2019.
- Vice Chancellor's Award for Advancing the Reputation of the University through Media, 2016.
- ANU Media and Outreach Awards, 2016. Highly commended for "*Impact award for reach and influence*".
- Dorothy Hill Award, Australian Academy of Science, 2015.
- Finalist for Malcolm McIntosh Prize for Physical Scientist of the Year, 2015 and 2016 Prime Minister's Prizes.
- ANU Media and Outreach Awards, 2014. Highly commended for "*Close up award for best talent on film*".
- Finalist for Eureka Prize for Environmental Research, 2007.
- Robert Hill Memorial Prize, ANU, 2003.
- University Medal, University of Sydney, 2000.
- Elliston Medal, Earth Resources Foundation, 2000.

Academic and Research Leadership

- Deputy Director, Australian Centre for Excellence in Antarctic Science (2021–present). This is a $25M research centre with 39 chief investigators across 7 universities, with further extensive national and international partnerships.

- Leader of Drought Program (2021–present) and member of Impact and Engagement Committee (2017–present), ARC Centre of Excellence for Climate Extremes. This is a $35M research centre with 16 chief investigators across 5 universities, with further extensive national and international partnerships.

- Co-lead of CoralHydro2k working group, PAGES 2k network (2017–present).

- Coordinating Lead Author, IPCC Special Report for the Ocean and Cryosphere in a Changing Climate (2017–2019). Involved co-leading a chapter team of 15 scientists spanning a diversity of career stages, geographic location, and expertise. Successfully delivered the chapter milestones to a tight-time frame, working with the leadership of the IPCC and negotiating the summary for policymakers through the government approval process.

- Coordinators team for PAGES 2k Network (2016–2021; Phases 2 and 3 of program). The longest running community project of the Past Global Changes program, with numerous project groups across a community of more than 1000 researchers.

- Member of Advisory Board for the ANU Climate Change Institute (2017–2020).

- Chair of Faculty, Research School of Earth Sciences (2018–2020).

- RSES Marketing and Outreach coordinator, and chair of committee (2012–2016).

Professional Service

- Chair of National Committee for Antarctic Research, Australian Academy of Science (2021–present).
- Co-Editor-in-Chief for peer-review journal, *Climate of the Past,* (2015–2017 and 2020–present).
- Member of the Australian Antarctic Science Council (2021–present).
- Selection committee for Dorothy Hill Medal, Australian Academy of Science (2019–2021).
- Member of National Committee for Antarctic Research, Australian Academy of Science (2016–2020).
- Member of the science sub-committee to the board of the Antarctic Science Foundation (2018–2020).
- Member of National Committee for Earth System Science, Australian Academy of Science (2015–2018).
- Editor for peer-review journal, *Climate of the Past* (2010–2015).
- I have been a frequent guest speaker for public events of the ANU Climate Change Institute
- I am a frequent science communicator, including writing for The Conversation where my articles have reached a readership of more than 788,000 people.

Research Funding

National Environmental Science Program 2 – Climate Systems Hub. Marsland, S., et al., including Abram as ANU lead-CI. $38M for 2021-2027 (Department of Agriculture, Water and Environment).

ARC Special Research Initiative for Excellence in Antarctic Science. King, M., and 39 other CIs, including 6 ANU CIs (Armand, Abram, Ellwood, Morrison, Rohling, Tregoning). *The Australian Centre for Excellence in Antarctic Science*. $20M for 2021-2025 (SE200100008).

ANU Major Equipment Grants: Ellwood, Abram, Fallon, Eggins, Opdyke. *Renewing ANU capabilities in trace element analysis for environmental studies*. $80,000 in 2019 for a new trace element ICP-OES system (19MEC18).

Department of Environment and Energy: Howden, M., Abram, N., Bai, X., *IPCC AR6 Authors*, $33,000 for 2019-2021.

Australian Antarctic Science Program: Vance, T., Abram, N.J., Curran, M., Gallant, A., Moy, A., Roberts, J., Vallelonga, P., Plummer, C., Favier, V. *IPICS 2k ice core array: Filling the climatological gap of the Indian Ocean sector from Wilhelm II Land.* 2017-2021 (AASP4414).

ARC Centres of Excellence: Pitman et al., and 16 other CIs (including Abram) from UNSW, ANU, Melbourne, Monash and University of Tasmania, *Centre of Excellence for Climate Extremes*, $30M for 2017-2023 (CE170100023).

ARC Future Fellowships: Abram (CI), *Quantifying and mitigating changes in Australia's rainfall belts*, $933,000 for 2017-2021 (FT160100029).

ANU Major Equipment Grants: Abram, Farquhar and Rohling, *ANU water isotope capabilities for climate, environmental and biological research*, $210,000 in 2016 for 2 new Picarro water isotope systems (16MEC11).

ANU Computational Merit Allocation Scheme: Abram, N. (lead CI), Ackerley, D., Lewis, S.E., Phipps, S.J., Dommenget, D. *An ensemble of simulations for Australasian palaeoclimate data-model assessments*, 320 kSU in 2016 (~$32,000 equivalent).

ANU Computational Merit Allocation Scheme: Abram, N.J. (lead CI), Lewis, S.E. and Phipps, S.J. *Testing the drivers of Southern Annular Mode changes over the last millennium*. 100 kSU in 2015 (~AUD$10,000 equivalent).

