defra
Department for Environment
Food and Rural Affairs

JACOBS BABTIE

Note on the anticipated application of the Direction making power

under

Section 12A of the Reservoirs Act 1975 (as amended)

Job Number 0022203/ 206
Rev A04 June 2006

Jacobs Babtie Thorncroft Manor, Dorking Road, Leatherhead, Surrey KT22 8JB
Tel 01372 863613 Fax +01372 863602

Contents

Document History Record

Rev	Date	Details	By	Chkd	App
01	29th Sept 05	Draft for discussion on principle	AJB	-	-
02	3rd Nov 05	Update following meeting on 26th Oct; issued to EPO with informal consultation on the Guide to Emergency planning	AJB	KB	AJB
03	8th March 06	Issue with Rev 03 of Guide	AJB	JDG	AJB
04.01	27th May 06	Issue to Defra for consent to mount on website	AJB	-	AJB
04.05	13th June 06	Approved for issue	AJB	KB/ IH	AJB

1 BACKGROUND AND PURPOSE OF DOCUMENT

The Reservoirs Act 1975, as amended by the Water Act 2003, gives the Secretary of State power to direct reservoir undertakers to prepare reservoir flood plans for their reservoirs and dams.

This note summarises current aspects of the draft proposals for the application of this power which are not given in the draft Engineering Guide to Emergency Planning. **These proposals are a preliminary draft only, intended to stimulate discussion on the various issues involved, and will be subject to a public consultation in due course.**

2 WHICH RESERVOIRS WOULD BE REQUIRED TO HAVE RESERVOIR FLOOD PLANS?

2.1 Requirement

The anticipated application of the Direction making power is shown in Table 2.1, together with the level of detail of plan. The criteria for which reservoirs will require a reservoir flood plan are the consequences of failure if the dam failed. Thus higher consequence dams which would affect significant numbers of people if they failed would be required to have more detailed plans, and exercise these more frequently, than reservoirs which pose insignificant risk to life. The consequence class of the dam would be as defined on Sheet 11.2 of the Interim Engineering Guide to Quantitative Risk Assessment for UK Reservoirs (2004), reproduced here as Figure 1.

It is therefore proposed that the Direction would be in two parts, a general Direction requiring all Undertakers to confirm the consequence class of their dam (using the rapid method of impact assessment where appropriate) and the second to prepare the level of Reservoir flood plan as shown in Table 2.1. The Engineering Guide will recommend that both the assessment of consequence class and the preparation of the reservoir flood plan are carried out under the supervision of a Qualified Civil Engineer (Inspecting or Construction Engineer) as defined in the Reservoirs Act 1975.

In recognition that the cost of a plan should be proportionate to the consequences of failure medium consequence (Class B) dams may use a simplified rapid method to estimate the extent of flooding and likely consequences, and will not be required to produce flood maps. A suitable method is that in the Interim Guide to QRA for UK Reservoirs, 2004). An estimate of the typical cost of the requirements for all classes of dam is given in Section 6, including an assessment of whether the cost is proportionate to the reduction in risk achieved.

