Document Control Sheet

Client	Dublin City Council			
Project	Eastern River Basin District – National POM/Standards Study			
Report	**Revised River Risk Assessment for Abstraction Pressures**			
Date	December 2008			
Project No: 39325		**Document Reference:** 39325/AB40/DG33 - S		
Version	**Author**	**Reviewed**	**Checked**	**Date**
01 (Draft)	B. Kolb	R. O'Carroll		November 2008
02 (Final)	B. Kolb	J. Walker		December 2008

Distribution	**Copy No.**
Master	01
DCC – Tom Leahy	02
DCC – Ray Earle	03
website www.erbd.ie	04
	05

Contents

Tables

Figures

Section 1 Introduction

1.1 Overview

This report describes the method and results of the revised risk assessment for rivers in Ireland. This work was added to the scope of the National Programme of Measures and Standards (POMS) Study to assess abstraction pressures in Ireland (established December 2005) by approval of the Project Steering Group on 13 March 2008. The National POMS study was commissioned by the Department of Environment Heritage and Local Government (DEHLG) under the Eastern River Basin District project.

The revised risk assessment for rivers is one component of the National Abstractions POMS study. The other work elements are noted below; each work element is reported separately:

- A revised risk assessment for lakes, which re-examined the risk for the 127 lakes judged to be 'at risk' or 'probably at risk' in the initial risk assessment. This report also includes recommendations for priority monitoring sites and general Programmes of Measures (PoMs) related to abstraction risks in lakes (CDM Document Reference: 39325/AB40/DG 51 – S).

- A pilot of a method to determine minimum instream flow needs (passby flows) for salmonids in rivers in the Central Plain region. This method could be part of a future regulatory programme to license surface water abstractions (CDM Document Reference: 39325/AB40/DG 43 – S).

- A review of the environmental flow methods assessing the usefulness of available international methods in evaluating the effects of abstraction pressures on non-fish biotic groups in Irish rivers (CDM Document Reference: 39325/AB40/DG 27 – S).

- A revised risk assessment for groundwater abstractions and guidance for a licensing programme for these abstractions (CDM Document Reference: 39325/AB40/DG 37 – S).

The report is organised as follows. The remainder of this section describes the previous risk assessment, gives an overview of the revised method, and discusses which abstractions were included/excluded in the revised risk assessment. Section 2 describes the input data used in the analysis. Section 3 presents the revised risk assessment results, compares them to the previous results, and discusses data limitations. Section 4 comments on the results focusing on how the underlying assumptions and data can result in underestimation and overestimation of the risk. Section 4 also discusses Programmes of Measures (PoMs) that can be implemented to reduce the risk from abstraction and return a waterbody to good ecological status.

1.2 The Initial Risk Assessment Method

An initial abstraction pressure assessment was performed in Ireland by individual river basin district (RBD) projects and reported by the EPA in the national Article V report, *The Characterisation and Analysis of Ireland's River Basin Districts* (EPA, 2005). The methodology used in Ireland to evaluate the risk from abstraction pressures was extended from methods developed by the United Kingdom Technical Advisory Group's (UK TAG) guidance document 7b *Abstraction and Flow Regulation Pressures on Surface Waters* and the Environment and Heritage Service's (EHS) guidance *Water Resources Methodology for the Assessment of Abstraction and Flow Regulation Pressures on Surface Waters and Transitional Waters in Northern Ireland.*

The document *Guidance on Thresholds and Methodology to be Applied in Ireland's River Basin Districts* (November 2004) for assessing risk to surface water hydrology describes the Irish method as follows:

> *The Irish methodology involves the compilation of a database of abstractions, discharges and major flow regulation structures within each RBD. Q95%ile flows were calculated for each water body at the furthest downstream point of the water body…. Total abstractions minus total discharges were calculated using available data to determine net abstractions for each water body. Net abstractions were then compared with Q95%ile flows (low flows) and reported as a percentage of the low flow figure. This figure was then compared with thresholds for high sensitivity surface waters from EHS and UK TAG guidance documents.*

The Q95 values for the initial risk assessment were prepared using hydrometric data from EPA and Northern Ireland's Rivers Agency for 471 gauging stations where the catchment area exceeded 10 km^2. These Q95 values were first normalised using the catchment area of the hydrometric gage. The 471 data points were then interpolated onto a 50-metre resolution grid using GIS software to develop contours. The interpolated raster values in each grid cell were then binned together to represent groups of cells that had values that fell within one of 32 quantile classifications. The median value of the grid cells within each binned group was selected to be the representative Q95 flow. The Q95 value assigned to each river water body (RWB) was, therefore, the median Q95 value that coincided with the furthest downstream location in each RWB.

The Working Group that created the November 2004 Guidance was aware of the limitations of the method used to asses abstractions pressures, noting gaps in information on abstractions and discharges and the need to use available data to estimate the Q95 flows for each RWB. In particular, they noted that the while other methods exist to estimate low flows the data needed to support those calculations did not exist at that time. Therefore, they concluded "what was developed was a screening tool suitable for initial characterisation" and "more detailed analysis may be required as part of further characterisation of water bodies at risk."

1.3 Updating the Risk Assessment

This work has been undertaken to provide RBD projects and others in Ireland improved information on river risk to be taken into account in the evaluation of abstraction pressures and the potential programmes of measures needed to address those pressures. The data can also be used to identify river water bodies for prioritisation of measures.

The revised risk assessment takes into account improvements in:

- Updates to an aggregated national abstractions register made through this project (Section 2.3)
- Updates to a national discharges register made through the Municipal and Industrial Regulations POMS study (Section 2.4)
- Inclusion of compensation flows when evaluating net abstractions against low river flows (Section 2.5)
- A much improved method for estimating Q95 flows that directly uses catchment characteristics and basin hydrology; the EPA/ESBI method for estimating the Q95 percentile flow in ungauged catchments was used (Section 2.6)

In addition, two assessments of risk are prepared; one uses net abstractions for surface-water-only abstractions whilst the other uses surface-water-plus-groundwater abstractions. The risk assessment considering only surface water abstractions is used for reporting purposes, whilst the one that also includes groundwater abstractions is used to provide estimates of the potential additional pressure that groundwater abstractions place on surface water resources.

1.4 General Approach to Revised Risk Assessment

This section outlines the steps that were followed to revise the river risk assessment. One methodology is outlined for RWBs with an abstraction within its catchment and a second methodology is outlined for all other RWBs. The data sources and additional details about each methodology and specific techniques are described in Section 2.

1.4.1 RWBs with Abstractions in their Catchments

The general approach for revised risk assessment of RWBs with abstractions within the catchment is as follows:

1. Delineate an 'abstractions catchment' contributing flow to the RWB containing the abstraction(s) of interest
2. Use the EPA/ESBI ungauged catchment estimation techniques to determine the Q95 flow for that catchment
3. In catchments with compensation flows, determine if the compensation flow would be additive to the Q95 based on the placement of the dam release point in

the catchment. If not additive, compare the compensation flow to the Q95 flow and retain the higher of the two values

4. Calculate the net abstractions in an abstractions catchment as the sum of abstractions in the catchment minus the sum of discharges in the catchment. Two net abstraction calculations were made: the first includes surface-water-only abstractions, while the second includes surface-water-plus-groundwater abstractions.

5. Calculate the ratio of the net abstraction (Step 4) to the flow obtained in Step 3.

6. Calculate the ratio of the net abstraction (Step 5) to Step 3 low flow (called herein the net abstraction to Q95 ratio), and assign risk based on the four risk-category risk classification scheme with threshold values shown in Table 1-1. This is the same scheme used in the Article V risk assessment. The risk category is assigned using the net abstraction ratio calculated using only surface water abstractions.

Table 1-1: Risk Categories and Thresholds for Revised River Risk Assessment

Risk Category	Risk Classification	Net-abstraction-to-Q95 Flow*
2b	Not at risk	<5%
2a	Probably not at risk	5-10%
1b	Probably at risk	10-40%
1a	At risk	>40%

** In a few cases, the compensation flow may be substituted or added to the Q95 flow*

1.4.2 All Other RWBs

After accounting for the RWBs that contain abstractions in their catchments, several types of RWBs remain:

- RWBs located in river systems without abstractions
- RWBs that contribute to a RWB containing an abstraction, but do not have one in their own catchments
- RWBs downstream of a RWB containing an abstraction

In the first two cases, the RWB is assigned the risk category 2b – not at risk. In the latter case, the following steps were taken to assign a risk category.

1. Query the register of discharges to determine if any discharges are located in these downstream RWBs; if yes, adjust the net abstraction for the discharge.

2. Use an area-weighted transposition of the calculated Q95 flow to determine the adjusted Q95 flow for the catchment of the downstream RWBs. Recalculate the

net-abstraction-to-Q95 ratio and assign the appropriate risk category. Continue until the ratio is less than 5%, and then assign all further downstream RWBs to the 2b risk category.

1.5 Extent of Revised Risk Assessment

The updated abstractions register (Section 2.3.1) includes 570 surface water abstractions. The accuracy of the revised risk assessment depends the quality of information on abstractions in Ireland. While extensive effort was made to update the abstractions registers and to obtain comprehensive information about identified abstractions, data gaps remain.

The revised risk assessment for abstraction pressures was determined for 482 abstractions located in 446 'abstractions catchments' (abstractions catchments are defined in Section 2.2) where Q95 flows could be estimated; these represent the vast majority RWBs potentially affected directly by abstraction pressures.

A number of surface water abstractions were not included in the revised risk assessment analysis; these are described below.

