

Viridian Logic :

Excellence in Planning Nature-based Solutions

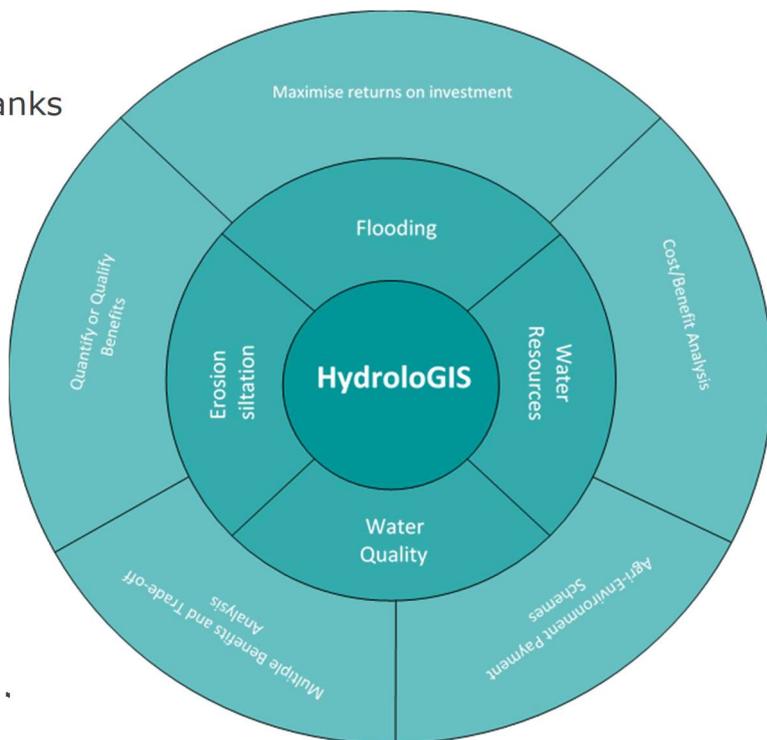
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Introducing HydroloGIS

Unique: Our HydroloGIS system identifies, ranks and prioritises all potential solutions* to river flooding, diffuse pollution and erosion/siltation.

Robust: Outputs can be combined to solve multiple additional problems: groundwater, pluvial and sewer flooding; drought; targeting agricultural management improvements; reverse auctions; irrigation

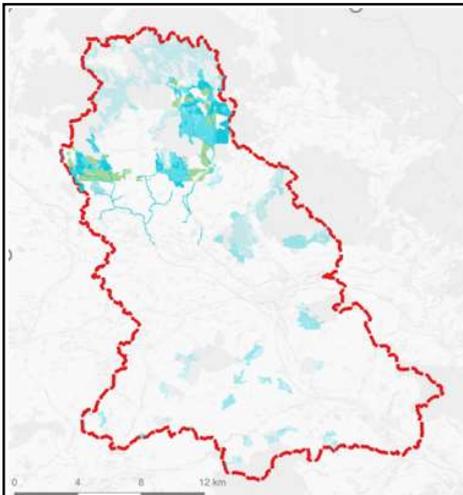
Versatile: Use open source or client data; control modelling by local constraints and aspirations; and integrate with our standard ecosystem service modelling (such as biodiversity, carbon, pollination or recreation).



Applications:

- Catchment Management
- Natural Flood Management
- Enhance water resource supplies
- Biodiversity and nutrient offsetting
- Climate resilience
- Policy, project planning and integration with engineered solutions
- Cost/benefit analysis and Natural Capital Accounting
- Maximise return on investment
- Quantifying benefits can inform project appraisal and funding applications

*Considering woodland, agroforestry, semi-natural grassland and water retention features



HydroloGIS solutions example: green is for woodland planting, blue for creating wetlands. The darker the colours, the more efficient that location will be at simultaneously reducing flooding, nitrate pollution, phosphate pollution and erosion/siltation.