ARC Discovery Projects Abram, N.J. (CI), Mulvaney, R. (PI), Curran, M.A.J. (PI), Treble, P.C. (PI) and Vance, T. (PI). *Equator to Pole: reconstructing tropical and Antarctic climate variability over the last millennium and their impacts on southern Australian rainfall*. AUD$480,000 for 2014-2016 (DP140102059).

ARC Discovery Projects (**including QEII Fellowship)** Gagan, M.K. (CI), Abram, N.J. (QEII), Hantoro, W.S. (PI), Natawidjaja, D.H. (PI), Shen, C.-C. (PI), Sieh, K. (PI), Edwards, R.L. (PI), Cheng, H. (PI) and Schmidt, G. (PI). Climate and natural hazards in Australasia: a comprehensive impact analysis of prehistoric droughts, great earthquakes, and the Toba super-eruption. AUD$835,000 for 2011-2016 (DP110101161).

NERC PhD studentships Abram, N.J. (CI), Blackwell, P. (CI), Wolff, EW. (PI) and Sime, L.C. (PI). *Annual layer counting in ice cores: developing an objective statistical tool. GBP£46,000 (approx.) for 2010-2013.*

Plenary, Keynote and Invited Lectures (selected examples since 2014)

2021 CLIVAR Tropical Basin Interactions workshop. **Invited**: *Paleoclimate perspectives on the Indian Ocean Dipole.*

2020 SCAR Open Science Conference. **David Walton Memorial Lecture**: *Discovering Antarctica's climate secrets.*

2020 Bureau of Meteorology Research and Development workshop. **Invited**: *Connections of climate change and variability to large and extreme forest fires in southeast Australia.*

2020 Celebrating Antarctica: climate change, biodiversity, and science, Climate Change Institute public event, co-hosted by Italian, French and British embassies. **Guest speaker**: *Antarctica in a warming world.*

2019 The IPCC ocean and cryosphere report, Climate Change Institute public event. **Guest speaker**: *The Ocean and Cryosphere in a Changing Climate.* Also delivered separately to the Department of Environment.

2019 Asia Oceania Geosciences Society, Singapore. **Distinguished lecture**: *Tight coupling of tropical Indian and Pacific variability through the last millennium.*

2019 ANU Climate Update 2019, Climate Change Institute public event. **Guest speaker**: *Climate Impacts: oceans and coral reefs.*

2018 AGU Fall Meeting, Washington DC. **Invited**: *Indian Ocean Dipole variability during the last millennium*

2018 Monash University. **Invited**: *Indian Ocean Dipole variability during the last millennium*.

2018 AntClim21 workshop, Davos. **Invited**: *Causes and impacts of pre-instrumental variations in the Southern Annular Mode.*

2017 Ice Core Analysis Techniques, Copenhagen (PhD and ECR training course). **Invited**: *Climate reconstructions.*

2017 PAGES Open Science meeting, Zaragoza. **Plenary**: *The onset of Industrial-era warming across the oceans and continents*.

2017 Time, Technologies and the Anthropocene symposium, ANU. **Invited**: *The onset of Industrial-era warming across the oceans and continents*.

2017 Lessons learnt from paleoscience on a possible 1.5 – 2^{o}C warmer world in the future, Bern. **Invited**: *The onset of Industrial-era warming across the oceans and continents*.

2017 Australian Meteorological and Oceanographic Society annual meeting, Canberra. **Plenary**: *The onset of Industrial-era warming across the oceans and continents*.

2015 Antarctica2k workshop (September 2015, Venice), Ocean2k workshop (October 2015, Barcelona), and Australasia2k workshop (October 2015, Auckland). **Invited**: *The onset of Industrial-era warming across the oceans and continents*.

2015 Large-scale climate variability in Antarctica and the Southern Ocean over decades to centuries, and links to extra-polar climate, San Diego. **Invited**: *Evolution of the Southern Annular Mode over the past millennium.*

2015 Invited seminars at Cambridge University, the British Antarctic Survey, and University of Copenhagen (April 2015).

2014 AGU Fall Meeting, San Francisco. **Invited**: *What can sea ice reconstructions tell us about recent regional trends in sea ice around Antarctic?* Sea Ice in Earth history session.

2014 ARC Centre of Excellence for Climate System Science Annual Workshop, Hunter Valley. **Invited**: *Evolution of the Southern Annular Mode over the past millennium.*

2014 International Symposium on Sea Ice in a Changing Environment, Hobart. **Keynote**: *Before satellites: reconstructing past sea-ice changes using proxy records.*

Conference organisation

- Organising committee member for *Paleo-ENSO workshop*, Belitung, Indonesia (August 2019).
- Organising committee member for *2018 Negative Emissions conference*, Shine Dome (October 2018).
- Co-chair of organising committee for 2017 Theo Murphy Australian Frontiers of Science conference on *The Antarctic Frontier: Developing research in an extreme environment*, Hobart (September 2017).

Publications

- Scopus statistics: H-index = 28, G-index = 55, Field-weighted citation impact = 3.1 (ID: 22633807400)
- Google Scholar statistics: H-index = 33 (last 5-years = 27), i10-index = 51 (last 5 years = 47)
- ORCID: 0000-0003-1246-2344

Scholarly Book Sections and Theses

B11. **IPCC** (2019) Summary for Policymakers. In: *Special Report on the Ocean and Cryosphere in a Changing Climate*.

