The river basin management plan for the Scotland river basin district 2009–2015

Chapter 1 Appendices

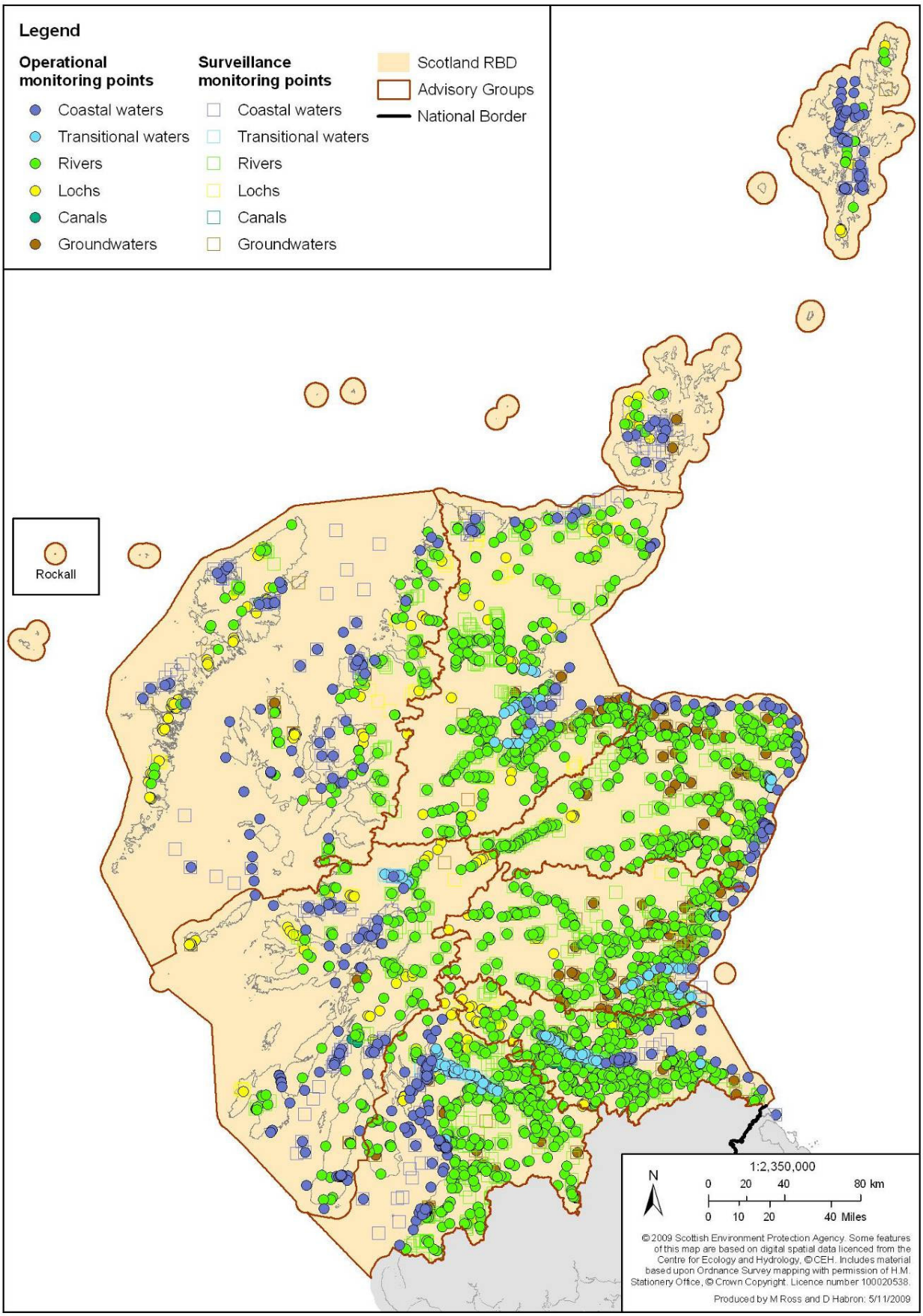
Appendix A: Summary technical information on how the status of water bodies was determined

This appendix provides further technical information on how the condition of the Scotland river basin district (RBD)'s water bodies was assessed.

A.1 Monitoring and assessment

Water bodies are classified on the basis of environmental monitoring and modelling results. Information on SEPA's monitoring network and its development can be found at on SEPA's website[1]. Map A1 below shows the spread of monitoring sites across the Scotland RBD.

[1] www.sepa.org.uk/water/monitoring_and_classification.aspx



Map A1: Distribution of surface water and groundwater monitoring locations in the Scotland RBD

The majority of SEPA's monitoring effort has been targeted on the basis of environmental risk assessments. SEPA completed its first risk assessment in 2004. This used an analysis of pressures on the water environment together with the then available monitoring information to identify water bodies likely to be adversely impacted. The initial risk analysis has been continually updated in the light of further information on pressures and new monitoring results. SEPA has used these reassessments to iteratively update monitoring priorities in the Scotland RBD. The classification results in this plan represent the most comprehensive assessment to date of impacts on the water environment.

As this plan is implemented, SEPA and relevant responsible authorities (See Table A1) will continue to monitor and assess the water environment. These ongoing assessments are important. They will identify where this plan's environmental objectives are on track to be achieved, where further action is needed and, ultimately, confirm that the objectives have been achieved.

Table A1: Contributions of public bodies, responsible authorities and other organisations to the assessment of the condition of the Scotland river basin district's water environment

Fishery Boards and Trusts	• information and advice on freshwater fish.
Scottish Natural Heritage	• assessments of the condition of species and habitats in protected areas: Special Areas of Conservation and Special Protection Areas; • advice and information on the impact of invasive non-native species.
Scottish Ministers' scientists	• monitoring data and advice on freshwater fish; • monitoring and pressure information relating to the marine environment.
Scottish Water, Local Authorities and Drinking Water Quality Regulator	• information on the quality of waters intended for human consumption.

On-going monitoring work is also important to improve understanding of the impacts of pressures, such as water abstraction and engineering works, which have only recently begun to be assessed. Monitoring information is also needed to help ensure sustainable water use and to identify risks of deterioration: Monitoring information enables SEPA to identify trends in quality and assess how much capacity the water environment has to accommodate further pressures, such as abstractions and discharges, without damage to its ecological quality.

A.2 Surface water classification schemes

For all surface waters, classification describes the ecological quality of water bodies. For heavily modified and artificial surface waters, classification takes account of the water bodies' heavily modified and artificial characteristics. Details of the classification schemes for surface waters, including heavily modified and artificial

water bodies, can be found in the Scotland River Basin District (Classification of Water Bodies) Directions 2009[2].

The natural characteristics of our surface waters differ markedly from place to place. For example, our rivers range from the wide, deep and slower flowing rivers of the lowlands to small, steep, shallow and very fast flowing rivers in the uplands. Differences in the characteristics of our waters are mirrored in differences in the plant and animal communities they support.

To be able to assess the extent to which ecological quality has been changed by human activities, SEPA needs to take account of this natural variation in the make up of water ecosystems. To help do this, SEPA subdivided our waters into types. Working with colleagues from across the UK, SEPA then developed assessment methods that take account of ecological variation between types. The methods allow SEPA to measure the extent to which the ecological quality of a water body differs from what it would be like in the absence of more than very minor impacts.

The types identified include:

- broad types that describe major changes in the environmental characteristics[3];
- a range of sub-types that reflect the different sensitivities of different plant and animal communities to change in different environmental conditions (water quality; water flows and levels etc).

Information on the broad types can be found in Appendix C below. Information on the assessment methods and associated subtypes can be found in the Scotland RBD (Surface Water Typology, Environmental Standards, Condition Limits and Groundwater Threshold Values) (Scotland) Directions 2009[4] and on the website of the UK Technical Advisory Group on the Water Framework Directive.

