VALUING PREFERENCES FOR FRESHWATER INFLOWS INTO SELECTED WESTERN AND SOUTHERN CAPE ESTUARIES

BY

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DECLARATION:

In accordance with Rule G4.6.3, I hereby declare that the above-mentioned treatise/dissertation/thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

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DATE: 6th April 2009

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EXECUTIVE SUMMARY

An estuary is the last stage of a river. It is where the river meets the sea. Estuaries are one of the most significant features of the South African coastline. In recent years, South Africa has witnessed an increase in the demand for freshwater for both industrial and domestic purposes. At the same time, there has been a gradual deterioration of river systems and their catchments. To add to this, there has been a gradual reduction in the amount of recorded rainfall, which is the primary source of freshwater for rivers.

This has resulted in decreased freshwater inflow into estuaries, a situation which poses a serious threat to the biological functioning of these estuaries and the services rendered to its recreational users. A deterioration of estuary services reduces the yield for subsistence households and their appeal for recreation. This study uses the contingent valuation method as its primary methodology to elicit users' willingness-to-pay to reduce the negative impacts of reduced freshwater inflow into selected western and southern cape estuaries. Eight estuaries were selected for this study: the Breede, Duiwenhoks, Great Berg, Kleinemond West, Mhlathuze, Mlalazi, Swartvlei and Olifants estuaries.

The contingent valuation (CV) method is widely used for studies of this nature because of its ability to capture active, passive and non-use values. The CV method involves directly asking people how much they would be willing to pay for specific environmental services. In this case, users were asked what they would be willing to pay to sustain freshwater inflows into selected estuaries in order to prevent the negative impacts of reduced inflows. Table E1 presents the values of freshwater inflow found in this study. The travel cost method (TCM) was used to generate an alternative comparative set of values for the purposes of convergence testing. This is because convergence testing is highly desirable as a validity test for CV estimates. The travel cost estimates are also presented in table E1.

Table E1: Recreational value of freshwater inflow into selected estuaries

	Estuary							
	Breede	**Duiwenhoks**	**Great Berg**	**Kleinemond West**	**Mhlathuze**	**Mlalazi**	**Olifants**	**Swartvlei**
TWTP (Rand)	228,987	531	109,200	276,763	22,838	31,050	1,025	33,640
Water Required p.a. (Millions m^3)	21.1	0.5	75	0.1	9.9	8.7	0.5	5.4
CV Value of water (R/m^3)	0.011	0.001	0.001	2.77	0.002	0.004	0.002	0.006
TCM Value of water (R/m^3)	0.013	0.002	0.001	2.42	0.01	0.007	0.04	0.01

The recreational value of the freshwater that flows into the selected estuaries varied enormously but in all cases was greater than zero. It was particularly high at the Kleinemond West estuary, where the value was R2.77 per cubic meter. The lowest value found was for the Olifants estuary, R0.002 per cubic meter of freshwater inflow. The TCM values found were consistent with the CV values. The highest TCM value found was for the Kleinemond West estuary, R2.42 per cubic meter and the lowest was for the Great Berg estuary, R0.001 per cubic meter.

The marginal social benefits of increased freshwater inflows for all the selected estuaries were positive. The implication of this is that there is a *prima-facie* case for the allocation of a specific amount of freshwater inflow into these estuaries per annum. However, the marginal social benefit should be compared with the marginal social cost in order to draw valid inferences. It is also important to note that the comparatively high marginal social benefit for the Kleinemond West estuary suggests that there is a particularly high preference for increased inflow beyond what is required to maintain the estuary in its current state.

The credibility of this CV study was assessed in terms of its content and construct validity. The study was compared to the Blue-Ribbon panel's guidelines with respect to the application of the CV method. Content validity relates to the design of the survey and its implementation. Construct validity on the other hand relates to how well the results obtained compare with those of other valuation methods and assesses the consistency of the results as far as theoretical expectations are concerned. It was found that there was a significant degree of compliance with respect to both content and construct validity. Table E1 shows that the CV values are consistent with the TCM values generated. The CV results were also consistent with theoretical expectations and the results of similar previous valuation studies.

As stated above, it is important to estimate the marginal social costs of increased freshwater inflows. This is an important task which is yet to be undertaken. The allocation of freshwater into estuaries should be informed by a comparison of marginal social benefit with marginal social cost. It is also recommend that more resources be committed to educating the public about the link between estuary services and the quantity and quality of the freshwater flowing into them. This education may help soften the resistance that some have to paying for water projects to secure freshwater inflows into estuaries.

The study supports the view that as many CV studies of estuaries are done as possible to help fine tune the technique and create a database against which other valuations may be compared.

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ABBREVIATIONS AND ACRONYMS

CV	–	Contingent Valuation
CVM	-	Contingent Valuation Methodology
DEAT	-	Department of Environmental Affairs and Tourism
DWAF	-	Department of Water and Forestry
GIS	-	Geographic Information System
HSRC	-	Human Sciences Research Council
LR	-	Log-likelihood Ratio
MAR	-	Mean Annual Runoff
NMMU	-	Nelson Mandela Metropolitan University
NOAA	-	National Oceanic and Atmospheric Administration
SANBI	-	South African National Biodiversity Institute
SNASBA	-	South African National Spatial Biodiversity Assessment
TWTP	-	Total Willingness to Pay
WTP	-	Willingness to Pay
WRC	-	Water Research Commission

CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION

The most widely accepted definition of an estuary is that it 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 freshwater derived from land drainage (Day & Mourato 2002).

There are 250 functioning estuaries in South Africa (Turpie 2005:20). These estuaries can be classified into five broad categories based mainly on physiographic, hydrographical and salinity characteristics (Whitfield 1992). These five types of estuaries are:

• Temporary open-closed estuaries
• Estuarine lakes
• Permanently open estuaries
• River mouths and
• Estuarine lagoons/bays.

The first two types of estuaries tend to close periodically. A sand bar forms at the mouth of the estuary blocking off their connection with the ocean. The other three types of estuaries remain open to the ocean on a permanent basis. Approximately 80% of South Africa's estuaries are of the temporarily open-closed type and therefore freshwater inflow from rivers is critically important in the length of time the mouth is kept open (Adams, 2004:5).

1.2 THE PROBLEM OF FRESHWATER DEPRIVATION

The loss of any environmental resource posses an economic problem because it involves the loss of natural capital. A reduction of freshwater inflow into estuaries reduces the services which these estuaries can offer to users, such boating area and the amount and diversity of the biota available (Adams 2001:2). The health status of an estuary is directly related to the quantity and quality of the water flowing into the estuary.

In South Africa, there has been a steady decrease in freshwater inflow into most estuaries, causing many of them to become smaller and decreasing the recreational, commercial and subsistence services which these estuaries offer to their users (Adams 2001:2). The reduction in the quality and quantity of freshwater that flows into estuaries was emphasised in the South African National Spatial Biodiversity Assessment Report (2005) released by the South African National Biodiversity Institute (SANBI). The study showed that over 80% of South Africa’s rivers are in such a bad state that they have been classified as "threatened". Of these river systems, 44% are critically threatened, 27% are endangered, 11% are vulnerable and 18% are least threatened.

Estuaries, being the last stage of rivers, are adversely affected because they inherit the problems from the rivers that flow into them. The SANBI report recommends that the number of protected estuaries should be increased, as only 14 of the country's 259 currently functioning estuaries are presently protected, and that a freshwater ‘reserve’ should be determined for those estuaries which are critically endangered. This freshwater ‘reserve’ is the amount of water needed in a river to enable it to function at some defined acceptable level (Nel, Maree & Moolman 2005: 2).

The government, partly in an attempt to deal with the growing problem of water allocation and management, enacted the National Water Act of 1998. One of the main requirements of the act is that water management authorities be established to administer river catchments. One of the main functions of these authorities is to ensure that the demand for freshwater by estuaries is taken into account in the management of catchment areas. In order to efficiently achieve this, the marginal social cost of the freshwater inflow into estuaries must be brought into equivalence with the marginal social value of the inflow.

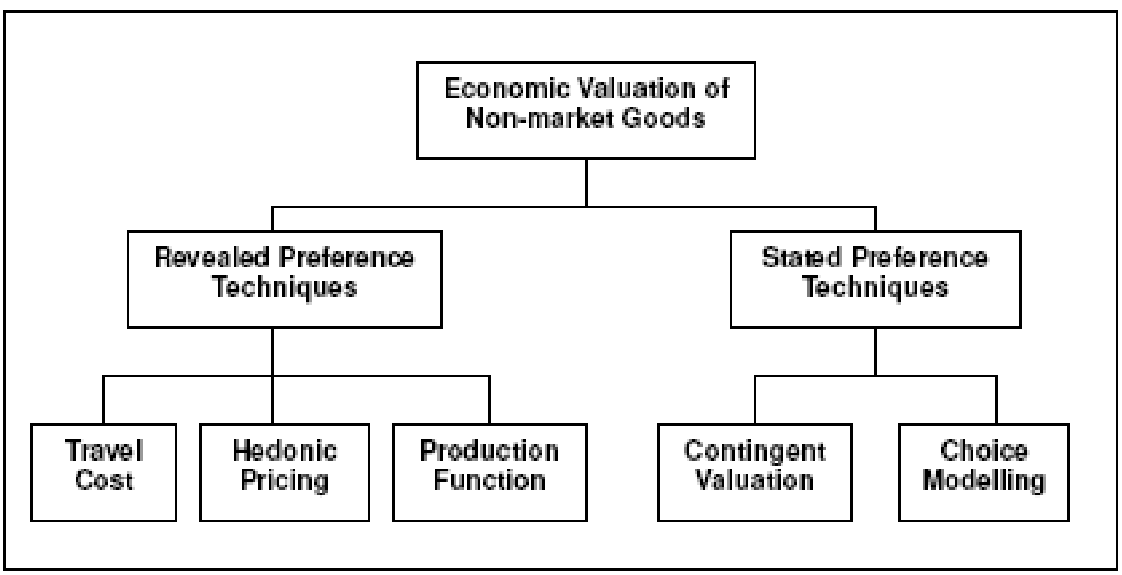
The marginal social cost of freshwater inflow into estuaries is what people are willing to pay to abstract freshwater upstream of the estuaries, while the marginal social value is the benefit which estuary users derive from the use of the water inflow into the estuary. This study focuses its attention on the estimation of the marginal social values of freshwater inflows into selected western and southern cape estuaries.

1.3 ECONOMIC VALUATION OF ENVIRONMENTAL RESOURCES

An economic valuation is the assignment of quantitative values to goods and services provided by the environment (Hanley & Spash 1993:146). The services provided by estuaries are, by their very nature, openly accessible and hence public goods (being non-excludable by law). As a result estuaries tend to be over-exploited.

Under normal circumstances, the economic value of a good or service is determined in the market place by the interaction of people who are willing to pay for the commodity and those willing to supply it. Where no markets exist for environmental resources, the values of these resources have to be inferred from related or hypothetical markets. There are essentially two ways of valuing environmental goods and services – through revealed preference techniques or stated preference techniques (see figure 1.1 below).

Figure 1.1: Economic valuation of non-market goods



(Source: Nel *et al*. 2005:30)

Revealed preference techniques determine the value of an environmental good by relating this good to prices in actual markets. This value is frequently obtained indirectly, for example, in property prices or the cost of travel to access the good. Stated preference techniques, on the other hand, determine the value of an environmental good by eliciting from people what economic value they attach to a good in a hypothetical market (Bateman, Jones, Lovett & Lake 2002: 230).

This study will primarily focus on the stated preference technique, using questionnaires to elicit an individuals' willingness-to-pay (WTP) for a particular good. There is no real market for the freshwater that flows into estuaries so the WTP must be determined in a hypothetical market. The users' stated WTP is used as a measure of the value of the resource, with the assumption that this is the price users would pay in real markets (Barbier, Acreman & Knowler 1997).

Figure 1.1 shows two branches of the stated preference technique. This study uses the contingent valuation method to establish the value of freshwater inflows into the selected estuaries. The travel cost method will be employed to generate comparative values.

This research forms part of an ongoing study for the Water Research Commission (WRC) to establish an economic value for the freshwater that flows into South Africa's estuaries. It is hoped that knowledge gained from this study will be used to assist in management decision making for the protection of estuaries in South Africa.

1.4 AIM OF THE STUDY

The primary aim of this study is to elicit users' willingness-to-pay for freshwater inflows into eight selected estuaries in the Western and Southern Cape: the Olifants, Breede, Duiwenhoks, Mlalazi, Kleinemond West, Mhlathuze, Swartvlei and Great Berg estuaries.

1.5 RESEARCH METHOD

General Approach

The contingent valuation method is the primary methodology employed in this study. Respondent data was collected through face-to-face interviews at the selected sites. The advantage of using face-to-face interviewing is the ability to interact directly with the respondent whilst explaining the purpose of the study and the context within which it is being applied. Face-to-face interviews are also useful where respondents are asked to select their answer form a range of values (Brace 2004: 231).

Population and Sample Selection

The target population of this study included those who received benefits or incurred costs as a result of changes to freshwater inflows. This study encompassed users who resided either permanently or temporarily within a 10 km radius of the estuary mouth or who were day visitors to the estuary. Once the population was identified, an appropriate sample representing the population was determined.

Method of Data Analysis

This study forms part of a bigger WRC project where river inflows into over 30 selected estuaries were valued. In this leg of the project, the survey data was collected from December 2006 to April 2007. This data was analysed using regression analysis for the selected estuaries. Two statistical models were used to generate predicted mean and median WTP values. These were the Ordinary Least Square (OLS) and Tobit models. The OLS and Tobit models both have continuous dependent variables explaining the variation in respondents WTP (Mendenhall & Sincich 1996).

The Research Team

Staff and students, mainly from the Zoology and Economic departments of the Nelson Mandela Metropolitan University, are actively involved with the WRC study and formed part of the decision making team as far as the content and nature of the surveys used for this study was concerned. They were also actively involved with the administration of the surveys at the selected sites and the capturing of the survey data.

1.6 ORGANISATION OF DISSERTATION

Chapter two of the dissertation reviews the contingent valuation method and the problems encountered in its application. Chapter three describes the eight sites selected for this study, namely the physical properties, hydrological conditions, ecosystem support and the various uses of the estuaries. The chapter also describes the state of the catchment areas that serve the estuaries. Sample design and survey administration are examined in chapter four. Chapter five discusses the valuation scenario and the survey results. Chapter six addresses the problems of multicollinearity and heteroscedasticity in the datasets and predicts household Willingness-To-Pay for each estuary based on respondent survey data. Chapter seven assesses the credibility of the predicted results whilst chapter eight applies the travel cost method to generate comparative values. The dissertation is concluded in chapter nine with a summary of the findings and recommendations.

CHAPTER TWO: THE CONTINGENT VALUATION METHODOLOGY

2.1 CHOOSING A VALUATION TECHNIQUE

Several methods can be used to value environmental goods and services. The contingent valuation method (CVM) is a survey based method for eliciting the value of environmental goods and services. Typically, the values of these environmental goods are not revealed in the marketplace because of their public good properties (Perman & McGilvray 1996:251). A further complicating factor is that the demand for these goods incorporates passive and non-current user willingness to pay, i.e. demand has a component that cannot be observed.

The CVM is able to incorporate these users and hence is an appropriate method to use when they are present. Where there are no passive or non-current users, other valuation techniques may be applied. One such technique is the Travel Cost method. The Travel Cost method is also frequently applied to value environmental goods and services that are used for recreation (Feather & Hellerstein 1997:155). The 'price' of access to a site is revealed by the time and travel cost expense that people incur to visit the site. Peoples' WTP to visit a site can be linked to the number of trips they make to the site and in this way, their demand for visits can be estimated.

Another revealed preference method is the Hedonic Pricing model. It decomposes the price of a composite good into its component parts (Feather & Hellerstein 1997:155). The price of a car, for instance, may be decomposed into the prices of its characteristics such as comfort, style, fuel consumption etc. The value of the individual characteristics of the car may be estimated from the coefficients of these characteristics in a multiple regression model.

Both the Travel Cost method and the Hedonic Pricing model can be applied to value changes to environmental goods and services, provided the changes can be incorporated into the estimated regression model. This condition may be difficult to realise in some situations, for instance, in cases where the available data does not reflect the differences between the condition with the change and the condition without the change. The value of the change may be revealed in markets in very limited ways, perhaps because the consumption of most environmental goods and services is by open access (Perman & McGilvray 1996:251). Under these circumstances, it is advantageous to use the CVM because it is able to value these changes directly.

2.2 APPLICATION OF THE CVM

The application of the CVM can be broken down into six steps or stages (Hanley & Spash 1993).

Step 1: Establishing a realistic market

The first step in applying the CVM is to establish a credible market. This market must be clearly defined on the questionnaire used to elicit users' WTP responses. It must have a clear purpose, be realistic and should be setup so that the respondent clearly understands the hypothetical scenario fully and accurately. This encourages truthful responses. Hanley and Spash (1993) recommend that in defining the valuation scenario, care should be taken to value a defined set of goods and services rather than a moral position. An example of the former is asking respondents how much in extra user fees they would be willing to pay per year for a project which would increase freshwater inflow into estuaries. An example of the latter (a moral question), is whether or not the health status of the estuary matters. Valuations that incorporate moral issues are said to have made a category valuation error. This is the error of valuing moral positions rather than packages of goods.

In order to minimise respondent fatigue, the amount of information provided to the respondent and the number of questions asked should not be excessive. Respondent fatigue causes the respondent to provide responses aimed at bringing the interview to a quick end. This problem can easily become a serious one in valuation exercises where a lot of (excessive) explaining is required.

An appropriate payment vehicle must be chosen which is realistic, relevant and acceptable to respondents. The payment vehicle describes the way in which the respondent is (hypothetically) expected to pay for the good (Arrow, Solow, Portney, Learner, Radner & Schuman 1993). The payment vehicle should ideally not be coercive, such as national or local tax, as respondents are often hostile towards taxes, even though such a payment vehicle is often the most realistic. A payment vehicle modelled around voluntary contributions may induce free-riding behaviour and consequently lower bids that would otherwise be made.

Arrow *et al* (1993) recommend that a pilot study be conducted where, among other things, the target population's attitude towards payment vehicles would be tested in order to minimise non-response.

Step 2: Administering the survey

Surveys can be administered by face-to face interview, telephonic interview or mail surveys. Face-to-face interviews are more effective in terms of response rates and avoid the misinterpretation of the questionnaire by the respondent. In eliciting WTP values, respondents need to bear in mind their budget constraint and the availability of substitutes to the services they are valuing. The respondents need to make compensating mental adjustments to other expenditures they would otherwise have made in order to accommodate their declared WTP responses. The questions should be limited in scope to cover only the services being valued. This ensures that the whole-part bias or embedding problem is avoided (Walsh 2000:15).

There are several different ways in which questions to elicit the WTP value can be framed. These include the open-ended elicitation approach, where respondents are asked to state their maximum WTP. No guide to an answer is provided in this case. The advantage of this technique is that it does not predispose the respondent toward particular amounts. The respondent is free to bid any value he or she finds acceptable, without worrying about pleasing or displeasing the interviewer. This approach helps to avoid anchoring biases, where the respondent's answers are 'anchored' around the initial value proposed by the interviewer. The downside is that it can cause an increase in non-response rates, protest and unrealistically large bids (Walsh 2000:117).

A different approach is to use the closed-ended question format, where specific WTP bid values are put to the respondents for them to accept or reject. This format is preferable over the open-ended method because it simplifies the decision required and is closer to the way trading takes place in real markets. Another advantage is that it minimises non-response rates and avoids unrealistic bids. Values elicited in this way are however highly susceptible to anchoring biases (Breedlove 1999:16).

The bidding game elicitation method is an extension of the closed-ended format. In this instance, if a respondent accepts a particular bid, another higher bid is put to the respondent and the process repeated until the respondent rejects the bid. If the respondent rejects the first bid, lower values are offered until the respondent accepts. In both of these cases, the highest accepted bid reflects the respondent's maximum WTP. Although this method is an improvement over the closed-ended format, it fails to eliminate the anchoring problem. There is also the possibility that the respondent will accept a bid, even if it does not match their true valuation, due to 'yea saying' (Wattage 2001:16).

The payment card elicitation method overcomes some of the problems of anchoring or starting point bias. With this method a range of values on a card are presented visually to the respondent, who then circles a value that represents their maximum WTP. This method reduces the number of outliers compared to the other formats and is well suited for face-to-face interviews (Walsh 2000:116). In addition to the WTP question, other follow-up questions, such as the approximate level of respondent income, should be asked. This enables the testing of the validity of the respondent's stated WTP for the good.

Apart from anchoring and yea- saying, the CV methodology is also susceptible to many other biases. These include compliant bias, where respondents gives answers which they feel the interviewer wants and strategic bias, where respondents intentionally misrepresent their preferences because they believe it will influence the amount of the good provided (Breedlove 1999:126).

Step 3: Screening the bids

The third step in the application of the CVM involves screening the bids made for validity. Protest bids are usually omitted. These bids are those in which the respondent indicated a zero willingness-to-pay value because they were protesting the hypothetical scenario or the chosen payment vehicle. Normal zero bids, where the respondent cannot afford to pay anything or where the respondent places no value on the resource are included in the WTP calculation (Hanley & Milne 1996:266).

Other bids excluded include cases where there are unrealistically high bids or where vital explanatory information such as annual income is not given or conflicts with the bid. In order to ascertain which bids are outliers, the sample mean bid is calculated. The norm for the exclusion of outliers is three standard deviations from the mean (Bateman *et al,* 2002:221).

Step 4: Generating a bid function

The fourth step in the application of the CVM is the estimation of bid functions, where the WTP is predicted from a set of explanatory variables. Of the other responses gathered in the questionnaire, some are selected as explanatory variables. Based on statistical analysis, these bid functions predict the variations in WTP as the independent variables change.

The estimation of the bid function is done in two phases. The first involves the estimation of the complete model, in which all relevant variables for which data has been collected, are included in the predictive bid function (Bateman *et al,* 2002:240). Following an analysis of the significance of the coefficients in the complete model, another model is estimated (in the second phase) in which only the variables with significant coefficients are included. This is the reduced model and is preferred for the prediction of WTP (Field & Field 2002)..

Step 5: Aggregation

The predicted mean or median bids are aggregated into a total population value, the total population willingness to pay (TWTP), by multiplying the predicted mean or median by the number of households thought to have a demand for the relevant environmental good or service.

Step 6: Assessing the credibility of the CVM application

The final step in the application of the CVM is to undertake an assessment of the credibility and validity of the CV exercise and estimates. This step involves the application of validity and reliability tests and reporting on deviations from the guidelines laid-down for CVM studies by the 'Blue-Ribbon' panel of eminent economists, commissioned by the NOAA to investigate the CV method (see Appendix E). Reliability tests measure the ability to replicate the results of the study (by applying the same method to a different data set). Validity tests, on the other hand, measure how valid the valuation method appears with reference to economic theory and other points of reference (Field & Field 2002).

One possible component of the validity assessment is the application of other methods, such as the Travel Cost method, to determine comparative values for the purposes of convergence testing. Such an assessment adds to the credibility of the CV exercise (Bateman *et al*, 2002:240).

2.3 CRITIQUES OF THE CVM

The CV methodology has been widely applied over the past two decades to value a wide variety of environmental goods and services. Real markets rarely exist for environmental goods and services, making it difficult to directly attach an economic value to them. The CV methodology circumvents this problem by presenting consumers with hypothetical markets in which these goods and services can be traded. But the hypothetical nature of this market, coupled with the fact that consumers' bids are also hypothetical, has been a source of controversy. Several economists, psychologists and sociologists do not accept the validity of the monetary estimates that result from CV studies. At the heart of this is whether the CV methodology adequately measures willingness to pay, given the hypothetical nature of markets and bids.

Studies show that there is a fundamental difference between how people make hypothetical decisions and how they make actual decisions (Hanley & Milne 1996:146). For instance, people may place unrealistically high bids if they believe they will not be actually required to pay for the good or service in question. This is true especially if the quantity of the goods and services supplied is dependent on their responses. Conversely, responses may be unrealistically low if respondents believe they will have to pay.

Some researchers argue that people generally find it difficult to mentally separate the services derived from an environmental good from the good itself. They tend to see the service as an intrinsic part of the good (Walsh 2000:95). Therefore, in cases where they are asked to value a specific service, their bids may reflect preferences for the good as well. This is known as 'embedding' and can be difficult to detect. The bids may also be highly sensitive to what respondents believe they are being asked to value as well as the context within which the valuation scenario is presented.

The type, amount and format of the information presented to the respondent may affect their answers, especially in situations where they are asked to value attributes they are not familiar with. They way in which the payment question is phrased may also affect bids. Theoretically, a respondent's willingness to pay for a resource should be the same as their willingness to accept compensation (WTA) for giving up the resource. However, in cases where the two formats have been compared, WTA significantly exceeds WTP (www.ecosystemvaluation.org). Critics have claimed that this result invalidates the CVM approach because it shows that responses are expressions of what respondents would like to have happen rather than true valuations.

Identifying the relevant user population could also pose a challenge in CV studies. This is particularly true in cases where the environmental good in question is openly accessible and incorporates a large passive use component. Even where the user population can be adequately identified, they may not be accessible. In such cases, getting a statistically representative sample is difficult and the results may be biased or over-fitted to the sample (Breedlove 1999:77).

The WTP bids expressed in CV studies are also susceptible to several respondent attitudinal biases. For instance, rather than expressing value for the good in question, the respondent might actually be expressing their feelings about the scenario being valued, the valuation exercise itself, or the chosen payment vehicle (www.ecosystemvaluation.org). So the respondent may express a positive WTP because they feel good about the act of giving for a social good although they believe that the good itself is unimportant. This is referred to as the 'warm-glow' bias. A respondent may also place a positive WTP bid in order to signal that they place importance on the good in question or may value the good but decline to pay for it because they are protesting the way in which the payment will be collected and administered. Respondents may also make associations among environmental goods that the researcher had not intended.

2.4 CONCLUSION

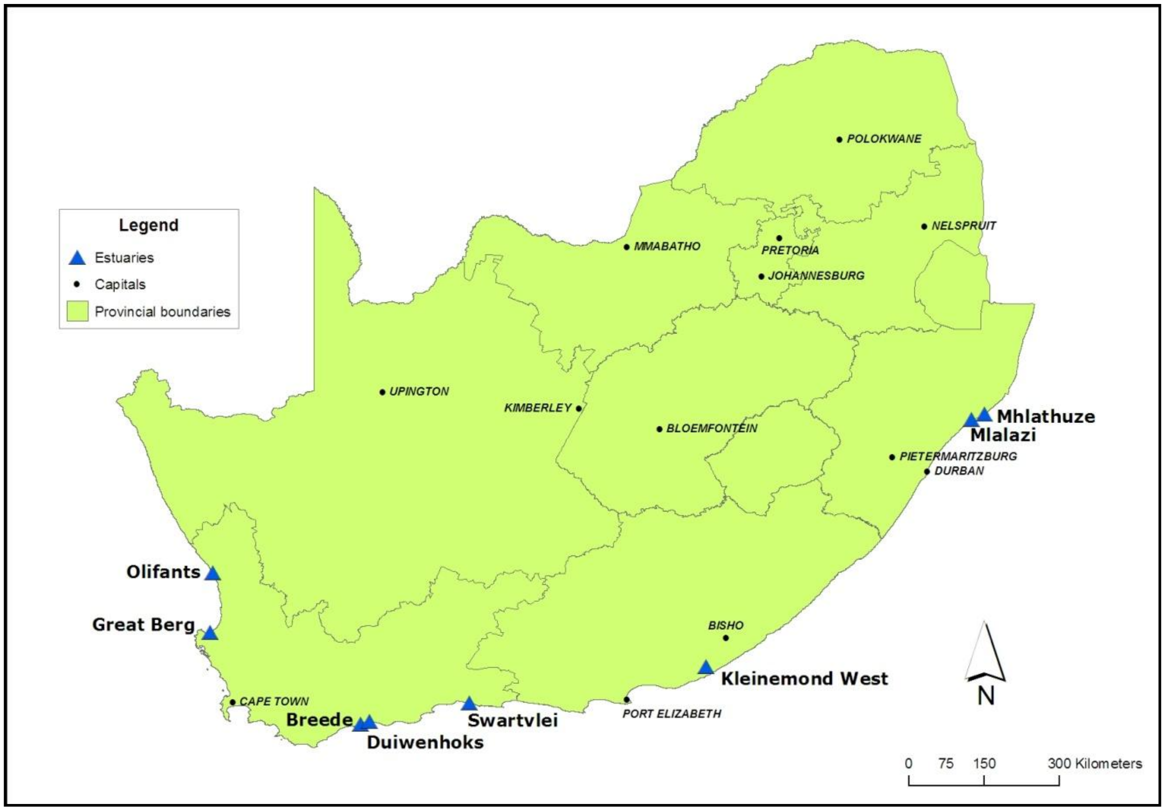
The contingent valuation method has become widely accepted as a means of valuing non-market goods. Two of its main advantages over other valuation methods are its ability to capture the non-use value inherent in environmental goods and to value environmental changes directly. In applying the CVM, a credible market must be established for the good being valued and the design and administration of the survey aimed at eliciting users WTP must closely follow accepted guidelines. The survey information is then used to estimate a bid function which is used in the prediction of sample mean or median values. The predicted mean or median bids are converted into total population WTP values by multiplying the sample mean or median with the total estimated household user population. The CVM is however susceptible to a large number of respondent biases and implementation issues and must therefore be accessed for credibility. There are various tests that may be applied to test for its credible application, one of which is the comparison of the CV estimates with those generated from alternative techniques or data sets. With the on-going controversy over the credibility of method due to its hypothetical nature and the biases it is susceptible to, the results of CV studies are more correctly interpreted as rough indications rather than precise results.

CHAPTER THREE: THE SELECTED ESTUARIES

3.1 INTRODUCTION

This chapter identifies and describes the salient hydrological and catchment area features of the eight estuaries selected for the purpose of valuing inflows of freshwater into them. These estuaries are the Breede, Duiwenhoks, Great Berg, Kleinemond West, Mhlathuze, Mlalazi, Olifants and Swartvlei estuaries. The locations of these estuaries are shown in figure 3.1

Figure 3.1: Locations of the eight selected estuaries



Source: HSRC- GIS Center (2007)

In addition to an overview of the key geographic, hydrological and catchment area information, the conservation importance of each estuary will also be considered. The conservation importance of an estuary may be calculated on the basis of its weighted size, habitat, zonal rarity and biodiversity importance. All of South Africa’s estuaries are ranked according to this conservation importance, which ranges from 0 to 100. A conservation importance of 100 indicates that failure to conserve the estuary will lead to permanent loss of the local biota (plants, invertebrates, fish and birds) and their habitats together with all associated services (Papadopoulos 2006).The mean annual runoff (MAR) of each estuary will also be presented.

3.2 THE SELECTED ESTUARIES

3.2.1 Breede Estuary

Figure 3.2 Breede Estuary

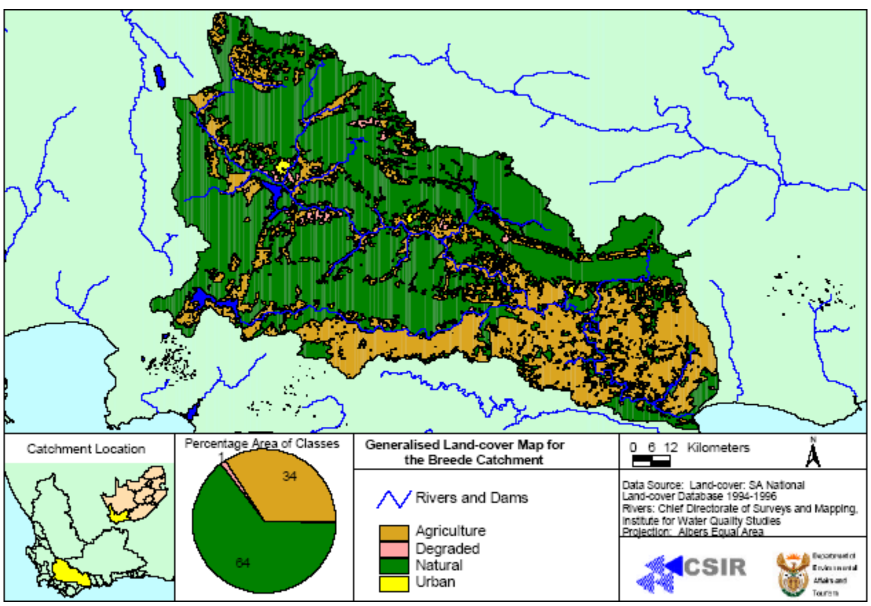
Source: Papadopoulos (2006)

Geographic and Catchment Area Description

The Breede estuary is a permanently open estuarine system. The estuary lies west of the coastal town of Mossel Bay in the Western Cape, near Cape Infanta. The overall structure of the estuary hasn't changed much over the years even though the incursion of marine sediments into the estuary has increased. This is evident in the last 2 km of the estuary where marine sands have formed extensive shoals and flats, particularly on the south bank (Papadopoulos 2006). Over the first 28 km of the estuary, average depths range from 3 to 6 meters. Tidal influence extends approximately 50 km upstream. The mouth of the estuary is expected to remain open under present conditions primarily due to its length and the relatively high run-off of the system. The estuary has been given a conservation importance rating of 86.8 (Papadopoulos 2006).

The estuary has a catchment area of 12 384km^2. 34% of the catchment is under active agricultural use. Approximately 64% of the land-cover is natural (see figure 3.3 below). There are a number of dams on the tributaries of the Breede River in the catchment areas and these are mostly used for local irrigation and domestic purposes. Annually, about 161 million m^3 of freshwater is extracted from the river. 5% of this water is used for domestic purposes, with 95% being used for irrigation (DWAF 2004). The Stettynskloof Dam, operated by the local water management authority, is the only dam of significant size for which the primary purpose is urban water supply. Of the dams supplying water for irrigation, the Greater Brandvlei Dam is the largest. It supplies about 153 million m^3 for irrigation annually *(ibid)*. This has resulted in decreased freshwater inflow into the estuary but it remains in a relatively good condition.

Figure 3.3: Breede Catchment Area



Source: DEAT (2001)

The total population living in the Breede river catchment area was estimated at 466 528 in 2006. 307 908 (66%) live in urban and peri-urban areas with the remaining 34% in rural areas. Of a workforce of 189 100 (2006 estimate), 62% are active in the formal economy. 19% are unemployed. The catchment area has a Mediterranean climate so irrigated agriculture, wheat cultivation and associated activities such as processing and packaging, are the primary economic activities. Consequently, 43% of those employed are in the agricultural sector, with 13% in manufacturing (DWAF 2004).

