Department
for Environment
Food & Rural Affairs

CONTRACT CHANGE NOTE

Contract Change Note Number	**CCN003**
Contract Reference Number and Title	Contract: AQ0843 (ecm_47373) - The Provision of Mapping and Modelling of Critical Loads and Critical Levels Exceedance 2016-19
Variation Title	Extension of contract for the Provision of Mapping and Modelling of Critical Loads and Critical Levels Exceedance 2016-19
Number of Pages	14

Whereas the UK Centre for Ecology & Hydrology and the Authority entered into a Contract for the provision of Mapping and Modelling of Critical Loads and Critical Levels Exceedance 2016-19 dated 06/05/2016 (the "Original Contract") and now wish to amend the Original Contract.

It is agreed as follows:

1. With effect from 01/04/2020 the Original Contract shall be amended as set out in this Contract Change Note:

Change Requestor / Originator	[redacted]	
Summary of Change	Contract extension	
Reason for Change	Continuation of service by 6 months with break points. An extension of work packages 1-8.	
Revised Contract Price	Original Contract Value	£367,134.81
	Previous Contract Changes	£124,881.00
	Contract Change Note CCN03	£77,618.03
	New Contract Value	£569,633.84
Revised Payment Schedule	See Annex C for details.	
Revised Specification	See Annex A for details.	
Revised Deliverables	See Annex B for details.	
Revised Contract Period	01/04/2020-30/09/2020 with break points.	
Change in Contract Manager(s)	As per the Original Contract.	
Other Changes	N/A	

2. Save as herein amended all other terms and conditions of the Original Contract shall remain in full force and effect.

Execution of the Contract Change Note is carried out in accordance with EU Directive 99/93 (Community framework for electronic signatures) and the Electronic Communications Act 2000. The revised Contract is formed on the date on which both Parties communicate acceptance of its terms on the Authority's electronic contract management system ("Bravo").

ANNEX A - SPECIFICATION

Details of the extension to the Original Contract to 30th September 2020.

This Contract Change Note extends the Original Contract AQ0843 (ecm_47373), Mapping and Modelling of Critical Loads and Critical Levels Exceedance 2016-2019, which would otherwise expire on 31st March 2020. The Contract Period will be extended to 30th September 2020, subject to break point reviews on the following dates: 29th May 2020, 30th June 2020, 31st July 2020 and 28th August 2020.

The requirements of the project remain the same as those detailed in the Original Contract. The details below describe the Services required for the six month extension.

Approach and methodology

Introduction

This project supports the UK National Focus Centre (NFC) under the International Cooperative Programme for Modelling and Mapping (ICP-M&M) under the UN-ECE convention on Long-Range Transboundary Air Pollution (LRTAP). The NFC provides data used in the annual "Biodiversity Indicators" summary and to support policy, development and management decisions at UK, devolved-administration and local levels. Trends in the pressure and impacts of acidifying and eutrophying pollutants are presented in the annual Trends Report (e.g. Rowe et al., 2019). The project also supports continuing development of evidence-based methods and models for assessing impacts of air pollution on ecosystems and informing measures for mitigation and abatement.

The NFC uses data and methods (for pollutant concentrations, deposition, critical loads, critical levels, and biodiversity modelling) that have been developed, updated and agreed through national and/or international workshops and meetings over the last 25 years. Method development in the UK over this time period is documented on the current project website (www.cldm.ceh.ac.uk). These data and methods have been applied in the development of pollutant abatement policies, and in the monitoring of the habitat areas at risk from the potential impacts of acidifying and eutrophying pollutants.

The Principal Investigator (PI) for the project will be [redacted] Project management is described below, under Work Package 7.

Work Package (WP) 1: Maintenance of the Critical Loads Database (CLDB) and Site Relevant Critical Loads database (SRCL-DB).

