CCC - Quality Assurance of Evidence and Analysis – Summary

Quality Assurance (QA) aims to ensure that the evidence we use is of good quality and fit for purpose.

This is essential for the quality of what we do, in terms of the recommendations we produce, for our reputation, and – ultimately – to the influence we have.

It is something for all of us. In essence, it requires:

- Planning: as the person responsible for producing the numbers/ analysis – or managing the contract to produce the numbers - decide what QA you will do right at the start, when it will be done and who will do it.

  Get your plans approved by the SRO (a bit like a “project director” – often the team leader in the mitigation team, or Head of Adaptation).

- Peer review: ensure there is scrutiny of key numbers and results, from outside the immediate team – depending on the analysis in question, could be provided by a colleague from another team, or an expert review group.

- Clearance: a senior manager/analyst decides if the analysis is fit-for-purpose and if there are any risks, issues or uncertainties that must be flagged for sign-off.

  Probably the most important thing here, in terms of responsibilities, is that the person providing clearance is not an analyst who has been conducting the work.

- Sign-off: agreement for use of the work from the relevant Committee or other delegated approver. The distinction between clearance and sign-off is generally that clearance is for internal purposes; sign-off is for external use or publication.

The scale of peer review and other checks, whether internal or external, and seniority of clearance and sign-off is linked to the complexity and risk attached to the analysis. And so should be planned for.

Steps to go through

So for a major project, what does this mean for you, as the lead analyst for an area of work, in terms of the steps you need to go through?

1. Develop your QA plan. For each of the key streams of analysis (e.g. literature review; consultancy; internal analysis or modelling; other government department modelling) this should include identifying the need for, and who will undertake:
    - Peer review of assumptions, data, results, interpretation;
    - Challenge sessions from colleagues and/or champions;
    - External advice and review (e.g. from an advisory group, consultancy steering group; expert review).

    You should identify who will provide these reviews, who is SRO (probably the team leader), who will provide clearance and sign-off, and when these activities are expected to happen.

    Frequently the elements of the plan will look similar between teams conducting the same kind of analysis; and between different streams of analysis. But you should give thought to what might be different for your specific work-stream.

2. The QA plan should be discussed with the SRO (at least). Views/comments can then be fed back into the QA plan. The clearer should be given the opportunity to discuss the plan and agree it is appropriate.

3. As the analytical work proceeds, ensure that the QA activities are undertaken at the appropriate time. Of course, keep the QA plan under review. Depending on how the analysis proceeds, or as your understanding of the uncertainties/risks/importance develop, you may need to adapt the plan and secure a higher or deeper level of review.

4. Keep a log of the limitations/weaknesses that you have not been fully able to address. These must be communicated, alongside a record of QA undertaken, to the SRO, clearers and approvers.

5. For a major project (like a Carbon Budget recommendation or CCRA), there will be an overall project manager who should be kept informed of progress. You should keep a QA log of your own progress (example template here), which could be the basis of a

collated log held by the project manager – both to be aware of progress (and consider wider knock-ons to other teams), and to form the basis of an overall log that could be published alongside final reports.

6. Obtain the necessary clearances for use or publication of the results and interpretation of results.

7. Ensure that quantitative results used in reports and their sources are checked by someone other than yourself.

8. Save the key spreadsheets/analysis to the shared drive – to include results, models, documentation, guidance, clearances, steps taken to address issues raised in peer review.

For lesser products the requirements are likely to be less, but you can use the steps above and template to prompt you in thinking through what will be useful and proportionate.

CCC - Quality Assurance of Evidence and Analysis

Foreword

1. Introduction
2. The essential principles of QA
3. The essential components of QA
4. Accountabilities and responsibilities

Annex A. Impact Matrix

Annex B. Model Complexity Matrix

Annex C. QA requirements in Invitations to Tender (ITTs)

Annex D. The QA framework – processes (mainly model related)

Annex E. Useful links.

Committee on Climate Change

v2, March 2020

Foreword

Evidence and analysis are key to what we do at the Committee on Climate Change. It is vital that we can be confident in them and fully understand their limitations.

Quality assurance must be embedded throughout our analysis in terms of our development, delivery and communication of analytical work.

It is some time – January 2014 – since we issued formal guidance on what is expected. We have been reviewing that guidance. The key principles in the earlier guidance remain applicable, but now – as we move on to work for the sixth carbon budget, and continue work for the Climate Change Risk Assessment - is a good time for a refresh, and to re-emphasise the need to plan for QA throughout the life of a project.

Good QA is about what we do, how we do it, and who is responsible at each stage. Putting it into practice is what matters and is a key focus for this guidance. Making QA easy helps make it happen, so in this update we have included a new summary and checklist and a new template for logging activities that are intended to make the process as easy as possible for analysts to follow and ensure important steps are not forgotten.

Over 20 pages of guidance may seem daunting. It is not meant to be, and much of what is contained here should be familiar and common-sense. The guidance is there to support analysts to undertake QA confidently, efficiently and consistently.

This document is for us – the CCC analysts. In line with our commitment to transparency we are publishing it on our website. If you're from outside CCC and see things we can do better, let us know.

Thank you to all the CCC analysts for their continued dedication to producing analysis of the highest quality and embedding QA in all that they do. Special thanks to our Chief Assurance Officer Adrian Gault for producing this guidance.

Mike Thompson

Director of Analysis

1. Introduction

Quality Assurance (QA) – in the context of the CCC's work - is an on-going process about understanding, minimising, and factoring in risks around the generation and use of evidence. QA aims to ensure that the analysis we undertake and the evidence we use is of good quality and is fit for purpose.

This guidance is intended to set out the principles behind good QA, summarise the processes that should be applied within CCC, and provide links to other material that may be useful.

Ultimately, however, guidance is only that – guidance. It is application that counts – proportionate to the importance, complexity and risks of the particular analysis that you are conducting, or that someone else is conducting for you.

Following the principles outlined here will reduce the risk to CCC analysis and reputation from producing, using and publishing evidence that could be incorrect, misleading or inconsistent.

