Estimation of Nitrogen and Phosphorus Budgets entering St. Aubin's Bay, Jersey

A report to the states of Jersey Public Services Department

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Executive Summary

1. The States of Jersey continue to seek improvements to the quality of its coastal waters and, in particular, that of St. Aubin's Bay. The bay is shallow and semi-enclosed exhibiting a low water exchange with offshore areas. The resultant low dispersion within St. Aubin's Bay may encourage the accumulation of pollutants.

2. Nutrient accumulation in North European temperate nearshore waters have been associated with algal blooms which can cause scums on beaches and contamination of shellfish, rapid growth of macrophytes and ecological disturbance. Some of these affects have been observed on Jersey beaches.

3. The Public Service Department of the States of Jersey are in a position to manage nutrient inputs from the final effluent discharged from the Bellozanne sewage treatment works. Consequently, the PSD are considering treatment options for decreasing nutrient loads in the final effluent.

4. Sources of nutrients present in the coastal waters of St. Aubin's Bay include runoff from agricultural areas where farming methods include application of fertilisers. Other sources include livestock, domestic properties and storm flows from the combined sewage system and natural land runoff.

5. The importance of nutrient input from the effluent of the Bellozanne plant, relative to catchment sources, was assessed utilising available data. Where possible, the analysis was carried out on five year data sets.

6. The nutrient budgets indicate that nitrate is the primary source of nitrogen into St. Aubin's Bay, providing 89% of the total nitrogen budget.

7. Approximately 50% of the total nitrogen budget is provided by the STW, 21% from the Grands Vaux/Vallèe des Vaux catchment and 13% from St. Peter's Valley. The STW provides approximately 46% of the nitrate nitrogen to St. Aubin's Bay, 88% of the nitrite nitrogen and 78% of ammonical nitrogen.

8. The STW is the primary source of phosphorus into the bay, accounting for 98% of the total budget.

9. Further improvement of water quality derived from the agricultural catchments would require an integrated strategy for catchment management and water quality control.

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Estimation of Nitrogen and Phosphorus Budgets entering St. Aubin's Bay, Jersey

1. Introduction

This report provides an estimate of nitrogen and phosphorus budgets entering St. Aubin's Bay based upon existing hydrological and chemical water quality data. It details nutrient inputs from surface water streams and the Bellozanne Sewage Treatment Works (STW) which discharge into St. Aubin's Bay. The bay is shallow and semi-enclosed exhibiting a low water exchange with offshore areas. The resultant low dispersion may encourage accumulation of nutrients which, in north European temperate nearshore waters, have been associated with algal blooms. These blooms can cause scums on beaches and contamination of shellfish, rapid growth of macrophytes and ecological disturbance.

Some of these effects have been observed at Jersey beaches. This might suggest that it would be wise to seek reductions in the nutrient inputs to nearshore waters from both treated sewage effluents and stream sources. The States of Jersey Public Services Department (PSD) are considering treatment options for the sewage stream entering Bellozanne STW and are concerned to place the impact of nutrient removal within the treatment works into the context of the total nutrient budget entering St. Aubin's Bay. The PSD is also keen for the treatment plant to conform with the requirements of EU legislation (although such legislation is not applicable to the States of Jersey), in particular, the Urban Waste Water Treatment Directive (91/271/EEC). This Directive specifies allowable nutrient concentrations in effluents discharged from waste water treatment plants.

2. Methods

2.1 Data availability

2.1.1 Flow Data

Daily flow data for the Bellozanne STW final effluent was provided by the PSD. A five year data set spanning the period 1/1/92 to 31/12/96 was used, reducing the effects of annual climatic variability.

Stream flow data for the v-notch weir in the Grands Vaux catchment was provided by the Institute of Hydrology (IoH) and from the Jersey New Waterworks Company (JNWC). A five year data set spanning the period 1/1/92 to 31/12/96 was extracted for use during this study.

2.1.2 Rainfall Data

Rainfall data were available from the JNWC rain gauge network and from the STW rain gauge (Figure 1). Again a five year data set, spanning the period 1/1/92 to 31/12/96, was used to calculate monthly mean rainfall figures. Rainfall for each catchment was characterised using the gauge sited closest to the centre of the catchment when data from more than one gauge within each catchment was available. Rainfall data for Grands Vaux/Vallèe des Vaux was characterised by data from the Grands Vaux Reservoir gauge as this is located closest to the Grands Vaux weir where flow data were recorded.

2.2.3 Nutrient Concentrations

Nutrient concentrations in final effluent discharged from the Bellozanne STW were provided by the PSD. The data set comprises: nitrate (NO_3), nitrite (NO_2) and ammonia (NH_3), all expressed as nitrogen concentration (NO_3-N, NO_2-N, NH_3-N), and orthophosphate, expressed as phosphorus concentration (PO_4-P). The nitrogen data span the period 1/1/95 to 30/12/96 (*n*=496) and phosphorus data is limited to the period 4/2/96 to 30/12/96 (*n*=208). The effluent stream was sampled 5 days per week on Sunday through to Thursday. These data are used to characterise the nutrient concentrations discharged from the STW.

Nitrate data in some of the streams draining into St. Aubin's Bay are available from JNWC at either the inflows to their reservoirs or at abstraction points from streams. Data are available for sites in the five largest catchments draining into St. Aubin's Bay: St. Aubin's Catchment, St. Peters Valley, Waterworks Valley, Bellozanne Valley and Grands Vaux/Vallèe des Vaux Catchment (Figure 1). The location of the sample sites are shown in Table 1. No data are available for the two small catchments at La Haule. Data are available for the 5 year period 1/1/92 to 31/12/96.

Table 1: Location of JNWC nitrate sample points.

