DEPARTMENT *of*
PRIMARY INDUSTRIES,
WATER *and* ENVIRONMENT

Tasmania

Water Quality of Rivers in the Jordan Catchment

A Report Forming Part of the Requirements for State of Rivers Reporting

PART 6

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The Department of Primary Industries, Water and Environment

The Department of Primary Industries, Water and Environment provides leadership in the sustainable management and development of Tasmania's resources. The Mission of the Department is to advance Tasmania's prosperity through the sustainable development of our natural resources and the conservation of our natural and cultural heritage for the future.

The Water Resources Division provides a focus for water management and water development in Tasmania through a diverse range of functions including the design of policy and regulatory frameworks to ensure sustainable use of the surface water and groundwater resources; monitoring, assessment and reporting on the condition of the State's freshwater resources; facilitation of infrastructure development projects to ensure the efficient and sustainable supply of water; and implementation of the *Water Management Act 1999*, related legislation and the State Water Development Plan.

3 Nutrient Load Estimates

3.1 Background

Load estimates for the Jordan River are based on flow and nutrients monitored at the Jordan River at Mauricetion (J11), which captures runoff from the top 60% of the catchment (742 km^2). For approximately 10months there was no flow at this site due to climatic conditions.

Nutrient loads analyses for the Jordan River catchment above Mauriceton is based on data from monthly, general ionic and flood sampling between January 1999 to December 2001 (Table 3.1). No automated sampler installed at this site and because there were very few high flow events during the period of the study, only a limited number of high flow samples (4) were collected. The river level monitoring station at J11 has been operational since 1966 and the flow record from this site is quality coded as a ‘fair’. These data were used to derive flow/nutrient relationships.

Table 3.1: Summary of statistics for nutrients and suspended solids sampled in the Jordan River at Mauriceton between January 1999 to December 2000.

	Turbidity NTU	Ammonia – N mg/L	Nitrate-N mg/L	Nitrite-N mg/L	DRP mg/L	TN mg/L	TP mg/L	TSS mg/L
No samples	45	38	38	38	38	41	41	19
Median	4.39	0.012	0.004	0.002	0.005	0.716	0.023	10
Min	0.78	0.002	0.001	0.002	0.002	0.368	0.002	10.0
Max	76.9	0.112	0.115	0.004	0.038	2.760	0.690	94.0

Figure 3.1 displays the flow (ML/day) in the Jordan River at Mauriceton since the start of record (1966). The plot clearly shows the decline in the frequency and magnitude of flood flows in the upper catchment since the start of monitoring, but most particularly since 1986. Since that time, drought conditions have become a more common feature of the climate for the catchment, and laid on top of this is the corresponding increase in water demand for agricultural activities. Analysis of flood regimes in the Jordan River catchment conducted by DPIWE in 2000 concluded that flood frequency has diminished significantly with the “historical regimes of flooding not present since the 1980’s” (Fallon *et al*, 2000). This report concluded that the reduction in perennial floods has occurred due to a decrease in annual rainfall and to a lesser degree the construction of dams.

Figures 3.2a to 3.2c illustrate the variations in flows at J11 for each year of this study. The reduced baseflows and periods of ‘no flow’ experienced between 1999 and 2001 are more clearly evident in these figures, particularly between November 1999 and June 2001. It was not until 6^{th} July 2001 that significant flow returned to this site. As is typical of catchments with highly unpredictable flows, flow at this site recommenced with a minor flood that peaked at 0.8 m, (16.3 cumecs) and re-established flow at this site for the remainder of the study. The highest flow during the study period occurred between 12^{th} October 2001 and 25^{th} October 2001, when river flow peaked at 30.5 cumecs and resulted in a total discharge of 6, 028 ML. This represents 87% of the total discharge for October and 27% of total flow for 2001. The loads calculated from this event are discussed in section 3.2.

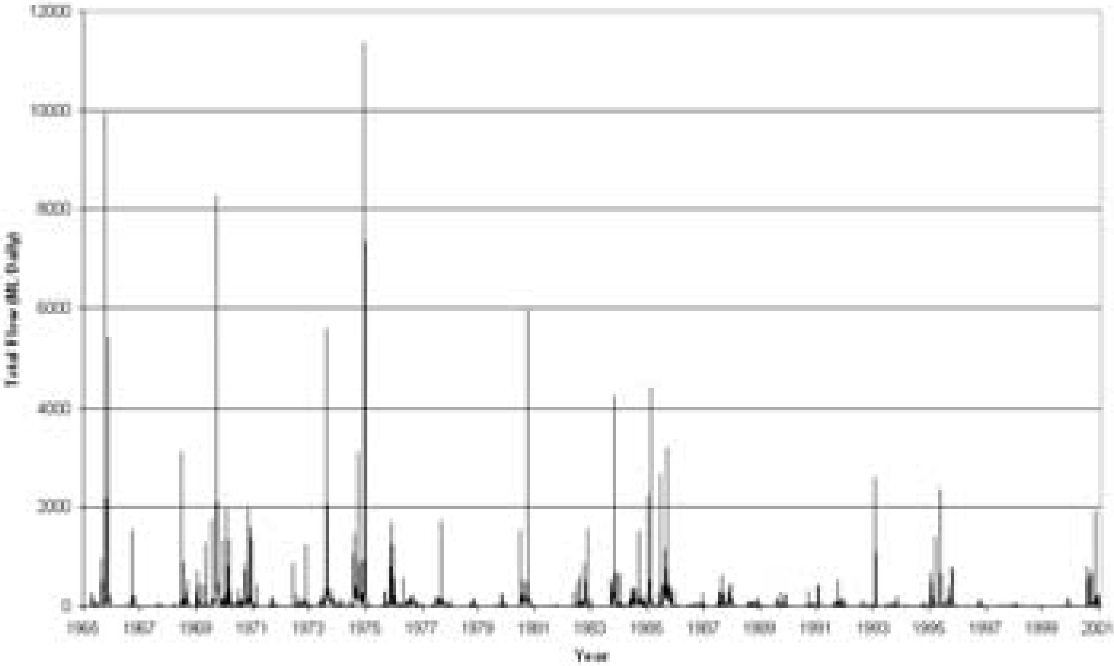

Figure 3.1: Total Flow (ML/daily) for the Jordan River at Mauricton (1966 –2001).