Coverage

This document aims to provide guidance as to what is expected for QA of evidence and analysis in general – this includes quantitative evidence, which itself includes the use of "models", but could relate to qualitative evidence as well:

- Sometimes our evidence draws on approaches we would all clearly recognise as "models" (e.g. BEIS Energy and Emissions Projections, or the Future Flood Explorer used in the CCRA). In these cases it is essential that analysts in CCC should understand the mechanics of the model – these should not be a "black box". This means understanding what are the key variables and how they drive results; being able to explain results; and triangulating results with off-model evidence.
- Numerical analysis may be provided through spreadsheet calculations. In such cases, there is a need – at the least - for validation and sense checking.
- Sometimes we may be reliant on data or results that we could not possibly QA ourselves, for example where the results reflect huge data inputs, many (possibly thousands) calculations, or pages and pages of code (which we may not have access to). In these cases, sense checking of results should still be possible. And knowledge of the QA processes that the external supplier has instituted should instil confidence.
- Qualitative evidence – appropriate use and completeness of sources need to be considered, even if there is no specific number to check.
- Sometimes we use previous analyses in a new report. In such cases the scale of QA required may be expected to be less. The underlying analysis should have been subject to full QA at the time it was conducted. But you will still need, at the very least, to do enough checks to confirm that the evidence is appropriate to the issue now being addressed, and that it remains up-to-date.

So, specific QA requirements are not the same for each case. Where a formal “model” is being used it is likely that the requirements will be more substantial; for a few minutes work to produce a number in answer to a specific query, clearly it’ll be less.

In all cases, there is a need to be proportionate. But in all cases sense-checking of findings is a minimum requirement!

Transparency

Making results and methods of analysis transparent can be an effective mechanism for driving up standards of quality. This is particularly critical for the CCC, being strongly based on evidence and high quality analysis. Transparency and robust QA will reduce the risks of reputational damage.

Consistent with this, aside from any requirements arising from FoI, we generally expect to publish the evidence base for Committee recommendations, including commissioned consultancy work. This includes spreadsheets with underlying calculations, methodology documents, or appendices outlining assumptions or data sources. Where these documents are too large to be easily housed on the CCC website (e.g. the database of outputs from the CCRA Future Flood Explorer), we should explicitly state that they are available on request.

2. The essential principles of QA

Since the 1st edition of this guidance was issued, further guidance on the production of quality analysis for government has been issued in the Aqua Book[1]. This recognises that approaches are likely to be tailored in practice, depending on the nature and requirements of the particular organisation. But the four principles it identifies are worth recording:

- Proportionality of response: The extent of analytical QA effort should be proportionate in response to the risks associated with the intended use of analysis.

- Assurance through development: QA considerations should be taken into account throughout the life cycle of the analysis and not just at the end.

- Verification and validation: Analytical QA is more than checking analysis is error-free and satisfies its specification (verification). It must also include checks that the analysis is appropriate, i.e. fit for purpose for which it is used (validation).

- Analysis with RIGOUR: Quality analysis needs to be repeatable, independent, grounded in reality, objective, have understood and managed uncertainty, and results should address the initial question robustly.

It might be tempting, particularly when busy, to see QA as an add-on, something that can be completed towards the end of the process, to review key results and obtain some independent checks (as in, from outside the immediate team). This is not adequate. QA should be planned for, thought about from the outset and throughout the project. Leaving QA to the end may mean that it is rushed, may identify issues but leave little time for their consideration or correction, and may mean opportunities to improve or develop analysis are lost.

[1] Aqua Book: guidance on producing quality analysis for government, March 2015. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/416478/aqua_book_final_web.pdf

3. The essential components of QA

The essential components of QA (Box 1) are:

1. **Plan** effectively to ensure proper QA can be done before use and publication of evidence
2. Use the expertise of appropriate people from relevant disciplines, internally and externally, to **peer review** and improve work
3. Seek **analytical clearance** of the evidence/analysis within a piece of work
4. Obtain **final approval (sign-off)** for publication or use of final product, taking account of risks and uncertainties in the analysis and its presentation

What CCC outputs need to have their evidence and analysis QA'd?

All analytical outputs should be subject to QA. The depth and type of QA will vary depending on the nature and scale of the analysis and risk attached to results.

What does this mean in practice?

When evidence or analysis is generated or used, proportionate checks must be made to ensure that risks and errors are identified and minimised. This means that high-risk, complex analysis is subject to rigorous scrutiny, and low-risk products are independently sense-checked.

The level of assurance required should increase with the assessed impact of the results and consequences of error (see **Annex A** for an approach to assessing such impact, and therefore whether something is low or high risk).

The more complex or innovative the approach, the higher the risk of error, and therefore the greater the level of QA that should be undertaken (see **Annex B** for an approach to assessing complexity).

Robust procedures and assurance will require that more than one person should be actively involved.

This should include thinking about who might be the best person/s to conduct peer review, and when, and seeing if time can be booked in for this.

