



WRSE Regional Plan

Strategic Environmental Assessment Environmental Report - Appendix J - Natural Capital and Biodiversity Net Gain Report

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1 Introduction

1.1 Overview

This Appendix presents the natural capital assessment (NCA) and Biodiversity Net Gain (BNG) Assessment that have been undertaken as part of the environmental assessment process to support development of the Water Resources South East (WRSE) Draft Regional Plan.

Water Resources South East (WRSE) is made up of an alliance of the six water companies that cover the South East region of England, these are:

- Affinity Water
- Portsmouth Water
- SES Water (Sutton & East Surrey)
- Southern Water
- South East Water
- Thames Water

WRSE's aim is to secure the water supply for future generations through a collaborative, regional approach to managing water resources. To meet this aim WRSE is developing a multi-sector, regional resilience plan in order to secure reliable and resilient water supplies for the south east of England. The WRSE regional plan takes a long-term view to 2100 and provides a consistent framework for the development of the member water companies Water Resources Management Plans (WRMP) 2024. Further information on the description and context for the WRSE Regional plan can be found in Chapter 2 of the WRSE Draft Regional Plan Strategic Environmental Assessment (SEA) Environmental Report.

1.2 Guidance

Appendix A2 regional planning, Section 3.1 of the water resources national framework stipulates that regional plans must look to use a natural capital approach in their decision making where appropriate and provide commentary explaining if they choose not to do so. This is reinforced by the Water Resource Planning Guidelines (WRPG) that states Water Resource Management Plans (WRMPs) should “use natural capital in decision-making and provide environmental net gain through their WRMPs”.

Each WRMPs must set out how water resources will be managed to deliver secure supplies of water for customers and the environment over the long term. This supports the Government's ambition of leaving the environment in a better state that we found it as described in the 25 Year Environment Plan and Defra's Guiding Principles. The Water Resource South East (WRSE) regional plan should therefore provide a reliable NCA that is suitable to the regional scale but provides a framework to be built upon within the individual water companies WRMP's.

To ensure that a natural capital approach is incorporated in a consistent way across the WRSE Regional Plan the NCA was produced in line with best practice and guidance where possible including:

- DEFRA, (2020) Enabling a Natural Capital Approach.
- HM Treasury and government finance, (2018) The Green Book: appraisal and evaluation in central government.

- Natural England, (2019), The Biodiversity Metric 2.0 auditing and accounting for biodiversity.
- Natural England, (2020), Natural Capital Indicators: for defining and measuring change in natural capital.
- The Environment Agency, (2020) Water Resource Planning Guidance.
- The Environment Agency, (2020) Water resources planning guideline supplementary guidance – Environment and society in decision-making.

1.2.1 Updates to guidance

It should be noted that since the assessments in this report were undertaken, both ENCA and the Biodiversity Metric have been updated.

ENCA updated their guidance in August 2021 to reflect changes to reflecting developments in the evidence base and in improvements in response to user feedback, including updated values for the quantification of ecosystem services that the NCA for WRSE have scoped in. This means that some of the provision of ecosystem services may be considered out of date values.

The Biodiversity Metric, in July 2021, updated the Metric from the 2.0 beta test version released for consultation in 2019 to Metric 3.0 following consultation feedback. Biodiversity unit values generated by Biodiversity Metric 3.0 are unique to this metric and cannot be compared to unit outputs from Metric 2.0. For existing projects, the guidance is to carry on using the Metric 2.0 and for new projects to use the Metric 3.0¹ or latest versions available as is anticipated these will be released over the coming year and be regularly updated.

The Water Resources Planning Guideline Supplementary Guidance ‘Environmental Society in Decision-Making’ was also updated in November 2021 and references the updated ENCA and BNG metric. Therefore, it is likely that the regulators will expect WRMP24 to reflect the latest guidance.

1.2.2 WRPg supplementary guidance

In line with the WRPg supplementary guidance ‘Environment and Society in Decision making’ the WRSE regional plan NCA method was developed in accordance with the following principles:

- The assessment included the valuation of natural capital assets and ecosystem services within the footprint of each option and their zone of influence (see section 3.2).
- The assessment methodology used the most relevant qualitative, quantitative and/or monetary valuation approaches for the NCA. The assessment of the options impact on the natural capital metrics was undertaken in a sequential manner with an initial qualitative assessment, follow by a quantitative analysis and finally a monetised assessment if enough confidence existed in the values.
- Not all ecosystem services can be monetised within the NCA, however, those that are were assessed against a consistent methodology. The monetised natural capital metrics were incorporated into the cost benefit ratio as a discreet input. This monetised value was a single figure defined by the maximum natural capital benefit. The cost of the option was not considered within this assessment as it is captured elsewhere within the multi criteria assessment.
- Ecosystem services that were not monetised were quantified and incorporated into the regional plan decisioning making process within the SEA assessment.

¹ Note: The DEFRA BNG 2.0 metric has been used as part of the assessments. Version 3.0 is now available; however version 4.0 is due to be released and it is intended that the assessments are updated to 4.0 once it is made available.

- The NCA was undertaken using open-source data in accordance with the guidance for regional assessments and to ensure that the approach is consistent across the entire study area.
- The NCA methodology aims to align the water companies WRMPs' natural capital and ecosystem services which have previously been undertaken using separate approaches. It is hoped that the united methodology will enable joint investment in strategic and catchment-based options.
- The assessment criteria were designed to enable the maximisation of the potential benefits from the regional plan.

1.3 Environmental net gain

Environmental net gain is an approach to development that aims to leave the natural environment in a measurably better state than before the plan or scheme is implemented. There is currently no defined methodology for the incorporation of environmental net gain within regional water planning guidance. However, in line with the WRPG requirements the Draft Regional Plan environmental net gain will align with HM Government's 25 Year Environment Plan commitments and targets of:

- Conserving and enhancing Sites of Special Scientific Interest (SSSIs) (Wildlife and Countryside Act (1981) as amended)
- Furthering the purposing of the Habitats Directive (and Regulations) Conservation of Habitats and Species Regulations (2017) as amended
- BNG for habitats and species of principal importance for the conservation of biodiversity – (Natural Environment and Rural Communities Act (2006))
- Promoting conservation, restoration and enhancement of priority habitats, ecological networks and the protection and recovery of priority species

The Draft Regional Plan will aim to demonstrate whether it has achieved Environmental Net Gain (ENG) through the individual assessment such as BNG and wider environmental gains quantified through the NCA.

1.3.1 Natural capital

Natural capital refers to the elements of the natural world that provide benefits to society and includes aspects such as woodland, grassland, freshwater, marine, urban greenspace and wetland habitats. The benefits that are provided vary from regulating services such as natural flood management to cultural services such as recreational value.

1.3.2 Biodiversity net gain

BNG refers specifically to the combination of habitats present within a site and their ability to support biodiversity. Each habitat is given a distinct score that relates to its area, condition, distinctiveness and connectivity. The change in habitat due to the construction and operation of the regional plan options informs the overall BNG score and whether they are likely to contribute to a net gain in biodiversity. The Environment Act 2021 has now specified a requirement for development to demonstrate a 10% BNG.

2 Methodology

2.1 Approach to NCA and BNG assessments for WRSE

2.1.1 Stage 1: Defining the natural capital baseline

2.1.1.1 Introduction

To align with guidance and best practice, the methodology used for assessing and quantifying NCA and BNG for the Draft Regional Plan was based on Defra's "Enabling and Natural Capital Approach" ENCA and Defra's BNG assessment methodology. It was important to ensure there was no double counting of benefits or disbenefits when assessing the effects of the options. Therefore, the assessment of those services that would be included in other metrics such as those for water quality, which were included in Water Framework Directive assessments have been excluded from the NCA.

2.1.1.2 An overview of natural capital and ecosystem services

Natural capital: is defined by the UK Government's 25-Year Environment Plan as 'the elements of nature that either directly or indirectly provide value to people'. Natural capital assets are the stocks of renewable and non-renewable natural capital and the natural processes that underpin them. For example, soils, forests, farmland, rivers, minerals and oceans.

Ecosystem services: are the benefits we obtain from these natural capital assets. These can often be obvious such as clean water, timber, food and opportunities for recreation. However, these services can also be indirect and 'invisible' such as pollinator services or a sense of well-being.

The 25 Year Environment Plan strongly encourages the use of natural capital in decision-making as part of its commitment to improving the environment and leaving it in a better state for future generations. Including natural capital assessment in your decision-making allows you to consider some of the impacts of your plan on the natural assets and society, and make better decisions that support environmental enhancement for the benefit of people now and in the future.

2.1.1.3 Study area

The study area for the regional NCA has been defined as the water resource zones of the six WRSE water companies in addition to the zones of influence of all feasible options that extend beyond this boundary (including Strategic Resource Options which can extend beyond the WRSE regional area).

2.1.1.4 Zone of influence for option level assessment

The zone of influence for each option is defined as the area of receiving (i.e., a watercourse receiving a discharge) or providing (i.e., an aquifer where abstraction will occur) environment with the potential to be altered or changed as a result of the option. This can include the operational catchment for a surface water abstraction or an aquifer for a groundwater abstraction in addition to the footprint of the option.