A.3 Classification process for surface waters

SEPA classified the ecological quality of surface waters by monitoring and assessing the condition of a number of indicators of ecological quality (See Table A2 below). These include a range of water plants and animals as well as environmental conditions necessary for water life: good water quality, good water flows and levels, good condition of beds, banks and shores and good continuity of rivers for fish migration.

For any particular water body, or group of water bodies, SEPA's assessments were based on the most sensitive indicator or indicators to each of the pressures on the water body. SEPA used its assessment results for the most adversely affected of these indicators to classify the ecological quality or status of the water body. To make these assessments, SEPA collected monitoring information on the relevant indicators from a large number of water bodies. Bodies that were not monitored were grouped with others that were. This was done on the basis of information from SEPA's analysis of water body characteristics and pressures. The monitoring of a

[2] www.scotland.gov.uk/Publications/2009/12/14130729/3
[3] Information on these types can be found in *The Scotland River Basin District; Characterisation and impacts analyses required by Article 5 of the Water Framework Directive; Summary Report.*
[4] www.scotland.gov.uk/Publications/2009/12/14130848/0

representative sub-set of water bodies allowed SEPA to model the condition of other bodies in the group.

Table A2: Indicators of ecological quality used in classifying water bodies

Rivers	Lochs	Estuaries	Coastal waters
Water plants • algae that live on the bed of rivers; • mosses and flowering plants. **Water animals** • fish; • insects and other invertebrate animals that live at the bottom of rivers or in river beds. **Water quality** • nutrient levels; • oxygen levels; • acidity; • temperature; • toxic pollutants, including priority substances and certain other pollutants identified at European level. **Beds, banks and shores** **Continuity for fish migration** **Water flows and levels**	**Water plants** • algae and bacteria that live in the water column collectively called phytoplankton; • algae that live on the bed of lakes and mosses; • flowering plants. **Water animals** • insects and other invertebrate animals that live at the bottom of lakes or in lake beds. **Water quality** • nutrient levels; • oxygen levels; • acidity; • salinity; and • toxic pollutants, including priority substances and certain other pollutants identified at European level. **Beds, banks and shores** **Continuity for fish migration** **Water flows and levels**	**Water plants** • seaweeds. **Water animals** • fish; • shellfish, worms and other invertebrate animals that live at the bottom of estuaries or in estuary beds. **Water quality** • nutrient levels; • oxygen levels; • toxic pollutants, including priority substances and certain other pollutants identified at European level. **Beds, banks and shores** **Water flows and levels**	**Water plants** • algae and bacteria that live in the water column collectively called phytoplankton; • seaweeds. **Water animals** • shellfish, worms and other invertebrate animals that live on or in the sea bed. **Water quality** • nutrient levels; • oxygen levels; • toxic pollutants, including priority substances and certain other pollutants identified at European level. **Beds, banks and shores** **Water flows and levels**

The classification results give us our best ever picture of the overall ecological condition of our waters, not just of the condition of the plants and animals SEPA has used as indicators in making the assessment.

SEPA is currently working with colleagues across the UK to develop the methods necessary to further expand the number of indicators it can use in assessing ecological quality. These additional indicators will include phytoplankton in estuaries, sea grasses and flowering plants of salt marshes in both estuaries and coastal waters and fish in lochs. However SEPA has ruled out using phytoplankton as an indicator in rivers because very few of our relatively short and fast-flowing rivers support phytoplankton communities, and where they do, they are transient and too variable to use as a reliable indicator.

A.4 Classification process for groundwater

Details of the classification schemes for groundwater can be found in The Scotland River Basin District (Classification of Water Bodies) Directions 2009[5]. The process of classifying a body of groundwater involves developing an understanding of how abstractions and inputs of pollutants are affecting groundwater flows, levels and quality and, in turn, the condition of associated surface waters and wetlands. For this, SEPA needs an understanding of the characteristics of our bodies of groundwater, including:

- the direction and rate of groundwater flow;
- the rate at which they are replenished by rainfall;
- their interactions with the surface waters and wetlands to which they are connected;
- the protection from pollution provided by their overlying soils and sub-soils;
- the nature and location of potential point and diffuse sources of pollution;
- the volumes and locations of groundwater abstractions.

SEPA completed an initial assessment of the characteristics of bodies of groundwater in 2004. It used this to inform an analysis of the likely impact of pressures on the status of the bodies. For bodies identified as "at risk" on the basis of this analysis, SEPA has since been iteratively improving its understanding of the bodies' characteristics and the affects of pressures on their status.

To facilitate this in relation to the chemical status of bodies of groundwater, SEPA has established a series of threshold values for those pollutants likely to be adversely affecting groundwater quality. SEPA uses its environmental monitoring results to identify whether threshold values are exceeded. Where they are exceeded, this acts as a further indication that groundwater chemical status may be adversely impacted. Further investigations are then conducted by SEPA to determine whether or not the body is meeting the criteria required for good groundwater chemical status. The threshold values are listed in The Scotland River Basin District (Surface Water Typology, Environmental Standards, Condition Limits and Groundwater Threshold Values) (Scotland) Directions 2009[6]. Information on how they were identified can be found in the relevant technical report of the UK Technical Advisory Group on the Water Framework Directive.

[5] www.scotland.gov.uk/Publications/2009/12/14130729/3
[6] www.scotland.gov.uk/Publications/2009/12/14130848/0

The Scottish Government has also identified a series of risk-indicators to help identify potential impacts on groundwater quantitative status and so focus further investigations by SEPA. These indicators along with the criteria for good groundwater quantitative status and for good groundwater chemical status are set out in the Scotland River Basin District (Classification of Water Bodies) Directions 2009[7].

[7] www.scotland.gov.uk/Publications/2009/12/14130729/3

Appendix B: Summary of results for different indicators used by SEPA in assessing the status of water bodies

This appendix provides a summary of the results for key indicators used by SEPA to assess the status of bodies of surface water and groundwater.

B.1 Monitoring results for selected indicators of surface water quality

The majority of SEPA's monitoring is targeted on the basis of risk assessments and collects information on the indicator or indicators most sensitive to the impacts of the particular pressures on each water body. This means that not all indicators are monitored in every water body.

The overall assessment of status relies on using the information provided by the monitored indicators in conjunction with an understanding of the risk assessment which determined what to monitor and where. For example, if the risk assessment identified that a water body is not subject to any of the types of pressure to which an indicator is sensitive, that indicator will not normally have been monitored and its condition will have been taken as "high" for the purposes of classifying the status of the water body. However, to confirm that the risk assessment was correct, a representative number of water bodies have been monitored for all indicators.

Tables B1 to B4 present the monitoring results for those indicators of pollution that have been monitored in surface water bodies and groups of surface water bodies.

Table B1: Results for indicators of water quality conditions in rivers in the Scotland RBD in 2008

Measured condition of indicator	phosphorus	bottom living algae	flowering plants and mosses	dissolved oxygen	ammonium	bottom-living insects and other invertebrates	acidity as pH	acid-sensitive bottom-living insects and other invertebrates
High	1,338	449	84	1,560	1,554	1,142	1,438	204
Good	202	181	69	38	68	357	190	81
Moderate	106	273	29	27	23	79	7	340
Poor	13	33	2	5	9	28	6	21
Bad	0	0	0	3	6	8	0	0

Notes to Table B1

- Bottom living algae and phosphorus concentrations are good indicators of the impacts of nutrient inputs.
- Bottom living insects and other invertebrate animals are good indicators of the impacts of inputs of organic matter and the resulting oxygen depletion. They also indicate the impacts of toxic pollutants, such as ammonium. The main assessment method for these animals may in some

cases also pick up impacts resulting from alterations to the bed, banks and shores. However, further development is needed before the method can act as a reliable indicator of the impacts of this pressure.