PI: [redacted]

The current CLDB consists of 1x1 km resolution data sets of critical loads for 8 habitats sensitive to acidification (plus the catchments of 1752 freshwater sites), and 13 habitats sensitive to eutrophication. The data will be maintained within a documented MS Access database and as ESRI ArcGIS files appropriate for spatial analysis tasks. The SRCL-DB provides critical loads for the habitat features of UK Sites/Areas of Special Scientific Interest (A/SSSIs), Special Areas of Conservation (SACs) and Special Protection Areas (SPAs). These data will also be maintained

within MS Access databases that can be linked to site boundaries within ArcGIS for spatial analysis. Methods and data used to derive UK critical loads and exceedances are documented in a "Methods Report" (Hall et al., 2015) published on the UK-AIR website to provide transparency. Historically, the critical loads data could not be made directly available due to Intellectual Property Rights issues related to the underpinning soils data. These issues have now been resolved, with an agreement from the National Soil Resources Institute that derived data can be published, so it is now possible to make the critical load exceedances data freely available.

The Authority requires the CLDB to be maintained (and updated as appropriate) to enable the UK to respond to calls for data from the Coordination Centre for Effects (CCE) of the UN-ECE Convention on Long-Range Transboundary Air Pollution (CLRTAP), where they are used in the development of pollutant abatement protocols. Nutrient nitrogen data for SACs and SPAs from the SRCL-DB have also formed part of data submissions to the CCE (Hall et al., 2017). The CLDB is also used extensively within the UK, to assess critical load exceedances and determine the areas of habitats at risk from the adverse impacts of acid and nitrogen deposition. Summary results are used for compliance reporting by the Authority (see WP3). The UK critical loads data (CLDB and/or SRCL-DB) are required for:

- Integrated assessment modelling (UK-IAM) and optimisation of emission reduction strategies at the national and country scales within the UK under the Authority's SNAPS contract
- Use in the Air Pollution Information System (APIS: www.apis.ac.uk) to enable Statutory Nature Conservation Bodies (SNCBs), site managers, researchers, or environmental consultants to carry out air pollution impact assessments for individual sites.
- The development of "Action Plans" by SNCBs to deliver future programmes for environmental protection of designated sites from the impacts of nitrogen deposition.
- Supporting environmental permitting across the UK as well as for local authority planning decisions involving atmospheric releases.

WP1 will provide two deliverables:

D1. *Project/data set-up and ongoing data management activities.* This includes management, documentation and archiving of the critical loads and levels datasets, and underpinning data.

D2. *Update protected site boundaries and features, and assign critical loads*. The current SRCL-DB uses boundaries for protected sites (SSSIs, ASSSIs, SACs and SPAs) that date from 2011. Site boundaries and lists of designated features will be updated to use the most recent information from the SNCBs, and critical loads will be assigned based on the designated features and other information.

Work Package 2: Maps of pollutant concentrations and deposition.

PI: [redacted]

The Concentration Based Estimated Deposition (CBED) method (RoTAP, 2012; Smith and Fowler, 2000; Smith et al., 2000) will be used to provide 3-year rolling mean data sets of current deposition (sulphur, nitrogen, and base cations) for critical loads and the corresponding concentrations of gases (SO_2, NO_x, NH_3) for critical levels calculations, mapped at the 5 x 5 km scale matched to the UK National Grid. The CBED methodology has been used to provide comparable annual data

series of deposition for some air pollutant components from 1986 onwards, with the full suite of current components only available since 2004. Outputs from CBED have been used nationally for UK mapping and budgets of pollutants (Fowler, 1997; Irwin et al., 1997; RoTAP, 2012) and internationally in discussions with EMEP and IIASA (e.g. Fowler et al., 2004). The method uses site-based measurements of rainfall ion, gas and particulate concentrations from the UK Eutrophying and Acidifying Pollutants (UKEAP) network. These are either directly interpolated to generate concentration maps or are used in combination with models based on emissions inventories to generate more detailed national and local-scale spatial mapping (for SO_2, NO_2 and NH_3).

