Lunan Monitored Priority Catchment Project

Environmental Focus Farms (SAC led)

Project aim: to assess what is *effective and proportionate mitigation* of pollution impacts in a catchment :

(a) representative of typical mixed arable land use in Scotland
(b) where water bodies are considered at risk.

Monitoring and Regulation (SEPA led)

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Main SEPA contributors: Jonathan Bowes, Jeanette Macdonald, Fiona Napier, Deborah Ballantine, John Shabeshow

Main SAC contributors: Carole Christian, Bill Jeffrey, Alex Sinclair, Ioanna Mouriatidou, Andy Barnes

Classification of water environment under EU Water Framework Directive

Surface water bodies		Heavily modified surface water bodies		Groundwater Bodies	
Ecological status	Chemical status	Ecological potential	Chemical status	Chemical status	Quantitative status

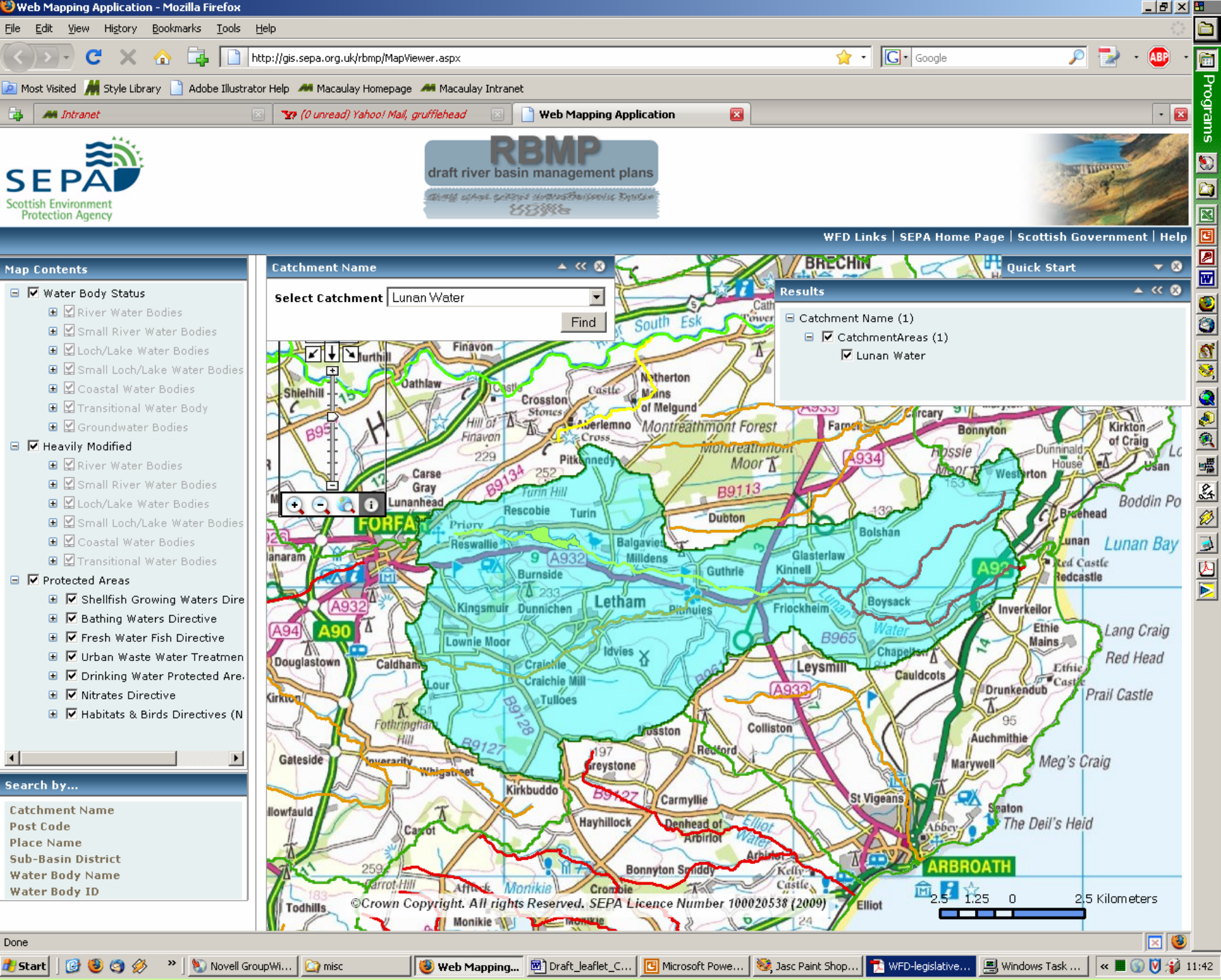
Loch classification (by area)

	High	Good	Moderate	Poor	Bad
Overall ecology	**18%**	**21%**	**22%**	**38%**	**2%**
Total P	**47%**	**32%**	**15%**	**2%**	**0.1%**

Total: 960 km^2

309 water bodies

http://www.sepa.org.uk/water/river_basin_planning.aspx/annex2


Web Mapping Application - Mozilla Firefox
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Web Mapping Application
SEPA
Scottish Environment Protection Agency
RBMP
draft river basin management plans
WFD Links | SEPA Home Page | Scottish Government | Help
Map Contents
Water Body Status
River Water Bodies
Small River Water Bodies
Loch/Lake Water Bodies
Small Loch/Lake Water Bodies
Coastal Water Bodies
Transitional Water Body
Groundwater Bodies
Heavily Modified
River Water Bodies
Small River Water Bodies
Loch/Lake Water Bodies
Small Loch/Lake Water Bodies
Coastal Water Bodies
Transitional Water Bodies
Protected Areas
Shellfish Growing Waters Dire
Bathing Waters Directive
Fresh Water Fish Directive
Urban Waste Water Treatmen
Drinking Water Protected Are
Nitrates Directive
Habitats & Birds Directives (N
Search by...
Catchment Name
Post Code
Place Name
Sub-Basin District
Water Body Name
Water Body ID
Catchment Name
Select Catchment
Lunan Water
Find
Quick Start
Results
Catchment Name (1)
CatchmentAreas (1)
Lunan Water
BRECHIN
FORFAR
ARBROATH
Letham
Leysmill
Montreathmont Forest
Montreathmont Moor
Lunan Bay
Red Head
Prail Castle
Meg's Craig
The Deil's Heid
©Crown Copyright. All rights Reserved. SEPA Licence Number 100020538 (2009)
2.5 1.25 0 2.5 Kilometers
Done
Start
Novell GroupWi...
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Web Mapping...
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Microsoft Powe...
Jasc Paint Shop...
WFD-legislative...
Windows Task ...
11:42

Pressures in Lunan Catchment

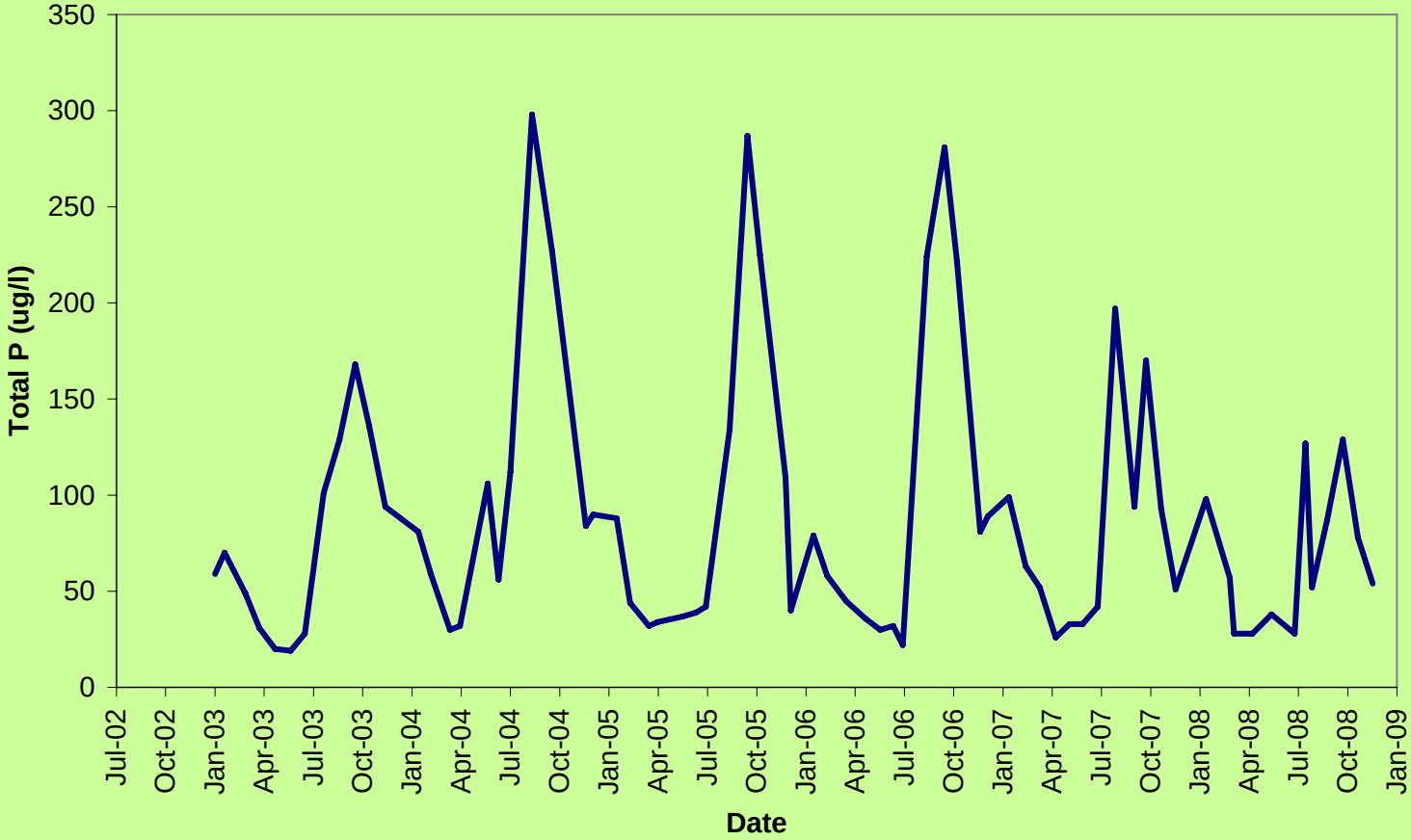
Impacts in Lunan Catchment

- **Rescobie and Balgavies Lochs have poor/moderate Ecological and chemical status**
- **Groundwater and Lunan Water has high nitrate concentration**
- **Lunan Water has poor salmon and sea trout numbers and moderate ecological status**

Lunan Water downstream of Balgavies Loch: late summer 2009

Aphanizomenon sp.

Late summer/Autumn TP peaks in Rescobie Loch



TP concentration in outlet to Rescobie

Restoration targets for Rescobie Loch

Targets for P input reductions

Loch total P concentration (annual geomean)	**70**	**µg P/L**
Good Status total P concentration	**27**	**µg P/L**
Total load reduction needed	**366**	**kg TP/year**

Equivalent to external source of:

tonnes of soil	**~360**	**tonnes**
septic tanks with P filter added	**~120**	**household**

Lunan Monitored priority catchment research

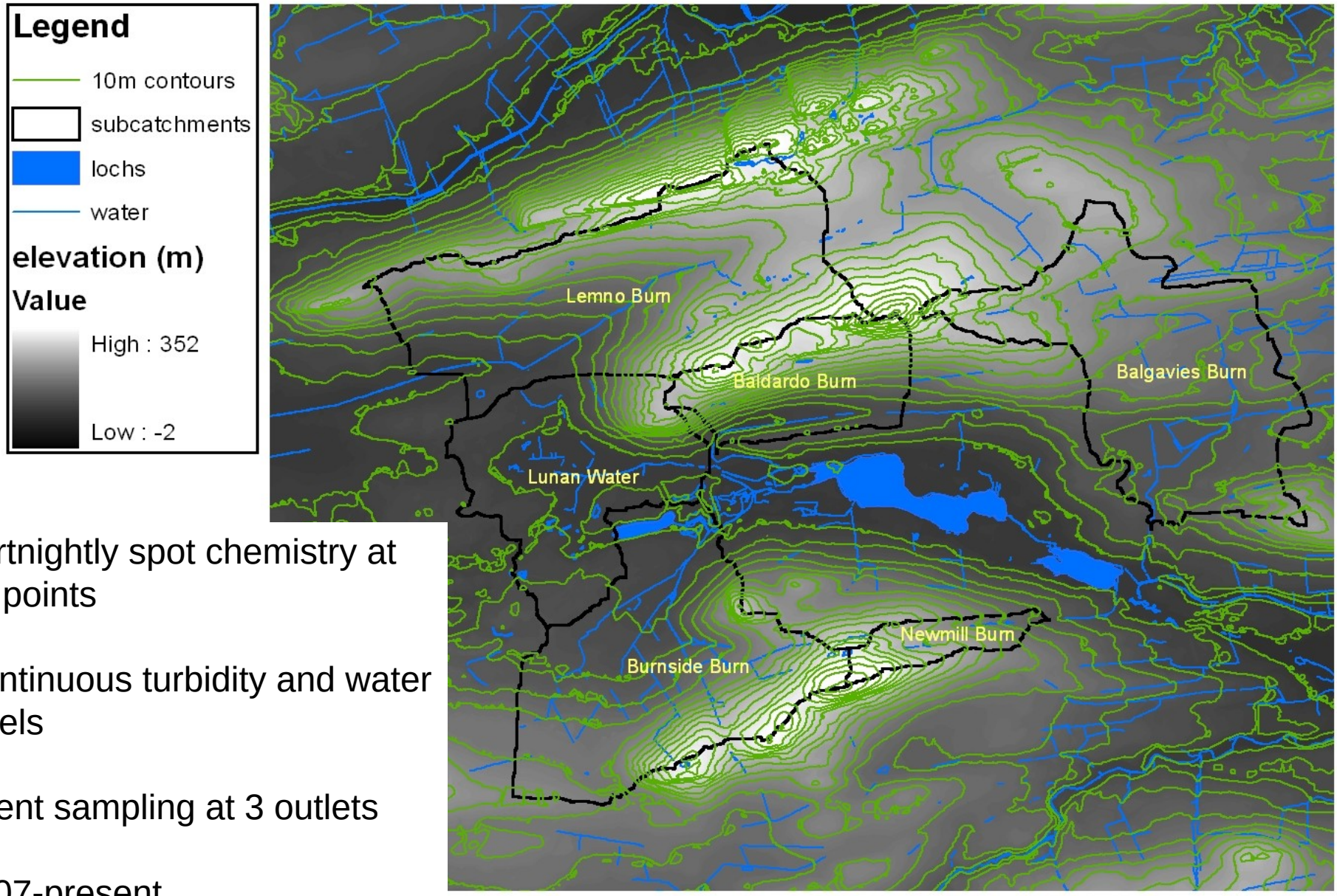
2006-2008 Baseline characterisation

2009 Diffuse Pollution audit

2009-2011
Mitigation Measures:
identification,
agreement,
funding,
implementation