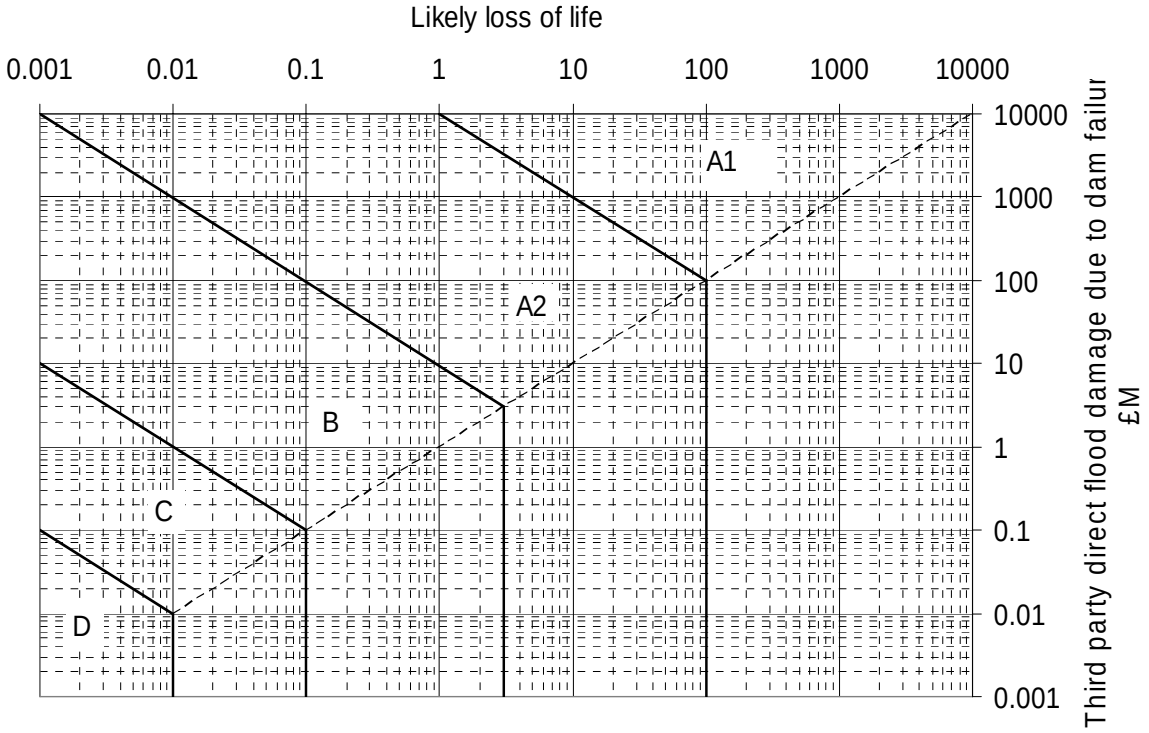
For low consequence dams (Class C and D) it is anticipated that the rapid impact assessment will be carried out as part of the existing periodic Inspection regime under Section 10 of the Reservoirs Act 1975, such that any additional cost should be modest. Once this impact assessment has been signed off by a Qualified Civil Engineer no further work would be necessary, other than reconfirming that the class has not changed in subsequent Section 10 Inspections; this may occur for example if there was new housing or other development downstream. However, in recognition of the fact that if the dam is about to fail the emergency services should be notified it is anticipated that the requirements for information in the Reservoir Record will be amended through a Statutory Instrument so that all Undertaker have to maintain a record of the contact address, phone and fax number for the Lead Category 1 responder in his area.

In terms of which types of reservoirs would be required to have reservoir flood plans it is anticipated that the power would apply to all impounding and non-impounding reservoirs coming under the provisions of the Reservoirs Act 1975, but not to Service Reservoirs (as defined in Regulation 2(3) of the Water Supply Regulations 2000). Nevertheless for Service Reservoirs the onus remains with the Undertaker to make his own assessment of the risks and thus determine whether the cost of some or all elements of a reservoir flood plan would be a proportionate risk reduction measure.

Table 2.1 : Normal minimum level of Reservoir flood plan required for UK dams

Highest Consequence Class of dam retaining a given reservoir	Element of Reservoir flood plan		
	I	II	III
	Impact assessment[2]	On site	External Interfaces in event of emergency at a reservoir
A1	Standard	Required	Required
A2	Standard	Required	Required
B	Rapid method	Required but reduced level of exercising	Required
C	Rapid method	Not required	Not required
D	Rapid method	Not required	Not required

Figure 1 : Overall Consequence class (as Sheet 11.2 of Interim Guide to QRA, ICE, 2004)



2.2 Transition requirements - Existing inundation maps

Where an undertaker has already prepared inundation maps, or other elements of a reservoir flood plan, but these do not comply with the contents specified in the Direction (and attachments), then these will be accepted as an interim plan, subject to the extent of flooding being available in GIS format and with a statement by a Qualified Civil Engineers that they are reasonable as an interim measure. However, a fully conforming plan will be required within five years.