Wet deposition is calculated within CBED as a combination of a pollutant concentration map with an annual precipitation map, using an orographic enhancement factor to take account of the "seeder-feeder" effect on the concentrations in precipitation in upland regions (Beswick et al., 2003; Dore et al., 2001). Gas, particulate and rainfall ion concentration maps are combined with spatially distributed estimates of vegetation-specific deposition velocities (Smith et al., 2000) to generate, respectively, values for dry, aerosol and cloud droplet deposition to different land cover types, which is important for calculating critical load exceedances. The concentration and deposition data are updated annually, but a rolling three-year mean of the data are used for the exceedance calculations to overcome inter-annual variations due to the natural variability in annual precipitation and the amount of polluted air imported from Europe. The contract specification outlines dependencies on data sourced from other contracts funded by the Authority, which include the UKEAP contract, the AURN contract with Ricardo-AEA for SO_2 and NO_2/NO_x concentration maps, with the UK Meteorological Office for annual precipitation maps, and with UKCEH for FRAME to provide an underlying NH_3 spatial mapping. The data generated under this contract will be used in WP3, WP4 and WP6 and are also required for:

- Other research projects funded by the Authority (e.g., SNAPS, Sustainable Intensification).
- The Air Pollution Information System (APIS: www.apis.ac.uk).
- Statutory casework carried out by the SNCBs.
- The application of the UK Nitrogen Decision Framework by the SNCBs, to allow them to more accurately identify and report on nitrogen impacts in site condition monitoring and reporting.
- Environmental impact assessments carried out by the Northern Ireland Environment Agency.
- Use by the Environment Agency to deliver permitting that addresses their legislative requirements (e.g. The Habitats Directive, CRoW Act).

FRAME is a Lagrangian model, originally developed for ammonia, but now extended to nitrogen and sulphur compounds. It simulates concentration and deposition over the UK using emissions inventories and a number of weather and vegetation related parameters. The mapped outputs can be at either a 1x1 km or 5x5 km resolution, with the 1km resolution giving better agreement with ammonia measurements, particularly for sites located in nature reserves (Hallsworth et al., 2010). The FRAME model will be updated annually to generate ammonia concentrations using the most recent emissions estimates from the National Atmospheric Emissions Inventory (http://naei.defra.gov.uk/) and Atmospheric Emissions for Natural Environmental Impacts (AENEID). Exceedance of ammonia critical levels (1 μg m^{-3} for lichens and bryophytes, 3 μg m^{-3} for higher plants) will be calculated using 3-year rolling mean FRAME 1x1 km NH_3 concentration data, calibrated relative to annually averaged measurements from the National Ammonia Monitoring Network (http://uk-air.defra.gov.uk/networks/network-info?view=nh3) to correct for some potential biases in the modelled data. In addition a 5x5 km version of the data will be used if data is requested for publication (i.e., due to issues with disclosure, 1x1 km data cannot be made publicly available at present).

It has been proposed that FRAME be replaced by EMEP4UK, an off-line atmospheric chemistry transport model (ACTM) based on the EMEP MSC-W model (www.emep.int). EMEP4UK is an Eulerian model, potentially allowing more accurate resolution of spatiotemporal dynamics, and has a wider developer and user community than FRAME. However, FRAME uses a more detailed vertical representation and is more sophisticated in its treatment of point sources of emissions. The Contractor will assess the difference that a change of model would make to exceedance statistics, and investigate possibilities for including aspects of the FRAME approach into EMEP4UK.

The spatial interpolation method used in the CBED model could potentially be improved by using a Bayesian approach that takes better account of the reliability / uncertainty in different input datasets. The Contractor will assess the difference this would make to exceedance statistics, to inform a decision about whether to change the interpolation method.

WP2 will provide three or four deliverables. (A decision as to whether deliverable 6 goes ahead will be made in break point review meetings.):

D3. *Report on implications of using EMEP4UK or FRAME to calculate ammonia concentrations*. The two models will be used to simulate concentrations for the same emissions map, for 2017. Differences will be explained, and the likely change in reported exceedance statistics assessed.

D4. *Report on implications of calculating spatiotemporal distribution of deposition using a Bayesian approach*. An alternative approach will be coded into CBED, the effect on reported statistics will be illustrated and summarised, and a recommendation made for the inclusion or not of this change.

D5. *Update "Methods Report"*. The Methods Report (Hall et al., 2015) documents methods used for calculating terrestrial and freshwater critical loads, critical levels and exceedances. It will be updated to maintain consistency with recent changes in data, calculation methods and code.