Chemical monitoring and ecological characterisation

Farmer Focus groups



Fortnightly spot chemistry at 10 points

Continuous turbidity and water levels

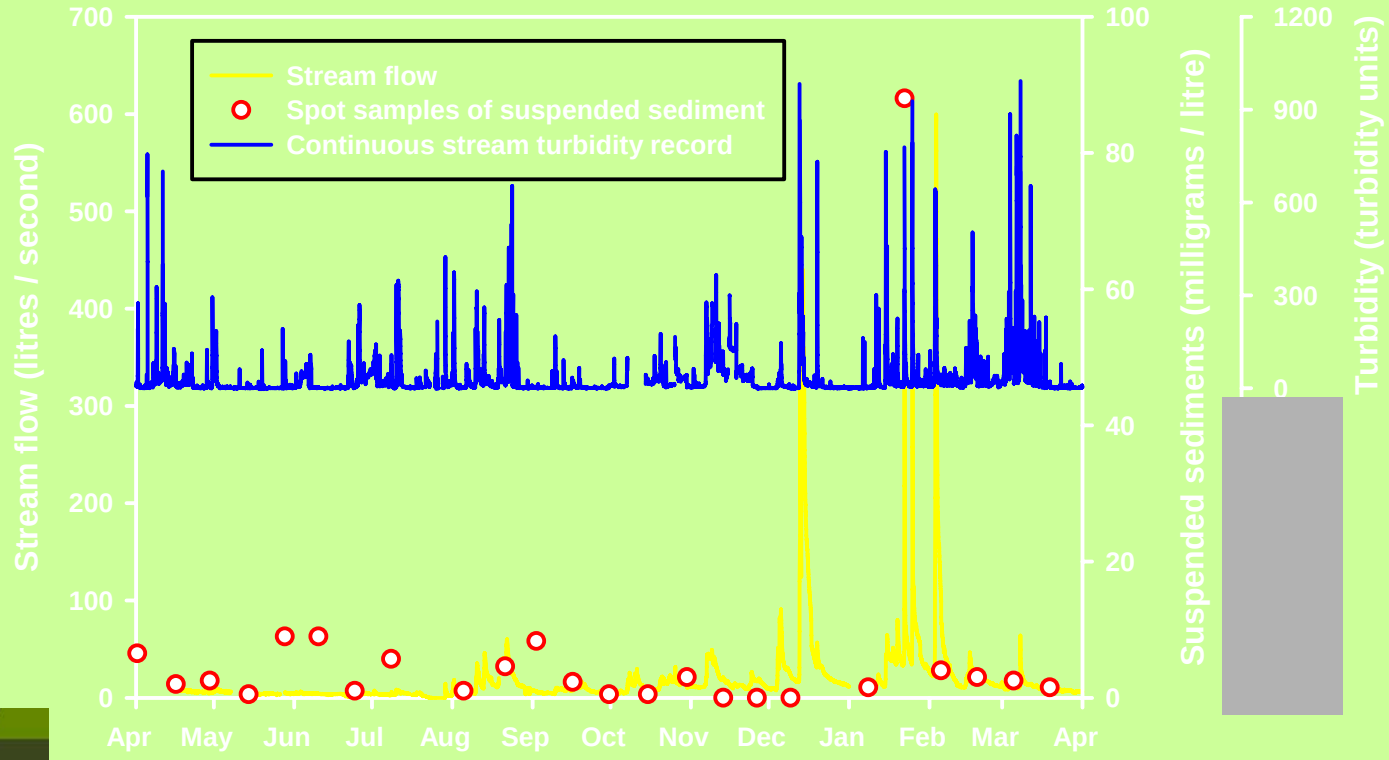
Event sampling at 3 outlets

2007-present

Monitored subcatchments

The requirement for high temporal resolution monitoring

Turbidity *(light scatter proportional to the number and size of particles present)* is a parameter which can be measured continuously



Approaches to assessing diffuse pollution of Rescobie and Balgavies Lochs

1. **Use event turbidity and discharge data directly to assess changes post-mitigation**
2. **Calibrate turbidity vsTP using event data to estimate TP annual loads vs targets**
3. **Use event TP data directly to estimate TP loads vs targets**

Multivariate model of paired catchment response to pollution mitigation treatment

$$\ln(T_{treat,i}) =$$

$$a + b\ln(T_{notreat,i}) + c\ln(peakQ_i) + d\ln(Q_i) + e(treat_i) + \varepsilon_i$$

Where

$T_{treat,\,i}$ = turbidity load in treated catchment, for event I

$T_{notreat,\,i}$ = turbidity load in treated catchment, for event I

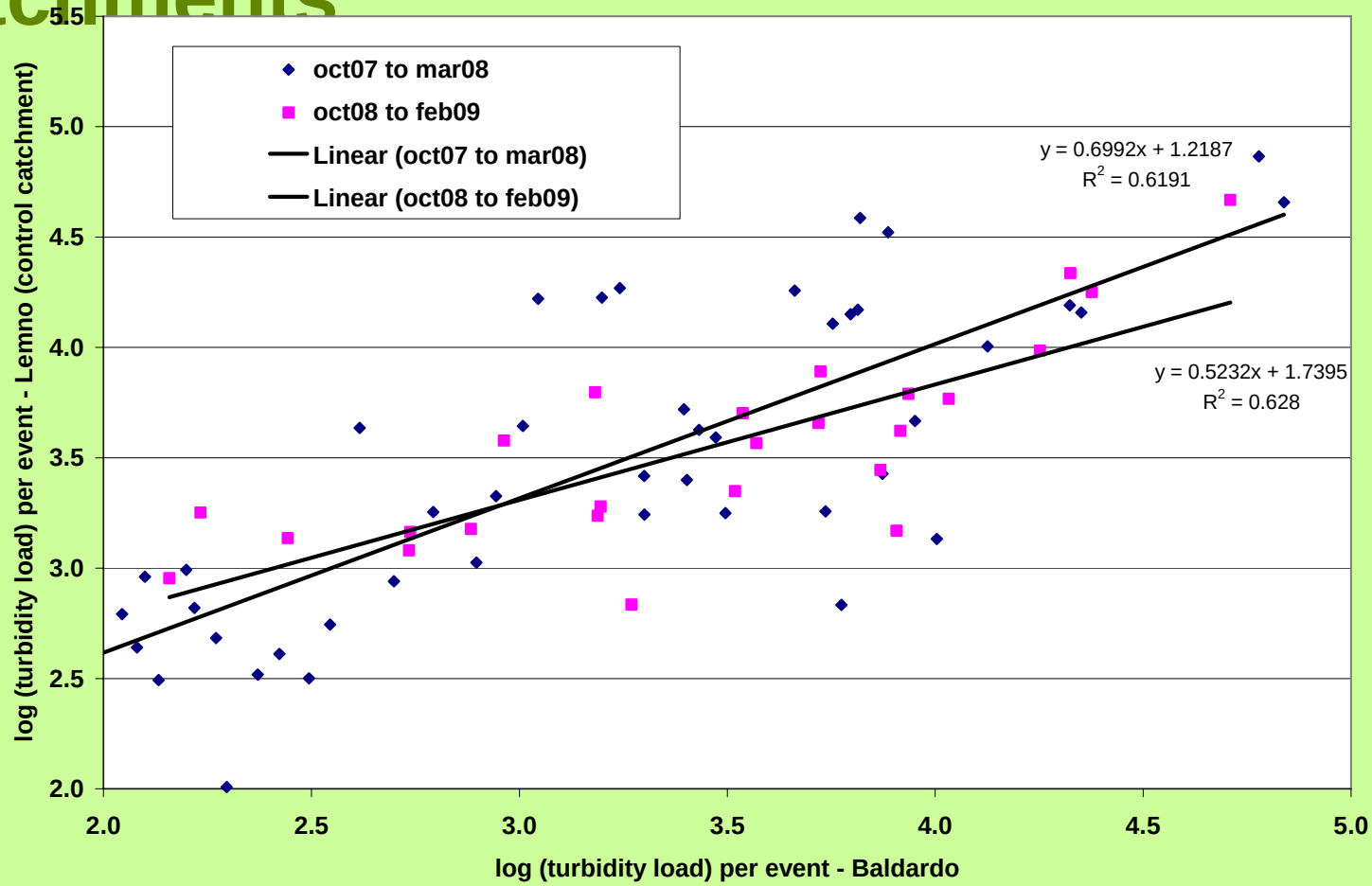
$Peak\ Q_i$ = peak discharge for event I

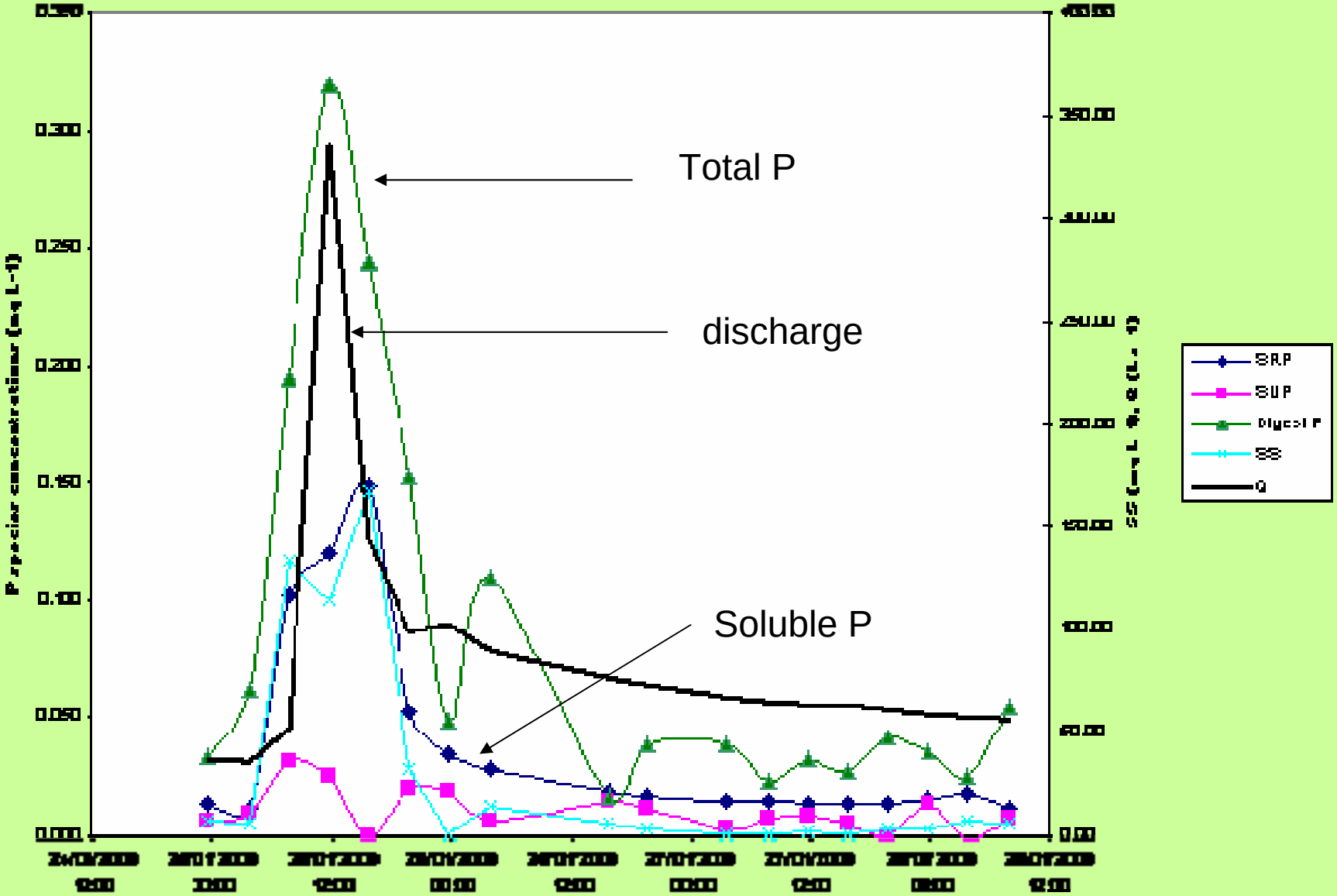
Q_i = total discharge for event I

$Treat_i$ = treatment index variable (0 before treatment, 1 after treatment)

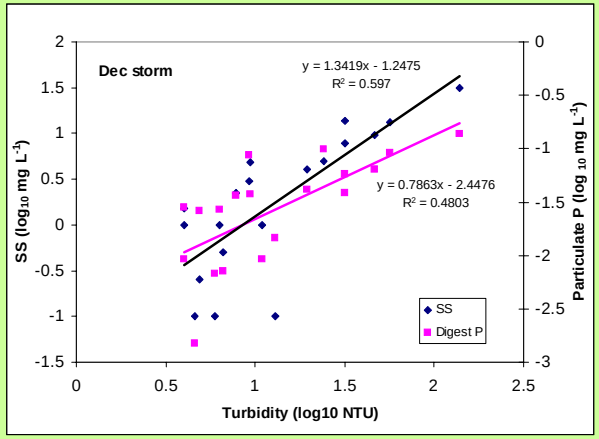
J Environ Qual 34:1087-1101 (2005)