3 WHO WILL RECEIVE COPIES OF THE PLAN

This is still under discussion with key stakeholders.

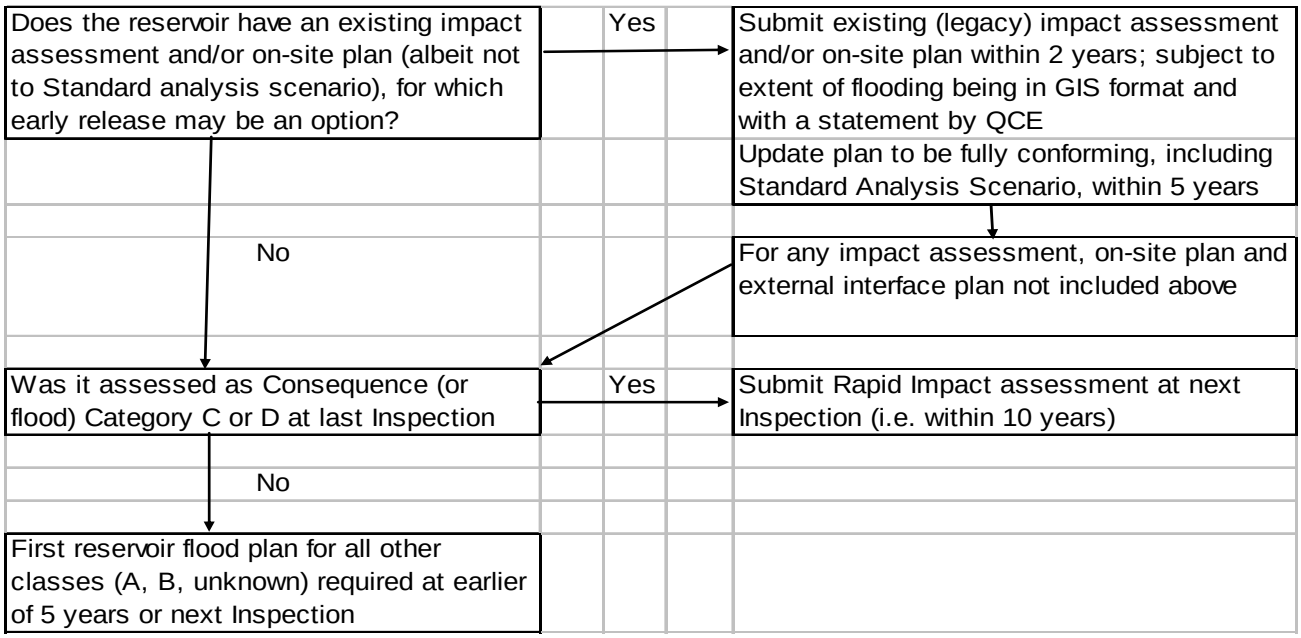
4 PROCESS FOR IMPLEMENTATION

4.1 Timescale for implementation

The current programme is anticipated as:

- Public consultation on the use of the Direction making power: Winter 2006
- Direction issued: Winter 2007
- Period to produce reservoir flood plans: as shown in Figure 2

Figure 2 : Flow chart to determine time to produce reservoir flood plans



4.2 Launch/ communication

A number of options are being explored for the public launch of reservoir flood plans and these are inter-related with decisions on the extent to which the plans are promulgated.

A communications plan for the public information campaign which will be required will be developed.