Sample Location	Catchment	Grid Reference	No. of data items (*n*)
Pont Marquet	St. Aubin's Catchment	593 494	130
Little Tesson	St. Peter's Valley	616 507	127
Tesson	St. Peter's Valley	616 507	127
Handois	Waterworks Valley	634 541	133
Dannemarche	Waterworks Valley	633 524	132
Millbrook	Waterworks Valley	632 512	135
Fern Valley	Bellozanne Valley	639 513	135
Grands Vaux	Weighbridge Catchment	667 513	124
Vallèe des Vaux	Weighbridge Catchment	657 498	128

A more limited data set was also available from intermittent spot samples from streams collected by PSD Pollution Control staff. These data contains concentrations of NO_3-N, NO_2-N, NH_3-N and PO_4-P at five locations within three catchments: Grands Vaux, Vallèe des Vaux, Millbrook (Waterworks Valley) and the two outlets of the St. Peter's Valley catchment. Data from intermittent spot samples are available for the period between January 1994 and October 1996. The number of data items for each nutrient at each site varies from *n*=4 to *n*=15.

2.2 Budget calculations

The nutrient budget calculations follow a similar method to previous estimates of microbial loading to St. Aubin's Bay by CREH (Jones *et al.*, 1993, Wyer *et al*,. 1995, Wyer *et al*,. 1996). The nature of the available data, however, required some modifications to the previous method to allow calculation for the complete suite of nutrients of interest. Budgets were based upon total flows, with no flow separation, as data were unsuitable to characterise both base flow and rainfall-response flow nutrient concentrations separately. However, there was no evidence from the available data of significant flushing or dilution following storm events.

Catchment areas (Table 2) were digitised from boundaries identified from contour patterns at 1:10 000 scale.

Table 2: Areas of catchments draining into St. Aubin's Bay.

Catchment	Area (km^2)
St Aubin's Valley	4.56
La Haule A	0.51
La Haule B	1.53
St Peter's Valley	12.97
Waterworks Valley	6.70
Bellozanne Valley	4.14
Grands Vaux/Vallèe des Vaux	18.70

Five year mean monthly discharge from each catchment was estimated using 5 year average values of: (i) rainfall input (RI(m^3)) and (ii) total flow (Q_t (m^3)) for the catchment to Grands Vaux weir (6.34km^2) for each month. The percentage of rainfall input contributing to total flow was estimated as:

$$(Q_t/RI) \times 100 \qquad (1)$$

The nutrient load from each catchment is given by the product of the total flow and the nutrient concentration:

$$L_t = Q_t \times C_t \qquad (2)$$

where

C_t = total flow concentration (kg/m^3)
L_t = total load (kg).

An annual load can be obtained simply by calculating the sum of the 12 monthly loads, while a total nitrogen load can be calculated by the sum of the nitrate nitrogen, nitrite nitrogen and ammonical nitrogen loads.

3. Results and Discussion

3.1 Hydrology

Monthly rainfall for all gauges showed considerable variation throughout the year (Table 3) with December and June showing maximum and minimum rainfall respectively (Figure 2). The rainfall pattern is typical of that exhibited by a temperate maritime climate.

Table 3: Five year average monthly rainfall (mm) for catchments draining into St. Aubin's Bay.

Catchment	St. Aubin's Valley	St. Peter's Valley	Waterworks Valley	Bellozanne Valley	Grands Vaux/ Vallèe des Vaux
Rain gauge Location	Airport	St. Peter's Rectory	Millbrook Reservoir	Bellozanne STW	Grands Vaux Reservoir
January	92.55	72.35	94.08	86.52	90.99
February	76.03	61.28	80.68	76.04	74.66
March	44.09	36.89	48.79	46.56	49.53
April	54.05	45.35	54.35	51.34	54.60
May	61.83	57.34	63.50	59.04	59.70
June	37.65	34.63	38.92	38.60	40.10
July	46.41	41.50	46.25	46.41	46.41
August	71.48	64.30	74.43	71.24	78.14
September	96.74	93.52	95.41	92.12	97.42
October	79.39	73.48	78.11	72.26	81.86
November	102.70	84.36	106.70	98.36	105.57
December	119.86	100.00	124.52	112.98	126.28

Five year mean monthly flows, and the proportion of rainfall input contributing to total flow at Grands Vaux weir, are shown in Table 4. Flows show seasonal variation with high flow during the winter months and low flow in the summer (Table 4). The greatest proportion of rainfall converted to flows occurs during January, when 80% of rainfall contributes. This is in contrast to the summer months, in particular August and September, when less than 11% of the rainfall produces stream flow. This reflects the changing surface conditions throughout the year, with greater amounts of the rainfall being taken up by the soil moisture deficit, groundwater recharge and evapotranspiration during the summer. It should be noted that the flow values calculated for the study catchments, do not incorporate any variation in catchment characteristics such as rapid runoff from urban areas or abstraction from reservoirs.

Calculated annual total flows are shown in Table 5. Monthly flows are included as Appendix I. Figure 3 shows the proportion of total flow to St. Aubin's Bay derived from catchments and the STW. The largest single discharge to the bay is the STW, providing 30% of the total discharge to the bay (Figure 3). The major catchment sources are Grands Vaux/Vallèe des Vaux (Weighbridge outfall) (28% of Q_t) and St. Peter's Valley (16% of Q_t). However, the combined discharges of catchment sources is greater than the discharge from the STW. Catchment sources account for 70% of the annual total flow (Figure 3).

Table 4: Five year average total flows (Q_t) and proportion of rainfall input (RI) contributing to Q_t for the Grands Vaux weir (%).

	Total Flow Q_t (m^3)	% RI contributing to Q_t
January	501 362	86.9
February	386 018	81.6
March	236 892	74.5
April	165 387	45.7
May	102 436	27.9
June	77 812	29.1
July	51 875	17.3
August	43 373	9.2
September	64 731	10.6
October	120 684	23.6
November	266 872	38.6
December	410 953	53.9

Table 5: Estimates of annual runoff components (m^3) for the catchments draining into St. Aubin's Bay.

	Total Flow (Q_t) (m^3)
St. Aubin's Valley	1 714 419
La Haule A	191 744
La Haul B	575 233
St. Peter's Valley	4 071 174
Waterworks Valley	2 609 111
Bellozanne Valley	1 504 639
Weighbridge Outfall	7 176 191
Input from all catchments	17 842 511
STW	7 779 104
Total Input	25 621 615

3.2 Nutrient concentrations

3.2.1 Jersey New Waterworks Co. NO3-N data

Nitrate nitrogen data provided by JNWC is available for 9 sites within 5 of the catchments which drain into St. Aubin's Bay (Table 5). No data were available for the two small La Haule catchments. Where more than one site was available within a catchment, data sets were combined. The 5 year record (1992-1996) was used to produce annual and monthly median concentrations (C_t). The median concentrations used to calculate the nitrate nitrogen budget are shown in Table 6 and

Table 7a: Nutrient concentrations (mg/l) used to estimate nutrient loading from St. Peter's Valley.