The Breede River contains sensitive aquatic ecosystems and supports various ecologically important wetlands. An example is the Papenkuils wetland in the upper reaches of the Breede River which contains a variety of terrestrial flora worthy of conservation (*ibid)*. The Papenkuils wetland is particularly vulnerable due to reduced water availability and retention, which is primarily caused by local disturbances and activities within the catchments upstream. Currently, the Breede River is extensively used for recreation, with one notable event being the Breede River canoe marathon which is held every year between the towns of Robertson and Swellendam. There are also planned housing developments in the upper catchments and along the banks of the Breede River in the near future. This could have a potential negative impact on freshwater inflow into the estuary. Selected hydrological and catchment area information about the Breede estuary is presented in table 3.1

Table 3.1: Breede Estuary hydrological and Catchment Area Information

Attribute	**Magnitude/Level**
Mean Annual Runoff (Estuary & Catchment)	1893×10^6 m^3
Catchment Area	12 384 km^2
Estuarine Surface Area	200 ha
Average Depth	2.5 m

Source: Papadopoulos (2006)

3.2.2 Duiwenhoks Estuary

Figure 3.4 Duiwenhoks Estuary

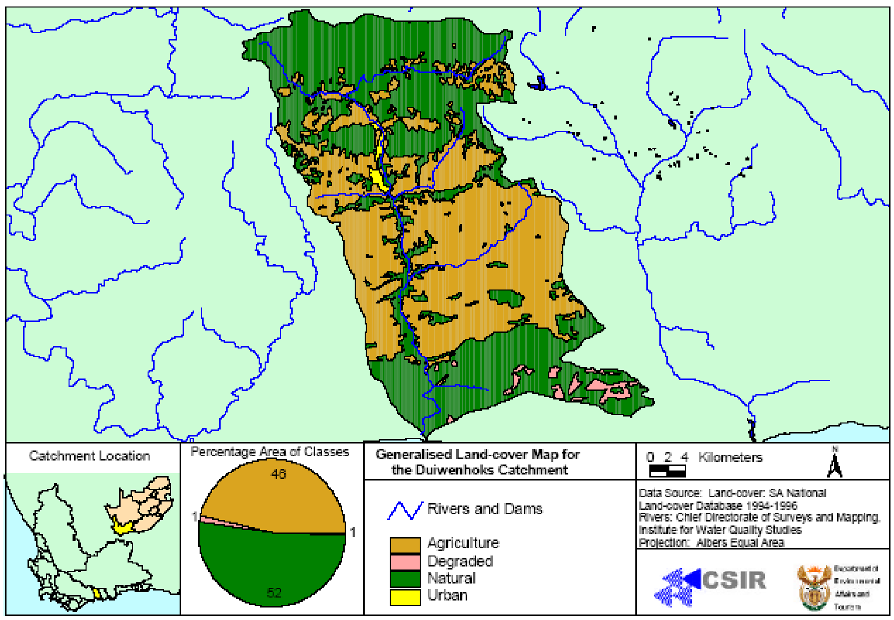
Source: Papadopoulos (2006)

Geographic and Catchment Area Description

The Duiwenhoks estuary is situated west of the coastal town of Mossel Bay in the Western Cape and is a permanently open estuarine system. The estuary has a constricted inlet and its large tidal exchange keeps the mouth permanently open. The major source of freshwater into the estuary is from the Duiwenhoks River, which has its origins on the southern slopes of the Langeberg Mountains. The river is about 83 km long and its occasional flooding is important in flushing marine sand out of the lower reaches of the estuary. The catchment area of the river is about 1 340 km^2. The only major town the Duiwenhoks River passes through is Heidelberg, roughly 40 km upstream of the estuary. The estuary has a relatively small surface area of 97 hectors and a length of about 14 km. The average depth of the estuary is 2 meters (Anderson, Hargey, Jennings & Veitch 2002)

46% of the catchment area is under agricultural cultivation (see figure 3.5). This largely consists of several privately owned citrus and dairy farms, especially in the upper reaches of the catchment. In the lower catchments, wheat is the major crop grown. 52% of the catchment area consists of natural shrublands, bushland and grassland. Urban development, mainly residential developments associated with Heidelberg, accounts for about 2% of the land cover in the Duiwenhoks catchment (DWAF 2004). The largest dam on the Duiwenhoks River is the Duiwenhoks Dam, which supplies water to Heidelberg, Askraal, Witsands, Vermaaklikheid and the surrounding farming communities for irrigation and urban consumption. The Duiwenhoks river system is a relatively small one. Because of this, even relatively small water use activities can create significant quantity and quality impacts on the estuary. Probable unlawful abstraction of the freshwater upstream appears to be resulting in an observed decrease of flow into the estuary (*ibid)*.

Figure 3.5: Duiwenhoks Catchment Area



Source: DEAT (2001)

Apart from Heidelberg, the rest of the towns in the catchment areas are sparsely populated. The Vermaaklikheid 'village' for instance was once a flourishing settlement relying on a grape crop that slowly dwindled. As a result, labour opportunities have decreased, resulting in a gradual move of residents to Mossel Bay, Cape Town and other cities (Munnik 2006). The current community of about 40 families is dependent on limited job opportunities ranging from farm labour, fishing, small-scale farming, building restoration and domestic help to landowners. Many of the residents also moved to

Slangrivier, a local township about 20km's away serving as a labour reserve with a high level of unemployment (Anderson *et al*. 2002). Those who have stayed have recently benefited from a pilot RDP housing project being undertaken by the local municipality.

The area around the estuary is part of the Cape Floristic Region (the smallest of the world's six floral kingdoms) and is especially significant due to the predominance of rare Limestone fynbos. This limestone provides a rare and unique floral habitat to endangered plant species such *as Amphithalea alba, Argyrolobium harmsianum, Harmannia trifoliata* and others. The area has therefore been declared a Nature Conservation Protectorate and the Duiwenhoks Conservancy has been established to help preserve its uniqueness. The Duiwenhoks Conservancy is a group of landowners and people who use the Duiwenhoks River and the surrounding wilderness and farm areas, for recreation and subsistence (Munnik 2006). The use of the estuary is subject to various national, provincial and municipal regulations governing the use of boats, fishing, bait and shellfish collection on the Duiwenhoks River.

The invasion of several alien plants species like rooikrans and black wattles, also pose a major threat to the survival of endangered indigenous plants. The alien plants absorb large amounts of freshwater and soil nutrients, decreasing availability for other plants. It is estimated that surface water runoffs into the Duiwenhoks River could be increased by as much as 10 million m^3 per annum through the complete removal of these invasive alien plants (Anderson *et al*. 2002). Recent archaeological studies in the close vicinity of the estuary have also uncovered evidence of the existence of 'modern' man at the site, dating back to about 77 000 years ago. It is envisaged that the site would be declared a World Heritage Site upon the completion of further studies (*ibid*). The estuary itself is ecologically important as it provides a habitat for several fish and marine species. The estuary has consequently been assigned a conservation importance rating of 83.6 (Papadopoulos 2006).

Apart from the threat posed by the invasion of alien plants, rapid urbanisation and the expansion of agricultural activity may negatively affect the amount of freshwater flowing into the estuary in the near future. Selected hydrological and catchment area information about the Duiwenhoks estuary is presented in table 3.2.

Table 3.2: Duiwenhoks Estuary hydrological and Catchment Area Information

Attribute	Magnitude/Level
Mean Annual Runoff (Estuary & Catchment)	436.73 x 10^6 m^3
Catchment Area	1,340 km^2
Estuarine Surface Area	97 ha
Average Depth	2.0 m

Source: Papadopoulos (2006)

3.2.3 Great Berg Estuary

Figure 3.6 Great Berg Estuary

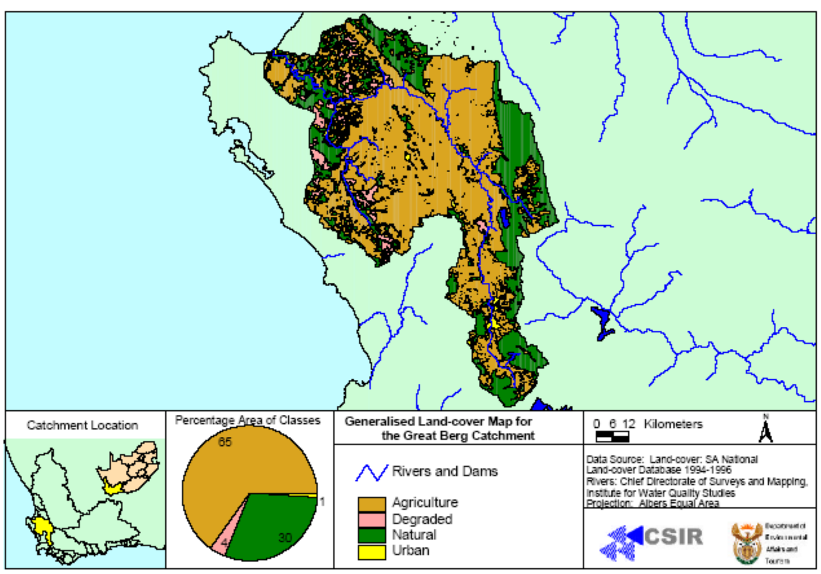
Source: Papadopoulos (2006)

Geographic and Catchment Area Description

The Great Berg estuary is located in the Western Cape and is found on the west coast, north of Cape Town. It is a permanently open estuarine system and is currently in a fair condition. The estuary is fed by the Berg River, which has its origins in the Drakenstein Mountains at Franschhoek. The Berg River is one of the largest in the Western Cape and is approximately 294 km long with a catchment area of 7 715 km^2 (Papadopoulos 2006). The estuary meanders over an extensive floodplain with tidal effects measurable up to 65 km from the sea (*ibid*). The ecology of the estuary is largely determined by seasonal changes in river discharge and the consequent changes in salinity and turbidity. The original mouth used to open to the south of its present position and is now a lagoon that runs parallel to the coast. The new mouth is protected by three breakwaters and the channel is dredged to allow for the passage of boats (Bennett 1994).

The Berg River catchment area includes the metropolis of Cape Town and the surrounding areas. Major towns in the catchment include Velddrift and Laaiplek near the coast, Piketberg, Hopefield and Darling, which are further inland as well as Wellington and Paarl in the upper catchment. About 65% of the catchment is under agricultural cultivation (see figure 3.7). This is mostly comprised of commercial dryland and irrigated agriculture including commercial forestry. Residential, commercial and industrial developments account for about 1% of the catchment. The Berg River is a major source of supply of potable water for the Cape Peninsula including the Cape Flats area (DWAF 2004). Two major dams have been built in the catchment, the Wemmershoek Dam and the Voelvlei Dam, supplying water for urban consumption and irrigation. As a result current annual freshwater inflow into the estuary is 30% less than historical flows (Papadopoulos 2006).

Figure 3.7: Great Berg Catchment Area



Source: DEAT (2001)

The domestic, industrial and agriculture demand for water is projected to increase due to urban expansion, new developments and rapid population growth. Strong economic growth in the Cape Town metropolitan area and its vicinity is expected in the foreseeable future, further increasing urban requirements for water. Given the lucrative nature of irrigated agriculture, continuous pressure also exists for more water to be made available for irrigation. Additionally, climate change projections for the region suggest that the winter rainfall, which is a major source of freshwater into the river and estuary, will be reduced during the next 50 years.

The recent construction of the Berg River Dam is expected to ease the impact of reduced inflow on the estuary by safeguarding its ecological reserve requirement (Rossouw 2008). The ecological reserve requirement of a resource is the quality, quantity and timing of water flows required to maintain the components, functions, processes and resilience of aquatic ecosystems which provide goods and services to people (DWAF 2004). The preliminary determination of the ecological reserve for the upper Berg River catchment (water quantity) was set at 44 million m^3, representing 31% of the mean annual runoff of 141.7 million m^3 (Rossouw 2008).

The estuary supports a wide variety of animal and plant species due to the diversity of the landscape. The vicinity of the estuary is therefore very rich in bio-diversity. The estuary accommodates large numbers of bird species. It is one of only two localities in South Africa to which approximately 30 000 birds migrate annually (Bennett 1994). It is considered a Ramsar site, primarily due to its international importance for the water fowl. The estuary therefore has a conservation importance rating of 98.4 (Papadopoulos 2006). It is very popular with bird watchers as most of the areas frequented by the birds are accessible by tar road and there is a good network of dirt roads which allows one to approach the birds very closely.

The Great Berg estuary is also an important breeding area for many fish, prawn and crab species. Some of the fish species can be dependent on the estuary for their entire life cycle. The most common fish species in the estuary is the mullet (harders) that feed on both detritus and plankton. The estuary also supports several endangered plant species but the invasion of alien plants such as Pines, Wattle and Hakea, poses a threat to their survival (Bennett 1994). Selected hydrological and catchment area information about the Great Berg estuary is presented in table 3.3.

Table 3.3: Great Berg Estuary hydrological and Catchment Area Information

Attribute	Magnitude/Level
Mean Annual Runoff (Estuary & Catchment)	1 663 x 10^6 m^3
Estuary Catchment Area	4 012 km^2
Estuarine Surface Area	215 ha
Average Depth	2.3 m

Source: Papadopoulos (2006)

3.2.4 Kleinemonde West Estuary

Figure 3.8 Kleinemonde West Estuary

Source: Papadopoulos (2006)

Geographic and Catchment Area Description

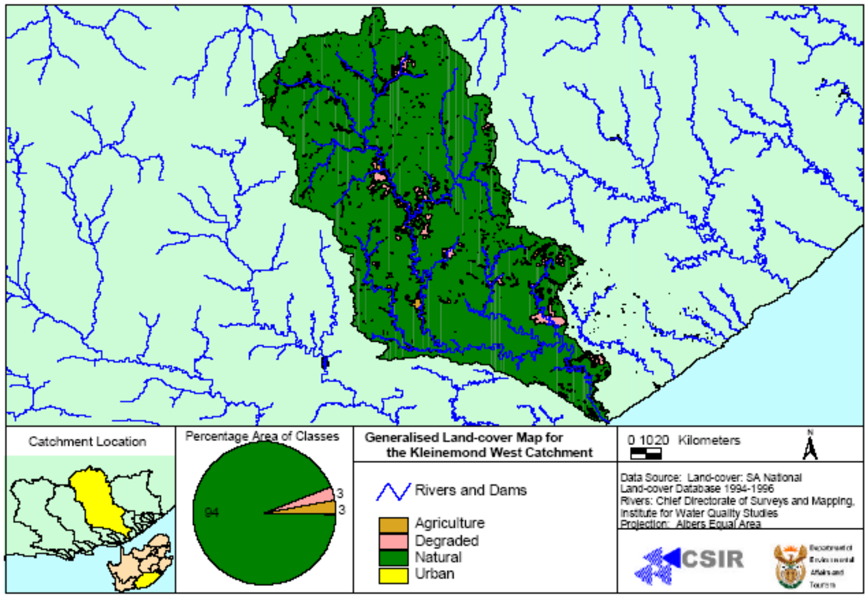
The Kleinemond West estuary is located on the southern coast of the Eastern Cape, approximately 15 km northeast of Port Alfred. It is a relatively small temporary open/closed estuarine system with a surface area of 17.5 hectors. The estuary is closed off from the sea for most of the year by a sandbar which forms at the mouth of the estuary.

Occasional flooding during the winter months flushes out sediments and opens up the estuary to the sea. The estuary then becomes tidal for a month or more before closing up again. The estuary was originally 10 km long before a barrage was built across it in 1960, enabling the upper reaches to be used for freshwater storage (Day 1981).

Presently, the estuary is navigable for approximately 5 km upstream and the widest portion in the lower reaches is 125 m. This narrows down to about 25 m in the upper reaches. The estuary is mostly shallow, with main channel depth ranging between 1 and 2 m in the navigable portion of the system. During periods of extended mouth closure, the estuary water level rises to about 2m above sea level. This is due to the extensive sandbar which forms at the mouth (Papadopoulos 2006). The estuary is in a good condition and has a conservation importance rating of 72.5 (*ibid*).

The Kleinemond West estuary drains 94 km^2 of dry farmland with a mean annual runoff of 178 million m^3. Seafield, a small township north of Port Alfred, surrounds most of the lower reaches of the estuary, as well as the neighboring Kleinemonde East estuary. The R72 coastal road between Port Elizabeth and East London crosses the estuary approximately 500 m from the mouth. Agriculture (mainly cattle ranching) comprises just about 3% of the catchment while 95% of the land-cover is natural. This distribution is shown in figure 3.9 below.

Figure 3.9: Kleinemond West Catchment Area



Source: DEAT (2001)

Fishing, swimming, water skiing and kayaking are very popular activities on the Kleinemond west estuary. This is largely due to the close proximity of residential property and various game reserves and parks where the Big Five can be seen on day and night drives. The estuary provides a habitat for the African Fish Eagle, Perlemoen (which is a protected species) and various other rare macrophytes such as *Ruppia Cirrhosa* and the seagrass *Holophila ovalis*. Selected hydrological and catchment area information about the Kleinemond West estuary is presented in table 3.4

Table 3.4: Kleinemond West Estuary hydrological and Catchment Area Information

Attribute	**Magnitude/Level**
Mean Annual Runoff (Estuary & Catchment)	178.04 x 10^6 m^3
Catchment Area	94 km^2
Estuarine Surface Area	17.5 ha
Average Depth	2.0 m

Source: Papadopoulos (2006)

3.2.5 Mhlathuze Estuary

Figure 3.10 Mhlathuze Estuary

Source: Papadopoulos (2006)

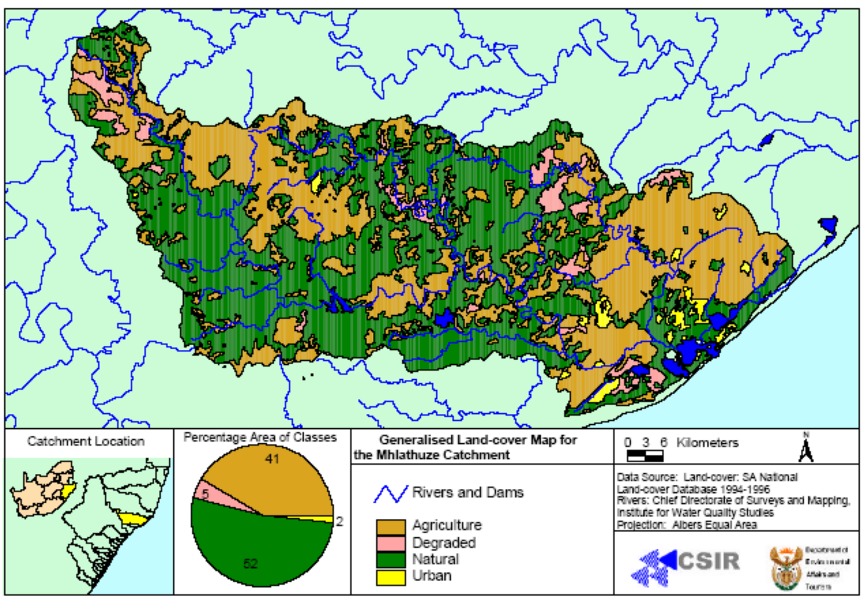
Geographic and Catchment Area Description

The Mhlathuze estuary is situated within the metropolitan area of Richards Bay in KwaZulu-Natal. With the development of a deep-water harbour at Richards Bay in the 1970s, the original Richards Bay estuary was divided into two sections by a 4 km berm wall. This divided the estuary into a new harbour area (the Richards Bay Harbour) and a sanctuary area (the Mhlathuze estuary), each with its own opening to the sea. The Mhlathuze River was canalized, diverting the natural flow of the river into the estuary. Prior to the construction of the harbour, the system comprised a large shallow expanse of water, fed primarily by the Mhlathuze River (Wegner 2006). Presently, the estuary is in relatively fair condition with a conservation importance of 93.5 (Papadopoulos 2006).

The estuary covers an area of approximately 12 km^2 and has a length of 6 km. It is 3 km wide near the mouth with a total shoreline length of 30 km (Wegner 2006). During 1975 a new mouth was dredged through the sandbar approximately 5 km to the south of the original mouth. The permanently open mouth is mainly maintained by strong tidal flows related to the considerable size of the estuary and the large vertical tidal variation. Mouth closure could, however, be expected sometime in the future if the estuary filled with sediment, reducing the tidal flows through the mouth (*ibid)*.

The Mhlathuze catchment is 4 209 km² in size and has three major towns namely Richards Bay, Empangeni and Melmoth . Approximately 41% of the catchment is under agricultural cultivation (see figure 3.11). This mainly comprises of commercial forestry, subsistence farming and sugar cane cultivation. 52% of the catchment is natural and comprises of grassland and bushland. Residential, industrial and commercial development, mainly associated with Richard's Bay and Empangeni, account for about 2% of the land cover (DWAF 2004). The Mhlathuze River system supplies water to the urban, industrial and mining sectors situated in and around Richards Bay and Empangeni. It also supplies water to the agricultural sector, irrigating mainly sugarcane and citrus trees. Rural communities in the catchment area are directly dependent on the river for all their water needs including that of drinking, washing and recreation.

Figure 3.11: Mhlathuze West Catchment Area



Source: DEAT (2001)

According to 2001 census data, the Black population makes up about 92% of the Mhlathuze river catchment. The total White population stands at 5% while the remainder of the population is Indian and Coloured. The age distribution figures show that 51.3% of the total population is below 20 years of age. This implies that a large proportion of the population is not considered economically active. The catchments' unemployment figure stands at 42.8%. This is higher than the KwaZulu Natal average of 39.1%. However, the percentage of professionals in the catchment is 13.9% of the population compared to the overall KwaZulu Natal figure of 11.5%. This is indicative of the contrasting characteristics of the Mhlathuze catchment area. The lower part of the catchment, where Richards Bay and Empangeni are situated, is highly productive hosting some of South Africa's largest industries, while the upper part is typical of rural South Africa (DWAF 2004).

The estuary is marine-driven and supports extensive mangrove areas. Sugar-cane is cultivated extensively on the floodplain of the estuary. In recent years the number of informal settlements and subsistence farms on the eastern shore of the estuary has increased drastically. Large tracts of mangrove swamps can be found on the southern and western banks of the estuary. These swamps, dominated by *Avicennia marina* and *Bruguiera gymnorrhiza*, represent about 80% of the mangroves found in South African estuaries and bays (Wegner 2006). There has been a considerable reduction in the amount of freshwater inflow into the estuary due to the rapid industrialisation of the Richards Bay area, bad agricultural practices and the construction of a dam in the upper catchment (Papadopoulos 2006). A study by Bezuidenhout, Mthembu, Puckree and Lin (2002) also found high concentrations of faecal bacteria in the river and estuary. This could pose significant health risks to the communities along the banks of the river. Current pressures on the estuary are primarily from subsistence fishing by inhabitants of the nearby town of eSikhawini and the dredging in the adjacent harbour area. Selected hydrological and catchment area information about the Mhlathuze estuary is presented in table 3.5.

Table 3.5 Mhlathuze Estuary hydrological and Catchment Area Information

Attribute	Magnitude/Level
Mean Annual Runoff (Estuary & Catchment)	1 095 x 10^6 m^3
Catchment Area	4 209 km^2
Estuarine Surface Area	12 km^2
Average Depth	2.0 m

Source: Papadopoulos (2006)

3.2.6 Mlalazi Estuary

Figure 3.12 Mlalazi Estuary

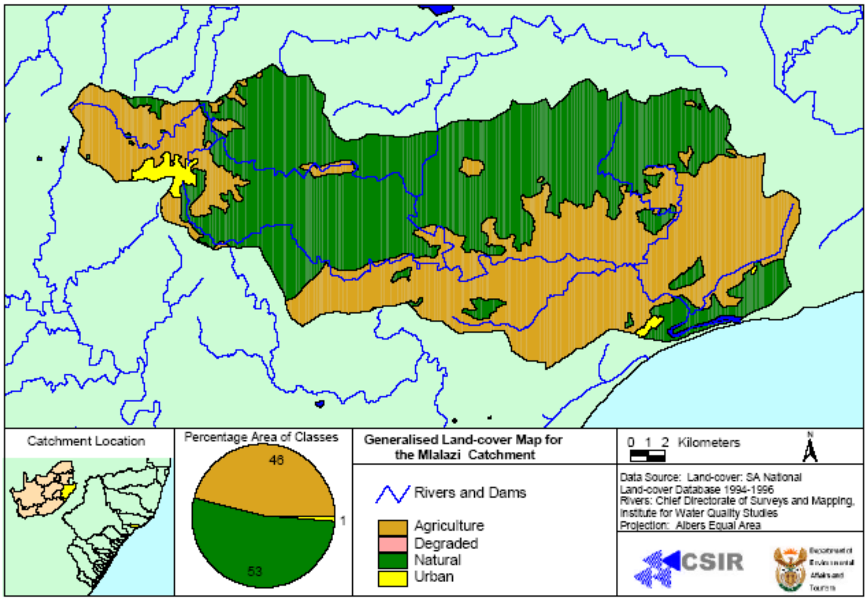
Source: Papadopoulos (2006)

Geographic and Catchment Area Description

The Mlalazi estuary is a permanently open estuarine system. The estuary is easily accessible by road and is close to the village of Mtunzini in KwaZulu-Natal. The estuary is about 11 km long, 100 meters wide and has an average depth of 2 meters. The Mlalazi River has been deflected northwards near Mtunzini, for about 4 km, and now flows through high forested sand dunes. The mouth has not closed during the past 35 years due to strong tidal action (Papadopoulos 2006).

The Mlalazi River drains a catchment area of about 492 km^2. Approximately 46% of the catchment area is under agricultural cultivation (see figure 3.13). This consists of subsistence farming, sugar cane and commercial farming. 53% of the land cover is comprised of natural grassland, bushland and forest. Residential and industrial developments associated with Mtunzini and the town of Eshowe (further inland) account for 1% of the catchment land cover (DWAF 2004).

Figure 3.13: Mlalazi Catchment Area



Source: DEAT (2001)

The estuary is popular for its many recreational attractions. These include boating, angling and picnicking along the banks. The Umlalazi Nature Reserve is located nearby and provides a home to several animals such as the Bushbuck, Reedbuck and Duiker. The nature reserve also has more than 300 recorded bird species, including the rare Palmnut Vulture. The Mlalazi River flows through the nature reserve and is home to several varieties of crocodiles and fish. The estuary also has educational value as it has been selected as a research site run by the Dept of Biological Sciences at the University of KwaZulu Natal (DWAF 2004).

The estuary is surrounded by extensive mangrove forests that support a typical mangrove associated fauna (Benzuidenhout *et al.* 2002). Mangroves also grow along watercourses through the mudflats where typical salt marsh species are dominant. Swampy freshwater parts of the floodplain support a rich flora, with numerous clumps of trees. The estuary provides a habitat for several species of frogs and vervet monkeys. Excessive siltation threatens the system and sugar cane encroachment into its upper reaches is a problem (DWAF 2004). Other threats include pollution by pesticides and fertilizers from sugar cane farms and a mining threat to the northern side of the dunes. The estuary has a conservation importance rating of 85.4 (Papadopoulos 2006). Selected hydrological and catchment area information about the Mlalazi estuary is presented in table 3.6

Table 3.6: Mlalazi Estuary hydrological and Catchment Area Information

Attribute	Magnitude/Level
Mean Annual Runoff (Estuary & Catchment)	1077×10^6 m^3
Catchment Area	492 km^2
Estuarine Surface Area	15.5 ha
Average Depth	2.0 m

Source: Papadopoulos (2006)

3.2.7 Olifants Estuary

Figure 3.14 Olifants Estuary

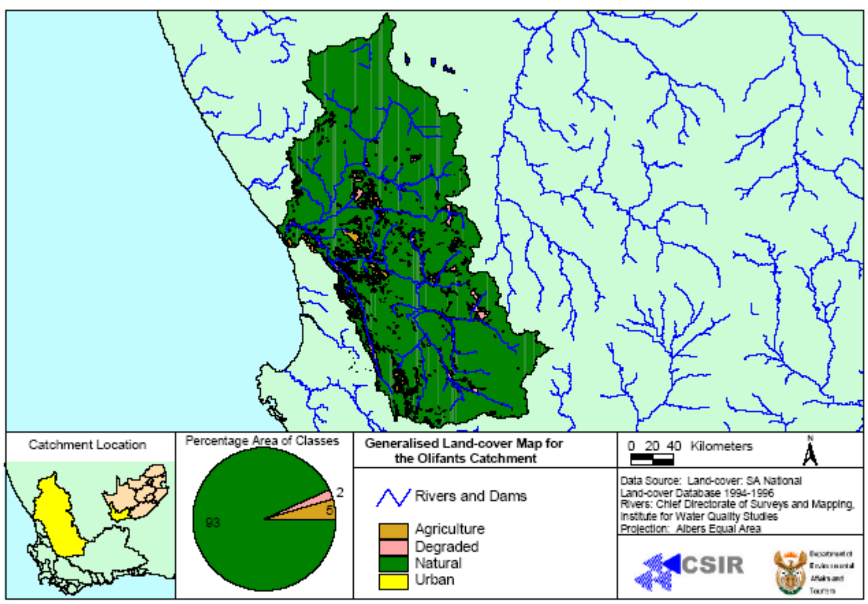
Source: Papadopoulos (2006)

Geographic and Catchment Area Description

The Olifants Estuary is situated 250 km northwest of Cape Town. The nearest towns are Lutzville and Vredendal, which lie 23.5 km and 42 km east of the estuary respectively. The estuary appears to be in an almost pristine condition. This is probably because there has been little local human activity to impact on it. This could be due to the relative inaccessibility of the estuary to the public. The mouth of the system is permanently open and is situated between a stable sand spit on the southern side and a rocky bluff on the northern side (Morant 1984). The estuary has a strong tidal influence and the upper reaches of the estuary are situated 15 km upstream. These upper reaches are narrow and water depths range from 1-3 m, while the lower reaches widen to about 400 m with water depths of between 0.5 -7 m (Day 1981, Morant 1984).

The estuary is fed by the Olifants River which is 285 km long and has a catchment area of about 46 000 km^2, much of which is arid. The River rises in the Agterwitzenberg, a plateau lying between the Winterhoek and the Skurweberg mountains. The mean annual runoff of the catchment is 1 230 million m3. Winter rains between June and September usually cause flooding in the catchments. There is very little river flow during the summer months. Agriculture comprises approximately 5% of the catchment land-cover (see figure 3.15). Most of this is devoted to temporary dryland agriculture and permanent commercial irrigated agriculture. Approximately 93% of the catchment is natural, mainly shrubland, bushland and grassland. Urban development accounts for less than 1% of the land-cover in the Olifants catchment. Most of this is made up of residential development, mines and quarries (DWAF 2004).

Figure 3.15: Olifants Catchment Area



Source: DEAT (2001)

The Clanwilliam and Bulshoek Dams are the two major dams on the Olifants River. They supply water for the towns and farming communities along the river. Almost the entire catchment is rural with farming as the most important activity. The area around the Clanwilliam is famous for its production of the Rooibos tea while irriagated fruit farming, mainly vines, is dominant in the other areas. Other activities include sheep and goat rearing and salt generation at the salt pans. The Cedarberg Divisional Council controls access to the estuary. Public access is also restricted because of marine diamond-mining along the northern shores of the river (Morant 1984). The most of the other areas in the Cedarberg region are managed as ‘Wilderness Areas’ with access by hikers controlled to minimize human impact.

The estuary has been identified as one of the ten coastal wetlands of major importance as wader habitats in the South-Western Cape. The estuary also provides a habitat for several species of fish, amphibians, reptiles and birds and has a conservation importance rating of 98.5 (Papadopoulos 2006). Immediate threats to the estuary include human encroachment and poor farming practices. This is because the expansive flood-plain is criss-crossed with vehicle tracks and off-road vehicles have damaged the vegetation around the estuary and along the river banks extensively. The terrestrial vegetation has also become drastically overgrazed in places causing soil erosion (*ibid*). selected hydrological and catchment area information about the Olifants estuary is presented in table 3.7

Table 3.7: Olifants Estuary hydrological and Catchment Area Information

Attribute	**Magnitude/Level**
Mean Annual Runoff (Estuary & Catchment)	1,230 x 10^6 m^3
Catchment Area	46,000 km^2
Estuarine Surface Area	245.5 ha
Average Depth	1.0 -7.0 m

Source: Papadopoulos (2006)

3.2.8 Swartvlei Estuary

Figure 3.16 Swartvlei Estuary

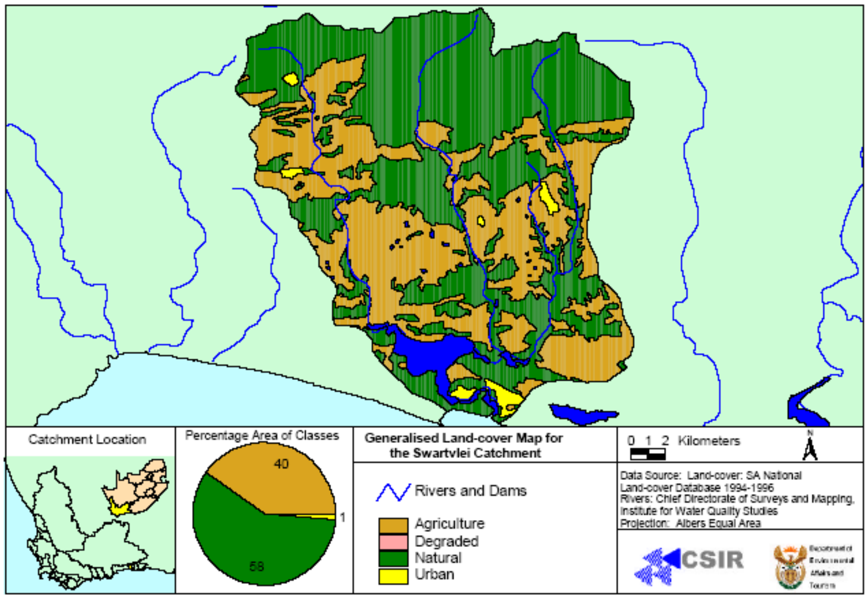
Source: Papadopoulos (2006)

Geographic and Catchment Area Description

The Swartvlei system is located midway between Knysna and Mossel Bay in the Western Cape. It is a temporarily open estuarine lake system and is in a relatively good condition. The estuary is about 7 km long and is linked to the estuarine lake that has an area of 8.8 km^2 and a maximum depth of 16 meters. The estuary is controlled by the South African National Parks. It is between 1-4 meters deep and has a narrow central channel that is bordered by intertidal sand flats of varying widths (Murrant 1984).

The Swartvlei River is 38 km long and has a catchment area of about 455 km^2. 40% of the catchment is comprised of commercial forestry, improved grasslands and temporary commercial irrigated agriculture. Approximately 58% of the catchment is natural, mainly comprised of bushland, forest and shrubland (see figure 3.17). Urban development accounts for about 1% of the land-cover and this is mostly residential development associated with the town of Sedgefield (DWAF 2004).

Figure 3.17: Swartvlei Catchment Area



Source: DEAT (2001)

The Swartvlei estuary provides a habitat for several amphibian and bird species and has well-developed Zostera capensis and Ruppja cirrhosa plant beds. It has a conservation importance of 96.5 (Papadopoulos 2006). Selected hydrological and catchment area information is presented in table 3.8. There are no major dams on the Swartvlei River but Sedgefield abstracts some of its water from the river. Continues increases in the growth of the local population have placed additional demands on the system. Two other main tributaries of the Swartvlei River are also tapped for irrigation, decreasing inflows into the system.

Table 3.8: Swartvlei Estuary hydrological and Catchment Area Information

Attribute	**Magnitude/Level**
Mean Annual Runoff (Estuary & Catchment)	837 x 10^6 m^3
Catchment Area	455 km^2
Estuarine Surface Area	16.0 ha
Average Depth	2.0 m

Source: Papadopoulos (2006)

3.3 CONCLUSION

Eight Western and Southern Cape estuaries were selected for this valuation study. The Kleinemond West and Swartvlei estuaries are temporary open-closed systems while the remainder are all permanently open to the ocean. All of these estuaries face the threat of reduced freshwater inflow due to increased abstraction for local irrigation and urban consumption. All the selected estuaries are rich in biodiversity and a significant reduction of the freshwater inflow into these estuaries will not only affect the recreational services available to users, but will also impact this biological diversity. The average conservation importance across the eight estuaries is 90. The average MAR into these estuaries is 1051 million m^3 with an average catchment area of 292 km^2. Of the collective catchment area, 38% is already under agricultural cultivation. The remaining 62% is covered by natural vegetation but increasing pressures from new housing developments and other urban demands threaten to reduce this further.

CHAPTER FOUR: SAMPLE DESIGN AND SURVEY ADMINISTRATION

4.1 INTRODUCTION

Sample design is an important element of CV studies. It entails the identification of a sample frame and the outlining of procedures by which an adequately large and representative sample may be selected.

4.2 SAMPLE DESIGN

Target Population

The target population of estuary users refers to those who locate themselves in close proximity to the estuary and who derive some form of utility either directly or indirectly from the estuary. The target population was divided into Local Residents and Visitors based on the residential status of the respondent. Local Residents were categorised as people who live within 10km of the estuary mouth and who derive some form of benefit, either actively or passively from the estuary. Visitors referred to people who did not live permanently within a 10km radius of the estuary mouth, but who occasionally visit the area in order to use the estuary.

Activities common at estuaries include angling, swimming, boating sports, bird watching, bait collection etc. A few people depend on the estuary for subsistence. Others make a living from the proximity of the estuary by setting up restaurants and guest houses along its banks. An estuary's ability to provide services is dependent on its freshwater inflows, among other things. For this reason, the users of these services should, in principle, be willing to pay to sustain these inflows. People who actively interact with the estuary to derive these services are referred to as active users. Other people reveal their demand for estuary services in more subtle ways, such as those who just enjoy the view of the estuary. Examples of these could be people who visit estuaries to watch boating sports or just to enjoy the view. These people are passive users of the estuary. This group includes people who buy or build property close to the estuary to take advantage of its scenic beauty.