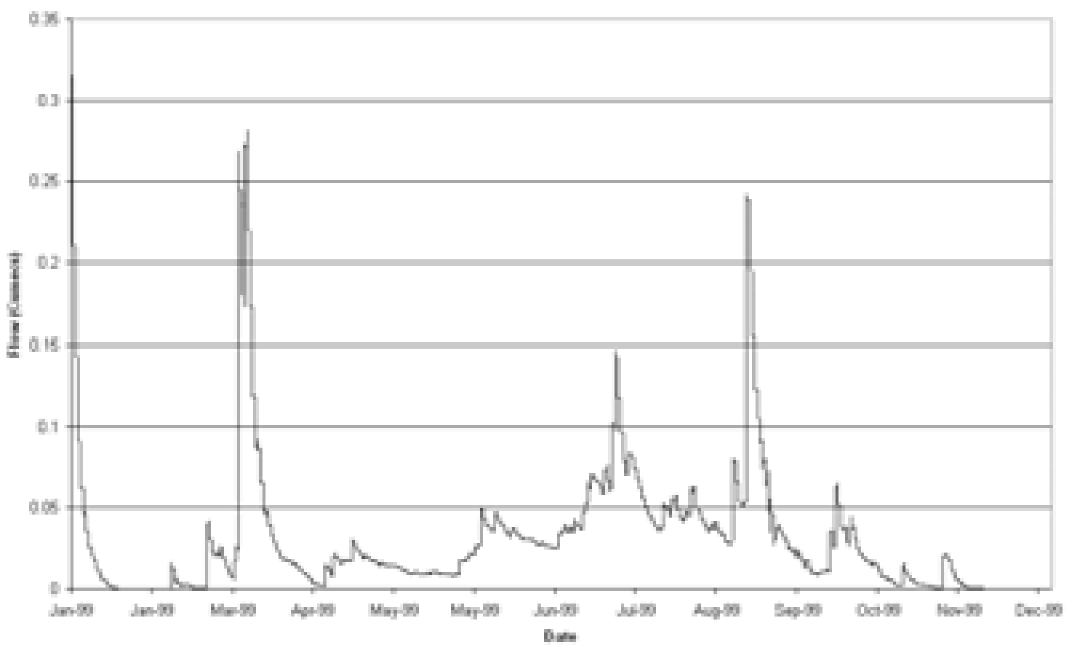

Figure 3.2a: Time series flow (cumecs) for the Jordan River at Mauriceton in 1999.

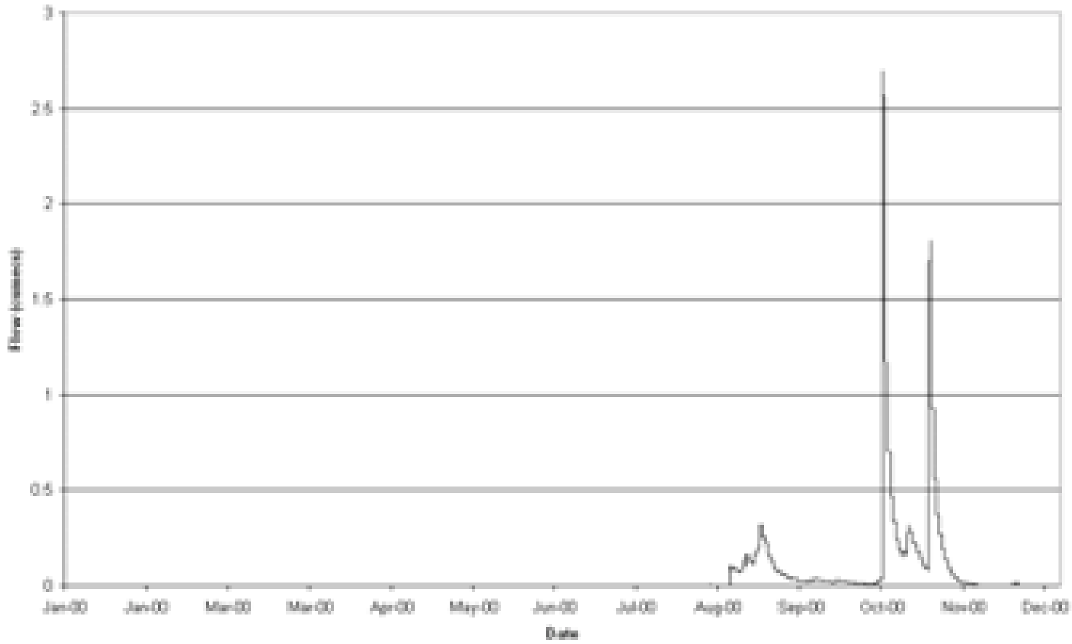

Figure 3.2: Time series flow (cumecs) for the Jordan River at Mauriceton for 2000.

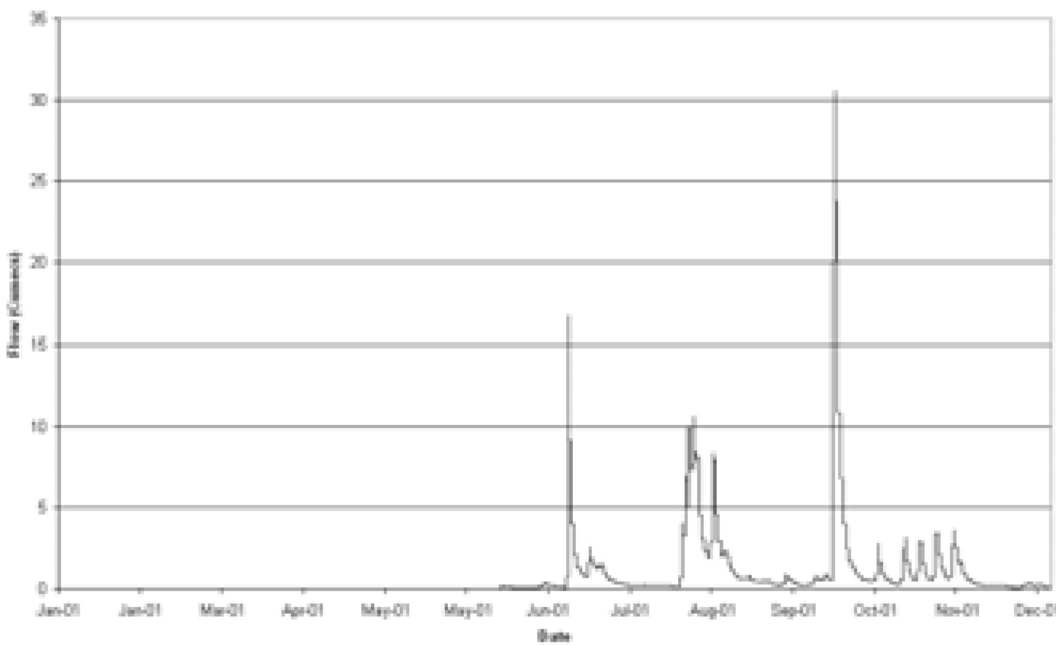

Figure 3.2c: Timer series flow (cumecs) for the Jordan river at Mauriceton for 2001.

