Few data have been published on pesticides in the Derwent Estuary, with the exception of some preliminary analyses of organochlorine compounds in brown trout (*Salmo trutta*) caught in the upper Derwent Estuary in 1989. This preliminary study suggested that organochlorine concentrations in these specimens far exceeded normal background concentrations (Davies and Kalish, 1989).

Polychlorinated biphenyls

Polychlorinated biphenyls (PCBs) are organic compounds which are widely used in industrial applications. Sources of PCBs entering the environment include wastes containing PCBs or open burning/incomplete combustion of PCBs. PCBs accumulate readily in sediments and biota and are toxic to marine aquatic organisms at low concentrations. ANZECC (1992) recommends that concentrations of PCBs in marine waters should not exceed 0.004 μg/L.

No data have been published on PCB concentrations in the Derwent Estuary.

7 Summary and recommendations

The environmental quality of the Derwent Estuary is a function of its physical setting, as well as historic and on-going inputs of pollutants. These physical features play an important and often controlling role in the ultimate fate and distribution of contaminants. The Derwent is a relatively deep, microtidal estuary, which is highly stratified in its upper reaches, and partially- to well-mixed in its broad lower reaches. Estuarine circulation is characterised by a relatively short residence time (approximately 2 weeks), and a large and consistent freshwater input from the Derwent River. Freshwater surface flows are directed toward the eastern shore, and saline bottom water travels slowly up-river. The Derwent is affected by strong seasonal influences: temperatures, coastal currents, winds and other factors which ultimately affect water quality. The Derwent River catchment is very large and sparsely populated. Water quality from the catchment is generally good, however, flows are strongly regulated for hydropower generation.

The Derwent, together with Mt Wellington, provide the focal point for Hobart, Tasmania's capital city. The estuary is heavily used for recreation, marine transport, boating and fishing, and is internationally known as the venue for the Sydney-to-Hobart Yacht Race. The Derwent is Tasmania's third largest port, and supports a large zinc refinery (Pasminco Hobart) and a large paper mill (ANM-Boyer). Despite existing degradation, it is an important and productive ecosystem and was once a major breeding ground for the Southern Right whale.

Since Hobart was established in 1803, the Derwent has received the majority of the City's urban and industrial wastewater, much of which was untreated or poorly treated until the 1980s/90s. Major contaminants of concern associated with wastewater discharges include pathogens, nutrients, BOD, TSS, heavy metals, arsenic, resin acids hydrocarbons and other organic compounds. There have been significant decreases in most end-of-pipe emissions over the past 5 to 10 years - particularly as a result of sewage treatment plant upgrades and improved treatment of wastewater from ANM and Pasminco Hobart. In 1996, ANM still contributed substantial end-of-pipe emissions to the estuary (BOD, TSS, resin acids), as did 12 sewage treatment plants (nutrients), but the remaining significant inputs to the estuary are primarily derived from diffuse sources, such as urban runoff, ground-and surface-water emissions from tips and contaminated sites (particularly ground-water leaching of heavy metals from Pasminco Hobart), nutrient and sediment loads from the Derwent River, and atmospheric contributions. Some pollutants may also be derived from contaminated sediments within the estuary itself.

For the present, the Derwent remains a highly degraded estuary - and it is difficult to predict if or when it will fully recover. The major environmental issues, identified in Figure 43 and Table 34, are summarised below. ***Heavy metals*** - particularly zinc, cadmium, lead and mercury - are the most severe and persistent problem, with concentrations in water, sediments and shellfish among the highest in Australia. ***Shellfish*** collected from most areas of the Derwent - particularly above Tasman Bridge, along the entire Eastern Shore and within Ralphs Bay ***should not be consumed***. Flathead from Ralphs Bay also have average mercury concentrations slightly in excess of NH&MRC guidelines. Human health issues aside, metals probably have significant toxic effects on the estuarine ecosystem, although this has not been quantified. Most troubling is the lack of substantial improvements in heavy metal concentrations in sediments or biota throughout most of estuary, despite significant end-of-pipe improvements over the past 20 years. It is unclear if this is due to continued diffuse source emissions of heavy metals, contaminated sediments continuing to release these metals over time, or both.

