THE VALUE OF FRESHWATER INFLOWS INTO THE KOWIE, KROMME AND NAHOON ESTUARIES

BY

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Submitted to

FACULTY OF BUSINESS AND ECONOMIC SCIENCES

NELSON MANDELA METROPOLITAN UNIVERSITY

In partial fulfilment of the requirements for the degree

MAGISTER COMMERCII (ECONOMICS)

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January 2007

ACKNOWLEDGEMENTS

My sincere thanks goes to Professor S. G. Hosking, School of Economics, Nelson Mandela Metropolitan University, who provided me with continual support throughout this journey.

I would like to thank the Water Research Council for the funding provided.

I would also like to thank the following persons:

Dr Mario du Preez, School of Economics, Nelson Mandela Metropolitan University, for his guidance.

Mr Radu Mihailescu and Mr Dods Blom who carried out part of the surveys.

Mr Gary Sharp, Mr Chung-Sing Lin and Mr Henri van der Westhuizen for their statistical expertise.

Professor T. Wooldrige, Department of Zoology, Nelson Mandela Metropolitan University, for his zoological input.

Dr Isabelle Papadopoulos, Department of Zoology, Nelson Mandela Metropolitan University, for her zoological input.

My parents, Peter and Orielle, for all their unconditional love and motivation.

My brother Paul for his constant encouragement and support.

EXECUTIVE SUMMARY

An estuary can be defined as a partially enclosed, coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage. Estuaries are extremely important environmental assets and the management of them is dependent on the active involvement of the people whose livelihoods depend on them.

There have been steady decreases in freshwater inflows into them during the past century due to abstraction of river water for human consumption and alien tree and plant infestations. Due to these decreases in freshwater inflows, many estuaries have become smaller and are providing reduced recreational services to users, such as boaters, fishermen and birders.

This reduction in recreational service provision has adverse economic consequences. The scale of these consequences have become of great interest to river catchment planners. Of particular interest is the value of the freshwater inflows into estuaries relative to other abstractions of this water. The value referred to here is in terms of the environmental services yielded to recreational users.

From a management perspective, it is desirable that these marginal values be compared with marginal cost values of this water in its best alternative use in order to guide the allocation of inflows into the respective estuaries.

The aim of this study is to place a monetary value on this freshwater inflow at the Kowie, Kromme and Nahoon estuaries. Due to the fact that the freshwater flowing into estuaries is not a traded good, an alternative method to market price must be used to value it. The method of valuation used in this study is the contingent valuation method. The contingent valuation method (CVM) is a survey technique which asks individuals to place values upon changes to environmental assets.

The questionnaires used in the surveys differed slightly. The one administered at the Nahoon Estuary was revised in the light of experience gained at the administration of

the ones at the Kowie and the Kromme estuaries. Some questions in the latter two surveys were found to be confusing to the respondents and were made clearer and some of the questions were found to yield little extra information and were scrapped from the Nahoon Estuary survey.

Table 1 shows the values of freshwater inflows into the three selected estuaries found in this study.

Table 1: Predicted value of water inflows into selected estuaries per m^3

Estuary	**Total Willingness to pay.**	**Change in inflow (million of m^3)**	**Value/m^3**
Kromme:	R 918 400	75.5	R0.012
Kowie:	R 937 860	13	R0.072
Nahoon:	R 48 807	3.78	R0.012

These predictions were generated using a Tobit statistical model. In Table 1 the total willingness to pay is defined as the product of the predicted median willingness to pay and the number of households deriving utility from the services of the estuary per annum. The change in inflow referred to is the amount of freshwater that would be required to improve the services of the estuary in specified ways. The willingness to pay was for this specified improvement. The Rand value per cubic meter of freshwater flowing into each estuary is derived by dividing the total willingness to pay by the change in freshwater inflow.

Contingent valuation studies are subject to many biases and, for this reason, should be subjected to tests for validity and reliability. In this study, expectations-based validation tests were administered. These tests are described in Chapters Three, Six and Seven. Moderate support was found for valuations of the Kromme and Nahoon estuaries and weak support was found for the valuation of the Kowie Estuary.

Based on the estimates in Table 1, it was deduced that of these three estuaries the freshwater inflow was most highly valued at the Kowie Estuary. It was not possible to draw conclusions on whether more or less freshwater should be allocated to these

estuaries as no marginal costs of this freshwater inflow were estimated (the value of the upstream abstraction).

Similar estimates have been made for several other estuaries in South Africa. Table 2 shows the values of freshwater inflows into the Groot Brak, Swartkops, Kariega, Klein Brak and Knysna estuaries as estimated by Hosking *et al* (2004).

Table 2: Predicted value of water inflows into selected estuaries per m^3

Estuary	**Total willingness to pay**	**Change in inflow (million m^3**	**Value/m^3**
Groot Brak	R 524 160	5.0	R0.105
Swartkops	R1 220 170	13.5	R0.090
Kariega	R 421 308	7.4	R0.057
Klein Brak	R 141 360	11.2	R0.013
Knysna	R 579 759	46.0	R0.013

Source: Hosking *et al* (2004)

The CV's shown in Table 2 also reflect a wide range of values. The Knysna and Klein Brak estuaries have similar values to the Kromme and the Nahoon estuaries, while the Kowie Estuary's value/m^3 falls between that of the Swartkops Estuary and the Kariega Estuary (see Tables 1 and 2).

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LIST OF ABBREVIATIONS

CV	Contingent valuation
CVM	Contingent valuation method
DWAF	Department of Water Affairs and Forestry
ha	Hectares
HP	Hedonic Pricing
HPM	Hedonic Pricing Method
MAR	Mean Annual Runoff
MC	Marginal Cost
MV	Marginal Value
P1	Value per cubic meter of a specified quantity of freshwater in the best alternative use to the estuary
P2	Value per cubic meter of a specified quantity of freshwater inflow into the estuary to users and non-users of the estuary
TC	Total opportunity cost per cubic meter of freshwater inflow into estuary (all people)
TV	Total value of freshwater inflow into an estuary (all people)
TWTP	Total willingness to pay
WTA	Willingness to accept
WTP	Willingness to pay

CHAPTER ONE: INTRODUCTION

1.1 THE WATER INFLOW PROBLEM IN ESTUARIES

Alien tree and plant infestations, coupled with ever-increasing human demand for freshwater, pose a serious threat to the functioning and structure of estuarine systems. The future functional status of many estuaries around the South African coastline will heavily depend on their receiving adequate freshwater inflows (Hosking, du Preez, Campbell, Wooldridge and du Plessis, 2002).

An estuary is “a partially enclosed, coastal body of water which is either permanently or periodically open to the sea and within which there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage” (Day, 1981). Estuaries are extremely important environmental assets and the management of them is dependent on the active involvement of the people whose livelihoods depend on them (Ngcobo, McKenzie and Sihlophe, 2001).

One of the reasons why South Africa’s estuaries are being threatened is that there is a perception that the benefits of damaging activities are greater than the benefits of conservation and sustainable use (van Niekerk, Taljaard and Schonegevel, 2006).

Examples of estuaries that are currently under threat due to alien tree and human abstraction of freshwater include the Kowie, Kromme and Nahoon estuaries. These three estuaries are located in the Eastern Cape. The Kowie Estuary runs through the town of Port Alfred, the Kromme Estuary can be found near the town of St. Francis Bay and the Nahoon Estuary is near the city of East London. These estuaries are discussed in detail in Chapter Four. Insufficient freshwater supplies

flowing into these estuaries has lead to a reduction in environmental goods and services provided by them. The same can be said for several other estuaries along the Eastern and Southern Cape coastline, e.g. the Keurboooms Estuary (Hosking *et al,* 2002).

This reduction in service provision has adverse economic consequences. The scale of these consequences is of great interest from the perspective of river catchment planning. Of particular interest is the value of the freshwater inflows into estuaries relative to other abstractions of this water. The value referred to here is of the environmental services yielded to recreational users.

The value of freshwater supplies to the Keurbooms Estuary near the Southern Cape town of Plettenberg Bay in terms of the environmental services yielded to recreational users, has been estimated using the contingent valuation method by Hosking and Du Preez (2001) to be between R0,046/m^3 and R0,012/ m^3.

Similar estimates have also been made by Hosking *et al* (2004) for several other estuaries found along the coastline of South Africa. Table 1.1 provides a summary of these estimates for the Groot Brak, Swartkops, Kariega, Klein Brak and Knysna estuaries.

Table 1.1 Value of water inflows into select estuaries per m³

Estuary	**Value per m³**
Groot Brak	R0.105
Swartkops	R0.090
Kariega	R0.057
Klein Brak	R0.013
Knysna	R0.013

Source: Hosking *et al* (2004)

As can be seen from Table 1.1, these estimates vary widely.

There are a large number of estuaries in South Africa - about 250 by some estimates (Day, 1981). This study focuses attention on just three of them; the Kowie, Kromme and Nahoon. These estuaries are all of the permanently open type and are located in the Eastern Cape (see Figure 1.1).

Figure 1.1: Map of the Eastern Cape

Source: www.safarinow.com

1.2 AIM OF THIS RESEARCH

The aim of this dissertation is to report contingent valuations on three South African Estuarine systems, namely the Kowie, Kromme and Nahoon Estuaries. The valuations of the Kowie Estuary and the Kromme Estuary were undertaken before the valuation at the Nahoon Estuary. The questionnaire used to value freshwater inflows into the Nahoon Estuary was revised in the light of problem responses elicited in the Kowie and Kromme surveys.

The data was gathered by means of personal interviews conducted along lines defined by set pre-coded questionnaires. The key question of the survey sought to determine the willingness of estuary users to pay for freshwater inflows so as to prevent the deterioration of services rendered by the above mentioned estuaries.

The contingent valuation method (CVM) is a survey technique which elicits bids from individuals to bring about specified changes (Turner, Pearce and Bateman, 1994). It is most often employed when markets fail to provide a reference for a value of the goods/services in question. The application of the CVM entails presenting respondents with hypothetical scenarios and asking how much money they would be willing to pay in order to bring about specified changes or prevent specified changes from taking place. The merits of applying this method of valuation to value freshwater inflows in estuaries will be discussed in greater detail in Chapter Three, along with a brief consideration of two other methods of valuing environmental goods and services, namely the travel cost method and the hedonic pricing method.

1.3 TYPES OF ESTUARIES PRONE TO WATER DEPRIVATION

South African estuarine systems have been classified into five categories (Whitfield, 1998). The five categories are estuarine bays, permanently open estuaries, river mouths, estuarine lakes and temporarily open/closed estuaries. The functioning of all of these estuaries are prone to disruption as a result of water inflow deprivation, especially the temporarily open/closed type. A brief discussion on each of the afore-mentioned estuary types follows.

1.3.1 PERMANENTLY OPEN ESTUARIES

Permanently open estuaries are estuaries which are continuously influenced by marine tidal action. The rivers which flow into this particular type of estuary are usually perennial in their natural condition. If the estuary is located in tropical areas, mangroves may be present.

These estuaries have a moderate tidal prism[1] (Whitfield, 1998). The catchment areas of permanently open estuaries are typically larger than 500km^2 and it is not unusual for permanently open estuaries to have catchment areas in excess of 10 000km^2.

The salinity values of these estuaries usually vary between 5 and 35 parts per thousand (Whitfield, 1998). An example of a permanently open estuary would be the Kowie Estuary in the East Cape Province.

The Kromme Estuary and the Nahoon Estuary are also examples of permanently open estuarine systems.

Permanently open estuaries are usually large systems and there is a strong tidal exchange with the sea. During conditions of low river flow the tidal exchange aids in keeping the mouth open (Breen and Mckenzie, 2001) but prolonged periods of reduced freshwater inflows may threaten temporary mouth closure.

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[1] Tidal prism refers to the difference between the volume of water in an estuary at high tide and that at low tide.

Figure 1.2: The permanently open Steenbras Estuary

Source: www.upe.ac.za

1.3.2 TEMPORARILY OPEN/CLOSED ESTUARIES

Due to the sandbar formation at the mouth, temporarily open/closed estuarine systems are blocked off from the sea for varying lengths of time and there are times when river flow is minimal or stops altogether (Whitfield, 1998). The Kariega Estuary is a good example of a temporarily open/closed estuary. This estuary is located in the Eastern Cape near the town of Port Alfred.

Figure 1.3: The temporarily open/closed Kariega Estuary

Source: www.upe.ac.za

1.3.3 RIVER MOUTHS

The river usually dominates the physical processes within river mouth estuarine systems. For this reason very low salinity values are common in most of the estuary. The catchment areas are generally large and the rivers often carry heavy silt loads. Due to the fact that a portion of this silt is deposited in the estuary, the river mouths are usually shallow, i.e., less than 2 metres deep (Whitfield, 1998). The Tugela River mouth, found in northern Kwazulu Natal, is an example of this type of estuarine system (Whitfield, 1998).

Figure 1.4: The Tugela River Mouth

Source: www.upe.ac.za

1.3.4 ESTUARINE LAKES

Estuarine lakes evolve from drowned river valleys that have been separated from the sea by vegetated sand dune systems. An estuarine lake loses its estuarine character when the dune barrier completely isolates the river. When the latter occurs it becomes a coastal lake rather than an estuarine lake (Whitfield, 1998). Estuarine lakes may have a permanent, seasonal or highly infrequent link to the sea. Salinities in estuarine lakes are variable and depend on the balance between freshwater input, evaporation and the periodicity of the marine connection. An example of an estuarine lake is the Swartvlei System, found in the Southern Cape (Whitfield, 1998).

Figure 1.5: The Swartvlei System

Source: www.suid-afrika.de

1.3.5 ESTUARINE BAYS

Estuarine bays have regular replacement of marine water in the lower and middle reaches due to their large tidal prisms (Whitfield, 1998). Southern Africa has only three estuarine bays, namely the Knysna Estuary, Durban Bay and Richards Bay. The mouths of these bays are usually more than 5m deep at spring tide (Whitfield, 1998).

Figure 1.6: Richards Bay Port

Source: www.chandling.com

1.4 CALLS TO ATTEND TO THE PROBLEM OF REDUCED WATER INFLOWS INTO ESTUARIES

As the degradation of estuaries has worsened, pressure has mounted from both national and international sources, on South Africa's Department of Water Affairs and Forestry (DWAF) to re-examine the basis by which river water is allocated in South Africa, particularly with a view of incorporating conservation demand. Similarly, there has been pressure on South Africa's Directorate of Marine and Coastal Management in the Department of Environmental Affairs and Tourism (DEAT) to counter the consequences of the degradation of estuaries caused by reductions of freshwater inflow.

The consequences of this pressure have also been evident at other levels of government (not just at the national level of government).

At the local level, municipalities along the coast have been required to formulate integrated development plans (IDP's) that include taking estuary management into account. At the provincial level provincial governments have been required to

include river catchment management into their provincial growth and development plans (PGDP's). At the international level South Africa is a signatory of the RAMSAR Convention and committed itself thereby to conserve wetlands, of which estuaries are an important type (Cowan, Dini, van der Walt and Kyle, 1995).

1.5 THE SPECIFIC ASPECTS OF THE ALLOCATION PROBLEM INVESTIGATED IN THIS DISSERTATION

a) The value of freshwater inflow into the Kowie Estuary.
b) The value of freshwater inflow into the Kromme Estuary.
c) The value of freshwater inflow into the Nahoon Estuary.

1.6 ORGANISATION OF THE DISSERTATION

This chapter has established that the problem of reduced freshwater inflows into estuaries needs urgent attention and that government at all levels is committing itself to addressing this issue. Estuaries are part of South Africa's natural assets, and in order to fully reap the benefits of these assets, their functioning must be maintained.

The Kowie, Kromme and Nahoon estuaries are permanently open type estuaries. It is of vital importance that these estuaries enjoy sufficient freshwater inflows so as to maintain their service function and prevent them from temporary mouth closure, thereby changing their status to a temporary open/closed type.

The remainder of this dissertation is organised as follows:

An economic model for valuing freshwater inflows into estuaries is presented in Chapter Two. A description of the method of valuation employed, namely the

contingent valuation method, is presented in Chapter Three, along with a discussion on the various biases encountered when using this method of valuation. Also described are two other popular valuation techniques of environmental change, namely the hedonic pricing method and the travel cost method.

A description of the ecology and services rendered by the Kowie, Kromme and Nahoon estuaries is provided in Chapter Four, as well as the user populations of each study site. Chapter Five discusses the questionnaires employed in this research along with sample design issues. The results of the surveys undertaken at the Kowie, Kromme and Nahoon estuaries are presented in Chapter Six, and overall conclusions are drawn and recommendations made in Chapter Seven.

CHAPTER 2: AN ECONOMIC MODEL FOR ALLOCATING FRESH WATER TO ESTUARIES

2.1 INTRODUCTION

The renewable natural resource, river water, is in high demand in South Africa. This demand is for household consumption and production inputs into industry, agriculture and forestry, *inter alia*. Unfortunately, as already pointed out in Chapter One, there have been some adverse consequences of abstraction to satisfy this demand, most notably, estuary degradation in the form of losses in areas of estuary available for recreational boating and losses of habitat for species of fish, birds and vegetation. As a result there has been reduced capacity to satisfy recreational demand for estuary services – a largely unpriced demand because of the public good nature of estuary recreation services.

It is generally accepted that sound water resource management requires that the benefits and costs of different water allocations be compared and an optimum determined (Loomis, 1998), including the allocation of river water (or alternatively, freshwater) inflows into estuaries. Chapter Two defines the conditions that need to be met in order to optimize inflows, and speculates on how these conditions could be used in practice to guide the allocation of river water to estuaries in South Africa.

2.2 DEFINING FRESHWATER INFLOWS

2.2.1 OPTIMIZING CONDITIONS

The optimum freshwater (river) inflow (Q*) into a given estuary at any given time is defined at that level where the positive difference between the total value and the

total cost of these inflows is maximized, or put differently, where the marginal value of the inflow equals the marginal cost. As the services generated from river inflows into estuaries are yielded and consumed mainly in the form of public goods[2], for instance, in areas suitable for boating, swimming and fishing, values for given changes in freshwater inflow into estuaries are defined in terms of the sum of all individual's willingness to pay for the given change. The value being referred to is a marginal value because it is what people (a community) would be willing to pay for an increment or decrement of the service. The latter value (community marginal value) can be defined as the sum of each individual's marginal value (Σ MVi) making up the community.

The total cost referred to in the above paragraph is the opportunity cost of the water not abstracted upstream, that is, the value of the best alternative use of this water. An example of an alternative upstream use is irrigation for the growing of agricultural crops.

2.2.2 THE MODEL

The primary variable of a model for allocating freshwater inflow into the estuary is the quantity of freshwater inflow into the estuary. The concepts relevant to such a model are defined below.

Q	=	Freshwater inflow into estuary in cubic meters
Q*	=	Pareto optimum freshwater inflow in cubic meters
ΔQ	=	Change in freshwater inflow into an estuary in cubic meters
P1	=	Value per cubic meter of a specified quantity of freshwater in the best alternative use to the estuary

[2]Goods that provide nonexclusive benefits to everyone in a group (Nicholson, 2004).

P2 = Value per cubic meter of a specified quantity of freshwater inflow into the estuary to users and non-users of the estuary

TC = Total opportunity cost per cubic meter of freshwater inflow into estuary (all people)

= f(P1;Q)

MC = Marginal cost of an incremental freshwater inflow into an estuary

= dTC/dQ

= P1.ΔQ

TV = Total value of freshwater inflow into an estuary (for all users)

= f(P2; Q)

MV = Marginal Value of freshwater incremental inflow into the estuary (all users)

= dTV/dQ

= $\sum$ MVi

= P2.ΔQ.

where i = 1……n people/users deriving utility from the fresh water inflow into the estuary.

MC = P1 if ΔQ = 1 cubic metre of water and MV = P2 if ΔQ =1 cubic metre of water.

Optimization takes place at the level of Q where the excess of TV over TC is maximized. A necessary condition[3] for this optimization to take place is that:

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[3] The first order condition for maximizing the difference between TV(Q) and TC(Q) is :

$$\frac{dTV(Q)}{dQ} - \frac{dTC(Q)}{dQ} = 0$$

$$MC = MV \quad (2.1)$$

and

$$P1 = P2 \quad (2.2)$$

It follows that
if $P1 > P2$,
then (the current inflow of freshwater into the estuary) $Q>Q^*$ (where Q^* the optimum inflow)
and if
$P1 < P2$,
then $Q <Q^*$.

A priori:

$$P1 = f(Q) \text{ and } dP1/dQ > 0 \quad (2.3)$$

$$P2 = f(Q) \text{ and } dP2/dQ < 0 \quad (2.4)$$

The P1 and P2 functions would be expected to change over time and, for this reason, the optimizing conditions (Equations 2.1 and 2.2) would be expected to yield different values at different moments in, or periods of, time. This research does not set out to explore or speculate on the time path of the relevant optimums.

Given the nature of the P1 and P2 functions (equations 2.3 and 2.4) it would be expected that at Q^*:

$TC < TV$

The condition for social optimality (P1 = P2) is underpinned by some fairly strong welfare assumptions. Social welfare (W) may be defined in terms of the utility (U_1) derived by those abstracting water upstream (-Q) and the utility (U_2) derived by those using services dependent on river inflow into the estuary (Q):

$$W = U_1(-Q) + U_2(Q) \qquad (2.5)$$

where utility is an increasing function in Q and welfare an increasing function in the respective utilities.

Welfare is maximized where the relevant partial welfare derivatives with respect to the respective utilities equate to zero.

From this welfare maximizing condition, it may be deduced that for a given change in Q welfare is maximized where $MU_1 = MU_2$. It follows that a welfare assumption is that when P1 = P2 that MU1 = MU2. Where the respective utilities are functionally related to prices in the same way the equivalence of prices becomes the condition for a welfare optimizing freshwater allocation into an estuary.

If MU1 > MU2, where P1 = P2, it would imply that welfare optimization would occur where P1 > P2. By similar reasoning, if MU2 > MU1, where P1 =P2, it would imply that welfare optimization would require where P1 < P2.

A priori, one may expect the relevant marginal utilities to differ in many cases, e.g., where the incomes and nature of use of the water users is fundamentally different, e.g., holiday enjoyment as the consumption need, and high income earner users versus subsistence users.

2.2.3 THE MARGINAL VALUE AND MARGINAL COST FUNCTIONS

The expected marginal value and cost functions (also see equations 2.3 and 2.4) are shown in Figure 2.1.