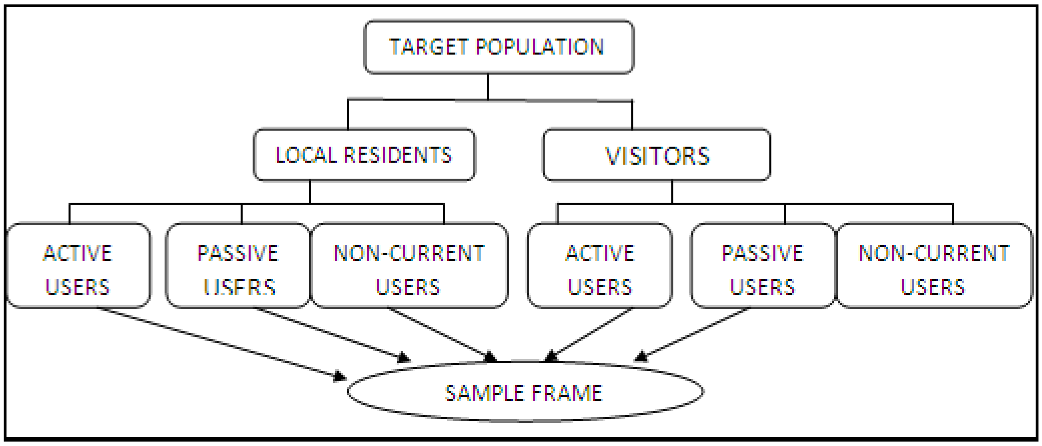
Others may not use the estuary either actively or passively but may derive utility from knowing that it is there and they can visit it in the future. These non-current users may also have a willingness to pay for freshwater inflows to estuary services. These active, passive and non-current users make up the target population of this study. Figure 4.1 illustrates the target population and sample frame (see below) of this study.

Sample Frame

The objective of this study was to generate a per annum user WTP value for the freshwater that flows into the relevant estuary. As such, the sample frame of the study includes all current active and passive users, as well as non-current users. Active users are usually found within very close proximity of the estuary, so their identification does not pose a major challenge. Passive users, on the other hand, are more difficult to identify and survey because the range of passive activities are very broad. For example, people who drive along arterial roads close to the estuary and who enjoy the view are passive users. It is however difficult to identify these people. For these and other reasons, only clearly identifiable passive users were included in the sample frame.

Identifying and surveying the non-current users is also a daunting task because no records are kept on them. For this reason, only the local non-current users were included in the sample frame.

Figure 4.1 Target population and sample frame



Sampling Method

This study used a stratified sampling method in respondent selection. With stratified sampling, the population is divided into homogenous sub-groups from which samples are randomly selected (Gujarati 2003). Estuary users were stratified according to their present or intended purpose of use of the estuary. This method was adopted to ensure that all user groups were represented in the sample. Boaters, swimmers, fishers and birders were classified as recreational users. Restaurant operators, B&B and guest house owners as well as commercial fishers, were classified as commercial users. People who depended on the estuary for subsistence were categorised as subsistence users. Those enjoying the view of the estuary or who were engaged in activities not related to active use of the estuary were classified as passive users. The proportion of users from each strata surveyed varied from estuary to estuary, depending on the most common activity at the particular estuary.

Sample Size

No official records are kept on the exact number of users of South Africa's estuaries, their areas of origin and other demographics. An estimate of the total user population has to be inferred from census data and from estimates obtained from local municipalities and tourism officials. Interviews were conducted with tourism authorities, water sports clubs, municipalities, Bed and Breakfast operators and other relevant local authorities in order to arrive at estimates of the total user population. Combined with GIS census data on the size and characteristics of the population living within 10km of the estuary mouths, the estimated number of households making use of the estuary was obtained (see table 4.3).

Cochran's (1977) formula for determining appropriate sample sizes was used to determine ideal minimum sample sizes for each estuary. Cochran's (1977) formula is based on two factors:

(1) The margin of error, which is the error level that the researcher is willing to accept and

(2) The alpha level, which is the level of acceptable risk that the true margin of error exceeds the acceptable margin of error.

The alpha level used for this study is 0.05. In Cochran's formula, the alpha level is incorporated through the use of the t-value for the selected alpha level. For instance, the t-value for an alpha level of 0.05 is 1.96 for population sizes above 120. A 3% margin of error is generally thought to be acceptable for studies using continuous data (Krejcie & Morgan, 1970).

The payment card system was chosen as the elicitation format for WTP bids. Respondents are presented with a range of amounts from R0 to R3000, from which a selection was required. These amounts were presented in an eleven-point scale (see Appendix C). A 3% margin of error would result in confidence that the true mean of the eleven-point scale is within ± 0.33 (0.03 times 11 points on the scale) of the mean calculated from the research sample. The population variance is a critical component of Cochran's formula. Researchers don't have direct control over variances, but must incorporate it into research design. Chocran (1977) outlined four ways of estimating population variances for sample size determination:

(1) The sample is taken in two steps, using the results of the first step to determine how many additional responses are needed to obtain an appropriate sample size in the second step. This will be based on the variance observed in the data in the first step.

(2) The results of a pilot study can be used.

(3) Data from previous studies of the same or similar population can be used.

In cases where the first three cannot be used, Cochran (1977) recommends a fourth approach:

(4) Estimating the structure of the population by mathematical logic.

In many educational and social research instances, it is not feasible to use any of the first three ways and researchers must estimate variances using the fourth method (Bartlett, Kotrlik & Higgins, 2001). The use of the payment card system in this study allows the application of a similar approach to that of Bartlett *et al* (2001) in the estimation of the population variance. In this approach, the range of the payment scale is divided by the number of standard deviations that would include all possible values. The result is then squared.

The range of the payment card scale used in this study is eleven and 10 standard deviations (five to each side of the mean) would capture 98% of all responses, so the estimate of the population standard deviation would be:

$$S = \frac{11}{10} = 1.1.$$

Example 4.1 applies Cochran's (1977) formula in the determination of the minimum sample size for the Olifants estuary.

Example 4.1: Determination of minimum sample sizes: Olifants Estuary

Alpha level: 0.05; Error margin: 3%; S: 1.1

$$n_0 = \frac{t^2 * S^2}{d^2} = \frac{1.96^2 * 1.1^2}{(11 * .03)^2} = 43$$

Therefore the required minimum sample size for the Olifants estuary is 43. This represents 8.6% of the total user population. Where the sample size exceeds 5% of the total user population, Cochran's (1977) correction formula is used to calculate the final sample size. These calculations are as follows:

$$n = \frac{n_0}{\left(1 + \frac{n_0}{N}\right)} = \frac{43}{\left(1 + \frac{43}{500}\right)} = 40$$

Where t = alpha level of 0.025 in each tail = 1.96

S = estimate of standard deviation in the population = 1.1

d = acceptable margin of error for mean = 0.33 (inclusive range of payment card scale * acceptable margin of error)

n_0 = minimum required return sample size according to Cochran's formula

n = minimum required return sample size because sample is > 5% of population.

Required minimum sample sizes for all other estuaries were calculated in a similar way and are shown in table 4.3 below. Required minimum sample sizes as a percentage of total user households ranges from 1% for the Swartvlei estuary to 31% for the Duiwenhoks estuary.

Table 4.3: User population estimates with Cochran (1977) sample sizes

Estuary:	Estimated number of households	Cochran required minimum sample size	Cochran sample size as a % of household population
Olifants	500	40	8
Great Berg	2 000	43	2
Breede	1 328	43	3
Duiwenhoks	100	31	31
Swartvlei	4 000	43	1
Kleinemond West	1 250	43	3
Mlalazi	1 500	43	3
Mhlathuze	725	41	6

The use of the Cochran formula results in minimum sample size that must be returned to enable valid inferences about the population to be drawn. Failure to achieve these required minimum sample sizes increases the variances of the estimates and undermines the significance of the generated WTP estimates (Bartlett *et al*, 2001). Salkind (1997) recommends 'over sampling' as a means of dealing with potential non-responses which could result in low returned sample sizes. Pilot study results or response rates from previous studies of the same or similar population can be used to guide the number of surveys that must be completed to ensure the achievement of the minimum sample sizes.

Based on previous studies by Lin (2005) and Van Der Westhuizen (2006), it is anticipated that in the worst case, 10% of respondents will protest the valuation scenario. The minimum required sample sizes were adjusted to take these protest bids into account. The results are presented below in table 4.4

Table 4.4: sample sizes adjusted for protest bids

Estuary:	Estimated number of households	Cochran required sample size	Cochran sample size as a % of households
Olifants	500	44	9
Great Berg	2000	48	2
Breede	1328	48	4
Duiwenhoks	100	34	34
Swartvlei	4000	48	1
Kleinemond West	1250	48	4
Mlalazi	1500	48	3
Mhlathuze	725	46	6

Survey Administration

The main survey exercise was conducted during December 2006 and from January to March 2007 to include both the school recess and non-school recess periods. It was assumed that distance was relevant in identifying users and for this reason, respondent selection was mainly made at the estuary sites, although some respondents were interviewed at their residences. The survey was extended to cover all areas within a 10 km radius of the estuary mouth. Care was taken to ensure that the proportion of respondents from each stratum matched the estimated use trends at the estuary.

At all estuaries, there were respondents who protested the valuation scenario. This was usually because they had objections to the hypothetical scenario as proposed to them by the interviewer. These respondents usually placed a zero WTP bid and follow-up questions were asked in order to distinguish these users from legitimate zero bidders. These protest bids were not used for predictive modelling purposes.

There were 1 612 valid responses out of a total of 1 711 questionnaires administered at all eight estuary sites. Table 4.5 reports the total number of surveys administered, protest bids, valid bids and minimum Cochran return sample sizes for each estuary. The budget available for the study allowed for the surveying of more respondents than the minimum return sample size. The eagerness and willingness to participate on the part of respondents also played a part in the success of the survey exercise. However, the minimum return sample size could not be met at the Duiwenhoks estuary. As a result, the predictive WTP estimates of the Duiwenhoks estuary may be over-fitted to the sample and not generalizable to the total user population.

Table 4.5: Questionnaires administered:

	Questionnaires			
Estuary	**Administered**	**Protest Bids**	**Valid Bids**	**Cochran minimum return sample size**
Breede	180	19	161	48
Duiwenhoks	30	2	28	34
Great Berg	268	20	248	48
Kleinemond West	150	18	132	48
Mlalazi	344	4	340	48
Mhlathuze	292	6	286	46
Olifants	95	15	80	44
Swartvlei	352	15	337	48
Total	**1711**	**99**	**1612**	**364**

4.3 CONCLUSION

Sample design is an important aspect of CV studies. With regard to sample selection, the objective was to achieve samples that were both representative and unbiased. For this reason, the user population was classified into Active, Passive and Non-Current users. A stratified sampling technique was used in respondent selection. User population identification proved a difficult task so secondary sources had to be relied on in estimating the user populations. In determining the sample sizes, Cochran's formula for the determination of minimum sample sizes was used. A total of 1 711 questionnaires were administered at the eight estuaries. Of these, 99 were protest bids and were not used in predictive modelling.

CHAPTER FIVE: VALUATION SCENARIO AND SURVEY RESULTS

5.1 INTRODUCTION

This chapter discusses the valuation scenario of this study. Descriptive information about the respondents of the survey exercise is also presented. The respondents of the survey exercise are examined in terms of their race, gender, permanent residence, level of education as well as their level of knowledge about the consequences of reduced freshwater inflow into estuaries. Respondent WTP bids are also presented and examined by race, educational level and user category.

5.2 VALUATION SCENARIO

The Department of Water Affairs and Forestry (2003) has evaluated all estuaries in South Africa and has estimated the amount of freshwater likely to flow into each of these estuaries by the year 2025, given the present abstraction levels. Summarised findings for the selected estuaries are presented in table 5.1. These findings were relayed to the respondents at each of the study sites in order to create a well informed platform for their WTP bids. Respondents were asked what they were willing to pay in additional user fees for a project that would prevent the stated reduction in freshwater inflow. Table 4.1 presents the amount of freshwater required the year 2025 to prevent a reduction in the level of the current services offered by the estuaries.

The chosen payment vehicle used for this study was in the form of increased user fees to the local authorities, as this was already the practice in most cases. Respondents were made to understand that the user fees would be collected by local authorities when the user accesses the site and through an estuary conservation levy collected from people who own property with a view of the estuary. These local authorities would be bound to use the fees collected to fund the rehabilitation of the estuary. A copy of the questionnaire is attached in Appendix C.

Another study was carried out by a team of estuarine scientists, led by Prof. Tris Wooldridge and Dr. Isabelle Papadopoulos, both of the NMMU, which considered the environmental impacts of this reduced freshwater inflow. Summarised findings of these impacts for the selected estuaries are presented in Table 5.2. This information was also relayed to respondents to inform their WTP bids.

Table 5.1: Required Estuarine Freshwater Inflow

Estuary	MAR of Catchment Area (Million m^3)	Catchment Water Demand (2006) (Million m^3)	Catchment Water Demand (2025) (Million m^3)	MAR of Estuary (Million m^3)	Estuary Water Demand (2006)* (Million m^3)	Estuary Water Demand (2025)* (Million m^3)	Inflow 2006** (Million m^3)	inflow 2025** (Million m^3)	% of MAR into Estuary 2006	% of MAR into Estuary 2025	Required Water Purchase by 2025 (Million m^3)	Estimated % decrease in inflow from 2006 to 2025
Breede	1882	764	785	1893	768.5	789.6	1124.5	1103.4	59.4	58.3	21.1	1.9
Duiwenhoks	347	60	62	89	15.4	15.9	73.6	73.1	82.6	82.1	0.5	0.6
Great Berg	1429	848	1306	234	138.9	213.9	95.1	20.1	40.6	8.6	75	78.8
Kleinemond West	174	25	33	4.04	0.6	0.8	3.4	3.3	84.1	81.0	0.1	3.7
Mhlathuze	938	253	312	157	42.3	52.2	114.7	104.8	73.1	66.8	9.9	8.6
Mlalazi	938	253	312	139	37.5	46.2	101.5	92.8	73.0	66.8	8.7	8.5
Olifants	1108	375	380	122	41.3	41.8	80.7	80.2	66.1	65.7	0.5	0.6
Swartvlei	771	118	181	66	10.1	15.5	55.9	50.5	84.7	76.5	5.4	9.7

Source: adapted from Papadopoulos (2006)

* It is assumed that the estuary demand for freshwater is the same as that for the river. Therefore, the estuary's demand for freshwater is calculated as $\frac{Catchment\ water\ demand}{MAR\ of\ catchment\ area} X\ MAR\ of\ estuary$

** The inflow is calculated as MAR of Estuary – Estuary Water Demand.

Table 5.2: Change in services provided by the selected estuaries

	Estuary							
	Breede	**Duiwenhoks**	**Great Berg**	**Kleinemond West**	**Mhlathuze**	**Mlalazi**	**Olifants**	**Swartvlei**
Mouth closure frequency	No change	No change	No change	75% increase	No change	50% increase	No change	10% increase
Boating Area & Swimmers	No change	No change	30% increase	10% increase	No change	No change	No change	No change
Fishers (Angling Fishing)	5% reduction	5% reduction	50% reduction	50% reduction	10% reduction	25% reduction	No change	50% reduction
View Area	5% reduction	5% reduction	No change	10% increase	No change	No change	No change	No change
Estuarine Vegetation	No change	Already severe loss	50% reduction	20% reduction	10% reduction	75% reduction	No change	10% reduction
Loss of Unique Features	No change	No change	10% reduction	10% reduction	10% reduction	75% reduction	No change	No change
Average Depth	No change	No change	10% increase	10% increase	No change	10-20% reduction	No change	No change

Source: Papadopoulos (2006)

5.3 RESPONDENT INFORMATION

Race of Respondents

Table 5.3 below reports the racial composition of the respondents surveyed per estuary. In this study, White refers to the Caucasian user population whilst Black is a collective term used to describe the African, Coloured, Asian and Indian user population. Of the total sample, 49% were Black whist 51% were White. Previous studies conducted by Van Der Westhuizen (2006), found that Black and White respondents had different WTP bids. For this reason, care was taken to ensure that the proportion of a particular race group surveyed was reflective of the proportion of users of that race group at the particular estuary.

Table 5.3: Race of Respondents:

	Black		**White**		**Total**
Estuary	Number	**%**	Number	**%**	Number
Breede	12	8%	149	92%	161
Duiwenhoks	3	11%	25	89%	28
Great Berg	121	49%	127	51%	248
Klienemond West	9	7%	123	93%	132
Mlalazi	273	80%	67	20%	340
Mhlathuze	244	85%	42	15%	286
Olifants	68	85%	12	15%	80
Swartvlei	67	20%	270	80%	337
Total	**797**	**49%**	**815**	**51%**	**1612**

Residential status of Respondents

Table 5.4 reports the residential status of the respondents surveyed at each estuary. A majority of the respondents were local residents. Local residents tend to make use of the estuary all year round and hence have a particularly strong interest in conserving the estuary.

Table 5.4: Residence of Respondents:

	Local Residents		Visitors		Total
Estuary	Number	%	Number	%	Number
Breede	74	46%	87	54%	161
Duiwenhoks	25	89%	3	11%	28
Great Berg	216	87%	32	13%	248
Kleinemond West	95	72%	37	28%	132
Mlalazi	306	90%	34	10%	340
Mhlathuze	234	82%	52	18%	286
Olifants	71	89%	9	11%	80
Swartvlei	299	89%	38	11%	337
Total	**1320**	**82%**	**292**	**18%**	**1612**

Gender of Respondents

There were more males than females surveyed at each estuary (see table 5.5). Popular activities at estuaries include boating, fishing, swimming, bird-watching, subsistence and commercial activities. There are activities which are more frequently patronised by males.

Table 5.5: Gender of Respondents:

	Male		Female		Total
Estuary	Number	%	Number	%	Number
Breede	103	64%	58	36%	161
Duiwenhoks	15	54%	13	46%	28
Great Berg	131	53%	117	47%	248
Kleinemond West	81	61%	51	39%	132
Mlalazi	231	68%	109	32%	340
Mhlathuze	156	55%	130	45%	286
Olifants	55	69%	25	31%	80
Swartvlei	193	69%	144	31%	337
Total	**965**	**60%**	**647**	**40%**	**1612**

Educational Level of Respondents

Previous valuation studies (Lin 2005 & Van Der Westhuizen 2006) have found a strong correlation between educational level and WTP. *A priori*, the higher the educational level of the respondent, the higher their awareness of environmental affairs and the consequences of a change in the state of an environmental good. This may result in a higher WTP for projects that will prevent a negative change in the state of the environmental good. An alternate view is that educated people may earn more and hence are able to pay more.

Individuals with a low level of education were broadly categorised as people with an education of grade 12 or less, whilst individuals with some tertiary education were regarded as highly educated. The highly educated respondents formed 46% of the sample population whilst the remaining 54% was comprised of respondents with a low level of education (see table 5.6).

Table 5.6: Educational Level of Respondents:

	Low		**High**		**Total**
Estuary	Number	**%**	Number	**%**	Number
Breede	35	22%	126	78%	161
Duiwenhoks	10	36%	18	64%	28
Great Berg	173	70%	75	30%	248
Kleinemond West	50	38%	82	62%	132
Mlalazi	176	52%	164	48%	340
Mhlathuze	136	48%	150	52%	286
Olifants	75	94%	5	6%	80
Swartvlei	210	62%	127	38%	337
Total	**865**	**54%**	**747**	**46%**	**1612**

Knowledge of Respondents

Respondents were tested on their knowledge of the effects of reduced freshwater inflow into estuaries. They were judged to be well informed of the impacts of reduced freshwater inflow if they were aware of at least one consequences of such a reduction. Appendix C is a copy of the questionnaire and lists 7 consequences of reduced freshwater inflow. Respondents who couldn't give any clear consequences of such a reduced inflow were judged to be uninformed.

About 70% of respondents were aware of the effects of reduced freshwater inflow into estuaries (see table 5.7). The correlation between the educational level of respondents and level of knowledge of the consequences of reduced freshwater inflow was particularly evident at the Breede, Duiwenhoks and Kleinemond West estuaries. At the Great Berg, Olifants and Swartvlei estuaries, although the level of education of most respondents was low, they had a reasonably good knowledge of the consequences of reduced freshwater inflow.

Table 5.7: Knowledge of Respondents:

	Uninformed		**Well Informed**		**Total**
Estuary	Number	**%**	Number	**%**	Number
Breede	27	17%	134	83%	161
Duiwenhoks	7	25%	21	75%	28
Great Berg	77	31%	171	69%	248
Klienemond West	44	33%	88	67%	132
Mlalazi	109	32%	231	68%	340
Mhlathuze	77	27%	209	73%	286
Olifants	29	36%	51	64%	80
Swartvlei	107	32%	230	68%	337
Total	**477**	**30%**	**1135**	**70%**	**1612**

Household Size and Pre-Tax Income

Respondents were also asked what their household size and pre-tax incomes were. These were expected to be important determinants of demand for estuary services. The higher the number of people in a household, the higher their demand for estuary services is likely to be, *ceteris paribus*. A higher pre-tax income would also be expected to translate into a higher demand of estuary services, given that all other things remain constant. Table 5.8 presents the mean and median household size and pre-tax income at each of the eight study sites.

Table 5.8: Respondent Household Size and Pre-Tax Income:

	Household Size (no. of people)		**Pre-Tax Income (Rand)**	
Estuary	Mean	Median	Mean	Median
Breede	4.5	4.0	281,521	225,000
Duiwenhoks	4.1	4.0	192,678	125,000
Great Berg	3.7	3.0	114,660	75,000
Klienemond West	4.4	4	356,484	175,000
Mlalazi	5.3	5	141,263	125,000
Mhlathuze	5.0	5.0	140,020	75,000
Olifants	3.7	3.0		
Swartvlei	2.9	2.0	176,104	125,000

At the Breede and Duiwenhoks estuary, all respondents disclosed their pre-tax income, whilst at the Great Berg estuary, only 15 people, representing 6% of the total respondents disclosed their pre-tax income. At the Kleinemond West estuary, 128 people representing 97% of respondents revealed their pre-tax income. At the Mlalazi and Mhlathuze estuaries, the percentages of respondents revealing their pre-tax income were 83% and 89% respectively, whilst 74% revealed their pre-tax income at the Swartvlei estuary. No pre-tax income data was recorded from the respondents selected at the Olifants estuary.

Conservation Value and Annual Levies

Respondents were asked if they believed it was important to conserve environmental resources. All respondents responded in the affirmative. This was done to ascertain the attitudes of the respondents to conservation in general. The respondents were then asked what they would be willing to sacrifice out of their present income to conserve environmental resources in general. The mean and median amounts they were willing to sacrifice are reported in table 5.9. Questions were also asked to ascertain the amount that users pay in annual levies to access and use the estuaries. The mean and median amounts are also reported in table 5.9.

Table 5.9: Respondent Conservation Value and Annual Levies:

	Conservation Value (Rand)		**Annual Levies (Rand)**	
Estuary	Mean	Median	Mean	Median
Breede	640	400	641	300
Duiwenhoks	1378	500	618	300
Great Berg	173	20	755	135
Klienemond West	1052	300	263	250
Mlalazi	201	30	61	0
Mhlathuze	97	30	32	0
Olifants	61	10	105	87
Swartvlei	239	50	110	0

Respondent Willingness-To-Pay Bids

Respondents were asked how much they would be willing to pay in user fees per year for a project that would release a specified amount of freshwater into the relevant estuary per annum. Table 5.10 reports the mean and median WTP bids for each estuary.

Table 5.10: Respondent Willingness-To-Pay Bids:

	Willingness-To-Pay Bids (Rand)	
Estuary	Mean	Median
Breede	303	75
Duiwenhoks	421	75
Great Berg	136	15
Kleinemond West	296	40
Mlalazi	108	40
Mhlathuze	111	25
Olifants	123	0
Swartvlei	174	40

The mean WTP for freshwater inflows ranged from R108 for the Mlalazi estuary to R421 for the Duiwenhoks estuary. The median WTP bids ranged between R0 for the Olifants estuary to R75 for the Duiwenhoks estuary. Table 5.11 below presents a more detailed examination of the WTP bids for the selected estuaries. Respondents could bid any amount between R0 and R3000. All bids between R0 and R100 were categorised as low range bids, those between R101 and R500 as mid range bids and those between R501 and R3000 as high range bids. The bids were examined in terms of the race and the educational level of respondents. Respondents were also classified into two user groups (Recreational/Passive or Commercial/Subsistence) for the purposes of analysing their bids.

Table 5.11: Respondent Willingness-To-Pay Bids by Race, Educational Level and User Category:

Estuary	WTP bids (R)	Total Bids	White	Black	Education (High)	Education (Low)	REC/PAS Users	COMM/SUB Users
Breede	0 – 100	67	55	12	42	23	55	10
	101 – 500	70	69	1	60	10	70	2
	501 - 3000	24	23	1	22	4	24	0
Duiwenhoks	0 – 100	13	12	1	7	6	10	4
	101 – 500	8	8	0	5	2	7	0
	501 - 3000	7	5	2	6	2	6	1
Great Berg	0 – 100	180	85	95	43	137	164	16
	101 – 500	49	26	23	23	26	48	3
	501 - 3000	19	15	4	10	9	15	2
Kleinemond West	0 – 100	56	47	9	27	29	54	2
	101 – 500	51	51	0	34	17	51	0
	501 - 3000	25	25	0	21	4	25	0
Mlalazi	0 – 100	237	29	208	95	142	227	10
	101 – 500	88	31	57	56	32	87	1
	501 - 3000	15	10	5	15	0	15	0
Mhlathuze	0 – 100	245	25	220	116	129	242	3
	101 – 500	36	15	21	32	4	36	0
	501 - 3000	5	2	3	2	3	5	0
Olifants	0 – 100	65	8	57	2	63	42	23
	101 – 500	11	2	9	2	9	9	2
	501 - 3000	4	2	2	1	3	4	0
Swartvlei	0 – 100	230	172	58	63	167	221	9
	101 – 500	71	67	4	47	24	71	0
	501 - 3000	36	31	5	16	20	35	1

Across all the selected estuaries, 68% of WTP bids were in the low range, 24% in the mid range and the remaining 8% in the high range. In terms of race, 53% of White respondents gave bids in the low range, 33% in the mid range and 14% in the high range. Of the Black respondents, 83% gave bids in the low range, 14% in the mid range and 3% in the high range. The fact that a majority of the bids by Black respondents fell in the low range seems to support an earlier finding by Van Der Westhuizen (2006) that race plays a part in determining WTP. This may be due to the fact that White respondents are generally better off and hence are able to pay more. In terms of the educational level of respondents, 53% of the highly educated respondents gave bids in the low range, 35% in the mid range and 12% in the high range. Of the respondents with a lower level of education, 81% gave bids in the low range, 14% in the mid range and 5% in the high range.

When the bids were compared in terms of the respondent's main use of the estuary, 67% of the 1 015 recreational and passive users of the various estuaries gave bids in the low range. 25% of the bids were in the mid range whilst the remaining 8% fell in the high range. 89 commercial and subsistence users were interviewed across the all estuaries. 87% of their bids were in the low range, 9% in the mid range and the remaining 4% in the high range.

5.4 CONCLUSION

There were 1612 valid WTP bids from respondents across all eight estuaries. The sample population was racially balanced with 51% of them being White with the remaining 49% being Black. Of all respondents, 82% of them were local residents while 18% were visitors to the estuaries. In terms of the educational level of respondents, 46% of them were highly educated, having at least 3 years of tertiary education. Most respondents were also knowledgeable about the consequences of reduced freshwater inflow into estuaries. Across all the selected estuaries, 70% of the respondents were able to give at least one clear consequence of reduced freshwater inflow. The average household size of respondents was 4 with an average pre-tax income of R177, 748 per annum.

Respondents were also quizzed about how much value they place on the conservation of environmental resources in general. This was in the form of the amount they would be willing to sacrifice out of their present income to conserve environmental resources in general. The average amount was R480. The average WTP across all eight estuaries was R219. Black respondents generally gave bids in the low range while most of the White respondent bids fell in the low to mid range. Respondents with a high level of education generally gave bids in the low to mid range. A majority of respondents with a lower level of education gave WTP bids in the low range. Commercial and subsistence users of the selected estuaries mostly gave bids that were in the low range. Recreational and passive users, on the other hand, mostly gave bids that fell in the low to mid ranges. Chapter six generates predictive models of respondents' WTP using regression analysis.

CHAPTER SIX: MODELLING HOUSEHOLD WILLINGNESS TO PAY

6.1 INTRODUCTION

This chapter reports the results of multivariate analyses conducted with the sample data collected from the eight estuaries. The multivariate analyses were conducted with the aim of generating predictive models which describe users WTP. The problems of multicollinearity and heteroscedasticity in the data are addressed and a suitable functional form is selected. The Mlalazi estuary is used as a case study to explain the regression results. Total Willingness-to Pay (TWTP) is then calculated and used to derive a Rand/m^3 value for freshwater inflow. The statistical models used for the analyses are the OLS and Tobit.

6.2 MODEL CONSIDERATIONS

A regression model specifies the relationship between the dependent variable and one or more independent variables. Regression models normally include an error term, usually denoted by ε, which accounts for all unobservable and random factors which may affect the dependent variable (Bowerman & O'Connell 1990:95). Three key assumptions are made about the error term (for classical linear regression models). These assumptions are that:

- ✓ The error term is normally distributed and has a mean of zero
- ✓ The error term has a constant variance
- ✓ The error terms are uncorrelated

In addition to the above, two further assumptions are made about the independent variables in the regression equation. These are that:

- ✓ The independent variables are not random i.e. their values are known prior to observing the values of the dependent variable and
- ✓ Any one of the independent variables is not an exact linear function of any of the others.

Meeting these assumptions is essential to ensure that the results obtained are reliable. Serious violations of the assumptions must be detected and corrected. There are two common causes for violations of these assumptions. These are through multicollinearity and heteroscedasticity.

Multicollinearity

Multicollinearity exists when the independent variables in a regression model are interrelated or are dependent on each other (Mendenhall & Sincich 1996:110). If multicollinearity is present, identifying which independent variable(s) is influencing the dependent variable is difficult. A multicollinearity problem reveals itself through low t-statistics and high P-values. It may be erroneously concluded that coefficients are insignificant and hence the affected variable(s) should be dropped from the regression model. In extreme cases, it is possible to find that all the coefficients are insignificant using t-statistics, while the R^2 is quite large (Gujarati 2003:56). This suggests that the independent variables as a group provide a great deal of explanatory power, but because of multicollinearity, it is difficult to decide which particular independent variable(s) is important.

Multicollinearity can increase the likelihood of rounding errors occurring and can cause coefficients to have opposite signs to those expected *a priori*. It can also cause small changes in the data to produce large changes in the parameter estimates. To determine if multicollinearity was present in the sample data collected for this study, a correlation matrix was constructed for each estuary. A correlation matrix shows the level of correlation between sets of independent variables in a regression model (Gujarati 2003:59). The correlation matrix for the Mlalazi estuary is shown below in table 6.1. Correlation matrices for all the other estuaries are shown in Appendix A.

Table 6.1: Correlation Matrix for the Mlalazi estuary

Variable	House	Freq	Income	Amount	Levies	Trav	Equip	Est_Redc %
House	1.00	-0.01	-0.05	-0.05	-0.04	0.08	-0.03	-0.01
Freq	-0.01	1.00	0.07	**0.17**	**0.21**	-0.21	-0.03	-0.01
Income	-0.05	0.07	1.00	**0.47**	**0.27**	0.07	**0.37**	**0.32**
Amount	-0.05	**0.17**	**0.47**	1.00	**0.48**	-0.01	**0.27**	0.09
Levies	-0.04	**0.21**	**0.27**	**0.48**	1.00	-0.05	**0.20**	0.03
Trav	0.08	**-0.21**	0.07	-0.01	-0.05	1.00	0.09	**0.20**
Equip	-0.03	-0.03	**0.37**	**0.27**	**0.20**	0.09	1.00	-0.01
Est_redc %	-0.01	-0.01	**0.32**	0.09	0.03	0.20	-0.01	1.00

The Correlations highlighted in boldface are significant at $p \leq 0.05$ (observations = 340)

Correlation coefficients can range from -1.00 to +1.00. A value of -1.00 represents a perfect negative correlation whereas a value of +1.00 represents a perfect positive correlation. A value of 0.00 indicates that there is no correlation between the sets of independent variables (Gujarati 2003: 62). Table 6.1 shows there are very few significant correlations among the variables selected. For example, the frequency of estuary use (Freq) is mildly positively correlated with the annual amount respondents are willing to pay for the conservation of environmental resources (Amount) and the annual levies they pay to use the estuary (Levies). Frequency of use is also mildly inversely correlated with the distance travelled to reach the estuary (Trav).

Income is mildly positively correlated with Amount, Levies, the value of equipment used by the respondent at the estuary (Equip) and the percentage reduction in estuary use by the respondent, should the surface area of the estuary reduce substantially (Est_Redc %). All other correlation coefficients are not significant at a statistically acceptable p-level of 0.05. A commonly used rule of thumb is that a correlation coefficient between two independent variables greater than 0.8 in absolute value indicates a strong linear association and a potentially harmful collinear relationship and hence should be attended to. The significant correlations in table 6.1 and in all other correlation matrices in Appendix A are all well below this threshold.

Heteroscedasticity

Heteroscedaticity is as a result of a violation of the constant variance assumption. In this case, the error term, ε, does not have a constant variance (Gujarati 2003:62). When heteroscedasticity is present in a sample data, parameter estimates do not have minimum variance. As such, the estimated standard errors are much larger than expected. This may lead to the erroneous deduction that variables are insignificant, even though they are in fact significant predictors (Greene 2003:12). Also, confidence intervals and hypothesis tests that use these erroneous standard errors may be misleading.

One way of detecting the existence of heteroscedasticity is to estimate the model using Least Squares and then to plot the residuals. The observable Least Squares residuals are proxies of the unobservable errors. If the errors are homoscedastic, there should be no patterns of any sort in the residuals. If the errors are heteroscedastic, they may tend to exhibit variation in some systematic manner (Mendenhall & Sincich 1996:121). This was the approach that was taken in this study to determine the presence of heteroscedasticity in the sample data. Where heteroscedasticity was present, the functional form of the regression model was transformed; this being one of the standard ways of reducing heteroscedasticity.

Choosing a functional form

Choosing a functional form for a regression model is very important. The functional form specifies the relationship between the dependent and the independent variables in the model. There are several functional forms that are commonly used, including the Linear, Log-Linear and Double-Log functional forms. In a similar application of the CVM, Lin (2005) employed the linear model to specify the relationship between the dependent and the independent variables. In linear models, all variables appear in their unmodified states.

With the Log-Linear (Semi-Log) functional form, the dependent variable appears as a logarithm and the independent variables appear in their unmodified states. The coefficient of the independent variable measures the percentage change in the dependent variable associated with a 1 unit change in the independent variable, holding all other variables constant (Greene 2003:213). The advantage of this form is that it allows the capturing of a multiplicative relationship between the dependent and an independent variable.

The Double-Log (Log-Log) functional form is a modification of the Semi-Log functional form. Here, both the dependent and independent variables appear as their natural logarithms. In the double-log functional form, the coefficients of the independent variables measure the percentage change in the dependent variable associated with a 1% change in an independent variable, holding all other variables constant (Greene 2003:231).

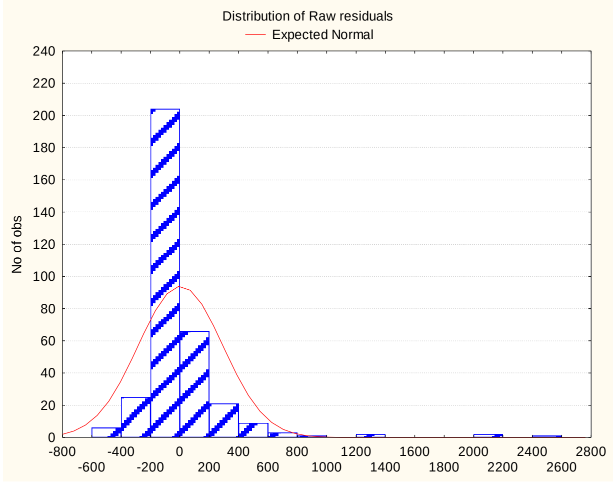
This study employed a mixed Log-Linear functional form, where some of the variables were linear and others logarithmic. The mixed Log-Linear functional form was also preferred by Van Der Westhuizen (2006) to the linear model used by Lin (2005), because of its ability to yield superior statistical properties.

