# Developing a cumulative effects framework (CEF) for key ecological receptors in relation to offshore wind in the UK

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# Project Overview

Robust assessment of cumulative effects requires a consistent and transparent approach to the collation and analysis of the best available data.

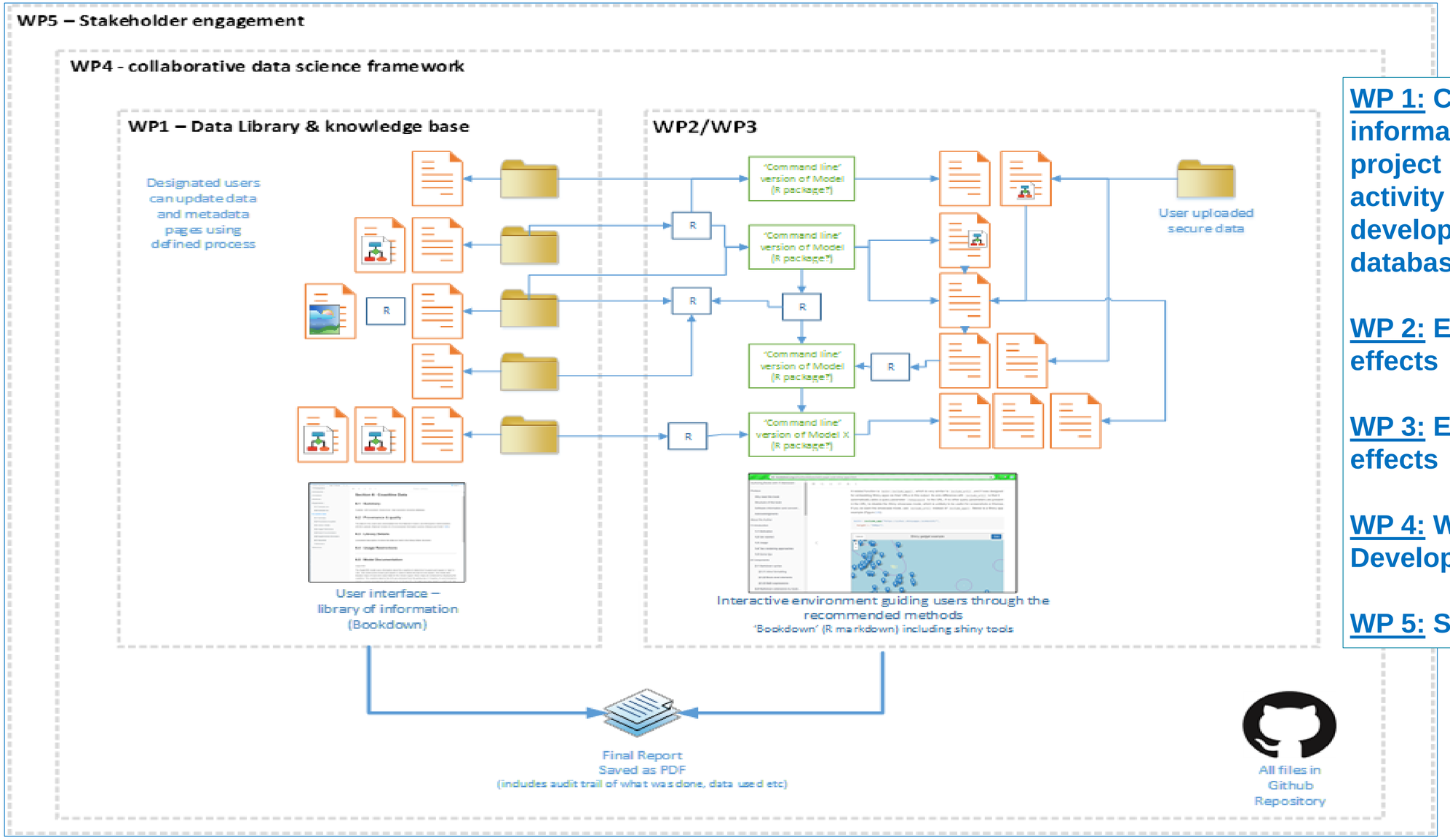
Three key requirements for developing a Cumulative Effects Framework (CEF):

- A Data Library, including Knowledge Base and Data Store, holding the key knowledge, parameters and data that feed into each of the modelling tools

- An R package that contains functions to run each of the modelling tools, link them together in feasible combinations, and perform a project-level or cumulative assessment

