

# DEEPENING, LENGTHENING AND WIDENING OF BERTH 203 TO 205, PIER 2, CONTAINER TERMINAL, PORT OF DURBAN

## Climate Change Adaptation Monitoring and Evaluation Plan

Authority Reference No: 14/12/16/3/3/2/275

February 2016

Final

Prepared for: Transnet National Port Authority










Environmental, Social and OHS Consultants


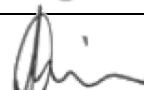
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# Title and Approval Page

Project Name:	Deepening, Lengthening and Widening of Berth 203 to 205, Pier 2, Container Terminal, Port of Durban
Report Title:	Climate Change Adaptation Monitoring and Evaluation Plan
Authority Reference:	14/12/16/3/3/2/275
Report Status	Draft

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Report Reference:	10451			R-PRO-REP 20150514	

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## Amendments Page

Date:	Nature of Amendment	Amendment Number:
10 November 2015	First draft for internal review	00
07 December 2015	Amended based on internal review	01
8 December 2015	Amended based on ZAA comments	02
13 February 2016	Amended based on Transnet Comments	03

## Executive Summary

Transnet plans to upgrade Berths 203 to 205, Pier 2, Container Terminal, Port of Durban. The existing Blockwork Quay wall structure along Pier 2 Berth 203 to 205 was designed in the 1970s to support dockside cranes with the lifting capacity of 4 tonnes. The quay walls are presently operating beyond their original design limitations. Recent studies have concluded that the existing quay walls do not meet the minimum Eurocode 7 Safety Standards and that there is a risk of potential quay wall failure (PRDW, 2011)

Nemai Consulting was appointed by Transnet to undertake the requisite Environmental Authorisation Process for the Proposed Berth 203 to 205, Pier 2 upgrade and the Department of Environmental Affairs granted the Environmental Authorisation for the development on 21 January 2015. The authorisation contained a number of specific conditions including the following:

*“A monitoring and evaluation plan with regards to Climate Change Adaptation must be compiled and submitted to the Directorate: Climate Change Adaptation – Natural Resources for the attention of Mr Sibonelo Mbanjwa for approval prior to the commencement of any construction activities.”*

In line with the requirements above, a meeting was held with Mr Mbanjwa on 13 October 2015 where it was explained that the Climate Change Adaptation Monitoring and Evaluation Plan must meet the following expectations:

- The document should be aligned to the Durban Climate Change Strategy;
- The document should incorporate measures from international examples; and
- The document should provide pro-active measures for adapting to Climate Change.

Based on the above expectations and the requirements of the Environmental Authorisation, this plan aims at ensuring proper implementation of all requisite Climate Change Adaptation measure required for the Berth 203 to 205 Expansion during construction and operation. The plan provides an overview of the baseline climatic conditions as well as an overview of Climate Change scenarios (obtained from international, national and local sources). It explains that adaptation measures adopted as part of the development in light of the Durban Climate Change Strategy and provides a framework for monitoring and evaluation.

With the successful implementation of the adaptation measures (assessed through proper and detailed monitoring and evaluation), it is possible to ensure that Berth 203 to 205 will not be vulnerable to Climate Change.

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# List of Abbreviations

AR4	Assessment Report 4
AR5	Assessment Report 5
ASSAF	Academy of Science South Africa
CCAMEP	Climate Change Adaptation Monitoring and Evaluation Plan
CD	Chart Datum
CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon dioxide
COP	Conference of the Parties
CSIR	Council for Scientific and Industrial Research
DEA	Department of Environmental Affairs
DM	Disaster Management
DWS	Department of Water and Sanitation
EA	Environmental Authorisation
EIA	Environmental Impact Assessment
ERF	Effective Radiative Forcing
GDP	Gross Domestic Product
GHGs	Greenhouse gases
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
LTAS	Long term adaptation scenarios
LWR	Longwave Radiation
M&E	Monitoring and Evaluation
mCDP	Chart Datum Port
MDG	Millennium Development Goals
N <sub>2</sub> O	Nitrous oxide
NATJOC	National Joint Operation Centre
NAVTEX	Navigational Telex
NE	North East
NEMA	National Environmental Management Act, 1998
NNE	North North East
NSRI	National Sea Rescue Institute
PLA	Port of London Authority
PSMSL	Permanent Service for Mean Sea Level
RF	Radiative Forcing

SAMSA	South African Maritime Safety Authority
SANDF	South African National Defence Force
SANHO	South African Navy Hydrographic Office
SAPS	South African Police Service
SAWS	South African Weather Service
SLR	Sea Level Rise
STS	Ship to Shore
SWR	Shortwave Radiation
TNPA	Transport National Ports Authority
UNFCCC	United Nations Framework Convention on Climate Change
WMA	Water Management Area

## List of Definitions

Adaptation	The process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.
Climate Change	A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer.
Evaluation	The act of verifying the effectiveness of the measures taken and adjusting them based on the observed outcomes.
Monitoring	An ongoing process of tracking and reviewing activities, their results, and the surrounding context. The aim is usually to make immediate adjustments to activities if deviations from objectives, targets, or standards are detected.
Vulnerability	The propensity or predisposition to be adversely affected by Climate Change

## 1 ADAPTATION, MONITORING AND EVALUATION

Transnet plans to upgrade Berths 203 to 205, Pier 2, Container Terminal, Port of Durban. The existing Blockwork Quay wall structure along Pier 2 Berth 203 to 205 was designed in the 1970s to support dockside cranes with the lifting capacity of 4 tonnes. The quay walls are presently operating beyond their original design limitations. Recent studies have concluded that the existing quay walls do not meet the minimum Eurocode 7 Safety Standards and that there is a risk of potential quay wall failure (PRDW, 2011)

Nemai Consulting was appointed by Transnet to undertake the requisite Environmental Authorisation (EA) Process for the Proposed Berth 203 to 205, Pier 2 upgrade and the Department of Environmental Affairs (DEA) granted the EA for the development on 21 January 2015. The authorisation contained a number of specific conditions including the following:

*“A monitoring and evaluation plan with regards to Climate Change Adaptation must be compiled and submitted to the Directorate: Climate Change Adaptation – Natural Resources for the attention of Mr Sibonelo Mbanjwa for approval prior to the commencement of any construction activities.”*

In line with the requirements above, a meeting was held with Mr Mbanjwa on 13 October 2015 and guidance was provided on the Department’s requirements. With this in mind, this document serves as the Climate Change Adaptation Monitoring and Evaluation (M&E) Plan for Berth 203 to 205 Expansion EIA. The M&E Plan is aligned to Durban Adaptation Strategy, incorporates international examples and provides proactive adaptation measures.

Firstly, in order to understand the concept on climate and climate change, it is important to distinguish between the concepts of climate and weather: Weather describes the conditions of the atmosphere at a certain place and time with reference to temperature, pressure, humidity, wind, and other key parameters (meteorological elements). Climate, on the other hand, is usually defined as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years (IPCC, 2013). The relevant quantities are most often surface variables such as temperature, precipitation and wind. Classically the period for averaging these variables is 30 years, as defined by the World Meteorological Organization (IPCC, 2013). The main difference is that while weather changes on a daily basis, climate represents the statistical distribution of weather patterns over time.

Taking the concepts of weather and climate further, and in line with the National Climate Change Response White Paper, Climate Change refers to an *ongoing trend of changes in the earth's general weather conditions*. A more formal definition is provided by the Intergovernmental Panel on Climate Change (IPCC): *"A change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer."* (IPCC, 2013).

Further, it is necessary to understand the concepts of vulnerability and adaptation. The IPCC defines **vulnerability** as the propensity or predisposition to be adversely affected whilst **adaptation** is defined (in human systems), *as the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities*. In natural systems, it is the process of adjustment to actual climate and its effects; however it should be noted that human intervention may facilitate adjustment to expected climate (IPCC, 2012).

The process of adaptation is not new and throughout history, people have been adapting to changing conditions, including natural long-term changes in climate (UNDP, 2004). There are a number of available actions that range from incremental steps to transformational changes for reducing risk from climate extremes and social, economic, and environmental sustainability can be enhanced by disaster risk management and adaptation approaches (IPCC, 2012). One of the main questions that are asked in regards to adaptation is whether the measures implemented have been effective. The type of evaluation used to answer this question is often carried out simultaneously with the monitoring of measures in an approach known as monitoring and evaluation (M&E).

**Evaluation** can help adaptation become a more conscious, anticipated and planned process by verifying the effectiveness of the measures taken and adjusting them based on the observed outcomes (Beaulieu, 2010). Evaluation can also help reactive and autonomous adaptation to be more effective. For example, a municipality that plans and implements landscaping in certain rural areas to prevent flooding in the city located downhill may make observations in order to decide whether it is worthwhile to build this landscaping in other communities or consider other options. It can verify whether or not the landscaping actually intercepts the runoff and whether or not the flooding in the town is reduced by the equivalent amount of rain in the drainage basin (Beaulieu, 2010).

Project specific Climate Change Adaptation M&E Plans are not common however there is extensive literature of the development of Climate change adaptation plans as well as M&E plans. According to Spearman (2011), **Monitoring** refers to an ongoing process of tracking and reviewing activities, their results, and the surrounding context. The aim is usually to make immediate adjustments to activities if deviations from objectives, targets, or standards

are detected. However, monitoring also generates information that can be used for in-depth evaluations of projects or programs. Because monitoring and evaluation are often considered a single “M&E system,” this plan has dealt with them together.

M&E can play an important role in any instance where there is a need to document results and improve performance. However, given the uncertainty and dynamism associated with climate change, M&E is especially important for adaptation. Specifically, M&E systems play two critical roles in promoting successful adaptation:

- Firstly, they provide critical support to the long-term process of learning “what works” in adaptation. M&E can broaden understanding of adaptation options to improve definitions of adaptation effectiveness, and over time, to ensure that adaptation efforts deliver their intended results.
- Secondly, they provide a powerful tool to help different stakeholders manage their work. For example, over the near term, practitioners may use M&E to:
  - Adjust adaptation activities based on how successful they are in achieving intended adaptation objectives;
  - Adjust adaptation activities to address unexpected challenges, unintended consequences, or other surprises;
  - Compare institutional structures, processes, and results across various interventions in different locations; and
  - Prompt discussion and shared learning among participants and stakeholders in a particular adaptation initiative (Spearman, 2011).

The Local Government Association of South Australia (2012) suggests the following methodology for the compilation of Adaptation Plans:

- **Scope:** Define the scope of the study in terms of geography (location, region) and sector (Council, industry, business) and identify key stakeholders;
- **General Climate Change Impacts:** Identify the relevant general climate change stresses that will occur and the likely impacts;
- **Key decisions:** Identify the detailed information required to make the key decisions or answer the key questions needed to respond to the general climate change impacts;
- **Climate change scenarios:** Source relevant downscaled climate change scenarios for the geographic area and timeframes required for detailed studies;
- **Detailed climate change impacts and vulnerabilities:** Quantify detailed climate change impacts and / or vulnerabilities relevant to the key decisions; and

- **Identify adaptation actions:** Identify adaptation actions based on outputs from the integrated climate change vulnerability assessment and prioritise (Local Government Association of South Australia, 2012)

The United Nations Framework Convention on Climate Change (UNFCCC) highlights the need to:

- Understand current trends;
- Assess impacts and vulnerability, and
- Plan for Adaptation (United Nations Framework Convention on Climate Change, 2011).

This approach has been modified to take into account the DEA's requirements for the the Climate Change Adaptation M&E Plan. A document roadmap is provided in **Table 1** and describes how the requirements of the DEA are addressed throughout this document.

**Table 1: Document Roadmap**

Chapter Number	Chapter Name	Overview	Alignment with EA's requirements
1.	Adaptation, Monitoring and Evaluation	<ul style="list-style-type: none"> <li>• Provides an overview of adaptation, monitoring and evaluation.</li> <li>• Describes the methodology used.</li> <li>• Describes how the DEA's requirements have been taken into account.</li> </ul>	-
2.	Overview of the Berth 203 to 205 Expansion	<ul style="list-style-type: none"> <li>• Define the scope of the project.</li> </ul>	-
3.	Climate Change Science and Impacts	<ul style="list-style-type: none"> <li>• Provides overview of relevant climate change scenarios.</li> </ul>	<ul style="list-style-type: none"> <li>• Take into consideration climate change projection work done in the country specifically work done in the Durban area around sea level rise and climate change adaptation response.</li> <li>• Be informed by the IPCC, National Research on Climate Change (Long Term Adaptation Scenarios flagship research (LTAS) and the Durban Adaptation Response.</li> </ul>
4.	Climate Change Policy and	<ul style="list-style-type: none"> <li>• Provides an overview of the policy which informed the</li> </ul>	-



Chapter Number	Chapter Name	Overview	Alignment with EA's requirements
	Framework	development of the plan.	
5.	Climate Change Projections for Durban Bay	<ul style="list-style-type: none"> <li>Provides overview of relevant climate change scenarios for the Durban area taking into account, IPCC information, LTAS information as well as relevant information from eThekweni Metropolitan Municipality.</li> <li>Information from the Durban Climate Change Strategy has also been highlighted.</li> </ul>	<ul style="list-style-type: none"> <li>Be informed by the IPCC, National Research on Climate Change (Long Term Adaptation Scenarios flagship research (LTAS) and the Durban Adaptation Response.</li> <li>Integrate input from the Climate Change Unit of the eThekweni Municipality and address issues of relevance as their input.</li> <li>Not only consider the past climate trends but also projected future climate change scenarios.</li> </ul>
6.	Climate Change Vulnerabilities and Adaptation Responses	<ul style="list-style-type: none"> <li>Quantifies climate change vulnerabilities relevant to the key decisions and identifies adaptation actions.</li> <li>Information on how the Climate Change Adaptation Plan is aligned with the Durban Climate Change Strategy is discussed in detail.</li> </ul>	<ul style="list-style-type: none"> <li>Indicate when the sea level rise projections are in line with the projections used by the eThekweni Municipality and when they are not, and must consider the Climate Change projections based on the LTAS done by this Department.</li> <li>Address immediate response capacity to unanticipated scenarios before it affects the development.</li> <li>Provide proactive mitigation measures (as opposed to re-active measures – fix after the damage) to manage the potential damages to the Central Sandbank extension due to inclement weather, wind, wave currents and storm surges.</li> <li>Integrate input from the Climate Change Unit of the eThekweni Municipality and address issues of relevance as their input.</li> <li>Provide proactive mitigation and adaptation measures (as opposed to re-active measures – fix after the damage) to manage the potential damage to the Central Sandbank extension due to Climate Change resulting inter-alia in changes in sea level and increase in severity of storm surge. <ul style="list-style-type: none"> <li>Include weather information or climate information for the Durban Port which must be</li> </ul> </li> </ul>



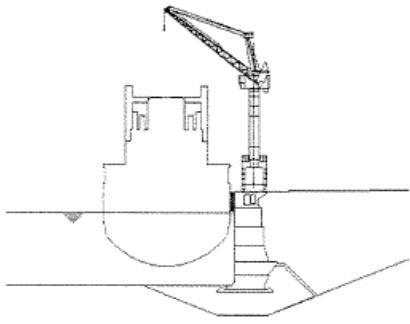
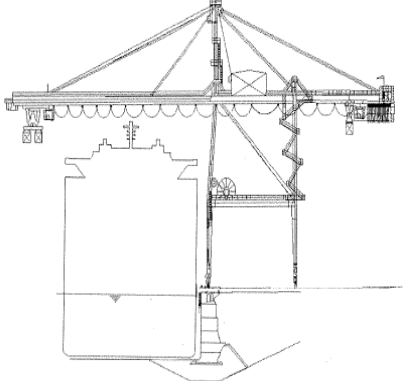
Chapter Number	Chapter Name	Overview	Alignment with EA's requirements
			recorded quarterly. The method of adapting in cases where the current measures are proven inadequate must be detailed. This must include the construction and operation phase of the development.
7.	Monitoring and Evaluation	<ul style="list-style-type: none"> <li>Includes process to be followed for the tracking and reviewing of activities, their results.</li> </ul>	<ul style="list-style-type: none"> <li>A monitoring and evaluation plan with regards to Climate Change Adaptation must be compiled and submitted to the Directorate: Climate Change Adaptation – Natural Resources for the attention of Mr Sibonelo Mbanjwa for approval prior to the commencement of any construction activities.”</li> </ul>

## 2 OVERVIEW OF THE BERTH 203 TO 205 EXPANSION

The existing blockwork quays of Berths 203 to 205 were designed in the 1970s and do not meet the required Eurocode 7 minimum standards of safety (PRDW, 2011). The recent Transnet (2009) study indicates that there is a potential risk for quay wall failure.

The existing berths have a design water depth of -12.8m Chart Datum Port (mCDP) which could accommodate a typical vessel draft of 11.5m. This would allow an underkeel clearance of approximately 1.3m.

**Table 2: Visual summary of original design conditions and current operating conditions at Durban Container Terminal (DCT)**

Original design conditions	Current operating conditions
	
The original quay wall was designed to accommodate a 1000 TEU vessel with wharf cranes	DCT is presently operating vessels of 6000 TEU and greater.
	

Presently the Port has to accommodate fully laden Post Panamax vessel with drafts of 12.5m. The underkeel clearance is therefore only 300mm and results in scour holes being formed which undermine the structural stability of the existing quay wall.

Major container shipping liners are using Super Post Panamax vessels with drafts of 14.5m. This is in excess of the permissible draft and these vessels therefore enter the Port partially laden and for safety reasons their arrival and departure is limited to the high tide window (Table 2).

The main motivation for the upgrade of the quay wall at Berth 203 to 205, Pier 2 is the current unsafe conditions at the berths. However, in order for the Port of Durban to remain competitive as a 'hub' port for southern Africa there is also a need to accommodate Super Post Panamax vessels which require deeper channels and longer berths. The combination of these motivating factors has contributed to the decision to upgrade and extend Berth 203 to 205 thus providing safe berthing conditions and meeting the present demand of shipping companies for ports which can accommodate large container vessels.

The upgrade includes the following activities:

- The westward lengthening of Berth 205 by 170m;
- The eastward lengthening of Berth 203 by 100m;
- The seaward widening of Berths 203 to 205 by 50m;
- The deepening of the berth channel, approach channel, and vessel turning basin from the current -12.7m CDP to -16.5m CDP;
- The excavation of trench to -19m CDP for the Caisson Quay Wall;
- The construction of caissons at Bayhead Lot 10;
- The offshore disposal of dredge material;
- The offshore sand winning for infill material; and
- The installation of new Ship to Shore (STS) cranes and associated infrastructure.

Due to concerns raised, a number of dredge footprints were assessed to minimise the impact to the Sandbank. In order to minimise the volume of dredge material disposed of as well as to decrease the impact the Sandbank, the alternative dredge footprints were refined to include the Sandbank Extension (Option 3B-3G).

Ship movement simulations were then undertaken and showed that the turning basin of Option 3G was larger than required. This resulted in a further modification of the dredge footprint (Option 3H). As with 3G, this option takes into account all concerns regarding Central Sandbank habitat loss and with the extension of the Central Sandbank however it results in an increased net gain of 0.8% of habitat and an increase in ecologically important habitats such as low subtidal and intertidal habitat (55% and 4.9% respectively) (**Figure 1**).