Water quality contamination by ***pathogens*** (via faecal indicator bacteria) is variable, but can be locally severe. Several embayments in the upper and middle estuary have not met guidelines for primary contact recreation in recent years, particularly at Windemere Bay, Elwick Bay, New Town Bay, Prince of Wales Bay and Browns River. The Jordan River consistently fails to meet primary contact guidelines, and in 1995/96 also failed to meet secondary recreational guidelines. The largest known contributor of faecal bacteria to Derwent in 1996 was untreated sewage discharged from the Sandy Bay outfall (> 95%). Other sources would include urban runoff, sewer overflows, etc. The Sandy Bay outfall was connected to the Selfs Point STP in February 1997 and it is hoped that some significant improvements will be observed in the next monitoring season.

The Derwent receives very large anthropogenic inputs of both ***organic matter and suspended solids***. The majority of these contaminants are derived from the ANM pulp mill at Boyer. Direct effects include the accumulation of sludge, depressed dissolved oxygen levels, and impoverished benthic communities. With the advent of primary treatment in 1988, sludge-affected areas appear to be decreasing and there have been some improvements in benthic faunal communities. However, large areas of the estuary remain affected.

Despite relatively elevated concentrations of ***nutrients*** (PO_4, NH_3, NO_x) in the middle and lower reaches of the estuary (derived predominantly from sewage and seasonal Southern Ocean currents), the Derwent does not experience recurrent annual algal blooms. Chlorophyll *a* concentrations are typically low to moderate, with slightly higher values recorded in the middle reaches of the estuary, particularly in Prince of Wales Bay. This lack of phytoplankton response to available nutrients remains an unresolved puzzle - The Derwent may be physically unsuited to algal blooms (rapidly flushed, cold water, limited light availability), or alternatively, algal growth may be inhibited by some natural or anthropogenic substance (e.g. humic/fulvic acids, heavy metals). The upper estuary, in contrast to the middle and lower reaches, shows extremely low concentrations of orthophosphate ($< 2\,\mu g/L$) at all times, and algal growth in this area could potentially be nutrient-limited.

Other environmental quality issues in the Derwent include effects of ***resin acids*** on fish in the upper estuary, ***hydrocarbon pollution*** from urban runoff, severe ***sedimentation*** in several embayments (e.g. New Town Bay). No or little data are available for other potential contaminants such as PCBs, phenolics and pesticides.

At the ecosystem level, ***introduced species*** have been identified as an issue of considerable concern, particularly the northern Pacific seastar (*Asterias amurensis*) and the toxic dinoflagellate (*Gymnadinium catenatum*), both of which are thought to have been introduced to the estuary via ballast water. ***Loss of*** extensive ***seagrass*** beds in lower estuary (e.g. Ralphs Bay) ***and*** the degradation of and potential loss of ***wetlands*** in the upper estuary (e.g. Murphys Flat) are also issues of concern.

These conclusions are supported by a reasonably large body of data, though most studies have been temporally and spatially discontinuous, and have tended to be issue- or project-driven. There is a poor understanding of many of the processes which control environmental quality in the Derwent, particularly with respect to sediments. There is also very little information available on biological communities (e.g. composition, toxic effects). Focused environmental monitoring programs and studies are needed to further assess existing conditions and to understand the processes which ultimately control environmental quality within the estuary. This would be best done within a management context.

In summary, despite significant improvements in some industrial and sewage emissions over the past 10 years, the Derwent remains a significantly degraded estuary. It is hoped that recently completed and planned improvements (specifically connection of the Sandy Bay outfall to Selfs Point, rehabilitation of the Loogana jarosite dump at Pasminco Hobart, and secondary treatment of ANM's effluent) will improve the situation over the next 10 years, however, the long-term effects of severe sediment contamination are unknown. It is clear, however, that as point sources are progressively upgraded, the remaining diffuse sources will gradually dominate. These diffuse sources - urban runoff, atmospheric inputs, ground-water contamination - are difficult and expensive to remediate and may require catchment-based planning and solutions.