HydroloGIS results cannot be created using standard GIS or hydrological methods. These cannot identify what type of interventions to create; they cannot prioritise or rank solutions; and they often suggest spending resources in inefficient locations.

HydroloGIS has 5m resolution in UK for analysis from 1km² to 3000km²; country-scale analysis best at 25m resolution.

Possible to 'zoom in' to smaller areas and rankings automatically reorganise themselves to be specific for that area alone

Introducing the founders

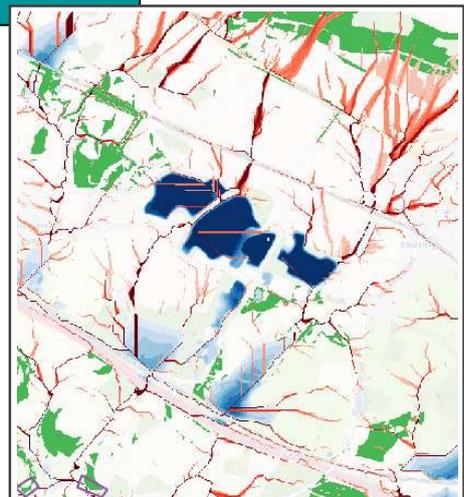
Angus Middleton, environmental engineer who excels at repurposing existing techniques to solve new problems.

Leon Baruah, Doctor of Extra-Galactic Astrophysics who uses his prodigious mathematical abilities to create new solutions.

We can model multiple services, such as carbon capture, habitat connectivity, air quality, heat and recreation. We can analyse benefit stacking and trade-offs.

We can produce all the data and biophysical analysis necessary to create natural capital baselines, NbS project plans, accounts and risk registers.

We can calculate ecosystem service flows and display all information simply and clearly, making it accessible to all users.



"What to do where, to get best bang for buck"

Case study 1: Interreg Multi-Benefit Modelling

This Interreg project covered the Stour catchment in Kent and the Authie catchment in northern France, which together cover an area of approximately 2500km². Viridian first sourced all the open-source data needed to run HydroloGIS in both these territories, then modelled the most efficient and effective solutions to a variety of local problems. These included:

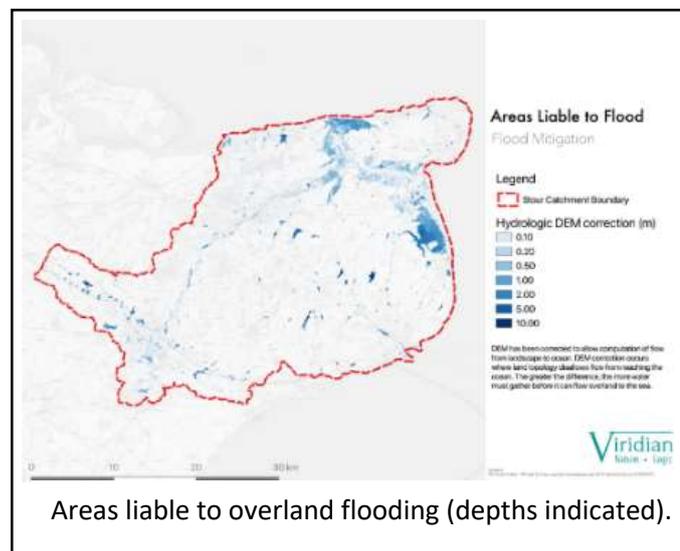
- Flooding of local towns and agriculture;
- Areas liable to accumulate water and cause pluvial flooding;
- Diffuse nitrate and phosphate pollution in the rivers;
- Soil being washed into the rivers to cause siltation; and
- Drought and reduced baseflow to the rivers during periods of low rain.

The client wished all these problems to be solved through natural catchment management, so that they would benefit wildlife and be robust to climate change.

HydroloGIS calculate the best interventions to make across the catchments at 5m and 25m scale, as well as ranking all

options for their effectiveness¹. This will give landowners a full range of informed choices, so that they can blend Viridian’s technical modelling with their local knowledge to make the best decisions for their land.