- One of the assessment methods for bottom living insects and other invertebrate animals, along with pH measurements, is a good indicator of the impact of acidification.

Table B2: Results for indicators of water quality conditions in lochs in the Scotland RBD in 2008

Measured condition of indicator	Total phosphorus	Bottom living algae	Phytoplankton	Flowering plants and mosses	Bottom-living insects and other invertebrates	Acidity as acid neutralising capacity	Acid-sensitive bottom-living insects and other animals
High	171	102	187	8	49	282	97
Good	81	17	90	49	3	1	11
Moderate	37	10	14	14	1	0	27
Poor	10	0	12	0	0	0	0
Bad	1	0	3	1	0	0	0

Notes to Table B2

- Bottom living algae, phytoplankton and total phosphorus concentrations are good indicators of the impacts of nutrient inputs.
- Acid-sensitive bottom living insects and other invertebrates and acid neutralising capacity are good indicators of the impact of acid rain.
- SEPA has not identified any lochs as being adversely affected by toxic pollution.

Table B3: Results for indicators of water quality conditions in estuaries in the Scotland RBD in 2008

Measured condition of indicator	Dissolved inorganic nitrogen	Dissolved oxygen	Seaweeds	Bottom-living shellfish, worms and other invertebrates	Specific pollutants
High	11	15	18	9	25
Good	11	8	2	4	0
Moderate	1	1	1	2	0
Poor	0	1	0	0	0
Bad	1	0	0	0	0

Notes to Table B3

- SEPA has used dissolved inorganic nitrogen and seaweed blooms as indicators

of impacts from nutrient inputs. Estuaries affected by this pressure include the Ythan Estuary and the Montrose Basin.

- Only the upper Clyde and upper Forth estuaries are still affected by occasionally low dissolved oxygen concentrations arising from treated sewage and other organic inputs.
- SEPA has not so far identified any impacts associated with toxic pollutants. It is investigating whether assessing toxic pollution by pollutant concentrations in bed sediments or water animals would provide a better indicator of impacts than measuring concentrations in the water.

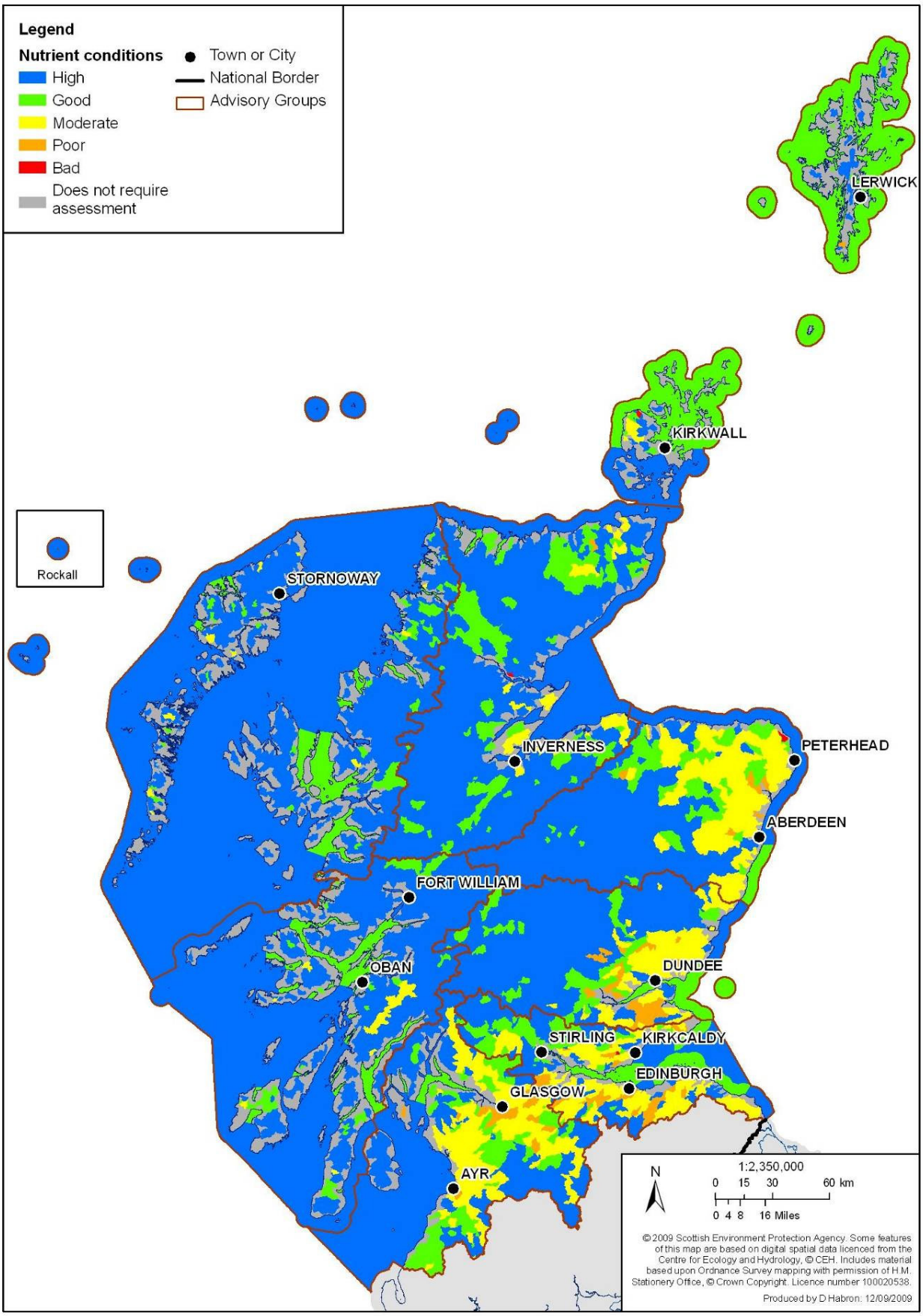
Table B4: Results for indicators of water quality conditions in coastal waters in the Scotland RBD in 2008

Measured condition of indicator	Dissolved inorganic nitrogen	Phytoplankton	Seaweeds	Dissolved oxygen	Bottom-living shellfish, worms and other invertebrates	Specific pollutant: Tri-butyl tin
High	260	322	88	291	130	6
Good	39	0	147	11	136	24
Moderate	0	0	0	0	21	4
Poor	0	0	0	1	0	0
Bad	0	0	0	0	0	0

Notes to Table B4

- Bottom living shellfish, worms and other invertebrate animals are good indicators of the impacts of inputs of organic matter and consequent oxygen depletion. However, there is some evidence that some of the impacts on these animals that have been detected may be the result of disturbance to the sea bed caused by the use of bottom trawling gear in commercial fishing operations. Further assessment work is on-going.
- SEPA used assessment of "imposex" (gender change) in dogwhelks as an indicator of the impact of the specific pollutant, tri-butyl tin. This pollutant is now banned from its previous use as an anti-fouling ingredient in boat paints, and the extent of affected waters continues to decline.
- Dissolved inorganic nitrogen, phytoplankton and seaweeds have been used as indicators of the impact of nutrient enrichment. No coastal waters have been identified as impacted by this pressure. The method used by SEPA to assess the condition of phytoplankton has only recently been finalised at UK level. For the majority of water bodies, the monitoring information SEPA has so far collected has enabled it to make a preliminary assessment of the condition of phytoplankton using the method. As SEPA collects further monitoring information, understanding of the condition of phytoplankton is expected to improve.
- SEPA found low oxygen levels in one water body, Loch Goil. This may be a natural feature of the water body. If this turns out to be the case, SEPA will revise the water body's classification accordingly.

