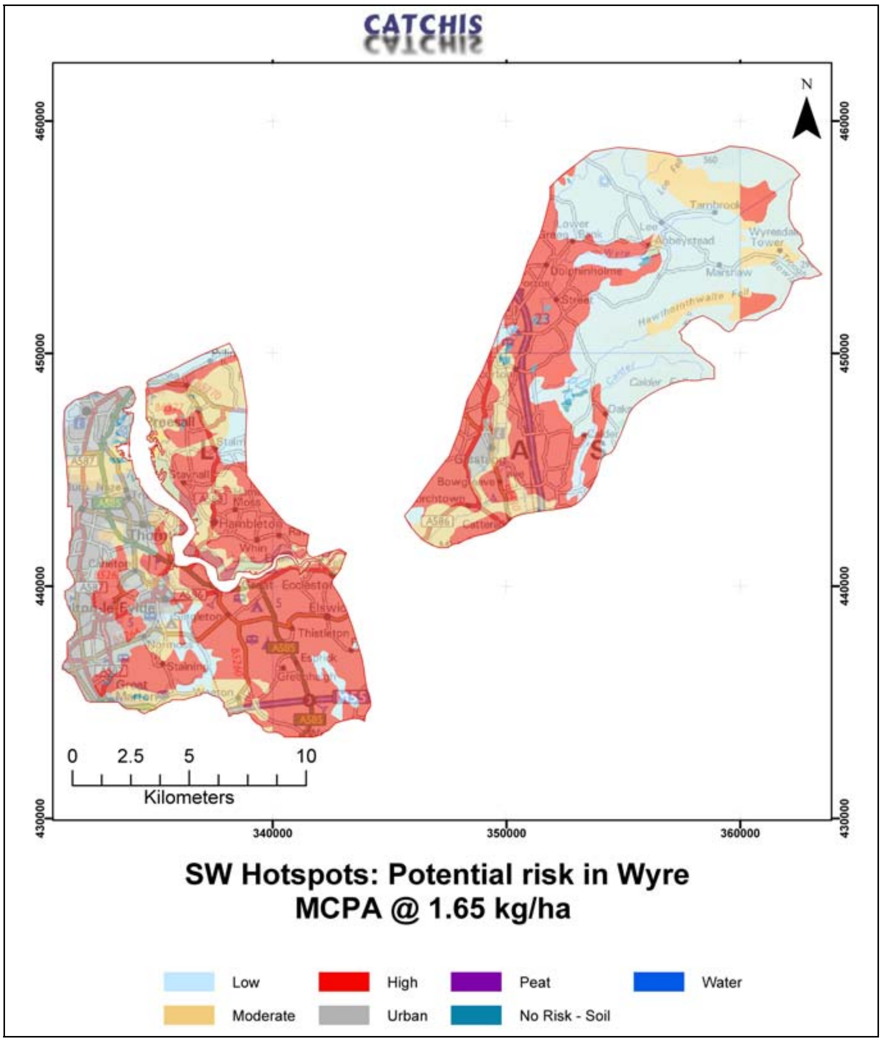
Pesticide risk maps for targeting advice activity in Wyre catchment

March 2007



CATCHIS

developed by:

Cranfield UNIVERSITY using GIS by ESRI technology

Executive summary

- Areas with high vulnerability of Mecoprop_P and MCPA entering streams during peak drainflow after pesticide application are in the majority of the western sub-catchment and south eastern part of the eastern sub-catchment
- The majority of soils in the above high risk areas are impermeable with slow, drainage due to clayey subsoils and are seasonally waterlogged. The soils wet-up rapidly in the autumn and during this time only small amounts of rainfall are required to initiate runoff.
- Some of the soils are climatically sensitive in the eastern sub-catchment. Peaty, seasonally waterlogged soils have high risk in the wetter area in the far north west of the sub-catchment. The high rainfall in combination with long periods when the soil is wetted-up promotes runoff. The same soils have moderate risks where they occur in drier parts of the catchment, where rainfall is lower and runoff risk is reduced.

Background to the surface water model and vulnerability map

The surface water vulnerability maps of the catchment is based on model estimations of the amount of pesticide draining from the field to which it is applied to any adjacent ditches or streams. The model uses information on local soil, rock and climatic conditions, combined with pesticide-specific data on representative application rate, how strongly it is held within the soil and how quickly it breaks down.

