OBSTRUCTIONS TO FISH PASSAGE IN NEW SOUTH WALES SOUTH COAST STREAMS

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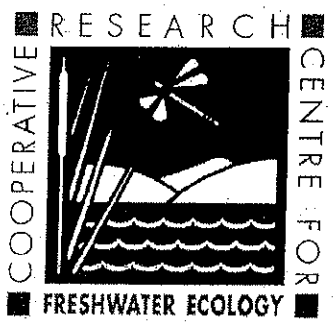
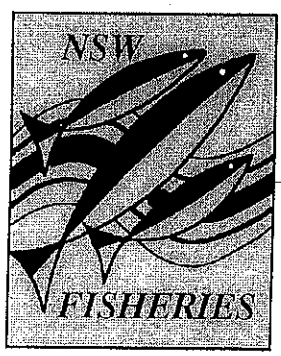
Robyn Pethebridge, Allan Lugg and John Harris

Cooperative Research Centre for Freshwater Ecology
NSW Fisheries Research Institute,
PO Box 21,
Cronulla NSW 2230





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1. SUMMARY

Native freshwater fish populations are affected by obstructions to fish passage because their natural movements throughout river systems are compromised. Artificial barriers such as dams, weirs, causeways and culverts obstruct the free passage of native fish by preventing or impeding their movement from one part of a stream to another. All freshwater fish need to move between habitat areas at some stage in their life cycle to spawn or seek food and shelter, with many having definite migration requirements. Therefore, obstructions which impede the free passage of fish often result in declining populations or local extinction.

A survey was made to identify and document fish passage obstructions in the coastal rivers of south-eastern New South Wales. The area studied ranged from the Wollongong Coast south of Sydney to the Victorian border, also including the Snowy River. This area comprised a total of nine of the Australian Water Resources Council Drainage Basins, including the Wollongong Coast (No. 214), Shoalhaven River (No. 215), Clyde River-Jervis Bay (No. 216), Moruya River (No. 217), Tuross River (No. 218), Bega River (No. 219), Towamba River (No. 220), East Gippsland (No. 221) and Snowy River (No. 222).

A total of 254 obstructions were documented, comprising high dams, farm dams, fixed crest-weirs, rock weirs, stream-gauging weirs, culverts, causeways, bridges and tidal floodgates. Overall, causeways and culverts were the most common structures found to obstruct fish passage. The largest number of obstructions occurred in the Shoalhaven River Basin, where a total of 90 artificial barriers were present. A total of 47 obstructions occurred in the Wollongong Coast Basin, 25 in the Clyde River-Jervis Bay Basin, 24 in the Snowy River Basin, 24 in the Bega River Basin, 18 in the Tuross River Basin, 17 in the Towamba River Basin, 6 in the Gippsland River Basin, and 3 in the Moruya River Basin.

A "fishway priority scheme" was developed to provide a quantative, objective basis to rank the priority of a fish-passage restoration project for any obstruction, either by building a fishway or removing the obstruction. Eleven criteria were used, including details of the size of the river system, location of the obstruction, presence of threatened species, severity of the obstruction and other relevant features.

The Fisheries Management Act (1994) has various provisions for maintaining fish passage in streams, these are summarised in the publication: "Policy and Guidelines. Aquatic Habitat Management and Conservation 1998." The current survey has shown that there are numerous obstructions to fish passage which impede migration and threaten biodiversity in many south coast streams. Fish passage needs to be restored as a major step in restoring healthy rivers.

2. INTRODUCTION

2.1 Migration of freshwater fishes in south coast streams of New South Wales

All Australian freshwater fish have a need to move between habitat areas in streams (Thorncraft and Harris 1996; Smith and Pollard 1998). Most of the freshwater species of south-eastern Australia are known to migrate at some stage of their life cycles (Mallen-Cooper 1994). The coastal rivers of southern New South Wales provide habitat for 48 species of freshwater fishes, of which 35 are native to this region (Harris 1995). These include two species of eels, two hardyhead species, freshwater herring, several species of gudgeons, and a number of species of galaxiids, gobies, mullets, cods and basses. The popular angling fish, Australian bass *(Macquaria novemaculeata),* is one migratory species that has been adversely affected by barriers to fish passage throughout its range (Harris 1988). The list also includes three threatened species, Macquarie perch *(Macquaria australasica)*, Australian grayling *(Prototroctes maraena),* and non-parasitic lamprey *(Mordacia praecox).*

The migration patterns of freshwater fishes have been classified into four different categories, which are described in Harris (1984a). 'Diadromous' fishes migrate between the sea and freshwater for the purpose of breeding. and thus may be either 'anadromous', 'catadromous' or 'amphidromous'. Anadromous fishes usually live in the sea and migrate to fresh water to breed, while catadromous fishes live most of their lives in fresh water and move to estuarine or marine waters to spawn. The catadromous cycle is the most common migration pattern of fishes found in coastal streams in south-eastern Australia (Mallen-Cooper 1994). Australian bass and striped mullet *(Mugil cephalus)* are two species which follow this pattern, which usually involves an autumn-winter migration to the estuaries or the sea, followed by a return to fresh water in early spring. Juveniles move back upstream in late spring to early summer (Mallen-Cooper 1994). Amphidromous fishes migrate between the sea and fresh water, not for breeding purposes, but to feed and to avoid predators. Common amphidromous species include the climbing galaxias and flat-tail mullet (Mallen-Cooper 1994). 'Potamodromous' fishes, such as the Macquarie perch, are those non-diadromous species which migrate within rivers without entering the sea.

Table 2.1 lists the fishes living in the freshwater reaches of coastal rivers of southern New South Wales, together with their known migratory patterns. A number of freshwater fishes have been introduced from countries outside Australia, some of which are regarded as pests (Harris 1995). These alien species are also listed in this table. The silver perch *(Bidyanus bidyanus)* is native to Australia, but has been translocated to coastal freshwater systems from western drainages, and in this context is referred to as an 'introduced' species (Harris 1995).

Table 2.1 Fishes found in the coastal rivers of southern NSW

Family	Species	Common name	Migratory Requirements	Distribution (Basin Nos)
Anguillidae	*Anguilla australis*	short-finned eel	catadromous	214-222
	A. reinhardtii	long-finned eel	catadromous	214-222
Atherinidae	*Atherinosoma microstoma*	small-mouthed hardyhead		214-221
	Pseudomugil signifer	Pacific blue-eye		214218
Bovichtidae	*Pseudaphritis urvilii*	tupong (congolli)	amphidromous	220-222
Clupeidae	*Potamalosa richmondia*	freshwater herring	catadromous	214-221
Cobitidae	*Misgurnus*	oriental weatherloach		222
Cyprinidae	*Carassius auratus**	goldfish		214-222
	*Cyprinus carpio**	common carp		215
Eleotridae	*Gobiomorphus australis*	striped gudgeon	amphidromous	214-221
	G. coxii	Cox's gudgeon	potamodromous	214-221
	Hypseleotris compressa	empire gudgeon		214-220
	H. galii	firetail gudgeon		214-220
	Philypnodon grandiceps	big-headed gudgeon		214-222
	Philypnodon sp. 1.	dwarf flathead gudgeon		214-222
Galaxiidae	*Galaxias brevipinnis*	climbing galaxias	amphidromous	214-222
	G. maculatus	common galaxias	catadromous	214-221
	G. olidus	mountain galaxias		214-222
Gobiidae	*Arenigobius bifrenatus*	bridled goby		214-221
	Pseudogobius olorum	Swan River goby	amphidromous	
	Redigobius macrostoma	large-mouthed goby		214-221
Mordaciidae	*Mordacia mordax*	short-headed lamprey	anadromous	214-222
	M. praecox	non-parasitic lamprey	anadromous	217-218
Mugilidae	*Aldrichetta forsteri*	yellow-eye mullet	amphidromous	214-221
	Mugil cephalus	striped mullet	catadromous	214-221
	M. petardi	freshwater mullet	catadromous	
Percichthyidae	*Macquaria australasica*	Macquarie perch	potamodromous	215
	M. colonorum	estuary perch		214-221
	M. novemaculeata	Australian bass	catadromous	214-221
Percidae	*Perca fluviatilis**	redfin perch		215, 222
Plotosidae	*Tandanus tandanus*	freshwater catfish		214
Poeciliidae	*Gambusia holbrooki**	gambusia		214-222
Prototroctidae	*Prototroctes maraena*	Australian grayling	anadromous	214-222
Retropinnidae	*Retropinna semoni*	Australian smelt	amphidromous	214-222
Salmonidae	*Oncorhynchus mykiss**	rainbow trout		222
	*Salmo salar**	Atlantic salmon		222
	*S. trutta**	brown trout		222
	*Salvelinus fontinalus**	brook trout		222
Scorpaenidae	*Notesthes robusta*	bullrout	catadromous	214-216
Terapontidae	*Bidyanus bidyanus#*	silver perch	potamodromous	

* Alien species, # Introduced species

The fish species mentioned above cover a range of sizes and swimming abilities. The migratory stage may be the adults and/or the juveniles of both large or small species. Many of the adult catadromous and amphidromous species may weigh less than 2 kilograms (Mallen-Cooper 1994), while Australian bass may grow to 3.8 kilograms (McDowall 1996). A single fish of some species may swim 1000 kilometres or more during a spring and summer (Mallen-Cooper 1994), while others may need to travel for only short distances.

2.2 Consequences of obstructions to fish passage

Since the arrival of European civilisation in Australia, there has been a marked decline in the range and abundance of freshwater fishes (Harris and Mallen-Cooper 1994, Mallen-Cooper 1994). A number of factors have led to this decline of Australian freshwater fish and fisheries, including habitat degradation, introduction of alien fish species, overfishing and obstruction of fish passage by obstructions such as dams, weirs, culverts and causeways (Mallen-Cooper 1988; Harris and Mallen-Cooper 1994; Smith and Pollard 1998). The decline of the Australian grayling to 'potentially threatened' status has been a result of such obstructions (Wager and Jackson 1993). Timms (1995) summarised the effects of obstructions to fish passage as shown in Figure 2.1

Obstructions to fish passage occur throughout the Australian continent, the driest in the world. Numerous dams and weirs have been built along river systems since the 1800s in order to provide reservoirs for water supply for Australia's growing population (Harris 1984a; Mallen-Cooper 1994). Numerous weirs have also been built in order to gauge the flow of rivers and streams. In addition to dams and weirs, causeways and culverts have been built across streams to provide access for vehicles. All of these structures form unnatural obstacles which impede or modify stream flow and the movement of fish from one part of the river to another. These obstacles prevent fish passage in periods of low flow, but many may allow the movement of fish in times of flood when inundation eventually provides free passage and the obstacle is said to be 'drowned-out'. Some obstacles prevent fish passage at all times, constituting a complete barrier which leads to local extinction of migratory species upstream, and possibly downstream also (Harris 1984a; Harris and Mallen-Cooper 1994; Marsden *et al.* 1997).

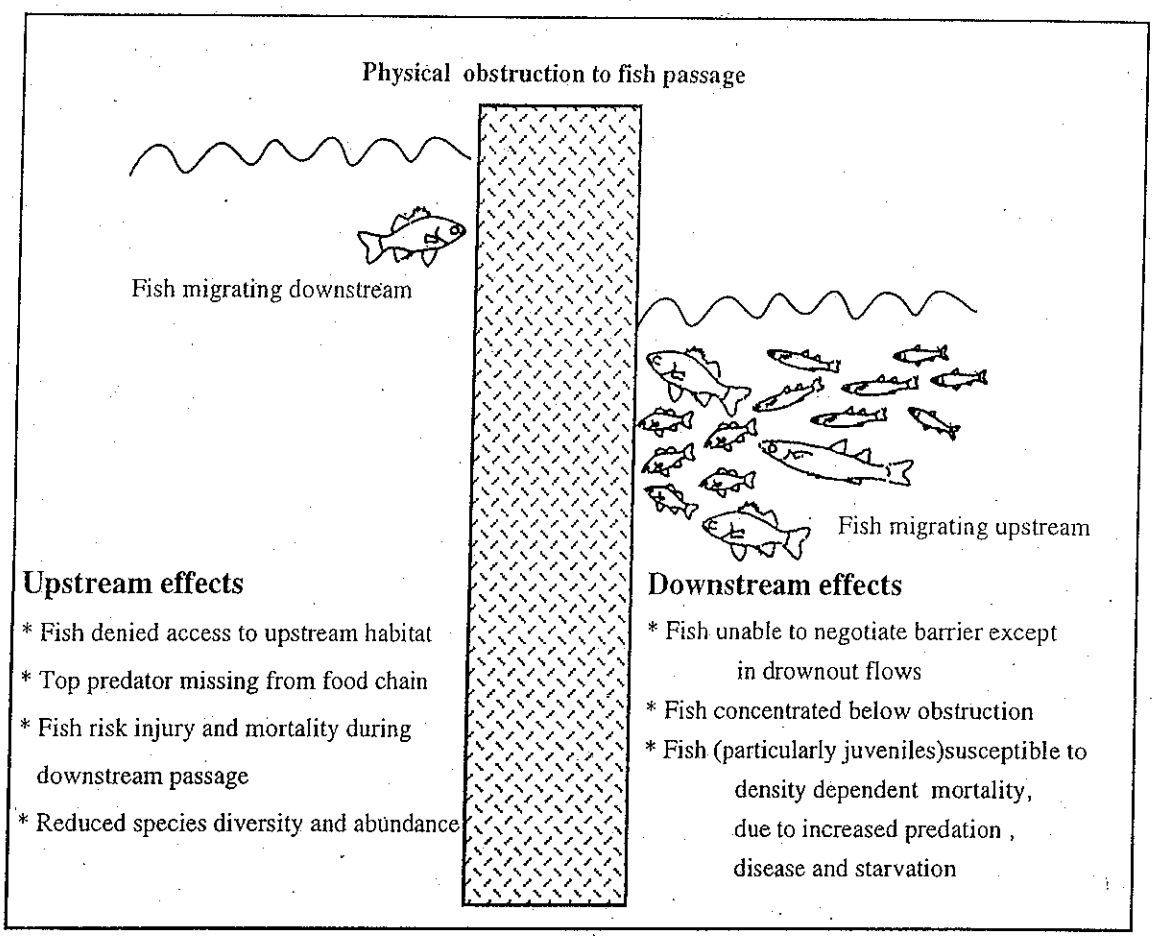

Figure 2.1. Consequences of obstructions to fish passage (modified from Timms 1995)

Harris (1984a) carried out a study to determine the amount of freshwater fish habitat obstructed by impoundments on the coastal drainages of south-eastern Australia within the geographical range of the Australian bass. This covered coastal drainages from the Mary River in Queensland to Lakes Entrance in eastern Victoria (22 drainage basins). A total of the barriers found, including 111 dams, 30 tidal barriers, 96 weirs and 56 high weirs. Most of these barriers (70%) were found in the more highly developed areas, which included Brisbane, the Gold Coast, Hunter-Hawkesbury, Sydney, Illawarra and Lakes Entrance. The largest number of barriers (80) in a single catchment was found on the Hawkesbury River System near Sydney. The results indicated that artificial barriers have obstructed about half of the total length of streams which are potentially available as fish habitat. These obstructions have contributed to the decline and loss of populations of catadromous fishes, such as the Australian bass.

Another study by Harris (1988) indicated that the spawning behavior of bass is triggered by flooding, with bass recruitment being higher in years of high winter river flows. Therefore, the recruitment of bass is not only affected by the obstruction of rivers by barriers, but also through the effects of dams on the flow regime. There have been very few studies carried out on the

biology of other native fishes which inhabit the coastal regions of south-eastern Australia, but it can be assumed that other migratory species having similar life-histories would be affected in a similar way.

Timms (1995) studied obstructions to fish passage in the Shoalhaven catchment below Tallowa Dam for a B.Sc. Honours project through the University of Wollongong. A total of 62 barriers (comprising dams, weirs, floodgates, levees, culverts and causeways) were found in this catchment. These barriers have the potential to alienate 67 km of estuarine and 87 km of freshwater fish habitat below the Tallowa.

It has been documented that obstructions to fish passage may have detrimental effects on all fish species, not just recognised migratory species (Koehn & O'Connor 1990; Harris and Mallen-Cooper 1994; Berghuis *et al.* 1997). Fishes need to move between stream habitat areas not only for spawning or feeding migrations, but also for recolonisation, and habitat selection (Koehn and O'Connor 1990). The result of obstructions can be to concentrate populations into smaller river reaches or pools, thus increasing the potential for disease starvation and predation.

2.3 Aims and objectives of this study

It was noted by Harris (1984a) that only limited information was available about the occurrence and features of physical barriers in Australian streams. Until recently there has also been little control over the construction of these barriers. In the Shoalhaven catchment below Tallowa Dam, only 11 structures were found by Harris (1984). In 1995, however, Timms found 62 barriers for the same area. However, Harris's study was on a broader scale, and only weirs and dams on streams were surveyed. Timms' (1995) study was more comprehensive study of one area, and including smaller-scale physical structures (e.g. low-level weirs, causeways, culverts and floodgates) as well as dams and weirs. These small-scale obstructions may still cause serious problems for fish passage. Because Harris's 1984 study was completed over a decade ago, and did not include small-scale obstructions the need for a more up-to-date inventory of barriers to fish passage on the streams of the south coast of NSW was identified.

The main aims of the project were:

* to locate, identify and document the barriers to fish passage which occur on NSW south coast streams,
* to estimate the amount of fish habitat being obstructed,

* to prioritise the barriers found in terms of the need to provide for fish passage at these sites, and
* to prepare a strategic plan of future actions to address the problems posed by these barriers.

3. METHODS

A steering committee was set up to plan and oversee the progress of the project. The committee was made up of staff from NSW Fisheries (NSWF) and the Department of Land and Water Conservation (DLWC) (Table 3.1). At the first meeting, in April 1996, the methodology for the study was discussed. It was decided to use NSW Central Mapping Authority (CMA) topographic maps for the identifying fish habitat and the preliminary location of sites.

Table 3.1 Project Steering Committee

Name	Department
Robyn Pethebridge (Project Officer)	NSWF
John Harris	NSWF
Allan Lugg	NSWF
David Pollard	NSWF
Rob Williams	NSWF
Mark Conlon	DLWC
Tim Entwistle	DLWC

3.1 Study area

The steering committee for the project decided to survey all of the coastal river systems from Lake Illawarra south to the Victorian border, including the Snowy River catchment area. The Australian Water Resources Council Drainage Division No. 2, which includes all of the coastal river basins of NSW, was used to determine catchment boundaries.

The drainage basins south of the Sydney region which were studied, include the Wollongong (No. 214), Shoalhaven River (215), Clyde River-Jervis Bay (216), Moruya River (217), Tuross River (218), Bega River (219), Towamba River (220), East Gippsland (221), and Snowy River (222) Basins (see Figure 3.1). The numbers in brackets indicate the numbers allocated by the Australian Water Resources Council (AWRC) 'Pinneena' maps.