- Five abstractions are located in catchments that extend into Northern Ireland. Q95 flows can not be calculated for these catchments because the required data to inform the EPA/ESBI methodology (e.g., soil, subsoil and aquifer characteristics) is not available. They are:
    - NB_ABS0033: Emy Lough serving the Glaslough-Tyholland GWS
    - NB_ABS0035: Lough More serving the Truagh GWS
    - NB_ABS0036: Muchno Mill Lough serving the Churchill-Oram GWS
    - NB_NEW_ABS0006: Fane River serving Inniskeen PWS
    - NB_NEW_ABS0009: Fane River serving Cavan Hill
- One abstraction is located on a transitional waterbody (SH_ABS0870) for Aughinish Alumina. This is a private abstraction of 600 m^3/day.
- 18 abstraction points are not included because neither the relevant RBD project or relevant local authority (LAs) provided northing and easting information. These abstraction points are included at the end of the table of surface water abstractions in Appendix B.
- 64 surface water abstractions are located in catchments that are not reportable RWB; these abstractions usually occur in small catchments that drain directly to the coast. The abstractions typically are from a small lake/reservoir that discharges to an order 1 stream.
- Six abstractions are from catchments where the only surface water body is a lake. In the Initial Characterisation, a risk value was given to these "river water bodies" for the river surface water hydrology risk test (called RHY1). Since it is not

reasonable to evaluate a risk for the RHY1 test for these water bodies, a risk category of 2b (not at risk) has been assigned. Abstraction pressures for these lakes are evaluated using the lakes abstractions risk test (called LHY1).

- Five abstraction are from catchments that contain a series of lakes interconnected by small streams. The EPA/ESBI method is not applicable to this type of physiographic / hydrologic setting; it is based on the presence of a river network to establish Q95 flows. These catchments also have their RHY1 risk results assigned as 2b (not at risk).

Section 2
Methodology and Input Data

2.1 Introduction

This section explains the methodology used to determine the net-abstraction-to-Q95 ratios used to re-evaluate the risk of abstraction pressures on rivers. It provides details about catchment delineations, updating the abstractions register, the updated discharges register obtained from the SWRBD as part of their POMS project, available data on compensation flows, and the EPA/ESBI method for estimating Q95 flows.

Section 3 includes a discussion of data gaps, limitations and improvements that can be made.

2.2 Catchment Delineation

Catchment delineations for the surface water abstractions are based on the existing RWB definitions. The alternative is to develop 'actual' catchments for each abstraction point using Ireland's Digital Terrain Model (DTM).

The Project Steering Group considered the advantages of these choices. The main advantage of using the 'actual' catchment is that the Q95 flow would be customised to the abstraction point. Using the RWB method (Figure 2-1), on the other hand, the Q95 flow estimate would be based on a larger catchment area (excepting a small number of cases where the abstraction coincided with the downstream end of the RWB) because the catchment would include the area of the RWB downstream of the abstraction point. Thus, the RWB method would most often result in a larger Q95 flow, which has the potential to understate the risk from abstraction pressures. In weighing the two alternatives, the Project Steering Group

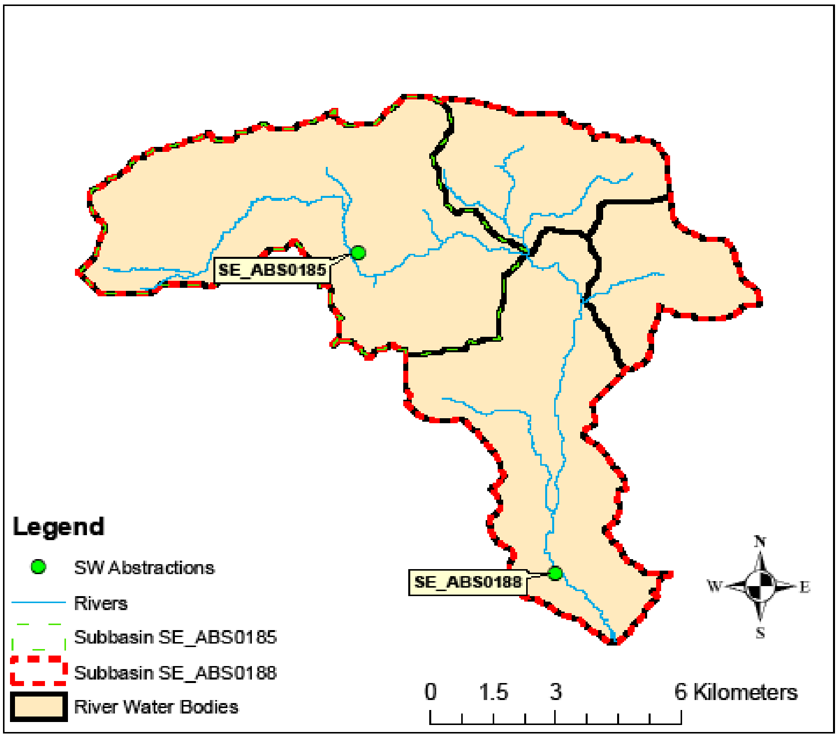

Figure 2-1: Whole Catchment Delineation Example

recommended the use of the RWB as the foundation for catchment delineation primarily because RWBs were the basis of the initial risk assessment and are the basis for reporting to the EU. The RWB approach also allows for better reconciliation of abstractions and discharges in a catchment as the net abstraction value can be determined in a fixed catchment area.

RWB-based catchments for surface water abstractions were developed in one of two ways (these are termed 'abstractions catchments' in this report):

- Whole catchment – The whole catchment includes all of the area upgradient to the RWB containing the abstraction(s) for which the catchment is being delineated. Figure 2-1 provides an example of two whole abstractions catchments, in this case one catchment (SE_ABS0185) is nested inside of the other (SE_ABS0188).

- Reduced catchment – A smaller catchment area is used when the RWB containing the abstraction has an additional tributary RWB(s) that joins the river downstream of the location of the abstraction in the RWB of interest. The reduced catchment method (explained below with an example) thus partially compensates for less conservative Q95 estimates that derive from using RWB as the foundation of catchment delineation.

Figure 2-2 is an example of a reduced catchment for the Slaney River where the downstream-most or terminal RWB (SE_12_925) includes one abstraction (red dot on Figure 2-2). The delineation of the whole catchment is shown as a red line, while the reduced catchment is shown as a dashed blue line. The area between the whole and reduced catchments comprises 12 RWBs (in southwest region of the whole catchment), which are tributary to the terminal RWB but whose flow enters the terminal RWB downstream of the abstraction location. The reduced catchment method provides a smaller, more conservative Q95 flow estimate on which to evaluate abstraction pressures than if the whole catchment method was used.

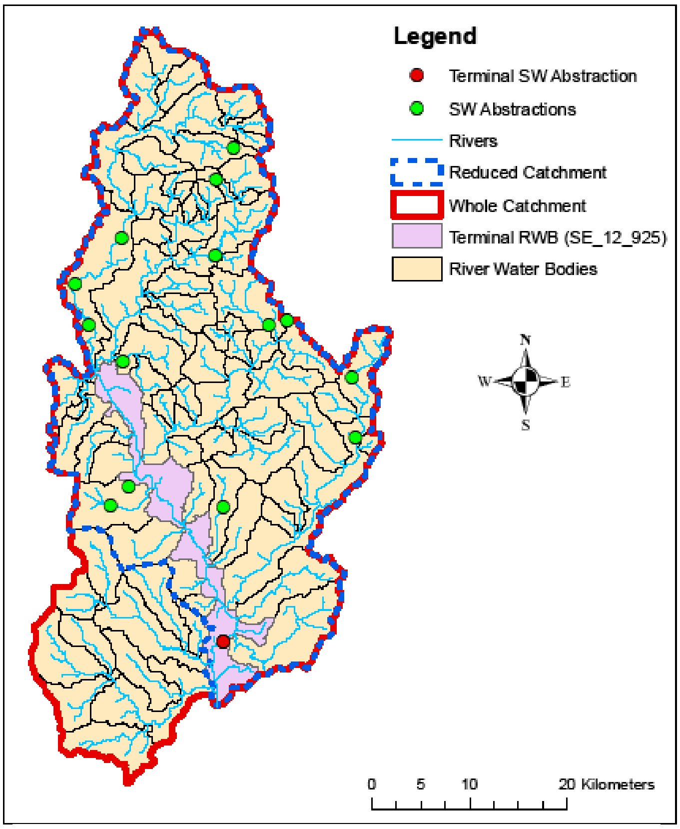

Figure 2-2: Reduced Catchment Delineation Example

A total of 446 'abstractions catchments' were identified. A separate abstractions catchment is needed for each RWB containing abstractions. In some cases individual abstractions catchments are needed when there are multiple abstractions in a single RWB. An example is the RWB for the Liffey River, which starts at and includes Poulaphouca Reservoir extending downstream to the transitional water body in Dublin. The whole catchment is used to evaluate the risk for the abstraction at Leixlip, whereas a reduced catchment (not including the RWBs the join the Liffey downstream of Leixlip) is used to evaluate the abstractions in the upper catchment. A listing of the abstractions catchments is included in the tables in Appendix A, which also includes the estimates of Q95 flows for these catchments.

2.3 Abstraction Data

2.3.1 Updating the Abstractions Register

As part of this project, a national register of abstractions was compiled from input provided by individual RBD projects and then updated with additional and revised input from the RBD projects and local authorities. Because abstractions data is the foundation of the evaluation of pressures, several rounds of enquiries were made to resolve incomplete or confusing datasets. Even with this effort, responsiveness varied; some updates that were sought were not obtained.

The updated register, however, is improved over versions used to perform the Article V Initial Characterisation in 2005. Records have been cross- and error-checked, new abstractions have been added or removed as appropriate, some wells have been removed (e.g. if decommissioned) and new or revised volumes of abstractions have been added, where available. It is believed that most public and group water schemes have been identified and included, but it is unlikely that all industrial, miscellaneous small private abstraction schemes (*e.g.*, schools, hospitals, or farms) are captured in the updated register. The register does not include domestic wells, as these are too numerous and considered less important from a resource quantity point of view. Most of the domestic abstractions are returned to ground via septic systems, and whilst this has an impact groundwater quality, it has less of an impact on quantities.

