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Catchment Risk Assessment of Steroid Oestrogens for Sewage Treatment Works

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The requirement

To predict where in the English and Welsh river network endocrine disruption risk is greatest

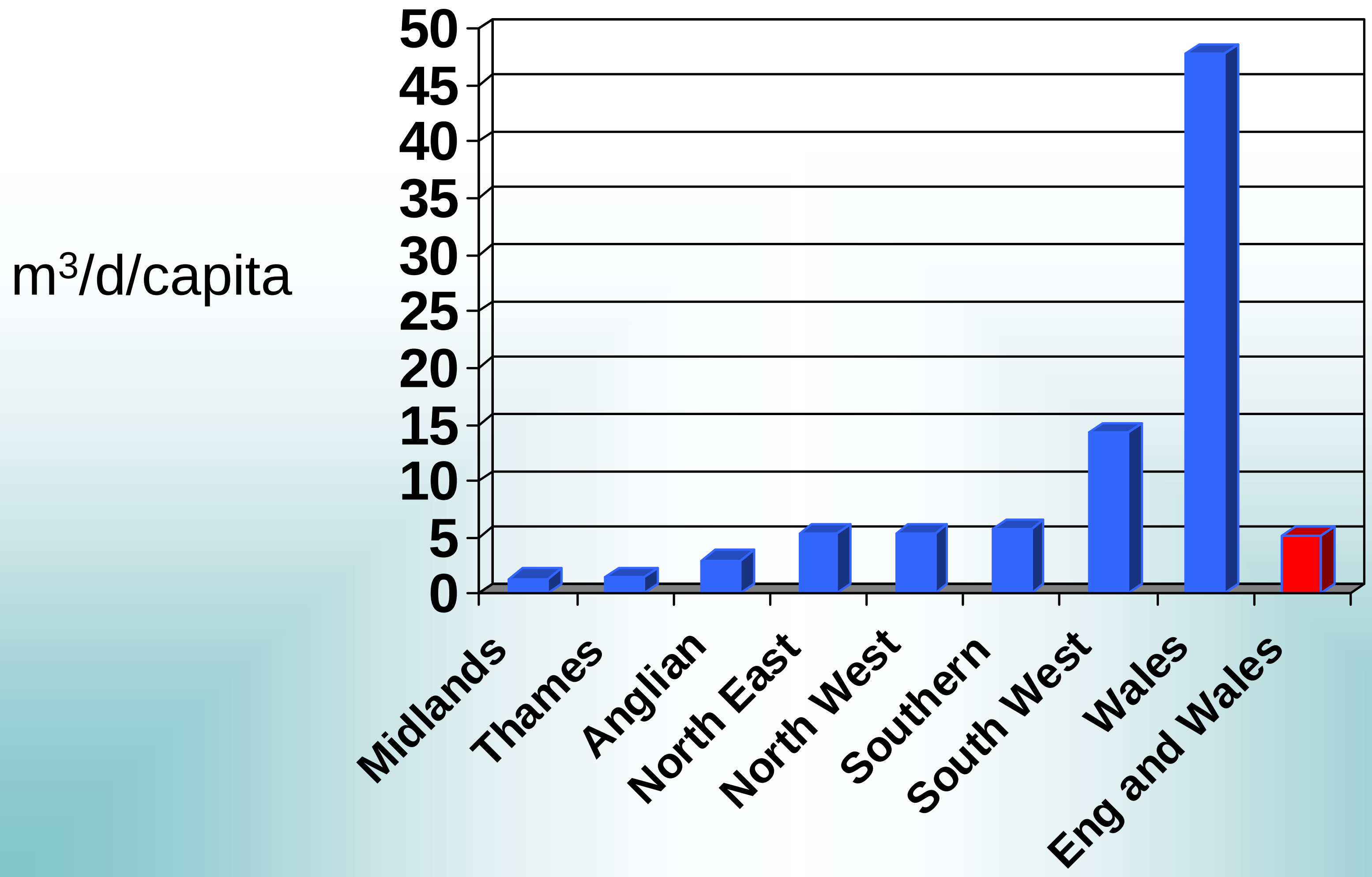
Help identify the sewage treatment works most responsible

Short summary

- LF2000-WQX has been adapted to enable it to model oestrogens and endocrine disruption risk in English and Welsh catchments
- To this end information on the location, dry weather flow, human PE and treatment type of every STP was collected from the EA and Water Companies – thank you!
- With this data, predictions for three individual steroid oestrogens were made in each of 357 catchments, 2,137 STPs and 10,313 river reaches

In general terms the concentrations of oestrogens in rivers will be a reflection of population density versus available dilution

Water available to dilute an individual's daily waste – a regional comparison



So before we get into detailed modelling, from the general regional population vs hydrology profile, we would expect high exposure to oestrogens in areas like the Midlands, but not in Wales!

Methodology

Model predicts oestrogen
excreted per capita

Oestrogen removal predicted in STW
from literature (majority)
Lower E1 removal rate assumed in Biological Filters
(SB)

Final effluent value dependent
on STW DWF

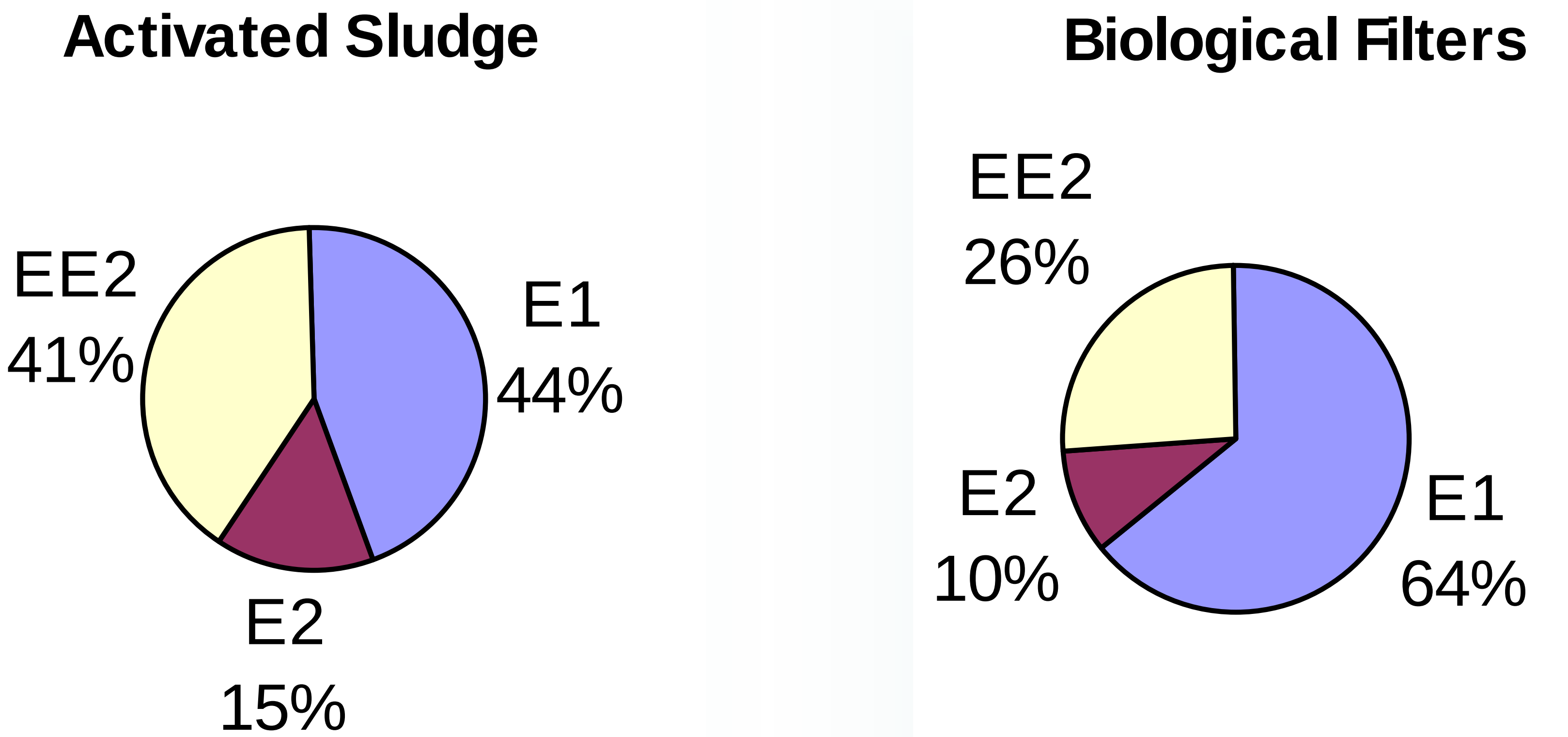
Receiving water concentrations calculated from
dilution (hydrological model) and biodegradation rate
(literature and mean water temperature)
Transformation of E2 into E1 calculated in the model