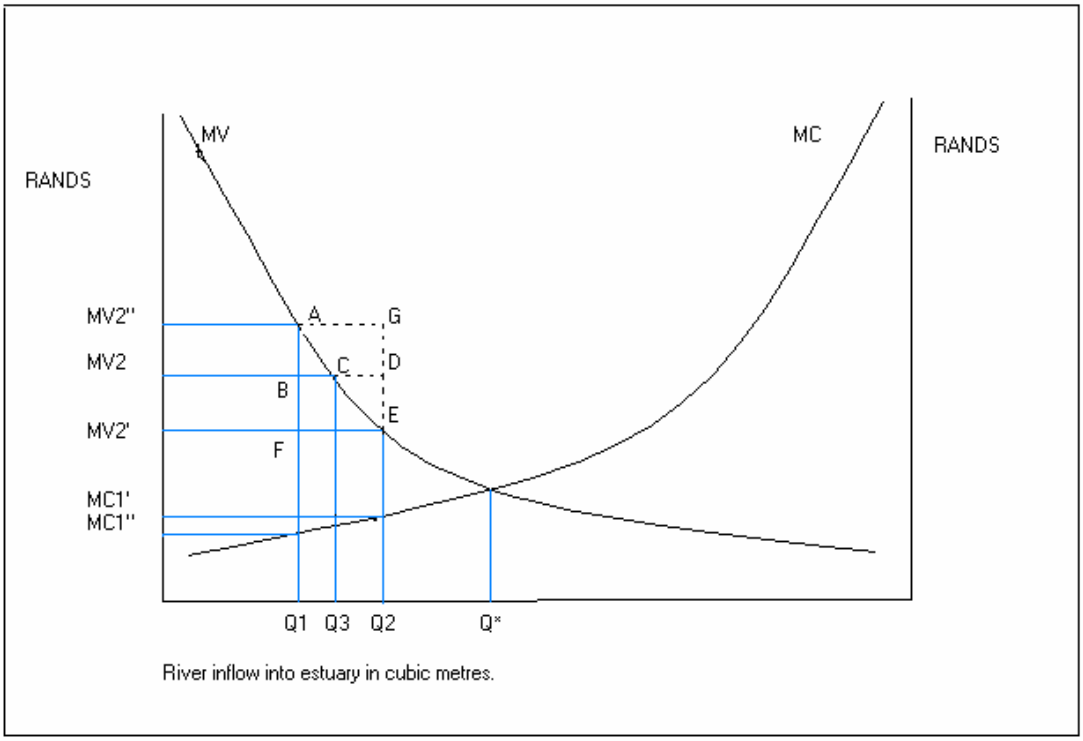

Figure 2.1: Expected MV and MC functions

In Figure 2.1 the river inflow into the estuary is shown in cubic meters on the X-axis and the marginal value and marginal cost of it in Rand is shown on the Y-axis. As freshwater inflow into the estuary increases, the marginal value of these inflows decreases, but the marginal costs associated with securing more freshwater increases. At the intersection of MV and MC curves the optimal freshwater inflow (Q*) is defined. At this level the excess of TV over TC is maximized. At any given time the actual freshwater inflow (Q) may, and most probably will, differ from the optimal inflow (Q*). Such a situation, for instance, would be where Q = Q1. At Q1:

MV2” > MC1” and net TV (or TV – TC) can be increased by increasing Q. For instance, if an increase of Q1Q2 is brought about, net TV increases by the vertical area between Q1 and Q2 and the MC and MV functions. After the increase, MV would have declined from MV2” to MV2’ and MC would have increased from MC1” to MC1’.

As it happens, in this case, further increases of Q would also be efficient. Only when P1 is brought into equivalence with P2 at Q* inflow into the estuary, would the optimum inflow be achieved.

2.3 A THEORY ON HOW TO MEASURE P2

The model of river water allocation presented above suggests that efficient allocation of river water in South Africa requires river catchment managers to be informed on both P1 and P2. There have been numerous attempts to estimate P1 in South Africa – using marginal cost and willingness to pay for agricultural land in South Africa (Hosking *et al*, 2002), but there has been less work done on estimating P2.

For this reason, at this point in time, the generation of estimators of P2 would appear to be where the greatest research need lies. In generating these estimates, the first question one is faced with is which MV2 should be targeted for the estimation of P2. Should it be MV2” or MV2’ or MV2 (see Figure 2.1)? Ideally the MV gained through the increase in inflow of Q1Q2 is estimated by MV2, where the excess valuation of Q3Q2 is almost exactly offset by the under-valuation of Q1Q3 (approximate equivalence of value areas CDE and ABC). The alternative of MV2” would yield too high an estimate (by value area AGE) of the MV, while MV2’ would yield too low an estimate (by value area AFE).

Unfortunately however, in practice it is either one of MV2" or MV2' that is likely to be identified by empirical research – the value prior to an increment in freshwater inflow or a decrement. It follows from the discussion that for a decrement of freshwater inflow, the price identified is likely to be MV2', i.e., too high. It would be expected that the error would be greater, the greater the derivative of the P2 function with respect to Q exceeds zero (see Equation 2.4), and the greater the change in Q being considered.

In principle there are several methods by which MV2 may be identified, for instance, hedonic price method (HPM), travel cost method (TCM) and contingent valuation method (CVM). Of these the one most amenable to the required fine-tuning, and for this reason preferred in this study, is the last mentioned. The way this method may be used to measure P2 is to value average willingness to pay for a specified ΔQ, one estuary at a time, to multiply this average by the total number of users/people with a demand for the services derived from the ΔQ, and finally to divide this product by the ΔQ.

It has already been established above that:

$P2 = \sum MVi / \Delta Q$, where i = 1…n people with a demand for estuary services.

In order to estimate $\sum MVi$ per cubic meter it is necessary to obtain every person's WTP and add them. However, this is impractical, and for that reason $\sum MVi$ must be approximated. Using the contingent valuation method, this approximation takes the form of estimating the total estuary WTP, i.e., TWTP. It follows that P2 may be estimated by formula 2.6:

$$P2 = TWTP/\Delta Q \quad (2.6)$$

where:

TWTP = (Total number of people with a demand for estuary services)(AWTP) given

AWTP = a before-the-ΔQ average willingness to pay for a specified change in water inflow into the estuary, as estimated by the contingent valuation method (MV2' or MV2" in Figure 2.1)

and

ΔQ = specified change in freshwater inflow measured in cubic meters.

2.4 ADDITIONAL INSIGHT TO BE GAINED ON ESTUARY VALUATION THROUGH THE APPLICATION OF CVM

In addition to generating information useful to guiding the allocation of freshwater to estuaries, contingent valuations can also be used to shed further light on the special role played by estuary characteristics in explaining public willingness to pay for estuary services – by examination of the coefficients in of a Total Estuary WTP function (see Equation 2.7 below). In this function the specified contributions of estuary characteristics are captured in the coefficients of the variables E1, E2 and E3 in function 2.7 below.

$$TWTP = f(D1; D2; D3; D4; D5; A1; A2; A3; A4; E1; E2; E3) \quad (2.7)$$

Where

TWTP = (AWTP)(N)

N = Number of people with a demand for freshwater inflow into the estuary (sample population)

Demographic explanatory variables

D1 = Population within a 10km radius of the mouth of the estuary

D2 = Average education of population within a 10km radius of the mouth of the estuary

D3 = Average income per capita of population within a 10km radius of the mouth of the estuary (or sample average stated income as an alternate)

D4 = Estimated recreational visitor population per annum

D5 = Other selected demographic statistics

Access and other attractions of the area related to the estuary

A1 = Road access index based on distance of mouth in km from nearest National Road, distance in km on gravel to mouth and quality of road

A2 = Estuary access rating, based on number of points of entry and rating thereof

A3 = Proximity by road of another estuary with similar attractions – the substitute good effect

A4 = Subjective rating of estuary attraction appeal relative to total attraction appeal of area for recreation – the complementary good effect

Estuary characteristics related to river inflow

E1 = Presence/absence of unique biotic and abiotic features or conservation status rating

E2 = relative change in Q inflow, $\Delta Q/Q$ (as reported by the DWAF and other sources for MAR)

E3 = total area covered by estuary

The advantage of this statistical fit is that it neutralizes some of the upward biases that may be incorporated in a contingent valuation to estuary services, due to the composite good nature of estuary services – from the consumer demand perspective.

2.5 FINDINGS DERIVED FROM THE FRESHWATER ALLOCATION MODEL

It is essential that an optimum inflow of freshwater to estuaries be established in order to facilitate sound water resource management in South Africa. The main findings of Chapter Two are that optimal allocations of fresh water inflows into South African estuaries occur when the marginal values of the inflow are brought into equivalence with the marginal costs. It follows that in order to guide catchment management towards optimal allocation of freshwater inflows into estuaries, regular comparative estimates are needed of the relevant marginal costs and marginal values. In order to estimate the marginal values (arguably the one of the two measures about which least is currently known) Chapter Two proposes that the contingent valuation method (CVM) be employed – and it is to the application of this method that we turn our attention in Chapter Three.

CHAPTER THREE: METHODOLOGICAL ISSUES TO CONSIDER WHEN VALUING ENVIRONMENTAL SERVICES

3.1 INTRODUCTION

There are several ways by which changes in environmental asset status can be valued, for example, the contingent valuation method, the hedonic pricing method and the travel cost method. Each method has its advantages and disadvantages. Chapter Three describes the methodological issues involved in valuing changes to environmental assets. A theoretical description of the contingent valuation method will be presented.

It will be shown that the CVM is both a credible and reliable method of valuing changes in environmental services. The CVM does, however, have disadvantages, the main ones being biased estimates of value and too small a sample size. These disadvantages will also be discussed in Chapter Three.

3.2 THE CONTINGENT VALUATION TECHNIQUE

Davis (1963) originally proposed the idea of the contingent valuation method. Following many empirical and theoretical refinements in the 1970's and 1980's, this technique has become accepted by resource economists (Hanley and Spash, 1993).

The CVM has become a tool used to value public goods and goods yielding services to different types of users including passive users. Public goods are non-rival and non-exclusive (Hanley and Spash, 1993). Estuary services, as already mentioned, have public good features (see Chapter Two).

Environmental resources often possess the characteristics of public goods and traditional markets for these goods often do not exist. As a result of this, the value of these goods is not revealed. The CVM has the ability to reveal these values and it is for this reason that the CVM has become a popular technique for valuing public environmental goods with resource economists.

3.2.1 STATED PREFERENCE VALUES

The economic value of a good to a person is what the person is willing and able to sacrifice for the good (Field, 1994). It is normally measured with reference to what is revealed in markets, but under certain circumstances this is not an option. In these cases the alternative of measuring value with reference to stated willingness-to-pay (WTP) or willingness-to-accept (WTA) has become attractive (Hanley and Spash, 1993).

A willingness-to-accept amount is the minimum amount of money (purchasing power) an individual is willing to accept for a negative event to occur, for example, there being an increase in pollution (Field, 1994). A willingness-to-pay amount is the amount of money an individual is willing to pay for a positive event to occur, for example, there being an increase in freshwater inflow into an estuary.

The concepts of willingness-to-pay and willingness-to-accept provide monetary measures of worth or value where market values (revealed preferences) are too difficult or impossible to determine.

3.2.2 THE APPLICATION OF THE CONTINGENT VALUATION METHOD

The contingent valuation method is applied in six steps: setting up the hypothetical market, obtaining bids, estimating the mean willingness-to-pay and/or willingness-

to-accept, estimating bid curves, aggregating the data and evaluating the reliability and validity of the values estimated (Hanley and Spash, 1993). The aforementioned steps are briefly discussed below.

Stage one: Setting up the hypothetical market.

A hypothetical market needs to be set up for the environmental flow that will be valued and a reason for payment must be provided. It is important to indicate how these funds will be raised and to provide a description of the bid vehicle (payment mechanism) to be used. Examples of bid vehicles include property taxes, income tax, utility bills, trust fund payments and entry fees (Bateman, Lovett and Brainard, 2005). How the fees will be set and whether all consumers will be liable to pay a fee should also be specified. Payment vehicles should also be customized to suit each study (Boyle and Bergstorm, 1999). It is important that the questionnaire be pre-tested before the main survey takes place (Hanley and Spash, 1993).

Stage two: Obtaining bids.

The second stage of a CVM consists of administering the survey. There are various ways that this administration can be done. For example it can be done through personal interviewing, telephone interviewing or mail survey (Frazer and Lawley, 2000). A disadvantage associated with telephone interviews and mail surveys is that it is difficult to convey a lot of information over the telephone due to time constraints. A disadvantage mail surveys suffer from are low response rates. A successful method of increasing response rates with mail surveys is to minimize the respondent's costs (Frazer and Lawley, 2000). This can be achieved by providing a reply paid envelope, by using an easy response format such as check boxes and by appealing to the respondent as an expert (Frazer and Lawley, 2000). Personal interviews are the generally preferred method of administering the survey, but also the most expensive. In this type of survey, the WTP question aims to elicit the maximum amount the good is worth to the respondent (Wattage, 2001).

This willingness-to-pay figure may be derived in a variety of different ways, namely through a bidding game, a close-ended referendum, a payment card or an open-ended question (Wattage, 2001). A bidding game entails suggesting progressively higher or lower amounts to respondents until their maximum willingness-to-pay is determined. A closed-ended referendum provides a yes/no answer to pay a specified sum. A payment card entails presenting a range of values on a card. The respondents are required to circle the value that represents their maximum willingness-to-pay or minimum willingness-to-accept. With an open ended question, individuals are asked to state their maximum willingness-to-pay, before any values have been suggested to them. The major disadvantage with open-ended questions is that most respondents have had little experience in bidding this way. Normally bidding takes place in a closed-ended way. One is offered a good or service at a price and one responds yes or no to the purchase/sale proposal.

Stage three: Calculating average WTP and/or mean WTA

Once all responses have been collected, the median and mean bids are calculated. The difference between the median measure and the mean measure is that the former is unaffected by very large bids in the upper tail in the distribution of bid's (Hanley and Spash, 1993). For this reason median bids are also usually lower than mean bids and often preferred (Hanley and Spash, 1993).

During this stage in applying CVM, the researcher needs to decide how to treat invalid responses. Two types of invalid responses are encountered in CV studies-protest bids and outliers. Protest bids occur when an individual refuses to state a willingness-to-pay amount. These bids have to be omitted in the calculation of means and medians. Outliers are defined as bids of unusually large (and seemingly unrealistic) value and they can significantly increase the mean. They are sometimes omitted on the grounds that the person conducting the survey does not

believe they reflect actual willingness-to-pay but rather strategic behaviour by the respondents.

Stage four: Estimating bid curves.

By using WTP/WTA amounts as the dependant variable, regressing this on other information collected about the respondents, a bid curve can be estimated. Bid curves are used to test if the results generated are consistent with theoretical expectations/economic theory and to generate predicted WTP/WTA estimates (Hanley and Spash, 1993).

Stage five: Aggregating the data.

The process of converting the mean bid or bids into a total population figure is known as aggregation (Hanley and Spash, 1993). Aggregation discussions revolve around three issues. Firstly, it is essential that all those who will be affected by the action, or those whose utility will be significantly affected by the action, are identified (Hanley and Spash, 1993). Secondly, the sample mean is used as a mean for the total population. According to Hanley and Spash (1993) and Turner *et al*, (1994) it is essential that the sample not be a biased reflection because the mean bid (average WTP) of the respondents must be multiplied by the total number of people who enjoy the environmental service flow in question, in order to secure an estimate of the total value (consumer surplus) which people attach to that service flow. Thirdly, it is important that the choice of the time period over which benefits should be aggregated is appropriate and that correct discounting procedures are used to convert the benefits over time to base year values (Hanley and Spash,1993).

Stage six: Evaluating the CVM exercise for reliability and validity.

A stated preference survey aims to determine a respondent's WTP or WTA for the change in provision of a good. Reliability and validity are the two main criteria upon

which the success of a survey is assessed (Bateman, Carson, Day, Hanemann, Hanley, Hett, Jones-Lee, Loomes, Mourato, Ozdemiroglu, Pearce, Sugden and Swanson, 2002).

Tests for reliability entail testing the degree of variation between results of similar studies (Breedlove, 1999). These variations may be the result of various biases. It must, however, be kept in mind that due to the fact that individuals are unique, this variability may be perfectly normal. Individuals respond differently under different circumstances, due to their unique characteristics. When individuals know little about the environmental service in question, they may respond with answers they feel the researcher “wants” to hear (Acks, 1995).

Tests for validity measure the success of the study in terms of the credibility of the values it predicts. There exist three types of tests for validity, namely content validity tests, convergent/construct validity tests and expectations-based validity tests (Bateman *et al*, 2002).

Content validity applies to the actual questionnaires’ content and the clarity and reasonability of the questions. If a survey has high content validity, respondents are able to answer with seriousness, truthfulness and thought. Bateman *et al* (2002), provides a framework of questions which need to be asked when assessing the content validity of a questionnaire. These types of questions are provided below.

Is the respondent able to understand the good or service in question?

Does enough reasonable information exist to describe the provision and payment scenario?

Are the consequences of non-payment described to the respondent?

Is the choice of welfare measure appropriate?

Are respondents made to feel that their input is of importance in the decision making process?
Has the correct population been identified and has this population been adequately sampled?
Is the administration of the survey of a high standard?
Is the preparation of the data of a high standard?
Does the questionnaire collect enough adequate data in order to permit construct validity testing?

Convergent validity, also known as construct validity, tests the study for consistency, by comparing the results generated with the results generated using other valuation techniques. Typical comparisons are made with revealed preference valuation methods, like the travel cost method and the hedonic pricing method (Breedlove, 1999).

Expectations-based validity tests are ones where the WTP/WTA values produced by the stated preference study are statistically related to other variables reported by the respondents to see if the correlation is theoretically plausible. For a stated preference study to show expectations based validity, the coefficients should display the right signs and be significant (Bateman *et al*, 2002).

It the parameters take unpredicted values, the validity of the results are thrown into question. If this is the case for a stated preference study, the findings of the particular study should be explained.

3.2.3 PROBLEMS ASSOCIATED WITH THE CONTINGENT VALUATION METHOD

There are problem areas associated with the contingent valuation method; two main ones being biased estimates of value and the incorrect choice of welfare measure (Field, 1994).

Biased responses occur when respondents systematically understate or overstate true WTP (Mitchell and Carson, 1989). There are many types of bias, e.g., strategic bias, design bias, mental account bias and hypothetical market error. Strategic bias occurs when respondents understate their willingness-to-pay for a welfare improving change because they believe the change will be made regardless of what they pay (the free-rider problem) (Hanley and Spash, 1993). There are four ways of minimizing strategic bias: removing all outliers, stressing that payment by others will be guaranteed, concealing other bids and establishing a reputation for making the environmental change dependent on the bid (Mitchell and Carson, 1989).

Design bias relates to the way in which information is presented to individuals – the question format and the order of questions. There are three main ways in which the design of the CVM study can affect responses: the choice of the bid vehicle, starting point bias and the nature of the information provided (Hanley and Spash ,1993).

Vehicle biases are biases based on different payment methods, which may lead to differences in WTP (Wattage, 2001). The choice of the bid vehicle, thus can influence the mean bid. If the bid vehicle is an entry charge (say for entry into a nature reserve), instead of a donation to a trust for example, respondents may feel they are being charged directly for a natural resource and may understate their willingness-to-pay (Hanley and Spash, 1993).

Whenever a bidding game format is used, starting point bias may arise (Bateman *et al*, 2002). Respondents may view this starting point as an approximation of the correct value. In order to combat this form of bias a payment card format may be used or starting points may be varied (Hanley and Spash, 1993).

If a respondent is asked to value a characteristic of which he or she has no previous experience, information bias may occur (Mitchell and Carson, 1989). In order for a respondent to be able to make an informed decision it is essential that sufficient information be provided regarding the environmental service flow in question.

Mental account bias relates to a two-step decision-making process on the part of an individual (Hanley and Spash, 1993). The first step involves people in decisions on how much income, time and wealth to spend on environmental goods in general within a given period of time and within the budget constraint. For the purpose of explanation, let us refer to the person's total environmental budget as "B" and the amount allocated to any asset *i* as B*i*. If we seek a CVM estimate of average budget value for asset *i* (the environmental asset), mental account bias will occur for an individual if he or she bids an amount B*i*, where B*i* =B.

In this extreme case of where B*i* =B, the whole environmental budget is allocated to this one asset. It is important to be aware of the possibility of the presence of this bias and make every effort to minimize it when conducting a CVM study.

Hypothetical market bias occurs when the people being interviewed respond as if they were answering questions relating to a hypothetical market rather than a real one. The occurrence of market bias will depend on factors such as how the questions are asked, the reliability and credibility of the hypothetical market and whether WTP or WTA is used (Hanley and Spash, 1993).

3.2.4 CHOICE OF WELFARE MEASURE

One of the aims of a CVM is to measure consumer surplus in terms of what consumers are WTP or WTA. If both the ratio of consumer surplus to income (expenditure) and the income elasticity of demand are low, then income allocated may approximately equal consumer surplus (Hanley and Spash, 1993).

One problem with WTA questions is that they generate relatively more protest bids than WTP questions. Usually WTA bids are found to exceed WTP bids (Breedlove, 1999).

There exist three reasons why willingness-to-accept bids typically are found to exceed willingness-to-pay bids. The first is loss aversion. The second is that willingness-to-accept bids are unconstrained by income, whereas willingness-to-pay bids are constrained by income. The third is risk aversion.

Risk-averse consumers will equate a higher amount for willingness-to-accept compensation for loss with a lower amount for willingness-to-pay for gain because of their having a diminishing marginal utility of income. In the interest of being conservative (CVM has been criticised for generating excessive values), willingness-to-pay has emerged in economic literature as the preferred choice of welfare measure (Hoehn and Randall, 1987).

3.3 ALTERNATIVE VALUATION TECHNIQUES

Due to the fact that the contingent valuation method is a stated preference based method and the constructed market is hypothetical in nature, it is good practice to compare (if possible) its results with those generated using alternative valuation techniques. Two such alternative methods are the hedonic pricing method and the

travel cost method. The advantage of these methods of valuation is that they are based on revealed WTP preferences as opposed to stated WTP preferences (Turner *et al*, 1994). In this study the contingent valuation method was the only method of valuation employed because the others could not be as easily adjusted to value the specific environmental service this study sought to value. A brief overview of the hedonic pricing method and the travel cost method are provided below.

3.3.1 THE HEDONIC PRICING METHOD

The hedonic pricing method values characteristics of composite goods by regressing revealed WTP on these characteristics and then analyzing the coefficients of these equations. One of the most common areas in which HPM is applied is in the property market (Turner *et al*, 1994). In this context the HPM seeks to find a relationship between the levels of environmental services and property prices.