- A user interface that allows non-technical users to generate predicted impacts at a population level for both individual projects and cumulative assessments, with a clear audit trail to provide transparency and reproducibility

# Key elements




**WP 1:** Collation of generic information e.g. biometrics and project level information on activity and key receptors, and development of associated database

**WP 2:** Estimation of project level effects

**WP 3:** Estimation of cumulative effects

**WP 4:** Web Application Development

**WP 5:** Stakeholder engagement

# Overview of tools

## Session 1: defining populations

## Session 2: apportioning

- SNH Apportioning tool
- MSS Apportioning tool
- BDMP

## Session 3: displacement

-Displacement Matrix

-SeabORD

## Session 4: collision

-sCRM

## Session 5: PVA

- NE/JNCC PVA tool

# CEF – TWG Consensus Defaults

## Session 1 – Defining populations

# Defining populations

The tools in the CEF need an input table in the (approximate) following format:

| Population | SPA | Long | Lat | Species | Count | Year of count | Type of count | Wind farm interactions | | | | | SeabORD only - list Seabird 2000 subsites |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Name… | Yes | x | y | BLKI | 1462 | 2015 | AON | WF1 | WF2 | WF3 | WF4 | WF5 | (select from drop down) |
| Aa | Yes | | | | | | | No | | | | | |
| Bb | Yes | | | | | | | Yes for assessment and apportioning | | | | | |
| Cc | No | | | | | | | Yes but only for apportioning | | | | | |
| … | … | … | … | … | … | … | … | … | … | … | … | … | … |
| | | | | | | | | | | | | | |

Is it possible for the SNCBs to supply the information for these tables for each OWF footprint that will be stored in the Data Library?

If not, is there a simple mapping functionality we could use within the CEF to help users population this table using datasets for SPA boundaries, the SMP, and SB200?

# Possible sources of population size/location data

| Tool | Source of population size and location data | Could this source be changed within the CEF? |
|---|---|---|
| FAME maps / ORJIP Sensitivity Mapping Tool | Seabird 2000 (sub-sites) | **No** – would require remodelling of GPS data, which is beyond scope |
| SNH Apportioning (as implemented in ORJIP Sensitivity Mapping Tool) | Seabird 2000 (sub-sites) | **Probably** – can be changed, but depending upon having a comprehensive set of counts that cover all colonies to be considered in apportioning |
| SeabORD | Various | **Yes**, very easily |
| NE/JNCC PVA tool | Various | **Yes**, very easily |

# Key issues - 1

Default data sources to use for SeabORD, Apportioning tools and NE/JNCC PVA tool - should the same source always be used within all of these tools?

Possible sources: SMP, Seabird 2000, other?

# Key issues - 2

Matching of colonies within data sources to SPA boundaries

Historic data (SMP, Seabird 2000) do not always align with SPA boundaries

How to resolve this?

# Key issues - 3

Set of colonies to consider for apportioning

Are all colonies/SPAs within foraging range considered?

How is foraging range selected?

Which year is used? (always the most recent from within the chosen data source?)

# Key issues - 4

Matching colonies to those used in producing FAME maps

This is necessary whenever using these maps as inputs to SeabORD, or when using the MSS Apportioning tool

Only relevant for 4 species (kittiwake, guillemot, razorbill, shag)

FAME maps produced using Seabird 2000 subsites, so involves aligning to these

# Key issues - 5

Making sure the tools can be aligned to S2k – “futureproofing”

# CEF – TWG Consensus Defaults

# Session 2 - Apportioning

# Overview of tools

## Session 1: defining populations

## Session 2: collision

-sCRM

## Session 3: displacement

-Displacement Matrix

-SeabORD

## Session 4: apportioning

- SNH Apportioning tool
- MSS Apportioning tool
- BDMPS

## Session 5: PVA

- NE/JNCC PVA tool

# Apportioning

For a particular location at sea what percentage of birds originate from each of the possible breeding colonies?