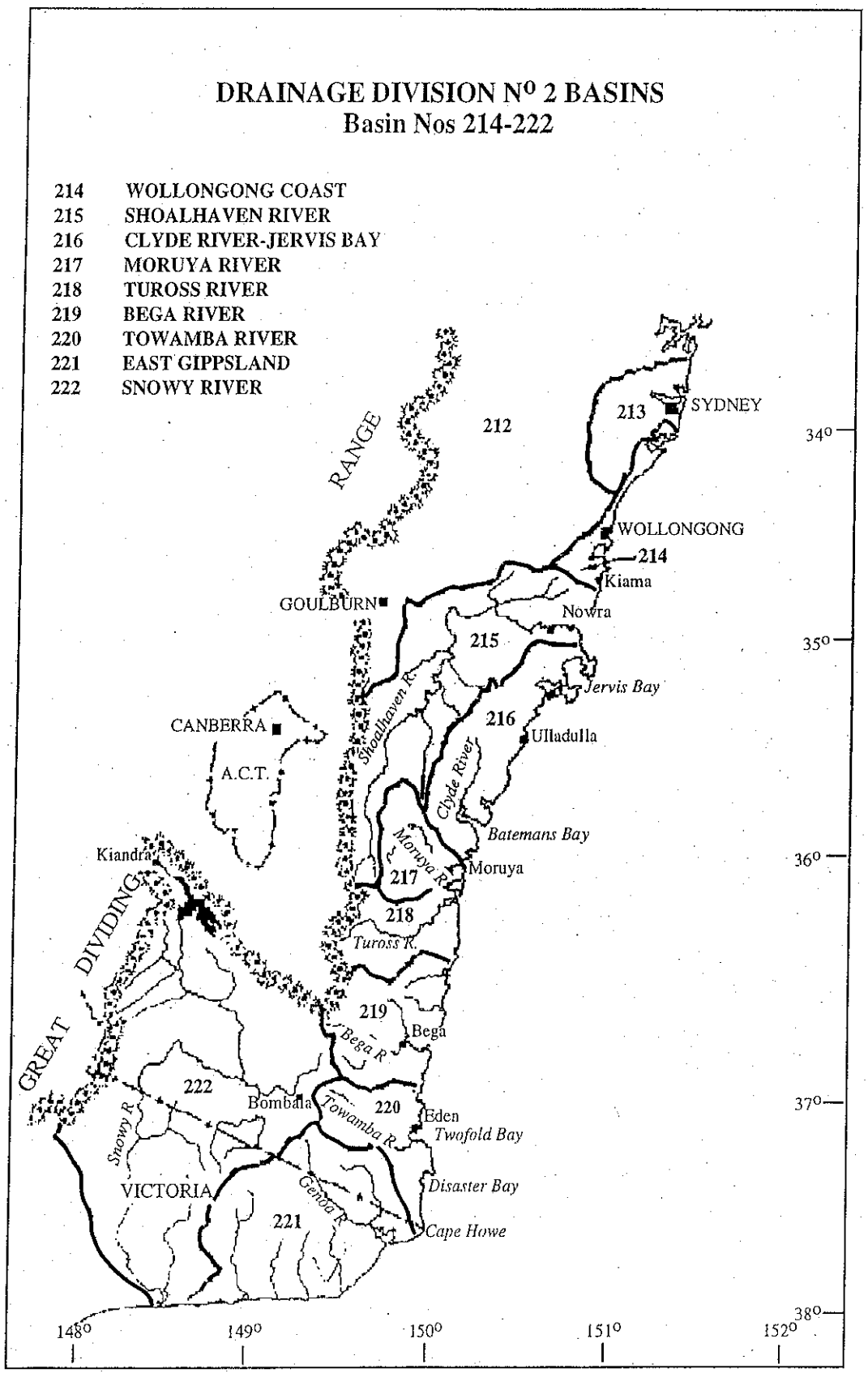

Figure 3.1: Study Areas showing Basin Numbers 214-222 (redrawn from AWRC Pineena Map)

3.2 Trial Survey Project

The project steering committee decided that the Minnamurra River, Macquarie Rivulet and Pambula River catchments would be used in a pilot survey because of their manageable size and fish-passage significance. The Minnamurra River and Macquarie Rivulet catchments are located in the Wollongong Basin (No. 214), while the Pambula River catchment is located in the Towamba River Basin (No. 220). The following methods for identifying and locating obstructions to fish passage were found to be efficient in the pilot survey and were therefore used for all other catchments.

3.3 Site selection

Relevant 1:100 000 topographic maps to be used were selected from the Commonwealth Mapping Authority's (CMA) 1995 catalogue. Each individual catchment boundary within each basin was marked out. From these maps, it was determined which 1:25 000 topographic maps were needed for a study of greater detail in each catchment. For the purpose of the survey, significant fish habitat was defined as perennial streams marked on the 1:25 000 scale maps. Any potential obstructions (e.g. dams, weirs, road and rail crossings etc.) were marked on these maps. Intermittent streams were excluded, generally being headwater streams subject to numerous natural barriers and temporary habitats.

3.4 Information collection

To seek information about the potential obstructions marked on the 1:25 000 CMA maps, and any other obstructions which may not be shown, letters were sent to relevant authorities including local government councils and other State Government authorities (e.g. State Forests, National Parks and Wildlife Service) informing them about the objectives of the survey and asking for information. These authorities were later contacted by telephone to arrange meetings to

discuss the project, to study maps and to seek local knowledge to determine which structures may constitute obstructions to fish passage.

The type of information needed about each structure was determined from the report of DLWC's Weir Inventory project, an inventory of licensed structures (DLWC 1996). Information gathered from this survey will be added to the DLWC inventory. A questionnaire (see Figure 3.2) was designed to accommodate this information. It was also used as a guideline for which relevant authorities could provide necessary information.

3.5 Field observations

For each catchment, field inspections took place after meetings with the relevant authorities. Each site was located using the 1:25 000 CMA maps, from which a grid reference was also obtained. Criteria used to determine the fish-passage significance of each site were:

1. Whether the structure altered the stream-bed profile sufficiently to create a vertical discontinuity in the water surface at low flows.
2. Whether the slope of the structure created a flow-velocity barrier in the stream flow
3. Whether a piped structure excessively reduced daylight penetration into the stream.

Obstructions were classified as one of nine different kinds of structure (Figure 3.2), and grouped into dams, weirs, road crossings and erosion control structures.

Figure 3.2. Survey Proforma

SURVEY OF FISH MIGRATION BARRIERS ON THE SOUTH COAST OF NSW

Robyn Pethebridge, NSW Fisheries, PO Box 21, Cronulla NSW 2230
ph: (02) 527 8411, fax: (02) 527 8576

1) Field details

Name of barrier (incl. NSW Fisheries code) _____
Name of river/stream _____
Name of major river catchment _____
Drainage Basin name _____
Drainage Basin number _____
Date and time of observation _____
Photographs of barrier (list negative numbers) _____

2) Barrier location

Map (1: 25 000): _____
Property: _____
Road: _____
Nearest cross road: _____

Grid reference: _____ Easting /Northing_____

Lat./long.: _____

Nearest town: _____

Directions from nearest town (with distances): _____

_____

Vehicle access (Yes/No) _____ 4WD or 2WD _____

3) Type of barrier

Dam	❑ High dam	❑ Farm dam	❑ Fabridam	
Weir	❑ Fixed crest	❑ Rock weir	❑ Sheet pile	❑ Gated weir
	❑ Bypass	❑ Stop log	❑ Stream gauging weir	
Road crossing		❑ Bridge	❑ Culvert	❑ Causeway
❑ Tidal Barrage				
❑ Natural (e.g. waterfall)				
Erosion control structure		❑ rock shute	❑ drop structure	
		❑ pipe drop	❑ silt trap	

4) Structural characteristics

Vertical height (m): ____ Base length (m): ____ Crest length (m): ___ Crest width (m): _____Head loss (m): _____

Height between tailwater and crest at low flow (m): _____

Diameter of outlet pipe (m): _____

Spillway type: Slope: Gradient: ____ height (m) ___ Width (m)_

Stepped: Height (m):___ Width: (m) ____

Vertical: Height: (m) ___ Width: (m) ____

Length of weir pool (m): _____

Capacity (ML): _____

Foundation material:	qRock	qAlluvium	qOther _____
Construction material:	q Concrete	qGabion	qRock
	q Steel	q Wood/Timber	q Earth
	qRock fill	qPermeable Rock	q Other_____

5) Other details

Year built: _____

Builder: _____

Proposed action (yes/no): _____

Barrier owner: _____

Owner's address: _____

Contact position and name: _____

License No.: _____

Licensing authority: _____

Barrier status: a) existing ___ b) proposed ___ c) removed ___

Structure in use (yes/no) _____

6) Fishway details

Fishway present (yes/no): _____

Gradient: _____

Type of fishway: q Denil
q Rock ramp
q Vertical slot
q Submerged orifice
q Weir pool
q Fish lock
q Fish pump
q Fish lift

7) Stream/ catchment characteristics

Flow characteristics of the river

q High spring flows with low summer flows

q High summer flows

q Stream dry for a period of each year

q Other _____

River regulation

distance to the nearest upstream barrier (m) _____

distance to the nearest downstream barrier (m) _____

Barrier drownout (yes/no) ____ Frequency of drownout _____

Catchment area above barrier (sq km) _____

Catchment condition upstream of the barrier

q Pristine, undisturbed (100% natural forest)

q Minor forestry and/or agriculture (< 25% of catchment area: > 75% natural forest)

q Moderate forestry and/or agriculture (25-50% of catchment area: 50-75% natural forest)

q Major forest and/or agriculture (51-75% of catchment area: 25-49% natural forest)

q Highly modified; major forestry and/or agriculture (<25% natural forest remaining)

Stream condition upstream of barrier

❑ Pristine, undisturbed (no apparent clearing of riparian vegetation, bank degradation, etc)

❑ Low disturbance (<25% of upstream areas degraded as above)

❑ Moderate disturbance (25-50% of upstream areas degraded as above)

❑ High disturbance (51-75% of upstream areas degraded as above)

❑ Very high disturbance (>75% of upstream areas degraded as above)

8) Environmental study details

Has an environmental study been carried out? (e.g. environmental flow, water quality, flora/fauna survey, etc) (yes/no) ____

Organisation which conducted study_____

Date of study_____

Other details_____

9) Fish survey details

Has a fish survey been carried out? (yes/no) _____

Organisation _____

Date of study _____

Fish species

upstream of the barrier _____

_____

_____

downstream of the barrier _____

_____

_____

If the structure did not pose a fish-passage problem (e.g. a road crossing which turned out to be a bridge with no impediment to stream flow or excessive shading), then the structure was marked on the topographic map with a circle. If the structure did pose a problem (e.g. a road crossing which was in the form of a restricting culvert or causeway), then photographs and measurements were taken. The measurements taken for each structure included the vertical height, crest length, base length, crest width and difference in height between tailwater and crest at low flow (see proforma (Figure 3.2). A GPS reading was also recorded for accurate latitude and longitude. Any other available information (e.g. ownership, builder and year built) was recorded.

3.6 Defining obstructions

A total of eight different types of structures were observed as obstructions to fish passage within the nine drainage basins studied. These belonged to three of the categories as described in part 3 of Figure 3.2, and included dams, weirs and road crossings.

Two dam types were recorded, high dams and farm dams. A high dam was defined as a large structure (above 10 m in height) which was used for major water storage for domestic, agricultural or industrial purposes. Farm dams were impoundments of streams and drainage lines, constructed from natural materials, which usually occur on private properties and which are used for domestic or private agricultural purposes.

The three types of weirs observed were the fixed-crest weir, rock weir and stream gauging weir. Fixed-crest weirs were usually built of concrete as fixed structures across stream beds. Rock weirs were also impoundments across streams, but were built from natural rock material. Stream-gauging weirs were usually concrete weirs with a v-notch.

Three types of road crossings were observed, including bridges, culverts and causeways. A bridge was defined as a structure which allowed for the stream to flow underneath, but which may impede flow at medium or high river levels. Culverts were identified as road crossings which traversed streams and which allowed for restricted flow because they contained pipes or other outlets. Causeways were identified as road crossings which impeded stream flow without any outlet pipes. Tidal floodgates were also recorded in the data, but were not observed in the field. Information about tidal floodgates was gathered from Timms (1995).

3.7 Data management

Data collected from field observations or contact with authorities were collated and data sheets were stored in folders, together with photographs for each structure, and sorted by catchment. A database was designed and set up using a Microsoft Access 2.0 software package on an IBM personal computer. This package enables the user to create a database, without programming, to access data in various files and file types, and to generate forms and reports (O'Dwyer Technology Training Pty Ltd 1994). Access was chosen as the database application to be consistent with the Weir Inventory (DLWC 1996).

When all data were entered and validated, they were summarised in the form of queries and reports according to drainage basin numbers. These summaries were translated into Microsoft Excel tables and thenceinto the Microsoft Word tables provided in the Appendices.

4. RESULTS

4.1 Overall results

A total of 254 obstructions were found in the nine drainage basins of the south coast of New South Wales. These obstructions were made up of high dams, farm dams, fixed-crest weirs, rock weirs, stream gauging weirs, causeways, culverts, bridges, and tidal floodgates. Table 4.1 summarises the results.

Table 4.1. Obstructions found on south-eastern NSW streams.

Type of structure	Number	Proportion
culvert	87	34%
causeway	73	29%
fixed crest weir	35	14%
tidal floodgate	24	9%
high dam	17	7%
stream gauging weir	7	3%
farm dam	5	2%
rock weir	3	1%
bridge	3	1%
Totals	254	100

The highest proportion of obstructions identified was that of culverts at 34%. This proportion was followed closely by causeways (29%). Therefore, it seems that out of 9 different types of obstructions, the most common types of obstruction are these two types of road crossings. Figure 4.1 displays the proportions of the various types of obstructions found.

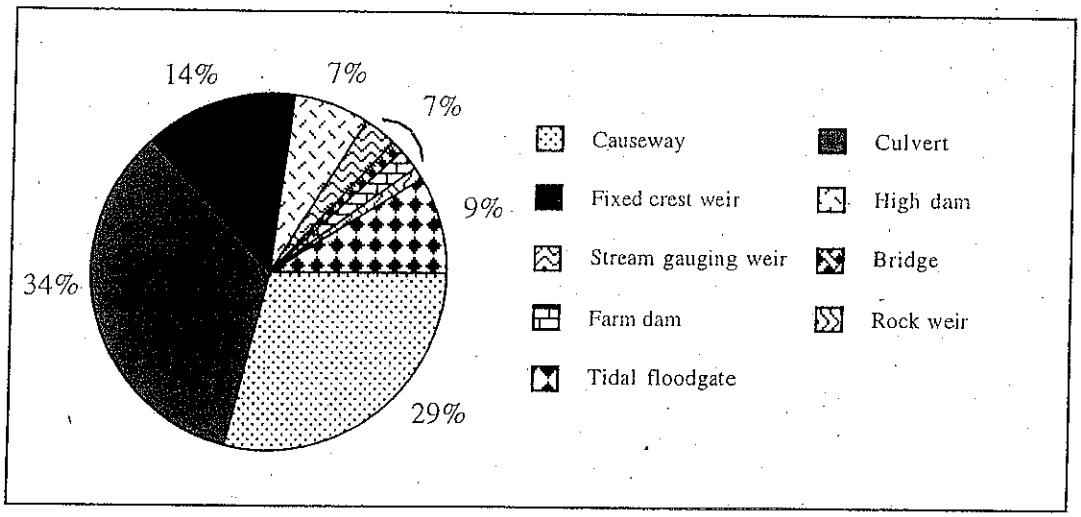

Figure 4.1. Proportions of various types of stream obstructions in south-eastern NSW

Figure 4.2 shows the proportional representation of obstruction types by river drainage basin. Culverts occur in all drainage basins, causeways occur in seven of the nine basins (78%) and bridges in two of the nine basins (22%). High dams occur in five of the nine basins (56%) and farm dams in four of the nine basins (33%). Fixed crest weirs occur in six of the nine basins (67%), rock weirs in two of the nine basins (22%) and stream gauging weirs in three of the nine basins (33%). Tidal floodgates occur only in the Shoalhaven Basin.

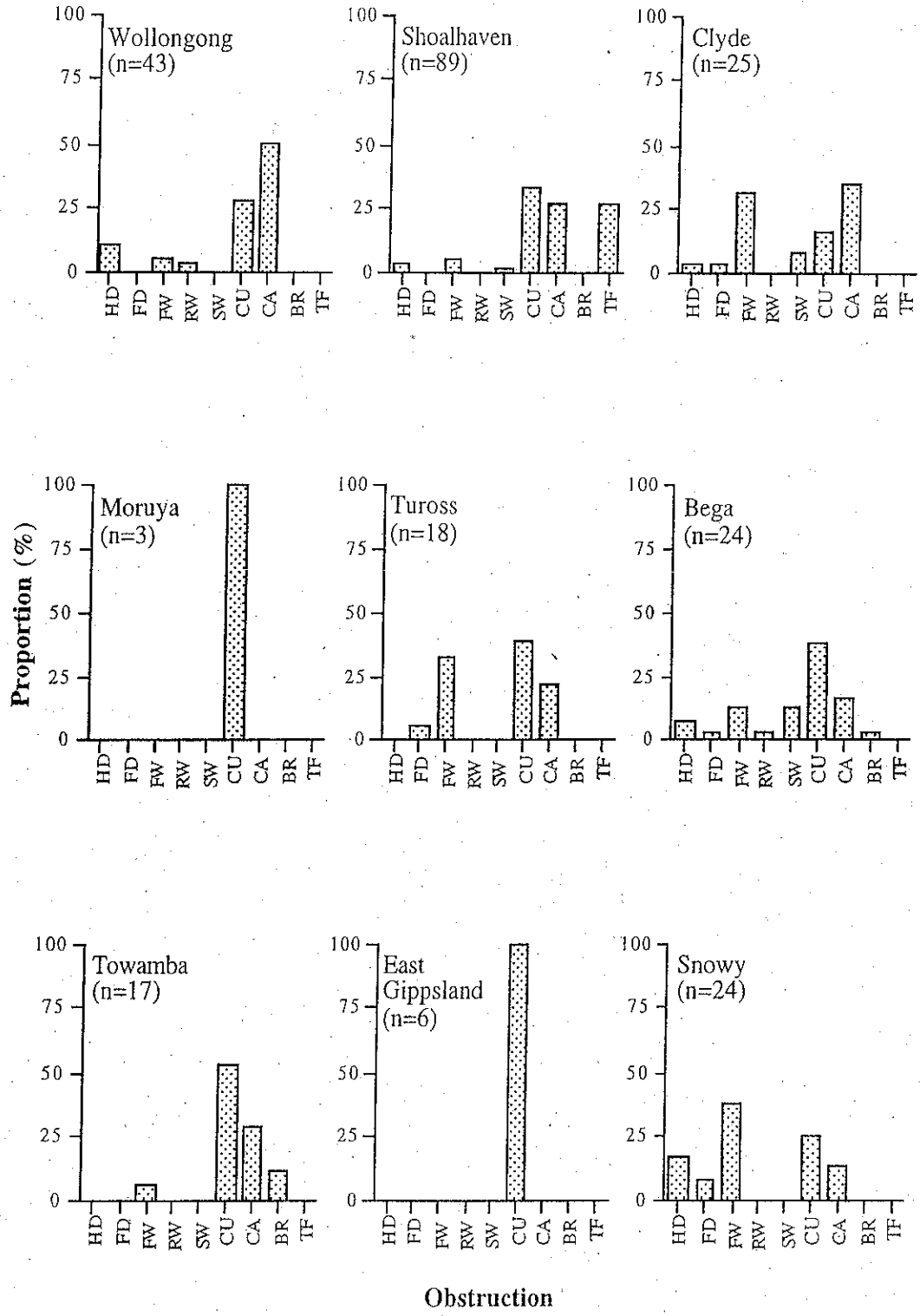

Figure 4.2. Proportional representation of obstruction types by drainage basin. (HD: High dam; FD: Farm dam; FW: Fixed crest weir; RW: Rock weir; SW: Stream gauging weir; CU: Culvert; CA: Causeway; BR: Bridge; TF: Tidal Floodgate n:total numbers of obstructions)

Most of the artificial obstructions found in the Wollongong drainage basin (Figure 4.3) are causeways and culverts, with a small number of high dams, fixed crest weirs and rock weirs. The majority of obstructions found in the Shoalhaven River Basin (Figure 4.4) are culverts, with a substantial proportion of causeways and tidal floodgates, a small proportion of high dams, fixed crest weirs and stream gauging weirs. Obstructions between the Clyde River to Jervis Bay Basin (Figure 4.5) are made up mostly of causeways a smaller proportion of fixed-crest weirs. A substantial number of culverts was also present, with small numbers of stream gauging weirs, high dams and farm dams. Moruya River Basin (Figure 4.6) obstructions included only culverts, and the Tuross River Basin (Figure 4.7) has mainly culverts and causeways, with a small proportion of farm dams and fixed-crest weirs. The Bega River Basin (Figure 4.8) obstructions were mostly culverts, with a substantial proportions of causeways and stream gauging weirs. Some high dams, farm dams, fixed-crest weirs, rock weirs and bridges were also found. The Towamba River Basin (Figure 4.9) obstructions are mostly made up of culverts and causeways and a smaller proportion of bridges. The six obstructions in the East Gippsland Basin (Figure 4.9) were all culverts Obstructions in the Snowy River Basin (Figure 4.10) are mainly made up of culverts and fixed crest weirs, with a substantial proportion of high dams and causeways, and a small proportion of farm dams. These proportions are outlined in further detail in the basin summaries (Section 4.2).

Fishways were present on only seven of the 254 individual obstructions (2.7%) in the nine drainage basins. These are listed in Table 4.2.

Table 4.2 Fishways on obstructions on south-eastern NSW streams.

Basin No.	Structure ID*	Structure name	Stream name	Structure type	Fishway
214	Mac 12	McDonalds Weir	Macquarie Rivulet	Rock weir	Rock-ramp
214	Min 13	Kurraroo Rock Weir	Minnamurra River	Rock weir	Rock-ramp
215	Sho 48	Tapitallee Weir	Tapitallee Creek	Fixed crest weir	Submerged orifice
216	Cly 10	Buckenbowra Weir	Buckenbowra River	Fixed crest weir	Submerged orifice
222	Sno 04	Nimmitabel Weir	McLaughlin River	Fixed crest weir	Weir and pool
222	Sno 08	Dalgety Weir	Snowy River	Fixed crest weir	Vertical slot/ rock ramp
222	Sno 24	Anglers Reach Weir	Long Plain Creek	Fixed crest weir	Weir and pool

* For codes see tables in Appendices A to I.