The first step in any HPM study is to determine which environmental quality variable is of interest, e.g., services derived from inflows of freshwater into an estuary. To apply the method, data need to be obtained on house prices and characteristics within the area influenced by the particular environmental service flow (Hanley and Spash, 1993). Once this data has been obtained, the HP exercise proceeds in two stages, namely estimation of a hedonic price function and estimation of a demand curve.

As property prices are influenced by many factors, the choice of explanatory variables is crucial. For example, property prices are typically a function of site characteristics (number of rooms, size of the garden and presence of a garage), neighborhood characteristics (crime rate and ethnic composition) and

environmental quality variables (air quality, noise levels and level of environmental services).

Using the explanatory variables above, the HP function would be as follows

$P = f(S, N, Q)$,

where,

P = House prices

S = Site characteristics

N = Neighborhood characteristics

Q = Environmental quality variables

The implicit price of a given environmental characteristic is obtained from the above equation by partially differentiating with respect to the characteristic of interest, e.g., the implicit price of Q would be:

$$\partial P/\partial Q = f(S, N, Q)$$

This implicit price ($\partial P/\partial Q$) is known as the rent differential, *r* and it is the measure of the value of a marginal change in the environmental quality variable, Q (Hanley and Spash, 1993). This rent differential shows the marginal cost of an increase in the environmental variable or the marginal benefit provided by an increase in the environmental variable under the assumption that the housing market is functioning perfectly (Freeman, 2003).

Using the information generated from the above regression, the next stage of the HPM involves generating a demand curve. Under the assumption of being in the short run, which is often a case of particular interest, house buyers must bid for a fixed supply of heterogeneous units. An implicit demand curve for Q can then be

obtained by regressing implicit prices, *r*, against Q, and socio-economic variables thought to be of relevance, for example income and age (Hanley and Spash, 1993).

There are many problem areas associated with HPM; one of the most important being the strong assumptions that need to be made about the related market, in this case the property market. Another problem is that data problems may be overwhelming in order to determine certain prices, e.g., that of freshwater inflows into estuaries.

3.3.2 THE TRAVEL COST METHOD

The travel cost method (TCM) is also a revealed preference valuation method. The TC approach also relies upon a survey in order to gather data (Bateman *et al*, 2005). This method can be used to estimate demand curves for environmental services and these can be used to estimate the consumer surplus generated by these services. The underlying assumption of the TCM is that the costs incurred when making use of an environmental service, for example, traveling expenses, reflect the value of those services (Turner *et al*, 1994). The expenses may include entry fees, on-site expenditures and all other costs incurred by the person in order to use the particular environmental asset. Questionnaires are used to determine where the people have traveled from in order to make use of the environmental asset. In this case the environmental asset would be the relevant estuary, the Kowie, Kromme or Nahoon (if the TCM was to be employed). From these responses, travel costs are related to the number of visits per annum. This information is used to generate a demand curve.

However, factors other than travel costs will influence how many times a person visits an estuary to make use of its services. One of these factors is income. For

this reason, income is often included in a TC study as one of the explanatory variables for the number of visits per annum.

Problems associated with a TC study include time costs, multiple visit journeys, substitute sites, house purchase decisions and non-paying visitors. The researcher needs to determine how to deal with the above factors when undertaking a TC study. The values generated relate to a composite environmental good/service, rather than specific components, e.g., those services of an estuary changed by reductions in freshwater inflow into the estuary.

3.4 CONCLUSION

During the last 50 years the contingent valuation technique has become a popular tool amongst environmental economists for valuing environmental changes. It has also become widely accepted as a credible way of estimating the value of goods and services, when proper procedures are followed. Nevertheless, there are many biases encountered in CVM applications, causing there to be some degree of controversy over the results.

Each CVM survey has its own challenges and these must be honestly confronted if the CV is to enjoy any degree of credibility. To assist in this process, guidelines have been drawn up on CVM procedure. One such set of guidelines has been drawn up by the Blue-Ribbon panel (see Appendix Four). These guidelines draw attention to issues that need to be taken into account. One of the main constraints inhibiting the success of CVM studies is the funding available for conducting the valuation. If insufficient funding is experienced, shortcuts become unavoidable, e.g., on sample size.

Despite issues surrounding the complexity of applying CVM, considerable progress has been made in developing the technique into what it is today. The technique has been recommended by Congress in the United States of America and many other governments (Breedlove, 1999).

Perhaps one of the most difficult tasks when performing a successful CVM study, is the correct estimation of the user population. The user populations of the Kowie, Kromme and Nahoon estuaries will be discussed in Chapter Four, along with specific study site information such as the services provided by each estuary, abiotic and biotic characteristics.

CHAPTER FOUR: STUDY SITE INFORMATION

On the Southern coast of South Africa lie three three very important environmental resources: the Kowie Estuary, the Kromme Estuary and the Nahoon Estuary. These estuaries are within roughly 400 kilometres of one another and are all classified as permanently open estuaries. The Kowie and the Kromme estuaries have marina developments situated at their mouths. These marinas are mostly used for recreational purposes, with holiday homes built on their banks. Many of the houses on these marinas stand empty for most of the year. The Nahoon Estuary does not have any significant structural development, but it is very popular with the residents of East London for recreational purposes. Chapter Four presents the physical descriptions of the Kowie, Kromme and Nahoon estuaries and provides a more detailed discussion on the services provided by each estuary.

Estimating the correct user population is critical if a CV is to be successful. This estimation was made by conducting interviews with the relevant tourism authorities and consulting GIS data on the population in the area of the estuary. Chapter Four also presents the results of these investigations.

4.1 THE KOWIE ESTUARY

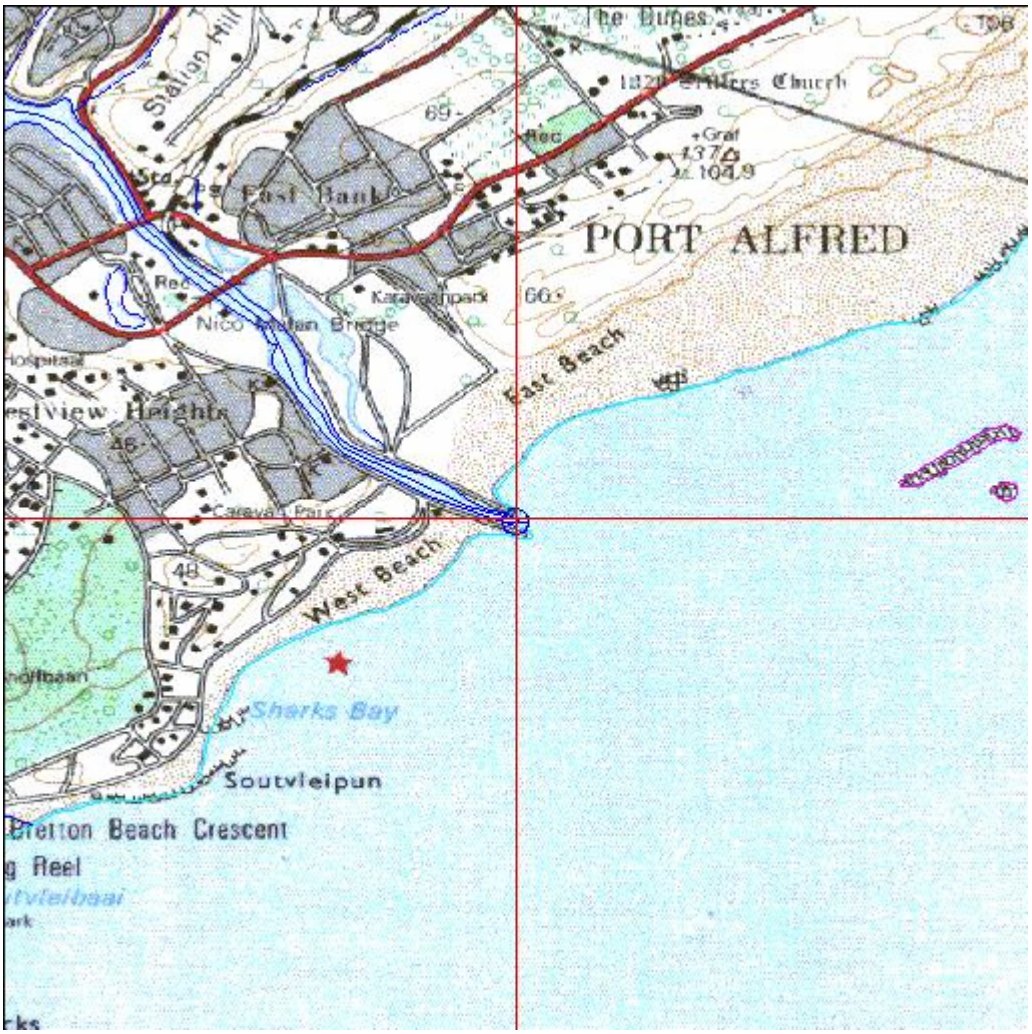

Figure 4.1: Map of Kowie Estuary

Source: www.upe.ac.za

Figure 4.2: Photo of the Kowie Estuary

Source: www.upe.ac.za

4.1.1 PHYSICAL DESCRIPTION AND USES

The estuary of the Kowie River opens to the Indian Ocean at 33°36”S, 26°54”E, and is found midway between East London and Port Elizabeth. The lower reaches of the estuary are located within the town of Port Aflred. Distances to the nearest towns, namely Port Elizabeth, East London and Grahamstown, are 160km, 140km and 58km respectively (Zwamborn, 1980). The Kowie Estuary is located approximately 100 km from the National Road (N2). Road access to the estuary is good. There exist approximately 25 points of access. Another estuary with similar characteristics is the Fish River Estuary and this is approximately 15km away, by road. The closest residential area is located on the banks of the estuary.

Abiotic features

Climate

The climate of the Kowie Estuary is temperate. Most of the rainfall occurs in spring and autumn. The mean annual precipitation of 650mm is evenly distributed over the catchment area (Heydorn and Grindley, 1982) although moderate droughts and floods are relatively common occurrences (Day, 1981).

Area of the river catchment

Estimates of area of the catchment of the Kowie River vary. One estimate is 576 km^2 (Day, 1981). This is considerably less than the estimate of the area by Noble and Hemens (1978) of 769 km^2. It is deduced that the catchment of the Kowie River is between 576 km^2 (Day, 1981) and 769 km^2 in size (Noble and Hemens, 1978).

Geology

A large part of the Kowie River lies within a strip of the Bokkeveld Series. The Bokkeveld Series consists of shale and subsidiary sandstone bands. The quarries and cuttings of Port Alfred show pronounced dipping and folding. The Alexandria Formation can be found along the coast, overlying and resting on the shale. The Alexandria Formation is a succession of thin, marine sediments. Resting on top of this Alexandria Formation one finds what is known as dune rock. The characteristic layers one finds in this formation provide evidence that the origin of the dune rock is windblown (Heydorn and Grindley, 1982).

River length

The length of the Kowie River from the mouth to the source is approximately 70kms. The last 21kms of the river, leading into the Indian Ocean, is tidal and is regarded as estuarine (Kowie Estuary Management Plan, 1999).

Land ownership and catchment users

The major part of the Kowie River catchment is made up of privately owned farms. The main agricultural activities of the region focus on the production of pineapples, chicory, citrus, fodder crops, beef cattle and goats (Zietsman and van der Merwe, 1981). Many activities are associated with the Kowie Estuary. The estuary is used as a harbour for commercial fishing boats, recreational boats and yachts. The recreational activities which take place in the estuary include fishing, sailing, skiing and jetskiing. Subsistence fishing also occurs in the estuary (Kowie Estuary Management Plan, 1999).

The steep slopes along the river banks are covered with indigenous vegetation and are used for growing crops. The main crop cultivation takes place on the level parts of the floodplain, mostly where the river bends.

The estuary provides 21kms of navigable water and is mainly used for recreation. The registering of boats is essential and regulations are enforced by a full-time river control officer. Due to the fact that recreational activities, such as skiing and fishing, are not fully compatible, the river is zoned for different uses. Well-situated, visible signs are utilised to ensure accidents are kept to a minimum. The lower reaches of the estuary have many salt marshes and mudflats. These have been semi-developed and used for recreational purposes. An excellent example of this semi-development is a tidal lagoon, formally known as Little Beach, now known as Kid's Beach, which is used by families with young children.

Obstructions

Many small bridges cross the Kowie River in the upper catchment area, but none of these structures obstruct the tidal flow of the river (Heydorn and Grindley, 1982). According to Day (1981), however, the stone beams which contain and concentrate the tidal and river flow of the Kowie Estuary form a major hindrance to

the natural configuration of the estuary and this has led to a general impoverishment of the system (Heydorn and Grindley, 1982). Certain sections of the river banks are lined with stone walls and due to the constant collapse and erosion of these walls, continual repair is necessary (Heydorn and Grindley, 1982). Many private waterfront homes are situated along the lower reaches of the estuary, particularly along the Western Bank. These homes often have jetties and slipways protruding into the main channel. These jetties, together with larger boats moored midstream, obstruct and limit the utilization of the main channel (Heydorn and Grindley, 1982).

Over time, the mouth and lower reaches of the estuary have been significantly developed and altered. During the last century the mouth of the estuary was canalized and infrastructural and residential development took place in and around the lower reaches of the estuary. A marina has been established on the east side of the estuary, close to the mouth (Kowie Estuary Management Plan, 1999).

Runoff and flow records

The flow in most Eastern Cape rivers is irregular (Heydorn and Grindley, 1982). Although the Kowie River is considered to be perennial, river flow can come to a halt for 2-3 months during drought conditions. Rain in the catchment does not necessarily result in river flow (Heydorn and Grindley, 1982). The Kowie River has a very swift run down period resulting in a high flow for a very short duration (Heydorn and Grindley, 1982). Mean annual run-off figures, in million m^3, have been estimated at between 23 (Noble and Hemens, 1978) and 23.6 (Midgley and Pitman, 1969).

Hydrological impact of alien plant infestations

The water resources of South Africa are extremely sensitive to alien invading plants (Chapman, Le Maitre and Versveld, 1998). The plant biomass of a specified invader must be known in order to generate a correct estimate of the stream flow reduction caused by the alien vegetation. The plant species invading Eastern Cape estuaries include *Hakea, Pinus spp, Acacia dealbata, Acacia melanoxylon* and *Eucalyptus spp,* with *Acasia mernsii* rated as the worst (Chapman *et al*, 1998).

Chapman *et al* (1998) found the catchment area of the Kowie and Riet River system to have an area of 115 623 ha, with 20.12% of it invaded. This equates to an area of roughly 23 263 ha of invading alien plants and is estimated to cause a loss in runoff amounting to about 24 million m^3 per annum (Chapman *et al,* 1998). One method of increasing the runoff of freshwater flowing into an estuary would be to reduce the amount of alien vegetation growing in the catchment.

Description of the Kowie Estuary

The Kowie Estuary complex can be divided into three parts: the upper reaches, the middle reaches and the final 3km to the mouth (Day, 1981). The upper reaches, which are 13 km long, 50-90m wide and 2-6m deep and have steep, rocky banks 1-3m high. Due to the steep banks the intertidal zone is only 3-10m wide. The tidal range at spring tide is 1.1m and currents vary from 12 -20 m^3 /second. The middle reaches wind through a broad valley 3km long. The estuary here ranges from 100-150m wide and is approximately 3m deep with troughs of up to 8m on bends. The floor is mainly sandy. The maximum tidal range is 1.5m and the currents in this section flow at rates of up to $12m^3$ sec.

The final 3km leads to the mouth. Prior to 1890 this section was dredged, straightened and stabilised by stony embankments. Breakwaters 75m apart guard

the mouth. The sandy bottom in this part of the estuary is approximately 3m deep. The spring tide range is 1.7m and currents here flow at up to $25m^3$ second.

Sedimentation

There are two piers that extend out through the surf zone. They have had a dramatic effect on the normal pattern of sediment drift at the mouth of the Kowie Estuary (Heydorn and Grindley, 1982). According to the Kowie Estuary Management Plan (1999) one of the main problems experienced in the estuary is the deposition and accumulation of sediment. This has been found to negatively interfere with the boating activities that take place on the river. It has also been found that the problem of sedimentation has major social and economic consequences for Port Alfred (Kowie Estuary Management Plan, 1999). Increased sedimentation leads to reduced boating and fishing activities and negatively affects tourism.

Temperatures

The seasonal temperatures at the mouth range from 14-22°C, while in the upper reaches they range from 11-27°C (Day, 1981).

Salinity

Salinity in the estuary is usually around 30 parts per thousand. However, in dry periods, it may increase to above 40 parts per thousand and during particularly wet times the surface of the estuary may even have zero salinity (Day, 1981).

Biotic features

The Kowie Estuary supports a vast range of flora and fauna. The flora include phytoplanktons (microscopic plants drifting in plankton), algae, aquatic vegetation, semi-aquatic vegetation and terrestrial vegetation. The fauna includes

zooplanktons (minute animals drifting in the water), aquatic invertebrates, fish, reptiles and amphibians, birds and mammals (Heydorn and Grindley, 1982).

Flora

Three main semi-aquatic vegetation mapping units have been identified around the Kowie Estuary, namely *Juncus cactus/scirpus maritimus,* red swamp and tidal salt marshes (Heydorn and Grindley, 1982). Terrestrial vegetation found around the Kowie Estuary includes Hummock, dune vegetation, warm temperate coastal forest, sub-succulent woodland, Acacia Karroo Bushdump and vegetation complex between coastal woodland and forest scrub (Heydorn and Grindley, 1982).

Fauna

A total of 39 species of zooplankton have been recorded in the Kowie Estuary (Grindley, 1976). They provide a valuable source of food for fish. The main fish species are mullet, juvenile stumpnose and steenbras. Spotted grunter appear in late summer. Resident species of the Kowie Estuary include Gobies, Silverside and Cob (Heydorn and Grindley, 1982). There also are a number of species of shrimps and prawns found in the estuary (Day,1981).

A total of 11 species of frog, 20 species of snail and four species of tortoise have also been recorded in the area (Heydorn and Grindley, 1982).

The Kowie Estuary also provides a suitable habitat for water birds in the mudflats and marsh areas (Heydorn and Grindley, 1982). The Kowie system supports 93 species of bird, including 35 species of waders. These waders are supported by the estuary itself. The remaining 58 species are found along the banks of the upper reaches of the Kowie River (Heydorn and Grindley, 1982).

Services provided by the Kowie Estuary

The Kowie Estuary provides many important environmental, social and economic services. These can be grouped as follows: agriculture, industry, formal residential, informal residential, resource harvesting, recreation and tourism and nature conservation. The aforementioned services are shown grouped by levels of importance in Table 4.1.

Table 4.1: Assessment of estuarine services – The estuarine services provided by the Kowie Estuary (Scores: 0 = none/absent, 1 = present, 2 = important and 3 = very important)

Estuarine Services	Score	Comment/details
Agriculture		
Dom. livestock grazing	2	Cattle farming takes place on both banks in the upper reaches
Wild livestock grazing	2	Bushbuck are often observed along the banks (middle and upper reaches)
Industry		
Buildings & infrastructure	3	Shops, restaurants and other industries have infrastructure on the estuary (lower reaches).
Solid and/or liquid effluent	1	Effluent from various industries has been reduced
Formal Residential		
Places for residential buildings	3	Houses surround the entire lower reaches and portions of the middle reaches.
Other infrastructure	3	Jetties, slipways and landscaped gardens infringe on the banks of the lower and middle reaches.
Solid and/or liquid effluent	3	Storm water drains and septic tank overflows enter the estuary at several points
Informal Residential		
Buildings	0	
Other infrastructure	0	
Solid and/or liquid efflucent	1	Effluent from Station Hill enters the estuary at the Bay of Biscay and the Kowie quarry.
Resource harvesting		
Recreational fishing	3	Mostly over holidays and weekends from boats and from the shore.
Recreational bait collecting	2	Sand prawns and mud prawns are heavily utilised by anglers throughout the year.
Subsistence fishing	1	Mostly at night and on weekends.
Subsistence bait collecting	3	Heavy utilisation of mud prawns, which are sold to recreational anglers.
Commercial activities	3	Enterprises such as canoe and booze cruise craft hire.
Recreational & tourism		
Water skiing	3	Mostly over Christmas holiday season and occasionally on weekends.
Canoe & hiking trails	3	Canoeist are often observed even out of season including the organised Kowie Canoe Trail.
Boat Cruises	3	Year round. tour groups and overseas visitors on a regular basis, and holiday makers seasonally.
Nature appreciation	2	Bird watching and appreciation of the overall aesthetics.
Organised sports	2	Annual events such as the Power Boat races and Inter-varsity Rowing attract many people to the area
Leisure activities	3	Swimming, windsurfing, rowing, sailing as well as occasional biathlons, triathlons and fishing competitions.
Nature Conservation		
Reserve areas	2	The Kowie Nature Reserve (WDC), Waters Meeting Reserve (DEAT) and the Mansfield Farm (Private).

Source: Cowley and Daniel (2001)

It is deduced from the information in Table 4.1 that the Kowie Estuary provides many important recreational and tourism services, such as water skiing, canoeing

and boat cruises. Much of the industry in Port Alfred would appear to be dependent on the spending of tourists attracted to the Kowie Estuary. There are many shops and restaurants established on the banks of the lower reaches to serve these visitors.

4.1.2 DETERMINATION OF TARGET POPULATION AND SAMPLE SIZE: KOWIE ESTUARY

There are approximately 18 399 permanent residents living within 10 kilometres of the Kowie Estuary (Davids, 2002), although not all of these permanent residents make use of the Kowie Estuary. The local tourism authority was consulted in order to estimate the total user population of the Kowie Estuary.

The preliminary estimate of the per annum population of users was 18 000. This estimate was made on the basis of estimates provided by local tourism authorities (Paterson, 2002). Further investigation suggested that this estimate was slightly low. According to Beverley Young (2002), of the local Port Alfred tourism authority, the per annum user population of the Kowie Estuary was 19 406 (see Table 4.2).