**Breeding season – SNH Apportioning** and **MSS Apportioning Tools**

**Non-breeding season – BDMPS**

MSS apportioning tool is only available for four species: Kittiwake, Guillemot, Razorbill, Shag

# SNH and MSS Apportioning Tools

Both of these tools assume that the percentage of birds arising from each colony $y$ at a particular location $x$ is proportional to:

Size of colony $y$ x Relative abundance of birds from colony $y$ at location $x$

Relative abundance is derived from:

a) **SNH tool** - an assumption that relative abundance is proportional to (1 / distance by sea to colony squared)

b) **MSS tool** - estimated colony-specific utilisation distributions, derived by modelling multi-colony GPS data (Wakefield et al., 2017)

# Defaults for apportioning tools

SNH and MSS apportioning tools rely on specification of:

a) Data on locations and sizes of **all** colonies

b) **Foraging range**

c) Any **exclusion rules** (e.g. colonies that are within the foraging range, but should *not* be included in apportioning)

For MSS apportioning tool (a) the colony locations follow Seabird 2000 sub-sites, (b) foraging ranges are as in Wakefield et al. (2017), and (c) there are no exclusion rules

SNH apportioning tool – what choices should we make for each of these?

# BDMPS

**BDMPS is both spatial and temporal**

- **spatial scale fixed**
  - but the population sizes in each region are required
  - should these be set as defaults (based on Furness report)?
  - Do they need to be updated?
- **Temporal variation relates to seasons**
  - These are likely to differ across the UK
  - There may be overlap between seasons, e.g., March may be both migration and breeding seasons
  - ‘extended breeding season’ = longest breeding season, March included in breeding but not in migration
  - ‘migration-free breeding season’ = shorted breeding season, March included in migration only

  - **Should these be set as defaults in the CEF? By region?**

# CEF – TWG Consensus Defaults

# Session 3 – Displacement

# Inconsistencies in ‘displacement’ and ‘avoidance’ rates

The displacement matrix, SeabORD and the sCRM all require an input parameter that captures ‘**macro-avoidance**’ in some form:

- **the percentage of birds seen in the footprint pre-construction that would be displaced entirely from the area and not enter the footprint post-construction**

However, there are important inconsistencies in how these parameters are specified and used within the two modelling approaches:

**In SeabORD:**

- The displacement rate is the proportion of individuals within a population that will not enter an OWF footprint to forage within it

- SeabORD also specifies a ‘barrier rate’ – the proportion of individuals who are displacement-susceptible that are also barrier-susceptible; this is usually set to 100% so all birds are either both displacement **and** barrier susceptible (will not forage within or fly through an OWF footprint), or they are susceptible to neither

# Inconsistencies in ‘displacement’ and ‘avoidance’ rates

## Displacement matrix and sCRM:

- The displacement rate in the matrix approach applies to ***all birds*** observed within an OWF footprint (in flight and on the water); whilst the avoidance rate in sCRM approaches is applied ***only to birds in flight***

- The avoidance rate used in sCRM calculations encompasses ***three different scales of avoidance: micro, meso and macro***. However, the displacement rate used within the matrix approach is intrinsically assumed to capture ***only macro avoidan***ce (birds not entering the OWF footprint at all)

- The avoidance rate used within sCRM models ***incorporates a correction*** to account for model error (e.g., in relation to how flux rate is estimated)

# Situations in which SeabORD may be used:

- **Species:** kittiwake, guillemot, razorbill, puffin

- **Locations:**
  - Ideally anywhere where there is good local GPS tracking data that can used to derived a colony Utilisation Distribution (UD)

  - FAME colony-level maps may also be used for colony UDs, but only for:
    - Kittiwake
    - Guillemot
    - Razorbill

  - The use of at-sea maps for deriving colony UDs for SeabORD (e.g., puffins) is difficult because:
    - SeabORD models only breeding birds, at-sea survey data comprises all birds
    - The SNH apportioning tool must be used to create a colony-level UD
    - At-sea survey data is variable in terms of the time period in which it was collected and may not be reflective of current habitat use

# Key issues

1. **What default rates should be used?**

    - Displacement and barrier rates in SeabORD
    - Displacement rate in the matrix
    - Avoidance rate in the sCRM
    - Mortality rate from displacement in matrix
    - Buffer distances

2. **Should displacement and avoidance rates be the same?**

3. **SeabORD has other inbuilt parameters that will have been calibrated against data, and will not be available for users to change**

