POTENTIAL IMPACT OF CLIMATE CHANGE ON NSCC'S $300M WASTEWATER CAPITAL WORKS PROGRAMME

T. Lockie (Hydraulic Analysis Limited)
N. Brown (North Shore City Council)

ABSTRACT

This paper discusses the application of the North Shore City Council's (NSCC) calibrated trunk sewer MOUSE model to assess the potential impact of NIWA's forecast climate change rainfall to the NSCC trunk wastewater network.

As part of a national program forecast climate change rainfall was developed by NIWA to estimate the potential climate change impacts on infrastructure across NZ. 30 years of climate change rainfall was generated from Regional Downscaling of the Global Circulation Model to produce a spatial and temporal forecast rainfall.

This analysis estimates the change in wastewater network performance and associated cost implication as a result of the forecast climate change rainfall as applied to the NSCC trunk sewer system.

A change of performance due to climate change is of particular importance, as consent conditions detailing the containment standard for wastewater networks are becoming more common. A containment standard is usually expressed as the number of times per annum a network is allowed to spill to the environment. The containment standard forms the basis for scoping and design of capital works.

The NSCC wastewater network targeted containment standard is an average of two overflows per annum by 2021, This containment standard is a core component of the NSCC wastewater network discharge consent. To achieve the Level Of Service (LOS), NSCC have developed a calibrated hydrological and hydraulic model of the trunk wastewater network, this model is utilised to assess and size upgrade works to meet the targeted LOS.

As a result of climate change the consented containment standards based on historical rainfall may not be appropriate. The cost implication of climate change on wastewater network capital budgets is currently unknown. Assessing the potential impact of climate change is important particularly as wastewater typically has the largest capital works budget of the 3 waters for cities in NZ. NSCC has a capital works budget for wastewater improvements of ~$300M before 2021 – it is the effect climate change may have on this budget which is being assessed.

This paper briefly outlines the development of the Project CARE strategic wastewater model, details the methodology applied to assess network performance from historical and forecast climate change rainfall, and summarises system performance impacts and the cost implication of the forecast climate change.

KEYWORDS

MOUSE, Wastewater Modelling, Climate Change

1 INTRODUCTION

This report discusses the application of the North Shore City Council's (NSCC) calibrated trunk sewer MOUSE model to assess the potential impact of projected climate change regionally downscaled rainfall data to the NSCC trunk wastewater network.

As part of a national programme on the potential climate change impacts on urban infrastructure and buildings in New Zealand, 15-minute resolution rainfall data were generated from NIWA's Regional Climate Model (RCM) for two periods; 1970-2000 and 2070-2100, with the future period based on a medium-to-high greenhouse gas emission scenario (known as A2). It must be stressed that these rainfall data are based on a single climate model and a single emission scenario for a single grid point over the Auckland region. In future phases of this work, multiple RCM runs encompassing a range of emission scenarios will be performed and analysed.

This preliminary study estimates the change in wastewater network performance and associated cost implication as a result of the projected change in rainfall from the single RCM run as applied to the NSCC trunk sewer system. The work is a demonstration of modelling capabilities and should be treated as a specific case study.

A change of performance due to climate change is of particular importance, as consent conditions detailing the containment standard for wastewater networks are becoming more common. A containment standard is usually expressed as the number of times per annum a network or overflow location is allowed to spill to the environment. The containment standard forms the basis for scoping and design of capital works.

The NSCC wastewater network targeted containment standard is an average of two overflows per annum by 2021. The containment standard is a core component of the NSCC wastewater network discharge consent. To achieve the Level Of Service (LOS), NSCC have developed a calibrated hydrological and hydraulic model of the trunk wastewater network, this model is utilised to assess and size upgrade works to meet the targeted LOS.

As a result of climate change the capital works program based on historical rainfall may not be appropriate. The cost implication of climate change on wastewater network capital budgets is currently unknown. Assessing the potential impact of climate change is important particularly as wastewater typically has the largest capital works budget of the 3 waters for cities in NZ. NSCC has a capital works budget for wastewater improvements of $303M to be completed prior to 2021 – it is the effect climate change may have on this budget which is being assessed.