D6. *Revise methods for calculating concentration and deposition*. Changes recommended following the reviews of methods (D3 and D4) will be incorporated into the code to be used for exceedance calculations later in 2020, i.e. for use in the Trends Report 2021. If the break clause has not been invoked, this deliverable will begin in August 2020.

Work Package 3: Exceedance data and indicators.

PI: [redacted]

A suite of Python scripts is used for spatial analysis, using data from WP1 and WP2 to provide annual updates of:

a) Critical load exceedance summary statistics (area and percentage area exceeded, Accumulated Exceedance (AE), Average Accumulated Exceedance (AAE)) by habitat and country for UK habitats sensitive to acidification and/or eutrophication, and summary AAE maps.
b) Critical load exceedance statistics by country, for sensitive habitat features of SACs, SPAs and A/SSSIs (number and percentage of sites with one or more features exceeded, number and percentage of features exceeded, maximum AAE) and summary maps (e.g. number features exceeded per site, maximum AAE per site).
c) Ammonia critical level (1 µg m^{-3} for lichens and bryophytes, 3 µg m^{-3} for higher plants) exceedance statistics by country within the UK: (a) land area exceeded; (b) broad habitat area exceeded (based on the habitat distribution maps used in the application of nutrient nitrogen critical loads); (c) number of designated sites (SACs, SPAs, A/SSSIs) exceeded.

[redacted]

WP3 will provide one deliverable:

D7. *Maintain, quality assure and archive Python scripts for calculating exceedances*.

Work Package 4: Maintain Project (CLDM) and pollutant deposition (APIS) websites, make data available via the Environmental Informatics Data Centre, and provide reports for publication on the UK-AIR (UK Air Information Resource)

PI: [redacted] Contributor: [redacted]

The Trends Report 2020, and underlying datasets, are likely to be approved for publication within the period of the extension. The Contractor will support the Authority in fulfilling its open data principles by providing relevant methods descriptions, results and reports to the third party managing the UK Air website (http://uk-air.defra.gov.uk). This will ensure transparency of the data and methods used in the UK for the derivation of critical loads, exceedances and dynamic modelling, and public access to the UK concentration and deposition data sets generated under WP2. The Contractor will agree the format for the provision of these data with the Authority and the third party.

The Contractor will maintain updated data on the APIS website, which allows easy access to information about critical loads, levels and exceedances for particular localities. The most recent datasets on pollutant concentrations, deposition rates and exceedances will also be published on

the EIDC (Environmental Informatics Data Centre) website, which provides a long-term and stable platform for accessing data and associated metadata.

WP4 will provide one deliverable:

D8. *Maintain and update data on the CLDM, APIS and EIDC websites, and publish any updates to the Methods and Trends Reports.*

Work Package 5: UK National Focal Centre (NFC).

PI: [redacted] Contributor: [redacted]

The operation of the NFC enables the UK (and the Authority) to meet its obligations to actively participate in programmes (i.e. ICP M&M) under CLRTAP. [redacted] will act as the Head of the UK NFC and will attend the annual CCE workshop and ICP M&M Task Force meeting in Stockholm, 21-23 April 2020. He will represent the UK, updating the meetings on activities related to critical loads and levels and developments in the UK through the meeting *Tour de Table*.

A new CLRTAP centre, the "Centre for Dynamic Modelling" (CDM), has recently been proposed to coordinate work on dynamic modelling of Nitrogen and acidity impacts on ecosystems and biodiversity, e.g. to allow for delays in damage and recovery due to buffering, and to link impacts more directly to biodiversity targets. At the time of writing the CDM has not been formally approved, but it seems likely to be set up. [redacted] A key focus of the most recent Call for Data by the CCE is to make progress towards a new revision of the empirical critical loads for European habitats. [redacted] will present the latest results from the "Call for Data" to the meeting, and participate in discussions on requirements for impacts modelling and data submissions under CLRTAP.

WP5 will provide two deliverables:

D9. *Prepare presentation(s) for ICP M&M CCE / CDM meeting in Stockholm*

D10. *Attend ICP M&M CCE / CDM meeting in Stockholm and present modelling results*.