2.1.1.5 Developing a natural capital baseline

As part of the NCA of the feasible options list, a natural capital baseline was developed for the study area. This baseline was developed using open-source data as described in NECR285² to generate a natural capital account of the stocks within the WRSE region. The list of stocks considered within the accounts and the methodology for mapping them are shown in Appendix A. The methodology used to map natural capital utilised the same breakdown of stocks as the National Natural Capital Atlas where possible. However, the list has been supplemented with additional abiotic stocks and key habitats that are vital to the WRSE region such as chalk streams and rivers.

The natural capital baseline reported the total quantity of each stock within the study area, and where suitable, an indication of natural capital condition. Monetary valuation of the natural capital baseline was not included within the regional natural capital baseline due to the availability of data.

2.1.2 Stage 2: Option level NCA

An NCA was undertaken for each feasible option that included assessments across the option footprints and zones of influence. The impact of each option on the natural capital stocks and indicators of condition was reported for each option quantitatively. This impact was reported for construction and post construction to give an estimation of the impact of the option's whole lifecycle. The results of the stock assessment were reported in total losses and gains within each option's zone of influence.

The results of the change in natural capital stocks informed the assessment against the six natural capital metrics (ecosystem services) listed below using the Natural England logic chains. The cost / benefit assessment was informed by the option type, option description and any embedded mitigation. The outputs of the NCA were compared to the pre-construction provision of services to assess the impact of the option. Five services were monetised, and the results of the assessment reported as a discreet monetary figure, water purification was assessed quantitatively, and the results incorporated within the water objectives of the SEA assessment.

Figure 2.1: Ecosystem services valuation logic chain



The metrics used to assess the impact on natural capital include:

- Carbon sequestration (Climate regulation)
- Natural hazard management

² Natural England, (2020) National Natural Capital Atlas: Mapping Indicators

- Water purification * Qualitative assessment
- Biodiversity and habitats * BNG assessment
- Air pollutant removal
- Recreation & amenity value
- Food production

Further explanation of the metrics is detailed in Section 2.1.3.

Biodiversity & habitats was assessed separately using DEFRA's BNG Metric 2.0, quantitative methodology, detailed in Section 2.1.4 below. The provision of public water supply has been excluded from all assessments to avoid potential double accounting of benefits within the multi-criteria optimisation. The value of leaving the water in the environment and the benefit this will provide to biodiversity, and other current and future abstractors was assessed through the Environmental Destination work and was not assessed as part of the NCA.

A description of the assessment by option type is given in Table 2.1.

Table 2.1: NCA by option type

Option type	Assessment process
Supply options	Each supply option was assessed individually against the full range of ecosystem service metrics within the option footprint and for natural hazard management and Water purification within the zone of influence.
Catchment options	Catchment options were not assessed for impacts against the ecosystem services as the option were not sufficiently developed at the time of assessment. The likely impact of catchment management options on the environment was reported qualitatively within the wider environmental assessment.
Demand options	Demand options were not assessed for impacts against the ecosystem services. The likely impact of demand options on the environment was reported qualitatively within the wider environmental assessment.

2.1.3 Ecosystem services screening

During the initial phase of the NCA, all of the six ecosystem services listed were reviewed and scoped in or out due to the geographical or socio-economic context of the option and its zone of influence. Specific guidance on the screening process for individual metrics is provided below.

2.1.3.1 Climate regulation

The climate regulation metric focuses on carbon sequestration which can be defined as the capture and secure storage of carbon that would otherwise be emitted to, or remain, in the atmosphere. The carbon sequestration NCA was in addition to constructional carbon and operational carbon calculations and provides a holistic assessment of option carbon emissions.

The assessment was determined by land management within each option footprint which influence the carbon store for prolonged periods of time and result in a change in net emissions. The estimate of the carbon stocks for each option footprint was based on the area of broad land use types according to literature and research. The estimated carbon stocks for broad habitat types are listed below and the sequestration rates are show in Table 2.2.

Table 2.2: Carbon sequestration rates for broad habitat types (JBA Consulting)^{3 4}

Land-use type	C Seq rate (t/CO ₂ e/ha/yr)
Woodland - (deciduous)	4.97
Woodland – (coniferous)	12.66
Arable Land	0.107
Pastoral land	0.397
Peatland - Undamaged	4.11
Peatland - Overgrazed	-0.1
Peatland - Rotationally burnt	-3.66
Peatland - Extracted	-4.87
Grassland	0.397
Heathland	0.7
Shrub	0.7
Saltmarsh	5.188
Urban	0
Green Urban	0.397

The carbon sequestration rates were converted to monetary values using standard methods and the Department for Business, Energy and Industrial Strategy (BEIS) Interim Non-Traded Carbon Values (Table 2.3).

Table 2.3: BEIS updated short-term traded sector carbon values for policy appraisal, £/tCO₂e (real 2018)

Year	Low	Central	High
2018	2.33	12.76	25.51
2019	0.00	13.15	26.30
2020	0.00	13.84	27.69
2021	4.04	20.54	37.04
2022	8.08	27.24	46.40
2023	12.12	33.94	55.75
2024	16.17	40.64	65.11
2025	20.21	47.33	74.46
2026	24.25	54.03	83.82
2027	28.29	60.73	93.17
2028	32.33	67.43	102.53

³ Alonso, I., Weston, K., Gregg, R. & Morecroft, M. 2012. Carbon storage by habitat - Review of the evidence of the impacts of management decisions and condition on carbon stores and sources. Natural England Research Reports, Number NERR043.

⁴ The Environment Agency, (2020) Water resources planning guideline supplementary guidance – Environment and society in decision making.

Year	Low	Central	High
2029	36.37	74.13	111.88
2030	40.41	80.83	121.24

2.1.3.2 Natural hazard regulation

Different habitat types have intrinsic flood risk management values by intercepting, storing and slowing water flows. This is known as natural flood management (NFM) and is listed as a policy within the 25-year Environment Plan. The capacity of habitats to achieve this can be quantified, and then a monetary value can be assigned based on the damage-costs avoided from flooding or replacement costs due to their capacity to regulate flood waters. The capacity for a given natural capital asset to provide a flood regulation service will depend on two factors:

- 1) Its capacity to slow overland flows
- 2) Whether the asset is located in an area of flood risk

This ecosystem service also applies in urban areas, where vegetation can reduce surface water flooding from heavy rainfall, with benefits to sewerage capacity. Coastal flood risk, which has been predicted to increase with future climate change, is reduced by coastal margin habitats such as saltmarsh.

Options were assessed on their ability to impact flood risk positively or negatively through the comparison of pre & post construction natural capital stocks and the catchment in which it is located. The assessment is restricted to catchment areas which drain to downstream communities impacted by flooding. These communities are identified using the Environment Agency's Indicative Flood Map, which overlays areas at risk of fluvial flooding and the National Receptor Database.

Reduced flood damage to downstream or coastal settlements as a result of reduced magnitude / frequency of flood / storm events; and / or lower sewer capacity or water storage costs was valued in line with the "valuing flood regulation services of existing forest cover to inform natural capital accounts" methodology. This assessment was developed to provide indicative national estimates of water regulation services of woodland to inform natural capital accounts, this is based on modelling to estimate the potential volume of flood water avoided by woodland ecosystems in flood risk catchment. The methodology adopts a replacement-cost (rather than damage cost) approach to valuing the flood regulation service of woodland by applying annualised average capital and operating costs of flood reservoir storage that would be required in the absence of the ecosystem service.

Central estimate of the average annual costs of reservoir floodwater storage is £0.42 / m³. The range is from £0.10 to £1.19 /m³ per year. These "replacement costs" can be considered a lower bound of the benefit if it can be assumed that such expenditure would be deemed value for money by the flooding authorities within flood risk catchments in terms of avoided flood damage costs.

2.1.3.3 Water purification

Based on their ecological functioning, different habitat types, have varying capacities for absorbing pollutants from a given water source. This service is dependent on the location of the natural capital asset and the nature of the surrounding area. If a natural capital asset has a high capacity to remove pollutants but is not close to a water source, the service will not be provided. Due to this, valuation of the static water purification services of different natural capital assets as part of the NCA was not considered appropriate. A common value for different habitat types could not be applied due to extensive variation in local factors which determine the provisioning of this service.

To account for the provision of this service within the NCA the impact of an option associated with the provision or removal of woodland and semi-natural grassland was assessed using the modelling results from the NEVO⁵ tool. The tool defines the resulting changes for the following water quality variables:

- Dissolved oxygen concentration
- Nitrogen concentration (including organic nitrogen, nitrate, nitrogen dioxide, ammonium)
- Phosphorous concentration (including organic and mineral phosphorous)
- Pesticide concentration (for eighteen different pesticide types)

This approach follows the methodology that if an area of woodland were to be lost, the resultant impacts on water quality can be quantified within the option's zone of influence. Any negative changes to the natural Capital in theory, reflects the loss of this service within each option's zone of influence.

2.1.3.4 Air pollutant removal

Air pollution presents a major risk to human health, resulting in premature deaths and reduced quality of life. By removing air pollution, habitats help to lessen these impacts on health and wellbeing. The provisioning of the service is positively related to several key aspects:

- The surrounding area of the natural capital assets with regards to background pollution, especially particulate pollutant
- The quantity and type of natural capital asset, woodland is the major service provider
- The density of population potentially benefiting from reduced exposure. Because pollutants are transported, beneficiaries may be downwind of the ecosystem

Each option was screened against the provision of air pollutant removal according to the location of the option. Air pollutant removal was only considered within build up areas or when the zone of influence included an Air Quality Management Area(s). The impact of the option was assessed according to changes in natural capital stocks.