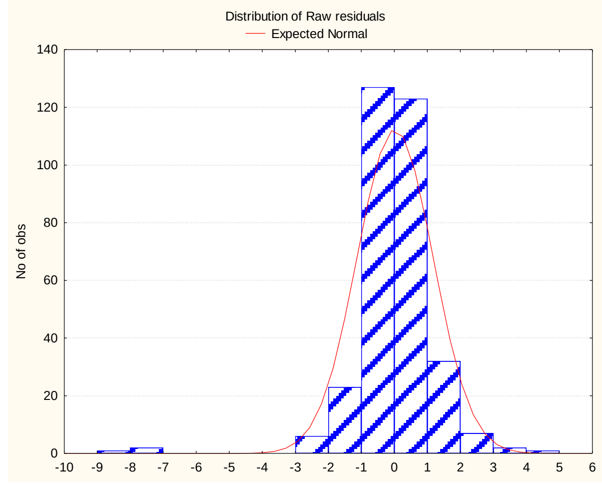
Functional form determination and Residual Analysis

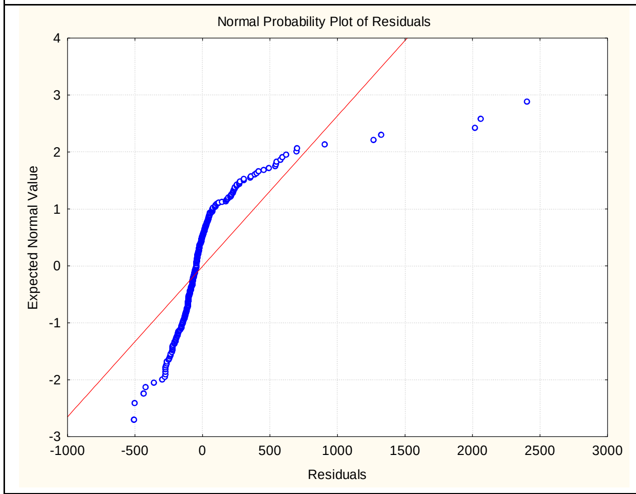
Mixed Log-Linear functional forms were estimated in the modelling of predictive household WTP. The mixed Log-Linear functional form was chosen over the Linear model used in an earlier study by Lin (2005), because it was shown to have superior statistical properties in capturing the curvature of the valuation function. Residual analyses were conducted for all estuaries to help determine the preferred functional form. The statistical validity of a regression model depends on the error term satisfying the assumptions of *Normality*, *Constant Variance* and *independence*. Residual analysis was used to check the validity of these assumptions for all eight estuaries. Figure 6.1 details the results of the residual analysis for the Mlalazi estuary.

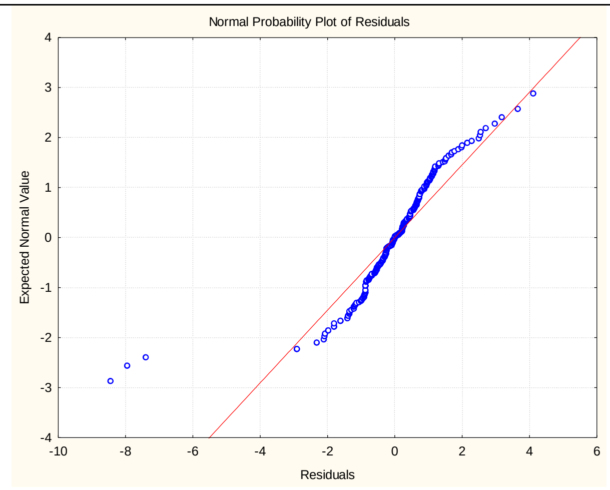
Figure 6.1: Residual Analysis of Untransformed and Log-Transformed model: Mlalazi Estuary

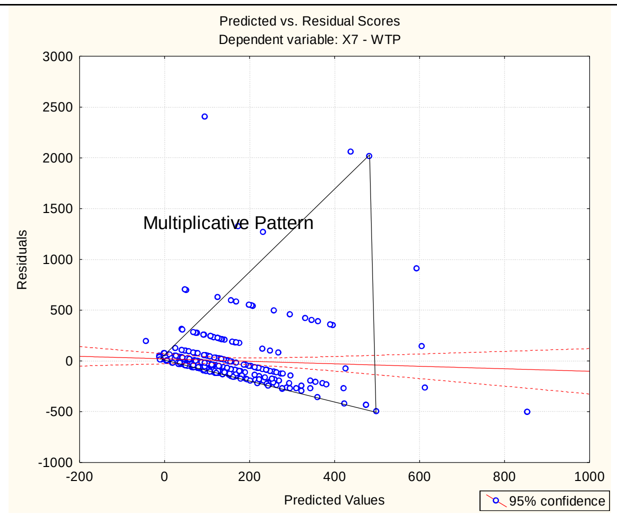
Untransformed Model	Log-Transformed Model

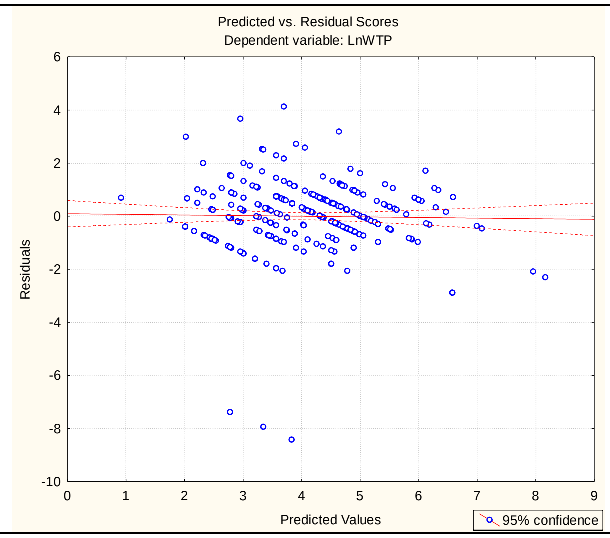












Conclusion: The Log-transformed model is preferred for data modelling because it results in less variation

The normality assumption was investigated by examining a histogram of the raw residuals of the reduced linear OLS and reduced log-linear OLS models. In panel 1 of figure 6.1, both graphs show a relative symmetric distribution with both means close to zero. The median of the linear model is -60 while in the log-linear model it is only 0.09. An inspection of the mound of the log-linear model also suggests that it is more normally distributed than the linear model, and hence better satisfies the normality assumption.

Further insight into the issue of compliance with the normality assumption was gained by employing a normal probability plot of the residuals. The residuals are graphed against the expected values of the residuals under the assumption of normality. Under normality, the residual values will be approximately equal to the expected values and we expect to observe a linear relationship between the expected values and the residuals. A non-linear trend would indicate a violation of the normality assumption (Mendenhall & Sincich 1996: 94).

The second panel in figure 6.1 shows the normal probability plot of both the linear OLS model and the log-linear OLS model. The normal probability plot of the linear OLS model traces out a non-linear relationship. This suggests that the functional form of the linear model is inadequate to properly account for the relationship between the independent and dependent variables. The non-normality of the probability plot distribution, as reflected by the linear untransformed model, is also often accompanied by heteroscedasticity. In contrast, the normal probability plot of the residuals of the log-linear model follows a near linear trend, supporting the initial assertion that the Log-transformed model is superior to the linear untransformed model.

The constant variance assumption holds when the residual plot fluctuates around zero because if little or no pattern exists in the plots, then the model is deemed to better account for the relationship between the dependent and independent variables (Bowerman & O'connell 1990:43). Panel 3 of figure 6.1 shows a plot of the residuals against the predicted WTP values. This plot displays a multiplicative pattern in the untransformed OLS model. This revealed pattern implies that the variances are unequal;

an indication of the presence of heteroscedasticity (Mendenhall & Sincich 1996). One of the ways to deal with heteroscedasticity of this nature is to transform the functional form of the model, so as to stabilize the variances. In contrast, the plot of the residuals against the predicted WTP values in the Log-transformed model shows very little variation.

Based on the above residual analysis, the log-transformed model is a better fitting model than the linear one. Similar analyses were conducted on the data from all the other estuaries (Appendix B). In all cases, the log-transformed model provided a better fit than the linear model.

Choosing reduced models

In predictive analysis, two models are normally generated. These are the complete and reduced models. A complete model contains all the independent variables thought to have an effect on the dependent variable. From the complete model, all insignificant independent variables are eliminated to get the reduced model. Reduced models are preferred for predictive purposes because they only include relevant variables.

This study uses the backward stepwise regression method to identify which independent variables are significant in the regression model. This method fits all potentially independent variables in a regression model and then identifies the variable with the lowest t-score and removes this variable if its t-score is below a specified critical value. This process is repeated iteratively with the reduced set of variables until no further insignificant variables can be found (Gujarati 2003:57).

The OLS and Tobit models were used for all eight estuaries. Both complete and reduced OLS and Tobit models were generated. To determine whether the exclusion of a particular variable improved the fit of the data, the complete and reduced OLS models were compared using an F-ratio statistic (see equation 6.1). The complete and reduced Tobit models were also compared using a chi-squared likelihood ratio test (see equation 6.2)

The hypotheses being tested in order to provide legitimacy for the exclusion of insignificant variables were:

H_0: The excluded variables in the reduced model do not contribute to the model
H_1: At least one of the excluded variables in the reduced model contributes to the model

$$\boldsymbol{F = \frac{(SSE_R - SSE_C)/(k-g)}{MSE_C}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6.1)$$

The rejection region for the null hypothesis (H_0) was if: $\boldsymbol{F \geq F_{\propto}\,(V_1, V_2)}$

The calculation of the likelihood test ratio was as follows:

$$\boldsymbol{LR = -2(L_R - L_C)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6.2)$$

The rejection region of the null hypothesis (H_0) was if: $\boldsymbol{LR \geq X^2_{\alpha}(v)}$

In the equations above:

- SSE_R = sum of squared errors for the reduced model
- SSE_C = sum of squared errors for the complete model
- MSE_C = mean square for the complete model
- n = sample size
- k = number of variables of the complete model
- g = number of variables of the reduced model
- (k-g) = number of excluded variables
- V_1 = (k-g)
- V_2 = n – (k+1)
- L_R = log-likelihood of reduced model
- L_C = log-likelihood of complete model
- v = the number of excluded variables and
- α = confidence level (set at 5% for this study)

Coding the variables

The responses elicited using the survey questionnaire were coded into variables as shown in table 6.2. The dependent variable, WTP, was transformed into its natural log form (for the reasons discussed above). Since the natural log of zero is undefined, using log variables does not yield comprehensible results if a variable takes on a zero value. There were some cases where respondents reported zero values for WTP. In such cases, Wooldridge (2003) suggests that the form ln(y+1) be used instead of log(y) but the coefficient estimates should still be interpreted as if the variable was log(y). This approach is valid as long as the data available on y is not dominated by zeros. For this study, where zero observations were reported for WTP, a value of 1 cent, i.e. R0.01 was used as a substitute. In table 6.2, the expected signs of the coefficients are based on economic theory and on the results of similar past valuation exercises.

Table 6.2: Variable Description

Dependent Variables		
Variable	**Description**	
ln(WTP)	The log transformed WTP is the amount a household is willing to pay for the increase in freshwater inflows	
Independent Categorised (dummy) Variables		
Variable	**Description**	**Expected Sign**
RACE	Race of the Respondent 1 = White 0 = Black	+ White respondents were expected to have a positive influence on WTP.
GEN	Gender of the Respondent 1 = Male 0 = Female	+ Male respondents were expected to have a positive influence on WTP.
RES	Residential status of the Respondent 1 = Visitor 0 = Local resident	+ Visitor respondents were expected to have a positive influence on WTP.
KNOW	Knowledge of the Respondent 1 = Well informed 0 = Uninformed	+ Well informed users were expected to have a positive influence on WTP.
EDUC	Educational level of the Respondent 1 = High level of education (Above grade 12) 0 = Low level of education (Grade 12 or less)	+ Highly educated respondents were expected to have a positive influence on WTP.
USE_CAT	Main reason why the Respondent uses the estuary 1 = Recreation or Passive Use 0 = Commercial or Subsistence Use	+ Recreational or passive users were expected to have a positive influence on WTP.

Table 6.2: Variable Description (continued)

Independent Continuous Variables		
Variable	**Description**	**Expected sign**
HOUSE	Household size – the number of people in the house making use of the estuary	+ The higher the number of people in a household, the higher the expected WTP.
INCOME	Annual household pre-tax income	+ The higher the household pre-tax income, the higher the expected WTP.
FREQ	Frequency of visits to the estuary per year	+ The higher the frequency of visits, the higher the expected WTP.
LEVIES	The levies paid (Rand) for using estuary services	+ The higher levies paid to use the estuary, the higher the expected WTP.
TRAV	How far the respondent has to travel to reach the estuary	+ The further the respondent has travelled to use the estuary, the higher the expected WTP.
EQUIP	Rand value of equipment used by the respondent at the estuary	+ The more expensive the equipment used at the estuary, the higher the expected WTP.
LOGAMT	The log-transformed annual amount the respondent will be willing to spend on the conservation of environmental resources	+ The higher the amount a respondent is willing to spend on conservation, the higher the expected WTP.
AMOUNT	The annual amount the respondent will be willing to spend on the conservation of environmental resources	+ The higher the amount a respondent is willing to spend on conservation, the higher the expected WTP.

Table 6.2: Variable Description (continued)

Independent Continuous Variables		
Variable	**Description**	**Expected sign**
EST_REDC %	The percentage of time reduction in estuary use should the surface area of the estuary decrease.	+ The higher percentage of time reduction in estuary use, the higher the expected WTP.

6.3 THE ESTIMATED HOUSEHOLD MODELS

The complete bid curve functional form employed for all the estuary users was:

Ln(WTP) = *f*(RACE, GEN, HOUSE, RES, FREQ, USE_CAT, INCOME, EDUC, AMOUNT, KNOW, LEVIES, TRAV, EQUIP, EST_REDC %)…………………….(6.3)

For each estuary, complete OLS and Tobit models were fitted. Backward stepwise regression was used to determine the significant variables, which made up the reduced model. The preferred model for predictive purposes was then selected based a comparison of the complete and reduced model. The Mlalazi estuary is used as a case study in this chapter. Similar analyses were carried out for all the other estuaries. These are presented in Appendix A.

Mlalazi Estuary

The results of fitting the complete OLS and Tobit models to the data for the Mlalazi estuary are shown in table 6.3. The adjusted R-Squared ($\bar{R}^2$) of the models represent how well the model fits the data, adjusted for the number of number of parameters being estimated (Mendenhall & Sincich 1996:78). Although the $\bar{R}^2$ for both the complete OLS and Tobit models are low by normal standards, it is common to observe such low values for studies of this nature. A minimum $\bar{R}^2$ of 15% or more is considered acceptable (Hanley & Spash 1993). At 27.24% and 27.02% for the complete OLS and Tobit models respectively, the $\bar{R}^2$ for both models are above minimal acceptability.

Table 6.3: Complete OLS and Tobit models: Mlalazi Estuary

Dependent Variable: Ln(WTP)								
Model: Complete								
Observations: 340								
Method:	Least Sqaures				Censored Normal (Tobit)			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	0.6598	0.2811	2.3471	0.0195	0.6598	0.2748	2.4007	0.0164
GEN	0.2468	0.1922	1.2841	0.2000	0.2468	0.1879	1.3134	0.1890
HOUSE	0.0263	0.0358	0.7336	0.4637	0.0263	0.0350	0.7503	0.4530
RES	-0.8877	0.3265	-2.7187	0.0069	-0.8877	0.3192	-2.7807	0.0054
FREQ	-0.0004	0.0010	-0.3765	0.7067	-0.0004	0.0010	-0.3851	0.7001
USE_CAT	-0.3526	0.5155	-0.6838	0.4946	-0.3526	0.5040	-0.6994	0.4843
INCOME	2.02E-06	8.69E-07	2.3258	0.0206	2.02E-06	8.49E-07	2.3789	0.0174
EDUC	0.8857	0.2084	4.2499	0.0000	0.8857	0.2037	4.3468	0.0000
AMOUNT	0.0012	0.0003	3.9249	0.0001	0.0012	0.0003	4.0144	0.0001
KNOW	-0.0646	0.2083	-0.3100	0.7567	-0.0646	0.2037	-0.3171	0.7511
LEVIES	0.0001	0.0004	0.2985	0.7654	0.0001	0.0004	0.3053	0.7601
TRAV	0.0471	0.0218	2.1526	0.0321	0.0471	0.0213	2.2017	0.0277
EQUIP	-0.0004	0.0003	-1.3060	0.1925	-0.0004	0.0003	-1.3358	0.1816
EST_REDC %	0.0039	0.0031	1.2444	0.2142	0.0039	0.0030	1.2728	0.2031
C	2.3282	0.5574	4.1766	0.0000	2.3283	0.5450	4.2719	0.0000
	R-Squared		0.3024		R-Squared		0.3024	
	Adjusted R-Squared		0.2724		Adjusted R-Squared		0.2702	
	F-statistic		10.0653		Log Likelihood		-633.7186	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		827.8444		Uncensored obs		340	

The backward stepwise regression procedure was then used to determine the variables to be returned in the reduced model. The significant variables identified were RACE, RES, INCOME, EDUC, AMOUNT and TRAV. These variables were included in the reduced OLS and Tobit models. The results are shown in table 6.4.

Table 6.4: Reduced OLS and Tobit models: Mlalazi Estuary

Dependent Variable: Ln(WTP)								
Model: Reduced								
Observations: 340								
Method:	Least Sqaures				Censored Normal (Tobit)			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	0.6872	0.2439	2.8175	0.0051	0.6872	0.2413	2.8469	0.0044
RES	-0.9801	0.3168	-3.0927	0.0022	-0.9801	0.3136	-3.1251	0.0018
INCOME	2.00E-06	8.04E-07	2.4830	0.0135	2.00E-06	7.96E-07	2.5090	0.0121
EDUC	0.9407	0.2019	4.6576	0.0000	0.9407	0.1998	4.7063	0.0000
AMOUNT	0.0012	0.0002	4.2360	0.0000	0.0012	0.0002	4.2803	0.0000
TRAV	0.0526	0.0208	2.5199	0.0122	0.0526	0.0206	2.5463	0.0109
C	2.2854	0.2318	9.8593	0.0000	2.2854	0.2294	9.9623	0.0000
	R-Squared		0.2897		R-Squared		0.2897	
	Adjusted R-Squared		0.2769		Adjusted R-Squared		0.2747	
	F-statistic		22.6354		Log Likelihood		-636.7986	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		842.9797		Uncensored obs		340	

As with the complete models, the $\bar{R}^2$ was used as a measure of goodness of fit; 27.69% of the variation in WTP was explained in the OLS model and 27.47% in the Tobit model. These $\bar{R}^2$ values are similar to those observed in the complete models, suggesting that no significant variables were left out of the reduced models. It is however unadvisable to make deductions about which models are preferable for predictive purposes based on a perceived negligible changed in the adjusted R-square value. Additional inferential tests, such as hypothesis testing, should be used for this purpose (Hanley & Splash 1993).

The relevant hypothesis tests in this regard are:

H_0: The excluded variables in the reduced model do not improve the model
H_1: At least one of the excluded variables in the reduced model improves the model

Table 6.5 below summarises the test statistics used for testing the above hypotheses.

Table 6.5: Model Comparison test statistics: Mlalazi Estuary

Employed observations and variables in regression	
Excluded variables	8
Observations	340
Degrees of freedom	325
OLS Model Comparison (nested F-test)	
Complete- Sum squared residuals	827.8444
Reduced- Sum squared residuals	842.9797
Mean squared	2.5472
Comparison F-Statistic (F*)	0.7427
Rejection F-Statistic – $F_{0.05}$(8,325)	1.9700
Conclusion	Fail to reject H_0 because F*< Fa, hence the excluded variables do not improve the model.
Tobit Model Comparison (Log-likelihood ratio test)	
Complete- Log-likelihood	-633.7190
Reduced- Log-likelihood	-636.7990
Comparison likelihood test ratio (LR)	6.1600
Rejection Statistic – $\chi^2_{0.05}$ (8)	15.5073
Conclusion	Fail to reject H_o because LR <$\chi^2_{0.05}$, hence the excluded variables do not improve the model.

The test statistic used to compare the OLS models, denoted by F*, was calculated to be 0.74. At a 5% significance level (α = 0.05), the critical value for the F-distribution for this sample was 1.97. Given that the test statistic is less than the critical value, the null hypothesis cannot be rejected in favour of the alternative. It was concluded that the reduced OLS model was superior to the complete OLS model for predictive purposes, as the omitted variables did not significantly improve the model.

With the Tobit models, the comparison test statistic used was the likelihood ratio, denoted by LR. It was calculated to be 6.16. The critical value for the Chi-squared ($\chi^2_{0.05}$) distribution for this sample was 15.50. As in the case of the OLS models, since the test statistic is less than the critical value, the null hypothesis was not rejected in favour of the alternative. It was concluded that the reduced Tobit model was superior to the complete Tobit model, as the omitted variables did not yield significant additional predictive power.

Coefficient Interpretation

The use of a log-transformed functional form changes the interpretation of the regression coefficients. After transformation, the coefficient of an independent variable represents the percentage contribution that variable makes to the dependent variable when there is a one-unit increment in the independent variable. This percentage increase is calculated by performing the following transformation of the coefficient (Mendenhall & Sincich 1996:44):

Percentage change = $(e^{\beta i} - 1) \times 100$ …………………………………………………. (6.4)

Table 6.6 below gives the coefficient interpretation of the independent variables in both the reduced OLS and Tobit models, as well as the monetary value of the constant (C).

Table 6.6: Coefficient Interpretation: Mlalazi Estuary

		Model	
Variable	**Interpretation**	**OLS**	**Tobit**
RACE	The percentage increase in WTP due to the race of a respondent changing from black to white	99.37%	99.37%
RES	The percentage decrease in WTP due to the residential status of a respondent changing from a local resident to a visitor	-62.47%	-62.47%
INCOME	The percentage increase in WTP due to a one-unit increase in a respondent's annual income	0.0002%	0.0002%
EDUC	The percentage increase in WTP due to the educational status of a respondent changing from a low level of education to a high level of education.	155.99%	155.99%
AMOUNT	The percentage increase in WTP due to a one-unit increase in a respondent's annual conservation amount	0.12%	0.12%
TRAV	The percentage increase in WTP due to a 1km increase in the distance travelled by a respondent to reach the estuary.	5.44%	5.44%
C	The intercept's Rand value.	R9.87	R9.87

All the independent variables affected WTP as expected except RES, as local residents had a higher WTP than visitors (see tables 6.2 and 6.6). As expected, the further away a respondent lived from the Mlalazi estuary, the more they were willing to pay for freshwater inflows into the estuary. This is in line with the travel cost approach to valuation. Previous similar studies (Van Der Westhuizen 2006) also found a similar pattern. Respondents living close to the estuaries usually choose to be there because of the presence and view of the beachfront and not just the estuary, whereas respondents who come from far away usually report that the estuary accounts for a large percentage of the reason why they are in the vicinity of the estuary.

Example 6.1 describes the effect of education on WTP for the Mlalazi estuary.

Example 6.1: the effect of Education on WTP for freshwater inflows into the Mlalazi Estuary

The reduced Tobit model for the Mlalazi estuary can be written as:

lnWTP = 2.29 + 0.69(RACE) – 0.98(RES) + 0.000002(INCOME) + 0.94(EDUC) + 0.0012(AMOUNT) + 0.053(TRAV)

In order to forecast with this model, we let $WTP_{(0)}$ denote the WTP of a respondent with a low level of education and $WTP_{(1)}$ denote a respondent with a high level of education.

All other variables are kept constant at the following levels:

RACE = 0 (black); RES = 0 (local resident); INCOME = R75000;

AMOUNT = R50; TRAV = 10 Km;

Substituting the above values into the model, the following results were obtained:

- $\ln WTP_{(0)}$ = 2.29 + 0.69(0) -0.98(0) + 0.000002(75000) + 0.94(0) + 0.0012(50) + 0.053(10) = 3.03. The ln inverse of this translates to a monetary value of R20.70
- $\ln WTP_{(1)}$ = 2.29 + 0.69(0) -0.98(0) + 0.000002(75000) + 0.94(1) + 0.0012(50) + 0.053(10) =3.97. The ln inverse of this translates to a monetary value of R52.98

The percentage change can be calculated as:

$$\frac{WTP(1) - WTP(0)}{WTP(0)} \text{ X } 100 = \frac{52.98 - 20.70}{20.70} \text{ X } 100 = 155.99\%$$

Using our transformation formula (equation 6.4 above):

Percentage change $_{(EDUC)}$ = $(e^{0.94} - 1) \times 100 = 155.99\%$

This means that WTP increases by 155.99% when a respondent's educational status changes from a lower level of education to a higher one.

6.4 AGGREGATION OF THE WTP

The reduced OLS and Tobit models for each set of estuary users were used to predict the mean and median WTP values for the relevant estuary. Table 6.7 details the findings.

Table 6.7: Predicted WTP – Reduced OLS and Tobit Models

		Estuary							
		Breede	**Duiwenhoks**	**Great Berg**	**Kleinemond West**	**Mhlathuze**	**Mlalazi**	**Olifants**	**Swartvlei**
Mean and Median Predicted WTP (Rand*)									
OLS	**Mean**	210.60	25.53	125.21	347.23	45.15	25.28	4.35	13.74
	Median	172.43	5.31	54.60	221.41	31.50	20.70	2.05	8.41
Tobit	**Mean**	210.60	25.53	125.21	347.23	45.15	25.28	4.35	13.74
	Median	172.43	5.31	54.60	221.41	31.50	20.70	2.05	8.41

* All values are at 2006 price levels

The mean WTP values range from a high of R347.23 for the Kleinemond West estuary to a low of R4.35 for the Olifants estuary, whilst the medians range from a high of R221.41 also for the Kleinemond West estuary to a low of R2.05 for the Olifants estuary. For valuation studies of this nature, it is often advisable to use the more conservative median estimates in the calculation of total population WTP. It is also preferable to use to Tobit models for such analyses, since it restricts the predicted WTP to positive values, censoring out all negative model predictions (Hosking *et al.* 2004).

Prediction of total willingness-to-pay (TWTP)

The total willingness-to-pay (TWTP) to sustain freshwater inflows into the estuaries was estimated as the product of the median WTP per annum and the total number of user households. The TWTP was divided by the amount of water required per annum to prevent a decrease in the services rendered by the estuaries (as described earlier) to arrive at the Rand/m^3 value. Table 6.8 details the TWTP of the users for all eight estuaries.

Table 5.8: Predicted TWTP values for freshwater inflows

	Estuary							
	Breede	**Duiwenhoks**	**Great Berg**	**Kleinemond West**	**Mhlathuze**	**Mlalazi**	**Olifants**	**Swartvlei**
Median WTP (Rand)	172.43	5.31	54.60	221.41	31.50	20.70	2.05	8.41
User population (Households)	1 328	100	2 000	1 250	725	1 500	500	4 000
TWTP (Rand)	228 987	531	109 200	276 763	22 838	31 050	1 025	33 640
Water Required p.a. (Millions m^3)	21.1	0.5	75	0.1	9.9	8.7	0.5	5.4
Value of water (Rand/m^3)	0.011	0.001	0.001	2.77	0.002	0.004	0.002	0.006

The value of water ranged from a low of 0.001 cent per m^3 for the Duiwenhoks and Great Berg estuaries to a high of R2.77 per m^3 for the Kleinemond West estuary. It was expected that estuaries most prone to high impacts from changes to freshwater inflow, such as temporary open/closed estuaries, would yield the highest value per m^3. This expectation was fully confirmed by the results. The Kleinemond West estuary is a temporary open/closed estuary and was found to have the highest value per m^3. This high value per m^3 may also indicate that there may be a strong WTP for freshwater inflows beyond the minimum amount required to maintain the estuary in its current state.

6.5 CONCLUSION

The generation of predictive WTP values poses many challenges. With cross sectional data, multicollinearity and heteroscedasticity are two common complications. This chapter addressed these problems by checking for significant correlation between the explanatory variables and transforming the functional form and some variables. Complete and reduced OLS and Tobit models were generated for each estuary. Statistical tests showed that the reduced Tobit models were acceptable for predictive purposes. The reduced models were used to predict household WTP means and medians, and these median values were used to generate TWTP (population) values. The TWTP was divided by the relevant required freshwater inflows to generate Rand/m^3 values. The recreational value of the freshwater flowing into all eight estuaries was found to be is greater than 0.

This value was particularly high for the Kleinemond West estuary which is a temporary open-closed estuary. The lowest Rand/m^3 values were those of the Duiwenhoks and Great Berg estuaries, which are both permanently open estuaries. The chapter seven assess the credibility of the values estimated in this chapter.

CHAPTER SEVEN: CREDIBILITY ANALYSIS

7.1 INTRODUCTION

Analysing the credibility of the results generated by contingent valuation is a very important step in applying the method because it entails many discretionary elements. This chapter reports the assessment of the credibility of the values generated and the way in which they were estimated.

7.2 CREDIBILITY ASSESSMENT

Table 7.1 compares this application of the CVM with the Blue-Ribbon guidelines. The validity of the CV study is examined in terms of content and construct validity. Content validity relates to survey design and implementation. Construct validity can be subdivided into convergent and expectations validity. Convergent validity relates to how well the results compare with results obtained from other valuation methods and studies, whilst expectations validity relates to the consistency of the CVM results in terms of theoretical expectations (Bateman *et al*. 2002:231).

Table 7.1: Credibility Assessment

Criteria	Satisfied	comment
Repeatability		
1.Replicate results by running method under same circumstances and conduct temporal averaging	x	No follow-up surveys have been done at the eight study sites yet.
Content Validity		
2. Assess whether the study employed a feasible hypothetical scenario	✓	This study is feasible as similar projects have been carried out in the study area.
3. Accurate information on the valuation exercise must be presented to respondents	✓	Data presented to the respondents are from scientific studies conducted by Papadopoulos (2006).
4. Sample sizes must be guided by expert advice and statistical sampling tools.	x	User populations were determined in consultation with local and tourism officials and well as GIS census data. However, these figures are only estimates and may be off by a few hundred.
5. The questionnaire should ask questions in a clear and appropriate manner	x	Pilot studies were conducted and the results used to improve the clarity of questions. However, there appeared to be variations in respondent comprehension of all issues. The different home languages used by respondents also posed challenges.
6. Questionnaire should minimise non-response rates while allowing for protest bids	✓	Only 99 of a total of 1711 bids could not be used. Protest bids were allowed.
7. Ideally, personal interviews should be conducted.	✓	Face-to-face interviews were conducted for this study
8. A closed ended bid format should be employed	✓	This study employed a WTP format with a close ended payment card system.
9. An acceptable payment vehicle should be chosen	✓	The payment vehicle chosen was in the form of increased user fees to the local authorities as this was already the practice in most cases.
10. The survey should include a variety of questions that help explain respondents' WTP	✓	The questionnaire did include follow-up questions.
11. Remind respondents of alternative expenditure possibilities to eliminate the 'warm-glow' effect due to moral contribution to the environment	x	This was done but the 'warm-glow' effect, embedding and other biases cannot be completely ruled out.

Table 7.1: Credibility Assessment (continued)

Criteria	Satisfied	comment
Construct Validity		
I. Convergent validity		
12.Different methods for valuing the given environmental change are reported	✓	Comparative travel cost estimates were generated and reported (see chapter eight)
13. similar analyses results are reported	✓	The results of this study were compared with those of previous studies and found to be similar
II. Expectation Validity		
14. Analysed whether bids would are consistent with what one would expect from economic theory.	✓	Bids were consistent with expectations
15. Preferably, A conservative model should be chosen.	✓	a) A WTP rather than a WTA format was chosen b) Residual analysis showed that the log-linear model used was conservative and showed less variation than other models c) median rather than mean WTP values were used for analyses.

Source: Hanley & Spash (1993), NOAA (1993), Bateman *et al*. (2002) and Turner *et al*. (2003) and own criteria.

7.3 VALIDITY ASSESSMENT

Validity tests measure the degree to which a study succeeds in measuring the intended values. With respect to content validity, the Blue-Ribbon guidelines stipulate that the information presented to respondents, based on which they make their WTP bids, be as accurate as possible. The information presented to respondents at the study sites was drawn from scientific studies conducted by Papadopoulos (2006). The choice of sample sizes was guided by GIS census data and consultations with local and tourism officials. A pilot study, as recommended by the Blue-Ribbon panel, was conducted at the Keurbooms estuary and the recommendations used to improve the questionnaire used for this study. A personal interview format was used to obtain responses and a payment card system was used to minimise starting point bias and the incidence of outliers. Table 7.1 summarises other measures taken to improve content validity.

Van Der Westhuizen (2006), reports that the main difficulty in testing for the validity of WTP values is finding yardsticks against which to compare the results. He recommends testing for construct validity, where the results obtained from the CV study are compared with results from revealed preference valuation methods, such as the Travel Cost or Hedonic Pricing model. This recommendation is implemented in this dissertation, where the Travel Cost method is used to generate alternative values to be compared with the results obtained from the application of the CVM. The Travel Cost estimates are reported in chapter eight.

Three criteria were used as a further test for construct validity (Hanley & Spash 1993:116):

- All models are statistically significant with an adjusted R-Squared of not less that 15% and a statistically significant F-Statistic of less than 0.05
- All reduced models contained the significant variables that they would be expected to contain
- The signs of the coefficients in the reduced model conformed to theoretical expectations

With reference to the three criteria above, four ratings were constructed:

- Strong support → if all three criteria are met
- Moderate support → if any two of the three criteria are met
- Weak support → if only one of the three criteria is met
- No support → if none of the three criteria is met.

Table 7.2 shows how the models generated in this study compare to the above criteria.

Table 7.2: Model Assessment

Estuary	Criteria			Model Support
	Model Statistically significant	Contains significant variables	Expected signs of coefficients	
Breede	✓	✓	✓	Strong
Duiwenhoks	✓	✓	✗	Moderate
Great Berg	✓	✓	✓	Strong
Kleinemond West	✓	✓	✗	Moderate
Mhlathuze	✓	✓	✗	Moderate
Mlalazi	✓	✓	✗	Moderate
Olifants	✓	✓	✓	Strong
Swartvlei	✓	✓	✓	Strong

7.4 RELIABILITY ASSESSMENT

Reliability refers to the degree of replicability of a measurement between the results of different samples of the same population. The aim of a reliability (repeatability) test is to show that the survey can be relied upon to provide the same results if the survey were administered repeatedly under similar conditions. One of the ways in which researchers can test for reliability is to examine the variation of the WTP responses. Valuations with a relatively low variation among responses are generally considered more reliable estimates of value than those with a high variation (Breedlove 1999:67). Repeatability tests could not be carried out because the survey has not yet been repeated at the study sites. As an alternative, reliability is assessed with reference to the findings made by other researchers of the values of freshwater inflows into different estuaries in South Africa.

Van Der Westhuizen (2006) conducted a contingent valuation of the recreational value of the freshwater flowing into the Bira, Bushmans, Kasouga, Keiskamma, Kleinemond East, Nahoon and Tyolomnqa estuaries. Table 7.3 below summarises his findings.

Table 7.3: Economic value of freshwater inflow (selected Southern and Eastern Cape estuaries)

	Estuary						
	Bira	**Bushmans**	**Kasouga**	**Keiskamma**	**Kleinemond East**	**Nahoon**	**Tyolomnqa**
User Pop (households)	1250	2800	1875	2800	1875	2800	1875
Water required (million m^3)	1.44	2.4	0.38	19	0.12	3.78	2.8
Mean WTP (Rand)	236	253	108	77	186	58	111
Median WTP (Rand)	117	118	71	4	3	30	4
Mean TWTP (Rand)	295 000	708 400	202 500	215 600	348 750	162 400	208 125
Median TWTP (Rand)	146 250	330 400	133 125	11 200	5 625	84 000	7 500
Mean value of water (R/m^3)	0.21	0.30	0.53	0.01	2.91	0.04	0.07
Median value of water (R/m^3)	0.10	0.14	0.35	0.0006	0.05	0.02	0.0027

Source: Van Der Westhuizen (2006)

The values of freshwater inflows were found to be higher for temporary open-closed estuaries like the Kasouga estuary, than for the permanently open ones such as the Keiskamma estuary. The values are higher for the temporary open-closed estuaries because their present inflows are small so further reductions severely undermine the services they yield.

Perhaps, one of the most important findings of Van Der Westhuizen (2006) was the existence of 'dual economies' at the selected estuaries. He found that there were two economic groups of estuary users. The first group belonged to the formal economy. These users tended to have very high income levels. The other group belonged to the informal economy and usually sold bait or engaged in other subsistence activities. The difference was typically captured in the 'RACE' variable in the regression models. The Gini Coefficient (which measures income inequality) of the sample was 0.57, which was very close to South Africa's current Gini coefficient of 0.60.

One implication of Van Der Westhuizen's (2006) 'dual economy' of users is that the skewness of the WTP distribution was 'legitimate' and that mean WTP values may be preferred to median values in the calculation of TWTP. Median values are usually used because they yield more conservative estimates. In cases where 'dual economy' user populations exist, the WTP bids of wealthier estuarine users may be unduly discounted when median, rather than mean WTP, is used to calculate TWTP and the freshwater values reported may not reflect the true value that the total population of users place on it.

An examination of the sample data used for this study also revealed a dualistic trend. The Gini Coefficient was 0.32 for the sample and in cases where 'RACE' was a significant predictor (Great Berg, Kleinemond West, Mlalazi and Swartvlei), change in the race of a respondent from 'BLACK' to 'WHITE' had a positive influence on WTP (see Appendix A). The mean and median values of water generated from this study were, however, much closer to each other than those reported by Van Der Westhuizen (2006) (see Table 7.4 below).