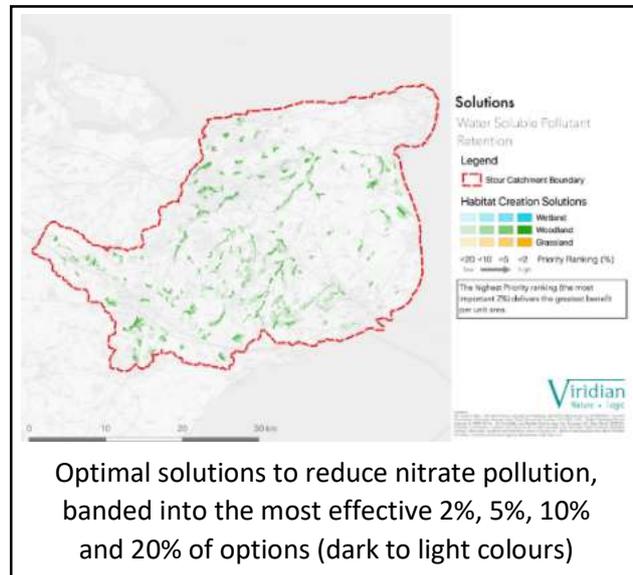
The HydroloGIS rankings were post-processed with the flow accumulation network, areas liable to flood and external data to understand the best opportunities for capturing irrigation water, improving groundwater resources and creating marshland habitats.



¹ Considering woodland, semi-natural grassland and water retention features

Viridian used all this modelling to create outline designs for the most effective 10% of solutions from the following options:

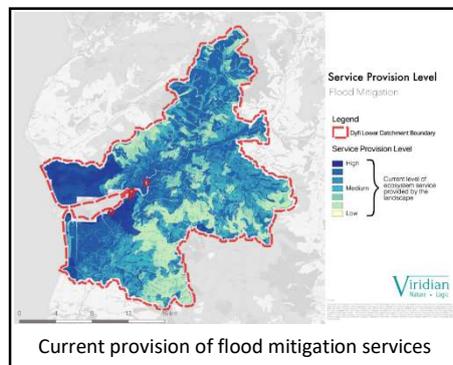
- Woodland planting;
- Creation of meadows (semi-natural grassland);
- Planting of hedgerows;
- Increasing soil infiltration;
- Construction of reservoirs or ponds;
- Construction of leaky dams or woody debris dams;
- Construction of mid-field, leaky bunds;
- Creating field margin swales or buffer strips;
- Creating or re-instating wetlands; and
- Reconnecting flood plains and offline storage ponds.



Finally, Viridian calculated a comprehensive range of natural capital metrics, such as areas of farmland lost and volumes of water stored. From these we quantified the associated ecosystem service flows (physical flow account). This allowed eftec and Viridian to identify all the multiple benefits, trade-offs and winners/losers. This in turn informed eftec to create full, natural capital accounts at sub-catchment scale in the Authie and Stour (approximately 40 units in all).

Case study 2: Using Nature-Based Solutions for Sustainable Land Management

Viridian undertook the data acquisition, preparation and modelling for various



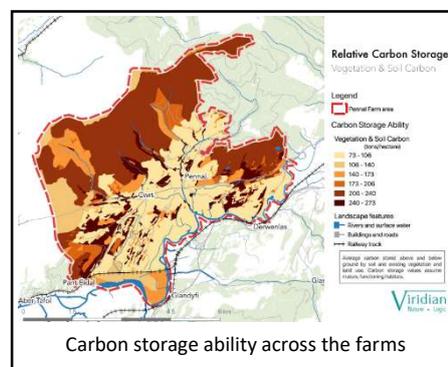
parts of the Dyfi catchment. This provided such a high level of evidence that the local Sustainable Management Scheme was the most successful in Wales. It also helped local farmers maximise the productivity and local benefits from their land. Viridian created maps showing how the landscape was currently functioning for a basket

of ecosystem services; where changes would yield the best results; and what those changes should be.

