Auckland Regional Council
TE RAUHĪTANGA TAIAO

Te Kaunihera o MANUKAU City Council

Risks to Estuarine Biota under Proposed Development in the Whitford Catchment

Summary Report

August 2003 TP204

Auckland Regional Council
Technical Publication No. 204, 2003
ISSN 1175-205X
ISBN -1-877353051
Printed on recycled paper

Risks to Estuarine Biota under Proposed Development in the Whitford Catchment: Summary Report

A. Senior
D. Ramsay

Prepared for
Manukau City Council
Auckland Regional Council

NIWA Client Report: HAM2003-016 (sum)
August 2003

NIWA Projects: ARC01264
ARC01265
ARC01266

National Institute of Water & Atmospheric Research Ltd
Gate 10, Silverdale Road, Hamilton
P O Box 11115, Hamilton, New Zealand
Phone +64-7-856 7026, Fax +64-7-856 0151
www.niwa.co.nz

Contents

Reviewed by:

R. Gorman

Approved for release by:

A. B. Cooper

Introduction

In September 2000, Manukau City Council (MCC) and Auckland Regional Council (ARC) asked the National Institute of Water and Atmospheric Research (NIWA) to conduct a study within the Whitford area. The details and results of this study are given in the NIWA client report HAM2003-016 "Risks To Estuarine Biota Under Proposed Development In The Whitford Catchment". A non-technical summary of this report is provided in the current document.

For ease of reference, this document is divided into three parts and written in the form of "questions and answers". Part 1 answers questions of a general nature, such as "What is the purpose of the study?" Part 2 goes into more detail on how the study was conducted, describing for example how computer models were used. Finally, Part 3 gives the results of the study.

View of the Whitford Embayment from Mangemangeroa

Part 1: General Questions

What was the purpose of the study?

The Manukau City Council (MCC) and the Auckland Regional Council (ARC) are investigating what impact more rural-residential living (more houses) would have on the Whitford area. The effects on the rural character, amenity values, ecology, land stability and erosion are being considered, together with the effects on the rural economy, physical and social infrastructure, including its associated costs.

The Whitford Embayment Study is one component of this wider investigation, which specifically addresses the risk to the marine ecology, due to mud washed off the surrounding landscape during construction, when bare earth is exposed.

What area is being studied?

Future rural-residential development could be accommodated where appropriate within parts of the Mangemangeroa, Turanga and Waikopua catchment areas. The figure on the next page shows these catchment areas and the current zoning of the catchments. The impact of the building works could be extra mud deposited in the Mangemangeroa, Turanga and Waikopua estuaries and the Whitford embayment as a whole.