Every abstraction was assigned as either surface water, groundwater, or mixture. Springs are included as groundwater abstractions. Only a few abstractions were designated as mixtures.

When CDM compiled the original abstractions register using data provided by the RBD projects, each abstraction had a unique identifier, known as an abstractions code. An example code is EA_ABS0005, which was assigned to an abstraction from the River Boyne in Drogheda. EA denotes an abstraction in the Eastern RBD. Abstractions were then numbered sequentially. In updating the register, many additional abstractions were identified; these were given a similar coding sequence excepting that the word NEW appears in the abstractions code. For example, NW_NEW_ABS0012 is an abstraction from Lough Altaskin in Cavan in the North West RB D.

The updated abstractions register used to complete the revised risk assessment is provided in Appendix B. The Appendix B tables include the abstraction code, point name, scheme name, and data on its location, volume and population served. The register contains other attributes (e.g., northing, easting, update information) that can be accessed in the GIS layer that will be provided to EPA.

2.3.2 Using the Updated Abstractions Data

The abstraction data includes the abstraction volume in cubic meters per day (m^3/d), and the population served. It is not always clear if the volumes provided represent current use or design capacity of the supply scheme (or indeed the source yield). We understand that most of the abstraction volumes represent the current volumes abstracted, although in some cases they represent the maximum volumes capable.

In some cases, an abstracted volume could not be obtained and the volume is estimated based on the number of population served. The volumes for 11 surface water abstractions were estimated using daily use of 200 litres/per person/day. In nine other cases, no abstracted volume or populations served was supplied.

2.4 Discharge Data

2.4.1 SWBRD's Updated Discharges Register

Information on the location and volume of discharges is needed to complete the net abstraction calculation. The register of discharges was updated with the most recently-available data from the South Western River Basin District (SWRBD) POMS project on pressures from municipal and industrial discharges; they collected information about the following point source discharges:

- Wastewater treatment plants (WWTPs)
- Integrated Prevention and Pollution Control (IPPC) industries licensed by EPA
- Section 4 (Water Pollution Act) dischargers licensed by Local Authorities (LAs)

Discharge data for the WWTPs are provided as average daily flows, where available. The discharge data for the IPPC and Section 4 industries are incomplete. Available discharge data is provided as maximum hourly or daily rates and generally are the licensed flow; actual discharges are known to be lower in some cases.

The sum of the discharges in an 'abstractions catchment' is provided in the results tables in Appendix C.

2.4.2 Using the Updated Discharges Data

The discharge data for wastewater treatment plants includes the volume in cubic meters per day (m^3/d), and the population served. Population data were used to estimate discharge flows in the absence of registered flows. The discharge flows were estimated to be 200 l/person/day.

Two discharges in the register were not included in the analysis: the Lough Ree and West Offaly power stations at Lanesborough and Shannonbridge. These stations have IPPC licensed discharges (380,000 and 600,000 m^3/day, respectively) but no abstraction in the abstractions register. If included in the analysis these very large discharges result in negative net abstractions, and hence, the Shannon River being evaluated as 'not at risk' (2b) from abstraction pressures. Therefore, the risk assessment has been completed without these IPPC discharges. This decision affects two abstractions catchments near Lough Ree (SH_ABS0956/NEW_0002; SH_ABS0950), while the catchments downstream of the West Offaly station at Shannonbridge would not change.

2.5 Compensation Flows

Compensation flows are releases from impounded water bodies to ensure that there is a specified flow in the downstream river. Information on compensation flows was sought so that these flows could be included in the comparison to the net abstraction ratio. Compensation flows were identified for the following impoundments:

River Liffey – Poulaphouca/Golden Falls: The Liffey Reservoir Act (S.I. 54/1936) includes the following requirements for statutory compensation flow.

> *The* [Electricity Supply] *Board shall at all times (including times at which the level of the water in the Reservoir is below low water level as hereinafter defined) be at liberty to discharge water from the Reservoir in such manner as the Board may think fit at a rate not exceeding 1.5 m^3/s averaged over each week from noon on Monday to noon on the following Monday as flow for compensation (hereinafter referred to as "compensation water") as compensation water to the river down stream of the* [Golden Falls] *dam….*

River Liffey – Leixlip Dam: The current minimum compensation release from Leixlip is 2 m^3/s (Dublin City Council: *Dublin Water New Sources Development*, McCarthy Hyder Consultants Report no: NE02171/D16/3, 2003).

> *Very occasionally, the compensation release at Leixlip can be manually dropped to 1.5 cumecs if reservoir levels are particularly low, or even stopped briefly for maintenance. Examination of the Leixlip record shows only 16 days out of 16,512 where the compensation release was equal to or less than 1.5 cumecs. Very few of these days occurred concurrently. Although almost all occurrences were in dry periods, only a few were during extreme droughts, indicating they are more directly related to the operation aspects of the reservoirs.*

The compensation water release at Leixlip is not a statutory requirement. It has evolved as a proportionate value to the upstream statutory compensation flow, and it also related to the requirements of mill owners in the Leixlip area in past times (Fingal County Council: *Yield of the River Liffey*, Nicholas O'Dwyer Ltd & Tobin Consulting Engineers, April 2005).

Because the Liffey downstream of Poulaphouca is a single RWB, only one compensation flow can be applied in this analysis; the lower compensation flow of 1.5 m^3/s for the Liffey RWB was selected as a conservative value. (Note: the risk results for the lower Liffey would not change at the higher level of compensation flow.)

River Dodder– Bohernabreena Reservoirs: Dublin City Council (*Dublin Water New Sources Development*, McCarthy Hyder Consultants Report no: NE02171/D23/2, 2003) report that compensation flow for these reservoirs was set at 0.11 m^3/s when they were constructed to provide the mills downstream with a steady base flow. Currently, however, they report in that the *Dodder Waterworks Manual* states that the reservoirs are operated preferentially for the benefit of the water supply. This means in practice the water actually released for compensation can be less than 0.11 m^3/s. Due to uncertainty in the release value, a compensation flow was not included in the analysis for the Dodder River. (Note: the risk results for the River Dodder would not change if a compensation flow of 0.11 m^3/s was used.)

River Lee– Inniscarra Reservoir: S.I. No. 321 of 1949 requires a compensation flow from Inniscarra Reservoir as follows:

> *The waters to be impounded and used for the purpose of the Scheme are the River Lee and tributaries thereof, provided, however, that a quantity of water not less than 1.5 m^3/s or thereby shall be discharged down the River Lee past the dam…*

River Shannon – Parteen Weir at Lough Derg: ESB provides a compensation flow of 10 m^3/s in the original River Shannon channel.

River Clady – Gweedore Regulating Weir: S.I. No. 320/1953 requires compensation flows to provide: (i) sufficient water to ensure an average flow immediately below the weir of 29,000 m^3/day or thereabouts throughout the year, and (ii) in addition, freshets up to a total not exceeding 5½ million cubic meters in each year (including natural spates and counting one natural spate as one freshet) in such quantities and at such times as may be agreed between the Minister for Agriculture and the Board. The regional fisheries board website provides the following description of the Clady River freshets (http://www.nrfb.ie/fishing/salmon/clady-crolly.htm):

> *The Clady River flows through wild moorland for around 5 miles draining Lough Nacung at Gweedore and flowing through Bunbeg to join the Crolly River estuary. Water is taken from the head of the Clady and channeled to a hydroelectric power station at the mouth of the River Crolly. This means the natural flow of the river has been affected and water is let down the Crolly in 24 freshets between May and September. The* [Claddy] *river flow is controlled by a hydroelectric power station at the head of the river. A total of 18 freshets are let down the river each season to assist fish in ascending the river in addition to the output of the station.*

2.6 Q95 Flow Estimation

Q95 flows in rivers are estimated using the EPA/ESBI karst and non-karst methods for ungauged catchments. The EPA/ESBI methodologies derive 'natural flow' values for streams. Discharge estimates for streams with catchments containing a significant component of conduit karst are derived using the EPA/ESBI Karst Method; discharges for streams with catchments containing all other rock types are estimated using the EPA/ESBI Non-Karst Method.

The data required for each method is presented in the subsequent sections. The tabulated data and the results of the ESBI method for each abstractions catchment are provided in Appendix A.

One limitation of the EPA/ESBI method (Tommy Bree-ESBI, personal communication) is that it does not provide reasonable estimates of Q95 flows in rivers in the first couple of kilometres downstream of lakes. Because of this limitation, we have not determined Q95 flows where the physical setting of the abstraction catchment is dominated by lakes, of which some may be linked with small streams. An example of this setting occurs in the drumlin region in Cavan.

2.6.1 EPA/ESBI Non-Karst Method

The EPA/ESBI Non-Karst method is based on a comparison of the study stream to the five closest reference streams within the EPA/ESBI dataset of 115 non-karst natural streams.

The eight significant hydrogeologic factors for the catchment area in the EPA/ESBI methodology (in descending order of weighting) are:

1. Rainfall (average annual 1961-1990);
2. Percentage of 'made' land;
3. Percentage of high-permeability subsoil;
4. Percentage of poorly-drained soil;
5. Percentage of well-drained soil;
6. Percentage of low-permeability subsoil;
7. Percentage of diffuse karst
8. FARL (flood attenuation from reservoirs & lakes)

FARL is a function of the area of a lake, the area of the subcatchment upstream of the lake and of the total catchment area. For example, flow estimates for the catchment of Lough Ramor would utilize the FARL parameter because Loughs Skeagh, Acurry, Nadreegeal and Drumkeery are located within its catchment.