The value provided by natural capital assets was taken from the UK government's air quality economic assessment methodology⁶. The assessment embeds these values (based on the damage cost approach, i.e., damage to health avoided from reductions in air pollution) and estimates the present value automatically based on the quantitative estimates provided.

Indicative average values for air pollution removal in 2015 for the different levels of air pollutant removal for each habitat types have been calculated from aggregate UK values published in February 2019, as shown in Table 2.4.

The value of each habitat was combined with the changes expected in natural capital stocks to provide a value for the change in service provision. The final impact was reported as a single value that was incorporated within the NCA metric.

Table 2.4: Air pollutant value by habitat type

Habitat group	Value (£ per hectare per year)
Urban Woodland	771
Rural Woodland	245

⁵ Luizzo, L., (2019) Natural Environment Valuation Online Tool - Chapter 6a: Water Quantity & Quality Model

⁶ Jones L., Vieno M., Morton Dan et al. (2019) Developing Estimates For The Valuation Of Air Pollution Removal In Ecosystem Accounts. Final Report For Office Of National Statistics - NERC Open Research Archive.

Habitat group	Value (£ per hectare per year)
Urban grassland	149
Enclosed farmland	14
Coastal margins	26

2.1.3.5 Recreation & amenity

The recreational value of green spaces can be significant. This value reflects both the natural setting and the facilities on offer at the site and often has a strong non-market element. It varies with the type and quality of habitat, location, local population density and the availability of substitute recreational opportunities. Recreational values can be beneficially affected by enhancements in green spaces, or adversely affected by new developments or infrastructure. The wider tourism and outdoor leisure sector is also dependent upon nature to varying degrees.

This metric depends on the extent to which the natural capital stocks the option provides will enhance the opportunity for recreation.

The key parameter needed to estimate in this category is the number of additional or enhanced recreational visits created because of the option. This was estimated using the Outdoor Recreation Valuation Tool (ORVal). ORVal is Referenced in HM Treasury Green Book. Random utility / travel cost model of recreational demand for all sites in England and Wales and generates probabilistic predictions of visitor numbers for any publicly accessible outdoor recreation park, path or beach. It takes account of scarcity of sites and substitution possibilities, as well as travel distances to sites and their attributes. This is useful for baseline initial assessment, accounting, and multiple sites. This should be seen as an estimation in the absence of site-specific data on visitor numbers.

The change in natural capital stocks and the creation or removal of greenspace was entered into Orval according to the NCA. The change in visitors and estimated change in value was reported for each option using the Orval online tool.

2.1.3.6 Food production

Food in its various forms is produced by a range of ecosystems in some cases, the food for human consumption is effectively the same as the ecosystem service (for example, wild fruit, capture fishing). More often the provisioning service is a raw material (for example, crops) that is harvested and processed by humans and produced capital into added value processed food (for example, bread). The boundary between what is provided by natural capital and the contribution of other forms of capital is often a grey area. For example, crops require agricultural management; livestock depends upon grassland ecosystems.

Food production has been calculated using the NEVO agricultural model, this is a structural model of agricultural land use and production for Great Britain estimated using Farm Business Survey (2005 – 2011) and June Agricultural Census data. The agricultural land use component in NEVO builds upon the approach developed by Fezzi and Bateman⁷.

⁷ Fezzi, C., Bateman, I., Hadley, D. & Harwood, A. 2019. Natural Environment Valuation Online Tool - Chapter 1: Agriculture Model

NEVO was used to assess the impact of the creation or removal of agricultural land for each option. The change in value of food provision for the footprint of each option was calculated using this online tool and reported within the NCA metric.

2.1.4 Biodiversity Net Gain

BNG or net loss must be considered at both the option and programme level and an environmental optimised programme suggested. Each option should look to maximise biodiversity net gain and any required mitigation should be included in the option cost. The Water Resources Planning Guideline Supplementary Guidance states that if there would be a significant additional cost for an option to get significant extra benefit, this could be included as a separate option for consideration.

A biodiversity baseline was developed from spatial data sets of habitats inventories (Appendix A) and assessed in line with the DEFRA BNG metric 2.0⁸ which can be used to calculate BNG change through land use of each option. The natural capital account was used to identify the biodiversity value of the footprint of each option prior to construction. The post construction land use including agreed mitigation was used to calculate the post construction biodiversity score.

As this assessment was carried out using only open-source data a precautionary approach was applied, presuming that where not specifically known, habitats were assigned the moderate habitat score. This is recommended as a suitable methodology for the scale of the regional plan and will allow for the individual companies to utilise this work within their own WRMPs and supplement the open-source habitat data with local datasets or Phase 1 site data to increase the accuracy of calculations for each option.

2.1.5 Stage 3: Reporting of results

The results of the NCA are summarised in this NCA report (see Section 3). The baseline natural capital assets within the regional plan study area are reported and key benefits, issues and opportunities summarised.

The changes in natural capital stocks were reported for each option with the results of the ecosystem services screening and detailed assessment. The separate natural capital metrics were aggregated into a single metric that was considered within the WRSE investment model and were used to support development of the Draft Regional Plan (Best Value Plan). The impacts of each option against the individual natural capital metrics were reported to allow for further analysis and optimisation. The results for each option were summarised in proforma that demonstrate the results of the assessment and for the justification behind the assessment.

The results of the NCA and BNG assessments was incorporated into WRSE decision making process through the conversion of the results into metrics as described below:

- **Natural capital metric:** A single discreet monetised value reported in £/year generated by combining the outputs of each of the six monetised natural capital metrics to provide a single cost / benefit figure.
- **BNG metric:** A single score for each option showing the percentage change in biodiversity net gain units for each option according to the metric.

⁸ Note: The DEFRA BNG 2.0 metric has been used as part of the assessments. Version 3.0 is now available; however version 4.0 is due to be released and it is intended that the assessments are updated to 4.0 once it is made available.

2.2 In-combination effects assessment

This technical appendix only reports on the NCA and BNG in-combination effects assessment of the chosen programmes of options selected in the Draft Regional Plan (referred to as the Best Value Plan (BVP)) and under Situation 4 (see SEA Environmental Report, Section 2.3 for an explanation of the BVP development and the use of a situation tree for adaptive planning):

- Draft Regional Plan (Best Value Plan) – Investment model pareto runs for Best Value Plan metrics (Customer Preference, SEA+, SEA-, natural capital, Carbon, Resilience (reliability, adaptability, evolvability), intergenerational equity), this is optimised on both individual Best Value Plan and cost metrics

The approach has involved two separate assessments which has comprised of options selected by 2050 and separately those selected post 2050 (and up until 2075) (see Section 4). The pre and post 2050 options have been assessed separately because up to 2050 is the 25-year statutory WRMP period and after this the plan becomes the regional strategy with uncertainty related to planning scenarios and technical improvements for options.

The two alternative programmes, the Least Cost Plan and the Best Environmental and Societal Plan, have not been subject to the NCA and BNG in-combination assessment.

The options included in BVP that were scoped in for NCA and BNG assessment were assessed as part of the in-combination effects assessment (see Section 4 for results). The in-combination effects assessment for NCA and BNG summarised the trends and results of BVP on the impacts on natural capital, ecosystem services and BNG whilst also summarising the BNG units the Draft Regional Plan requires to purchase in order to achieve a 10% lift in BNG.

The in-combination effects assessment only included the in-combination effects of the selected options. Wider in-combination effects with other plans, programmes and projects will be undertaken at the WRMP level.

2.3 Assumptions and limitations

The following assumptions were used within the assessments:

For NCAs:

- The costs for constructing, operating, and maintaining the options were not considered within the assessments.
- Natural capital stocks identified within the areas allocated for above ground infrastructure were assumed to be completely lost as a result of the option construction.
- Natural capital stocks presumed temporarily lost were expected to be reinstated/compensated.

For BNG Assessments:

- No enhancement of biodiversity post construction was considered, apart from where this has been explicitly included in the option description/design. BNG habitat units were assigned to the pre-construction land use according to the habitats present within each option boundary. The post construction land use, including agreed mitigation (if any), was used to calculate the post construction biodiversity score.
- The desk-based assessment was carried out using open-source data. As such, a precautionary approach was applied, presuming that where not specifically known, habitats were assigned the

moderate habitat score. Habitat identification will need to be refined with habitat survey data at later design stages to refine the accuracy of the BNG calculations for each option.

- The duration of disturbance and timeline for habitat creation has not been included in the assessment. Durations of disturbance, including proposals for creating habitats in advance of disturbance, will need to be refined with greater design detail at later stages to refine the accuracy of the BNG calculations for each option.
- The BNG assessments were undertaken using the most up-to date Defra BNG Metric at the time (2.0 Metric). However, since then the Metric has been updated to the 3.1 Metric which was published on the 21st April 2022. Guidance states that projects should continue to use the Metric that was in use at the time (unless requested to do so otherwise by their client or consenting body) for the duration of the project it is being used for as they may find that certain biodiversity unit values Metric 3.1 generates will differ from those of previous Metrics.