Predicted concentrations of E1, E2, and EE2 converted
to one of three endocrine disruption risk levels

Risk Classes in E2 Equivalents

Risk Class	E2 Equivalent (ng/L)
No Risk	**<1**
At Risk	**> 1 and <10**
High Risk	**>10**

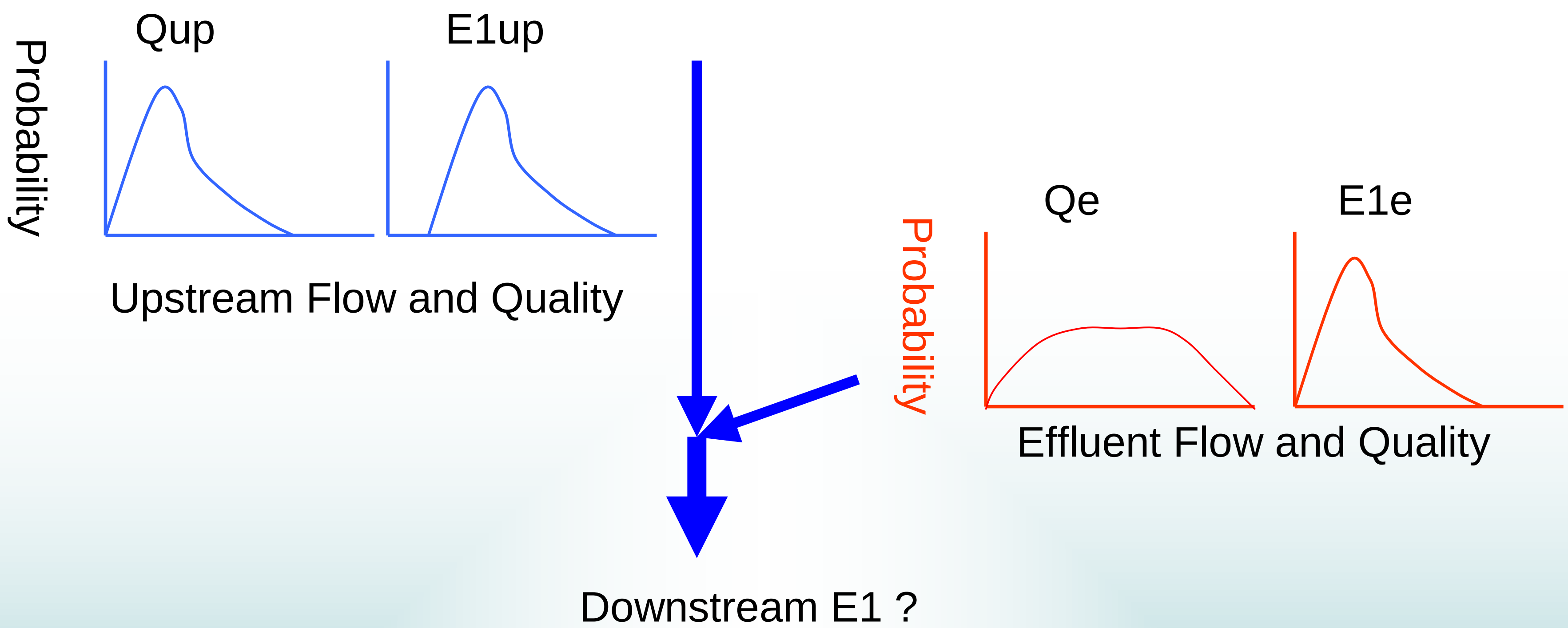
Contribution of individual steroid oestrogens to overall oestrogenic potency in effluent



Results are expressed as mean concentrations, how does this work?

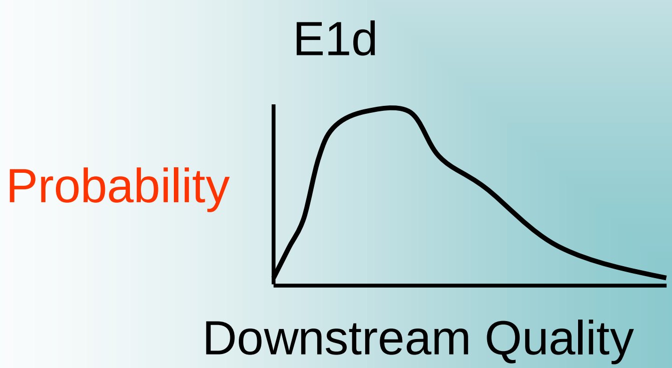
- The model estimates the probability distribution of concentrations of each steroid in each river reach
- This distribution comes from combining other distributions that describe both the flow and chemistry of upstream flows and discharges
- Calculated within a Monte Carlo framework
- These results are given as a mean concentration (90^{th} percentile vales are also given in the report).