B10. **Abram, N.J.**, Gattuso, J.-P., Prakash, A., Chidichimo, M.P., Crate, S., Enomoto, H., Garschagen, M., Gruber, N., Harper, S., Holland, E., Kudela, R.M., Rice, J., Steffen, K., and von Schuckmann, K. (2019). Framing and Context (Chapter 1). In: *Special Report on the Ocean and Cryosphere in a Changing Climate*.

B9. **Abram, N.J.**, Cheung, W., Cheng, L., Frolicher, T., Hauser, M., He, S., Hollowed, A., Marzeion, B., Morin, S., Pirani, A., and Swingedouw, D. (2019). Scenarios, pathways and reference periods (Cross-Chapter Box 1). In: *Special Report on the Ocean and Cryosphere in a Changing Climate*.

B8. Adler, C., Oppenheimer, M., **Abram, N.J.**, McInnes, K., and Schuur, E. (2019). Confidence and Deep Uncertainty (Cross-Chapter Box 5). In: *Special Report on the Ocean and Cryosphere in a Changing Climate*.

B7. **Abram, N.J.** (2018). FactCheck Q&A: Was it four degrees hotter 110,000 years ago? In: Watson, J. *The Conversation Yearbook 2017: 50 articles that informed public debate*. Melbourne University Press, ISBN: 9780522872668.

B6. **Abram, N.J.** (2014) Antarctic Ice: Going, going,…. In: Hay, A. (ed.) 2014 *Best Australian Science Writing*. UNSW Press

B5. **Abram, N.J.** (2013) Antarctic Ice: Going, going, going? In: Dayton, L. (ed.) The Curious Country. ANU Press, for the Office of the Chief Scientist.

B4. Gagan, M.K. and **Abram, N.J.** (2011). Stable isotopes and trace elements. In: Hopley, D. (ed) *Encyclopedia of modern coral reefs: structure, form and process*. Encyclopedia of Earth Science Series, Springer-Verlag.

B3. Hodgson, D.A., **Abram, N.J.**, Anderson, J., Bargelloni L., Barrett P., Bentley M.J., Bertler N.A.N., Chown S., Clarke A., Convey P., Crame A., Crosta X., Curran M., di Prisco G., Francis J.E., Goodwin I., Gutt J., Masse G., Masson-Delmotte V., Mayewski P.A., Mulvaney R., Peck L., Portner H.-O., Rothlisberger R., Stevens M.I., Summerhayes C.P., van Ommen T., Verde C., Verleyen E., Vyverman W., Wiencke C. and Zane L. (2009) *Antarctic climate and environmental history in the pre-instrumental period*. In: Turner, J. Convey P., di Prisco G., Mayewski P.A., Hodgson D.A., Fahrbach E, Bindschadler R. and Gutt J. (eds) *Antarctic Climate Change and the Environment*. Scientific Committee for Antarctic Research, Cambridge.

B2. **Abram N.J**. (2004). Multi-proxy coral reconstruction of Holocene climate and reef growth in the eastern Indian Ocean. *PhD thesis, Research School of Earth Sciences, The Australian National University*, 262pp.

B1. **Abram N.J.** (1999). High resolution record of Holocene environmental variations at Kikai-jima, Japan. *BSc Advanced Honours thesis, School of Geosciences, The University of Sydney*, 84 pp.

Refereed Journal Articles

* Indicates publication led by a PhD student
† Indicates Scopus 90th to 99th percentile for citations (40% of my publications are in top 10% of citations worldwide)
‡ Indicates Scopus 99th percentile for citations
§ Indicates Web of Science "Highly Cited Paper" (top 1% of field) in last 5 years
84% of my publications are published in the top 10% of journals (Scopus SciVal)

J54. **Abram, N.J.**, Henley, B.J., Sen Gupta, A. Lippmann, T.J.R., Clarke, H., Dowdy, A.J., Sharples, J.J., Nolan, R.H., Zhang, T., Wooster, M.J., Wurtzel, J.B., Meissner, K.J., Pitman, A.J., Ukkola, A.M., Murphy, B.P., Tapper, N.J., Boer, M.M. (2021). Connections of climate change and variability to large and extreme forest fires in southeast Australia. *Communications Earth and Environment* 2, 8, doi: 10.1038/s43247-020-00065-8.

J53. McConnell, J.R., Chelman, N.J., Mulvaney, R., Eckhardt, S., Stohl, A., Plunket, G., Kipfstuhl, S., Freitag, J., Isakssan, E., Gleason, K.E., Brugger, S., McWethy, D.B., **Abram, N.J.**, Liu, P. and Aristarain, A.J. (2021). Hemispheric black carbon increase after 13th C Māori arrival in New Zealand. *Nature.* (in press, accepted 27/07/2021).

J52. Ummenhofer, C.C., Murty, S.A., Sprintall, J., Lee, T., and **Abram, N.J.** (2021). Heat and freshwater changes in the Indian Ocean region. *Nature Reviews Earth and Environment* 2, 525–541.