	NO_3-N (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	PO_4-P (mg/l)
January	12.48	0.06	0.67	0.12
February	14.58	0.03	0.40	0.08
March	15.64	0.05	0.40	0.16
April	16.70	0.07	0.40	0.24
May	15.87	0.07	0.48	0.18
June	15.03	0.07	0.55	0.12
July	12.80	0.12	0.31	0.31
August	9.60	0.18	0.27	0.17
September	11.30	0.23	0.23	0.17
October	3.90	0.02	0.65	0.22
November	6.35	0.03	0.35	0.17
December	8.80	0.03	0.05	0.13

Table 7b: Nutrient concentrations (mg/l) used to estimate nutrient loading from Waterworks Valley.

	NO_3-N (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	PO_4-P (mg/l)
January	14.00	0.04	0.66	0.32
February	14.35	0.01	1.20	0.06
March	13.30	0.02	1.30	0.01
April	11.40	0.03	0.95	0.06
May	11.93	0.08	0.75	0.08
June	12.45	0.08	0.75	0.09
July	14.70	0.12	0.56	0.09
August	13.00	0.09	0.07	0.12
September	10.75	0.05	0.40	0.13
October	8.20	0.04	0.01	0.05
November	11.10	0.05	0.06	0.08
December	11.10	0.06	0.12	0.10

Table 7c: Nutrient concentrations (mg/l) used to estimate nutrient loading from Grands Vaux/Vallèe des Vaux Valley.

	NO_3-N (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	PO_4-P (mg/l)
January	13.45	0.05	0.59	0.22
February	13.80	0.03	0.76	0.11
March	13.30	0.04	0.33	0.04
April	11.63	0.04	0.44	0.08
May	12.50	0.04	0.42	0.11
June	13.38	0.04	0.42	0.22
July	11.28	0.04	0.40	0.13
August	7.95	0.03	0.21	0.10
September	8.15	0.03	0.25	0.17
October	7.45	0.05	0.02	0.14
November	10.45	0.06	0.22	0.17
December	10.45	0.07	0.42	0.20

No clear spatial patterns emerge from the data, with concentrations of each nutrient generally similar between each catchment (Figure 5). St. Peter's Valley tends to display the highest concentrations of nitrite nitrogen and phosphate phosphorus. Ammonical nitrogen is generally greater in Waterworks valley between February and July. This valley also displays higher nitrate nitrogen concentration from July to December. Given the lack of spatial pattern in this data this assumption is unlikely to introduce significant error.

In order to provide an overall estimate of nutrient inputs for all the major catchments draining into St. Aubin's Bay, it was necessary to assign concentrations to the two catchments, for which PSD data were unavailable, St. Aubin's Catchment and Bellozanne Valley. These two catchments are of a similar area to that of Waterworks valley, for which data are available. Thus, it was assumed that concentrations for St. Aubin's Catchment and Bellozanne Valley were identical to those in Waterworks Valley.

Figures 6a-c show comparisons between the nitrate nitrogen data supplied by JNWC and PSD Pollution Control. Nitrate nitrogen concentrations are generally similar and display similar seasonal variation within St. Peter's Valley and Grands Vaux/Vallèe des Vaux (Figures 6a and 6c). However, the two data sets show distinctly different seasonal patterns within Bellozanne Valley, although the range of concentrations throughout the year are similar.

3.2.3. Bellozanne STW final effluent

Total flow <u>concentrations</u> (Ct) are illustrated in Figures 7a-d. Generally, nutrient concentrations in the final effluent are greater than those in the streams, with nitrite nitrogen, ammonical nitrogen and orthophosphate phosphorus concentrations being an order of magnitude greater (Table 8).

Some seasonal patterns are evident in the monthly concentrations. Nitrate nitrogen shows two seasonal peaks in concentration, in April, and again between September and November (Figure 7a). Nitrite nitrogen concentrations(Figure 7b) are generally higher between January and March, peaking in February, while ammonical nitrogen concentrations peak in December/January and between May and August (Figure 7c). Orthophosphate phosphorus concentrations (Figure 7d) are generally higher during the summer, with a maximum concentration in September. Lowest Orthophosphate phosphorus concentrations are experienced during February.

Table 8: Nutrient concentrations (mg/l) for total flow (Q_t) used to estimate nutrient loading from Bellozanne sewage treatment works.

	NO_3-N (mg/l)	NO_2-N (mg/l)	NH_3-N (mg/l)	PO_4-P (mg/l)
January	17.46	0.86	4.95	6.23
February	17.79	1.57	3.46	5.85
March	21.88	1.04	3.83	7.70
April	26.68	0.63	4.56	9.95
May	22.05	0.77	5.11	9.90
June	22.65	0.90	3.46	10.90
July	22.66	0.62	4.50	11.30
August	21.40	0.55	4.35	11.35
September	28.65	0.63	2.63	11.60
October	26.04	0.45	1.83	9.75
November	30.14	0.24	1.33	6.95
December	18.84	0.51	6.04	6.60

3.3 Budget Calculations

Nitrate nitrogen, nitrite nitrogen, and ammonical nitrogen and orthophosphate phosphorus budgets were calculated using equation 2 and total flow concentrations (C_t) in Tables 6, 7a-c and 8. Again, the lack of nutrient concentration data for the two La Haule catchments prevented individual loads from these catchments being determined. However, the small size of these catchments and the relatively low contribution to the total discharge (Table 5; Figure 3) into St. Aubin's Bay suggests that the load from these catchments will be similarly low. The resultant annual nutrient loads (L_t) calculated using PSD Pollution control data are shown in Table 9, whilst monthly loads are included as Appendix II. The nitrate nitrogen load calculated using JNWC data is shown in Table 12.