Typical examples of the various kinds of obstructions recorded in south in south coast streams during field work are illustrated in Figures 4.11 - 4.17. Examples of a typical culvert and

causeway are displayed in Figures 4.11 and 4.12. Figures 4.13 and 4.14 show a typical fixed-crest weir and a stream gauging weir. Figures 4.14a and Figure 4.14b are views of a rock weir found in the Wollongong Coast Basin. Figure 4.14a shows the view across this weir, while Figure 4.14b shows a wider view of the both the upstream and downstream pools. Figures 4.15a and 4.15b display views of both the upstream dam wall and the upstream lake of Jindabyne Dam, an example of a high dam in the Snowy River Basin. The downstream views are displayed in Figures 4.15c and 4.15d. Figure 4.16 is an example of a farm dam and Figure 4.17 displays a view of a low bridge. The above figures (4.11a to 4.17) are computer scans of photographs which were taken during field observations.

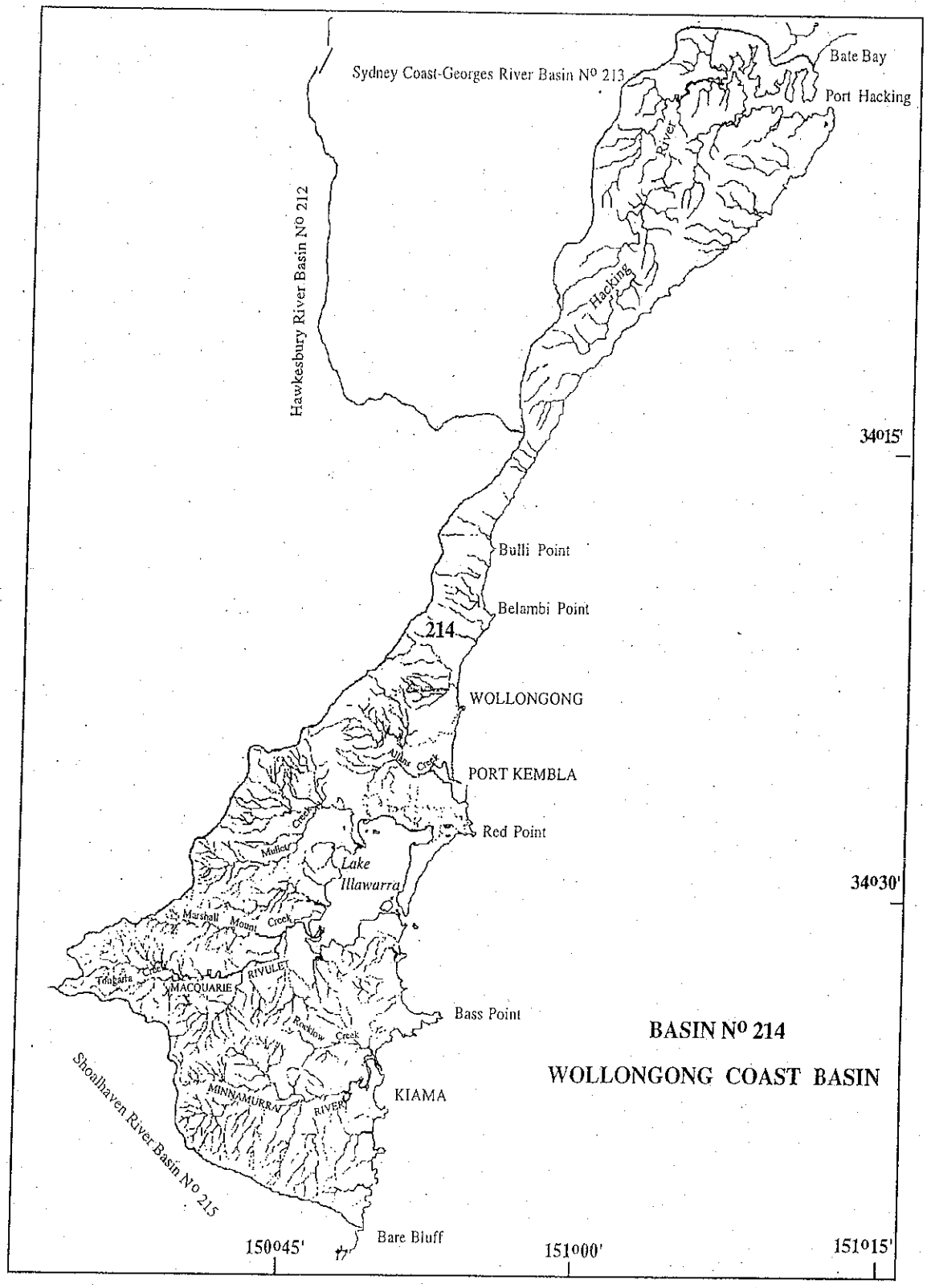

FIGURE 4.3: Wollongong Coast Basin

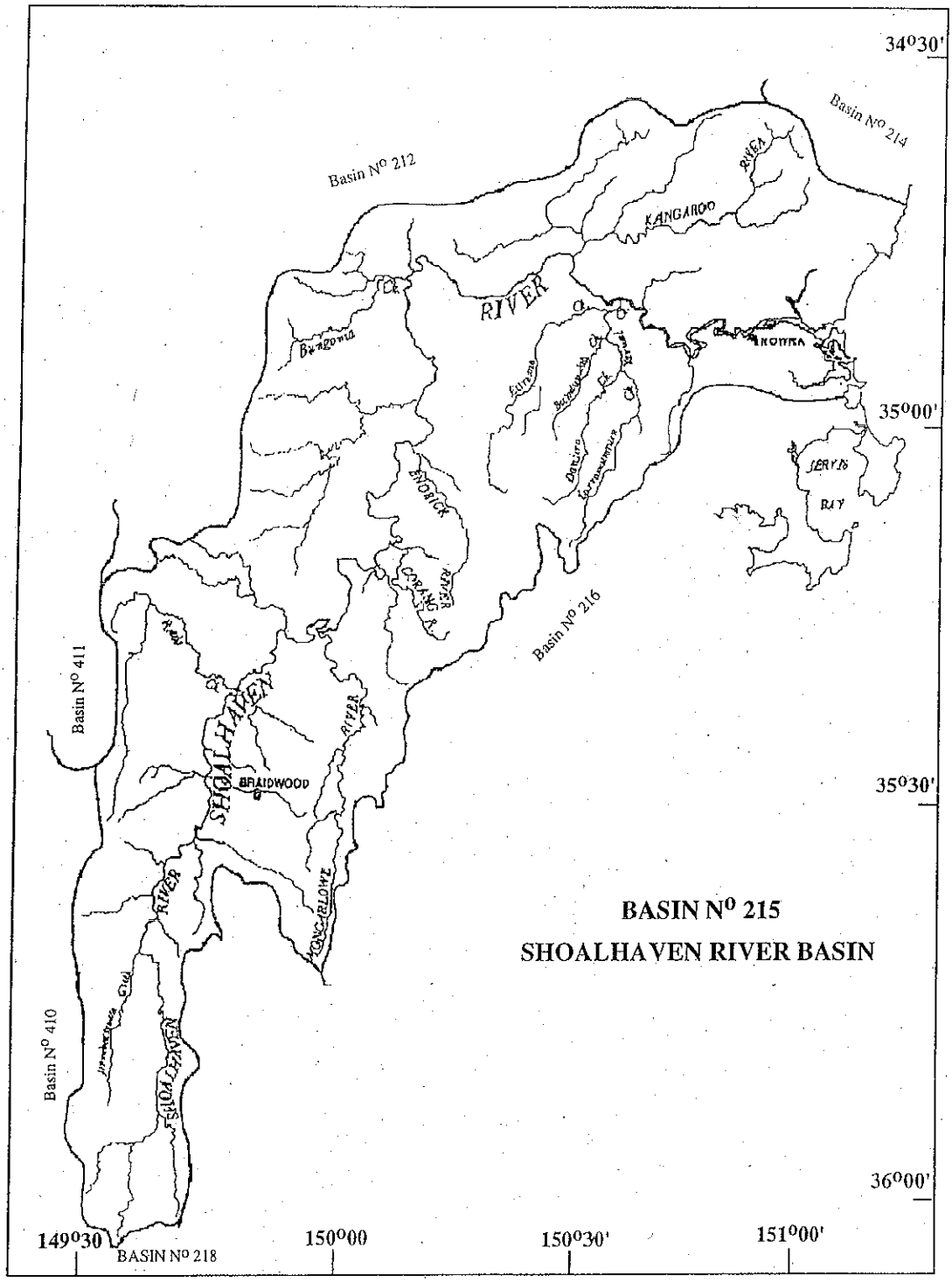

FIGURE 4.4: Shoalhaven River Basin

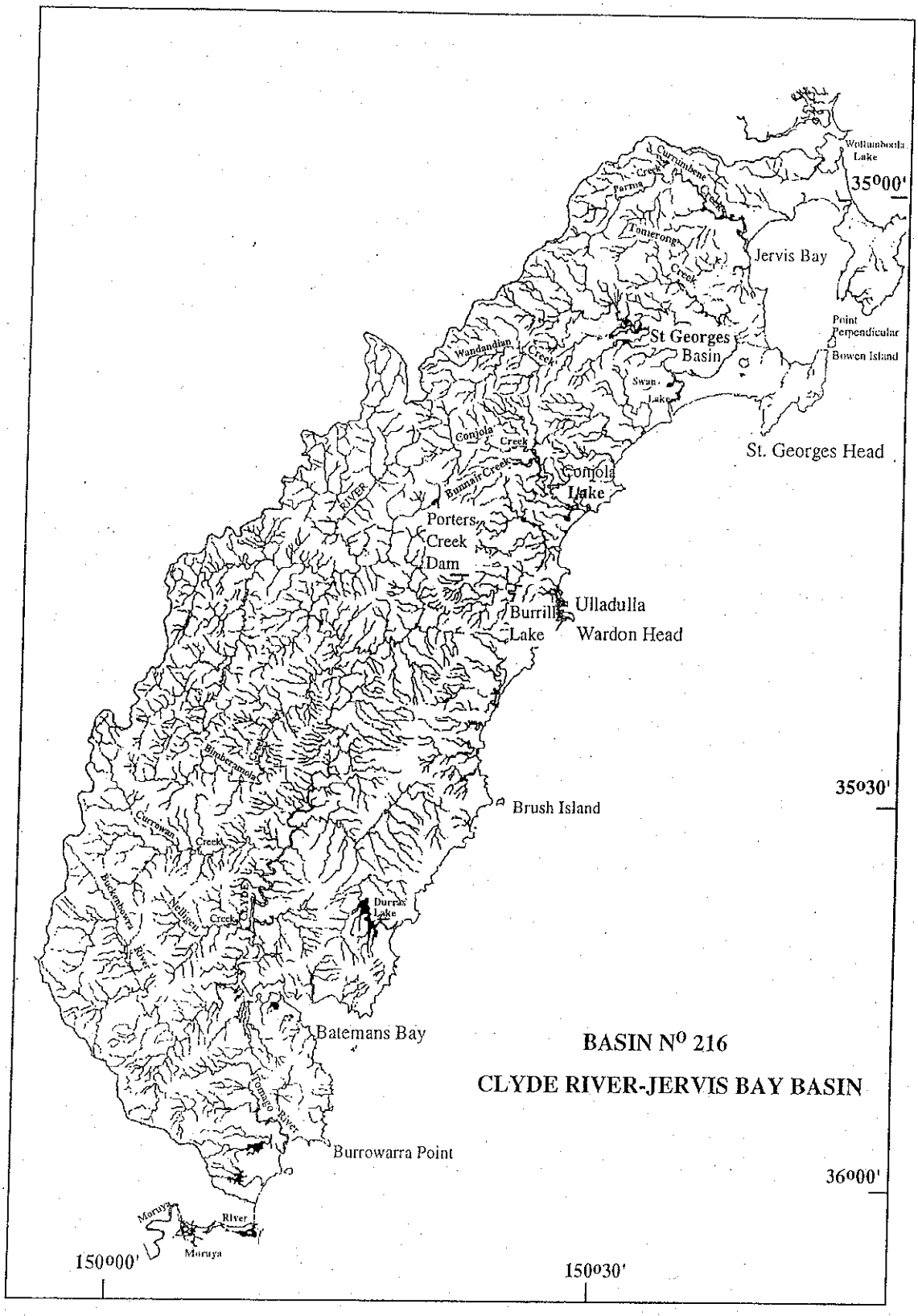

FIGURE 4.5: Clyde River - Jervis Bay Basin

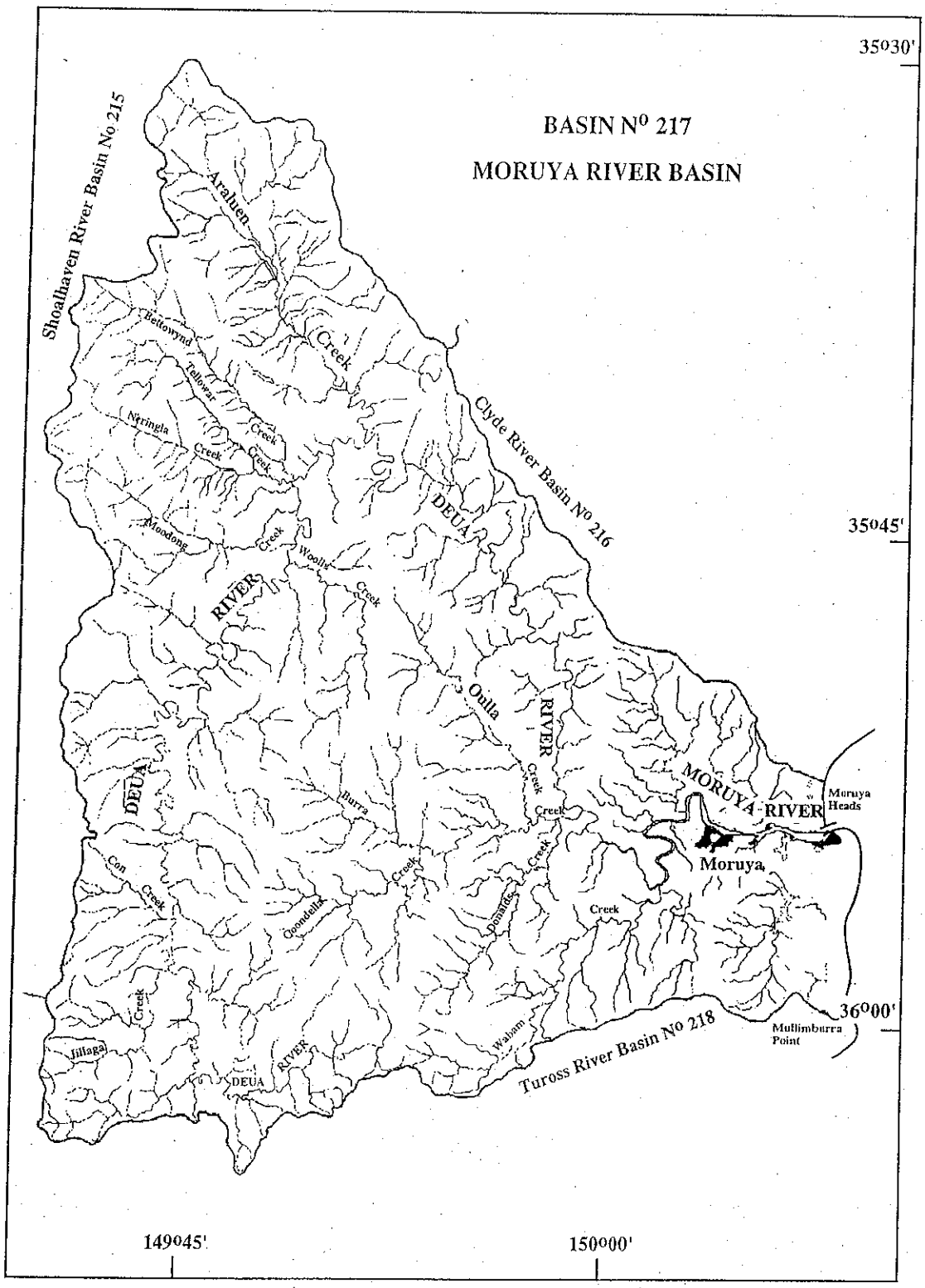

FIGURE 4.5: Moruya River Basin

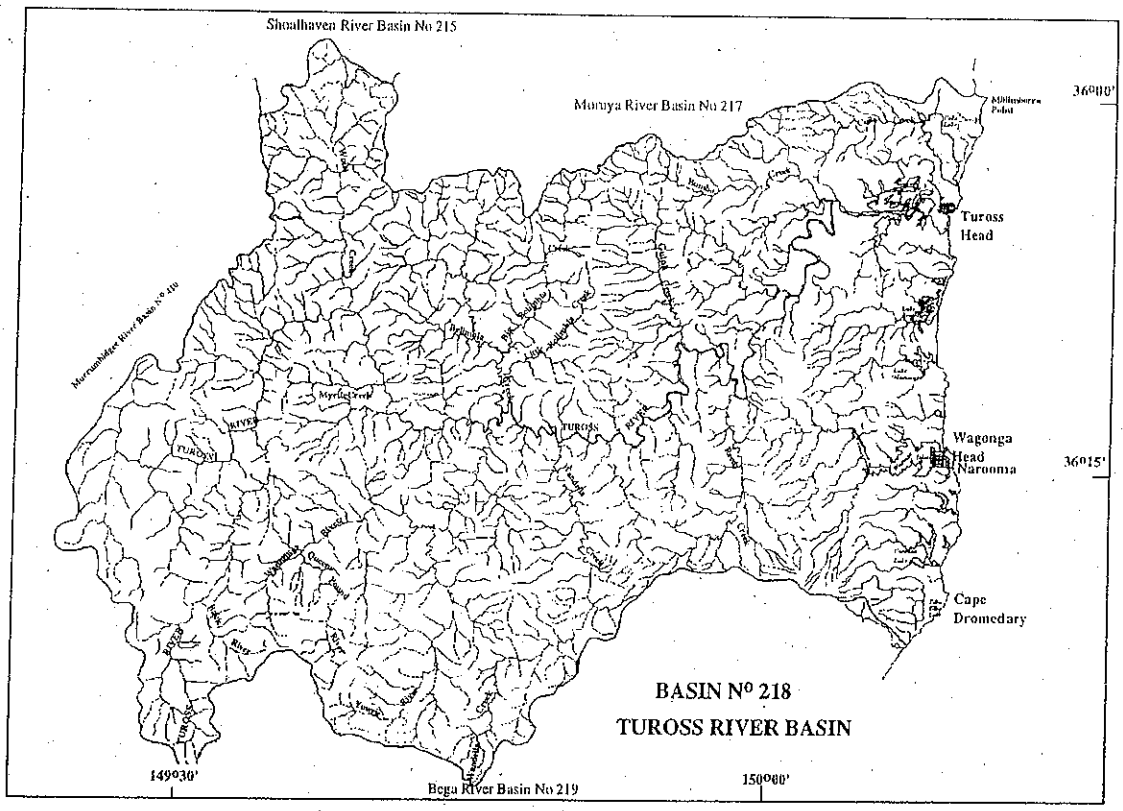

FIGURE 4.7: Tuross River Basin

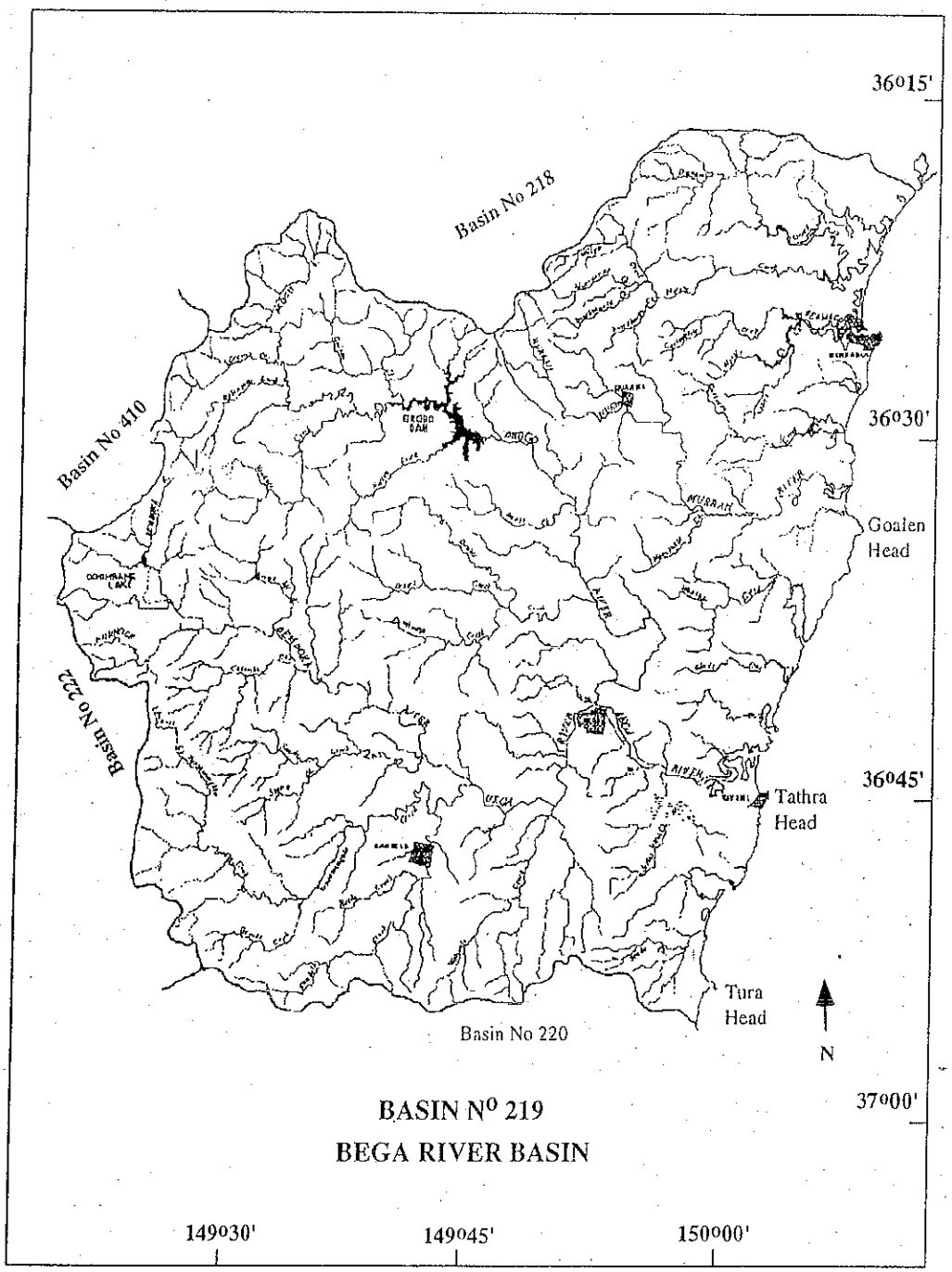

FIGURE 4.8: Bega River Basin

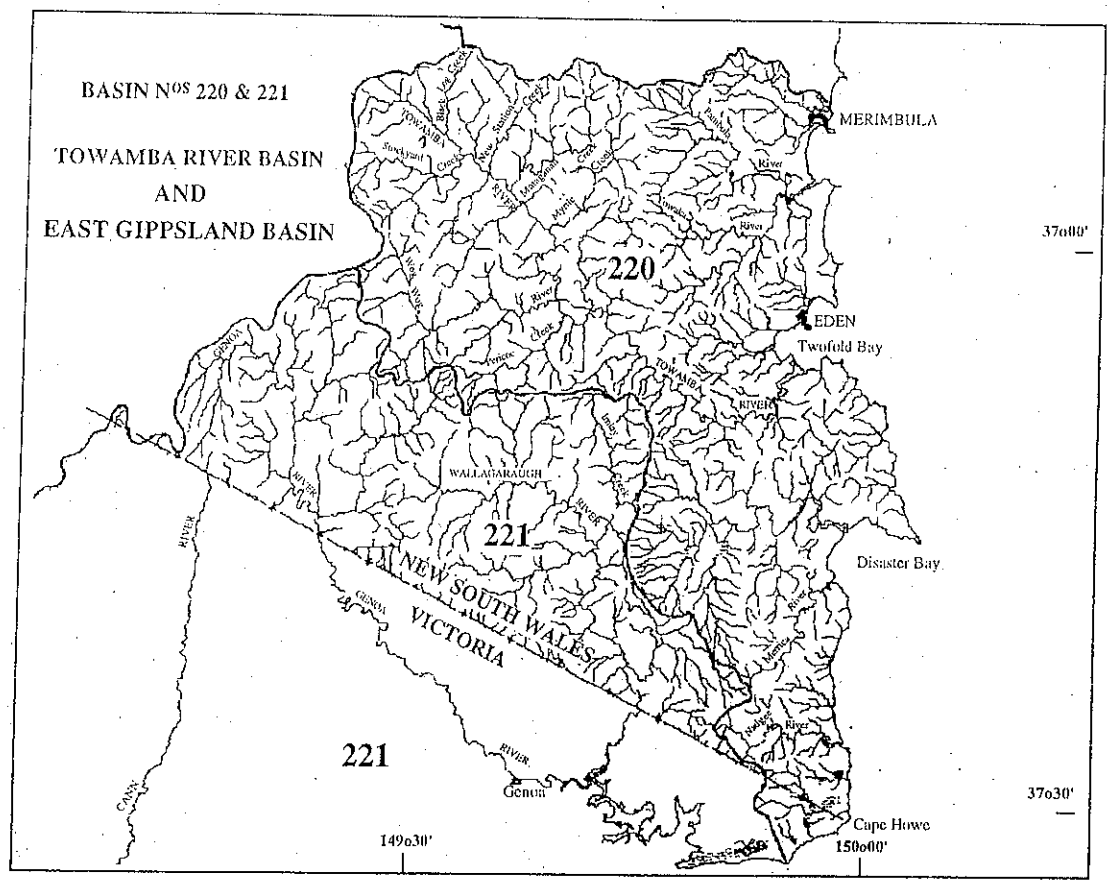

FIGURE 4.9: Towamba River and East Gippsland Basins

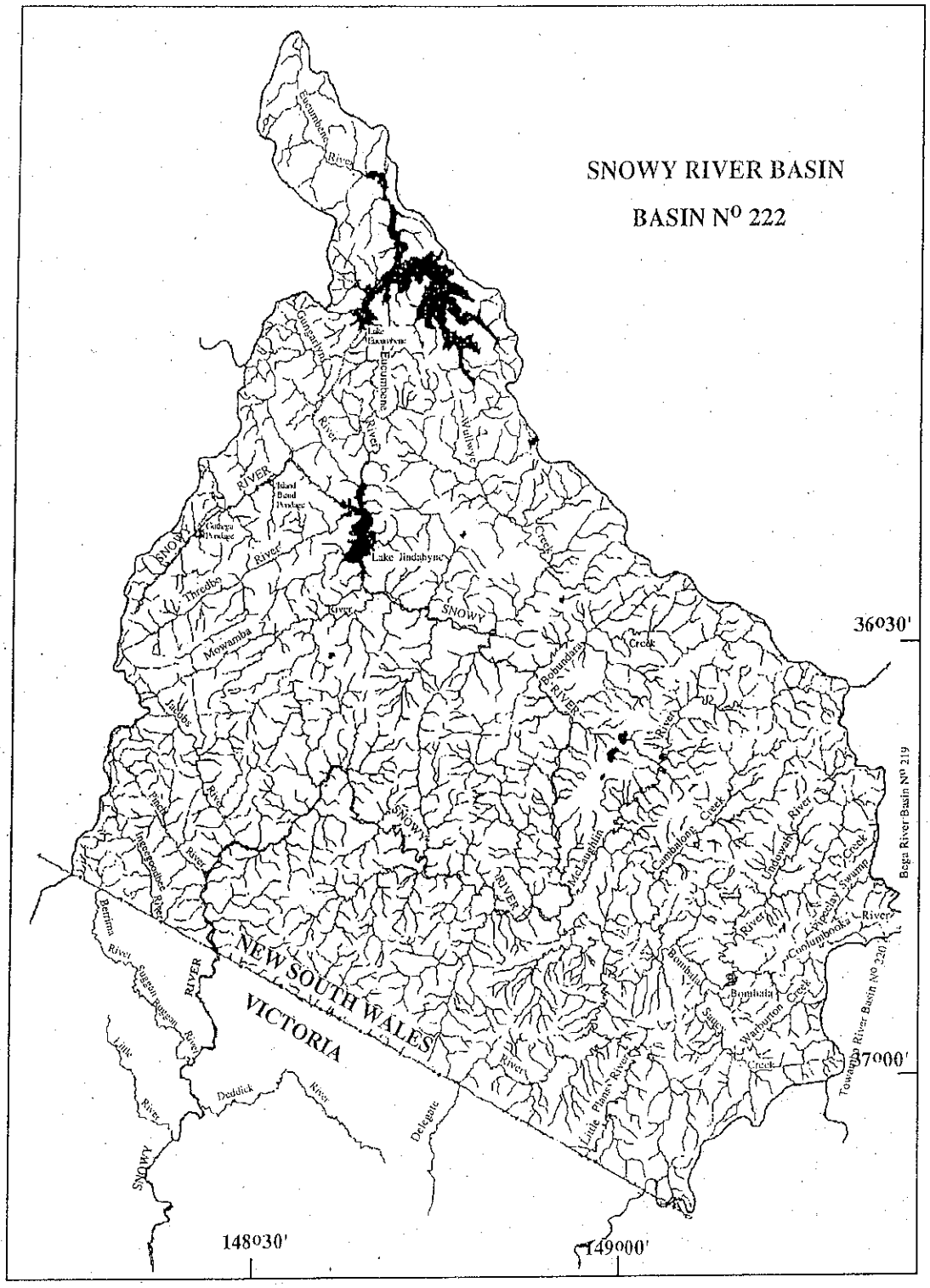

FIGURE 4.10: Snowy River Basin

4.2 Basin Summaries

4.2.1 Wollongong Coast Basin (No. 214)

The Wollongong Coast Basin is the northernmost of the nine drainage basins which were surveyed. It lies just south of Sydney, from the Hacking River (about 34°05' S) to Bare Bluff south of Kiama (about 34°30'S). All three catchments were surveyed, including Lake Illawarra, Macquarie Rivulet and Minnamurra River. A total of 43 obstructions were found on streams in the Wollongong Basin. The details of these obstructions are summarised in Table 4.3.

Table 4.3 Obstructions found in the Wollongong Coast Basin.

Type of structure	Number	Proportion
Causeway	24	51%
Culvert	13	28%
High dam	3	6%
Rock weir	2	4%
Fixed crest weir	5	11%
Total	47	100%

Identification, location and structural details of those obstructions which occur in the Wollongong Coast Basin are given in Appendix A, Tables 8.1, 8.2 and 8.3.

Fishways are fitted on two of the obstructions, MacDonalds Weir (Mac 12) (site code) and Kurarroo Rock Weir (Min 13). Both of these are rock-ramp fishways (Thorncraft and Harris 1997; Berghuis *et al.*. 1997; Harris *et al.*. 1998). The maximum vertical height of an obstruction (14.8 m) was at Fountaindale Dam (Min 02), the minimum height (0.25 m) at Miala Crossing (Ill 02), and the average obstruction height was 2.48 m.

4.2.2 Shoalhaven River Basin (No. 215)

The Shoalhaven River Basin lies south of the Wollongong Coast Basin and west of the Clyde River-Jervis Bay Basin. It has been classified into the Upper Shoalhaven River catchment and the Lower Shoalhaven catchment for the purpose of this survey. The Upper Shoalhaven catchment consists of the river and its tributaries in the region above Tallowa Dam, while the Lower Shoalhaven River consists of streams below Tallowa Dam. Tallowa Dam is a major barrier preventing fish from migrating upstream. All obstructions documented in the Lower Shoalhaven

River are those which were documented by Timms (1995) during his Honours Degree project at Wollongong University. Those listed for the Upper Shoalhaven were located and identified during the present project. A total of 89 obstructions are documented in the Shoalhaven River Basin. Identification, location and structural details are given in Appendix B, Tables 8.4, 8.5 and 8.6. The various types of structures found are listed in Table 4.4.

Table 4.4 Obstructions found in the Shoalhaven River Basin.

Type of structure	Number	Proportion
Culvert	30	33%
Causeway	24	27%
Floodgate	24	27%
Fixed crest weir	5	6%
High dam	5	5%
Stream gauging weir	2	2%
Total	90	100%

There are no fishways fitted on any of the above obstructions. The maximum vertical obstruction height was 43.0 m at Tallowa Dam (Sho 88), the minimum height was 0.05 m at Nowra Creek Crossing 2 (Sho 45), and the average height was 2.7 m.

4.2.3 Clyde River-Jervis Bay Basin (No. 216)

The Clyde River-Jervis Bay Basin occurs south of the Wollongong Coast Basin from Jervis Bay (35°00'S) to Burrowarra Point just south of Batemans Bay (35°45'S). This drainage basin consists of the Clyde River catchment and the Jervis Bay catchment, and a total of 25 obstructions were found here. The tables in Appendix C (Tables 8.7, 8.8 and 8.9) outline the identification, location and structural details. Table 4.5 summarises details of these obstructions.

Table 4.5 Obstructions found in the Clyde River-Jervis Bay Basin.

Type of structure	Number	Proportion
Causeway	10	40%
Culvert	4	16%
Fixed crest weir	8	32%
High dam	1	4%
Farm dam	1	4%
Stream gauging weir	1	4%
Total	25	100%

The only fishway on obstructions in the Clyde River-Jervis Bay Basin was at Buckenbowra Weir, but this fishway does not provide effective fish passage (Harris 1984b). The maximum vertical height was 17.0 m at Porters Creek Dam (Cly 18), the minimum height was 0.4 m at Boagsville Crossing (Jer 01), and the average height was 2.0 m. Most of the obstructions found were causeways (40%), with a large proportion of fixed crest weirs (32%) also being found. Culverts were the third most abundant structure to be identified and documented (16%), and stream gauging weirs and 5% high dams.

4.2.4 Moruya River Basin (No. 217)

The Moruya River Basin is located about two-thirds of the way down the coast between Sydney and the Victorian border. It is located between about 35°30'S to about 36°00'S. It is a relatively small basin compared to the Clyde River and Shoalhaven Basins. The area is partly agricultural, with a large portion of the region being made up of National Parks. The Deua River is the main tributary which runs into the Moruya River before it reaches marine waters. Only three obstructions were found in this basin. Table 4.6 summarises details of these. Appendix D contains Tables 8.10 - 8.12 with identification, location and structural details of these obstructions.

Table 4.6 Obstructions found in the Moruya River Basin.

Type of structure	Number	Proportion