J51.* Crockart, C.K., Vance, T.R., Fraser, A.D., **Abram, N.J**., Criscitiello, A.S., Curran, M.A.J., Favier, V., Gallant, A.J.E., Kjær, H.A., Klekociuk, A.R., Jong, L.M., Moy, A.D., Plummer, C.T., Vallelonga, P.T., Wille, J., and

Zhang, L. (2021). El Niño Southern Oscillation signal in a new East Antarctic ice core, Mount Brown South, *Climate of the Past*.

J50.†§ **Abram, N.J.,** Wright, N.M., Ellis, B., Dixon, B.C., Wurtzel, J.B., England, M.E., Ummenhofer, C.C., Philibosian, B., Cahyarini, S.Y., Yu, T.-L., Shen, C.-C., Cheng, H., Edwards, R.L., Heslop, D. (2020). Coupling of Indo-Pacific climate variability through the last millennium. *Nature.* 579, 385-392

J49.† **Abram, N.J.,** Hargreaves, J.A., Wright, N.M., Thirumalai, K., Ummenhofer, C.C. and England, M.H. (2020). Palaeoclimate perspectives on the Indian Ocean Dipole. *Quaternary Science Reviews* 237, 106302.

J48. Konecky, B.L., McKay, N.P., Churakova (Sidorova), O.V., Comas-Bru, L., Dassié, E.P., DeLong, K.L., Falster, G.M., Fischer, M.J., Jones, M.D., Jonkers, L., Kaufman, D.S., Leduc, G., Managave, S.R., Martrat, B., Opel, T., Orsi, A.J., Partin, J.W., Sayani, H.R., Thomas, E.K., Thompson, D.M., Tyler, J.J., **Abram, N.J.**, Atwood, A.R., Cartapanis, O., Conroy, J.L., Curran, M.A., Dee, S.G., Deininger, M., Divine, D.V., Kern, Z., Porter, T.J., Stevenson, S.L., von Gunten, L., and Iso2k Project Members (2020). The Iso2k database: a global compilation of paleo-$\delta^{18}O$ and $\delta^{2}H$ records to aid understanding of Common Era climate, *Earth Syst. Sci. Data*, 12, 2261–2288

J47.*†§Freund, M.B., Henley, B.J., Karoly, D.J., McGregor, H.V., **Abram, N.J.**, and Dommenget, D. (2019). Higher frequency of Central Pacific El Niño events in recent decades. *Nature Geoscience*. doi: 10.1038/s41561-019-0353-3

J46. Bracegirdle, T.J., Colleoni, F., **Abram, N.J.**, Bertler, N., Dixon, D.A., England, M., Favier, V., Fogwill, C., Fyfe, J.C., Goodwin, I., Goosse, H., Hobbs, W., Jones, J.M., Keller, E.D., Khan, A., Phipps, S.J., Raphael, M., Russell, J., Sime, L., Thomas, E.R., van den Broeke, M., Wainer, I. (2019). Back to the Future: Using long-term observational and paleo-proxy reconstructions to improve model projections of Antarctic climate. *Geosciences* 9 (6), 255. doi:10.3390/geosciences9060255

J45.* Datwyler, C., **Abram, N.J.**, Grosjean, M., Wahl, E., Neukom, R. (2019). ENSO variability, teleconnection changes and response to large volcanic eruptions since AD 1000. *International Journal of Climatology*. doi: 10.1002/joc.5983

J44.* Dey, R., Lewis, S., and **Abram, N.J.** (2019). Investigating observed northwest Australian rainfall trends in CMIP5 detection and attribution experiments. *International Journal of Climatology*, 39 (1), 112-127, doi: 10.1002/joc.5788

J43.*†§Dey, R., Lewis, S., Arblaster, J., and **Abram, N.J.** (2019). A Review of Past and Projected Changes in Australia's Precipitation: Trends, Means and Extremes. *WIRES Climate Change*, https://doi.org/10.1002/wcc.577

J42.* Ellis, B., Grant, K., Mallela, J., **Abram, N.J.** (2019). Is XRF core scanning a viable method of coral palaeoclimate temperature reconstructions? *Quaternary International*. doi: 10.1016/j.quaint.2018.11.044

J41.* Krause, C.E., Gagan, M.K., Dunbar, G.B., Helstrom, J.C., Cheng, H., Edwards, R.L., Hantoro, W.S., **Abram, N.J.**, and Rifai, H. (2019). Meridional and zonal drivers of Australasian monsoon hydroclimate over the last 40,000 years. *Earth and Planetary Science Letters*, 513, 103-112, doi: 10.1016/j/epsl.2019.01.045

J40.* Klein, F., **Abram, N.J.**, Curran, M.A.J., Goosse, H., Goursaud, S., Masson-Delmotte, V., Moy, A., Neukom, R., Orsi, A., Sjolte, J., Steiger, N., Stenni, B., and Werner, M. (2019). Assessing the robustness of Antarctic temperature reconstructions over the past two millennia using pseudoproxy and data assimilation experiments. *Climate of the Past*. 15, 661-684, doi: 10.5194/cp-15-661-2019

J39. Turney, C.S.M, McGregor, H.V., Francus, P., **Abram, N.**, Evans, M.N., Goosse, H., von Gunten, L., Kaufman, D., Linderholm, H., Loutre, M.F. and Neukom, R. (2019). Introduction to the Special Issue on Climate of the Past 2000 Years: Global and Regional Syntheses. *Climate of the Past*, 16, 611-615, doi: 10.5194/cp-15-611-2019