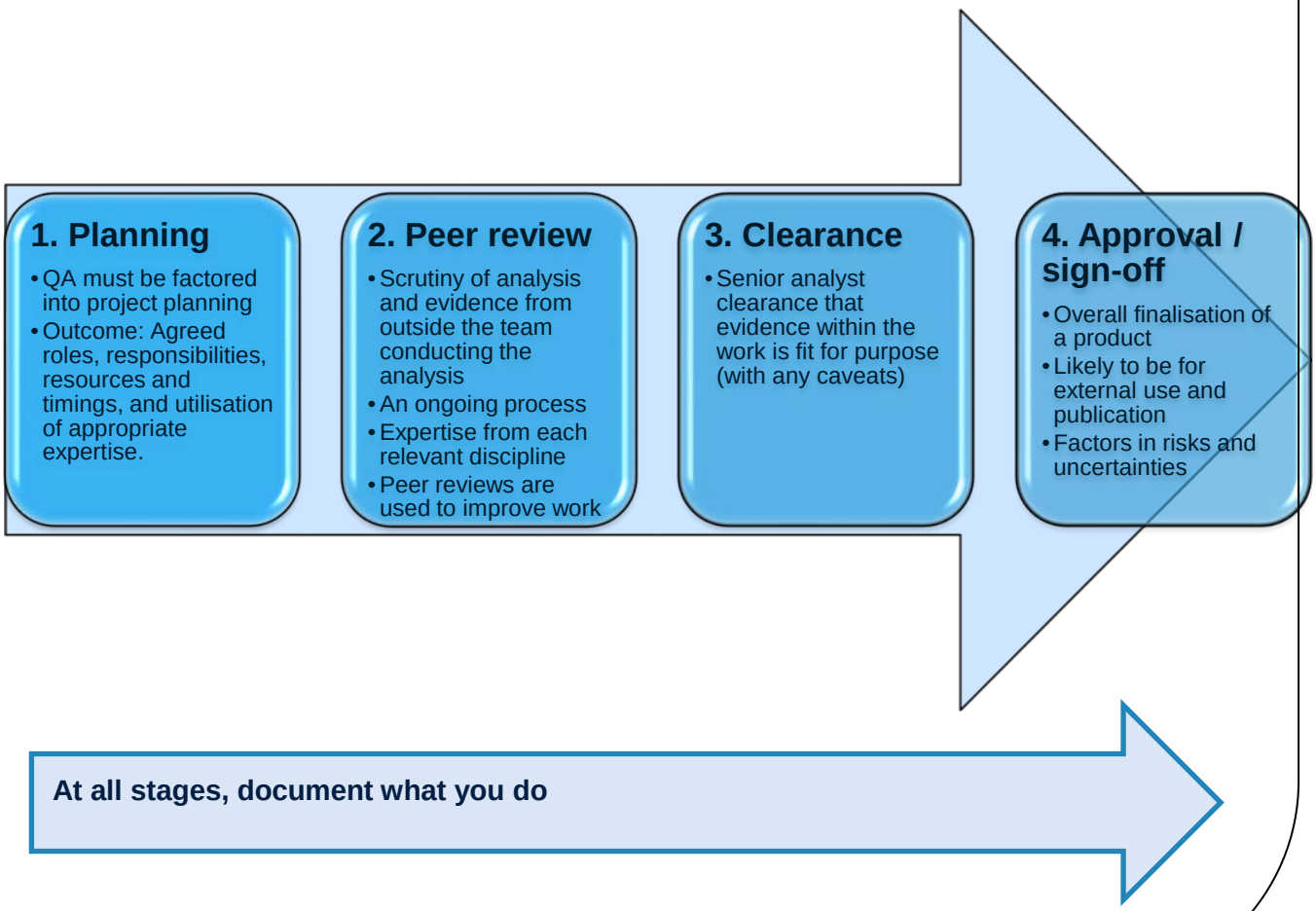
QA should be planned for, alongside analysis. When analytical plans are put together these are likely to include elements relating to:

- Understanding the issue;
- Designing the analytical approach;
- Conducting the analysis;
- Communicating the results.

Requirements for QA can be considered alongside each of these elements.

Box 1: the stages of QA

There are four stages to successful analytical quality assurance, illustrated in the diagram below and explained further, in terms of responsibilities, in section 4 of this paper.



Isn't this what we and the Committee do all the time?

Essentially, yes!

The CCC is an analytical body. We frequently use external research, combined with our own analysis and review, and test this out with stakeholders, Committee members and in Committee meetings.

In the end, the Committees have to be content with the analysis and sign-off publication of reports.

The Committee members are experts in their fields and will want to know about methodologies used, robustness and uncertainties of results, and how they have been tested. Frequently, they will pick up on results that are unexpected or look a little odd.

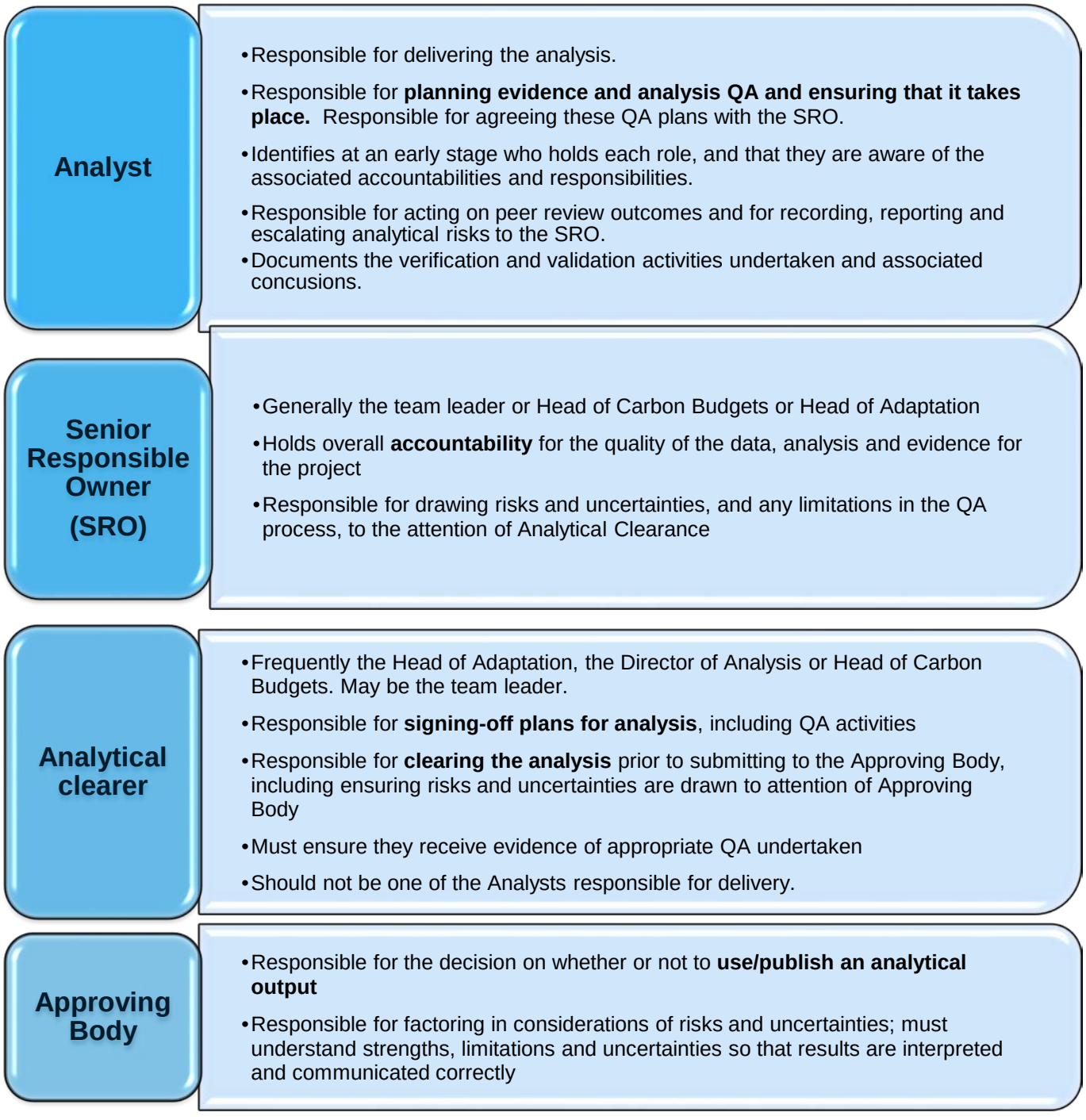
But it is important that we conduct good QA ourselves, and also that we have processes in place that allow us to demonstrate this is the case (for the Committees and beyond).