Work Package 6: Dynamic modelling.

PI: [redacted] Contributors: [redacted]

The combined effects of acid and eutrophying air pollutants on ecosystems and biodiversity can be simulated using models of biogeochemical change and consequent changes in habitat-suitability for species. The UK has developed a model chain (Rowe et al., 2015) consisting of the MADOC soil-vegetation biogeochemistry model (Rowe et al., 2014) and the MultiMOVE model of habitat-suitability for ~1300 plant and lichen species (Henrys et al., 2015). Following consultation with habitat specialists from the SNCBs, the Contractor also developed a metric of overall habitat-quality based on the suitability of the habitat for 'positive indicator' species (the Authority's contracts AQ0828, AQ0832 and AQ0840). This metric was shown to reflect biodiversity recovery following declines in nitrogen and sulphur pollution, and was adopted as a standard approach at the CCE Workshop in 2014, in particular for defining biodiversity-based critical load functions (Rowe et al., 2016). Critical load functions have been calculated for major pollution-sensitive habitats at 1x1 km scale and were submitted to the CCE in response to Calls for Data.

A key aspect of the metric used to reflect overall biodiversity value is the choice of indicator species. There are some discrepancies in the existing species lists, e.g. poorly-defined taxa such as "*Carex* species". The Contractor will contact experts in the SNCBs review the indicator-species used to derive the habitat quality metric, and report its recommendations for changes to the lists.

The MADOC biogeochemistry model reflects thinking on soil organic matter cycling and acid-base dynamics from the early 2010s, since when there have been several developments in the science of soil organic matter stability. If the extension is for six months, the Contractor will assess the biogeochemical modelling and data inputs, and identify priorities for model improvement and data gap-filling.

WP6 will provide one or two deliverables:

D11. *Refine biodiversity-based critical load calculations: update lists of indicator species.*

D12. (Only if the extension runs for 6 months). *Refine biodiversity-based critical load calculations: review biogeochemical modelling.*

Work Package 7: Reporting and Project management and meetings.

PI: [redacted] Contributors: [redacted]

[redacted] will be responsible for managing the project and the production of project reports, and will attend the twice yearly progress meetings with the Authority's nominated officer and the project Steering Group. [redacted] will be responsible for the management of WP6 and will deputise as project manager if necessary; he will also attend the progress meetings. Members of the project team will also attend other meetings with the Authority and/or the SNCBs, or other forums (e.g. CAPER: Committee for Air Pollution Effects Research) as required throughout the contract. [redacted]

[redacted] Project staff time and resources will be managed by [redacted], and through regular staff and finance reports generated by the UKCEH Finance Team. The planning and management of deliverables will be achieved through regular meetings and teleconferences with the project team, to monitor progress and determine any risks or concerns that can be raised with the Authority's nominated officer through the monthly Contact Management Reports. The project Risk Assessment will be maintained and reviewed prior to the delivery of each Quarterly Report; [redacted]. Project reports (including the project summary and Evidence Support Summary) will be generated as specified in the Contract and to the deadlines given for deliverables, unless otherwise agreed with the nominated officer. Any changes made to the UK methods for calculating critical loads and their exceedances will be documented in an updated version of the "Methods Report", and the report on "Trends in critical loads exceedances" will be updated annually. Both reports will be provided to the Authority's nominated officer for approval prior to submitting for uploading onto the project website. The web publication of these reports are important for providing transparency of the methods and data (and results) used in the UK to the Authority, the Devolved Administrations, SNCBs, other researchers, and NFCs in other countries (WP5).

WP7 will provide three deliverables:

D13. *Provide quarterly reports/updates to the Authority's nominated officer.*

D14. *Provide final project report to the Authority's nominated officer.*

D15. *Attend progress meetings with the Authority's nominated officer and project Steering Group.*

Work Package 8: Provision of *ad hoc* advice to the Authority, Devolved Administrations and SNCBs.