The main pollution pressure on surface waters in the Scotland RBD is inputs of nutrients. Map B1 below shows the status of indicators sensitive to nutrient inputs in those water bodies that have been monitored for one or more of those indicators.



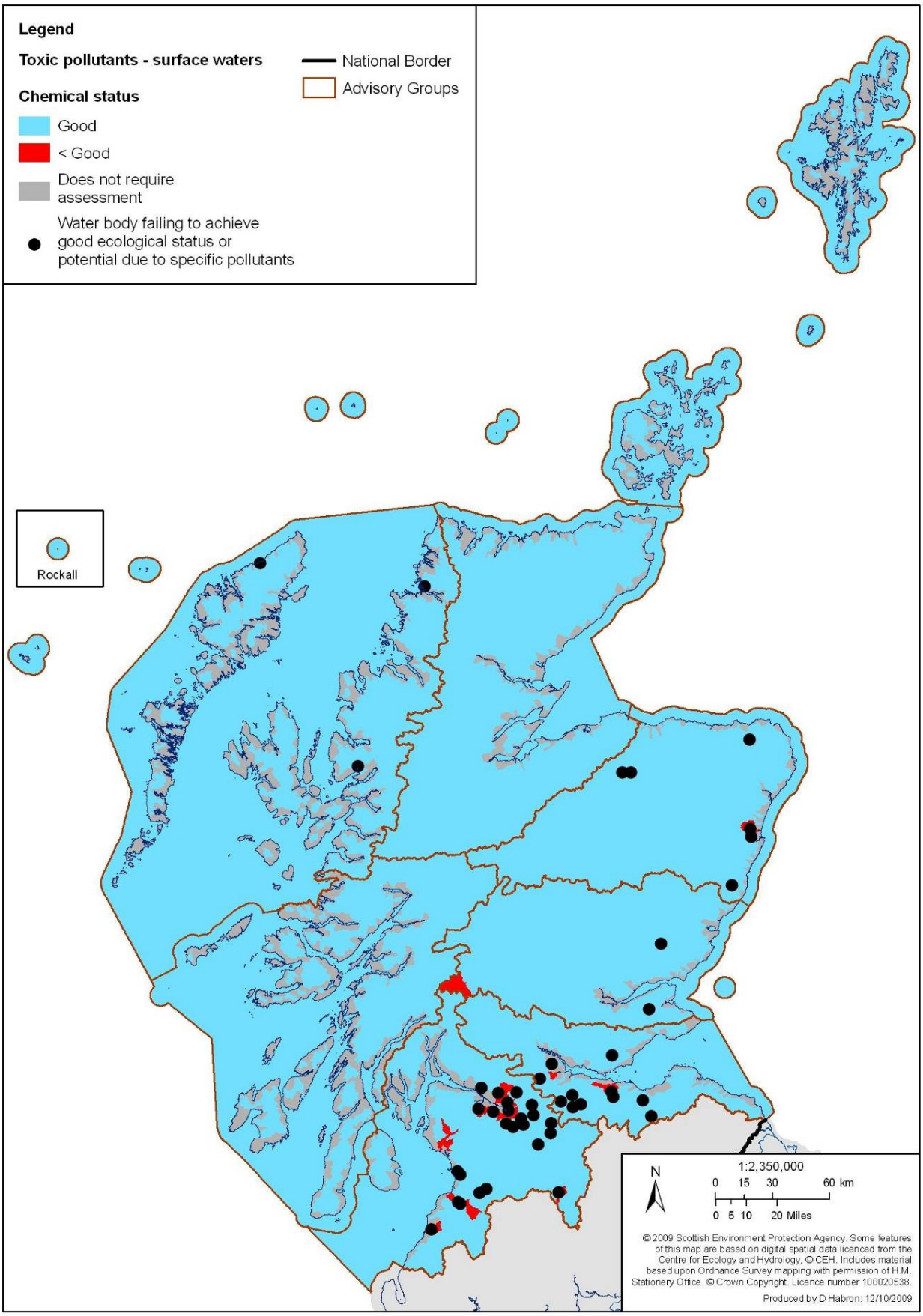
Map B1: Status of indicators sensitive to nutrient inputs in the Scotland RBD in 2008

B.2 Overall assessment in terms of pollutants toxic to water plants and animals

Less than 2% of surface water bodies in the Scotland RBD are known to be affected by pollutants toxic to water plants and animals. Of the few problems identified, inputs of ammonium to rivers are the largest. The results of SEPA's assessment of toxic pollutants are summarised in Table B5 and Map B2 below.

Table B5: Water quality of bodies of surface water in the Scotland river basin district in 2008 in terms of pollutants toxic to aquatic plants and animals

Water quality in terms of toxic pollutants	**Priority substances and certain other pollutants identified at EU level**		**Other synthetic and non-synthetic toxic pollutants** (including ammonium)		**All toxic pollutants**	
	Number of water bodies	Proportion (%)	Number of water bodies	Proportion (%)	Number of water bodies	Proportion (%)
Good or better	2,796	99.5	2,766	98.4	2,759	98.2
Less than good	17	0.6	45	1.6	52	1.8
Totals	2,811	100	2,811	100	2,811	100



Map B2: Water quality of bodies of surface water in the Scotland RBD in 2008 in terms of pollutants that are toxic to aquatic plants and animals

B.3 Beds, banks, shores, fish migration and water flows and levels

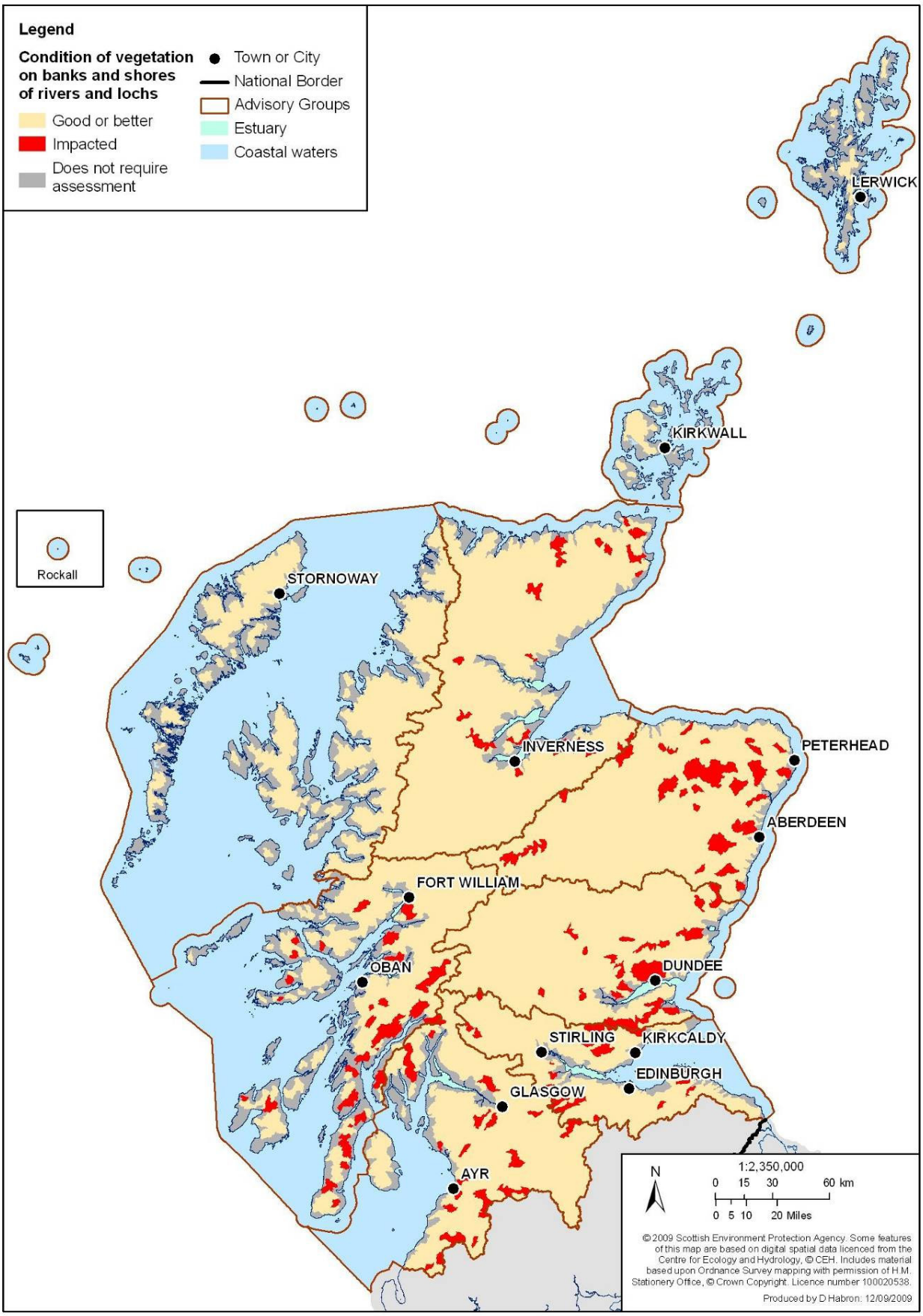
SEPA's assessments of the impacts of alterations to beds, banks and shores; and to water flows and levels have primarily been made using direct indicators of the scale of alterations to ecologically important surface water habitats and to ecologically important flows and levels, respectively.