4. Accountabilities and responsibilities

Key accountabilities and responsibilities within the QA process are outlined below. Just who will take these roles may vary depending on the analysis in question.

For some outputs, and given the size and nature of the secretariat, it is possible that 2 of the roles here may be merged to be taken by the same person. For example:

- The SRO may also be an analyst for the work in question.
- The analytical clearer could be the same person as the SRO, depending on complexity and risk. But not if the SRO is involved as an analyst.
- The approver could be the same person as the analytical clearer. But not where approval requires Committee sign-off.



Some CCC specific examples of who might take these roles are provided at the end of the section.

4.1 Analyst – planning and peer review

The Lead Analyst must identify and agree with the SRO and analytical clearer the required QA activities and responsibilities. This is likely to be as part of a wider discussion of the analytical approach and evidence to be used for the project. This will include:

- Who is responsible for arranging QA activities (usually the Lead Analyst or delegated analyst);
- Who will review the work, which analytical discipline should be included, what type of review or challenge is needed, at what points QA is needed;
- Who will provide analytical clearance;
- What are the arrangements for final sign-off for publication/use of analysis;
- What are the relevant timings for each action.

Within the analyst role, there is a particular requirement to consider the role of **peer review.** The function of peer review is to *independently* (i.e. from outside the immediate analytical team) scrutinise the evidence and analysis, and to help the project team improve the quality of the evidence and reduce its risks. The form of peer review may vary greatly between projects, depending on the subject, the risks and the complexity of the evidence and analysis.

Reviewing outputs of external analysis

When awarding research/consultancy work, the QA processes of the potential contractors will form part of the assessment of who to contract with (see requirements at L:\Committee on Climate Change\Corporate Team\Staff Guidance\Contract forms . We need to be assured, through the response to tender and interviews (and subsequent project management) that the proposal will meet our requirements and standards.

In relation to QA, you should start from the standard words provided at Annex C. You may want to extend this for a particular project. If you want to scale back from this, it should be discussed with the SRO and analytical clearer. This includes a new requirement that QA conducted by the contractor should be explicitly reviewed.

Consideration should be given to the required output from the contract. Where possible, where contractors have to develop a modelling capability as part of the work, we generally expect to acquire that model, and user guidance, as part of the final output. Sometimes where a contractor runs their own model that may not be possible – provenance of the model and QA processes in the course of the contract are then even more critical.

During the contract, part of the role of the CCC Project Manager will be to ensure that quality standards are being met. It is likely that an Advisory Group will also feed into the review of progress.

The Project Manager will clearly need to check results being received from contractors, which may include checking of model results and workings. The onus should be on the

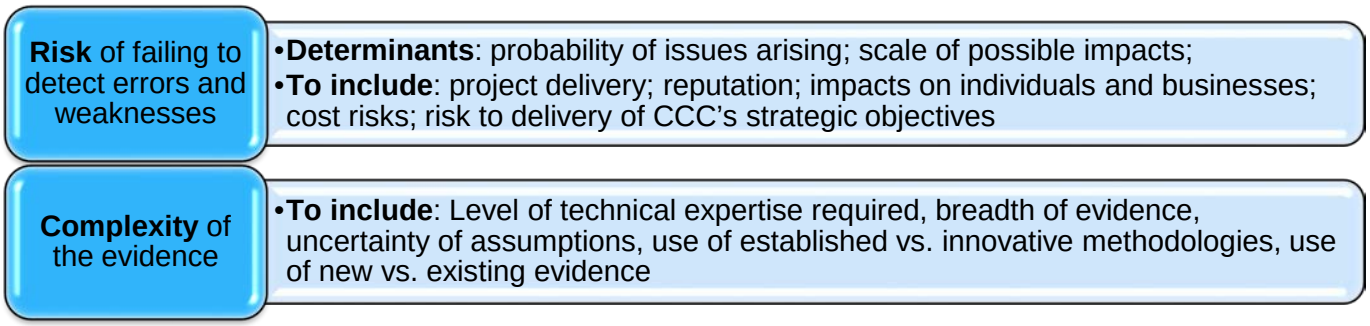
contractor to provide these checks and assurance, but we have experience of picking up errors even after consultants' QA processes have been applied. So results provided by contractors cannot be assumed to be correct. The extent of our own checks should extend to sense-checking at the least, but depending on complexity, risk and experience with the contractor, may go beyond this.

What type of peer review is required and who needs to peer review?

Peer review can take several forms, and will involve different expertise. The Analyst should agree with the SRO the type of peer review required as early as possible in the project, and the relevant disciplines that must be consulted.