Table 7.4: Mean and Median values of freshwater inflow

	Estuary							
	Breede	**Duiwenhoks**	**Great Berg**	**Kleinemond West**	**Mhlathuze**	**Mlalazi**	**Olifants**	**Swartvlei**
Mean value of water (R/m^3)	0.01	0.005	0.033	4.77	0.003	0.004	0.004	0.01
Median value of water (R/m^3)	0.011	0.001	0.001	2.77	0.002	0.004	0.002	0.006

Lin (2005) undertook a similar valuation study of freshwater inflows into the Klein Brak, Groot Brak, Kynsna, Kromme, Swartkops, Kariega and Kowie estuaries. The contingent valuation model was applied in arriving at the estimates reported in Table 7.5 below.

Table 7.5: Economic value of freshwater inflow (selected Southern and Eastern Cape estuaries)

	Estuary						
	Klein Brak	**Groot Brak**	**Kynsna**	**Kromme**	**Swartkops**	**Kariega**	**Kowie**
User Pop (households)	1178	2730	3891	3200	5000	2000	3234
Water required (million m^3)	11.2	5	46	75.5	13.5	7.4	13
Mean WTP (Rand)	129	272	199	373	308	380	325
Median WTP (Rand)	120	192	149	287	244	211	290
Mean TWTP (Rand)	151,962	742,560	774,309	1,193,600	1,540,000	760,000	1,051,050
Median TWTP (Rand)	141,360	524,160	579,759	918,400	1,220,000	422,000	937,860
Mean value of water (R/m^3)	0.014	0.149	0.017	0.016	0.114	0.103	0.081
Median value of water (R/m^3)	0.013	0.105	0.013	0.012	0.090	0.057	0.072

Source: Lin (2005)

The value of freshwater inflow was highest for the only temporary open-closed estuary included in the study (Groot Brak). The mean value of freshwater inflows ranged from a high of R0.149 per m^3 to a low of R0.014 per m^3 for the Klein Brak estuaries. Median values ranged from R0.105 per m^3 for the Groot Brak to a low of R0.012 per m^3 for the Kromme estuary. Lin (2005) did not investigate the effect of a dualistic population at the selected sites but the mean and median WTP values of water were reported. The differences in the mean and median values are quite small for all the selected estuaries (see Table 7.5).

7.5 CONCLUSION

This chapter assessed the credibility of this CV methodology applied in this study in terms of content and construct validity and against the background of the Blue-Ribbon Panel guidelines. With respect to both construct and content validity, there was a significant degree of compliance. The regression models generated at the estuaries were also evaluated in terms of model significance, the presence of significant variables in the reduced model and their adherence to theoretical expectations. Moderate model support was found for the Duiwenhoks, Kleinemond West, Mhlathuze and Mlalazi estuaries. There was strong support for the models generated for the Breede, Great Berg, Olifants and Swartvlei estuaries. Repeatability tests could not be conducted because the survey has not been repeated at the study sites, but a number of similarities in the findings of other similar analyses were identified.

One important element of the credibility assessment yet to be covered is that relating to convergent testing. Chapter eight applies that TCM to generate alternative values for the services yielded by increased freshwater inflows into the estuaries covered in this dissertation.

CHAPTER EIGHT: CONVERGENCE TESTING – THE TRAVEL COST METHOD

8.1 INTRODUCTION

For the purposes of convergence testing, the Travel Cost Method (TCM) will be applied to values the changes in services yielded through an increase in freshwater inflows into the estuaries. An overview of the Travel Cost Method is presented, followed by an application of the technique and a discussion of some of the issues and limitations involved in the application of the TCM. Finally, the TCM results will be compared to the CVM values, with the aim of assessing convergence.

8.2 THE TRAVEL COST METHOD

The main assumption of the TCM is that the value of a site or its recreational services is reflected in the amount that people are willing to pay to get to the site and access it (www.ecosytemvaluation.org). It is a 'revealed preference' method, reflecting actual behaviour and choices. The primary argument of the Travel Cost Method is that the time and travel cost expenses incurred by people to visit a site represents their WTP to access the site. This is similar to a person's willingness to pay for a private good (Shaw 1992).

The Travel Cost Method may be applied in various ways, for example, to estimate the economic benefits or costs associated with a change in the access cost for a recreational site, the elimination of an existing recreational site or the addition of a new recreational site. It may also be used to value changes in the environmental quality at a recreational site. The method is relatively inexpensive to apply and the results generated are usually easy to interpret and explain (Mitchell & Carson 2000).

8.3 APPLYING THE TRAVEL COST METHOD

There are three generally accepted ways of applying the TCM:

The Zonal Travel Cost Approach

The zonal travel cost approach uses mostly secondary data together with limited data on the user population. It is normally used to estimate the existence value of an environmental good and as such is unsuitable for valuing changes in the quality of a good (Shaw 1992). In the valuation of a recreational site for example, the zonal travel cost method is applied by collecting information on the number of visits to the site from different distances. Travel and time costs will increase with distance so this information allows the researcher to generate a model which can predict the number of visits demanded at different travel costs and to estimate the consumer surplus for the site.

The application of the zonal travel cost method can be divided into seven steps (www.ecosystemvaluation.org). The first step is the identification of the population per travel zone with the WTP to visit the site. The zones may be defined by concentric circles drawn around the site at varying distances or by geographic divisions such as metropolitan areas or provinces. International visitors may be regarded as temporary local residents. The second step involves the identification of the number of current year users (visitors per annum) per zone. Information may be collected on the characteristics of the users from each zone, such as average household size, income levels etc. Step three involves the calculation of the current visitation rate for each zone. The total visits per year from each zone is divided by the zone's population to arrive at the current visitation rate. The fourth step involves the determination of the round-trip distance and the travel time to the site from each zone. Using the average travel cost per km and per hour of travel time, the researcher can calculate the travel cost per trip.

The fifth step estimates a trip generating function (TGF), where the visits per zone is related to travel costs and other important variables. Step six entails generating a market demand function from the TGF, the first point on the demand curve being the total number of visits to the site at the current access cost. The other points are found by estimating the number of visits demanded at other travel costs. The seventh and final step estimates the total consumer surplus. This may be done by calculating the area under the demand curve. This gives the total estimate of economic benefit from recreational users of the site.

The Individual Travel Cost Approach

The Individual Travel Cost approach uses survey data from individual visitors in the statistical analysis rather than average travel cost data for each travel zone. More data is collected in this case than in the zonal approach and the analysis of the data is done into greater detail, yielding more precise results (www.ecosystemvaluation.org). The survey might ask the visitor for information on their travel expenses to get to the site, the amount of time spent there, location of the visitor's home, how far they travelled to the site, etc. The researcher uses regression analysis to estimate the relationship between the number of visits respondents made to the site and their travel costs. The researcher may also include other relevant variables in the analysis.

The demand function for the 'average' visitor to the site is captured in the regression equation. The researcher can estimate the average consumer surplus from the area under the demand curve (www.ecosystemvaluation.org). The total consumer surplus is obtained by multiplying the total user population with the average consumer surplus.

The Random Utility Approach

The random utility approach allows for much more flexibility in calculating benefits although it is complicated and expensive to apply. It is a good approach to use to estimate benefits for specific characteristics or quality changes. It is also the most appropriate approach when there are many substitute sites. The random utility approach assumes that individuals will pick the site that they prefer out of all possible sites. As individuals normally make tradeoffs between site quality and the cost of travel to the site, this model requires information on all sites that the respondent might visit, as well as quality characteristics of the site and the travel costs to each site (www.ecosystemvaluation.org).

8.4 GENERATING TRAVEL COST DEMAND FUNCTIONS

Methodology

The Individual Travel Cost Method (ITCM) is used to generate demand functions for visits to the estuaries.There are five steps in the application of the ITCM (Ortacesme, Ozkan & Karaguzel 2001):

Step 1: Average Visitation

The first step involves the estimation of the average number of visits to the site by an individual user over a specific period of time, usually a year. This average number of visits becomes the dependent variable in an individual demand function. Other relevant variables which might explain the respondent's demand for visits include the distance travelled to access the site, the respondent's income and educational level. These serve as the explanatory variables of the demand function.

Step 2: Travel cost determination

Travel costs were determined with reference to the Automobiles Association's (AA) rates for cars. The survey data from all eight estuaries showed that 95% of vehicles used by the respondents were petrol vehicles and had an average engine capacity of between 2500 and 3000 cc. Given the dominance of this class of vehicles, it was decided that for costing purposes, all vehicles would be treated as petrol cars with an engine capacity of 2500-3000 cc. The average respondent travelled about 20 000 km per year, so for the purposes of calculating the total vehicle operating costs, it was assumed that the respondent travelled 20 000 km per year.

Petrol prices and vehicle operating costs for 2006 were used as this was the year in which the surveys were conducted. The travel cost per kilometre was calculated to be R2.50. This cost per kilometer was multiplied by the total distance travelled (in km) to obtain the total vehicle operating costs. Where levies were paid to access the estuary, they were added to this figure to obtain a total access (travel) cost. Information was also collected in the survey on other explanatory variables such as income, educational level and household size.

Step 3: Model specification

The demand function estimated for visits to the various estuaries was formed as:

$V_i = f(TC_i, F_i, X1_i, X2_i, X3_i, \ldots\ldots XN_i)$ …………………………………… (8.1)

Where:

> V_i = Number of days an individual *i* spends visiting the estuary per year
>
> TC_i = Travel costs of individual *i* involved in his/her visiting the estuary. This travel cost was apportioned over the number of day visits for each 'holiday visit'.
>
> F_i = Dummy variable for whether an individual will undertake the same number of day trips (1) or decrease the number of day trips per year to the estuary (0) by at least 40%, if the quality of the estuary deteriorates.
>
> $X1_i \ldots\ldots XN_i$ = Other variables explaining the demand for visits to the estuary.

Step 4: Determination of individual consumer surplus

Consumer surplus is the net consumer welfare value measure of all visits to the estuary. Consumer surplus was estimated in this analysis using the procedure outlined by Hellerstein and Mendelsohn (1993) for consumer utility maximization subject to an income constraint, where number of visits is a non-negative integer. They show that the conventional formula used to estimate consumer surplus for a semi-log model can also be used in the case where the dependent variable is integer constrained ('number of days spent visiting' can only be an integer). A Poisson regression, with a linear relation on the travel cost variable, is equivalent to a semi-log functional form. Adamowicz, Fletcher & Tomasi (1989), show that the annual consumer surplus estimate for demand with continuous variables is E(r)/(- β), where β is the estimated slope of the demand function and E(r) is the mean annual visits from the estimated trip demand function.

Consumer surplus is thus determined by the following equation:

$CS = -\frac{q}{\beta_{TC}}$ ……………………………………………………………….. (8.2)

Where:

CS = consumer surplus

q = number of days spent visiting the estuary per year

β_{TC} = slope of the demand function (the travel cost coefficient)

<u>Step 5: Determination of total consumer surplus</u>

The total consumer surplus is generated by multiplying consumer surplus by the total estimated user population, i.e. TCS = CS * total estimated user population.

Where:

TCS = Total Consumer Surplus

<u>Application of the ITCM</u>

The above steps were followed in the application of the ITCM to the user population of the eight estuaries included in this study. The regression results for the Breede estuary is presented in table 8.1 below:

Breede Estuary

Table 8.1: Travel Cost Regression Results: Breede Estuary

Dependent Variable: Visits				
Model: Reduced				
Observations: 161				
Method:	Least Sqaures			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	228.2449	28.3364	8.0548	0.0000
QUALITY	0.3025	15.4606	1.6686	0.0972
RES	-118.8965	13.6951	-8.6816	0.0000
INCOME	-0.0001	3.05E-05	-3.4695	0.0007
KNOW	36.9239	17.4573	2.1151	0.0360
USE_CAT	-83.2456	27.4587	-3.0316	0.0029
TRAVEL COST	-0.0058	0.0026	-2.2226	0.0277
	R-Squared		0.4307	
	Adjusted R-Squared		0.4085	
	F-statistic		19.4195	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		975029	

Travel cost is negatively related to visits, implying that as travel cost increased the number of days spent visiting the estuary decreased. Income is negatively related to the number of visits, suggesting that visits to the estuary may be an ‘inferior’ good. The residence of the respondent is also a significant factor in determining the number of visits made to the estuary. Local residents visited the estuary more often than visitors. Commercial and subsistence users of the estuary also visited the estuary more often than passive and recreational users. Example 8.1 calculates the consumer surplus resulting from a project that ensures the freshwater inflow required to prevent a quality deterioration of the estuary.

Example 8.1: Consumer surplus computation: Breede Estuary

From Table 8.1 above, the number of days spent visiting the estuary per annum for the Breede estuary is given by:

VISITS = 228.24 + 0.30*QUALITY – 118.90*RES – 0.0001*INCOME + 36.92* KNOW – 83.25*USE_CAT – 0.0058*TRAVEL COST/VISIT……………………….8.3

The following median values apply for respondents sampled at the Breede Estuary:

RES: 1 (visitor); **INCOME:** R225000; **KNOW:** 1 (Well-informed); **USE_CAT:** 1 (Recreational/passive user); **TRAVEL COST:** R250.

CURRENT

Demand for visits to the estuary in its current state is:

$\mathbf{VISITS_{CURRENT}}$ ⇒228.24 + 0.30*1 – 118.90*1 – 0.0001*R225000 + 36.92*1 – 83.25*1 – 0.0058*R2500 = **39.36** days per capita per year.

Consumer surplus under current conditions is:

$\mathbf{CS_{CURRENT}} = -\frac{39.36}{-0.0058}$ = **R6786** per capita per year.

Total consumer surplus is:

$\mathbf{TCS_{CURRENT}}$ = R6786 *5310 ⇒ **R36 033 660** per year.

DECREASED INFLOW

The visitation rate if estuary quality deteriorates is:

$\mathbf{VISITS_{DECREASED}}$ ⇒ 228.24 + 0.30*0 – 118.90*1 – 0.0001*R225000 + 36.92*1 – 83.25*1 – 0.0058*R2500 = **39.06** days per capita per year.

The consumer surplus is:

$\mathbf{CS_{DECREASED}} = -\frac{39.06}{-0.0058}$ = **R6734** per capita per year

The total consumer surplus is:

$\mathbf{TCS_{DECREASED}}$ = R6734 *5310 ⇒ **R35 757 540** per year.

The loss in consumer surplus as a result of decreased freshwater inflow is:

R36 033 660 – R35 757 540 = **R276 120.**

Conversely, this is the gain in consumer surplus from securing the freshwater inflows.

Example 8.1 continued

With an estimated freshwater inflow requirement of 21.1 million m^3 for the Breede Estuary, the per cubic meter value of inflows is = $\frac{276\ 120}{21\ 100\ 000}$ = **R0.013** per m^3.

The Contingent valuation estimate was **R0.011** per m^3, a difference of **R0.002** per m^3.

The information above is summarised in table 8.2 below:

Table 8.2: Summarised Consumer Surplus Computation: Breede Estuary

Estuary: Breede			
Median Values:		**Consumer Surplus:**	
RES	1 (Visitor)	Estimated user population	5310
INCOME	R225000	$CS_{DECREASED}$ (per capita/annum)	R6734
KNOW	1 (Well-informed)	$CS_{CURRENT}$ (per capita/annum)	R6786
USE_CAT	1(Passive\Recreational)	**Total Consumer surplus**	
TRAVEL COST/VISIT	R250	$TCS_{DECREASED}$	R35 757 540
Visits		$TCS_{CURRENT}$	R36 033 660
$VISIT_{DECREASED}$	39.06	$\mathbf{TCS_{(CURRENT\ -\ DECREASED)}}$	R276 120
$VISIT_{CURRENT}$	39.36	Fresh water inflow	21 100 000 m^3
		ITCM estimate (Rand/m^3)	**CV estimate (Rand/ m^3)**
		0.013	0.011

The ITCM predictive models and consumer surplus computation for all other estuaries are presented in Appendix D. Table 8.3 summarises the ITCM values per m^3 of freshwater inflow for all estuaries.

Table 8.3: Predicted ITCM values for freshwater inflows

	Estuary							
	Breede	**Duiwenhoks**	**Great Berg**	**Kleinemond West**	**Mhlathuze**	**Mlalazi**	**Olifants**	**Swartvlei**
$TCS_{DECREASED}$	R35 757 540	R17 620	R454 960	R89 950	R19 343	R90 720	R104 740	R876 960
$TCS_{CURRENT}$	R36 033 660	R18 388	R553 200	R332 450	R127 049	R153 480	R122 740	R930 560
$TCS_{(CURRENT - DECREASED)}$	R276 120	R768	R98 240	R242 500	R107 706	R62 760	R18 000	R53 600
Water Require p.a. (million m^3)	21.1	0.5	75	0.1	9.9	8.7	0.5	5.4
Value of water (Rand/m^3)	0.013	0.002	0.001	2.42	0.01	0.007	0.04	0.01

* All Rand amounts are at 2006 price levels

Issues and limitations of the Travel Cost Method

The travel cost method is widely used because it is easy and inexpensive to apply. It also mimics traditional valuation techniques where economic value is revealed by market choices. In most simple applications of the travel cost method, it is assumed that individuals take trips for a single purpose. In reality, most recreational trips are rarely single purpose. They combine sightseeing and the use of various capital and service items with both the travel and site visit. Most recreational trips to a particular site also include side trips which should be taken into account (Walsh, Loomis & Gillman 1990). Failing this, the value of the site may be overestimated. The apportionment of travel costs among the various purposes is required when a specific environmental service is part of an integrated package. However, this apportionment introduces a subjective and hypothetical element into the valuation – undermining the method's claim to be closely linked to market choices.

Another difficulty encountered in the application of the TCM involves the definition and measurement of the opportunity cost of travel time. Is leisure time truly 'free' time or time that has an opportunity cost? Amoako-Tuffour & Epeneira (2008) suggest that if leisure time is viewed as time off work or a stretch of time during which no work is done, then it might be conceivable to assign a zero value to the time spent travelling and on the site. However, De Grazia (1962) contends that the time used in the consumption of leisure can be considered as a planned input, so although the individual is not at work, the time is not 'free' (with no opportunity cost).

The calculation of the opportunity cost of time is one of the thorniest issues encountered in applying the TCM. There is no strong consensus on what the appropriate measure of the opportunity cost of time should be. Some researchers use the respondent's wage rate (Cesario & Knetsch 1976) or a fraction of the wage rate (Englin & Cameron 1996). Whichever value is chosen, it will have large effects on the resultant values calculated. Failure to account for travel time altogether may also result in biased and underestimated values. If people enjoy travelling to the site, as suggested by Amoako-Tuffour *et al* (2008), then travel time becomes a benefit, not a cost. In this case, the value of the site may be overestimated. At some of the selected study sites, like the Duiwenhoks and Kleinemond West estuary, some respondents refused to disclose their income whilst in the case of the Olifants estuary, no income data was collected at all. In the latter instance, the reluctance of respondents to disclose income related information led this research team to abandon the inclusion of the opportunity cost of travel time.

The availability of substitute sites also affects values. If two people travel the same distance, it is assumed that they both have the same value. In reality, if one person has several substitutes available but travels to that particular site, because it is preferred, then this person's valuation of that particular site is actually higher (www.ecosystemvaluation.org). Failure to account for the availability of substitute sites may result in the underestimation of the value of a site. In other cases, such as was encountered at the Mlalazi estuary, those who value the site may choose to live nearby. If this is the case, these respondents will have very low travel costs to the site, when in reality they value the site highly.

The application of the travel cost method also has an inherent sample selection bias, as only those who visit the site are surveyed. Those who do not visit the site, but nonetheless value it are completely left out (Walsh *et al.* 1990). The method thus fails to account for the non-use or intrinsic values associated with the site. For this reason, sites that have unique qualities and have substantial non-current users will be undervalued.

8.5 CONCLUSION

The travel cost method involves the determination of demand for visits to a site based on the travel cost incurred. It is a revealed preference method as it infers value based on the actual travel costs incurred by the respondents. This contrasts with stated preference methods like the CVM, where respondents are asked to respond to hypothetical scenarios. The individual travel cost approach was used in this study because it produces more precise results than the zonal approach.

A comparison of the TCM results with those generated by the CVM showed the results were convergent. At the Duiwenhoks estuary, for instance, the difference between the two values was R0.001 per m^3, while it was R0.004 per m^3 and R0.003 per m^3 respectively at the Swartvlei and Mlalazi estuaries. The two values were the same for the Great Berg estuary. The TCM values of freshwater inflows ranged from a low of R0.001 per m^3 for the Great Berg estuary to a high of 2.42 per m^3 for the Kleinemond west estuary. Table 8.4 below summarises the CVM and TCM freshwater values generated by this study.

Table 8.4: Comparison of the CVM estimates with the TCM values

	Estuary							
	Breede	**Duiwenhoks**	**Great Berg**	**Kleinemond West**	**Mhlathuze**	**Mlalazi**	**Olifants**	**Swartvlei**
CV Value of water (R/m^3)	0.011	0.001	0.001	2.77	0.002	0.004	0.002	0.006
TCM Value of water (R/m^3)	0.013	0.002	0.001	2.42	0.01	0.007	0.04	0.01

The travel cost method has a number of limitations. It is difficult to take multi-purpose trips into account and to account for the opportunity cost of travelling time. It fails to account for non-use values and also has an inherent selection bias.

CHAPTER NINE: CONCLUSION AND RECOMMENDATIONS

Estuaries are one of the most significant features of the South African coastline, but in recent years, their functioning has been threatened by increases in the demand for freshwater for both industrial and domestic purposes (Adams 2001:2). At the same time, there has been a gradual deterioration of river systems and their catchments and a reduction in the amount of recorded rainfall feeding the catchments.

The net result has been a decrease in freshwater inflows into estuaries; a situation which not only threatens the biological functioning of these estuaries, but also undermines the services rendered to its recreational users. This deterioration of estuaries' services reduces their appeal for recreation. This dissertation applied the contingent valuation method to values preferences for freshwater inflows with respect to selected western and southern cape estuaries.

The contingent valuation method is suited to studies of this nature because of its ability to capture both active and passive use values. The CV method involves directly asking people how much they would be willing to pay for specific environmental services. In this case, users were asked what they would be willing to pay to sustain freshwater inflows into the selected estuaries, so as to prevent specified negative effects of reduced inflows. The CV method is controversial because it is based on what people say they would do, as opposed to what people are observed to do.

The eight estuaries selected for this study were the Breede, Duiwenhoks, Great Berg, Kleinemond West, Mhlathuze, Mlalazi, Swartvlei and Olifants estuaries. These estuaries all face considerable threats to their functionalities from increased freshwater abstraction. Papadopoulos (2006) estimated that by the year 2025, there would be an 83% reduction in freshwater inflow into the Great Berg estuary, a 12.3% inflow reduction into the Swartvlei estuary and an 11% reduction in inflow into the Mhlathuze and Mlalazi estuaries. Considering that inflows into these and other estuaries are already low, these reductions could be expected to severely undermine the services rendered by them.

The CV surveys were conducted at the study sites over the period December 2006 to April 2007. A total of 1711 questionnaires were administered. Of these, 99 protest bids were eliminated from the sample, leaving a total of 1612 valid bids. Of the valid bids:

- 49% of the respondents were Black and 51% White.
- 82% lived within 10km of the estuaries and 18% visited from outside a 10km radius.
- 60% were male and 46% possessed a high level of education.
- The mean annual household pre-tax income of respondents was R176 104.
- 70% of respondents were well informed of the effects of reduced freshwater inflow into the estuaries.
- The mean household WTP was R209 and the median was R40.

The user population of the estuaries was estimated using GIS census data, comparisons with other estuaries and interviews with selected local and tourism authorities. The total user populations estimated ranged from a low of 400 for the Duiwenhoks estuary to a high of 16 000 for the Swartvlei estuary. Minimum acceptable return sample sizes were met for all estuaries surveyed except the Duiwenhoks estuary.

The generation of predictive WTP values poses many challenges, including multicollinearity and heteroscedasticity. This study addressed these problems by checking for significant correlations between sets of variables. Correlation matrices were constructed for all sets of variables. Where two variables were found to be significantly correlated one of them was either dropped or transformed. A mixed log-linear functional form was selected for this study because it was found to better capture the curvature of the demand function. Residual analyses were also conducted for each model to test for violations of the assumptions of the error term. The residual analyses showed that the use of the mixed log-linear form resulted in fewer violations than the linear model, lending support to the argument that the log-linear functional form was statistically preferable to the linear model. Complete and reduced OLS and Tobit models were generated for each estuary. Statistical tests showed that the reduced Tobit models were suitable for predictive purposes. Both mean and median WTP values were predicted but the medians were preferred in the calculation of TWTP values due to the skewed distribution of WTP data.

The value of the freshwater that flows into the selected estuaries varied but in all cases the marginal social benefit was positive (see Table 9.1 below).

Table 9.1: CVM and TCM estimated values

	Estuary							
	Breede	**Duiwenhoks**	**Great Berg**	**Kleinemond West**	**Mhlathuze**	**Mlalazi**	**Olifants**	**Swartvlei**
CV Value of water (R/m^3)	0.011	0.001	0.001	2.77	0.002	0.004	0.002	0.006
TCM Value of water (R/m^3)	0.013	0.002	0.001	2.42	0.01	0.007	0.04	0.01

The marginal social benefit was particularly high at the Kleinemond West estuary; R2.77 per cubic meter. The Kleinemond West estuary has a sizable user population, about 12% of whom participated in the survey. The freshwater requirement of the Kleinemond West estuary was also the lowest, 250 000 m^3. The lowest value found was for inflows into the Olifants estuary, where the median WTP was R2.05. The value per cubic meter of freshwater inflow was R0.002.

The fact that the marginal social benefits were positive across all estuaries implies that there may be a *prima-facie* case for the allocation of a specific amount of freshwater inflow into these estuaries per annum. However, the marginal social benefit should be compared with the marginal social cost in order to draw valid inferences. It is also important to note that the comparatively high marginal social benefit for the Kleinemond West estuary suggests that there is a particularly high preference for increased inflow beyond what is required to maintain the estuary in its current state.

The Blue-Ribbon guidelines (NOAA 1993) were applied to assess the credibility of the CV conducted by this study. Of the 15 guidelines identified (table 7.1 and Appendix E), 11 of these were met. The Blue-Ribbon guidelines advocate convergence testing i.e. comparing the values generated with those estimated through different methods, inter alia. The travel cost method was applied for the purposes of convergence testing and the results found to be consistent with those generated using the CV method (Table 9.1).

Based on these findings, the following recommendations are made:

User Population Determination

The research team faced considerable difficulty in determining the user population of the estuaries because no official records are kept on the number of users of most environmental resources. Researchers are forced to rely on secondary sources to estimate user populations, such as tourism officials and B&B operators. These estimates are usually subjective and prone to controversy.

Recommendation 1: Provincial and municipal authorities make efforts to officially record the number of users and the purpose of use of estuaries and other environmental resources in their municipalities.

Research Methodology

The contingent valuation method has been criticised as a valuation technique, but many of the problems with it are due to difficulties in applying the method rather than with the soundness of the technique (Barbier *et al.* 1997). Other valuation techniques may be used to test for convergence but these methods cannot claim supremacy over the CVM as there are many difficulties encountered in their application as well. Some valuation techniques may be more suitable than others depending on the particular valuation circumstance and the information available.

Recommendation 2: As many estuary valuations of this nature should be conducted as possible in order to improve the credibility of the estimates and understanding of the determinants of value.

Recommendation 3: The survey questionnaire should be modified to capture information about alternative sites, in order to make it possible to apply random utility valuation models. An appropriately modified questionnaire is attached (Appendix F).

Interdisciplinary Cooperation

The determinations of estuary freshwater inflow requirements require the expertise and collaboration of many scientists. The information provided by various scientists was crucial in informing the WTP bids of respondents.

Recommendation 4: Estuarine scientists should be directly involved in all attempts to value freshwater inflows into estuaries.

Water Allocation Decisions

Policy decisions affecting estuaries and other environmental resources are often made on economic and financial grounds.

Recommendation 5: If the freshwater allocation into estuaries is to compete with alternative uses, more research must be undertaken to estimate the marginal social benefits of this freshwater allocation.

Public Education

Many respondents encountered questioned the need for introducing charges for water flowing into the estuaries (as it has always been 'free'), and were resistant to the idea of paying to sustain inflows. Providing education to the target population about the negative impact on estuarine services due to reduced inflows will go some way to improve awareness of the underlying public good problems associated with interfering with this inflow.

Recommendation 6: More resources should be committed to educating the public about the link between estuary services and the quantity and quality of the freshwater flowing into them.

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APPENDIX A: CORRELATION MATRICES, OLS AND TOBIT MODELS

BREEDE ESTUARY

Correlation Matrix for the Breede Estuary

Variable	House	Freq	Income	Amt	Levies	Trav	Equip	Est_Redc %
House	1.00	**-0.24**	0.08	**-0.16**	0.01	**-0.24**	0.01	0.15
Freq	**-0.24**	1.00	**-0.22**	0.02	**0.18**	**0.50**	0.08	**-0.24**
Income	0.08	**-0.22**	1.00	**0.18**	-0.04	-0.05	0.14	0.12
Amt	**-0.16**	0.02	**0.18**	1.00	-0.01	**0.16**	0.08	**-0.16**
Levies	0.01	**0.18**	-0.04	-0.01	1.00	**0.18**	0.01	-0.08
Trav	**-0.24**	**0.50**	-0.05	**0.16**	**0.18**	1.00	-0.01	-0.11
Equip	0.01	0.08	0.14	0.08	0.01	-0.01	1.00	0.00
Est_redc %	0.15	**-0.24**	0.12	**-0.16**	-0.08	-0.11	0.00	1.00

The Correlations highlighted in boldface are significant at $p \leq 0.05$ (observations = 161)

Complete OLS and Tobit Model: Breede Estuary

Dependent Variable: Ln(WTP)								
Model: Complete								
Observations: 161								
Method:	**Least Sqaures**				**Censored Normal (Tobit)**			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	1.6241	0.6777	2.3963	0.0178	1.6241	0.6453	2.5164	0.0119
GEN	0.5860	0.2918	2.0081	0.0465	0.5860	0.2778	2.1088	0.0350
HOUSE	-0.0282	0.0616	-0.4574	0.6480	-0.0282	0.0587	-0.4803	0.6310
RES	0.1282	0.3518	0.3645	0.7160	0.1283	0.3350	0.3827	0.7019
FREQ	-0.0004	0.0017	-0.2148	0.8302	-0.0004	0.0017	-0.2256	0.8215
USE_CAT	2.3523	0.7394	3.1812	0.0018	2.3523	0.7041	3.3407	0.0008
INCOME	2.22E-06	6.72E-07	3.3071	0.0012	2.22E-06	6.40E-07	3.4729	0.0005
EDUC	-0.4767	0.4147	-1.1494	0.2522	-0.4767	0.3949	-1.2071	0.2274
AMOUNT	0.0003	0.0001	2.3344	0.0209	0.0003	0.0001	2.4514	0.0142
KNOW	0.6994	0.3809	1.8359	0.0684	0.6994	0.3627	1.9280	0.0539
LEVIES	3.13E-05	4.24E-05	0.7368	0.4624	3.13E-05	4.04E-05	0.7737	0.4391
TRAV	0.0253	0.0480	0.5271	0.5990	0.0253	0.0457	0.5534	0.5799
EQUIP	-6.97E-05	8.68E-05	-0.8024	0.4236	-6.97E-05	8.27E-05	-0.8426	0.3994
EST_REDC %	-0.0045	0.0041	-1.0958	0.2749	-0.0045	0.0039	-1.1508	0.2498
C	-0.0874	0.8330	-0.1049	0.9166	-0.0874	0.7932	-0.1101	0.9123
	R-Squared		0.3813		R-Squared		0.3813	
	Adjusted R-Squared		0.3220		Adjusted R-Squared		0.3173	
	F-statistic		6.4271		Log Likelihood		-299.7925	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		390.5896		Uncensored obs		161	

Reduced OLS and Tobit Model: Breede Estuary

Dependent Variable: Ln(WTP)								
Model: Reduced								
Observations: 161								
Method:	Least Sqaures				Censored Normal (Tobit)			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	1.2759	0.6369	2.0033	0.0469	1.2759	0.6229	2.0483	0.0405
GEN	0.5058	0.2774	1.8236	0.0702	0.5058	0.2712	1.8645	0.0622
USE_CAT	2.1412	0.6808	3.1453	0.0020	2.1412	0.6657	3.2160	0.0013
INCOME	1.93E-06	6.19E-07	3.1180	0.0022	1.93E-06	6.06E-07	3.1881	0.0014
AMOUNT	0.0003	0.0001	2.7165	0.0074	0.0003	0.0001	2.7775	0.0055
KNOW	0.5573	0.3611	1.5431	0.1249	0.5573	0.3532	1.5778	0.1146
C	0.0912	0.6367	0.1432	0.8863	0.0912	0.6227	0.1464	0.8835
	R-Squared		0.3607		R-Squared		0.3607	
	Adjusted R-Squared		0.3358		Adjusted R-Squared		0.3314	
	F-statistic		14.4789		Log Likelihood		-302.4345	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		403.6215		Uncensored obs		161	

Coefficient Interpretation: Breede Estuary

		Model	
Variable	Interpretation	OLS	Tobit
RACE	The percentage increase in WTP due to the race of a respondent changing from black to white	259.66%	259.66%
GEN	The percentage increase in WTP due to the gender of a respondent changing from female to male	66.53%	66.53%
USE_CAT	The percentage increase in WTP due to the category of a respondent changing from a commercial/subsistence user to a passive/recreational user	749.94%	749.94%
INCOME	The percentage increase in WTP due to a one-unit of increase in a respondent's annual income	0.0002%	0.0002%
AMOUNT	The percentage increase in WTP due to a one-unit of increase in a respondent's annual conservation amount	0.03%	0.03%
KNOW	The percentage increase in WTP due to a change in a respondent's knowledge from uninformed to well informed	75.07%	75.07%
C	The intercept's Rand value.	R1.09	R1.09

Model Comparison Test Statistics: Breede Estuary

Employed observations and variables in regression	
Excluded variables	8
Observations	161
Degrees of freedom	146
OLS Model Comparison (nested F-test)	
Complete- Sum squared residuals	390.5896
Reduced- Sum squared residuals	403.6215
Mean squared	2.6753
Comparison F-Statistic (F*)	0.6089
Rejection F-Statistic – $F_{0.05}$(8,146)	1.94
Conclusion	Fail to reject H_o because F*< Fa, hence the excluded variables do not improve the model.
Tobit Model Comparison (Log-likelihood ratio test)	
Complete- Log-likelihood	-272.2506
Reduced- Log-likelihood	-289.5433
Comparison likelihood test ratio (LR)	5.2840
Rejection Statistic – $\chi^2_{0.05}$ (8)	15.5073
Conclusion	Fail to reject H_o because LR <$\chi^2_{0.05}$, hence the excluded variables do not improve the model.