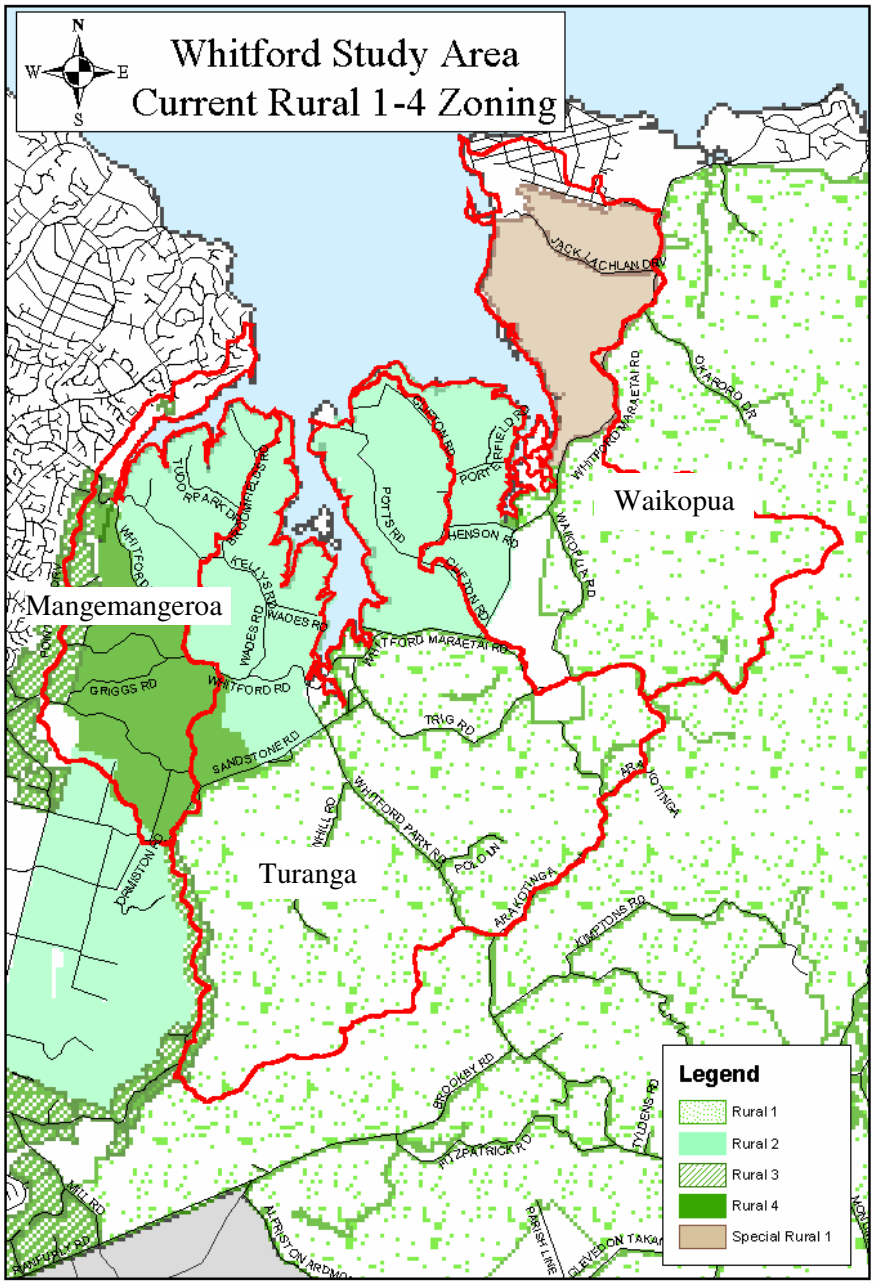
What development scenarios were considered?

The study investigated two possible housing development scenarios, based on the current subdivision rules of the Manukau Operative District Plan. These two scenarios are compared against the current level of housing.

Scenario 1: 431 new house sites with 5.4km of new road (54 new house sites and 0.9km of road per year). This scenario applied the current subdivision rules in Chapter 12 'Rural Areas' of the Manukau District Plan 2002 as they relate to the four different rural zones (Rural 1 – 4 zones) included in the Whitford Catchment.

Scenario 2: 1004 new house sites with 15km of new road (174 new house sites and 2.5km of road per year). This scenario applied the current subdivision rules in Chapter 12 'Rural Areas' of the Manukau District Plan 2002 as they relate to the Rural 2, Rural 3 and Rural 4 zones within the Whitford Catchment. However, in Scenario 2 the Rural 2 rules (average lot size of 4 hectares) were applied to all of the Rural 1 zoned land included in the Study.

Map shows the Whitford catchment areas and the current zoning of these catchments.



How does such development impact on the estuaries and the embayment?

When earthworks occur as part of a housing development, rain can much more easily erode exposed earth from the land. Streams carry this mud into the tributary estuaries (Mangemangeroa, Turanga and Waikopua) and then into the Whitford Embayment. At each stage (but particularly in the estuary and embayment) the mud may be deposited onto the stream/estuary bed, potentially smothering animals which live on the bed (e.g. shellfish). If these animals are regularly buried by thick layers of mud, many of them are likely to die. Some species of animals are affected more than others, so the increase in mud can change the range of species in the embayment, otherwise called the biodiversity. This biodiversity is important to the environmental value of the area.