Table 4.2: User population estimate: Kowie Estuary

USER GROUPS	NUMBER OF VISITORS PER ANNUM		
	RESIDENT	**TOURIST**	**TOTAL**
Recreation:			
Boat sports	100	1000	1100
Swimmers	100	200	300
Fisher/bait collectors	150	800	950
Birders	15	1000	1015
Proxiity/view	10000	6000	16000
Commercial:	21	0	21
Subsistence:	20	0	20
All Groups	**10406**	**9000**	**19406**

Source: Young (2002)

It is clear from Table 4.1 that the majority of users at the Kowie Estuary are recreational users. Boating and fishing are very popular activities, especially with tourists, i.e., people not living in Port Alfred. Birding also appears to be very popular, with approximately 1015 users enjoying this activity per annum. There are also a number of restaurants operating on the banks of the Kowie Estuary (commercial users).

The users of this estuary can be broken down into three main categories: recreation, commercial/subsistence and passive users. Recreational users indulge in boating, swimming, fishing/bait collecting, bird watching or are simply attracted to the estuary for aesthetic reasons. Most recreational users are multi-users of the estuary.

A total of 150 respondents were interviewed – about 4,6% of the sample frame – assuming 6 person size households.

4.2 THE KROMME ESTUARY

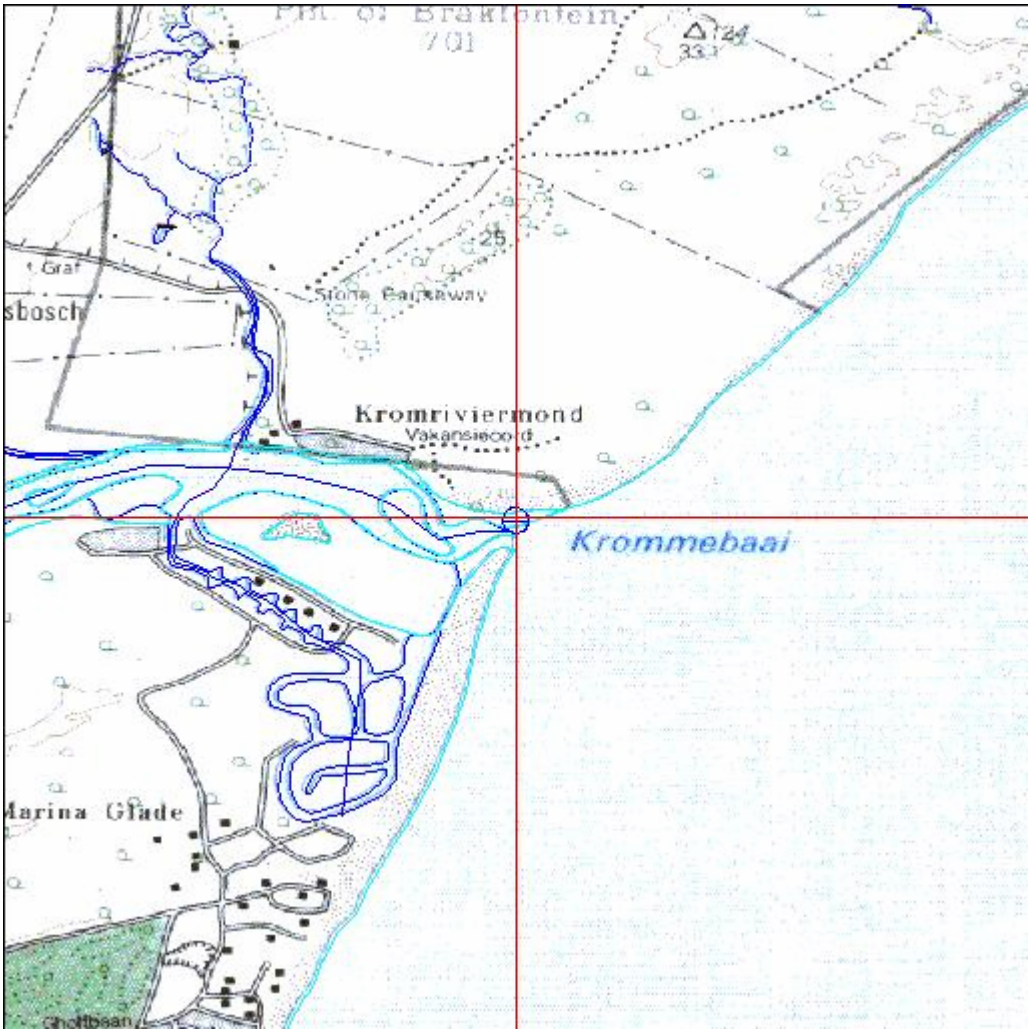

Figure 4.3: Map of the Kromme Estuary

Source: www.upe.ac.za

Figure 4.4: Photo of the Kromme Estuary

Source: www.upe.ac.za

4.2.1 PHYSICAL DESCRIPTION AND USES

The estuary of the Kromme River opens into St. Francis Bay (Indian Ocean) at 34°08”S : 24°51”E. The estuary is located in the Eastern cape approximately 55km west of Port Elizabeth and is classified as a permanently open estuary. It is one of the larger estuaries found in the Eastern Cape and has a relatively undisturbed catchment area (Heymans, 1992).

Abiotic Features

Climate

Rainfall occurs throughout the year in the areas surrounding the Kromme River. The annual rainfall varies between 700mm and 1200mm (Baird, Marais and Bate, 1992).

Area of the river catchment

The area of the river catchment is between 936km^2 (Baird *et al*, 1992) and 1085km^2 (Day, 1981).

Geology

The sediment yield of the Kromme River is small and consists of soil weathered from Bokkeveld slates (Reddering and Esterhysen, 1985). The sediment input is reduced due to the ability of the quartzitic in the catchment to resist weathering and erosion.

The middle reaches of the river meander through hilly foreland south of the Kouga mountains near Humansdorp. This foreland consists mainly of soft overlying sandstone and shale of the Bokkeveld Group as well as friable sandstone and quartzite from the Table Mountain Group.

River length

The total length of the Kromme River is approximately 95km. The last 14km of the river is tidal and is regarded as estuarine (Heymans, 1992).

Land ownership and catchment users

Minimal industrial activity occurs in the catchment or in the estuary floodplain (Baird *et al*, 1992). Small agricultural and urban settlements are found in the catchment area. The catchment area comprises 11.73km^2 of natural forest,

79.6km^2 of fynbos and 1462.05 km^2 of private farmland, on which the main activities are stock raising and grain cultivation (Heymans, 1992). The catchment area is about 155 338 ha and roughly 10104 ha of it is invaded by alien plants. A marina canal system was constructed in a marshy area next to the estuary mouth. It was excavated for the construction of these canals. The canal system has since undergone numerous expansions in order to accommodate more houses with water frontage. Another construction on the estuary is a bridge over it.

Run-off and Flow records

The flow in the Kromme River is erratic, with floods occasionally occurring between March and October (Bickerton and Pierce, 1988). The mean annual run-off estimates for the Kromme in million m^3 are as follows: 105.5 (Reddering and Esterhuysen, 1985) and 116.8 (Bickerton and Pierce, 1988). The high MAR is due to the geomorphological characteristics of the catchment, namely the high relief, rocky slopes and sparse vegetation.

Two major dams have been constructed in the catchment area of the Kromme Estuary, namely the Churchill Dam (completed in 1943) and the C.W. Malan Dam (completed in 1982). The Churchill dam supplies water to the Port Elizabeth area and has a holding capacity of 33 000 000 m^3 (Heymans, 1992). Numerous small dams are also situated on the tributaries of the Kromme River. These dams greatly reduce freshwater input into the estuary (Baird *et al*, 1992). The dams have the combined capacity of storing approximately 133% of the MAR of the Kromme River catchment (Baird *et al*, 1992). As a result the freshwater inflow inflow into the Kromme Estuary is irregular and relatively low. The mean annual inflow rate into the estuary is about 11 000m^3. The system is considered to be freshwater starved (Baird *et al*, 1992).

Hydrological impact of alien plant infestations

About 6.5% of the catchment area of the Kromme River system has been invaded by alien plant species. The worst of these invaders are *Hakea, Pinus spp, Acacia dealbata, Acacia melanoxylon* and *Eucalyptus spp,* with *Acasia mernsii* (Chapman *et al*, 1998). This invasion reduces annual water runoff by about 27.90 million m^3 per annum (Chapman *et al*, 1998).

General Description of the Kromme Estuary

The Kromme River rises in the Tsitsikamma Mountains. Its main tributary is the Dwars River. The water in it is clear and of good quality. The flow of river water into the estuary is controlled by the sluice gates of the Churchill Dam. These gates are usually closed for the duration of the summer (Day, 1981).

Sedimentation

The damming of the Kromme river has decreased the scouring effect of floods (Heymans, 1992). As a result there has been sediment accumulation in the lower reaches of the estuary. This sediment buildup occurs because there are no strong floods to transport the sediment out to sea. Supplementing this sediment build up has been the creation and vegetation of a large sand-spit of approximately half a kilometer long in order to provide protection to the marina against strong South Easterly gales.

Temperatures

The seasonal temperatures range between 14° and 24° (Day, 1981).

Salinity

Due to the fact that the sluice gates of the Churchill Dam are closed during the summer, salinity values in this season often rise to above 35 parts per thousand in

parts of the estuary. The normal salinity values vary from about 20 – 33 parts per thousand in the middle reaches to about 35 parts per thousand near the mouth (Day, 1981).

Biotic Characteristics

The Kromme River Estuary is a marine dominated one, with a rich fauna and flora.

Services provided by the Kromme Estuary

The Kromme River Estuary and the canals connected with it are the main recreational attractions of the town of St. Francis Bay. Recreational activities on the estuary include fishing, birding, bait collection, waterskiing, canoeing, boat cruisers, hiking and swimming.

4.2.2 DETERMINATION OF TARGET POPULATION AND SAMPLE SIZE: KROMME ESTUARY

There are approximately 2 549 permanent residents living within 10 kilometres of the Kromme Estuary (Davids, 2002), although not all of these permanent residents make use of the Kromme Estuary. The local tourism authority was consulted in order to estimate the total user population of the Kromme Estuary. As the Kromme Estuary is very popular with visitors, it was expected that the total user population would be substantially larger than the permanent resident population.

The local tourist authority estimated the per annum population of users to be about 18 000. Based on additional information gained during the surveys, this figure was revised upwards to 19 200. Users were broken down into three main categories: recreation, commercial/subsistence and non-users. Recreational users were asked for which type of use they mainly valued the estuary: boating, swimming, fishing/bait collecting, bird watching or aesthetic appeal. The majority of those

interviewed were multi-users of the estuary. A total of 150 respondents were interviewed. Assuming an average of six people per household, this sample amounted to about 5% of the target population.

4.3 THE NAHOON ESTUARY

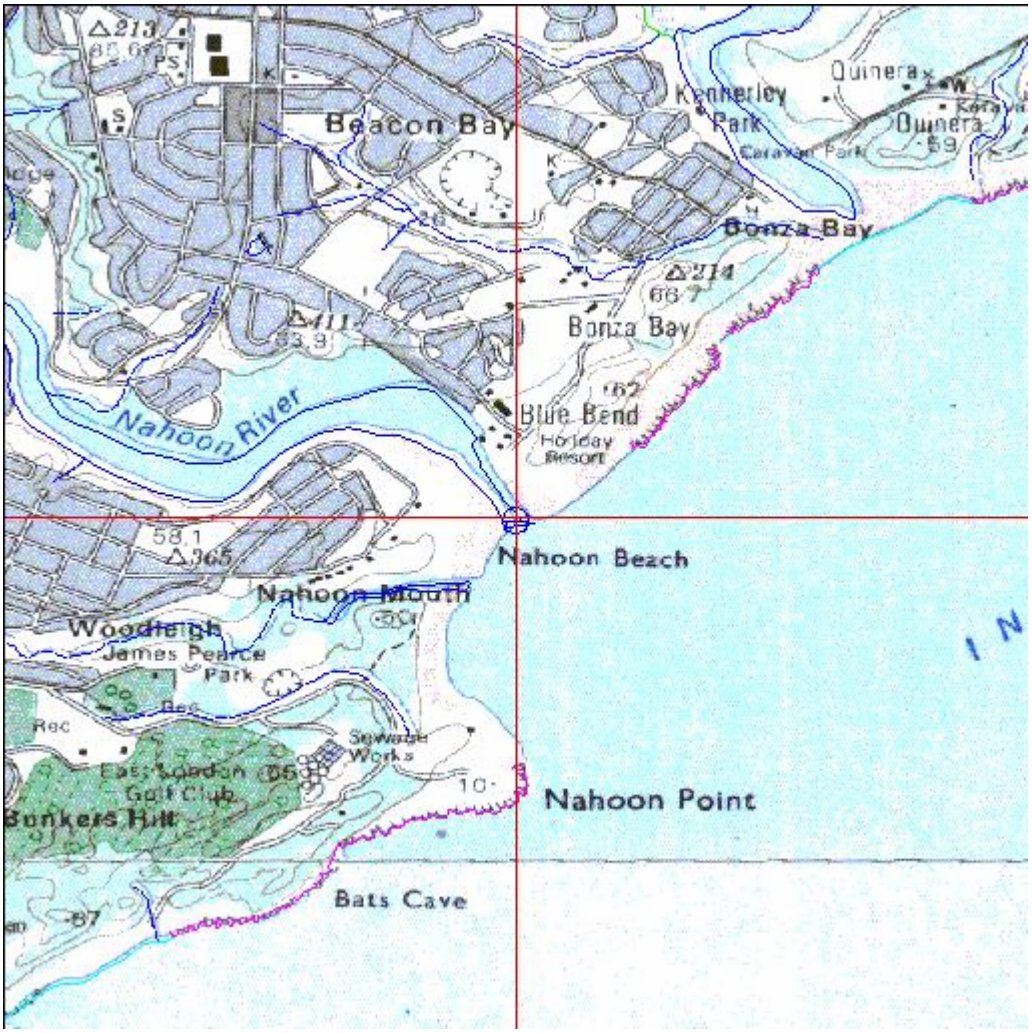

Figure 4.5: Map of the Nahoon Estuary

Source: www.upe.ac.za

Figure 4.6: Photo of the Nahoon Estuary

Source: www.faculty.valencia.cc.fl.us

4.3.1 PHYSICAL DESCRIPTION AND USES

The Nahoon Estuary is located near the coastal city of East London. The Nahoon river flows into the Indian Ocean approximately 6.8km north-east of East London harbour. The co-ordinates of the Nahoon River mouth are 32°59'S : 27°57'E. The estuary is situated within a residential area (Wiseman, Burns and Vernon, 1993). The Nahoon River is approximately 77km long.

Abiotic Features

Climate

The climate of the South East Cape (where the Nahoon Estuary is situated) is humid and temperate with rainfall in all seasons. The major climatic influences are the warm, offshore, southward flowing Agulhas Current, the topography of the coastline and the interaction between the east moving cyclones of the circumpolar

westerlies and the sub-tropical belt of anti-cyclonic high pressure cells (Wiseman *et al*, 1993).

Area of river catchment

Estimates of the area of the river catchment vary from 625km^2 (Heydorn and Grindley, 1980) to 574km^2 (Reddering and Esterhuysen, 1985).

Geology

The catchment of the Nahoon River has geological formations typical of the Karoo system. Dolorite sills and dykes are evident. Examples of these dolorite outcrops can be seen at Nahoon point and at the Nahoon river mouth. The soil types present within the catchment area are determined by the underlying geological formations. Sedimentary rock is also present in the catchment. The soil type differs greatly within the region, depending on whether its origin is dolomite or sedimentary (Wiseman *et al*, 1993).

Tributaries

The Nahoon River has numerous small, unnamed tributaries entering from both the North and the South. Upstream of the Nahoon dam, the Ngqkana and Kwetyana tributaries enter from the North, and the Rwantsa tributary joins the Nahoon from the South (Wiseman *et al*, 1993).

Land ownership and catchment users

The catchment of the Nahoon River has minimal forested area (Reddering and Esterhuysen, 1985). Domestic livestock farming is an important agricultural activity in the area. Cattle are the most commonly kept livestock. About 60% of the cattle are used for beef, while the remaining 40% are used for dairy. Sheep, goats, pigs and poultry farming is also practiced in the catchment area.

Obstructions

A number of small farm dams exist on the tributaries of the Nahoon River, but the only major dam on the river is the Nahoon dam, which is situated about 27km upstream from the mouth of the estuary. The Nahoon dam was completed in 1966 and is the property of the Department of Water Affairs. As a result of increases in the demand for water in the area, the Department of Water Affairs decided to raise the height of the dam wall. The dam now supplements urban and industrial water supplies to the East London Metropolitan area and certain adjoining townships. The dam is classified as medium-sized in relation to the MAR feeding the river (Baird and Allanson, 1999).

The Abbotsford Causeway obstructs both river and tidal flow. This causeway constricts natural water flow in the river and confines estuarine conditions, including tidal affects, to the river course downstream of its position (Wiseman *et al,* 1993). Three other bridges cross the Nahoon River in its lower reaches, but have no significant influence on the natural flow of the water. They are the National Road Bridge, the North East Expressway Bridge and the Jack Batting Bridge (Wiseman *et al*, 1993).

Run-off and Flow records

Estimates of the MAR for the Nahoon River in million m^3 vary from 34 (Midgley, Pitman and Middleton, 1981) to 33,65 (Baird and Allanson, 1999).

Hydrological impact of alien plant infestations

About 1.61% of the catchment area of the Nahoon River system has been invaded by alien plant species. The worst of these invading species are *Hakea, Pinus spp, Acacia dealbata, Acacia melanoxylon, Eucalyptus spp,* especially *Acasia mernsii* (Chapman *et al*, 1998). This invasion reduces annual water runoff by about 3.44 million m^3 per annum (Chapman *et al*, 1998).

Sedimentation

There has been a sediment build up in the Nahoon River system as a result of erosion in the catchment area. The erosion in the catchment is partly caused by the variable characteristics of the regional climate and partly by reduced vegetative cover due to intensive grazing (Wiseman *et al,* 1993). The area is prone to periodic droughts and floods.

Temperatures

The seasonal range of temperature at the mouth is 14-22°C (Day, 1981).

Biotic Characteristics

The Nahoon Estuary supports a large variety of flora and fauna.

Services provided by the Nahoon Estuary

The Nahoon Estuary provides many services that support recreation, especially boating, swimming, fishing and birding. According to Christo Hunt of the Coastal Conservation Office, there are fewer access points to the Nahoon Estuary than one would expect for an estuary entirely surrounded by a city. Steep banks and vegetation are part of the reason and its short length (say compared to the Swartkops Estuary in Port Elizabeth) another part.

4.3.2 DETERMINATION OF TARGET POPULATION AND SAMPLE SIZE: NAHOON ESTUARY

There are approximately 182 026 permanent residents living within 10 kilometers of the Nahoon Estuary (Davids, 2002). Interviews were conducted with the local tourism authority in order to determine the estimated user population of the Nahoon Estuary. Table 4.3 summarizes population information available from relevant conservation authorities consulted.

Table 4.3: User population estimate: Nahoon Estuary

USER GROUPS	NUMBER OF USERS PER ANNUM		
	RESIDENT	TOURIST	TOTAL
1) RECREATIONAL			
a)Boaters	500	145	645
b)Swimmers	250	125	375
c)Fishers	400	150	550
d)Birders	150	125	275
e)Proximity/view	1900	2100	4000
Total	**3200**	**2645**	**5845**
2) COMMERCIAL	0	0	0
3) SUBSISTANCE	30	0	30
4) PASSIVE USE	**1500**	**1500**	**3000**
(Viewing estuary coincidentally or enjoyment not related to active use)			
5) ALL GROUPS	**4730**	**4145**	**8875**

Source: Hunt and Rheeder (2004)

The total user population of the Nahoon Estuary is about 8875 (see Table 4.3). From Table 4.3, it appears as if the Nahoon Estuary does not have as many users as one would think, i.e., the Nahoon Estuary is situated near the city of East London. This may be due to the fact that the Nahoon Estuary is one of four estuaries serving East London, the other three being the Buffalo, Bonza and Gonubie estuaries. Fishing appears to be a popular activity, with a total of about 550 users per annum. Boating does not appear to be all that popular (when compared to the Kowie and Kromme estuaries) with a total of about 645 users per annum.

If it is assumed that there are an average of 6 persons per household in the Nahoon area, an estimated 1479 households are currently making use of the Nahoon Estuary per annum. A total of 294 users were interviewed. This amounted to about 20% of the target population.

4.4 CONCLUDING COMMENTS

Each of the three study sites selected for this study, namely the Kowie, Kromme and Nahoon estuaries, are unique in biological features (Whitfield, 2000). The Kowie Estuary is rated high/protected in terms of plant, bird and conservation importance and medium/partially protected in terms of invertebrate importance. The Kromme Estuary is rated low/not protected regarding fish importance and high/protected for plants and invertebrates. Insufficient information is available to rate the bird importance according to this classification. The Nahoon Estuary is rated as high/protected for plant and fish importance and medium/moderately protected for birds and invertebrates.

The user populations of the Kowie, Kromme and Nahoon estuaries are unique. The Kowie and the Kromme estuaries are very popular for recreational use and have large recreational user populations. Many people visit the towns of Port Alfred and St Francis Bay in order to make use of these estuaries. The Nahoon Estuary is also popular for recreational use, however, the total per annum user population is relatively small when compared to the user populations of the Kowie and the Kromme. This may be due to the fact that the Nahoon Estuary is one of four estuaries servicing the city of East London. The total user populations of the Kowie, Kromme and Nahoon estuaries are 19 406, 19 200 and 8 875 respectively.

In what follows (Chapter Five) the various questionnaires used for this research will be discussed, along with sample design issues.

CHAPTER FIVE: SAMPLE AND QUESTIONNAIRE DESIGN ISSUES

5.1 INTRODUCTION

Proper questionnaire design and appropriate administration of the questionnaire is of vital importance if the data thereby generated is to be used to guide decision making. A poorly designed questionnaire will result in sub-standard data, will not successfully address the relevant research question and will be of minimal use to the decision maker (Frazer and Lawley, 2000). Chapter Five will examine the crucial aspects that need to be considered when designing a research questionnaire as well as outline a method of generating an acceptable sample size.

The questionnaires which were used to elicit values of freshwater inflows into the Kowie, Kromme and Nahoon Estuaries will also be described. Some improvements were made to the questionnaires used to value freshwater inflows into the Nahoon Estuary.

The surveys for the Kowie and the Kromme estuaries were administered in January 2003. Mr Michael Sale carried out the survey at the Kowie Estuary and Mr Dods Blom carried out the survey at the Kromme Estuary. The survey for the Nahoon Estuary was performed by Mr Radu Mihaelescu during December 2004. Every effort was made to ensure consistency and the elicitation of credible responses.