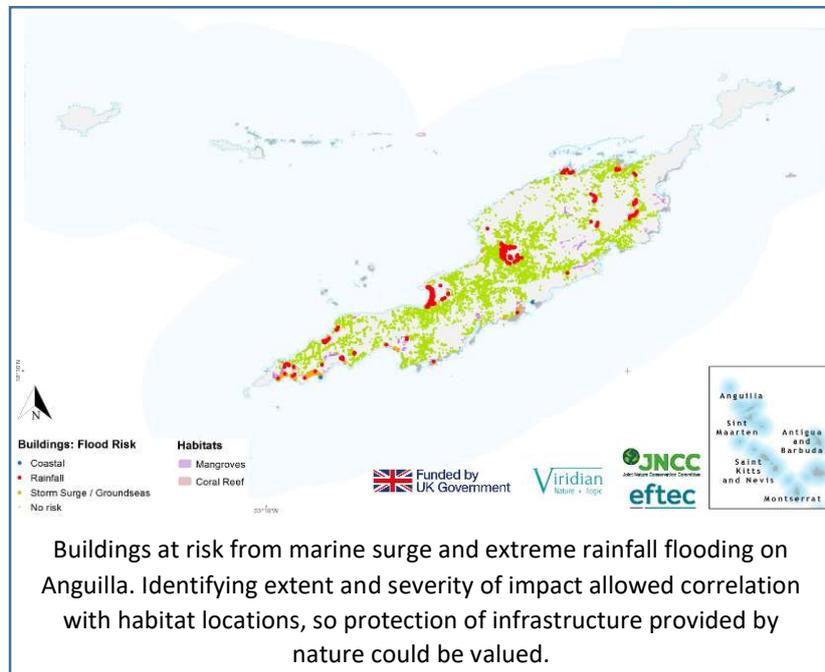
The ecosystem services included:

- Calculating and mapping current and future potential for carbon sequestration within vegetation and soil.
- Natural Flood Management to protect local villages.
- Mapping of the Natural Capital assets across the farms in question.
- Reducing erosion on the farms and keeping silt out of the Dyfi.
- Identifying gaps in pollinator abundance and where to create habitats to fill those gaps.
- Identifying the best places to create new habitats to improve connectivity and species flow.

Viridian trained the group in use of the GIS data, ensuring that the supplied products were sufficiently simple and documented to allow non-GIS users to manipulate them as required. The maps were designed to be intuitive and appeal to a non-specialist audience. These have been used to good effect in engaging other stakeholders and are highly valued by the Group. They have found them perfect for integrating with their local knowledge, so they can make the best overall decisions on land use changes.



Case Study 3: Natural Capital Valuations and National Ecosystem Assessments for Caribbean Islands



Viridian identified and sourced all necessary data from international research, satellite and NGO sources, as well as local organisations.

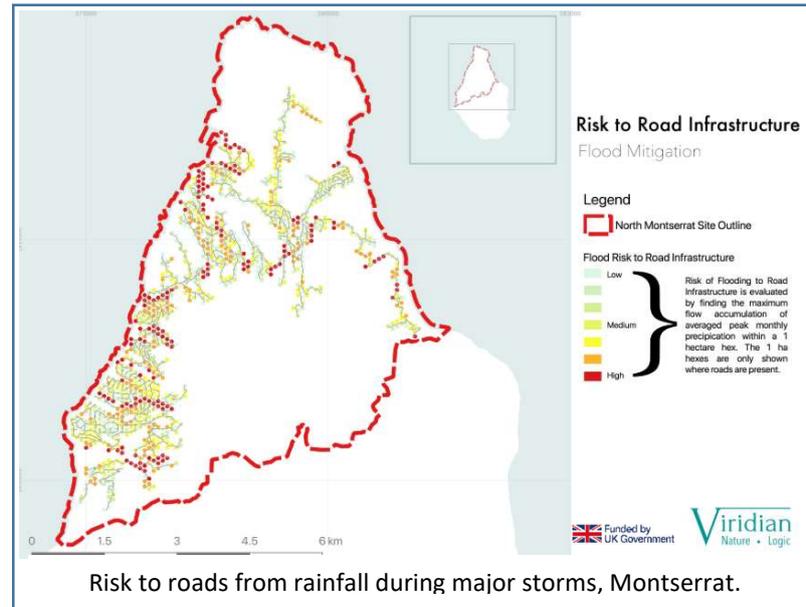
We assembled, cleaned, reconfigured and readied all data to ensure compatibility within our models. We then ran the data