The results of SEPA's assessment of the main pressures (ie different types of physical alterations) on the bed, banks and shores of rivers that are preventing ecological quality being good are summarised in Table B6.

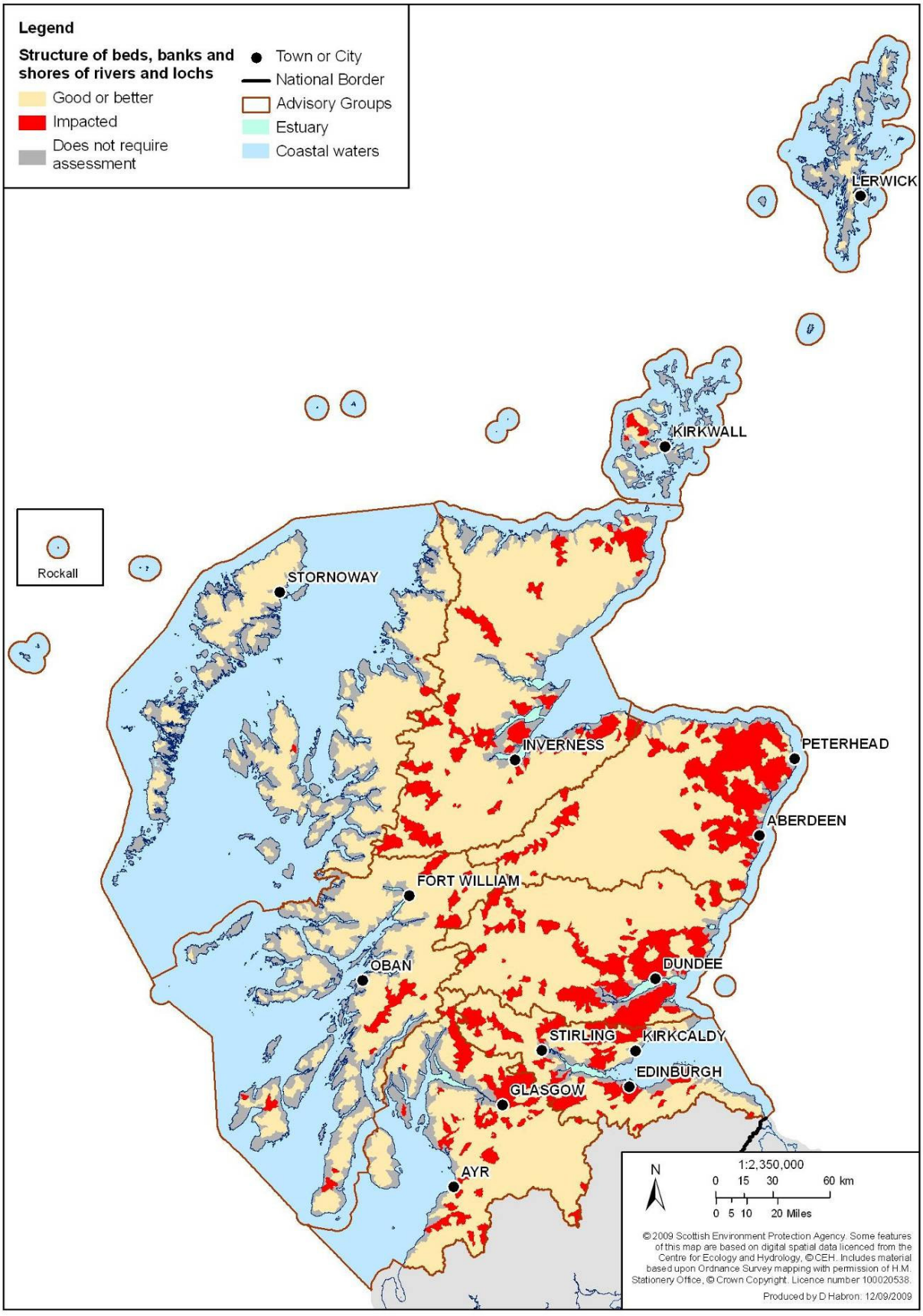
Table B6: Adverse impacts on the ecological quality of rivers attributable to different pressures on beds, banks and shores

	Water bodies caused to be at less than good status or heavily modified as a result of physical alterations to their beds, banks and shores	
Pressure	**Number of water bodies whose banks, beds or shores are not in good condition that are affected by the pressure**	**Relative contribution of the pressure to causing the condition of beds, banks and shores not to be in a good condition (%)**
Channel realignment (eg straightening)	235	51
Removal or degradation of bank vegetation	342	21
Embankments and floodwalls	156	12
Culverting	228	9
Dams	151	2

Maps B3 and B4 illustrate the distribution of impacts on the condition of the beds, banks and shores of rivers and lochs caused by engineering works and the removal or degradation of vegetation on the banks or shores, respectively.



Map B3: Rivers and lochs in which alterations to the vegetation on banks and shores is a cause of their not being at good status in 2008



Map B4: Rivers and lochs in which engineering works to their beds, banks and shores are a cause of their not being at good status in 2008

SEPA has also made assessments of fish in rivers and estuaries, and flowering plants and mosses in rivers and lochs. The assessments of fish in rivers have identified 715km of rivers in which fish are not in a good condition. Fish are sensitive to a number of different pressures, including acidification, diffuse pollution, barriers to migration and alterations to flows, beds and banks. Salmon and sea trout populations in some west coast rivers may be less than good because of impacts occurring at sea.

Flowering plants and mosses are sensitive to nutrient inputs but they can also indicate changes to beds, banks, shores, flows and levels. In lochs used as water storage reservoirs, they can be used to assess impacts resulting from alterations in the water level regime in the loch.

B.4 Assessment results for the different conditions required for good groundwater status

Table B7 below summarises SEPA's assessment results for each of the conditions required for good groundwater chemical status. Impacts on the overall quality of groundwater and hence its ability to support human uses is the principal reason for bodies of groundwater not being at good chemical status. This is a cause of 19% of our bodies of groundwater being at poor status.