As it may take a long time for a mud-impacted estuary to recover naturally, and as rehabilitation is difficult, prevention of such damage occurring is by far the best option. Being able to quantify the risks that future potential housing developments pose is important information for decision makers.

What is the state of the embayment at the moment?

Although the Whitford embayment and tributary estuaries show evidence of previous ecological degradation due to historic activities within the catchment, the embayment still has important animal communities. Further loss of important species and biological diversity could occur if care is not taken.

Why are the estuaries and embayment important?

The Whitford embayment and tributary estuaries have environmental, social, aesthetic and financial value. Features which contribute to these values include:

- Bird and fish life
- Commercial fishing
- Recreational fishing
- Recreational activities
- Visual aesthetics

How might these values be affected?

Changes in the biodiversity of the small animals that live on the embayment bed can lead to changes in animal communities that feed off them. Fish life and bird life, for example, may be indirectly affected by more frequent deposition of mud in the embayment. This in turn affects fishing catches. Following rainstorms, the water may also look muddier, and larger areas of mud flats may change the visual appeal of the area.

What did the study involve?

The study used a computer model to predict how much mud might be eroded from the catchments and delivered to each of the tributary estuaries, during the earthworks phase of the development scenarios, for various sizes of rainstorms. Another computer model predicts how this mud might be distributed within the tributary estuaries and the embayment. The mud is dispersed throughout the region by water currents, the tide, wind and waves, but at the same time, falls slowly down through the water by gravity. Together these models show how thick the mud layer will be in the aftermath of a variety of possible storms. An ecological survey was also conducted to find out how many species of animals live in the Whitford embayment and tributary estuaries, the number of animals within each species, and where they are living at the moment.

Previous studies have shown the percentage of species that are likely to be killed by various thicknesses of mud. Combining all this information shows how the risk of ecological damage changes due to implementing either of the two development options.

Part 2: Details on how the study was carried out.

How do you calculate how much mud is delivered to each tributary estuary?

The shape of the land (the topography), the land use (e.g. vegetation, forest, pasture or urban), and the properties of the various soils are put into a computer model. For any given amount of rainfall, the model can calculate the amount of mud eroded from each of the catchments. The model then predicts how this mud is delivered to each of the tributary estuaries. The model also predicts how much of the rain water is delivered to the estuaries, taking account of how much water percolates into the ground, and how much is lost due to evaporation and transpiration from plants. In this study approximately 40 years of rainfall data from local weather stations were used, to obtain a variety of possible storm conditions.

How are proposed developments incorporated into the computer model of the catchments?

During the earthworks phase of the two development scenarios, it was assumed that ¼ hectare (2500 m2) of bare earth would be exposed at each new housing site. Where new roads were planned, bare earth 20 m wide was incorporated into the model. Sediment control measures were incorporated into the new road schemes but not for new residential property, as per current Manukau City Council requirements.

How can you be confident that the computer model of the catchment is correct?

Measurements of water flow and suspended sediment within the streams confirm that the computer model does accurately simulate the catchments as they are at the moment. Obviously, it is impossible to check the development scenarios against measured data, but given the good results obtained with the existing land use, the model can be used with reasonable confidence to predict the effects of these development scenarios.

What impacts do the proposed developments have on the run-off of mud from the catchments?

The more intense development of Scenario 2 delivers more mud to the tributary estuaries than Scenario 1. Overall, Scenario 1 delivers 15% more mud to the tributary estuaries than under the existing land use. Scenario 2 deliveries 47% more mud than under the existing land use.

How are the results from the catchment computer model used to calculate the thickness of the mud layer within each of the estuaries and the embayment?

The mud eroded from each catchment is used as an input to a second computer model, which simulates the movement of water and mud throughout the tributary estuaries and the Whitford embayment.