The soils data

The soil data used are the National Soil Map (NatMap) and spatial polygons of soil associations and the proportion of specific soil series that comprise the polygon. Mapping is at a scale of 1:250,000. Data from soil properties are used to derive a ‘soil runoff potential’ class based on its hydrological response to rainfall (as indicated from its Hydrology Of Soil Types – HOST – class; Boorman *et al.*, 1995) and its organic matter and clay content as it determines soil adsorption potential. The methods for allocating soils to a runoff potential class are described in Hollis, 1991.

The climatic data

The climatic parameter used by the model is the duration of the climatic field capacity period (FC Days). This is used to determine the average length of time between pesticide application and the rainfall event that triggers soil drainage. Data on FC days at 5 km x 5 km grid resolution has been calculated for England & Wales as a component of the ‘agro-climatic databases (Jones & Thomasson, 1985) held in the NSRI/ Defra Land Information System (LandIS).

The pesticide data

The pesticide fate model used requires information on how quickly the compound breaks down in the soil (the pesticide half life in soil, or $T_{1/2}$) and how strongly it is held within the soil against drainage (the soil sorption coefficient, normalised for organic carbon content, or Koc). Realistic ‘best-case’ values for Koc (maximum sorption) and $T_{1/2}$ (minimum half life) were derived from data held within the NSRI – Severn-Trent Water Catchment Information System (CatchIS, Breach *et al*, 1994). These data comprise a realistic range of values for the Koc and half life of individual compounds compiled from various published sources and verified with the companies who registered the compounds for use in the UK.

Chemical	Koc	$T_{1/2}$
Atrazine	174	17
Chlorotoluron	384	30
Diuron	534	30
Isoproturon	235	13
MCPA	60	6
Mecoprop-P	40	7
Propyzamide	990	16
Simazine	377	20
Trietazine	400	50

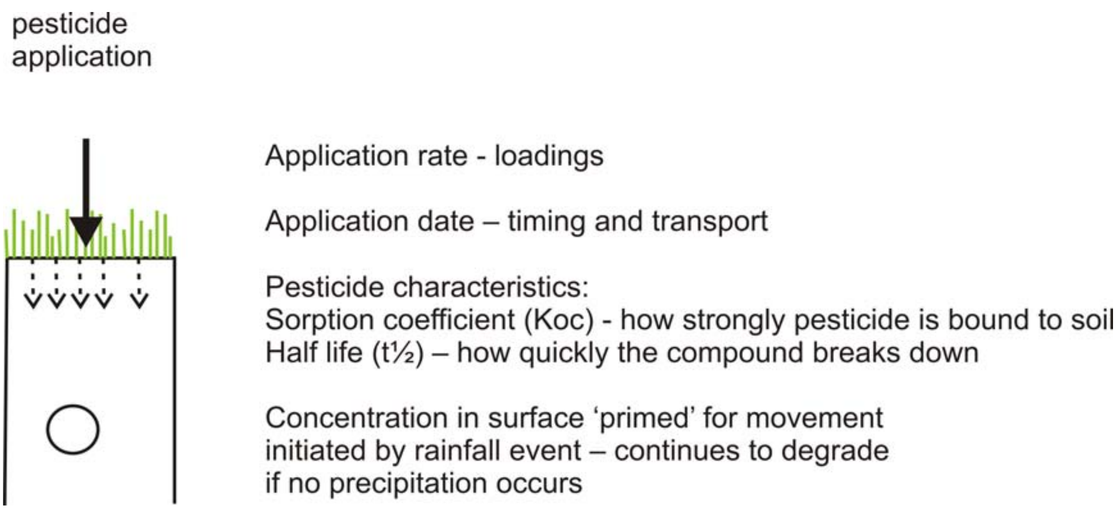
The pesticide fate model

The pesticide fate model used to produce the vulnerability maps is based on an adaptation of the Surface Water Attenuation Model (SWAT) (Brown & Hollis, 1996).