3.2 Load Estimation

Because continuous turbidity was not monitored at this site, load estimation for the upper Jordan River are based on nutrient/flow relationships calculated individually for rising and falling flows based on flood and monthly nutrient concentrations data. This method relies heavily upon the frequency of nutrient sampling covering a range of flows. Because below average flows occurred throughout most of the study period (for a large period of time there was no flow), the derived nutrient/flow relationships are primarily based on monthly baseline samples. These samples were generally taken during falling flows, when nutrient concentrations are generally less. Therefore these estimates can be considered only as generally indicative for the Jordan catchment and have a high degree of uncertainty.

A total of 37 monthly nutrient samples were collected between January 1999 and December 2001 with only 4 high flow samples taken (Table 3.1). From a total of 41 nutrient samples, 15 represent no flow situations. As these data cannot be compared against flow they have not been included in the data set for analysis. The flow/nutrient relationships for rising and falling flows were best described by the linear equations as follows;

Total Nitrogen

Rising flows	$y = 0.1895x + 0.5905$	($R^2 = 0.9523$), n = 7
Falling flows	$y = 0.5691x + 0.5445$	($R^2 = 0.7982$), n = 22

Total Phosphorous

Rising flows	$y = 0.0083x + 0.027$	($R^2 = 0.7202$), n = 7
Falling flows	$y = 0.0227x + 0.0182$	($R^2 = 0.0.5239$), n = 22

* Where y = the nutrient, and x = flow at Mauriceton

A reasonable total suspended solid/flow relationship could not be derived.

As mentioned above, load estimates for the Jordan were based on dividing the flow record into rising and falling flows. The above equations are then applied to each flow data set to derive monthly nutrient load estimates. The reliability of this method hinges heavily upon the number of samples that are taken and the accuracy of the flow record, which is generally within an error range of +/- 10%. In the case of this study, the very low number of samples collected are the main cause of uncertainty surrounding the catchment load estimates, particularly as there were so few high flow and flood samples, which is when the vast majority of transport would have occurred. As such, the estimates made here should be viewed as conservative.

Table 3.2 presents the estimates of monthly nutrient transport between January 1999 and 2001. This table includes periods of 'no data' for either whole or partial months, when flow in the river at this location ceased. From the table it can be seen that variations in both TN and TP loads generally followed variations in discharge, with higher loads being generated during months of high discharge. As previously mentioned, the highest flow during the study occurred between 12th - 25th October 2001. The total discharge for this event was 6,028 ML. Using the equations above, the following total load estimated for this event were;

Total Nitrogen = 31,984kg
Total Phosphorous = 7,837kg

Total discharge for this event contributed 87% of discharge for the month and 27% of discharge for 2001. The corresponding load estimates for TN suggest that this event contributed 98% of TN for the month, and 54% of TN for 2001. Similar estimates for TP suggest that this event contributed 99% of TP for the month and 59.3% of TP for 2001.

Table 3.2: Estimated monthly nutrient load and discharge for the Jordan River at Mauriceton between January 1999 and December 2001.

Date	Discharge Total Volume (ML)	Median Monthly TN (mg/L)	TN Load (kg)	Median Monthly TP (mg/L)	TP Load (kg)
January-99	104.36	0.549	69.91	0.018	2.42
February-99	17.26	0.557	9.92	0.019	0.39
March-99	158.23	0.562	96.69	0.019	3.79
April-99	39.09	0.555	22.26	0.019	0.85
May-99	32.26	0.592	18.56	0.027	0.76
June-99	84.63	0.565	48.64	0.019	1.84
July-99	166.43	0.597	99.27	0.027	4.07
August-99	125.18	0.572	72.62	0.019	2.73
September-99	157.87	0.577	94.55	0.019	3.56
October-99	58.56	0.564	33.68	0.019	1.31
November-99	14.77	0.547	8.33	0.018	0.32
December-99	0.58	0.545	0.32	0.018	0.01
January-00	No Flow	No Flow	No Flow	No Flow	No Flow
February-00	No Flow	No Flow	No Flow	No Flow	No Flow
March-00	No Flow	No Flow	No Flow	No Flow	No Flow
April-00	No Flow	No Flow	No Flow	No Flow	No Flow
May-00	No Flow	No Flow	No Flow	No Flow	No Flow
June-00	No Flow	No Flow	No Flow	No Flow	No Flow
July-00	1.60	0.591	0.93	0.027	0.04
August-00	2.72	0.545	1.52	0.018	0.06
September-00	256.25	0.594	158.98	0.029	9.96
October-00	345.99	0.560	301.55	0.024	31.99
November-00	575.75	0.638	425.65	0.045	41.86
December-00	2.36	0.545	1.33	0.018	0.05
January-01	No Flow	No Flow	No Flow	No Flow	No Flow
February-01	No Flow	No Flow	No Flow	No Flow	No Flow
March-01	No Flow	No Flow	No Flow	No Flow	No Flow
April-01	No Flow	No Flow	No Flow	No Flow	No Flow
May-01	0.95	0.591	0.55	0.027	0.02
June-01	170.74	0.593	104.56	0.028	5.54
July-01	3171.51	0.852	5682.32	0.094	1190.04
August-01	6127.63	0.660	14554.86	0.063	2887.28
September-01	2179.01	0.789	2894.17	0.111	672.99
October-01	6907.54	0.873	32720.24	0.136	7910.62
November-01	2969.57	0.937	3208.49	0.144	475.10
December-01	679.03	2.047	493.51	0.063	57.97
Total	**24,349.9**		**61,123.4**		**13,305.6**

3.3 Export Coefficients

General comparisons can be made between catchments using total load exports. However the derivation of export coefficients (also known as ‘Runoff Coefficients’) enable a more robust method for nutrient loss comparisons between catchments of different sizes and discharge. The method for calculating these coefficients is presented in the Glossary at the front of this report, but is basically a mass load transported past a location on a river per millimeter of rainfall and per square kilometre of catchment area. This is equivalent to Total Load per Megalitre Discharge (kg/ML).

The export coefficients for the Jordan River at Mauriceton (J11) for each year are given in Table 3.3. The high flows experienced in the Jordan River during 2001 resulted in a higher export coefficient for TN and TP from the catchment for that year. It worth noting that discharge in 1999 and 2000 was well below the annual average (21,000ML) for the Jordan River, while the discharge for 2001 was slightly above the annual average (Table 3.3), with the majority of flow occurring in the later half of the year (Table 3.2). The much higher loads and export coefficients calculated for 2001 are likely to be a result of the combined impact of an extended dry period preceding the increase in flow, and a lack of vegetation and ground-cover on the surrounding hillsides through overgrazing during the drought period. Both of these factors will have left soils exposed to erosion and easily mobilised once rain eventually arrived. The instream works that were carried out upstream prior to 2001 would have further facilitated transport and assisted in elevating the export coefficients in this year.

Table 3.3: Export coefficients for the Jordan River at Mauriceton derived from data collected between January 1999 and December 2001.