The catchment model provides the mud eroded from the landscape due to various sizes of storms that have occurred in the last 40 years. The estuary model simulated 6 of these storms, ranging from a small rain storm which might occur two or three times a year, to a major rain storm which would be expected to occur once every 40 years or so. Each storm was simulated under different wind conditions and different tide ranges. For each housing development scenario (Existing, Scenario 1 and Scenario 2), 90 types of storm conditions were simulated by the estuary/embayment model.

What does the computer model of the estuaries and embayment do?

This model simulates the water movement in the tributary estuaries and the embayment, which is mainly due to tidal currents and wind driven currents. As the water flows from one area to another it carries mud with it. This mud slowly falls to the estuary bed under gravity, until it settles onto the bed. Later, more powerful currents, or waves, may lift the mud off the bed again, and the water can then move it further on. The mud may be picked up, transported and deposited again many times. Eventually most of the mud will be deposited in areas of the estuary and embayment where waves or water currents are not strong enough to move it any further. These areas tend to be in sheltered regions, often with mangroves. The computer model can tell us how thick the layer of mud may get in these areas.

How does the computer model of the estuaries and embayment work?

The first step is to find the shape (*bathymetry*) of the coastline, the tributary estuaries and the embayment, from coastal navigation charts and surveys. This bathymetry is represented in the computer by overlaying a grid, where each grid cell is 50 m × 50 m, and specifying the height of the seabed at each grid cell.

Where the Whitford embayment opens out into the Tamaki Strait (in the model this boundary is from Mellons Bay to Beachlands), the rise and fall of the tide is input to the model. At the head of each tributary estuary, the stream flow and mud is also input to the model. Wind, measured from Musick Point Meteorological Station, can also be input to the model. The wind generates waves and also blows the surface water in the direction of the wind.

The computer then solves complex equations at each grid cell to calculate the water flow, tidal water level and amount of mud.

Do you compare the computer model predictions with what occurs in real life?

The computer model of the estuaries and embayment is checked against measurements of water currents, tide levels, mud transport rates and mud deposition rates. Generally the model simulations of the existing conditions compared well with measured data. This provides the confidence to then apply the model to the different development scenarios.

What are the main factors that control the deposition of the mud?

Not surprisingly, the main factor controlling how much mud is deposited in the estuary is the size of the rainstorm. The bigger the flood, the more mud is delivered to each of the tributary estuaries. However, the increase in stream flow also means that more mud is carried from the tributary estuaries and into the embayment. The direction from which the wind was blowing during the storm was found to control the pattern of mud deposition. For example, a strong wind from the north-west will tend to create a circular current in the embayment that pushes the mud towards the south-east corner of the embayment, and into the Waikopua estuary. Under south-east and south-westerly wind, mud is blown seawards, out towards the Tamaki Strait.

How do you assess the impact of this mud on the animals that live in the estuary?

A survey was carried out to count the number of species of animals that live on the bed of the estuary and embayment (*benthic biota*). The type of animal changes throughout the estuary and embayment, depending on the character of the particular location, for example if it is *sub-tidal* (always underwater) or *intertidal* (underwater at high tide but dries out at low tide), or if it is in a channel or a mud flat. The sediment *grain size* (mud consists of fine small particles, whereas sand consists of larger grains) and *vegetation* (e.g. mangrove) also define the character of the area. The number of species gives a measure of the biodiversity within the region. The number of animals within each species (the *abundance*) was also counted. To perform this survey, 95 sediment cores were taken at various locations. This involves pushing a plastic tube about 15 cm long into the mud. This is then taken back to the laboratory where the animals were identified and counted, the sediment was analysed, and the amount of food available for these animals was measured.

Typical sediment core, taken from a cockle bed area.