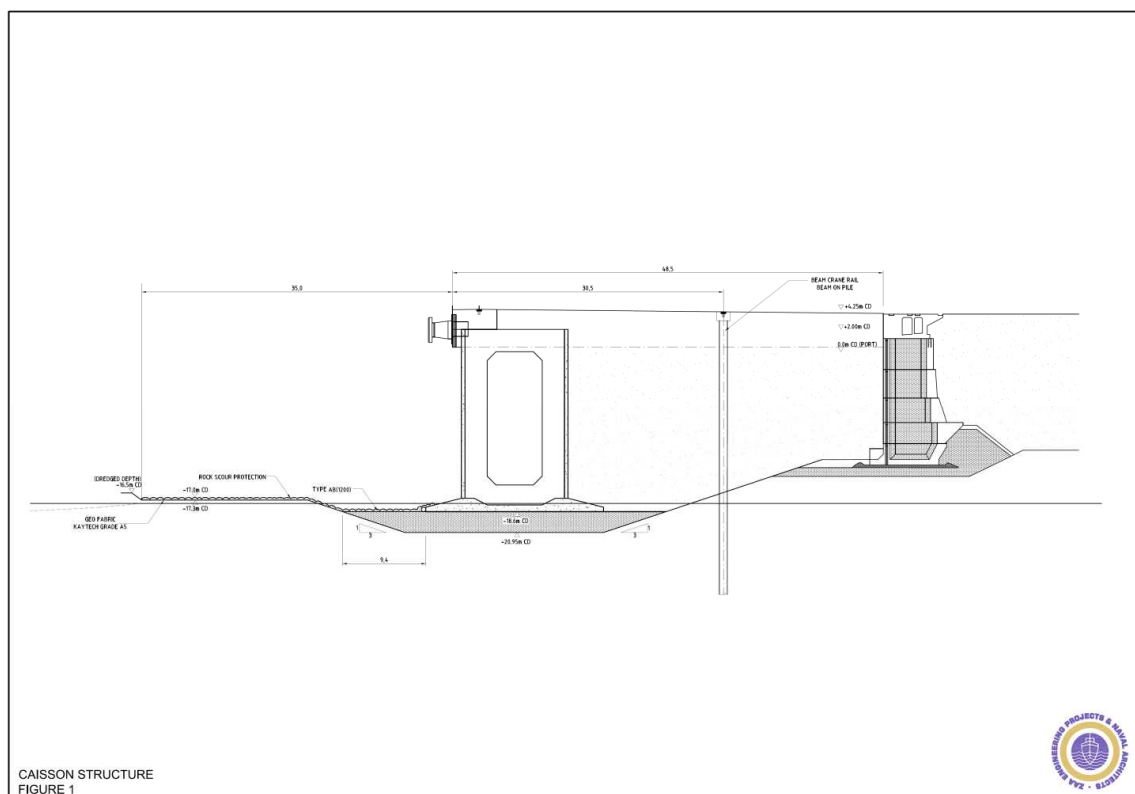


**Figure 1: Option 3H**

In addition, a number of different types of alternatives were assessed as part of the Environmental Impact Assessment (EIA) process. Based on the findings of the specialist studies and technical assessment, the following alternatives were recommended and subsequently approved:

- Caisson quay wall (**Figure 2**);
- Offshore Sandwinning Area 1a.

Bayhead Lot 10 will be used for the construction of caissons and dredged material will be disposed offshore at the existing disposal site



### Figure 2: Caissons

### 3 CLIMATE CHANGE SCIENCE AND IMPACTS

### 3.1 A Brief Overview of Climate Change

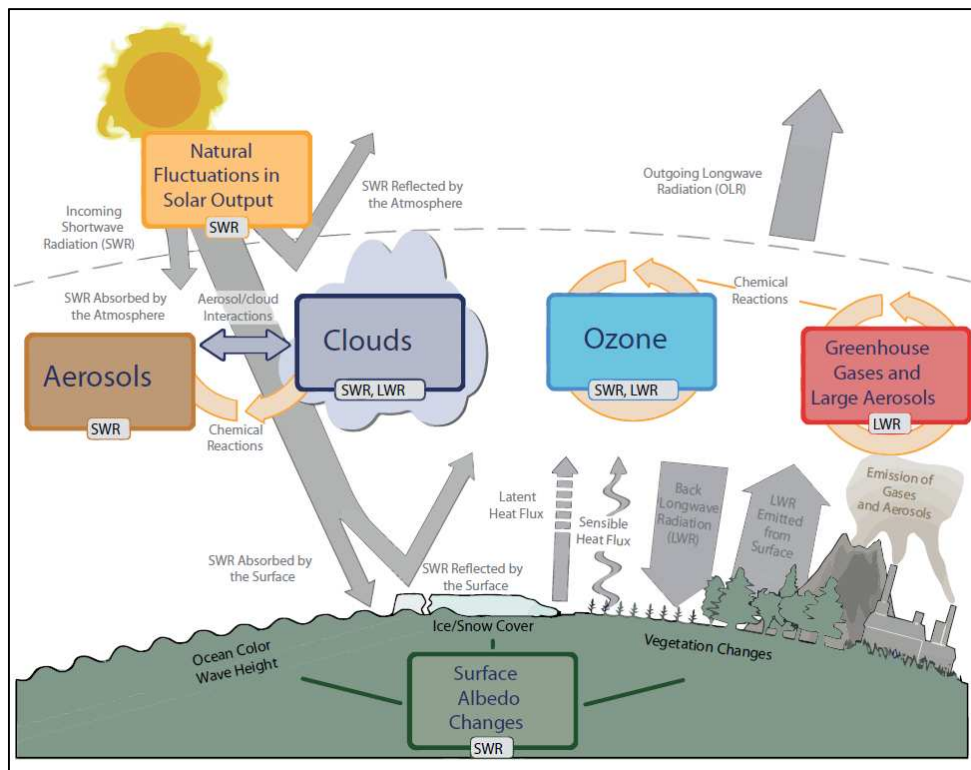
In order to adequately respond and adapt to Climate Change, it is necessary to understand the available information regarding climatic trends. The IPCC was set up in 1988 by the World Meteorological Organization and the United Nations Environment Programme to provide governments with a clear view of the current state of knowledge about the science of climate change, potential impacts, and options for adaptation and mitigation through regular assessments of the most recent information published in the scientific, technical and socio-economic literature worldwide. There have been a number of IPCC reports through the years and the most recent work (IPCC AR5) presents the most up-to-date assessment of the current state of research regarding climate change (IPCC, 2012a). The information summarised below has been taken from the Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the



Intergovernmental Panel on Climate Change (IPCC, 2013) and aims to provide the reader with a broad overview of the science of Climate Change.

### 3.1.1 What is Climate Change?

**Figure 3** below provides an overview of the Earth's climate system which is primarily powered by solar radiation. Aspects such as solar shortwave radiation (SWR) and longwave radiation (LWR) influence the temperature of the earth with about 20% of SWR being absorbed in the atmosphere.(IPCC, 2013). LWR is however largely absorbed by certain atmospheric constituents—water vapour, carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O) and other greenhouse gases (GHGs); and clouds, which themselves emit LWR into all directions. The downward directed component of this LWR adds heat to the lower layers of the atmosphere and to the Earth's surface. This is often called the greenhouse effect (IPCC, 2013).



**Figure 3: Main Drivers of Climate Change (IPCC, 2013)**

There are also a number of global climate 'drivers' such as natural fluctuations in solar output (solar cycles) - which can cause changes in the energy balance (through fluctuations in the amount of incoming SWR) as well as human activity – which changes the emissions of gases and aerosols, resulting in modified O<sub>3</sub> and aerosol amounts. O<sub>3</sub> and aerosol particles absorb, scatter and reflect SWR, changing the energy balance. In addition, some aerosols

act as cloud condensation nuclei modifying the properties of cloud droplets and possibly affecting precipitation. As the cloud interactions with SWR and LWR are large, small changes in the properties of these clouds have important implications for the radiative budget. In addition, anthropogenic changes in GHGs (e.g., CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, O<sub>3</sub>, CFCs) and large aerosols (>2.5  $\mu$  m in size) modify the amount of outgoing LWR by absorbing outgoing LWR and re-emitting less energy at a lower temperature.

In addition to changing the atmospheric concentrations of gases and aerosols, humans are affecting both the energy and water budget of the planet by changing the land surface, including redistributing the balance between latent and sensible heat fluxes (sensible heat is the energy associated with the temperature of a body whilst latent heat is the energy associated with changing the "phase" of a substance, that is, changing the state from gas to fluid or from fluid to solid, or the reverse). Land use changes change the characteristics of vegetation, including its colour, seasonal growth and carbon content. For example, clearing and burning a forest to prepare agricultural land reduces carbon storage in the vegetation, adds CO<sub>2</sub> to the atmosphere, and changes the reflectivity of the land (surface albedo), rates of evapotranspiration and longwave emissions.

Another important concept is that of radiative forcing (RF) – where changes in the atmosphere, land, ocean, biosphere and cryosphere (both natural and anthropogenic) can perturb the earth's radiation budget, producing a RF that affects climate. RF is a measure of the net change in the energy balance in response to an external perturbation (IPCC, 2013). However, the concept of RF cannot capture the interactions of anthropogenic aerosols and clouds and thus it is necessary to also take into account effective radiative forcing (ERF) that accounts for rapid response in the climate system. Once a forcing is applied, complex internal feedbacks determine the eventual response of the climate system, and will in general cause this response to differ from a simple linear one. There are many feedback mechanisms in the climate system that can either amplify ('positive feedback') or diminish ('negative feedback') the effects of a change in climate forcing.

In summary, GHGs are emitted from, and are reabsorbed by, a variety of natural sources, but the rate at which human economies and societies are emitting these gases far exceeds the capacity of natural ecosystems to reabsorb them. The evidence that current global warming is due to human activities associated with industrialisation and modern agriculture is overwhelming and the rate of change to the earth's climate exceeds the ability of all types of ecosystems (marine, coastal, freshwater, and terrestrial) to adapt as well as compromising their ability to function effectively. It is therefore necessary to ensure that developments take into account adaptation responses to Climate Change.



### 3.1.2 How do we know that Climate Change is happening?

While the first IPCC assessment depended primarily on observed changes in surface temperature and climate model analyses, more recent assessments include multiple lines of evidence for climate change. The first line of evidence in assessing climate change is based on careful analysis of observational records of the atmosphere, land, ocean and cryosphere systems (**Figure 4**). There is incontrovertible evidence from in situ observations and ice core records that the atmospheric concentrations of GHGs such as CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O have increased substantially over the last 200 years.

In addition, instrumental observations show that land and sea surface temperatures have increased over the last 100 years.

Satellites allow a much broader spatial distribution of measurements, especially over the last 30 years. For the upper ocean temperature the observations indicate that the temperature has increased since at least 1950. Observations from satellites and in situ measurements suggest reductions in glaciers, Arctic sea ice and ice sheets. In addition, analyses based on measurements of the radiative budget and ocean heat content suggest a small imbalance. These observations, all published in peer-reviewed journals, made by diverse measurement groups in multiple countries using different technologies, investigating various climate-relevant types of data, uncertainties and processes, offer a wide range of evidence on the broad extent of the changing climate throughout our planet.

In addition to observational information, Climate models have improved since the AR4 and findings suggest that:

- The long-term climate model simulations show a trend in global-mean surface temperature from 1951 to 2012 that agrees with the observed trend (very high confidence). There are, however, differences between simulated and observed trends over periods as short as 10 to 15 years (e.g., 1998 to 2012).
- The observed reduction in surface warming trend over the period 1998 to 2012 as compared to the period 1951 to 2012, is due in roughly equal measure to a reduced trend in radiative forcing and a cooling contribution from natural internal variability, which includes a possible redistribution of heat within the ocean (medium confidence). The reduced trend in radiative forcing is primarily due to volcanic eruptions and the timing of the downward phase of the 11-year solar cycle. However, there is low confidence in quantifying the role of changes in radiative forcing in causing the reduced warming trend. There is medium confidence that natural internal decadal variability causes to a substantial degree the difference between observations and the simulations; the latter are not expected to reproduce the timing of natural internal variability. There may also be a contribution from forcing

inadequacies and, in some models, an overestimate of the response to increasing greenhouse gas and other anthropogenic forcing (dominated by the effects of aerosols).

- On regional scales, the confidence in model capability to simulate surface temperature is less than for the larger scales. However, there is high confidence that regional-scale surface temperature is better simulated than at the time of the AR4.
- There has been substantial progress in the assessment of extreme weather and climate events since AR4. Simulated global-mean trends in the frequency of extreme warm and cold days and nights over the second half of the 20th century are generally consistent with observations.
- There has been some improvement in the simulation of continental-scale patterns of precipitation since the AR4. At regional scales, precipitation is not simulated as well, and the assessment is hampered by observational uncertainties.
- Some important climate phenomena are now better reproduced by models. There is high confidence that the statistics of monsoon and El Nino-Southern Oscillation based on multi-model simulations have improved since AR4.
- Climate models now include more cloud and aerosol processes, and their interactions, than at the time of the AR4, but there remains low confidence in the representation and quantification of these processes in models.
- There is robust evidence that the downward trend in Arctic summer sea ice extent since 1979 is now reproduced by more models than at the time of the AR4, with about one-quarter of the models showing a trend as large as, or larger than, the trend in the observations. Most models simulate a small downward trend in Antarctic sea ice extent, albeit with large inter-model spread, in contrast to the small upward trend in observations.
- Many models reproduce the observed changes in upper-ocean heat content (0–700 m) from 1961 to 2005 (high confidence), with the multi-model mean time series falling within the range of the available observational estimates for most of the period.
- Climate models that include the carbon cycle (Earth System Models) simulate the global pattern of ocean-atmosphere CO<sub>2</sub> fluxes, with outgassing in the tropics and uptake in the mid and high latitudes. In the majority of these models the sizes of the simulated global land and ocean carbon sinks over the latter part of the 20th century are within the range of observational estimates.

### 3.1.3 Summary of Findings of IPCC AR5 Report

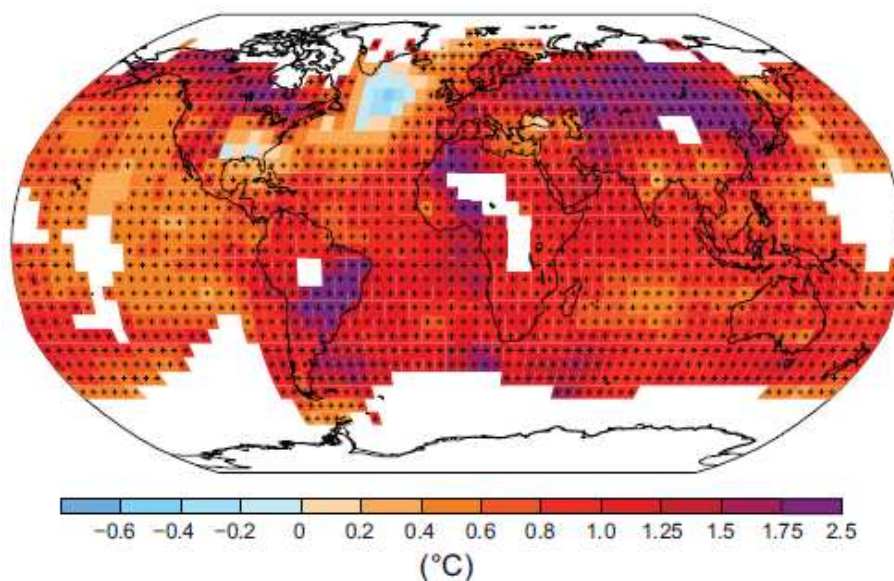
#### 3.1.3.1 Atmosphere

Each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850 with the globally averaged combined land and ocean

surface temperature data as calculated by a linear trend, show a warming of 0.85 [0.65 to 1.06] °C, over the period 1880 to 2012 (IPCC, 2013).

Changes in many extreme weather and climate events have also been observed since about 1950 and the frequency of heat waves has increased in large parts of Europe, Asia and Australia. There are also more land regions where the number of heavy precipitation events has increased. The frequency or intensity of heavy precipitation events has likely increased in North America and Europe. (IPCC, 2013).

The AR5 also notes that it is very likely that the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale.



**Figure 4: Observed change in surface temperature 1901–2012(IPCC, 2013)**

### 3.1.3.2 Ocean

Ocean warming dominates the increase in energy stored in the climate system and accounts for more than 90% of the energy accumulated between 1971 and 2010. It is *virtually certain* that the upper ocean (0–700 m) warmed from 1971 to 2010. On a global scale, the ocean warming is largest near the surface, and the upper 75 m warmed by 0.11 [0.09 to 0.13] °C per decade over the period 1971 to 2010.

### 3.1.3.3 Cryosphere

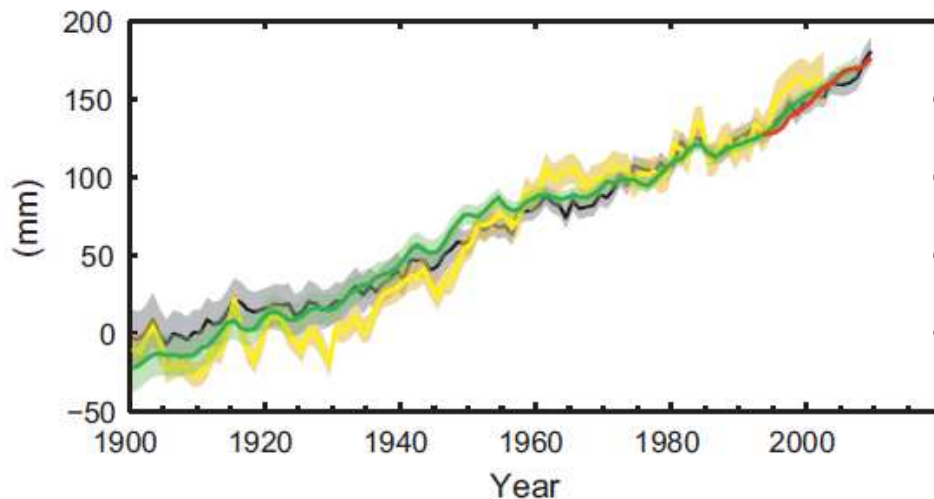
Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent.

In addition, there is very high confidence that the extent of Northern Hemisphere snow cover has decreased since the mid-20<sup>th</sup> century. Northern Hemisphere snow cover extent

decreased 1.6 [0.8 to 2.4] % per decade for March and April, and 11.7 [8.8 to 14.6] % per decade for June, over the 1967 to 2012 period (IPCC, 2013).