# SeabORD parameters

| Baseline – size and mass | Source | Change default? |
|---|---|---|
| Breeding adult body mass (at start of chick rearing period) | From literature/empirical data | Yes, but recalibrate prey availability |
| Initial chick body mass | From literature/empirical data | Yes, but recalibrate prey availability |
| Maximum chick mass gain per day | From literature | No, requires additional calibration against time-energy budgets |
| **Baseline - energetics and prey** | | |
| Adult daily energy expenditure | From literature | No, requires additional calibration against time-energy budgets |
| Chick daily energy requirement | From literature | No, requires additional calibration against time-energy budgets |
| Maximum prey intake rate | Fixed in calibration | No, requires additional calibration against time-energy budgets |
| Intake rate function parameters | Fixed in calibration | No, requires additional calibration against time-energy budgets |
| Assimilation efficiency | From literature | No, requires additional calibration against time-energy budgets |
| Energy gained from prey | From literature | No, requires additional calibration against time-energy budgets |
| Energy density of the bird's tissue | From literature | No, requires additional calibration against time-energy budgets |
| Energy cost of nesting at colony | From literature | No, requires additional calibration against time-energy budgets |
| Energy cost of flight | From literature | No, requires additional calibration against time-energy budgets |
| Energy cost of resting at sea | From literature | No, requires additional calibration against time-energy budgets |
| Energy cost of foraging | From literature | No, requires additional calibration against time-energy budgets |
| Energy cost of warming food | From literature | No, requires additional calibration against time-energy budgets |
| **Baseline - demography** | | |
| Baseline adult survival rates | From literature/empirical data | Yes, but recalibrate mass-survival relationship |
| Length of chick rearing period | From literature/empirical data | No, requires additional calibration against time-energy budgets |
| Body mass below which adult is assumed dead (as proportion of mean mass) | From literature | No, requires additional calibration against time-energy budgets |
| Body mass below which adult abandons chick (as proportion of mean mass) | Fixed in calibration | No, requires additional calibration against time-energy budgets |
| Body mass below which chick is dead (as proportion of initial mass) | From literature | No, requires additional calibration against time-energy budgets |
| Time threshold for unattendance at nest before chick dies | Fixed in calibration | No, requires additional calibration against time-energy budgets |
| Adult mass-survival relationship - slope parameter | From literature | Potentially could be changed? |
| **Baseline - behaviour** | | |
| Flight speed | From literature | No, requires additional calibration against time-energy budgets |
| Time step to use for modelling foraging | From literature/empirical data | No, requires additional calibration against time-energy budgets |

# CEF – TWG Consensus Defaults

# Session 4 - sCRM

# Stochastic CRM: MS tool

1. Band Option(s)

2. Flight Heights: Project specific data?

3. Nocturnal activity; Garthe & Hüppop 2004 sCRM

# Band Options

Option 1: **basic** Band model using **site specific** data for **proportion** of birds at risk height.

Option 2: **basic** Band model using **generic** data for **proportion** of birds at risk height.

Option 3: **extended** Band model using **generic** data for flight height **distributions**.

Option 4: **extended** Band model using **site specific** data for flight height **distributions**.

# Flight Heights

Band Option 3: generic flight height information (Johnston et al 2014)

Band Option 2: generic flight height information (PCH)

Band Option 1: PCH from boat surveys? Not available all projects…

# Nocturnal activity

Garthe & Hüppop 2004 rankings (on a scale of 1-5).

sCRM tool: Proportion of daytime activity (0-1). With SD of this proportion.

Other evidence? (e.g. northern gannet: Furness et al. 2018, nocturnal activity 8% of daytime, SD 9.1)

# CEF – TWG Consensus Defaults

# Session 5 - PVA

# Inputs for NE/JNCC PVA tool

1. Baseline demographics
2. Initial population size(s) and year(s)
3. First and final year of ORE operation

Annual effects of OREs – within the CEF derived from outputs from other tools (sCRM, Displacement Matrix, SeabORD)

# 1. Baseline demographics

| Rate | Geographic level | Source |
|---|---|---|
| Productivity | Colony specific where possible, otherwise generic | Colony specific: SMP; Generic: Horswill & Robinson (2015) |
| Adult survival | Colony specific where possible, otherwise generic | Horswill & Robinson (2015) |
| Juvenile survival | Colony specific where possible, otherwise generic | Horswill & Robinson (2015) |
| Age at first breeding | Generic | Horswill & Robinson (2015) |
| Maximum brood size | Generic | Horswill & Robinson (2015) |