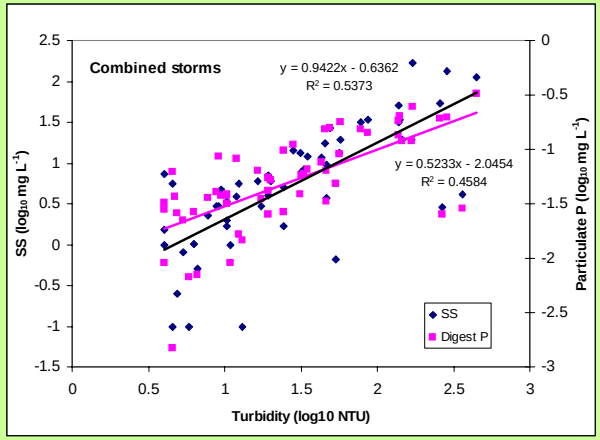
Log-log plot of turbidity load for paired events on Lemno and Baldardo catchments

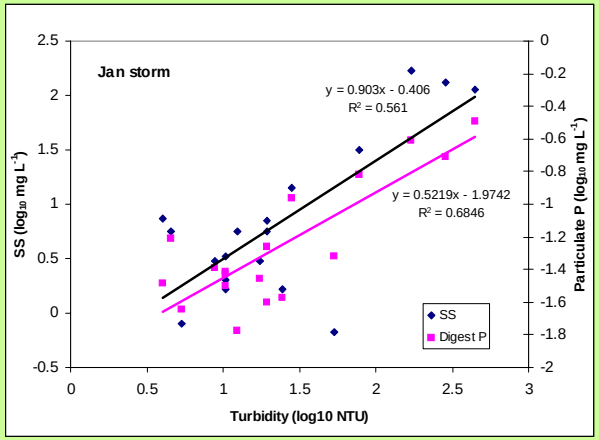


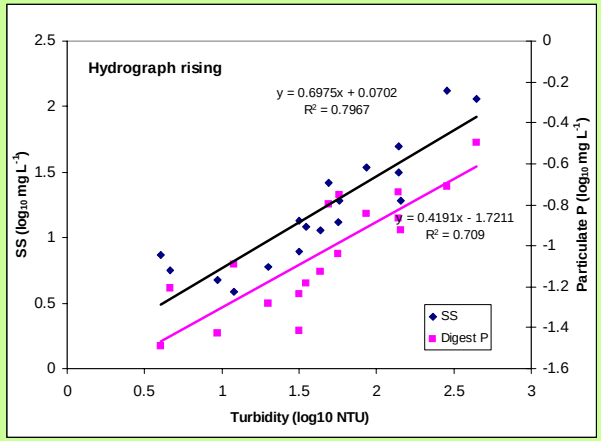

Total P
discharge
Soluble P
SRP
SUP
Digest P
SS
Q

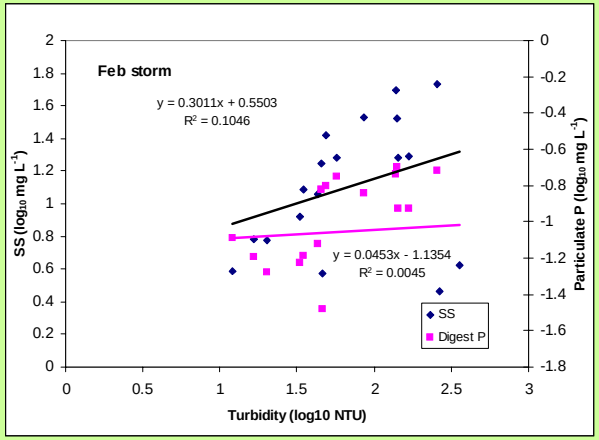
Total P vs turbidity calibrations

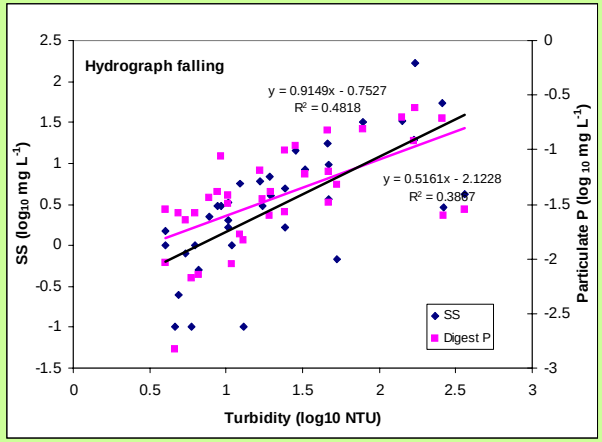








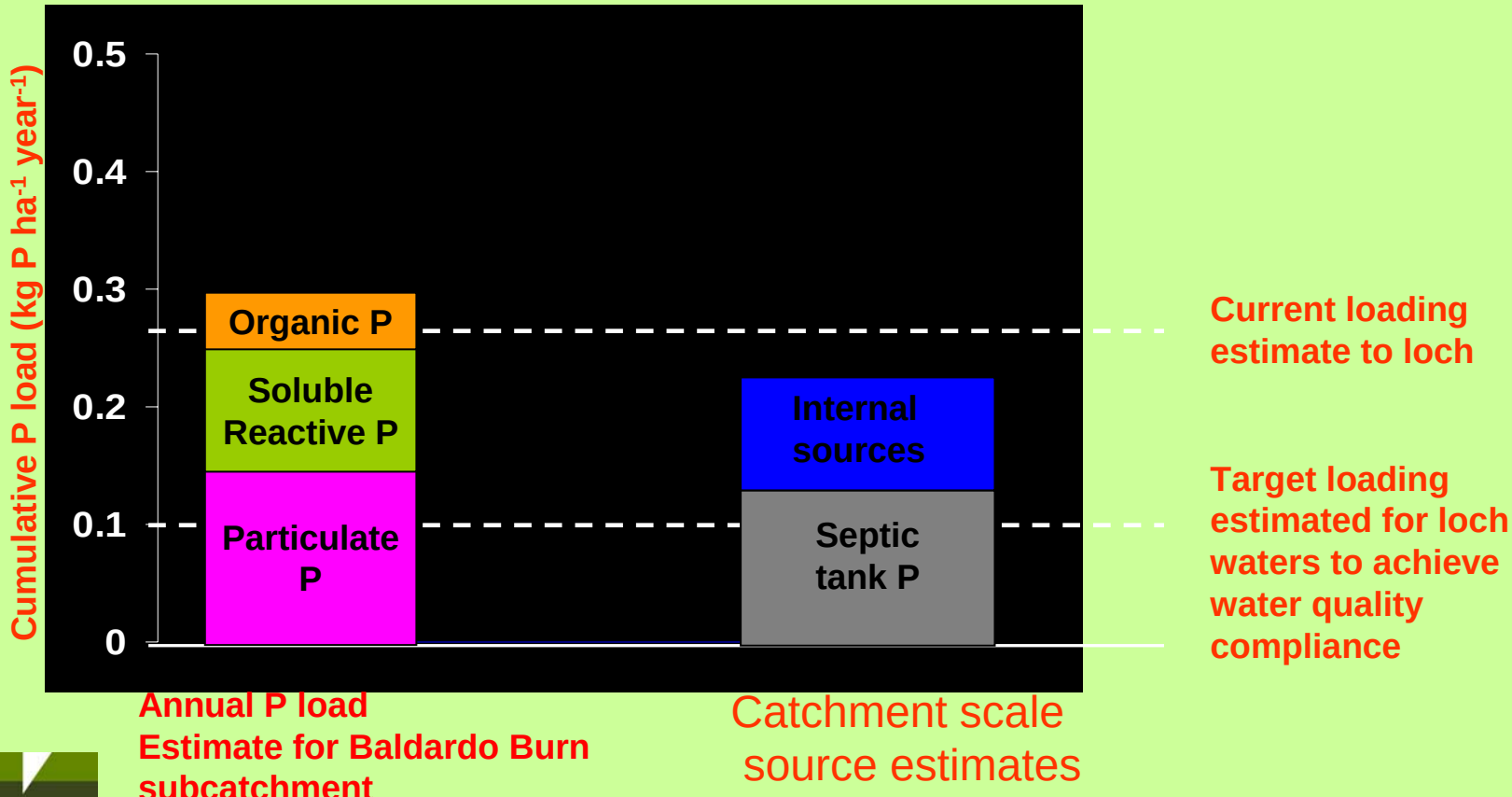




Particulate P load estimates for 3 subcatchments, using turbidity vs particulate P calibration

2008 quarter	Baldardo	Balgavies	Lemno
1	22	33	38
2	4	6	11
3	9	22	17
4	20	45	35
kg TP	**60**	**106**	**102**

Estimates of P sources for Rescobie



Farmer focus groups (with SAC)

Diffuse pollution measures: General Binding Rules came into force in April 08. eg.cultivation

- **no land cultivated for crops:**

- within two metres of any surface water or wetland

- within five metres of any spring that supplies water for human consumption or any well or borehole that has not been capped to prevent the ingress of water

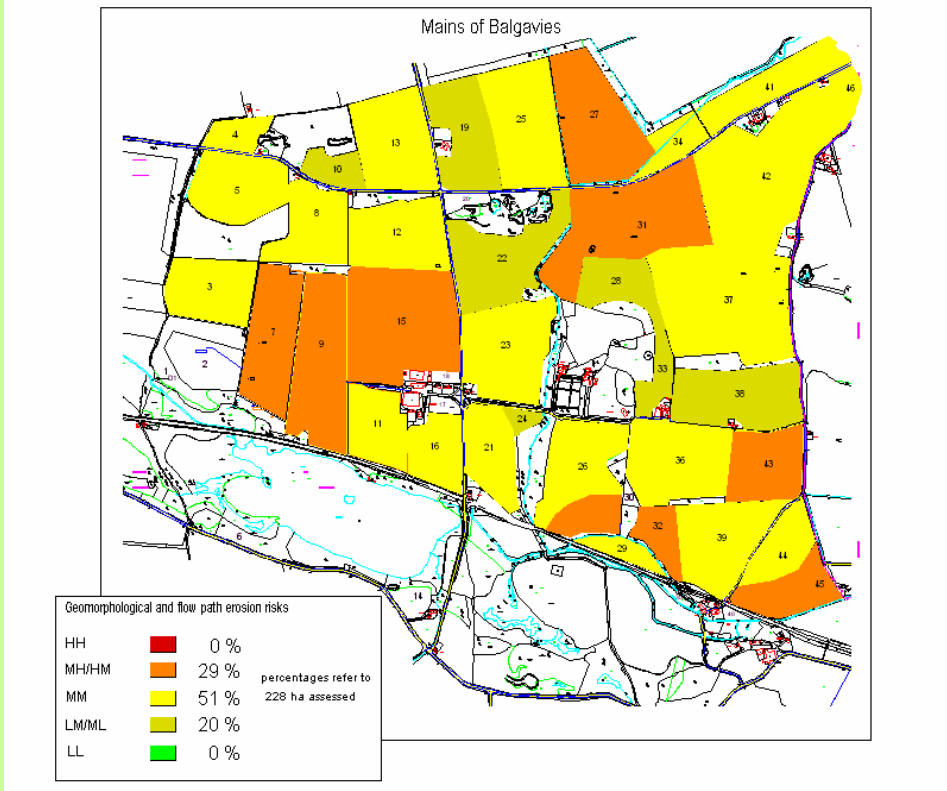
- **when waterlogged (ie soil at water retaining capacity)**

- **land is cultivated in a way that minimises the risk of pollution to the water environment.**

Audits this autumn

Voluntary diffuse agricultural pollution measures

- grants for some Best Management Practices (eg. 6m. Buffer strips)
- Farmer-led initiatives: interrupted tramlines, move to spring cereals, tied-ridging in potatoes
- Farm wetlands
- Risk assessment for erosion and nutrient loss



Septic System Maintenance

Proper septic system maintenance, including regular tank emptying, and using low-phosphate cleaning products can reduce phosphorus inputs to surface waters.

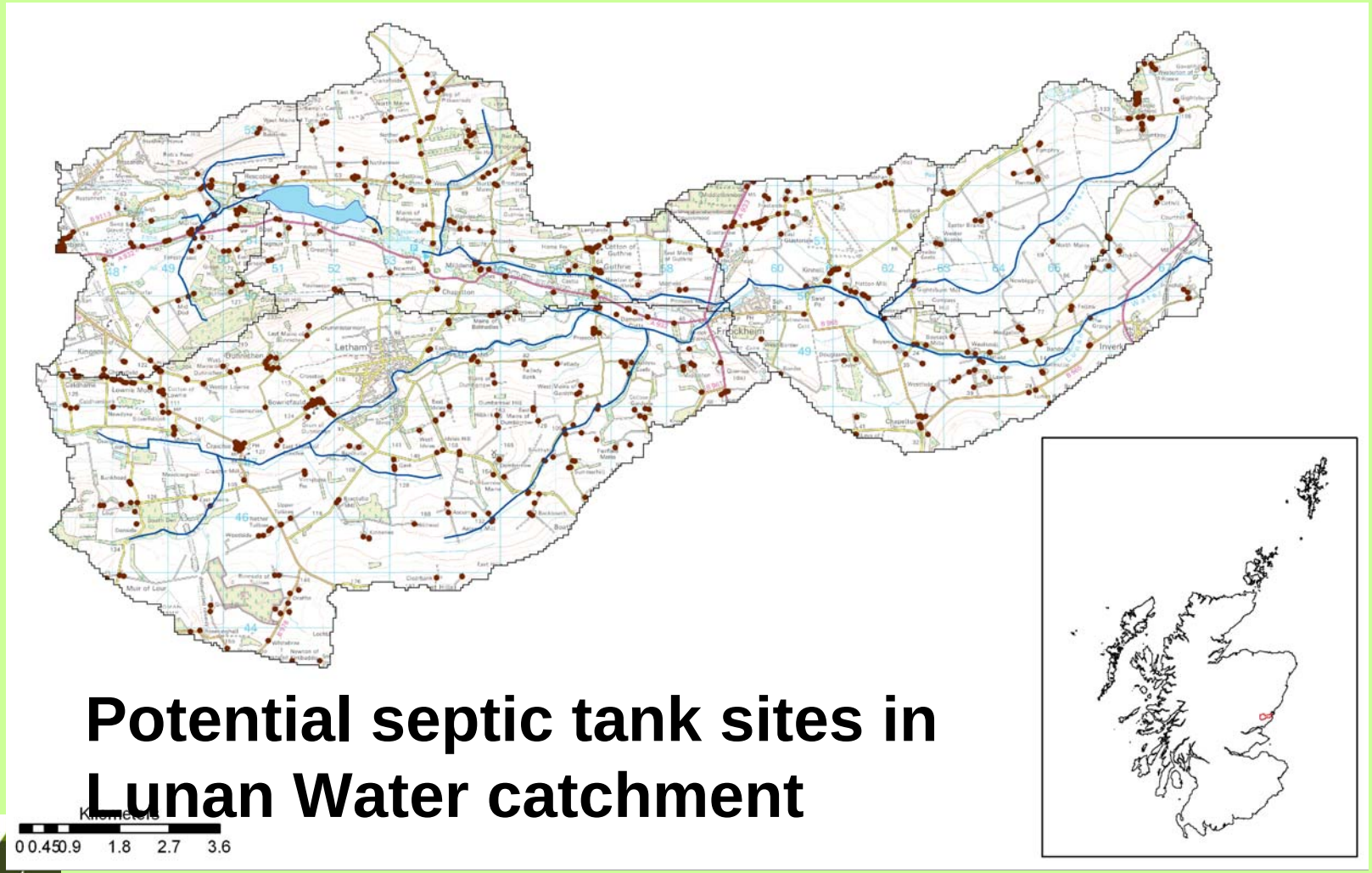
Techniques exist to capture the phosphorus in septic system effluent.