#### 3.1.3.4 Sea Level

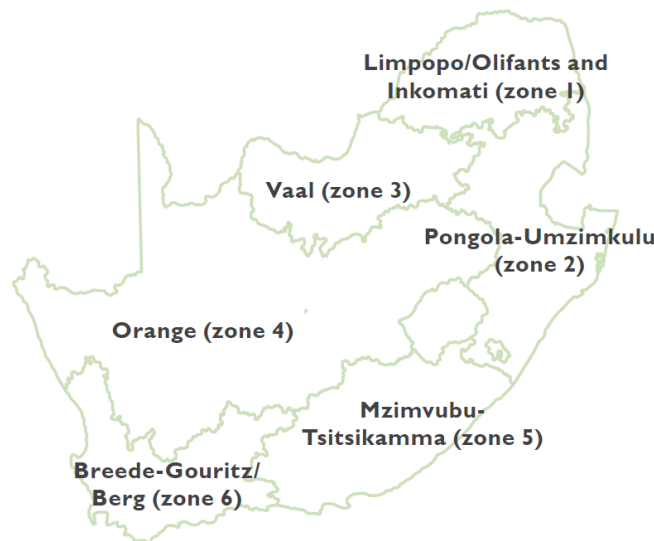
The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia. Over the period 1901 to 2010, global mean sea level rose by 0.19 [0.17 to 0.21] m (IPCC, 2013) (**Figure 5**).



*Figure 5: Global average sea level change (IPCC, 2013)*

## 3.2 The South African Context

The DEA has undertaken the Long Term Adaptation Scenarios Flagship Research Programme (LTAS) which aimed at responding to the South African National Climate Change Response White Paper by developing national and sub-national adaptation scenarios for the country under plausible future climate conditions (Department of Environmental Affairs, 2013). As part of LTAS, Climate trends and projections were done at both a national and local scale, in relation to six hydrological zones of South Africa (**Figure 6**).



*Figure 6: Boundaries of the six modelled hydrological zones (Department of Environmental Affairs , 2013)*

This approach was followed due to that fact that a majority of climate change impacts across South African economic and other sectors will be mediated through primary impacts on the water sector. The six hydrological zones reflect the boundaries defined by water management areas (WMAs) in South Africa. These include:

- **Zone 1:** the Limpopo, Olifants and Inkomati WMAs in the northern interior (Limpopo/Olifants/Inkomati);
- **Zone 2:** the Pongola-Umzimkulu WMA in KwaZulu-Natal in the east (Pongola-Umzimkulu);
- **Zone 3:** the Vaal WMA in the central interior (Vaal);
- **Zone 4:** the Orange WMA in the north west (Orange);
- **Zone 5:** the Mzimvubu-Tsitsikamma WMA in the south east (Mzimvubu-Tsitsikamma); and
- **Zone 6:** Breede-Gouritz and Berg Olifants WMAs in the south west (Breede-Gouritz/Berg).

A summary of the LTAS findings is provided below to provide place the IPCC findings discussed above into the South African context.

### **3.2.1 Observed Climate Trends for South Africa (1960-2012)**

Over the last five decades the following climate trends have been observed in South Africa.

- Mean annual temperatures have increased by at least 1.5 times the observed global average of 0.65°C reported by the AR4 of IPCC for the past five decades.

- Maximum and minimum daily temperatures have been increasing annually, and in almost all seasons. A notable exception is the central interior (Zone 3, Vaal), where minimum temperatures have been increasing less strongly, and some decreases have been observed.
- High and low temperatures (i.e. hot and cold extremes) have respectively increased and decreased in frequency in most seasons across the country, particularly in the western and northern interior.
- The rate of temperature change has fluctuated, with the highest rates of increase occurring from the middle 1970s to the early 1980s, and again in the late 1990s to middle 2000s.
- Rainfall has shown high inter-annual variability, with smoothed rainfall showing amplitude of about 300 mm, about the same as the national average.
- Annual rainfall trends are weak overall and nonsignificant, but there is a tendency towards a significant decrease in the number of rain days in almost all hydrological zones. This implies a tendency towards an increase in the intensity of rainfall events and increased dry spell duration.
- There has also been a marginal reduction in rainfall for the autumn months in almost all hydrological zones.
- Extreme rainfall events show a tendency towards increasing in frequency annually, and especially in spring and summer, with a reduction in extremes in autumn.
- Overall, rainfall trends are similar in all the hydrological zones, with rainfall being above average in the 1970s, the late 1980s, and mid to late 1990s, and below average in the 1960s and in the early 2000s, reverting to the long-term mean towards 2010.

### **3.2.2 Projected Rainfall and Temperature Changes for South Africa (2050 and Beyond)**

LTAS also incorporated climate projections which were simulated over southern Africa using both statistical and dynamic downscaling of the output of AR4 (A2 and B1 emissions scenarios) and AR5 (RCPs 8.5 and 4.5) representing unmitigated (A2 and RCP8.5) and mitigated (B1 and RCP4.5) future energy pathways. In addition, a pattern scaling method, using a two dimensional atmospheric model of the Massachusetts Institute of Technology (MIT) Integrated Global System Model was used employing 450ppm CO<sub>2</sub> stabilisation as a mitigated scenario, contrasted with an unmitigated pathway.

The findings of the Climate change projections for South Africa up to 2050 and beyond under unmitigated emission scenarios include:



- All modelling approaches project warming trends until the end of this century, but most approaches project the possibility of both drying and wetting trends in almost all parts of South Africa.
- Very significant warming, as high as 5–8°C, over the South African interior by the end of this century. Warming would be somewhat reduced over coastal zones.
- A general pattern of a risk of drier conditions to the west and south of the country and a risk of wetter conditions over the east of the country.
- Many of the projected changes are within the range of historical natural variability, and uncertainty in the projections is high.
- Effective global mitigation action is projected to reduce the risk of extreme warming trends, and to reduce the likelihood of extreme wetting and drying outcomes by at least mid-century.
- High resolution regional modelling suggests even larger benefits of effective global mitigation by the end of this century, when regional warming of 5–8°C could be more than halved to 2.5–3°C.
- Overall, there is far greater certainty in temperature than in rainfall projections.

### **3.2.3 Projected climate futures for South Africa (2015–2035, 2040–2060 and 2070–2090)**

South Africa's climate future up to 2050 and beyond can be described using four fundamental climate scenarios at national scale, with different degrees of change and likelihood that capture the impacts of global mitigation and the passing of time.

1. warmer (<3°C above 1961–2000) and wetter with greater frequency of extreme rainfall events.
2. warmer (<3°C above 1961–2000) and drier, with an increase in the frequency of drought events and somewhat greater frequency of extreme rainfall events.
3. hotter (>3°C above 1961–2000) and wetter with substantially greater frequency of extreme rainfall events.
4. hotter (>3°C above 1961–2000) and drier, with a substantial increase in the frequency of drought events and greater frequency of extreme rainfall events.

Effective international mitigation responses would reduce the likelihood of scenarios 3 and 4, and increase the likelihood of scenarios 1 and 2 during this century. In both wetter and drier futures a higher frequency of flooding and drought extremes could be expected, with the range of extremes significantly increased under unconstrained emissions scenarios. **Table 3** gives rainfall projections for these scenarios for South Africa's six hydrological zones.

**Table 3: Rainfall projections for each of South Africa's six hydrological zones**

Scenario	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
<b>Warmer and Wetter</b>	Increase in Spring and Summer	Increase in Spring	Increase in Spring and Summer	Increase in all seasons	Increase in all seasons	Decrease in Autumn, increase in winter and spring
<b>Warmer and Drier</b>	Decrease in Summer, Spring Autumn	Decrease in Spring and strong decrease in Summer and Autumn	Decrease in Spring and Summer and strong decrease in Autumn	Decrease in Summer, Spring Autumn	Decrease in all seasons and strong decrease in Summer and Autumn	Decrease in all seasons and strong decrease in the west.
<b>Hotter and Wetter</b>	Strong increase in Spring and Summer	Strong increase in Spring.	Increase in Spring and Summer	Increase in all seasons	Strong increase in all seasons	Decrease in autumn, increase in Winter and Spring.
<b>Hotter and Drier</b>	Strong decrease in Summer, Spring Autumn	Decrease in Spring and strong decrease in Summer and Autumn	Decrease in Spring and Summer and strong decrease in Autumn	Decrease in Summer, Spring Autumn	Decrease in all seasons and strong decrease in Summer and Autumn	Decrease in all seasons and strong decrease in the west.

### 3.2.4 Climate Change Impacts

Climate change impacts on South Africa are likely to be felt primarily via effects on water resources (Department of Environmental Affairs , 2013). Projected impacts are due to changes in rainfall and evaporation rate, but hydrological modelling approaches are also essential for translating these into potential water resource impacts. The findings show the following:

- Preliminary projections for national runoff range from a 20% reduction to a 60% increase by as early as mid-century based on an unmitigated emissions pathway. Across the country, this ranges from increases along the eastern seaboard and central interior to decreases in much of the Western and Northern Cape. If global emissions are constrained to stabilise at 450 ppm CO<sub>2</sub>, these changes are projected to lie between a 5% decrease and a 20% increase in annual runoff.
- Under all four future climate scenarios, a higher frequency of flooding and drought extremes is projected, with the range of extremes exacerbated significantly under the unconstrained global emissions scenario.
- Under a **wetter future** climate scenario, significant increases in runoff would result in increased flooding, human health risks, ecosystem disturbance and aesthetic impacts.
- **Drier future** climate scenarios would result in reduced surface water availability, but would not exclude the risk of extreme flooding events.



- Areas showing highest risks in extreme runoff related events (and flooding conditions) include **KwaZulu-Natal**, parts of southern Mpumalanga and the Eastern Cape. Specific areas at risk to increased evaporation, decreased rainfall and decreased runoff include the south-west and western regions, and to some extent the central region and the extreme north-east.
- Climate-related changes in wind, upwelling, sea surface temperature, productivity, oxygen levels, storm frequency, precipitation, freshwater flow and runoff patterns, may all have impacts on estuaries, inshore and offshore ecosystems.
- Accelerated sea level rise, changes in river flows and increased frequency of high-intensity coastal storms and high water events pose a significant risk to estuarine, inshore and offshore fisheries.
- Sea level rise may reduce estuarine nursery habitat, and decreased rainfall may cause temporarily open estuaries to close more frequently or even permanently, impacting on linefish.
- On a regional scale, KwaZulu-Natal and west coast estuaries are likely to be the most affected from a structural and functional perspective especially under wetter climate scenarios.

### **3.3 Climate Change in Ports**

Ports vary considerably in the functions they perform, in the type of cargo they handle and in the extent to which they carry out cargo handling themselves. The Port of London Authority (PLA) for example is essentially purely a safety and navigation authority for the tidal River Thames and the Thames Estuary, providing pilotage, navigation and dredging services. The PLA does not do any cargo handling nor does it own land on which cargo handling is carried out by others. At the other end of the spectrum there are ports which provide a wide range of cargo handling and warehousing services themselves. Given this diversity, the scope and significance of climate change risks will be very different from port to port (IFC, 2011).

Due to this, the International Finance Corporation (IFC), a member of the World Bank Group, has published a comprehensive framework for assessing the risks of climate change on port operations and options for adapting to risks. The report, titled "Climate Risk and Business: Ports," analyses the climate-related risks and opportunities facing IFC client Terminal Maritimo Muelles el Bosque, a port in Cartagena, Colombia and provides a quantitative assessment of the impact of climate change and potential responses for adapting (IFC, 2011). Some of the main risks include:

- Due to their long lifetimes, Ports will face considerable climate change;

- By virtue of their locations on coasts, rivers or lakes, they are often exposed to a range of climate hazards, including sea level rise, storm surges, extreme wind and waves, and river flooding;
- Shipping movements into and out of ports can be affected by adverse climatic conditions, causing delays to port operations;
- They are vulnerable to the economic impacts of climate change, through impacts on global trade;
- They can transport goods for which demand or supply is climatically-sensitive, such agricultural products or fuel;
- Inland movement of goods from ports relies on transport infrastructure which is likely to be managed by others, and which is, in turn, vulnerable to climate change; and
- Like any other industrial facility, ports are vulnerable to disruptions to utilities, for example water and electricity. Water and electricity supply are both vulnerable to climate change, and decreased reliability of these utilities due to climate change is likely to be a material risk to some ports.

A conceptual model of a port, showing the main Port activities which can be affected by climate change, is presented in **Figure 7**.



**Figure 7: Conceptual model of a port and the main activities which can be affected by climate change**

The key climate change and climate change-related factors which can affect port performance are listed below:

- Increasing mean sea level;
- Increasing storm surge heights;
- Possible increases in storm intensity;
- Changes in seasonable precipitation amounts;

- Increasingly intense precipitation events;
- Increasing seasonal air temperatures;
- Increasing air temperature extremes and heat waves;
- Increasing sea surface temperatures; and
- Increasing CO<sub>2</sub> concentrations (IFC, 2011).

For many coastal ports it is likely that the compound effects of mean sea level rise, high tides and increased storm surges will be the most significant risks of climate change (IFC, 2011).

In terms of storms, high winds can restrict port operations and many port operations have critical thresholds relative to wind speeds. For example, cranes cannot be moved when wind speeds are over a certain threshold, and in extreme wind speeds they have to be taken out of operation all together to avoid damage. In addition, lightning can also force crane operations to be suspended. Heavy rain can also affect a crane's electrical systems and port operability is also reduced during heavy downpours because of the risk of goods spoilage, for goods that are perishable or non-water resistant (IFC, 2011).

The capacity of port drainage systems can also be overwhelmed by extreme precipitation, leading to surface flooding. For those ports with drainage outlets discharging to a water body, increased water levels can further reduce drainage capacity: if water levels on docks and harbours rise above the level of drainage outlets, drainage pipes can be surcharged (especially if the gradient between the level where water enters the pipe and the level of the outlet is low) and the flow through them can be reduced. Higher average temperatures can also increase growth rates of invasive aquatic vegetation, leading to the clogging of drains and consequent need for increased maintenance (IFC, 2011).

Rates of metal corrosion by seawater are an important factor for ports, affecting the structural integrity and strength of metal components (OCIMF, 1997). Corrosion rates depend on a range of factors, including the metal material, cycles of wetting and drying and the water's hydrochemical parameters. It is expected that climate change will affect metal corrosion rates through changes in variables which are known to have a corrosive action. The compound effect of changes in flooding, sea spray, humidity, air temperature, seawater acidity and salinity could significantly accelerate rates of corrosion at some ports. As sea levels rise and storminess increases, new areas of ports may become exposed to sea spray and may require coating or other forms of protection (IFC, 2011). High levels of humidity and high temperatures can also lead to increased corrosion. Research in controlled laboratory conditions found that metal corrosion rates doubled for every 10°C increase in air temperature, though there is uncertainty on whether this relationship is valid in 'real life' conditions (IFC, 2011).

Within South Africa, these risks relate primarily to permanent sea level rise projections as well as with temporary storm events (i.e. “storm surges”) which are anticipated to become both more frequent and more intense in many areas (WSP Environmental, 2013).

## 4 CLIMATE CHANGE POLICY AND FRAMEWORK

### 4.1 The United Nations Framework Convention on Climate Convention

The UNFCCC is the foundation of global efforts to combat global warming. Opened for signature in 1992 at the Rio Earth Summit, its ultimate objective is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. This level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The Convention also sets out some guiding principles which include the precautionary principle (the lack of full scientific certainty should not be used as an excuse to postpone action when there is a threat of serious or irreversible damage) as well as the principle of the ‘common but differentiated responsibilities’ (which assigns the lead in combating climate change to developed countries). Other principles deal with the special needs of developing countries and the importance of promoting sustainable development.

Both developed and developing countries accept a number of general commitments. All Parties will develop and submit national communications containing inventories of greenhouse gas emissions by source and greenhouse gas removals by sinks.. They will adopt national programmes for mitigating climate change and develop strategies for adapting to its impacts. They will also promote technology transfer and the sustainable management, conservation, and enhancement of greenhouse gas sinks and .reservoirs. (such as forests and oceans). In addition, the Parties will take climate change into account in their relevant social, economic, and environmental policies; cooperate in scientific, technical, and educational matters; and promote education, public awareness, and the exchange of information related to climate change.

### 4.2 The Conference of the Parties (COP)

The supreme body of the Convention is the Conference of the Parties (COP). The COP comprises all the states that have ratified or acceded to the Convention (185 as of July

2001). It held its first meeting (COP-1) in Berlin in 1995 and will continue to meet on a yearly basis unless the Parties decide otherwise. The COP's role is to promote and review the implementation of the Convention. It will periodically review existing commitments in light of the Convention's objective, new scientific findings, and the effectiveness of national climate change programmes. The COP can adopt new commitments through amendments and protocols to the Convention.

#### **4.3 The Kyoto Protocol**

The Kyoto Protocol to the UNFCCC aims to strengthen the international response to climate change. Adopted by consensus at the third session of the Conference of the Parties (COP-3) in December 1997, it contains legally binding emissions targets for Annex I (industrialized) countries. By arresting and reversing the upward trend in greenhouse gas emissions that started in these countries 150 years ago, the Protocol promises to move the international community one step closer to achieving the Convention's ultimate objective of preventing dangerous anthropogenic interference with the climate system.

#### **4.4 The National Climate Change Response White Paper, 2011**

The National Climate Change Response White Paper (2011) presents the South African Government's vision for an effective climate change response and the long-term, just transition to a climate-resilient and lower-carbon economy and society. The response details South Africa's response to climate change which has two objectives:

- Effectively manage inevitable climate change impacts through interventions that build and sustain South Africa's social, economic and environmental resilience and emergency response capacity.
- Make a fair contribution to the global effort to stabilise GHGs concentrations in the atmosphere at a level that avoids dangerous anthropogenic interference with the climate system within a timeframe that enables economic, social and environmental development to proceed in a sustainable manner.

The response is guided by the principles set out in the Constitution, the Bill of Rights, the National Environmental Management Act (NEMA), the Millennium Development Goals (MDGs) and the UNFCCC. The principles include, amongst others:

- Common but differentiated responsibilities and respective capabilities – aligning our domestic measures to reduce the country's GHG emissions and adapt to the adverse effects of climate change with our unique national circumstances, stage of development and capacity to act.

- Equity – ensuring a fair allocation of effort, cost and benefits in the context of the need to address disproportionate vulnerabilities, responsibilities, capabilities, disparities and inequalities.
- Special needs and circumstances – considering the special needs and circumstances of localities and people that are particularly vulnerable to the adverse effects of climate change, including vulnerable groups such as women, and especially poor and/or rural women; children, especially infants and childheaded families; the aged; the sick; and the physically challenged.
- Uplifting the poor and vulnerable – climate change policies and measures should address the needs of the poor and vulnerable and ensure human dignity, whilst endeavouring to attain environmental, social and economic sustainability.
- Intra- and Inter-generational sustainability – managing our ecological, social and economic resources and capital responsibly for current and future generations.
- The Precautionary Principle – applying a risk-averse and cautious approach, which takes into account the limits of current knowledge about the consequences of decisions and actions.
- The Polluter Pays Principle – those responsible for harming the environment paying the costs of remedying pollution and environmental degradation and supporting any consequent adaptive response that may be required.
- Informed participation – enhancing public awareness and understanding of climate change causes and impacts to promote participation and action at all levels.
- Economic, social and ecological pillars of sustainable development – recognising that a robust and sustainable economy and a healthy society depends on the services that well-functioning ecosystems provide, and that enhancing the sustainability of the economic, social and ecological services is an integral component of an effective and efficient climate change response.

In terms of adaptation, the National Climate Change Response includes a risk-based process to identify and prioritise short- and medium-term adaptation interventions to be addressed in sector plans.

The response note that all states in the Southern African sub-region face the challenges of rural and urban poverty, limited water or access to water resources, food insecurity, and other development challenges. A regional approach that achieves climate resilience will have significant socio-economic benefits for South Africa, including a smaller risk of unmanaged regional migration.