Monte Carlo approach to predict downstream oestrone concentrations and assign a probability distribution



Sample from Distributions and do this mass balance calculation many times (shots)

$$E1d = \frac{Qup*E1up + Qe*E1e}{Qd}$$



Health Warning

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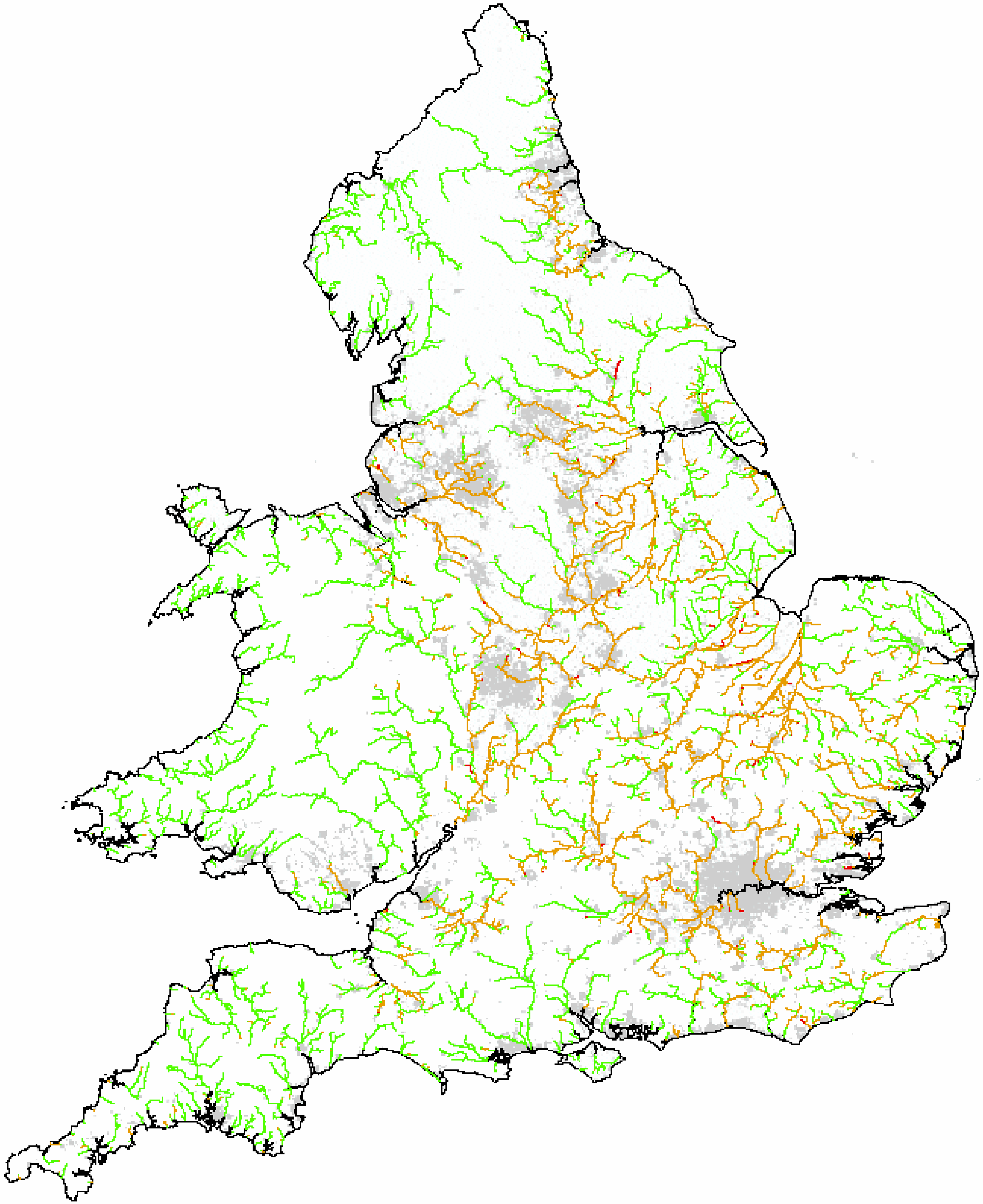
- This risk assessment has been based on readily available data sets and due diligence has been taken in quality controlling these data. However, there are limitations:
  - The use of consented STW dry weather flows rather than measured values
  - The use of a universal removal efficiency in STPs (save for biological filters)
  - The selected PNEC used (which might change the class boundaries and the calculation of E2 equivalent concentrations).
  - Was the association between the STP and receiving water course correct?
  - Model so far only tested against effluents, accuracy at catchment scale still untested!

- The risk assessment could be refined in accordance with:
  - Developments in the scientific understanding of oestrogen effects on the species of concern,
  - New information on treatment efficiencies
  - When the specific objective is to devise a strategy for environmental improvement, or risk reduction, at the local scale.



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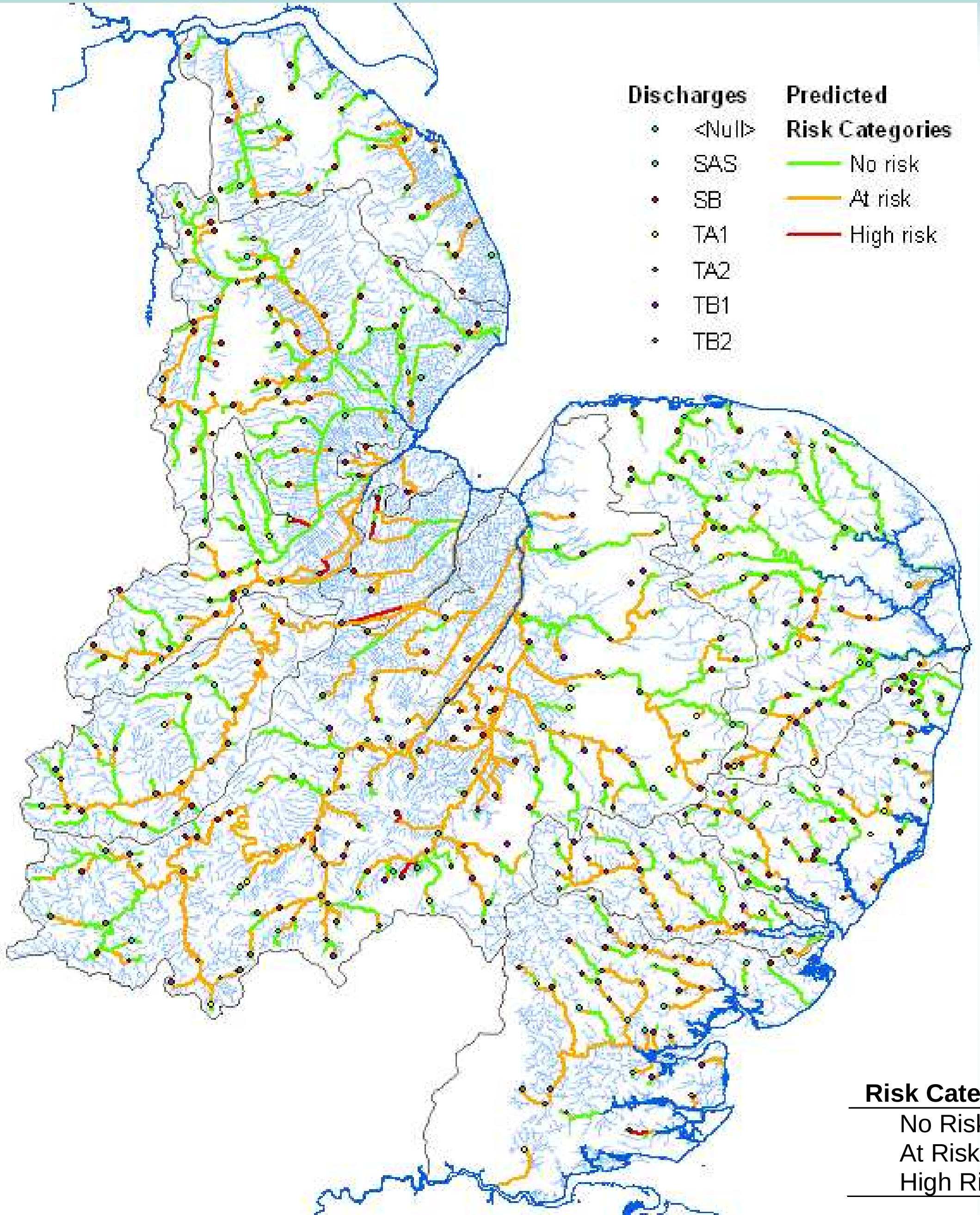
Overview Risk Assessment Map