Conclusions

- **Lochs are downgraded due to ecology and chemistry**
- **Significant agricultural, septic and internal sources of P discharge to Rescobie Loch**
- **Systems in place to monitor and quantify improvements**
- **Compliance with regulatory measures are being assessed by audits**
- **Voluntary approach will also be explored**

Ecological quality elements	Rivers	Lakes	Transitional	Coastal
Phytoplankton				
Macrophytes and benthic algae				
Benthic invertebrates				
Fish	2009		2009	
Morphology				
Hydrology				
Nutrients				
Oxygenation				
Thermal				
Acidity				
Specific pollutants and priority substances				

Identifying P and sediment sources
Septic tanks



Potential septic tank sites in Lunan Water catchment

Approach to investigation impact of measures

Multivariate Analysis of Paired Watershed Data to Evaluate Agricultural Best Management Practice Effects on Stream Water Phosphorus

Patricia L. Bishop,*, W. Dean Hively, Jerry R. Stedinger, Michael R. Rafferty, Jeffrey L. Lojpersberger and Jay A. Bloomfield

J Environ Qual 34:1087-1101 (2005)

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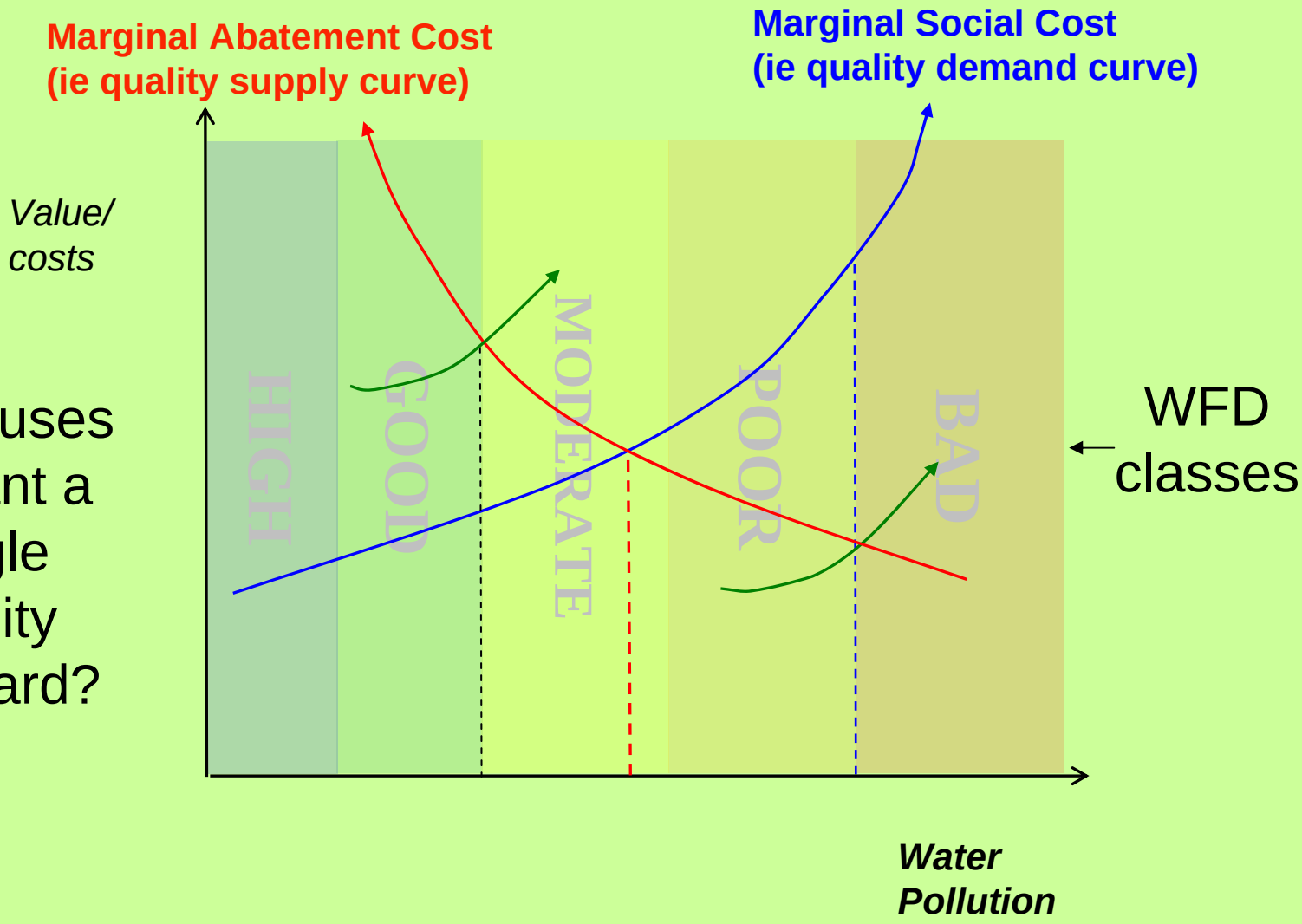
Do all uses warrant a single quality standard?



Water Costs and values with respect to Loch P mitigation

P Standards for Good Ecological Status from regulator

Prediction of P status of water bodies

- source apportionment of current P loads to Lochs/rivers
- Likelihood of [P] exceedance for lochs (and rivers)
- P loading reductions needed for GES

P Mitigation measures

- National scale land use and sewage inputs
- Mitigation cost curves for managed Grass, Arable, Upland, Septic tank and Sewage treatment works P

Mitigation cost minimisation across sources

Analysis of costs, disproportionality and uncertainty

Classification of Good status with respect to [total P] for Scottish Lochs

Type of lake		Reference level of Phosphorus[1]		Class Boundaries			
				High		Good	
		Range	Type[3]	Range	Type	Range	Type
		Annual (geometric) mean (µg/l)					
High Alkalinity – deep		There are too few lakes of this type					
High Alkalinity shallow	Northern/ Atlantic	8-17	13	10-22	16	14-30	23
	Central	12-27	20	16-34	25	22-46	35
High Alkalinity very shallow	Northern/ Atlantic	12-29	18	15-36	23	21-48	31
	Central	18-44	28	23-55	35	33-75	49
Moderate Alkalinity, Deep		3-8	6	5-11	8	7-16	12
Moderate Alkalinity – shallow		5-11	8	7-15	11	10-21	16
Moderate Alkalinity – very shallow		8-19	12	10-25	15	15-36	22
Low Alkalinity – deep		2-7	4	2-9	5	3-15	8
Low Alkalinity – shallow		2-10	5	3-13	7	4-19	10
Low Alkalinity – very shallow		3-17	7	4-23	9	6-34	14
Marl – shallow		N/a	N/a	N/a	9	N/a	20
Marl – very shallow		N/a	N/a	N/a	10	N/a	24

P loads modelled with PSYCHIC and Screening Tool

This uses the modified Morgan Finney equations (Morgan 2001) for predicting soil loss:

$$F = K \times \left(KE_{DT} + KE_{CC}\right) \times 10^{-3}$$

F= annual quantity of soil eroded (kg/m^2)
KE_{DT} = kinetic energy from direct through fall (J/m2)
KE_{CC}= kinetic energy from canopy fall (J/m2)
K = soil erodibility parameter

The Screening Tool project provided summary database of P loads on 1 km^2 and on catchment scales for 550 Scottish Lochs

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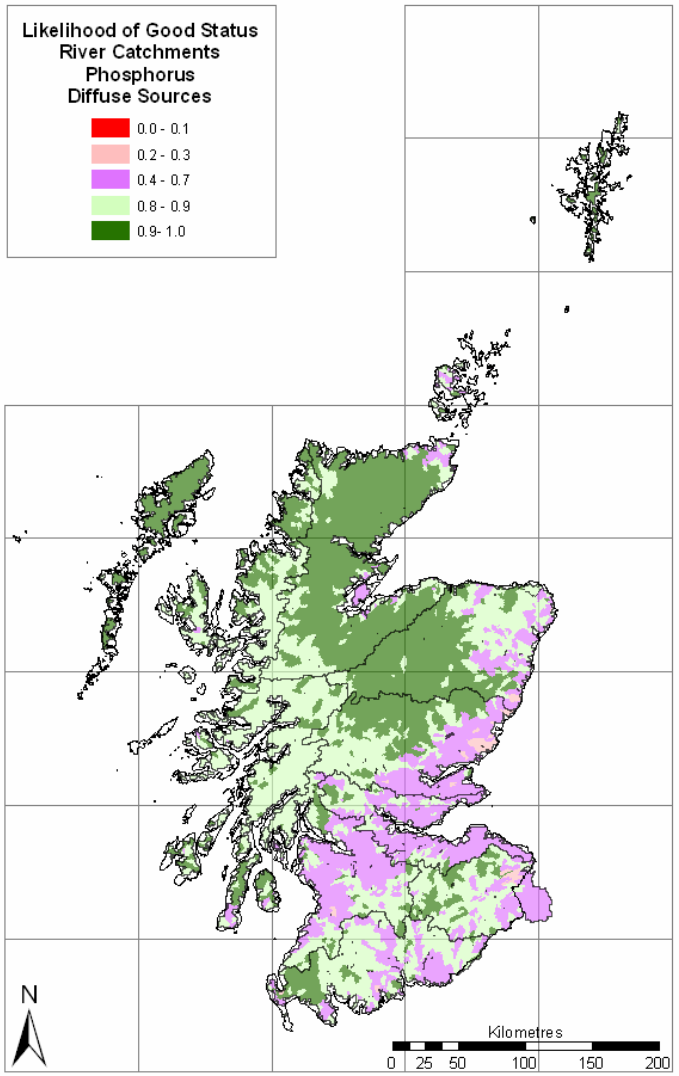
Loch P concentrations, estimated using catchment loads

$$[lochP] = \frac{1.118 \cdot \frac{10^5 \cdot L}{H}}{\left(1+\sqrt{t}\right)^{1.135}}$$

[*loch* P] is the predicted mean total phosphorus concentration (μg l^{-1}),
L is the catchment average load (kg P ha^{-1})
H is the modelled average catchment drainage (mm),
t is the average hydraulic residence time of the lake (y).

Vollenweider(OECD 1982).

Spatial distribution of likelihood of good Phosphorus status for river catchments, diffuse sources



Spatial distribution of Phosphorus status for loch catchments, diffuse sources

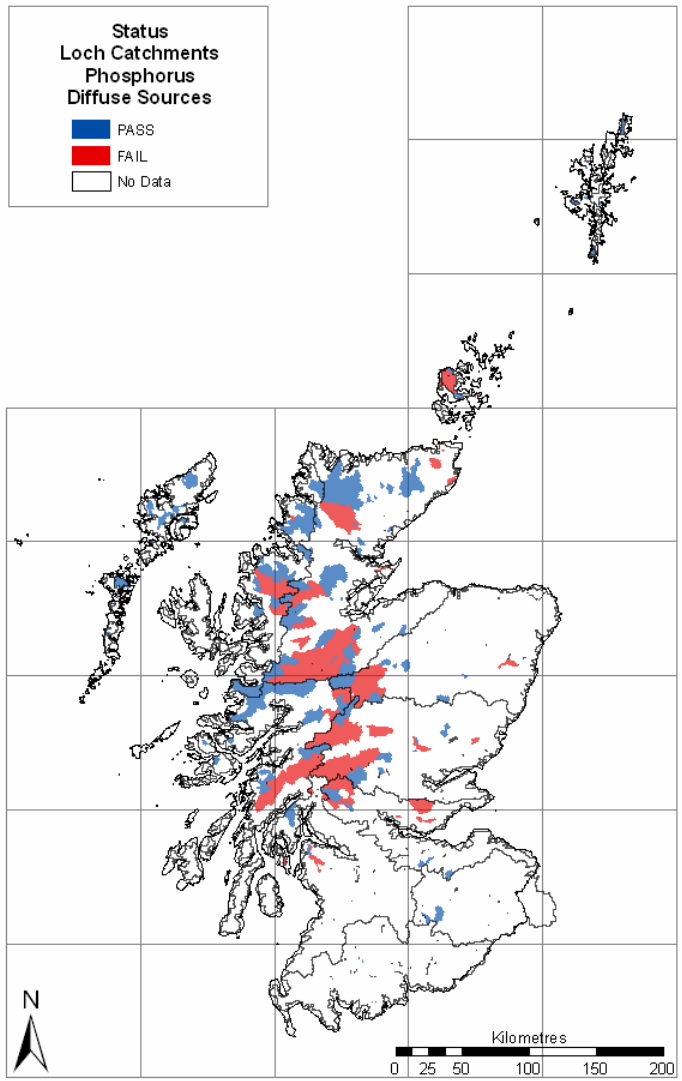


Figure 4.4a - Spatial distribution of good phosphorus status for river catchments, all sources