Table B7: Assessment results for each of the conditions required for good groundwater chemical status in 2008

Condition of criteria	**Conditions for good groundwater chemical status (number of water bodies)**				
	Ingress of salty water or polluted water into the body	Effects on the condition of associated surface water bodies	Effects on the condition of wetlands dependent on groundwater	Protection of the quality of water abstracted for human consumption	Other environmental risks to groundwater quality, including to its ability to support human uses
Good	284	273	284	282	231
Poor	0	11	0	2	53

Table B8 below summarises SEPA's assessment results for each of the conditions required for good groundwater quantitative status. The adverse effects of over-abstraction of groundwater on river flows and levels are the principal reason for bodies of groundwater not being at good quantitative status. Failure of this condition causes 12% of our ground water bodies to be at poor status.

Table B8: Assessment results for each of the conditions required for good groundwater quantitative status				
Condition of criteria	**Conditions for good groundwater quantitative status (number of water bodies)**			
	Ingress of salty water or polluted water into the body	Effects on the condition of associated surface water bodies	Effects on the condition of wetlands dependent on groundwater	Long-term balance between abstraction and groundwater replenishment
Good	284	251	284	281
Poor	0	33	0	3

Appendix C: Water body characteristics

Surface water bodies have been grouped into broad types according to their physical and chemical characteristics. These types give a general indication of the sorts of plants and animals that are likely to be present in water bodies of that type in undisturbed conditions.

For rivers, broad types have been distinguished on the basis of altitude, catchment size and geology[8]. Fifteen different river types are found in the Scotland RBD (Map C1). All these types lie within the Great Britain ecoregion for rivers and lochs[9].

Loch types have been distinguished on the basis of natural characteristics that have the greatest bearing on their ecological condition of lochs. These are the geology of the catchment, expressed as the base status (alkalinity) of the loch, and the depth of the loch, expressed as the mean depth[10]. Ten different loch types are found in the Scotland RBD (Map C2).

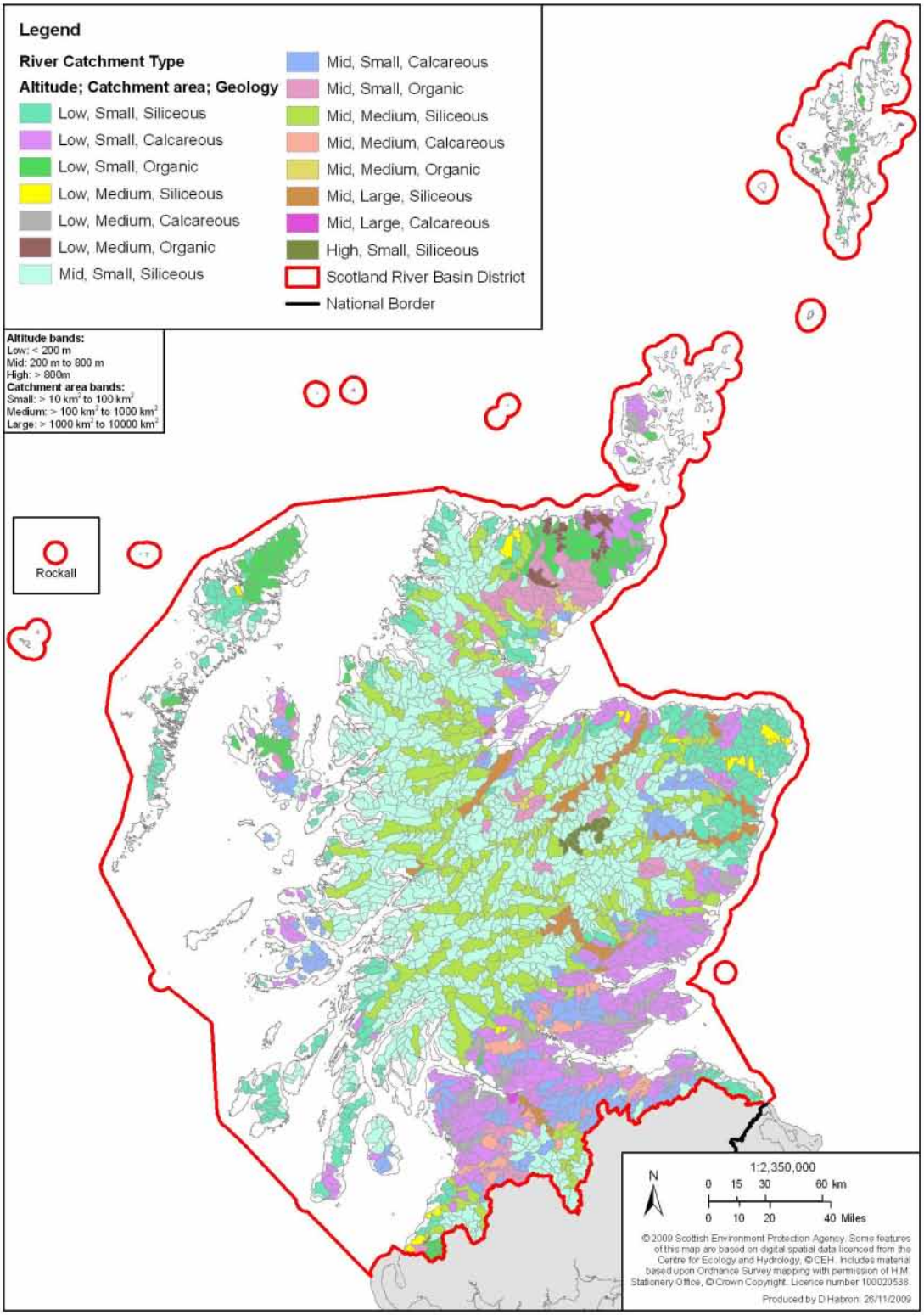
Estuary and coastal water types have been distinguished on the basis of latitude, longitude, tidal range, salinity, mixing characteristics, mean substratum composition and wave exposure[11]. Five different estuary types and nine coastal water types are found in the Scotland RBD (Maps C3 & C4 respectively).

Scotland is geologically diverse, containing many groundwater aquifers with differing characteristics. The aquifers have been grouped into categories based on how groundwater flows within them and how much water is available for abstraction (their productivity).