- At the simplest level, peer review will involve sense-checking by a colleague, independent to the project.
- At a higher level, Committee Champions and/or stakeholder workshops could be drawn on.
- Where a formal model is being used, it's unlikely that Committee Champions or stakeholders are going to get into detailed checks (though they might look at broad structure). Getting a colleague to look at model calculations is an option.
- At the highest level, formal, external expert peer review might be commissioned.

The person responsible for Analytical Clearance has a role to challenge and agree the peer review activities to ensure they are sufficiently rigorous. This will be based on two considerations:



By way of examples:

- To advise on the development of Committee analysis/reports we have sometimes used Advisory Groups, drawing on experts from outside CCC – for example, for the 2019 Net Zero report there were three such groups, on UK scenarios, on international issues, and on costs and benefits. These can be considered to perform – in part - a peer review function. They have tended to advise on overall approach to analysis, rather than detailed assessment of results.
- Stakeholder groups have also been used, on both mitigation and adaptation issues, providing advice on approaches, providing insight on what may be missing, and providing challenge.
- On the adaptation side, and for more specialist mitigation reports, specific paragraphs of a report, and charts, are often fact-checked or sense-checked with stakeholders. This has to be done carefully, and is generally concerned with analytical checks or factual understanding (particularly numbers), rather than the conclusions that the Committee may be drawing.

- Challenge sessions with colleagues outside the immediate team may be a useful way to review plans, progress, and emerging results, e.g. with the Chief Assurance Officer, Head of Adaptation, Head of Carbon Budgets or Director of Analysis.
- All numbers quoted in reports should be reviewed. To enable this, lead analysts for some chapters/sections have sometimes created a spreadsheet of each such number, with the source. A colleague has then been asked to review this.

What do I do with peer review comments?

The project team should use the advice received through the peer review process to improve the evidence and analysis, reducing risks and uncertainties.

The Analyst must record details of the peer review process. They should communicate to the SRO and for Analytical Clearance:

- Scope of peer review
- Peer review findings, and actions taken or proposed to address these findings
- What risks and issues identified by the peer reviewer still remain (and why)
- Overall reviewer opinion on fitness for purpose (if that was part of the peer review).

What if sufficient QA or QA in line with initial plan is not possible (e.g. due to unforeseen circumstances; pressure of higher priorities)?

Where there are time or resource constraints, the Analyst should use a risk-based approach to highlight areas of greatest potential error or risk, and focus assurance efforts on these.

It is also important that the impact of any reduction in thoroughness of analytical QA activities is communicated to and understood by the Analytical Clearer and Approving Body. The Analytical Clearer may factor this into his provision of assurance and should ensure the risks and limitations are communicated to the Approving Body. The Approving Body must factor the risks highlighted during analytical clearance into their decisions on use of the analysis and its wider communication.

4.2 Senior Responsible Owner (SRO)

The Macpherson review recommended that there should be a single Senior Responsible Owner for each business critical model. We can extend this to analytical outputs more generally. Key functions for the SRO are:

- to confirm that the QA applied is appropriate;
- to draw any limitations in the QA process to the attention of the person providing analytical clearance;
- to ensure that the risks, uncertainties, limitations and major assumptions around the model or results are drawn to the attention of the person providing analytical clearance and are understood by users.

Frequently the SRO in the CCC will be the relevant team leader, Head of Carbon Budgets, or Head of Adaptation.

4.3 Analytical clearance

Clearance is the process by which a senior analyst/manager (generally the Head of Adaptation, Director of Analysis or Head of Carbon Budgets) indicates that either a) he/she views the analytical aspects of the work as fit for purpose, or b) that the work has serious risks, issues, or uncertainties that must be factored into any final sign-off or approval decision to be made with the work.

The person clearing the work is responsible for ensuring their key concerns around the evidence and analysis are accurately reported.

What do I need to do to clear analysis or evidence in a piece of work?

The clearance decision does not require full fresh scrutiny of each small detail. Instead, it should be based on comments received from the peer review process, and also follow-up challenge through discussion with the project team.

The clearance statement should be written in the case of analysis for publication and decisions or, for unpublished material (e.g. a Committee presentation), may be oral.

Key aspects for consideration at clearance should be communicated to the approver:

- The scope, type and level of QA that has been undertaken
- The key outstanding risks, uncertainties and issues around the analysis and evidence. **Any significant remaining risks around quality must be clearly communicated to the approver.**

4.4 Approval (Final sign-off)

Approval/sign-off comes after analytical clearance, and constitutes the agreement from the relevant Committee, Champion, or other delegated approver, that the analysis may proceed for use/publication.

The **Approving Body** is accountable for factoring into their decision the evidence risks that they have been advised of.

The Approving Body will vary depending on the output under consideration (see Table 1 for examples).

Record keeping

The final results, together with the underlying method and analysis, records of peer reviews, clearance and approval decisions, should be filed onto CCC's L:Drive by the Analyst or Project Manager. The underlying calculations and methods may be published or should be available to share with interested stakeholders on request, so need to be clear and understandable.

A record of what steps were taken to address issues raised during peer review must be filed, together with a record of outstanding issues (e.g. the peer reviewers supported the findings of the report subject to certain caveats).

Table 1: QA responsibilities for specific CCC products

Note: Analytical clearance and approval responsibilities will in some instances be delegated. This table presents expected approaches, but should be clarified as part of the analytical plan.