culvert	3	100%
Total	3	100%

All three obstructions found in the Moruya River Basin were culverts. The maximum height was 2.2 m at South Head Road Crossing (Mor 01), the minimum height was 0.5 m at Candoin Creek Crossing (Mor 03), and the average height was 1.2 m.

4.2.5 Tuross River Basin (No. 218)

The Tuross River Basin lies south of the Moruya River Basin. It is located between about 36°00'S and 36°15' S. It is made up of the Tuross River catchment and its tributaries. The main tributaries are Reedy Creek, Wandella Creek, Wadbilliga River, Back Creek, Myrtle Creek, Belimbla Creek and Gulph Creek. A total of 18 obstructions were found in this drainage basin, as identified in Table 8.13 in Appendix E. The locations of these obstructions are defined in Table 8.14, and the structural details in Table 8.15. Table 4.7 summarises these details.

Table 4.7 Obstructions found in the Tuross River Basin.

Type of structure	Number	Proportion
Culvert	7	39%
Causeway	4	22%
Fixed crest weir	6	33%
Farm dam	1	6%
Total	18	100%

The maximum vertical height of these obstructions was 3.5 m, the minimum height was 0.2 m and the average vertical height for obstructions in the Tuross River Basin was 1.3 m. The majority of obstructions identified were culverts (50%), with a large proportion of causeways (36%) also being found. Fixed crest weirs and farm dams were both found in much smaller numbers, with 7% frequency.

4.2.6 Bega River Basin (No 219)

The Bega River Basin extends from about 36°S to about 37°S latitude, and is made up of four catchments . These include the Bermagui River, Brogo River, Bega River and Bemboka River catchments. A total of 24 obstructions was found in this drainage basin. Details of these obstructions are listed in Appendix F in Tables 8.16-8.18. Table 4.8 summarises these details.

Table 4.8 Obstructions found in the Bega River Basin.

Type of structure	Number	Proportion
Culvert	9	38%
Causeway	4	17%
Stream gauging weir	3	13%
High dam	2	8%
Farm dam	1	4%
Fixed crest weir	3	13%
Rock weir	1	4%
Bridge	1	4%
Total	24	100%

The maximum vertical height of the above structures was 43 m at Brogo Dam (Beg 05). The minimum height for a structure is the stream was Wicks End Weir (Beg 18) at 0.3 m, and the average height for the above structures was 4.2 m. The majority of obstructions found in the Bega River Basin were culverts (41%). Other obstructions were causeways (18%), stream gauging weirs (14%), high dams (9%), and fixed crest weirs, farm dams and bridges (each 5%).

4.2.7 Towamba River Basin (No. 220)

The Towamba River Basin extends from Merimbula on the far south coast of New South Wales at about 36"45'S to just south of the Victorian Border at Cape Howe (about 37"30'S). It consists of the Towamba River catchment and its tributaries, including Nadgee River, Merrica River, Pericoe Creek, Wog Wog River, Stockyard Creek, Black Log Creek, New Station Creek, Mataganan Creek and Myrtle Creek. The Pambula River catchment, which includes the Yowaka River as its main tributary, is also a part of the Towamba River Basin. Tables 8.19 to 8.21 in Appendix G lists the identification, location and structural details the 18 obstructions found in this drainage basin. Table 4.9 summarises these details.

Table 4.9 Obstructions found in the Towamba River Basin.

Type of structure	Number	Proportion
Culvert	9	53%
Causeway	5	29%
Bridge	2	12%
Fixed crest weir	1	6%
Total	17	100%

No fishways were found fitted to obstructions in the Towamba River Basin. The maximum vertical obstruction height was 3.5 m at Ruggs Road Crossing (Pam 08), the minimum height was 0.35 m at Gill Fire Trail (Pam 06), and the average height was 1.4 m. Most of the obstructions found were culverts, with a high proportion of causeways as well. A few of bridges and fixed crest weirs were also present.

4.2.8 East Gippsland Basin (No 221)

The East Gippsland Basin lies in the far south of New South Wales and extends into Victoria. Only streams located in New South Wales were surveyed for obstructions. The main rivers in this basin are the Wallagaraugh and Genoa Rivers and their tributaries. A total of six obstructions were found in this basin. Details of these are listed in Tables 8.22 to 8.24 in Appendix H. These details are summarised in Table 4.10.

Table 4.10 Obstructions found in the East Gippsland Basin.

Type of structure	Number	Proportion
Culvert	6	100%
Total	6	100%

All obstructions found in the East Gippsland Basin were culverts. The maximum vertical obstruction height was at Imlay Road Crossing (Gip 01), with a value of 3.0 m. The minimum height was 0.6 m at Bungan Road Crossing (Gip 05). The average vertical height for these obstructions was 1.53 m.

4.2.9 Snowy River Basin (No. 222)

The Snowy River Basin is located west of the Bega River, Towamba River and East Gippsland Basins. It comprises the Snowy River, with its main tributaries being Little Plains River, Delegate River, Ingeegoodbee River, Pinch River, Jacobs River, Mowamba River, Thredbo River, Gungarlin River, Eucumbene River, Wullwye Creek, Bobundara Creek, McLaughlin River, Cambalong Creek, Bombala River and Coolumbooka River. A total of 24 obstructions were identified in this river basin. A substantial proportion of these obstructions found were high dams, built for the Snowy Mountains Hydro Electric Scheme. The details of these are summarised in Table 4.11. The identifications, location and structural details are listed in Tables 8.25 to 8.27 in Appendix H.

Table 4.11 Obstructions found in the Snowy River Basin.

Type of structure	Number	Proportion
Fixed crest weir	9	38%
Culvert	6	25%
High dam	4	17%
Causeway	3	13%
Farm dam	2	8%
Total	24	100%

Three fishways were found fitted to obstructions in the Snowy River Basin. The McLaughlin River Weir (Sno 04) has a pool and weir type fishway constructed on it, the Dalgety Weir on the Dalgety River (Sno 08) has a combined vertical slot/rock-ramp fishway, which was being constructed at the time of the field observation (6 March 1997) and is now operational. Anglers Creek Weir (Sno 24) also has a pool and weir fishway constructed on it. Both the McLaughlin River fishway and Anglers Creek Weir fishway are ineffective (Harris 1984b). The maximum height for obstructions found was 116.1 m at Eucumbene Dam (Sno 17), the minimum height was 0.6m at Brivale Crossing (Sno 19), and the average height was 13.96 m.

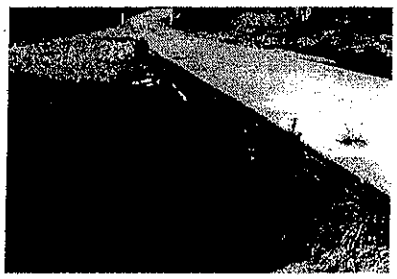

Figure 4.11: Culvert in the Shoalhaven River Basin (Sho 70).