Predicted

Risk Class

- No risk
- At risk
- High risk

Detailed regional Assessments

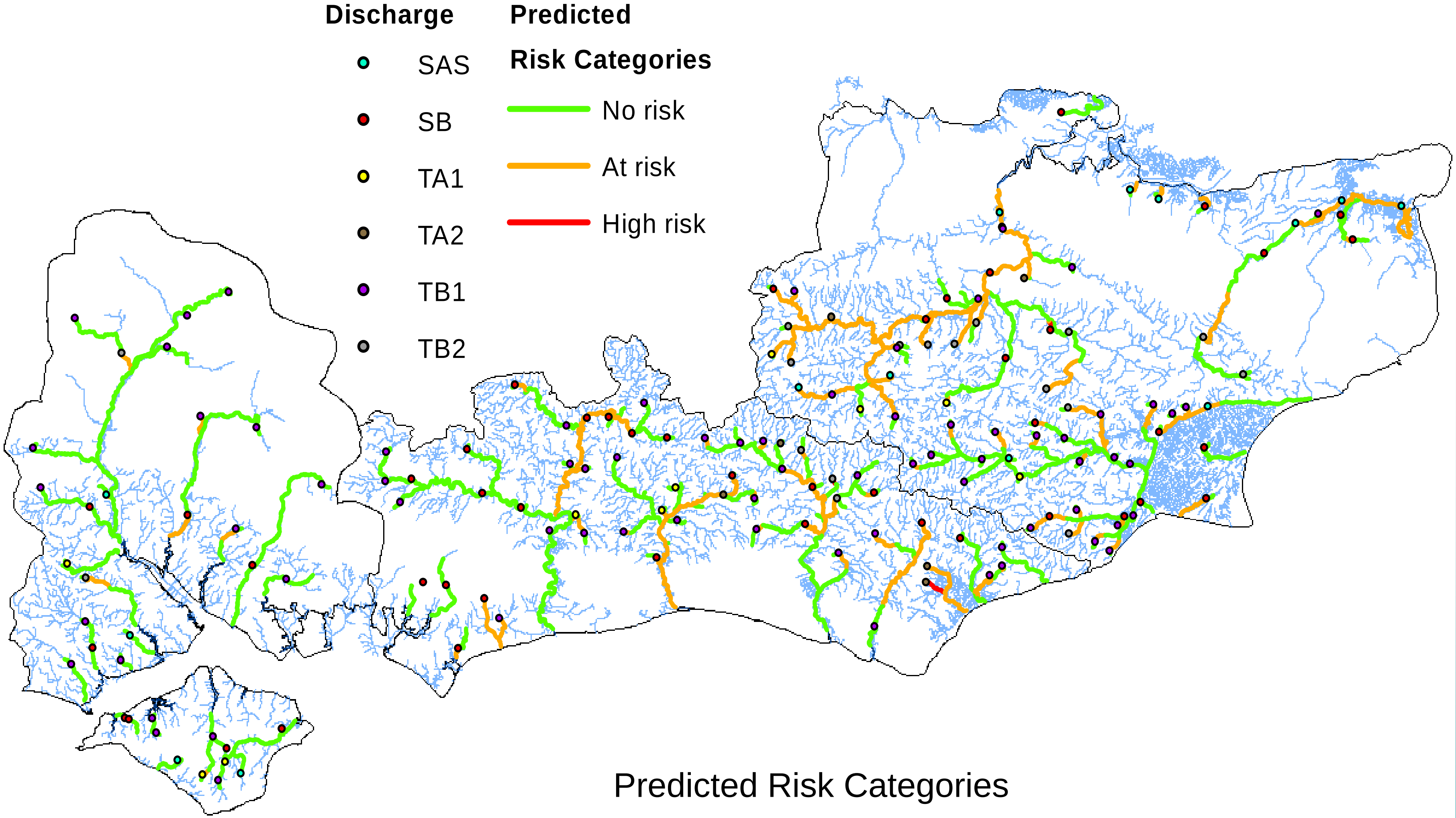


Anglian Risk Assessment Map

Predicted Risk Categories

	Number Reaches		Length (km)		% Total Length	
Risk Category	Mean	90th	Mean	90th	Mean	90th
No Risk	1,163	834	2,434	1,534	48	30
At Risk	1,007	1,177	2,571	3,183	50	63
High Risk	70	229	89	377	2	7