Recommendations

Improve environmental quality information

- continue/refine on-going monitoring programs
- initiate circulation and water column studies
  - focused circulation studies for embayments, effluent plumes, etc.
  - assess interaction between organic matter/nutrients and algae in upper Derwent. What are potential effects of reduced organic load from ANM?
  - assess interaction between organic matter/metals in middle/lower Derwent
- initiate sediments studies
  - prepare sediment distribution maps
  - assess role of sediments as source/sink for metals and other contaminants
  - continue/improve monitoring of sludge distribution/thickness; assess ultimate fate (degradation and/or redistribution?)
  - is denitrification in sediments an important process in removal of N from system?
  - what role does sediment resuspension play in contaminant availability/dispersion?

- initiate biologic surveys/studies
  - macrobenthic surveys for entire estuary
  - mapping of existing estuarine ecosystems, biological communities
  - map and survey upper Derwent wetlands
  - seagrass surveys; evaluate loss of seagrasses in Ralphs Bay. Reestablish?
  - surveys of threatened species and their habitats (e.g. spotted handfish)
  - follow up on studies of phytoplankton/nutrient dynamics. What is limiting algal growth at present. Are nutrients (PO_4) potentially limiting in upper Derwent?
  - assess ecotoxicity of metals on Derwent biota - existing effects, levels at which could expect improvements
- revise and publish this document periodically to improve understanding, review progress and raise awareness. This would presumably feed into the SOE process.

Review/refine estimates

- Review of licensed premises monitoring data/requirements. Mass emissions should be routinely determined for all point and diffuse inputs. Flow-proportional monitoring may be necessary. Not all major contaminants are monitored; additional parameters may be needed for certain classes of premises (e.g. STPs) or individual premises.
- Sewage mass loadings should be refined to include inputs from storm-induced overflows and spills. Sewage strategies may need to focus more on storm-induced overflows and prevention of spills.
- Review/estimate diffuse inputs from smaller industries.
- Inputs from contaminated sediments should be assessed.
- Review/estimate inputs from municipal and industrial tips and landfills.

Possible actions to improve environmental quality in the Derwent

- develop a coordinated water quality management plan for the Derwent Estuary. This will require a proactive steering committee, clear and achievable objectives, adequate funding and staff and a time frame.
- Remediation of Pasminco Hobart's Loogana/Inshallah stockpile and secondary treatment of ANM effluent should proceed as rapidly as possible.
- Determine sources and remediate elevated bacterial levels at Jordan River, Browns River and other affected sites.
- Develop a coordinated catchment-based urban runoff strategy; rank urban catchments in terms of impacts/inputs, and focus efforts accordingly.
- If sediments are determined to be a significant source of heavy metal emissions to the Derwent, remediation options should be considered for highly contaminated areas (e.g. around Pasminco Hobart wharf, in New Town Bay)
- Evaluate effects of any proposed dredging/spoil disposal as regards metal contamination and ecosystem impacts.
- Remediate local sedimentation problems (e.g. New Town Bay), taking contamination issues into account; incorporate local catchment management strategies.
- Assess viability of controlling existing introduced species; develop/implement strategy to avoid new problems (e.g. ballast water controls);
- Maintain, preserve or rehabilitate important ecosystems (e.g. wetlands, seagrasses).
- Develop and implement plans to protect rare and endangered species (e.g. spotted handfish, Southern right whale).