The model predicts the average pesticide concentration entering streams in the peak drainage from fields following the first rainfall event to initiate drainage after pesticide application. This concentration is calculated by assuming that, during the rainfall event, all rainwater interacts with the upper part of the topsoil by displacing and mixing with the mobile water fraction. It is this displaced and diluted soil water fraction that moves rapidly to streams, either via surface flow or through the soil fissure/macropore systems and field drains, if present. During this process, some additional attenuation of pesticide is likely to occur as a result of sorption onto soil aggregate surfaces. The predicted drain concentration is thus calculated from the predicted solute concentration within the upper 1 mm of soil at the time of the rainfall event adjusted using a dilution factor to account for displacement and mixing by rain and a partition factor to account for pesticide sorption during transport to drains.

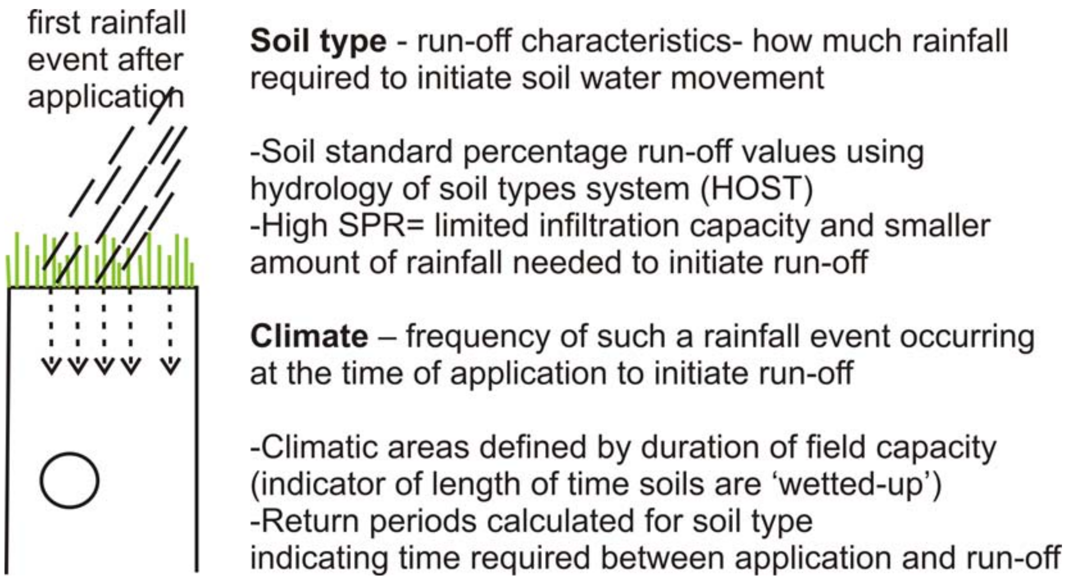
Pesticide concentration in the topsoil water fraction during the runoff event