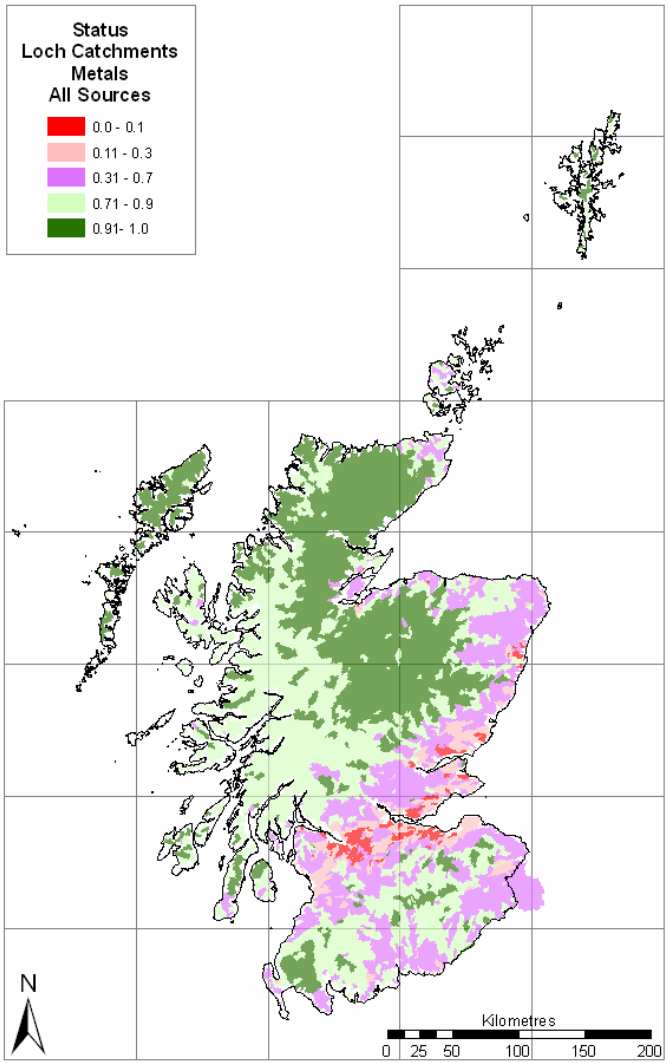
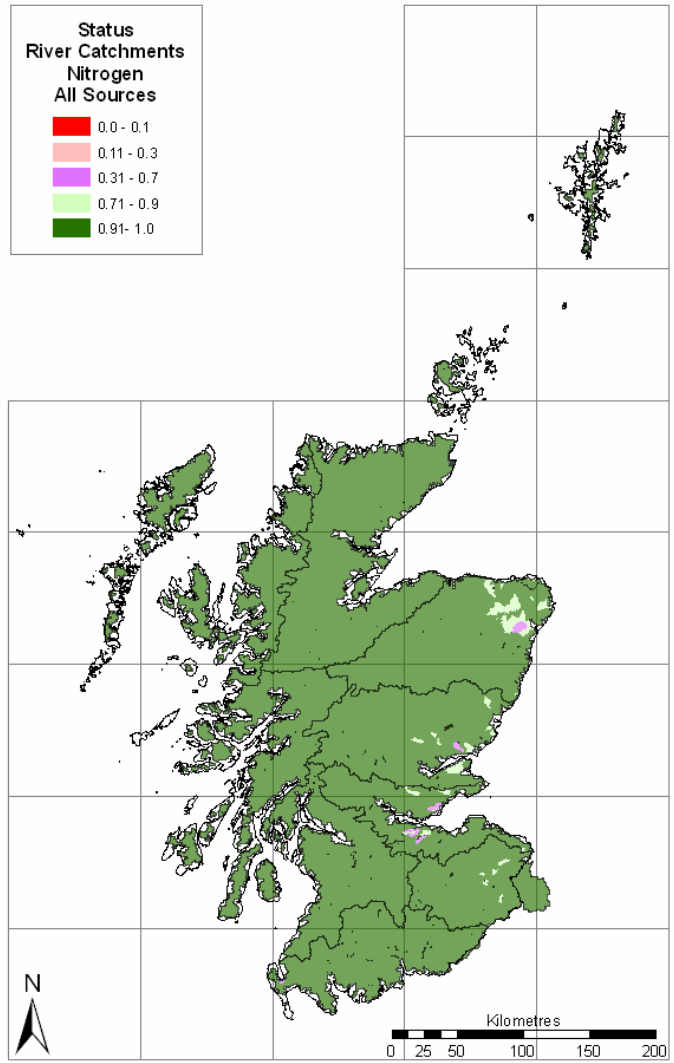
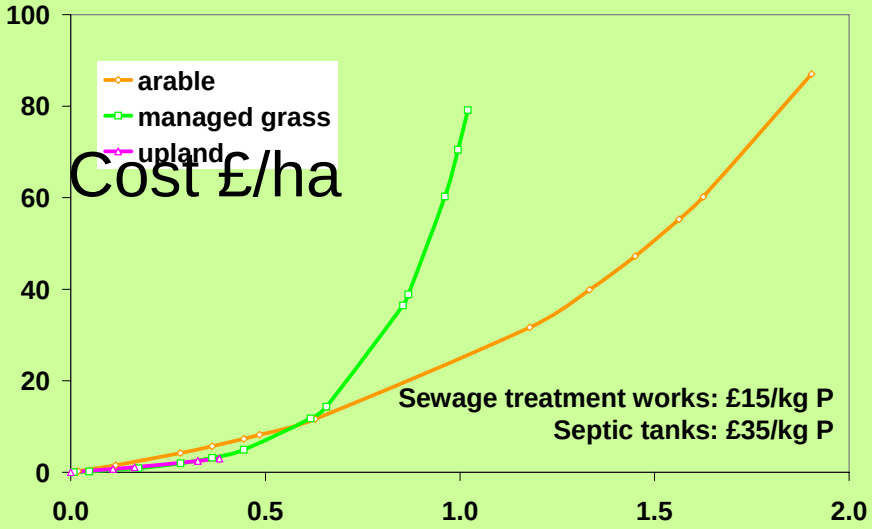


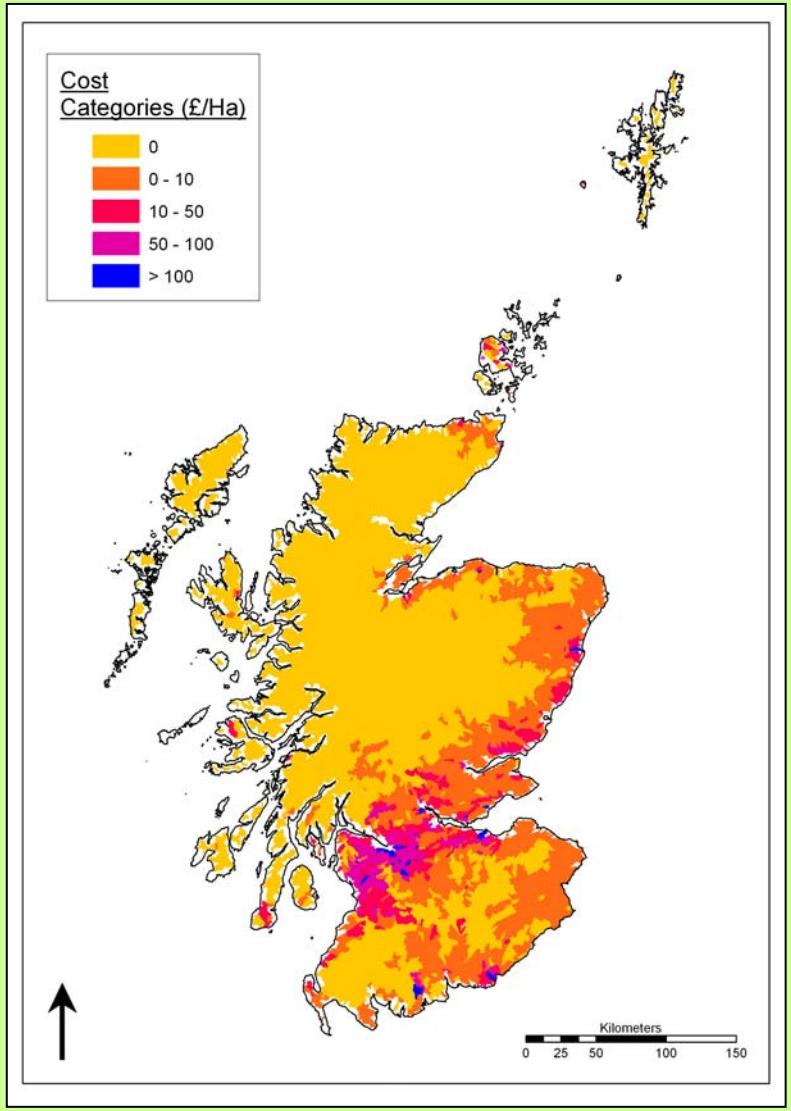
Figure 4.3(a) - Spatial distribution of good nitrogen status for river catchments, all sources



Mitigation cost curves – eg DEFRA, Scottish Best Management Practices Handbook

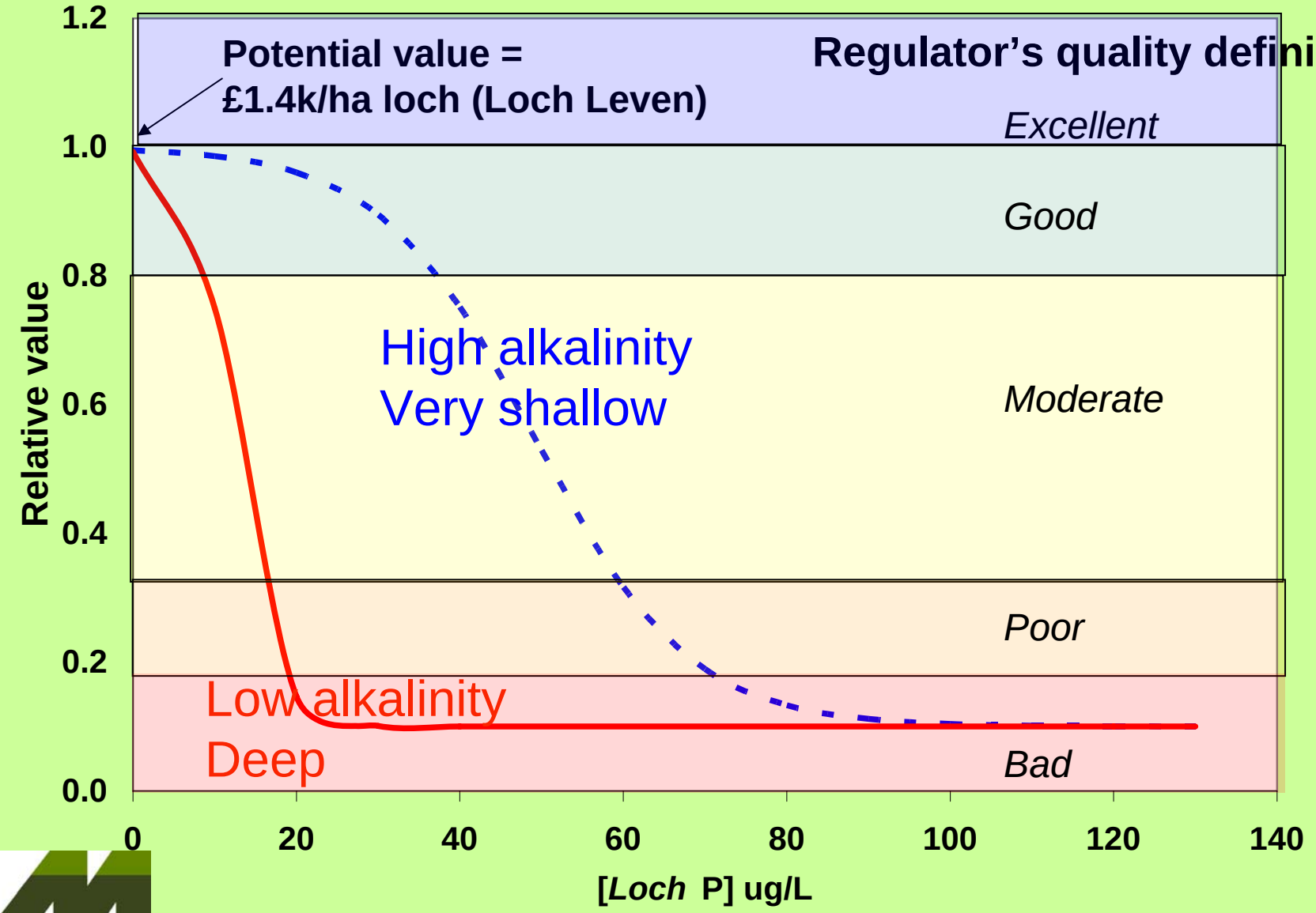


Load reductions and costs



Mitigation Cost to achieve 80% likelihood of good P status for rivers (40 ug/L)