Document type	Examples	Analyst	SRO	Analytical clearance	Approving Body	*Notes*
Committee Report (statutory or non-statutory)	*Budget recommendation, Progress Report*	**Team member (varying by topic)**	**Team Leader**	**SCS** (Head of Adaptation, Head of Carbon Budgets or Director of Analysis)	**Committee**	
Committee letter		**Team member**	**Team Leader**	**SCS**	**Committee**	
Technical Report	*Net Zero – Technical Report, CCRA Synthesis Report*	**Team member**	**Team Leader**	**SCS, Champions**	**Chief Executive**	
Consultancy Report	*CCRA flood and water projections reports*	**Team member**	**Team Leader**	**Team Leader**	**SCS**	*Depends on scope. Relevant analytical disciplines need to be involved in QA of assumptions (e.g. science and economics) Committee Champions should be consulted, while external peer review likely needed for high-profile products*
Consultations	*Calls for evidence*	**Team member**	**Team Leader, Head of Carbon Budgets**	**SCS**	**Committee**	
Committee presentations		**Team member**	**Team Leader**	**SCS**	**Team Leader**	
Adaptation Committee presentations		**Senior Analyst**	**Senior Analyst**	**Head of Adaptation**	**Head of Adaptation**	
Research specifications	*ITT for external research/consultancy*	**Team member**	**Team Leader**	**Team Leader, Head of Adaptation**	**SCS**	
In-house model use (ultimately feeding into reports)		**Team member**	**Team Leader**	**SCS**	**SCS**	
Other analysis or evidence				*The principles set out in this guidance should be followed. Clearance and approval responsibilities will vary, but proportionate quality assurance must always be conducted and risks always need to be communicated to decision-makers.*		

Annex A: Impact Matrix

Description	Low (1)	Medium (2)	High (3)
Role of analysis in the final decision	Model or analysis is one of many factors determining the decision and is not critical.	Model or analysis is one of the most important factors in the decision-making process	The model output is the most important factor in the decision-making process
Size of the financial allocation to which the model relates	Modelling is used to inform recommendations which bear on a small (below £100million) amount of Govt funding	Modelling is used to to inform recommendations which bear on a medium (£100-500million) amount of Govt funding	Model is used to inform recommendations which bear on a large (over £500million) amount of Govt funding
Size of the wider welfare impacts	Gross welfare impact (positive or negative) <£100 million	Gross welfare impacts (positive or negative) >£100million <£500million	Wider welfare benefits or costs over £500million
Level of reputational risk	Model is only used internally	Model output is likely to inform a public statement but not explicitly stated	Model output is quoted publicly
Model is essential to business plan activities	Model has no relevance to business plan or activities	Model forms part of the reporting for business plan	Model is likely to determine success against a business plan objective
Number of times model is used	One-off single use	Used for one or two projects annually	Used frequently, for multiple projects

Annex B: Model Complexity Matrix

Description	Low (1)	Medium (2)	High (3)
Form of the Model	Simple spreadsheet, perhaps using one or two sheets with limited amount of data transformation	Complicated spreadsheet, perhaps over several worksheets with multiple sources of data and calculations.	Model is an application running through code.
Innovation	Model follows well-established techniques with a strong evidence-base	Model follows well established techniques but may involve the generation of new evidence, ie econometric modelling or some other forms of innovation	Model is innovative and either applies techniques in a new way or involves developing a new approach.
Interactions / Iterations	Modelling requires no iteration or interaction with other models	Modelling requires a limited amount of iterations and interactions with other models but not too complex	Model involves a high degree of iteration and interactions between models.
Scale / Visibility	Easy to gain oversight of the whole modelling process and limited amount of key information to check and report	Modelling is challenging to oversee, relying on a number of key assumptions and results to gain confidence in the output.	Modelling is very challenging to oversee, relying on oversight across a range of models and model interactions.

Annex C: Suggested Quality Assurance wording for ITTs

This project must comply with the 'CCC – Quality Assurance of Evidence and Analysis' guidance[2] and bidders must set out their approach to quality assurance in their response to this ITT.

All research tasks and modelling must be quality assured and documented. Contractors should:

- Include a quality assurance (QA) plan that they will apply to all of the research tasks and modelling,
- Specify who will take lead responsibility for ensuring quality assurance and ensure that this responsibility rests with an individual not directly involved in the research, analysis or model development,
- Provide a QA log to demonstrate the QA undertaken, including who undertook the QA and the scope, type and level of QA that has been undertaken (e.g. a log entry only stating 'the data was checked' will not be sufficient),
- Allow for a meeting with CCC staff to run through QA performed.

Sign-off for the quality assurance must be done by someone of sufficient seniority within the contractor organisation to be able take responsibility for the work done. Acceptance of the work by the CCC will take this into consideration. The CCC reserves the right to refuse to sign off outputs which do not meet the required standard specified in this invitation to tender.

The successful bidder will be responsible for any work supplied by sub-contractors and should therefore provide assurance that all work in the contract is undertaken in accordance with the quality assurance expectation agreed at the beginning of the project.

For primary research, contractors should be willing to facilitate CCC (and potentially Defra or BEIS) staff to attend interviews or listen in to telephone surveys as part of the quality assurance process.

Bidders must demonstrate their ability to produce deliverables of quality, in particular following best practice regarding analysis and presentation of results.

[2] https://www.theccc.org.uk/about/transparency/

Annex D: The QA framework – processes (mainly model-related)

> **Box 1: What is a model?**
>
> As set out in the Treasury's "Review of Quality Assurance", a model is:
>
> *" a mechanism for analysing or investigating some aspect of the real world. It is usually a quantitative method, system or approach which applies statistical, economic, financial or mathematical theories, techniques, and assumptions to process input data into quantitative estimates. There are typically three parts to a model:*
>
> - *Inputs – in the form of data and assumptions;*
> - *a processing component – often through calculations; and*
> - *outputs – the key figures as well as the risks and limitations of the models."*
>
> *Source: Review of quality assurance of Governmant analytical models: final report (HM Treasury, March 2013)*

A wide range of QA processes can be deployed. They should go beyond the simple checking of whether a model calculates without error. In particular, QA should ensure that:

1. The model is securely managed, stored and operated (Model Control Environment).
2. The primary data being input to the model is of good quality
3. Model is developed to perform accurately and reliably.
4. Model is accurate and reliable in use.
5. Appropriate governance is in place.
6. Results make sense!

Where model development or use is contracted outside CCC, the tender documents should include requirements for an appropriate QA regime.

The information contained within this annex is intended to provide a little more clarity around the specific processes that can be adopted. It is not intended to be exhaustive or limiting, as specific areas and model types are likely to have a greater depth of QA process than can be captured in general guidance.

1 Model Control Environment

Access Control

Access control is aimed at ensuring that changes are not made maliciously or accidentally by external parties.

Given the small size of CCC, this may be enacted by placing the model within the L: drive, as a secure file area.