4.3 Process for preparation of plans

A draft is shown in Table 4.1

Table 4.1 : Summary of activities relating to preparation of first Reservoir flood plans

Activity	Secretary of State	Environment Agency, as Enforcement Authority	Undertaker	Qualified Civil Engineer, appointed by	
				Undertaker	Agency
Determine criteria for which reservoirs shall have a plan	L				
Identify individual reservoirs for which a Reservoir flood plan is required		L			
Serve Direction	L	S	R		
For reservoirs in cascade					
Decide if wish to propose one plan for the whole cascade, rather than one plan per reservoir		R	L		
For all elements in reservoir flood plan					
Prepare			L	S[1] (Insp)	
Consider need for more detailed plan			L	L (Insp)	
Submit for examination		R	L		
Examine		L			(S)[2]
Distribution of copies of accepted Reservoir flood plan			L		
Ongoing maintenance			L	M (Sup)	
Enforcement (The Undertaker would receive a communication from the Enforcement Authority)					
Plan not received in specified period from Notice		L	R	S (Sup)	
Plan examined and accepted		L	R	S (Sup)	
Contents of Plan do not conform with Direction (and associated Specification)		L	R		

Notes

1 Ideally this would be carried out as part of a Section 10 Inspection but the timing may not be appropriate if the next inspection is many years away.

2 Only where the submission is not accompanied by a statement by a Qualified Civil Engineer

3 L- Lead, S-Support, R-Receive, M-Moniter
(Insp) –Inspecting Engineer, (Sup)-Supervising Engineer

5 COSTS OF RESERVOIR FLOOD PLANS

An estimation of the possible magnitude of cost of preparing each element of a Reservoir flood plan is given in Table 5.1. Clearly there are some significant simplifying assumptions, in particular regarding the average annual inputs required for training and exercising. Feedback to improve these would be welcomed. It can be seen that

a) costs of exercising and maintaining the plans are significant. The most significant elements are attributable to
   - the cost of detailed hydraulic modelling of the likely extent of inundation due to the flood wave, which requires a mathematical model to be built of the valley downstream, inputting cross sections into the model typically at several hundred metre centres over the length for which the dambreak flood magnitude would cause significant damage, which typically varies between 10 to 80km
   - the need for regular exercising and review of the on-site and external interface plans, to ensure they are realistic and would work as intended in an emergency, even if this occurred at 5pm on a Friday evening
b) where a dam owner owns a number of dams the costs are likely to reduce, partly because of economies of scale in preparing plans and also because the number of exercises can be reduced (rather than one for every dam in the portfolio).

Table 5.1 : Estimate of cost of reservoir flood plans

Class	Preparation £ (build-up in Table 5.2)	Maintenance £/yr (build-up in Table 5.3)**
Single reservoir		
A1	12,000	8,000
A2	12,000	1,700
B	2,500	600
One of 10 reservoirs		
A1	8,000	2,400
A2	8,000	600
B	1,600	200

** these costs are largely cost of time of personnel, who generally would already be employed by the Undertaker i.e. not necessarily additional external costs

6 REASONABLENESS OF THE COST OF RESERVOIR FLOOD PLANS

6.1 ALARP Analysis of maintenance

To check the reasonableness of proposals for reservoir flood plans an As Low As Reasonably Practicable (ALARP) analysis has been carried out of the estimated maintenance costs, as set out in Tables 6.1 and 6.2 at the end of this Note. This compares the reduction in risk with the cost of risk control measures, evaluating this as the cost for preventing a fatality. The approach is valuable in providing an indication of the whether the cost of the proposed reservoir flood plans is proportionate to the reduction in risk achieved.

Current guidance suggests that additional safety measures on reservoirs are a worthwhile investment where the cost to prevent a fatality is less than £10M (see Section 11.4.3 of Interim Guide to QRA).

The output from the calculation suggest that the cost of the proposed reservoir flood plans is proportionate for all Class A1 reservoirs, and for Class A2 reservoirs where the annual probability of failure is equal to, or higher, than the median probability of failure for UK reservoirs. For Class B reservoirs the cost of the reservoir flood plan proposals is proportionate where the annual probability of failure is more than ten times the median for UK reservoirs; however on average these dams probably are less safe than the median such that the proposals are on average reasonable. For Class C and D reservoirs, the reduction is risk is due to the rapid impact assessment, and although marginally

disproportionate the cost is minimised by carrying it out at the same time as the existing ten yearly Section 10 Inspection under the Reservoirs Act 1975.