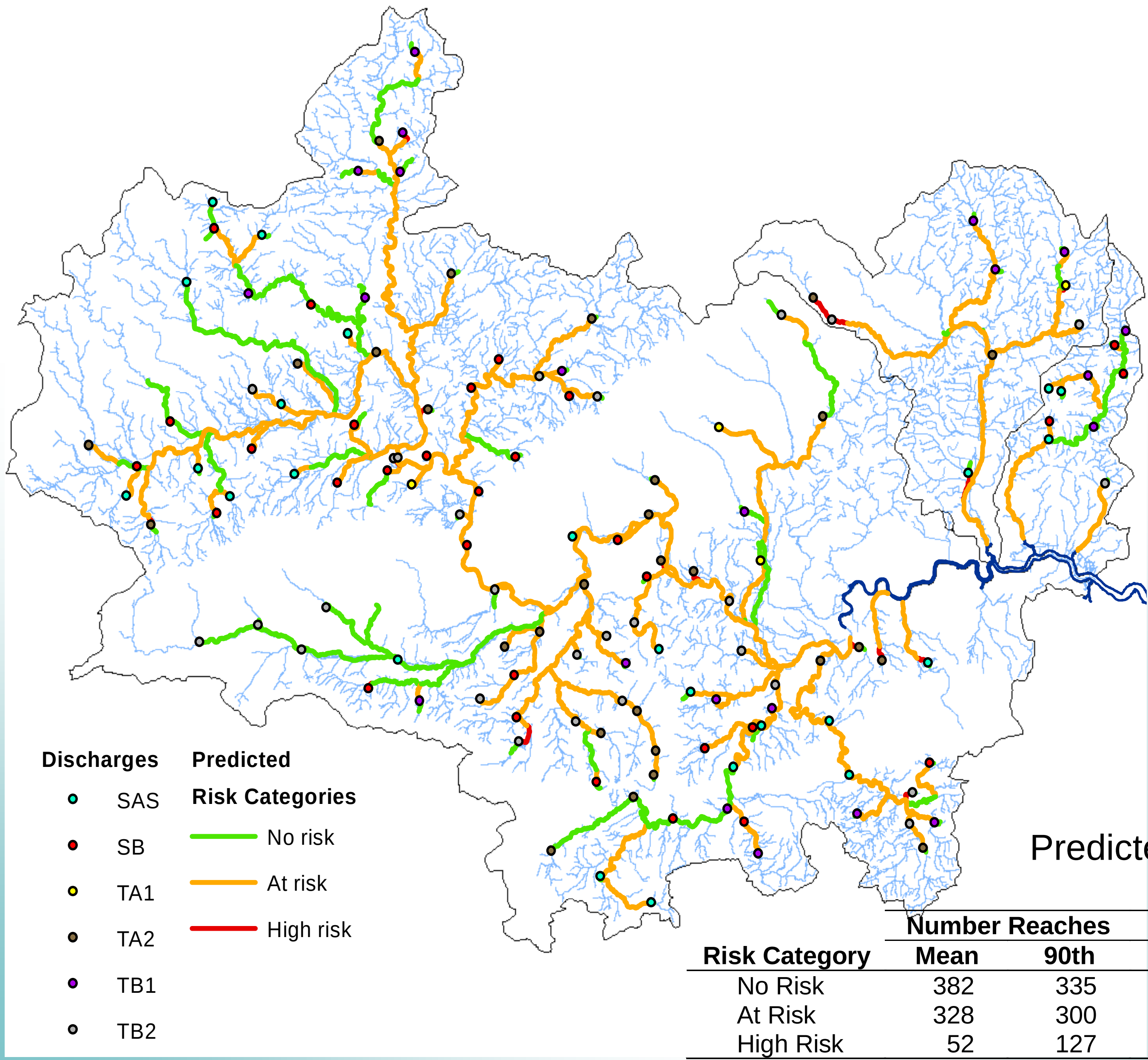
Southern Risk Assessment Map



Predicted Risk Categories

Risk Category	Number Reaches		Length (km)		% Total Length	
	Mean	90th	Mean	90th	Mean	90th
No Risk	882	728	981	793	65	53
At Risk	353	444	508	652	34	43
High Risk	21	84	10	54	1	4

Thames Risk Assessment Map



Predicted Risk Categories

Risk Category	Number Reaches		Length (km)		% Total Length	
	Mean	90th	Mean	90th	Mean	90th
No Risk	382	335	509	311	30	19
At Risk	328	300	1,107	1,127	67	68
High Risk	52	127	44	222	3	13

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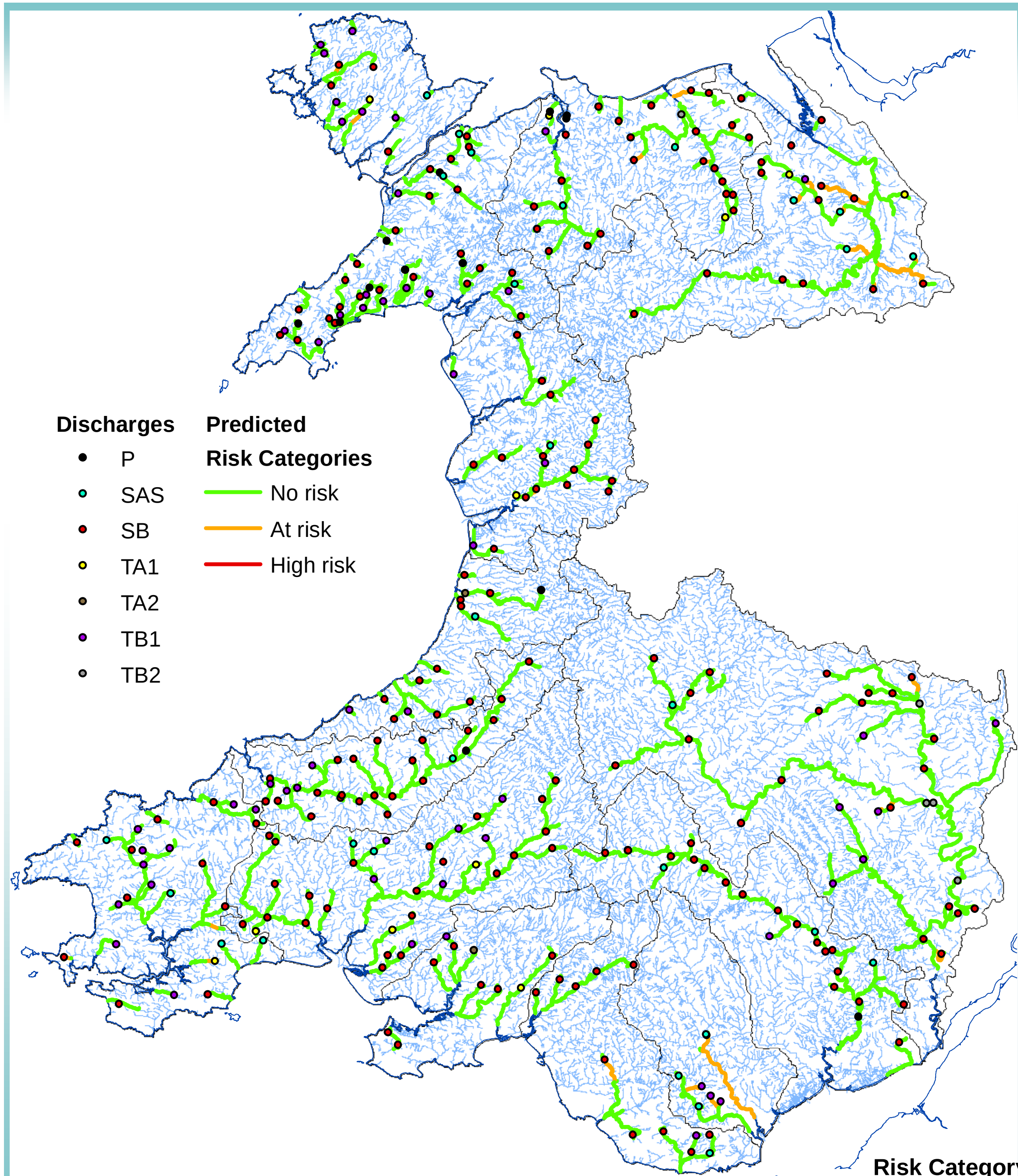

Wales Risk Assessment Map

Predicted Risk Categories

Risk Category	Number Reaches		Length (km)		% Total Length	
	Mean	90th	Mean	90th	Mean	90th
No Risk	1447	1323	2,597	2,415	95	88
At Risk	105	225	133	312	5	11
High Risk	3	7	1	4	> 1	1