This report briefly outlines the development of the Project CARE strategic wastewater model, details the methodology applied to assess network performance from historical and projected rainfall, and summarises system performance impacts and the cost implication of a climate change scenario.

1.1 STUDY OBJECTIVE

The objective of this study is to assess the effect of a climate change rainfall scenario on the North Shore City Council trunk wastewater network and associated impact on the proposed capital works program.

1.2 STUDY BACKGROUND

1.2.1 PROJECT CARE BACKGROUND

Project CARE (Council Action in Respect of the Environment) is a programme to improve beach water quality in North Shore City by reducing the number of wet weather overflow events from well over 12 times per annum down to no more than two per annum by 2021. The North Shore City Council started the Wastewater Network Strategic Improvement Programme (WNSIP), estimated at $231 million, in 2002. Council committed to a full review every six years to ensure the improvement programme will be completed and the wet weather overflow target met by 2021 as agreed with the community.

The recently completed ProjectCARE Review is the first review of the original ProjectCARE model and capital works programme. Where the overall key objective of the ProjectCARE Review study is to confirm or redefine the works required for the trunk wastewater system to achieve a system performance of an average overflow containment standard of 2 overflows per annum from the wastewater network.

The output from the ProjectCARE Review is:

- An updated WNSIP programme of capital works and budget to implement the revised programme
- An updated model to assist with NSCC planning, projects and operations requirements

1.2.2 NSCC'S LEVEL OF SERVICE

The wastewater network consent condition is currently under appeal, with the NSCC proposed revised consent condition being:

> *A design target for all of the network, of an average of no more than two wet weather overflow events per year by 2021, as assessed by computer modelling.*

The primary design target used for the ProjectCARE Review was an average of no more than two wet weather overflow events citywide per year by 2021 as assessed by computer modelling using a 17 year rainfall time series.

1.2.3 SYNTHETIC CLIMATE CHANGE RAINFALL GENERATION BACKGROUND

Regional climate models (RCMs) are higher resolution physical simulations of climate for a limited area of the globe. Typically the resolution might range from 30 to 50 km, which contrasts to a Global Climate Model (GCM) which might have a resolution of about 300 km. Unlike many GCMs, RCMs do not generally have an ocean component. They simulate the main atmospheric-land processes that influence climate. RCMs are nested within a GCM and variables like atmospheric winds, temperature and humidity from a GCM are used as input to the RCM.

NIWA has been implementing the RCM of the United Kingdom Met Office (known as PRECIS) and using it to simulate New Zealand climate under historic conditions, as well as for a limited number of future scenarios. The model requires atmospheric inputs from a version of the United Kingdom Met Office GCM called HadAM3P, or from reanalyses such as ERA-40. Currently the model has been used to simulate the A2 and B2 emission scenarios for a future time slice of 2070 to 2100. Utilising the RCM NIWA produced a 30 year time series of 15 minute synthetic rainfall data for existing (historic) and future climate conditions.

1.3 STUDY SCOPE AND METHODOLOGY

Utilising the existing North Shore calibrated trunk wastewater model and the 30 year rainfall time series generated for the existing and future climate, the following steps were undertaken to assess the effect of the projected climate change rainfall:

1. Existing Climate Analysis

   a. Run A: Simulate NSCC WW model with the first 10yrs of the existing climate rainfall from the RCM

   b. Run B: Simulate NSCC WW model with last 10yrs of the existing climate rainfall from the RCM

   c. Compare model performance (wastewater overflow frequency and volumes) between Run A and B to assess the variance in network performance across the existing climate rainfall period from the RCM. The objective is to check the natural variation within the RCM-generated present climate to assist with comparison with the future climate rainfall.

Note 10 years is considered a statistically long enough period to run the model for as the containment standard is a 6 month containment standard, therefore the period of record is 20 times longer than the target level of service.