Figure 4.12: A causeway in the Wollongong Coast Basin (Min 17).

Figure 4.13: A fixed-crest weir in the Clyde River-Jervis Bay Basin (Cly 05).

Figure 4.14: A stream gauging weir in the Shoalhaven River Basin (Sho 71).

Figure 4.15a: View across a rock ramp fishway in the Wollongong Coast Basin (Mac 12).

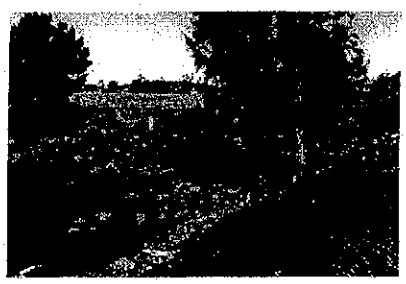

Figure 4.15b: View showing pools both upstream and downstream of the fishway

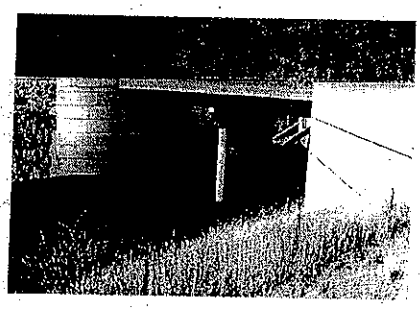

Figure 4.16a: Upstream view of high dam wall at Jindabyne on the Snowy River Basin (Sno 06).

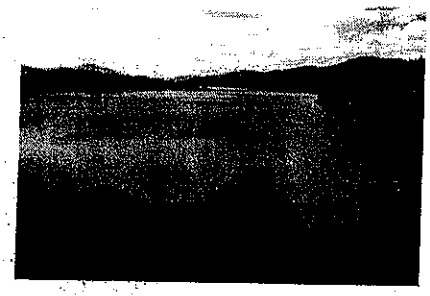

Figure 4.16b: View of the storage upstream of Sno06.

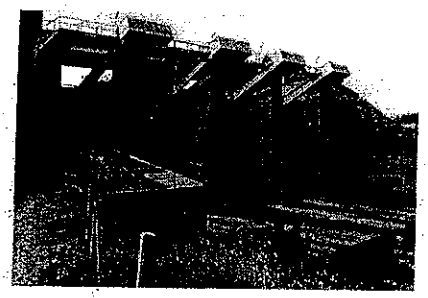

Figure 4.16c: Downstream view of the dam wall of Sno 06.

Figure 4.16d: View of the river downstream of Sno 06.

Figure 4.17: View of a farm dam in the Bega River Basin.

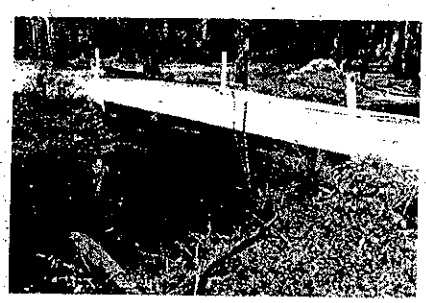

Figure 4.18: A low bridge in the Moruya River Basin (Mor 02).

4.3 Fishway Priority Scheme

To allocate priority rankings to fish-passage restoration work throughout New South Wales as objective and strategically based method was developed.. The criteria that need to be considered when assessing the priority of individual structures include the following features:

1.) the size of the river or stream,

2.) whether or not the structure occurs in a tidal zone, in coastal regions, or in a 'core habitat area' (see 4.3.1 below) in inland waters,

3.) the presence of threatened or endangered fish species,

4.) the amount of fish habitat upstream of the structure,

5.) the number of obstructions which occur downstream,

6.) the proportion of the river obstructed by the barrier,

7.) the drownout frequency of the obstruction,

8.) the type of barrier (weirs, culvert, causeway, etc.),

9.) the presence and effectiveness of any existing fishways,

10.) the cost of building a fishway and

11) the level and support from community and other groups for providing fish passage.

These criteria are arranged into a priority ranking scheme for assessing individual structures in Figure 6.1.

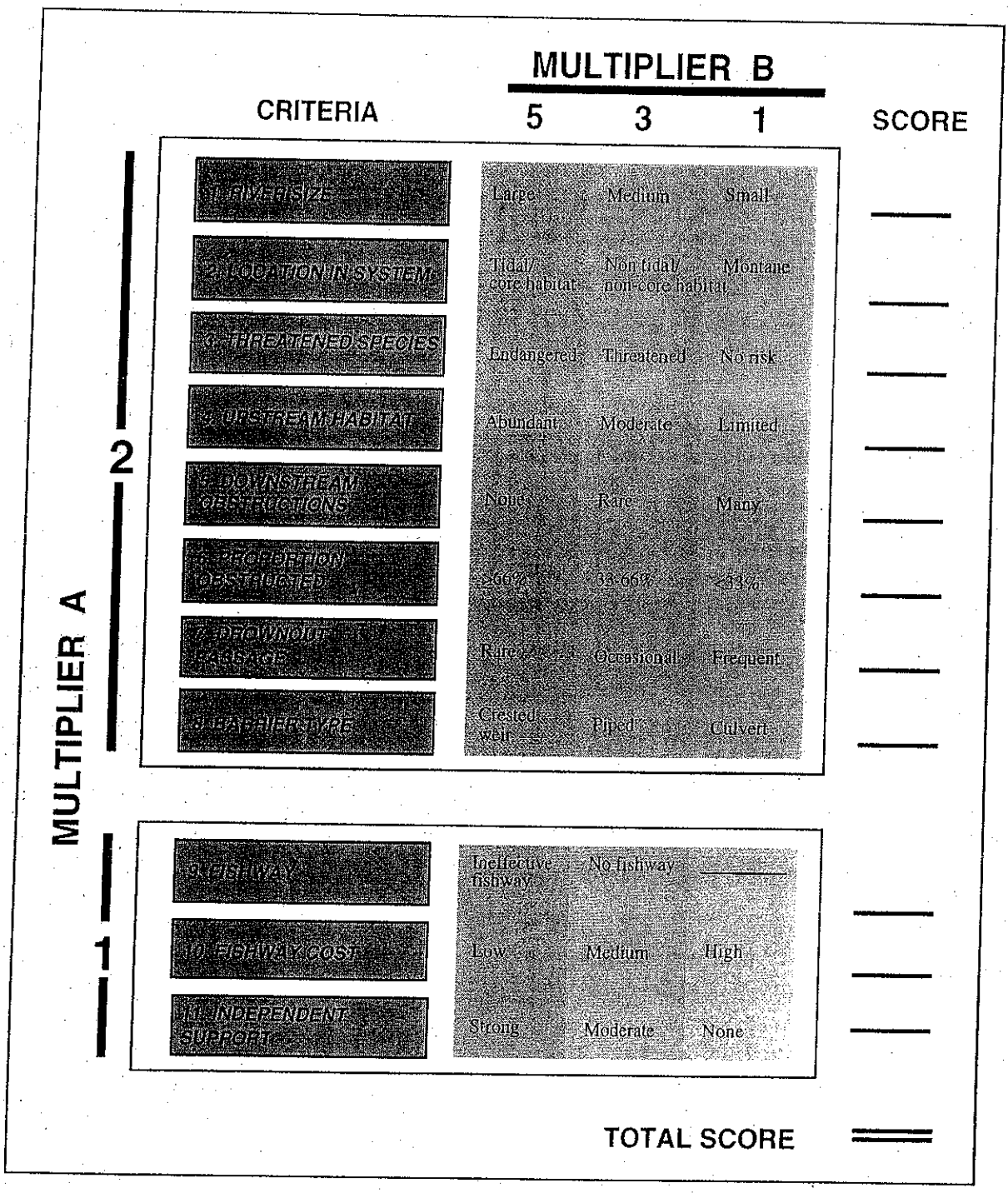

Figure 6.1. Priority-ranking scheme for fish passage obstructions

4.3.1 Using the Fishway Priority Scheme

This scheme provides a quantitative method for ranking the priority of sites for providing fishways. Rankings are produced by assessing each site according to all of the 11 criteria listed, then classifying it according to the descriptors in the three associated columns in the right side of the scheme.

The 11 criteria (rows) are grouped in the scheme in order of importance, with two broad groups having priority-weighting multipliers (multiplier A) of one or two. Multiplier B is allocated to the three descriptor columns, with weighting levels of five, three and one. To apply the scheme for a site, a score is produced for each of the 11 criteria by multiplying the two relevant priority-weighting multipliers , recording the result in the 'Score' column, then summing over all criteria. The total score is then used as the measure of the overall priority of any particular site against other sites on a local, river-basin, regional or state-wide basis. Notes explaining details of the individual criteria are listed below.

1. River size: Relative size of the whole catchment of the particular river or stream

2. Location in system: Tidal sites in coastal rivers are critical for migration of juveniles of many fish species. Similarly 'core habitat' in inland rivers refers to sites in lowland regions believed to be critical for large-scale recruitment of fish. These are generally downstream of Echuca (Murray River), Wilcannia (Darling River), Narrandera (Murrumbidgee River) and Condobolin (Lachlan River). Montane habitats are above 700 m in altitude.

3. Threatened species: Refers to the presence of in the river reach of species nationally classified as endangered, threatened or not at risk.

4. Upstream habitat: Amount of upstream habitat which would become accessible when a fishway is installed.

5. Downstream obstructions: Occurrence and severity of other artificial and natural barriers downstream of the site.

6. Proportion obstructed: Proportion of the whole catchment of the particular stream which lies upstream of the site.

7. Drownout passage: Frequency with which high flows create effective drownout conditions at the site, so that head-loss and velocity are minimal and fish can pass upstream.

8. Barrier type: basic structure of the barrier, which influences the ability of migrating fish to pass upstream.

9. Fishway: Presence/absence of an effective fishway on the barrier

10. Fishway cost: Likely cost of building a fishway

11. Independent support: Level of financial and other support from local government, landholders, industry, community groups, etc.

5. DISCUSSION

This survey has identified a large number (254) of obstructions throughout the coastal streams of southern New South Wales. The number and type of obstructions varied greatly from basin to basin, and from catchment to catchment. There was no pattern determined as to the locations of these obstructions. For example, the numbers of obstructions did not decrease with distance south of Wollongong, the regional centre of human population.. The Bega River Basin (No. 219) contained the most varied types of structures, with all structure types being identified except for tidal floodgates, which were only documented in the Shoalhaven River Basin. Included in the Bega River Basin were high dams, farm dams, fixed-crest weirs, rock weirs, stream gauging weirs, culverts, causeways and bridges. The Moruya River and East Gippsland Basins both contained only one type of structure, culverts. Culverts were common to all drainage basins (see Figure 4.2).

All nine drainage basins surveyed suffered at least some alienation of fish habitat. In order to determine the amount of habitat alienated, it would be necessary to study the individual streams within catchments and to estimate what proportion of stream length was compromised by these obstructions. This would involve the quantitative study of relevant 1: 25 000 topographic maps with all obstructions marked on them. These maps are now available because of this study, but such a analysis was beyond the scope of the present study.

The majority of obstructions found throughout the nine drainage basins were road crossings, which were made up of causeways and culverts. These road crossings occurred most frequently and were the easiest to survey. However, most of these crossings were low in height and often contained pipes or culverts, which allow for some water to flow through. Therefore, many of them would not have as great an impact on fish passage as a large weir or dam would have.

Fixed crest weirs were the next most common type of obstruction identified. Many of these occurred on private properties, and were therefore difficult to locate because they may not be licensed or legally constructed. Also, gaining access to private properties can be sometimes difficult and time consuming. Some of the weirs found in this survey were found by chance, and not through the available sources of information.

Tidal floodgates were the third most frequently identified obstructions. However, as they were identified only from the Shoalhaven River Basin this pattern does not give an overall representation of the signifance of these obstructions throughout the south coast region

High dams were the fourth most common obstructions throughout the area. Even though these obstructions do not occur very frequently, they obviously create the biggest barrier to fish passage, because of their large size and because they control water flow over large reaches of the streams. Tallowa Dam alienates more than 200 km of fish habitat within the Shoalhaven River Catchment (Marsden *et al.*. 1996). However, a scientific study by NSW Fisheries is assessing the requirements and design of a fishway for this dam.

Smaller numbers of stream gauging weirs, farm dams, rock weirs and bridges were also located. Stream-gauging weirs ranged in height from 0.3m to1.1m. They have less impact than dams or most fixed-crest weirs, because the v-notch allows for concentrated water flow and some fish movement. Therefore, these structures are not as high on the priority list as some other obstructions requiring removal or modification to increase fish passage. The farm dams surveyed also had the potential to decrease fish habitat and impede fish passage by reducing stream flow. The bridges surveyed were low in impact, because they allowed for unimpeded stream flow at all times other than during floods. The two rock weirs found were constructed with rock ramp fishways, and therefore do not constitute barriers to fish passage. Rock-ramp fishways generally provide effective fish passage, and are simple and low-cost (Thorncraft and Harris 1996; Berghuis *et al.*; Harris *et al.* 1998). The bridges found were low bridges, and therefore unlikely to obstruct fish migration except perhaps at medium to high flows.

Table 2.1 lists the fish species found in streams within the study area, together with their known migratory requirements and distributions. Many of the fish species have been classified into the various categories according to their migration requirements after Harris (1984). However, it is important to note that these are not the only fishes which would have their life cycles affected by obstructions to river flow. All freshwater fishes must move between habitat areas to spawn or to seek food and shelter at some point in their life cycles.

There are important differences in the relative effects of the different types of structures. In culverts, even though water may be flowing through the pipes, these are often too narrow, or too elevated above the surface of the water, so they would not to allow fish passage upstream. An example of this type of culvert is the crossing near Thredbo (Sno 12) (see Figure 6.2).

Generally, causeways which have a large vertical height will obstruct fish passage far more than those which are low in height. This is because causeways do not contain outlet pipes to allow passage for those fish species which may be able to take advantage of piped flow. Furthermore, lower structures drown-out at lower stream-flows. Fixed-crest weirs identified in the survey varied in size considerably in vertical heigh from 0.3 m to 7.0 m. Again, the higher weirs would have a larger impact on fish passage than smaller weirs.

The impact of tidal floodgates is variable, depending on their location and whether they are held open or closed. However, because of their tidal position affecting very small catadromous fishes, floodgates may cause considerable impact.

High dams were usually located on large streams and used as water supply reservoirs. Therefore, they generally have the maximum impact upon fish migration requirements. Dam heights varied from 7.0 m at Stanwell Dam in the Wollongong Coast Basin to 116 m at Eucumbene Dam in the Showy River Basin. A comparison of the upstream and downstream views of the river at Jindabyne Dam (Figures 4.14a-4.15b) show the huge difference in stream levels.

Although fishways have been constructed on seven of the south coast stream obstructions to allow for fish passage, some of them are ineffective. For example, the fishway observed on the McLaughlin River Weir (Sno 04) was a pool fishway, and completely ineffective at low flow because most of the pools are above the surface level of the water (see Figure 6.3). Fishways at Tapitallee Weir, Buckenbowra Weir and Anglers Reach were also recorded by Harris (1984b) as being non-functional.

5.1 Conclusions

An important conclusion from this study is that the migration requirements of all fish must be taken into account when structures are proposed to be built or modified. The various state and local government agencies involved must be aware of the environmental consequences of obstructions to fish passage in the regions under their control. Also, the possible removal, fitting of a fishway, or modification of existing structures should be considered at each site. The maintenance of fish passage through dams, reservoirs and impoundments is provided for in the NSW Fisheries Management Act (1994) (Smith and Pollard 1998). It is important for individuals, landowners, community groups and agencies (e.g. the Roads and Traffic Authority, State Rail, National Parks and Wildlife Service and local government councils) to ensure that obstructions to fish passage are not created in the future and that the environmental impact of existing obstuctions is mitigated as far as possible. Fish passage needs to be restored in south coast streams as a major step in rehabilitating their fish communities and restoring healthy rivers.

Figure 6.2: A culvert in the Snowy River Basin (Sno 13)

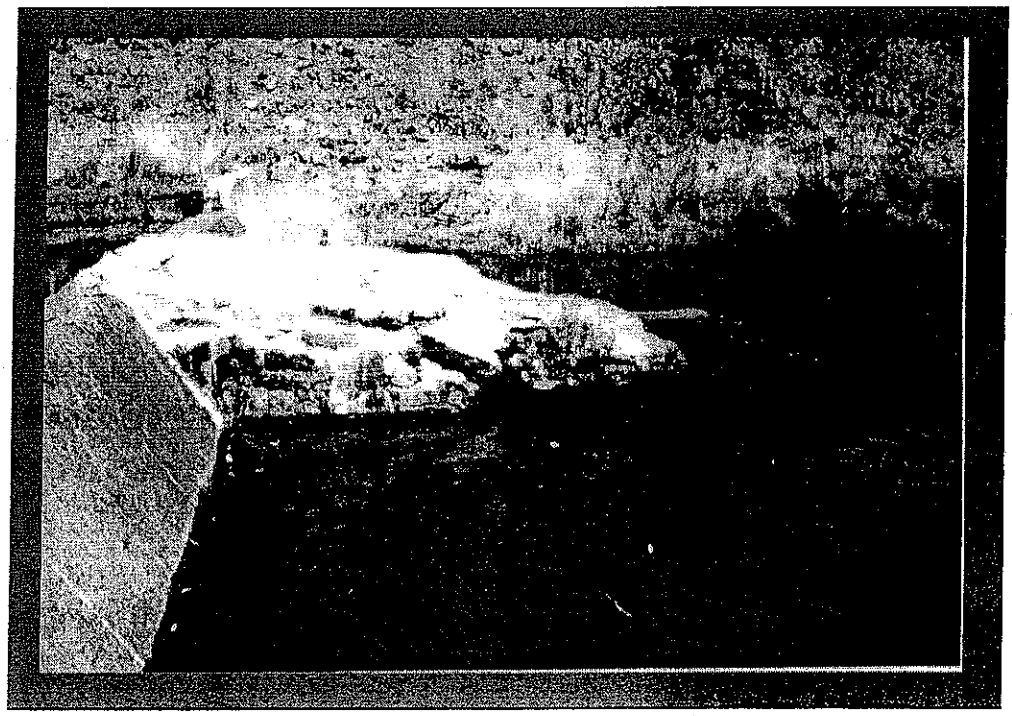

Figure 6.3: An ineffective fishway in the Snowy River Basin (Sno 04)

6.

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8. APPENDICES

APPENDIX A. Obstructions in the Wollongong Coast Basin (No. 214).

Table 8.1. Identification of obstructions in the Wollongong Basin

Structure ID	Catchment name	Structure name	Stream name
Ill 01	Lake Illawarra	Merrygold Crossing	Duck Creek
Ill 02	Lake Illawarra	Miala Crossing	Duck Creek
Ill 03	Lake Illawarra	Heather Brae Crossing	Duck Creek
Ill 04	Lake Illawarra	Woodville Crossing	Duck Creek
Ill 05	Lake Illawarra	Lakelands Drive Crossing	Brooks Creek
Ill 06	Lake Illawarra	Serenity Farm Crossing	Mullet Creek
Ill 07	Lake Illawarra	Serenity Farm Weir	Mullet Creek
Ill 08	Lake Illawarra	William Beach Park Weir	Mullet Creek
Ill 09	Lake Illawarra	Hooka Creek Road Crossing	Hooka Creek
Ill 10	Lake Illawarra	Illawarra Power Station	Duck Creek
Ill 11	Lake Illawarra	Northcliffe Drive 01	Minnegang Creek
Ill 12	Lake Illawarra	Northcliffe Drive 02	Budiong Creek
Ill 13	Lake Illawarra	Budiong Ck Causeway	Budiong Creek
Mac 01	Macquarie Rivulet	Hendry and James Crossing	Macquarie Rivulet
Mac 02	Macquarie Rivulet	Green Valley Crossing	Macquarie Rivulet
Mac 05	Macquarie Rivulet	Nth Macquarie Rd Crossing	Macquarie Rivulet
Mac 06	Macquarie Rivulet	Yellow Rock Road Crossing	Yellow Rock Creek
Mac 07	Macquarie Rivulet	Homewood Crossing 1	Yellow Rock Creek
Mac 08	Macquarie Rivulet	Homewood Crossing 2	Unnamed
Mac 09	Macquarie Rivulet	Calderwood Road Crossing	Marshall Mount Creek
Mac 10	Macquarie Rivulet	Oakleigh Crossing	Marshall Mount Creek
Mac 11	Macquarie Rivulet	Calderwood Farm Crossing	Marshall Mount Creek
Mac 12	Macquarie Rivulet	McDonald's Weir	Macquarie Rivulet
Min 01	Minnamurra River	Jerrara Creek Dam	Jerrara Creek
Min 02	Minnamurra River	Fountaindale Dam	Fountaindale Creek
Min 03	Minnamurra River	Hvams Ck Dam	Hvams Ck
Min 04	Minnamurra River	Derewinanka Crossing	Fountaindale Creek
Min 05	Minnamurra River	Elban Crossing	Jerrara Creek
Min 06	Minnamurra River	Clover Hill Road Crossing	Carwa Creek
Min 07	Minnamurra River	Nuninuna Dr Crossing 1	McFaul's Creek
Min 08	Minnamurra River	Nuninuna Dr Crossing 2	Tongalla Creek
Min 09	Minnamurra River	Nuninuna Dr Crossing 3	Fountaindale Creek
Min 10	Minnamurra River	Woodbrook Crossing	Wallaces Creek
Min 11	Minnamurra River	The Ridge Crossing	Hvams Creek
Min 12	Minnamurra River	Turpentine Creek C Crossing	Turpentine Creek
Min 13	Minnamurra River	Kurraroo Rock Weir	Minnamurra River
Min 14	Minnamurra River	Factory Lane Rd Crossing	Colvers Creek
Min 15	Minnamurra River	Curramore Rd Crossing 1	Turpentine Creek
Min 16	Minnamurra River	Curramore Rd Crossing 2	Turpentine Creek
Min 17	Minnamurra River	William Coles Bridge	Fry's Creek
Min 18	Minnamurra River	Minnamurra Falls Rd Crossing	Minnamurra River
Min 19	Minnamurra River	Daltons Rd Crossing 1	Fry's Creek
Min 20	Minnamurra River	Daltons Rd Crossing 2	Fry's Creek

Table 8.2. Location details of obstructions in the Wollongong Basin.