A leading international assessment of the effects of climate change on the global economy, the Stern Review, estimates that damages from unmitigated climate change could range between 5% and 20% of global Gross Domestic Product (GDP) annually by 2100. In the



absence of effective adaptation responses, such levels of damages would certainly threaten and even reverse many development gains made in South Africa.

Future climate trends are uncertain and the uncertainty rises steeply over the longer-term. Objectives for adaptation must therefore be able to adjust to changing circumstances and time-frames. For this reason, South Africa needs to plan flexibly for a wide range of possible responses over the medium- to long-term. We also need focused monitoring and evaluation systems to update our knowledge of how rapidly the change is occurring and the effectiveness of adaptation responses.

A key feature of adaptation responses is that they have a much stronger local context than do mitigation responses and their benefits may appear much faster and are often more tangible, such as an improvement in local environmental quality, for instance. Effective adaptation responses can also potentially create many jobs, particularly “green jobs”, and could contribute significantly to sustainable development goals. Well planned adaptation responses can thus be effectively integrated with sustainable development policies.

#### **4.5 The Provincial Policy Context**

In 2008 a Provincial vulnerability assessment study was commissioned to provide information for the planning and development of Climate Change adaptation and mitigation implementation strategy in KwaZulu-Natal. The findings of the study provided insight on the following:

- The potential impacts and vulnerabilities of the various sectors;
- Strategic issues of concern, areas at risk, gaps and uncertainties and available information on climate change; and
- Existing initiatives and activities that are aimed at mitigating the consequences of climate change and to identify potential opportunities for climate change projects.

In addition, a cabinet resolution was passed on 13 August 2010 that the Department of Agriculture, Environmental Affairs and Rural Development (DAERD) should report on Climate Change Forecasting and Planning. The resolution noted that changes in climatic trends over the KwaZulu-Natal region are being observed and that these trends are consistent with climate change projections (such as observed warming trends in the north-eastern, Midlands and south coastal parts of the province and wetting trends have been observed over parts of the region during February).

In September 2012, the KwaZulu-Natal Provincial Government became the first provincial government to establish a Climate Change and Sustainable Development Council, which boosts multi-stakeholder membership. The Council has set up three Working Groups,

namely Policy and Regulatory Alignment Working Group; Adaptation and Mitigation Working Group and Renewable Energy Working Group.

Since its inception the Council has had several meetings and initiated a number of bi-laterals agreements with foreign governments. The Council participated at the Rio+20 Sustainable Development in 2011 and also at the COP18 at Doha, Qatar. The Council aims to pursue localization of manufacturing of renewable energy plant components, and also encourages tertiary institutions to pursue more vigorously Innovation, science and technology in the green industries related sectors.

The province is also in the early stages of developing the Climate Change Response and Sustainable Development Plan.

The KwaZulu-Natal Provincial Government is also working closely with the United Nations (UNIDO) and United Nations Development Programme (UNDP) in rolling out the Sustainable Energy for All Programme (SE4ALL) in the Province, including the implementation of the following activities:

- biomass-to-energy project;
- mini-grid project;
- a timber hub;
- electricity retrofitting in government buildings; and
- KZN renewable energy innovation centre and manufacturing hub.

In 2012, the KwaZulu-Natal provincial government was accepted as one of the member regional governments of The Climate Group. The membership has afforded KwaZulu-Natal an opportunity to observe best international practice on innovative and sustainable climate change response programmes. To this end, various KwaZulu-Natal delegations have participated in important international dialogues since becoming members, including

- Showcasing technological innovations in the various regions by members of the States and Regions Alliance and deliberating on the 2012 Programme of Action for the Alliance at the States and Regions General Assembly meeting at the City of Vitoria, the Basque Country, Spain in March 2012;
- A Business for Environment (B4E) conference hosted in Berlin, Germany to explore greater SME involvement in the green economy in May 2012; and
- Government and business summits, including the international launch of The Clean Revolution Campaign, Rio+20 Conference in Rio, Brazil – June 2012.



#### 4.6 eThekwini Policy

eThekwini Metropolitan Municipality is one of the front runners in the country when it comes to understanding and planning for Climate Change in the region. In addition to a number of studies and reports, **the Durban Climate Change Strategy (eThekwini Metropolitan Municipality, 2014)** has been influential in managing Climate Change in the region.

The Metropolitan is also a signatory of the Durban Adaptation Charter (DAC) which was a key output of the *Durban Local Government Convention: adapting to a changing climate – towards COP17/CMP7 and beyond* (2-4 December 2011) which ran concurrently with the United Nations Framework Convention on Climate Change (UNFCCC) COP17/CMP17 held in Durban, South Africa (28 November - 9 December 2011). The DAC was signed by 107 mayors and elected officials representing over 950 local governments. The aim of the DAC was to complement existing local government climate change initiatives, such as the Mexico City Pact (signed prior to COP16/CMP6) and the associated *carbons Climate Registry*. Together they provide a holistic vision for transforming the world's cities and local governments and making them more 'climate smart'. The streamline reporting effort, DAC signatory cities report on their adaptation actions using the *carbons Climate Registry*.

The following main clauses formed part of DAC:

- **Mainstreaming adaptation as a key informant of all local government development planning:** We commit to climate change adaptation as a key consideration in all key local government development strategies and spatial development frameworks. Institutionally climate change should be located in a high level integrating office such as the Executive Mayor or City Manager's office of the local authority.
- **Understand climate risks through conducting impact and vulnerability assessments:** We will undertake local level impact and vulnerability assessments to determine the exposure, sensitivity and adaptive capacity of human and natural systems as guided by best available science and traditional knowledge.
- **Prepare and implement integrated, inclusive and long-term local adaptation strategies designed to reduce vulnerability:** We will prepare evidence-based, locally relevant adaptation strategies and will develop and adopt measures to ensure that the objectives of these strategies are implemented, monitored evaluated and mainstreamed into statutory government planning processes. This planning will guide the development of infrastructure and investments that are climate-smart and environmentally sustainable, and that ensure that urban and rural development provide opportunities for adaptive, sustainable development.

- **Ensure that adaptation strategies are aligned with mitigation strategies:** We will ensure that adaptation actions taken are in synergy with mitigation actions in order to promote cost-effective and sustainable solutions, and limit increases in the production and release of greenhouse gases. Similarly, we will ensure that mitigation activities do not increase vulnerability or result in mal-adaptation.
- **Promote the use of adaptation that recognises the needs of vulnerable communities and ensures sustainable local economic development:** We will ensure that the use of Community Based Adaptation (CBA) is prioritised in order to improve the quality of life in our communities, including the urban and rural poor, who are vulnerable to the harmful impacts of climate change, especially vulnerable groups such as women, children, youth, the elderly, physically and mentally challenged, disadvantaged minority and indigenous populations. We will engage our citizens in our actions to address climate change, and will support proposals from civil society that efficiently and cost-effectively encourage changes in lifestyles that contribute to our local climate actions. We will assess climate adaptation strategies for compatibility with local economic development strategies.
- **Prioritise the role of functioning ecosystems as core municipal green infrastructure:** We will ensure that sustainable management, conservation and restoration of ecosystems and the related ecosystem services are used to enable citizens to adapt to the impacts of climate change, which is known as Ecosystem-based Adaptation (EBA). We will strive to maintain and enhance resilience, and reduce the vulnerability of ecosystems and people to the adverse impacts of climate change.
- **Seek the creation of direct access to funding opportunities:** We will build our climate financing through generating funds internally and through seeking the development of innovative financing mechanisms that enable direct access to national and international funding for our registered adaptation actions. We support the creation of a local adaptation thematic window in the Green Climate Fund, and in so doing, we will seek the support of national governments and multilateral funding institutions.
- **To develop an acceptable, robust, transparent, measurable, reportable and verifiable (MRV) register:** MRV systems should reflect the local context in which adaptation takes place.
- **Promote multi-level and integrated governance and advocate for partnerships with sub-national and national governments on local climate action:** We will ensure cooperation with all levels of government to implement plans and measures at the local level that harness and strengthen approaches to multi-level governance and improve interdepartmental cooperation in order to more effectively address

factors reaching beyond local government boundaries, including climate change hazards, trends like urbanisation and migration, and institutional and legal frameworks. In this regard we would support the appropriate representation of local governmental stakeholders, with relevant experience on the Adaptation Committee of the Cancun Adaptation Framework.

- **Promote partnerships at all levels and city-to-city cooperation and knowledge exchange:** We agree to seek active partnerships and promote city-to-city cooperation, at regional and global levels including information and knowledge sharing, capacity development and technology transfer in all areas relevant to adaptation, and to encourage and invite other leaders of local and sub-national governments to join our climate actions.

#### 4.7 **Climate Change Policy Framework for State Owned Companies**

In 2011, the Department of Public Enterprises (DPE) released its climate change policy framework for state owned companies (SOCs), including Transnet. The framework is intended to “provide direction to the Boards and management of SOCs in relation to the accomplishment of the goals that have been articulated in the October 2011 National Climate Change Response White Paper”. It is also intended to guide longer term actions required to put South Africa on a low carbon development path and to ensure that SOCs are leading as agents of change in this process.

The overarching approach is based on four core principles which underline the design of the DPE policy:

- SOCs should focus on optimising the overlap between commercial, economic, developmental and environmental objectives whilst carefully managing areas where these objectives conflict.
- Climate change, broader environmental and green economy considerations must be integrated into the heart of SOC planning, procurement and operational processes (while acknowledging that this will be an on-going process of learning).
- Each SOC requires flexibility in the way it responds to the challenges of climate change given the diversity of sectors within which the SOC operates.
- The development of the green economy requires a high level of collaboration across SOCs and between SOCs and government.

Whilst the Framework does not provide much detail, it clearly commits all SOCs to actively contribute to the national climate change response goals related to both adaptation and mitigation.

#### 4.8 Transnet Policy

Transnet is at the initial stage of developing an integrated strategic response to climate change. In its voluntary submission to the CDP Investor Response for 2011, Transnet indicated that the following activities have been concluded:

- High Level Risk and Vulnerability Assessment;
- GHG Emission Inventory 2011/2012;12; and
- General mitigation roadmap.

In addition, Transnet is part of the Industry Task Team on Climate Change (ITTCC), a voluntary non-profit association established to undertake fact-based technical work on climate change and to work with Government to find optimal solutions for achieving a sustainable, low carbon economic growth path for South Africa.

While Transnet's plans on Climate Change are still being formulated, it is expected that Transnet's GHG emissions will *"increase over the next five years due to an aggressive growth mandate that will provide for infrastructure investment, job creation, local supplier development and increase South Africa's overall global competitiveness"* (CDP, 2012). Of key relevance to the proposed development is that the growth strategy supports a modal shift of freight from road to rail to service the inland market (Gauteng etc.). This is in line with the mitigation measures outlined in the Long Term Mitigation Strategy to underpin GHG emissions reductions in the Transport Sector (where most of the emissions are related to road vehicles and where alternatives such as rail are considered to have a lower GHG emissions intensity. Hence Transnet's approach is predicated on the fact that even if its GHG emissions increases (in absolute terms), this is likely to be beneficial from a national perspective, as the alternative would likely be even higher GHG emissions associated with increased road freight.

In addition, Transnet is acting to prioritise energy efficiency within major equipment expenditure contracts. Examples include the energy regeneration capabilities in Class 15E and Class 19E locomotives on the iron ore and coal lines respectively, installation of 6 Liebherr STS Cranes also with regenerative capabilities, and the inclusion of energy efficiency within the selection criteria for new locomotive fleet.

#### 4.9 Storm Surge Early Warning System for South Africa

The South African Weather Service (SAWS) is the legally mandated institution as per Weather Service Act (Act No.8 of 2001) responsible for the issuing of alerts in South Africa. However SAWS has noted that due to the complexity of storm surge alerts, a

multidisciplinary approach is required. It was thus recognised that the contribution and collaboration of other institutions is key to the effectiveness of this early warning system.

Based on this, the Council for Scientific and Industrial Research (CSIR), Disaster Management (DM), South African Navy Hydrographic Office (SANHO) and SAWS have developed guidelines for early warnings in order to formalise effective collaboration on matters pertaining to storm surge alerts in South Africa

The key objective is to standardise the procedures and processes for the issuing of storm surge alerts in line with standard processes of the multi-hazard early warning system as applied in South Africa. This will also act as a guideline for the dissemination and communication of such information. The primary recipients of storm surge alerts are listed below:

- DEA Oceans and Coasts
- Disaster Management
- Department of Water and Sanitation (DWS) – Catchment management authorities
- Health Department (Pathological services)
- National Key points/Critical resource installations
- National Tourism Office
- NAVTEX (Navigational Telex)
- National Sea Rescue Institute (NSRI)
- Petro/ Chemical coastal installations (Petro SA)
- Power generation and distribution facilities (ESKOM)
- Radio stations (national and local)
- SA Navy Hydrographic Office
- South African Maritime Safety Authority (SAMSA)
- South African National Defence Force (SANDF) National Joint Operation Centre (NATJOC)
- South African Police Service (SAPS)
- Transport National Ports Authority (TNPA)

## 5 CLIMATE CHANGE PROJECTIONS FOR DURBAN BAY

eThekweni Metropolitan Municipality is one of the front runners in the country when it comes to understanding and planning for Climate Change in the region. In order to understand Climate Change in the context of the local environment, information was summarised from the following sources:

- Climatic Future for Durban (CSIR Environmentek, 2006);
- Towards a Low Carbon City: Focus on Durban (Academy of Science of South Africa (ASSAf), 2011);
- The ICLEI case study on Durban entitled: EThekweni (Durban), South Africa - A municipality's climate protection program (ICLEI, 2012);
- Coastal Adaptation to Climate Change: A Case Study in Durban, South Africa (MSc Thesis to Delft University) (Geldenhuys, 2011);
- The Durban Climate Change Strategy - Water Theme Report (eThekweni Metropolitan Municipality, 2014);
- The Durban Climate Change Strategy (eThekweni Metropolitan Municipality, 2014);
- Published Peer reviewed articles on sea level rise (Mather & Stretch, 2012); and
- Published Peer reviewed articles in Environment and Urbanisation regarding Durban and Climate Change (Roberts, 2008); (Robert & O' Donoghue, 2013).

Information from the IPCC AR5 Summary for Policy Makers (IPCC, 2013) as well as the Long Term Adaptation Scenarios Study (Department of Environmental Affairs, 2013) have also been incorporated to provide context.

The main climate factors that may influence the Berth 203 to 205 Expansion (including the Central Sandbank Extension) are as follows:

1. Sea Level;
2. Storm Surge;
3. Rainfall;
4. Wind; and
5. Temperature.

Climate Change projections for the Durban/eThekweni area are summarised for each of these factors below.

## 5.1 Sea Level

The IPCC Fifth Assessment Report on Climate Change (IPCC, 2013) predicts that Mean Sea Level by 2100 will be between 0.45m to 0.82m. **Table 4** provides an overview of the different predictions between 2046-2065 and 2081-2100 based on different scenarios (relative to the reference period of 1986-2005). This is illustrated in **Figure 8**.

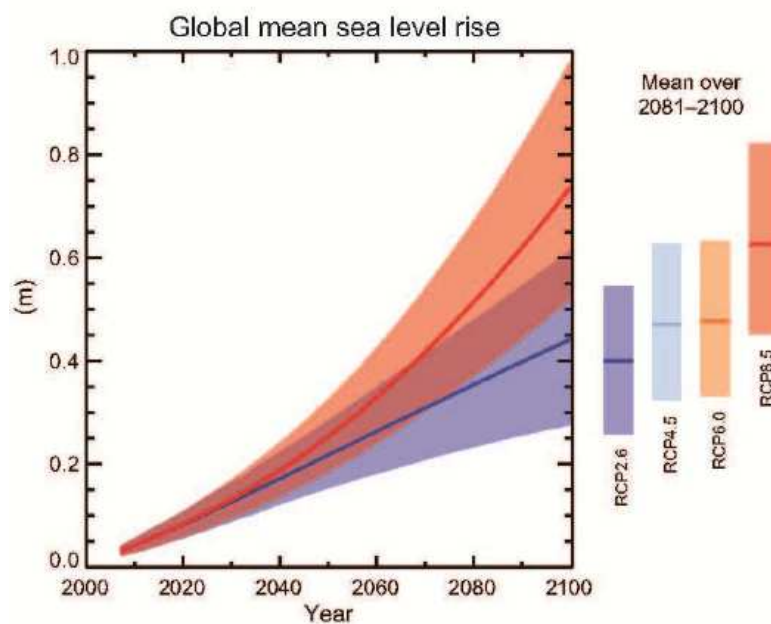
**Table 4: Sea Level Rise (mean and range) predictions between 2046-2065 and 2081-2100 based on different scenarios (relative to the reference period of 1986-2005) (IPCC, 2013)**

Scenario	2046-2065	2081-2100
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		Mean	Likely Range	Mean	Likely Range
Global Mean Sea Level rise (m)	RCP 2.6	0.24	0.17-0.32	0.40	0.26-0.55
	RCP 4.5	0.26	0.19-0.33	0.47	0.32-0.63
	RCP 6.0	0.25	0.18-0.32	0.48	0.33-0.63
	RCP 8.5	0.30	0.22-0.38	0.63	0.45-0.82

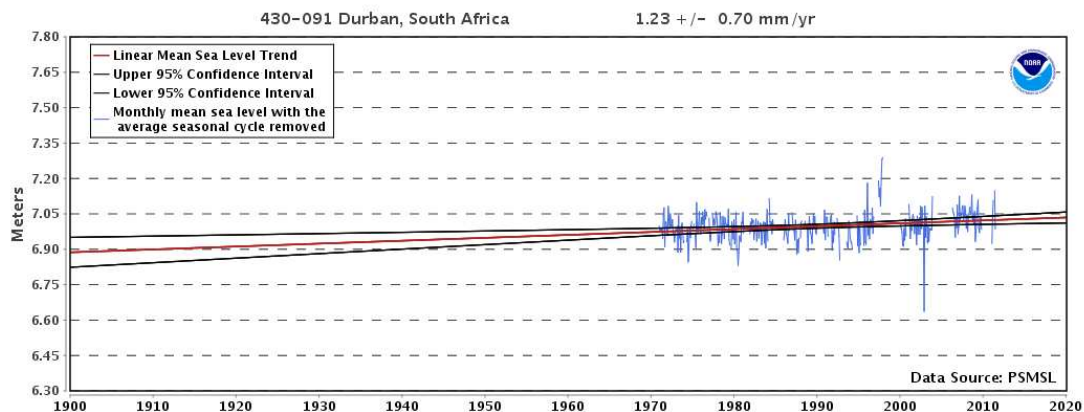
However, sea level rise will not be uniform. By the end of the 21st century, it is very likely that sea level will rise in more than about 95% of the ocean area. About 70% of the coastlines worldwide are projected to experience sea level change within 20% of the global mean sea level change.



**Figure 8: Sea Level Rise Ranges (shaded bands) and Medians (horizontal bands) Projections up to 2100 relative to 1986-2005 for different scenarios (IPCC, 2013)**

At a local context, sea level data for Durban was available from 1971 to 2011 from the Permanent Service for Mean Sea Level (PSMSL) which collects, publishes and analyses sea level data from the global network of tide gauges (<http://www.psmsl.org/data/obtaining/stations/284.php#docu>) and is provided in **Figure 9**. The **current** monthly mean sea level trend is 1.23mm +/- 0.70mm per year (based on monthly Mean Sea Level Data from 1971 to 2011) which is equivalent to 0.12192 m in 100 years.