2. Future Climate Analysis

   a. Run C: Simulate NSCC WW model with first 10yrs of the future climate rainfall from the RCM

   b. Run D: Simulate NSCC WW model with last 10yrs of the future climate rainfall from the RCM

   c. Compare model performance (wastewater overflow frequency and volumes) between Run C and D to assess variance in network performance across the future climate rainfall period from the RCM.

   d. Compare network performance between Run A & B vs Run C & D, to estimate implications for network performance i.e. changes to the number of locations (wastewater discharges to the environment) failing the LOS of 2 spills per year and the change in wastewater volume spilt to the environment.

3. Simulation of historical rainfall recorded (17yr rainfall time series from a rain gauge) within the NSCC wastewater catchment. Comparison of network performance from this historic rainfall time series with the RCM-based synthetic rainfall scenarios.

4. Re-cost capital improvement works based on climate change impacts on the wastewater network.

1.4 PREVIOUS STUDIES

This project utilised the NSCC's Project CARE strategic wastewater network model, details on the development of this model and the Project CARE study can be found in the following reports:

- Project CARE 2006 Model Build and Calibration, NSCC, 2009
- Project CARE Review System Performance, NSCC, April 2010

- Project CARE Review WNSIP Progress and Review, NSCC, May 2010

- Project CARE Review Sensitivity Analysis, NSCC, May 2010

Further details on NIWA's Regional Climate Model can be found in the following paper:

Baskaran, B., Renwick, J. and Mullen, A. B. 2002: On the application of the Unified Model to produce finer scale climate information for New Zealand. *Weather and Climate 22*, 19-27

1.5 CATCHMENT DESCRIPTION

NSCC's trunk sewer system serves a population of approximately 217,000 distributed over ~12,000 ha of which ~7,500 Ha is serviced by 110km of trunk sewer lines and 1,200km of local public sewer lines. Wastewater generated within the NSCC catchment drains via gravity sewer to a number of pump stations which pump the collected wastewater over ridges within the catchment to the NSCC's Wastewater Treatment Plant located in

1.6 STUDY ASSUMPTIONS

The following constraints and assumptions are applied to this study (Note: these are only the core assumptions and additional assumptions have been made and are a stated in the report text):

- This report should be read in conjunction with the Project CARE 2006 Model Build and Calibration report (NSCC, 2009), which details assumptions associated with the model build and calibration and the Project CARE Review System Performance Report (NSCC, April 2010)

- Model results are indicative estimates of system performance

- The rainfall time series are simulated/recorded at one grid point/location and no account of spatial rainfall variation has been undertaken. Therefore it is expected that the predicted performance of the system will vary if a spatially distributed rainfall was applied.

- The growth predictions applied to this study are estimates and subject to a number of variables including timing, magnitude and location of growth.

- To assess future scenarios, assumptions were made regarding an increase in network leakiness due to the deterioration of the network as it ages and an increase in the number of private wastewater laterals from densification of development. The increase in leakiness due to deterioration of the network was adopted as per the original Project CARE study, and the densification assumption was developed as part of the Project CARE Review.

2 MODEL SETUP AND INPUT DATA

2.1 OVERVIEW

This section details the input data utilised to develop system performance scenarios. The below table outlines the core model setups.

Table 2-1: System Performance Model Setup Scenarios

Run	Rainfall	Network	Wastewater Catchment Loads	Operational
A	RCM Current (1971 – 1981)*	2006 (Base)	2060	No RTC
B	RCM Current (1989 – 1999)*	2006 (Base)	2060	No RTC
C	RCM Future (2071 – 2081)*	2006 (Base)	2060	No RTC
D	RCM Future (2088 – 2089)*	2006 (Base)	2060	No RTC
E	17yr Historical Rainfall	2006 (Base)	2060	No RTC

*Synthetic rainfall generated by NIWA

2.2 SCENARIO DEVELOPMENT

2.2.1 POPULATION SCENARIO

All model scenarios were simulated with the 2060 population estimate. This estimate was developed from City Blue Print high growth projection v16, except for Albany catchment for which the Harrison and Grierson population estimate (HG, 2007) was adopted and Takapuna populations which were calculated from the v17 high growth projection.

