Memo

To	:	Defra In Situ Contaminated Sediments Project Board
From	:	Alison Hallas
Date	:	16 July 2015
Copy	:	Nicola Clay, Ian Dennis, Christa Page
Our reference	:	9Y1410-02A/M01/303250/Lond
Subject	**:**	**In Situ Contaminated Sediments: National Hazard Screening Methodology**

Dear All,

Following on from your initial comments on the "National Risk Assessment Methodology", the Project Workshop 2 on the 19th May and the subsequent comments received from members of the steering group, we have edited the method to the point where we can start the assessment/screening exercise.

Key changes since the workshop are:

- Renaming the assessment from "National Risk Assessment" to "National Hazard Screening exercise". This is in order to underline that this forms the first step in the process of focusing down on areas of concern (which will be continued in Work Package 4A), that interventions will not be implemented based on the results of this exercise alone and that the methodology will mainly look at relative risks/hazards rather than absolute risk levels;
- Changing the "hazard levels" from green - amber - red to green – amber (1) – amber (2). This had been changed to acknowledge that this methodology is unlikely to have sufficient detail to identify areas of unacceptable risk/hazard level; and
- Incorporation of the suggested initial comparison between contaminant concentrations for in-channel sediments and floodplain soils (although this will only be possible for catchments covered by the BGS GBase data set).

Since the methodology may need to be refined as the exercise (Work Package 3A) progresses, we have summarised the method below rather than present it in a finalised report. Should you have any additional comments on the method at this stage, please feel free to email them over. In the meantime, we will progress with applying the method and will be in touch with the Project Board should any significant changes need to be made. A full report detailing the review of existing risk assessment mythologies, the final (implemented) hazard screening methodology, and the result of the screening exercise will be produced at the end of Work Package 3A.

Kind regards,

Alison

Potential National Risk Assessment steps – proposed hazard screening methodology

The desired end point of the national sediment risk assessment process (within the project scope) is to prioritise sites in England for evaluation of potential intervention measures to tackle risks from sediment contamination. In order to reach this point, it is considered that a series of steps may be needed. The first, presented here, is a hazard screening step, which is intended to be a precursor step to more detailed consideration of risks.

The screening step is intended to identify: areas of lowest concern, for which further action is considered to be a low priority; those areas with a high level of uncertainty associated with the potential hazards from sediment contamination; and those with a potentially unacceptable hazard level. It is intended that the screening exercise will identify a limited number of areas in the two latter categories of site which could be the focus of resource for more detailed assessment.

Work Package 4A will consider significance and prioritisation methods, although it is not clear at this stage whether sufficient detailed information is available at the national scale to enable prioritisation of areas.

1 Aquatic Receptor Hazard Screening Assessment

In order to provide comparability, where possible, assessment of marine and freshwater receptors has been approached using the same overarching method but using Sediment Quality Guideline levels (SQG) appropriate to the different aquatic environments and different data sets (e.g. substrate categorisation) where these are specific to either the marine or freshwater environment.

1.1 Assessment of Likelihood of Effect

The proposed approach to assessing the likelihood of an effect on aquatic receptors is to consider a combination of substrate type, exceedance of SQG (where sediment quality analytical data are available) and consideration of potential pollutant sources in the catchment. **Table 1** summarises proposed likelihood categories using sediment type and SGG exceedance.

Table 1 Likelihood Sediment type/Sediment Quality data

Likelihood Level	Likelihood Description
High	Fine silt present in all/nearly all of water body and concentrations confirmed by any sediment quality concentrations* greater than SQG_{upper}
Medium	Fine silt present in over half the water body area and concentrations confirmed by any sediment quality test results* being between SQG_{lower} and SQG_{upper}
Low	Some silts present but majority of substrate coarse grained, any sediment quality concentrations* between SQG_{lower} and SQG_{upper}
Very Low	Substrate all/nearly all coarse grained, contaminant concentrations not confirmed by data
Remote	Substrate all /nearly all coarse grained, all sediment quality concentrations* below SQG_{lower}

* Assessment of reliability of sediment quality test results would be based on professional judgement

As part of the work undertaken to formulate this hazard screening methodology, the advantages and disadvantages of using SQG as the basis (or part of the basis) of a sediment contamination risk assessment process have been explored and will be presented in the Work Package 3A report.

The SQG in **Table 2** are suggested for use in the assessment of likelihood of effect. This is based on the following points:

- Canadian SQG are based on minimal risk levels for Canadian habitats which do not incorporate UK background concentrations and the PEL levels are likely to be over-precautionary. It is noted that in selected areas, background may exceed the Canadian SQG PEL. The risk assessment would conclude that this risk is acceptable if sediment concentration is at or below background i.e. that there is a theoretical risk to ecology due to natural concentrations but that it does not require intervention.
- Cefas Action Level 1 values are mainly based on observed background levels from UK sediment data (for metals) and ecotoxicological information for organic contaminants. They have been set at a level which is considered (by Cefas) to represent a lowest reasonable assessment level for use in the UK marine environment. However, AL1 have only been defined for certain contaminants. These were developed for use in assessments for disposal of dredged sediments at sea.
- BGS have also defined background levels for England based on geochemistry and dividing the country into domains. However, it is noted that these also contain an element of 'anthropogenic background'. Again, these are available only for certain contaminants. The principal domains cover very wide areas and do not allow consideration of any more regional or local scale variations. These were developed to support the process of assessing contaminated land within the definition in Part 2A of the Environmental Protection Act 1990 (as amended) and the upper limit of "normal" levels of contaminants in soil (the upper 95% confidence limit of the 95th percentile). The project presented other percentiles and their confidence limits in the published supplementary information and it is considered more appropriate to use a lower percentile in the context of this precautionary first assessment step. The upper 95th confidence limit of the 50th percentile has been selected.

- Cefas Action Level 2 values are intended for assessment of disposal of sediment at marine disposal sites. They may not necessarily constitute a precautionary approach for assessment of risks from in-situ contaminated sediments. The revised Action Level 2 values consider ecotoxicological effects. Although these have not yet been implemented in England, they are already in use in Scotland and in the process of implementation in Northern Ireland (although the implemented analysis method is different).
- Canadian PEL levels are evidence based and based on detailed studies of ecological effects. However these are used only within a weight of evidence approach as "an additional sediment quality assessment tool that can be useful in identifying sediments in which adverse biological effects are more likely to occur (CCME, 1999).

Table 2 Suggested SQG for Aquatic Receptors

Environment	SQG_{Lower}	SQG_{Upper}
Marine/Estuarine	Cefas Action Level 1 where available Where unavailable, Canadian SQG TEL	Revised Action Level 2 Canadian SQG PEL
Freshwater (River and Lake)	BGS Normal Background Concentrations (based on 50th percentile) for the catchment (by judgement if the catchment crosses between BGS defined Domains). Where unavailable, Canadian SQG TEL.	Canadian SQG PEL

For Polycyclic Aromatic Hydrocarbons (PAH), Effects Range Low (ERL) and Effects Range Median (ERM) levels have been derived by the US EPA for groups of low and high molecular weight compounds. These are derived by summing the individual PAH ERLs and ERMs. Low molecular weight PAHs include 2- and 3-ring PAH compounds: Naphthalene, monomethyl naphthalenes, acenaphthene, acenaphthylene, fluorine, phenanthrene and anthracene. High molecular weight PAHs include the 4- and 5-ring PAH compounds: fluoranthene, pyrene, benz(a)anthracene, chrysene, benzo(a)pyrene and dibenz(a,h)anthracene. These have been adopted by Cefas for assessment of marine sediments and are considered to be at an appropriate level for use as SQG in this hazard screening exercise. The ERLs and ERMs are summarised in **Table 3**.

Table 3 SQG for PAH compounds

PAH compounds	ERL (µg kg^{-1} dw)	ERM (µg kg^{-1} dw)
LMW PAH	552	3,160
HMW PAH	1,700	9,600

Alternative Assessment Options Considered: Use of SQG

- It is accepted that the SQG in **Tables 2 and 3** are not ideal for this purpose; however no suitable alternative SQG have been identified.
- Marine background concentrations were considered as a possible SQG_{lower}. However, the Action Level 1 is considered to be set at a pragmatic screening level

The proposed approach to considering the likely presence of sources of sediment pollution uses a combination of information on urbanisation, mineralisation and mining in the catchment. The density of types of consented discharges which are considered to have the potential to result in sediment contamination (provisionally to include industrial, trade or sewage effluent and combined sewer overflows) has also been included. This is summarised in **Table 4**.