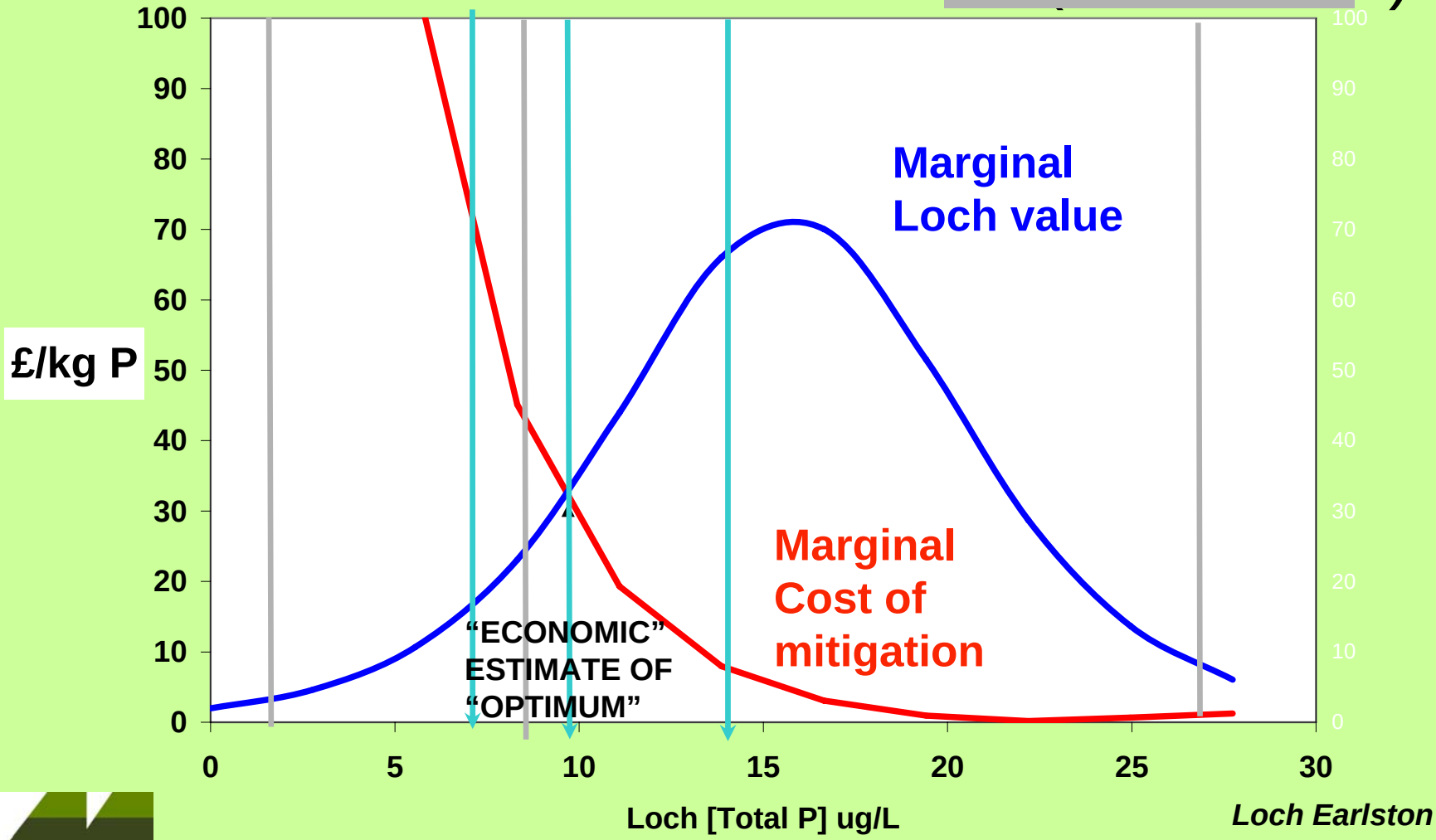
Interim approach to loch values (3.5.2)



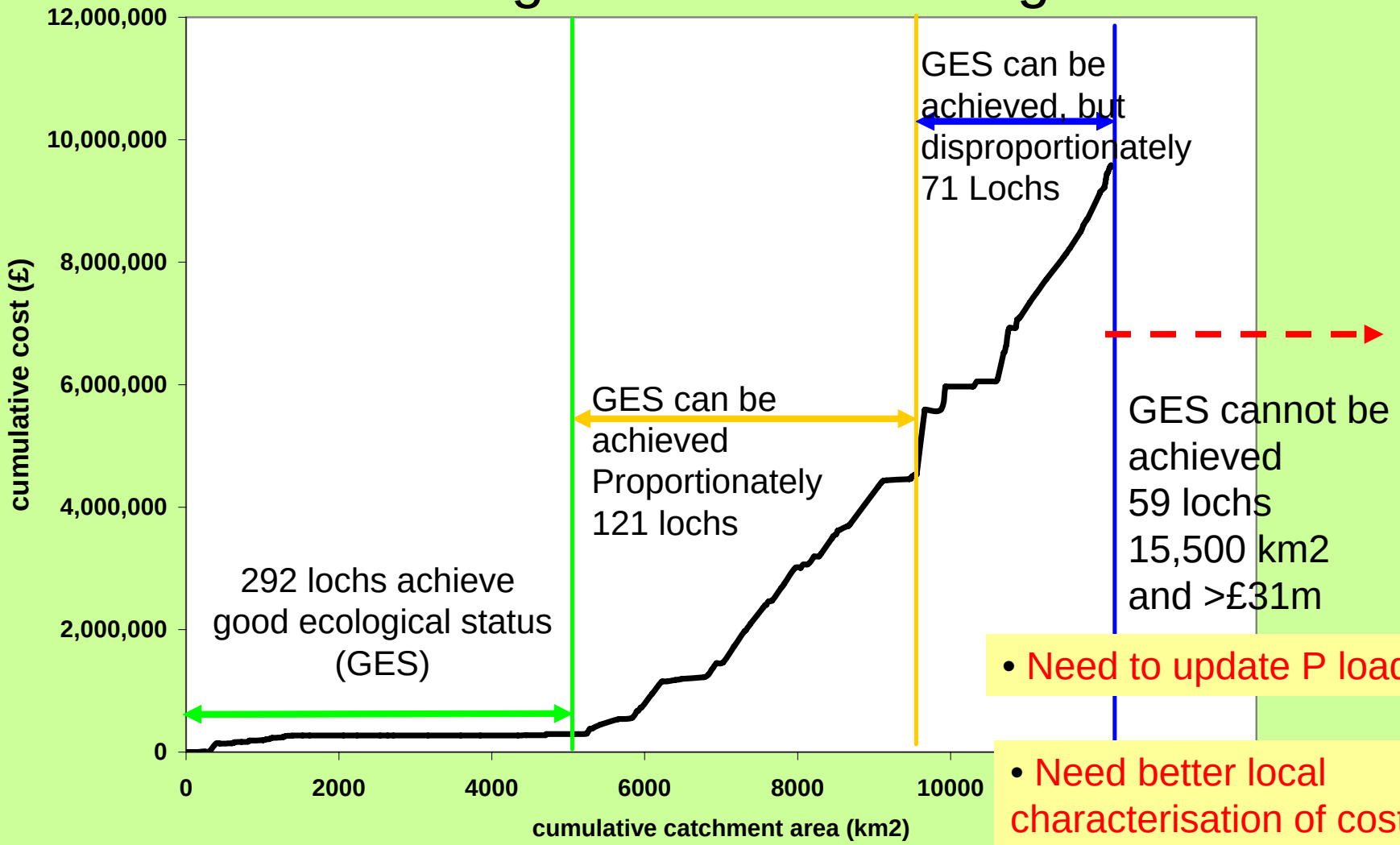
Environmental Economics of Lochs (3)

Regulator's Good Ecological Status

Current predicted status

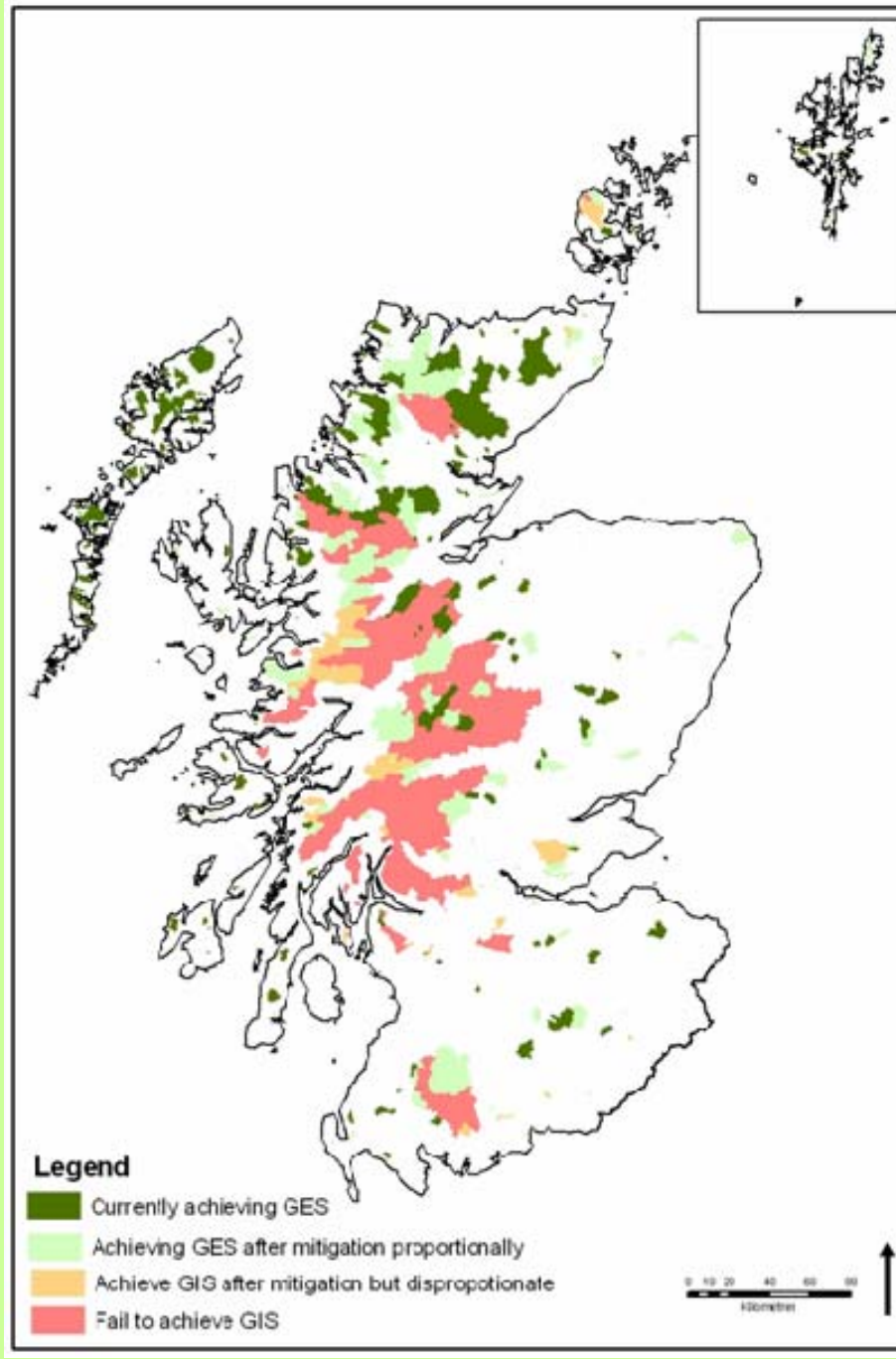


Disproportionality analysis for Loch P mitigation using national screening tool dataset



- Need to update P loads
- Need better local characterisation of costs and effectiveness

Catchment areas of Loch water bodies achieving/not achieving GES

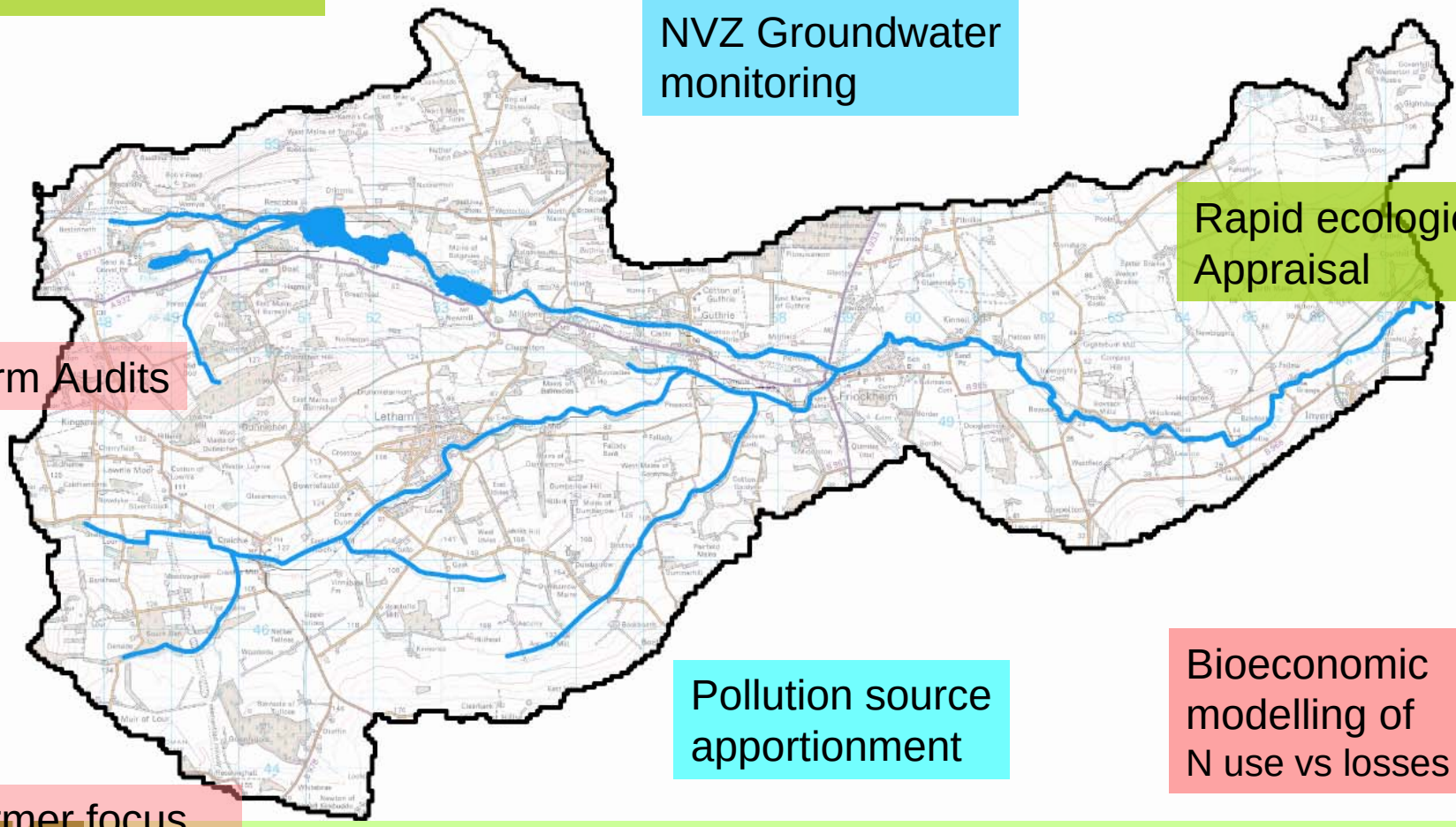


Flow and chemistry monitoring on 5 subcatchments

Groundwater dating and turnover time (3.4)

LANDSFACTS Rotation model (3.8)