2.2.2 CATCHMENT DETERIORATION

To assess the future development leakage the calibrated leakage parameters were adjusted to account for the assumed increase in I/I due to:

- Age: Deterioration of network as it ages, where a 25% increase in I/I per 50yrs is assumed.
- Intensity: Increase in the number of private wastewater laterals (catchment density). Where an absolute 1% increase in catchment I/I for an increase in density of 10 People / Hectare, with an upper limit of 50 PE / Ha above which no increase in I/I contribution is assumed.

The above rates were applied to each model scenario by increasing the calibrated Fast Response Component (FRC) and Slow Response Component (SRC) % connectivity factors by the intensification and deterioration rate for a given development horizon.

2.3 RAINFALL AND EVAPORATION DATA

2.3.1 NIWA'S SYNTHETIC RAINFALL

NIWA supplied two sets of synthetic rainfall for the current and future climate. These synthetic rainfall time series were generated from the NIWA Regional Climate Model (RCM), which has been adapted from United Kingdom Met Office PRECIS model. The model requires atmospheric inputs from a version of the United Kingdom Met Office Global Climate Model (GCM) called HadAM3P. NIWA performed a bias correction on both rainfall scenarios to better match the statistical properties of the observational data provided by NSCC from rain gauge NSCC07 (Wairau Valley). The current climate scenario is considered to be a reasonable representation of the 15-minute rainfalls for this location for the period 1970-2000, although it is unlikely that the most extreme rainfalls have been completely captured. The future climate rainfall was bias corrected in the same way as the current climate data. The future climate rainfall is a projection for the period 2070-2100 based on a single future emission scenario known as A2. The A2 emission scenario is considered medium-to-high, based on the suite of possible emission scenarios from the IPCC.

2.3.2 HISTORICAL RAINFALL – NSCC07

The historical rainfall record was sourced from the long term rain gauge NSCC07 located at the Wairau testing station, for a seventeen year period from August 1981 to January 1999.

2.3.3 POTENTIAL EVAPOTRANSPIRATION

Potential Evapotranspiration data recorded at Khyber Pass from August 2006 to July 2007 was utilised for calibration of the RDII hydrological model, for this analysis the time series was repeated to match the length of rainfall record being assessed. Evaporation data was sourced from the NIWA website www.cliflo.niwa.co.nz.

2.4 OVERFLOW CATEGORISATION

Overflows are characterised into three types as below:

- Constructed - Overflows from formal structures designed to release to prevent uncontrolled spills upstream. Generally these structures spill to watercourses or directly to the harbour.

- Uncontrolled - Overflows from informal structures normally through manhole lids. In many cases these overflows will occur onto road / driveway surfaces from where the spill is collected by the stormwater system and conveyed to a nearby watercourse and harbour.

- Catchment overflows – Overflows which occur upstream of the modelled network extents. These unmodelled overflows will include both actual overflows (generally uncontrolled), and artificial overflows which in reality will, due the capacity of the sewer being exceeded, not enter the network as I/I and will leave the catchment as stormwater runoff.

Overflows from the above types were also classified based on annual spill volumes into the following classes:

- Type I – Spill volume > 1000m3/yr

- Type II – Spill volume < 1000m3/yr

- Type IV – Catchment Overflows

3 MODEL RESULTS AND DISCUSSION

3.1 OVERFLOW PERFORMANCE ASSESSMENT

3.1.1 OVERFLOW PERFORMANCE ANALYSIS METHODOLOGY

The performance of the NSCC trunk sewer model was assessed by calculating the frequency of simulated overflow from controlled structures, uncontrolled locations (through manhole lids) and catchment lumped overflows.

Overflow Event Identification

Individual Location

Overflow events were identified as events where the spill discharge exceeded 0L/s and is separated by a 24hour dry period.