DUIWENHOKS ESTUARY

Correlation Matrix for the Duiwenhoks Estuary

Variable	House	Freq	Income	Amt	Levies	Trav	Equip	Est_Redc %
House	1.00	0.08	-0.00	-0.16	0.06	-0.08	-0.00	-0.14
Freq	0.08	1.00	-0.21	-0.22	-0.01	0.16	-0.14	-0.18
Income	-0.00	-0.21	1.00	**0.39**	0.09	-0.14	0.02	-0.08
Amt	-0.16	-0.22	**0.39**	1.00	0.10	-0.25	-0.10	0.02
Levies	0.06	-0.01	0.09	0.10	1.00	**0.41**	0.22	-0.12
Trav	-0.08	0.16	-0.14	-0.25	**0.41**	1.00	-0.13	-0.21
Equip	-0.00	-0.14	0.02	-0.10	0.22	-0.13	1.00	0.10
Est_redc %	-0.14	-0.18	-0.08	0.02	-0.12	-0.21	0.10	1.00

The Correlations highlighted in boldface are significant at $p \leq 0.05$ (observations = 28)

Complete OLS and Tobit Model: Duiwenhoks

Dependent Variable: Ln(WTP)								
Model: Complete								
Observations: 28								
Method:	Least Sqaures				Censored Normal (Tobit)			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	-0.6898	2.9629	-0.2328	0.8195	-0.6898	2.0188	-0.3416	0.7326
GEN	0.0300	1.6651	0.0180	0.9859	0.0300	1.1346	0.0264	0.9789
HOUSE	-0.6836	0.4910	-1.3920	0.1873	-0.6836	0.3345	-2.0430	0.0411
RES	-1.1202	2.8555	-0.3922	0.7012	-1.1202	1.9457	-0.5757	0.5648
FREQ	-0.0032	0.0083	-0.3799	0.7101	-0.0032	0.0056	-0.5576	0.5771
USE_CAT	5.0163	2.6481	1.8942	0.0806	5.0163	1.8043	2.7800	0.0054
INCOME	-1.86E-06	3.86E-06	-0.4806	0.6387	-1.86E-06	2.63E-06	-0.7054	0.4805
EDUC	-3.4657	1.9905	-1.7411	0.1053	-3.4657	1.3563	-2.5552	0.0106
AMOUNT	0.0036	0.0012	2.8802	0.0129	0.0036	0.0008	4.2270	0.0000
KNOW	1.3731	1.9811	0.6930	0.5005	1.3731	1.3499	1.0171	0.3091
LEVIES	-7.88E-05	0.0015	-0.0507	0.9603	-7.88E-05	0.0010	-0.0745	0.9406
TRAV	0.0867	0.2864	0.3027	0.7668	0.0867	0.1951	0.4443	0.6568
EQUIP	0.0004	0.0003	1.3245	0.2081	0.0005	0.0002	1.9439	0.0519
EST_REDC %	0.0014	0.0280	0.0501	0.9608	0.0014	0.0190	0.0735	0.9413
C	1.5212	4.7457	0.3205	0.7537	1.5211	3.2336	0.4704	0.6381
	R-Squared		0.606063		R-Squared		0.600847	
	Adjusted R-Squared		0.181823		Adjusted R-Squared		0.101907	
	F-statistic		1.428586		Log Likelihood		-65.53139	
	Probability (F-Statistic)		0.263375		Left Censored obs		0	
	Sum Squared Residual		176.8215		Uncensored obs		28	

Reduced OLS and Tobit Model: Duiwenhoks Estuary

Dependent Variable: Ln(WTP)								
Model: Reduced								
Observations: 28								
Method:	**Least Sqaures**				**Censored Normal (Tobit)**			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
HOUSE	-0.6315	0.3423	-1.8447	0.0786	-0.6315	0.3034	-2.0811	0.0374
USE_CAT	4.6512	1.6906	2.7511	0.0117	4.6512	1.4985	3.1037	0.0019
EDUC	-3.1581	1.4114	-2.2374	0.0357	-3.1581	1.2511	-2.5242	0.0116
AMOUNT	0.0034	0.0008	4.1958	0.0004	0.0034	0.0007	4.7335	0.0000
EQUIP	0.0005	0.0002	1.9671	0.0619	0.0005	0.0002	2.2192	0.0265
C	1.5761	2.2104	0.7130	0.4833	1.5761	1.9593	0.8044	0.4212
	R-Squared		0.5776		R-Squared		0.5727	
	Adjusted R-Squared		0.4816		Adjusted R-Squared		0.4506	
	F-statistic		6.0165		Log Likelihood		-66.5082	
	Probability (F-Statistic)		0.0011		Left Censored obs		0	
	Sum Squared Residual		189.6004		Uncensored obs		28	

Model Comparison Test Statistic: Duiwenhoks Estuary

Employed observations and variables in regression	
Excluded variables	9
Observations	28
Degrees of freedom	13
OLS Model Comparison (nested F-test)	
Complete- Sum squared residuals	176.8215
Reduced- Sum squared residuals	189.6004
Mean squared	13.6017
Comparison F-Statistic (F*)	0.1044
Rejection F-Statistic – $F_{0.05}$(9,13)	2.7100
Conclusion	Fail to reject H_o because F*< Fa, hence the excluded variables do not improve the model.
Tobit Model Comparison (Log-likelihood ratio test)	
Complete- Log-likelihood	-65.5314
Reduced- Log-likelihood	-66.5083
Comparison likelihood test ratio (LR)	1.9538
Rejection Statistic – $\chi^2_{0.05}$ (9)	16.9190
Conclusion	Fail to reject H_o because LR < $\chi^2_{0.05}$, hence the excluded variables do not improve the model.

Coefficient Interpretation: Duiwenhoks Estuary

Variable	Interpretation	Model	
		OLS	Tobit
USE_CAT	The percentage increase in WTP due to the category of a respondent changing from a commercial/subsistence user to a passive/recreational user.	10358.50%	10358.50%
HOUSE	The percentage decrease in WTP due to a 1 person increase in the number of people in the respondent's household making use of the estuary	-46.74%	-46.74%
EDUC	The percentage decrease in WTP due to the educational status of a respondent changing from a low level of education to a high level of education.	-95.76%	-95.76%
EQUIP	The percentage increase in WTP due to a one-unit of increase in the value of equipment used on the estuary by the respondent	0.05%	0.05%
AMOUNT	The percentage increase in WTP due to a one-unit of increase in a respondent's annual conservation amount	0.34%	0.34%
C	The intercept's Rand value.	R4.95	R4.95

GREAT BERG ESTUARY

Correlation Matrix for the Great Berg Estuary

Variable	House	Freq	Amt	Levies	Trav	Equip	Est_Redc %
House	1.00	-0.01	-0.02	0.03	0.11	-0.01	0.12
Freq	-0.01	1.00	0.09	0.03	**-0.32**	-0.02	-0.01
Amt	-0.02	0.09	1.00	**0.13**	0.00	**0.21**	**0.19**
Levies	0.03	0.03	**0.13**	1.00	-0.01	**0.34**	-0.02
Trav	0.11	**-0.32**	0.00	-0.01	1.00	-0.05	-0.03
Equip	-0.01	-0.02	**0.21**	**0.34**	-0.05	1.00	0.12
Est_redc %	0.12	-0.01	**0.19**	-0.02	-0.03	0.12	1.00

The Correlations highlighted in boldface are significant at $p \leq 0.05$ (observations = 248)

Complete OLS and Tobit Model: Great Berg Estaury

Dependent Variable: Ln(WTP)								
Model: Complete								
Observations: 248								
Method:	Least Sqaures				Censored Normal (Tobit)			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	0.0998	0.3384	0.2949	0.7683	0.0998	0.3287	0.3036	0.7614
GEN	0.3122	0.2697	1.1575	0.2482	0.3122	0.2620	1.1916	0.2334
HOUSE	0.0256	0.0647	0.3948	0.6933	0.0256	0.0629	0.4064	0.6844
RES	0.3500	0.4634	0.7552	0.4508	0.3500	0.4501	0.7775	0.4368
FREQ	0.0007	0.0009	0.6588	0.5107	0.0007	0.0009	0.6782	0.4976
USE_CAT	0.2586	0.4906	0.5270	0.5987	0.2586	0.4765	0.5425	0.5874
EDUC	-0.2058	0.3068	-0.6705	0.5032	-0.2058	0.2980	-0.6903	0.4900
AMOUNT	0.0034	0.0005	6.3342	0.0000	0.0034	0.0005	6.5210	0.0000
KNOW	-0.0363	0.2907	-0.1246	0.9009	-0.0363	0.2824	-0.1283	0.8979
LEVIES	-0.0003	0.0008	-0.3477	0.7283	-0.0003	0.000817	-0.3580	0.7203
TRAV	-0.0350	0.0374	-0.9328	0.3519	-0.0349	0.0363	-0.9603	0.3369
EQUIP	-1.60E-05	5.39E-05	-0.2967	0.7669	-1.60E-05	5.23E-05	-0.3055	0.7600
EST_REDC %	0.0037	0.0036	0.9994	0.3186	0.0037	0.0035	1.0288	0.3035
C	2.6054	0.6863	3.7958	0.0002	2.6054	0.6667	3.9077	0.0001
	R-Squared		0.1830		R-Squared		0.1830	
	Adjusted R-Squared		0.1376		Adjusted R-Squared		0.1339	
	F-statistic		4.0309		Log Likelihood		-517.3140	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		941.4668		Uncensored obs		248	

Complete OLS and Tobit Model (with natural log of AMOUNT): Great Berg Estaury

Dependent Variable: Ln(WTP)								
Model: Complete								
Observations: 248								
Method:	**Least Sqaures**				**Censored Normal (Tobit)**			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	0.2994	0.1786	1.6755	0.0952	0.2994	0.1735	1.7249	0.0845
GEN	0.0600	0.1438	0.4171	0.6770	0.0600	0.1396	0.4294	0.6676
HOUSE	0.0605	0.0345	1.7550	0.0806	0.0605	0.0335	1.8067	0.0708
RES	-0.1532	0.2474	-0.6191	0.5364	-0.1532	0.2404	-0.6374	0.5239
FREQ	0.0007	0.0005	1.3520	0.1777	0.0007	0.0005	1.3919	0.1640
USE_CAT	0.2759	0.2605	1.0588	0.2907	0.2759	0.2530	1.0900	0.2757
EDUC	-0.0994	0.1624	-0.6120	0.5411	-0.0994	0.1577	-0.6301	0.5286
LOGAMOUNT	0.8746	0.0323	27.0320	0.0000	0.8746	0.0314	27.8289	0.0000
KNOW	-0.1139	0.1538	-0.7403	0.4598	-0.1139	0.1494	-0.7622	0.4459
LEVIES	-0.0001	0.0004	-0.2233	0.8234	-0.0001	0.0004	-0.2299	0.8181
TRAV	0.0015	0.0198	0.0759	0.9395	0.0015	0.0193	0.0781	0.9377
EQUIP	1.37E-05	2.85E-05	0.4813	0.6308	1.37E-05	2.77E-05	0.4954	0.6203
EST_REDC %	0.0029	0.0019	1.5184	0.1302	0.0029	0.0018	1.5632	0.1180
C	-0.5889	0.3843	-1.5320	0.1269	-0.5889	0.3733	-1.5772	0.1147
	R-Squared		0.7678		R-Squared		0.7659	
	Adjusted R-Squared		0.7549		Adjusted R-Squared		0.7518	
	F-statistic		59.5344		Log Likelihood		-361.2879	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		267.5118		Uncensored obs		248	

Reduced OLS and Tobit Model: Great Berg

Dependent Variable: Ln(WTP)								
Model: Reduced								
Observations: 248								
Method:	**Least Sqaures**				**Censored Normal (Tobit)**			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	0.2934	0.1467	1.9999	0.0466	0.2934	0.1455	2.0162	0.0438
HOUSE	0.0664	0.0333	1.9937	0.0473	0.0664	0.0330	2.0100	0.0444
LOGAMT	0.8750	0.0318	27.4979	0.0000	0.8750	0.0315	27.7224	0.0000
C	-0.2257	0.2175	-1.0375	0.3005	-0.2256	0.2157	-1.0460	0.2956
	R-Squared		0.7596		R-Squared		0.7576	
	Adjusted R-Squared		0.7566		Adjusted R-Squared		0.7536	
	F-statistic		256.9981		Log Likelihood		-365.6130	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		277.0073		Uncensored obs		248	

Model Comparison Test Statistic: Great Berg

Employed observations and variables in regression	
Excluded variables	10
Observations	248
Degrees of freedom	234
OLS Model Comparison (nested F-test)	
Complete- Sum squared residuals	267.5118
Reduced- Sum squared residuals	277.0073
Mean squared	1.1432
Comparison F-Statistic (F*)	0.8306
Rejection F-Statistic – $F_{0.05}$(10,234)	1.8300
Conclusion	Fail to reject H_o because F*< Fa, hence the excluded variables do not improve the model.
Tobit Model Comparison (Log-likelihood ratio test)	
Complete- Log-likelihood	-361.288
Reduced- Log-likelihood	-365.613
Comparison likelihood test ratio (LR)	8.6502
Rejection Statistic – $\chi^2_{0.05}$ (10)	18.3070
Conclusion	Fail to reject H_o because LR $<\chi^2_{0.05}$, hence the excluded variables do not improve the model.

Coefficient Interpretation: Great Berg Estuary

		Model	
Variable	**Interpretation**	**OLS**	**Tobit**
RACE	The percentage increase in WTP due to the race of a respondent changing from black to white	33.64%	33.64%
HOUSE	The percentage increase in WTP due to a 1 person increase in the number of people in the respondent's household making use of the estuary	7.25%	7.25%
LOGAMT	The percentage increase in WTP due to a one percent increase in the annual amount spent on conservation	0.88%	0.88%
C	The intercept's Rand value.	R0.79	R0.79

KLEINEMOND WEST ESTUARY

Correlation Matrix for the Kleinemond West Estuary

Variable	House	Freq	Income	Amt	Levies	Trav	Equip	Est_Redc %
House	1.00	**-0.19**	0.04	0.08	**0.18**	**-0.18**	0.12	0.02
Freq	**-0.19**	1.00	-0.06	0.03	-0.08	**0.44**	-0.10	-0.05
Income	0.04	-0.06	1.00	**0.38**	**0.20**	**-0.32**	0.10	**0.20**
Amt	0.08	0.03	**0.38**	1.00	0.04	-0.04	0.06	0.09
Levies	**0.18**	-0.08	**0.20**	0.04	1.00	-0.10	**0.33**	0.05
Trav	**-0.18**	**0.44**	**-0.32**	-0.04	-0.10	1.00	0.00	**-0.23**
Equip	0.12	-0.10	0.10	0.06	**0.33**	0.00	1.00	0.08
Est_redc %	0.02	-0.05	**0.20**	0.09	0.05	**-0.23**	0.08	1.00

The Correlations highlighted in boldface are significant at $p \leq 0.05$ (observations = 132)

Complete OLS and Tobit Model: Kleinemond West

Dependent Variable: Ln(WTP)								
Model: Complete								
Sample: 132								
Method:	Least Sqaures				Censored Normal (Tobit)			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	3.7594	1.0428	3.6047	0.0005	3.7594	0.9818	3.8289	0.0001
GEN	-0.1058	0.4626	-0.2286	0.8195	-0.1058	0.4355	-0.2428	0.8081
HOUSE	0.1518	0.1193	1.2724	0.2057	0.1518	0.1123	1.3515	0.1765
RES	-0.7896	0.5316	-1.4850	0.1402	-0.7896	0.5005	-1.5773	0.1147
FREQ	-0.0052	0.0026	-1.9566	0.0528	-0.0052	0.0025	-2.0783	0.0377
USE_CAT	1.0382	2.0669	0.5022	0.6164	1.0382	1.9459	0.5334	0.5937
INCOME	2.07E-06	9.89E-07	2.0970	0.0381	2.07E-06	9.31E-07	2.2274	0.0259
EDUC	-0.3696	0.4953	-0.7461	0.4571	-0.3696	0.4663	-0.7925	0.4280
AMOUNT	0.0009	0.0003	2.9936	0.0034	0.0009	0.0002	3.1797	0.0015
KNOW	0.6190	0.5083	1.2175	0.2258	0.6190	0.4786	1.2932	0.1959
LEVIES	0.0007	0.0010	0.6019	0.5484	0.0007	0.0010	0.6393	0.5226
TRAV	-0.0201	0.0583	-0.3459	0.7300	-0.0202	0.0549	-0.3674	0.7133
EQUIP	-4.42E-05	0.0001	-0.3830	0.7024	-4.42E-05	0.0001	-0.4068	0.6841
EST_REDC %	-0.0154	0.0079	-1.9305	0.0560	-0.0154	0.0075	-2.0505	0.0403
C	-0.1866	2.1073	-0.0885	0.9296	-0.1866	1.9839	-0.0940	0.9251
	R-Squared		0.3923		R-Squared		0.3919	
	Adjusted R-Squared		0.3196		Adjusted R-Squared		0.3133	
	F-statistic		5.3951		Log Likelihood		-297.4340	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		700.2946		Uncensored obs		132	

Reduced OLS and Tobit Model: Kleinemond West

Dependent Variable: Ln(WTP)								
Model: Reduced								
Observations: 132								
Method:	**Least Sqaures**				**Censored Normal (Tobit)**			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	4.1314	0.8807	4.6908	0.0000	4.1314	0.8604	4.8012	0.0000
FREQ	-0.0044	0.0022	-1.9776	0.0502	-0.0044	0.0021	-2.0241	0.0430
INCOME	2.12E-06	8.75E-07	2.4235	0.0168	2.12E-06	8.55E-07	2.4805	0.0131
AMOUNT	0.0010	0.0003	3.3104	0.0012	0.0010	0.0002	3.3883	0.0007
USE_CAT	-0.0153	0.0076	-2.0097	0.0466	-0.0153	0.0074	-2.0570	0.0397
C	0.8326	0.9571	0.8698	0.3860	0.8326	0.9351	0.8903	0.3733
	R-Squared		0.3487		R-Squared		0.3478	
	Adjusted R-Squared		0.3228		Adjusted R-Squared		0.3165	
	F-statistic		13.4931		Log Likelihood		-302.0055	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		750.5196		Uncensored obs		132	

Model Comparison Test Statistic: Kleinemond West

Employed observations and variables in regression	
Excluded variables	9
Observations	132
Degrees of freedom	117
OLS Model Comparison (nested F-test)	
Complete- Sum squared residuals	700.2946
Reduced- Sum squared residuals	750.5196
Mean squared	5.9854
Comparison F-Statistic (F*)	0.9324
Rejection F-Statistic – $F_{0.05}$(9,117)	1.8800
Conclusion	Fail to reject H_o because F*< Fa, hence the excluded variables do not improve the model.
Tobit Model Comparison (Log-likelihood ratio test)	
Complete- Log-likelihood	-297.4340
Reduced- Log-likelihood	-302.006
Comparison likelihood test ratio (LR)	9.1430
Rejection Statistic – $\chi^2_{0.05}$ (9)	16.9190
Conclusion	Fail to reject H_o because LR <$\chi^2_{0.05}$, hence the excluded variables do not improve the model.

Coefficient Interpretation: Kleinemond West Estuary

		Model	
Variable	**Interpretation**	**OLS**	**Tobit**
USE_CAT	The percentage decrease in WTP due to the category of a respondent changing from a commercial/subsistence user to a passive/recreational user	-1.52%	-1.52%
RACE	The percentage increase in WTP due to the race of a respondent changing from black to white	6117.79%	6117.79%
FREQ	The percentage decrease in WTP due to an additional day spent per year at the estuary.	-0.44%	-0.44%
INCOME	The percentage increase in WTP due to a one-unit of increase in a respondent's annual income	0.0002%	0.0002%
AMOUNT	The percentage increase in WTP due to a one-unit of increase in a respondent's annual conservation amount	0.1%	0.1%
C	The intercept's Rand value.	R4.95	R4.95

MHLATHUZE ESTUARY

Correlation Matrix for the Mhlathuze Estuary

Variable	House	Freq	Income	Amt	Levies	Trav	Equip	Est_Redc %
House	1.00	**0.15**	0.01	-0.02	**-0.18**	-0.01	**-0.13**	0.01
Freq	**0.15**	1.00	0.05	0.06	0.07	-0.11	0.00	**0.19**
Income	0.01	0.05	1.00	**0.39**	-0.00	0.04	0.02	**0.30**
Amt	-0.02	0.06	**0.39**	1.00	0.08	-0.06	0.00	**0.24**
Levies	**-0.18**	0.07	-0.00	0.08	1.00	-0.02	**0.14**	**0.16**
Trav	-0.01	-0.11	0.04	-0.06	-0.02	1.00	0.07	0.07
Equip	**-0.13**	0.00	0.02	0.00	**0.14**	0.07	1.00	0.00
Est_redc %	0.01	**0.19**	**0.30**	**0.24**	**0.16**	0.07	0.00	1.00

The Correlations highlighted in red are significant at $p \leq 0.05$ (observations = 286)

Complete OLS and Tobit Model: Mhlathuze Estuary

Dependent Variable: Ln(WTP)								
Model: Complete								
Observations: 286								
Method:	Least Sqaures				Censored Normal (Tobit)			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	0.2257	0.3629	0.6217	0.5346	0.2257	0.3533	0.6386	0.5230
GEN	-0.0534	0.2374	-0.2247	0.8223	-0.0534	0.2311	-0.2309	0.8174
HOUSE	-0.0158	0.0589	-0.2684	0.7886	-0.0158	0.0574	-0.2757	0.7827
RES	0.2961	0.3168	0.9347	0.3507	0.2961	0.3083	0.9602	0.3369
FREQ	-0.0020	0.0014	-1.3549	0.1766	-0.0020	0.0014	-1.3919	0.1639
INCOME	1.75E-06	9.84E-07	1.7772	0.0766	1.75E-06	9.57E-07	1.8258	0.0679
EDUC	0.9969	0.2706	3.6831	0.0003	0.9969	0.2634	3.7837	0.0002
AMOUNT	0.0031	0.0006	4.6877	0.0000	0.0031	0.0006	4.8157	0.0000
KNOW	0.9734	0.2759	3.5279	0.0005	0.9734	0.2685	3.6242	0.0003
LEVIES	0.0009	0.0004	1.9273	0.0550	0.0009	0.0004	1.9800	0.0477
TRAV	0.0745	0.0299	2.4859	0.0135	0.0745	0.0291	2.5537	0.0107
EQUIP	-1.71E-06	9.09E-06	-0.1884	0.8507	-1.71E-06	8.85E-06	-0.1936	0.8465
EST_REDC %	-0.0011	0.0045	-0.2475	0.8047	-0.0011	0.0043	-0.2542	0.7993
C	0.9880	1.2417	0.7956	0.4269	0.9880	1.2087	0.8173	0.4137
	R-Squared		0.2999		R-Squared		0.2998	
	Adjusted R-Squared		0.2637		Adjusted R-Squared		0.2609	
	F-statistic		8.2914		Log Likelihood		-587.2327	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		1017.025		Uncensored obs		286	

Reduced OLS and Tobit Model: Mhlathuze Estuary

Dependent Variable: Ln(WTP)								
Model: Reduced								
Observations: 286								
Method:	**Least Sqaures**				**Censored Normal (Tobit)**			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
INCOME	1.87E-06	9.42E-07	1.9879	0.0478	1.87E-06	9.30E-07	2.0127	0.0441
EDUC	0.9911	0.2600	3.8119	0.0002	0.9910	0.2568	3.8594	0.0001
AMOUNT	0.0031	0.0006	4.8696	0.0000	0.0030	0.0006	4.9303	0.0000
KNOW	1.0004	0.2709	3.6926	0.0003	1.0004	0.2675	3.7386	0.0002
LEVIES	0.0008	0.0004	1.8639	0.0634	0.0008	0.0004	1.8872	0.0591
TRAV	0.0827	0.0290	2.8451	0.0048	0.0826	0.0286	2.8805	0.0040
C	0.3560	0.4106	0.8669	0.3867	0.3560	0.4055	0.8777	0.3801
	R-Squared		0.2893		R-Squared		0.2892	
	Adjusted R-Squared		0.2740		Adjusted R-Squared		0.2713	
	F-statistic		18.9255		Log Likelihood		-589.3847	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		1032.446		Uncensored obs		286	

Model Comparison Test Statistic: Mhlathuze Estuary

Employed observations and variables in regression	
Excluded variables	8
Observations	286
Degrees of freedom	271
OLS Model Comparison (nested F-test)	
Complete- Sum squared residuals	1071.0250
Reduced- Sum squared residuals	1032.4460
Mean squared	3.7529
Comparison F-Statistic (F*)	0.5136
Rejection F-Statistic – $F_{0.05}$(8,271)	1.9400
Conclusion	Fail to reject H_o because F*< Fa, hence the excluded variables do not improve the model.
Tobit Model Comparison (Log-likelihood ratio test)	
Complete- Log-likelihood	-587.2330
Reduced- Log-likelihood	-589.3850
Comparison likelihood test ratio (LR)	4.3040
Rejection Statistic – $\chi^2_{0.05}$ (8)	15.5073
Conclusion	Fail to reject H_o because LR <$\chi^2_{0.05}$, hence the excluded variables do not improve the model.

Coefficient Interpretation: Mhlathuze Estuary

		Model	
Variable	**Interpretation**	**OLS**	**Tobit**
EDUC	The percentage increase in WTP due to the educational status of a respondent changing from a low level of education to a high level of education	169.12%	169.12%
KNOW	The percentage increase in WTP due to a change in a respondent's knowledge from uninformed to well informed	171.82%	171.82%
LEVIES	The percentage increase in WTP due to a one-unit increase in levies paid at the estuary	0.08%	0.08%
TRAV	The percentage increase in WTP due to a 1km increase in the distance travelled by a respondent to reach the estuary.	8.65%	8.65%
INCOME	The percentage increase in WTP due to a one-unit of increase in a respondent's annual income	0.0002%	0.0002%
AMOUNT	The percentage increase in WTP due to a one-unit of increase in a respondent's annual conservation amount	0.31%	0.31%
C	The intercept's Rand value.	R1.43	R1.43

OLIFANTS ESTUARY

Correlation Matrix for the Olifants Estuary

Variable	House	Freq	Amt	Levies	Trav	Equip	Est_Redc %
House	1.00	0.01	0.02	-0.11	-0.08	0.02	-0.15
Freq	0.01	1.00	**-0.28**	-0.18	**-0.45**	0.08	-0.18
Amt	0.02	**-0.28**	1.00	**0.38**	-0.01	0.11	**0.23**
Levies	-0.11	-0.18	**0.38**	1.00	-0.09	0.21	**0.29**
Trav	-0.08	**-0.45**	-0.01	-0.09	1.00	-0.02	**0.22**
Equip	0.02	0.08	0.11	0.21	-0.02	1.00	-0.00
Est_redc %	-0.15	-0.18	**0.23**	**0.29**	**0.22**	-0.00	1.00

The Correlations highlighted in red are significant at $p \leq 0.05$ (Observations = 80)

Complete OLS and Tobit Model: Olifants Estuary

Dependent Variable: Ln(WTP)								
Model: Complete								
Observations: 80								
Method:	Least Sqaures				Censored Normal (Tobit)			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	0.3894	1.5328	0.2540	0.8003	0.3894	1.3922	0.2796	0.7797
GEN	-0.3318	0.9526	-0.3482	0.7287	-0.3318	0.8653	-0.3834	0.7014
HOUSE	0.3970	0.2282	1.7391	0.0867	0.3970	0.2073	1.9146	0.0555
RES	2.0102	1.9786	1.0159	0.3134	2.0102	1.7972	1.1184	0.2634
FREQ	0.0009	0.0042	0.2031	0.8397	0.0009	0.0038	0.2236	0.8230
USE_CAT	3.2662	1.0047	3.2508	0.0018	3.2662	0.9125	3.5790	0.0003
EDUC	1.8175	2.0033	0.9072	0.3676	1.8175	1.8196	0.9988	0.3179
LOGAMT	0.0037	0.0015	2.3262	0.0231	0.0037	0.0014	2.5611	0.0104
KNOW	1.2069	0.8703	1.3865	0.1702	1.2069	0.7905	1.5265	0.1269
LEVIES	-0.0096	0.0099	-0.9565	0.3423	-0.0096	0.0090	-1.0531	0.2923
TRAV	0.1151	0.1223	0.9401	0.3506	0.1151	0.1111	1.0350	0.3006
EQUIP	0.0006	0.0020	0.3118	0.7561	0.0006	0.0018	0.3433	0.7313
EST_REDC %	0.0121	0.0127	0.9509	0.3451	0.0121	0.0116	1.0469	0.2951
C	-5.9912	2.0068	-2.9853	0.0040	-5.9912	1.8227	-3.2867	0.0010
	R-Squared		0.4749		R-Squared		0.4597	
	Adjusted R-Squared		0.3715		Adjusted R-Squared		0.3434	
	F-statistic		4.5924		Log Likelihood		-206.0825	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		809.3334		Uncensored obs		80	

Reduced OLS and Tobit Model: Olifants Estuary

Dependent Variable: Ln(WTP)								
Model: Reduced								
Observations: 80								
Method:	Least Sqaures				Censored Normal (Tobit)			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
HOUSE	0.3445	0.2258	1.5257	0.1312	0.3445	0.2201	1.5653	0.1175
USE_CAT	3.9253	0.8826	4.4473	0.0000	3.9252	0.8602	4.5628	0.0000
AMOUNT	0.0049	0.0013	3.6664	0.0005	0.0049	0.0013	3.7617	0.0002
C	-4.2833	1.0443	-4.1014	0.0001	-4.2833	1.0179	-4.2080	0.0000
	R-Squared		0.3667		R-Squared		0.3499	
	Adjusted R-Squared		0.3417		Adjusted R-Squared		0.3152	
	F-statistic		14.6714		Log Likelihood		-213.5777	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		976.1266		Uncensored obs		80	

Model Comparison Test Statistic: Olifants Estuary

Employed observations and variables in regression	
Excluded variables	10
Observations	80
Degrees of freedom	66
OLS Model Comparison (nested F-test)	
Complete- Sum squared residuals	809.3334
Reduced- Sum squared residuals	976.1266
Mean squared	12.2626
Comparison F-Statistic (F*)	1.3618
Rejection F-Statistic – $F_{0.05}$(10,66)	1.9500
Conclusion	Fail to reject H_o because F*< Fa, hence the excluded variables do not improve the model.
Tobit Model Comparison (Log-likelihood ratio test)	
Complete- Log-likelihood	-206.0830
Reduced- Log-likelihood	-213.5780
Comparison likelihood test ratio (LR)	14.9904
Rejection Statistic – $\chi^2_{0.05}$ (10)	18.4070
Conclusion	Fail to reject H_o because LR $<\chi^2_{0.05}$, hence the excluded variables do not improve the model.

Coefficient Interpretation: Olifants Estuary

Variable	Interpretation	Model	
		OLS	Tobit
HOUSE	The percentage increase in WTP due to a 1 person increase in the number of people in the respondent's household making use of the estuary	40.49%	40.49%
USE_CAT	The percentage increase in WTP due to the category of a respondent changing from a commercial/subsistence user to a passive/recreational user.	4990.69%	4990.69%
AMOUNT	The percentage increase in WTP due to a one-unit of increase in a respondent's annual conservation amount	0.49%	0.49%
C	The intercept's Rand value.	R0.014	R0.014

SWARTVLEI ESTUARY

Correlation Matrix for the Swartvlei Estuary

Variable	House	Freq	Income	Amt	Levies	Trav	Equip	Est_Redc %
House	1.00	**-0.23**	0.07	-0.02	0.03	**0.23**	0.03	0.05
Freq	**-0.23**	1.00	**-0.13**	-0.08	0.05	**-0.30**	-0.04	**-0.13**
Income	0.07	**-0.13**	1.00	**0.17**	0.07	**0.11**	0.05	**0.22**
Amt	-0.02	-0.08	**0.17**	1.00	0.04	**0.13**	**0.39**	**0.16**
Levies	0.03	0.05	0.07	0.04	1.00	-0.04	**0.15**	0.11
Trav	**0.23**	**-0.30**	**0.11**	**0.13**	-0.04	1.00	0.01	**0.14**
Equip	0.03	-0.04	0.05	**0.39**	**0.15**	0.01	1.00	0.10
Est_redc %	0.05	**-0.13**	**0.22**	**0.16**	0.11	**0.14**	0.10	1.00

The Correlations highlighted in boldface are significant at $p \leq 0.05$ (Observations = 337)

Complete OLS and Tobit Model: Swartvlei Estuary

Dependent Variable: Ln(WTP)								
Model: Complete								
Observations: 337								
Method:	**Least Sqaures**				**Censored Normal (Tobit)**			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	1.0999	0.4278	2.5703	0.0106	1.0999	0.4182	2.6295	0.0085
GEN	-0.7004	0.3192	-2.1939	0.0290	-0.7004	0.3120	-2.2444	0.0248
HOUSE	0.1160	0.1053	1.1008	0.2718	0.1160	0.1029	1.1261	0.2601
RES	0.2870	0.5247	0.5470	0.5848	0.2870	0.5129	0.5595	0.5758
FREQ	-0.0009	0.0012	-0.6884	0.4916	-0.0009	0.0012	-0.7043	0.4812
USE_CAT	0.6747	0.9459	0.7132	0.4762	0.6747	0.9246	0.7296	0.4656
INCOME	2.97E-06	8.96E-07	3.3156	0.0010	2.97E-06	8.76E-07	3.3919	0.0007
EDUC	1.2478	0.3502	3.5628	0.0004	1.2478	0.3423	3.6448	0.0003
LOGAMT	0.0017	0.0002	6.0061	0.0000	0.0017	0.0002	6.1444	0.0000
KNOW	-0.2771	0.3523	-0.7864	0.4322	-0.2771	0.3444	-0.8046	0.4211
LEVIES	0.0006	0.0005	1.2138	0.2257	0.0006	0.0004	1.2418	0.2143
TRAV	-0.0183	0.0393	-0.4662	0.6414	-0.0183	0.0384	-0.4769	0.6334
EQUIP	-1.68E-05	6.78E-05	-0.2476	0.8045	-1.68E-05	6.62E-05	-0.2533	0.8000
EST_REDC %	0.0022	0.0041	0.5233	0.6011	0.0022	0.0040	0.5353	0.5924
C	0.6542	1.0929	0.5985	0.5499	0.6542	1.0683	0.6123	0.5403
	R-Squared		0.2947		R-Squared		0.2942	
	Adjusted R-Squared		0.2641		Adjusted R-Squared		0.2612	
	F-statistic		9.6115		Log Likelihood		-812.4599	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		2450.203		Uncensored obs		337	

Reduced OLS and Tobit Model: Swartvlei Estuary

Dependent Variable: Ln(WTP)								
Model: Reduced								
Observations: 337								
Method:	**Least Sqaures**				**Censored Normal (Tobit)**			
Variable	Coefficient	Std. Error	t-statistic	Probability	Coefficient	Std. Error	z-statistic	Probability
RACE	0.9539	0.3927	2.4286	0.0157	0.9539	0.3892	2.4505	0.0143
GENDER	-0.7217	0.3082	-2.3413	0.0198	-0.7217	0.3054	-2.3624	0.0182
INCOME	3.23E-06	8.46E-07	3.8216	0.0002	3.23E-06	8.39E-07	3.8561	0.0001
EDUC	1.3299	0.3384	3.9297	0.0001	1.3299	0.3353	3.9651	0.0001
AMOUNT	0.0017	0.0002	6.6866	0.0000	0.0017	0.0002	6.7469	0.0000
C	1.5019	0.3644	4.1214	0.0000	1.5019	0.3611	4.1586	0.0000
	R-Squared		0.2812		R-Squared		0.2806	
	Adjusted R-Squared		0.2703		Adjusted R-Squared		0.2675	
	F-statistic		25.8972		Log Likelihood		-815.6628	
	Probability (F-Statistic)		0.0000		Left Censored obs		0	
	Sum Squared Residual		2497.223		Uncensored obs		337	

Model Comparison Test Statistic: Swartvlei Estuary

Employed observations and variables in regression	
Excluded variables	9
Observations	337
Degrees of freedom	322
OLS Model Comparison (nested F-test)	
Complete- Sum squared residuals	2450.203
Reduced- Sum squared residuals	2497.223
Mean squared	7.609326
Comparison F-Statistic (F*)	0.6866
Rejection F-Statistic – $F_{0.05}$(9,322)	1.8800
Conclusion	Fail to reject H_o because F*< Fa, hence the excluded variables do not improve the model.
Tobit Model Comparison (Log-likelihood ratio test)	
Complete- Log-likelihood	-812.4600
Reduced- Log-likelihood	-815.6630
Comparison likelihood test ratio (LR)	6.4058
Rejection Statistic – $\chi^2_{0.05}$ (9)	16.9190
Conclusion	Fail to reject H_o because LR <$\chi^2_{0.05}$, hence the excluded variables do not improve the model.