NVZ Groundwater monitoring



Rapid ecological Appraisal

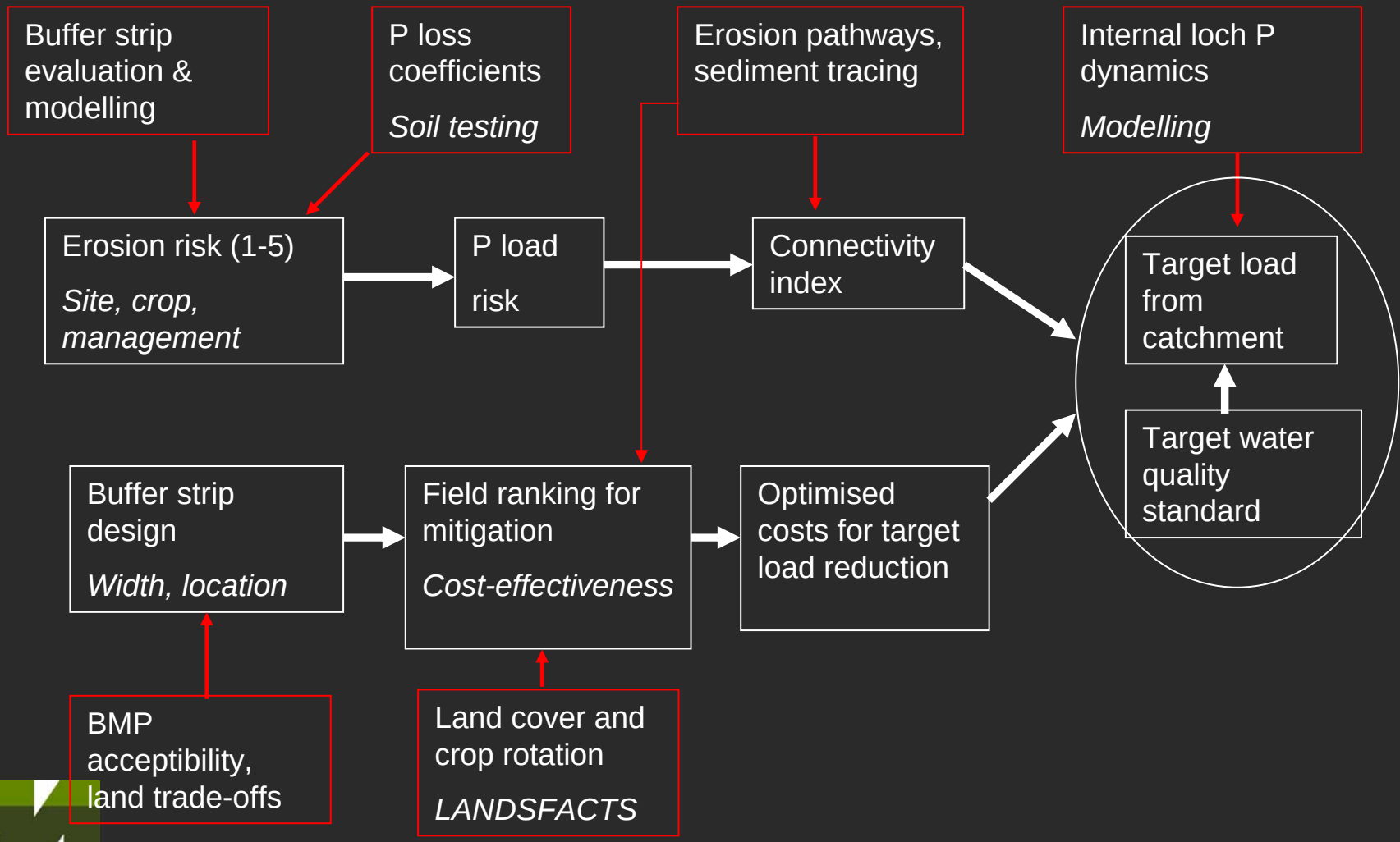
Farm Audits

Pollution source apportionment

Bioeconomic modelling of N use vs losses

Farmer focus group

Landscape based cost effectiveness analysis



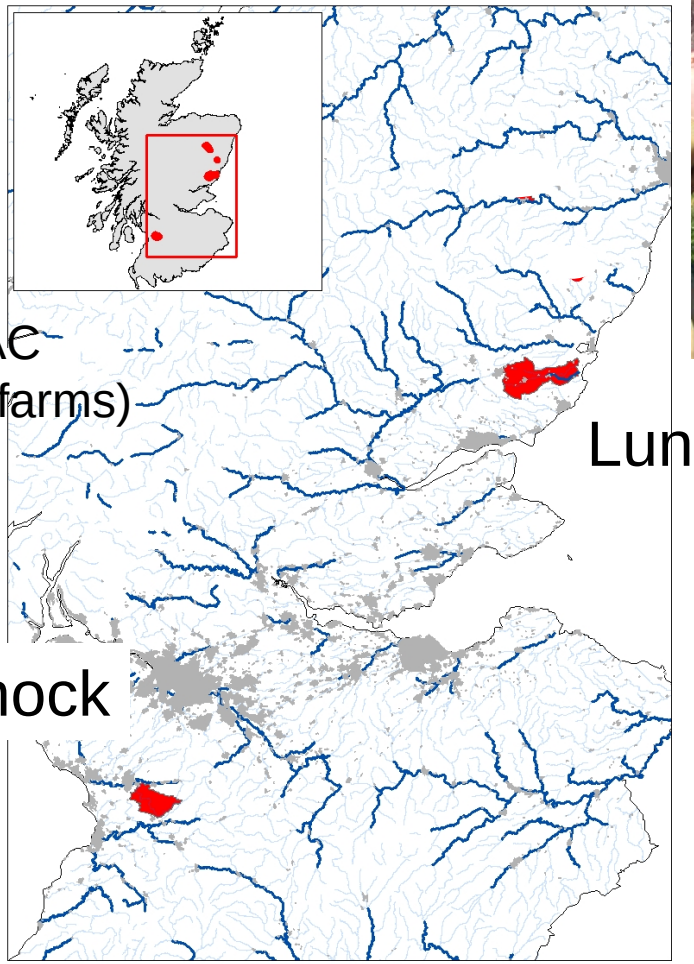
Monitored priority catchments (3.5.4, 3.5.5)

Partnership approach

SEPA (measures)

Macaulay (catchment research)

SAC (focus farms)



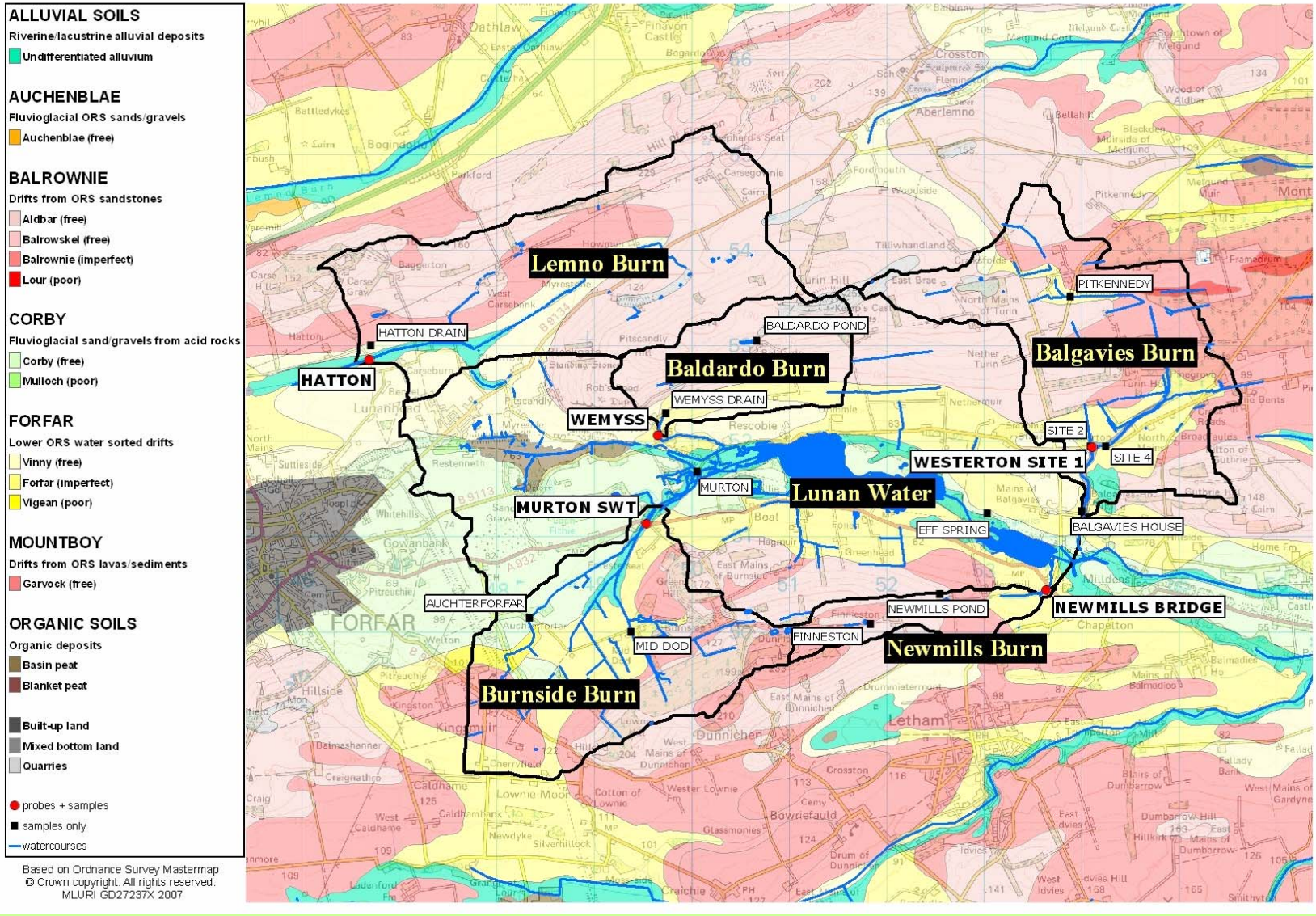
Lunan

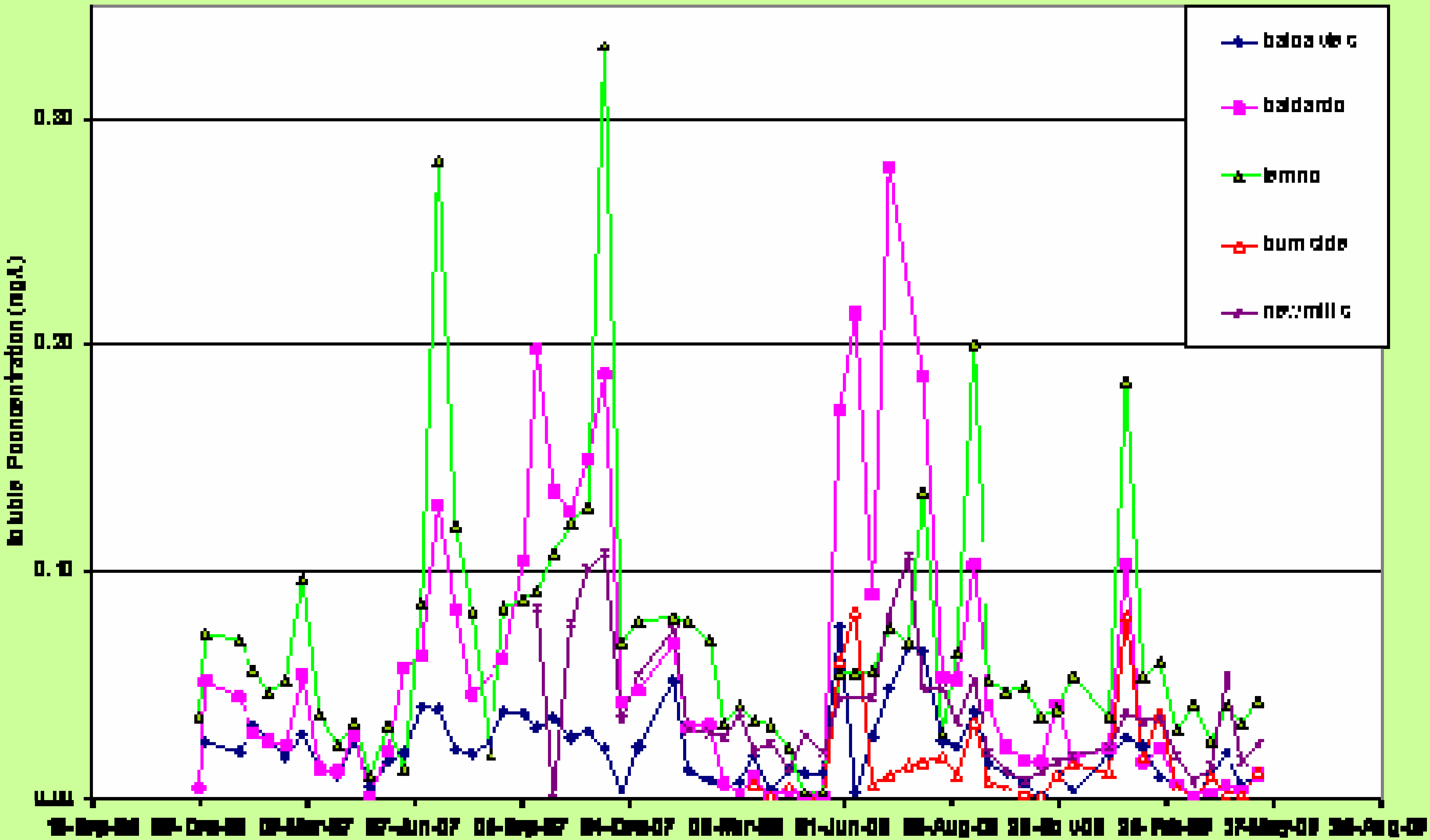
Cessnock

Typical dairy and mixed arable catchments

- **Good Ecological Status**

- **Proportionate mitigation costs**


ALLUVIAL SOILS
Riverine/lacustrine alluvial deposits
Undifferentiated alluvium
AUCHENBLAE
Fluvioglacial ORS sands/gravels
Auchenblae (free)
BALROWNIE
Drifts from ORS sandstones
Aldbar (free)
Balrowskel (free)
Balrownie (imperfect)
Lour (poor)
CORBY
Fluvioglacial sand/gravels from acid rocks
Corby (free)
Mulloch (poor)
FORFAR
Lower ORS water sorted drifts
Vinny (free)
Forfar (imperfect)
Vigean (poor)
MOUNTBOY
Drifts from ORS lavas/sediments
Garvock (free)
ORGANIC SOILS
Organic deposits
Basin peat
Blanket peat
Built-up land
Mixed bottom land
Quarries
probes + samples
samples only
watercourses
Based on Ordnance Survey Mastermap
© Crown copyright. All rights reserved.
MLURI GD27237X 2007
Lemno Burn
HATTON DRAIN
HATTON
BALDARDO POND
Baldardo Burn
WEMYSS DRAIN
WEMYSS
PITKENNEDY
Balgavies Burn
SITE 2
SITE 4
WESTERTON SITE 1
MURTON
Lunan Water
MURTON SWT
EFF SPRING
BALGAVIES HOUSE
AUCHTERFORFAR
NEWMILLS POND
NEWMILLS BRIDGE
MID DOD
FINNESTON
Newmills Burn
Burnside Burn
FORFAR