2.6.2 EPA/ESBI Karst Method

The EPA/ESBI Karst method was developed in the same manner as the EPA/ESBI Non-Karst Method. However, only 11 natural-flow gauging stations are located on streams with conduit karst geology. Thus, the EPA/ESBI Karst method is only used for catchments with significant karst, which was defined as catchments where the percentage of the conduit karst rock type (GIS code = RkcLk) is greater than 45%. In these catchments the Q95 flow is determined by using the average figure of 1.78 for the log of the Q95 flow in mm.

Section 3
Revised Risk Assessment Results

3.1 Revised Risk Categories

Net abstractions for each 'abstractions catchment' were calculated as the total of the abstractions listed in the National Abstractions Register minus total of any known discharges from the National Discharge Register.

The updated abstractions data were used to aggregate total abstractions in an 'abstractions catchment'. This was done for surface-water-only abstractions (those from rivers and lakes) and for surface-water-plus-groundwater abstractions. For the revised river risk assessment, mixtures are included as surface water.

In the case of surface-water-plus-groundwater abstractions, there is an implicit assumption that the groundwater withdrawal occurs from an aquifer hydrologically connected to the surface water catchment. This assumption is reasonable except possibly in areas of conduit karst. The abstractions register was queried to determine the number of groundwater abstractions found in areas of conduit karst (331 of the 2,542 groundwater abstractions); of these, 242 are also located within a surface water abstractions catchment. The total volume of these 242 groundwater abstractions is 73,054 m^3/d. Given the large volume associated with these abstractions, we wanted to include them in the risk assessment, and therefore, decided to account for them in the surface water catchment in which they are located.

RWBs were assigned to a risk category using the method described in Section 1.2.2. The number of RWBs and the total river length in each risk category is provided in Table 3-1. These results are based on the surface-water-only abstractions. Maps showing the results of the revised abstraction risk assessment for Ireland and each RBD are included as Figures 3-1 to 3-7.

Table 3-1: Count of RWBs and Total River Length by Risk Category for the Revised Risk Assessment

Risk Category	Count of RWBs	River Length (km)
2b	4,168	18,486
2a	60	472
1b	141	960
1a	97	525

The majority (>90%) of the RWBs in the 2b (not at risk) risk category either are in river systems with no surface water abstractions or have no abstraction in their upstream catchments. The remaining RWBs in the 2b risk category have a net-abstraction-to-Q95 ratio that is negative or <5%. Section 3.3 discusses negative ratios. Just over 5% of the RWBs were placed into either the 'at risk' or 'probably at risk categories.

Appendix C provides tables with the results of the ratio of net-abstraction-to-Q95 flow and the resultant risk category, for each of the 446 abstraction catchments.

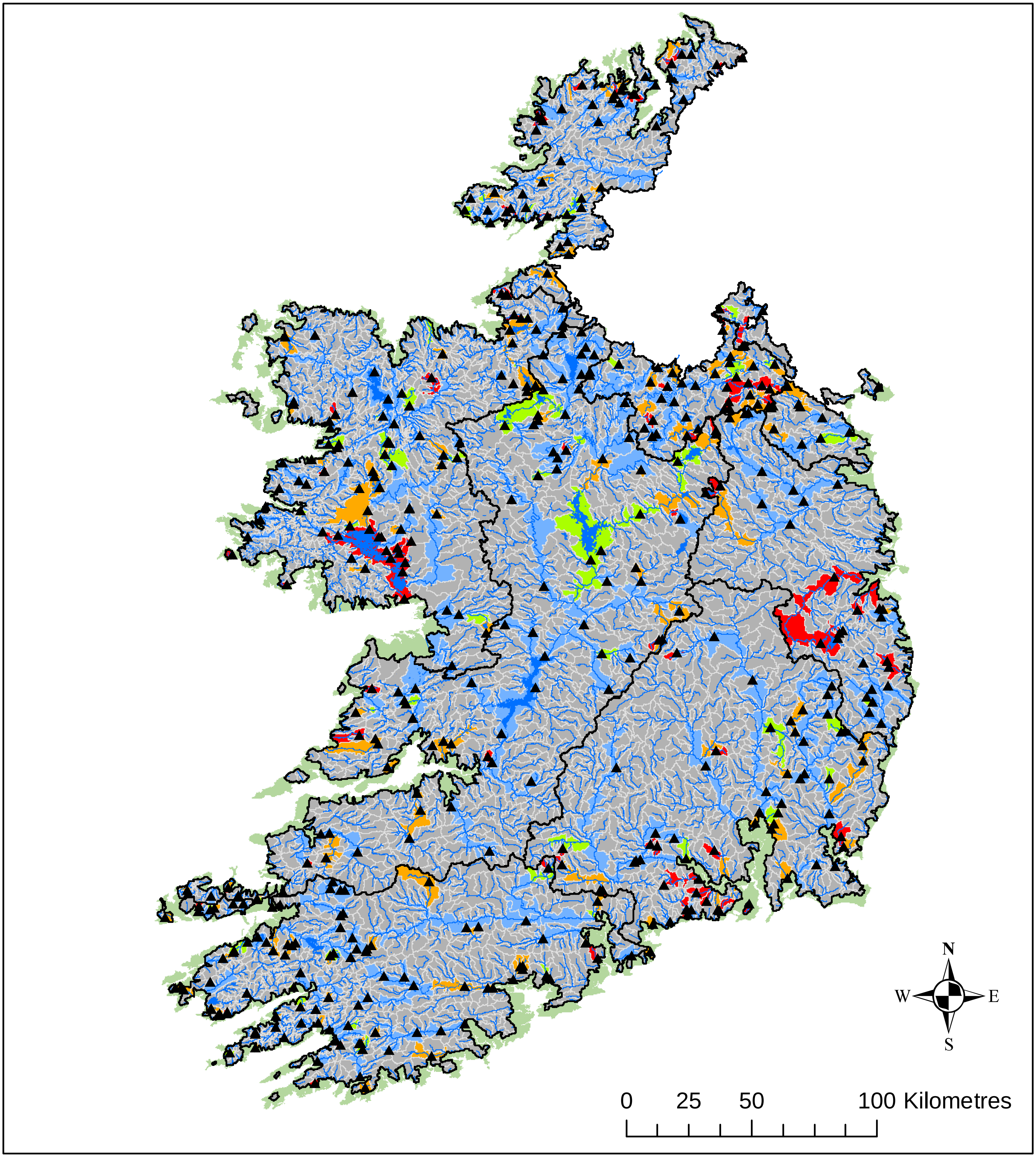

Figure 3-1: Updated Risk Assessment
Abstraction Pressures in Rivers
All RBDs

SW Abstraction
RBD
River
Lake
Transitional
RWB

River Risk Categories
1a - At Risk
1b - Probably At Risk
2a - Probably Not At Risk
2b - Not At Risk
No Abstractions

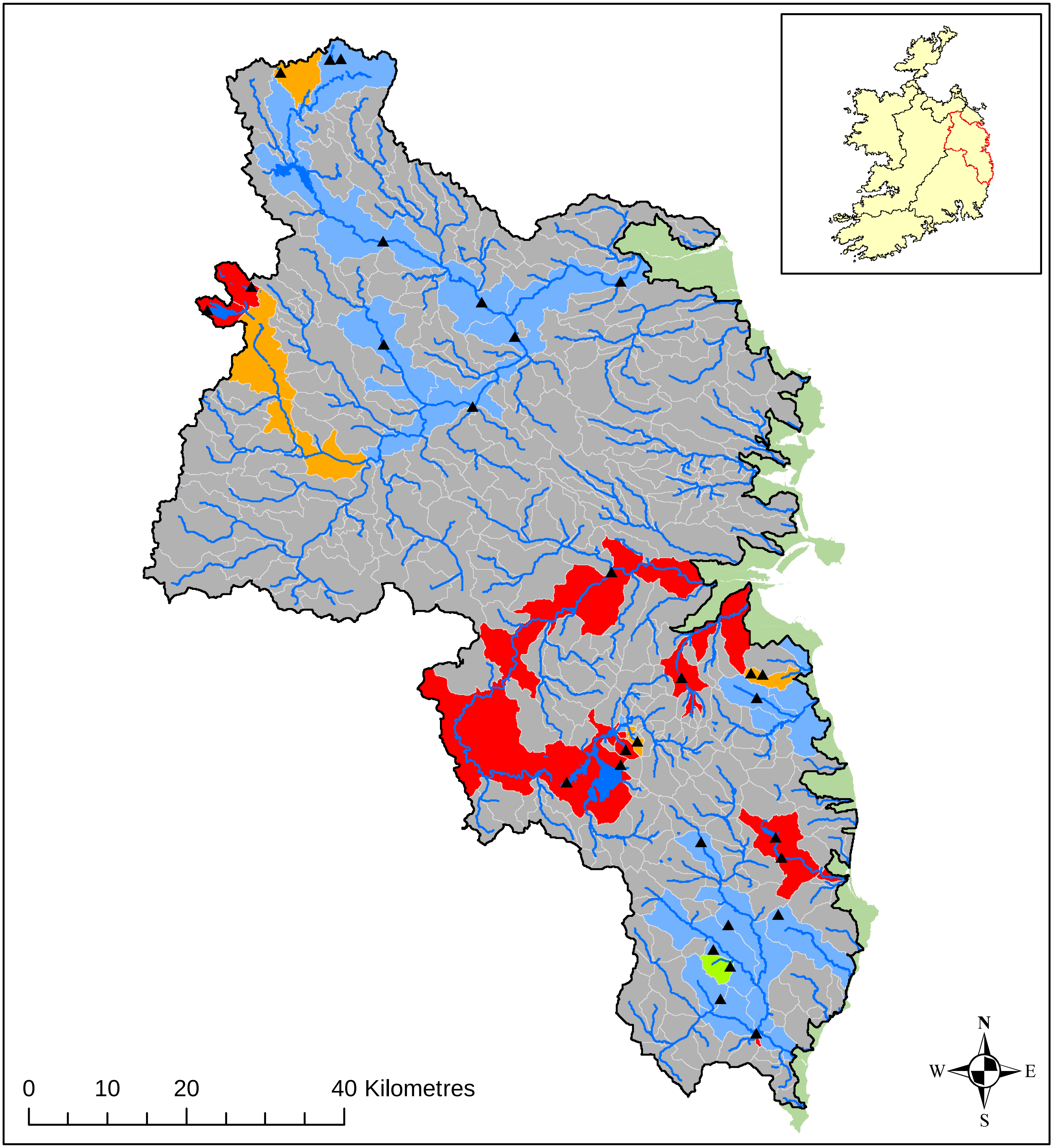

Figure 3-2: Updated Risk Assessment

Abstraction Pressures in Rivers

Eastern RBD

SW Abstraction
ERBD
River
Lake
Transitional
RWB

River Risk Categories
1a - At Risk
1b - Probably At Risk
2a - Probably Not At Risk
2b - Not At Risk
No SW Abstractions