In the unlikely event that there is a need to go beyond that, then this could involve password protection with limited distribution of that password to a list of users that is logged and regularly reviewed. If such a need is identified for consideration it should be raised with a team leader in the first instance, and the Director of Analysis should be notified.

Change Control

Changes made to the model should be subject to a proportionate approvals process. This process should be clear to all those using or developing a model.

Local teams will want to consider what those processes should be, with what levels of delegation, appropriate to each model.

Changes should be recorded.

It is also important to consider whether controls are needed to prevent changes to the structure of the model or its inputs by, for example, the use of a read-only version.

Version Control

Version control is a simple process to embed within the development and use of a model and is fundamental to ensuring that the version in question is the one that it is believed to be. For example, a document may be circulated for comment and involve multiple comments made by a range of people simultaneously. Version control of a model acts to ensure that a record is kept of all 'comments' that have been made on the model. It is possible that there could be multiple versions of a model performing slightly different functions to different policy areas. Version control is vital to ensuring such situations are documented.

The approach to version control can be relatively informal, perhaps through the use of consistent date stamping on file names.

Where models are important or complex, with lots of inter-connected files and programs, it is advisable to keep a log of all versions (e.g. as an extra sheet within an Excel workbook), complete with the date, name and time that a new version was created. That log should record what is different about the new version and perhaps how this has altered the main output.

Whether formal or informal, there should be a standard approach to version control that is consistently understood and applied by all model users.

Note: Excel Workbooks

For Excel workbooks it is recommended that standard practice should be to have a sheet for Version Control and a Welcome sheet.

The former would document changes made to the model.

The latter would cover: creator; date of creation; purpose; source inputs/assumptions; basic user guide with link to further model guidance if needed/available; example outputs/findings; spreadsheet “map”; formatting conventions.

There is a template here - **TEMPLATE FOR ANALYSIS**

In developing spreadsheet models it is also recommended that you:

- Avoid hard-wiring data into formula
- Keep data inputs and assumptions on sheets separate to analysis.

Back-Up and Recovery

To ensure that CCC is resilient to IT or infrastructure failure, all models should be able to be restored if the primary version of the model or access to IT system on which the primary version of the model is stored is disrupted. If the primary storage area is the L: drive, there should be a back-up version elsewhere.

To enable a proper audit trail of past decision-making, it is recommended that live versions of the models, upon which recommendations were made, should be stored.

It also helps if subsequent errors are found, in that analysis can be completed on previous model versions to understand the size of any error. Storage of previous live versions of a model will also aid any future ex-post evaluation.

Single Person Dependency

Where the development, use or interpretation of a model is reliant on a single person, this imports a significant amount of risk into the use of analysis and decision-making based on that modelling. This may be an acceptable risk where the modelling is straightforward or of limited impact. Where it is more complex and high impact, then it is likely that the risk will need to be mitigated. Consideration should be given to building capability amongst a wider number of staff.

The second risk however, is that the use of a single developer or user, through no fault of their own, may increase that chances that errors in the model or model approach go unchallenged. This may point towards the need for higher levels of independent review when the model has been developed or is used by a single person.

User Guide and Succession Planning

Ideally each CCC model should contain either a user guide or instructions within the interface that, as a minimum, enable an ‘intelligent new user’ to produce new model runs without, or with clearly described, further input.

More comprehensive user guides can prove resource-intensive, and the precise format and content should take into account how frequently the model may be used in the future, how complex the model is to use and how wide the scope for error is in the operation or interpretation of the model. Where external contractors have been paid to develop a model, a comprehensive user guide should be seen as a way to protect that investment.

Strong QA practice would also include succession planning, where someone with the right skills and experience to take over the primary model user role is identified. Ideally this would encompass a period of handover to properly facilitate the transfer of the modelling function and capability.

Documentation Standards

There should be documentation of methods, sources and underlying reasoning which is a reference source, to allow new developers to understand the model's construction, and enable them to undertake new development work or create a new version.

All users and developers should have an understanding of what is expected. This may include formal documentation of elements such as model procedures, controls, structure and use. Model parameters and assumptions should be transparent and evidence-based.

Skills and Experience

Model developers and users should have appropriate levels of skill and experience in developing and using the model or model techniques. For complex models it may be appropriate to ensure

sufficient skills internally to operate and update a model, but with external expertise used for development.

If the appropriate capability does not exist within CCC, it may be necessary to build the capability through the use of a training and development plan that formally considers the appropriate skill mix and sets out how any gaps are to be filled.

Where there are multiple models interacting, there should be at least one member of staff that understands how they all fit together and has oversight of their interaction. Currently, in relation to mitigation, the Head of Carbon Budgets has this role.

2 Primary (input) data

Model results can only be as good as the data being fed in.

Data sources and year should be recorded. Where more recent data become available, consideration should be given to updating the dataset. The modelling framework should attempt to recognise the uncertainties and reflect these in its use and results.

Weaknesses and uncertainties in input data, for the task in hand, should be considered. They should be drawn to the attention of SRO, analytical clearer and approving body.

3 Model Accuracy and Reliability in development

The development of an analytical model can be thought of in three stages:

- Specification: The development of a common understanding of what the model is needed for; what questions the model will answer; what the risks and limitations around the different possible approaches are; what the timescales are; and what complexity and quality is required.
- Build: During the model build stage, the model owner or developer should be ensuring that the model is developed or used in line with the agreed specification and that any deviations or problems are communicated.
- Test: The final stage in the model life-cycle comes when the outputs are tested against requirements to ensure that they answer the question that was set and that any limitations and uncertainty are understood.

Input Validation

Input validation provides assurance that the data inputs and assumptions entering into the model and upon which the model calculations are made, are accurate and reliable. By accurate, we mean that the inputs are in the correct format and do not contain any errors. By reliable we mean that they are the correct inputs for the question in hand, for example the correct measure of GDP or inflation.

As well as data inputs, the model is also likely to have parameters. These are structural properties of the model, such as elasticities, and might be fixed for many runs of the model. These parameters will also need to be kept under review as part of the input validation process.

Once data and assumptions have been entered into the model, good practice is to formally log their sign-off, perhaps in a separate register.