5.2 METHODOLOGICAL ISSUES TO CONSIDER WHEN DESIGNING A RESEARCH QUESTIONNAIRE

There are five steps involved in designing a research questionnaire (Frazer *et al*, 2000). Each of these steps will be described and related to the questionnaire used in this study.

Step One

The first step in designing a questionnaire is to determine the information required and establish from whom the information should be sought (the target population). The critical question in this study was to determine the individual's willingness to pay for freshwater increases, where the benefit of these increases was improved estuarine recreational services. The questions needed to be phrased in such a way as to reduce the types of bias that are commonly experienced in studies like this (see Chapter Three). The information was sought from users of the relevant estuary, both active and passive. A passive 'user' is a person who derives utility from an estuary as a by-product of some other activity not directly related to the estuary, e.g., view while going passed in a car (Carson, Flores and Mitchell, 1999). The active users were further categorized into recreational or commercial/subsistence users.

Step Two

The second step in questionnaire design is to determine the interview method and the length of the questionnaire. There are a number of choices available to the designer of the questionnaire: mail questionnaires, personally administered questionnaires, telephonic interviews and internet based questionnaires. Each of these methods has advantages and disadvantages. In this study, use was made of the personally administered questionnaire technique because the extensive information exchange required. It was particularly important that the consequences

of freshwater inflow changes into estuaries be properly explained to the respondent. Most respondents possessed some knowledge on estuary ecology but had gaps in their knowledge. One of the main disadvantages of the personal interview technique is that it is very time consuming.

A payment card system was used in order to elicit the willingness to pay bids for the freshwater inflows. In order to limit respondent fatigue the questionnaire was restricted to 19 questions.

The scenario being valued was kept as concise as possible and the number of questions was kept to a minimum so as not to impose excessively on respondents. A balance had to be made between providing enough information for respondents to understand the economic good they were being asked to bid for and minimizing the time imposition on them.

Step Three

Once the content of the questionnaire has been determined a draft must be prepared. There are four main features to be considered when preparing the draft, namely question content, question wording, the desired format for the responses and the layout of the questionnaire.

Step Four

Once the questionnaire has been drafted, a pilot study should be performed.

Step Five

Finally, the answers elicited through the questionnaire must be assessed for reliability and validity (Frazer *et al*, 2000).

5.3 SAMPLE SIZE DETERMINATION

The target population in this particular application of the CVM was defined to be all the people with a demand for the services of each respective estuary. It proved to be a difficult task identifying these people as no records are kept on user population figures for the majority of South African estuaries. After much consideration it was deduced that the best method available to generate realistic user population estimates was to hold interviews with the appropriate conservation authorities.

Once the user populations were identified, the appropriate sample sizes had to be determined. Sample size determination is a very important part of studies of this sort. Too small a sample size undermines the power of the statistical tests for the significance (Hair, Anderson, Tatham and Black, 1998). The sample should represent the entire population.

Due to budget constraints, the sample sizes were set at a fixed proportion of 5% of the preliminary estimated target populations. Preliminary estimates of the target population were generated from interviews with local authorities on the user population. These preliminary estimates were approximate and similar in scale. They are shown in Tables 5.1 and 5.4.

Table 5.1: Sample sizes based on preliminary user population estimates

Estuary	Estimates of number of households	Sample size of households at 5% of sample population
Kowie	3000	150
Kromme	3000	150

Source: Survey team estimates

The preliminary estimates of the target population were revised after additional insights had been gained during the administration of the surveys. The revised estimates are shown in Table 5.2.

Table 5.2: Revised sample sizes based on reviewed population estimates

Estuary	Estimates of number of households	Sample size of respondents	Sample size as % of target population
Kowie	3234	150	4.64%
Kromme	3200	150	4.69%

Source: Survey team estimates

These sample sizes were smaller than was desirable – based on the approach advocated by Cochrane (1977) with respect to random sampling with continuous data. In terms of this approach sample size should be as follows (Equations 5.1 and 5.2):

$$n = \frac{n_o}{1 + \left(\frac{n_o}{N}\right)} \quad \text{.....(5.1)}$$

$$n_o = \left(\frac{z_{\alpha/2} s}{r\bar{Y}}\right)^2 \quad \text{.....(5.2)}$$

where n_0 = first approximation of n

n = minimum sample size

$z_{\alpha/2}$ = area under the normal distribution

r = relative error (error allowance about the mean)

s = standard error of estimate

$\bar{Y}$ = sample mean

N = population size

The approach assumes a normal distribution of the estimated sample size. In order to populate these formulas the relevant mean and the standard error statistics were needed. As a proxy mean and standard error statistics were used from a pilot study carried out in the year 2000 by members of the survey team. These values were 273.67 and 262.26 respectively (du Preez, 2002). It was assumed that the mean WTP for each of the selected estuaries would vary within 10% of the pilot study mean and with a 95% confidence level. The estimated sample sizes for the selected estuaries, in terms of the Cochrane (1977) method, are shown in Table 5.3. These sample size estimates are based on the preliminary target population estimates.

Table 5.3: Preferred sample sizes using random sampling technique and revised user population estimates

Estuary	Estimates of number of households	Preferred sample size of respondents*	Preferred minimum sample size as % of target population
Kowie	3000	315	10.5%
Kromme	3000	315	10.5%

Note: * using formulas 5.1, 5.2 and du Preez's (2002) Keurbooms data

As can be seen in Table 5.3, the preferred sample sizes are significantly higher than those that were selected, especially for the cases where the target populations were smaller. The main impact of this error in the method used to value the freshwater inflow into these estuaries was to undermine the significance of the WTP function parameters.

The Cochrane (1977) method for determining sample sizes was also used in order to determine the sample size for the Nahoon Estuary. The relevant population size is shown in Tables 5.4 and 5.5.

Table 5.4: Sample size based on population estimate: Nahoon Estuary

Estuary	Estimates of number of households	Sample size of respondents	Sample size as % of target population
Nahoon	1479	294	19.8%

Source: Hunt and Rheeder (2004)

Using the Cochrane method for determining sample size and du Preez's Keurbooms mean and standard error results, the preferred sample size for the Nahoon Estuary is as shown below in Table 5.5.

Table 5.5: Preferred minimum sample size: Nahoon Estuary

Estuary	Estimates of number of households	Preferred sample size of respondents	Preferred minimum sample size as % of target population
Nahoon	1479	193	13%

Note: * using formulas 5.1, 5.2 and du Preez's (2002) Keurbooms data

The preferred minimum sample size is lower than the sample size (Table 5.5).

5.4 QUESTIONNAIRE USED TO VALUE THE FRESHWATER INFLOWS INTO THE KOWIE AND KROMME ESTUARIES

A pre-coded questionnaire was designed for the Kowie and Kromme user populations taking into account the five steps recommended by Frazer *et al* (2002). The people conducting the interviews were trained and educated about the various sites in order to limit information bias. A scenario was formulated to make respondents aware of the consequences of a reduction of water inflows. The main consequences were reductions in estuary size and deterioration in quality of

habitat for fish. The respondent's willingness-to-pay was for a water supply arrangement to prevent these consequences. These changes (specific to each estuary) are presented below, along with the supporting information supplied on the WTP question.

5.4.1 THE SPECIFIED CHANGE AND WILLINGNESS TO PAY QUESTION: KOWIE ESTUARY

The willingness to pay question presented to potential respondents at the Kowie Estuary was based upon changes specified by Prof. T. Wooldridge of the NMMU. Users of the Kowie Estuary were informed that an increase of 56% of current fresh water inflow into the Kowie Estuary, would be expected to have consequences of the following magnitudes:

For boaters: No change in estuary services would occur.
For swimmers: No change in estuary services would occur.
For fishers/bait collectors: A 25% increase of angling fish that use the estuary and a 25% increase in the availability of mudprawn.
For birders: A 25% increase of foraging birds in the intertidal areas.
From the perspective of view: No change in estuary services.
From the perspective of the world generally: No change.
Prof Wooldridge argued that fishers, bait collectors and birders would be most affected by changes to the Kowie Estuary brought about by increased freshwater inflows.

In the survey, most of the respondents interviewed appeared to be interested but poorly informed about the freshwater inflow issues relating to estuaries. Some of the interviews lasted over one hour as a result of the need to communicate the necessary information.

5.4.2 THE SPECIFIED CHANGE AND WILLINGNESS TO PAY QUESTION: KROMME ESTUARY

The contingent valuation at the Kromme was also undertaken with reference to changes specified by Prof T. Wooldridge of NMMU. Respondents were informed that an increase of 812% of current fresh water inflow into the Kromme Estuary, would be expected to have consequences of the following magnitudes:
For boaters: No change in estuary services would occur.
For swimmers: No change in estuary services would occur.
For fishers/bait collectors: A 25% increase of angling fish that use the estuary and a 25% increase in the availability of mudprawn.
For birders: A 25% increase of foraging birds in the intertidal areas.
From the perspective of view: No change in estuary services.
From the perspective of the world generally: No change.

Prof Wooldridge argued that fishers, bait collectors and birders would be most affected by the changes to the Kromme Estuary induced through increased inflows of freshwater. As the Kromme Estaurine system is essentially freshwater starved, this required freshwater change seems relatively large in comparison to the Kowie and the Nahoon estuaries.

5.4.3 THE SPECIFIED CHANGE AND WILLINGNESS TO PAY QUESTION: NAHOON ESTUARY

The willingness to pay question presented to potential respondents at the Nahoon Estuary was also based upon changes specified by Prof. T. Wooldridge of the NMMU. Respondents were informed that a 67% reduction of freshwater inflow into the Nahoon Estuary, would have consequences of the following magnitudes:

For boaters: 10% reduction in boating area due to increased evaporation.
For swimmers: A 10% reduction in area for swimming due to increased evaporation.
For fishers/baiters: Biomass of angling fish will experience a 25% reduction, due to hypersaline conditions and biomass of bait will experience a 25% reduction, also due to hypersaline conditions.
For birders: A 25% reduction in the biomass of birds due to hypersaline conditions.
General view: A 10% change.

Respondents were reminded of the substitutes that were available before being asked to answer the WTP question. In the case of the Nahoon Estuary there were many. The WTP question was linked to a possible future event (the scenario) about a change in freshwater inflow. Using a levy as the payment vehicle was found to be credible with the respondents. They were told that the same levy would be charged to residents and tourists. Many of the respondents already paid similar such levies.

The 19 questions making up the whole questionnaire are discussed below.

Question one asked what the predominant use of the estuary was for each respondent. It provided for the respondent to use the estuary for commerce as well as recreation, but if his primary use was commerce, the respondent was allotted into the commercial category. A non-user category was added to the options, to capture those who would offer to give up part of a personal budget in order to conserve a specific estuary they did not directly use. No non-users of the Kowie Estuary were identified, although a very small number of non-users were identified at the Kromme Estuary.

Questions two and three asked the race and sex of respondents. The purpose of including them was to enable testing to take place to see if race and sex explained differences in willingness to pay.

Question four asked if the respondent was a visitor or a resident. It was expected that residents would have a stronger desire than tourists to conserve an estuary because they would use it more often. Visitors could simply go elsewhere and make use of a substitute.

Question five tested the respondent's knowledge about the estuary. It was an interactive question and the interviewer's responsibility was to fill in the gaps in the respondent's knowledge.

Question six asked whether the respondent made a living out of the estuary. It proved to be unnecessary as the information revealed nothing additional to that of question one.

Questions seven, eight and nine elicited information about the frequency of use of the estuary by the respondent. The higher the number of estuary users a respondent answered to and the higher the frequency of use for these users, the higher the willingness to pay was expected to be.

Question ten asked the respondent to rank the different attributes and activities for the estuary. The purpose of this question was to reinforce the knowledge of the different services yielded by the estuary and their relevance to the user. The higher the ratings assigned to the activities/attributes, the higher the respondents willingness-to-pay was expected to be.

Question 11 asked the respondents what their current cost was of using the estuary.

Question 12 asked what the respondent was WTP to secure an increase in fresh water inflow. The main aim of a contingent valuation is to determine the WTP of each respondent. The payment vehicle was in the form of an annual levy. This fresh water inflow would ensure that the attributes or activities that respondents associated with a particular estuary were maintained or improved. To provide the fresh water to conserve the services provided by the estuaries would lead to a cost in the form of funding a project to do so.

The *payment vehicle* (annual levy) was a fee over and above what the respondent already paid to ensure adequate fresh water inflows. The payment card method was used to elicit the WTP. This method reduces starting point bias by providing a visual range of options from which the respondent chooses. Some of the people conducting the interviews felt that the ranges were far too wide for some user groups, e.g., subsistence users. A disadvantage of this method for determining a bid is that it differs from the way purchases are normally made, where an offer is made and the buyer accepts or rejects that price.

Question 13 was a follow-up question on the zero responses. The respondent was asked for his/her reasons for a zero response, if this was made. It was recognized that a zero WTP could either be a protest response against the payment collection system or a real bid.

Question 14 asked what the respondents sacrificed to make this payment. It was recognized that every respondent faces a budget constraint. The purpose of reminding respondents of their budget constraints was to get the respondents to reflect one last time on their WTP response. After responding to this question the

people conducting the interviews were asked to check if the respondent was still happy with their WTP answer (given to question 12).

Questions 15 to 18 asked for information that would help explain the respondent's WTP. Question 15 asked how far the respondents stayed from the estuary. Respondents who lived closer to a specific estuary were expected to have a higher WTP. Question 16 asked what the value was of the equipment owned by the respondent that was directly used to access the estuary services. Question 17 asked what the person's level of education was. Question 18 asked what the respondent's level of income was. It was expected that level of income and WTP would be positively correlated.

Question 19 was an open question in which respondents were invited to discuss any issues related to the research being undertaken. The purpose of this question was to highlight issues affecting WTP that were not covered in the questionnaire.

5.5 QUESTIONNAIRE USED TO VALUE THE FRESHWATER INFLOWS INTO THE NAHOON ESTUARY

Various changes were made to the questionnaire used to value freshwater inflows into the Nahoon Estuary in the light of experience gained in administering the questionnaires at the Kromme and Kowie estuaries. These changes will now be discussed.

Question one

More detail was extracted from the respondent in terms of user category. The respondent was asked to attach the relative importance of various activities / attributes of the Nahoon Estuary, instead of merely stating which user category he

/ she fell into. This was done in order to try and predict the behaviour of the respondents (in terms of WTP) more accurately.

Questions two, three and four

As previously stated, question two, three and four extracted the race of the respondent, the gender and whether the respondent was a visitor or resident. No changes were made to these questions.

Question five

Question five was a new question. The person conducting the interview had to indicate on a map of the estuary provided with the questionnaire where each particular interview took place.

Question six

Question six asked the respondent how often he / she made use of the estuary.

Question seven

Question seven was slightly changed from the previous research questionnaire. Instead of merely asking the respondent how many members in the household there were, the respondent was now asked how many members of the household made use of the estuary in some or other way. This was done to exclude non-using members of the household and concentrate solely on household members deriving utility from the Nahoon Estuary.

Question eight

Question eight asked the respondent to reveal his or her gross annual pretax income. It was decided to increase the number of options available to the respondent. A positive relationship was expected to emerge between WTP and income of respondent.

Question nine

Question nine was a new question asking the respondent what percentage of their pre-tax income he / she would be prepared to spend on the conservation of environmental resources. This question was included, to try examine the part – whole bias issue.

Question ten

Question ten attempted to extract the respondent's knowledge regarding the functioning of the Nahoon Estuary. No changes were made to this question.

Question 11

Question 11 was the critical WTP question. No changes were made to this question.

Question 12

Question 12 asked the respondent to provide a reason for non-payment (if their WTP was zero). No changes were made to this question.

Question 13

Question 13 asked the respondent how much he / she was already paying in fees to access the estuary. This question was similar to the one used in the previous questionnaire, but an open ended question format was made use of instead of a payment card elicitation method.

Questions 14, 15 and 16

Questions 14, 15 and 16 were new questions asking respondents to reveal their user costs of making use of the Nahoon Estuary, in terms of travel costs, accommodation costs and equipment costs.

Question 17

Question 17 asked how important the Nahoon Estuary was to the respondent, regarding their choice of the resident / vacation area.

Question 18

Question 18 was a new question, asking respondents to reveal how important an attraction the Nahoon Estuary was as a factor influencing them to visit the area.

Question 19

Question 19 was an open ended question providing the opportunity for the respondent to add any comments / suggestions on issues relating to the estuary.

5.6 CONCLUSION

One of the most crucial aspects of a CV study is proper sample design. The objective in such studies is to achieve a representative and unbiased sample of the user population. It proved to be very difficult to identify the exact user populations of each of the three selected study sites. For budget constraint reasons the sample sizes were set at 5% of the estimated target population for the Kowie and the Kromme estuaries. These samples proved to be less than the minimum preferred in terms of statistical theory. The sample size for the Nahoon Estuary was increased to overcome this problem.

There are a number of important methodological issues to consider when designing a research questionnaire. These were taken into account in designing the questionnaires administered at the Kowie and Kromme estuaries. Various changes and improvements were made to the questionnaire used to value the freshwater inflows into the Nahoon Estuary (using lessons learned from the questionnaires administered at the Kowie and the Kromme). In addition to sound

questionnaire design it is also important for the interviewer to be well trained and familiar with the research.

The sample sizes at the Kowie, Kromme and Nahoon estuaries respectively were 150, 150 and 294.

Chapter Six presents the statistical results of the three surveys that were administered at these estuaries.

CHAPTER SIX: RESULTS OF APPLYING THE CONTINGENT VALUATION METHOD TO VALUE WATER INFLOWS INTO THE KOWIE, KROMME AND NAHOON ESTUARIES

6.1 INTRODUCTION

Chapter Six describes the data collected at the respective study sites. The format of Chapter Six is that the descriptive statistics of the various study sites are presented and discussed. After this a description of the selected variables in the multiple regression analysis is presented and discussed. Following this presentation the estimated WTP (bid) functions are reported on. Two statistical models were used for this purpose, namely the OLS and Tobit models. Finally, the issues of validity and reliability relating to the WTP estimates are addressed.

6.2 DESCRIPTIVE STATISTICS

6.2.1 SAMPLE SIZES AND RESPONSE RATES

The proportion of valid responses for the Kromme Estuary was 100%, while that for the Kowie Estuary was 67%. The reason for the lower response rate at the Kowie Estuary was that many of the respondents were reluctant to provide information on their annual pre-tax income. The proportion of valid responses in the Nahoon Estuary survey was 92%.

The relevant sample sizes and response rates are summarized in Table 6.1 below.

Table 6.1: Sample sizes and response rates

Estuary:	**Kowie**	**Kromme**	**Nahoon**
Questionnaires administered	150	150	294
Valid responses	100	150	270

6.2.2 USER CATEGORIES OF RESPONDENTS

Table 6.2 shows the categories of users/respondents in the Kowie and Kromme estuary surveys.

Table 6.2: User categories of respondents: Kowie and Kromme

Estuary:	**Kowie**	**Kromme**
Recreation	97	138
Commercial/ subsistence	3	4
Non-users	0	7
Recreation Commercial/subsistence	0	1

The majority of users surveyed at the Kowie and the Kromme estuaries were recreational. There were few users whose primary use was for commerce or subsistence. The question regarding user categories for the Nahoon Estuary was slightly different to that of the Kowie and the Kromme. The respondent was presented with activities or attributes of the Nahoon Estuary and asked to rate the importance he or she placed on each activity. The respondent was presented with five options ranging from unimportant (1) to extremely important (5). A summary of responses per activity/attribute is provided in Table 6.3. The question was intended

to elicit information on what services the user population of the Nahoon Estuary found to be most important.

Table 6.3: Relative importance of activities/attributes of the Nahoon Estuary.

	Percentage of respondent's rating:				
Activity:	**Unimportant**			**Extremely important**	
	1	**2**	**3**	**4**	**5**
Boat sports	54.72%	6.42%	9.81%	10.94%	18.11%
Swimming	23.79%	9.29%	15.99%	13.75%	37.17%
Fishing	59.77%	8.81%	8.81%	6.51%	16.09%
Viewing	2.23%	2.97%	4.09%	22.30%	68.40%
Proximity: Banks for picnics etc	3.72%	5.58%	8.18%	15.61%	66.91%
Bird watching	55.02%	13.38%	16.73%	6.69%	8.18%
Commercial Activity	84.35%	5.34%	0.76%	2.29%	7.25%
Subsistence	86.42%	9.43%	2.64%	0.38%	1.13%
Preservation of unique features	68.18%	3.03%	2.27%	5.30%	21.21%
Passive use (not related to active use)	75.09%	5.28%	3.77%	3.40%	12.45%

Boat sports are not very popular among the uses of the Nahoon Estuary (see Table 6.3). A possible reason for this lack of popularity is that the Nahoon Estuary does not have an abundant supply of access points from which to launch a boat and has a relatively small area to accommodate boating activities. Swimming in the estuary is relatively important especially during the summer months. Fishing is rated as unimportant by the majority of respondents (59.77%). There appear to be many other preferred fishing areas in East London, especially directly in the surf zone. About 68.40% of the respondents rated viewing the estuary as extremely important. This finding was expected as the Nahoon estuary is aesthetically pleasing and people derive pleasure from viewing naturally beautiful resources. Proximity was also rated as extremely important (66.91%) but bird watching was not a popular activity among the users of the Nahoon Estuary, with just over half of the respondents (55.02%) rating this activity as unimportant. Again it appears that there are many other (often better) areas for bird watching in East London, for example, around the Gonubie Estuary.

Commercial activity was rated as unimportant by 84.35% of the respondents surveyed. The users of the Nahoon Estuary survey wanted the estuary to be kept as undeveloped and as natural as possible. Subsistence use was considered unimportant by most of the respondents, with only 1.13% of the respondents rating subsistence use to be extremely important. Virtually all of the respondents did not rely on the estuary as a source of direct food. Surprisingly, more than half of respondents (68.18%) did not appear to be concerned with preserving the unique features of the Nahoon Estuary, even though they were against increased commercial activity. Passive use was rated as unimportant by most of the respondents interviewed (75.09%).

6.2.3 SOCIO-ECONOMIC PROFILE OF RESPONDENTS

Table 6.4 summarizes the socioeconomic profile of the respondents in the surveys conducted at the Kowie, Kromme and Nahoon estuaries.