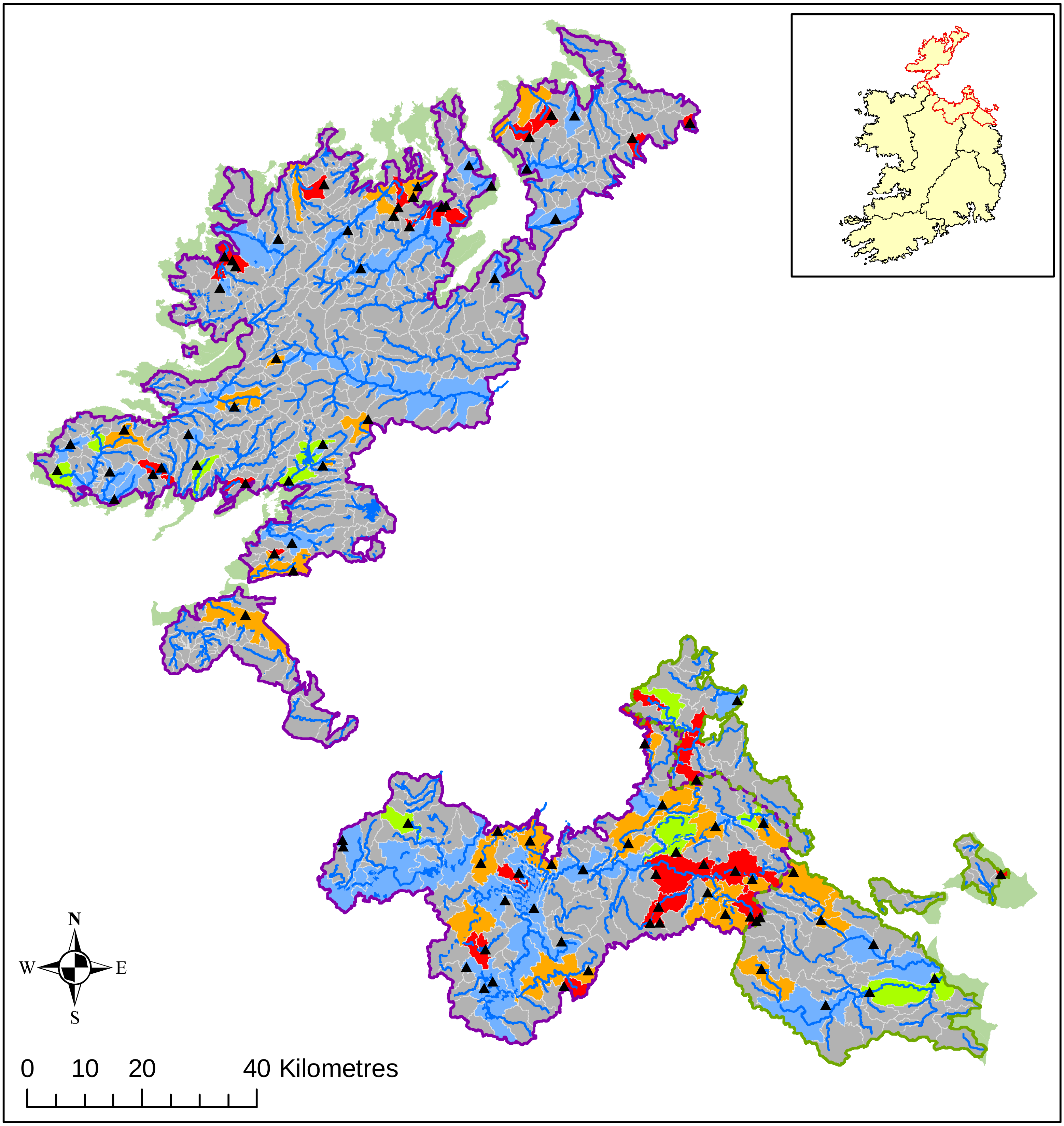

Figure 3-3: Update Risk Assessment
Abstraction Pressures in Rivers
North Western RBD &
Neagh Bann RBD

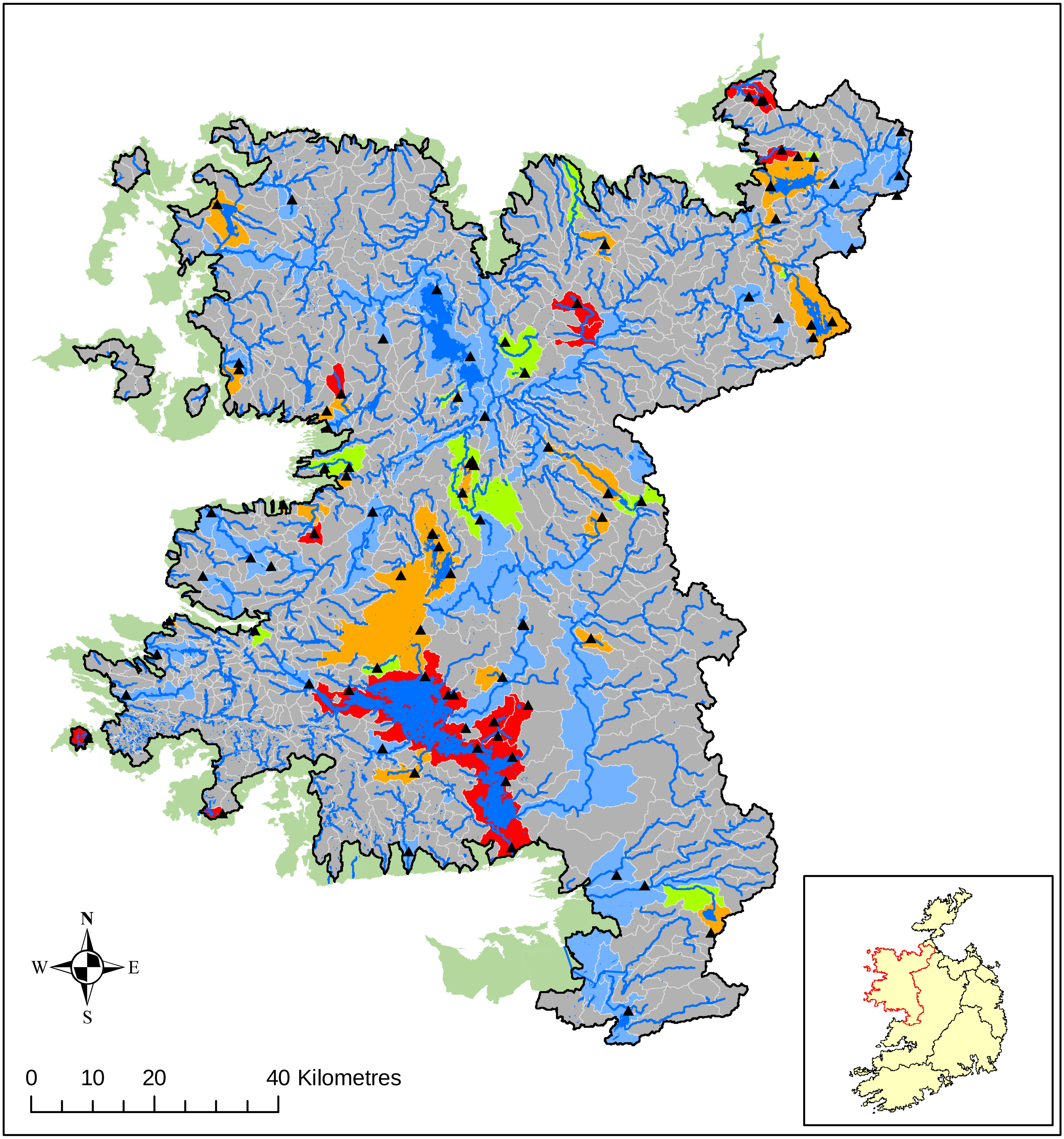

Figure 3-4: Updated Risk Assessment

Abstraction Pressures in Rivers

Western RBD

SW Abstractions
WRBD
River
Lake
Transitional
RWB

River Risk Categories

1a - At Risk
1b - Probably At Risk
2a - Probably Not At Risk
2b - Not At Risk
No Abstractions