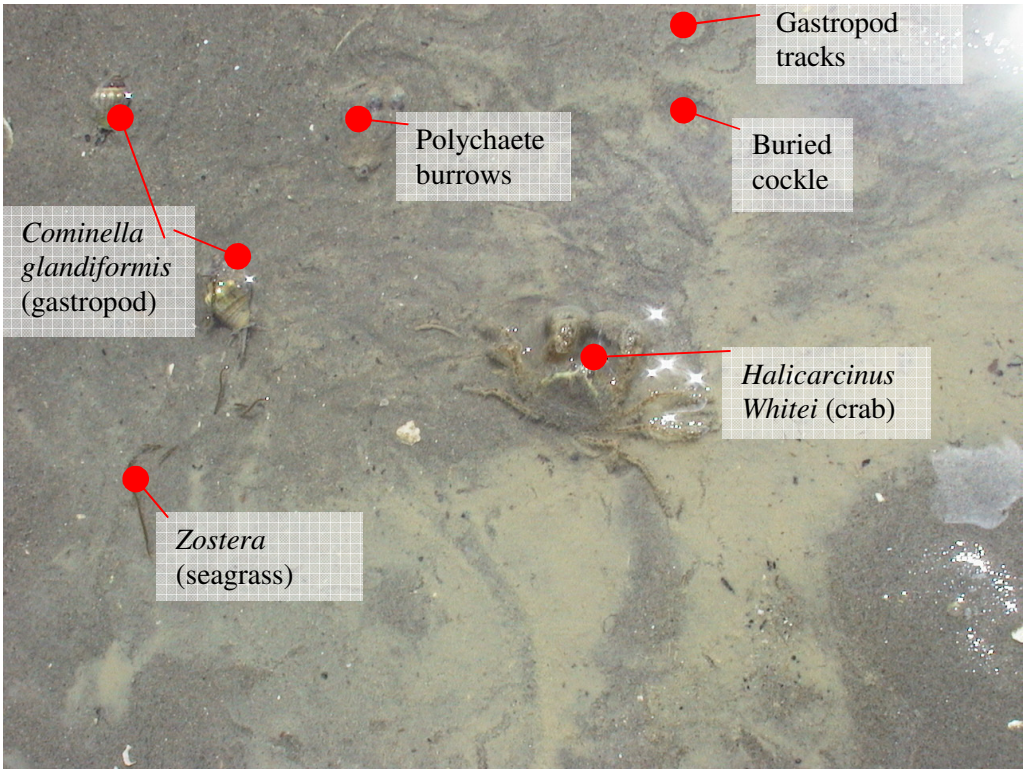
Previous experimental studies by NIWA have found a simple relationship between biodiversity and thickness of mud. Knowing the expected mud thickness from the computer model, the percentage decrease in the number of species can be calculated. This relationship will change throughout the embayment as the character changes.

What did the ecological survey find?

It was found that some species are widespread, covering various different habitats, whilst others are much more limited in their extent. Areas which are already very muddy were found to have much less diversity than areas consisting mostly of sand. The intertidal sandflats in the embayment have particularly high diversity in the species of animals. Conversely, the upper reaches of the tributary estuaries were found to have large numbers of animals, but fewer species.

Experimental study area.

Photograph showing some of the different animals which live on the estuary bed.



A Maldanid worm and cast

How does the number of animals and species change with different amounts of mud?

The following has been found to be generally true:

- In general, the thicker the layer of mud, the more animals will be killed. This will affect both the number of species and the number of animals within each species, however some species are more sensitive than others.
- If mud that has been washed down a stream to one of the tributary estuaries or the embayment results in a mud layer greater than 2 cm thick, remaining for longer than five days, then all the resident animals in that area (with the exception of mobile crabs and shrimp) will be killed due to lack of oxygen.
- A mud thickness of around ½ cm, persisting for longer than 10 days, will reduce the number of animals and the number of species, thereby changing the structure of the animal community.
- Frequent deposition of mud, less than ½ cm, may still have long-term impacts that can change the animal communities.