Structure ID	Nearest town	Location map	Map reference	Grid ref.	Lat/Long
Ill 01	Albion Park	Robertson	9028-4-N	911755	34°32.412'S. 150°43.422'E
Ill 02	Albion Park	Robertson	9028-4-N	935754	34°32.510'S. 150°44.965'E
Ill 03	Albion Park	Albion Park	9028-1-N	938755	34°32.430'S. 150°45.172E
Ill 04	Dapto	Albion Park	9028-1-N	950762	34°31.953'S. 150°46.086'E
Ill 05	Dapto	Albion Park	9028-1-N	975798	34°30.226'S. 150°47.636'E
Ill 06	Dapto	Wollongong	9029-2-S	968802	34°29.934'S. 150°47.212'E
Ill 07	Dapto	Wollongong	9029-2-S	968802	34°29.934'S. 150°47.212'E
Ill 08	Dapto	Wollongong	9029-2-S	986822	34°28.941'S. 150°48.381'E
Ill 09	Wollongong	Wollongong	9029-2-S	009823	34°28.859'S. 150°49.960'E
Ill 10	Dapto	Albion Park	9028-1-N	974767	34°31.829'S. 150°47.568'E
Ill 11	Warrawong	Wollongong	9029-2-S	047811	34°29.592'S. 150°52.592'E
Ill 12	Berkeley	Wollongong	9029-2-S	028829	34°29.086'S. 150°51.154'E
Ill 13	Berkeley	Wollongong	9029-2-S	028829	34°29.086'S. 150°51.154'E
Mac 01	Albion Park	Robertson	9028-4-N	865716	34°34'35"S. 150°40'15"E
Mac 02	Albion Park	Robertson	9028-4-N	894712	34°34'50"S. 150°42'10"E
Mac 05	Albion Park	Robertson	9028-4-N	913714	34°34'45"S. 150°43'25"E
Mac 06	Albion Park	Robertson	9028-4-N	928698	34°35'35"S. 150°44'25"E
Mac 07	Albion Park	Robertson	9028-4-N	918691	34°35'55"S. 150°43'45"E
Mac 08	Albion Park	Robertson	9028-4-N	918691	34°35'35"S. 150°43'45"E
Mac 09	Dapto	Robertson	9028-4-N	892745	34°32'55"S. 150°42'05"E
Mac 10	Dapto	Robertson	9028-4-N	916744	34°33'05"S. 150°43'35"E
Mac 11	Dapto	Robertson	9028-4-N	932741	34°33'10"S. 150°44'40"E
Mac 12	Albion Park	Albion Park	9028-1-N	962746	34°32'58"S. 150°46'50"E
Min 01	Kiama	Kiama	9028-1-S	993611	34°40'15"S. 150°48'40"E
Min 02	Kiama	Kiama	9028-1-S	971601	34°40'50"S. 150°47'10"E
Min 03	Jamberoo	Kiama	9028-1-S	946603	34°40'45"S. 150°45'35"E
Min 04	Kiama	Kiama	9028-1-S	976621	34°39'40"S. 150°47'20"E
Min 05	Kiama	Kiama	9028-1-S	998615	34°40'05"S. 150°48'35"E
Min 06	Jamberoo	Kiama	9028-1-S	972615	34°40'05"S. 150°47'15"E
Min 07	Jamberoo	Kiama	9028-1-S	963597	34°41'02"S. 150°47'15"E
Min 08	Jamberoo	Kiama	9028-1-S	964596	34°41'04"S. 150°46'45"E
Min 09	Jamberoo	Kiama	9028-1-S	965593	34°41'15"S. 150°46'50"E
Min 10	Jamberoo	Kiama	9028-1-S	951627	34°39'20"S. 150°45'55"E
Min 11	Jamberoo	Kiama	9028-1-S	946617	34°39'58"S. 150°45'40"E
Min 12	Jamberoo	Kiama	9028-1-S	947659	34°37'40"S. 150°45'40"E
Min 13	Jamberoo	Kiama	9028-1-S	982643	34°38'30"S. 150°47'55"E
Min 14	Jamberoo	Kiama	9028-1-S	975635	34°38'55"S. 150°47'30"E
Min 15	Jamberoo	Robertson	9028-4-N	935665	34°37'15"S. 150°44'50"E
Min 16	Jamberoo	Albion Park	9028-1-N	944661	34°37'28"S. 150°45'27"E
Min 17	Jamberoo	Kiama	9028-1-S	944644	34°38'30"S. 150°45'25"E
Min 18	Jamberoo	Kangaroo Val.	9028-4-S	924649	34°38'15"S. 150°44'10"E
Min 19	Jamberoo	Kangaroo Val.	9028-4-S	917627	34°39'20"S. 150°43'40"E
Min 20	Jamberoo	Kangaroo Val.	9028-4-S	915629	34°39'18"S. 150°43"33"E

Table 8.3. Structural details of obstructions in the Wollongong Basin

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Head loss (m)	Fishway
Ill 01	Causeway	0.25	8.60	0.15	FALSE
Ill 02	Causeway	0.40	18.50	0.20	FALSE
Ill 03	Causeway	0.31	21.60	0.45	FALSE
Ill 04	Causeway	0.50	16.00	0.50	FALSE
Ill 05	Causeway	3.30	18.00	0.00	FALSE
Ill 06	Culvert	1.50	12.00	0.00	FALSE
Ill 07	Causeway	0.70	8.10	1.00	FALSE
Ill 08	Fixed crest weir	1.05	15.00	0.65	FALSE
Ill 09	Culvert	0.80	18.00	0.50	FALSE
Ill 10	Culvert	1.50	50.00	1.30	FALSE
Ill 11	Causeway	2.10	20.00	0.20	FALSE
Ill 12	Causeway	0.65	10.00	0.30	FALSE
Ill 13	Causeway	2.00	50.00		FALSE
Mac 01	Causeway	0.76	15.00	0.58	FALSE
Mac 02	Causeway	0.58	27.30	0.57	FALSE
Mac 05	Causeway	1.29	21.00	1.05	FALSE
Mac 06	Causeway	0.90	23.00	0.00	FALSE
Mac 07	Causeway	0.80	14.40	0.52	FALSE
Mac 08	Causeway	0.52	16.10	0.42	FALSE
Mac 09	Causeway	2.00	14.00	0.50	FALSE
Mac 10	Causeway	0.60	19.20	0.20	FALSE
Mac 11	Causeway	1.80	25.40	0.60	FALSE
Mac 12	Rock weir	0.80	28.00	0.80	TRUE
Min 01	High dam	13.00			FALSE
Min 02	High dam	14.80			FALSE
Min 03	High dam	14.00			FALSE
Min 04	Culvert	1.10		1.00	FALSE
Min 05	Culvert	1.30	12.50	1.10	FALSE
Min 06	Culvert	1.40	13.00	1.00	FALSE
Min 07	Culvert	1.60	8.50	0.50	FALSE
Min 08	Culvert	1.70	7.50	0.50	FALSE
Min 09	Culvert	1.50	8.00	0.50	FALSE
Min 10	Culvert	0.82	7.00	0.80	FALSE
Min 11	Culvert	2.50	16.00	1.00	FALSE
Min 12	Causeway	1.75	13.50	1.50	FALSE
Min 13	Rock weir	1.50	11.50	1.30	TRUE
Min 14	Culvert	1.10	7.00	0.40	FALSE
Min 15	Causeway	1.50	11.00		FALSE
Min 16	Causeway	1.20	10.50	1.10	FALSE
Min 17	Causeway	1.00	20.50	0.90	FALSE
Min 18	Causeway	3.00	25.00	2.20	FALSE
Min 19	Causeway	1.15	10.00	1.20	FALSE
Min 20	Culvert	2.75	0.90	1.50	FALSE

APPENDIX B Obstructions in the Shoalhaven River Basin (215)

Table 8.4 Identification of obstructions in the Shoalhaven River Basin

Structure ID	Catchment Name	Structure name	Stream Name
Sho 01	Lower Shoalhaven River	Danjerra Dam	Danjerra Ck
Sho 02	Lower Shoalhaven River	Flat Rock Dam	Flat Rock Ck
Sho 03	Lower Shoalhaven River	Floodgate 01	Abernethys Ck
Sho 04	Lower Shoalhaven River	Floodgate 02	Terrara Ck
Sho 05	Lower Shoalhaven River	Floodgate 03	Drain 7
Sho 06	Lower Shoalhaven River	Floodgate 04	Drain 1
Sho 07	Lower Shoalhaven River	Floodgate 05	Drain 6
Sho 08	Lower Shoalhaven River	Floodgate 06	Drain 5
Sho 09	Lower Shoalhaven River	Floodgate 07	Tandingulla Ck
Sho 10	Lower Shoalhaven River	Floodgate 08	Flying Fox Ck
Sho 11	Lower Shoalhaven River	Floodgate 09	Flying Fox Ck
Sho 12	Lower Shoalhaven River	Floodgate 10	Drain 4
Sho 13	Lower Shoalhaven River	Floodgate 11	Drain 3
Sho 14	Lower Shoalhaven River	Floodgate 12	Drain 6
Sho 15	Lower Shoalhaven River	Floodgate 13	Wileys Ck
Sho 16	Lower Shoalhaven River	Floodgate 14	Eelwine Ck
Sho 17	Lower Shoalhaven River	Floodgate 15	Crookhaven Ck
Sho 18	Lower Shoalhaven River	Floodgate 16	Connecting Channel 1
Sho 19	Lower Shoalhaven River	Floodgate 17	Connecting Channel 2
Sho 20	Lower Shoalhaven River	Floodgate 18	Crookhaven Ck
Sho 21	Lower Shoalhaven River	Floodgate 19	Drain 12
Sho 22	Lower Shoalhaven River	Floodgate 20	Drain 13
Sho 23	Lower Shoalhaven River	Floodgate 21	Drain 11
Sho 24	Lower Shoalhaven River	Floodgate 22	Drain 9
Sho 25	Lower Shoalhaven River	Floodgate 23	Drain 10
Sho 26	Lower Shoalhaven River	Levee 1	Ryans Ck
Sho 27	Lower Shoalhaven River	Bomaderry Weir	Bomaderry Ck
Sho 28	Lower Shoalhaven River	Bengalee Ck Crossing	Bengalee Ck
Sho 29	Lower Shoalhaven River	Saltpan Ck Crossing	Saltpan Ck
Sho 30	Lower Shoalhaven River	Saltpan Ck Crossing 2	Saltpan Ck
Sho 31	Lower Shoalhaven River	Nowra Ck Crossing	Nowra Ck
Sho 32	Lower Shoalhaven River	Stream D Crossing	Stream D
Sho 33	Lower Shoalhaven River	Broughton Ck Crossing	Broughton Ck
Sho 34	Lower Shoalhaven River	Connollys Ck Crossing	Connollys Ck
Sho 35	Lower Shoalhaven River	Broughton Mill Ck Crossing	Broughton Mill Ck
Sho 36	Lower Shoalhaven River	Cabbage Tree Ck Crossing	Cabbage Tree Ck
Sho 37	Lower Shoalhaven River	Bundewallah Ck Crossing	Bundewallah Ck
Sho 38	Lower Shoalhaven River	Broughton Mill Ck Crossing 2	Broughton Mill Ck
Sho 39	Lower Shoalhaven River	Connollys Ck Crossing 2	Connollys Ck
Sho 40	Lower Shoalhaven River	Jaspers Ck Crossing	Jaspers Ck
Sho 41	Lower Shoalhaven River	Tandingulla Ck Crossing	Tandingulla Ck
Sho 42	Lower Shoalhaven River	Tullian Ck Crossing	Tullian Ck
Sho 43	Lower Shoalhaven River	Drain 7 Crossing	Drain 7
Sho 44	Lower Shoalhaven River	Tullian Ck Crossing	Tullian Ck
Sho 45	Lower Shoalhaven River	Nowra Ck Crosssing 2	Nowra Ck
Sho 46	Lower Shoalhaven River	Broughton Ck Crossing 2	Broughton Ck
Sho 47	Lower Shoalhaven River	Burrier Weir	Shoalhaven River
Sho 48	Lower Shoalhaven River	Tapitalee Weir	Tapitalee Ck
Sho 49	Lower Shoalhaven River	Eelwine Ck Crossing	Eelwine Ck

Table 8.4 continued

Structure ID	Catchment Name	Structure name	Stream Name
Sho 50	Lower Shoalhaven River	Crookhaven Ck Crossing	Crookhaven Ck
Sho 51	Lower Shoalhaven River	Crookhaven Ck Crossing 2	Crookhaven Ck
Sho 52	Lower Shoalhaven River	Saltpan Ck Crossing 3	Saltpan Ck
Sho 53	Lower Shoalhaven River	Connollys Ck Crossing 3	Connollys Ck
Sho 54	Lower Shoalhaven River	Jaspers Ck Crossing 2	Jaspers Ck
Sho 55	Lower Shoalhaven River	Tullian Ck Crossing 3	Tullian Ck
Sho 56	Lower Shoalhaven River	Tullian Ck Crossing 4	Tullian Ck
Sho 57	Lower Shoalhaven River	Stream B 2	Stream B
Sho 58	Lower Shoalhaven River	Nowra Ck Crossing 3	Nowra Ck
Sho 59	Lower Shoalhaven River	Bevans Ck Crossing	Bevans Ck
Sho 60	Lower Shoalhaven River	Tapitalee Ck Crossing	Tapitalee Ck
Sho 61	Lower Shoalhaven River	Bevans Ck Crossing 2	Bevans Ck
Sho 62	Lower Shoalhaven River	Drain 7 Crossing	Drain 7
Sho 63	Lower Shoalhaven River	Nowra Ck Crossing 4	Nowra Ck
Sho 64	Lower Shoalhaven River	Tapitalee Ck Crossing 3	Tapitalee Ck
Sho 65	Upper Shoalhaven River	Farringdon Crossing	Shoalhaven River
Sho 66	Upper Shoalhaven River	Reedy Ck Weir	Reedy Ck
Sho 67	Upper Shoalhaven River	Snowball Road Crossing 1	Currumbene Ck
Sho 68	Upper Shoalhaven River	Snowball Road Crossing 3	Jinden Ck
Sho 69	Upper Shoalhaven River	Bombay Creek Crossing	Bombay Ck
Sho 70	Upper Shoalhaven River	Little Bombay Ck Crossing	Little Bombay Ck
Sho 71	Upper Shoalhaven River	Gillamatong Ck Weir	Gillamatong Ck
Sho 72	Upper Shoalhaven River	Northengera Road Crossing	Mongarlowe River
Sho 73	Upper Shoalhaven River	Myrtle Grove Crossing	Feagens Ck
Sho 74	Upper Shoalhaven River	Mongarlowe Guaging Station	Mongarlowe River
Sho 75	Upper Shoalhaven River	Charlies Forest Road Crossing 1	Faegans Ck
Sho 76	Upper Shoalhaven River	Charlies Forest Road Crossing 2	Bobs Ck
Sho 77	Upper Shaolhaven River	Charlies Forest Road Crossing 3	Sapling Yard Ck
Sho 78	Upper Shoalhaven River	Charlies Forest Road Crossing 3	Third Crradux Ck
Sho 79	Upper Shoalhaven River	Charlies Forest Road Crossing 5	Wog Wog Ck
Sho 80	Upper Shaolhaven River	Nerriga Road Crossing	Nadgengutta Ck
Sho 81	Upper Shoalhaven River	Stuarts Crossing	Boro Ck
Sho 82	Upper Shoalhaven River	Larbert Road Crossing	Durran Durra Ck
Sho 83	Upper Shoalhaven River	Mayfield Road Crossing	Pipeclay Ck
Sho 84	Upper Shoalhaven River	Mayfield Road crossing 2	Millendale Ck
Sho 85	Upper Shoalhaven River	Windellama Road Crossing	Millendale Ck
Sho 86	Upper Shoalhaven River	Oallen Ford Road Crossing	Nadgegama Ck
Sho 87	Upper Shoalhaven River	Windellama Road Crossing	Jacqua Ck
Sho 88	Upper Shoalhaven River	Bundanoon Creek Dam	Bundanoon Creek
Sho 89	Upper Shoalhaven River	Talong Dam	Barbers Creek
Sho 90	Shoalhaven River	Tallowa Dam	Shoalhaven River

Table 8.5. Location of obstructions in the Shoalhaven River Basin

Structure ID	Nearest town	Location map	Map reference	Grid reference	Lat/Long
Sho 01		Yalwal	8928-2-S	610327	
Sho 02	Nowra	Nowra	9028-3-S	782366	
Sho 03	Bombaderry	Berry	9028-3-N	818400	
Sho 04	Nowra	Berry	9028-3-N	821391	
Sho 05	Shoalh'n Heads	Berry	9028-3-N	923400	
Sho 06	Bomaderry	Berry	9028-3-N	868435	
Sho 07	Berry	Berry	9028-3-N	885459	
Sho 08	Shoalh'n Heads	Berry	9028-3-N	882448	
Sho 09	Shoalh'n Heads	Berry	9028-3-N	854435	
Sho 10	Berry	Berry	9028-3-N	883464	
Sho 11	Berry	Berry	9028-3-N	888470	
Sho 12	Berry	Berry	9028-3-N	875448	
Sho 13	Shoalh'n Heads	Berry	9028-3-N	873434	
Sho 14	Berry	Berry	9028-3-N	885457	
Sho 15	Bomaderry	Berry	9028-3-N	858440	
Sho 16	Nowra	Berry	9028-3-N	866395	
Sho 17	Greenwell Pt	Nowra	9028-3-S	869351	
Sho 18	Greenwell Pt	Nowra	9028-3-S	870352	
Sho 19	Greenwell Pt	Nowra	9028-3-S	870329	
Sho 20	Greenwell Pt	Nowra	9028-3-S	893314	
Sho 21	Greenwell Pt	Nowra	9028-3-S	909320	
Sho 22	Greenwell Pt	Nowra	9028-3-S	881330	
Sho 23	Greenwell Pt	Nowra	9028-3-S	918331	
Sho 24	Greenwell Pt	Nowra	9028-3-S	905365	
Sho 25	Greenwell Pt	Nowra	9028-3-S	914355	
Sho 26	Greenwell Pt	Nowra	9028-3-S	905366	
Sho 27	Nowra	Nowra	9028-3-S	795413	
Sho 28	Nowra	Nowra	9028-3-S	736426	
Sho 29	Greenwell Pt	Nowra	9028-3-S	884334	
Sho 30	Greenwell Pt	Nowra	9028-3-S	886340	
Sho 31	Nowra	Nowra	9028-3-S	798369	
Sho 32	Berry	Kangaroo V.	9028-4-S	898540	
Sho 33	Gerringong	Berry	9028-3-N	942512	
Sho 34	Gerringong	Berry	9028-3-N	890518	
Sho 35	Berry	Kangaroo V.	9028-4-S	898535	
Sho 36	Nowra	Nowra	9028-3-S	768359	
Sho 37	Berry	Berry	9028-3-N	854520	
Sho 38	Berry	Berry	9028-3-N	905518	
Sho 39	Berry	Berry	9028-3-N	890521	
Sho 40	Berry	Berry	9028-3-N	833478	
Sho 41	Bomaderry	Berry	9028-3-N	827440	
Sho 42	Bomaderry	Berry	9028-3-N	809438	
	Shoalh'n Heads	Berry	9028-3-N	926414	
Sho 44	Bomaderry	Berry	9028-3-N	821432	