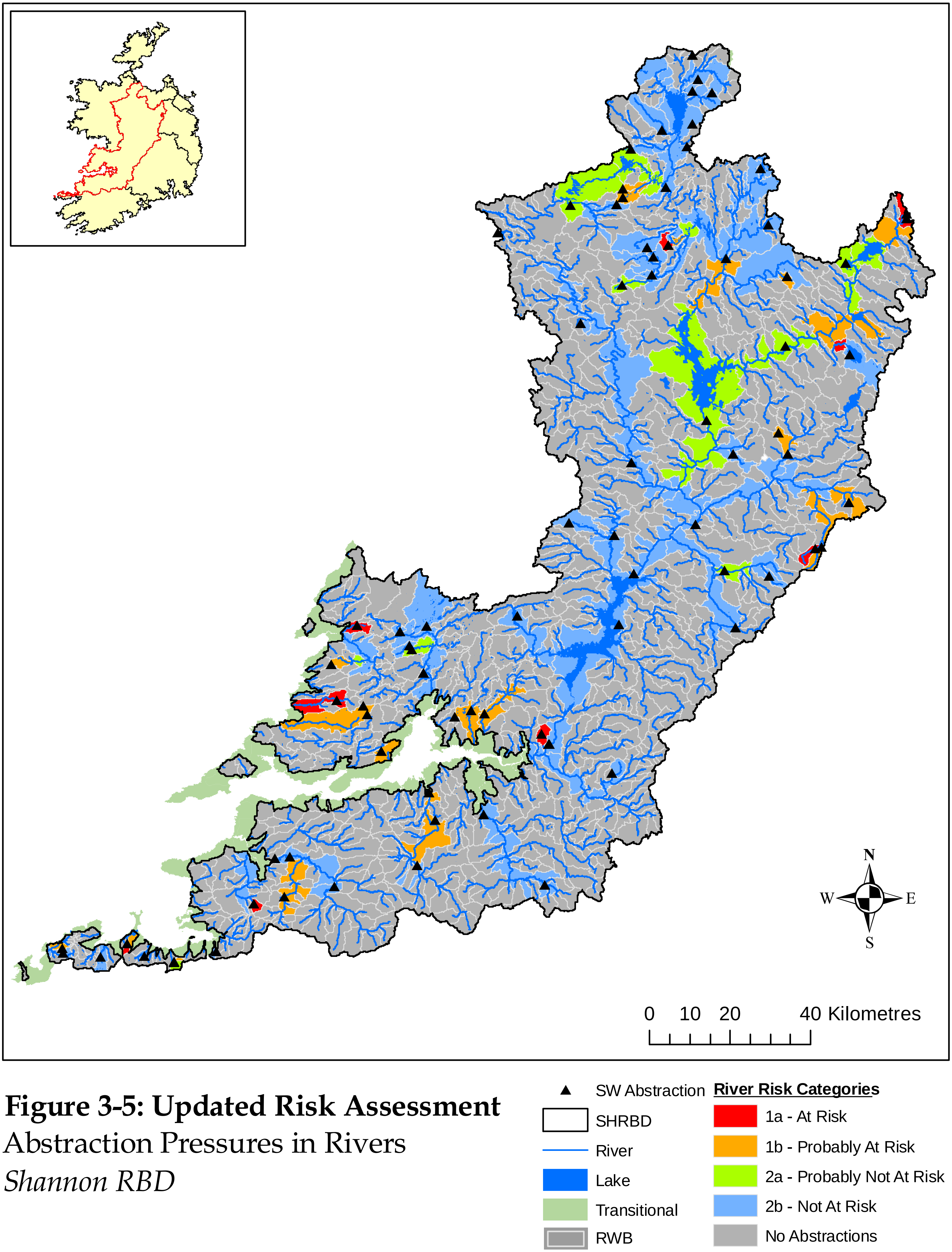

Figure 3-5: Updated Risk Assessment
Abstraction Pressures in Rivers
Shannon RBD

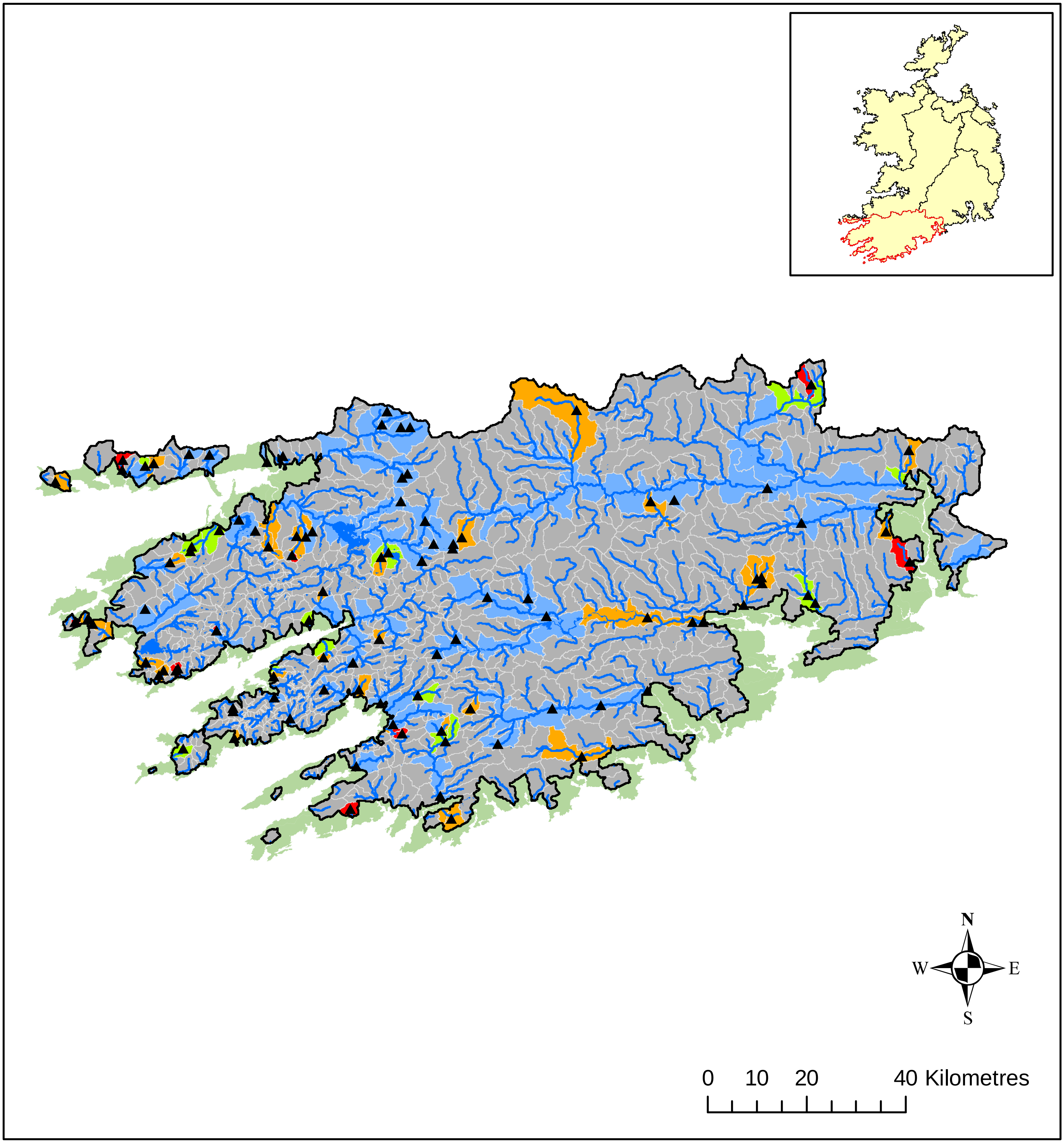

Figure 3-6: Updated Risk Assessment

Abstraction Pressures in Rivers

South Western RBD

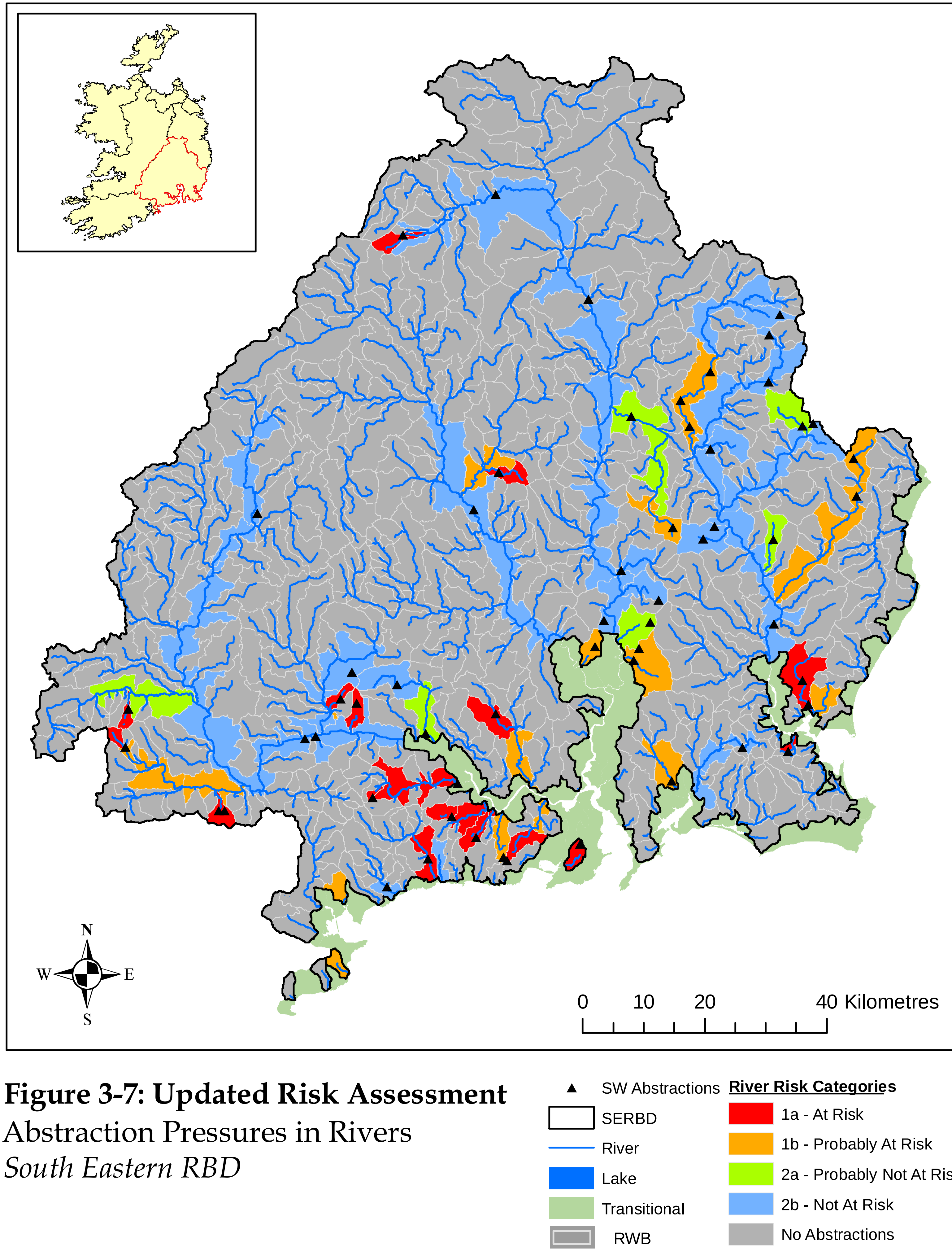

Figure 3-7: Updated Risk Assessment

Abstraction Pressures in Rivers

South Eastern RBD

Individual tables are provided for the abstractions catchments in each RBD. The results are sorted in descending order of the net-abstraction-to-Q95 ratio.

Table 3-2 compares the risk category of 'abstractions catchments' when groundwater abstractions are also taken into account that that for surface-water-only catchments. Overall 38 of the abstractions catchments (about 8%) changed risk categories when groundwater abstractions are considered, suggesting that assigning risk on the basis of surface-water-only abstractions is generally reasonable. Seven abstractions catchments moved to the 1a 'at risk' category, five of these were previously evaluated 'probably at risk'. Of the 17 catchments that moved to the 'probably at risk category', ten were previously in the 'probably not at risk' category, while seven were previously 'not at risk.' Examples of abstractions catchments where groundwater abstractions have a larger impact on abstractions pressure are discussed in Section 4.

Table 3-2: Count of Abstraction Catchments by Risk Category for Surface-Water-Only and Surface-Water-plus-Groundwater Abstractions

Risk Category	Surface-Water-Only Abstractions	SW + GW Abstractions
2b	174	152
2a	47	50
1b	120	132
1a	105	112

3.2 Comparison to Previous Risk Assessment Results

Table 3-3 compares the number of RWBs in each risk category for the revised risk assessment to the initial characterisation results. While overall there appear to be only small changes, it must be remembered that most RWBs are in river systems that do not have surface water abstractions.

Table 3-3: Comparison of Initial and Revised Risk Assessment Results

Risk Category	Initial Risk Assessment	Revised Risk Assessment
2b	4,201	4,168
2a	64	60
1b	107	141
1a	95	97

In general, the results shown in Table 3-3 indicate a trend toward increased risk. However, it is difficult to attribute significance to the change in risk categories because of the fundamentally different approaches used to estimate Q95 flows that underpin the analyses. The revised river risk assessment differs from the Initial Characterisation because it uses catchment-specific Q95 values and evaluates abstraction pressures in a hydrologically significant manner (*i.e.*, starting at the headwaters of river systems and moving downstream).

3.3 Data Gaps and Limitations

Derivation of the revised risk assessment using net-abstraction-to-Q95 ratio is subject to several sources of error. The most significant potential sources of error appear to be the accuracy and completeness of the data for abstractions and for discharges within the catchments. Significant effort was expended by this project to update the abstractions register, and by the SWRBD on the discharges registers. However, the records remain incomplete, and many could be out-of-date or have inaccurate volumetric, population or location data.

3.3.1 Abstractions Data

The abstraction data used in this study is based on that used for the 2005 Initial Characterisation; enquiries were then made to both RBDs and Local Authorities to validate or update existing information and add missing abstractions. The register of surface water abstraction is thought to include most public and group water schemes, but many small private abstraction schemes (*e.g.*, industries, schools, hospitals, farms) are not captured in the register. Section 4 discusses examples of known discharges for which a paired abstraction is not included in the abstractions register.

Apart from the potential for omission of an abstraction in the register and for the inclusion of an inactive abstraction, the location data (Easting and Northing) present another potential source of error. The location data for many surface water abstractions are not considered accurate, and in some instances are known to be in error by several hundred meters. For instance, the location of several surface water abstractions as far from any known surface water feature (river network or lake). Similarly, some abstractions noted as using a lake as source water do not plot near the named lake. In some cases, the northing/easting data may denote the location of the water treatment plant, while in other cases the abstractions may simply be misplaced. The location data in the national abstractions database should be improved upon by the responsible bodies.

Data on abstraction volumes are also not well known. In most instances a single volume is provided, which could represent an average or maximum flow for the current or design period. In 20 cases, either only the population served is reported or no metric is given.

3.3.2 Discharge Data

A significant limitation of the discharge data used in this analysis is that many of the volumes are based on licensed values, not actual discharges. There are several examples where actual discharges are considerably lower than licensed values.

As with the abstractions register, the discharge data for the IPPC and Section 4 industries are incomplete. Improvements are needed to complete the database of discharge data including accurate information on the receiving water body, the discharge point, current discharge, and licensed discharge.