3 Option Level NCA and BNG findings

3.1 Net gain, summary of findings

The results of the BNG and NCAs for all of the options scoped in for detailed assessment have been used to identify the likely impacts of the options on these assets. The impacts have been measured quantitatively either in terms of natural capital stocks, ecosystem services or through the DEFRA Metric 2.0.

At present, most options are resulting in a net-loss to habitats, natural capital assets and corresponding ecosystem services. Broad habitats lost include:

- Woodland and forest
- Rivers and lakes
- Grassland
- Heathland and shrub
- Urban
- Cropland
- Sparsely vegetated land

These broad habitats correspond with the following habitat types:

- Ponds
- Lowland mixed deciduous woodland
- Broadleaved woodland
- Coniferous woodland
- Modified grassland
- Heathland and shrub
- Urban
- Cropland
- Sparsely vegetated land
- Neutral grassland

Correspondingly, the habitat loss is resulting in a net loss of natural capital assets and ecosystem services including:

- Carbon sequestration (Climate regulation)
- Natural hazard management
- Air pollutant removal
- Water purification
- Food production

- Recreation & amenity value

Some options such as reservoir options are resulting in a net-increase in habitats, natural capital assets and corresponding ecosystem services. Broad habitats gained include:

- Abiotic

This broad habitat corresponds with the following habitat type:

- Modified waters (reservoirs)

3.2 Catchment options

The catchment options were developed to improve targeted local environmental conditions and are subject to further development, therefore, they were not included in the scope of the NCA or BNG. It is recognised that catchment management options have the potential to provide biodiversity net gain and increase provision of ecosystem services. The potential opportunities of assessing NCA and BNG of these options are presented in Section 4.3.

4 In-combination effects assessment of the BVP

4.1 Summary of findings

The in-combination effects assessment was undertaken for the Draft Regional Plan (Best Value Plan) pre and post 2050 for both the NCA and BNG assessments. For the NCA and BNG assessments, the in-combination effects assessment only considered the BVP options and does not include an assessment of the alternative plans. The in-combination effects assessment for the BVP considered the option assessments as a whole and the habitat units that would be required to be purchased in order to achieve a 10% net gain in BNG. This provided an estimate of the value of the potential mitigation or enhancement opportunities that will need to be developed further. Additionally, where possible, the BVP could aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve overall BNG in line with regulatory requirements for BNG (at the time of the project consenting) as stated as a mandatory requirement within the Environment Act 2021. The latter could be achieved by identifying local sites of ecological interest and proposing measures which enhance these features.

The in-combination effects have been assessed for the option that were scoped in for NCA and BNG assessment and are summarised in Appendix B and C. To avoid double counting, options that are considered to benefit multiple water companies were considered as one option. A high-level summary of the main outputs of the in-combination effects assessment are provided in the sub-sections below.

4.1.1 Natural capital

At present, nearly all of the options are resulting in a net-loss to habitats, natural capital assets and corresponding ecosystem services. Broad habitats lost include:

- Woodland and forest
- Rivers and lakes
- Grassland
- Heathland and shrub
- Urban
- Cropland
- Sparsely vegetated land

These broad habitats correspond with the following habitat types:

- Ponds
- Lowland mixed deciduous woodland
- Broadleaved woodland
- Coniferous woodland
- Modified grassland

- Heathland and shrub
- Urban
- Cropland
- Sparsely vegetated land
- Neutral grassland

Some options such as the reservoir options are resulting in a net-increase in habitats, natural capital assets and corresponding ecosystem services. Broad habitats gained include:

- Abiotic

This broad habitat corresponds with the following habitat type:

- Modified waters (reservoirs)

4.1.1.1 Ecosystem services

Correspondingly, the habitat loss expected as part of the construction of the options within the BVP are resulting in a net loss of natural capital assets and ecosystem services including:

- Carbon sequestration (Climate regulation)
- Natural hazard management
- Air pollutant removal
- Water purification
- Food production
- Recreation & amenity value

However, the net NCA results for the Draft Regional Plan are an indicator of each options impact on natural capital as their overall net change on the provision of ecosystem services do not include the catchment management options which have the potential to provide an ecosystem services provision and wider benefits to natural capital.

Two of the options within the BVP options selected pre-2050 result in the overall net increase in ecosystem services. The options are both reservoirs and summarised in Table 4.1. The overall net increase in ecosystem services can be accounted to the addition of habitat creation associated with their reservoir landscape plans which are summarised in Table 4.2. The options are expected to generate new services during operation including the provision of recreational and amenity value due to their landscape plans, offering recreation & amenity benefits to the public.

Table 4.1: Summary of options resulting in an overall net gain in ecosystem services for the BVP options selected pre 2050

Option name	Overall change in carbon sequestration (£/year)	Overall change in natural hazard management (£/year)	Overall change in air pollutant removal (£/year)	Overall change in recreation & amenity value (£/year)	Overall change in food production (£/year)	Overall net natural capital change (£/year)
Havant Thicket Winter Storage	-£10,940.61	Scoped out	Scoped out	£335,412.00	-£34,500.00	£289,971.39

Option name	Overall change in carbon sequestration (£/year)	Overall change in natural hazard management (£/year)	Overall change in air pollutant removal (£/year)	Overall change in recreation & amenity value (£/year)	Overall change in food production (£/year)	Overall net natural capital change (£/year)
Reservoir - Classic						
Reservoir Abingdon 100 (Lon) - Construction	-£4,203.49	Scoped out	Scoped out	£249,021.00	-£142,600.00	£102,217.51

There are no options expected to result in an overall net increase in ecosystem services for the BVP options selected post-2050.

4.1.2 BNG

4.1.2.1 Overview of BNG

The BNG principle establishes the simple objective of achieving a greater diversity of plants and animals after development has taken place than was present before. The concept is key to implementation of the UK Government's stated policy objective to leave the environment in better condition when we pass it on than it was in when we inherited it. It can be demonstrated in a simple equation as follows:

- The value of the existing habitat – the value of future habitat = Biodiversity Gain or Loss

This requirement to achieve quantified BNG marks a step change in the regulatory approach to environmental protection, the focus shifting away from species protection and towards habitats and ecosystems.

Planning policy requires achievement of an uplift in biodiversity as measured using a biodiversity metric such as Natural England's Biodiversity Metric 2.0. Tools such as these are used to assess the baseline 'biodiversity unit' value of a site, and then to calculate the predicted unit value of the developed site based on the proposed layout. It allows different on-site and offsite compensation scenarios to be modelled and the creation and long-term management costs to be compared.

Where achieving biodiversity net gain is not possible on site whilst still delivering a viable project, developers have the option to contribute at a local or regional scale to off-site Offsetting or Compensation. This approach can often successfully result in greater gains for biodiversity than could be provided within a constrained development site. It supports delivery of Local Nature Recovery Strategies.

4.1.2.2 BNG results for the BVP

Overall, most of the options in the BVP result in a net loss of BNG which can be accounted to the temporary and permanent loss of habitats during the construction of the options. However, the BNG results for the Draft Regional Plan are an indicator of each options impact on BNG as their overall net unit change for BNG do not include the catchment management options which have the potential to provide biodiversity net gain and additional benefits.

Options that result in an overall net gain in BNG for the BVP options selected pre-2050 and post-2050 are summarised in Table 4.2 and Table 4.3 below. The options listed are new reservoirs and the overall net gain in BNG can be accounted to the addition of new surface water that is created during construction. Additionally, two of the options results in habitat creation associated with their reservoir landscape plans, namely Havant Thicket Winter Storage Reservoir - Classic and Reservoir Abingdon 100 (Lon) - Construction, which are summarised in Table 4.2. Although some of the options summarised in Table 4.2 result in an overall net increase in BNG, DEFRA's BNG Metric 2.0 excludes ancient woodland from calculations, therefore, the reservoirs impact on BNG is likely negative.

Table 4.2: Summary of options resulting in an overall net gain in BNG for the BVP options selected pre-2050

Option name	Overall decrease in natural capital stocks (Ha)	Overall increase in natural capital stocks (Ha)	Total net unit change BNG
Havant Thicket Winter Storage Reservoir - Classic	<ul style="list-style-type: none"> -142.32Ha of pastures -16.79Ha of ancient woodland -0.54Ha of greenspace -1.18Ha of active floodplain -0.34Ha of ponds & linear features 	<ul style="list-style-type: none"> +34.78Ha of other semi-natural grassland +16.35Ha of broadleaved, mixed and yew woodland +134.2Ha of modified waters (reservoirs) 	155.11
Storage: River Adur offline Reservoir	<ul style="list-style-type: none"> -45.93Ha of arable land -0.46Ha of ancient woodland -0.03Ha of active floodplain -0.2Ha of ponds & linear features 	<ul style="list-style-type: none"> +45Ha of modified waters (reservoirs) 	73.53
Reservoir Abingdon 100 (Lon) - Construction	<ul style="list-style-type: none"> -724.27Ha of arable land -52.2Ha of pastures -0.18Ha of orchards and top fruit -2.21Ha of coniferous woodland -268.81Ha of active floodplain 	<ul style="list-style-type: none"> +14.36Ha of coastal and floodplain grazing marsh +244.4Ha of other semi-natural grassland +12.42ha of broadleaved, mixed and yew woodland +647.94Ha of modified waters (reservoirs) +7.3Ha of ponds & linear features 	1217.7
Aldington Flood Storage Area	<ul style="list-style-type: none"> -8Ha of arable land 	<ul style="list-style-type: none"> +8Ha of modified waters (reservoirs) 	21.87