J38.†§ Fischer, H., Meissner, K., Mix, A., et al., including **Abram N.J.** (2018), Palaeoclimate constraints on the impact of 2°C anthropogenic warming and beyond. *Nature Geoscience*. doi: 10.1038/s41561-018-0146-0

J37. Kaufman, D. and PAGES 2k special-issue editorial team, including **Abram, N.J.** (2018), Technical Note: Open-paleo-data implementation pilot – The PAGES 2k special issue, *Climate of the Past*, https://doi.org/10.5194/cp-14-593-2018

J36.† NEEM Aerosol Community, led by Fischer, H. and including **Abram, N.J.** (2018), Greenland records of aerosol source and atmospheric lifetime changes from the Eemian to the Holocene. *Nature Communications*, 9:1476, doi: 10.1038/s41467-018-03924-3

J35. Sigl, M., **Abram, N.J.**, Gabrieli, J., Jenk, T.M., Osmont, D., and Schwikowski, M. (2018), 19th century glacier retreat in the Alps preceded the emergence of industrial black carbon deposition on high-alpine glaciers, *The Cryosphere*, https://doi.org/10.5194/tc-12-3311-2018

J34.* Wurtzel, J.B., **Abram, N.J.**, Lewis, S.E., Bajo, P., Helstrom, J.C., Troitzsch, U. and Heslop, D. (2018). Tropical Indo-Pacific hydroclimate response to North Atlantic forcing during the last deglaciation as recorded by a speleothem from Sumatra, Indonesia. *Earth and Planetary Science Letters*, 492, 264-278, https://doi.org/10.1016/j.epsl.2018.04.001

J33.*† Datwyler, C., Neukom, R., **Abram, N.J.**, Gallant, A., Grosjean, M., Jacques-Coper, M., Karoly, D., and Villalba, R. (2017). Teleconnection stationarity, variability and trends of the Southern Annular Mode (SAM) during the last millennium. *Climate Dynamics*, doi:10.1007/s00382-017-4015-0.

J32. Hessl, A., Allen, K., Vance, T., Abram, N.J. and Saunders, K. (2017). Reconstructions of the Southern Annular Mode (SAM) during the Last Millennium. *Progress in Physical Geography*. doi:10.1177/0309133317743165

J31.‡§ PAGES 2k Consortium, led by Emile-Geay, J. and including **Abram, N.J.** (2017). A global multiproxy database for temperature reconstructions of the Common Era. *Nature Scientific Data*, doi: 10.1038/sdata.2017.88

J30.† Stenni, B., Curran, M., **Abram, N.J.**, Orsi, A., and 14 others from the Antarctica 2k working group (2017). Antarctic climate variability at regional and continental scales over the last 2,000 years, *Climate of the Past*, doi:10.5194/cp-13-1609-2017

J29.‡§ **Abram, N.J.,** McGregor, H.V., Tierney, J.E., Evans, M.N., McKay, N.P., Kaufman, D.S. and the PAGES 2k Consortium^ (2016). The onset of Industrial-era warming across the continents and oceans. *Nature.*
^PAGES 2k Consortium name includes an additional 21 authors.

J28.†§ Jones, J.M., Gille, S.T., Goosse, H., **Abram, N.J.**, and 21 other co-authors (2016). Assessing recent trends in high-latitude Southern Hemisphere surface climate. Nature Climate Change, 6, 917-926, doi:10.1038/nclimate3103

J27. Hobbs, W., Curran, M.A.J., **Abram, N.J.** and Thomas, E.R. (2016). Century-scale perspectives on observed and simulated Southern Ocean sea ice trends. Journal of Geophysical Research, 121, 7804-7818, doi: 10.1002/2016JC012111

J26. Thomas, E.R. and **Abram, N.J.** (2016). Ice core reconstruction of sea ice change in the Amundsen-Ross Seas since 1702AD. *Geophysical Research Letters*, 43, 5309-5317, doi: 10.1002/2016GL068130

J25. Vance, T., Roberts, J., Moy, A., Curran, M., Tozer, C., Gallant, A., **Abram, N.J.**, van Ommen, T., Young, D., Blankenship, D., Siegert, M., and Grima, C. (2016). Optimal site selection for a high resolution ice core record in East Antarctica. *Climate of the Past*, 12, 595-610, doi:10.5194/cp-12-595-2016

J24. **Abram, N.J.,** Dixon, B.C., Rosevear, M.G., Plunkett, B., Gagan, M.K., Hantoro, W.S. and Phipps, S.J. (2015). Optimised coral records of the Indian Ocean Dipole: an assessment of location and length considerations. *Paleoceanography*, 30, 1391-1405, doi: 10.1002/2015PA002810

J23.‡ Tierney, J.E., **Abram, N.J.**, Anchukitas, K.J., Evans, M.N., Giry, C., Kilbourne, K.H., Saenger, C.P., Wu, H.C., Zinke, J. (2015). Tropical sea-surface temperatures for the past four centuries reconstructed from coral archives. *Paleoceanography* 30, 226-252, doi: 10.1002/2014PA002717.

J22.‡ **Abram, N.J.**, Mulvaney, R., Vimeux, F., Phipps, S.J., Turner, J., England, M.E. (2014). Evolution of the Southern Annular Mode during the last millennium. *Nature Climate Change* 4, 564-569, doi:10.1038/nclimate2235.