Year	Catchment area (km^2)	Discharge (ML)	Total P ($kg/mm/km^2$)	Total N ($kg/mm/km^2$)
1999	742	959.21	0.023	0.599
2000	742	1184.67	0.071	0.751
2001	742	22,205.98	0.594	2.687

Table 3.4 provides export coefficients that have been estimated for other Tasmanian catchments for comparison with the Jordan River at Mauriceton. Some of the estimates in Table 3.4 are averages calculated over several years, while others have been calculated from a single year or 9 months worth of data. This is important to keep in mind when making comparisons, as the amount of rainfall that occurred during the study period and the agricultural activities that take place in the catchment will influence these export coefficients. As was found during the Jordan River study, export coefficients that are calculated during a period of below average rainfall will provide lower underestimate than those made for wetter years.

When compared to other catchments in Tasmania examined under the State of Rivers program, the Jordan at Mauriceton has the second lowest annual average discharge. However, both TN and TP coefficients (averaged over the 3 years) are within the upper 30% of those estimated for other catchments, some of which support more intensive agricultural activities. While agricultural activities in the upper Jordan River catchment may be less intensive than other catchments with similar export coefficients, these results highlight the degraded condition of the river system.

Total N exports for the Jordan are similar to those for the Kermandie River, which also receives discharge from the Geeveston wastewater treatment plant (Bobbi, 1998). It is also reasonable to assume that export loads and export coefficients will be greater in catchments which are intensively farmed (ie Duck River and Montagu River catchments). It is also import to consider that load estimates within a catchment will vary over time depending on agricultural activities and catchment conditions. Given that the upper Jordan catchment is not very intensively farmed, the high TN and TP export coefficients for this area are likely to reflect the lack of riparian vegetation and high erosion potential of soils exposed as a result of the drought during the earlier part of the study.

Table 3.4: Export coefficients for a variety of Tasmanian rivers. Results for rivers where data has been collected over several years have been averaged.

Catchment	Years of Data	Catchment Area (km^2)	Mean Annual Discharge (ML)	Total P ($kg/mm/km^{-2}$)	Total N ($kg/mm/km^{-2}$)
Jordan River at Mauriceton	3	742	8116.62	0.23	1.346
Coal River at Richmond	9 mths	536	4485	0.011	0.42
North Esk River at Ballroom	2	362.6	138,949	0.005	0.098
North Esk River at Corra Linn	2	870	417,204	0.002	0.046
Duck River at Scotchtown	3	339	141,172	0.532	1.67
Montagu River at Stuarts Road	3	323	98,778	0.800	2.66
Inglis River at railway bridge	3	175	116,030	0.081	1.16
Pipers River	1	298	96,700	0.083	1.17
Brid River	1	136	40,986	0.066	1.13
Meander River at Strathbridge	3	1,012	427,904	0.058	0.67
Liffey River	3	224	80,661	0.052	0.78
South Esk at Perth	3	3,280	624,508	0.034	0.66
Break O'Day River	3	240	53,177	0.065	0.94
Huon River above Judbury	1	2,097	2,562,475	0.010	0.33
Kermandie River**	1	130	36,760*	0.122	1.42

* Estimated flow data

** Export figures include nutrients discharged to the river from the Geeveston sewage treatment plant.

3.4 Snapshot Flood Sampling

Flood samples were taken at a number of sites around the Jordan River catchment to provide a 'snapshot' illustrating changes in turbidity and nutrient concentrations during surface runoff events. Throughout the 3-year study it was noticed that rainfall within the Table Mountain region provided significant flow to the Jordan River via Exe Rivulet, however the data from this section of the catchment indicates that this delivers relatively good quality water during rainfall events. Figures 3.3 to 3.8 illustrate the variation in turbidity, TN and TP during two separate flood monitoring events on 9^{th} July 2001 and 28^{th} August 2001. When considering these data it is important to note that not all the same sites were visited during each monitoring snapshot.

Figures 3.3 and 3.4 show that sites in the middle to lower catchment (J1 to J11) generally recorded high turbidity levels in comparison to the upper catchment sites. During both events it appears that Jordan at Elderslie Road Bridge (J6) and Jordan upstream tidal limit (J1) have the highest turbidity level. Figures 3.5 and 3.6 indicate the TN contributions during these two events. High TN values during both events were predominant on the mainstream stream with J1 and J6 recording the highest concentrations. Both of these sites are subject to landuse pressures that would impact on runoff water quality. As expected TP concentrations mirrored those for TN for each event. Higher TP concentrations generally occurred in the lower catchment from J1 to J11. Both J1 and J6 recorded the highest TP concentrations for each event.

Collectively, these data illustrate that the highest inputs of turbidity, TN and TP originate at sites that have been identified as having high concentrations of nutrients during the monthly monitoring (Section 2.3). Therefore it is reasonable to assume that during periods of flow in the Jordan these sites (in particular J6) appear to contribute to the degradation of water quality downstream. In the upper catchment sites J20, J18, J15 and J11 are likely to contribute to elevated turbidity, TN and TP concentrations downstream.