6.2 Number of private and charitable owners of Consequence Class A dams

The costs are likely to be proportionately greatest for those undertakers who only own one or two high consequence dams. As a separate assessment of the reasonableness of the proposed measures the records of the Enforcement authority for the Reservoirs Act 1975 (the Environment Agency) have therefore been inspected to determine how many private owners and charitable organisations own higher consequence class dams.

This has been subdivided into two classes of undertaker, commercial and "amenity lakes", following the subdivision within the enforcement authority database. The latter are owned by private landowners, registered charities and agricultural interests. It is accepted that alternative differentiation could be used, for example some private landowners may use the lakes for commercial purposes, whilst some of the dams under the "commercial category" may no longer be used for commercial purposes. Nevertheless it illustrates the issue.

This assessment considers Flood Category rather than Consequence Class as this is the data available on the enforcement database. The results of the assessment are shown in Table 6.4. In relation to ownership of a single Flood Category A dam retaining an "amenity lake", for which the reservoir flood plan requirements would be relatively expensive, it can be seen that

- 18 out of 305 undertakers own a single Category A dam, and three own 3 to 5 dams
- if increased in proportion to the number of dams for which the category is unknown these would increase to 26 and 30 respectively.

The issue then becomes whether the overall benefits of reservoir flood plans are reasonable, set against the particular difficulties it may create for a limited number of undertakers (10% of the "amenity lake" category). It is considered that this proportion is sufficiently small that it should not lead to a change in the proposals.

Table 5.2 : Build-up of cost of preparing the first plan

	Single reservoir			Owner of > 10 reservoirs	
	Person days	Average daily cost of personnel involved	Average Cost	Person days	Average Cost/ reservoir/ year
Rapid Impact assessment					
Note: Extra over consequence assessment as part of ten yearly inspection					
	1	500	£500	0.7	**£350**
Standard Impact assessment					
Note : Assume necessary base mapping etc provided free by Environment Agency					
Modelling + maps	15	450	£6,750	10.0	£4,500
Consequence assessment	5	450	£2,250	3.0	£1,350
Produce plan	3	450	£1,350	2.0	£900
	Total (Standard plan)		**£10,350**		**£6,750**
On-site Plan					
Note: It is assumed that the Undertaker has reasonable data on his reservoir, including capacity of outlet works					
Collect data	1.0	350	£350	1.0	£350
Draft Plan	2.0	350	£700	1.0	£350
Liaison EA, Category 1 Resp, finalise	1.0	350	£350	0.5	£175
		Total	**£1,400**		**£875**
External Interface Plan					
Draft plan	0.5	350	£175	0.5	£175
Liaison EA, cat 1, finalise	1.0	350	£350	0.5	£175
		Total	**£525**		**£350**
Total (all 3 elements)					
Cost to prepare first plan					
Single	Cons Class A		**£12,275**		
	Cons Class B		**£2,425**		
One of 10 reservoirs	Cons Class A				**£7,975**
	Cons Class B				**£1,575**

Notes

1. The assumed typical daily rate varies depending on who does the work, which is taken as a Panel AR Engineer for the Rapid assessment, external consultants for impact assessment and Undertaker's staff for on-site and external interface plans.