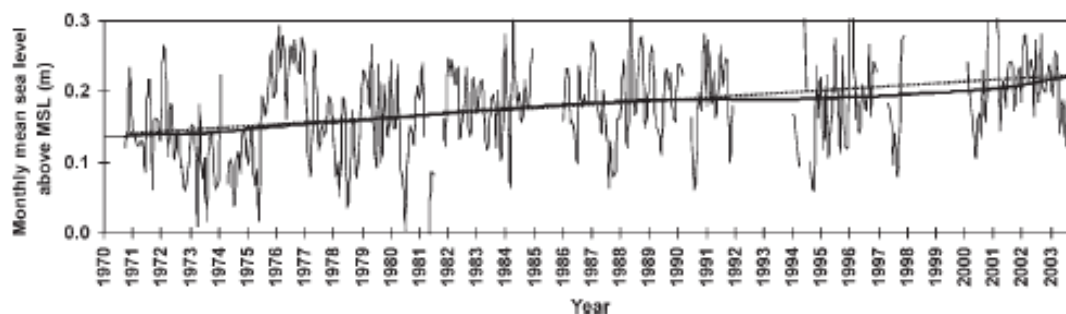




**Figure 9: Mean Sea Level Trends for Durban is 1.23mm +/- 0.70mm per year (based on monthly Mean Sea Level Data from 1971 to 2011)**

In terms of predicted future sea level rise, the DEA reported that: “Sea-level is rising around the South African coast, but there are regional differences. On the west coast, the sea level is rising by 1.87 mm per year; on the south coast by 1.47 mm per year; and on the east coast by 2.74 mm per year. Modelling has shown that some areas along the coastline will be more susceptible to sea level rise than others, but the understanding is incomplete” (DEA, 2011).

In addition, Mather and Stretch (2012) note that the observed Sea Level Rise (SLR) trend in Durban is  $+2.7 \pm 0.05$  mm per year and for the eastern region of South Africa is estimated as  $+2.74$  mm per year (Mather & Stretch, 2012). This is in line with the IPCC predictions. These results are also in line with worldwide tide gauge and TOPEX/ Poseidon altimeter measurements which range between 2.4mm and 3.2mm per year. The figure below shows the monthly sea level changes and derived no linear trends reported by Mather and Stretch (2012).



*Figure 10: Monthly sea level changes and derived no linear trends reported by Mather and Stretch (2012)*

## 5.2 Storms and Storm Surge

CSIR Environmentek (2006) notes the following likely trends:

- Increases in flooding and storm events will impact human settlements, infrastructure, human health, and inevitably place a greater burden on those communities living below the poverty line.
- Increases in temperature will also result in higher sea surface temperatures. In some parts of the African continent, this could possibly lead to greater storm surges, destroying infrastructure, affecting human life and marine ecosystems along the coast.

Roberts (2008) also notes that based on the analysis of Global Sea Level Observing System data, results indicate that a number of economic and tourist areas may be affected by sea-level rise. Infrastructure, together with coastal vegetation, will be damaged. Damage can be expected from extreme events such as flooding, which may cause the high tide level to increase, thus resulting in potential impacts to infrastructure, increased flooding and coastal erosion, and ultimately placing a significant portion of the population at risk (Roberts, 2008).

In response to the challenges that climate change poses, eThekweni Municipality initiated a Municipal Climate Protection Programme in 2004 with the purpose of:

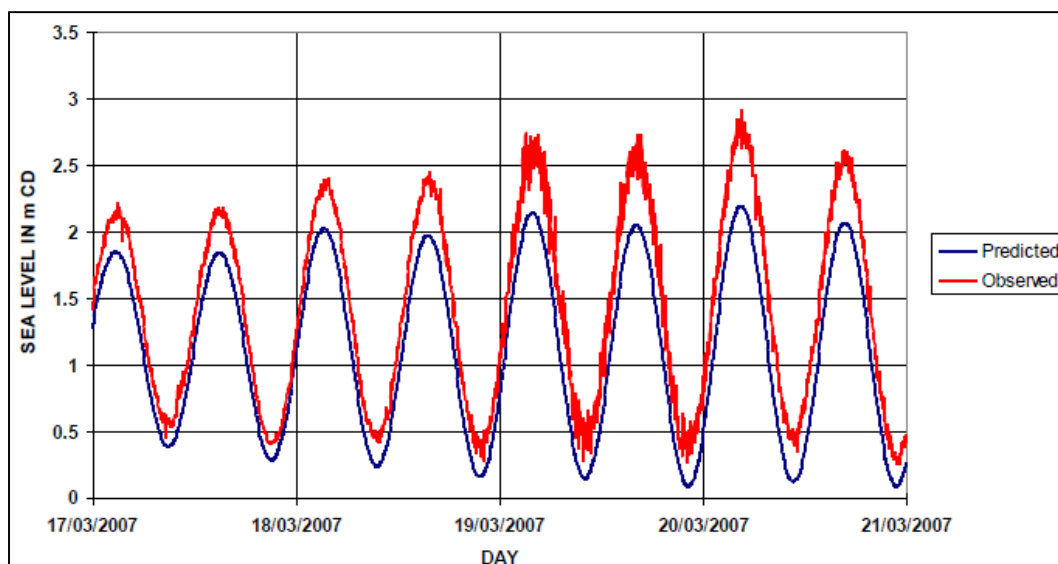
- Ensuring that Durban contributes to solving the climate change problem by promoting low-carbon development that prioritises energy efficiency and renewable energy and minimises the production of greenhouse gases.
- Ensuring that Durban's citizens are able to cope with climate change impacts, such as rising temperatures, changes in rain fall intensity and distribution and sea level rise by transforming the way we plan and manage the city.
- Developing tools to assist strategic decision-making in the city in the context of climate change, and
- Mainstreaming climate change concerns into city planning and development (ICLEI , 2012)

As part of this programme, EThekweni Municipality has recently mapped projected sea level rise along its coast. The high water mark, as defined according to the new Integrated Coastal Management Act was plotted with a wave run up model developed using actual wave run up heights recorded during the KwaZulu-Natal March 2007 storm event. Three sea level rise scenarios were mapped using values of 300 mm, 600 mm and 1000 mm, reflecting

the current rate of rise, a doubling of that rate and a scenario to address accelerated ice melt (eThekweni Metropolitan Municipality, 2011-2012).

Storm surge another important concept and is an abnormal rise of water generated by a storm, over and above the predicted astronomical tides. Storm surge is produced by water being pushed toward the shore by the force of the winds moving cyclonically around the storm (wind set up) together with the low barometric pressure associated with intense storms causing a rise in sea water level. The US National Weather Service, who have records of extreme storm surge events, state that the wind setup component is the primary component accounting for 95% of the total storm surge with the low pressure component accounting for only 5% of the storm surge ([http://www.nws.noaa.gov/om/hurricane/resources/surge\\_intro.pdf](http://www.nws.noaa.gov/om/hurricane/resources/surge_intro.pdf)).

As storm surge is based on the above factors, it is dissimilar in different areas. Storm surge is usually calculated by comparing 'predicted' sea levels values (based on high tides) and the actual water levels observed. The difference between the observed and predicted values is the storm surge (Geldenhuys, 2011). **Figure 11** shows the storm surge during the March 2007 storm event. Although the tides played a significant role in the coastal flooding and damage on 19 March 2007, the major cause of both the high water levels and the destruction in the coastal zone was the storm surge associated with the deep, semi-stationary cut-off low, offshore. The (onshore) wind speeds and the resultant wave heights were exceptional.



**Figure 11: Predicted and Observed Sea Levels in Durban (Geldenhuys, 2011)**

Tide records for the Port of Durban for the period 1972 to 2001 have been analysed and compared these with astronomical tide predictions (the difference between the two giving the

storm surge value). A statistical analysis on these results revealed an increase in tide level of 0.69m for a 1:100 year storm surge event (i.e. storm surge is 0.69m for a 1:100 year storm).

### 5.3 Rainfall

Monthly average rainfall trends for Durban are provided in **Table 5**. The area is generally wet, receiving an average rainfall of 1054 mm/year. Most of the rainfall is received in summer (MER/ERM, 2011).

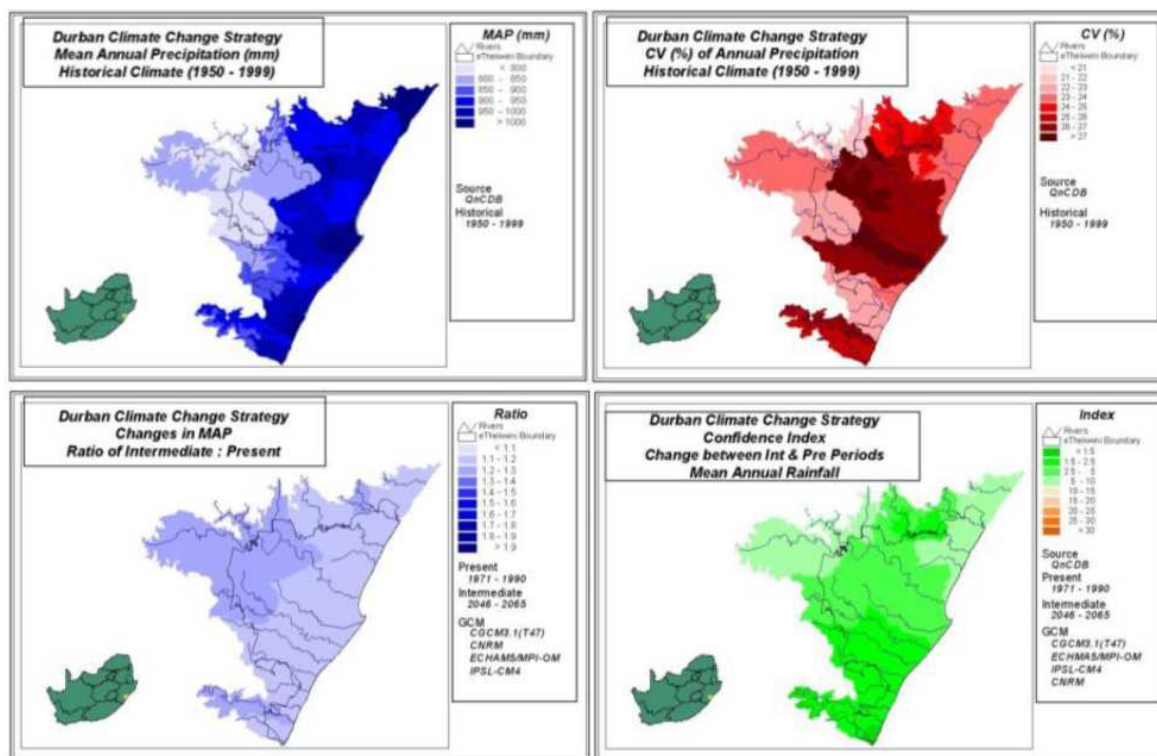
*Table 5: Monthly average rainfall recorded at Durban Airport (MER/ERM, 2011)*

	J	F	M	A	M	J	J	A	S	O	N	D
Durban-Rainfall (mm)	119	127	132	84	56	33	36	48	74	109	117	119

Similar to global trends in rainfall variability, projections show that in Durban, rainfall events greater than 10mm and 25mm will increase for the period 2070-2100 (CSIR Environmentek, 2006).

More recent information is in line with this and shows that projected annual rainfall changes are likely to include an increase in aggregated rainfall by 2065, with an increase of up to 500 millimetres by 2100. This is likely to manifest itself as an increase in extreme rainfall events and stream flow intensity across the municipal area, with prolonged dry spells between rainfall events. There is likely to be an increase (from 30 per cent to a potential doubling) of rainfall variability between the middle and the end of the century (Robert & O' Donoghue, 2013).

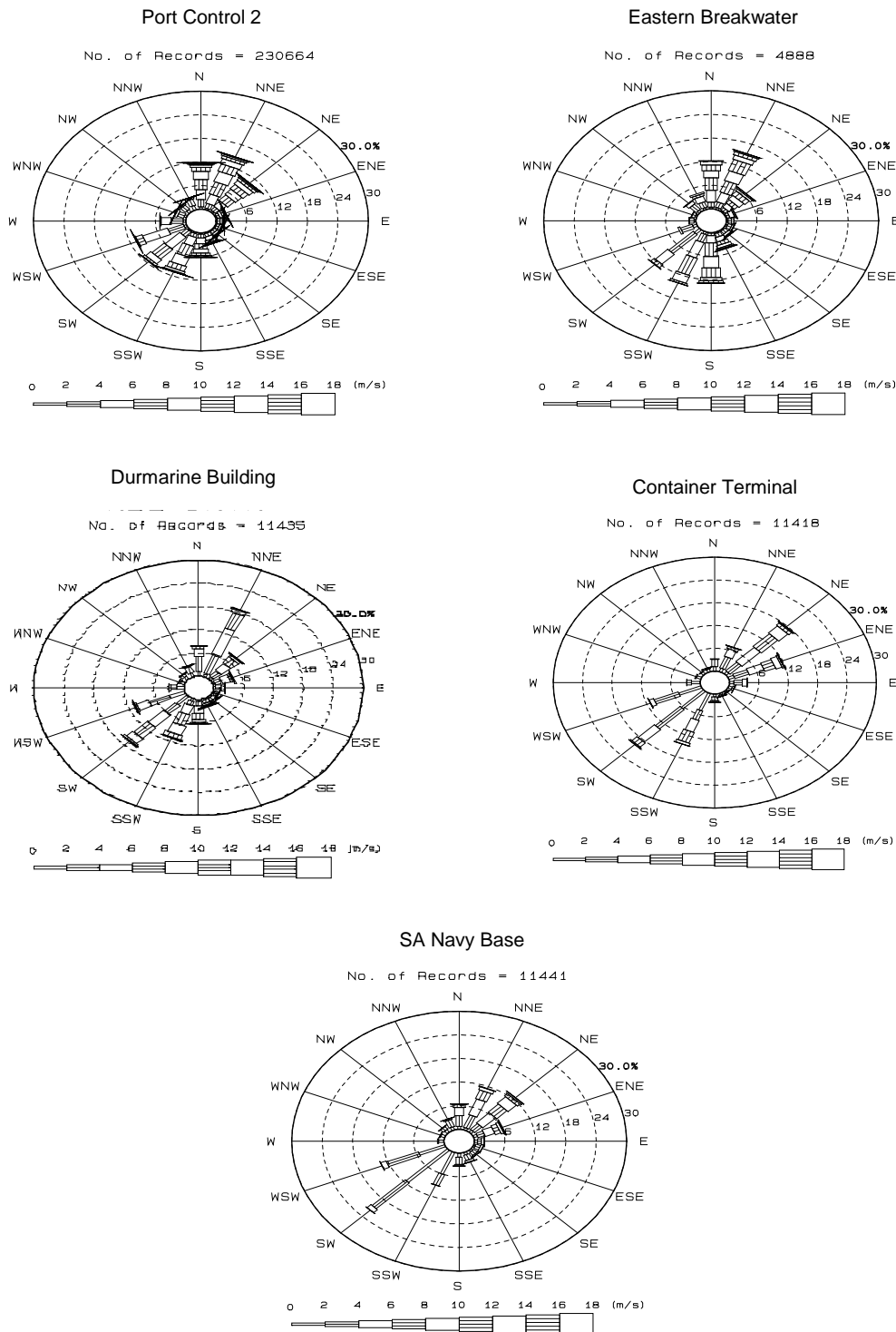
The LTAS Summary for Policy Makers notes that KwaZulu-Natal will have a high risk of increased extreme runoff related events (and flooding conditions) (Department of Environmental Affairs, 2013). The Durban Climate Change Strategy - Water Theme Report (eThekweni Metropolitan Municipality, 2014) notes that there is a likely increase in mean annual precipitation, which are projected by the climate models used in the detailed study to be higher in the inland than the coastal regions of Durban (**Figure 12**). The Report also notes that there is a projected increase in the variability of annual rainfall, implying the possibility of enhanced droughts (although tempered by the projected increase in rainfall) (eThekweni Metropolitan Municipality, 2014).



**Figure 12: Distributions of mean annual precipitation (top left) and the coefficient of variation (%) of annual precipitation (top right) under historical climatic conditions as well as the ratio of change in MAP derived from multiple GCMs and the inter-GCM confidence index of MAP (eThekweni Metropolitan Municipality, 2014)**

## 5.4 Wind

Winds inside the Bay are significantly less than those measured at the Port Control tower and on the eastern breakwater. Within the Bay, the Salisbury Island area is sheltered from SW to SSW winds that predominate in winter. To a lesser extent the same observation can be made for the container terminal. However, winds measured on the northern part of the Bay between the yacht basin and the T-jetty do not show similar sheltering effects with respect to SW to SSW winds. All sites seemingly are fully exposed to the NNE and NE winds that predominate in spring and summer, the strongest NNE/NE winds being observed at Salisbury Island (**Figure 13**) (CSIR, 2011).



**Figure 13: Annual wind roses for various locations in the Port of Durban for the period May 2010 to October 2011**



The IPCC AR5 Summary for Policy makers note that there is generally low confidence in predictions of future wind speed changes. Several model studies have suggested increased average and/or extreme wind speeds but some studies point in the opposite direction. The changes in both average and extreme wind speeds may be seasonally variable, but the details of this variation appear to be model-dependent. IPCC predicts that future tropical cyclones will likely become more severe with greater wind speeds (IPCC, 2013).

According to the Durban Climate Change Strategy - Water Theme Report (eThekweni Metropolitan Municipality, 2014), there is a predicted increase in the frequency of extreme storms and cyclones because of the mid-latitude westerly winds strengthening since the 1960s. In addition, South Africa is likely to experience an increase in average wind speed throughout the year caused by stronger prevailing winds. The effect of just a 10% increase in wind speed on the coastal environment creates an order of magnitude increase of other coastal processes. This 10% increase in wind speed is predicted to result in a 26% increase in wave heights and potential increasing longshore transport rates by between 40% and 100%. Actual changes will be co-determined by many other factors, including local factors, such as, sediment availability, wave transformation, etc. (eThekweni Metropolitan Municipality, 2014).

## 5.5 Temperature

The Port of Durban is subjected to a warm maritime climate with average minimum temperatures of 16°C during the winter months of May to July and an average of 27°C during the hotter summer months of January to March (MER/ERM, 2011) (Table 6).

**Table 6: Minimum and Maximum Monthly temperatures recorded at Durban Airport (MER/ERM, 2011)**

	J	F	M	A	M	J	J	A	S	O	N	D
Durban-Max (°C)	27	27	27	24	23	23	22	22	22	23	25	26
Durban-Min (°C)	22	22	22	19	16	16	16	17	17	18	20	21

The IPCC has found that each of the last three decades has been successively warmer at the Earth's surface than any preceding decade since 1850. The globally averaged combined land and ocean surface temperature data as calculated by a linear trend, show a warming of 0.85 [0.65 to 1.06] °C, over the period 1880 to 2012 (IPCC, 2013). In South Africa, over the last five decades the following climate trends have been observed in South Africa in regards to temperature:



- Mean annual temperatures have increased by at least 1.5 times the observed global average of 0.65°C reported by the Fourth Assessment Report (AR4) of the International Panel on Climate Change (IPCC) for the past five decades.
- Maximum and minimum daily temperatures have been increasing annually, and in almost all seasons.
- High and low temperatures (i.e. hot and cold extremes) have respectively increased and decreased in frequency in most seasons across the country, particularly in the western and northern interior.