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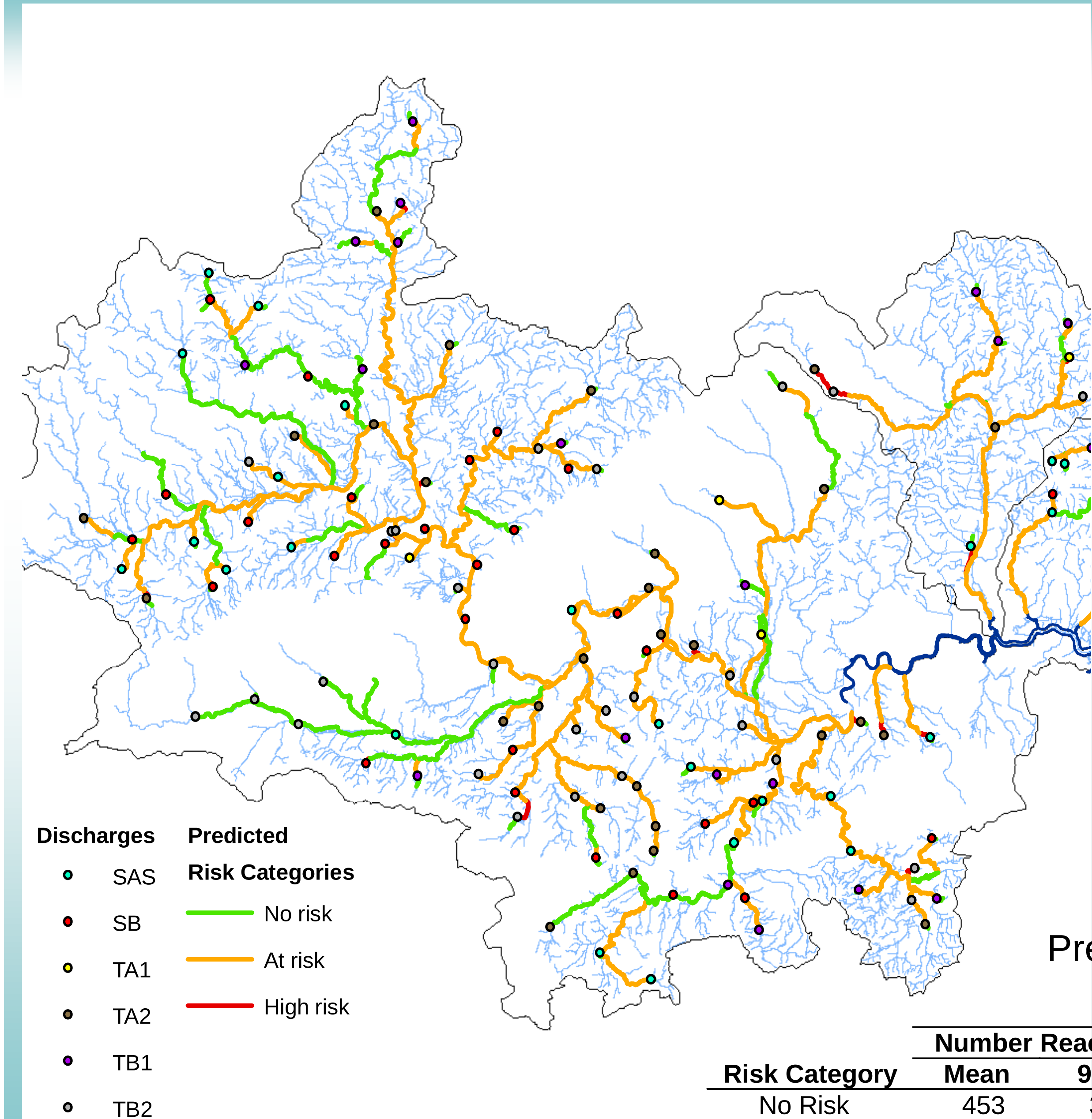
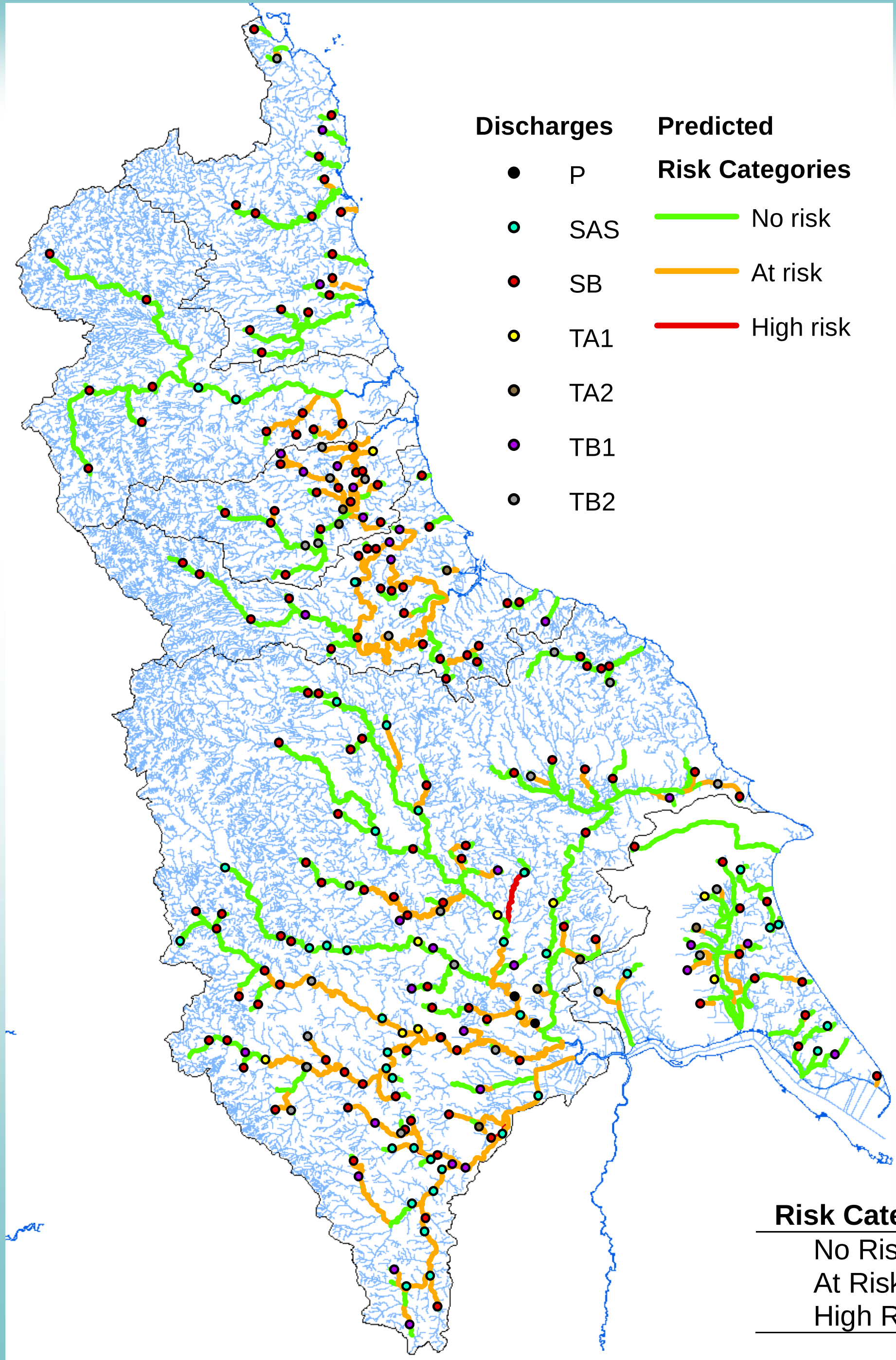
Midlands Risk Assessment Map