Table 4 Likelihood – Pollutant sources

Category	Likelihood Example Definitions
High	>75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents
Medium	50%-75% catchment/coastline urban/industrial, mineralisation/mine assets, medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents
Low	25%-49.9% catchment/coastline urban/industrial, mineralisation/mine assets, low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents
Very Low	10%-<24.5% catchment/coastline urban/industrial, mineralisation/mine assets, only surface water discharge consents present
Remote	<10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present.

1.1.1 Use of Statistics in Assessing Likelihood of Effect

A number of statistical approaches could be taken to assessing exceedances of SQG and it is noted that the International Standard (ISO 5667-20) on Water Quality Sampling – Part 20; Guidance on the use of sampling data for decision making – Compliance with thresholds and classification systems (ISO 2008) advocates the use of a percentile approach to avoid false positive. However, this is applied to time series data sets for ongoing water quality monitoring and is not considered to be appropriate for the hazard screening stage of the national sediment quality risk assessment. For this initial step it is proposed that a single exceedance of SQG would result in the whole assessment area 'exceeding' the assessment criterion. This decision has been made in order to maintain a precautionary approach at this stage of the assessment.

It is proposed that the sediment quality data will be divided by water body boundary. It may also be necessary to consider operational catchment boundaries in the freshwater environment. However, this is likely to result in large assessment areas for some locations and, combined with the above approach to exceedances, could result in large areas being placed into a higher hazard level category. It is therefore proposed that the water bodies and/or catchments be subdivided. At present, a suitable existing set of boundaries has not been identified. If one cannot be found, a grid system will be applied.

1.2 Assessment of Consequence of Effect

Given a lack of direct evidence of causal linkages between sediment contamination and harm in environmental receptors (discussed in the Work Package 1A report for this project), WFD data has been chosen for this initial scale of consequence since it provides a classification system for all water bodies in England. Benthic invertebrate and fish have been chosen as the key Biological Quality Indicators since some of the most highly exposed organisms to sediment contamination are likely to be bottom dwelling organisms and filter feeders.

The condition status of designated sites has been included as a second measure of consequence since to incorporate Habitats Directive and Wildlife and Countryside Act objectives. An example of this approach is presented in the table below. This would be applied to the assessment of certain water bodies where a designated site is present. It is noted that the boundary of the designated site is likely to encompass only part of the catchment/water body under assessment. The condition of the site may therefore only be influenced by some of the area under assessment.

It is accepted that any detrimental effect on the classification of a WFD Biological Quality Indicator or the condition of a designated site may not be wholly or even partly attributed to sediment quality. Information has therefore been requested from Natural England to confirm whether sediment contamination is considered to have influenced the condition of the habitat. Where this is available, it will be incorporated into the assessment.

However, should this information not be available, a ‘lines of evidence’ approach has been adopted for this exercise which ensures that evidence from several sources is needed to produce a higher hazard level result for a given location. This approach has been adopted in light of the lack of direct evidence of harm from sediment contamination. **Table 5** summarises the proposed consequence descriptions. This table will need to be adapted should information be provided on the role of sediment contamination in habitat condition.

Table 5 Risk Consequence Categories

Consequence Level	Consequence Description
Severe	Benthic Invertebrates/ Fish Classification Poor SSSI/SPA/SAC habitat destroyed permanently or part destroyed. Favourable condition unachievable

Consequence Level	Consequence Description
Medium	Benthic Invertebrates/ Fish classification Moderate SSSI/SPA/SAC present and in unfavourable condition - declining SSSI present and in unfavourable condition - declining
Mild	Benthic Invertebrates/ Fish classification Good SSSI/SPA/SAC present and in unfavourable condition – no change
Minor	Benthic Invertebrates/ Fish classification High SSSI/SPA/SAC present and in unfavourable condition - recovering
Negligible	Does not require assessment under WFD SSSI/SPA/SAC present and in favourable condition

Alternative Assessment Options Considered: Use of quantitative models

- A more detailed approach could be taken using some of the wide range of quantitative risk assessment tools and models available. Each model has been developed to simulate receptors and pollutant linkages, In order to capture all of the linkages identified in the conceptual model, several risk models would need to be used. There would be a potential need to adapt models to the UK situation where not in the food chain developed for the UK and not already adapted.
- For risks to ecological receptors, PIANC (2006) proposes use of one of several fate and transport models capable of modelling sediment borne contamination, coupled with models which simulate contamination uptake and accumulation in the food chain. All the food chain models cited were developed in either the US or Canada. Adaptation might therefore be needed for food chains typical of aquatic systems in England.

For the national level hazard screening exercise, these approaches were considered to be too data and resource intensive to be feasible.

- Assessment of consequence using bioassay information was considered and would offer a scientifically based method of assessment. However, there is insufficient information available for this to be feasible on a national scale. As noted in the hazard screening flowchart use of bioassay information may be considered at later stages of assessment.

1.3 Hazard Level Characterisation and Consideration of Uncertainty

This process entails professional judgement about the acceptability (tolerability) of the hazards identified, with the framework for this agreed with stakeholders during consultation. The acceptability of the hazards is assessed using a matrix to plot the consequence of a hazard against its likelihood of occurrence (see **Table 6**).

The hazards are assessed and put into one of the following risk categories, using the traffic light system presented in OSPAR (2009) as a basis. In this methodology, the green and blue categories of the OSPAR method have been combined and it is considered that there is insufficient direct evidence to categorise sites into a 'red' category where there is confidence that the hazard level is unacceptable. The categories have therefore been defined as follows:

- Amber (2) – potentially unacceptable hazard level. Concentrations of contaminants are at levels where a risk to the environment and its living resources at the population or community level is possible – above SQG_{upper}. Substrate type dominant which is highly likely to bind contaminants. Many types of potential pollution sources present or fewer types present but in more prevalent. Biological Quality Indicators not in good condition. Recommended that resources are prioritised in order to investigate the potential risk levels.
- Amber (1) – uncertain hazard level. Greater uncertainty over potential effects. There is some evidence for concern such as concentrations are between SQG_{upper} and SQG_{lower}, some potential sources of contamination identified, significant areas of substrate which may bind contaminants or biological quality indicators are classified as moderate or poor condition. However, not all lines of evidence indicate a likely unacceptable hazard level. Further evidence would be needed to characterise the potential hazards further.
- Green – likely acceptable hazard level. The evidence suggests that little or no hazards are posed to the environment and its living resource at the population or community level. No significant hazards of adverse effects to the environment are in the long term based on the available evidence. Concentrations are close to background or zero or there are no data to indicate the presence of contamination. Sediments are generally coarse grained. Few potential sources of contamination have been identified. Biological Quality Indicators are classified as Good or High condition. Recommended that further assessment is a low priority.

Following completion of the assessment for hazards identified within the conceptual model, it is suggested that all areas where the two categories amber (1) and amber (2) are identified and carried forward for more detailed assessment of significance or, where the risk is provisionally assessed as potentially unacceptable due to lack of data, further information gathering is undertaken.

Under the OSPAR method, risk control measures are used to reduce residual risks that are either As Low As Reasonable Practicable (ALARP) or acceptable using reasonable measures that are technically practicable and incur costs that are not disproportionate to the benefits gained. Possible interventions are the subject of Work Packages 1B to 3B and are not discussed further in this report. However, it is considered that further, more detailed and /or site specific assessment of potential risk levels would be needed for any area identified as amber (1) or amber (2) prior to consideration of any intervention measures.

The proposed hazard screening process is summarised in **Figure 1**.

Data sets to be used in this assessment are:

- WFD water body catchment boundaries (river basin, management and operational catchments)
- Catchment subdivision boundaries or grid system
- Marine substrate type –– JNCC UK SeaMap Substrate/Substrate Confidence

- Freshwater substrate type — EA River Habitat Survey
- Sediment quality data (from Work Package 1A)
- Urbanised area data set – Ordnance Survey Strategi Urban Regions or BGS urbanisation index
- Mining and mineralisation data set – awaited from Coal Authority
- Environment Agency trade/sewage effluent consent locations, industrial operator scores, compliance rating scores
- Defra locations of trading estates of concern to water quality
- WFD benthic invertebrate and fish classification
- SSSI/SPA/SAC/MCZ condition and whether influenced by sediment contamination, where available