Overflow Characteristics – Performance Criteria

The overflow performance assessment is based on a consideration of the following:

- Spill frequency < 6mth ARI – Acceptable
- Spill frequency > 6mth ARI – Fails

Overflow Performance Analysis Results and Discussion

Comparison of Run A & Run B Simulated Results (Current Climate Synthetic Rainfall)

There is significant variation in the simulated system performance for the RCM current climate, where the model simulates 61 system failure locations (~124 ML/yr of annual spill volume) for the first decade (Run A) of the current synthetic rainfall and 44 failures (~97 ML/yr of annual spill volume) for the last decade (Run B). See Table 3-1 and Table 3-2 for tabulated values.

Of the simulated runs, Run A (the first decade of the current climate synthetic rainfall) simulates the greatest number of system failures, and exceeds the future climate synthetic rainfall run by 11%-15%.

Comparison of Run C & Run D Simulated Results (Future Climate Synthetic Rainfall)

There is insignificant variation in system performance for the RCM future climate scenario, where the model simulates 55 system failure locations (& ~140 ML/yr of annual spill volume) for the first decade (Run C) of the future rainfall and 53 failures (& ~133ML/yr of annual spill volume) for the last decade (Run D). See Table 3-1 and Table 3-2 for tabulated values.

The number of failure locations simulated by Run C & D are exceeded by Run A, while Run C & D simulated spill volumes exceed both Run A & B.

Comparison of Historical Rainfall Simulated Results

The historical gauge rainfall model run simulated 96 system failure locations (~240ML/yr of annual spill volume). This is approximately twice the number of failure locations and spilt volume from the current synthetic rainfall scenario and also greatly exceeds the future rainfall scenario. See Table 3-1 and Table 3-2 for tabulated values.

Comparison of Current and Future Simulated Results

Due to the variability in the RCM current rainfall, as discussed above, an envelope approach was undertaken to highlight the differences between the current and future rainfall scenarios. The minimum, average and maximum difference in simulated system performance was identified based on the below runs:

- Minimum – Difference between Run A (Current) and Run D (Future)
- Average – Difference between the average of Run A & B (Current) and Run C & D (Future)
- Maximum – Difference between Run B (Current) and Run C (Future)

The above calculated ranges were utilised to estimate the potential impact on the NSCC's Capital Works program. See Table 3-4 for tabulated simulation differences.

Effect on overflows of climate change

Based on the above envelope approach the change in overflow frequency and volumes attributable to climate change based on NSCC's trunk wastewater network ranges from:

- a decrease of 8 non complying overflow locations per annum (a 13% reduction) to an increase of 11 non complying overflow locations per annum (a 25% increase).
- an increase of 2% in overflow volume in the design event to an increase of 18% in overflow volume in the design event.

See Table 4-1 for tabulated costs.

Changes in overflow frequency and volume are not directly comparable to cost, Section 4 details the impact of climate change on capital works cost.

Table 3-1: Locations Exceeding NSCC's Level of Service

Receiving Beach	**No. Of Simulated Release Points Exceeding 2 Spills per Year**						
	Run A	**Run B**	**Run C**	**Run D**	**Average (Run A & Run B)**	**Average (Run C & Run D)**	**17Yr Historical Rainfall**
System Wide	61	44	55	53	48	54	96

Table 3-2: Annual Spill Volume Summary

Item	**Run A**	**Run B**	**Run C**	**Run D**	**Average (Run A & Run B)**	**Average (Run C & Run D)**	**17Yr Historical Rainfall**
System Wide Annual Spill (m^3/yr)	123,828	96,368	139,377	133,148	110,098	136,262	240,685

Table 3-3: Combined 6mth Spill Volume Summary

Item	**Run A**	**Run B**	**Run C**	**Run D**	**Run A & Run B**	**Run C & Run D**	**17Yr Historical Rainfall**
System Wide 6mth Spill Volume (m^3)*	15,760	13,980	16,560	16,110	14,760	16,090	31,340