through our algorithms and standard GIS analytical techniques to create Natural Capital Baseline maps of the terrestrial and marine environments.

We used these analyses to create sufficient information for eftec to complete the National Capital Valuation of the islands in question. This involved considerations such as carbon sequestration, agricultural productivity, fish landings, mining, water resources, cultural heritage, flooding, erosion and protection against storm surges.

The project included substantial liaison and stakeholder engagement with a variety of community, government, commercial and NGO organisations from the islands. This ensured that all relevant data, constraints and aspirations were collated for the ecosystem assessments and valuations, as well as ensuring that the results were understood and applied widely.

The project was successful in identifying important natural assets across the islands. It highlighted their importance to the local economy, the wellbeing of communities, and the sense of identity for inhabitants.



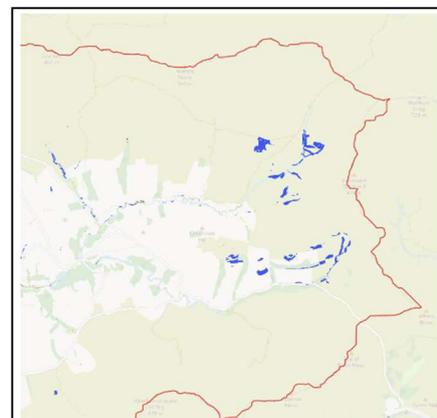
The outputs from the project will help with both the formulation of policy and the implementation of actions to maximise the benefits that nature provides to the islands. The economic valuations will ensure that natural capital is not overlooked during government planning, and the modelling will ensure that the right interventions are created in the right places.

The long-term outcome will be the best use of these comparatively low-cost and simple solutions, which will make the islands more resilient to the intense droughts and hurricanes inflicted on them as the climate changes.

Case Study 4: Property-level Cost/Benefit Analysis of Natural Flood Management: Piloting Institutional Investment in Natural Capital

United Utilities in conjunction with the Environment Agency, the Rivers Trust and Cooperative Insurance were interested in understanding the potential for Natural Flood Management (NFM) to protect communities in the North West, as well as deliver broader environmental benefits. This trial focused on the Wyre valley in Lancashire, where downstream communities are regularly flooded by water draining from five river catchments, which together cover 150km².

Viridian ran their HydroloGIS model to prioritised which natural interventions to create across these catchments to most reduce flooding at a village for least cost. The interventions included planting woodland, reversion to semi-natural grassland or creating water retention features. Viridian identified the best 2%, 5% and 10% of solutions for reducing flooding, as well as the best 2%, 5% and 10% of solutions to simultaneously reduce flooding, diffuse pollution and erosion/siltation. Ambiant entered these solutions into ReFH2 and hydraulic models to calculate the reduction in flood heights they would give at individual properties, looking mainly at 1 in 50 and 1 in 500 year flood events.



Extract of most effective 2% flood reduction solutions: rewetting peat, water retention features and grassland reversion

Viridian converted the flood data into economic benefit using the avoided costs associated with flood defences at the property scale (PFR); or the cost of renovating a house post-flood for those properties that expect a water depth great than 600mm (where entry to the property can no longer be prohibited for fear of structural damage). Finally, Viridian identified the carbon sequestration benefits of the best 2% NFM solutions and APEM quantified the reduction in diffuse nutrient loading in the stream due to the combined solutions.