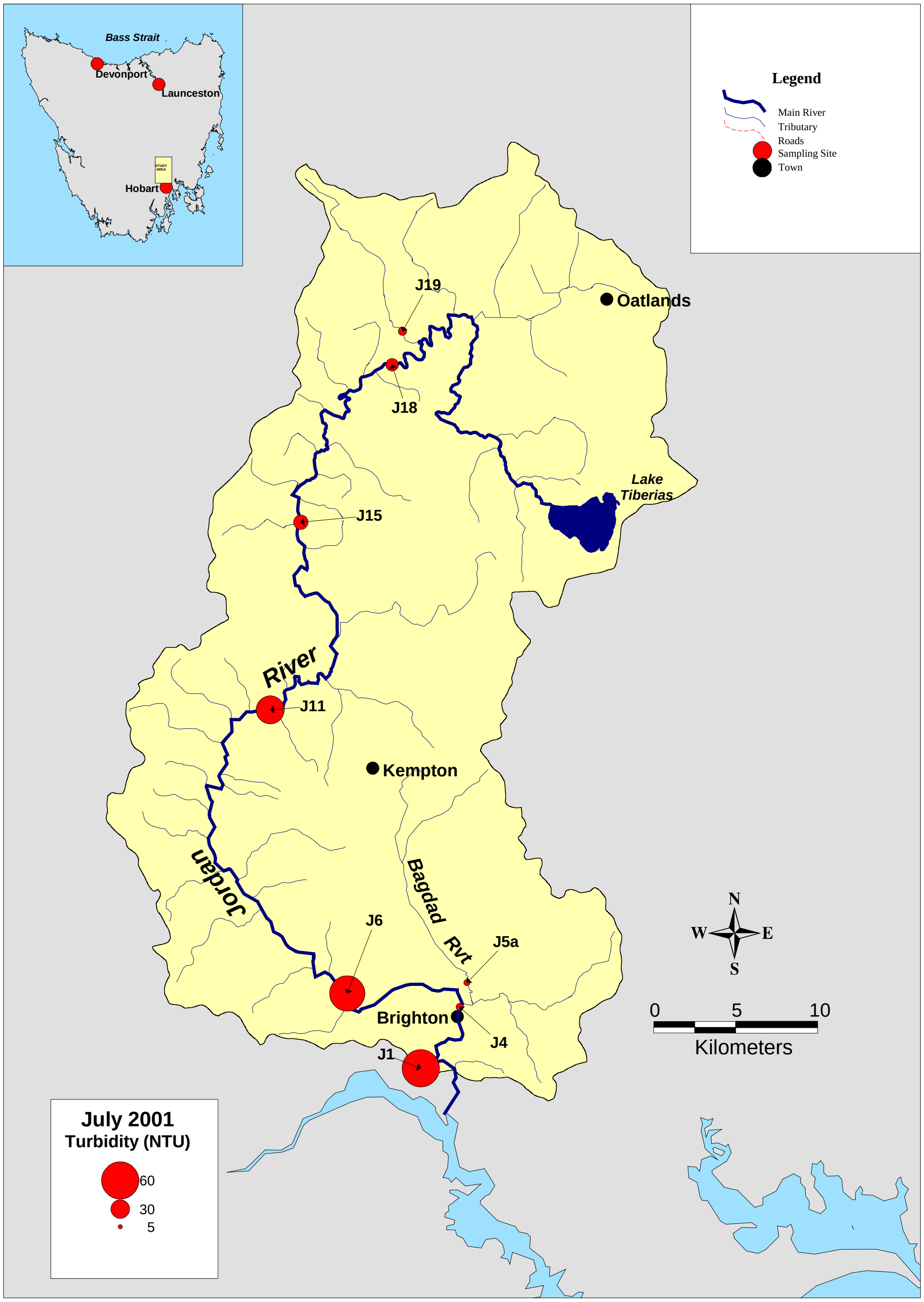

Figure 3.3: Flood snapshot of turbidity on 9th July 2001 at selected sites in the Jordan River catchment.

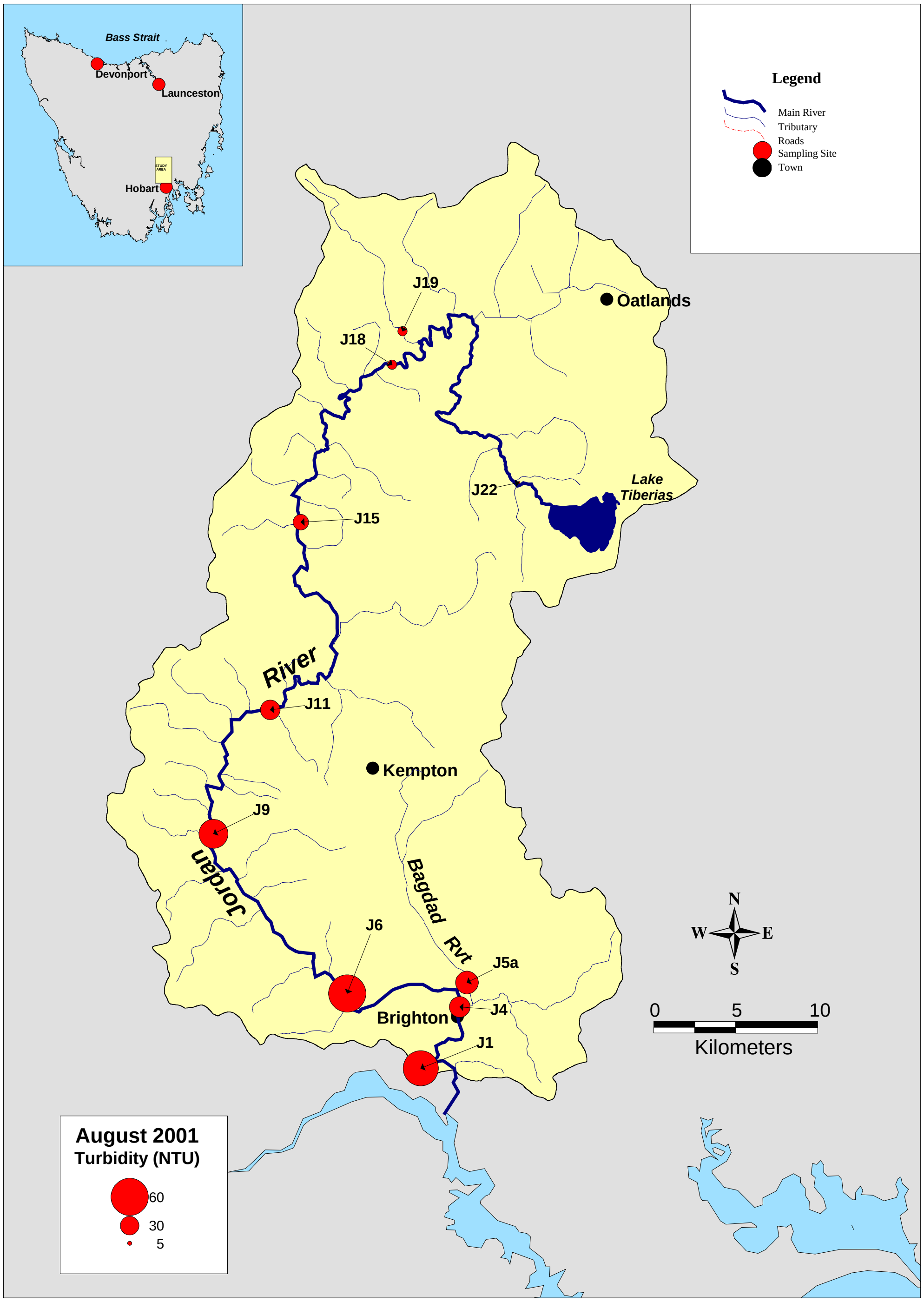

Figure 3.4: Flood snapshot of turbidity on 28th August 2001 at selected sites in the Jordan River catchment.