Table 5.3 : Build-up of indicative cost of maintaining a reservoir flood plan

Annual maintenance cost (in first 10 years)																
Element	Common assumptions regarding rates			Consequence Class A1 reservoirs (Appendix H)				Consequence Class A2 reservoirs (Appendix H)				Consequence Class B reservoir (as Appendix G)			
	Average daily cost of personnel involved	Overall increase in hours, for portfolio of 10 reservoirs	External costs e.g. plant hire	Frequency of review/ exercise (yrs)	Person days	Average Cost/yr/ reservoir		Frequency of review/ exercise (yrs)	Person days	Average Cost/yr/ reservoir		Frequency of review/ exercise (yrs)	Person days	Average Cost/yr/ reservoir	
						Single reservoir	Portfolio of 10 reservoirs			Single reservoir	Portfolio of 10 reservoirs			Single reservoir	Portfolio of 10 reservoirs
Impact assesment															
Emergency measures	450	3		1	0.5	£225	£68	2	0.5	£113	£34	5	0.5	£45	£14
						£225	**£68**			**£113**	**£34**			**£45**	**£14**
On-site Plan (table 4.14 of Guide)															
Review/ update main plan				At end of 10 years				At end of 10 years				At end of 10 years			
Contact verification/ update appendices	350	5		0.25	0.25	£350	£175	0.5	0.25	£175	£88	1	0.25	£88	£44
Call-out simulation	350	5		1	1	£350	£175	5	0.5	£35	£18	10	0.5	£18	£9
Seminar (Internal)	350	3		1	4	£1,400	£420	2	4	£700	£210	5	3	£210	£63
Tabletop	350	3		1	4	£1,400	£420	Incl in seminar				Not required			
Control Room	350	2		Incl in tabletop			£0	Incl in seminar				Incl in seminar			
Site attendance	350	2		2	5	£875	£175	5	5	£350	£70	5	1	£70	£14
Emergency measures	350	2	£5,000	5	6	£1,420	£213	Not required				Not required			
						£5,795	**£1,578**			**£1,260**	**£385**			**£385**	**£130**
External Interface Plan (table 5.1 of Guide)															
Review/ update main plan				At end of 10 years				At end of 10 years				At end of 10 years			
Contact verification/ update appendices	350	5		0.25	0.25	£350	£175	0.5	0.25	£175	£88	1	0.25	£88	£44
Seminar (Internal)	350	3		1	1	£350	£105	2	1	£175	£53	with on-site seminar			
Call-out simulation	350	5		1	0.25	£88	£44	5	0.25	£18	£9	Not required			
Tabletop	350	3		1	4	£1,400	£420	Incl in seminar				Not required			
Control Room	350	2		Incl in tabletop				Incl in seminar				10	1	£35	£7
Total (all 3 elements)						**£2,188**	**£744**			**£368**	**£149**			**£123**	**£51**
Annual maintenance cost															
Single						**£8,208**				**£1,740**				**£553**	
One of 10 reservoirs							**£2,389**				**£568**				**£194**

Table 6.1 : Assumptions in ALARP analysis as to the benefits of reservoir flood plans

	The annual probability of failure	Consequences of failure
Existing risk level		
Assumption	2×10^{-5}/annum	The midpoint of each consequence class defined in Section 11.2 of the Interim Guide to Quantitative risk assessment (2004).
Sensitivity	Values of 0.1, 10 and 100 times this.	
Basis	The median UK dam, as described in the research project for an "Integration of Floods and reservoir safety"	
Benefits of Reservoir flood plans	**Of on-site plan on annual probability of failure**	**Impact assessment and External interface plan in reducing loss of life**
Assumption	Reduces the probability of failure by a factor of 5	Reduce the fatality rate by a factor of 2.5 for Class A to B, by 1.5 for C, D
Sensitivity	Reduces AP by 10	
Basis		US BOR report on effect of warning on fatalities

Table 6.2 : Sensitivity study of ALARP calculation of maintenance costs of proposed requirements for elements of reservoir flood plan