Table 4.3: Summary of options resulting in an overall net gain in BNG for the BVP options selected post-2050

Option name	Overall decrease in natural capital stocks (Ha)	Overall increase in natural capital stocks (Ha)	Total net unit change BNG
Broyle Place Reservoir	<ul style="list-style-type: none"> -87.44Ha of arable land -0.75Ha of pastures -1.86Ha of broadleaved, mixed and yew woodland -0.2Ha of ponds & linear features 	<ul style="list-style-type: none"> +90Ha of modified waters (reservoirs) 	478.64

4.2 Mitigation and enhancements

Following the in-combination BNG and NCA assessments, opportunities fulfil one or both of the following:

- Mitigation: Opportunities to offset the net loss of biodiversity asset(s) and/or natural capital stock(s) (ecosystem service)
- Enhancements: Opportunities that, once introduced and established, would result in a net gain to a biodiversity asset and/or natural capital stock(s) (ecosystem service)

A summary of the potential natural capital, BNG mitigation and enhancement measures for each option sub-component type are outlined in Table 4.4. Further explanation into the potential enhancement measures is provided within the sections below.

As a core principle, where possible, WRSE should aim to not only reinstate lost habitat, but also provide a greater or more diverse habitat than is lost, to achieve overall Biodiversity Net Gain, therefore, this would mitigate and offset the impact on biodiversity and ecosystem services. The latter could be achieved by identifying local sites of ecological interest and proposing measures.

Table 4.4: Summary of potential net gain mitigation and enhancement opportunities

Option sub-component type	Mitigation opportunity	Enhancement opportunity
All option types	Scheme layouts to be amended to avoid the permanent loss of high value natural capital assets that once lost, cannot be easily reinstated. Assets include ancient woodland and traditional orchards.	Creation of higher value habitat within grassland, arable and pasture natural capital assets onsite to achieve an increase in Biodiversity Units (BU) and work towards a 10% uplift in BNG.
	Schemes to identify area for the creation and/or reinstatement of high value natural capital assets, including: <ul style="list-style-type: none"> • Coastal and floodplain grazing marsh 	Habitat creation work within the adjacent priority habitats. Options fall within or are in the vicinity of habitat network zones ⁹ : <ul style="list-style-type: none"> • Habitat restoration-creation • Restorable habitat

⁹ Edwards J, Knight M, Taylor S & Crosher I. E (May 2020) 'Habitat Networks Maps, User Guidance v.2', Natural England

Option sub-component type	Mitigation opportunity	Enhancement opportunity
	<ul style="list-style-type: none"> • Lowland fens • Lowland raised bog • Reedbeds • Blanket bog • Hay meadows • Dwarf shrub heath • Broadleaved, mixed and yew woodland • Coniferous woodland • Bluespace • Greenspace 	<ul style="list-style-type: none"> • Fragmentation action zone • Network enhancement zones 1 and 2 • Expansion zone <p>These areas identify specific locations for a range of actions to help improve the ecological resilience for each of the habitats/habitat networks. Schemes should look to identify habitat network zones and priority habitats within the near vicinity and look to improve/create/restore habitats which would help to work towards increasing BU and work towards a 10% uplift in BNG.</p>
	Construction practices to be considered to reduce the amount of clearance required for, especially in areas that include high value natural capital assets (see above for list).	Increase the quality/quantity of freshwater assets, including lakes, ponds and existing reservoirs located in designated SSSI's, pending detailed assessment of local conditions and available space.
	Directional drilling to be used where possible to avoid loss of high value natural capital assets (see above for list).	<p>Schemes to identify suitable areas offsite for the creation, enhancement and/or restoration in order to develop off-site net gains, working towards achieving a 10% uplift in BNG.</p> <p>Identify areas of local peatland restoration</p>
	Desalination, direct river abstraction and other options that contain above ground infrastructure	Seeding of grassland within footprints of the above ground infrastructure, where possible.
Reservoir		Provide the provision of recreation & amenity value by providing public access to the reservoir and surrounding landscape.

4.2.1.1 BNG unit purchase

The BNG and natural capital metrics identified as part of the detailed options assessments were included in the investment model to influence the selection of the Draft Regional Plan (Best Value Plan) as part of the best value plan framework. The amount of BNG unit's each option requires to be purchased to obtain a 10% increase in BNG was included as part of the investment model. The BNG units required to be purchased for each option of the Draft Regional Plan Situation 4 in order to achieve a 10% net BNG are summarised in Appendix B and C.

There are several possibilities that all of the options assessed as part of the BNG assessments that could be adopted in order for the Draft Regional Plan to achieve a net gain in BNG of 10%, including:

- On-site: Improve the existing habitats on-site through post construction remediation and replacement of low BNG value habitats with higher BNG value habitats
- Off-site: Purchase suitable areas of off-site land within the local area and/or at a regional scale to offset BNG decrease by improving the existing habitats within the off-site land and/or by replacing existing habitats with higher BNG value habitats.
- On-site and off-site: Improve existing habitats and/or replacement of low BNG value habitats with higher BNG value habitats as part of the catchment management options.

4.2.1.2 Network enhancement zones

The Government's 25 Year Environment Plan¹⁰ includes provision for a Nature Recovery Network (NRN) and states that it will deliver on the recommendations of the Lawton Report¹¹ and that recovering wildlife will require more habitat; in better condition; in bigger patches that are more closely connected. As well as helping wildlife thrive, the NRN could be designed to bring a wide range of additional benefits: greater public enjoyment; pollination; carbon capture; water quality improvements and flood management.

Natural England have produced a series of habitat network maps¹² to help address the challenges outlined in the Lawton report and believe they should provide a useful baseline for the development of a NRN as required within the 25 Year Environment Plan and Local Nature Recovery Strategies as proposed within the Environment Bill. The maps have been created to provide a national overview of the distribution of habitat networks with suggestions for future action to enhance biodiversity, to help stimulate local engagement with partners and to agree local priorities and identify where action might help build more ecologically resilient ecosystems across landscapes.

- **Habitat Creation/Restoration:** Areas where work is underway to either create or restore the primary habitat
- **Restorable Habitat:** Areas of land, predominantly composed of existing semi-natural habitat where the primary habitat is present in a degraded or fragmented form and which are likely to be suitable for restoration.
- **Network Enhancement Zone 1:** Land connecting existing patches of primary and associated habitats which is likely to be suitable for creation of the primary habitat. Factors affecting suitability include proximity to primary habitat, land use (urban/rural), soil type, slope and proximity to coast. Action in this zone to expand and join up existing habitat patches and improve the connections between them can be targeted here.
- **Network Enhancement Zone 2:** Land connecting existing patches of primary and associated habitats which is less likely to be suitable for creation of the primary habitat. Action in this zone that improves the biodiversity value through land management changes and/or green infrastructure provision can be targeted here.
- **Fragmentation Action Zone:** Land within Enhancement Zone 1 that connects existing patches of primary and associated habitats which are currently highly fragmented and where fragmentation

¹⁰ 25 Year Environment Plan - GOV.UK (www.gov.uk)

¹¹ Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.A., Tew, T.E., Varley, J., & Wynne, G.R. (2010) Making Space for Nature: a review of England's wildlife sites and ecological network. Report to Defra.

¹² Edwards J, Knight M, Taylor S & Crosher I. E (May 2020) 'Habitat Networks Maps, User Guidance v.2', Natural England

could be reduced by habitat creation. Action in this zone to address the most fragmented areas of habitat can be targeted here.

- **Network Expansion Zone:** Land beyond the Network Enhancement Zones with potential for expanding, linking/joining networks across the landscape i.e., conditions such as soils are potentially suitable for habitat creation for the specific habitat in addition to Enhancement Zone 1. Action in this zone to improve connections between existing habitat networks can be targeted here.

There are opportunities for options to support the NRN, for example where pipelines are to be constructed as part of the options within one of the identified habitat zones, reinstatement of land following construction could be linked to the priorities of that area such as habitat creation, restoration or improvement.

It is proposed that these opportunities are further explored as the Final Regional Plan develops. It should be noted that the national approach and process is evolving, and guidance is due to be published. This will be reviewed if it is available in time for the Final Plan. Catchment management schemes could be targeted at certain identified areas and wider partnership working with landowners, conservation groups and other organisations should be explored to help deliver opportunities for biodiversity enhancement. The individual water companies can explore these opportunities further as part of the WRMP24 development and as options are taken forward for planning.

4.3 Catchment options

Catchment management options have the potential to provide biodiversity net gain and increase provision of ecosystem services through habitat creation and enhancement of existing habitats in order to provide catchment management, therefore having the potential to provide Environmental Net Gain. As the catchment management options are further developed opportunities for net gain will be explored.