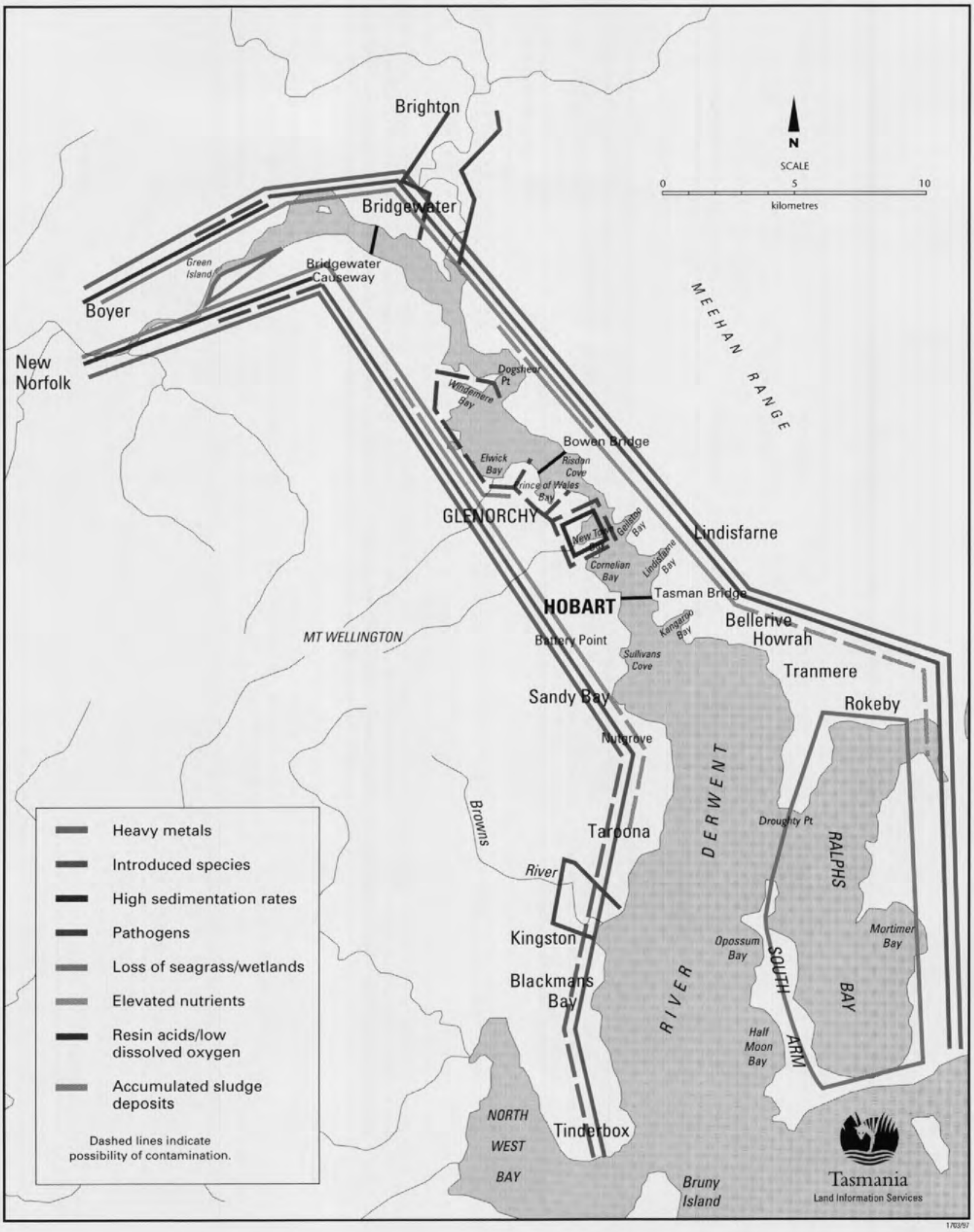

Figure 43 Major environmental issues

Table 34 Summary of environmental issues in the Derwent Estuary

ISSUE	STATE	PRESSURE	POSSIBLE ACTIONS	INFORMATION
Pathogens	Jordan River and Browns River frequently exceed primary contact recreation guidelines	sewage, industry, agriculture, stormwater, wildlife, recreational boats	investigate; remediate	monitored weekly during summer months;
	beaches around middle estuary (Windemere, Elwick, Prince of Wales, New Town, etc.) occasionally exceed primary contact recreation guidelines	Sewage, agriculture, stormwater, wildlife, recreational boats	investigate.	monitored weekly during summer months; 1988 to present
Dissolved oxygen	in upper estuary, DO levels between ANM outfall and Bridgewater are often < 6 mg/L; DO levels immediately downstream of ANM outfall often < 2 mg/L during summer months	high BOD in ANM paper mill effluent, poor estuarine circulation at depth in upper estuary	secondary treatment of ANM effluent (reduce BOD load); improve flushing	monthly surveys 1988; fortnightly surveys at 51 sites 1993/194; fortnightly surveys 1994 to present
Suspended sediments	low to moderate throughout estuary (< 20 mg/L)	natural inputs from catchment, tidal mixing and resuspension; inputs from ANM, stormwater, STPs	secondary treatment of ANM effluent, stormwater controls	fortnightly surveys at 51 sites (1993/1994);
Sedimentation	high sedimentation rates in several embayments (e.g. New Town, Lindisfarne)	erosion within catchment and along stream banks; alteration of nearshore currents (e.g. jetty construction)	assess and remediate sources; control bank erosion; sediment traps and other pollution controls; dredging; revegetation.	studies of Lindisfarne Bay (1988) and New Town Bay (1996/7)
Nutrients	variable in time and space; NH_3, PO_4 and TP elevated in middle reaches; seasonal NO_x peaks from ocean and river sources; TN highest in river/upper estuary	sewage, industry, agriculture, stormwater, natural background from coastal waters.	identify factor(s) controlling algal growth in Derwent	fortnightly surveys at 51 sites 1993/1994; monthly/bimonthly surveys (1994 to present)