Table 6 **Aquatic Receptor Hazard Screening Matrix**

Consequence	Remote	Very Low	Low	Medium	High
Severe	• Substrate all/nearly all coarse grained • All sediment quality concentrations* below SQGlower • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Benthic Invertebrates/ Fish Classification Poor • SSSI/SPA/SAC habitat destroyed permanently or part destroyed. Favourable condition unachievable	• Substrate all/nearly all coarse grained • Contaminant concentrations not confirmed by data • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Benthic Invertebrates/ Fish Classification Poor • SSSI/SPA/SAC habitat destroyed permanently or part destroyed. Favourable condition unachievable	• Some silts present but majority of substrate coarse grained • At least one sediment quality concentration* between SQG_{lower} and SQG_{upper} • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Benthic Invertebrates/ Fish Classification Poor • SSSI/SPA/SAC habitat destroyed permanently or part destroyed. Favourable condition unachievable	• Fine silt present in over half/nearly all the water body area • At least one sediment quality concentration * between SQG_{lower} and SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Benthic Invertebrates/ Fish Classification Poor • SSSI/SPA/SAC habitat destroyed permanently or part destroyed. Favourable condition unachievable	• Fine silt present in all/nearly all of water body • At least one sediment quality concentration* greater than SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Benthic Invertebrates/ Fish Classification Poor • SSSI/SPA/SAC habitat destroyed permanently or part destroyed. Favourable condition unachievable
Medium	• Substrate all/nearly all coarse grained • All sediment quality concentrations* below SQG_{lower} • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Benthic Invertebrates/ Fish classification Moderate • SSSI/SPA/SAC present and in unfavourable condition - declining SSSI present and in unfavourable condition - declining	• Substrate all/nearly all coarse grained • Contaminant concentrations not confirmed by data • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Benthic Invertebrates/ Fish classification Moderate • SSSI/SPA/SAC present and in unfavourable condition - declining SSSI present and in unfavourable condition - declining	• Some silts present but majority of substrate coarse grained • At least one sediment quality concentration* between SQG_{lower} and SQG_{upper} • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Benthic Invertebrates/ Fish classification Moderate • SSSI/SPA/SAC present and in unfavourable condition - declining SSSI present and in unfavourable condition - declining	• Fine silt present in over half/nearly all the water body area • At least one sediment quality concentration * between SQG_{lower} and SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Benthic Invertebrates/ Fish classification Moderate • SSSI/SPA/SAC present and in unfavourable condition - declining SSSI present and in unfavourable condition - declining	• Fine silt present in all/nearly all of water body • At least one sediment quality concentration* greater than SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Benthic Invertebrates/ Fish classification Moderate • SSSI/SPA/SAC present and in unfavourable condition - declining SSSI present and in unfavourable condition - declining
Mild	• Substrate all/nearly all coarse grained • All sediment quality concentrations* below SQG_{lower} • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Benthic Invertebrates/ Fish classification Good • SSSI/SPA/SAC present and in unfavourable condition – no change	• Substrate all/nearly all coarse grained • Contaminant concentrations not confirmed by data • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Benthic Invertebrates/ Fish classification Good • SSSI/SPA/SAC present and in unfavourable condition – no change	• Some silts present but majority of substrate coarse grained • At least one sediment quality concentration* between SQG_{lower} and SQG_{upper} • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Benthic Invertebrates/ Fish classification Good • SSSI/SPA/SAC present and in unfavourable condition – no change	• Fine silt present in over half/nearly all the water body area • At least one sediment quality concentration * between SQG_{lower} and SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Benthic Invertebrates/ Fish classification Good • SSSI/SPA/SAC present and in unfavourable condition – no change	• Fine silt present in all/nearly all of water body • At least one sediment quality concentration* greater than SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Benthic Invertebrates/ Fish classification Good • SSSI/SPA/SAC present and in unfavourable condition – no change
Minor	• Substrate all/nearly all coarse grained • All sediment quality concentrations* below SQG_{lower} • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Benthic Invertebrates/ Fish classification High • SSSI/SPA/SAC present and in unfavourable condition - recovering	• Substrate all/nearly all coarse grained • Contaminant concentrations not confirmed by data • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Benthic Invertebrates/ Fish classification High • SSSI/SPA/SAC present and in unfavourable condition - recovering	• Some silts present but majority of substrate coarse grained • At least one sediment quality concentration* between SQGlower and SQGupper • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • . • Benthic Invertebrates/ Fish classification High • SSSI/SPA/SAC present and in unfavourable condition - recovering	• Fine silt present in over half/nearly all the water body area • At least one sediment quality concentration * between SQG_{lower} and SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Benthic Invertebrates/ Fish classification High • SSSI/SPA/SAC present and in unfavourable condition - recovering	• Fine silt present in all/nearly all of water body • At least one sediment quality concentration* greater than SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Benthic Invertebrates/ Fish classification High • SSSI/SPA/SAC present and in unfavourable condition - recovering
Negligible	• Substrate all/nearly all coarse grained • All sediment quality concentrations* below SQG_{lower} • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Does not require assessment for benthic invertebrates or fish • SSSI/SPA/SAC present and in favourable condition	• Substrate all/nearly all coarse grained • Contaminant concentrations not confirmed by data • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Does not require assessment for benthic invertebrates or fish • SSSI/SPA/SAC present and in favourable condition	• Some silts present but majority of substrate coarse grained • At least one sediment quality concentration* between SQG_{lower} and SQG_{upper} • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • effluent/combined sewer overflow discharge consents • Does not require assessment for benthic invertebrates or fish • SSSI/SPA/SAC present and in favourable condition	• Fine silt present in over half/nearly all the water body area • At least one sediment quality concentration * between SQG_{lower} and SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Does not require assessment for benthic invertebrates or fish • SSSI/SPA/SAC present and in favourable condition	• Fine silt present in all/nearly all of water body At least one sediment quality concentration* greater than SQG_{upper} • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Does not require assessment for benthic invertebrates or fish • SSSI/SPA/SAC present and in favourable condition
	Remote	Very Low	Low	Medium	High

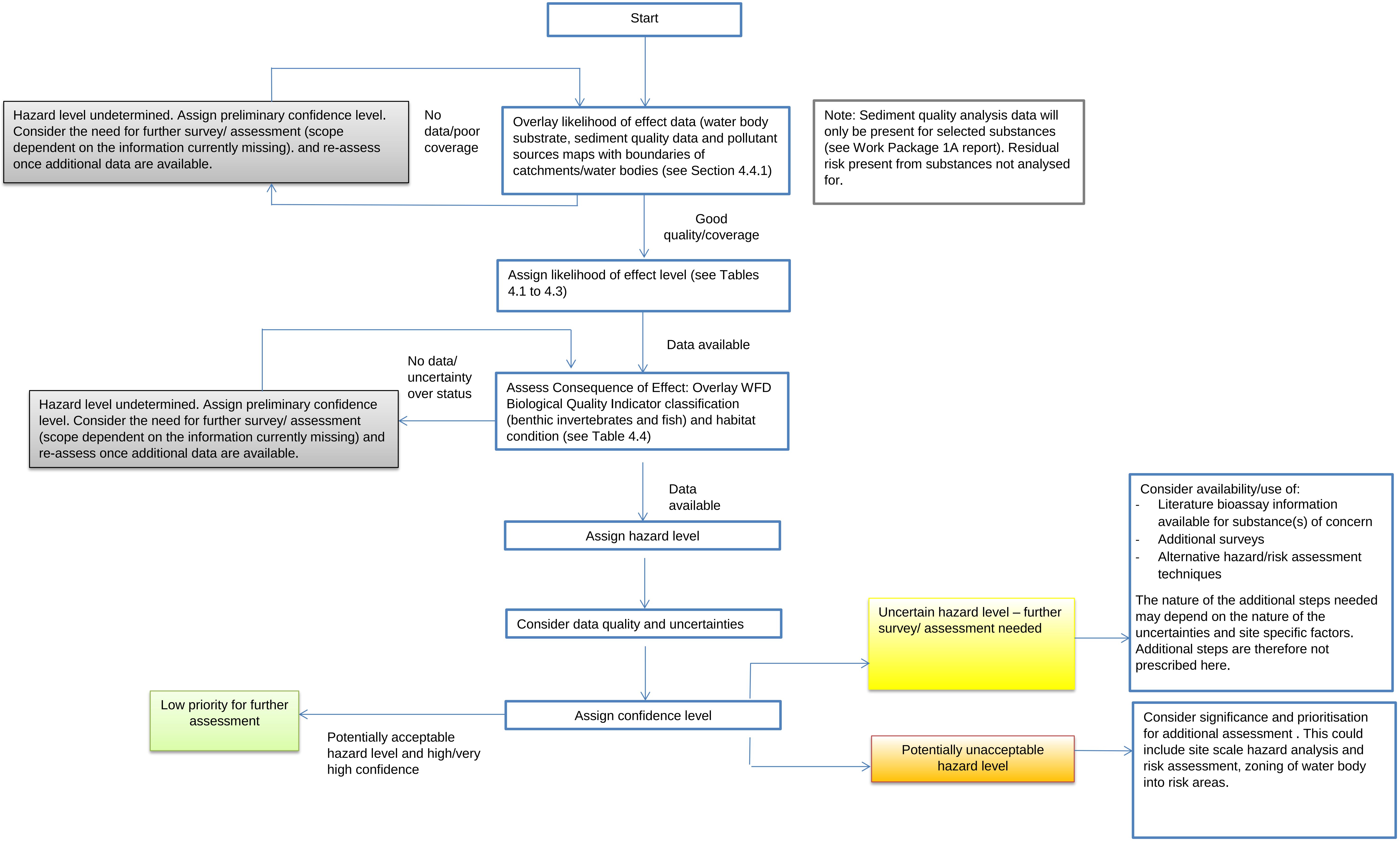
Likelihood

Notes:

* Reliability of sediment analysis results will need to be considered by professional judgement

- Risk categories are intended to reflect the likely risk to receptors from sediment contamination rather than other pressures or pathways such as water pollution (not entering the sediment) or physical modification of water bodies
- Coarse grained sediments are assumed to be an indicator of areas where contaminants are unlikely to bind to sediments and therefore the sediment is unlikely to form a significant part of any contaminant exposure linkages.
- The precautionary approach of assessing based on one sample exceeding a SQG is intended to be protective of water bodies with discrete areas of contamination ("hotspot" areas)
- The table provides examples to illustrate the possible likelihood and severity categories and how they are interpreted into the different levels of risk. However, many other combinations of pressures and effects may be found during the risk assessment and judgement will be required in these cases in order to assess which category best fits those conditions.

Figure 1: Aquatic Receptor Hazard Screening Flowchart



2 Terrestrial receptor assessment

In the assessment of hazard screening assessment for terrestrial receptors, hazards arising from ongoing and historic sediment deposition are considered to require separate assessment. This is because it is expected that some catchments may have historical (e.g. mining) contamination but the floodplain may now be protected from new contaminated sediments inputs. Due to the potential for many other sources to have influenced the quality of historically deposited sediments, assessment of these has been excluded from this project. However, it is noted that there may be ongoing hazards from this source in certain areas and it is recommended that this be considered by Defra in due course. Hazard screening for ongoing sediment deposition is discussed further below.

2.1 Potential hazards from ongoing sediment deposition

Step 1: Comparison of in-channel sediment concentrations to floodplain soil concentrations
Concentrations of some metals in sediments and floodplain soils are provided by the BGS Gbase data set. As a first step, the mean concentration in the in-channel sediments will be compared against the mean concentration in the floodplain to establish whether an influx of sediments will increase the metal concentrations in the floodplain soils. However, it is noted that Gbase data is available only for metals and only for some catchments in England. Suggested likelihood scales for this method are outlined in **Tables 7** and **8**.

Step 2: Qualitative consideration of likelihood of floodplain contamination by in-channel sediments
Since Gbase information is available only for metals and only for some catchments in England, an alternative method of assessment may be need in order to complete a national scale hazard screening exercise.

In the proposed methodology, areas are identified which are most likely to receive sediment influxes (due to flooding) on a sufficiently frequent basis for sediment to be considered a primary pathway for contamination.

Flood defences, where present, will reduce or eliminate the transfer of sediments into areas of the natural floodplain during flood events. These are therefore expected to reduce the risk from ongoing contaminated sediment sources.

Proposed likelihood and consequence scales are provided in **Tables 9 and 10**.

Table 7 Suggested Likelihood Levels

Likelihood Level	Likelihood description
High	Concentrations of contaminant(s) in metals exceed floodplain concentrations and flood likelihood greater than or equal to 1:30
Medium	Concentrations of contaminant(s) in metals exceed floodplain concentrations and flood likelihood between 1 in 30 and 1:100 (fluvial) or 1:200 (coastal)
Low	Concentrations of contaminant(s) in metals exceed floodplain concentrations and flood likelihood between 1:100 (fluvial) or 1:200 (coastal) and 1:1000
Very Low	Concentrations of contaminant(s) in metals exceed floodplain concentrations and flood likelihood greater than 1:1000
Remote	Concentrations of contaminants in metals below floodplain concentrations

Table 8 Likelihood - Flood Return Period and Standard of Protection: Ongoing sediment influxes

Likelihood Level	Likelihood based on Environment Agency Flooding from Rivers and the Sea maps and Flood Risk For Planning Maps
High	Within Flood zone 3 not benefitting from protection
Medium	Within Flood Zone 3 (1:100 or 1:200 year floodplain) benefitting from flood protection
Low	Within Flood Zone 2 (1:1000 year floodplain)
Very Low	Outside Flood Zone 1 (outside 1:1000 year floodplain)
Remote	Outside Flood Zone 1 (outside 1:1000 year floodplain)

Table 9 Likelihood – Pollutant sources

Category	Likelihood Example Definitions
High	>75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents
Medium	50%-75% catchment/coastline urban/industrial, mineralisation/mine assets, medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents
Low	25%-49.9% catchment/coastline urban/industrial, mineralisation/mine assets, low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents
Very Low	10%-<24.5% catchment/coastline urban/industrial, mineralisation/mine assets, only surface water discharge consents present

Category	Likelihood Example Definitions
Remote	<10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present.

No existing classification system has been identified which is equivalent to the WFD water body classifications (to be used in the aquatic receptor hazard screening) for floodplain land affected by contamination. In addition, no published SQG relating to the risks to floodplain receptors from contaminated in-channel sediments are washed onto the floodplain have been identified as part of this study. Although evidence for a plausible linkage and potential for health impacts has not been dismissed, evidence of impacts on human health specifically due to soil/sediment contamination is very rarely documented even from heavily contaminated sites (Defra 2009 report SP1002: Potential health effects of contaminants in soil). In Step 2, it is therefore proposed that consequence is considered based on a qualitative scale of the sensitivity of the land affected.

In the Codes of Good Agricultural Practice (online: accessed 2015) Defra notes that: "*For most contaminants, but not molybdenum and selenium, the risk of poisoning livestock which graze on a contaminated soil depends almost entirely on the amount of soil swallowed and the concentration of the contaminant in that soil rather than the concentration in the grass. This concentration factor is more important than the fact that the contaminant may be released more easily from grass than from the soil once it is in the digestive system of the animal. The amount of soil contamination on grass will vary with the type of sward, its thickness, the time of year, weather conditions, stocking density and how grazing is managed. In a thick sward, or where there is a surface mat of grass, soil contamination of the diet may be less than 3% of the dry matter*."

Abrahams and Steigmajer (2003) indicate that soil ingestion in sheep may be higher in the winter due to factors including increased appetite, slower grass growth, presence of worm casts and soiling of pastures. However, it is noted that other, site-specific factors are likely to influence this including (for example) prolonged flooding preventing use of the land for grazing

It is therefore considered likely that land which is grazed intensively, likely to be re-sown on a regular basis and/or where livestock are overwintered outside will present a higher risk. flood events in the late summer / autumn may also pose a greater risk as deposited material will be present at the surface during the winter.

There is some evidence to suggest that sheep are at greater risk through ingestion of soil than cattle. Thornton and Abrahams (1983) noted that "*grazing cattle involuntarily ingest from 1% to nearly 18% of their dry matter intake as soil; sheep may ingest up to 30%. Soil ingestion varies seasonally and with farm management. Calculations based on soil, plant and faecal analyses show that from 9% to 80% percent of the Pb and 34% to 90% of the As intake into cattle on contaminated land is due to ingested soil*". However, a detailed investigation of this and any associated food chain risks is outside the scope of this project and hence, for the purposes of the national risk assessment methodology proposed here, no differentiation has been made. It has been assumed in the descriptions of consequence levels, that (in general) uptake by crops is a lower consequence than uptake by livestock. This is considered likely to be true for most persistent compounds, although an additional pathway may be via ingestion f sediment attached to silage (Foulds et al, 2014).

Table 10 summarises the proposed consequence categories for risks from in-channels sediments to floodplain receptors. It is noted that, for some contaminants with high crop availability and/or bioaccumulation potential in livestock, agricultural or allotment uses may be more sensitive than residential garden uses. Given the complexity of urban areas, it is considered unlikely that individual land uses will be able to be separated in the assessment. Allotment uses in the medium consequence category and industrial/commercial uses in the negligible category related only to distinct and easily distinguishable areas.