Part 3: Results

How do you measure and compare the 'risk' of ecological damage, due to the deposition of mud, for each of the housing development scenarios?

In this study, we measure the *risk of ecological damage* as a combination of:

a) the reduction in species diversity due to burial by mud washed off the surrounding landscape during rain storms, and

b) the likelihood of these rain storms occurring during the earthworks phase of the housing development.

Using computer models and an ecological survey, the reduction in species diversity was obtained for 90 different types of storm, for each of the development options (including the existing land use).

The likelihood of each of these storms occurring can be found from historical data, i.e. how many times have each of the different types of storm hit the Whitford area?

For any location in the Whitford embayment or the tributary estuaries, it is now possible to calculate how likely it is that a given thickness of mud will be deposited. This can then be converted into how likely is it that a given proportion of the species will be killed.

The risk associated with each of the housing development options can then be compared against what is occurring under the existing level of development.

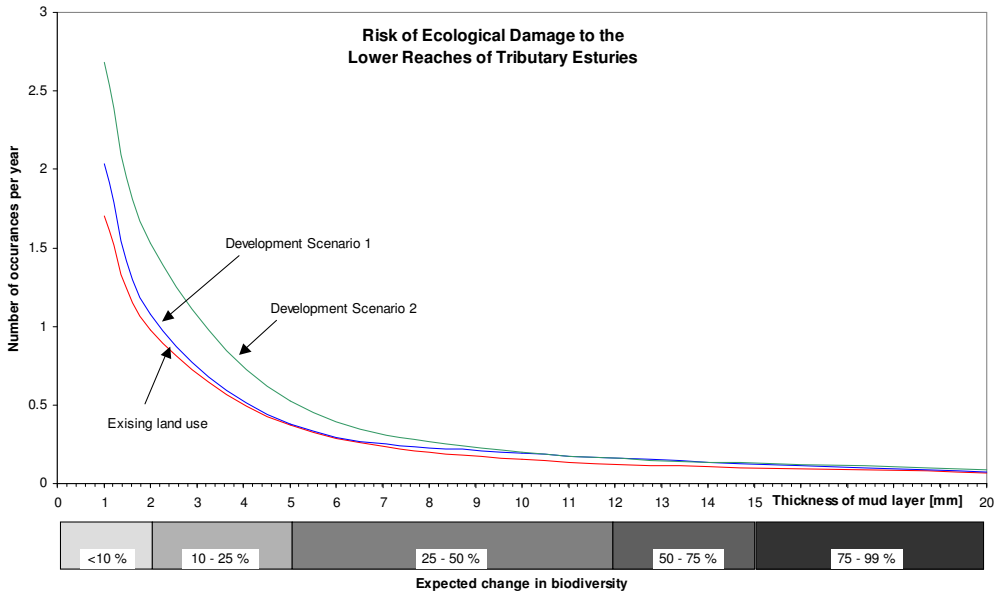
What do the results show?