5 Conclusions

The NCA, BNG and ecosystem services outputs of the BVP identified the following:

- **Natural capital:** The BVP will cause the temporary and permanent loss of natural capital stocks. The BVP is likely to cause the permanent loss of ancient woodland and orchards and top fruit stocks, that once lost cannot be replaced. It is recommended that as part of further options design, these areas are avoided by re-aligning the routes to avoid these high-value natural capital stocks.
- **Ecosystem services:** The plan presents opportunities to improve the existing habitats along and surrounding options through post construction remediation and the replacement of low value habitats with higher value habitats. The potential permanent loss of ancient woodland, orchards and top fruit, coastal and floodplain grazing marsh, broadleaved, mixed and yew woodland, active flood plain, rivers, woodland priority habitat, arable and pastoral habitat could result in the permanent loss of several ecosystem services that the stock provides in synergy, including carbon sequestration, natural hazard management, air pollution removal, recreation & amenity value, and food production. The potential permanent loss of arable and pastoral stock could result in the permanent loss of food production.
- **BNG:** The BVP is likely to result in a loss of biodiversity units due to the permanent loss of natural capital assets during construction. Mitigation and enhancement opportunities have been suggested within Section 4, which can work in tandem to maintaining the gain of BNG and introducing environmental net gain.
- The opportunities identified in the BNG/NCA assessment for the BVP have the potential to contribute to government ambitions for environmental net gain. This could take the form of habitat compensation, creation and/or species relocation schemes. Any options would need to be taken forward based on a comprehensive understanding on the interaction between natural systems and between natural systems and social uses of land.

A. Natural capital stocks and mapping methodology

Broad Natural Group	Sub-group	Mapping Methodology
Freshwater	Active flood plain	Areas at high or medium risks within the Environment Agency (EA)'s Risk of Flooding from Rivers and Sea dataset.
	Blanket Bog	Area of blanket bog mapped using Natural England's Priority Habitat Inventory.
	Chalk Rivers*	Mapped using the EA chalk rivers dataset and mapping intersections with OS watercourse polygons
	Coastal and floodplain grazing marsh	Area of coastal floodplain and grazing marsh mapped using Natural England's Priority Habitat Inventory
	Lakes and standing waters	Area of lakes and reservoirs mapped using the Centre for Ecology and Hydrology (CEH)'s UK Lakes Portal dataset.
	Lowland Fens	Area of lowland fens mapped using Natural England's Priority Habitat Inventory.
	Lowland raised bog	Area of lowland raised bog mapped using Natural England's Priority Habitat Inventory
	Modified waters e.g. reservoirs	Area of reservoirs mapped by selecting Ordnance Survey (OS) surface water polygons (VectorMap District) that coincide with CEH's Inventory of UK reservoirs (points).
	Other semi-natural habitats	Area of other semi-natural habitat mapped using Natural England's Priority Habitat Inventory (including upland and lowland grasslands, heathland and saltmarsh).
	Ponds and ditches	Mapped by selecting surface waterbodies (from OS VectorMap District) that do not intersect rivers, are smaller than 2ha in size.
	Reedbeds	Area of reedbed habitat mapped using NE's Priority Habitat Inventory
	Rivers	Length of rivers mapped using EA's Water Framework Directive (WFD) river waterbodies dataset (cycle 1, to include coastal streams)
Mountain, Moor and Heath	Blanket bog	Area of blanket bog mapped using Natural England's Priority Habitat Inventory.
	Dwarf shrub heath	Mapped using Natural England's Priority Habitat Inventory ('fragmented heath', 'lowland heathland' and 'upland heathland')
	Inland rock, scree and pavement (AML*)	Area of inland rock and limestone pavement above the moorland line, mapped using CEH's LCM2015 ('inland rock'), Natural England's Priority Habitats Inventory ('limestone pavement') and the Rural Payment Agency (RPA)'s Moorland Line dataset.
	Lakes & Reservoirs	Area of lakes and reservoirs above the moorland line, mapped using CEH's UK Lakes dataset, CEH's Inventory of UK reservoirs dataset and RPA's Moorland Line dataset.
	Mountain heath and willow scrub	Area of mountain heath and willow scrub mapped using Natural England's Priority Habitat Inventory.
	Rivers (AML)	Length of rivers mapped using EA's WFD river waterbodies dataset and RPA's Moorland Line dataset.
	Semi-natural grassland (AML*)	Area of semi-natural grassland above the moorland line, mapped using Natural England's Priority Habitat Inventory and RPA's moorland line dataset.
	Upland flushes fens and swamps	Area of upland flushes, fens and swamps, mapped using Natural England's Priority Habitat Inventory.

Broad Natural Group	Sub-group	Mapping Methodology
Urban	Wood pasture (AML*)	Area of wood pasture above the moorland line, mapped using Natural England's provisional Wood-Pasture and Parkland BAP Priority Habitat Inventory and RPA's Moorland line dataset.
	Woodland (AML*)	Area of woodland above the moorland line, mapped using FC's National Forest Inventory and RPA's moorland line dataset.
	Blue space	Mapped by intersecting OS VectorMap District Surface Water with the Office for National Statistic (ONS)'s Built-Up areas dataset.
	Green space - not semi-natural	Area of urban green space (not semi-natural), mapped using the OS Open Greenspace Layer.
	Open mosaic habitats	Area of open mosaic habitats on previously developed land, mapped using Natural England's draft Open Mosaic Habitat dataset
	Woodland, scrub and hedge	While urban scrub and hedge are difficult to map at a national scale, the area of urban woodland is mapped here by intersecting FC's National Forest Inventory with ONS Built-Up Areas.
	Semi-natural habitats	Mapped by intersecting Natural England's Priority Habitat Inventory habitats (excluding woodland, good quality semi-improved grassland and traditional orchards) with ONS Built-Up Areas
Farmland	Arable and rotational leys	Area of arable and rotational leys, and horticulture individually, this map shows the area of arable and horticulture combined. Mapped using (UK Land Cover 2018 Sub Classes).
	Horticulture	Area of arable and rotational leys, and horticulture individually, this map shows the area of arable and horticulture combined. Mapped using CEH's Land Cover Map 2015 (LCM2015).
	Improved grassland	Area of improved grassland mapped using CEH's LCM2015.
	Orchards and top fruit	Area of orchards and top fruit mapped using Natural England's Priority Habitat Inventory ('traditional orchards')
Woodland	Ancient Woodland	Mapped using Natural England's Ancient Woodland dataset.
	Broadleaved, mixed and yew woodland	Mapped using FC's National Forest Inventory.
	Coniferous woodland	Area of coniferous woodland mapped using FC's National Forest Inventory
	Woodland priority habitats	Mapped using Natural England's Priority Habitat Inventory ('deciduous woodland').
Grasslands	Hay meadows	Area of hay meadow mapped using Natural England's Priority Habitat Inventory ('upland meadow' and 'lowland meadow').
	Other semi-natural grasslands	Area of other semi-natural grassland, mapped using Natural England's Priority Habitat Inventory ('upland calcareous', 'lowland calcareous', 'lowland dry acid', 'good quality semi-improved', 'grass moorland' and 'purple moor grass and rush pasture').
Coastal	Beach	Area of beach mapped using OS VectorMap District ('foreshore'). Note that this dataset includes areas of intertidal sediment as well as beaches.
	Coastal lagoons	Area of coastal lagoons mapped using Natural England's Priority Habitat Inventory ('saline lagoons').
	Mudflats	Area of intertidal mudflats mapped using the EMODnet (Natural England) Intertidal Mudflats dataset.
	Salt marsh	Area of saltmarsh mapped using EA's Saltmarsh Extent dataset.
	Sand dunes	Area of sand dunes mapped using Natural England's Priority Habitat Inventory ('coastal dunes')
	Sea Cliff	Area of sea cliff habitat mapped using Natural England's Priority Habitat Inventory ('maritime cliff and slopes').
	Shingle	Area of shingle mapped using Natural England's Priority Habitat Inventory ('coastal vegetated shingle').
Marine	Intertidal rock	Area of intertidal rock mapped using Natural England's Open Marine Evidence Base (EUNIS code A1).

Broad Natural Group	Sub-group	Mapping Methodology
	Maerl beds	Area of maerl beds mapped using Natural England's Open Marine Evidence Base (EUNIS code A5.51).
	Reefs	Area of potential reefs mapped using JNCC's Potential Annex 1 Reefs
	Sea grass beds	Area of seagrass beds mapped using Natural England's Open Marine Evidence Base (EUNIS code A2.61)
	Shallow subtidal sediment	Area of shallow subtidal sediment mapped using JNCC's UKSea Map 2018 (biozone = shallow intercalittoral or infralittoral and substrate = sediment, sand or mud).
	Shelf subtidal sediment	Area of shelf subtidal sediment mapped using JNCC's UKSea Map 2018 (biozone = deep circalittoral and substrate = sediment, sand or mud).
	Subtidal rock	Area of subtidal rock mapped using JNCC's UKSea Map 2018 (substrate = rock).
Soils	Nutrient Status of Soil	Mean estimates of total nitrogen concentration in topsoil (0-15cm depth) - % dry weight of soil, mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016).
	Soil Carbon/Organic Matter	Mean estimates of carbon density in topsoil (0-15cm depth) – tonnes per hectare, mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016)
	Soil Biota	Mean estimates of total abundance of invertebrates in topsoil (0-8 cm depth), mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016)
Indicators of condition	Natural Aquifer Function	Area of groundwater catchment with 'good' quantitative status for WFD 2016, mapped using EA's WFD data and groundwater catchment boundaries (C2).
	Naturalness of Flow Regime	The WFD hydrological regime classification describe the naturalness of river flows. This map shows the length of river with 'high' WFD hydrological status in 2016, mapped using EA's WFD data and river water bodies (C2)
	Lack of Physical Modifications of Water Bodies	Lack of physical modification of rivers, mapped using EA's Reasons for Not Achieving Good Status data (SWMI = 'physical modification'), 2013-2016.
	Presence & Frequency of Pollinator Food Plants	Mean estimates of number of nectar plant species for bees per 2x2m plot, mapped using data produced from Natural England and CEH's 'Mapping Natural Capital' project (2016)

B. Summary of the BNG and NCA in-combination effects assessment included in the BVP options selected pre-2050

This appendix provides a summary table of the BVP pre-2050 options in the in-combination effects assessments for the scoped in for NCA and BNG assessment for the BVP, including NCA and BNG outputs and BNG habitat unit purchase (i.e. how many BNG units are required to offset the loss plus achieve a 10% net gain). The table does not include options related to Drought Permits, Change in Level of Service to enhance water available for use (WAFU) including NEUBS and TUBS, and demand management options as these were all scoped out of the assessment as they are not expected to result in any land-use change and therefore subsequent impacts on BNG or NCA.