Without NFM, 54 properties in a single village of 120 properties were modelled to

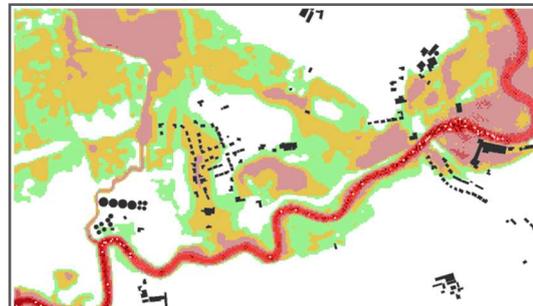
flood during a 1 in 50 year event, 12 of which were undefendable due to the depth of flooding. The top 2% NFM solutions reduce these numbers to zero

In addition to this, for a 1 in 500 year storm, the same NFM interventions would reduce the number of flooded properties from 90 to 52 and the undefendable properties from 50 to zero.

In this location 1 in 50 year events have happened every 5 years, which means the top 2% NFM give up to £11M cost benefit over 30 years relative to PFR alone. Carbon sequestration adds approximately £250k of value over 30 years and the reduction in nutrient loads range between zero and 86%, depending on the river reaches considered.

These benefits from the nature-based solutions are much greater than was anticipated. This is because people are used to solutions being designed using GIS methods alone, which result in them being placed in inefficient locations. HydroloGIS ensures the right types of solutions are created in the most efficient and effective places, thus ensuring the maximum degree of benefit is realised.

This approach is being used to underpin and inform the next steps of the project: institutional investment. A commercial investment institution will provide the capital to create the nature-based solutions, with returns being provided by a range of beneficiaries on a payment-by-results basis. This is possible as the ranking system provides comfort to the investor by allowing robust sensitivity analysis, risk profiling and contingency planning.



Showing flood depths for the current situation (top image) and after the most effective 2% of potential NFM measures have been created (bottom image).

The white areas are outside of the flood zones; the green areas will flood to less than 200mm depth; the orange areas between 200mm and 600mm; and the red areas deeper than 600mm.

The 2% NFM measures comprise 60 hectare of water-retention features and 10 hectares of reversion to semi-natural grassland.

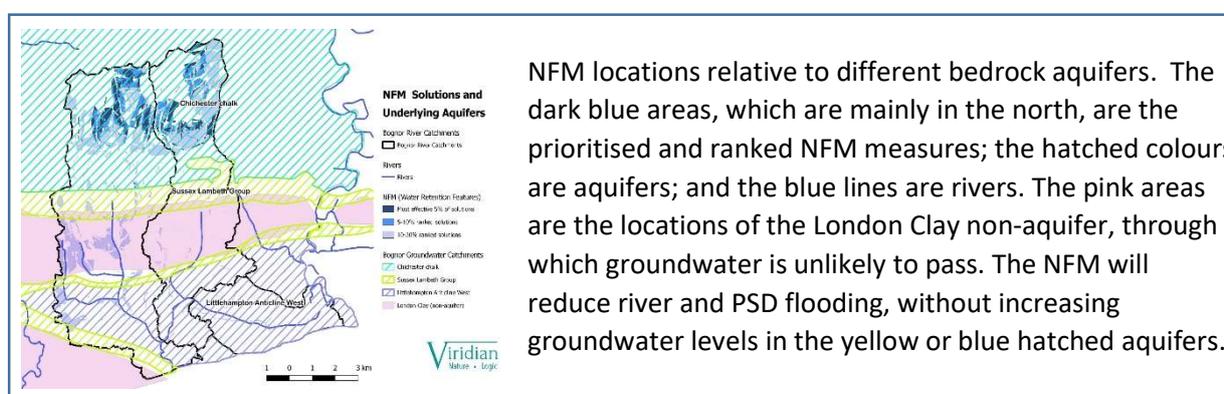


Case study 5: Using Nature-Based Solutions to Reduce Fluvial, Pluvial and Groundwater Flooding