Table 10 and Figure 8 summarise the results of the budget estimates in terms of the contribution of each source to the total nutrient load. Clearly, the largest single source for all nutrients is the STW, providing approximately 46% of NO_3-N, 88% of NO_2-N, 78% of NH_3-N and 98% of PO_4-P. However, the combined catchment sources input a greater proportion of nitrates than the STW effluent. The greatest catchment sources are provided by Grands Vaux/Vallèe des Vaux and St. Peter's valleys, reflecting the larger surface area and greater flows of these catchments.

Table 9: Estimates of annual nutrient loads (kg) from catchments draining into St. Aubin's Bay.

	NO_3-N (kg)	NO_2-N (kg)	NH_3-N (kg)	PO_4-P (kg)
St. Aubin's Valley	21 432	71	1 065	213
St. Peter's Valley	48 022	212	1 632	601
Waterworks Valley	32 666	107	1 638	321
Bellozanne Valley	18 857	62	953	184
Weighbridge Outfall	85 291	312	3 247	312
Input from all catchments	206 268	764	8 535	1 631
STW	176 921	5 738	30 326	68 606
Total Input	383 189	6 503	38 862	70 237

Table 10: Estimated contribution of annual nutrient delivery (%) from catchments and the STW.

	NO_3-N (%)	NO_2-N (%)	NH_3-N (%)	PO_4-P (%)
St. Aubin's Valley	5.6	1.1	2.7	0.3
St. Peter's Valley	12.5	3.3	4.2	0.9
Waterworks Valley	8.5	1.7	4.2	0.5
Bellozanne Valley	4.9	1.0	2.5	0.3
Weighbridge Outfall	22.3	4.8	8.4	0.4
Input from all catchments	53.8	11.8	22.0	2.3
STW	46.2	88.2	78.0	97.7

The combined nutrient loads from the catchments (Figures 9a-d) display a strong seasonal pattern in response to the seasonal flow patterns (Section 3.1). Nutrient loads from catchment sources are greatest during the winter months when flows are high, with peak loads input during January, falling to a minimum in August.

Loads from the STW do not possess this seasonal pattern, which varies from nutrient to nutrient. Nitrate nitrogen loads (Figure 9a) are relatively constant throughout the year with a slight increase in loads between June and November. The minimum nitrate nitrogen load from the STW was input during February and between November and April the combined catchment sources input a greater load. Nitrite nitrogen loads from the STW display a peak in February (Figure 9b). Ammonical nitrogen loads (Figure 9c) from the STW display a minimum during November and Peak in December. Between June and November ammonical nitrogen loads from the STW are generally lower than the maximum loads of combined catchment sources, which occur during January and February. Orthophosphate phosphorus loads from the STW (Figure 9d) generally show an increase from March to a peak in September.

The total nitrogen load ($L_{t(NO3\text{-}N)} + L_{t(NO2\text{-}N)} + L_{t(NH3\text{-}N)}$) and the percentage contribution of each nutrient to this load are shown in Table 11 and Figure 10. Nitrogen input into St. Aubin's Bay is dominated by that provided by nitrate (89%), with ammonia providing 9% and nitrite less than 2%. The Bellozanne treatment plant supplies approximately 50% of the nitrogen input to St. Aubin's Bay despite representing 30% of the total flow (Section 3.1). This is a function of the higher concentrations of nitrogen based nutrients in the effluent stream.

Table 11: Total annual nitrogen budget ($L_{t(NO3\text{-}N)} + L_{t(NO2\text{-}N)} + L_{t(NH3\text{-}N)}$) and the contribution to annual nitrogen delivery from catchments and STW.

	Total Nitrogen (kg)	Total Nitrogen (%)	NO_3-N (%)	NO_2-N (%)	NH_3-N (%)
St. Aubin's Valley	22 568	5.3	5.0	0.02	0.2
St. Peter's Valley	49 866	11.6	11.2	0.05	0.4
Waterworks Valley	34 411	8.0	7.6	0.03	0.4
Bellozanne Valley	19 872	4.6	4.4	0.01	0.2
Weighbridge Outfall	88 849	20.7	19.9	0.07	0.8
Input from all catchments	215 568	50.3	48.1	0.18	2.0
STW	212 986	49.7	41.3	1.34	7.1
Total Input	428 553	100.0	89.4	1.52	9.1

As an internal check on this work, the PSD and JNWC data were analysed separately. The nitrate nitrogen load calculated using JNWC data (Table 6) is shown in Table 12. The nitrate nitrogen load calculated using PSD Pollution Control data is also included in Table 12 for reference. The absolute loads of nitrate nitrogen from catchment sources calculated using JNWC data are greater than those calculated using PSD data. Both sets of data display a similar pattern in terms of relative contributions, with the STW being the largest single source, and the Weighbridge and St. Peter's Valley catchments being the largest catchment sources. The greater absolute loads calculated using JNWC data, however, result in the STW displaying lower relative importance (Figure 11). The similarity in the nitrate nitrogen loads (Table 12; Figure 11) is encouraging, indicating that the limitations of the PSD Pollution Control data set do not significantly affect the results.

Table 12: Estimated nitrate nitrogen load (kg) and contribution of each source to the nutrient delivery (%) from catchments and STW using JNWC data. The nitrate nitrogen load calculated using PSD Pollution Control data is also included for reference.

	JNWC Data		PSD Data	
	NO_3-N (mg/l)	NO_3-N (%)	NO_3-N (mg/l)	NO_3-N (%)
St. Aubin's Valley	22 398	5.6	21 432	5.9
St. Peter's Valley	63 899	16.1	48 022	13.2
Waterworks Valley	35 315	8.9	32 666	9.0
Bellozanne Valley	25 533	6.4	18 857	5.2
Weighbridge Outfall	72 569	18.3	65 402	18.0
Input from all catchments	219 714	55.4	186 379	51.3
STW	176 921	44.6	176 921	48.7
Total	396 635	100.0	363 301	100.0

4. Summary and Conclusions

The methodology of previous studies estimating microbial inputs into St. Aubin's Bay was extended and adapted to facilitate an estimation of nutrient inputs using existing data. The nutrients of interest were nitrate, nitrite, ammonia and orthophosphate. Where possible, five year data sets were used. The limited data available characterising nutrient concentrations resulted in the development of a method incorporating monthly budget estimates based on total flows. Comparison of the nitrate budgets produced using different data sets suggests that limited nitrite, ammonia and orthophosphate data sets may be sufficient to indicate nutrient budgets.