*The system wide 6mth spill overflow is the 6mth spill volume summed for all locations failing the NSCC LOS of 2 spills per year. Note: Spill volume does not necessarily occur concurrently

Table 3-4: Comparison of Current and Future Rainfall Scenarios

Item	**Minimum**				**Average**				**Maximum**			
	Run A	**Run D**	**Difference**	**% Difference**	**Run A & Run B**	**Run C & Run D**	**Difference**	**% Difference**	**Run B**	**Run C**	**Difference**	**% Difference**
6 Month Spill Volume (m3)	15,760	16,110	350	2%	14,760	16,090	1,330	9%	13,980	16,560	2,580	18%
Locations exceeding 2 spills per year	61	53	-8	-13%	48	54	6	13%	44	55	11	25%

4 COST IMPLICATIONS OF CLIMATE CHANGE

4.1 COSTING METHODOLOGY

As discussed above there is a significant discontinuity between the historical rainfall simulated system performance and the current RCM rainfall simulated performance. The result of this discontinuity is that the current RCM rainfall cannot be utilised to generate and size capital improvement works. To resolve the rainfall discontinuity it was assumed that the change in simulated system performance from the current RCM to future RCM can be utilised to scale the capital works program generated from the historic rainfall time series. In addition cost estimates were developed for two differing scenarios:

- Cost Scenario 1 (Anticipated Climate Change): Assumes that capital works to meet the forecast climate change are undertaken and planned as part of NSCC's capital work program
- Cost Scenario 2 (Unanticipated Climate Change): Assumes that no planning or account of climate change is taken upfront and that capital works are only undertaken once the impacts of the forecast climate change are experienced.

Cost Scenario 1 (Anticipated Climate Change)

To complete the Cost Scenario 1 scaling the following steps were applied:

- Identification of locations that are simulated to fail the NSCC's LOS under the Current RCM
- Cost capital works to resolve the above Current RCM identified issues, utilising NSCC's cost curves
- Identification of locations that are simulated to fail the NSCC's LOS under the Future RCM
- Cost capital works to resolve the above Future RCM identified issues, utilising NSCC's cost curves in 2008 $
- Based on the above costs identify % difference in cost from the Current RCM to Future RCM in 2008 $
- Final cost estimate is based on scaling the 2008 WNSIP cost estimate ($303 Million (2008 $)) by the % difference estimated above

Cost Scenario 2 (Unanticipated Climate Change)

To complete the Cost Scenario 2 scaling the following steps were applied:

- Identification of locations that are simulated to fail the NSCC's LOS under the Current RCM
- Cost capital works to resolve the above Current RCM identified issues, utilising NSCC's cost curves
- Find locations which *degrade* in performance from the Current to Future scenario
- Cost capital works to resolve the above Future RCM degraded locations only
- To generate the Future RCM capital cost, in this scenario the degraded cost estimated is added to the Current RCM capital cost to get the Future RCM capital cost. i.e. Here we are delaying improvement works until the forecast climate change impacts are seen.
- Based on the above costs identify % difference in cost from the Current RCM to Future RCM in 2008 $
- Final cost estimate is based on scaling the 2008 WNSIP cost estimate ($303 Million (2008 $)) by the % difference estimated above
- A further refinement to this cost scenario is to calculate the NPV value of the delayed capital works, where these capital works were assumed to be implemented on average

10 years post the RCM Current capital works using a discount rate of 2.5% (The discount rate is made up of a standard discount rate less a capital cost escalation rate)

Each of the above cost scenarios were applied to the system performance envelope as described in the previous section, which produced the final estimated cost envelope approach applied for the forecast climate change.

4.2 COST IMPLICATION OF CLIMATE CHANGE ON NSCC'S CAPITAL WORKS PROGRAM

Based on the envelope approach and cost estimate Scenario 1 (Anticipated Climate Change) the estimated cost implication of climate change on NSCC's $303 million capital work program ranges from a reduction of $10.5 million (a 3% reduction) to an increase of $57 million (a 19% increase), in 2008 dollars. See Table 4-1 for tabulated costs.