Option name	Overall net BNG change (BU)	Net Gain Purchase (BU)	Overall change in natural capital (£/year)
Portfolio 1 (Standard): Colne	Scoped out	Scoped out	Scoped out
Ickenham 2 to Oxheywood	-25.41	29.31	-£127.90
GUC option 3 50 MI/d phase 1 & 2 LB	-185.96	-25.48	-£185.96
Arkley North	Scoped out	Scoped out	Scoped out
Canals & Rivers Trust Slough	Scoped out	Scoped out	Scoped out
Didcot Iver 4 Confidential Trading Option	Scoped out	Scoped out	Scoped out
New Iver 2 WTW 50 MI/d Phase 1 & 2	-11.4	12.54	-£1,169.61
Brent Reservoir Transfer to Iver	Scoped out	Scoped out	Scoped out
Egham to Iver 50MLD (Supply 2040)	-22.07	33.34	-£247.61
Epping Scheme	-79.27	76.76	-£1,698.05
Egham LGS - Construction & Operation	Scoped Out	Scoped Out	Scoped Out
Hythe Beach Wells RO Desal (brackish water)	-9.42	10.21	-£74.99
Tappington South	Scoped out	Scoped out	Scoped out
Dover Docks Reservoir - Broomfield Banks Effluent Reuse	-1.55	27.58	-£83.28
Hythe Effluent Reuse Scheme	Scoped out	Scoped out	Scoped out
Dover Constraint Removal	Scoped out	Scoped out	Scoped out
Deal Supply Scheme	-8.2	12.38	-£36.46
Aldington to Saltwood Import Increase by 6 MI/d	-11.32	14.53	-£42.36
Barham Import Increase (of 4MI/d) to 6 MI/d	-19.95	27.19	-£86.35

Option name	Overall net BNG change (BU)	Net Gain Purchase (BU)	Overall change in natural capital (£/year)
Conjunctive Benefit to London of a Pinn WTW Phase 1 & 2 (50MI/d)	Scoped out	Scoped out	Scoped out
Aldington Flood Storage Area	21.87	-20.11	-£2,787.94
Aldington Scale Up	Scoped out	Scoped out	Scoped out
Western Rother licence and storage programme	Scoped out	Scoped out	Scoped out
Upgrade Source O Booster to 25Mld	Scoped out	Scoped out	Scoped Out
Works A increased treatment capacity as part of Havant Thicket Development	Scoped out	Scoped out	Scoped Out
Havant Thicket Winter Storage Reservoir - Classic	155.11	N/A	£289,971.39
SRN Source D To Havant Thicket: 50MI/d	-127.68	72.46	-£351.47
Outwood Lane borehole - licence increase	Scoped out	Scoped out	Scoped out
Bough Beech reservoir - raising	-15.65	22.16	-£53.77
Transfer from Merton (TW) to SES Boundary at 15MI/d	Scoped out	Scoped out	Scoped out
RZ1 Zonal Scheme - [CTR-40] - Additional storage at Blackhurst	Scoped out	Scoped out	Scoped out
New Bulk Supply: SESW to SEW RZ1 Transfer - Bough Beech to Riverhill SR (10MI/d)	-14.63	20	-£69.97
New Company Transfer: RZ3 to RZ2 - Arlington to Barcombe (10MI/d) Phase 1	0	9.37326962	0
Conjunctive Use of Surface Water & Groundwater - River Ouse	Scoped Out	Scoped Out	Scoped Out
New Company Transfer: RZ3 to RZ2 - Arlington to Barcombe (10MI/d)	-28.51	39.79	-£25.62
AMP7 Company Transfer: RZ7 to RZ2 Transfer - Bewl to Cottage Hill (5MI/d)	-63.95	60.50	-£224.80
New Company Transfer: RZ3 to RZ2 - Arlington to Barcombe (10MI/d)	0	9.37	0
Peacehaven Recycling at Arlington (30MI/d Option)	77.6	N/A	-£4.03
Portfolio 1 (Standard): Test and Itchen	Scoped out	Scoped out	Scoped out
New Bulk Supply: PRT to SEW RZ5 Transfer - Farlington WTW to Tilmore SR (20 MI/d)	Scoped out	Scoped out	Scoped out
Potable Resource for Spur from Honor Oak-Burham Pipeline to Exedown	-69.23	61.45	-£501.41
Groundwater Licence Trade - Halling	Scoped Out	Scoped Out	Scoped Out

Option name	Overall net BNG change (BU)	Net Gain Purchase (BU)	Overall change in natural capital (£/year)
RZ6 Zonal Scheme - [LIC-20] Complete reinforcement to Halling Reservoir	-7.95	60.96	-£22.79
New Company Transfer: RZ1 to RZ6 Transfer - Blackhurst to Aylesford (4MI/d)	-69.76	85.47	-£386.97
New Company Transfer: RZ8 to RZ6 Transfer - Canterbury to Maidstone (10 MI/d)	-86.24	58.82	-£314.13
New Company Transfer: RZ1 to RZ7 Transfer - Blackhurst to Bewl (4MI/d)	-12.09	15.17	-£16.22
New Company Transfer: RZ2 to RZ7 Transfer - Cottage Hill to Bewl (5MI/d)	-66.34	80.28	-£738.58
Potable Resource for Wingham to Canterbury (Broad Oak)	-13.35	27.72	-£97.92
Desalination at Reculver (30MI/d Option)	-5.81	16.17	-£18.80
RZ8 Zonal Scheme - [RES-31] - Distribute extra water from Broad Oak	-28.06	31.15	-£65.84
RZ8 Zonal Scheme - [DES-15] - Transfer of water from Ford WTW	-2.73	4.65	-£6.22
Broad Oak Reservoir	17	N/A	-£50,148.74
New Bulk Supply: SWS to RZ8 - Brede to Kingsnorth (10MI/d)	-158.71	81.42	-£17.27
Hampshire grid	-23.42	29.06	-£68.81
Newbury Groundwater	Scoped out	Scoped out	Scoped out
Romsey Groundwater	Scoped out	Scoped out	Scoped out
Transfer: Romsey Town & Broadlands valve (HSW-HRZ) (3.1MI//d)	Scoped out	Scoped out	Scoped out
Import from Portsmouth Water	-280.85	347.1	-£613.47
Import: PWC Gaters Mill Source to Moor Hill reservoir extension (30MI/d)	Scoped Out	Scoped Out	Scoped Out
Southampton link main	-80.81	59.01	-£295.13
Import: PWC Gaters Mill source to Moor Hill reservoir (30MI/d)	Scoped Out	Scoped Out	Scoped Out
Treatment capacity: upgrade Lower Itchen WSW	Scoped out	Scoped out	Scoped out
Transfer: Sandy Lane Abbotswood (HSE-HRZ) (1.1MI/d)	Scoped Out	Scoped Out	Scoped Out
Import from Portsmouth Water	-280.85	347.1	-£5,164.19