Table 8.5 continued

Structure ID	Nearest town	Location map	Map reference	Grid reference	Lat/Long
Sho 45	Bomaderry	Berry	9028-3-N	802357	
Sho 46	Kiama	Kiama	9028-1-S	950560	
Sho 47		Yalwal	8928-2-S	6513388	
Sho 48	Nowra	Berry	9028-3-N	768423	
Sho 49	Greenwell Pt	Nowra	9028-3-S	877338	
Sho 50	Greenwell Pt	Nowra	9028-3-S	860360	
Sho 51	Greenwell Pt	Nowra	9028-3-S	862364	
Sho 52	Greenwell Pt	Nowra	9028-3-S	885340	
Sho 53	Berry	Berry	9028-3-N	890515	
Sho 54	Berry	Berry	9028-3-N	840479	
Sho 55	Bomaderry	Berry	9028-3-N	802450	
Sho 56	Bomaderry	Berry	9028-3-N	803447	
Sho 57		Yalwal	8928-2-S	679362	
Sho 58	Nowra	Nowra	9028-3-S	807336	
Sho 59	Shoalh'n Heads	Berry	9028-3-N	897395	
Sho 60	Nowra	Berry	9028-3-N	734436	
Sho 61	Shoalh'n Heads	Berry	9028-3-N	895394	
Sho 62	Shoalh'n Heads	Berry	9028-3-N	931424	
Sho 63	Nowra	Nowra	9028-3-S	806351	
Sho 64	Nowra	Berry	9028-3-N	769421	
Sho 65	Braidwood	Bendoura	8826-4-N	422671	35°30.420'S. 149°39.920'E
Sho 66		Manar	8827-3-N	706426	
Sho 67	Braidwood	Snowball	8826-3-S	341233	35°54.327'S. 149°35.580'E
Sho 68	Snowball	Snowball	8826-3-S	338256	35°53.191'S. 149°35.432'E
Sho 69	Braidwood	Bombay	8827-3-S	445772	35°25.154'S. 149°41.587'E
Sho 70	Braidwood	Bombay	8827-3-S	427778	35°24.803'S. 149°40.386'E
Sho 71	Braidwood	Bombay	8827-3-S	494757	35°25.597'S. 149°44.119'E
Sho 72	Braidwood	Braidwood	8827-2-S	665732	35°26.993'S. 149°56.202'E
Sho 73	Mongarlowe	Braidwood	8827-2-S	694750	35°25.908'S. 149°58.056'E
Sho 74	Mongarlowe	Braidwood	8827-2-S	665760	35°25.386'S. 149°56.087'E
Sho 75	Mongarlowe	Braidwood	8827-2-S	693765	35°25.079'S. 149°57.953'E
Sho 76	Mongarlowe	Braidwood	8827-2-S	713794	35°23.504'S. 149°59.170'E
Sho 77	Mongarlowe	Corang	8927-3-N	285839	35°21.050'S. 150°00.783'E
Sho 78	Mongarlowe	Corang	8927-3-N	282852	35°20.241'S. 150°00.609'E
Sho 79	Nerriga	Endrick	8927-4-S	295952	35°14.901'S. 150°01.631'E
Sho 80	Nerriga	Endrick	8927-4-S	327075	35°08.382'S. 150°03.951'E
Sho 81	Tarago	Oallen	8827-1-S	592976	35°13.892'S. 149°50.820'E
Sho 82	Braidwood	Durran Durra	8827-2-N	521880	35°19.199'S. 149°46.325'E
Sho 83		Oallen	8827-1-S	541996	35°12.844'S. 149°47.470'E
Sho 84		Boro	8827-4-S	493077	35°08'474'S. 149°44.513'E
Sho 85	Tarago	Oallen	8827-1-S	538027	35°11.145'S. 149°47.332'E
Sho 86	Windellama	Windellama	8827-1-N	635130	35°05.496'S. 149°53.389'E
Sho 87	Bungonia	Kooringaroo	8828-2-S	685308	34°55.747'S. 149°56.350'E
Sho 88	Bundanoon				
Sho 89	Talong				
Sho 90	Nowra	Burrier	8928-2-N	540486	45"E34°46'23"S. 150°18'

Table 8.6. Structural details of obstructions in the Shoalhaven River Basin

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Head loss (m)	Fishway
Sho 01	High dam	24.00			FALSE
Sho 02	High dam	12.00			FALSE
Sho 03	Tidal floodgate				FALSE
Sho 04	Tidal floodgate				FALSE
Sho 05	Tidal floodgate				FALSE
Sho 06	Tidal floodgate				FALSE
Sho 07	Tidal floodgate				FALSE
Sho 08	Tidal floodgate				FALSE
Sho 09	Tidal floodgate				FALSE
Sho 10	Tidal floodgate				FALSE
Sho 11	Tidal floodgate				FALSE
Sho 12	Tidal floodgate				FALSE
Sho 13	Tidal floodgate				FALSE
Sho 14	Tidal floodgate				FALSE
Sho 15	Tidal floodgate				FALSE
Sho 16	Tidal floodgate				FALSE
Sho 17	Tidal floodgate				FALSE
Sho 18	Tidal floodgate				FALSE
Sho 19	Tidal floodgate				FALSE
Sho 20	Tidal floodgate				FALSE
Sho 21	Tidal floodgate				FALSE
Sho 22	Tidal floodgate				FALSE
Sho 23	Tidal floodgate				FALSE
Sho 24	Tidal floodgate				FALSE
Sho 25	Tidal floodgate				FALSE
Sho 26	Tidal floodgate				FALSE
Sho 27	Fixed crest weir				FALSE
Sho 28	Culvert	3.00			FALSE
Sho 29	Culvert	1.00			FALSE
Sho 30	Culvert	1.00			FALSE
Sho 31	Causeway	0.60			FALSE
Sho 32	Culvert	0.60			FALSE
Sho 33	Culvert	0.50			FALSE
Sho 34	Causeway	0.40			FALSE
Sho 35	Causeway	0.40			FALSE
Sho 36	Causeway	0.40			FALSE
Sho 37	Causeway	0.30			FALSE
Sho 38	Causeway	0.30			FALSE
Sho 39	Causeway	0.25			FALSE
Sho 40	Causeway	0.20			FALSE
Sho 41	Causeway	0.20			FALSE
Sho 42	Culvert	0.20			FALSE
Sho 43	Culvert	0.15			FALSE
Sho 44	Culvert	0.15			FALSE
Sho 45	Culvert	0.05			FALSE

Table 8.6 continued

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Head loss (m)	Fishway
Sho 46	Culvert	0.05			FALSE
Sho 47	Fixed crest weir	1.50			FALSE
Sho 48	Fixed crest weir	1.50			FALSE
Sho 49	Culvert	0.00			FALSE
Sho 50	Culvert	0.00			FALSE
Sho 51	Culvert	0.00			FALSE
Sho 52	Culvert	0.00			FALSE
Sho 53	Culvert	0.00			FALSE
Sho 54	Culvert	0.00			FALSE
Sho 55	Culvert	0.00			FALSE
Sho 56	Culvert	0.00			FALSE
Sho 57	Culvert	0.00			FALSE
Sho 58	Culvert	0.00			FALSE
Sho 59	Culvert	0.00			FALSE
Sho 60	Culvert	0.00			FALSE
Sho 61	Culvert	0.00			FALSE
Sho 62	Culvert	0.00			FALSE
Sho 63	Causeway	0.00			FALSE
Sho 64	Causeway	0.00			FALSE
Sho 65	Causeway	2.00	60.00	1.60	FALSE
Sho 66	Stream gauging weir	0.35	30.00		FALSE
Sho 67	Causeway	2.70	27.20	0.40	FALSE
Sho 68	Causeway	0.10	7.50	0.10	FALSE
Sho 69	Culvert	1.35	37.30	0.00	FALSE
Sho 70	Culvert	1.10	20.00	0.00	FALSE
Sho 71	Fixed crest weir	0.78	16.30	0.26	FALSE
Sho 72	Causeway	1.30	35.00	0.45	FALSE
Sho 73	Culvert	1.00	18.00	0.00	FALSE
Sho 74	Fixed crest weir	0.70	14.30	0.40	FALSE
Sho 75	Causeway	0.25	10.00	0.30	FALSE
Sho 76	Causeway	1.00	15.30	0.46	FALSE
Sho 77	Causeway	0.70	14.50	0.00	FALSE
Sho 78	Culvert	0.80	3.00	0.00	FALSE
Sho 79	Causeway	1.00	14.70	0.05	FALSE
Sho 80	Culvert	1.30	29.30	0.20	FALSE
Sho 81	Stream gauging weir	0.52	12.30	0.20	FALSE
Sho 82	Causeway	0.95	40.70	0.55	FALSE
Sho 83	Causeway	0.60	27.50	0.20	FALSE
Sho 84	Causeway	1.50	22.30	0.60	FALSE
Sho 85	Causeway	1.50	29.80	0.60	FALSE
Sho 86	Culvert	2.50	34.00	2.40	FALSE
Sho 87	Causeway	2.40	37.00	2.20	FALSE
Sho 88	High dam	35.00	45.00		FALSE
Sho 89	High dam	10.00	50.00		FALSE
Sho 90	High dam	43.00	520.00		FALSE

APPENDIX C. Obstructions found in the Clyde River-Jervis Bay Basin (No. 216)

Table 8.7. Identification of obstructions in the Clyde River-Jervis Bay Basin

Structure ID	Catchment name	Structure name	Stream name
Cly 01	Clyde River	River Road Crossing	Currowan Creek
Cly 02	Clyde River	Shallow Crossing	Clyde River
Cly 03	Clyde River	Croobyar Ford	Croobyar Creek
Cly 04	Clyde River	Bonnie View Crossing	Stony Creek
Cly 05	Clyde River	Avonlea Weir	Croobyar Creek
Cly 06	Clyde River	Bellevue Weir	Croobyar Creek
Cly 07	Clyde River	Croobyar Weir 1	Croobyar Creek
Cly 08	Clyde River	Croobyar Weir 2	Croobyar Creek
Cly 09	Clyde River	Croobyar Weir 3	Croobyar Creek
Cly 10	Clyde River	Buckenboura Weir	Buckenboura River
Cly 11	Clyde River	Quart Road Crossing	Buckenboura River
Cly 12	Clyde River	Buckenbowra Crossing	Buckenboura River
Cly 13	Clyde River	Quart Pot Road Crossing 2	Quart Pot Creek
Cly 14	Clyde River	River Road Crossing	Nelligen Creek
Cly 15	Clyde River	Old Bolaro Road Crossing	Paradise Creek
Cly 16	Clyde River	Runnyforf Road crossing	Mundarlow Creek
Cly 17	Clyde River	Runnyford Road Crossing 2	Waterfall Creek
Cly 18	Clyde River	Porters Creek Dam	Porters Creek
Cly 19	Clyde River	Cockwhy Creek Weir	Cockwhy Creek
Cly 20	Clyde River	Croobyar Weir 4	Croobyar Creek
Cly 21	Clyde River	Yackungarrah Weir	Yackungarrah Ck
Jer 01	Jervis Bay	Boagsville Crossing	Yerrinyong Gully
Jer 02	Jervis Bay	Parma Farm Crossing	Parma Creek
Jer 03	Jervis Bay	Athol Brae Crossing	Yerriyong Gully
Jer 04	Jervis Bay	Woollamia Road Crossing	Currumbene Creek

Table 8.8. Location of obstructions in the Clyde River-Jervis Bay Basin

Structure ID	Nearest town	Location Map	Grid reference	CMA Map Reference	Lat/Long
Cly 01	Kiola	Currowan	425596	8926-4-N	35°34'25"S. 150°09'40"E
Cly 02	Kiola	Currowan	459644	8926-4-N	35°31'55"S. 150°12'00"E
Cly 03	Milton	Milton	610889	8927-2-N	35°18.871'S. 150°22.273'E
Cly 04	Milton	Milton	632875	8927-2-N	35°19.761'S. 150°24.006'E
Cly 05	Milton	Milton	667913	8927-2-N	35°17.615'S. 150°26.077'E
Cly 06	Milton	Milton	658901	8927-2-N	35°25.365'S. 150°25.365'E
Cly 07	Milton	Milton	646896	8927-2-N	35°18.515'S. 150°24.549'E
Cly 08	Milton	Milton	650896	8927-2-N	35°18.605'S. 150°24.829'E
Cly 09	Milton	Milton	633899	8927-2-N	35°18.530'S. 150°23.653'E
Cly 10	Mogo	Nelligen	347414	8926-4-S	35°44.123'S. 150°03.990'E
Cly 11	Mogo	Nelligen	349420	8926-4-S	35°43.785'S. 150°04.144'E
Cly 12	Mogo	Nelligen	330413	8926-4-S	35°44.175'S. 150°02.861'E
Cly 13	Batemans Bay	Nelligen	293452	8926-4-S	35°42.057'S. 150°00.537'E
Cly 14	Nelligen	Nelligen	398518	8926-4-S	35°38.581'S. 150°07.614'E
Cly 15	Nelligen	Nelligen	359507	8926-4-S	35°39.190'S. 150°04.955'E
Cly 16	Mogo	Nelligen	394429	8926-4-S	35°43.442'S. 150°07.067'E
Cly 17	Mogo	Mogo	412399	8926-3-N	35°44.363'S. 150°08.009'E
Cly 18	Lake Conjola	Milton	572942	8927-2-N	35°15'50"S. 150°19'55"E
Cly 19	Kiola	Kiola	628595	8926-1-N	35°33.038'S. 150°20.811'E
Cly 20	Milton	Milton			
Cly 21	Milton	Milton			
Jer 01	Parma	Nowra	781283	9028-3-S	34°57.778'S. 150°34.516'E
Jer 02	Parma	Nowra	779267	9028-3-S	35°58.402'S. 150°33.902'E
Jer 03	Parma	Nowra	753287	9028-3-S	34°57.581'S. 150°32.426'E
Jer 04	Woollamia	Huskisson	845233	9027-4-N	35°00.898'S. 150°38.213'E

Table 8.9 Structural details of obstructions in the Clyde River - Jervis Bay Basin

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Head loss (m)	Fishway
Cly 01	Causeway	1.00	26.80	0.40	FALSE
Cly 02	Causeway	0.40	100.00	0.20	FALSE
Cly 03	Causeway	0.50	13.00	0.40	FALSE
Cly 04	Causeway	0.40	16.00	0.10	FALSE
Cly 05	Fixed crest weir	2.80	9.00	1.60	FALSE
Cly 06	Fixed crest weir	2.50	27.80	1.90	FALSE
Cly 07	Fixed crest weir	1.40	23.00	0.60	FALSE
Cly 08	Fixed crest weir	1.50	14.00	1.20	FALSE
Cly 09	Fixed crest weir	1.60	0.30	0.90	FALSE
Cly 10	Fixed crest weir	3.25	48.00	1.45	FALSE
Cly 11	Causeway	0.55	25.00	0.35	FALSE
Cly 12	Causeway	0.50	27.00		FALSE
Cly 13	Causeway	0.40	36.50	0.30	FALSE
Cly 14	Culvert	1.40	42.00	0.00	FALSE
Cly 15	Causeway	0.55	25.00		FALSE
Cly 16	Culvert	1.10	13.00	0.10	FALSE
Cly 17	Culvert	0.90	5.00	0.10	FALSE
Cly 18	High Dam	17.00	237.00		FALSE
Cly 19	Stream guaging weir	1.10	4.10	0.60	FALSE
Cly 20	Fixed crest weir	2.00			FALSE
Cly 21	Fixed crest weir	2.00			FALSE
Jer 01	Stream guaging weir	0.40	9.00	0.35	FALSE
Jer 02	Causeway	1.50	10.00	1.50	FALSE
Jer 03	Farm dam	2.20	50.00		FALSE
Jer 04	Culvert	1.70	12.50	0.30	FALSE

APPENDIX D. Obstructions found in the Moruya River Basin (No. 217).

Table 8.10.. Obstructions found in the Moruya River Basin.

Structure ID	Catchment name	Structure name	Stream name
Mor 01	Moruya River	South Head Road Crossing	Gilmores Creek
Mor 02	Moruya River	Congo Road Crossing	Congo Creek
Mor 03	Moruya River	Candoin Creek Crossing	Candoin Creek

Table 8.11 Location details of obstructions in the Moruya River Basin

Structure ID	Nearest town	Location map	Grid reference	Lat/Long
Mor 01	Moruya	Moruya	413217	35°54.916'S, 150°08.010'E
Mor 02	Moruya	Moruya	414186	35°56.630'S, 150°07.930'E
Mor 03	Moruya	Moruya	341178	35°56.898'S, 150°03.121'E

Table 8.12 Structural details of obstructions in the Moruya Basin

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Crest width (m)	Head loss (m)	Fishway
Mor 01	Culvert	20.00	12.00	0.00	0	FALSE
Mor 02	Culvert	5.50	3.70	0.00	0	FALSE
Mor 03	Culvert	22.50	3.60	0.00	0	FALSE

APPENDIX E. Obstructions in the Tuross River Basin (No. 218)

Table 8.13. Obstructions in the Tuross River Basin.

Structure ID	Catchment name	Structure name	Stream name
Tur 01	Tuross River	River Road Crossing	Gulf Creek
Tur 02	Tuross River	River Road Crossing 2	Gulf Creek
Tur 03	Tuross River	Coopers Island Crossing	Tuross River
Tur 04	Tuross River	Wild Horse Crossing	Punkally Creek
Tur 05	Tuross River	Victiria Creek Dam	Victoria Creek
Tur 06	Tuross River	Mt Dromedary Trail Crossing	Dromedary Creek
Tur 07	Tuross River	Mt Dromedary Trail Crossing 2	Dromedary Creek
Tur 08	Tuross River	Gulph Creek Weir	Gulph Creek
Tur 09	Tuross River	Sunnyside Road Crossing	Victoria Creek
Tur 10	Tuross River	Olson's Creek Crossing	Olsons Creek
Tur 11	Tuross River	Wandella Crossing	Wandella Creek
Tur 12	Tuross River	Little Belimbla Weir	Little Belimbla Creek
Tur 13	Tuross River	Wadbilliga Crossing	Wadbilliga River
Tur 14	Tuross River	Lake Creek Crossing	Lake Creek
Tur 15	Tuross River	Illawambra Dam	Illawambra Creek
Tur 16	Tuross River	Dromedary Dam	Dromedary Creek
Tur 17	Tuross River	Tilba Dam	
Tur 18	Tuross River	Bate's Weir	

Table 8.14 Location of obstructions in the Tuross River Basin

Structure ID	Nearest town	Location map	Map reference	Grid reference	Lat/Long
Tur 01	Nerrigundah	Nerrigundah	8825-1-N	612985	36°07.516'S. 149°54.105'E
Tur 02	Nerrigundah	Nerrigundah	8825-1-N	611988	36°07.335'S. 149°54.063'E
Tur 03	Bodalla	Bodalla	8925-4-N	367060	36°03.365'S. 150°04.636'E
Tur 04	Narooma	Narooma	8925-4-S	358850	36°14.604'S. 150°03.618'E
Tur 05	Central Tilba	Central Tilba	8925-3-N	366794	36°18.070'S. 150°03.977'E
Tur 06	Central Tilba	Central Tilba	8925-3-N	351822	36°16.097'S. 150°03.104'E
Tur 07	Central Tilba	Central Tilba	8925-3-N	349819	36°16'15"S. 150°03'00"E
Tur 08	Narooma				
Tur 09	Mystery Bay	Central Tilba	8925-3-N	409787	36°18.049'S. 150°06.915'E
Tur 10	Narooma	Central Tilba	8925-3-N	398842	36°15.067'S. 150°06.268'E
Tur 11	Narooma	Wandella	8825-2-N	551808	36°17.008'S. 149°50.449'E
Tur 12	Nerrigundah	Cadgee	8825-1-S	543972	36°08.229'S. 149°49.535'E
Tur 13	Yowrie	Yowrie	8825-3-N	346821	36°16.633'S. 149°36.708'E
Tur 14	Cobargo	Yowrie	8825-3-N	385835	36o15.785'S, 149o39.340'E
Tur 15	Cobargo				
Tur 16	Tilba Tilba				
Tur 17	Tilba Tilba				
Tur 18	Tilba Tilba				

Table 8.15. Structural details of obstructions in the Tuross River Basin.