Nitrate nitrogen is a dominant nitrogen source to the coastal waters of St. Aubin's bay. Approximately 41% of this is provided by the STW final effluent. However, when other nitrogen sources are considered, the STW accounts for approximately half of the total nitrogen input. Nearly all of the orthophosphate phosphorus input into the bay is provided from the treatment plant (98%).

It is clear, however, that catchment management can also play an important part in reducing the nitrogen input, with catchment sources accounting for approximately half of the estimated nitrogen budget.

Thus, treatment for nitrogen and phosphorus at Bellozanne STW may significantly reduce loads. However, catchment sources will remain, particularly in the case of the nitrate input. Such sources will require an integrated strategy for catchment management and water quality control.

It is important to emphasise that care must be exercised when interpreting these results. The nitrite and ammonical nitrogen and orthophosphate budgets are based on limited data sets. However, the similarity between the nitrate nitrogen budget calculated using (i) the PSD Pollution Control data set and (ii) using a larger data set provided by JNWC is encouraging.

5. References

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FIGURES

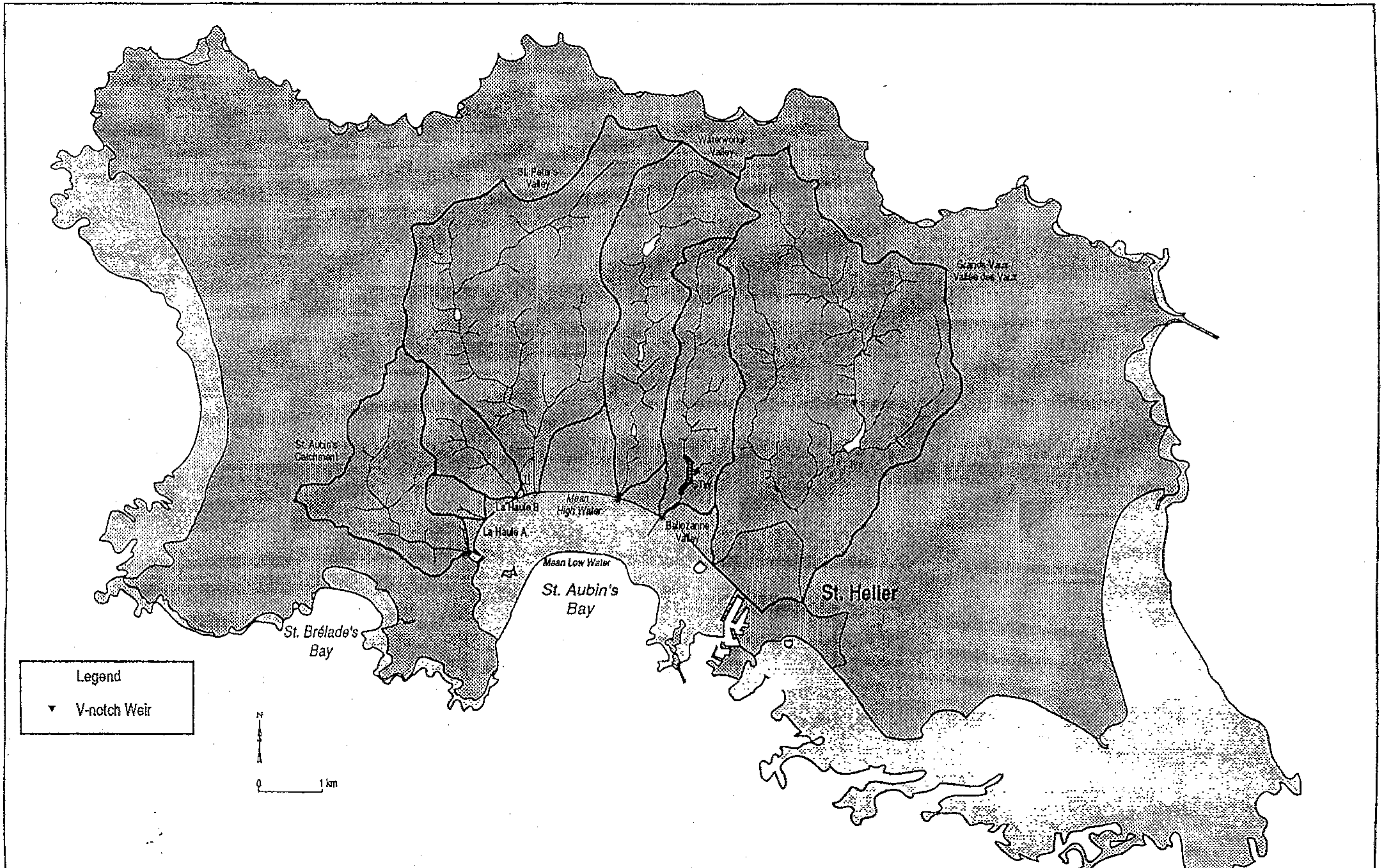

Figure 1 Catchments draining to St Aubin's Bay

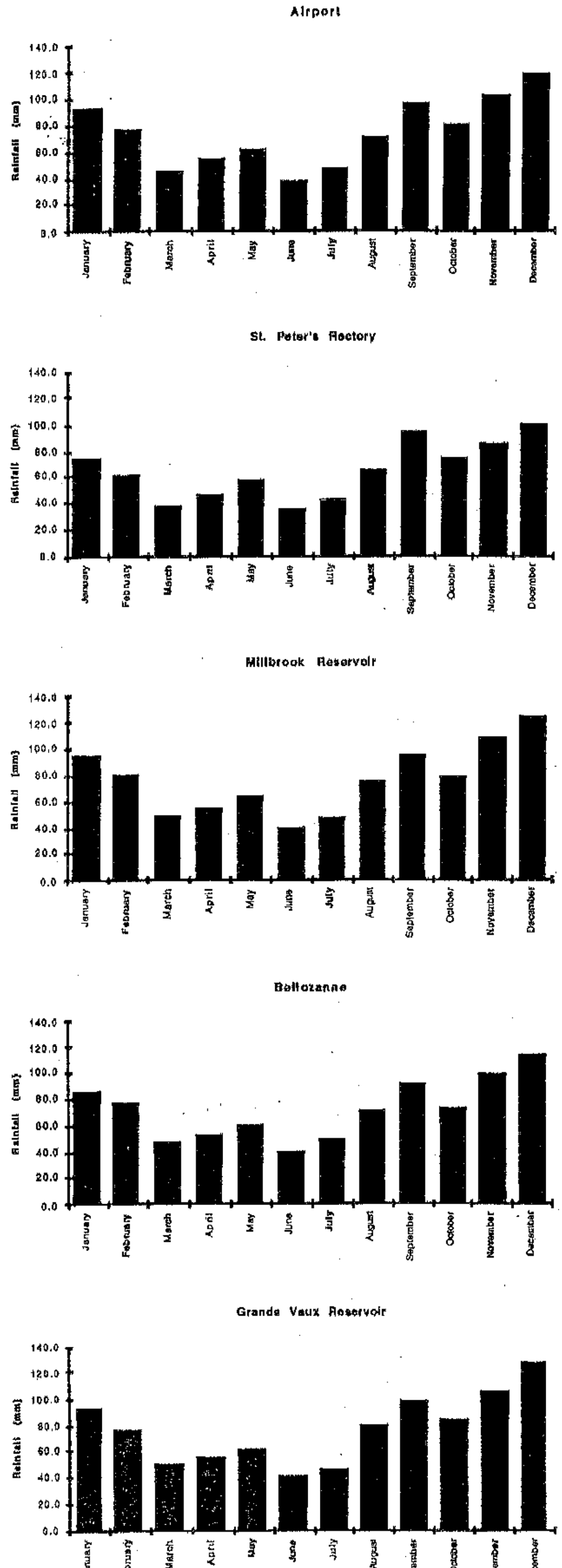

Figure 2: Five year monthly average rainfall data used in the nutrient budget calculations

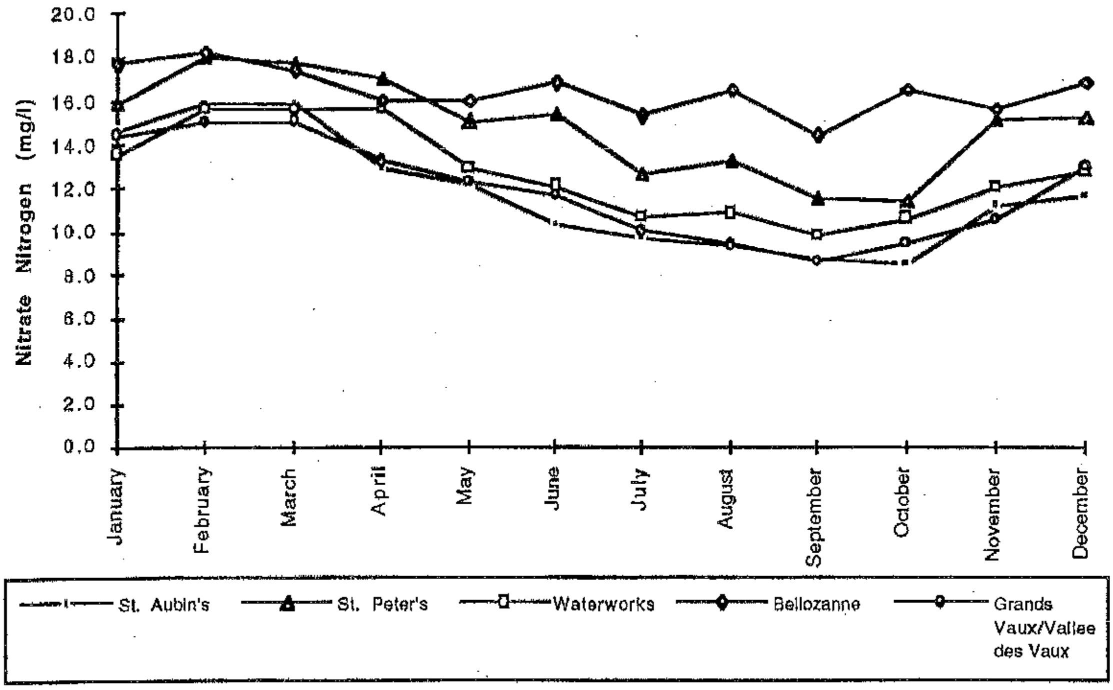

Figure 4: Monthly nitrate nitrogen concentrations calcualted from Jersey New Waterworks Company data.