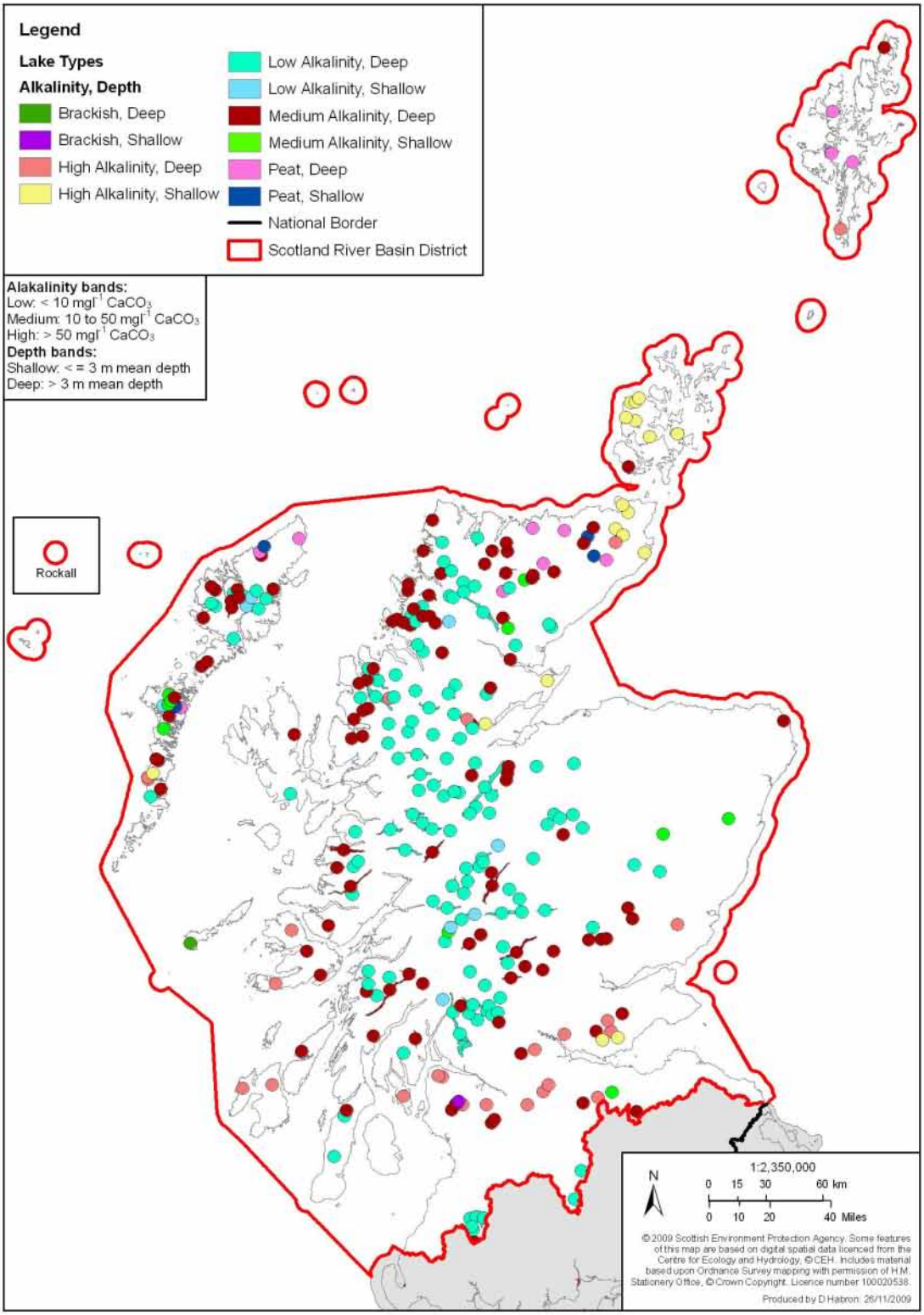
The aquifer categories range from the low productivity mountainous highlands to low-lying, highly productive sandstone basins. The flow mechanism and size of the aquifer determines how much interaction there is between the rock and the groundwater. Greater interaction means that more contaminants are likely to be removed or reduced by physical filtration, chemical or biological reactions. For example, bedrock aquifers are dominated by flow in rock fractures and hence the potential for reducing contaminants is minimal.

Bodies of groundwater have been identified to reflect the eight different aquifer categories found in the Scotland RBD (Map C5).

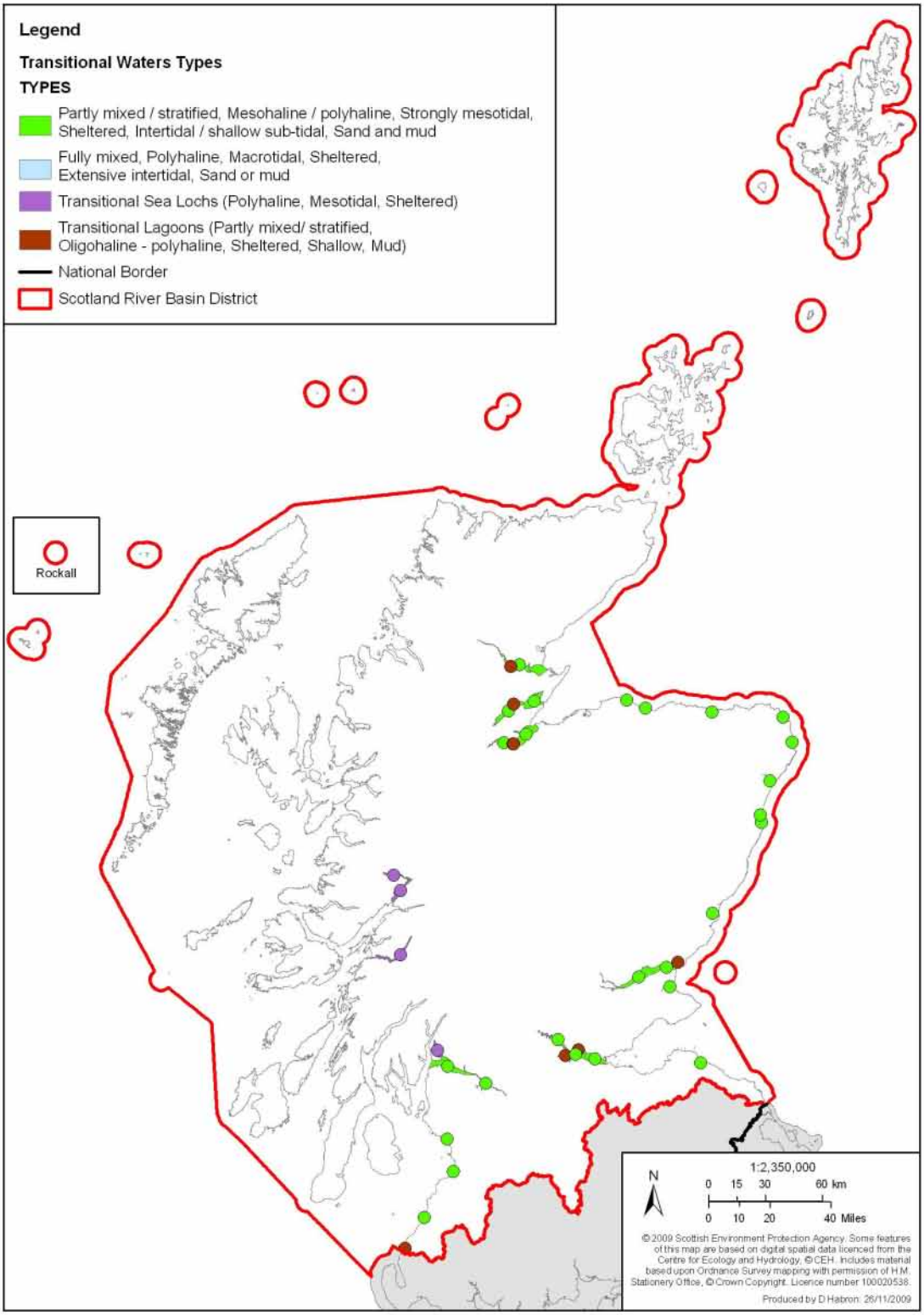
[8] The system used for identifying river types (System A) is set out in Annex II to the Water Framework Directive.
[9] See Annex XI to the Water Framework Directive.
[10] The system used for identifying loch types (System B) is set out in Annex II to the Water Framework Directive. The other factors in system B (altitude, latitude, longitude and size) are of less relevance to ecological character of lochs in the Scotland RBD and were therefore allocated to a single category for the UK.
[11] The system used for identifying estuary and coastal water types (System B) is set out in Annex II to the Water Framework Directive.