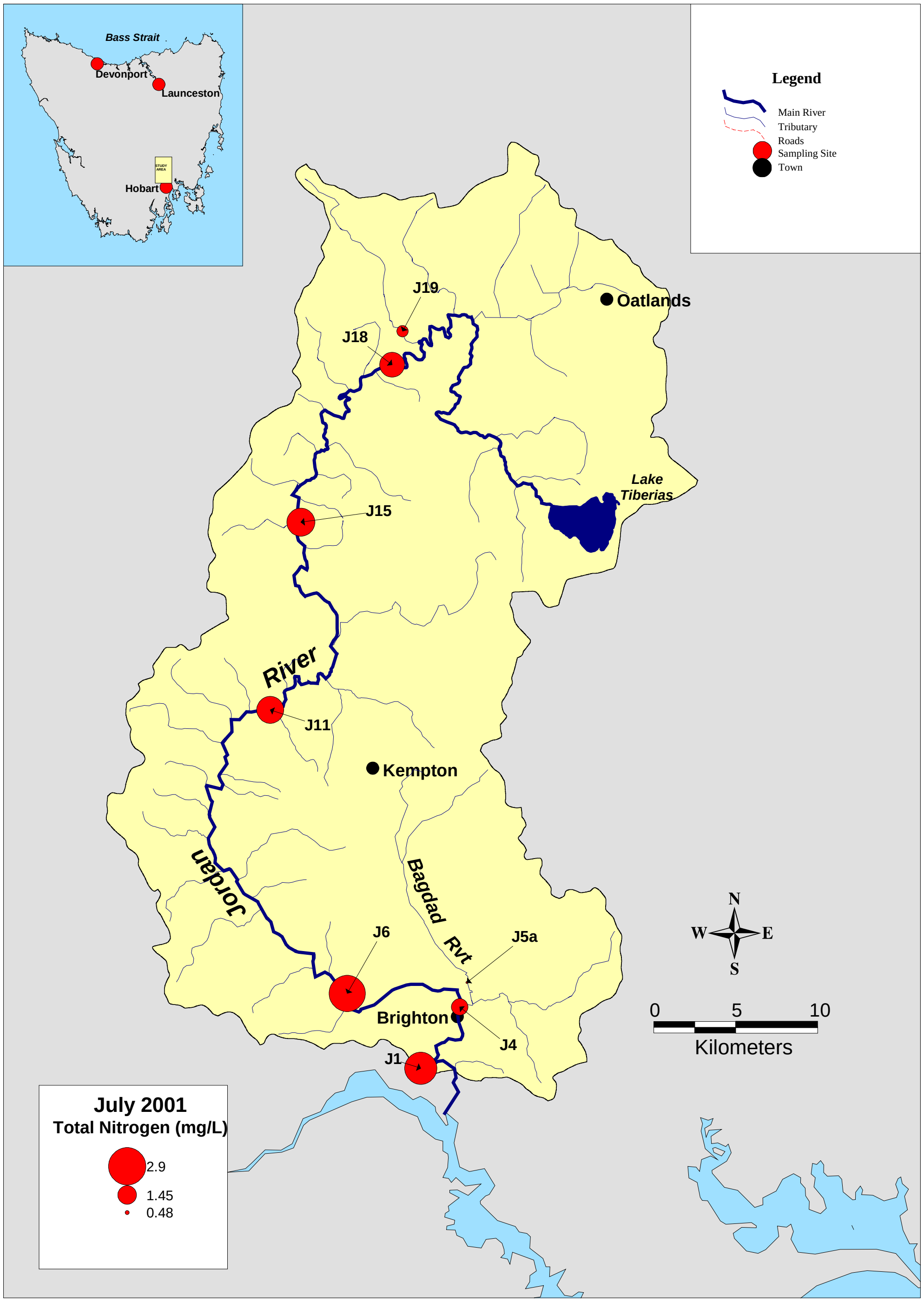

Figure 3.5: Flood snapshot of total nitrogen (mg/L) at selected sites on 9th July 2001 in the Jordan River catchment.

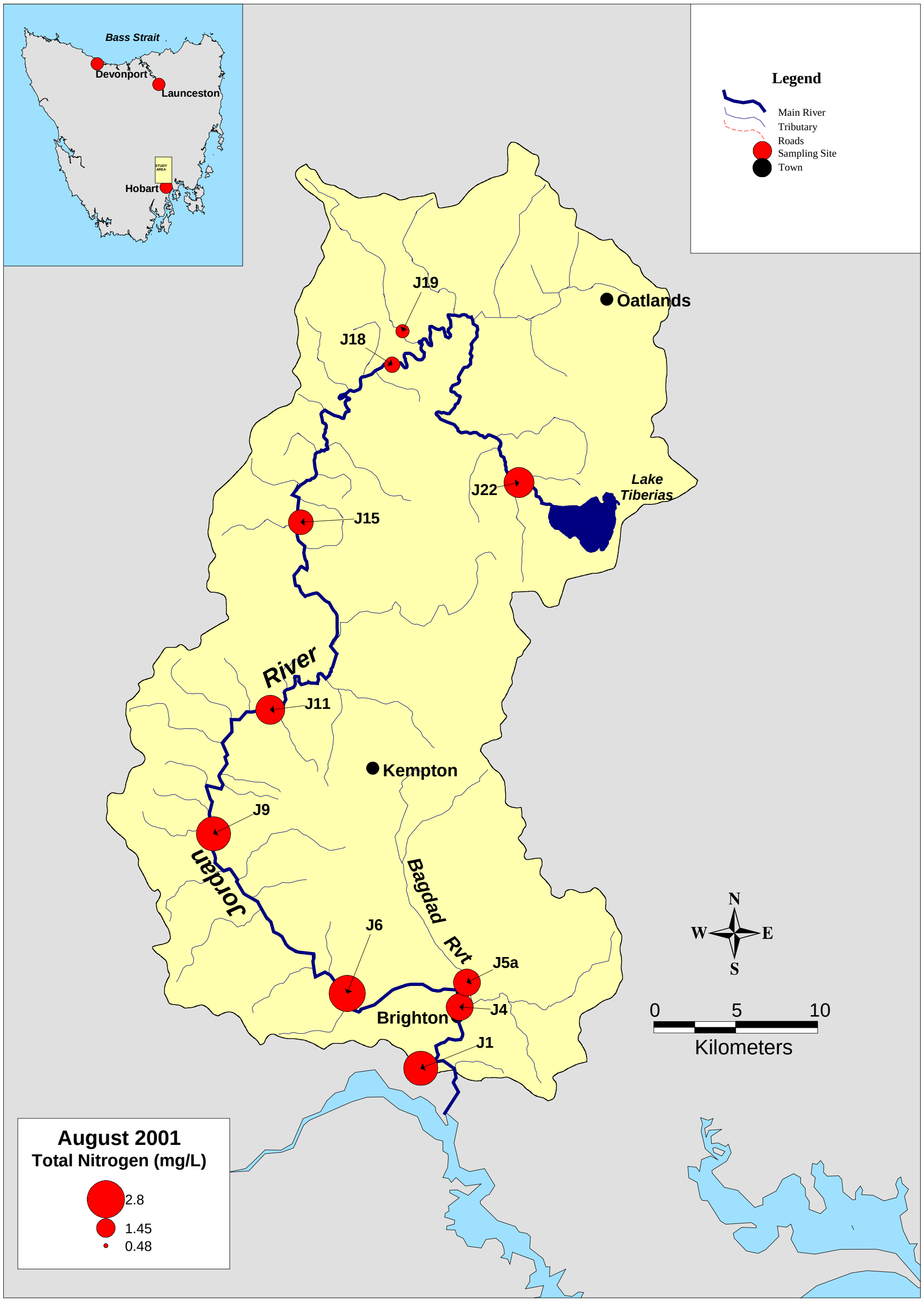

Figure 3.6: Flood snapshot of total nitrogen (mg/L) at selected sites on 28th August 2001 in the Jordan River catchment.