Table 6.4: Socio-economic profiles of respondents: Kowie, Kromme and Nahoon estuaries

Averages	**Kowie**	**Kromme**	**Nahoon**
Household size (No. of people)	4.0	2.8	3.3
Annual levies paid (in Rands)	335	391	98
Distance of respondents' current accommodation (in Km)	2	3	5*
Approximate worth of respondents' vehicles and boats owned (in Rands)	219340	208173	856**
Education level of respondents (No. of years)	13	13	***
Annual pre-tax income (in Rands)	258500	186833	****

*Median value

**Approximate worth of equipment used to access estuary per annum

*** The respondents were not asked this question in the Nahoon Estuary survey.

****The majority of respondents were not comfortable answering this question.

The surveys for the Kowie and the Kromme estuaries were conducted during the month of January 2003 and the survey for the Nahoon Estuary was conducted during December 2004.

6.2.4 WILLINGNESS TO PAY

Table 6.5 shows a summary of the willingness to pay responses elicited for the stated improvements to estuary services in the Kowie and the Kromme estuaries that would be brought about by specific fresh water inflows.

Table 6.5: Percentage of respondents who gave positive WTP responses and zero WTP

Willingness to pay (WTP) in Rands	**Kowie (% of respondents)**	**Kromme (% of respondents)**
Zero willingness to pay		
0	22.7	28.7
Non-zero bids (Rands)		
5	1.0	0.0
15	3.0	0.0
25	2.0	0.0
40	10.0	0.7
75	18.0	7.3
150	15.0	8.7
350	22.0	33.3
750	9.0	12.7
1500	2.0	8.7
2500	0.0	0.0
3500	0.0	0.0
4000	1.0	0.0
Mean (Rands)	255.5	360.4
Median (Rands)	75	350

Note: These values relate to the month of January 2003.

Table 6.6 below shows the sample median and mean willingness to pay for estuarine service improvements for the Nahoon Estuary.

Table 6.6: Sample median and mean willingness to pay of respondents at the Nahoon Estuary.

Mean WTP	R130
Median WTP	R75

Note: These values relate to the month of December 2004.

The Tables 6.5 and 6.6 show the mean and median willingness to pay as gathered from the respondents surveyed. Only 1 percent of the respondents for the Kowie Estuary had a WTP in excess of R4000. These respondents were treated as outliers and excluded in generating predicted WTP mean and median values.

The descriptions of the explanatory variables selected for the purpose of generating predictive WTP models are shown in Tables 6.7 and 6.8. Their expected relationships in terms of economic theory with household WTP are also shown.

Table 6.7: Description of selected variables in the multiple regression analysis: Kowie and Kromme estuaries

Variable	Description	Expected sign
	Dependent variable:	
WTP_H_Q	amount household would pay for increased fresh water inflow.	
	Independent variable:	
Recreation	1= if respondent uses estuary for recreation purposes; 0= otherwise	+ or -
Comm/subs	1= if respondent uses estuary for commercial/subsistence purposes; 0= otherwise	+ or -
Race	1= if respondent belongs to white racial group; 0= otherwise	+ or -
Male	1= if gender of respondent is male; 0= otherwise	+ or -
Visitor	1= if respondent uses estuary as visitor; 0= otherwise	+ or -
Well-informed	1= if respondent is well-informed regarding the impact of increase of water inflow into estuary; 0= otherwise	+
People/house	number of people making up the respondent's household	+
Levies	Amount of levies paid in Rands by the respondent's household for fishing, boating, bait collection and other activities per year	+
Distance	distance in kilometers of respondent's current accommodation	-
V_B_Worth	approximate worth of respondent's vehicles and boat owned at current prices	+
Education	highest education level attainment of respondent	+
Income	gross annual pre-tax income of respondent	+

Table 6.8: Description of selected variables in the multiple regression analysis: Nahoon Estuary

Variable	Description	Expected Sign
Dependent Variables		
Ln_WTP	The amount a household is willing to pay for increase of freshwater inflows.	
Independent / Explanatory Variables		
Race	1 = White 0 = Other	+
Gender	1 = Male 0 = Female	+ or -
Visitor	1 = Visitor 0 = Resident	+ or -
Knowledge	1 = Informed 0 = Unimformed	+
Return_Visit	If estuary deteriorates will respondent: 1 = Still visit 0 = Visit other estuary	+
Household_size	Number of people in house making use of estuary.	+
Income	Household annual income	+
Freq	Amount of days spent at estuary per annum	+
Ln_Levies	Amount of levies paid in Rands for fishing, boating, bait collection and other activities at the estuary.	+
Trav	Distance of the respondent permanent residence to estuary.	-
Value_Equip	Per annum amount spent on boating, fishing, viewing and other recreational equipment. (Depreciated over 10 years.)	+

6.3 RESULTS OF BID FUNCTION FITS TO THE KROMME ESTUARY DATA

For the purpose of fitting bid functions to the survey data gathered at the Kromme Estuary, two statistical models were used, the OLS and Tobit Models. Table 6.9 shows the results generated by fitting the complete OLS and Tobit models to the data collected at the Kromme Estuary.

Table 6.9: Complete form of the WTP function for the Kromme Estuary survey using OLS and Tobit models

Dependent Variable: WTP_H_Q								
Model: Complete model								
Method:	**Least Squares**				**ML - Censored Normal**			
	OLS				**Tobit**			
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**p-value**	**Coefficient**	**Std.Error**	**z-Statistic**	**p-value**
Constant	-178,483	227.976	-0,783	0,435	-734,351	350,311	-2,096	0,036
Comm_subs	-29,866	193,495	-0,154	0,878	-114,532	260,120	-0,440	0,660
Distance	11,432	10,786	1,059	0,291	18,860	13,669	1,380	0,168
Education	7,622	15,530	0,491	0,624	13,109	20,913	0,627	0,531
Income	-1,79E-04	2,25E-04	-0,797	0,427	-2,09E-04	2,83E-04	-0,737	0,461
Levies	0,856	0,106	8,055	0,000	0,905	0,134	6,760	0,000
Male	15,483	66,249	0,234	0,816	2,070	83,566	0,025	0,980
People_household	31,421	22,278	1,410	0,161	50,399	28,296	1,781	0,075
Race	-44,073	180,901	-0,244	0,808	254,949	301,191	0,846	0,397
Recreation	-187,019	120,261	-1,555	0,122	-202,897	159,893	-1,269	0,205
V_B_worth	0,001	0,000	2,943	0,004	0,001	0,000	3,061	0,002
Visitor	64,734	62,745	1,032	0,304	55,634	79,259	0,702	0,483
Well_informed	103,911	55,398	1,876	0,0063	140,111	70,730	1,981	0,048
R^2	0,577				0,604			
Adjusted R^2	0,540				0,567			
Log likelihood					-814,538			
F-Statistic	15,603							
p-Value (F-statistic)	0,000							

The following three features stood out with respect to the fit of the complete model (Table 6.9):

- The independent variables found to have a statistical significance of less than or equal to 10% (in the Tobit model) and displaying positive coefficients were levies, worth of vehicles and boats, household size and how well informed the respondent is.

- The signs of all of these variables are consistent with the expectations presented in Table 6.7.

- The variable household size had a p-value of greater than 10% in the complete OLS model, but less than 10% in the complete Tobit model ($p = 0.075$).

The variables significant at the 10% level in the Tobit model were also included in a reduced model (see Table 6.10).

Table 6.10: Reduced form of the WTP function for the Kromme Estuary survey using OLS and Tobit models

Dependent Variable: WTP_H_Q								
Model: Reduced model								
Method:	**Least Squares**				**ML - Censored Normal**			
	OLS				**Tobit**			
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**p-value**	**Coefficient**	**Std.Error**	**z-Statistic**	**p-value**
Constant	-146,809	111,114	-1,321	0,189	-435,439	156,797	-2,777	0,006
Distance	7,913	9,038	0,876	0,383	16,622	11,873	1,400	0,162
Levies	0,835	0,094	8,851	0,000	0,908	0,123	7,408	0,000
People_household	36,970	19,347	1,911	0,058	47,323	25,177	1,880	0,060
Recreation	-136,550	87,313	-1,564	0,120	-69,301	120,040	-0,577	0,564
V_B_worth	0,001	0,000	3,567	0,001	0,001	0,000	3,791	0,000
Well_informed	91,900	49,207	1,868	0,064	126,066	63,923	1,972	0,049
R^2	0,572				0,595			
Adjusted R^2	0,554				0,575			
Log likelihood					-816,105			
F-Statistic	31,852							
p-Value (F-statistic)	0,000							

Table 6.10 shows the results generated by fitting the reduced OLS and Tobit models to the data collected at the Kromme Estuary. Using the nested test, the complete OLS and reduced OLS models were compared for goodness of fit. It was deduced that for predictive purposes the reduced OLS model was preferable to the complete model because the F-test statistic value of 0.29 was smaller than the critical value of 2.17, and for this reason the null hypothesis (all the coefficients of variables excluded in the reduced model equal zero) could not be rejected.

The test statistic used for this purpose was:

$$F = \frac{(SSEr - SSEc)/(k-g)}{SSEc/(n-(k+1))} \qquad (6.1)$$

These values are not reported in the individual tables as they are calculated by comparing the models (Sharp, 2007).

The complete and reduced Tobit models were also compared by using the log-likelihood ratio test. The likelihood ratio statistic is twice the difference in the log-likelihoods (Wooldridge, 2005):

$$LR = -2\,(Lr - Lc) \qquad (6.2)$$

Where: LR = The likelihood ratio
Lr = The log-likelihood ratio value of the reduced model
Lc = The log-likelihood ratio value of the complete model.

The log-likelihood ratio statistic value was 3.13, smaller than the X^2 (chi-square) value of 12.59, corresponding to the upper 5% significance level with six degrees of freedom. For this reason, it was deduced that the reduced Tobit model had superior predictive qualities to the complete Tobit model.

The reduced form OLS model predicts that for every additional Rand paid in levies for estuary services, WTP increased by R0.835 and by R0.91 in the reduced Tobit model (Table 6.10). WTP was predicted to increase by R37 for every additional member in the family in the reduced OLS model and by R47 in the reduced Tobit model (Table 6.10). The worth of vehicles and boats currently owned was highly

significant in both models. The WTP was predicted to increase by R1 for every R1000 increase in the worth of vehicles and boats in the Tobit model.

None of these findings is implausible or serves to cast doubt on the validity of the two models as tools to predict WTP (but see a more detailed analysis in Section 6.7). Due to its superior statistical qualities (censoring of negative WTP predictions) the Tobit model was preferred to the OLS model for predictive purposes. The Tobit model is a censored regression model which restricts WTP values to ensure a value of WTP ≥ 0. The model ensures that negative WTP values are not possible. In the case of the OLS model, predicted WTP negative values are possible from a modelling perspective, yet impossible from a logical perspective. This is a slight drawback of the OLS model, hence the Tobit model is preferable (Sharp, 2007). The median reduced Tobit model WTP predictive value was R287 and the mean predicted value was R373. Due to the skewed distribution of WTP predictions, the median value was judged to be the more reliable measure of central tendency.

6.4 RESULTS OF BID FUNCTION FITS TO THE KOWIE ESTUARY DATA

For the purpose of fitting bid functions to the survey data gathered at the Kowie Estuary, the same two statistical models were used as for the Kromme Estuary, namely the OLS and Tobit Models. Table 6.11 shows the results generated by fitting the complete OLS and Tobit models to the data collected at the Kowie Estuary.

Table 6.11: Complete form of the WTP function for the Kowie Estuary survey using OLS and Tobit models

Dependent Variable: WTP_H_Q								
Model: Complete model								
Method:	**Least Squares**				**ML - Censored Normal**			
	OLS				**Tobit**			
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**p-value**	**Coefficient**	**Std.Error**	**z-Statistic**	**p-value**
Constant	-516,62	370,289	-1,395	0,167	-703,714	405,671	-1,735	0,083
Distance	-14,601	19,760	-0,739	0,462	-26,917	22,325	-1,206	0,228
Education	36,462	23,315	1,564	0,121	48,379	25,346	1,909	0,056
Income	2,51E-04	4,18E-04	0,600	0,550	2,73E-04	4,52E-04	0,604	0,546
Levies	0,377	0,190	1,981	0,051	0,390	0,208	1,873	0,061
Male	29,566	126,959	0,233	0,816	36,177	138,071	0,262	0,793
People/house	20,483	33,835	0,605	0,547	11,960	36,771	0,325	0,745
Race	-274,785	245,954	-1,117	0,267	-430,608	264,188	-1,630	0,103
Recreation	245,264	289,318	0,848	0,399	370,300	322,406	1,176	0,239
V_B_worth	0,001	4,29E-04	1,637	0,105	0,001	4,68E-04	1,971	0,049
Visitor	-218,871	107,085	-2,044	0,044	-263,413	116,776	-2,256	0,024
Well_inform	135,088	191,132	0,707	0,482	151,815	204,748	0,741	0,458
R	0,285				0,300			
Adjusted R	0,195				0,204			
Log likelihood					-636,472			
F-Statistic	3,182							
p-Value (F-statistic)	0,001							

The following three features stand out with respect to the fit of the complete model (Table 6.11):

- The independent variables found to have statistical significance of less than or equal to 10% (in the Tobit model) and displaying positive coefficients

were education, amount paid in levies and the current worth of vehicles and boats.

- The independent variable, visitor was statistically significant (p=0.024) and carried a negative sign.

- The signs of these variables were consistent with expectations (see Table 6.7).

All of the variables significant at the 10% level were included in the reduced models (see Table 6.12).

Table 6.12: Reduced form of the WTP function for the Kowie Estuary survey using OLS and Tobit models

Dependent Variable: WTP_H_Q								
Model: Reduced model								
Method:	**Least Squares**				**ML - Censored Normal**			
	OLS				**Tobit**			
Variable	**Coefficient**	**Std.Error**	**t-Statistic**	**p-value**	**Coefficient**	**Std.Error**	**z-Statistic**	**p-value**
Constant	-357,734	266,736	-1,341	0,183	-497,548	298,721	-1,666	0,096
Education	41,213	21,718	1,898	0,061	49,756	24,181	2,058	0,040
Levies	0,447	0,172	2,605	0,011	0,447	0,195	2,288	0,022
V_B_worth	0,001	3,51E-04	2,430	0,017	0,001	4,00E-04	2,735	0,006
Visitor	-170,972	94,969	-1,800	0,075	-210,095	107,175	-1,960	0,050
R^2	0,260				0,261			
Adjusted R^2	0,220				0,213			
Log likelihood					-638,608			
F-Statistic	6,595							
p-Value (F-statistic)	0,000							

Table 6.12 shows the results generated by fitting the reduced OLS and Tobit models to the data collected at the Kowie Estuary. Using the nested test, the complete OLS and reduced OLS models were compared for goodness of fit. It was deduced that for predictive purposes the reduced OLS model was preferable to the complete model because the F-test statistic value of 0.51 was smaller than the critical value of 2.17, and for this reason the null hypothesis (all the coefficients of variables excluded in the reduced model equal zero) could not be rejected. The test statistic used for this purpose was:

$$F = \frac{(SSEr - SSEc)/(k-g)}{SSEc/(n-(k+1))} \qquad (6.3)$$

These values are not reported in the individual tables as they are calculated by comparing the models (Sharp, 2007).

The complete and reduced Tobit models can also be compared by using the log-likelihood ratio test. The likelihood ratio statistic is twice the difference in the log-likelihoods (Wooldridge, 2005):

$$LR = -2\,(Lr - Lc) \qquad (6.4)$$

The log-likelihood ratio statistic value was 4.272, smaller than the X^2 (chi-square) value of 12.59, corresponding to the upper 5% significance level with six degrees of freedom. For this reason, it was deduced that the reduced Tobit model had superior predictive qualities to the complete Tobit model.

It was found that for every additional year of education attained by the respondent, WTP increased by an additional R41 in the OLS model and by a further R49 in the Tobit model (Table 6.12). Levies and worth of boats and vehicles were also

positively correlated to the WTP. WTP increased by R0.44 for every extra Rand spent in levies in the OLS model and by the same value in the Tobit model (Table 6.12). For every R1000 increase in worth of vehicles and boats, WTP increase by R1 in both statistical models.

None of these findings are implausible and serve to cast doubt on the validity of the two models as tools to predict WTP (but see a more detailed analysis in Section 6.7). Due to its superior statistical qualities (censoring of negative WTP predictions) the Tobit model was preferred (see section 6.3). The median reduced Tobit model WTP predictive value was R290 and the mean predicted value was R325. Once again, due to the skewed distribution of WTP predictions, the median value was judged to be the more reliable measure of central tendency, as for the Kromme.

6.5 RESULTS OF BID FUNCTION FITS TO THE NAHOON ESTUARY DATA

As was the case for both the Kromme and the Kowie estuaries, for the purpose of fitting bid functions to the survey data gathered at the Nahoon Estuary, two statistical models were used, the OLS and Tobit Models. Table 6.13 shows the results generated by fitting the complete OLS and Tobit models to the data collected at the Nahoon Estuary.

Table 6.13: Complete form of the WTP function for the Nahoon Estuary survey using OLS and Tobit models

Dependent Variable: LOG_WTP								
Model: Complete								
Observation: 269								
Method:	**Least Squares**				**Censored Normal (TOBIT)**			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**P-value**	**Coefficient**	**Std. Error**	**z-Statistic**	**P-value**
RACE	3.1159	0.4675	6.6655	0.0000	3.5768	0.5405	6.6176	0.0000
GEN	0.1107	0.4296	0.2578	0.7968	0.1258	0.4926	0.2554	0.7984
VIS	-0.0271	0.6122	-0.0442	0.9648	0.0695	0.6980	0.0996	0.9207
FREQ	0.0035	0.0074	0.4736	0.6362	0.0037	0.0085	0.4387	0.6609
HOUSE	0.4326	0.1329	3.2548	0.0013	0.4967	0.1530	3.2454	0.0012
KNOW	0.2732	0.4389	0.6224	0.5343	0.3956	0.5043	0.7844	0.4328
LOG_LEV	0.0998	0.0492	2.0260	0.0438	0.1145	0.0560	2.0442	0.0409
TRAV	-0.0001	0.0002	-0.4034	0.6870	-0.0001	0.0003	-0.4512	0.6519
EQUIP	0.0000	0.0002	0.1680	0.8667	0.0000	0.0002	0.0423	0.9663
RTNVIS	-0.3103	0.4463	-0.6952	0.4875	-0.3791	0.5110	-0.7418	0.4582
C	-0.6209	0.7781	-0.7980	0.4256	-1.4194	0.9075	-1.5641	0.1178
	R-squared		0.2325		R-squared		0.2236	
	Adjusted R-squared		0.2028		Adjusted R-squared		0.1903	
	F-statistic		7.8169		Log likelihood		-657.8179	
	Prob(F-statistic)		0.0000		Left censored obs		39	
					Uncensored obs		230	

The following two features stood out with respect to the fit of the complete model (Table 6.13):

- The independent variables with coefficients displaying positive signs and statistical significance (p-values of less than 10%) were race, number of members in the household and the amount of money paid in levies (log_lev).

- These signs were consistent with predictions (see Table 6.8).

All of the variables identified as significant at the 10% level were also included in reduced models (see Table 6.14).

Table 6.14: Reduced form of the WTP function for the Nahoon Estuary survey using OLS Tobit models

Dependent Variable: LOG_WTP								
Model: Reduced								
Observation: 269								
Method:	**Least Squares**				**Censored Normal (TOBIT)**			
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**P-value**	**Coefficient**	**Std. Error**	**z-Statistic**	**P-value**
RACE	3.0824	0.4039	7.6315	0.0000	3.5270	0.4745	7.4338	0.0000
HOUSE	0.4249	0.1300	3.2686	0.0012	0.4908	0.1518	3.2330	0.0012
LOG_LEV	0.1167	0.0388	3.0076	0.0029	0.1305	0.0448	2.9153	0.0036
C	-0.2805	0.5900	-0.4754	0.6349	-0.9962	0.6965	-1.4303	0.1526
	R-squared		0.2285		R-squared		0.220594	
	Adjusted R-squared		0.2198		Adjusted R-squared		0.208785	
	F-statistic		26.1666		Log likelihood		-658.552	
	Prob(F-statistic)		0.0000		Left censored obs		39	
					Uncensored obs		230	

The interpretation of the coefficients in the Nahoon Estuary model is different to that of the coefficients in the models relating to the previous two estuaries; the reason being that a semilog model was used to correlate the Nahoon Estuary data (Gujarati, 2003).

Respondents from the white racial group were found to have a WTP of 2081% more than respondents from other races. This percentage relates to a WTP change from under R0.50 (other races) to above R40 (white respondents).

For every extra member in household size, WTP was found to increase by 52%.

In order to interpret log_levies, it is important to observe that in the loglinear equation, measured changes are in proportional or percentage terms (Greene, 2003). For every 1% increase in levies paid, WTP was found to increase by 12%.

None of these findings is implausible or serves to cast doubt on the validity of the models as tools to predict WTP (but see a more detailed analysis in Section 6.7). Due to its superior statistical qualities (censoring of negative WTP predictions) the Tobit model was preferred to the OLS model for predictive purposes. The median reduced Tobit model WTP predictive value was R32.92 and the mean predicted value was R57.

6.6 QUALITY OF RESPONSES: COMMENTS BY THE PEOPLE CONDUCTING THE SURVEYS

6.6.1 KOWIE

The survey was carried out in January 2003. The majority of respondents were polite and friendly, although a small fraction of aggressive and rude respondents were also encountered. Due to the fact that the survey took place over a holiday period no difficulties were encountered in locating suitable respondents.

A high degree of sensitivity was encountered in the survey on the question of how much they earned. Many respondents were resistant to reveal their pre-tax income, even when assured of the anonymous nature of the questionnaire. The person conducting the survey expressed concern at the reliability of some of the answers given in this regard. He also noted that many respondents, especially locals, felt that other issues regarding the Kowie Estuary were of greater importance than the river inflow issue, especially the excessive sedimentation caused by the marina development.

6.6.2 KROMME

Mr Dods Blom, who was trained by Dr Mario du Preez of the Nelson Mandela Metropolitan University, administered the survey. Mr Blom reported that the majority of respondents were interested in the study being carried out. He also found that complex scenarios had to be explained fully to many of the respondents, as many possessed little or no knowledge of the freshwater issue relating to the estuary.

6.6.3 NAHOON

The survey was undertaken by Mr Radu Mihailescu of the Nelson Mandela Metropolitan University. Training was provided by members of the project team, led by Prof. Stephen Hosking of the Nelson Mandela Metropolitan University. The survey took place during December 2004.

According to Mr Mihailescu, the majority of respondents were interested in the freshwater inflow issue. Other issues regarding estuarine health were also raised by certain respondents.