Phytoplankton/ chlorophyll *a*	variable, but generally moderate to low throughout most of estuary; high in Prince of Wales Bay	nutrients; circulation; light; temperatures, other	identify factor(s) controlling algal growth in Derwent; investigate at POWB	weekly (summer)/bimonthly (winter) surveys, 1994 to present

ISSUE	STATE	PRESSURE	POSSIBLE ACTIONS	INFORMATION
Heavy metals	elevated Zn, Cd, Pb, Hg and Cu in waters, sediments and biota throughout estuary	industry; contaminated sediments	reduce diffuse source inputs (e.g. Loogana remediation); assess continuing releases from contaminated sediments; evaluate remediation options	See Tables 28, 29 and 30
Fluoride	unknown	industry	determine if fluoride is a concern in aquatic/marine ecosystems	no data
Hydrocarbons	high concentrations in sediments of upper estuary and Prince of Wales Bay; no data for rest of estuary	urban runoff, industry, STPs, shipping/spills	investigate	upper estuary survey (1988); POWB survey (1996)
PAHS	elevated in sediments from Prince of Wales Bay; no data for rest of estuary	urban runoff; industry, shipping/spills	investigate	POWB survey (1996)
Phenols	unknown	industry	investigate	no data
Pesticides	some indications of elevated levels in trout from upper estuary	industry, agriculture	investigate	limited survey of trout from upper estuary(1988)
PCBs	no data	industry	investigate	no data
Introduced species				
Northern Pacific seastar	severe infestation throughout estuary, particularly in middle reaches	introduced in ballast water in early 1980s	control/contain	surveys of middle/lower estuary (1993 - 1995)
Toxic dinoflagellates	significant blooms occurred in SE Tasmanian waters in 1986, 1991 and 1993	introduced in ballast water in early 1970s	monitoring/warning program; identify factor(s) controlling growth	weekly (summer)/bimonthly (winter) surveys, 1994 to present
Wetlands	little data on current extent or condition; large wetland in upper Derwent (Murphys Flat) burned off and trenched in 1997	clearing, draining and filling for agricultural and residential land uses	investigate; preserve/rehabilitate	very little data
Seagrass beds	little data on current extent or condition; 400 ha of seagrass beds lost in Ralphs Bay since 1950s	nutrients from STPs, toxicants, mechanical disturbance	investigate; preserve/rehabilitate	survey of Ralphs Bay (based on aerial photos) completed in early 1990s