Table 10 Suggested Consequence Levels

Consequence Level	Consequence description
Severe	Mixed urban areas including residential land Intensively farmed land Land grazed intensively by livestock and likely to be often re-sown and for livestock to be overwintered outdoors with little supplementary feed from off-site.
Medium	Intensively used public open space (e.g. public parks). Land designated for ecological sensitivity (SSSI/SPA/SAC). Allotments.
Mild	Less intensively farmed land. Less intensively used land with public access e.g. large estates and woodlands, national parks.
Minor	Land extensively farmed. Little public access.
Negligible	Land industrial/commercial

Alternative Assessment Options Considered: In-channel sediments
Direct contact of human receptors

- Assume that direct contact of water body users with sediment is a minor pathway compared to contact with water (protected via water quality risk assessment frameworks)
- Use scenario for direct contact developed in SediSoil
- Develop a new scenario based on UK receptor activity information

Indirect contact of human receptors with in-channel sediment - consumers of fish/shellfish
In the Netherlands, national Maximum Acceptable Risk values for sediment have been derived (Maximum Toelaatbaar Risico; abbreviation: MTRsediment). The values are calculated via the SediSoil Model using:

- Maximum Acceptable Risk for human. Mortality is less than 1 person per million per year.
- Maximum Acceptable Risk for ecology. Potentially affected fraction is less than 50% of the population.

If the pollution in the sediment exceeds the screening values models such as Sedisoil or Sedias are used to determine the exact risk level. A similar approach could be taken for England, constructing a 'typical' scenario for recreational or commercial users of water bodies and using UK data for consumption of fish and shellfish. It is possible that this would need to take into account cultural differences in communities within England (e.g. anecdotal indications that communities originating from Eastern Europe are more likely to consume river fish such as carp).

Quantitative modelling approaches were considered too data and resource intensive to be feasible at the hazard screening stage.

2.2 Hazard Level Characterisation

Proposed descriptions for the green, amber (1) and amber (2) hazard level categories with respect to floodplain receptors are provided below:

- Amber (2) – Potentially unacceptable hazard level. Transfer of sediments by floodwaters is highly likely and land uses are highly sensitive to contamination. Many potential pollutant sources are present.
- Amber (1) – Uncertain hazard level. Greater uncertainty over effects. Some potentially sensitive land uses and a lower risk of flooding. Some potential contamination sources are present. Not all lines of evidence indicate a likely unacceptable risk.
- Green – Potentially acceptable hazard level. The evidence suggests that little or no risks are posed to floodplain receptors. Risk of sediment transfer by flooding is low and land uses are generally unlikely to be sensitive to sediment contamination. Few potential pollutant sources present. Recommended that further action is given a low priority.

A proposed hazard screening matrix for risks from in-channel sediments is provided as **Table 11** with a flow chart to show the risk assessment process provided as **Figure 2**.

Data sets to be used in this assessment are:

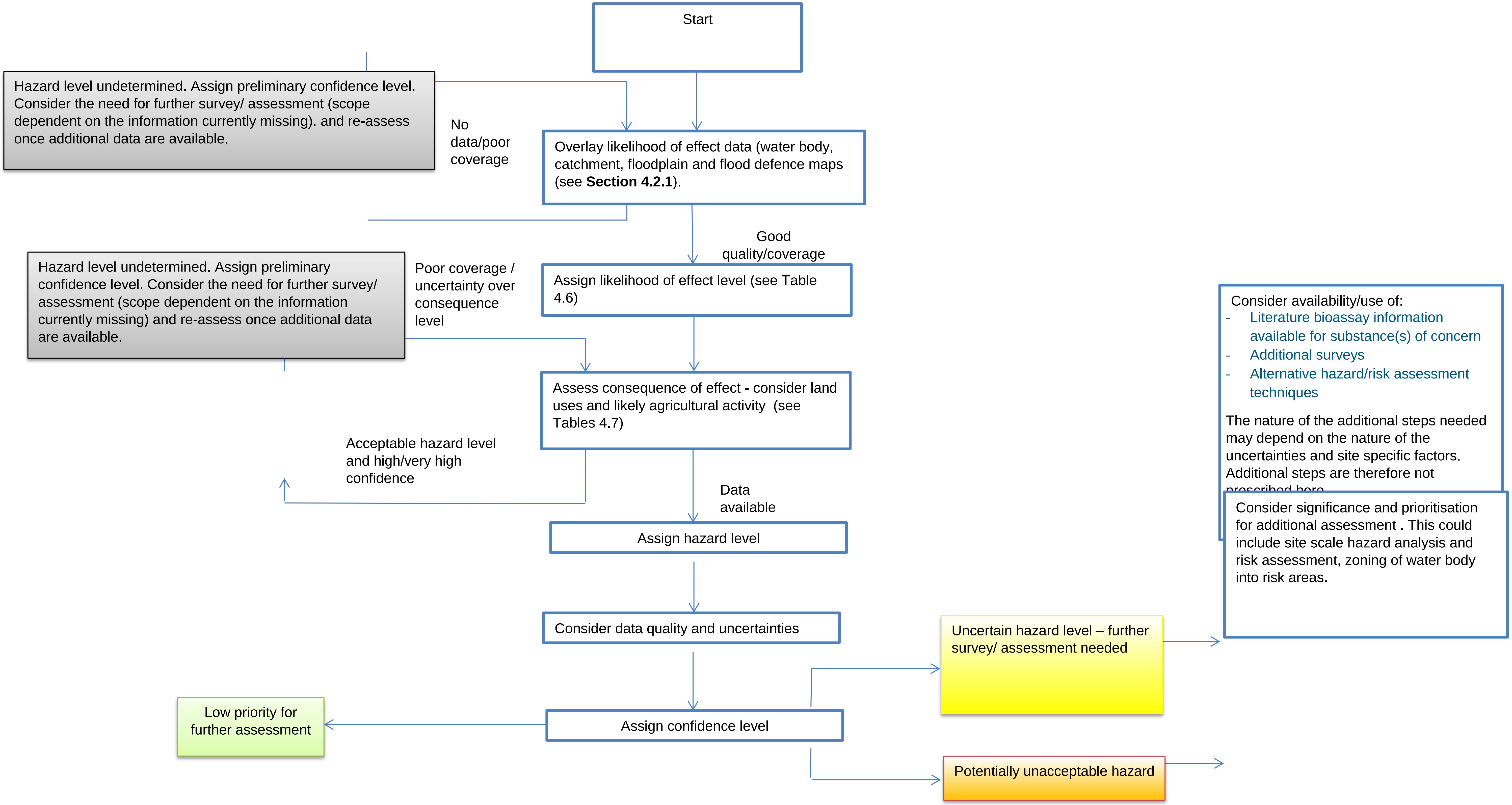
- Gbase stream
- Gbase surface soil
- Environment Agency NaFRA flood risk zones including influence of flood defences
- Environment Agency pollution information and Defra trading estates information (as for aquatic receptor hazard screening assessment)
- Land use/land cover mapping (to be identified)

Table 11 **Draft Floodplain Receptor Hazard Screening Matrix: In-channel Sediments**