6.7 ASSESSMENT OF THE CREDIBILITY OF THE RESULTS

The credibility of WTP results are typically assessed in terms of validity and reliability criteria (see Chapter Three). Construct validity refers to how well a valuation explains the values generated (Hanley and Spash, 1993).

The three criteria used to assess the overall validity of the CV studies were (1) overall fit - an adjusted R value greater than 15%, (2) sufficiency of predictive model - at least two key variables retained in the reduced model and (3)

correspondence of the signs of the coefficients with economic expectations (Hanley and Spash, 1993). Four ratings were constructed in terms of these criteria:

- Strong support: All of the above criteria are met.
- Moderate support: Two of the above criteria are met.
- Weak support: One of the above criteria is met.
- No support: None of the above criteria is met.

Table 6.15 summarizes the validity ratings of the three estuaries.

Table 6.15 Sample validity rating

Estuary	**Validity of the results**
Kowie	Weak support
Kromme	Moderate Support
Nahoon	Moderate Support

It was deduced that the Kowie Estuary survey yielded results which weakly supported the validity of the predicted WTP finding, the Kromme Estuary survey yielded results which moderately supported the predicted WTP finding and the Nahoon Estuary survey yielded results which also moderately supported the predicted WTP finding. A possible reason for the lack of strong support is the insufficiency of the sample sizes.

In order to test a CVM study for reliability, surveys need to be repeated at the same estuaries (Hanley and Spash, 1993) but due to budget constraints, this was not possible.

6.8 CONCLUSION

From the surveys undertaken at the Kowie, Kromme and Nahoon estuaries, it is evident that peoples' willingness to pay for freshwater inflow into South Africa's estuaries is influenced by many different factors. These factors include, among others, the amount they have already paid in levies to access the estuary, the size of the household to which the recreation user belongs, the education level and knowledge of estuarine function possessed by the user and the value of equipment used by the user to gain access to the estuary. Surprisingly income was not found to be one of these factors – it was not found to be significant in any of the six bid functions estimated.

With respect to the predictive models of value generated for inflows into the three estuaries:

- Although statistically significant, vehicle and boat worth had a small effect on WTP in the case of the Kowie and the Kromme.
- As would be expected, education and knowledge of estuarine function were positively correlated to WTP.
- In all three cases WTP was positively correlated with levies already paid to gain access to the services of the estuary.
- In the case of the Nahoon, respondents from the white racial group were willing to pay more to improve estuarine services than respondents from other races.

The main objective of this application of the contingent valuation method was to generate predicted mean and median WTP's. The predicted mean and median WTP's for the improved recreational services associated with increased freshwater

inflows into the three estuaries are shown in Table 6.16. The Tobit models were preferred to the OLS models for the purpose of predicting WTP because they avoid the problem of negative willingness to pay predictions. The Tobit model is a censored regression model which restricts WTP values to assume a value of y >= 0. The model ensures that <0 values are not possible. In the case of the OLS model, predicted WTP negative values are possible from a modelling perspective yet impossible from a logical perspective (Sharp, 2007).

Table 6.16: Predicted mean and median WTP

Estuary	**Mean of predicted WTP (Rands)**	**Median of predicted WTP (Rands)**
Kromme	373	287
Kowie	325	290
Nahoon	57	33

The predicted median WTP for changes in freshwater inflow into the three estuaries vary widely, from R33 at the Nahoon Estuary to R290 at the Kowie Estuary and R287 at the Kromme Estuary. There are many possible reasons for the differences in the WTP values at each of the three sites. Two of these reasons are the different characteristics of each estuary and interpretation by the respondents of the questionnaire differently at the different estuaries (interviewer bias).

The predicted median values generated at the three sites are lower than the predicted mean values (Table 6.16). This difference may partially be explained by outliers (unrealistically large bids) inflating the predicted mean WTP value. Given the preference for conservative values (see Chapter Three), the median predicted

WTP value was preferred for the purpose of predicting total willingness to pay in order to estimate the recreational value of water inflow per m^3 (see Chapter Two).

CHAPTER SEVEN: CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSION ON VALUES

The main objective of this study was to place a value on freshwater flowing into the Kowie, Kromme and Nahoon estuaries in South Africa, so as to assist river catchment planners with reference values by which to allocate freshwater to select SA estuaries. Chapter One outlined the water inflow problem to estuaries in South Africa. Chapter Two presented an economic model by which the allocation of freshwater into estuaries could be guided. Chapter Three identified an appropriate method by which to generate values for this water. Chapter Four described the study site information of each estuary considered. Three were considered, the Kowie, Kromme and Nahoon estuaries. Chapter Five outlined the thinking that went into designing the questionnaire sample.

The primary aim of a contingent valuation is to determine an estimate of the TWTP for a specified good or service. In this case the goods were services derived through changes to freshwater inflows into the Kromme, Kowie and Nahoon estuaries. The relevant results were reported in Chapter Six. The TWTP figure is calculated as a product of the median WTP and the estimated number of households making use of the respective estuary. The main reason for the use of a median WTP value rather than a mean WTP value is that the median value reduces biases induced by unrealistically large bids and protest zero bids (Hanley and Spash, 1993). Table 7.1 displays the TWTP estimates for the Kowie, Kromme and Nahoon estuaries.

Table 7.1: TWTP: Kowie, Kromme and Nahoon estuaries

Estuary	Predicted median of WTP*	Estimates of number of households**	TWTP
Kromme:	287	3200	R 918 400
Kowie:	290	3234	R 937 860
Nahoon:	33	1479	R 48 807

* From Chapter Six
** From Chapter Four

These TWTP values can be used to generate the per cubic metre Rand value of water flowing into each estuary. In order to do this, the specified change (m^3) is divided into the TWTP figure (see Table 7.2).

Table 7.2: Value of water per m^3 – Kowie, Kromme, Nahoon estuaries.

Estuary	TWTP pa	Change in inflow (millions of m^3 p.a)	Value/ m^3
Kromme	R 918 400	75.5	R0.012
Kowie	R 937 860	13	R0.072
Nahoon	R 48 807	3.78	R0.012

It is concluded that in 2004 the per cubic meter per annum Rand value of freshwater inflow into the Kowie Estuary was R0.072, into the Kromme Estuary was R0.012 and into the Nahoon Estuary was R0.012.

This analysis suggests that freshwater inflows into these estuaries is most valuable at the Kowie Estuary and least valuable at the Kromme Estuary, although the total willingness to pay amounts are similar, namely R937 860 and R918 400

respectively. The reason for the large difference in the per annum m^3 value is because the Kromme Estuary requires a significantly larger change in freshwater inflow in order to bring about the positive changes in estuary services (see Chapter Five). The Nahoon Estuary has a relatively low total willingness to pay per annum, but requires less freshwater inflow in order to create positive changes in estuarine services compared to the Kowie and the Kromme. Its per annum Rand value of freshwater of R0.012 is the same as the value generated at the Kromme Estuary.

The size of the user population is an important determinant of TWTP value. The results in Table 7.2 confirm this. The Kowie and the Kromme estuaries, which have large user populations, have higher TWTP values than the Nahoon Estuary which has a relatively smaller user population.

It is widely accepted that there are adverse consequences for estuaries if they are deprived of adequate freshwater inflows. The opportunity cost of freshwater abstraction will be the deterioration in services provided by South Africa's estuaries. There are many negative consequences of this deterioration for recreation, for example, reductions in angling fish, reductions in bait species, reductions in bird species and in many cases a reduction in recreational area.

The towns of Port Alfred and St Francis Bay and the city of East London depend on these natural resources attracting visitors to their area. If their recreational needs are not met at these estuaries, visitors may choose alternate sites to visit. It is thus of vital importance that these estuaries be given adequate freshwater to ensure that this. Management responsible for river system function need to take the recreational costs of freshwater deprivation into account.

This study advocates that the allocation of river flows should be guided by the notion of optimality and efficiency. In order to determine the optimal freshwater

inflow into an estuary, marginal values need to be estimated and compared with marginal costs. This study applied CVM to estimate marginal values of this inflow into the Kowie, Kromme and Nahoon estuaries. It was not possible to make deductions on the efficiency issues for these specific estuaries because the required marginal cost values were not available.

There have been many other similar estimates of per annum Rand value of freshwater inflows generated by Hosking *et al* (2004) for other South African estuaries. These estimates are shown in Table 7.3.

Table 7.3 :Value of water inflows into selected estuaries per m³

Estuary	**Total Willingness to pay**	**Change in inflow (million m³)**	**Value/m³**
Groot Brak	R 524 160	5	R 0.105
Swartkops	R 1 220 170	13.5	R 0.090
Kariega	R 421 308	7.4	R 0.057
Klein Brak	R 141 369	11.2	R 0.013
Knysna	R 579 759	46.9	R 0.013

Source: Hosking *et al* (2004)

The CV's shown in Table also reflect a wide range of values, with freshwater appearing to be most valuable in the case of the Groot Brak Estuary (R0.105/m³) and least valuable in the case of the Klein Brak and Knysna estuaries (R0.013/m³).

7.2 CONFIDENCE IN RESULTS

Contingent valuations are subject to many biases (Wattage, 2001). For this reason that valuations of this nature need to be subjected to tests for validity and reliability (as identified in Chapter Three of this dissertation).

The contingent valuations generated in this research (see Chapter Six) were subjected to expectations-based tests. Weak support was found for the valuations of the freshwater flowing into Kowie Estuary and moderate support was found for the valuations of water flowing into the Kromme and Nahoon estuaries.

It was not possible to test the reliability of the estimates as only one survey was conducted per estuary.

7.3 RECOMMENDATIONS

It is recommended that further research of this nature should pay careful attention to the issue of sample design. Although budget constraints will always play a role in applications of CVM, it is important that samples of adequate size be selected. Failure to do so undermines the credibility of the results.

It is also recommended that a test for reliability be carried out for the respective sites. These tests should form part of a follow up study.

For obvious reasons the description of the scientific impact of changes in freshwater inflow conveyed to the respondent needs to be as accurate as possible. It is this information that the respondent will process when deciding how much he or she will be willing to pay for changes to estuarine services. The values generated from CVM studies are sensitive to this information. In order to assist with

the information problem it is also recommended that the questionnaires be administered in the home language of the respondent.

It is also recommended that social investments continue to be made into educating the public affected by changes to estuary services induced by reduced freshwater inflows. These people should be made aware of the relationship that exists between freshwater inflows and the healthy functioning of an estuary. Many respondents were of the opinion that because freshwater has always been free, they should not be made to pay any fee to secure increased inflows. They should be made aware that a continuation of public good provision requires such fees to be paid.

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APPENDIX 1: Kowie Questionnaire

WRC CVM QUESTIONNAIRE – ADMINISTERED BY UPE – PUBLIC ISSUE OF FRESH WATER INFLOW INTO THE KOWIE ESTUARY

INSTRUCTIONS TO PERSON ADMINISTERING THE QUESTIONNAIRE.

(A) NAME OF PERSON ADMINISTERING QUESTIONNAIRE (NOT RESPONDENT):_____

(B) NO RESPONDENTS NAME IS TO BE RECORED AND THE INFORMATION GIVEN BY THEM IS TO BE TREATED AS CONFIDENTIAL.

(C) THERE ARE 19 QUESTIONS. PLEASE TICK THE APPROPRIATE BLOCKS.

1. CATEGORY OF RESPONDENT

CATEGORY OF USER/RESPONDENT	
RECREATION BOAT SPORTS SWIMMER FISHER/BAIT COLLECT BIRDER PROXIMITY/VIEW	1
COMMERCIAL/SUBSISTENCE	2
NON-USERS	3

2. RACE OF RESPONDENT

RACE	
BLACKS	1
WHITES	2
COLOUREDS	3
INDIANS	4
OTHER	5

3. GENDER OF RESPONDENT

MALE	1
FEMALE	2

4. VISITOR OR RESIDENT?

4.1 VISITOR	1
4.2 RESIDENT	2

5. WHAT DO YOU THINK WILL HAPPEN IF THERE IS A SIGNIFICANT REDUCTION OF FRESH WATER INFLOW INTO THE ESTUARY?

PERSON IS WELL INFORMED –KNOWS MORE THAN 3 OF THE IMPACTS LISTED BELOW	1
PERSON HAS PARTIAL KNOWLEDGE - KNOWS 1-3 OF THE IMPACTS LISTED BELOW	2
PERSON IS POORLY INFORMED – KNOWS 0 OF THE IMPACTS LISTED BELOW	3

FILL IN THE GAPS IN THE PERSON'S KNOWLEDGE – IMPACTS TO BE READ TO THE RESPONDENT

THE INCREASE OF 56 % OF CURRENT FRESH WATER INFLOW INTO THE ESTUARY CAN BE EXPECTED TO HAVE CONSEQUENCES OF UP TO THE FOLLOWING MAGNITUDES:

FOR BOATERS
1. NO CHANGE

FOR SWIMMERS
1. NO CHANGE

FOR FISHERS/BAIT COLLECTORS
1. A 25% INCREASE IN ANGLING FISH
2. A 25% INCREASE IN THE AVAILABILITY OF MUDPRAWN

FOR BIRDERS
1. A 25% INCREASE OF FORAGING BIRDS IN THE INTERTIDAL AREAS

FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY
1. NO CHANGE

FROM THE PERSPECTIVE OF THE WORLD GENERALLY
1. NO CHANGE

6. DO YOU MAKE A LIVING FROM THE ESTUARY?

YES	1
NO	2

7. HOW OFTEN PER YEAR DO YOU USE THE ESTUARY ON AVERAGE?

DAYS	
LESS THAN 1	0
1	1
2-7	2
8-14	3
21-28	4
29-59	5
60 +	6

8. HOW MANY PEOPLE MAKE UP YOUR HOUSEHOLD?

NUMBER OF MEMBERS OF HOUSEHOLD	
1	1
2	2
3	3
4	4
5	5
6	6
7+	7

9. OF THE MEMBERS OF YOUR HOUSEHOLD, HOW MANY USE THE ESTUARY IN SOME WAY OR OTHER IN THE YEAR – FOR RECREATION OR MAKING A LIVING?

NUMBER OF MEMBERS OF HOUSEHOLD	
1	1
2	2
3	3
4	4
5	5
6	6
7+	7

10. RATE THE RELATIVE IMPORTANCE YOU ATTACH TO THE FOLLOWING ACTIVITIES/ATTRIBUTES OF THE ESTUARY:

EX IMP = EXTREMELY IMPORTANT
V IMP = VERY IMPORTANT
M IMP = MODERATE IMPORTANCE
UNIMP= UNIMPORTANT

ACTIVITIES/ ATTRIBUTES	EX IMP	V IMP	M IMP	UNIMP	
10.1 BOAT SPORTS (EXCLUDING FISHING)	4	3	2	1	
10.2 SWIMMING	4	3	2	1	
10.3 FISHING	4	3	2	1	
10.4 VIEWING ESTUARY	4	3	2	1	
10.5 PROXIMITY - BANKS FOR PICNICS OR - ACCOMMODATION CLOSE TO IT	4	3	2	1	
10.6 BIRD WATCHING	4	3	2	1	
10.7 COMMERCIAL – ALL BUSINESS ACTIVITIES	4	3	2	1	
10.8 PRESERVATION OF UNIQUE FEATURES	4	3	2	1	
10.9 OTHER (SPECIFY)	4	3	2	1	SPECIFY

11. HOW MUCH DOES YOUR HOUSEHOLD PAY PER YEAR IN LEVIES FOR USE/ACCESS TO THE ESTUARY IN FISHING, BOATING, BAIT COLLECTION AND OTHER FEES?

RAND PAYMENTS	
0 – 50	1
51 - 100	2
101 – 200	3
201 – 400	4
401 – 500	5
501 – 800	6
801 – 1000	7
1001 +	8

WORKING BOX

BACKGROUND INFORMATION (PER ANNUM OR PER VISIT) – E.G., KEURBOOMS
BOATING FEE (R250 P.A. AND R115 FOR A 30 DAY LICENCE MOTORISED)
ANGLING FEE (R35 P.A.)
BAIT COLLECTION FEE (R50 P.A.)
LAUNCHING FEE (FREE)
ACCESS TO BANKS FEE (FREE)

12. WHAT LEVY PER YEAR ARE YOU WILLING TO PAY (INCLUDING WHAT YOU ALREADY DO PAY) FOR A PROJECT TO INCREASE THE RIVER WATER INFLOW (DUE TO URBAN AND AGRICULTURAL ABSTRACTION OR REDUCED FLOWS THROUGH FORESTRY OR VEGETATION CHANGES) INTO THE ESTUARY OF 56% OVER WHAT CURRENTLY FLOWS INTO THE ESTUARY. ANOTHER WAY OF SEEING THIS IS WTP TO INCREASE THE PROPORTION OF MAR INFLOW INTO THE ESTUARY FROM 34% TO 80%.

THE LEVY WOULD BE COLLECTED BY THE LOCAL AUTHORITY FROM ALL USERS WHO DERIVE BENEFIT DIRECTLY OR INDIRECTLY, INCLUDING THOSE PROVIDING VISITORS ACCESS TO THE KOWIE ESTUARY. THIS LEVY WOULD BE COLLECTED IN RATES AND USER FEES TO THOSE ACCESSING THE WATER. IT WOULD BE USED TO FUND THE 'PURCHASE' OF 13 MILLION M^3 OF WATER, I.E., ENOUGH FRESH WATER INFLOW TO SECURE THE CHANGES IN ESTUARY SERVICES INDICATED.

FOR BOATERS
1. NO CHANGE

FOR SWIMMERS
1. NO CHANGE

FOR FISHERS/BAIT COLLECTORS
1. A 25% INCREASE IN ANGLING FISH
2. A 25% INCREASE IN THE AVAILABILITY OF MUDPRAWN

FOR BIRDERS
1. A 25% INCREASE OF FORAGING BIRDS IN THE INTERTIDAL AREAS

FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY
1. NO CHANGE

FROM THE PERSPECTIVE OF THE WORLD GENERALLY
1. NO CHANGE

AMOUNT WILLING TO PAY UNDER HIGH IMPACT SCENARIO DESCRIBED ABOVE (RAND)			
0	0		
1 – 10	1		
11 - 20	2		
21 – 30	3		
31- 50	4		
51 – 100	5		
101 - 200	6		
201 – 500	7		
501 – 1000	8		
1001 – 2000	9		
2001 – 3000	10		
3001 – 4000	11		
4001 + (SPECIFY)	12	SPECIFY	13

13. IF YOUR ANSWER TO EITHER OF THE ABOVE (QUESTION 12) IS ZERO, WHAT ARE YOUR REASONS (YOU MAY HAVE MORE THAN ONE)?

REASON	
13.1 CANNOT AFFORD THE FEES	1
13.2 GET NO OR NEGLIGIBLE VALUE OUT OF ESTUARY SERVICES	2
13.3 ABUNDANCE OF SERVICE OPTIONS – NO SCARCITY, THEREFORE WHY PAY	3
13.4 LACK OF CONFIDENCE IN GOVERNMENT TO COLLECT AND USE FEES COLLECTED FOR THE WATER PURCHASE	4
13.5 OTHER (SPECIFY)	5

14. WHAT WOULD YOUR HOUSHOLD SACRIFICE IN ORDER TO MAKE THIS PAYMENT? (THE MONEY HAS TO COME FROM SOMEWHERE – THE BUDGET CONSTRAINT – MAY TICK MORE THAN ONE BLOCK)

SERVICE INCOME WOULD BE REALLOCATED FROM		
14.1 RECREATION ACTIVITIES	1	
14.2 DOMESTIC/HOUSEHOLD LIVING	2	
14.3 DIS-SAVING	3	
14.4 OTHER (SPECIFY)	4	SPECIFY

15. DISTANCE IN KILOMETRES OF RESPONDENT'S CURRENT ACCOMMODATION (NOT NECESSARILY PLACE OF PERMANENT ABODE) FROM THE ESTUARY.

DISTANCE FROM ESTUARY (KM)	
0-1	1
1-3	2
3-10	3
10 +	4

16. APPROXIMATE WORTH OF RESPONDENTS VEHICLES AND BOATS OWNED AT CURRENT PRICES:

TOTAL VALUE (RAND)	
0	0
1- 2 000	1
2001- 10 000	2
10 001- 50 000	3
50 001- 100 000	4
100 001- 200 000	5
200 001-400 000	6
400 001 +	7

17. HIGHEST EDUCATIONAL LEVEL ATTAINMENT OF RESPONDENT.

EDUCATIONAL LEVEL	
NO SCHOOLING	1
COMPLETED 7 – 11 YEARS OR SCHOOLING	2
COMPLETED 12 YEARS OF SCHOOLING	3
COMPLETED SCHOOLING PLUS 3 OR MORE YEARS TERTIARY SCHOOLING	4

18. GROSS ANNUAL PRE-TAX INCOME OF RESPONDENT.

PRE TAX INCOME (RAND)	
0 – 50 000	1
50 001 – 100 000	2
100 001 – 150 000	3
150 001 – 200 000	4
200 001 – 250 000	5
250 001 – 350 000	6
350 001 – 500 000	7
500 001+	8

19. DO YOU HAVE ANY OTHER COMMENTS YOU WOULD LIKE TO CONTRIBUTE ON THIS PUBLIC ISSUE?

_____

_____

_____

Questionnaire compiled by members of the Departments of Economics and Zoology, UPE. Questions about this project may be directed at Prof SG Hosking,, tel 041-5042205

APPENDIX 2: Kromme Questionnaire

WRC CVM QUESTIONNAIRE – ADMINISTERED BY UPE – PUBLIC ISSUE OF FRESH WATER INFLOW INTO THE KROMME ESTUARY

INSTRUCTIONS TO PERSON ADMINISTERING THE QUESTIONNAIRE.

(A) NAME OF PERSON ADMINISTERING QUESTIONNAIRE (NOT RESPONDENT):_____

(B) NO RESPONDENTS NAME IS TO BE RECORED AND THE INFORMATION GIVEN BY THEM IS TO BE TREATED AS CONFIDENTIAL.

(C) THERE ARE 19 QUESTIONS. PLEASE TICK THE APPROPRIATE BLOCKS.