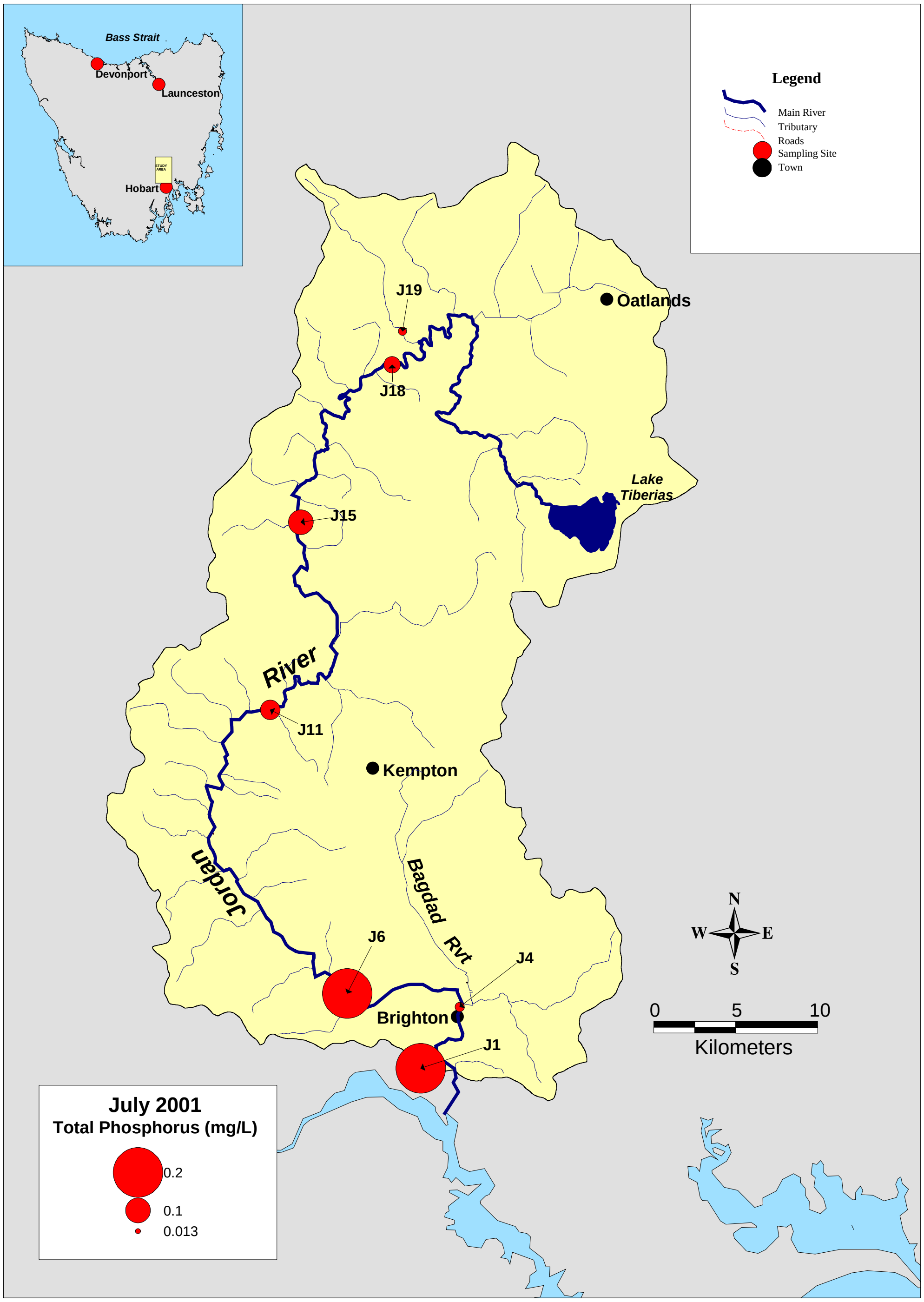

Figure 3.7: Flood snapshot of total phosphorus (mg/L) at selected sites on 9th July 2001 in the Jordan River catchment.