Predicted Risk Categories

Risk Category	Number Reaches		Length (km)		% Total Length	
	Mean	90th	Mean	90th	Mean	90th
No Risk	453	352	1,329	865	43	28
At Risk	537	501	1,691	1,850	55	60
High Risk	52	189	50	355	2	12



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North East Risk Assessment Map

Predicted Risk Categories

Risk Category	Number Reaches		Length (km)		% Total Length	
	Mean	90th	Mean	90th	Mean	90th
No Risk	604	462	1,646	1,186	61	44
At Risk	437	496	1,004	1,358	38	51
High Risk	31	114	33	139	1	5

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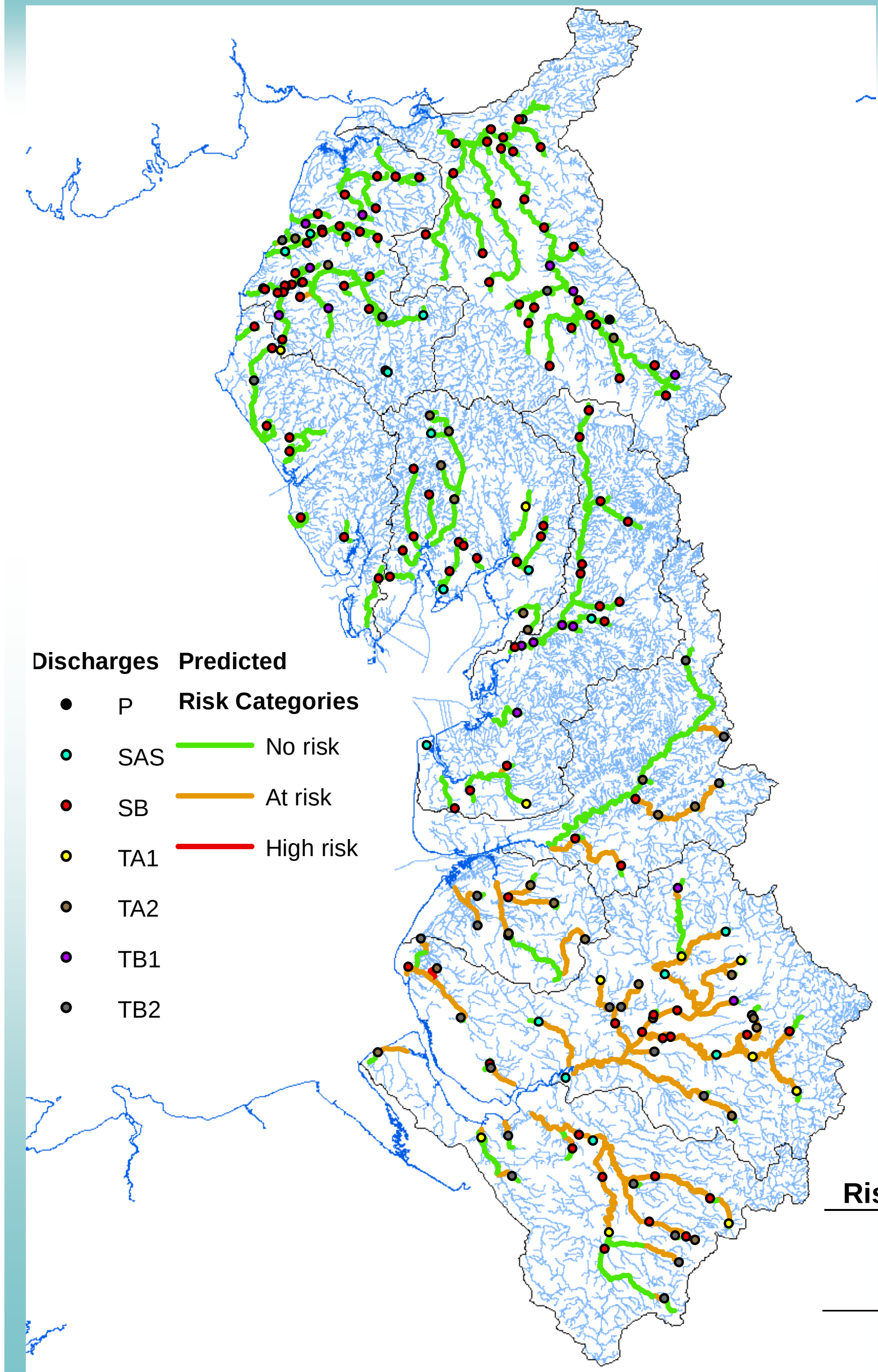

North West Risk Assessment Map

Predicted Risk Categories

Risk Category	Number Reaches Mean	Number Reaches 90th	Length (km) Mean	Length (km) 90th	% Total Length Mean	% Total Length 90th
No Risk	593	540	1,169	1,026	65	57
At Risk	226	238	601	82	34	5
High Risk	19	60	16	678	1	38

South West Risk Assessment Map

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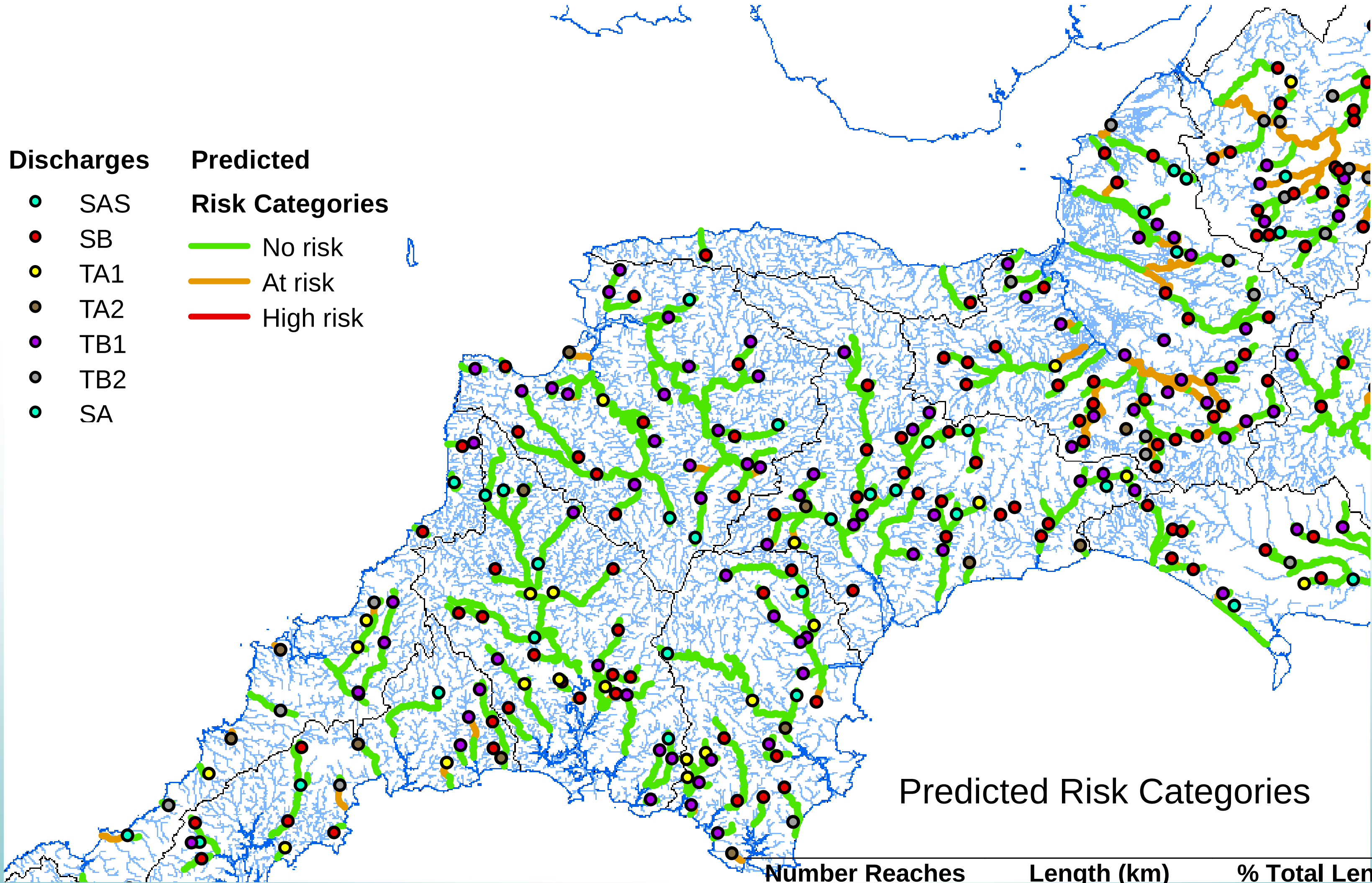