Data from 2005 indicates that daily maximum temperatures range from 20-26° C. In terms of future climate projections, based on the IPCC globally used 2070-2100 scenario, Durban is likely to experience an increase in monthly maximum temperatures of about 2-3° C. These projections were obtained using a regional climate model called C-CAM (CSIR Environmentek, 2006).

More recent projects from 2011 (Academy of Science of South Africa (ASSAf), 2011) show temperature projections for the immediate future (2045 – 2065) and distant future (2081 – 2100) are expected to increase 1.5 – 2.5°C and 3.0 – 5.0°C respectively. Heat-waves (3 or more consecutive days with maximum temperatures reaching 30°C) are expected to increase by approximately 30% and extreme heat-waves (3 or more consecutive days with maximum temperatures reaching 35°C) are expected to double in the immediate future.

## 6 CLIMATE CHANGE VULNERABILITIES AND ADAPTATION RESPONSES

### 6.1 Alignment with eThekweni Climate Change Strategies and Plans

In order to provide the Adaptation Plan detailed in **Section 6.2.** in context, an overview of the Plan's alignment with eThekweni's Climate Change Strategies and Plans is provided below. It should be noted that the numbering of objectives from the Durban Climate Change Strategy Main Report (eThekweni Metropolitan Municipality, 2014) has been kept consistent so to enable the reader to draw linkages between the two documents. In addition, specific sub-objectives that are aligned to the Berth 203 to 205 CCAMEP are in *italics*.

#### 6.1.1 Sea Level Rise and Storms

The eThekweni Climate Change Municipal Adaptation Plan - Health and Water (eThekweni Metropolitan Municipality, 2009) notes that the key impact of climate change in coastal areas

is the amplification of wave run-up and storm damage due to sea level rise. The Municipality highlights that the impact of sea level rise and amplified flooding is limited through risk-averse planning and appropriate infrastructure and building standards. The plan also highlights the need to protect biological defences such as estuaries. The development of a reliable early warning system was also noted as important. Another adaptation measure is the reduction of risk to existing infrastructure through modifications (e.g. increase bridge height, culverts etc).

The Durban Climate Change Strategy Main Report (eThekweni Metropolitan Municipality, 2014) had the following objectives which relate to Sea Level Rise and Storms.

- **Objective B.1: The impact of sea level rise is limited through risk-averse planning and appropriate infrastructure, building standards and enhancement of ecological infrastructure.**
  - B.1.1 Adopt and enforce the provincial coastal management line and risk zones to manage current and future development in the face of climate change.
  - B.1.2 Develop a coastal management policy for the management of the existing built environment in the face of climate change.
  - B.1.3 Adopt and enforce a risk-averse approach to spatial, land use and infrastructure planning and development control that responds to all potential coastal flooding and other coastal risks.
  - *B.1.4 Research, review and adapt infrastructure and building design standards to respond to current and future sea levels and coastal storm risks.*
  - *B.1.5 Adopt and enforce adaptive engineering approaches that are flexible and can evolve in response to changing threats and coastal erosion risk.*
  - B.1.6 Prioritise the relocation or upgrading of informal and low income settlements that are vulnerable to sea level rise, coastal storms and coastal erosion.
  - B.1.7 Relocate existing municipal buildings and infrastructure that are in high risk zone to areas of lower risk at the end of their economic life or when severely damaged by storms.
  - B.1.8 Retrofit and modify existing buildings and infrastructure to provide protection against future sea level rise and increased coastal storms.
  - B.1.9 Recognise and make use, wherever possible, of the natural defence systems of coastal dunes to provide protection services against sea level rise, coastal storms and coastal erosion.
- **Objective C.1: Ecosystem functioning and connectivity are enhanced through integrated planning and effective action to reduce climate change impacts on biodiversity and maximise the delivery of ecosystem services**

- C.1.1. Maximise the extent and enhance the habitat representivity of Durban's network of public and private open spaces across a range of environmental gradients, to sustain viable species populations and to increase heterogeneity of species populations in order to improve resilience of species to climate change impacts.
- *C.1.2 Adopt and enforce integrated planning approaches and development controls that protect the integrity and enhance the functionality and resilience of Durban's biodiversity and natural capital to withstand climate change impacts.*
- *C.1.3 Design and manage the built environment to contribute positively to the supply of ecosystem services, minimise pollution and degradation of the natural environment, contribute towards biodiversity conservation and the sequestration of carbon dioxide.*
- C.1.4 Ensure that linkages between open spaces are conserved and maintained to allow for poleward and altitudinal movement of plant and animal populations to ensure that gene flow and diversity are maintained, and that species are able to adapt to climate change impacts where such potential exists.
- C.1.5 Actively manage the spread of alien invasive species in freshwater, marine and terrestrial habitats to protect against the increased spread of these species as a result of climate change.
- *C.1.6 Restore and manage degraded natural open spaces through government, business and community efforts to improve resilience of ecosystems to climate change impacts.*
- C.1.7 Acknowledge that there will be changes in biodiversity due to climate change and implement measures to manage the negative effects and enhance the benefits of these changes.
- *C.1.8 Promote consideration of climate change impacts in the Environmental Impact Assessment process where it is likely that the development will affect the resilience or adaptive capacity of species, habitats or ecosystems to climate change.*
- C.1.9 Identify mechanisms for incentivising land owners to protect and manage natural environments on their properties to maximise ecosystem functioning and resilience in order to withstand climate change impacts.
- C.1.10 Prioritise the restoration, protection and management of habitats and ecosystems that are most vulnerable to the effects of climate change.
- C.1.11 Prioritise the restoration, protection and management of ecosystems that play a key role in alleviating the impacts of climate change on vulnerable communities or infrastructure.

- C1.12 Prioritise the restoration, protection and management of ecosystems that contribute towards mitigating climate change through carbon sequestration and storage.
- **Objective E.2: Strengthen and promote emergency management services to better handle emergency and disaster situations related to climate change and health.**
  - *E.2.1 Develop community emergency plans in response to possible climate related disasters that include use of early warning systems with associated public health advice.*
  - E.2.2 Equip local health facilities to handle climate related emergencies and extreme weather events in order to prevent or lessen referrals to tertiary health facilities. Ensure health facilities are able to function under climate related disaster conditions (i.e. potable water reserves, electricity generation back-up, access even during floods, etc.).
  - E.2.3 Establish adequate stockpiles of medications, medical supplies, assistive devices and other resources that may be required during climate change related disasters and events.

The Berth 203 to 205 Adaptation Plan is aligned to eThekweni's adaptation response in the following ways:

- Transnet is to meet with eThekweni to discuss the potential inclusion of the Port of Durban in eThekweni's existing Disaster Management Strategy. Based on the outcomes of these discussions, Transnet should develop a contingency plan for disasters at Berth 203 to 205.
- Weather station should be set up on Pier 2 and weather data should be taken into account throughout the construction process. During operation, weather data should continue to be collected in line with the Transnet Port Terminal's Weather Operating Procedures (once finalised);

As discussed in Section 4.9., there is an existing Early warning Storm Surge Guideline in place and TNPA is one of the main recipients of early warnings.

In addition to the above, the design of the Berth 203 to 205 Expansion took into account sea level rise and storm surge by making sufficient allowance in design cope level of +4.25 m CDP to prevent overtopping so that structure is safe to end of Design Life in 2069 and beyond to 2100. **Figure 14** below shows the current quay wall level allows for the full tidal range, waves and storm surge, as well as 443mm of freeboard whilst the new design with a cope level of +4.25mCDP will have a freeboard at 2019 relative tidal range, waves and

predicted storm surge of 973mm. By the end of the design life (2069), the freeboard will be approximately 324mm. The design, 31 years after the end of the design life will still take into account sea level rise at this time.

Storm surge was calculated by taking the analysed tide records from 1972 to 2001 for the Port and comparing these with astronomical tide predictions with the difference between the two giving the storm surge value. The effects of Climate Change were then added by using a 5% increase in wind speed and applying this to the various components which affect storm surge.

- Increase in storm surge =  $(1.05)^2 * 0.95$  (Wind setup) +  $1.05 * 0.05$  (Low pressure) = 1.1
- Therefore a 10% increase is applied to the residual storm setup value.
- i.e. Design criteria storm setup value =  $0.69 \times 1.1 = \mathbf{0.759\ m}$  (ZAA, 2013).

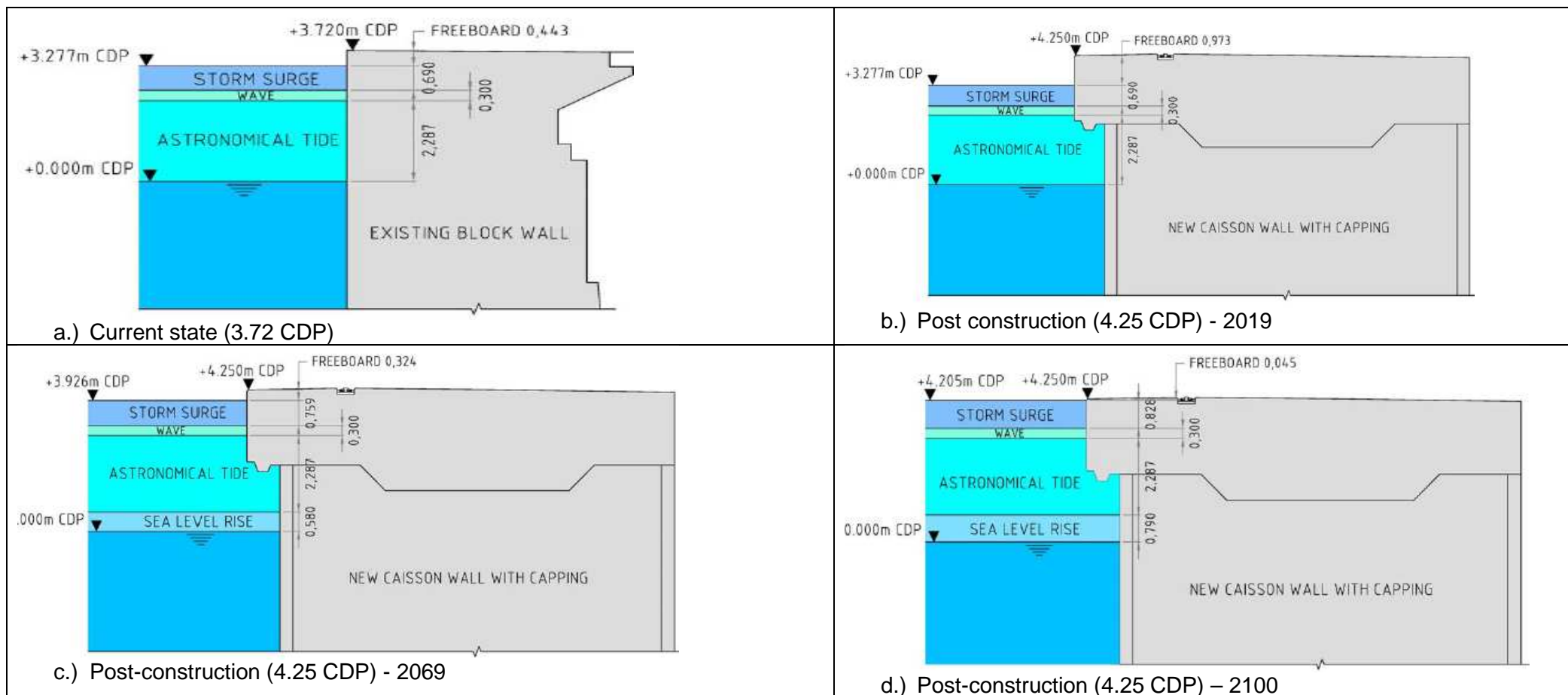


Figure 14: Design of Cope Level taking into account Sea Level Rise and Storms

Further, through the extension of the Central Sandbank, the greatest impact to the estuary as a whole is successfully mitigated through the increase of central sandbank habitat. This is in line with eThekweni's emphasis on protecting biological defences such as estuaries.

The effect of Climate Change was also taken into account in the Sandbank Extension design as four scenarios were simulated; each incorporating identical spring tide cycles, with associated high and low tides as occurring over a three day period. For the existing and extended sandbank layouts, extreme storm events characterised by 1 in 50 year wind velocities (increased by 5% to allow for climate change), from North-easterly and South-westerly directions, were generated.

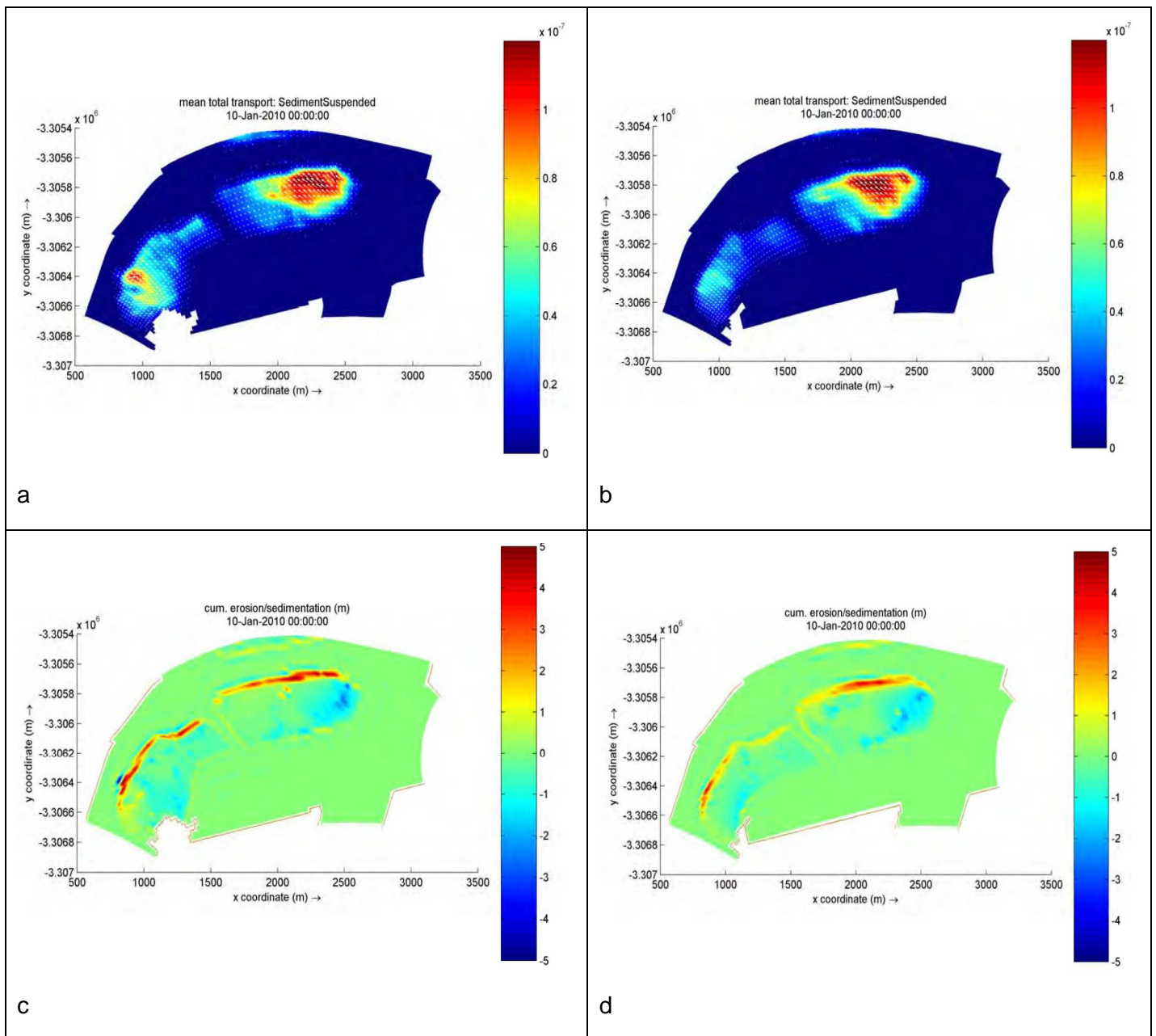
Wind speed was ramped up from zero to a 48 hour average of 24.7 m/s over the first day of the simulation, where after it is maintained for the next two days until the end of the simulation. Wave conditions were constant for all scenarios. A single offshore open boundary was defined. Water level (tidal) forcing was applied at this boundary as a time series of recorded water levels. This boundary was also used in the coupled wave simulation. A constant 3m wave from 146° with 10s period was applied for all scenarios.

The simulations were also repeated for far higher average wind speeds of 40 m/s and 44 m/s which yielded similar conclusions that the extended sandbank would be at least as stable as the existing sandbank under future extreme event conditions, taking account of anticipated climate change. Further simulations were carried out for the post berth deepening scenario, but with increased water level to account for sea level rise of 0.58m due to climate change added to a storm surge of 0.759m where it was seen that the effect of sea level rise slightly reduces the transport volume with no associated adverse effects. In addition, a morphological acceleration factor has been applied to a 10 day simulation to effectively illustrate the effect of erosion and sedimentation on the central sandbank, after a 50 year period. This simulation has been performed for both scenarios, and has been repeated for the Option 3H scenario with the effects of ocean waves omitted.

It has to be noted that the varying wind directions and velocities used for this 10 day period, are typical for a spring season (actual recorded data for early October 2012 has been used). Hence the accelerated results more closely represent what might be expected after a 50 year long spring season. The main purpose of these simulations is to compare pre- and post-construction scenarios and ascertain whether or not construction of the sandbank extension resulted in significantly different erosion and deposition.

**Figure 15** shows that mean sediment transport with the current bathymetry would be almost identical to the mean sediment transport taking into account the changed bathymetry of Option 3H. In terms of Cumulative Erosion/Sedimentation (no maintenance dredging) there is also no discernible differences between the pre-and post- construction layouts.





**Figure 15: Mean sediment transport and Cumulative Erosion/Sedimentation – Pre- construction (a and c) and Post construction (b and d)**

### 6.1.2 Rainfall

According to the eThekweni Climate Change Municipal Adaptation Plan - Health and Water (eThekweni Metropolitan Municipality, 2009), potential increases in the intensity of rainfall events for the Durban region could lead to higher runoff and stream flow (due to higher overland flow and reduced infiltration) which could lead to an increase in flooding in flood prone areas. Modelling suggests a potential increase in flooding through the following:

- An increase in mean annual rainfall of up to 20% by mid-century and 30-100% by the end of the century;
- An increase in the number of days with more than 10mm rain of 10-30% by mid-century and 30-100% by the end of the century; and
- The change in flood magnitudes for a two year return period varies in the medium term but could potentially double by the end of the century.