2. CATEGORY OF RESPONDENT

CATEGORY OF USER/RESPONDENT	
RECREATION BOAT SPORTS SWIMMER FISHER/BAIT COLLECT BIRDER PROXIMITY/VIEW	1
COMMERCIAL/SUBSISTENCE	2
NON-USERS (0 OR +WTP)	3

2. RACE OF RESPONDENT

RACE	
BLACKS	1
WHITES	2
COLOUREDS	3
INDIANS	4
OTHER	5

3. GENDER OF RESPONDENT

MALE	1
FEMALE	2

4. VISITOR OR RESIDENT?

4.1 VISITOR	1
4.2 RESIDENT	2

5. WHAT DO YOU THINK WILL HAPPEN IF THERE IS A SIGNIFICANT REDUCTION OF FRESH WATER INFLOW INTO THE ESTUARY?

PERSON IS WELL INFORMED –KNOWS MORE THAN 3 OF THE IMPACTS LISTED BELOW	1
PERSON HAS PARTIAL KNOWLEDGE - KNOWS 1-3 OF THE IMPACTS LISTED BELOW	2
PERSON IS POORLY INFORMED – KNOWS 0 OF THE IMPACTS LISTED BELOW	3

FILL IN THE GAPS IN THE PERSON'S KNOWLEDGE – IMPACTS TO BE READ TO THE RESPONDENT

THE INCREASE 812 % OF CURRENT FRESH WATER INFLOW INTO THE ESTUARY CAN BE EXPECTED TO HAVE CONSEQUENCES OF UP TO THE FOLLOWING MAGNITUDES:

FOR BOATERS
1. NO CHANGE
FOR SWIMMERS
1. NO CHANGE
FOR FISHERS/BAIT COLLECTORS
1. A 25% INCREASE IN ANGLING FISH
2. A 25% INCREASE IN THE AVAILABILITY OF MUDPRAWN

FOR BIRDERS
1. A 25% INCREASE OF FORAGING BIRDS IN THE INTERTIDAL AREAS

FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY
1. NO CHANGE

FROM THE PERSPECTIVE OF THE WORLD GENERALLY
1. NO CHANGE

6. DO YOU MAKE A LIVING FROM THE ESTUARY?

YES	1
NO	2

7. HOW OFTEN PER YEAR DO YOU USE THE ESTUARY ON AVERAGE?

DAYS	
LESS THAN 1	0
1	1
2-7	2
8-14	3
21-28	4
29-59	5
60 +	6

8. HOW MANY PEOPLE MAKE UP YOUR HOUSEHOLD?

NUMBER OF MEMBERS OF HOUSEHOLD	
1	1
2	2
3	3
4	4
5	5
6	6
7+	7

9. OF THE MEMBERS OF YOUR HOUSEHOLD, HOW MANY USE THE ESTUARY IN SOME WAY OR OTHER IN THE YEAR – FOR RECREATION OR MAKING A LIVING?

NUMBER OF MEMBERS OF HOUSEHOLD	
1	1
2	2
3	3
4	4
5	5
6	6
7+	7

10. RATE THE RELATIVE IMPORTANCE YOU ATTACH TO THE FOLLOWING ACTIVITIES/ATTRIBUTES OF THE ESTUARY:

EX IMP = EXTREMELY IMPORTANT
V IMP = VERY IMPORTANT
M IMP = MODERATE IMPORTANCE
UNIMP= UNIMPORTANT

ACTIVITIES/ ATTRIBUTES	EX IMP	V IMP	M IMP	UNIMP	
10.1 BOAT SPORTS (EXCLUDING FISHING)	4	3	2	1	
10.2 SWIMMING	4	3	2	1	
10.3 FISHING	4	3	2	1	
10.4 VIEWING ESTUARY	4	3	2	1	
10.5 PROXIMITY - BANKS FOR PICNICS OR - ACCOMMODATION CLOSE TO IT	4	3	2	1	
10.6 BIRD WATCHING	4	3	2	1	
10.7 COMMERCIAL – ALL BUSINESS ACTIVITIES	4	3	2	1	
10.8 PRESERVATION OF UNIQUE FEATURES	4	3	2	1	
10.9 OTHER (SPECIFY)	4	3	2	1	SPECIFY

11. HOW MUCH DOES YOUR HOUSEHOLD PAY PER YEAR IN LEVIES FOR USE/ACCESS TO THE ESTUARY IN FISHING, BOATING, BAIT COLLECTION AND OTHER FEES?

RAND PAYMENTS	
0 – 50	1
51 - 100	2
101 – 200	3
201 – 400	4
401 – 500	5
501 – 800	6
801 – 1000	7
1001 +	8

WORKING BOX

BACKGROUND INFORMATION (PER ANNUM OR PER VISIT) – E.G., KEURBOOMS
BOATING FEE (R250 P.A. AND R115 FOR A 30 DAY LICENCE MOTORISED)
ANGLING FEE (R35 P.A.)
BAIT COLLECTION FEE (R50 P.A.)
LAUNCHING FEE (FREE)
ACCESS TO BANKS FEE (FREE)

12. WHAT LEVY PER YEAR ARE YOU WILLING TO PAY (INCLUDING WHAT YOU ALREADY DO PAY) FOR A PROJECT TO INCREASE RIVER WATER INFLOW (DUE TO URBAN AND AGRICULTURAL ABSTRACTION OR REDUCED FLOWS THROUGH FORESTRY OR VEGETATION CHANGES) INTO THE ESTUARY OF 812 % OVER WHAT CURRENTLY FLOWS INTO THE ESTUARY. ANOTHER WAY OF SEEING THIS IS WTP TO INREASE THE PROPORTION OF MAR INFLOW INTO THE ESTUARY FROM 10% TO 80%.

THE LEVY WOULD BE COLLECTED BY THE LOCAL AUTHORITY FROM ALL USERS WHO DERIVE BENEFIT DIRECTLY OR INDIRECTLY, INCLUDING THOSE PROVIDING VISITORS ACCESS TO THE KROMME ESTUARY. THIS LEVY WOULD BE COLLECTED IN RATES AND USER FEES TO THOSE ACCESSING THE WATER. IT WOULD BE USED TO FUND THE 'PURCHASE' OF 75.5 MILLION M^3 OF WATER, I.E., ENOUGH FRESH WATER INFLOW TO SECURE THE CHANGES IN ESTUARY SERVICES INDICATED.

FOR BOATERS
1.NO CHANGE

FOR SWIMMERS
1.NO CHANGE

FOR FISHERS/BAIT COLLECTORS
1. A 25% INCREASE IN ANGLING FISH
2. A 25% INCREASE IN THE AVAILABILITY OF MUDPRAWN

FOR BIRDERS
1. A 25% INCREASE OF FORAGING BIRDS IN THE INTERTIDAL AREAS

FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY
1. NO CHANGE

FROM THE PERSPECTIVE OF THE WORLD GENERALLY
1. NO CHANGE

AMOUNT WILLING TO PAY UNDER HIGH IMPACT SCENARIO DESCRIBED ABOVE (RAND)			
0	0		
1 – 10	1		
11 - 20	2		
21 – 30	3		
31- 50	4		
51 – 100	5		
101 - 200	6		
201 – 500	7		
501 – 1000	8		
1001 – 2000	9		
2001 – 3000	10		
3001 – 4000	11		
4001 + (SPECIFY)	12	SPECIFY	13

13. IF YOUR ANSWER TO EITHER OF THE ABOVE (QUESTION 12) IS ZERO, WHAT ARE YOUR REASONS (YOU MAY HAVE MORE THAN ONE)?

REASON	
13.1 CANNOT AFFORD THE FEES	1
13.2 GET NO OR NEGLIGIBLE VALUE OUT OF ESTUARY SERVICES	2
13.3 ABUNDANCE OF SERVICE OPTIONS – NO SCARCITY, THEREFORE WHY PAY	3
13.4 LACK OF CONFIDENCE IN GOVERNMENT TO COLLECT AND USE FEES COLLECTED FOR THE WATER PURCHASE	4
13.5 OTHER (SPECIFY)	5

14. WHAT WOULD YOUR HOUSHOLD SACRIFICE IN ORDER TO MAKE THIS PAYMENT? (THE MONEY HAS TO COME FROM SOMEWHERE – THE BUDGET CONSTRAINT – MAY TICK MORE THAN ONE BLOCK)

SERVICE INCOME WOULD BE REALLOCATED FROM		
14.1 RECREATION ACTIVITIES	1	
14.2 DOMESTIC/HOUSEHOLD LIVING	2	
14.3 DIS-SAVING	3	
14.4 OTHER (SPECIFY)	4	SPECIFY

15. DISTANCE IN KILOMETRES OF RESPONDENT'S CURRENT ACCOMMODATION (NOT NECESSARILY PLACE OF PERMANENT ABODE) FROM THE ESTUARY.

DISTANCE FROM ESTUARY (KM)	
0-1	1
1-3	2
3-10	3
10 +	4

16. APPROXIMATE WORTH OF RESPONDENTS VEHICLES AND BOATS OWNED AT CURRENT PRICES:

TOTAL VALUE (RAND)	
0	0
1- 2 000	1
2001- 10 000	2
10 001- 50 000	3
50 001- 100 000	4
100 001- 200 000	5
200 001-400 000	6
400 001 +	7

17. HIGHEST EDUCATIONAL LEVEL ATTAINMENT OF RESPONDENT.

EDUCATIONAL LEVEL	
NO SCHOOLING	1
COMPLETED 7 – 11 YEARS OR SCHOOLING	2
COMPLETED 12 YEARS OF SCHOOLING	3
COMPLETED SCHOOLING PLUS 3 OR MORE YEARS TERTIARY SCHOOLING	4

18. GROSS ANNUAL PRE-TAX INCOME OF RESPONDENT.

PRE TAX INCOME (RAND)	
0 – 50 000	1
50 001 – 100 000	2
100 001 – 150 000	3
150 001 – 200 000	4
200 001 – 250 000	5
250 001 – 350 000	6
350 001 – 500 000	7
500 001+	8

19. DO YOU HAVE ANY OTHER COMMENTS YOU WOULD LIKE TO CONTRIBUTE ON THIS PUBLIC ISSUE?

_____

_____

_____

Questionnaire compiled by members of the Departments of Economics and Zoology, UPE. Questions about this project may be directed at Prof SG Hosking,, tel 041-5042205

APPENDIX 3: Nahoon Questionnaire

WRC CVM QUESTIONNAIRE – ADMINISTERED BY UPE – PUBLIC ISSUE OF FRESH WATER INFLOW INTO THE NAHOON ESTUARY.

INSTRUCTIONS TO PERSON ADMINISTERING THE QUESTIONNAIRE.

(A) NAME OF PERSON ADMINISTERING QUESTIONNAIRE (NOT RESPONDENT):_____

(B) DATE INTERVIEW CONDUCTED):_____

(C) NO RESPONDENTS NAME IS TO BE RECORED AND THE INFORMATION GIVEN BY THEM IS TO BE TREATED AS CONFIDENTIAL.

(D) THERE ARE 19 QUESTIONS. PLEASE TICK THE APPROPRIATE BLOCKS OR FILL IN THE ANSWERS.

1. *RATE THE RELATIVE IMPORTANCE YOU ATTACH TO THE FOLLOWING ACTIVITIES/ATTRIBUTES OF THE ESTUARY:*

EXTREMELY IMPORTANT = 5
UNIMPORTANT = 1

ACTIVITIES/ ATTRIBUTES	**EX IMP**				**UNIMP**
10.1 BOAT SPORTS (EXCLUDING FISHING)	5	4	3	2	1
10.2 SWIMMING	5	4	3	2	1
10.3 FISHING	5	4	3	2	1
10.4 VIEWING ESTUARY(ACTIVELY)	5	4	3	2	1
10.5 PROXIMITY - BANKS FOR PICNICS, WALKING, CYCLING ETC	5	4	3	2	1
10.6 BIRD WATCHING	5	4	3	2	1
10.7 COMMERCIAL – ALL BUSINESS ACTIVITIES- USING ESTUARY PROXIMITY	5	4	3	2	1
10.8 SUBSISTANCE- SOURCE OF FOOD	5	4	3	2	1
10.9 PRESERVATION OF UNIQUE FEATURES	5	4	3	2	1
10.10 PASSIVE USE- VIEWING ESTUARY CO-INCIDENTLY OR ENJOYMENT NOT RELATED TO ACTIVE USE.	5	4	3	2	1

2. RACE OF RESPONDENT

RACE	
BLACKS	1
WHITES	2
COLOUREDS	3
INDIANS	4
OTHER	5

3. GENDER OF RESPONDENT

MALE	1
FEMALE	2

4. VISITOR OR RESIDENT?

4.1 VISITOR	1
4.2 RESIDENT	2

5. LOCATION INTERVIEW CONDUCTED (CONSULT MAP)

6. HOW OFTEN PER YEAR DO YOU USE THE ESTUARY ON AVERAGE?

DAYS	
1	1
2 -7	2
8 -14	3
15 -28	4
29 -59	5
60 +	6

7. OF THE MEMBERS OF YOUR HOUSEHOLD, HOW MANY USE THE ESTUARY IN SOME WAY OR OTHER DURING THE YEAR?

NUMBER OF MEMBERS OF HOUSEHOLD	
1	1
2	2
3	3
4	4
5	5
6	6
7+	7

8.GROSS ANNUAL PRE-TAX INCOME OF HOUSEHOLD.

PRE TAX INCOME (RAND)	
0 – 10 000	1
10 001- 30 000	2
30 001 –50 000	3
50 001 – 100 000	4
100 001 – 150 000	5
150 001 – 200 000	6
200 001 – 250 000	7
250 001 – 350 000	8
350 001 – 500 000	9
500 001+	10

9.WHAT PERCENTAGE OF YOUR GROSS ANNUAL PRE-TAX INCOME WOULD YOU BE PREPARED TO SPEND, IN TOTAL, ON THE CONSERVATION OF ENVIRONMENTAL RESOURCES?_____%

10. what do you think will happen if there is a significant reduction of freshwater inflow into the estuary?

PERSON IS WELL INFORMED –KNOWS MORE THAN 3 OF THE IMPACTS LISTED BELOW	1
PERSON HAS PARTIAL KNOWLEDGE - KNOWS 1-3 OF THE IMPACTS LISTED BELOW	2
PERSON IS POORLY INFORMED – KNOWS 0 OF THE IMPACTS LISTED BELOW	3

FILL IN THE GAPS IN THE PERSON'S KNOWLEDGE – IMPACTS TO BE READ TO THE RESPONDENT

THE DECREASE OF 67 % OF CURRENT FRESH WATER INFLOW INTO THE ESTUARY CAN BE EXPECTED TO HAVE CONSEQUENCES OF THE FOLLOWING MAGNITUDES:

FOR BOATERS

1. 10% DECREASE DUE TO EVAPORATION.

FOR SWIMMERS

1. 10% DECREASE DUE TO EVAPORATION.

FOR FISHERS/BAIT COLLECTORS

1. BIOMASS OF ANGLING FISH: 25% REDUCTION DUE TO MOUTH CLOSURE AND HYPERSALINE CONDITIONS.
2. BIOMASS OF BAIT: 25% REDUCTION DUE TO MOUTH CLOSURE AND HYPERSALINE CONDITIONS.

FOR BIRDERS

1. 25% REDUCTION DUE TO MOUTH CLOSURE AND HYPERSALINE CONDITIONS.

FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY

1. 10% CHANGE DUE TO EVAPORATION.

FROM THE PERSPECTIVE OF LOSS OF UNIQUE HABITATS

1. BIODIVERSITY: 25% REDUCTION DUE TO WATER COLUMN PRODUCTIVITY.

11.WHAT EXTRA AMOUNT IN USER FEES PER YEAR ARE YOU WILLING TO PAY, SPECIFICALLY FOR A PROJECT TO INCREASE/PREVENT A DECREASE IN RIVER WATER INFLOW (DUE TO URBAN AND AGRICULTURAL ABSTRACTION OR REDUCED FLOWS THROUGH FORESTRY OR VEGETATION CHANGES) INTO THE ESTUARY OF 14% OVER WHAT CURRENTLY FLOWS INTO THE ESTUARY TO PREVENT/INCREASE THE PROPORTION OF MAR INFLOW INT0 THE ESTUARY DECREASING FROM 82% TO 71%.

THE USER FEES WOULD BE COLLECTED IN TWO WAYS:
- BY THE LOCAL AUTHORITY IN USER FEES FROM ALL USERS WHO WISH TO ACCESS THE NAHOON ESTUARY
- BY THE LOCAL AUTHORITY IN A SPECIAL EXTRA PER ANNUM ESTUARY CONSERVATION LEVY COLLECTED FROM PEOPLE OWNING PROPERTY WITH A VIEW OF THE ESTUARY.

THE LOCAL AUTHORITY WOULD BE BOUND TO USE THE FEES SO COLLECTED TO FUND THE 'PURCHASE' OF 3.78 MILLION M^3 OF WATER, I.E., ENOUGH FRESH WATER INFLOW TO PREVENT OR BRING ABOUT THE CHANGES IN ESTUARY SERVICES INDICATED BELOW.

DESCRIPTION OF CHANGES:

FOR BOATERS

1. 10% DECREASE DUE TO EVAPORATION.

FOR SWIMMERS

3. 10% DECREASE DUE TO EVAPORATION.

FOR FISHERS/BAIT COLLECTORS

1. BIOMASS OF ANGLING FISH: 25% REDUCTION DUE TO MOUTH CLOSURE AND HYPERSALINE CONDITIONS.

4. BIOMASS OF BAIT: 25% REDUCTION DUE TO MOUTH CLOSURE AND HYPERSALINE CONDITIONS.

FOR BIRDERS

1. 25% REDUCTION DUE TO MOUTH CLOSURE AND HYPERSALINE CONDITIONS.

FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY

1. 10% CHANGE DUE TO EVAPORATION.

FROM THE PERSPECTIVE OF LOSS OF UNIQUE HABITATS

1. BIODIVERSITY: 25% REDUCTION DUE TO WATER COLUMN PRODUCTIVITY.

AMOUNT WILLING TO PAY (RAND) PER YEAR		
0	0	
1 – 10	1	
11 - 20	2	
21 – 30	3	
31- 50	4	
51 – 100	5	
101 - 200	6	
201 – 500	7	
501 – 1000	8	
1001 – 2000	9	
2001 – 3000	10	
3001 – 4000	11	
4001 + (SPECIFY)	12	SPECIFY

12. IF YOUR ANSWER TO THE ABOVE (QUESTION 11) IS ZERO, WHAT ARE YOUR REASONS (YOU MAY HAVE MORE THAN ONE)?

REASON	
13.1 CANNOT AFFORD THE FEES	1
13.2 GET NO OR NEGLIGIBLE VALUE OUT OF ESTUARY SERVICES	2
13.3 ABUNDANCE OF SERVICE OPTIONS – NO SCARCITY, THEREFORE WHY PAY	3
13.4 LACK OF CONFIDENCE IN GOVERNMENT TO COLLECT AND USE FEES COLLECTED FOR THE WATER PURCHASE	4
13.5 PAYING ENOUGH TAXES, FEES ETC ALREADY	5
13.6 OTHER REASONS (SPECIFY)	6

13. HOW MUCH DOES YOUR HOUSEHOLD PAY PER YEAR IN LEVIES FOR USE/ACCESS TO THE ESTUARY IN FISHING, BOATING, BAIT COLLECTION AND OTHER FEES?
R_____

WORKING BOX

BACKGROUND INFORMATION (PER ANNUM OR PER VISIT) – E.G., KEURBOOMS BOATING FEE (R250 P.A. AND R115 FOR A 30 DAY LICENCE) ANGLING FEE (R35 P.A.) BAIT COLLECTION FEE (R50 P.A.) LAUNCHING FEE (FREE) ACCESS TO BANKS FEE (FREE) LOCAL AUTHORITY CHARGES TO CONSERVE ESTAURY

14. HOW FAR DO YOU HAVE TO TRAVEL FROM HOME BY CAR/TRUCK TO REACH THE ESTUARY? (RETURN TRIP DISTANCE):

A) PERMANENT RESIDENCE TO ESTUARY: _____KM
B) ACCOMODATION NEAR ESTUARY TO ESTUARY ITSELF: _____KM
C) WHAT MAKE OF VEHICLE DO YOU USE TO TRAVEL TO THE ESTUARY?
D) MAKE_____ AND YEAR (MODEL) _____
E) DO NOT GO BY VEHICLE, BUT BY OTHER MEANS?

- IF SO WHAT MEANS_____ (E.G., FLY AND HIRE CAR OR CATCH BUS)
- APPROXIMATE COST OF RETURN TRIP TO ESTUARY BY THIS MEANS R _____

15. WHAT IS THE APPROXIMATE TOTAL COST OF THE ACCOMODATION YOU MAKE USE OF WHEN VISITING THE ESTUARY? (WHOLE PERIOD - RESIDENTS PAY ZERO)

R_____

16. WHAT DO YOU SPEND ON EQUIPMENT PER ANNUM TO ACCESS THE SERVICES OF THE ESTUARY-IN BOATS, FISHING EQUIPMENT, VIEWING EQUIPMENT ETC?

R_____

17.IF THE AREA AVAILABLE FOR BOATING AND THE NUMBERS OF FISH, BAIT, BIRDS ARE REDUCED SUBSTANTIALLY

17.1 I WOULD STILL VISIT THE ESTUARY	1
17.2 I WOULD VISIT OTHER ESTUARIES INSTEAD	2

18. USING THE ESTUARY IS APPROXIMATELY _____% OF THE REASON I VISIT THE ESTUARY OR LIVE IN THE AREA.

19. DO YOU HAVE ANY OTHER COMMENTS YOU WOULD LIKE TO CONTRIBUTE ON THIS PUBLIC ISSUE?
_____
_____
_____
_____
_____

Questionnaire compiled by members of the Departments of Economics and Zoology, UPE.
Questions about this project may be directed at Prof SG Hosking,, tel 041-5042205

APPENDIX 4: Blue-ribbon guidelines

1. A total sample size of at least 1000 is required for a DC question (yes-no type format).
2. If a survey has very high non-response rates, the survey will be deemed unreliable.
3. For this reason, it is recommended that personal interviews are used, although budget constraints often prevent this.
4. Good practice requires that a full report on the data and questionnaires is presented.
5. Pilot surveys are essential for any CV study.
6. A design which is conservative and more likely to underestimate WTP is preferred to a design likely to overestimate WTP.
7. A WTP format is generally preferred to a WTA format.
8. The valuation question should be posed as a vote on a referendum.
9. The valuation information must be accurately presented to the respondent.
10. The respondent should be made aware of the status of any undamaged substitute commodities.
11. Independently drawn samples should be taken at different points in time.
12. A “no answer” option should be made available to the respondent.
13. Yes/no responses should be followed by the open ended “why?’ question.
14. The survey should include a variety of other questions that help to interpret the responses to the primary valuation question.
15. The respondent should be reminded of alternative expenditure possibilities.

Source: Barbier, Acreman and Knowler, (1997)