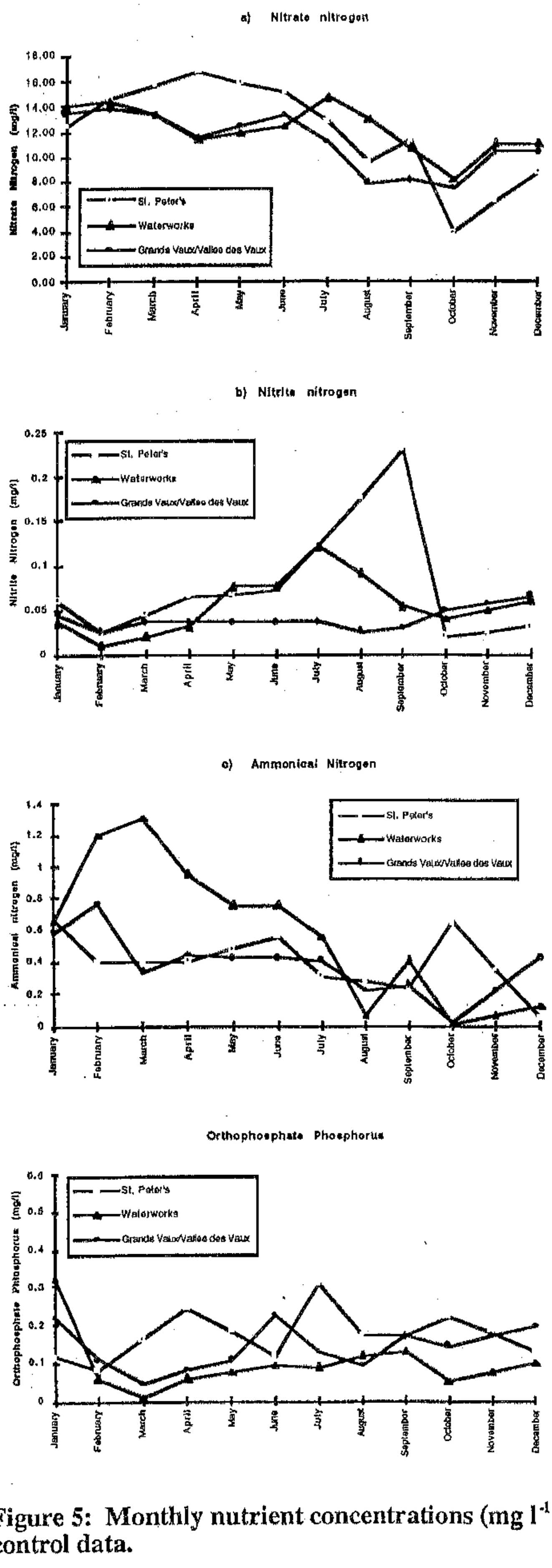

Figure 5: Monthly nutrient concentrations (mg l^{-1}) calculated from PSD Pollution control data.

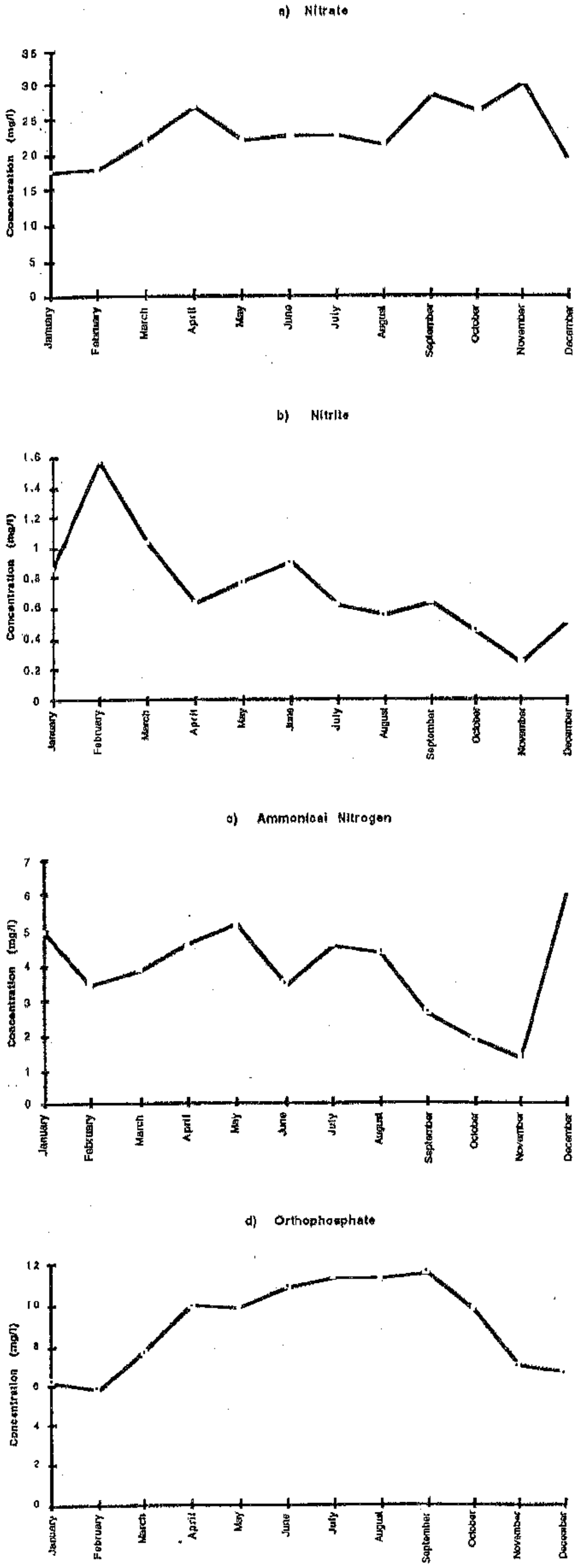

Figure 7: Nutrient concentrations (mg l^{-1}) in Bellozanne sewage treatment works final effluent.

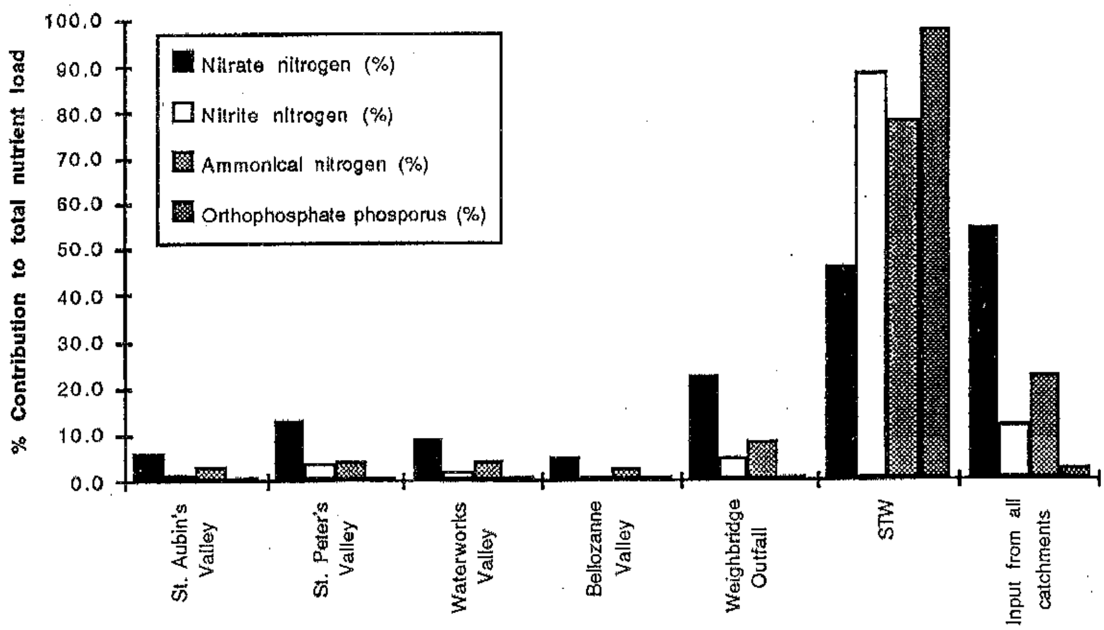

Figure 8: Estimated proportion of nutrient delivery to St. Aubin's Bay (%) from catchments and the STW.