In order to deal with this, eThekweni Metropolitan Municipality has suggested a number of actions for itself for managing vulnerabilities related to increased rainfall. These relate to developments taking into account 1:50 year floodlines and 1:100 year floodlines as well as ensuring regular routine inspection, clearance and maintenance of all storm water channels for water during extreme precipitation events. In addition, the Municipality aims to run public awareness campaign to raise awareness of the benefits of retrofitting storm water run-off reduction techniques e.g. green roofs, retention/wet basin, detention/dry basin, infiltration basins, rain water harvesters etc. to reduce runoff from existing developments.

Further, the Municipality notes that it may be prudent to increase designs by 10 % or even more as a precaution against increased extreme events under future climatic conditions (eThekweni Metropolitan Municipality, 2014).

The Municipality also aims to develop a reliable early warning system alerting residents and disaster management to the likely occurrence of emergencies related to extreme rainfall (flooding).

The Durban Climate Change Strategy Main Report (eThekweni Metropolitan Municipality, 2014) had the following objectives which relate to Rainfall. Specific sub-objectives that are aligned to the Berth 203 to 205 CCAMEP are in *italics*.

- **Objective A.2: The impact of amplified flooding and increased levels of storm water as a result of climate change is limited through risk-averse planning and appropriate infrastructure, building standards and enhancement of ecological infrastructure**
  - A.2.1 Adopt and enforce a risk-averse approach to spatial, land use and infrastructure planning and development controls that respond to potential climate change amplified flood risk
  - A.2.2 Research conducted into changes in projected rainfall and flood lines is incorporated into guidelines that are used when designing, planning and implementing all types of infrastructure. Considerations should include location of new infrastructure, infrastructure design and choice of materials

- *A.2.3 Adopt and enforce adaptive engineering approaches that are flexible and can evolve in response to changing threats and levels of flooding.*
- *A.2.7 Monitor the effectiveness of storm water systems and upgrade where necessary to respond to variability in precipitation events and the projected increases in volumes of water and waste.*

The Berth 203 to 205 Adaptation Plan is aligned to eThekweni's adaptation response in the following ways:

- A Stormwater Management Plan was compiled and includes the 1: 50 year floodline (**Appendix 1**);
- The storm water system has been designed with additional capacity to cope with flows from storms with potential increased rainfall intensity. The capacity of the system has been checked and is in excess of the capacity required for a 10% increase in rainfall intensity as recommended in "Durban Climate Change Strategy - Water Theme Report (eThekweni Metropolitan Municipality, 2014);
- Transnet is to meet with eThekweni to discuss the potential inclusion of the Port of Durban in eThekweni's existing Disaster Management Strategy. Based on the outcomes of these discussions, Transnet should develop a contingency plan for disasters at Berth 203 to 205;
- Transnet will be required to undertake routine inspection, clearance and maintenance of all storm water channels at Berth 203 to 205;
- As the Port stormwater channels are influenced by stormwater management at the catchment level, Transnet to meet with eThekweni to discuss potential partnerships for stormwater channel monitoring between eThekweni and Transnet where eThekweni would be responsible for monitoring at a catchment level and Transnet would be responsible at the Port; and
- The associated buildings on Berth 203 to 205 should take into account green building design techniques as per the TPT Green Building Requirements.

### 6.1.3 Wind

The eThekweni Climate Change Municipal Adaptation Plan - Health and Water (eThekweni Metropolitan Municipality, 2009) notes that high winds disrupt the entry of ships to the Durban harbour and prevent the operation of port-side cranes. The Adaptation Plan also notes that wind has been incorporated into the eThekweni Disaster Management Plan. There were however no specific interventions related to winds. The 2014 Durban Climate Change Strategy Water Theme Report however does note that planting salt and wind tolerant indigenous plants on coast may assist in managing increased winds. The Report also notes

that South Africa is likely to experience an increase in average wind speed throughout the year caused by stronger prevailing winds (eThekweni Metropolitan Municipality, 2014).

The Berth 203 to 205 Adaptation Plan is aligned to eThekweni's adaptation response in the following ways:

- Extreme wind velocities have been increased by a factor of 10% over the current extreme level which is in line with the 2014 eThekweni Report.

In addition, a number of specific adaptation measures have been suggested including the following:

- Equipment including cranes and stacks should be adequately secured from damage during a weather event. This may include the use of storm brakes, wedges, slings or shackles or lowering stack height where appropriate. This should be undertaken in line with Transnet Port Terminal's Weather Operating Procedures (once finalised);
- Wind should be monitored on Ship to Shore Cranes and at the Terminal. Operations should be halted when wind speeds reach the thresholds of both the wind monitors on the Cranes and at the Terminal;
- Weather station should be set up on Pier 2 and weather data should be taken into account throughout the construction process. During operation, weather data should continue to be collected in line with the Transnet Port Terminal's Weather Operating Procedures (once finalised);
- Transnet is to meet with eThekweni to discuss the potential inclusion of the Port of Durban in eThekweni's existing Disaster Management Strategy. Based on the outcomes of these discussions, Transnet should develop a contingency plan for disasters at Berth 203 to 205

#### **6.1.4 Temperature**

Temperatures are expected to rise in the Durban area with an average annual temperature increase by approximately 2-2.5°C in the intermediate future (by 2045-2065) and by approximately 4-5°C in the distant future (2081-2100) (eThekweni Metropolitan Municipality, 2014). This can result in increased demand for potable water as well as an increased electricity consumption related to the increased need for air conditioners etc. Hot and dry conditions also increase fire risk. Impacts to electrical infrastructure might include cable sagging and reduced carrying capacity of overhead conductors and underground cables. Adaptation strategies developed by eThekweni include:

- Promote cooling technologies that do not increase the consumption of fossil fuels and exacerbate greenhouse gas emissions;

- Investigate the impact of climate change on food e.g. red tide poisoning and impact of increased survival of microbes in the warmer temperatures on food poisoning;
- Develop a reliable early warning system alerting residents and disaster management to the likely occurrence of emergencies high temperature and humidity levels;
- Public awareness campaigns to alert the population regarding dealing with heatwaves (reduce exercise, consumer liquids, stay indoors etc); and
- Assess the impact of high temperatures on transport infrastructure and incorporate adaptation scenarios into future planning.

The Durban Climate Change Strategy Main Report (eThekweni Metropolitan Municipality, 2014) had the following objectives related to energy use. This is indirectly related to temperature. Specific sub-objectives that are aligned to the Berth 203 to 205 CCAMEP are in *italics*:

- **Objective F.2: Energy in Durban is used efficiently by all sectors.**
  - *F.2.2 Businesses adopt a range of energy efficiency technologies with 90% of lighting, heating, ventilation and cooling (HVAC) and water heating equipment within facilities becoming energy efficient by 2030.*
  - *F.2.4 Promote programmes to implement energy efficient technologies and design in buildings and developments beyond existing national standards in local building regulations.*

The Berth 203 to 205 Expansion Adaptation Plan takes into account increased temperature through adaptive management. This is aligned to eThekweni's plan as follows:

- Material specifications should take into account increased temperature predictions (including Expansion joints will be provided for thermal considerations, Corrosion protection and all concrete specifications to Transnet specifications S420);
- The associated buildings on Berth 203 to 205 should take into account green building design techniques as per the TPT Green Building Requirements;
- Weather station should be set up on Pier 2 and weather data should be taken into account throughout the construction process. During operation, weather data should continue to be collected in line with the Transnet Port Terminal's Weather Operating Procedures (once finalised); and
- Altered work regimes in compliance with Transnet OHSAS Procedures.

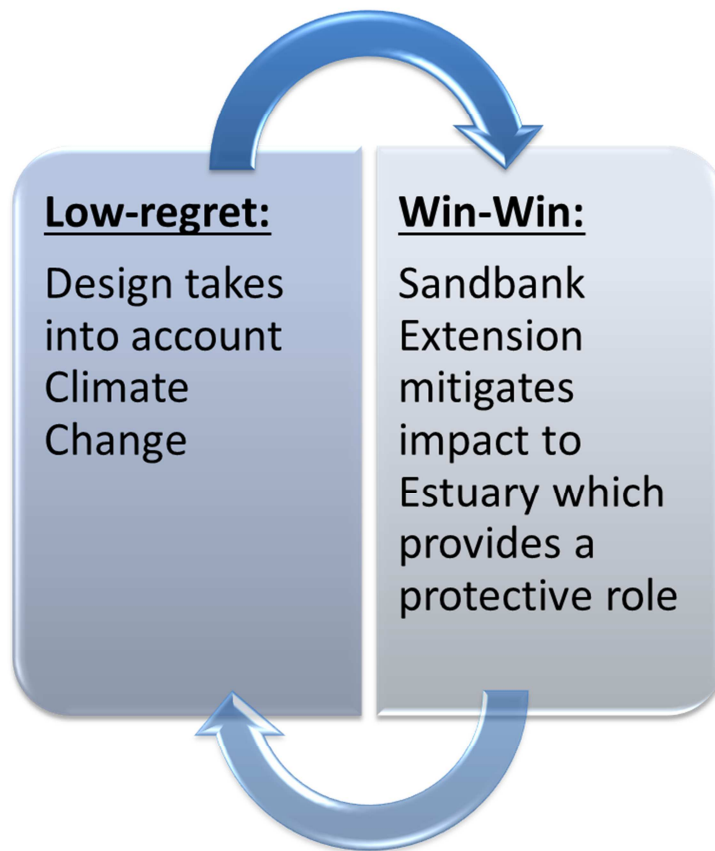
## 6.2 Berth 203 to 205 Adaptation Plan

It is important to note that decisions regarding adaptation are made in the face of uncertainty about future climate change. Under these conditions, there are various types of adaptation action that can be considered. These include:

- 'No regret' adaptation measures, which are actions with benefits that outweigh their costs, whatever the extent of future climate change. For instance, if a port is already experiencing weather-related problems, then cost-effective measures to address them should also help to build resilience against future climate change.
- 'Low regret' options are low cost measures with potentially large benefits under climate change. They are most often available at the design stage for new assets, when extra capacity to cope with future climate change can be built in more efficiently than through later retrofit.
- 'One-off' adaptation involves investing in one up-front adaptation measure which provides resilience against climate change throughout a certain period of time.
- 'Adaptive management' is an approach whereby adaptation actions are applied incrementally in response to changing conditions or new knowledge, allowing the most appropriate decisions to be made at each point in time, based on the latest evidence.
- 'Win win' options contribute to climate adaptation while also delivering other benefits. Mangrove protection, for example, can provide coastal protection from hazards such as erosion and flooding due to storm waves and surges, and also promotes biodiversity and protects community livelihoods (Global Environment Facility Independent Evaluation Office, 2014).

The main adaptation responses utilised for the Berth 203 to 205 project can be classified as 'low-regret' and 'win-win'. The relationship between these responses are illustrated in **Figure 16** below.





*Figure 16: Adaptation Response for Berth 203 to 205*

The main vulnerabilities to the Berth 203 to 205 Expansion project (including the Central Sandbank Extension) are provided in **Table 7**. These have been separated into construction and operation phases of the Berth 203 to 205 Expansion project. Most risks were identified during the EIA Phase by ZAA Engineering Projects and Naval Architecture and project stakeholders (ZAA, 2014) while additional risks identified in the Climate Change Adaptation Guidelines for Ports have also been included (Scott, H, McEvoy, D, Chhetri, P, Basic, F & Mullett, J, 2013). Adaptation responses for identified vulnerabilities have also been provided (Mills-Knapp, S., Bourdeau E., Falco, G., Resler, C., Tovar H and Zoegall, S., 2011).

Please note that the alignment of these adaptation responses to the eThekweni Climate Change Strategy has been discussed in **Section 6.1**.



**Table 7: Berth 203 to 205 Vulnerabilities and Adaptation Plan**

Phase	Climate Variable	Identified Vulnerability	Adaptation Response
Construction	Increased Rainfall	Inclement Weather - Rainfall much higher than expected during construction resulting in delays in Project Schedule during construction Phase	<ul style="list-style-type: none"> <li>Provide for schedule delays in Project programme</li> </ul>
	Increased winds, storms (frequency and intensity) and storm surge	High swell conditions at sea resulting in delay in dredging schedule during construction	<ul style="list-style-type: none"> <li>Allow for schedule delays in construction programme.</li> <li>Obtain regular weather reports and plan accordingly.</li> </ul>
		Damage to dredging work due to weather and sea conditions (Large amounts of sand deposited in dredged basins and channels)	<ul style="list-style-type: none"> <li>Damage to any dredging work to be repaired by contractor.</li> </ul>
		Damage to Central Sand Bank Extension due to inclement weather, wind, waves, currents and storm surge (Extension slips into dredged basin)	<ul style="list-style-type: none"> <li>Hydrodynamic and morphological analyses of anticipated severe storms and variations in sea level have been carried out to demonstrate that the stability of the sandbank extension will be at least equal to that of the existing sandbank. The numerical model has been set up using the Delft3D suite of tools to simulate the interaction between inter alia the following processes: water level variation due to changes in sea level caused by climate change, storm surges and tides, flow patterns within the port, wind and waves.</li> <li>Extreme wind velocities have been increased by a factor of 10% over current extreme levels.</li> <li>Central Sand Bank and Little Lagoon area protected by steel/sheetpile caisson wall.</li> <li>Contract dredging procedures specify the limits of weather conditions for dredging activities.</li> <li>The extension has been designed so the existing Central Sandbank cannot be damaged by the sandbank extension.</li> <li>Bathymetric surveys of Sandbank extension should be undertaken at the start of the sandbank extension and throughout the infill process where necessary.</li> <li>Bathymetric surveys and checks should be undertaken after each storm event during the construction of Berth 203 to 205 (Sandbank extension)</li> </ul>

Phase	Climate Variable	Identified Vulnerability	Adaptation Response
			<p>and quay wall upgrade) to confirm that no slumping has occurred.</p> <ul style="list-style-type: none"> <li>A bathymetric survey must be undertaken at the start of construction and must be used as the baseline. Detailed, accurate, high resolution, bathymetric surveys must be undertaken annually from the date of commencement of the sandbank extension phase and for the duration of the construction phase. Should any slippage occur, numerical simulations to confirm requirements for repair should be performed and the area must be repaired.</li> </ul>
	Increased temperature and frequency of heatwaves	Safety of construction workers/dehydration/sun stroke (Delays in Project Schedule during construction Phase; Construction workers are negatively impacted by heat)	<ul style="list-style-type: none"> <li>Monitoring of weather during construction phase.</li> <li>Altered work regimes in compliance with Transnet OHSAS Procedures</li> </ul>
Operation	Sea Level Rise	Damage due to Long Term Sea Level Rise (Overtopping of Cope due to High Tides, Storm Surge, Waves and SLR) resulting in damage to infrastructure and delays to port activities.	<ul style="list-style-type: none"> <li>Sufficient allowance was made in design cope level (+4.25 m CDP) to ensure overcapping due to long term sea level rise does not occur (structure is safe to end of Design Life in 2069 and beyond to 2100).</li> <li>Continual monitoring of the sea level during the operational life.</li> <li>Transnet to develop an Adaptation Strategy which should deal with potential impact of climate change on port activities (Note: This cannot be dealt with at a berth level as climate change will impact operational activities as a port level).</li> <li>Transnet is to meet with eThekweni to discuss the potential inclusion of the Port of Durban in eThekweni's existing Disaster Management Strategy. Based on the outcomes of these discussions, Transnet should develop a contingency plan for disasters at Berth 203 to 205.</li> </ul>
		SLR exceeds design values due to extreme ice sheet loss (eg UKCP09 H++ scenario) resulting in overtopping of Cope due to High Tides, Storm Surge, Waves and SLR and damage to infrastructure.	<ul style="list-style-type: none"> <li>The design has included a freeboard allowance which will keep the cope safe against overtopping until the year 2069 at the end of the design life, even if this most extreme event occurs. If the decision is then made to extend the life of the structure beyond 2069, then the current design allows for adaption of the cope to a higher level.</li> <li>Continual monitoring of the sea level during the operational life.</li> </ul>

Phase	Climate Variable	Identified Vulnerability	Adaptation Response
		High wave conditions in Port resulting in greater spray and overtopping of quay walls resulting in damage to infrastructure.	<ul style="list-style-type: none"> <li>Sufficient allowance was made in design cope level (+4.25 m CDP) to ensure overcapping due to long term sea level rise does not occur (structure is safe to end of Design Life in 2069 and beyond to 2100).</li> <li>Continual monitoring of the sea level during the operational life.</li> <li>New Infrastructure at Berths (buildings, cranes etc.) must take into account potential spray and associated corrosion into the design. Corrosion protection and all concrete specifications to Transnet specifications S420).</li> </ul>
	Increased winds, storms (frequency and intensity) and storm surge	Cyclone direct hit on Durban - High winds, heavy rainfall storm surge, waves, currents (Damage to quay wall, Damage to infrastructure and buildings at Berths, Damage to buildings due to flooding, Delays in berthing, Incurred costs, Impacts to reputation and Overtopping of Cope)	<ul style="list-style-type: none"> <li>Sufficient allowance was made in design cope level (+4.25 m CDP) to ensure overcapping due to long term sea level rise does not occur (structure is safe to end of Design Life in 2069 and beyond to 2100).</li> <li>Continual monitoring of the sea level during the operational life.</li> <li>Transnet to develop an Adaptation Strategy which should deal with potential impact of climate change on port activities (Note: This cannot be dealt with at a berth level as climate change will impact operational activities as a port level).</li> <li>Transnet is to meet with eThekwin to discuss the potential inclusion of the Port of Durban in eThekwin's existing Disaster Management Strategy. Based on the outcomes of these discussions, Transnet should develop a contingency plan for disasters at Berth 203 to 205.</li> <li>Weather station should be set up on Pier 2 and weather data should be taken into account throughout the construction process. During operation, weather data should continue to be collected in line with the Transnet Port Terminal's Weather Operating Procedures (once finalised).</li> </ul>
		Storm surge - Higher than usual waves in Port combined with storm surge leads to higher water levels (Damage to quay wall, Damage to infrastructure and buildings at Berths, Damage to buildings due to flooding, Delays in berthing, Incurred costs, Impacts to reputation and overtopping of Cope)	
		Damage to maintenance dredging work due to weather and sea conditions (Large amounts of sand deposited in dredged basins and channels)	<ul style="list-style-type: none"> <li>Maintenance dredging to clear damaged areas.</li> </ul>
		Damage to Central Sand Bank Extension due to inclement weather, wind, waves, currents and storm surge (Extension slips into dredged basin)	<ul style="list-style-type: none"> <li>Hydrodynamic and morphological analyses of anticipated severe storms and variations in sea level have been carried out to demonstrate that</li> </ul>