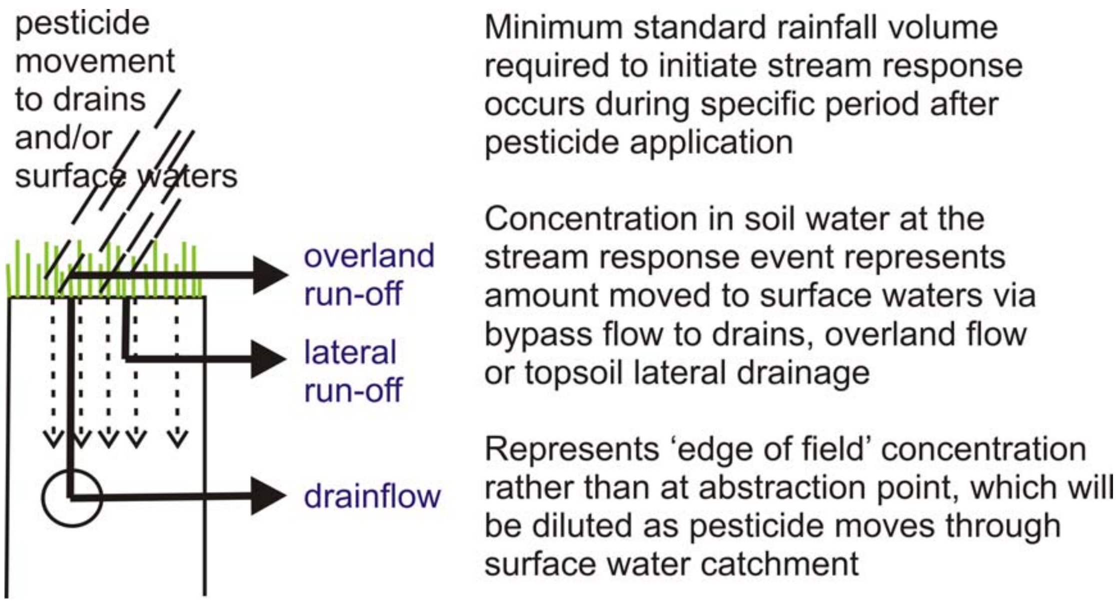
The concentration of pesticide in the topsoil water fraction is calculated using the Attenuation Factor concept. The model assumes that as soon as it impacts at the soil surface, the applied pesticide penetrates to a depth of 2 mm and then begins to move down through the topsoil. The depth to which the pesticide penetrates during the time between application and the rainfall event that initiates run-off (time, t) is calculated from the length of this time, the average soil water flux during this time (assuming the soil is at or near to field capacity) and a pesticide-specific retardation factor that takes into account sorption and volatilisation during pesticide flow. The average pesticide solute concentration within this depth is then calculated from the initial mass of pesticide impacting at the surface divided by the total water content of the topsoil within the calculated depth of solute penetration, multiplied by an attenuation factor that takes into account the degradation that has occurred during the solute transport time (t). These calculations assume a first order degradation relationship with the pesticide half life and also include a time-dependent increase in sorption. The mass of pesticide impacting at the surface is calculated from the pesticide application rate adjusted to take into account any likely crop interception.



Period between pesticide application and the first rainfall event initiating runoff

The interval between pesticide application and initiation of run-off is a function of both soil type and climate. Soil types determine the amount of rainfall that is necessary to initiate run-off and climate determines the relative frequency of such an event. Using the Hydrology of Soil Types (HOST) classification, soils are grouped into five classes (S1 to S5) according to their predicted Standard Percentage Run-off (SPR) value. Soils with the highest SPRs require only small volumes of rain to initiate run-off whereas those with the lowest SPRs require large volumes of rain. Rainfall volumes of 5, 7, 10, 18 and 20 mm have been selected to reflect the increasing infiltration capacity of soil classes with increasingly lower SPRs. By statistical analysis of daily weather data sets, the average return periods for each of these rainfall events within each climatic area defined by the duration of their field capacity period, has then been calculated. These calculated return periods range from 1 to 10 days for S1 soils with greater than 50 % SPR, to 12 to 115 days for S5 soils with less than 10 % SPR. These values are used within the model to define the average time duration between pesticide application and the first rainfall event that initiates run-off.





Output from the model

The model calculates the pesticide concentration for each of the individual soil series that are defined by the soil spatial data. The calculated pesticide concentration is thus assumed to apply to all the area represented by the soil series. The calculated value represents the concentration of pesticide draining from individual fields which contributed to the surface water network. Because of the uncertainties relating to the derivation of input parameters to the model and the fact that concentrations of pesticide draining from individual fields are likely to be subject to dilution and dissipation within the surface water network, the predicted concentrations are not treated as absolute values but are translated into one of three relative risk categories: Low, Medium or High. The range of concentrations associated with each class is as follows:

Low $0 – 1\ \mu g\ l^{-1}$

Medium $1.01 – 4\ \mu g\ l^{-1}$

High $> 4\ \mu g\ l^{-1}$

Interpretation of the map

When interpreting the maps it is important to remember certain assumptions on which the risk assessment is based.

1. The mapped areas are independent of land use and crop data. The map represents the combination of soil and climate characteristics that produce vulnerable situations with high runoff potential giving rise to enhanced pesticide

concentration in drainage waters at ‘edge of field’. Therefore, the model assumes that the pesticide is applied over the whole area (unless it non-agricultural eg ‘urban’ or ‘upland peat’) and gives vulnerability should the pesticide be applied to the specific area. Assessment of actual cropping and land use should be sought from agronomists in the catchment and used in association with the vulnerability maps.