Consequence	Remote	Very Low	Low	Medium	High
Severe	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Residential land with gardens likely to be played in by children and/or used regularly by adults.	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Residential land with gardens likely to be played in by children and/or used regularly by adults.	• Within Flood Zone 2 (1:1000 year floodplain) • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Residential land with gardens likely to be played in by children and/or used regularly by adults.	• Within Flood Zone 3 (1:100 or 1:200 year floodplain) benefitting from flood protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Residential land with gardens likely to be played in by children and/or used regularly by adults.	• Within Flood zone 3 not benefitting from protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Residential land with gardens likely to be played in by children and/or used regularly by adults.
Medium	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Land grazed intensively by livestock and likely to be often re-sown and for livestock to be overwintered outdoors with little supplementary feed from off-site. Intensively used public open space (e.g. public parks). Land designated for ecological sensitivity (SSSI/SPA/SAC). Allotments.	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Land grazed intensively by livestock and likely to be often re-sown and for livestock to be overwintered outdoors with little supplementary feed from off-site. Intensively used public open space (e.g. public parks). Land designated for ecological sensitivity (SSSI/SPA/SAC). Allotments.	• Within Flood Zone 2 (1:1000 year floodplain) • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Land grazed intensively by livestock and likely to be often re-sown and for livestock to be overwintered outdoors with little supplementary feed from off-site. Intensively used public open space (e.g. public parks). Land designated for ecological sensitivity (SSSI/SPA/SAC). Allotments.	• Within Flood Zone 3 (1:100 or 1:200 year floodplain) benefitting from flood protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Land grazed intensively by livestock and likely to be often re-sown and for livestock to be overwintered outdoors with little supplementary feed from off-site. Intensively used public open space (e.g. public parks). Land designated for ecological sensitivity (SSSI/SPA/SAC). Allotments.	• Within Flood zone 3 not benefitting from protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Land grazed intensively by livestock and likely to be often re-sown and for livestock to be overwintered outdoors with little supplementary feed from off-site. Intensively used public open space (e.g. public parks). Land designated for ecological sensitivity (SSSI/SPA/SAC). Allotments.
Mild	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Land grazed less intensively by livestock. Livestock likely to be overwintered indoors. Less intensively used land with public access e.g. large estates and woodlands, national parks.	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Land grazed less intensively by livestock. Livestock likely to be overwintered indoors. Less intensively used land with public access e.g. large estates and woodlands, national parks.	• Within Flood Zone 2 (1:1000 year floodplain) • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. . • Land grazed less intensively by livestock. Livestock likely to be overwintered indoors. Less intensively used land with public access e.g. large estates and woodlands, national parks.	• Within Flood Zone 3 (1:100 or 1:200 year floodplain) benefitting from flood protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Land grazed less intensively by livestock. Livestock likely to be overwintered indoors. Less intensively used land with public access e.g. large estates and woodlands, national parks.	• Within Flood zone 3 not benefitting from protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Land grazed less intensively by livestock. Livestock likely to be overwintered indoors. Less intensively used land with public access e.g. large estates and woodlands, national parks.
Minor	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Land grazed intermittently or extensively by livestock. Intensive crop growing. Little public access.	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Land grazed intermittently or extensively by livestock. Intensive crop growing. Little public access.	• Within Flood Zone 2 (1:1000 year floodplain) • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Land grazed intermittently or extensively by livestock. Intensive crop growing. Little public access.	• Within Flood Zone 3 (1:100 or 1:200 year floodplain) benefitting from flood protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Land grazed intermittently or extensively by livestock. Intensive crop growing. Little public access.	• Within Flood zone 3 not benefitting from protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Land grazed intermittently or extensively by livestock. Intensive crop growing. Little public access.
Negligible	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • <10% catchment/coastline urban/industrial, mineralisation/mine assets. No discharge consents present. • Land industrial/commercial/paved or non-food/feedstock crops.	• Outside Flood Zone 1 (outside 1:1000 year floodplain) • 25%-49.9%catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at 10%-24.5%. Only surface water discharge consents present. • Land industrial/commercial/paved or non-food/feedstock crops..	• Within Flood Zone 2 (1:1000 year floodplain) • 50%-75% catchment/coastline urban/industrial, mineralisation/mine assets or 1 pressure present at25%-49.9%. Low density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Land industrial/commercial/paved or non-food/feedstock crops..	• Within Flood Zone 3 (1:100 or 1:200 year floodplain) benefitting from flood protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, or 1 pressure present at 50%-75%. Medium density of industrial/trade or sewage effluent/combined sewer overflow discharge consents. • Land industrial/commercial/paved or non-food/feedstock crops..	• Within Flood zone 3 not benefitting from protection • >75% catchment/coastline urban/industrial, mineralisation/mine assets, high density of industrial/trade or sewage effluent/combined sewer overflow discharge consents • Land industrial/commercial/paved or non-food/feedstock crops..
	Remote	*Very Low*	*Low*	*Medium*	*High*

Likelihood

Figure 2: Floodplain Receptor Hazard Screening Flowchart (in channel sediment)



3 Potential Hazards from Floodplain Sediment Erosion

A significant area of concern is whether, particularly in light of predicted climate change effects, contaminated sediment which is currently stored at depth in the floodplain could be remobilised, potentially causing hazards to sensitive receptors (aquatic and floodplain receptors) in the future.
Key questions connected to the potential hazard level are considered to include:

- Is the river currently eroding or likely to erode in the future?
- Is the floodplain likely to be storing historic contaminants in buried sediments?
- Is the catchment likely to be affected by climate change in terms of increased erosion?

3.1 Likelihood of erosion

The erosion potential of rivers and coasts has been characterised by separate data sets. The River Habitat Survey divides reaches of rivers into categories of: Eroding Cliff, Stable Cliff, Exposed Bedrock, Exposed Boulders, and Vegetated Bedrock/Boulders. High risk of erosion may equate to large areas of eroding cliff, although it is noted that currently stable cliffs might be eroded by more extreme flood events under climate change. It is noted that, as this information is available by river reach, it will be necessary to produce an overall categorisation from this at the water body/catchment level.
Risk of erosion in the coastal environment has been categorised by the Environment Agency National Coastal Erosion Risk mapping Project.

The presence of flood defences protecting the floodplain from future erosion will also affect the likelihood. In the coastal environment, the management policy for defences is described by the Environment Agency Coastal erosion maps by the following categories:

- No active intervention;
- Hold the existing defence line;
- Managed realignment;
- Advance the line; and
- Information not currently available

Provisionally, the likelihood of historical sediments eroding has been divided into the levels shown in **Table 12**.

Table 12 Likelihood of eroding sediment

Likelihood Level	Likelihood based on erosion and existing/planned erosion protection measures
High	Inside 1:1000 year floodplain. At high risk of erosion. No defences/ managed realignment proposed
Medium	Inside 1:1000 year floodplain. At high risk of erosion with defences present. Or medium risk of erosion with no defences/ managed realignment proposed

Likelihood Level	Likelihood based on erosion and existing/planned erosion protection measures
Low	Inside 1:1000 year floodplain. At medium risk of erosion with defences present. No active intervention
Very Low	Inside 1:1000 year floodplain. At low risk of erosion. Or at higher risk but advance the line policy or hold existing defence line. Or no information available.
Remote	Inside 1:1000 year floodplain. At very low risk of erosion.

3.2 Likelihood of historic contamination

No comprehensive existing digital data sets have been identified which show historic urban or industrial use of catchments. A number of potential sources of information have been considered:

- Ordnance Survey historical maps are available from the 1830's onwards. However, we are not aware that these have been interpreted into a national urbanisation/industrialisation data set;
- The Natural England National Character Area profiles may provide some high level information of, for example, historic mining landscape area. However, these are understood not to give sufficient resolution;
- The National Land Use Database of Previously Developed Land (DCLG were contacted for further information but have not responded); and
- The Dudley Stamp Land Use Inventory (England and Wales) data set from 1931-35. This has been provided by Natural England and will be applied in the first instance.

Although BGS G-base subsurface soil data may give indications of existing contamination in deposited sediments, assessment of soil quality in floodplains has been excluded from the assessment due to the potential for influence by other contamination sources. Provisional likelihood categories are provided in **Table 13**, although these may be subject to alteration based on the data sets used.

Alternative Assessment Options considered:

- Use professional judgement to estimate the likelihood of historic contamination of floodplain sediments based on current development and, for example, presence of historic mine sites.

Use of the data sets above will be examined further. If it is not possible for historic industrial usage to be determined using these, analysis by professional judgement may be necessary.

Table 13 Likelihood of historic sediment contamination at depth

Likelihood Level	Likelihood based on erosion and existing/planned erosion protection measures
High	Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets
Medium	Historically 50%-75% catchment/coastline urban/industrial

Likelihood Level	Likelihood based on erosion and existing/planned erosion protection measures
Low	Historically 25%-49.9% catchment/coastline urban/industrial
Very Low	Historically 10%-<24.5% catchment/coastline urban/industrial
Remote	Historically <10% catchment/coastline urban/industrial

3.3 Consequence of Impact: Influence of climate change

Predictions are available of the likely effects of climate change on different areas of the country via the Met Office UK Climate Projections Project (UKCP). These provide indications of likely change in parameters including changes in summer and winter precipitation.

It is intended that this information will be combined with a measure of the 'flashiness' of individual river catchments, to give a scale of the likelihood of and increased frequency of more severe flood events occurring in a catchment which would be (assumed) more likely to be able to scour historically deposited sediments.

The Centre for Ecology and Hydrology holds hydrological and land cover data sets that could be utilised to assess the flashiness of a catchment. The data is held for river gauging station locations. If these are available as a national data set, they could be incorporated into the assessment.

It is noted that given the spatial scale and variability of catchments, the gauging station location may not be representative of the wider catchment. However, further interpolation of this data is considered to be outside the scope of this initial stage of assessment

In the coastal environment, it is proposed that the effect on climate change will be gauged using UK Climate Projections project information on changes in surges and extreme water levels.

Despite incorporation of the above data sets, it is consider that applying the above data sets is likely to require considerable amounts of professional judgement and the methodology may need to be altered as the exercise processes. A provisional consequence scale is summarised in **Table 14** but detailed descriptions have not yet been formulated.