PI: [redacted]; Contributors: other project team members as required

[redacted] will respond to requests from the Authority, the Devolved Administrations and the SNCBs for advice relating to the use and interpretation of critical loads and exceedance data, or requests for data, maps, or results not covered under other work packages. [redacted]. All project staff responding to *ad hoc* requests will record the time spent on these tasks [redacted] and the total time spent per month will be submitted for approval to the Authority's nominated officer in the monthly contact management reports.

WP7 will provide one deliverable:

D13. *Provision of ad hoc advice to the Authority, Devolved Administrations and SNCBs*.

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ANNEX B – DELIVERABLES

Work Package	Deliverable	Description	Deliverable due
1	D1	Project/data set-up and ongoing data management activities	Project start and then ongoing
1	D2	Update protected site boundaries and features, and assign critical loads	May – July
2	D3	Report on implications of using EMEP4UK or FRAME to calculate ammonia concentrations	June – August
2	D4	Report on implications of calculating spatiotemporal distribution of deposition using a Bayesian approach	June – August
2	D5	Update "Methods Report"	May – July
2	D6	Revise methods for calculating concentration and deposition.	August – September
3	D7	Maintain, quality-assure and archive Python scripts for calculating exceedances.	Ongoing
4	D8	Maintain and update data on the CLDM, APIS and EIDC websites, and publish any updates to the Methods and Trends Reports.	Following completion of D5
5	D9	Prepare presentation(s) for ICP M&M CCE / CDM meeting in Stockholm	April
5	D10	Attend ICP M&M CCE / CDM meeting in Stockholm and present modelling results.	April
6	D11	Refine biodiversity-based critical load calculations: update lists of indicator species.	June - July
6	D12	Refine biodiversity-based critical load calculations: review biogeochemical modelling.	August – September
7	D13	Provide quarterly reports/updates to Defra nominated officer.	Quarterly
7	D14	Provide final project report to Defra nominated officer	At finish of project
7	D15	Attend progress meetings with Defra nominated officer and project Steering Group.	Monthly
8	D16	Provide ad hoc advice to Defra, Devolved Administrations, SNCBs	Ongoing

ANNEX C - PRICE

The Contractor's pricing information for a six-month Contract extension:

Total Cost to deliver (including expenses) - £ excluding VAT

Work Package	Deliverable	Description	Six month extension, e.g. 1st April 2020 to 30th Sept 2020	Total £
1	D1	Project/data set-up and ongoing data management activities	[redacted]	[redacted]
1	D2	Update protected site boundaries and features, and assign critical loads	[redacted]	[redacted]
2	D3	Report on implications of using EMEP4UK or FRAME to calculate ammonia concentrations	[redacted]	[redacted]
2	D4	Report on implications of calculating spatiotemporal distribution of deposition using a Bayesian approach	[redacted]	[redacted]
2	D5	Update "Methods Report"	[redacted]	[redacted]
2	D6	Revise methods for calculating concentration and deposition.	[redacted]	[redacted]
3	D7	Maintain, quality-assure and archive Python scripts for calculating exceedances.	[redacted]	[redacted]
4	D8	Maintain and update data on the CLDM, APIS and EIDC websites, and publish any updates to the Methods and Trends Reports.	[redacted]	[redacted]
5	D9	Prepare presentation(s) for ICP M&M CCE / CDM meeting in Stockholm	[redacted]	[redacted]
5	D10	Attend ICP M&M CCE / CDM meeting in Stockholm and present modelling results.	[redacted]	[redacted]
6	D11	Refine biodiversity-based critical load calculations: update lists of indicator species.	[redacted]	[redacted]
6	D12	Refine biodiversity-based critical load calculations: review biogeochemical modelling.	[redacted]	[redacted]
7	D13	Provide quarterly reports/updates to Defra nominated officer.	[redacted]	[redacted]

7	D14	Provide final project report to Defra nominated officer	[redacted]	[redacted]
7	D15	Attend progress meetings with Defra nominated officer and project Steering Group.	[redacted]	[redacted]
8	D16	Provide ad hoc advice to Defra, Devolved Administrations, SNCBs	[redacted]	[redacted]

Total Cost of Project, including expenses £ 77,618.03

All prices excluding VAT