For cost estimate Scenario 2 (Unanticipated Climate Change) (absolute cost impact no NPV assumptions) the estimated cost implication of climate change on NSCC's $303 million capital work program ranges from an increase of $95 million (a 31% increase) to an increase of $143 million (a 47% increase), in 2008 dollars. See Table 4-2 for tabulated costs.

For cost estimate Scenario 2 (Unanticipated Climate Change) (NPV calculation, where capital works are assumed to be implemented 10 years post the RCM Current capital works at a discount rate of 2.5%) the estimated cost implication of climate change on NSCC's $303 million capital work program ranges from an increase of $74 million (a 25% increase) to an increase of $112 million (a 35% increase), in 2008 dollars. See Table 4-3 for tabulated costs.

Table 4-1: Cost Scenario 1 (Anticipated Cost) Implication of Climate Change on NSCC's Capital Works Program Budgets

NSCC's 2008 Capital Works Budget	Minimum (2008 $Million)			Average (2008 $Million)			Maximum (2008 $Million)		
	Revised Budget Estimate (Run A to Run D)	Difference from 2008	% Difference from 2008	Revised Budget Estimate (Run A&B to Run C&D)	Difference from 2008	% Difference from 2008	Revised Budget Estimate (Run B to Run C)	Difference from 2008	% Difference from 2008
303	292	-11	-3%	329	26	9%	360	57	19%

*NSCC 2008 Capital Works Budget

Table 4-2: Cost Scenario 2 (Unanticipated Cost) Implication of Climate Change on NSCC's Capital Works Program

NSCC 2008 Capital Works Budget	Minimum (2008 $Million)			Average (2008 $Million)			Maximum (2008 $Million)		
	Revised Budget Estimate (Run A to Run D)	Difference from 2008	% Difference from 2008	Revised Budget Estimate (Run A&B to Run C&D)	Difference from 2008	% Difference from 2008	Revised Budget Estimate (Run B to Run C)	Difference from 2008	% Difference from 2008
303	398	95	31%	425	122	40%	446	143	47%

Table 4-3: Cost Scenario 2 (Unanticipated Cost, NPV cost estimate) Implication of Climate Change on NSCC's Capital Works Program

NSCC 2008 Capital Works Budget	Minimum (2008 $Million)			Average (2008 $Million)			Maximum (2008 $Million)		
	Revised Budget Estimate (Run A to Run D)	Difference from 2008	% Difference from 2008	Revised Budget Estimate (Run A&B to Run C&D)	Difference from 2008	% Difference from 2008	Revised Budget Estimate (Run B to Run C)	Difference from 2008	% Difference from 2008
303	377	74	25%	398	95	31%	415	112	37%

5 CONCLUSIONS

The regionally downscaled rainfall was not an accurate reflection of the historic rain which fell on the catchment. Undertaking further work to match synthetic rainfall produced from regional downscaling to the statistics of actual gauge data will yield a more readily useable data set.

The theoretical cost of climate change if accounted for prior to it occurring is a nominal increase in predicted cost – approximately 10%.

The theoretical cost of climate change if nothing is done until after the change occurs is a significant cost of approximately 40% (or 31% if using NPV).

Wastewater systems are very sensitive to changes in rainfall patterns and the cost implications of climate change are large. Additional work is required to determine the best way to account for climate change with regard to capital works programmes.

The risk of the climate change rainfall estimates being incorrect are very high.

Growth is the largest unknown in the planning assumptions used for future scenarios and design horizons. The capital cost is influenced heavily by growth. Between the original Project CARE work and the Project CARE Review predicted growth changed by 25% over an 8 year period. Over the design life the impact of the variance of growth on the capital programme could be significant requiring significant changes to the programme.

Growth determines when upgrades occur, the level of service gives the size the asset needs to be, any climate change effect is a safety factor additional to the LOS.

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