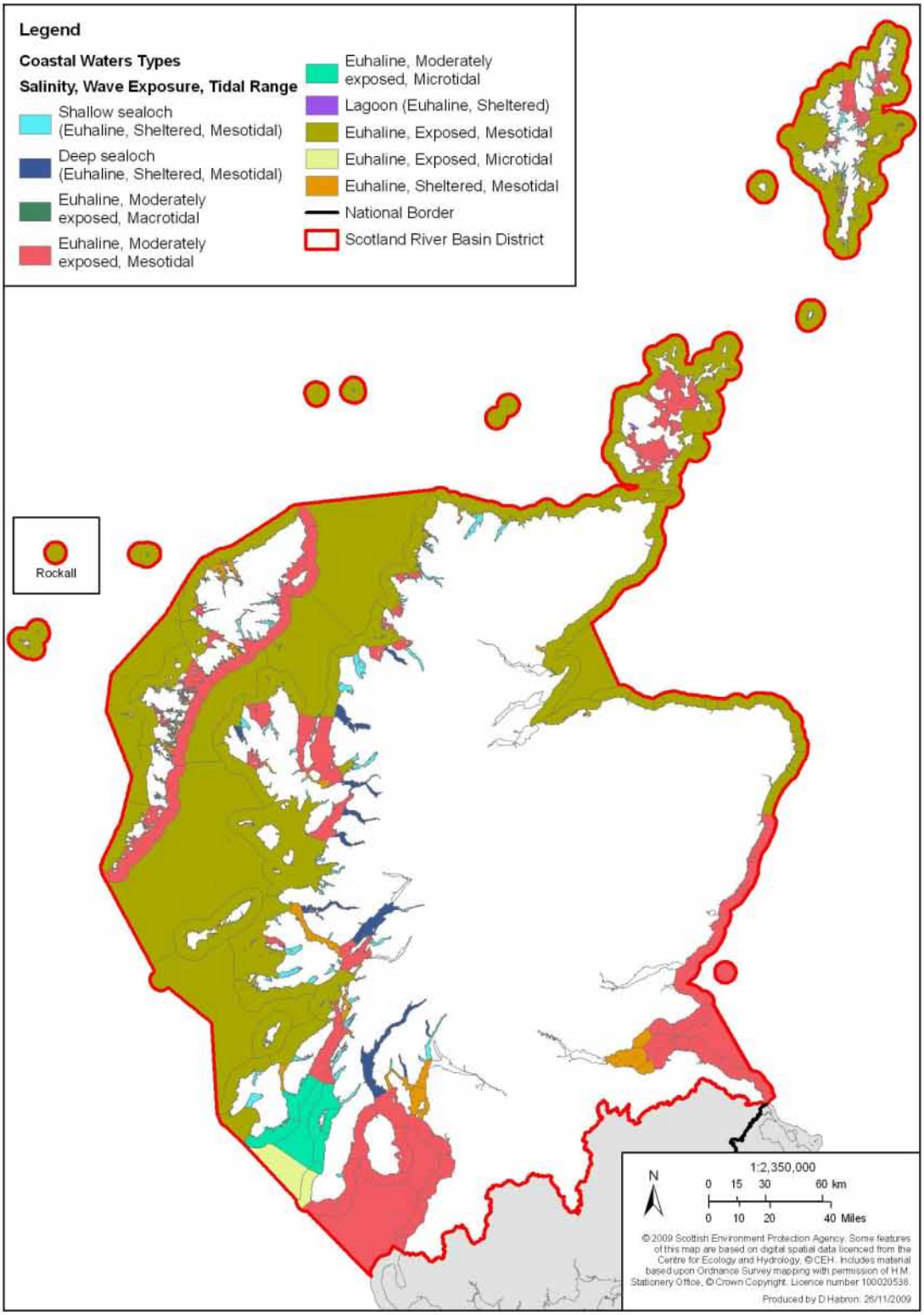
Map C1: River types in the Scotland RBD.



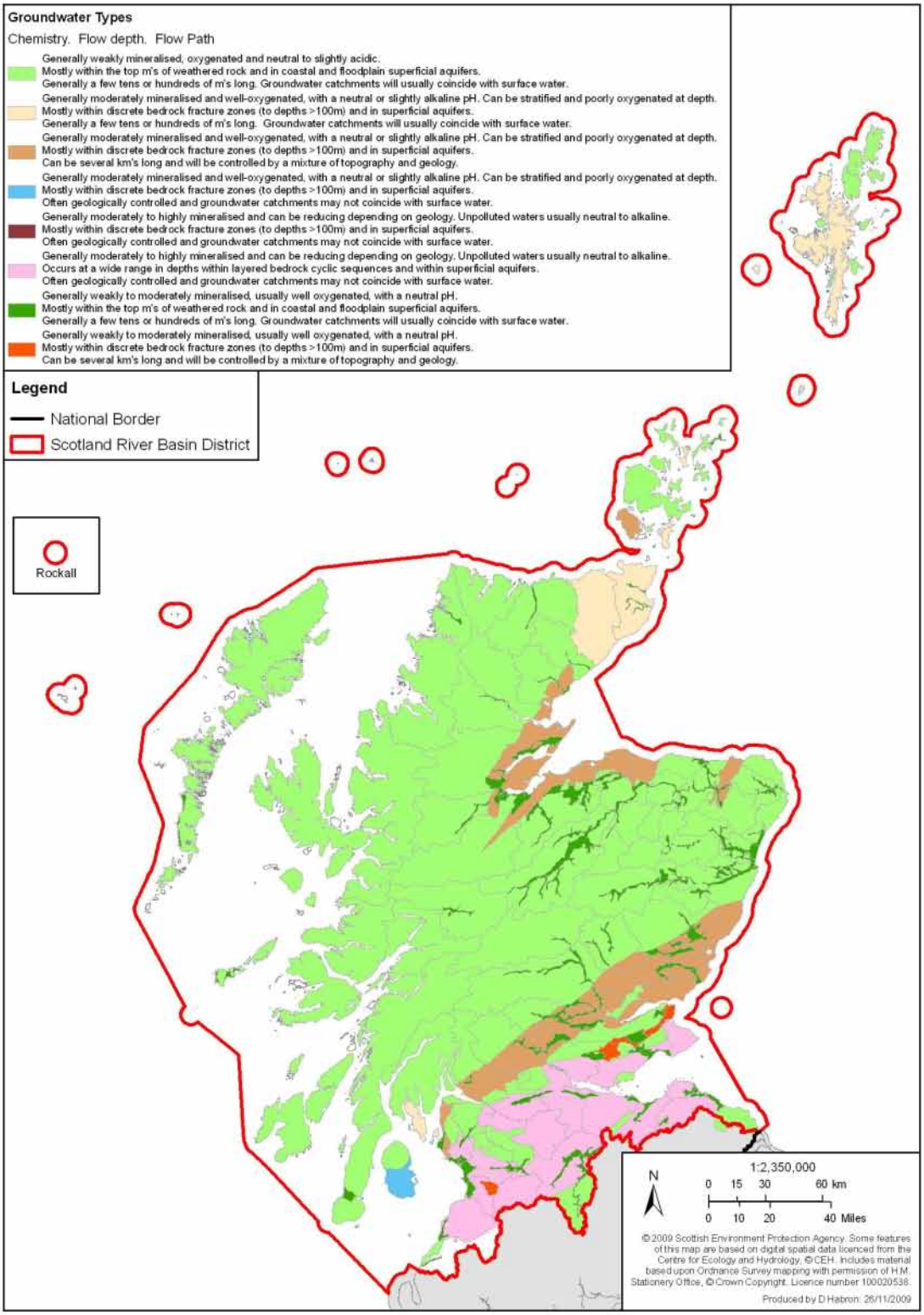
Map C2: Loch types in the Scotland RBD.



Map C3: Estuary types in the Scotland RBD.



Map C4: Coastal water types in the Scotland RBD.



Map C5: Aquifer categories and bodies of groundwater in the Scotland RBD.