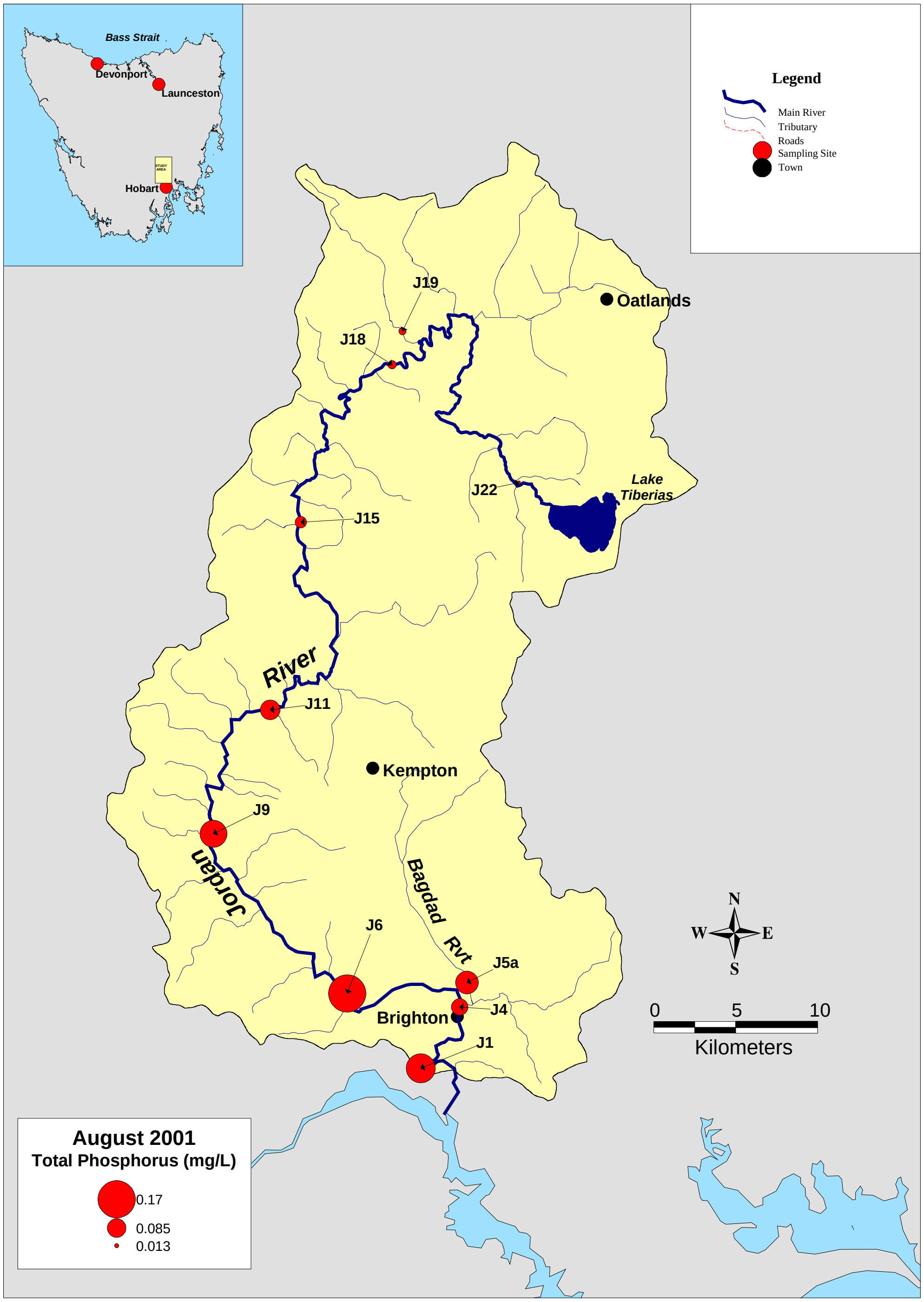

Figure 3.8: Flood snapshot of total phosphorus (mg/L) at selected sites on 28th August 2001 in the Jordan River catchment.

4 Summary and Comments

Data from monthly monitoring indicates that salinity throughout much of the catchment and nutrient concentrations at specific locations are significant concerns within the Jordan River catchment.

Baseline conductivity ranged from 119 μS/cm to 6220 μS/cm with median concentrations at all sites except J14a and J19 above the recommended trigger value of 350 μS/cm $^{-1}$. The Jordan River catchment has naturally high salt content for soils, groundwater and surface waters, however, the level of landclearing and agricultural practices that occur within the catchment are major factors that are likely to have contributed to elevated salinity levels. The problem is further exacerbated in years of very low rainfall when groundwater sources contribute saline waters to surface waters. In general the combination of saline ground and surface waters along with sodic soils in various parts of the catchment, will have serious implications for future agricultural and irrigation development.

Monthly monitoring at a number of sites in the Jordan River catchment showed signs of oxygen 'imbalance'. Assessing ecosystem 'health' using the 90% trigger level for saturation of dissolved oxygen (ANZECC, 2000) determined that the majority of sites in the Jordan River are 'impacted' or 'disturbed'. Monitoring of diurnal variations in dissolved oxygen at a number of sites confirmed this assessment, with some sites showing 'extreme' fluctuations in dissolved oxygen. These extreme fluctuations can often be linked to the level of nutrient enrichment that was found. Both the Jordan at Elderslie Road bridge at Green Glory (J6) and the Jordan River upstream of tidal limit (J1) exhibited extremely low dissolved oxygen concentrations and high nutrient levels indicative of eutrophic conditions.

Data from monthly nutrient monitoring illustrated the degree to which agricultural and other landuse activities have impacts on waterways in the catchment. Median concentrations for TN and TP throughout the catchment were consistently above recommended trigger values for upland rivers (ANZECC, 2000). This was further supported by nutrient export coefficients for the upper catchment, which were amongst the highest so far estimated in Tasmania under the 'State of River' program. This includes catchments such as the Duck River, Montagu River and Kermandie River, where high nutrient concentrations are influenced by intensive dairy practices or sewerage effluent (Kermandie River). Therefore it is reasonable to assume river management and landuse activities within the Jordan catchment are having a significant impact on nutrient transport. In interpreting the load estimates and coefficients presented in this report it is important to consider that this study was conducted during and following a significant drought period.

A broader view of ecosystem health across the catchment was gained through summer and winter 'snapshot' surveys. Most heavy metals were found to be at or below laboratory detection limits. The results for aluminium however, indicate that there may be some risk to aquatic biota and river health. Faecal contamination in the upper and middle reaches of the Jordan River are indicative of agricultural activities. Stock access to streams draining these areas is likely to enhance the movement of faecal contamination into waterways.

The data collected during this 3-year study provides valuable information on the current state of water quality in the Jordan River catchment. From the data that was collected through this and other parallel studies, it can be concluded that past and present agricultural activities have heavily modified the Jordan River. Impacts range from high nutrient concentrations, high salt levels, large fluctuations in dissolved oxygen and site-specific faecal pollution. The ephemeral and unpredictable nature of rainfall and flow in the catchment, and the clear decline in the incidence and magnitude of flood flows are also factors that compound these impacts. The data presented here indicates that water quality within the Jordan River is significantly degraded duriong periods of extended drought. During this study it was noted that a number of sites were subject to extensive and significant instream modification, and these are likely to exacerbate and contribute to degraded water quality in the immediate area and downstream of such modifications.

The future challenge for Natural Resource Management in this catchment will be to determine the level of impact on the aquatic ecosystem is acceptable whilst continuing to maintain agricultural production. At present it appears that these impacts are considerable. There are a number of techniques available that can be employed to improve water quality, such as the establishment of riparian vegetation, fencing streamside zones, more effective use and application of fertilisers and land treatment of dairy shed wastes. If issues that have arisen form this study are to be appropriately addressed, an integrated land and water management response is essential.

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Appendix 1.

Bacteriological data for summer (February 2000, and winter (July 2000) snapshot surveys in the Jordan River catchment.

Site Name	SITE No.	Winter Thermotolerant (faecal) Coliforms	Summer Thermotolerant (faecal) Coliforms
Jordan upstream tidal limit	J1	80	80
Stathallan Rivulet at Tea Tree	J2	10	
Jordan River upstream confluence of Stathallan Rivulet	J4b	390	
Jordan River at Midlands Highway, Pontville	J5	10	
Bagdad Rivulet at Riffle Range Road	J5a	30	
Bagdad Rivulet at Eddington Road	J5b	820	80
Jordan River at Bridge before ‘Green Glory’	J5c	180	
Jordan River at Elderslie Road Bridge	J6	180	720
Jordan River at Andersons Road Bridge	J7	60	40
Green Valley Rivulet at Cockatoo Valley Road	J8	80	5300
Jordan River at Roydon Road	J9		170
Jordan River at the ford at Clifton vale Road	J10	30	10
Jordan River at Mauriceton	J11	80	120
Jordan River at Sheepwash Corner	J13	80	10
Donnybrook Rivulet at Den Road	J14	10	400
Jordan River at Apsley	J15	10	50
Jordan River at Lower Marshes Road at Glen Iris	J16a	30	190
Jordan River at Lower marshes Road at Glenmore Sugarloaf	J17	20	210
Jordan River at Bellvale Road	J18	10	490
Exe Rivulet	J19		2100
Dulverton Rivulet at Waverly Lodge on Bowhill Road	J20	270	7400