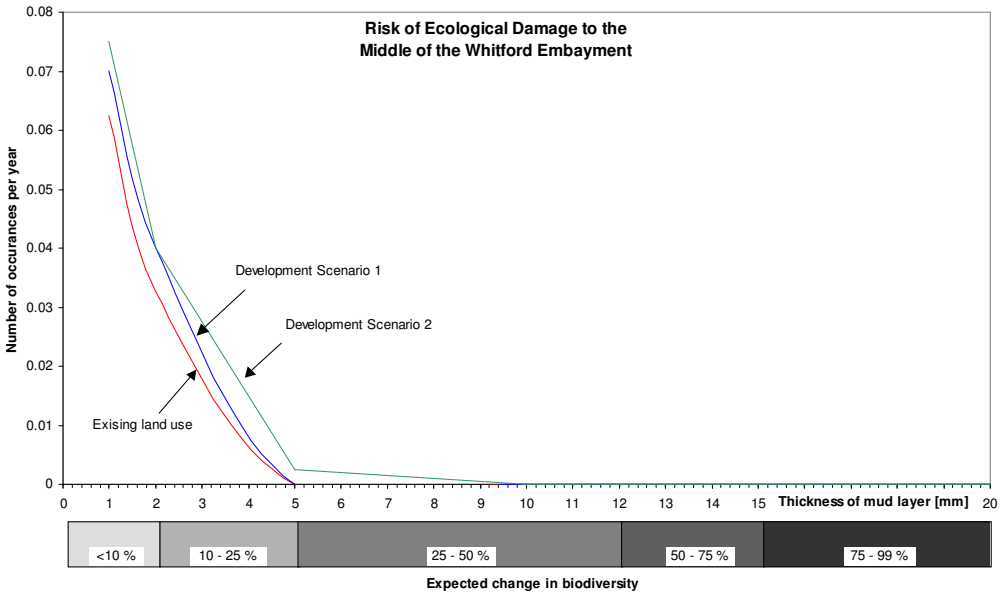
The study provides a great deal of information and not all of the results can be reproduced here. The figure below however shows the important trends.

Using the first graph we can ask: "How frequently can we expect more than 25% of the species to be killed, over more than 1% of the lower reaches of the tributary estuaries?" This can be found by finding where the grey boxes change from "10-25%" to "25-50%". This corresponds to a layer of mud ½ cm thick. Draw a line up from here until it intersects with the red graph line, and then draw a horizontal line across to the vertical axis. This shows that we expect a ½ cm mud layer to cover 1% of the lower reaches of the tributary estuaries

0.4 times per year (about once every 2½ years) under existing conditions. Continuing the vertical line until it intersects with the green line, and following this across, shows that under the development Scenario 2 option, we expect a ½ cm mud layer to occur 0.5 times per year, which is once every two years.

Graphs showing how the level of risk changes for each development option, within the lower reaches of the tributary estuaries (top figure) and the middle of the Whitford Embayment (bottom figure)





What other information can we get from the results?

The Scenario 1 and Scenario 2 proposed development options deliver more mud to the embayment than at present. A given thickness of mud, and a corresponding level of ecological damage, will occur least often under the Existing land use, more often under Scenario 1 and most often under Scenario 2.

Most of the mud will usually be deposited in the upper reaches of the tributary estuaries, near where the streams enter. A walk round this area shows that it is already extremely muddy: approximately 4 times each year the mud layer thickness in these upper reaches is expected to exceed 1 mm for over 1% of the area of the region.

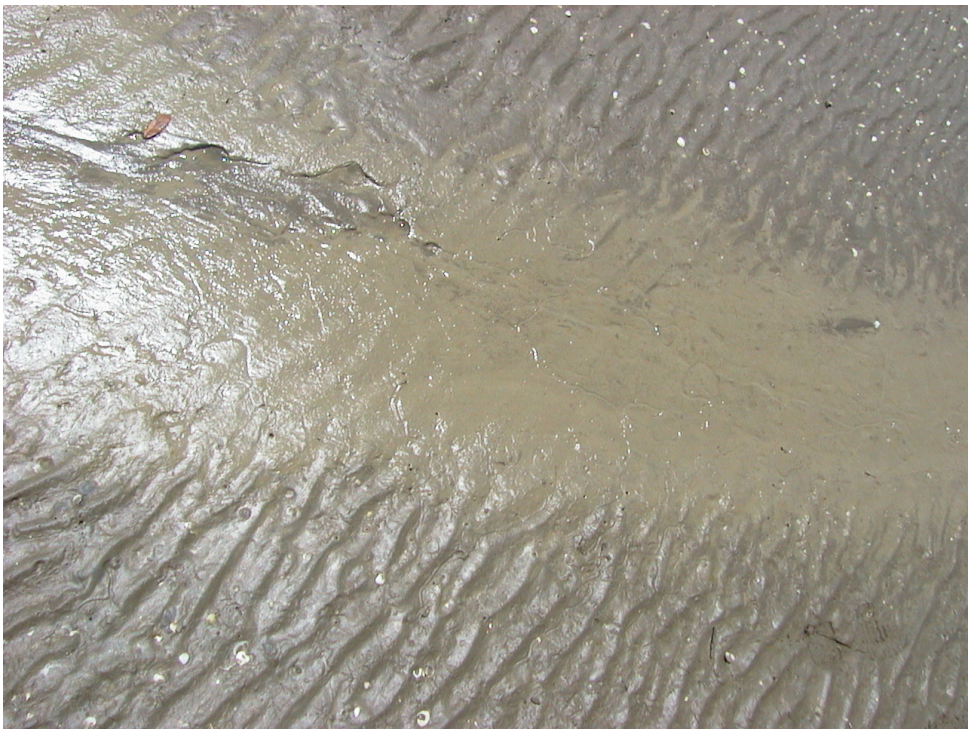
The areas most likely to experience significant loss of animal species are the shallow intertidal regions of the embayment and the entrances to the tributary estuaries. For example, a greater than 10% reduction in animal diversity over 1% of the area is predicted to occur just under once per year with existing conditions. This increases to just over once a year under Scenario 1 and 1½ times a year under Scenario 2 – this is a 50% increase over what is happing now. The outer embayment presents the least risk of ecological damage.