Table 14 Suggested Consequence Levels – Influence of climate change on erosion

Consequence Level	Consequence Description Examples
Severe	Catchment at high risk of significantly increased precipitation under climate change and river(s) expected to respond very quickly to rainfall with high peak flow. Coastline at high risk from storm surges and sea level rise
Medium	Catchment at moderate risk of significantly increased precipitation and river(s) expected to respond very quickly to rainfall with high peak flow; or

Consequence Level	Consequence Description Examples
	Catchment at high risk of precipitation but river(s) expected to respond moderately quickly and/or with moderately high flow. Coastline at moderate risk from storm surges and sea level rise
Mild	Catchment at moderate risk of significantly increased expected to respond moderately quickly and/or with moderately high flow. Coastline at low risk from storm surges and sea level rise
Minor	Catchment at low risk of significantly increased precipitation and rivers expected to respond relatively slowly and/or with relatively low peak flow; or Catchment of moderate risk of significantly increased precipitation and catchment expected to respond very slowly to rainfall with very low peak flow. Coastline at very low risk from storm surges and sea level rise
Negligible	Catchment at low risk of significantly increased precipitation and river(s) expected to respond slowly to rainfall with a very low peak flow. Coastline at negligible risk from storm surges and sea level rise

3.4 Hazard Level Characterisation

Indicative descriptions of the green, amber (1) and amber (2) risk categories with respect to risk from release of stored historic contaminated sediments are provided below:

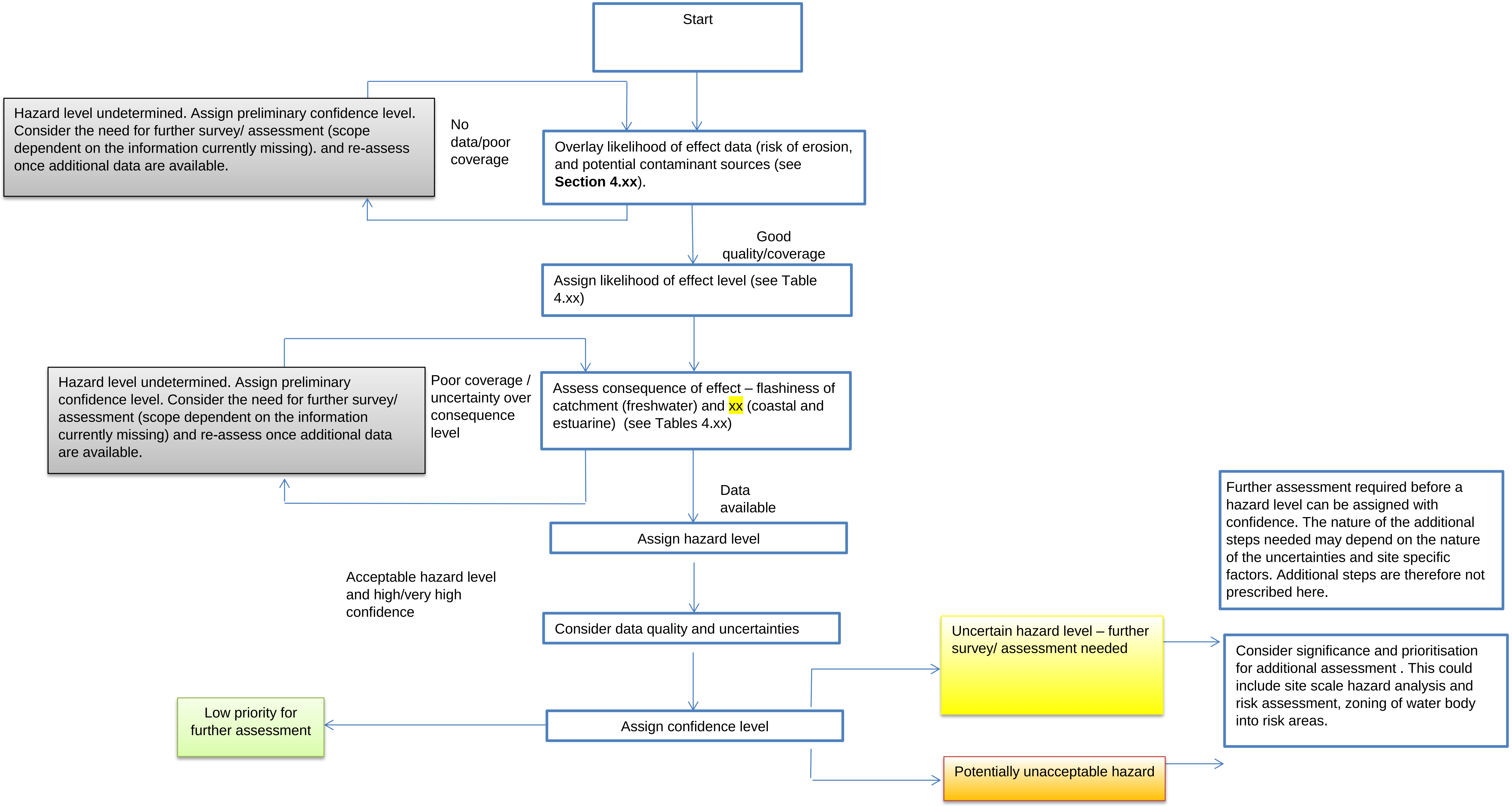
- Amber (2) – Potentially unacceptable hazard level. High likelihood of erosion based on bank/coastline type and many historic potential sources of contamination. Nature of flood events (with climate change) considered highly likely to be able to scour historic deposited sediments.
- Amber (1) – Uncertain hazard level. Greater uncertainty over potential effects. Medium risk of based on bank/coastline type and some potential contamination sources present. Nature of flood events (with climate change) considered moderately likely to be able to scour historic deposited sediments.
- Green – Potentially acceptable hazard level. Low likelihood of erosion based on bank/coastline type and few historic potential source so contamination. Nature of flood events (with climate change) considered unlikely to be able to scour historic deposited sediments.

A proposed hazard screening matrix for risks from erosion of stored sediments is provided as **Table 15** with a flow chart to show the risk assessment process provided as **Figure 3**.