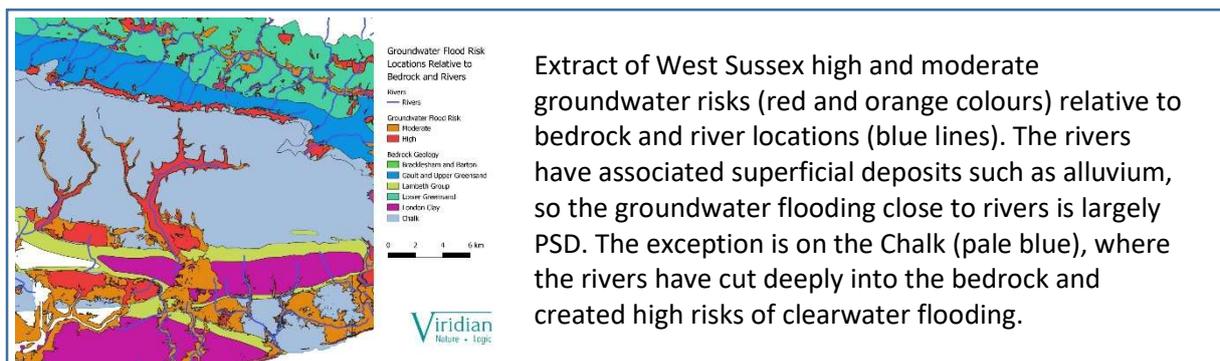
West Sussex County Council were interested in understanding how natural flood management (NFM) could be used to reduce groundwater flooding in the county. The ability to link this type of flooding to fluvial and pluvial flooding was also of interest, so that single interventions could reduce all three simultaneously.

Discussion with the British Geological Survey highlighted that groundwater flooding is not deterministically modelled, but rather relies on physical indicators to identify risk. The models consider two types of flooding: 'clearwater' flooding from bedrock aquifers, and 'PSD' flooding from near-surface sand and gravel deposits. The model outputs do not distinguish between these mechanisms, but present them as an aggregated risk map.

Viridian identified a pilot catchment where groundwater and fluvial flood risks coincide. They ran their HydrologIS model to prioritise the nature-based solutions to fluvial flooding, then combined this with the GeoSmart groundwater flood risk and infiltration maps, geological maps, hydrogeological maps, surface and groundwater catchment boundaries, borehole data and topography. This allowed Viridian to disaggregate clearwater from PSD mechanisms, identify the sources of both and identify where NFM would reduce groundwater flood risk. They used this pilot exercise to create a standard methodology for applying NFM to groundwater flooding across West Sussex.



In the pilot area, the fluvial NFM were also the most effective interventions at reducing PSD flooding, without adversely influencing clearwater risks. There were no opportunities for reducing clearwater flooding in the pilot, but there will be elsewhere in the county. Viridian have therefore created a robust, step-by-step methodology for analysing the causes of clearwater and PSD flooding, then reducing the associated risks using NFM measures.



No modelling of NFM was undertaken for pluvial flooding in the pilot area, but a methodology was created for so doing. This involves identifying the 'catchments' of each area affected by pluvial flooding, then using HydroloGIS to identify the most effective natural solutions within each of these 'catchments'.

The solutions to fluvial, pluvial and groundwater flooding can then be compared in GIS to identify single interventions that will address multiple flood types.

Acknowledgement

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- Anguilla habitat data courtesy of Joint Nature Conservation Committee (JNCC) and government of Anguilla, Turks and Caicos Islands with mapping funded by UK Government;
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- West Sussex County Council Lead Local Flood Authority Groundwater & Natural Flood Management Evidence Base for commissioning Case Study 5.
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