Dam Consequence Category	Elements of Flood plan required	Existing median		Reduction of risk due to plan, by a factor of		Typical annual cost of maintenance of flood plan		Cost for preventing a fatality (£M), for varying number of dams owned, and varying annual probability of failure (Note Cost is proportionate where CPF < £10M)							
								Owner of single dam				Portfolio of 10 dams			
		Likely loss of life (existing)	Damage in dam failure	Probability of failure (onsite plan)	Loss of life (due to Impact assessment, External interface plan)	Owner of single dam	Portfolio of 10 dams								
			£M			£/annum	£/annum	£M	£M	£M	£M	£M	£M	£M	£M
					Annual probability of failure			2.0E-06	2.0E-05	2.0E-04	2.0E-03	2.0E-06	2.0E-05	2.0E-04	2.0E-03
A1	All	400	400	5	2.5	8,208	2,389	10.3	0.2	-0.8	-0.9	10.3	0.2	-0.8	-0.9
A1	All	200	200	5	2.5	8,208	2,389	21.4	1.4	-0.6	-0.8	21.4	1.4	-0.6	-0.8
A2	All	20	20	10	2.5	1,740	568	44.4	3.6	-0.5	-0.9	44.4	3.6	-0.5	-0.9
A2	All	20	20	5	2.5	1,740	568	46.4	3.9	-0.4	-0.8	46.4	3.9	-0.4	-0.8
B	All, but I = Rapid	0.8	0.8	10	2.5	553	194	358.8	35.0	2.7	-0.6	358.8	35.0	2.7	-0.6
B	All, but I = Rapid	0.8	0.8	5	2.5	553	194	374.5	36.7	2.9	-0.5	374.5	36.7	2.9	-0.5
C	I (Rapid)	0.04	0.1	1	1.5	50	35	1,839	184	18	2	1,839	184	18	2
D	I (Rapid)	0.004	0.01	1	1.5	50	35	18,386	1,839	184	18	18,386	1,839	184	18
								Note: Negative value implies justified purely in economic terms (i.e. reduction of risk of damage), excluding any consideration of likely loss of life							

Table 6.3 : Distribution of ownership of dams, subdivided by Flood Category

Distribution of ownership of dams, subdivided by consequence category

Type of Undertaker	Total Number of dams							Number of Undertakers owning							For category A dam, number of Undertakers owning				
	Totals	in Category A	in Category B	in Category C and D	Not Applicable	Unknown		Total	1 dam	2 dams	3 dams	4 dams	5 dams	>5 dams	1 dam	2 dams	3-5 dams	≤ 5 dams	> 5 dams
						No	% total												
Commercial																			
Water Company	735	409	91	62	72	101	14%	20	3	0	1	0	0	16					
British Waterways	71	36	19	14	0	2	3%	1	0	0	0	0	0	1					
Environment Agency	149	46	17	45	5	36	24%	1	0	0	0	0	0	1					
Industrial	88	23	4	26	11	24	27%	33	17	8	4	0	0	4					
Other Government Agency	36	6	8	16	0	6	17%	24	18	4	1	0	0	1					
Other/Unknown	193	35	27	82	4	45	23%	151	130	13	2	2	2	2					
Private Utility	25	4	4	5	0	12	48%	5	1	0	0	1	1	2					
Public Utility	225	57	38	70	1	59	26%	143	98	31	7	2	3	2					
Sub total	***1522***	***616***	***208***	***320***	***93***	***285***		***378***	***267***	***56***	***15***	***5***	***6***	***29***					
%		40%	14%	21%	6%	19%			71%	15%	4%	1%	2%	8%					
% (adjusted for unknown)		54%	18%	28%															
Amenity lakes																			
Private Landowner	242	22	41	130	2	47	19%	192	159	25	3	2	2	1	14	0	2	16	6
Registered Charity (incl National Trust)	63	6	10	32	2	13	21%	13	7	2	3	0	0	1	0	0	1	1	5
Agriculture (Farms and Fisheries)	131	3	8	35	8	77	59%	100	79	15	4	1	0	1	4	0	0	4	-1
Sub total	***436***	***31***	***59***	***197***	***12***	***137***		***305***	***245***	***42***	***10***	***3***	***2***	***3***	***18***	***0***	***3***	***21***	***10***
%		7%	14%	45%	3%	31%			80%	14%	3%	1%	1%	1%					
Grand Total	1958	647	267	517	105	422			512	98	25	8	8	32					