It is likely that many industrial abstractions are balanced by the corresponding discharges, with no significant quantitative effect on the watershed. Industrial discharges may include a component of public water supply derived from outside the watershed, resulting in a net discharge. This level of information should be reviewed for significant industrial water users.

Section 4
Use of Revised Risk Assessment Results

The revised risk results provide a better assessment of abstractions pressures on Ireland's rivers than those in the Initial Characterisation (2005). The results can be used to identify RWBs and river systems where an abstraction(s) may be causing an impact to the ecological health of the stream. In this way the results can assist RBD projects in targeting programmes of measures to address abstraction pressures which are having a negative impact.

The revised risk assessment results can both potentially underestimate and overestimate risk from abstraction pressures in some catchments. This stems from limitations in data available as inputs for this work and from the methodology itself. This section provides some examples of (1) how data inputs and/or limitations can lead to understating or overstating the risk from abstraction pressures in an individual RWB, and (2) programmes of measures to address RWBs at risk from abstraction pressures.

The assessment of abstraction pressures in rivers should be an ongoing process. Reassessment should occur as better data become available for abstractions and discharges, as well as improvements in low flow data estimation techniques.

4.1 Potentially Understated Risks

Risk can potentially be understated as follows: (1) if the abstraction is located in the headwaters of an RWB, (2) if the discharges register includes a discharge for which there is probably a paired abstraction, but no such abstraction is included in the abstractions register, or (3) if the catchment has a groundwater abstraction that discharges to surface water.

An example of the first case is easiest to explain assuming the RWB containing the abstraction of interest and its catchment are coincident. Because the RWB is the basis for the abstractions risk analysis, the Q95 flow is calculated using the entire area of the RWB/catchment. When the abstraction is located in the headwaters or upper portion of the RWB, a smaller portion of the catchment actually contributes baseflow (that supports the Q95 flow) at the point of abstraction (*i.e.*, the Q95 flow is smaller at the point of the abstraction than at the end of the RWB). The net-abstraction-to-Q95 ratio would be larger if the evaluation was made at the point of the abstraction (because the Q95 flow is smaller), potentially understating the risk for that abstraction.

An example of the second case is the Milbrook salmon hatchery located in 'abstractions catchment' ABS_NW0080. This Section 4 licensed discharge (7200 m^3/day) is much larger than that catchment's total abstractions (208 m^3/day), resulting in a negative net-abstraction-to-Q95 ratio. It is likely, however, that the salmon hatchery obtains its water from the same catchment to which it discharges, probably with little consumptive use. If true, the abstractions in this catchment would be understated and the actual net-abstraction-to-Q95 ratio would be positive. Currently abstractions catchment ABS_NW0080 is judged 'not at risk'; depending on the size of the unknown abstraction for the salmon hatchery, this risk is potentially understated.

Quarries pose a related problem in the assessment of abstractions pressures but here the understated risk occurs because of (1) possible errors or omissions in the abstractions and/or discharges registers and (2) not including groundwater abstractions in the risk assessment. Quarries generally abstract groundwater to dewater the working part of the mine and discharge to pumped flow to a surface water, typically with little consumptive use. Comparison of available data on quarry abstractions and discharges shows that the difference is often quite large. An example of this occurs in abstractions catchment SE_ABS0146, for which the register has an groundwater abstraction for the Lisheen Mine of 65,536 m^3/d. The discharges in this catchment include: 25,000 m^3/d for the Lisheen mine, two IPPC licencees that discharge an aggregate of 10,000 m^3/d, and a WWTP at 1,800 m^3/d. The discharges total 36,800 m^3/d. Thus on the basis of surface-water-only net abstractions, this RWB is 'not at risk' from abstraction pressures, but when groundwater abstractions are considered there is a significant net abstraction (28,736 m3/day). If the groundwater abstraction is included in the net-abstraction-to-Q95 ratio, abstractions catchment SE_ABS-0146 would have been placed in the 'at risk' categories for abstractions pressure.

4.2 Potentially Overstated Risks

Risk from abstraction pressures, on the other hand, can be overstated if (1) the catchment has an abstraction and a corresponding discharge but that discharge is not included in the discharges register (e.g., the discharge data for IPPC and Section 4 license holders is known to be incomplete) or the discharge volume is inaccurately low, or (2) in cases where RWB configurations do not change at the confluence of two streams.