Table 15 **Historic Sediments Hazard Screening Matrix**

Consequence					
Severe	• At very low risk of erosion. • Historically <10% catchment/coastline urban/industrial • Catchment at high risk of significantly increased precipitation under climate change and river(s) expected to respond very quickly to rainfall with high peak flow. Coastline at high risk from storm surges and sea level rise	• At low risk of erosion. Or at higher risk but advance the line policy or hold existing defence line. Or no information available. • Historically 10%-<24.5% catchment/coastline urban/industrial • Catchment at high risk of significantly increased precipitation under climate change and river(s) expected to respond very quickly to rainfall with high peak flow. Coastline at high risk from storm surges and sea level rise	• At medium risk of erosion with defences present. No active intervention • Historically 25%-49.9% catchment/coastline urban/industrial • Catchment at high risk of significantly increased precipitation under climate change and river(s) expected to respond very quickly to rainfall with high peak flow. Coastline at high risk from storm surges and sea level rise	• At high risk of erosion with defences present. Or medium risk of erosion with no defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment at high risk of significantly increased precipitation under climate change and river(s) expected to respond very quickly to rainfall with high peak flow. Coastline at high risk from storm surges and sea level rise	• At high risk of erosion. No defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment at high risk of significantly increased precipitation under climate change and river(s) expected to respond very quickly to rainfall with high peak flow. Coastline at high risk from storm surges and sea level rise
Medium	• At very low risk of erosion. • Historically <10% catchment/coastline urban/industrial • Catchment at moderate risk of significantly increased precipitation and river(s) expected to respond very quickly to rainfall with high peak flow; or Catchment at high risk of precipitation but river(s) expected to respond moderately quickly and/or with moderately high flow. Coastline at moderate risk from storm surges and sea level rise.	• At low risk of erosion. Or at higher risk but advance the line policy or hold existing defence line. Or no information available. • Historically 10%-<24.5% catchment/coastline urban/industrial • Catchment at moderate risk of significantly increased precipitation and river(s) expected to respond very quickly to rainfall with high peak flow; or Catchment at high risk of precipitation but river(s) expected to respond moderately quickly and/or with moderately high flow. Coastline at moderate risk from storm surges and sea level rise.	• At medium risk of erosion with defences present. No active intervention • Historically 25%-49.9% catchment/coastline urban/industrial • Catchment at moderate risk of significantly increased precipitation and river(s) expected to respond very quickly to rainfall with high peak flow; or Catchment at high risk of precipitation but river(s) expected to respond moderately quickly and/or with moderately high flow. Coastline at moderate risk from storm surges and sea level rise.	• At high risk of erosion with defences present. Or medium risk of erosion with no defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment at moderate risk of significantly increased precipitation and river(s) expected to respond very quickly to rainfall with high peak flow; or Catchment at high risk of precipitation but river(s) expected to respond moderately quickly and/or with moderately high flow. Coastline at moderate risk from storm surges and sea level rise.	• At high risk of erosion. No defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment at moderate risk of significantly increased precipitation and river(s) expected to respond very quickly to rainfall with high peak flow; or Catchment at high risk of precipitation but river(s) expected to respond moderately quickly and/or with moderately high flow. Coastline at moderate risk from storm surges and sea level rise.
Mild	• At very low risk of erosion. • Historically <10% catchment/coastline urban/industrial • Catchment at moderate risk of significantly increased expected to respond moderately quickly and/or with moderately high flow. Coastline at low risk from storm surges and sea level rise.	• At low risk of erosion. Or at higher risk but advance the line policy or hold existing defence line. Or no information available. • Historically 10%-<24.5% catchment/coastline urban/industrial • Catchment at moderate risk of significantly increased expected to respond moderately quickly and/or with moderately high flow. Coastline at low risk from storm surges and sea level rise.	• At medium risk of erosion with defences present. No active intervention • Historically 25%-49.9% catchment/coastline urban/industrial • Catchment/coastline at moderate risk of significantly increased expected to respond moderately quickly and/or with moderately high flow. Coastline at low risk from storm surges and sea level rise.	• At high risk of erosion with defences present. Or medium risk of erosion with no defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment/coastline at moderate risk of significantly increased expected to respond moderately quickly and/or with moderately high flow. Coastline at low risk from storm surges and sea level rise.	• At high risk of erosion. No defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment/coastline at moderate risk of significantly increased expected to respond moderately quickly and/or with moderately high flow. Coastline at low risk from storm surges and sea level rise.
Minor	• At very low risk of erosion. • Historically <10% catchment/coastline urban/industrial • Catchment at low risk of significantly increased precipitation and rivers expected to respond relatively slowly and/or with relatively low peak flow; or catchment of moderate risk of significantly increased precipitation and catchment expected to respond very slowly to rainfall with very low peak flow. Coastline at very low risk from storm surges and sea level rise	• At low risk of erosion. Or at higher risk but advance the line policy or hold existing defence line. Or no information available. • Historically 10%-<24.5% catchment/coastline urban/industrial • Catchment at low risk of significantly increased precipitation and rivers expected to respond relatively slowly and/or with relatively low peak flow; or catchment of moderate risk of significantly increased precipitation and catchment expected to respond very slowly to rainfall with very low peak flow. Coastline at very low risk from storm surges and sea level rise	• At medium risk of erosion with defences present. No active intervention • Historically 25%-49.9% catchment/coastline urban/industrial • Catchment at low risk of significantly increased precipitation and rivers expected to respond relatively slowly and/or with relatively low peak flow; or catchment of moderate risk of significantly increased precipitation and catchment expected to respond very slowly to rainfall with very low peak flow. Coastline at very low risk from storm surges and sea level rise	• At high risk of erosion with defences present. Or medium risk of erosion with no defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment at low risk of significantly increased precipitation and rivers expected to respond relatively slowly and/or with relatively low peak flow; or catchment of moderate risk of significantly increased precipitation and catchment expected to respond very slowly to rainfall with very low peak flow. Coastline at very low risk from storm surges and sea level rise	• At high risk of erosion. No defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment at low risk of significantly increased precipitation and rivers expected to respond relatively slowly and/or with relatively low peak flow; or catchment of moderate risk of significantly increased precipitation and catchment expected to respond very slowly to rainfall with very low peak flow. Coastline at very low risk from storm surges and sea level rise
Negligible	• At very low risk of erosion. • Historically <10% catchment/coastline urban/industrial • Catchment/coastline at low risk of significantly increased precipitation and river(s) expected to respond slowly to rainfall with a very low peak flow Coastline at negligible risk from storm surges and sea level rise	• At low risk of erosion. Or at higher risk but advance the line policy or hold existing defence line. Or no information available. • Historically 10%-<24.5% catchment/coastline urban/industrial • Catchment/coastline at low risk of significantly increased precipitation and river(s) expected to respond slowly to rainfall with a very low peak flow Coastline at negligible risk from storm surges and sea level rise	• At medium risk of erosion with defences present. No active intervention • Historically 25%-49.9% catchment/coastline urban/industrial • Catchment/coastline at low risk of significantly increased precipitation and river(s) expected to respond slowly to rainfall with a very low peak flow Coastline at negligible risk from storm surges and sea level rise	• At high risk of erosion with defences present. Or medium risk of erosion with no defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment/coastline at low risk of significantly increased precipitation and river(s) expected to respond slowly to rainfall with a very low peak flow Coastline at negligible risk from storm surges and sea level rise	• At high risk of erosion. No defences/ managed realignment proposed • Historically >75% catchment/coastline urban/industrial, mineralisation/mine assets • Catchment/coastline at low risk of significantly increased precipitation and river(s) expected to respond slowly to rainfall with a very low peak flow Coastline at negligible risk from storm surges and sea level rise

Figure 3 : Historic Sediment Hazard Screening Flowchart



4 Assessment of lake sediments

At present, it is considered that a lack of baseline information on substrate type and sediment quality results precludes a national risk assessment. In addition, in terms of floodplain receptor risk assessment, the Environment Agency Risk of Flooding from reservoirs gives maximum extent of flood rather than scale of risk; however there is no mapping of risk levels. This is recommended as an area to be considered in a future project.

5 Assessment of canal sediments

An extensive database of canal sediment results has been produced by the Canal and Rivers Trust. This was included in the assessment of sediment quality data undertaken in Work Package 1A. However, other key data sets may not be available (e.g. substrate mapping). In addition, it is unlikely that canals will have the same relationship with the sources of contamination as assumed for natural water bodies e.g. discharge consents are more likely to connect to rivers than canals. This is also recommended as an area to be considered in a future project.

6 Considering uncertainty

Gaps and uncertainties in the sediment quality analysis data available were discussed in Work Package 1A. These included:

- Spatial distribution (data area viable for some areas but not the whole of England);
- Contaminants (some potential contaminants of concern have been analysed for routinely but for others there are little or no data available); and
- Variability in sampling method (making comparison between results tentative).

Additional data gaps may also be encountered is using some of the other data sets provisionally included in the proposed risk assessment methodology. In some cases this has been allowed for in the hazard screening matrices. For example, since it is known that some locations will not have sediment test results associate with them, this has been assigned a risk level (very low – in line with previous frameworks this approach was used as a guiding principle in Clearing the Waters (Environment Agency, 2012).

In addition, it is proposed that the results of the risk assessment are accompanied by confidence classification, as shown in **Table 16**.

Table 16 Suggested Confidence Classifications

Classification	Description	Effect on assessment
Very high	Data available for: • Substrate type • Contaminant concentrations • Benthic invertebrates/Fish status All data good quality/high density sampling	Assessment completed
High	Data available for: • Substrate type • Contaminant concentrations	Assessment completed

Classification	Description	Effect on assessment
	• Benthic invertebrates/Fish status Data moderate quality/moderate density sampling	
Moderate	Data available for two out of: • Substrate type • Contaminant concentrations • Benthic invertebrates/Fish status And data moderate quality/moderate density sampling. Or data available for all three elements but poor quality/poor density sampling	Assessment completed but with qualifications on uncertainties
Low	Data available for two out of: • Substrate type • Contaminant concentrations • Benthic invertebrates/Fish status And data poor quality/moderate density sampling.	Assessment result not considered reliable without further information
Very Low	Data available for one out of three elements	Recommended that assessment not completed without further information

It is further recognised that broad assumptions are necessary in order to undertake an assessment at this scale, which introduce uncertainty. For example it is assumed that a higher concentration of industrial/effluent discharge consents in the catchment equates to an increased risk of sediment contamination; however, the nature of the discharges is likely to vary considerably from location to location.

7 Consideration of Background Concentrations in the National Hazard Screening Assessment

Background concentrations have been considered in the proposed risk assessment methodology mainly through the use of SQG_{lower}. Although risks to receptors may still be present from background concentrations of (primarily) metals, this hazard screening stage assessment does not seek to assign absolute risk levels. Rather, the primary purpose is to differentiate between hazard levels in waterbodies/catchments to enable further assessment and prioritisation in later stages.

The hazard level associated with background concentrations will, in this methodology, fall into the lower (green) category. SQG_{lower} was set as the Cefas AL 1, where available, for risk to aquatic receptors from marine sediments. AL 1 have been compared to the mean background level by Defra (2005) as noted above and it is understood that marine background concentrations are the subject of ongoing further research. For comparability, freshwater sediments SQG_{lower} was set at the BGS Normal Background Concentration upper confidence limit of the 50^{th} percentile (where available). These were derived for a specific purpose (in support of regulation under Part 2A of the Environmental Protection Act 1990 (as amended) and, as such, the principal domains cover very wide areas and do not allow for analysis of regional or local scale variability. They do, however, differentiate between broad domains, based on geochemistry and areas of mining.