J21. Murphy, E.J., Clarke, A., **Abram, N.J.** & Turner, J. (2014). Variability of sea-ice in the northern Weddell Sea during the 20th century. *Journal of Geophysical Research*, 119, doi:10.1002/2013JC009511.

J20.† **Abram, N.J.**, Mulvaney, R., Wolff, E.W., Triest, J., Kipfstuhl, S., Trusel, L.D., Vimeux, F., Fleet, L. & Arrowsmith, C. (2013). Acceleration of snowmelt in an Antarctic Peninsula ice core during the twentieth century. *Nature Geoscience,* 6, 404-411. doi:10.1038/ngeo1787.

J19.† **Abram, N.J.**, Wolff, E.W. & Curran, M.A.J. (2013). A review of sea ice proxy information from polar ice cores. *Quaternary Science Reviews* 79, 168-183. doi:10.1016/j.quascirev.2013.01.011.

J18.† Mulvaney, R^., **Abram, N.J^**., Hindmarsh, R.C.A., Arrowsmith, C., Fleet, L., Triest, J., Sime, L.C., Alemany, O. & Foord, S. (2012). Recent Antarctic Peninsula warming relative to Holocene climate and ice-shelf history. *Nature* 489, 141-144, doi:10.1038/nature11391. ^equal contributions.

J17.* Wheatley, J.J., Blackwell, P.G., **Abram, N.J**., McConnell, J.R., Thomas, E.R. and Wolff, E.W. (2012). Automated ice-core layer-counting with strong univariate signals. *Climate of the Past,* 8, 1869-1879, doi:10.5194/cp-8-1869-2012.

J16. **Abram, N.J.,** Mulvaney, R. & Arrowsmith, C. (2011). Environmental signals in a highly resolved ice core from James Ross Island, Antarctica. *Journal of Geophysical Research,* 116, D20116, doi:10.1029/2011jd016147.

J15. D'Arrigo R., **Abram N.J**., Ummenhoffer C., Palmer J. and Mudelsee M. (2011). Reconstructed streamflow for Citarum River, Java, Indonesia: linkages to tropical climate dynamics. *Climate Dynamics* 36, 451-462.

J14. **Abram, N.J.**, Thomas, E.R, McConnell, J.R., Mulvaney, R., Bracegirdle, T.J., Sime, L.C., and Aristarain, A.J. (2010). Ice core evidence for a 20th century decline of sea ice in the Bellingshausen Sea, Antarctica. *Journal of Geophysical Research* 115, D23101, doi:10.1029/2010JD014644.

J13.† Rothlisberger R., Crosta X., **Abram N.J**., Armand L. and Wolff E.W. (2010). Potential and limitations of marine and ice core sea-ice proxies: An example from the Indian Ocean sector. *Quaternary Science Reviews* 29, 296-302.

J12.† **Abram N.J**., McGregor H.V., Gagan M.K. Hantoro W.S. and Suwargadi B.W. (2009). Oscillations in the southern extent of the Indo-Pacific Warm Pool during the mid-Holocene. *Quaternary Science Reviews* 28, 2794-2803.

J11.† Convey, P., Bindschadler, R., Di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D.A., Mayewski, P.A., Summerhayes, C.P., Turner, J., and the ACCE Consortium incl. **Abram N.J.** (2009). Antarctic Climate Change and the Environment. *Antarctic Science*, 21(6), 541-563.

J10.* Ault T.R., Cole J.E., Evans M.N., Barnett H., **Abram N.J**., Tudhope A.W. and Linsley B.K. (2009). Intensified decadal variability in tropical climate during the late 19th century, *Geophysical Research Letters* 36, L08602, doi:10.1029/2008GL036924.

J9.† **Abram N.J**., Gagan M.K., Cole J.E., Hantoro W.S., and Mudelsee M. (2008). Recent intensification of tropical climate variability in the Indian Ocean, *Nature Geoscience* 1, 849-853.

J8. McGregor H.V. and **Abram N.J**. (2008). Images of diagenetic textures in *Porites* corals from Papua New Guinea and Indonesia, *Geochemistry Geophysics Geosystems* 9, Q10013, doi:10.1029/2008GC002093.

J7.† Reda T., Plugge C.M., **Abram N.J.** and Hirst J. (2008). Reversible interconversion of carbon dioxide and formate by an electroactive enzyme. *Proceedings of the National Academy of Sciences* 105, 10654-10658, doi:10.1073/pnas0801290105.

J6. **Abram N.J.,** Curran M.A.J., Mulvaney R. and Vance T. (2008). The preservation of methanesulphonic acid in frozen ice-core samples. *Journal of Glaciology* 54 (187), 680-684.

J5. **Abram N.J**., Mulvaney R. Wolff E.W. and Mudelsee M. (2007). Ice core records as sea ice proxies: An evaluation from the Weddell Sea region of Antarctica. *Journal of Geophysical Research* 112, D15101, doi:10.1029/2006JD008139.

J4. **Abram N.J**., Gagan M.K., Liu, Z., Hantoro W.S., McCulloch M.T. and Suwargadi B.W. (2007). Seasonal characteristics of the Indian Ocean Dipole during the Holocene epoch, *Nature* 445, 299-302.