Developer Testing

Developer testing is a catch-all term for a wide range of processes and tests that can be undertaken to ensure that the model is reliable. This element of the QA regime may prove the most time and resource heavy part of the process. It will be for individual areas and model owners to identify the processes that are appropriate to their modelling.

Further to identifying the available range of developer tests, it is for model owners to agree the appropriate set of tests, addressing the trade-off between time, quality, cost and resulting risk that is considered acceptable.

Communication of Model Limitations and Uncertainty

The results from a particular analytical model are more often than not, only going to be one part of the overall decision-making process. For the Committee to understand the weight they may wish to place on those results, the limitations and uncertainty in the modelling need to be communicated. To inform this, consideration should be given to:

- Sensitivity testing – how sensitive are results to plausible changes in individual assumptions.
- Scenario testing – how sensitive are results to plausible changes in a group of assumptions.
- Uncertainty in the modelling – the range of statistical uncertainty that exists around a result, perhaps caused by the uncertainty in the forecasts of inputs or model parameters.
- The limitations of the model – what are the questions that the model cannot or should not be used to inform.
- Risks from the QA approach - what are remaining risks given the mix of QA that has and has not been conducted, with reference to model impact and complexity?

Independent Review

Independent review is a strong element of any model QA. The degree of independent review that is desirable should be considered at the start of an analytical project and time and resource built into the project plan to allow for it. As a project evolves, it may be that the modelling turns out to be more risky than had been anticipated, either through complexity or profile. In such circumstances, it is likely that the degree of independent review that is desirable would increase.

Irrespective of the type of review that is chosen, it will always make sense to include someone other than the model developer or user performing a high level sense check of the final results.

The exact nature of the review and the checks and assurance that you are seeking to achieve, should be made explicit in a Terms of Reference. It is likely that the mechanism for ensuring independent review may vary from model to model. For example:

- Internal Review - usually defined as being undertaken by someone other than the modeller or model developer, but internal to the organisation. This may range from high-level sense checks, to more detailed interrogation of a model.
- External Review - External review may of itself be no more stringent than an internal review, but it is defined as being by someone outside of CCC. This could be a professional services firm, a government department or an academic institution.
- External Peer Review - tends to be a sub-set of external review, usually associated with a more academic approach to testing the overall quality of the approach taken and whether it fits with accepted best practice. The review tends not to focus heavily on the checking of calculations, but may, for example, consider whether the overall approach is valid.

- Internal Model Audit - Internal audit is likely to perform a different function to a review and will involve the use of a professional audit firm or possibly an audit team from within government. Internal audit may focus more on the risks in the process for undertaking the modelling and test the controls that are in place to mitigate those risks.
- External Model Audit - External audit will involve the use of a professional external audit function. An external audit is likely to be a comprehensive test of how the model functions, with the aim of signing off the final set of results as being accurate.

4 Model Accuracy and Reliability in Use

Effective model use means understanding what a model can and cannot do, asking the right question and understanding why it comes up with the answer it does. That answer should then be used within its limitations, and alongside other available evidence, to inform the Committee's position. Recommendations/decisions should never simply be justified *"because the model says so"*!

Input Validation

Similar to input validation for model in development, but will be focused on ensuring the input data and parameters remain valid.

Testing of Model Runs

Testing covers a wide range of processes and tests that can be undertaken to ensure that the model is reliable. This element of the QA regime may prove the most time and resource heavy part of the QA process. It will be for individual model owners to identify the processes that are appropriate to their modelling.

Communication of Model Limitations and Uncertainty

Similar to the processes used for model development, but as the model is likely to have been used in the past, it might be possible to glean more information about uncertainty by comparing past results with actual outcomes. The use of benchmarking against past outcomes and reviewing past model performance should help explore these questions in more depth.

Independent Review

Again, the main types of independent review will be the same for a model in use as for a model in development. However, if a model has been extensively tested during development it may be that stringent reviews need only take place when significant changes are made to the model. Where that is not the case, independent review is likely to focus on the interpretation of results, understanding why they have changed from one run to the next and ensuring that the approach is suitable for the question being asked.

5. Model Governance and Transparency

Governance

Governance is the process by which risk is managed and the appropriate QA regime signed off. Appointing a Senior Responsible Officer for each model helps to drive leadership and should form part of the governance framework. The appropriate level for the SRO will be determined by the impact of the model, but for business critical models, it is unlikely that the SRO will be below team leader level.

Thinking about the three stages of model development, governance should play an important role in all three:

- Model Specification
  - Establish the appropriate QA regime taking account of the model impact matrix and the degree of model complexity.
  - Identify resources and timescales for delivery.

- Model Build (running and use of model)
  - Monitor progress towards timescales
  - Provide a forum through which risks to delivery can be raised and mitigated.
  - Consider whether the QA regime remains appropriate.

- Model Testing (signing off results)
  - Provide challenge to final outputs.
  - Establish that the QA regime was followed.
  - Communicate risk and uncertainty to decision-makers.
  - Sign-off the completion of the modelling.

Transparency

Transparency is a powerful tool for improving the quality of analytical work. It encourages those producing something for public consumption to undertake more rigorous checks. It opens up the approach and results to a wide range of external experts and can spark challenge, debate and research.

On occasion there may be specific reasons which limit transparency - commercial sensitivity for example. But in general CCC expects to make analytical modelling work as transparent as possible.

6 Sense checking

Think about the results.

Again and again!

Annex E: Useful links

Macpherson Review

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/206946/review_of_qa_of_govt_analytical_models_final_report_040313.pdf

Aqua Book

https://www.gov.uk/government/publications/the-aqua-book-guidance-on-producing-quality-analysis-for-government

Checklist to help you plan what is needed but may be useful at any point as an aide memoire

checklist

Template for Excel workbooks (includes sheets for Version Control and Assumptions log)

TEMPLATE FOR ANALYSIS

Example published Assumptions log

Net zero report - https://www.theccc.org.uk/wp-content/uploads/2019/07/Net-Zero-assumptions-log.xlsx

External research/consultancy – contract terms

L:\Committee on Climate Change\Corporate Team\Staff Guidance\Contract forms