Option name	Overall net BNG change (BU)	Net Gain Purchase (BU)	Overall change in natural capital (£/year)
HWZ to Otterbourne (200) Potable - Construction	Scoped out	Scoped out	Scoped out
Test MAR	Scoped out	Scoped out	Scoped out
Treatment capacity: Upgrade Testwood WSW (60MI/d)	-80.81	59.01	-£276.55
Transfer: Havant Thicket reservoir - Otterbourne WSW - first Section, raw (90MI/d)	-180.82	85.52	-£468.84
Hampshire grid	-23.42	47.19	-£68.81
Groundwater: Eastern Yar replacement BH (1.5MI/d)	Scoped out	Scoped out	Scoped out
Groundwater: Newchurch LGS (1.9MI/d)	Scoped out	Scoped out	Scoped out
Transfer: Cross-Solent (HSW-IOW) (18MI/d)	Scoped out	Scoped out	Scoped out
Transfer: Triplicate cross-Solent main - bi-directional transfer (8MI/d)	-194.48	227.57	-£1,579.91
Recycling: Sandown WwTW (8.1MI/d)	-73.88	55.17	-£19.23
Desalination: Isle of Sheppey (20MI/d)	Scoped out	Scoped out	Scoped out
Groundwater: recomission Gravesend source (2.7MI/d)	Scoped out	Scoped out	Scoped out
Recycling: Sittingbourne industrial reuse (7.5MI/d)	-20.82	26.39	-£50.90
Desalination: River Thames estuary (20MI/d) Phase 1 & 2	-184.41	214.64	-£1,150.94
Recycling: Medway WwTW (12.8MI/d)	-41.81	73.30	-£197.60
Desalination: East Thanet coast & transfer (20MI/d)	-13.93	15.32	-£69.59
Import: AFW at Napchester (0.1MI/d)	Scoped out	Scoped out	Scoped out
Transfer: Utilise full existing Selling-Fleete (KME-KTZ) transfer capacity (9MI/d)	-1.85	2.93	-£13.31
Transfer: Selling WSR to Fleete Manston WSR (KTZ-KME) (14MI/d)	Scoped out	Scoped out	Scoped out
Canterbury (Broad Oak) to Near Canterbury: 20MI/d	-13.35	19.55	-£97.92
Import: SEW Kingston to KTZ Near Canterbury (2MI/d)	Scoped out	Scoped out	Scoped out
Raw resource: Havant Thicket-Otterbourne transfer (61MI/d)	-180.82	85.52	-£468.84
Import: Havant Thicket - Otterbourne direct raw water transfer - second section (90MI/d)	-180.82	85.52	-£468.84

Option name	Overall net BNG change (BU)	Net Gain Purchase (BU)	Overall change in natural capital (£/year)
Otterbourne to Gaters Mill: 45MI/d	-80.18	93.91	-£10.44
Conjunctive Benefit of Budds farm 60 M/d to Havant Thicket	-122.73	75.81	-£54.86
Recycling: Recharge of Havant Thicket reservoir from Budds Farm and new WRP (60MI/d)	-122.73	75.81	-£54.86
Desalination: Sussex Coast (Modular 0-10MI/d) (10MI/d)	-15.89	18.48	-£133.19
Tenants Hill Worthing to Brighton: 40MI/d	-227.92	261.91	-£42.98
Transfer: SWZ-SBZ v6 valve (17MI/d)	Scoped out	Scoped out	Scoped out
Transfer: SWZ-SBZ additional through v6 valve (13MI/d)	Scoped out	Scoped out	Scoped out
Transfer: Winter transfer Stage 2: New main Shoreham/North Shoreham and Brighton A (4MI/d)	-109.07	123.88	-£230.74
Reconfigure Brede Wells - replacing boreholes to increase yield and resilience (increased redundancy)	Scoped out	Scoped out	Scoped out
Recycling: Hastings WTW conjunctive use with Darwell reservoir (15.3MI/d)	Scoped out	Scoped out	Scoped out
Weir Wood to SHZ: 10000MI/d	Scoped out	Scoped out	Scoped out
Import: PWC at Hardham extension (15MI/d)	scoped out	scoped out	scoped out
Import: PWC to Hardham (15MI/d)	scoped out	scoped out	scoped out
Transfer: Rock Road bi-directional transfer (SWZ-SNZ) (15MI/d)	scoped out	scoped out	scoped out
Recycling: Littlehampton WwTW (15MI/d)	-186.87	229.41	-£288.40
Groundwater: Haslingbourne WSW return to service with a new borehole (4.0MI/d)	Scoped out	Scoped out	Scoped out
Blackstone Reservoir	73.53	N/A	-£15,700.96
Havant Thicket To Hardham WTW: 50MI/d	-127.68	157.93	-£351.47
Tilmore to Hardham: 10MI/d	-136.32	165.16	-£107.89
Outwood To Turners Hill: 10MI/d	Scoped out	Scoped out	Scoped out
Transfer: Winter transfer stage 1 - Provision of a permanent sludge treatment facility at Pulborough WSW (2MI/d)	-109.07	88.45459597	-£230.74
Hardham to Tenants Hill Worthing: 60MI/d	-78.32	94.3	-£124.89
Culham (120) - potable - Construction	Scoped out	Scoped out	Scoped out

Option name	Overall net BNG change (BU)	Net Gain Purchase (BU)	Overall change in natural capital (£/year)
Culham to Sparsholt (200) Potable - Construction	Scoped out	Scoped out	Scoped out
Raw water Transfer between Otterbourne WSW and Testwood lakes - 60 MI/d.	-133.37	156.23	-£483.11
Groundwater Development - Removal of Constraints to Dapdune DO	Scoped out	Scoped out	Scoped out
SouthEast Water to Guildford	-183.02	208.56	-£1,980.66
Thames Water (Kennet Valley) to Thames Water (Henley) Conveyance	scoped out	scoped out	scoped out
TLT extension from Lockwood PS to King George V Reservoir intake	Scoped out	Scoped out	Scoped out
Direct River Abstraction - Teddington to Thames Lee Tunnel Shaft 75 MLD	-2.38	2.62	-£119.67
Mortimer Disused Source (Recommission)	Scoped out	Scoped out	Scoped out
T2ST Culham to Speen transfer	-4.07	5.15	-£6.35
River Thames to Fobney Transfer	-42.55	47.71	-£709.42
Groundwater Addington	Scoped out	Scoped out	Scoped out
Southfleet/Greenhithe (new WTW)	-15.92	19.64	-£35.71
ASR Horton Kirby	-6.94	8.46	-£38.66
TWRM extension - Hampton to Battersea - Construction	Scoped out	Scoped out	Scoped out
Kempton - 150 - Construction	-135.77	151.5	-£797.13
Reservoir Abingdon 100 (Lon) - Construction	1217.7	N/A	£102,217.51
Raw Water Transfer Deerhurst to Culham 500 MI/d (Lon only) - Construction	-289.13	392.74	-£41.75
Datchet Increase DO	Scoped out	Scoped out	Scoped out
SWOX to SWA (Abingdon WTW to Long Crendon to supply SWA)	-240.45	292.84	-£1,227.90
Moulsford 1	Scoped out	Scoped out	Scoped out
Woods Farm Increase DO	-11.91	14.66	-£85.40
Britwell Removal of Constraints	Scoped out	Scoped out	Scoped out
Wessex Water to SWOX (Flaxlands)	-42.79	55.35	-£1.70
Abingdon WTW Ph1 - Construction	-15.3	17.53	-£1,342.59
New WTW Abingdon - Additional Phase	-15.3	17.53	-£1,342.59
Henley to SWOX – 5 MI/d	-83.43	94.51	-£893.71
Abingdon to Farmoor Reservoir pipeline (CON-RWS-ABI-FMR)	-92.29	111.11	-£53.00

Option name	Overall net BNG change (BU)	Net Gain Purchase (BU)	Overall change in natural capital (£/year)
Thames Water (SWA) to Thames Water (SWOX) Conveyance	Scoped out	Scoped out	Scoped out
Teddington DRA 75 MLD - Construction	Scoped out	Scoped out	Scoped out
Mogden to Teddington outfall 75 Ml/d	-15.09	16.86	£1269.92
500: Unsupported flow	-289.13	0	£41.75

C. Summary of the BNG and NCA in-combination effects assessment included in the BVP options selected post 2050

This appendix provides a summary table of the BVP post-2050 options in the in-combination effects assessments for the scoped in for NCA and BNG assessment for the BVP, including NCA and BNG outputs and BNG habitat unit purchase (i.e. how many BNG units are required to offset the loss plus achieve a 10% net gain). The table does not include options related to Drought Permits, Change in Level of Service to enhance water available for use (WAFU) including NEUBS and TUBS, and demand management options as these were all scoped out of the assessment as they are not expected to result in any land-use change and therefore subsequent impacts on BNG or NCA.

Option name	Overall net BNG change (BU)	Net Gain Purchase (BU)	Overall change in natural capital (£/year)
STT Support for 500 MI/d Pipeline interconnector - Vyrnwy Phase 4 Additional 30MI/d (105 MI/d total)	-459.38	174.94	-£5,118.76
STT Support for 500 MI/d Pipeline interconnector - Vyrnwy Phase 2 Additional 35MI/d (60 MI/d total)			
STT Support for 500 MI/d Pipeline interconnector - Vyrnwy Phase 3 Additional 15MI/d (75 MI/d total)			
STT Support for 500 MI/d Pipeline interconnector - Vyrnwy Phase 1 25MI/d			
STT Support - 500 Pipeline - Minworth Phase 2			
STT Support - 500 Pipeline - Netheridge			
STT Support - 500 Pipeline - Minworth Phase 1			
Deephams Reuse – 46.5 MI/d, to TLT - Construction	-12.34	77.34	-£140.19
New WTW at Kempton - 100MI/d - Construction	-135.77	102.02	-£797.13
Recycling: Tunbridge Wells WTW conjunctive use with Bewl reservoir (3.6MI/d)	Scoped out	Scoped out	Scoped out
Broyle Place Reservoir	478.64	N/A	-£30,002.10
Ford WTW Upgrade	Scoped Out	Scoped Out	Scoped Out
Desalination: Sussex Coast (Modular 10-20MI/d) (10MI/d)	-15.89	63.89	-£133.19
Groundwater Development – Merton Recommissioning	Scoped out	Scoped out	Scoped out