2. As the maps are based on the National Soil Map at 1; 250,000, care should be taken when extrapolating the assessment to specific smaller scale areas (eg. fields) within the map units displayed on the map. For smaller scale areas more detailed characterisation of soil types within certain fields would need to be undertaken.
3. As climate data is indicative of meteorological conditions over long-term periods it represents areas of agroclimatic significance that determine appropriate cropping and land use. The climatic data used to in the model to determine events that trigger drainage is representative of ‘average’ conditions determined from long-term data. Consideration of weather patterns in a specific timeframe within the catchment and observations of drainflow should also be taken into account. There are likely to be some years when drainage is triggered sooner (eg. because of a particularly wet late summer and early autumn) than the period used in the model (giving higher concentrations) as well as some years when it is triggered later (giving lower concentrations).
4. The assessment only takes into account diffuse agricultural sources and assumes best practice. It does not take into account point sources, non-agricultural sources or inputs from bad practice.

The map is thus simply a generalised vulnerability assessment that attempts to integrate the inherent local environmental risk factors (soil and climate) with the risks attached to the pesticide characteristics and the time of application. The risk classes used also try to take into account attenuation of the edge-of field concentrations during transport through the catchment surface water network. Taking into account these assumptions therefore, the classes can be interpreted as follows:

- **Low** risk (coloured blue) indicates that if the pesticide is used on the licensed crops in these areas, the amount draining to surface waters in most years is unlikely to give water quality problems at the abstraction source.
- **Medium** risk (coloured orange) indicates that if the pesticide is used on the licensed crops in these areas, then, in some years the amounts draining to surface

waters are likely to give intermittent local water quality problems at the abstraction source, at least over the late autumn and winter periods.

- **High** risk (coloured red) indicates 'hot-spot' areas within the catchment where the combination of soil rock and climatic conditions create particularly vulnerable environments. If the pesticide is used on the licensed crops in these areas, then it is very likely that the amounts subsequently draining to surface waters will give intermittent water quality problems at the abstract source over the late autumn, winter and, possibly, the spring periods.

Interpretation of differences in the vulnerability maps

Western sub-catchment

High areas

High risk areas for both Mecoprop-p and MCPA are slowly permeable, seasonally waterlogged fine loamy over clayey soils (Salop association) where pesticides remain in solution during wet periods and little rainfall is required to flush them out of the system. Slowly permeable soils with groundwater at shallow depths controlled by drainage (Rockcliffe association) and seasonally waterlogged, slowly permeable fine loamy over clayey brown earths (Flint association) have moderate run-off potentials. These soils have high risk for Mecoprop-p and moderate risk for MCPA. Mecoprop-p has lower absoption capacity than MCPA and hence will remain in solution for longer and have a higher risk of flushing to surface waters via by-pass flow and drains.

Moderate areas

Slowly permeable soils with waterlogging at depth due to groundwater have moderate run-off potentials and risk is potentially exacerbated by drainage providing a rapid conduit for pesticides in solution to surface waters.

Low areas

Soils are low risk on areas on drained deep peat (Altcar association) with high absorption capacities.

Eastern sub-catchment

There is a climatic gradient across this part of the catchment. Areas in the north east experience longer periods when the soil is wetted up and greater amounts of rainfall during the field capacity than areas in the south west.

High areas

High risk areas for both Mecoprop-p and MCPA are slowly permeable, seasonally waterlogged fine loamy over clayey soils (Salop and Brickfield associations) where little rainfall is required to flush pesticide out of the system into surface waters via by-pass flow. Soils in close proximity to the river (Warfe association), albeit well drained, can present a risk due to flooding during very wet periods.

Moderate areas

See below for climate-sensitive soil types

Low areas

Soils in low risk areas are upland blanket peat which have has low risks because they are not normally under agricultural management.

Climate-sensitive soil types

As previously discussed the sub-catchment has a strong climate gradient from the south west to the uplands in the north east. The slowly permeable, seasonally waterlogged upland peaty soils (Belmont and Wilcocks associations) have variable risks depending on the location within the sub-catchment. The high organic matter contents increases their pesticide absorption capacity and have low to moderate risks in the drier parts of the uplands, where rainfall is insufficient to induce by-pass flow and the pesticide remains in the soil system long enough degrade by absorption to the organic matter. In the wetter upland regions in the east soils are wet for very long periods of time and effective rainfall is high during this period. The slow permeability of the soils becomes a major factor and pesticides are moved through the system via by-pass flow with little opportunity to absorb to organic matter, creating high risk for surface water concentrations.