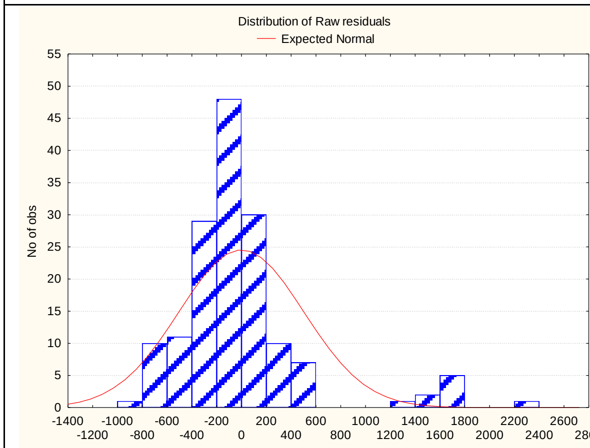
Coefficient Interpretation: Swartvlei Estuary

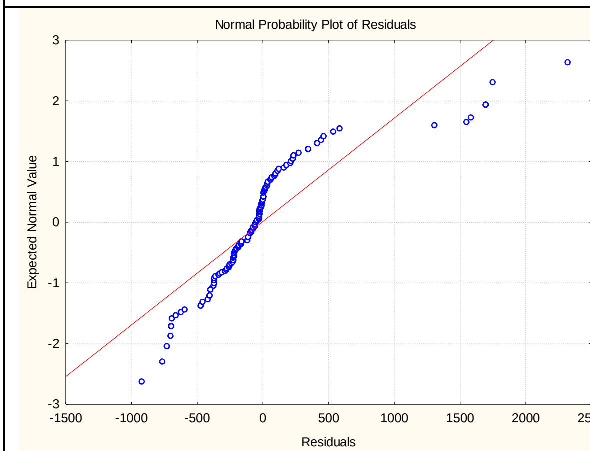
		Model	
Variable	**Interpretation**	**OLS**	**Tobit**
RACE	The percentage increase in WTP due to the race of a respondent changing from black to white	158.57%	158.57%
GEN	The percentage decrease in WTP due to the gender of a respondent changing from female to male	-51.32%	-51.32%
INCOME	The percentage increase in WTP due to a one-unit of increase in a respondent's annual income	0.0003%	0.0003%
EDUC	The percentage increase in WTP due to the educational status of a respondent changing from a low level of education to a high level of education.	278.10%	278.10%
AMOUNT	The percentage increase in WTP due to a one-unit of increase in a respondent's annual conservation amount	0.17%	0.17%
C	The intercept's Rand value.	R4.48	R4.48

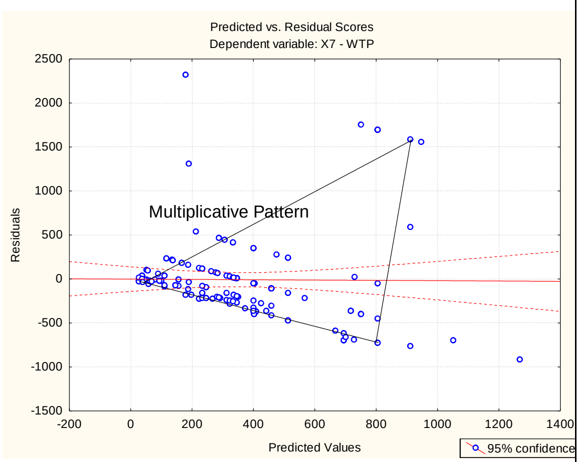
APPENDIX B: FUNCTIONAL FORM VALIDITY: RESIDUAL ANALYSIS

Figure B1: Residual Analysis: Untransformed and Log-Transformed Model: Breede Estuary

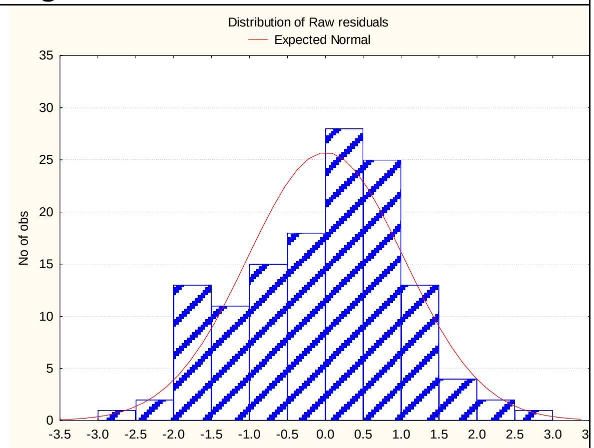
Untransformed Model

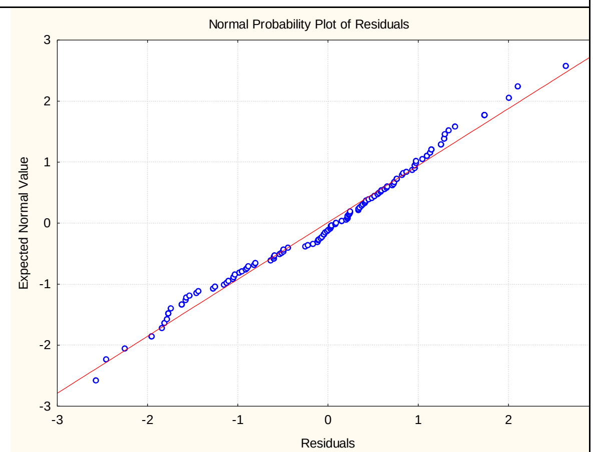






Log-Transformed Model

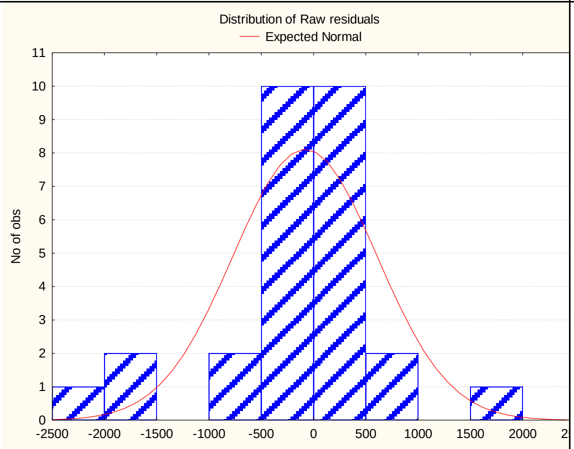
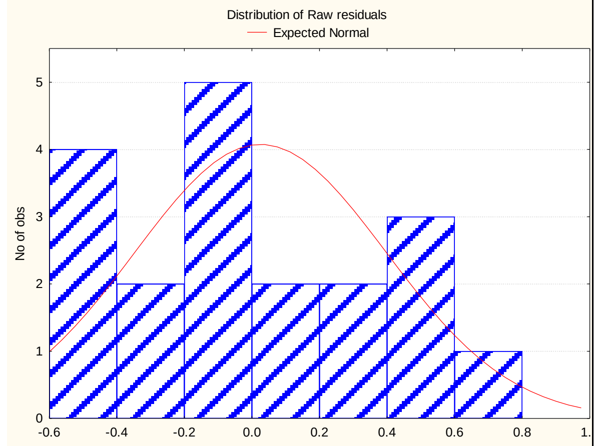
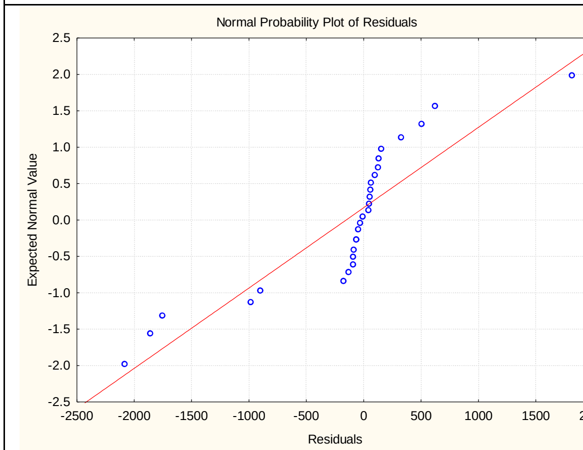
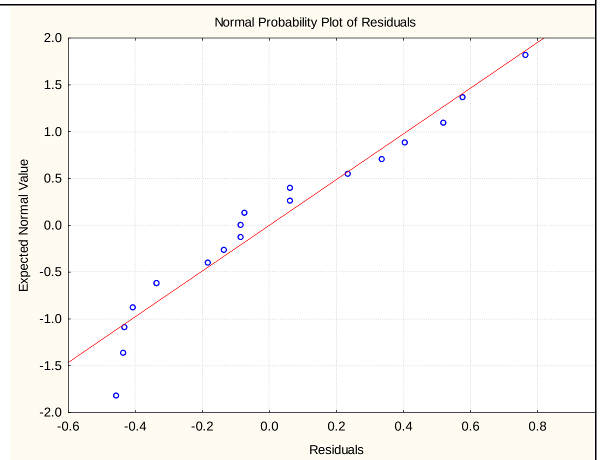
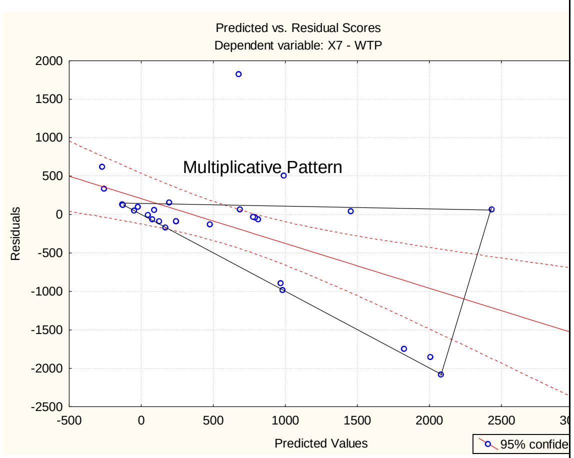
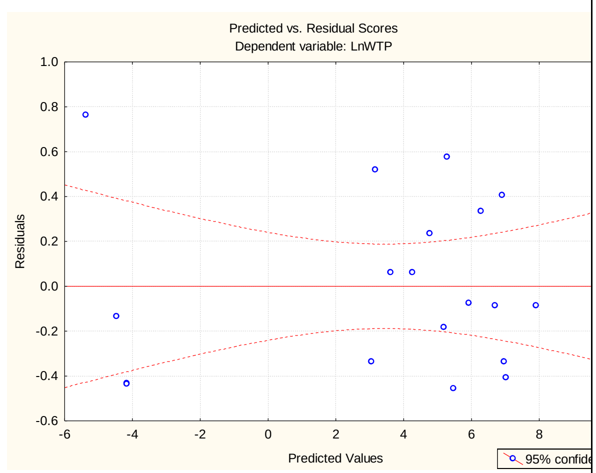




Conclusion: The Log-transformed model preferred for data modelling

DUIWENHOKS ESTUARY

Figure B2: Residual Analysis: Untransformed and Log-Transformed Model: Duiwenhoks Estuary

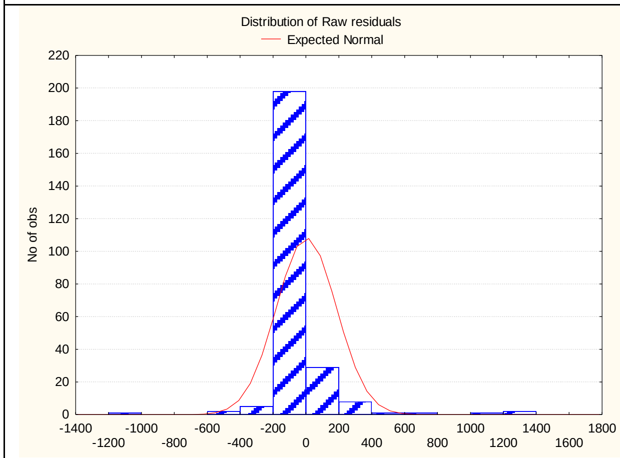
Untransformed Model	Log-Transformed Model
	
	
	

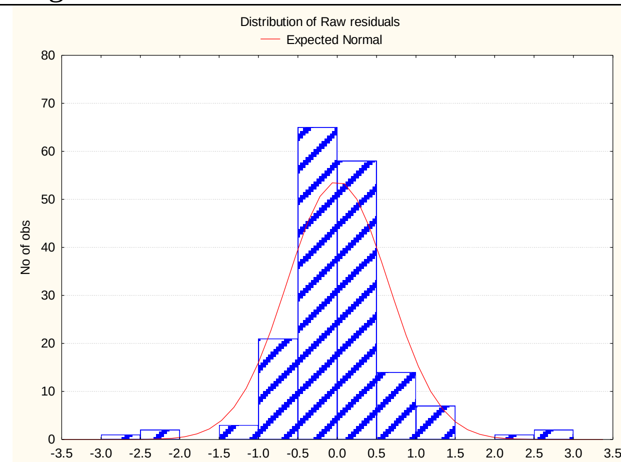
Conclusion: The Log-transformed model preferred for data modelling because it results in less variation

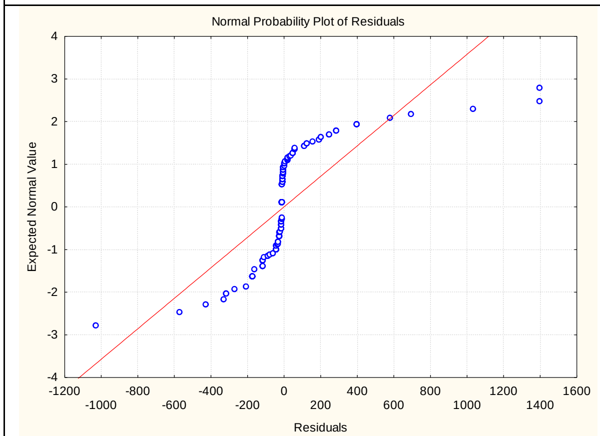
GREAT BERG ESTUARY

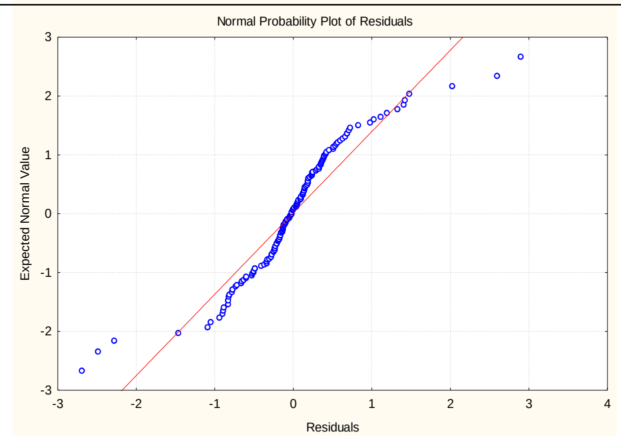
Figure B3: Residual Analysis: Untransformed and Log-Transformed Model: Great Berg

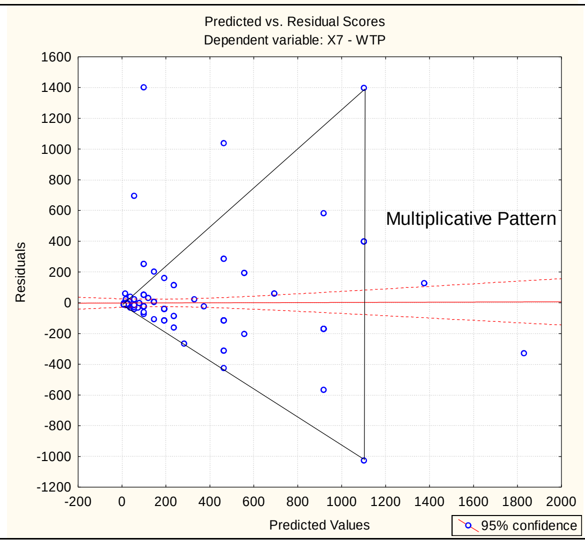
Untransformed Model	Log-Transformed Model

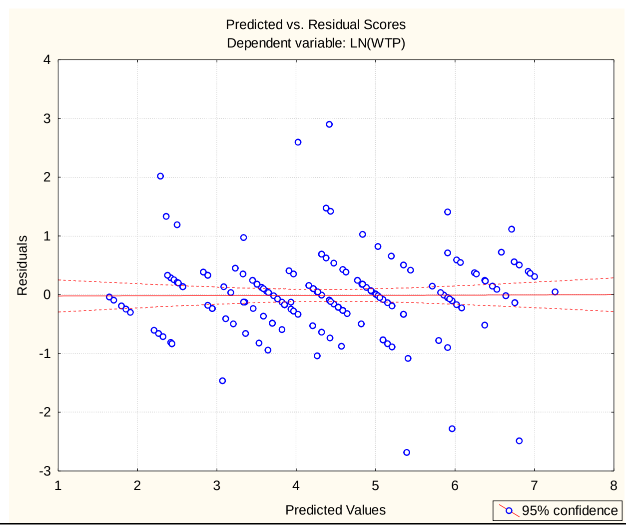








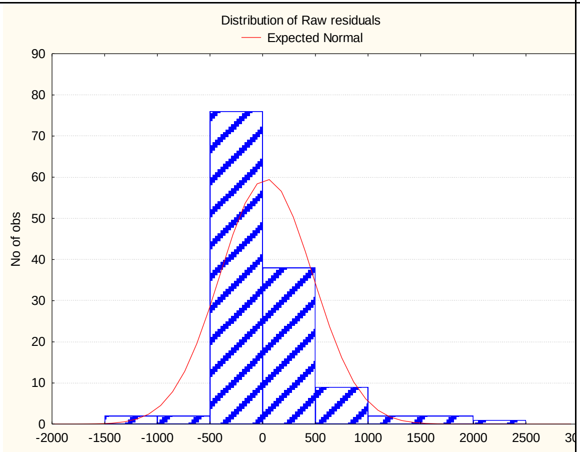
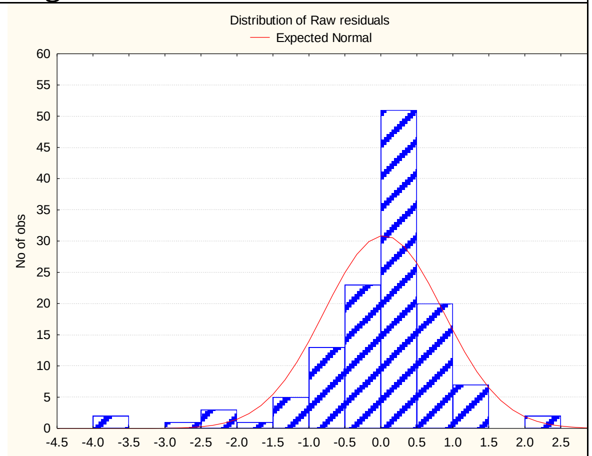
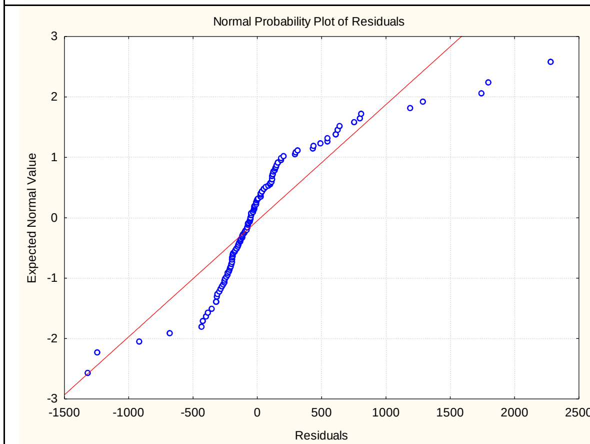
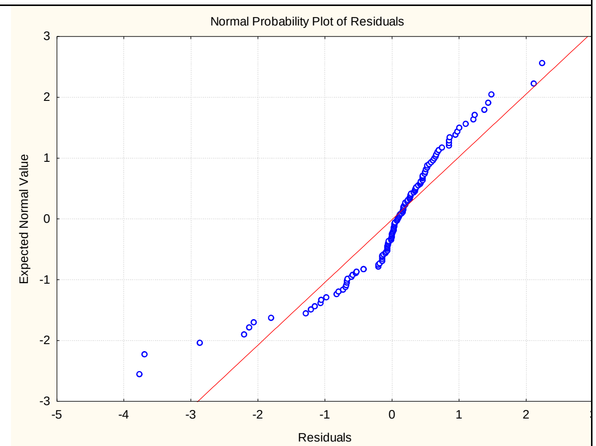
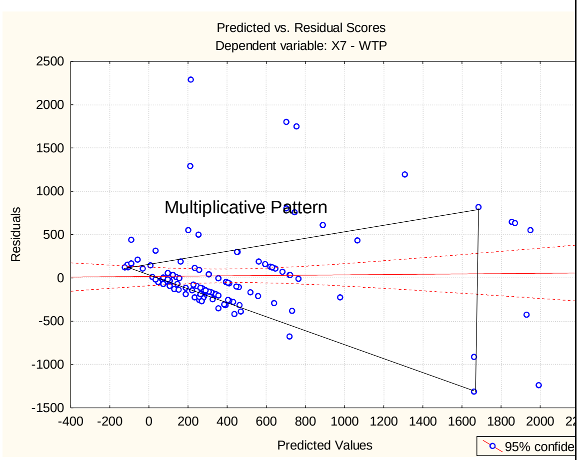
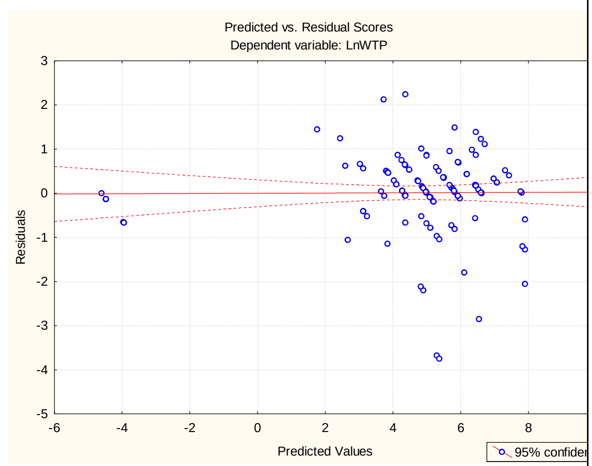




Conclusion: The Log-transformed model preferred for data modelling because it results in less variation

KLEINEMOND WEST ESTUARY

Figure B4: Residual Analysis: Untransformed and Log-Transformed Model: Kleinemond West

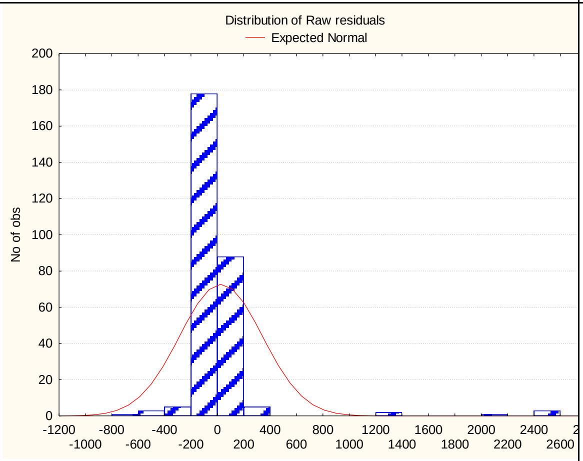
Untransformed Model	**Log-Transformed Model**
	
	
	

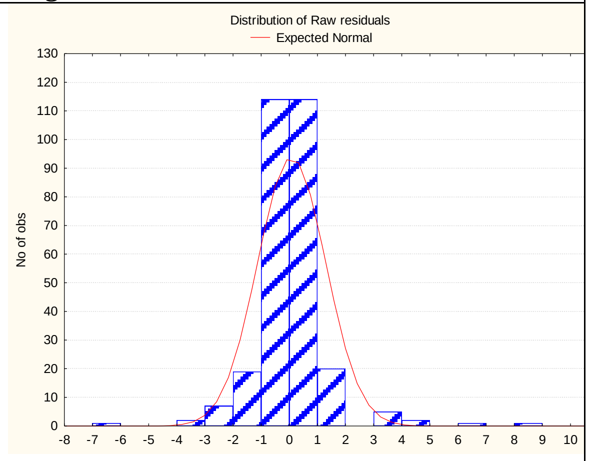
Conclusion: The Log-transformed model preferred for data modelling because it results in less variation

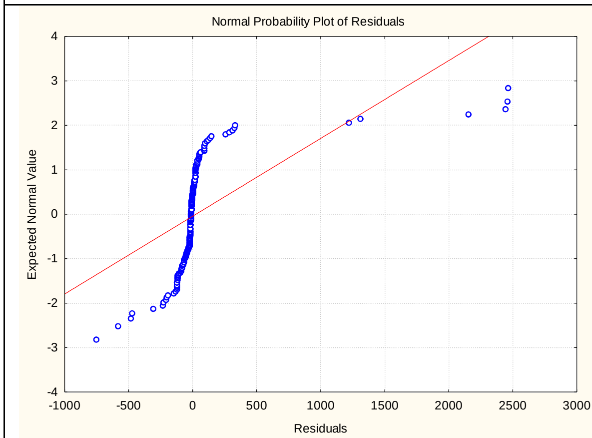
MHLATHUZE ESTUARY

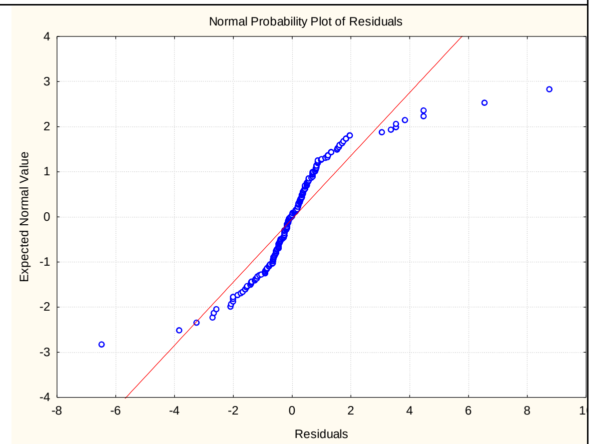
Figure B5: Residual Analysis: Untransformed and Log-Transformed Model: Mhlathuze Estuary

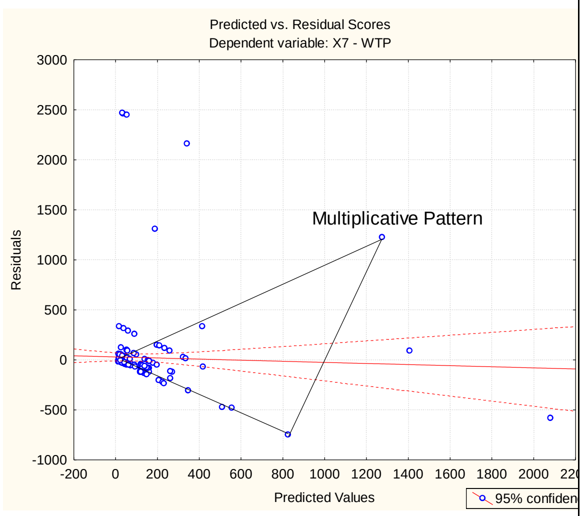
Untransformed Model	Log-Transformed Model

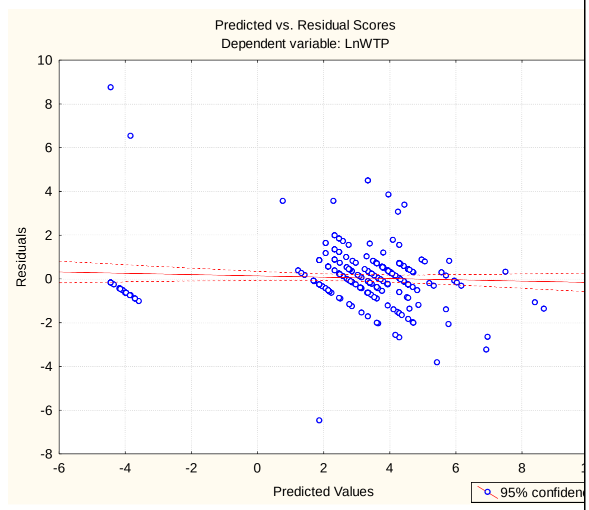










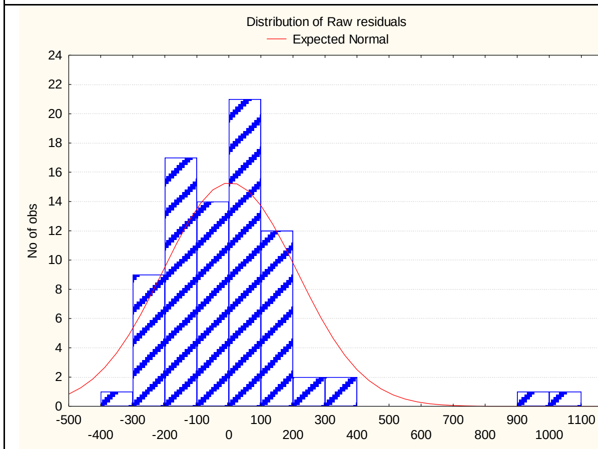


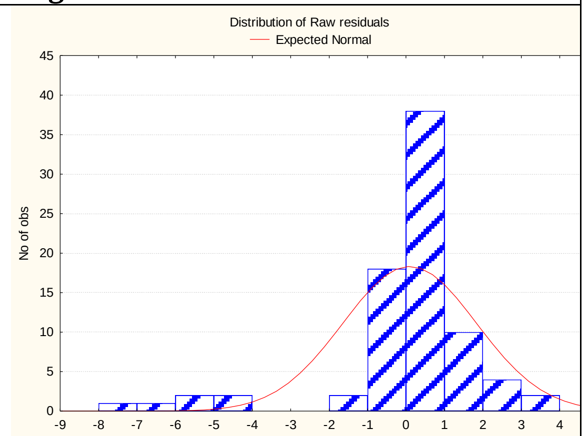
Conclusion: The Log-transformed model preferred for data modelling

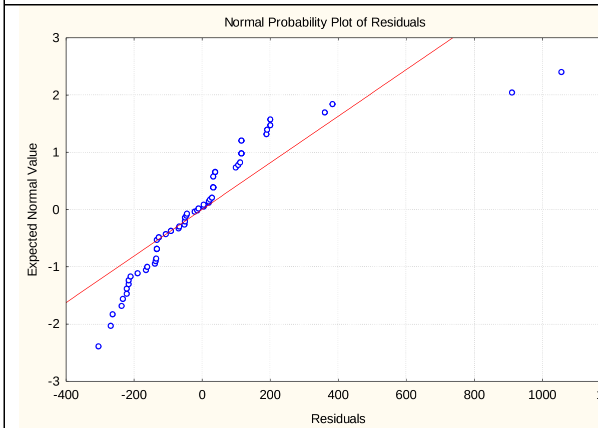
<u>**OLIFANTS ESTUARY**</u>

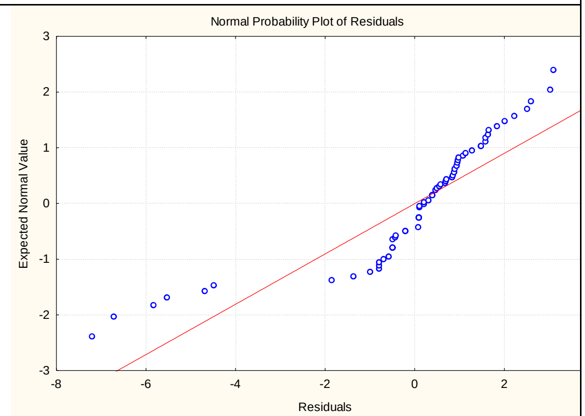
Figure B6: Residual Analysis: Untransformed and Log-Transformed Model: Olifants Estuary

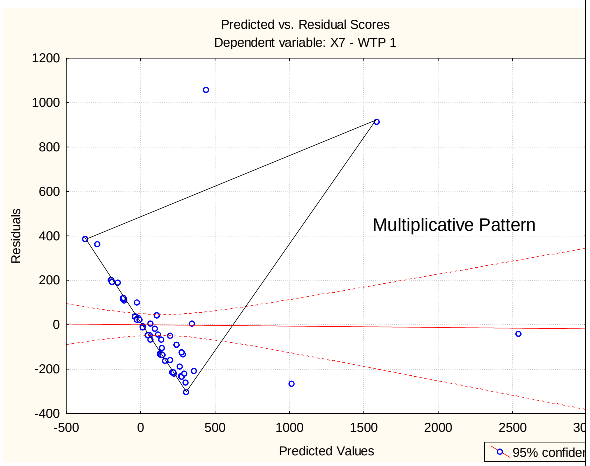
Untransformed Model	**Log-Transformed Model**

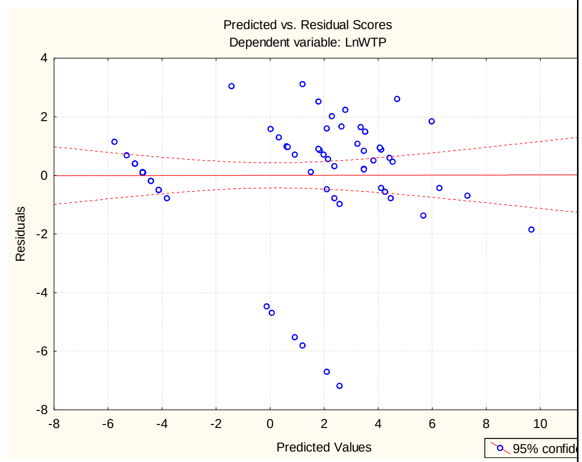








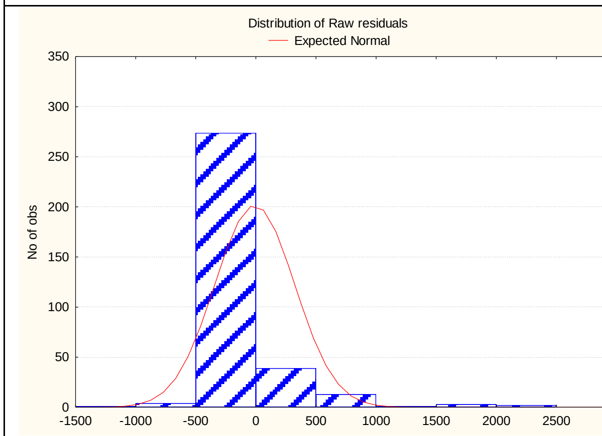
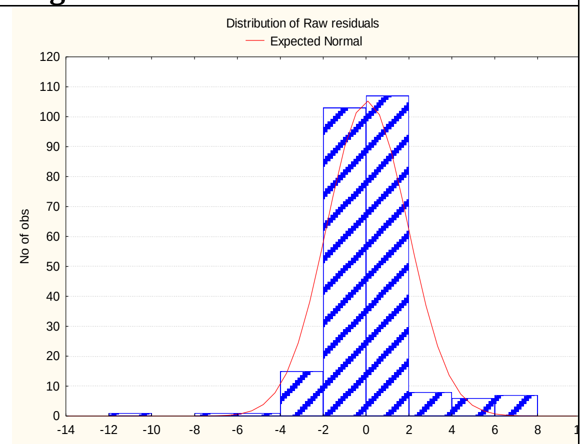
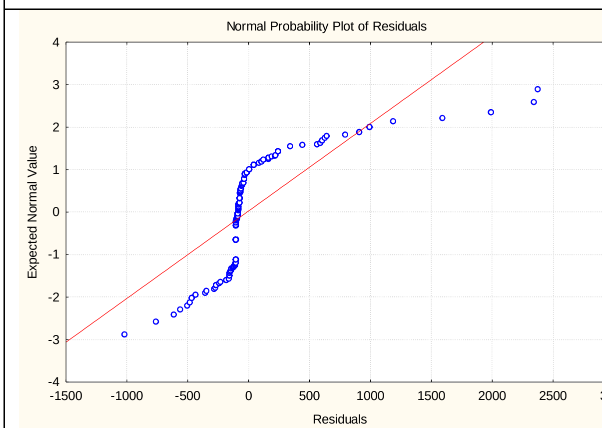
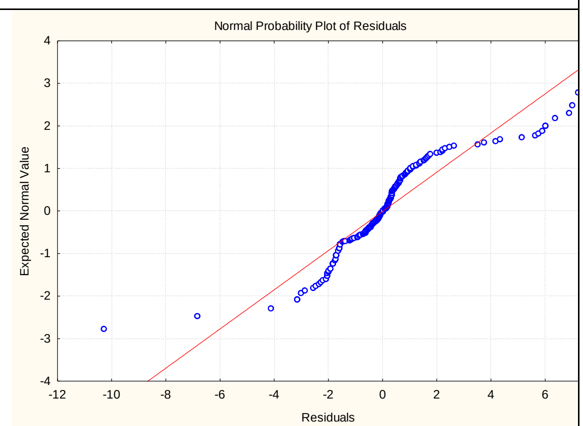
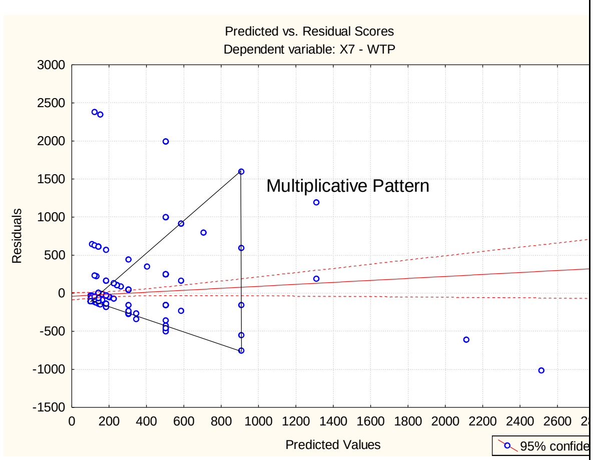
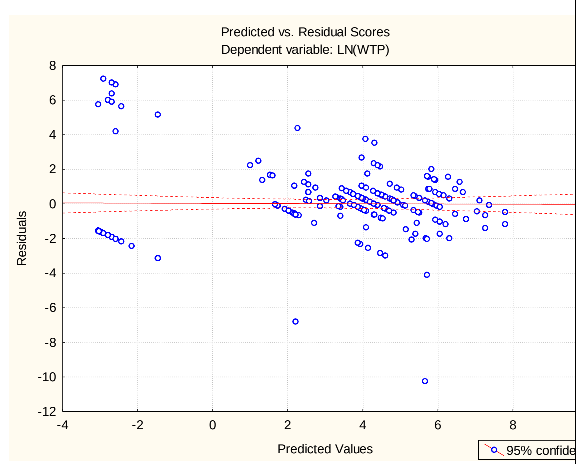




Conclusion: The Log-transformed model preferred for data modelling because it results in less variation

SWARTVLEI ESTUARY

Figure B7: Residual Analysis: Untransformed and Log-Transformed Model: Swartvlei Estuary

Untransformed Model	Log-Transformed Model
	
	
	

Conclusion: The Log-transformed model preferred for data modelling because it results in less variation

APPENDIX C: SURVEY QUESTIONNAIRE

WRC CONTINGENT VALUATION METHOD QUESTIONNAIRE

PUBLIC ISSUE OF FRESHWATER INFLOW INTO THE KLEINEMOND WEST ESTUARY

ADMINISTERED BY NELSON MANDELA METROPOLITAN UNIVERSITY

INSTRUCTIONS TO PERSON ADMINISTERING THE QUESTIONNAIRE.