Risk Category	Number Reaches Mean	Number Reaches 90th	Length (km) Mean	Length (km) 90th	% Total Length Mean	% Total Length 90th
No Risk	1216	998	2,462	2,059	84	70
At Risk	316	489	461	821	16	28
High Risk	16	61	6	49	> 1	2

Key scientific findings

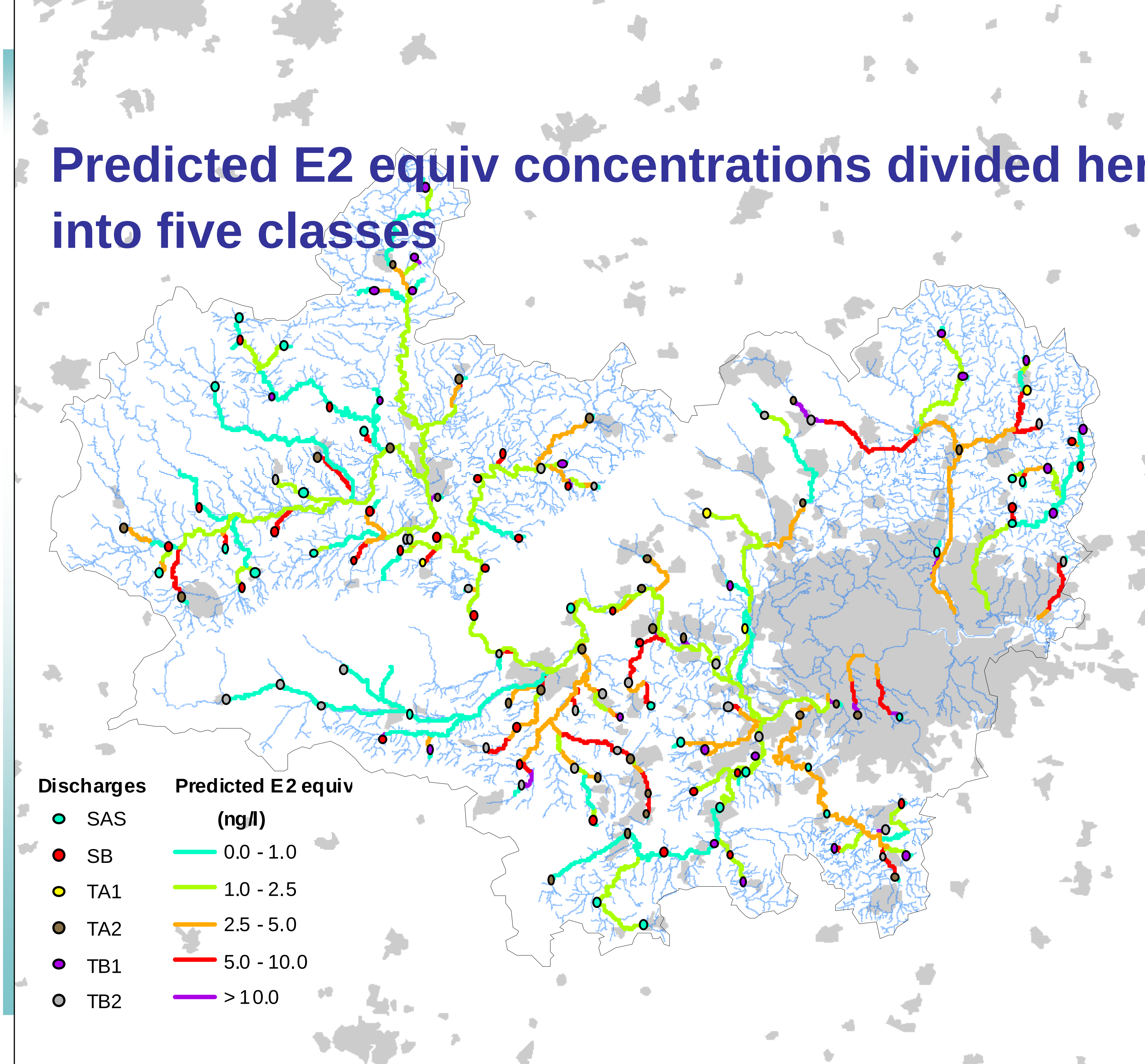
- Majority of reaches in England and Wales are predicted to be not at risk of endocrine disruption (61%)
- Significant minority predicted to fall within the at risk category (39%)
- Only around 1% of reaches fall into the high risk endocrine disruption category
- All regions contain some locations at risk, but Thames, Midlands and Anglian most affected

How the model might be used

- Enables the regulator to rapidly identify the river reaches most at risk from endocrine disruption
- Assists the regulator to identify the STW that make the greatest (negative) contribution to the most at risk river reaches

Changing the model output can help highlight the uppermost group of reaches at risk and focus on the responsible STWs

Predicted E2 equiv concentrations divided here into five classes



Confidence in the model predictions?

- Helpful to compare these risk predictions with previous EA surveys of the incidence and severity of intersex in wild roach (desk study).
- Also would be helpful to compare the PECs generated by the model against measured oestrogen concentrations throughout some selected river catchments (i.e. field monitoring study testing not only the models ability to predict effluent concentrations, but also in-stream concentrations as influenced by dilution and attenuation).

Key uncertainties?

- Have we got our understanding of deconjugation of EE2 within sewage treatment correct? Important because it is such a potent endocrine disrupter.

- Removal rates in different types of STP, have we got them right?

- Is the England and Wales wide equation to convert of flow to velocity (in-river residence time) acceptable everywhere? Greater residence times mean more in-stream degradation, could be important in slow flowing regions like Anglian?