0.30
0.20
0.10
07-Jun-07
04-Dec-07
01-Jun-08

Paired sub-catchment approach to assessing mitigation effects

- **Lemno catchment is “control”**
- **Baldardo, Balgaviesare “treated” from**
  - **? time of farmer contact**
  - **? Time of audit**
  - **? Time of uptake of GBRs**
  - **? Time of uptake of BMPs**

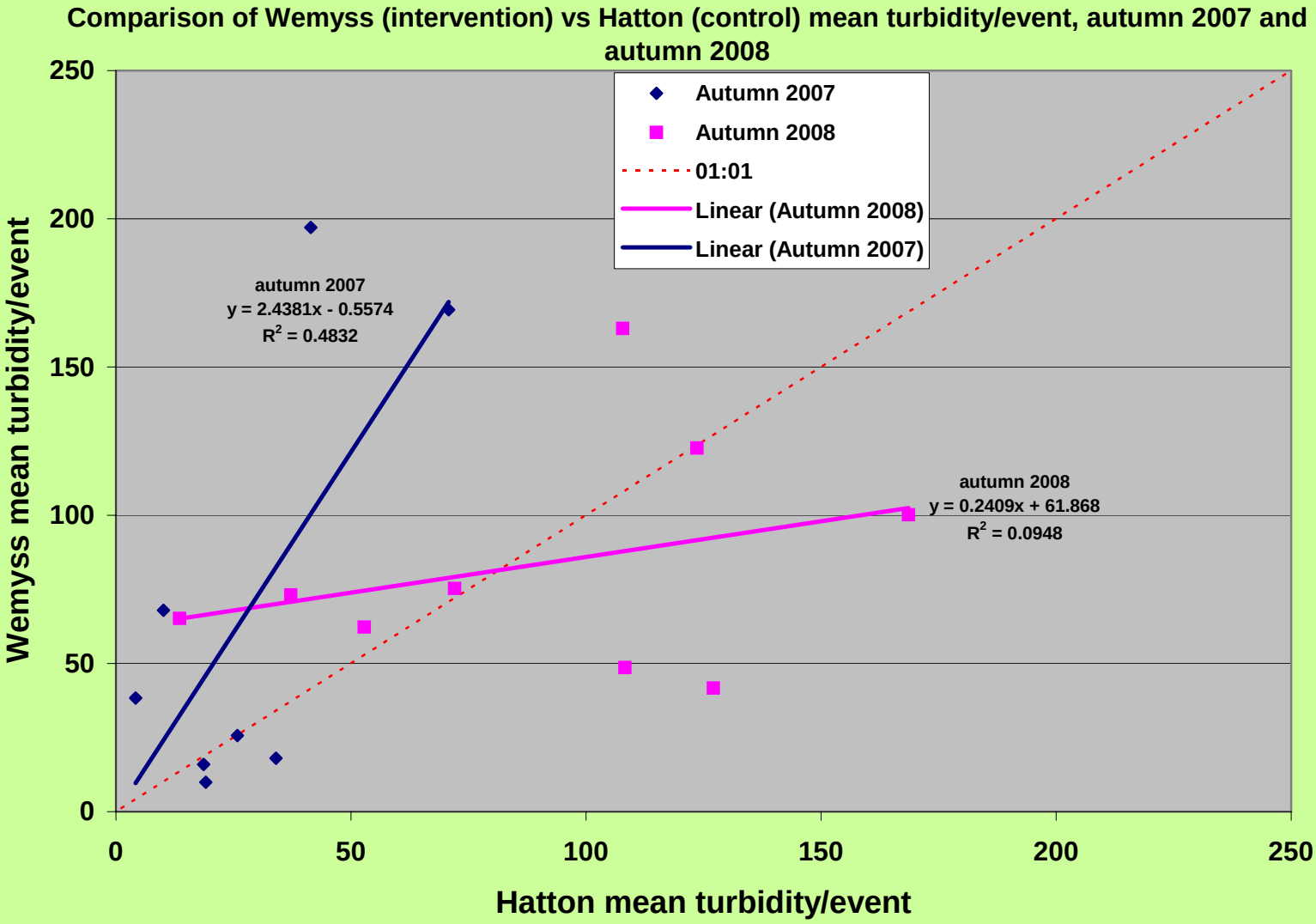
- **Newmills, Burnside is to be “treated” in future, after longer baseline**

- **Compare paired events on control vs. “treated” catchments, before and after intervention**

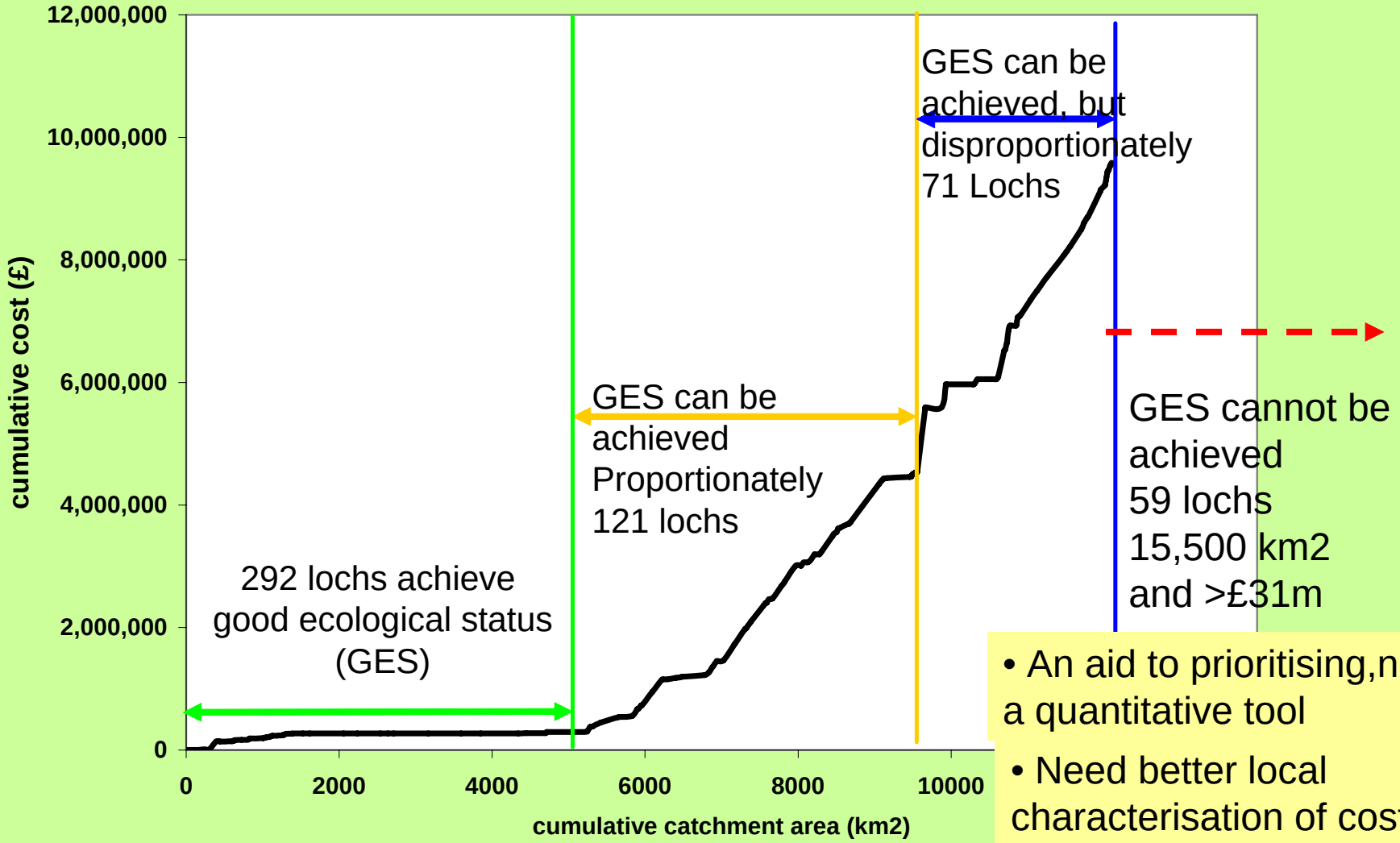
- **Multivariate or univariate analysis**

Treatments per catchment - proposal

- **GBR audit 4 farms in Wemyss catchment this autumn,**
- **then pursue funding for buffer strip/soil retention measures**
- **Continue current inputs on good practice from SAC**
- **Try to engage Drimmie (Baldardo) with measures to reduce erosion from potatoes (tied ridges)**
- **Delay further year on Burnside catchment, then audit only**
- **No audit on Newmills**
- **Uptake of GBRs survey in final year of project**


Comparison of Wemyss (intervention) vs Hatton (control) mean turbidity/event, autumn 2007 and autumn 2008
Autumn 2007
Autumn 2008
01:01
Linear (Autumn 2008)
Linear (Autumn 2007)
autumn 2007
y = 2.4381x - 0.5574
R2 = 0.4832
autumn 2008
y = 0.2409x + 61.868
R2 = 0.0948
Wemyss mean turbidity/event
Hatton mean turbidity/event
0
50
100
150
200
250

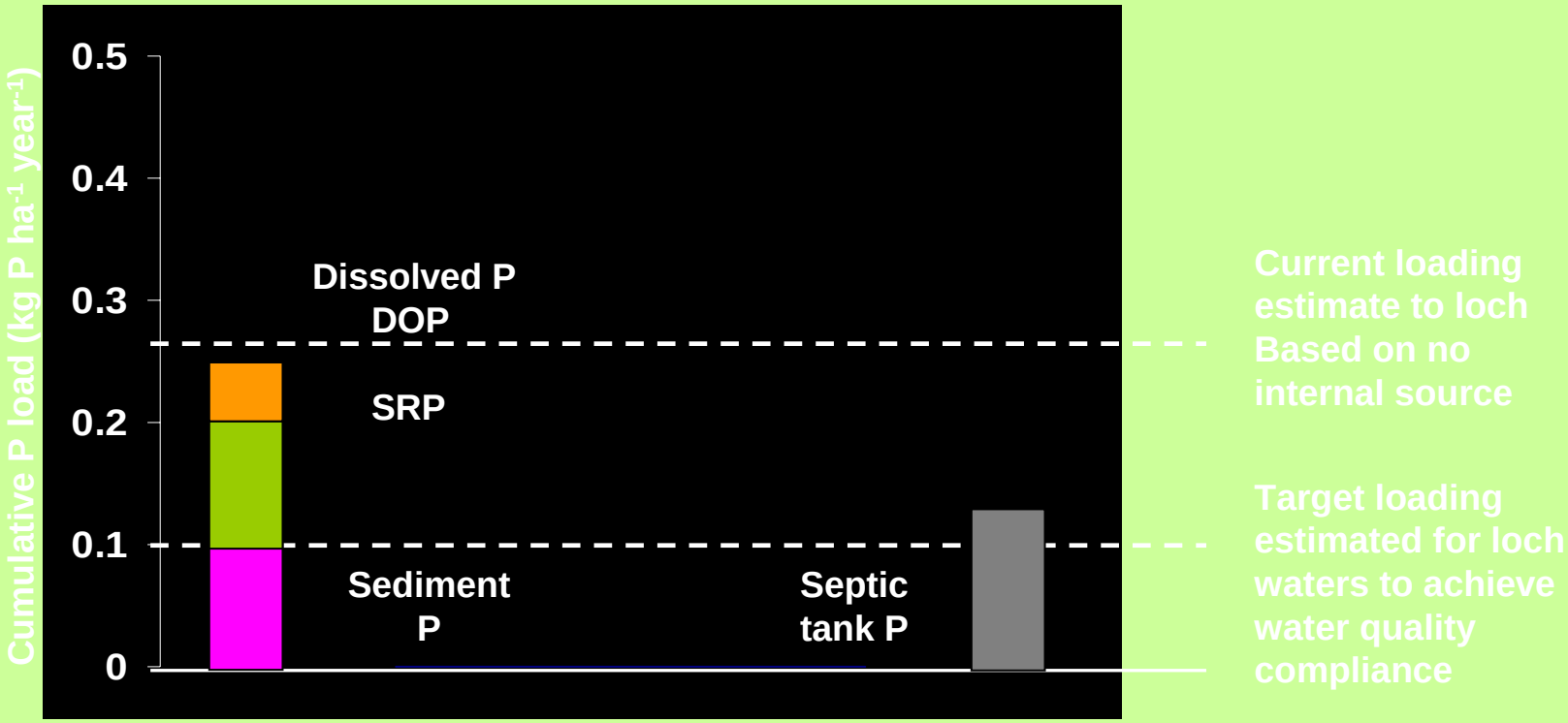
Disproportionality analysis for Loch P mitigation



- An aid to prioritising,not a quantitative tool
- Need better local characterisation of costs and effectiveness

Estimates of P load to Rescobie based on Baldardo

A number of sources contribute phosphorus to the lochs and these imply an integrated approach to nutrient load reductions across the catchment



Annual load estimate Baldardo Burn

Septic source at Lunan catchment scale

3.Mitigation

Local knowledge from user groups & stakeholders
eg. Farmers and Farming associates
Fisheries
septic tank owners