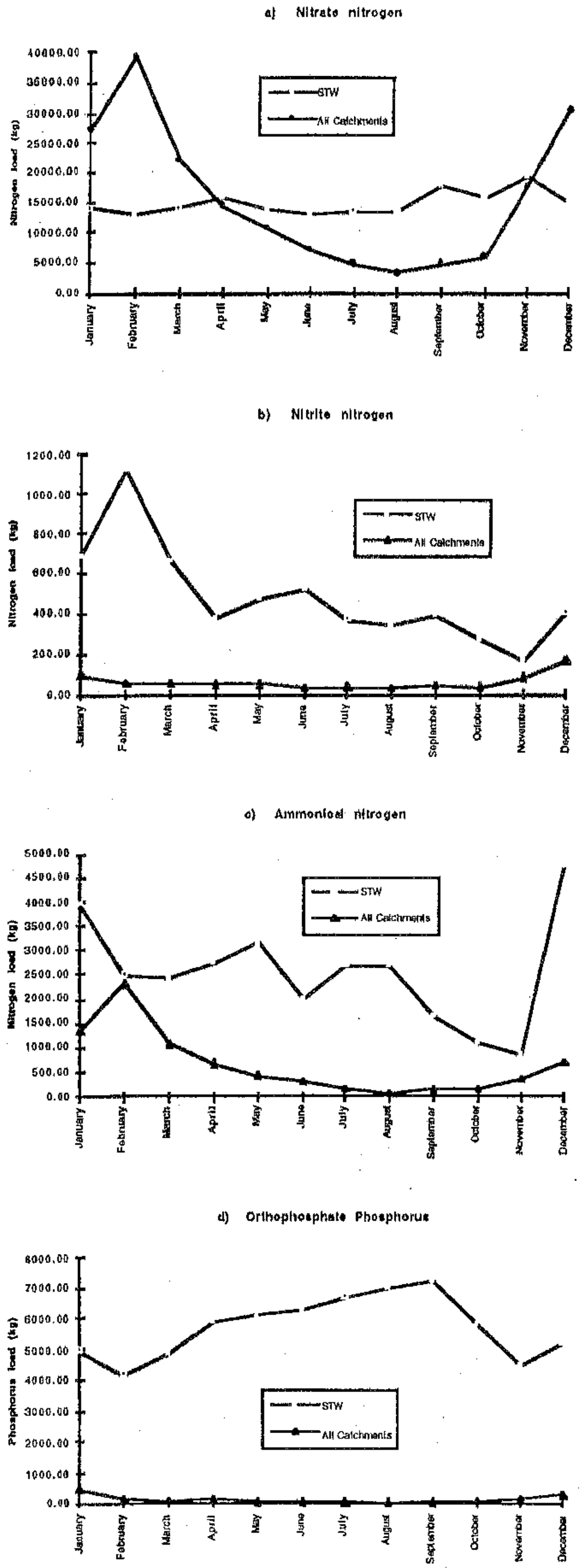

Figure 9: Estimated nutrient loads (kg) from combined catchment and STW sources into St. Aubin's Bay (PSD data).

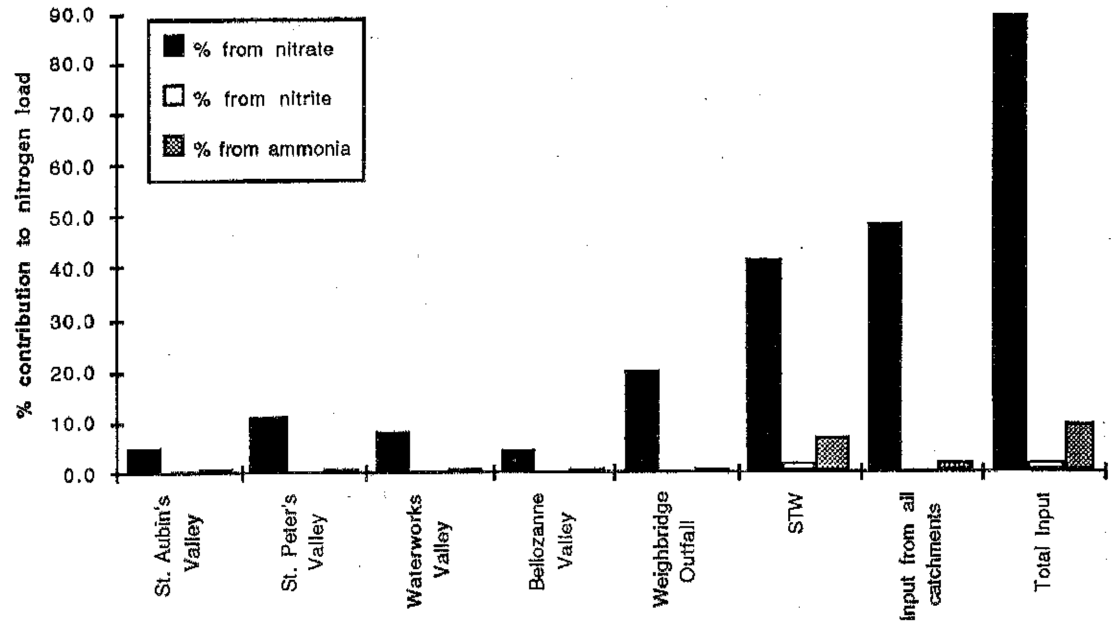

Figure 10: Estimated contribution of catchment and STW sources (%) to the total nitrogen budget entering St. Aubin's Bay (PSD Data).