References

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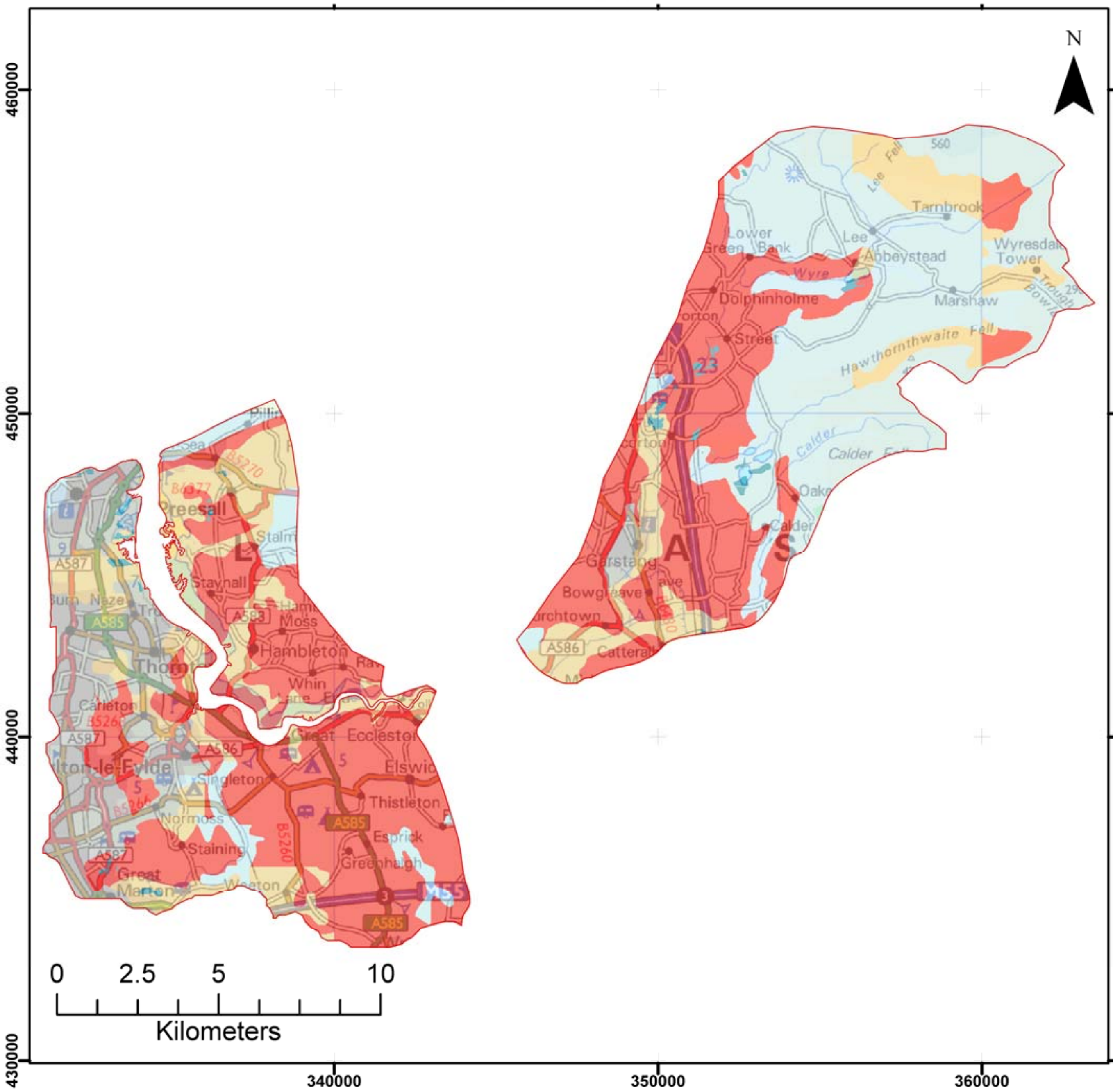