J3.* Grumet N.S., **Abram N.J**., Beck J.W., Dunbar R.B., Gagan M.K. Guilderson T.P., Hantoro W.S. and Suwargadi B.W. (2004). Coral radiocarbon records of Indian Ocean water mass mixing and wind-induced upwelling along the coast of Sumatra, Indonesia, *Journal of Geophysical Research* 109, C05003.

J2.*† **Abram N.J**., Gagan M.K., McCulloch M.T., Chappell J. and Hantoro W.S. (2003). Coral reef death during the 1997 Indian Ocean Dipole linked to Indonesian wildfires, *Science* 301, 952-955.

J1.* **Abram N.J**., Webster J.M., Davies P.J. and Dullo W-C. (2001). Biological response of coral reefs to sea surface temperature variation: Evidence from the raised Holocene reefs at Kikai-jima (Ryukyu Islands, Japan), *Coral Reefs*, 20, 221-234.

Other Publications

The following publications demonstrate my commitment to communicating scientific information with a broad audience, including policy makers and the public. I am a frequent publisher with The Conversation, where my articles have reached a readership of more than 788,000 people.

O28. King, A., **Abram, N.J.,** Perkins-Kirkpatrick, S. (2021). Climate Change – how bad could it get? *The Conversation*.

O27. McGregor, S., Reef, R., and **Abram, N.J.** (2021) 'How high above sea level am I?' If you've googled this, you're likely asking the wrong question — an expert explains. *The Conversation*.

O26. Pitman, A., **Abram, N.J.,** Alexander, L., Arblaster, J., King, A., Macadam, I., McGregor, S., Perkins-Kirkpatirck, S., Sherwood, S., and Stone, A. (2021) The Intergovernmental Panel on Climate Change 6th Assessment Report. *Special Briefing from the ARC Centre of Excellence for Climate Extremes*.

O25. **Abram, N.J.,** King, A., Pitman, A., Jacob, C., Arblaster, J., Alexander, L., Perkins-Kirkpatrick, S., McGregor, S and Sherwood, S. (2021) Yes, a few climate models give unexpected predictions – but the technology remains a powerful tool. *The Conversation*.

O24. Pitman, A., Macadam, I., **Abram, N.**, Sherwood, S., and De Kauwe M. (2021) Can we limit global warming to 1.5ºC? *ARC Centre of Excellence for Climate Extremes, Briefing Note 15*.

O23. **Abram, N.J.,** De Kauwe, M. and Perkins-Kirkpatrick, S. (2021) Matt Canavan suggested the cold snap means global warming isn't real. We bust this and 2 other climate myths. *The Conversation*.

O22. Wright, N., Ellis, B. and **Abram, N.J.** (2020) A rare natural phenomenon brings severe drought to Australia. Climate change is making it more common. *The Conversation*.

O21. Melbourne-Thomas, J., McIness, K., Bindoff, N. and **Abram, N.J.** (2019) A landmark report confirms Australia is girt by hotter, higher seas. But there's still time to act. *The Conversation*.

O20. **Abram, N.J.,** England, M.H., and King, M. (2019) Arctic ice loss is worrying, but the giant stirring in the South could be even worse. *The Conversation*.

O19. **Abram, N.J.** (2019) Time will tell is this is a record summer for Greenland ice melt, but the patterns of the past 20 years is clear. *The Conversation*.

O18. Freund, M.B., Henley, B.J., Karoly, D.J., McGregor, H.V., and **Abram, N.J.**, (2019). El Niño has rapidly become stronger and stranger, according to coral records. *The Conversation.*

O17. **Abram, N.J.** (2018). Past warming events in the Arctic linked to shifting winds in the Antarctic. *Nature*, 563, 630-631

O16. **Abram, N.J.** (2017). FactCheck Q&A: Was it four degrees hotter 110,000 years ago? *The Conversation*.

O15. Dasse, E., and 37 others including **Abram, N.J.** (2017). Saving our marine archives. *Eos*, 98, https://doi.org/10.1029/2017EO068159

O14. Henley, B, and **Abram, N.J.** (2017). The three-minute story of 800,000 years of climate change with a sting in the tail. *The Conversation.*

O13. Turner, J., Comiso, J., and 20 co-signatories including **Abram, N.J.** (2017). Solve Antarctica's sea-ice puzzle. *Nature*, 547, 275–277, doi:10.1038/547275a

O12. McGregor, H.V., **Abram, N.J.**, Gergis, J. and Phipps, S. (2016). The Industrial Revolution kick-started global warming much earlier than we realised. *The Conversation.*

O11. **Abram, N.J.**, England, M.E., and Vance, T.R. (2016). Record high to record low: what on earth is happening to Antarctica's sea ice? *The Conversation.*

O10. **Abram, N.J.** (2016). Climate's Playground. *Nature Geoscience*, doi:10.1038/ngeo2856

O9. **Abram, N.J.** (2016). Climate shenanigans at the ends of the Earth: why has sea ice gone haywire? *The Conversation*

O8. King, P.L., Edwards, A., and **Abram, N.J.** (2015) Recognising biases that affect women geoscientists in the workplace. *Elements Magazine*, 11 (April), 88-89.