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Head loss (m)	Fishway
Tur 01	Culvert	1.45	13.70	0.00	FALSE
Tur 02	Culvert	1.45	13.00	0.00	FALSE
Tur 03	Culvert				FALSE
Tur 04	Culvert	1.60	21.30	0.00	FALSE
Tur 05	Farm dam				FALSE
Tur 06	Causeway	0.40	9.00	0.55	FALSE
Tur 07	Causeway	0.40	10.00	0.30	FALSE
Tur 08	Causeway	0.20	8.00	0.10	FALSE
Tur 09	Culvert	1.00	7.00	0.00	FALSE
Tur 10	Culvert	2.10	29.50	0.00	FALSE
Tur 11	Culvert	1.50	35.00	0.00	FALSE
Tur 12	Fixed crest weir	3.50	18.00	3.20	FALSE
Tur 13	Causeway	1.30	52.70	0.52	FALSE
Tur 14	Causeway	0.70	19.50		FALSE
Tur 15	Fixed crest weir	4.00			FALSE
Tur 16	Fixed crest weir	4.00			FALSE
Tur 17	Fixed crest weir	3.00			FALSE
Tur 18	Fixed crest weir	0.40			FALSE

APPENDIX F. Obstructions in the Bega River Basin (No. 219)

Table 8.16.Identification of obstructions in the Bega River Basin

Structure ID	Catchment Name	Structure name	Stream Name
Beg 01	Dignams Creek	Dignams Rock Weir	Dignams Creek
Beg 02	Dignams Creek	Dignams Creek Crossing	Dignams Creek
Beg 03	Wallaga Lake	Brandy-wine Crossing	Barrabaroo Creek
Beg 04	Brogo River	Upper Brogo Rd Crossing	Brogo Swamp Road
Beg 05	Brogo River	Brogo Dam	Brogo River
Beg 06	Brogo River	Dorrigo Road Crossing	House Creek
Beg 07	Brogo River	House Creek Road Crossing	House Creek
Beg 08	Middle Lagoon	Booths Creek Crossing	Booths Creek
Beg 09	Wapengo Lagoon	Unnamed Creek Crossing	Unnamed Creek
Beg 10	Wapengo Creek	Unnamed Creek Crossing 2	Unnamed Creek
Beg 11	Bermagui River	Westrops Road Crossing	Coolagolite Creek
Beg 12	Brogo River	Clavering Crossing	Stony Creek
Beg 13	Brogo River	Sullivans Gap Crossing	Pollacks Flat Creek
Beg 14	Bega River	Stoney Creek Crossing	Stoney Creek
Beg 15	Bega River	Devils CreekWeir	Devils Creek
Beg 16	Bega River	Devils Creek Weir 2	Devils Creek
Beg 17	Bega River	Running Creek Crossing	Running Creek
Beg 18	Bega River	Wicks End Weir	Devils Creek
Beg 19	Bega River	Willbob Creek Weir	Willbob Creek
Beg 20	Bega River	Dragon Swamp Creek Crossing	Dragon Swamp Creek
Beg 21	Bega River	Tantawangalo Weir	Tantawangalo Creek
Beg 22	Bemboka River	Cochrane Dam	Bemboka River

Table 8. 17 Location details of obstructions found in the Bega River Basin

Structure ID	Nearest town	Location map	Map reference	Grid reference	Lat/Long
Beg 01	Cobargo	Wandella	8825-2-N	687726	36°21.349'S, 149°59.714'E
Beg 02	Cobargo	Wandella	8825-2-N	687726	36°21.349'S, 149°59.714'E
Beg 03	Cobargo	Cobargo	8825-2-S	578659	36°24.465'S, 149°52.480'E
Beg 04	Cobargo	Puen Buen	8825-3-S	456606	36°28.095'S, 149°44.581'E
Beg 05	Bega	Puen Buen	8825-3-S	455580	36°29'30"S, 149°44'30"E
Beg 06	Bega	Brogo	8824-1-N	495515	36°32.979'S, 149°47.128'E
Beg 07	Bega	Brogo	8824-1-N	523529	36°32.117'S, 149°49.120'E
Beg 08	Tathra	Bega	8824-1-S	667409	36°38.335'S, 149°59.045'E
Beg 09	Bermagui	Brogo	8824-1-N	676470	36°35.045'S, 149°59.461'E
Beg 10	Bermagui	Brogo	8824-1-N	679474	36°34.834'S, 149°59.747'E
Beg 11	Bermagui	Cobargo	8825-2-S	685667	36°24.464'S, 149°59.649'E
Beg 12	Bega	Bega	8824-1-S	515425	36°37'30"S, 149°48'45"E
Beg 13	Bemboka	Yankees Gap	8824-4-N	320449	36°35'55"S, 149°35'40"E
Beg 14	Bimbaya	Bemboka	8824-4-S	312330	36°43'20"S, 149°35'25"E
Beg 15	Candelo	Candelo	8824-3-N	311245	36°47'55"S, 149°35'20"E
Beg 16	Candelo	Candelo	8824-3-N	311245	36°47'55"S, 149°35'20"E
Beg 17	Candelo	Candelo	8824-3-N	268251	36°47'35"S, 149°32'25"E
Beg 18	Cathcart	Glen Allen	8724-1-S	225346	36°41'30"S, 149°29'20"E
Beg 19	Cathcart	Glen Allen	8724-1-S	223333	36°43'13"S, 149°29'10"E
Beg 20	Cathcart	Glen Allen	8724-1-S	174347	36°42'27"S, 149°26'08"E
Beg 21	Candelo	Candelo	8824-3-N	286248	36°47'37"S, 149°33'42"E
Beg 22	Nimmitabel	Nimmitabel	8724-1-N	196503	36°34'20"S, 149°27'10"E

Table 8.18. Structural details of obstructions in the Bega River Basin

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Head loss (m)	Fishway
Beg 01	Rock weir	0.60	16.00	0.40	FALSE
Beg 02	Causeway	0.65	19.00	0.15	FALSE
Beg 03	Farm Dam	1.00	100.00	1.00	FALSE
Beg 04	Culvert	1.70	52.20	0.00	FALSE
Beg 05	High dam	43.00	260.00		FALSE
Beg 06	Culvert	1.40	20.50	0.60	FALSE
Beg 07	Causeway	1.80	51.50	0.60	FALSE
Beg 08	Bridge	1.00	15.80		FALSE
Beg 09	Culvert	0.70	16.00		FALSE
Beg 10	Culvert	0.90	15.50		FALSE
Beg 11	Causeway	1.80	39.00		FALSE
Beg 12	Culvert	0.50	15.50	0.00	FALSE
Beg 13	Culvert	1.10	28.00	1.10	FALSE
Beg 14	Culvert	0.95	17.50		FALSE
Beg 15	Stream gauging weir	1.10	15.00	0.45	FALSE
Beg 16	Causeway	0.80	15.00	0.55	FALSE
Beg 17	Culvert	1.50	19.00	0.30	FALSE
Beg 18	Stream gauging weir	0.30	4.00	0.10	FALSE
Beg 19	Stream gauging weir	0.70	4.50	0.70	FALSE
Beg 20	Culvert	1.10	17.50	0.25	FALSE
Beg 21	Fixed crest weir	3.00	0.45		FALSE
Beg 22	High dam	27.20	140.00		FALSE

APPENDIX G. Obstructions in the Towamba River Basin (No. 220)

Table 8.19. Identification of obstructions in the Towamba River Basin

Structure ID	Catchment name	Structure name	Stream name
Pam 01	Pambula River	Cobandrah Crossing	Pambula River
Pam 02	Pambula River	Wolumla Peak Road Crossing	Pambula River
Pam 03	Pambula River	Chalkhills Road Crossing	Chalkhills Creek
Pam 04	Pambula River	Rats Valley Road Crossing 1	Chalkhills Creek
Pam 05	Pambula River	Rats Valley Road Crossing 2	Unnamed CReek
Pam 06	Pambula River	Gill Fire Trail Crossing	Chalkhills Creek
Pam 07	Pambula River	Mine Road Crossing	Yowaka River
Pam 08	Pambula River	Ruggs Road Crossing	Centipede Creek
Pam 09	Pambula River	Pipeclay Weir	Pipeclay Creek
Tow 01	Towamba River	Nadgee Crossing	Merrica River
Tow 02	Towamba River	Cow Bail Creek Crossing	Cow Bail Creek
Tow 03	Towamba River	Reedy Creek Crossing	Reedy Creek
Tow 04	Towamba River	Stony Creek	Stony Creek
Tow 05	Towamba River	Dunblane Crossing	Jingo Creek
Tow 06	Towamba River	Jingo Ck Crossing	Jingo Creek
Tow 07	Towamba River	Sheepskin Road Crossing	Towamba River
Tow 08	Towamba River	Myrtle Creek Crossing	Myrtle Creek

Table 8.20 Location details of obstructions in the Towamba River Basin

Structure ID	Nearest town	Location map	Grid reference	Map reference	Lat/Long
Pam 01	Pambula	Pambula	519075	8824-2-S	36°56'50"S, 149°49'35"E
Pam 02	Pambula	Pambula	491111	8824-2-S	36°54'50"S, 149°47'40"E
Pam 03	Pambula	Pambula	489118	8824-2-S	36°54'30"S, 150°47'30"E
Pam 04	Pambula	Pambula	466138	8824-2-S	36°53'25"S, 149°46'00"E
Pam 05	Pambula	Wolumla	466157	8824-2-N	36°51'20"S, 149°46'05"E
Pam 06	Pambula	Wyndham	448138	8824-3-S	36°53'20"S, 149°44'45"E
Pam 07	Pambula	Pambula	494027	8824-2-S	36°59'20"S, 149°48'10"E
Pam 08	Eden	Eden	506973	8823-1-N	37°02'25"S, 149°49"00E
Pam 09	Pambula	Pambula	548041	8824-2-S	36°58'38"S, 149°51'45"E
Tow 01	Eden	Narrabarba	591670	8823-2-N	37°18'19"S, 149°55'15"E
Tow 02	Rocky Hall	Coolumbooka	207123	8724-2-S	36°54'30"S, 149°28'33"E
Tow 03	Burragate	Wyndham	295050	8824-3-S	36°58'29"S, 149°34'45"E
Tow 04	Towamba	Burragate	383952	8823-4-N	37°03'30"S, 149°40'40"E
Tow 05	Burragate	Burragate	359981	8823-4-N	37°01'54"S, 149°39'02"E
Tow 06	Burragate	Burragate	352993	8823-4-N	37°01'13"S, 149°38'35"E
Tow 07	Burragate	Burragate	321983	8823-4-N	37°01'45"S, 149°36'30"E
Tow 08	Wyndham	Wyndham	583054	8824-3-S	36°57'53"S, 149°39'15"E

Table 8.21. Structural details of obstructions in the Towamba River Basin

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Head loss (m)	Fishway
Pam 01	Culvert	0.72	35.00	1.00	FALSE
Pam 02	Bridge	1.80	26.60	0.00	FALSE
Pam03	Bridge	1.50	8.00	0.00	FALSE
Pam 04	Causeway	0.72	20.50	0.30	FALSE
Pam 05	Causeway	0.82	19.50	0.90	FALSE
Pam 06	Causeway	0.35	12.90	0.55	FALSE
Pam 07	Causeway	0.70	8.20	0.64	FALSE
Pam 08	Culvert	3.50	12.80	1.60	FALSE
Pam 09	Fixed crest weir	3.00	35.00	0.80	FALSE
Tow 01	Culvert	0.90	22.00	0.20	FALSE
Tow 02	Culvert	1.50	29.50	1.00	FALSE
Tow 03	Culvert	0.90	64.00	0.70	FALSE
Tow 04	Causeway	1.90	46.00	0.70	FALSE
Tow 05	Culvert	1.40	15.20	0.30	FALSE
Tow 06	Culvert	1.80	42.80	0.10	FALSE
Tow 07	Culvert	1.20	55.50	0.10	FALSE
Tow 08	Culvert	0.90	34.00		FALSE

APPENDIX H. Obstructions found in the East Gippsland Basin (No. 221)

Table 8.22. Identification of obstructions in the East Gippsland Basin.

Structure ID	Catchment Name	Structure Name	Stream Name
Gip 01	Genoa River	Bondi Creek Crossing	Bondi Creek
Gip 02	Wallagaraugh River	Heathy Gap Creek Crossing	Heathy Gap Creek
Gip 03	Wallagaraugh River	Wallagaraugh River Crossing	Wallagaraugh River
Gip 04	Wallagaraugh River	Stanley Creek Crossing	Stanley Creek
Gip 05	Wallagaraugh River	Imlay Creek Crossing	Imlay Creek
Gip 06	Wonboyn River	Wonboyn River Crossing	Wonboyn River

Table 8.23. Location details of obstructions in the East Gippsland basin

Structure ID	Nearest town	Location map	Map reference	Grid reference	Lat/Long
Gip 01	Bombala	Nungatta	8723-1-S	058873	37°08.204'S, 149°18.969'E
Gip 02	Towamba	Mount Imlay	8823-4-S	275782	37°12.891'S, 149°35.276'E
Gip 03	Towamba	Mount Imlay	8823-4-S	258767	37°13.788'S, 149°32.752'E
Gip 04	Towamba	Mount Imlay	8823-4-S		37°13.869'S, 149°32.576'E
Gip 05	Towamba	Mount Imlay	8823-4-S	367850	37°08.493'S, 149°39.112'E
Gip 06	Narrabarba	Narrabarba	8823-2-N		37°15.970'S, 149°46.224'E

Table 8.24. Structural details of obstructions in the East Gippsland Basin.

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Head loss (m)	Fishway
Gip 01	Culvert	3.00	49.50		FALSE
Gip 02	Culvert	1.80	24.00	1.50	FALSE
Gip 03	Culvert	2.20	43.60		FALSE
Gip 04	Culvert	0.80	8.50	0.50	FALSE
Gip 05	Culvert	0.60	4.00	0.40	FALSE
Gip 06	Culvert	0.80	13.30	0.80	FALSE

APPENDIX I. Obstructions found in the Snowy River Basin (No. 222)

Table 8.25. Identification of obstructions in the Snowy River Basin

Structure ID	Catchment name	Structure name	Stream name
Sno 01	Snowy River	Bombala Water Supply Reservoir	Coolumbooka River
Sno 02	Snowy River	Delegate Guaging Station	Delegate River
Sno 03	Snowy River	Green Creek Crossing	Green Creek
Sno 04	Snowy River	Mclaughlin River Weir	McGlaughlin River
Sno 05	Snowy River	Riverview Crossing	Mcglaughlin River
Sno 06	Snowy River	Jindabyne Dam	Snowy River
Sno 07	Snowy River	Arable Road Crossing	Wullwye Creek
Sno 08	Snowy River	Dalgety Weir	Snowy River
Sno 09	Snowy River	Mowamba Weir	Mowamba River
Sno 10	Snowy River	Island Bend Dam	Snowy River
Sno 11	Snowy River	Guthega Pondage	Snowy River
Sno 12	Snowy River	Thredbo Crossing	Thredbo River
Sno 13	Snowy River	Alpine Road Crossing	Thredbo River
Sno 14	Snowy River	Little Thredbo River Crossing	Little Thredbo River
Sno 15	Snowy River	Cobbin Creek Weir	Cobbin Creek
Sno 16	Snowy River	Cobbin Creek Crossing	Cobbin Creek
Sno 17	Snowy River	Eucumbene Dam	Eucumbene River
Sno 18	Snowy River	Stony Creek Crossing	Stony Creek
Sno 19	Snowy River	Brivale Crossing	Cootralantra Creek
Sno 20	Snowy River	Gungarlin Weir	Gungarlin River
Sno 21	Snowy River	Burrunbugge Weir	Burrunbugge River
Sno 22	Snowy River	Arable Farm Dam 1	Arable Creek
Sno 23	Snowy River	Arable Farm Dam 2	Arable Creek

Table 8.26 Location details of obstructions in the Snowy River Basin.

Structure ID	Nearest town	Location map (1:50 000)	Map reference	Grid reference	Lat/Long
Sno 01	Bombala	Bombala (1:25 000)	8724-3-S	004140	36°53.943'S, 149°14.908'E
Sno 02	Delegate	Delegate	8623-N	716982	37°02.772'S, 148°55.662'E
Sno 03	Delegate	Delegate	8623-N	759980	37°02.839'S, 149°58.743'E
Sno 04	Nimmitabel	Nimmitabel (1: 25 000)	8724-1-N	048511	36°33.775'S, 149°17.282'E
Sno 05	Nimmitabel	Nimmitabel (1: 25 000)	8724-1-N	O50510	36°33.841'S, 149°17.432'E
Sno 06	Jindabyne	Berridale	8625-S	462664	36°26.014'S, 148°37.941'E
Sno 07	Berridale	Berridale	8625-S	712709	36°23.547'S, 148°54.617'E
Sno 08	Dalgety	Numbla Vale	8624-N	639584	36°30.353'S, 148°49.883'E
Sno 09	Jindabyne	Berridale	8625-S	461626	36°28.271'S, 148°37.872'E
Sno 10	Jindabyne	Mount Kosciusko	8525-S	330799	36°19.063'S, 148°28.936'E
Sno 11	Guthega Village	Mount Kosciusko	8525-S	228730	36°22.911'S, 148°22.203'E
Sno 12	Thredbo	Mount Kosciusko	8525-S	178599	36°29.913'S, 148°18.946'E
Sno 13	Thredbo	Thredbo	8524-N	130571	36°31.484'S, 148°15.778'E
Sno 14	Thredbo	Mount Kosciusko	8525-S	295649	36°27.076'S, 148°26.721'E
Sno 15	Jindabyne	Berridale	8625-S	455654	36°26.713'S, 148°37.526'E
Sno 16	Jindabyne	Berridale	8625-S	458655	36°26.634'S, 148°37.681'E
Sno 17	Berridale	Eucumbene	8625-N	452002	36°07.669'S, 148°37.107'E
Sno 18	Berridale	Berridale	8625-S	612801	36°18.656'S, 148°47.736'E
Sno 19	Berridale	Berridale	8625-S	642828	36°17.132'S, 148°49.726'E
Sno 20	Jindabyne	Berridale	8625-S	369842	36°16'20"S, 148°30'42"E
Sno 21	Jindabyne	Berridale	8625-S	357840	36°16'23"S, 148°30'20"E
Sno 22	Berridale	Berridale	8625-S	753718	36°21'28"S, 148°33'53"E
Sno 23	Berridale	Berridale	8625-S	756723	36°21'20"S, 148°53'38"E

Table 8.27 Structural Details of obstructions in the Snowy River Basin

Structure ID	Structure type	Vertical ht (m)	Crest length (m)	Head loss (m)	Fishway
Sno 01	Fixed crest weir	5.80	72.00		FALSE
Sno 02	Fixed crest weir	0.60	10.00	0.30	FALSE
Sno 03	Causeway	1.40		1.30	FALSE
Sno 04	Fixed crest weir	1.15	32.00	0.50	TRUE
Sno 05	Culvert	0.80	28.00	0.40	FALSE
Sno 06	High dam	71.00	335.00		FALSE
Sno 07	Causeway	0.70	5.80	0.30	FALSE
Sno 08	Fixed crest weir	1.30	85.40	0.80	TRUE
Sno 09	Fixed crest weir	2.50	40.00	2.20	FALSE
Sno 10	High dam	48.80	146.30		FALSE
Sno 11	High dam	33.50	139.00		FALSE
Sno 12	Culvert	3.00	20.00	0.50	FALSE
Sno 13	Culvert	5.00	14.00	0.30	FALSE
Sno 14	Causeway	3.30	10.00	0.30	FALSE
Sno 15	Fixed crest weir	2.00	7.50		FALSE
Sno 16	Culvert	2.80	17.00	2.50	FALSE
Sno 17	High dam	116.10	579.10		FALSE
Sno 18	Culvert	1.40	41.00	0.70	FALSE
Sno 19	Culvert	0.60	14.30	0.40	FALSE
Sno 20	Fixed crest weir	6.00	51.80	3.10	FALSE
Sno 21	Fixed crest weir	5.20	17.00	2.40	FALSE
Sno 22	Farm dam	4.00	182.90		FALSE
Sno 23	Farm dam	4.10	91.40		FALSE

Other titles in this series:

No.1 Andrew, N.L., Graham, K.G., Hodgson, K.E. and Gordon, G.N.G., 1998.

Changes after 20 years in relative abundance and size composition of commercial fishes caught during fishery independent surveys on SEF trawl grounds. Final Report to Fisheries Research and Development Corporation. Project no. 96/139

No.2 Virgona, J.L., Deguara, K.L., Sullings, D.J., Halliday, I. and Kelly,K., 1998.

Assessment of the stocks of sea mullet in New South Wales and Queensland waters. Final Report to Fisheries Research and Development Corporation. Project no. 94/024

No.3 Stewart, J., Ferrell, D.J. and Andrew, N.L., 1998

Ageing Yellowtail (Trachurus novaezelandiae) and Blue Mackerel (Scomber australasicus) in New South Wales. Fisheries Research and Development Corporation. Project no. 95/151