SW Hotspots: Potential risk in Wyre MCPA @ 1.65 kg/ha

Low	High	Peat	Water
Moderate	Urban	No Risk - Soil	

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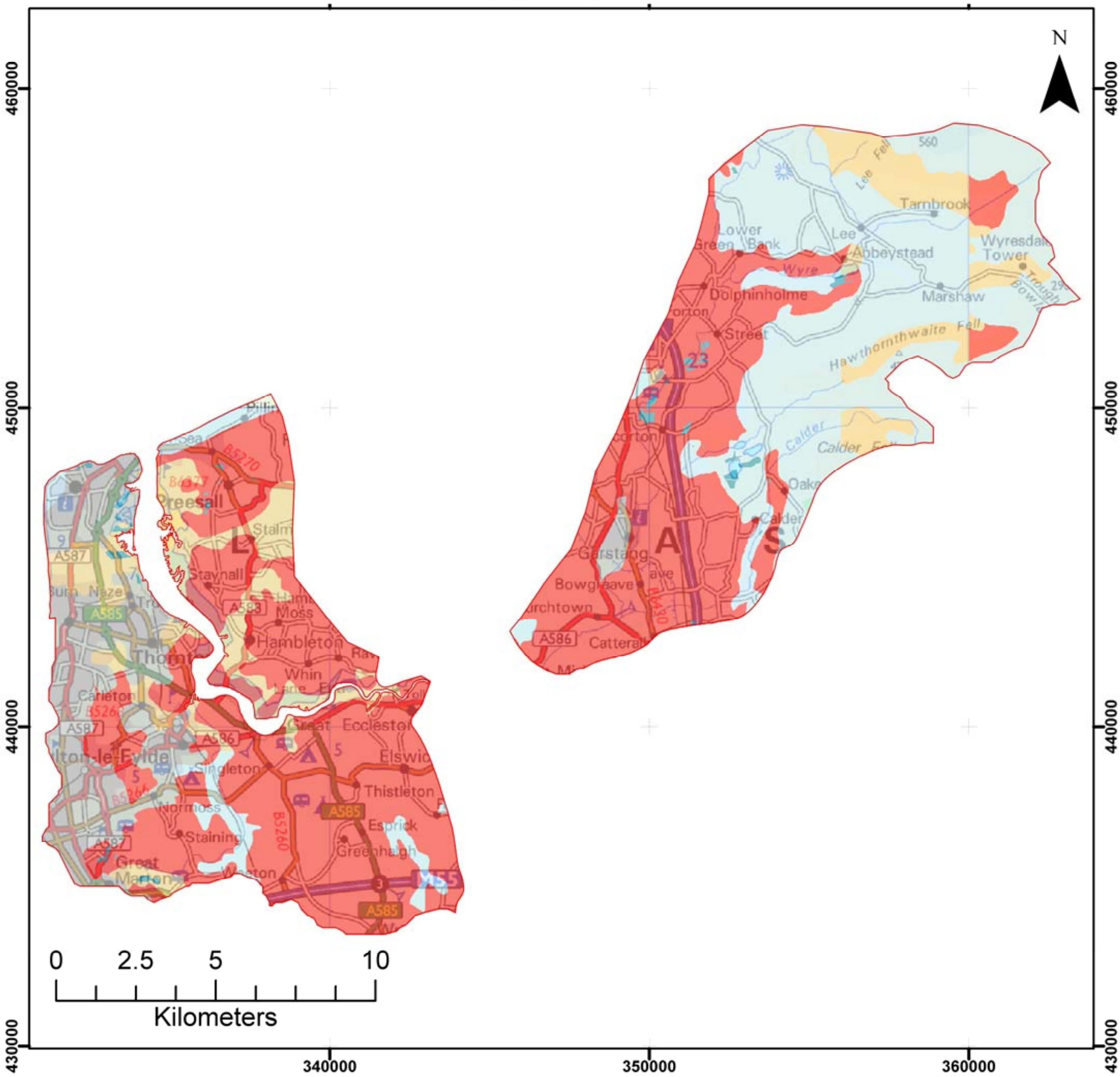

SW Hotspots: Potential risk in Wyre
Mecoprop-P @ 1.5 kg/ha

Low
High
Peat
Water
Moderate
Urban
No Risk - Soil