(A) NAME OF SURVEYOR (NOT RESPONDENT):____

(B) DATE INTERVIEW CONDUCTED): D D / M M / Y Y Y Y

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

(D) LOCATION INTERVIEW CONDUCTED: ____

(E) THERE ARE 20 QUESTIONS. PLEASE TICK THE APPROPRIATE BLOCKS OR FILL IN THE ANSWERS.

1. RACE OF RESPONDENT

RACE	
BLACK	1
WHITE	2
COLOURED	3
INDIAN	4
OTHER	5

2. GENDER OF RESPONDENT

GENDER	
MALE	1
FEMALE	2

3. NUMBER OF THE MEMBERS IN YOUR HOUSEHOLD THAT MAKE USE OF THE ESTUARY IN ONE WAY OR ANOTHER DURING THE YEAR?

MEMBERS OF HOUSEHOLD	**NUMBER**
Male	
Female	
Total	

4. VISITOR OR RESIDENT

MAIN RESIDENCE	
VISITOR	1
PERMANENT RESIDENT	2
HOLIDAY (HOUSE) RESIDENT	3

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

DAYS	
1 DAY PER YEAR	1
1 WEEK (2 -7 DAYS)	2
2 WEEKS (8 -14 DAYS)	3
3 WEEKS (15 -28 DAYS)	4
1 - 2 MONTHS (29 - 59 DAYS)	5
3 - 4 MONTHS (60 - 90 DAYS)	6
PERMANENT RESIDENCE	7

6. WHAT IS THE MAIN PURPOSE OF YOUR USE OF THE ESTUARY?

CATEGORY OF RESPONDENT	
RECREATION (BOAT SPORTS, SWIMMER, FISHER/BAIT COLLECT, BIRDER, PROXIMITY/VIEW)	1
COMMERCIAL	2
SUBSISTENCE	3
NON-USERS / PASSIVE USE	4

7. RANK THE RELATIVE IMPORTANCE YOU ATTACH TO THE FOLLOWING ACTIVITIES/ATTRIBUTES OF THE ESTUARY

UNIMPORTANT = 0 (E.G. ACTIVITIES NOT IMPORTANT TO HOUSEHOLD) EXTREMELY IMPORTANT = 5

ACTIVITY	**RANKING**					
	UNIMPORTANT		**MODERATE**			**EXTREMELY IMPORTANT**
SUBSISTANCE	0	1	2	3	4	5
COMMERCIAL	0	1	2	3	4	5
BOATING	0	1	2	3	4	5
FISHING	0	1	2	3	4	5
SWIMMING	0	1	2	3	4	5
BIRD WATCHING AND VIEW OF ESTUARY	0	1	2	3	4	5

8. DECLARED GROSS ANNUAL TAXABLE INCOME OF HOUSEHOLD

PRE TAX INCOME (RAND)	
0	0
1 - 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 IS YOUR HIGHEST LEVEL OF EDUCATION?

EDUCATION	YEARS
UNSCHOOLED	0
PRIMARY SCHOOL	7
GRADE 10	10
GRADE 12	12
DIPLOMA/DEGREE	15
HONOURS	16
MASTERS	19
DOCTORATE	20+

10. WHAT ANNUAL AMOUNT WOULD YOU BE PREPARED TO SPEND ON THE CONSERVATION OF ENVIRONMENTAL RESOURCES?

R ______________

11. WHAT DO YOU THINK WILL HAPPEN IF THERE IS A SIGNIFICANT REDUCTION OF FRESHWATER INFLOW INTO THE ESTUARY?

CATEGORY OF RESPONDENT	
WELL INFORMED –KNOWS MORE THAN 3 OF THE IMPACTS LISTED BELOW	1
PARTIAL KNOWLEDGE - KNOWS 1-3 OF THE IMPACTS LISTED BELOW	2
POORLY INFORMED – KNOWS 0 OF THE IMPACTS LISTED BELOW	3

INFORMATION:

THE DECREASE OF 7.2% OF CURRENT FRESH WATER INFLOW INTO THE ESTUARY CAN BE EXPECTED TO HAVE CONSEQUENCES OF THE FOLLOWING MAGNITUDES:

FOR BOATERS
- A 10% INCREASE IN AREA AVAILABLE FOR BOATING DUE TO MOUTH CLOSURE AND INCREASED VOLUME IN THE LAGOON

FOR SWIMMERS
- A 10% INCREASE IN AREA AVAILABLE FOR SWIMMING DUE TO MOUTH CLOSURE AND INCREASED VOLUME IN THE LAGOON

FOR FISHERS/BAIT COLLECTORS
- BIOMASS OF ANGLING FISH: 50% REDUCTION
- BIOMASS OF BAIT: NO CHANGE

FOR BIRDERS
- BIOMASS OF BIRDS: 25% REDUCTION.

FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY
- 10% CHANGE

FROM THE PERSPECTIVE OF LOSS OF UNIQUE HABITATS
- BIODIVERSITY: 10% REDUCTION.

12. WHAT WOULD YOU BE WILLING TO PAY IN USER FEES PER YEAR FOR A PROJECT THAT WOULD RELEASE 100,000 M^3 OF WATER (ANNUALLY) INTO THE ESTUARY TO PREVENT THESE MENSIONED CHANGES?

AMOUNT (RAND) WILLING TO PAY 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

ADDITIONAL INFORMATION ON SCENARIO

THE EXTRA AMOUNT IN USER FEES PER YEAR IS SPECIFICALLY FOR A PROJECT TO INCREASE RIVER WATER INFLOW OR TO PREVENT A DECREASE IN RIVER INFLOW, DUE TO URBAN AND AGRICULTURAL ABSTRACTION OR REDUCED FLOWS THROUGH FORESTRY OR VEGETATION CHANGES. THE PROJECT IS TO PREVENT A DECREASE IN FRESHWATER INFLOW OF 7.2% OVER WHAT IS CURRENTLY FLOWING INTO THE ESTUARY. THUS IT PREVENTS THE PROPORTION OF MEAN ANNUAL RUNOFF FLOWING INTO THE ESTUARY DECREASING FROM 87% TO 81%.

THE USER FEES WOULD BE COLLECTED IN TWO WAYS:

- BY THE LOCAL AUTHORITY IN USER FEES FROM ALL USERS WHO WISH TO ACCESS THE 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 0.1 MILLION M^3 OF WATER, I.E., ENOUGH FRESH WATER INFLOW TO PREVENT THE CHANGES IN ESTUARY SERVICES INDICATED.

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

REASON	
CANNOT AFFORD THE FEES	1
GET NO OR NEGLIGIBLE VALUE OUT OF ESTUARY SERVICES	2
ABUNDANCE OF SERVICE OPTIONS – NO SCARCITY, THEREFORE WHY PAY	3
LACK OF CONFIDENCE IN GOVERNMENT TO COLLECT AND USE FEES COLLECTED FOR THE WATER PURCHASE	4
PAYING ENOUGH TAXES, FEES ETC ALREADY	5
THE METHOD OF COLLECTION/PAYMENT PROPOSED IS UNFAIR. IT SHOULD BE COLLECTED IN THE FOLLOWING WAY ____	6
OTHER REASONS (SPECIFY) ____ ____	7

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

FEE	**RAND**
BOATING FEE (R250 P.A)	
ANGLING FEE (R35 P.A.)	
BAIT COLLECTION FEE (R50 P.A.)	
SUBSISTANCE FISHING FEE (R45 P.A.)	
SHELL COLLECTION (R50 P.A.)	
LAUNCHING FEES	
ACCESS TO BANKS FEE	
LOCAL AUTHORITY CHARGES TO CONSERVE ESTUARY	
OTHER	
TOTAL	

15. TRAVEL COST:

SECTION A: VEHICLE USE TO ACCESS ESTUARY

I. WHAT MAKE OF VEHICLE DO YOU USE TO TRAVEL FROM YOUR PERMANENT HOME TO YOUR ACCOMMODATION NEAR THE ESTUARY OR FROM HERE TO THE ESTUARY?

VEHICLE	
MAKE	
MODEL	
YEAR	
ENGINE CAPACITY	
MARKET (CURRENT) VALUE OF VEHICLE	
DO NOT KNOW DETAILS	**LARGE / SMALL**
LOCAL RESIDENT AND DO NOT USE A VEHICLE	**NONE USED**

SECTION B: PERMANENT LOCAL RESIDENT (STAY WITHIN 10KM OF ESTUARY) IF VISITOR OR HOLIDAY RESIDENT PROCEED TO SECTION C
I. HOW MANY TIMES A WEEK DO YOU MAKE USE OF THE ESTUARY ON AVERAGE? ______________________ II. HOW FAR DO YOU HAVE TO TRAVEL TO USE THE ESTUARY? _____________KM X2 = ______________KM III. HOW DO YOU ACCESS THE ESTUARY (CAR, WALK, TAXI OR OTHER)? ________________________________ VI. WHAT IS YOUR TRAVEL COST TO GET TO THE ESTUARY (RETURN TRIP FUEL OR FARE)? **R**______________

SECTION C: VISITORS AND HOLIDAY HOMES (IF PERMANENT LOCAL RESIDENT PROCEED TO SECTION C)
I. WHERE IS YOUR PERMANENT HOME? _________________________ II. IF YOU DO NOT TRAVEL BY YOUR OWN VEHICLE, BY WHICH OTHER MEANS DO YOU TRAVEL E.G. TAXI, FLY AND HIRE CAR OR BUS? _______________________________________ III. HOW FAR DO YOU HAVE TO TRAVEL FROM YOUR PERMANENT HOME TO REACH YOUR HOLIDAY ACCOMMODATION FROM WHICH YOU VISIT THE ESTUARY? (ONE WAY) ______________KM X2 = ______________KM IV. HOW FAR DO YOU HAVE TO TRAVEL FROM HOLIDAY HOME TO USE THE ESTUARY? ______________KM X2 = ______________KM V. WHAT WAS THE TRAVEL COST TO GET HERE FROM YOUR PERMANENT HOME (RETURN TRIP FUEL OR FARE)? **R**_____________________________________ VI. HOW MANY DAYS DO YOU MAKE/PLAN TO SPEND AWAY FROM YOUR PERMANENT HOME AT THIS HOLIDAY HOME? _______________________________________ VII. DO YOU INCUR A SALARY SACRIFICE BY VISITING THE ESTUARY? YES / NO IF YES, APPROXIMATELY HOW MUCH? R___________________

16. IF YOU ARE A VISITOR WHAT IS THE APPROXIMATE TOTAL COST OF THE ACCOMMODATION YOU MAKE USE OF WHEN VISITING THE ESTUARY?

R_____________________

17. WHAT DO YOU SPEND ON EQUIPMENT PER ANNUM TO ACCESS THE SERVICES OF THE ESTUARY IN BOAT, FISHING OR VIEWING EQUIPMENT? (NOTE: BOATS AND EQUIPMENT ARE DEPRECIAT OVER 10 YEARS)

R_____________________

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

YOU WOULD	
STILL VISIT THE ESTUARY	1
VISIT OTHER ESTUARIES INSTEAD	2

19. THE ESTUARY IS APPROXIMATELY WHAT PERCENTAGE OF THE REASON YOU VISIT OR LIVE IN THE AREA.

PERCENTAGE OF ESTUARY USE (%)	
0 (NON USER / PASSIVE)	1
1- 20	2
21 - 40	3
41 - 60	4
61 - 80	5
81 - 100	6

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

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Questionnaire compiled by members of the Departments of Economics and Zoology, NMMU. Questions about this project may be directed to Prof SG Hosking on telephone number: 041-5042205

APPENDIX D: TRAVEL COST MODELS

DUIWENHOKS ESTUARY

Table D1: Travel Cost Regression Results: Duiwenhoks

Dependent Variable: Visits				
Model: Reduced				
Observations: 28				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	80.6397	10.3328	12.3667	0.0000
QUALITY	12.0853	2.1494	2.1447	0.0021
RES	-3.5321	22.8744	-4.1339	0.0025
KNOW	4.7294	6.6304	2.6828	0.0002
TRAVEL COST	-1.0775	12.8407	-7.3832	0.0000
	R-Squared		0.2922	
	Adjusted R-Squared		0.2517	
	F-statistic		15.4911	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		125033	

Table D2: Consumer Surplus Computation: Duiwenhoks

Estuary: Duiwenhoks			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user population	400
TRAVEL COST	R35	$CS_{DECREASED}$ (per capita/annum)	R44.05
KNOW	1	$CS_{CURRENT}$ (per capita/annum)	R45.97
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	47.57	$TCS_{DECREASED}$	R17,620
$VISIT_{CURRENT}$(per capita/annum)	49.65	$TCS_{CURRENT}$	R18,388
		$TCS_{(\text{ CURRNET - DECREASED})}$	R 768
		Fresh water inflow	500,000 m3
		ITCM estimate (Rand per m^3)	**CV estimate (Rand per m^3)**
		0.002	0.001

GREAT BERG ESTUARY

Table D3: Travel Cost Regression Results: Great Berg

Dependent Variable: Visits				
Model: Reduced				
Observations: 248				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	181.1022	18.6620	9.7043	0.0000
RES	-126.9409	27.4162	-4.6301	0.0000
EDUC	33.9438	18.1894	1.8661	0.0632
QUALITY	30.9686	16.6702	1.8577	0.0644
TRAVEL COST	-2.5168	0.8930	-2.8182	0.0052
	R-Squared		0.2311	
	Adjusted R-Squared		0.2132	
	F-statistic		14.8184	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		4096589	

Table D4: Consumer Surplus Computation: Great Berg

Estuary: Great Berg			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user pop	8000
TRAVEL COST	R15	$CS_{CURRENT}$ (per capita/annum)	R56.87
EDUC	0 (low level)	$CS_{IMPROVED}$ (per capita/annum)	R69.15
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	143	$TCS_{DECREASED}$	R454,960
$VISIT_{CURRENT}$ (per capita/annum)	174	$TCS_{CURRENT}$	R553,200
		$TCS_{(CURRNET - DECREASED)}$	R98,240
		Fresh water inflow	75,000,000 m3
		ITCM estimate (Rand per m^3)	**CV estimate (Rand per m^3)**
		0.001	0.001

KLEINEMOND WEST ESTUARY

Table D5: Travel Cost Regression Results: Kleinemond west

Dependent Variable: Visits				
Model: Reduced				
Observations: 132				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	53.0255	22.3515	7.4932	0.0227
RES	-16.9508	16.8389	-2.1943	0.0301
KNOW	24.1707	15.9308	2.8982	0.0044
QUALITY	49.9531	17.7771	0.7922	0.0297
TRAVEL COST	-1.0314	0.0008	-1.6927	0.0930
	R-Squared		0.2971	
	Adjusted R-Squared		0.2633	
	F-statistic		8.8059	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		871264	

Table D6: Consumer Surplus Computation: Kleinemond West

Estuary: Kleinemond West			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user pop	5000
TRAVEL COST	R33.50	$CS_{CURRENT}$ (per capita/annum)	R17.99
KNOW	0(low level)	$CS_{IMPROVED}$ (per capita/annum)	R66.49
Demand for Visits		**Total Consumer surplus**	
$VISIT_{DECREASED}$(per capita/annum)	18.53	$TCS_{DECREASED}$	R89,950
$VISIT_{CURRENT}$ (per capita/annum)	68.48	$TCS_{CURRENT}$	R332,450
		$TCS_{(CURRNET\ -DECREASED)}$	R 242,500
		Fresh water inflow	100,000 m3
		ITCM estimate (Rand per m^3)	**CV estimate (Rand per m^3)**
		2.42	2.77

MHLATHUZE ESTUARY

Table D7: Travel Cost Regression Results: Mhlathuze

Dependent Variable: Visits				
Model: Reduced				
Observations: 286				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	22.6082	18.8510	1.1993	0.0314
RES	-18.0546	12.5373	-1.4400	0.1510
TRAVEL COST	-1.0524	0.4904	-2.1457	0.0328
QUALITY	38.8559	9.8790	3.9331	0.0001
	R-Squared		0.2381	
	Adjusted R-Squared		0.2053	
	F-statistic		10.5321	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		149243	

Table D8: Consumer Surplus Computation: Mhlathuze

Estuary: Mhlathuze			
Median Values:		**Total Consumer surplus**	
RES	0 (local)	$TCS_{DECREASED}$	R19343
TRAVEL COST	R15	$TCS_{CURRENT}$	R127049
Demand for Visits		$TCS_{(CURRNET - DECREASED)}$	R 107706
$VISIT_{DECREASED}$(per capita/annum)	7	Fresh water inflow	9,900,000 m3
$VISIT_{CURRENT}$ (per capita/annum)	46	**ITCM estimate (Rand per m^3)**	**CV estimate (Rand per m^3)**
Consumer Surplus:		0.01	0.002
Estimated user population	2900		
$CS_{DECREASED}$ (per capita/annum)	R6.67		
$CS_{CURRENT}$ (per capita/annum)	R43.81		

MLALAZI ESTUARY

Table D9: Travel Cost Regression Results: Mlalazi

Dependent Variable: Visits				
Model: Reduced				
Observations: 161				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	119.3596	26.2638	4.8873	0.0000
AMOUNT	0.0282	0.0133	2.1216	0.0346
TRAVEL COST	-0.8554	0.4338	-1.9717	0.0495
RACE	75.8510	12.2245	6.2048	0.0000
RES	-49.6743	16.0878	-3.0876	0.0022
QUALITY	9.5979	10.6300	-0.9029	0.3672
USE_CAT	-80.9615	24.9934	-3.2393	0.0013
	R-Squared		0.3284	
	Adjusted R-Squared		0.2957	
	F-statistic		13.5453	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		219376	

Table D10: Consumer Surplus Computation: Mlalazi

Estuary: Mlalazi			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user population	6000
TRAVEL COST	R30	$CS_{CURRENT}$ (per capita/annum)	R15.12
AMOUNT	R50	$CS_{IMPROVED}$ (per capita/annum)	R25.58
RACE	0 (Black)	**Total Consumer surplus**	
USE_CAT	1(passive)	$TCS_{DECREASED}$	R90720
Demand for Visits		$TCS_{CURRENT}$	R153480
$VISIT_{DECREASED}$(per capita/annum)	13	$TCS_{(CURRNET\ -\ DECREASED)}$	R 62760
$VISIT_{CURRENT}$ (per capita/annum)	22	Fresh water inflow	8,700,000 m3
		ITCM estimate (Rand per m^3)	**CV estimate (Rand per m^3)**
		0.007	0.004

OLIFANTS ESTUARY

Table D11: Travel Cost Regression Results: Olifants

Dependent Variable: Visits				
Model: Reduced				
Observations: 80				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	321.0291	25.65298	12.51430	0.0000
QUALITY	38.00708	25.86857	1.469238	0.1460
TRAVEL COST	-4.224758	1.154030	-3.660875	0.0005
RES	-191.4852	39.76575	-4.815329	0.0000
USE_CAT	-57.65215	25.26089	-2.282269	0.0253
	R-Squared		0.2236	
	Adjusted R-Squared		0.1934	
	F-statistic		15.5016	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		751106	

Table D12: Consumer Surplus Computation: Olifants

Estuary: Olifants			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user population	2000
TRAVEL COST	R10	$CS_{CURRENT}$ (per capita/annum)	R52.37
USE_CAT	1(passive)	$CS_{IMPROVED}$ (per capita/annum)	R61.37
Demand for Visits		**Total Consumer surplus**	
$VISIT_{DECREASED}$(per capita/annum)	221	$TCS_{DECREASED}$	R104740
$VISIT_{CURRENT}$ (per capita/annum)	259	$TCS_{CURRENT}$	R122740
		$TCS_{(CURRNET - CURRENT)}$	R 18000
		Fresh water inflow	500,000 m3
		ITCM estimate (Rand per m^3)	**CV estimate (Rand per m^3)**
		0.04	0.002

SWARTVLEI ESTUARY

Table D13: Travel Cost Regression Results: Swartvlei

Dependent Variable: Visits				
Model: Reduced				
Observations: 337				
Method:	**Least Squares**			
Variable	Coefficient	Std. Error	t-statistic	Probability
C	180.2703	15.9628	14.3627	0.0000
HOUSE	-12.4892	4.3994	-2.8387	0.0048
QUALITY	114.4729	36.8799	3.1039	0.0021
TRAVEL COST	-2.3944	0.6554	-3.6528	0.0003
RES	-106.7295	21.3961	-4.9882	0.0000
	R-Squared		0.2722	
	Adjusted R-Squared		0.2610	
	F-statistic		17.4473	
	Probability (F-Statistic)		0.0000	
	Sum Squared Residual		352184	

Table D14: Consumer Surplus Computation: Swartvlei

Estuary: Swartvlei			
Median Values:		**Consumer Surplus:**	
RES	0 (local)	Estimated user population	16000
TRAVEL COST	R10	$CS_{CURRENT}$ (per capita/annum)	R54.81
HOUSE	2	$CS_{IMPROVED}$ (per capita/annum)	R58.16
Demand for Visits:		**Total Consumer surplus:**	
$VISIT_{DECREASED}$(per capita/annum)	131	$TCS_{DECREASED}$	R876,960
$VISIT_{CURRENT}$ (per capita/annum)	139	$TCS_{CURRENT}$	R930,560
		$TCS_{(CURRNET - DECREASED)}$	R 53,600
		Fresh water inflow	5,400,000 m3
		ITCM estimate (Rand per m^3)	**CV estimate (Rand per m^3)**
		0.01	0.006

APPENDIX E: BLUE-RIBBON GUIDELINES

1. For a single DC question (yes-no type) format, a total sample size of at least 1000 respondents is required. Clustering and stratification should be accounted for and tests for interviewer and wording biases are needed
2. High non-response rates would render the survey unreliable
3. Face-to-face interviewing is likely to yield the most reliable results
4. Full reporting of data and questionnaires is required for good practice.
5. Pilot surveying and presenting are essential elements in any CVM study
6. A conservative design more likely to underestimate WTP is preferred to one likely to overestimate WTP
7. A WTP format is preferred to a WTA format
8. The valuation question should be posed as a vote on a referendum, i.e. a DC question related to the payment of a particular level of taxation
9. Accurate information on the valuation situation must be presented to respondents with particular care over the use of photographs.
10. Respondents must be reminded of the status of any undamaged possible substitute commodities
11. Time-dependent measurement 'noise' should be reduced, by averaging across independently drawn samples taken at different points in time.
12. A 'no-answer' option should be explicitly allowed in addition to the 'yes' and 'no' vote options on the main valuation question.
13. Yes and No responses should be followed by the open-ended question: 'why did you vote yes or no?'.
14. On cross-tabulation, the survey should include a variety of other questions that help to interpret the responses to the primary valuation question, i.e. income, distance to site, prior knowledge of the site etc.
15. Respondents must be reminded of alternative expenditure possibilities, especially when 'warm glow' effects are likely to be present, i.e. purchase of moral satisfaction through the act of charitable giving.

Source: Barbier *et al* (1997)

APPENDIX F: MODIFIED SURVEY QUESTIONNAIRE

WRC CONTINGENT VALUATION METHOD QUESTIONNAIRE

PUBLIC ISSUE OF FRESH WATER INFLOW INTO THE KLEINEMOND WEST ESTUARY

ADMINISTERED BY NELSON MANDELA METROPOLITAN UNIVERSITY

INSTRUCTIONS TO PERSON ADMINISTERING THE QUESTIONNAIRE.

(A) NAME OF SURVEYOR (NOT RESPONDENT):____

(B) DATE INTERVIEW CONDUCTED): D D / M M / Y Y Y Y

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

(D) LOCATION INTERVIEW CONDUCTED: ____

(E) THERE ARE 20 QUESTIONS. PLEASE TICK THE APPROPRIATE BLOCKS OR FILL IN THE ANSWERS.

1. RACE OF RESPONDENT

RACE	
BLACK	1
WHITE	2
COLOURED	3
INDIAN	4
OTHER	5

2. GENDER OF RESPONDENT

GENDER	
MALE	1
FEMALE	2

3. NUMBER OF THE MEMBERS IN YOUR HOUSEHOLD THAT MAKE USE OF THE ESTUARY IN ONE WAY OR ANOTHER DURING THE YEAR?

MEMBERS OF HOUSEHOLD	NUMBER
Male	
Female	
Total	

4. VISITOR OR RESIDENT

MAIN RESIDENCE	
VISITOR	1
PERMANENT RESIDENT	2
HOLIDAY (HOUSE) RESIDENT	3

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

DAYS	
1 DAY PER YEAR	1
1 WEEK (2 -7 DAYS)	2
2 WEEKS (8 -14 DAYS)	3
3 WEEKS (15 -28 DAYS)	4
1 - 2 MONTHS (29 - 59 DAYS)	5
3 - 4 MONTHS (60 - 90 DAYS)	6
PERMANENT RESIDENCE	7

6. WHAT IS THE MAIN PURPOSE OF YOUR USE OF THE ESTUARY?

CATEGORY OF RESPONDENT	
RECREATION (BOAT SPORTS, SWIMMER, FISHER/BAIT COLLECT, BIRDER, PROXIMITY/VIEW)	1
COMMERCIAL	2
SUBSISTENCE	3
NON-USERS / PASSIVE USE	4

7. RANK THE RELATIVE IMPORTANCE YOU ATTACH TO THE FOLLOWING ACTIVITIES/ATTRIBUTES OF THE ESTUARY

UNIMPORTANT = 0 (E.G. ACTIVITIES NOT IMPORTANT TO HOUSEHOLD) EXTREMELY IMPORTANT = 5

ACTIVITY	RANKING					
	UNIMPORTANT		MODERATE			EXTREMELY IMPORTANT
SUBSISTANCE	0	1	2	3	4	5
COMMERCIAL	0	1	2	3	4	5
BOATING	0	1	2	3	4	5
FISHING	0	1	2	3	4	5
SWIMMING	0	1	2	3	4	5
BIRD WATCHING AND VIEW OF ESTUARY	0	1	2	3	4	5

8. DECLARED GROSS ANNUAL TAXABLE INCOME OF HOUSEHOLD

PRE TAX INCOME (RAND)	
0	0
1 - 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 IS YOUR HIGHEST LEVEL OF EDUCATION?

EDUCATION	YEARS
UNSCHOOLED	0
PRIMARY SCHOOL	7
GRADE 10	10
GRADE 12	12
DIPLOMA/DEGREE	15
HONOURS	16
MASTERS	19
DOCTORATE	20+

10. WHAT ANNUAL AMOUNT WOULD YOU BE PREPARED TO SPEND ON THE CONSERVATION OF ENVIRONMENTAL RESOURCES?

R ______________

11. WHAT DO YOU THINK WILL HAPPEN IF THERE IS A SIGNIFICANT REDUCTION OF FRESHWATER INFLOW INTO THE ESTUARY?

CATEGORY OF RESPONDENT	
WELL INFORMED –KNOWS MORE THAN 3 OF THE IMPACTS LISTED BELOW	1
PARTIAL KNOWLEDGE - KNOWS 1-3 OF THE IMPACTS LISTED BELOW	2
POORLY INFORMED – KNOWS 0 OF THE IMPACTS LISTED BELOW	3

INFORMATION:

THE DECREASE OF 7.2% OF CURRENT FRESH WATER INFLOW INTO THE ESTUARY CAN BE EXPECTED TO HAVE CONSEQUENCES OF THE FOLLOWING MAGNITUDES:

FOR BOATERS
- A 10% INCREASE IN AREA AVAILABLE FOR BOATING DUE TO MOUTH CLOSURE AND INCREASED VOLUME IN THE LAGOON

FOR SWIMMERS
- A 10% INCREASE IN AREA AVAILABLE FOR SWIMMING DUE TO MOUTH CLOSURE AND INCREASED VOLUME IN THE LAGOON

FOR FISHERS/BAIT COLLECTORS
- BIOMASS OF ANGLING FISH: 50% REDUCTION
- BIOMASS OF BAIT: NO CHANGE

FOR BIRDERS
- BIOMASS OF BIRDS: 25% REDUCTION.

FROM THE PERSPECTIVE OF VIEW AND PEOPLE STAYING NEAR THE ESTUARY
- 10% CHANGE

FROM THE PERSPECTIVE OF LOSS OF UNIQUE HABITATS
- BIODIVERSITY: 10% REDUCTION.

12. WHAT WOULD YOU BE WILLING TO PAY IN USER FEES PER YEAR FOR A PROJECT THAT WOULD RELEASE 100,000 M^3 OF WATER (ANNUALLY) INTO THE ESTUARY TO PREVENT THESE MENSIONED CHANGES?

AMOUNT (RAND) WILLING TO PAY 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

ADDITIONAL INFORMATION ON SCENARIO

THE EXTRA AMOUNT IN USER FEES PER YEAR IS SPECIFICALLY FOR A PROJECT TO INCREASE RIVER WATER INFLOW OR TO PREVENT A DECREASE IN RIVER INFLOW, DUE TO URBAN AND AGRICULTURAL ABSTRACTION OR REDUCED FLOWS THROUGH FORESTRY OR VEGETATION CHANGES. THE PROJECT IS TO PREVENT A DECREASE IN FRESHWATER INFLOW OF 7.2% OVER WHAT IS CURRENTLY FLOWING INTO THE ESTUARY. THUS IT PREVENTS THE PROPORTION OF MEAN ANNUAL RUNOFF FLOWING INTO THE ESTUARY DECREASING FROM 87% TO 81%.

THE USER FEES WOULD BE COLLECTED IN TWO WAYS:

- BY THE LOCAL AUTHORITY IN USER FEES FROM ALL USERS WHO WISH TO ACCESS THE 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 0.1 MILLION M^3 OF WATER, I.E., ENOUGH FRESH WATER INFLOW TO PREVENT THE CHANGES IN ESTUARY SERVICES INDICATED.

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

REASON	
CANNOT AFFORD THE FEES	1
GET NO OR NEGLIGIBLE VALUE OUT OF ESTUARY SERVICES	2
ABUNDANCE OF SERVICE OPTIONS – NO SCARCITY, THEREFORE WHY PAY	3
LACK OF CONFIDENCE IN GOVERNMENT TO COLLECT AND USE FEES COLLECTED FOR THE WATER PURCHASE	4
PAYING ENOUGH TAXES, FEES ETC ALREADY	5
THE METHOD OF COLLECTION/PAYMENT PROPOSED IS UNFAIR. IT SHOULD BE COLLECTED IN THE FOLLOWING WAY ____	6
OTHER REASONS (SPECIFY) ____ ____	7

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

FEE	RAND
BOATING FEE (R250 P.A)	
ANGLING FEE (R35 P.A.)	
BAIT COLLECTION FEE (R50 P.A.)	
SUBSISTANCE FISHING FEE (R45 P.A.)	
SHELL COLLECTION (R50 P.A.)	
LAUNCHING FEES	
ACCESS TO BANKS FEE	
LOCAL AUTHORITY CHARGES TO CONSERVE ESTUARY	
OTHER	
TOTAL	

15. TRAVEL COST:

SECTION A: VEHICLE USE TO ACCESS ESTUARY

I. WHAT MAKE OF VEHICLE DO YOU USE TO TRAVEL FROM YOUR PERMANENT HOME TO YOUR ACCOMMODATION NEAR THE ESTUARY OR FROM HERE TO THE ESTUARY?

VEHICLE	
MAKE	
MODEL	
YEAR	
ENGINE CAPACITY	
MARKET (CURRENT) VALUE OF VEHICLE	
DO NOT KNOW DETAILS	**LARGE / SMALL**
LOCAL RESIDENT AND DO NOT USE A VEHICLE	**NONE USED**

SECTION B: PERMANENT LOCAL RESIDENT (STAY WITHIN 10KM OF ESTUARY) IF VISITOR OR HOLIDAY RESIDENT PROCEED TO SECTION C
I. HOW MANY TIMES A WEEK DO YOU MAKE USE OF THE ESTUARY ON AVERAGE? ______________________ II. HOW FAR DO YOU HAVE TO TRAVEL TO USE THE ESTUARY? _____________KM X2 = ______________KM III. HOW DO YOU ACCESS THE ESTUARY (CAR, WALK, TAXI OR OTHER)? _______________________________ VI. WHAT IS YOUR TRAVEL COST TO GET TO THE ESTUARY (RETURN TRIP FUEL OR FARE)? **R**_____________

SECTION C: VISITORS AND HOLIDAY HOMES
I. WHERE IS YOUR PERMANENT HOME? _________________________ II. IF YOU DO NOT TRAVEL BY YOUR OWN VEHICLE, BY WHICH OTHER MEANS DO YOU TRAVEL E.G. TAXI, FLY AND HIRE CAR OR BUS? ______________________________________ III. HOW FAR DO YOU HAVE TO TRAVEL FROM YOUR PERMANENT HOME TO REACH YOUR HOLIDAY ACCOMMODATION FROM WHICH YOU VISIT THE ESTUARY? (ONE WAY) ______________KM X2 = ______________KM IV. HOW FAR DO YOU HAVE TO TRAVEL FROM HOLIDAY HOME TO USE THE ESTUARY? ______________KM X2 = ______________KM V. WHAT IS THE APPROXIMATE TOTAL COST OF THE ACCOMMODATION YOU MAKE USE OF WHEN VISITING THE ESTUARY? R_____________________ VI. WHAT WAS THE TRAVEL COST TO GET HERE FROM YOUR PERMANENT HOME (RETURN TRIP FUEL OR FARE)? **R**_____________________________________ VII. HOW MANY DAYS DO YOU MAKE/PLAN TO SPEND AWAY FROM YOUR PERMANENT HOME AT THIS HOLIDAY HOME? ______________________________________ VIII. DO YOU INCUR A SALARY SACRIFICE BY VISITING THE ESTUARY? YES / NO IF YES, APPROXIMATELY HOW MUCH? R___________________

16. DO YOU VISIT OTHER ESTUARIES?

VISIT OTHER ESTUARIES	
YES	1
NO	2

IF YOU ANSWERED YES TO THE ABOVE, PLEASE COMPLETE SECTION D

SECTION D: ALTERNATIVE SITES

I. IF YOU DID'NT VISIT THIS ESTUARY, WHICH ESTUARY WOULD YOU MOST LIKELY VISIT? ________________ _________________________

II. HOW MANY TIMES HAVE YOU VISITED THE ESTUARY SPECIFIED ABOVE IN THE PAST 12 MONTHS?

____

III. HOW FAR IS YOUR PERMANENT RESIDENCE FROM THE ESTUARY SPECIFIED ABOVE? (ONE WAY)

______________KM X2 = ______________KM

VI. WHAT IS YOUR TRAVEL COST TO GET TO THE SPECIFIED ESTUARY (RETURN TRIP FUEL OR FARE)?

R_____________________________________

V.

YOU VISIT THE SPECIFIED ESTUARY BECAUSE IT HAS:	
BETTER CATCH RATES	1
BIGGER BOATING AREA	2
BETTER FOR SWIMMING	3
GREATER VARIETY OF BIRDS	4
NICER VIEWS	5

17. WHAT DO YOU SPEND ON EQUIPMENT PER ANNUM TO ACCESS THE SERVICES OF THIS ESTUARY IN BOAT, FISHING OR VIEWING EQUIPMENT? (NOTE: BOATS AND EQUIPMENT ARE DEPRECIAT OVER 10 YEARS)

R____________________

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

YOU WOULD	
STILL VISIT THE ESTUARY	1
VISIT OTHER ESTUARIES INSTEAD	2

19. THE ESTUARY IS APPROXIMATELY WHAT PERCENTAGE OF THE REASON YOU VISIT OR LIVE IN THE AREA.

PERCENTAGE OF ESTUARY USE (%)	
0 (NON USER / PASSIVE)	1
1- 20	2
21 - 40	3
41 - 60	4
61 - 80	5
81 - 100	6

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

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Questionnaire compiled by members of the Departments of Economics and Zoology, NMMU. Questions about this project may be directed to Prof SG Hosking on telephone number: 041-5042205