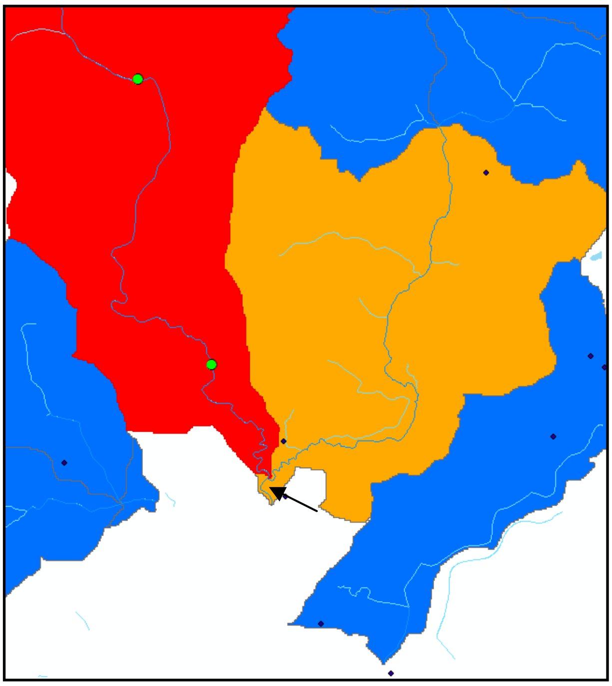

Figure 4-1: Updated Risk Results for the River Sow, Wexford

Figure 4-1 is an example of potentially overstated risk due to RWB configurations. The figure shows that two branches of the River Sow join together just prior to flowing into Wexford Harbour. The RWB on the west has two abstractions (green circles) and was assigned the risk category 1a (at risk; the red catchment) because the net-abstraction-to-Q95 ratio is 56%. The RWB on the east has no abstractions, however, it is assigned a risk category of 1b (probably not at risk;

the orange catchment) because its net-abstraction-to-Q95 ratio is 38%. This occurs because the westerly RWB is tributary to the easterly one and thus the reduced flows in the westerly catchment affect the flows in the main River Sow downstream of the confluence (section indicated by the arrow). The risk for the entire easterly RWB is thus elevated and overstated along most of its length because of the configuration of the RWBs.

4.2 Programmes of Measures

The cost of returning a water body affected by abstractions to good ecological status is likely to be significant and could require more than one cycle to implement. Programmes of measures for abstraction pressures fall into several categories, which are discussed in subsequent sections:

1. Modernising abstractions legislation and regulations

2. Addressing data limitations and additional monitoring needs

3. Specific measures for rivers affected by regulated flows

4. Site-specific measures that either focus on decreasing the abstraction of water or increasing the quantity of water in the RWB.

5. Education, further studies or research programmes

4.2.1 Modernising Abstractions Legislation and Regulations

Ireland's current institutional arrangements to support the evaluation of the effects of surface water abstractions need to be modernised. The primary governing legislation for water supplies (Water Supplies Act, 1942) does not consider environmental issues. Environmental impact assessment is not generally required for abstraction projects although significant abstractions are de facto subjected to environmental assessment using the Water Supplies Act.

In addition, the Water Framework Directive requirements for abstractions include:

Article 7 - Identifying all bodies of water abstracted with the intended use of human consumption providing more than 10 m^3/day as an average or serving more than 50 people, and those bodies of water intended for such use,

Article 11.3(e) – Having "controls over the abstraction of fresh surface water and groundwater, and impoundment of fresh surface water, including a register or registers of water abstractions and a requirement for prior authorisation for abstraction and impoundment. These controls shall be periodically reviewed and, where necessary updated. Member states can exempt from these controls, abstractions and impoundments which have no significant impact on water status."

Modernisation of Ireland's statutes and regulatory practices could include:

- Responsibility for a comprehensive, national register of abstractions being transferred to the EPA or another agency

- Developing and implementing a system of licensing abstractions, with accompanying thresholds for registration and licensing
- Establishing metrics for instream flows (or tool to decide these)

Guidance on a licensing programme for groundwater abstractions has been developed under another task of this project.

4.2.2 Addressing Data Limitations and Additional Monitoring Needs

The process of developing the revised risk assessment highlighted many data gaps in the information needed to assess potential impacts. The programme of measures addressing abstraction pressures must first address the basic data needs, including data on the presence, location and volume of surface water and groundwater abstractions.

Basic information could be obtained by requiring the registration of all abstractions. Even if abstraction legislation is not updated, Section 23 of the Local Government Act allows that Local Authorities can serve notice to any person abstracting water, requiring specified information to be provided. While this data can be collected and maintained on a local basis, it also needs to be regularly aggregated and updated into a national register. A harmonisation with the requirements of the registration programme recently implemented in Northern Ireland would serve as an excellent starting point. At a minimum, the registration should include:

- Accurate location (Northing and Easting) information on the abstraction point itself, preferably gathered using GPS.
- Current annual average and maximum daily abstraction rates for individual abstractions
- Design capacity of the water supply scheme
- Source type (river, lake, reservoir, spring, groundwater etc.)
- Name of the water body being abstracted, along with its Water Framework Directive code.

There also needs to be a programme to update this register on a regular basis. The updates should include inclusion of abstractions formerly omitted and removal of inactive abstractions.

The ongoing assessment of abstraction pressures will require up-to-date information on the volume of water abstracted, and thus, a programme to collect (or make available currently collected) data on daily abstraction volumes should be implemented.

Similarly, the national database of discharges should be updated to include all discharges, including the name of the receiving water body and accurate coordinates of the discharge location. The discharge register should also be updated regularly to include changes in average discharge rates, add discharges not previously included, and remove inactive discharges. Where the discharge data is being determined using population equivalents, necessary steps should be taken to allow measurement of WWTP flow. Actual daily WWTP discharges should be measured in lieu of using the estimation methods based on the population served by the plant.

Improved hydrometric data is also needed for in small (<20 km^2) catchments. In addition to adding new stations, the existing stations can be reviewed to determine if improved stage-discharge relationships would allow for better estimation of low flows.

A modern abstractions regulatory programme will require the ability to know in real time or extrapolate from existing gauges the flow in rivers being abstracted. The hydrometric network should be reviewed to determine if additional stations are needed.

The companion report on abstraction pressures in lakes provides the additional data needs for these abstractions.

4.2.3 Specific Measures for Rivers affected by Regulated Flows

The following rivers have regulated flow because of impoundment and risk assessment results that suggest the downstream RWBs are at risk or possibly at risk from abstraction pressures.

- River Dodder downstream of the Glenasmole Reservoirs
- River Liffey downstream of Pollaphuca, Golden Falls and Leixlip
- River Varty downstream of the Varty Reservoirs

Specific measures proposed for these RWBs include setting or re-examination of compensation flow requirements (described in Section 2.5). The compensation flows should be established to support the ecology of the river and include, as needed, requirements for minimum flows, freshets, and other releases. When assessing the compensation flows consideration should be given as to whether the river is proposed as Heavily Modified since the target ecology will be different (*i.e.* good ecological potential rather than good ecological status).

4.2.4 Site-specific Measures

Where abstractions are causing impacts, measures to remedy those impacts will need to be determined on an abstraction specific basis. In general measures reduce the abstraction pressure by (1) reducing water demand or (2) making more water available in the catchment. Table 4-1 provides a menu of measures that managers will need to evaluate to determine the best approach for each abstraction scheme.

Table 4-1: Menu of Site-specific POMs to Reduce Impacts of Abstraction Pressures

Control Demand/Decrease Abstraction	Increase Water Available in RWB
Reduce leakage/unaccounted for water in water supply transmission/ distribution systems building on the national water leakage reduction programme that is being implemented under the Water Service Investment Programme to support sustainable water use	Establish minimum environmental flows for rivers and evaluate current abstractions against them (includes the re-evaluation of existing compensation flows)
Implement (or expand current) water conservation programmes for domestic and industrial sectors	Where feasible in developed areas, promote infiltration of stormwater runoff (e.g. sustainable urban drainage schemes – SUDS)
Modify plumbing codes to support water conservation	Promote water re-use of grey water and treated wastewater
Support for voluntary initiatives such as water conservation and rainwater harvesting schemes	Identify and build infrastructure to develop alternative water sources
Investigations of implementing a number of smaller water supply schemes so that the abstracted volume from any one water body can be reduced	Identify and build infrastructure to store water as a supplemental supply when river flow is too meagre to be abstracted
Reducing current abstractions particularly at times critical for stream ecology by altering abstraction timing, managing available water resources conjunctively, or withdrawing abstraction volume	Introduction of a new code of water conservation good practice – this could be used as a planning condition for all operations including private or unregulated activities in high status or protected areas.
Daily metering of abstractions themselves	Implement more small schemes to reduce the demand in any given catchment
Water metering programmes and water charging programme for residential customers	
Impose restrictions on new developments in areas where abstraction capacity has been reached until further upgrade of facilities is put in place, demand has been reduced, or new supplies, operation schemes, or facilities (e.g., storage) have been identified and built	

4.2.5 Education and Research Needs

The following education and research projects are also recommended:

- Information awareness campaigns on water conservation, rainwater harvesting, and sustainable drainage programmes
- Determine instream flow needs for rivers outside of the Central Plain region

Section 5
References

McCarthy Hyder Consultants. 2003. Dublin Water New Sources Development: Ballyboden Water Treatment Works Source Report (Draft). Prepared for Dublin City Council.

Veolia Water and RPS. 2006. Greater Dublin Water Supply – Major Source Options Draft Feasibility Study. Prepared for Dublin City Council.

Working Group on Characterisation and Risk Assessment. November 2004. *Guidance on Thresholds and Methodology to be Applied in Ireland's River Basis Districts: WFD Surface Water Hydrology Risk Assessment Method.*