| Species | MBS | AFB | Populations in H&R (2015) with data for: | |
|---|---|---|---|---|
| | | | Adult survival | Juvenile survival |
| Arctic Skua | 2 | 4 | Foula | Fair Isle |
| Atlantic Puffin | 1 | 5 | Fair Isle, IoM, Skomer | Canada |
| Common Guillemot | 1 | 6 | Canna, Colonsay, IoM, Skomer | IoM |
| Common Tern | 4 | 3 | USA | Germany |
| Northern Fulmar | 1 | 9 | Eynhallow | Antarctica |
| Great Black-Backed Gull | 3 | 5 | Non-UK | Non-UK |
| Great Cormorant | 4 | 3 | Denmark | Denmark |
| Herring Gull | 3 | 5 | IoM, Skomer | IoM, Skomer |
| Black-Legged Kittiwake | 2 | 4 | IoM, Foula, Skomer | North Shields |
| Lesser Black-Backed Gull | 3 | 5 | IoM, Skomer | Skomer |
| Little Tern | 1 | 2 | Non-UK | Non-UK |
| Northern Gannet | 1 | 5 | Bass Rock, Ailsa Craig | Bass Rock, Ailsa Craig |
| Razorbill | 1 | 5 | IoM, Skomer, Shiants | Canada |
| Sandwich Tern | 3 | 3 | UK? | UK? |
| European Shag | 4 | 2 | IoM | IoM |

# 1. Baseline demographics

Questions:

a) What amount of productivity data in the SMP is sufficient to use colony-level rather than generic rates?

b) What if productivity data are only available for part of an SPA?

c) Should colony-level data only be used within the SPA they originate from, or should they also be used at nearby colonies? If the latter, how nearby?

d) Should colony-specific rates for adult/juvenile survival always be used when these are available?

# 2. Initial population sizes

Possible sources:

SMP

Seabird 2000

Other

Note: aim will be to future-proof the CEF to be able to use S2K data in future, but timescales mean this will not be one of the data sources in the initial version of the CEF

# 3. First and last year of ORE operation

Needed for each project within the Data Store

Project specifications (e.g. number of turbines) are currently assumed to be constant between the first and last year of operation

Assumption is that effects become zero after the last year of operation

# CEF – TWG Consensus Defaults

# SYNTHESIS: what have we agreed?

# Overview of tools

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UK Centre for Ecology & Hydrology

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# CEF – TWG Consensus Defaults

# Synthesis Defining populations

# Defining populations

*Some sort of mapping functionality within the CEF to help users populate table, using datasets for SPA boundaries, the SMP, and SB200*

*Crude but generically applied approach to matching SMP count sections with SMP boundaries*

*Acknowledged that Seabirds Count will be in SMP: future proofed approach*

# CEF – TWG Consensus Defaults

# Synthesis Apportioning

# Colonies/Apportioning

Are all colonies/SPAs within foraging range considered?

*YES. Might include non-UK colonies*

How is foraging range selected?

*Based on Woodward et al. 2019, details TBC*

Which year is used?

*CEF makes suggestions, user to choose*

# BDMPS

spatial scale fixed

*Look at updating regions based on SMP?*

*I.e. more interactive version of BDMPS*

Temporal variation relates to seasons:

- *Generic seasons within each region*
- *But need to consider how to approach 'deviant' colonies where there is evidence for different timings*

# CEF – TWG Consensus Defaults

# Synthesis Displacement

# Key issues

1. What default rates should be used?
    - Displacement and barrier rates in SeabORD:
    - Displacement rate in the matrix:
    - Mortality rate from displacement in matrix

    *USER DEFINED. NO DEFAULT SHOULD BE SUPPLIED*

2. Should displacement and avoidance rates be the same?

*NOT ESSENTIAL. Flag if non-sensible combinations applied.*

3. Buffers. *Preference to use project data where possible. Ideally facility to apply different displacement rate to buffer.*

# CEF – TWG Consensus Defaults

# Synthesis sCRM

# Stochastic CRM: MS tool

1. **Band Option**(s): *All available. Constrain to 'BASIC' (option 1 or 2), or 'EXTENDED' (option 3 or 4).*

2. **Flight Heights:** *Project specific data incorporated where available and suitable.*

3. **Nocturnal activity:** *Garthe & Hüppop 2004 sCRM: suggestions please!*

# CEF – TWG Consensus Defaults

# Synthesis PVA

# 1. Baseline demographics

Default position is to carry over from existing tool.

*CEF team to flag with PVA PSG if issues arise when applying in cumulative context.*

CEF to update PVA tool to allow different effects over time (ORE on/off grid).

*CEF team to ask RUK for project-specific timelines.*