O7. **Abram, N.**, Armand, L., Chase, Z., De Decker, P., Ellwood, M., Exon, N., Gagan, M., Goodwin, I., Howard, W., Lough, J., McCulloch, M., McGregor, H., Meissner, K., Moy, A., O'Leary, M., Phipps, S., Skilbeck, G., Webster, J., Welsh, K. and Zinke, J. (2014), Dealing with Climate Change: Palaeoclimate Research in Australia. White paper for the National Marine Science Plan. *Quaternary Australasia.*

O6. Zinke, J., McGregor, H., Lough, J., **Abram, N.**, Webster, J., O'Leary, M., Gagan, M., McCulloch, M. and Goodwin, I. (2014), Dealing with climate change through understanding tropical ocean-atmosphere climate interactions and their impacts on marine ecosystems. White paper for the National Marine Science Plan. *Quaternary Australasia.*

O5. Hope, P., Gergis, J., **Abram, N.**, Brown, J., Phipps, S.J., Drysdale, R., Henley, B.J., Lorrey, A.M., Roop, H., and Tyler, J. (2014). Australasia's past climate variability – strengths drawn from palaeoclimate and model data over the last 2,000 years. *Bulletin of the Australian Meteorological and Oceanographic Society*, 27 (5), 92-95.

O4. Hope, P., Gergis, J., **Abram, N.**, Henley, B. (2014). Australasia's climate variability: clues drawn from paleoclimate and model data over the last 2000 years. *PAGES Magazine*, 22 (2), 101.

O3. **Abram N**, (2009). Corals predict rainfall decline, *Australasian Science*, April, 25-27 (invited).

O2. Rothlisberger, R. and **Abram N.** (2009) Sea-ice proxies in Antarctic ice cores. *PAGES News*, **17** (1), 24-26.

O1. **Abram N.** (2004). Fire threat to coral reefs, *Australasian Science*, March, 21-23 (invited).

Open-Access Data and Code Publications

I am committed to the principles of FAIR data (Findable, Accessible, Interoperable, Reusable) as a way to accelerate scientific discovery and safeguard scientific integrity and investment. Through the PAGES 2k Network I have worked to improve data archiving practices within the paleoclimate community (e.g. see publications J37 and J31).

D17. Data archive for Abram et al., 2020 (*Nature*) Southern Mentawai Islands d18O and d13C Data and Indian Ocean Dipole reconstruction over the last millennium: https://www.ncdc.noaa.gov/paleo-search/study/28451

D16. Data archive for Konecky et al., 2020 (*ESSD*) Iso2k Database Global Common Era Paleo-d18O and d2H Records: https://www.ncdc.noaa.gov/paleo/study/29593

D15. Data archive for Freund et al., 2019 (*Nature Geoscience*) 400 year El Nino event type reconstruction: https://www.ncdc.noaa.gov/paleo/study/26270

D14. Data archive for Datwyler et al., 2019 (*International Journal of Climatology*) 1000-year ENSO reconstructions: https://www.ncdc.noaa.gov/paleo/study/25891

D13. Data archive for Sigl et al., 2018 (*Cryosphere*) Colle Gnifetti ice core black carbon data: https://doi.org/10.1594/PANGAEA.894788

D12. Data archive for Wurtzel et al, 2018 (*Earth and Planetary Science Letters*) 16,000-year speleothem $\delta^{18}O$ data: https://www.ncdc.noaa.gov/paleo/study/23790

D11. Data archive for Datwyler et al., 2017 (*Climate Dynamics*) Southern Annular Mode reconstructions: https://www.ncdc.noaa.gov/paleo/study/23130

D10. Data archive for PAGES2k Consortium, 2017 (*Nature Scientific Data*) Global temperature database: https://www.ncdc.noaa.gov/paleo/study/21171

D9. Data archive for Stenni et al., 2017 (*Climate of the Past*) Antarctica 2k database: https://www.ncdc.noaa.gov/paleo/study/22589

D8. Code and data archive for Abram et al., 2016 (*Nature*) Onset of industrial-era warming: https://www.ncdc.noaa.gov/paleo/study/20083

D7. Data archive for Tierney et al., 2015 (*Paleoceanography*) Ocean 2k high-resolution database: https://www.ncdc.noaa.gov/paleo/study/17955

D6. Data archive for Abram et al., 2015 (*Paleoceanography*) Sunda Strait and South Pagai coral $\delta^{18}O$ data: https://www.ncdc.noaa.gov/paleo/study/18895

D5. Data archive for Abram et al., 2014 (*Nature Climate Change*) 1000-year Southern Annular Mode reconstruction: https://www.ncdc.noaa.gov/paleo/study/16197

D4. Data archive for Abram et al., 2013 (*Nature Geoscience*) 1000-year James Ross Island ice core melt and $\delta^{18}O$ data: https://www.ncdc.noaa.gov/paleo/study/14201

D3. Data archive for Mulvaney et al., 2012 (*Nature*) Holocene ice core $\delta^{18}O$ data from the James Ross Island ice core: https://www.ncdc.noaa.gov/paleo/study/13954

D2. Data archive for Abram et al., 2009 (*Quaternary Science Reviews*) Holocene Sr/Ca SST reconstructions for the Indo-Pacific Warm Pool: https://www.ncdc.noaa.gov/paleo/study/9819

D1. Data archive for Abram et al., 2008 (*Nature Geoscience*) Dipole Mode Index reconstruction: https://www.ncdc.noaa.gov/paleo/study/8607