Are the results what we might expect?

Yes. We know that mud is already accumulating in the upper reaches of the tributary estuaries and intertidal areas of the embayment, just as the study shows. The photographs below show mud on an intertidal estuary bed, following a recent rainstorm. We would also expect that during the earthworks phase of development, mud is more likely to be washed off the landscape and deposited into the estuaries and embayment. The more intense the housing development, the more likely it is that mud will be washed off the land.

The study provides more information than this however – it tells us how much more frequently the mud will be deposited in the estuaries and the embayment, and we can put numbers to how many animals will be killed.

Photographs showing a "stream" of mud deposited on an intertidal flat following a recent rainstorm.



Is this the whole story?

Unfortunately not. The processes which control the movement of mud from the landscape to the embayment, and how the mud affects the animals, are numerous and very complex. Although we understand a great deal about these processes, there is still much we don't know. Some of these processes could not be included in the study at all. For example, many of the animals will not only be affected by being buried by the mud, they may also be harmed by the mud when it is being carried along by the water. This mud carried in suspension will decrease the amount of light reaching the animals, and may interfere with feeding.

The results of the study do however provide valuable information which will help to make informed decisions regarding any future housing development.

Can the amount of sediment be reduced?

The development scenarios assume that sediment controls are not employed to the housing sites. Applying sediment controls may significantly reduce the amount of mud washed into the estuary. Various methods are available, but can be divided into 2 groups:

a) Protection during earthworks: Hay bales and ditches surrounding a construction site can trap mud washed from the exposed earth

b) Long term measures: If strips of land adjoining developed areas, or bordering streams, are designated as "no activity" areas, then sediment has an opportunity to settle here, before it reaches the streams and gets washed into the embayment. Planting trees etc. enhances this natural sediment filtering process.

What can we conclude from this study?

- Mud washed off the landscape during rainstorms reduces the number of animal species living in the Whitford Embayment and its tributary estuaries. This already happens quite frequently, but will occur more often during the earthworks phase of housing development. It will occur more frequently under Scenario 2 than under Scenario 1.
- Most of the mud will usually be deposited in the upper reaches of the tributary estuaries, near where the streams enter.
- The areas most likely to experience significant loss of animal species are the shallow intertidal regions of the embayment and the entrances to the tributary estuaries.
- The outer embayment presents the least risk of ecological damage.

- Although we understand a great deal about how mud is moved from the landscape to the sea, there is still much to be learnt. The results of the study do however provide valuable information which will help to make informed decisions regarding any future housing development.