Phase	Climate Variable	Identified Vulnerability	Adaptation Response
			<p>the stability of the sandbank extension will be at least equal to that of the existing sandbank. The numerical model has been set up using the Delft3D suite of tools to simulate the interaction between inter alia the following processes: water level variation due to changes in sea level caused by climate change, storm surges and tides, flow patterns within the port, wind and waves. Extreme wind velocities have been increased by a factor of 10% over current extreme levels.</p> <ul style="list-style-type: none"> <li>• Central Sand Bank and Little Lagoon area protected by steel/sheetpile caissons after construction.</li> <li>• Should any slippage occur, perform numerical simulations to confirm requirements for repair.</li> <li>• Dredge material out of the basin and repair damaged area.</li> <li>• Contract dredging procedures specify the limits of weather conditions for dredging activities (maintenance dredging).</li> </ul>
		Toppling of containers in stacking yards (Damage to containers, Incurred costs)	<ul style="list-style-type: none"> <li>• Equipment including cranes and stacks should be adequately secured from damage during a weather event. This may include the use of storm brakes, wedges, slings or shackles or lowering stack height where appropriate. This should be undertaken in line with Transnet Port Terminal's Weather Operating Procedures (once finalised).</li> </ul>
		Damage to crane and/or ships during loading/offloading in high wind conditions.	<ul style="list-style-type: none"> <li>• Wind should be monitored on Ship to Shore Cranes and at the Terminal. Operations should be halted when wind speeds reach the thresholds of both the wind monitors on the Cranes and at the Terminal;</li> <li>• Weather station should be set up on Pier 2 and weather data should be taken into account throughout the construction process. During operation, weather data should continue to be collected in line with the Transnet Port Terminal's Weather Operating Procedures (once finalised).</li> <li>• Equipment including cranes and stacks should be adequately secured from damage during a weather event. This may include the use of storm brakes, wedges, slings or shackles or lowering stack height where appropriate. This should be undertaken in line with Transnet Port</li> </ul>

Phase	Climate Variable	Identified Vulnerability	Adaptation Response
			Terminal's Weather Operating Procedures (once finalised).
		Closure of the Port during storms (Delays in berthing, Incurred costs and Impacts to reputation)	<ul style="list-style-type: none"> <li>Transnet to develop an Adaptation Strategy which should deal with potential impact of climate change on port activities (Note: This cannot be dealt with at a berth level as climate change will impact operational activities as a port level).</li> </ul>
		Damage to navigation and communication equipment (Delays in berthing, Incurred costs and Impacts to reputation)	<ul style="list-style-type: none"> <li>Equipment including cranes and stacks should be adequately secured from damage during a weather event. This may include the use of storm brakes, wedges, slings or shackles or lowering stack height where appropriate. This should be undertaken in line with Transnet Port Terminal's Weather Operating Procedures (once finalised).</li> <li>It is suggested that backup power system be put in place to manage communication equipment during storms/black outs.</li> </ul>
	Increased intensity of Rainfall	Extreme flooding and flash floods which impact on infrastructure (Loss to berth equipment, Capacity overload of stormwater system and Damage to buildings due to flooding. Potential for oil in equipment to rise due to the rising water level)	<ul style="list-style-type: none"> <li>A stormwater management plan has been put in place and was designed for a 1:50 year flood.</li> <li>The storm water system has been designed with additional capacity to cope with flows from storms with potential increased rainfall intensity. The capacity of the system has been checked and is in excess of the capacity required for a 10% increase in rainfall intensity as recommended in "Durban Climate Change Strategy - Water Theme Report (eThekweni Metropolitan Municipality, 2014).</li> <li>Transnet will be required to undertake routine inspection, clearance and maintenance of all storm water channels at Berth 203 to 205.</li> <li>As the Port stormwater channels are influenced by stormwater management at the catchment level, Transnet to meet with eThekweni to discuss potential partnerships for stormwater channel monitoring between eThekweni and Transnet where eThekweni would be responsible for monitoring at a catchment level and Transnet would be responsible at the Port.</li> <li>Transnet is to meet with eThekweni to discuss the potential inclusion of the Port of Durban in eThekweni's existing Disaster Management Strategy. Based on the outcomes of these discussions, Transnet should</li> </ul>

Phase	Climate Variable	Identified Vulnerability	Adaptation Response
			<p>develop a contingency plan for disasters at Berth 203 to 205.</p> <ul style="list-style-type: none"> <li>Weather station should be set up on Pier 2 and weather data should be taken into account throughout the construction process. During operation, weather data should continue to be collected in line with the Transnet Port Terminal's Weather Operating Procedures (once finalised).</li> </ul>
	Increased temperature frequency and of heatwaves	Influence of heat on materials Faster rate of deterioration of materials)	<ul style="list-style-type: none"> <li>Material specifications should take into account increased temperature predictions (including Expansion joints will be provided for thermal considerations, Corrosion protection and all concrete specifications to Transnet specifications S420)</li> </ul>
		Increased cooling requirements in buildings (Increased costs, Increased electricity consumption)	<ul style="list-style-type: none"> <li>The associated buildings on Berth 203 to 205 should take into account green building design techniques as per the TPT Green Building Requirements.</li> </ul>
		Drought conditions (decreased availability of water)	<ul style="list-style-type: none"> <li>Grey water system should be implemented where possible to reduce reliance for potable water.</li> </ul>
		Impact of high temperatures on staff working at the Berths (heatstroke etc.)	<ul style="list-style-type: none"> <li>Monitoring of weather during operation.</li> <li>Transnet is to meet with eThekwinini to discuss the potential inclusion of the Port of Durban in eThekwinini's existing Disaster Management Strategy. Based on the outcomes of these discussions, Transnet should develop a contingency plan for disasters at Berth 203 to 205. This should include the potential for altered work regimes in compliance with Transnet OHSAS Procedures.</li> </ul>

## 7 MONITORING AND EVALUATION

Monitoring refers to an ongoing process of tracking and reviewing activities, their results, and the surrounding context. The aim is usually to make immediate adjustments to activities if deviations from objectives, targets, or standards are detected. However, monitoring also generates information that can be used for in-depth evaluations of projects or programs. (Beaulieu, 2010) (Spearman, 2011). Evaluation can help adaptation become a more conscious, anticipated and planned process by verifying the effectiveness of the measures taken and adjusting them based on the observed outcomes (Beaulieu, 2010). M&E can play an important role in any instance where there is a need to document results and improve performance.

The main differences between monitoring and evaluation are summarised in **Table 8** below (Department of Environmental Affairs, 2014).

**Table 8: Differences between Monitoring and Evaluation**

Monitoring	Evaluation
A continuing function	Periodic assessment of overall achievements (midterm, at the end and a substantial period after the project has ended)
Keeps track, reviews and reflects on progress or lack thereof in relation to project objectives	Time-bound; to determine relevance, efficiency, effectiveness, impact & sustainability
Systematic collection of data on specified indicators, enabling stakeholders to check whether an initiative is on track to achieving set objectives	Determining the worth or significance of a development activity, policy or programme
Routine, daily assessment of on-going activities and progress	Measuring the impact or effectiveness of an intervention in achieving set objectives
Usually an internal process	Internal and/or external process

The evaluation approach and method must be adapted to the nature of the project or program. The main types of evaluation include the following:

- **Project evaluations** look at projects under implementation (either at the end of the intervention (terminal evaluation), after the project ends (ex post evaluation) or before the project starts (ex ante—quality at entry));
- **Program evaluations** looks at a set of interventions which are focused on attaining a set of global, regional, country, or sector objectives and assesses whether these have been met;
- **Country-level evaluations** look at measures at a country level and looks at issues such as how funding is used;



- **Impact evaluations** assess the impacts of an intervention (these can be intended, unintended, direct, and indirect long-term adaptation impacts);
- **Cross-cutting and thematic evaluations** assess a selection of interventions that address a particular adaptation challenge in one or more countries, regions, or sectors;
- **Process and performance evaluations** look at the internal dynamics of participating organizations, instruments, mechanisms, and management practices; and
- **Ad hoc reviews of programs** and processes that do not require a full evaluation but do need independent assessment (Inventory of Methods for Adaptation to Climate Change – IMACC, 2013).

Based on the requirements of the EA and taking into account relevant types of evaluation, a **project evaluation** is suggested.

Whilst the monitoring will take place throughout the construction and operation of the project, the evaluation component will take place at the defined periods and will look at the following criteria:

- **Relevance:** the extent to which an activity is suited to the local and national environmental priorities and policies and to the funds' focus on adaptation benefits; relevance analysis should include an assessment of change over time
- **Effectiveness:** the extent to which an objective has been achieved (or how likely it is to be achieved)
- **Efficiency:** the extent to which results have been delivered with the least costly resources possible
- **Results:** include direct project outputs, short- to medium-term outcomes, progress toward longer term impacts, replication, and local effects
- **Sustainability:** the likelihood that an intervention will continue to deliver benefits after completion; evaluations should include analysis of environmental, financial, and social sustainability

In order to monitor and evaluate adaptation to Climate Change, indicators linked to objectives, goals and outputs are required. In addition, information on the date required for verification, responsible person and frequency of the data collection is required.

There are a number of different types of indicators including implementation indicators which relate to the phases or stages of implementation, impact indicators (which report on the impact of the response measure such as reduced GHG emissions etc.) and effectiveness indicators (measure the effectiveness of the response measures in responding to climate

change such as such as CO<sub>2</sub> sequestered/Rand) (Department of Environmental Affairs, 2014).

Monitoring will be undertaken by Transnet every 6 months throughout construction and every two years during operation thereafter. Evaluation will be undertaken by an independent environmental specialist at the following intervals:

- 2 years from the start of construction;
- At the end of construction; and
- Once every five years after construction is completed.

The adaptation plan presented in **Table 8** above has been linked to a number of objectives, goals and indicators. Information on the data required for verification, responsible person and frequency of the data collection has also been provided. The monitoring and evaluation plan for construction and operation are provided in **Table 9** and **Table 10** respectively.

**Table 9: Construction Phase Monitoring and Evaluation**

Goal	To reduce any climate change related impacts on the construction phase of the Berth 203 to 205 expansion project.			
Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring for monitoring
Objective 1	Delays to the project programme due to increased storminess, increased rainfall and increased temperature have been adequately addressed in the project programme and are effective in reducing unplanned delays to the project.			
Detailed weather reports as well as climate change projections for the Durban area have been taken into account in the construction programme.	Climate change projections included in project programme	Programme	Checked at start and at every new programme version	Transnet
	Ratio of number of extreme abnormal weather stoppages to the total number of expected weather stoppages (abnormal/expected)	Project records	Collected monthly	Contractor
	Detailed weather reports are available	Project records	Collected monthly	Contractor
Detailed weather reports are obtained regularly and taken into account in short term planning	Ratio of number of extreme abnormal weather stoppages to the total number of expected weather stoppages (abnormal/expected)			
Objective 2	The stability of the Sandbank Extension is satisfactory and there is no evidence that the extension is negatively influenced by increased storminess, storm surge, increased frequency of storms and sea level rise.			
The design and method statement for the Sandbank Extension take into account climate change predictions for the Durban Area.	Sandbank Extension Design and method statement show evidence of climate change consideration	Project records	At start of project	Transnet

Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring for monitoring
Sandbank Extension is protected from waves etc. during construction through the use of sheet piles.	Method Statement	Project records	At start of project	Transnet
	Sheet piles on site	Site verification		
Bathymetric surveys of Sandbank extension should be undertaken at the start of the sandbank extension and throughout the infill process.	Video surveys are undertaken	Project records showing bathymetric surveys were undertaken and analysed	Daily during sandbank extension	Contractor
	Evidence of the degree of slippage or Sandbank instability is available			
Bathymetric surveys and checks should be undertaken after each storm event during the construction of Berth 203 to 205 (Sandbank extension and quay wall upgrade) to confirm that no slumping has occurred.	Video surveys are undertaken after each storm event	Project records showing bathymetric surveys were undertaken and analysed after storm events. Records of all storm events	After each storm event during construction	Contractor
	Evidence of the degree of slippage or Sandbank instability is available			
A bathymetric survey must be undertaken prior to construction to be used as a baseline. Detailed, accurate, high resolution, bathymetric surveys must be undertaken annually from the date of commencement of the sandbank extension phase and for the duration of the construction phase. Should any slippage occur, perform numerical simulations to confirm requirements for repair. Dredge material out of the basin and repair damaged area.	Changes in bathymetry of Sandbank extension and Central Sandbank.	Baseline bathymetric survey prior to construction	At start of the project	Contractor
		Annual bathymetric surveys	Yearly for 5 years	
	Percentage difference between expected bathymetry including expected natural erosion and sand movement (based on	Analysis records	Yearly for 5 years	Contractor

Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring for monitoring
	method statement and specialist studies) versus actual bathymetry			
	Numerical simulations are available to confirm requirements for repair (if necessary based on changes)	Numerical simulations	As necessary (based on need for repair)	Contractor
	Percentage difference between expected bathymetry including expected natural erosion and sand movement(based on method statement and specialist studies) versus actual bathymetry (after repairs have been undertake)	Analysis records	After each repair event	Contractor
Contract dredging procedures specify the limits of weather conditions for dredging activities.	Contractor dredging procedures are available and specify the limits for dredging activities	Contract dredging procedures	At start of project	Transnet
	Number of days where weather conditions/turbidity exceed limits set by procedure	Project records	Quarterly	Contractor
	Evidence of work stoppage when limits are exceeded	Project records	Quarterly	Contractor
Objective 3	Climate change related heat impacts (e.g. heatwaves etc.) on construction workers during the construction phase of the Berth 203 to 205 Expansion are reduced through proper management of the workforce.			
Monitoring of weather during construction phase.	Weather data (temperature, humidity, wind, rainfall, storms)	Project records	Collected monthly	Contractor

Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring for monitoring
Altered work regimes in compliance with Transnet OHSAS Procedures	Altered work regimes system in place for heatwaves	Method statement	At start of project	Transnet
	Number of injuries related to increased temperature	Project records	Quarterly	Contractor
	Evidence of work stoppage/altered work regimes when temperatures exceed Transnet OHSAS levels	Project records	Quarterly	Contractor

**Table 10: Operation Phase Monitoring and Evaluation**

Goal	To reduce any climate change related impacts on the operational phase of the Berth 203 to 205 expansion project.			
Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring
Objective 1	The impact of sea level rise on the operations of Berth 203 to 205 and the functioning of the sandbank extension is limited through the proper planning and design.(Long Term in the next 30 to 40 years)			
Make sufficient allowance in design cope level of +4.25 m CDP to prevent this so that structure is safe to end of Design Life in 2069 and beyond to 2100.	The quay wall in place is in line with design.	Project design	Once off at end of construction	Transnet
Continual monitoring of the sea level during the operational life.	Sea level rise data is available	Sea level rise monitoring data	Every 5 years	Transnet
	Percentage difference between expected sea level level (based on design and specialist studies) versus actual sea level.	Analysis of sea level data		
Transnet to develop an Adaptation Strategy which should deal with potential impact of climate change on port activities (Note: This cannot be dealt with at a berth level as climate change will impact operational activities as a port level).	Transnet Climate Change Adaptation Strategy is in place and deals with port activity disruptions.	Adaptation Strategy	5 years after construction is completed	Transnet
New Infrastructure at Berths (buildings, cranes etc,) must take into account potential spray and associated corrosion into the design. Corrosion protection and all concrete specifications to Transnet specifications S420).	Material specifications for berth infrastructure have been assessed and equipment will not corrode significantly given specified maintenance procedures.	Specifications	Once off at end of construction	Transnet
	No significant corrosion visible.	Site Visit	Every 5 years	



Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring
The design and method statement for the Sandbank Extension take into account climate change predictions for the Durban Area.	Sandbank Extension is in line with design	Project records	Once off at end of construction	Transnet
A bathymetric survey must be undertaken prior to construction to be used as a baseline. Detailed, accurate, high resolution, bathymetric surveys must be undertaken annually from the date of commencement of the sandbank extension phase and for the duration of the construction phase. Should any slippage occur, perform numerical simulations to confirm requirements for repair. Dredge material out of the basin and repair damaged area.	Changes in bathymetry of Sandbank extension and Central Sandbank.	Bathymetric surveys undertaken after construction is completed	5 years after construction is completed	Transnet
	Percentage difference between expected bathymetry including expected natural erosion and sand movement (based on method statement and specialist studies) versus actual bathymetry 5 years after construction is completed.	Analysis records	5 years after construction is completed	Transnet
	Numerical simulations are available to confirm requirements for repair (if necessary based on changes)	Numerical simulations	As necessary (based on need for repair) after 5 years	Transnet
	Percentage difference between expected bathymetry including expected natural erosion and sand movement (based on method statement and specialist studies) versus actual bathymetry (after repairs have been undertake)	Analysis records	After each repair event (if necessary).	Transnet
Objective 2	Impacts to the Berth 203 to 205 operations related to increased winds, storms (frequency and intensity) and storm surge are minimised. (Long Term in the next 30 to 50 years)			
Weather station should be set up on Pier 2 and weather data should be taken into account throughout the construction process. During operation, weather data should continue to be collected in line with the Transnet Port Terminal's	Weather Station is functioning on site	Site Visit	Once off at end of construction and every 5 years thereafter	Transnet
	Weather data is available	Records		

Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring
Weather Operating Procedures (once finalised).				
Transnet is to meet with eThekwin to discuss the potential inclusion of the Port of Durban in eThekwin's existing Disaster Management Strategy. Based on the outcomes of these discussions, Transnet should develop a contingency plan for disasters at Berth 203 to 205.	Evidence of meetings with eThekwin regarding Disaster Management Plan.	Minutes/Attendance Registers	5 years after construction has finished.	Transnet
	eThekwin Disaster Management Plan to include Port of Durban or if necessary contingency plan for disaster management is in place.	eThekwin Disaster Management Plan incorporates the Port OR Transnet has a contingency plan for disaster management in place.	5 years after construction has finished.	Transnet
	Rand value of damaged incurred due to unmanaged storm events for the period.	Records	Every 5 years	Transnet
Maintenance dredging to clear damaged areas of dredge footprint should storms result in increased sedimentation of dredge footprint.	Maintenance dredging in place	Records	Every 5 years	Transnet
Equipment including cranes and stacks should be adequately secured from damage during a weather event. This may include the use of storm brakes, wedges, slings or shackles or lowering stack height where appropriate. This should be undertaken in line with Transnet Port Terminal's Weather Operating Procedures (once finalised).	Rand value of equipment and stacks damaged during weather events/storms.	Records	Every 5 years	Transnet
	Number of stack and equipment falls/collapses due to wind and storms during the period.			
Wind should be monitored on Ship to Shore Cranes and at the Terminal. Operations should be halted when wind speeds reach the thresholds of both the wind monitors on the Cranes and at the Terminal.	Crane specifications showing wind monitors	Records	Once off at end of construction and every 5 years thereafter	Transnet

Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring
	Records of wind monitoring data.	Records	Every 5 years	Transnet
	Number of work stoppages occurring in comparison to wind speed data for the period.			
Transnet to develop an Adaptation Strategy which should deal with potential impact of climate change on port activities (Note: This cannot be dealt with at a berth level as climate change will impact operational activities as a port level).	Transnet Climate Change Adaptation Strategy is in place and deals with port activity disruptions.	Adaptation Strategy	5 years after construction is completed	Transnet
Backup power system be put in place to manage communication equipment during storms/black outs, subject to increased storm intensities being observed.	Backup power system	Records	Every 5 years	Transnet
	Number of communication losses/failure due to storm events			
Objective 3	The impact of amplified flooding and increased levels of storm water as a result of increased rainfall is limited through proper storm water management and planning.			
A storm water management plan has been put in place and was designed for a 1:50 year flood. The storm water system has been designed with additional capacity to cope with flows from storms with potential increased rainfall intensity. The capacity of the system has been checked and is in excess of the capacity required for a 10% increase in rainfall intensity as recommended in “Durban Climate Change Strategy - Water Theme Report (eThekweni Metropolitan Municipality, 2014).	The storm water management system in place is in line with the design requirements.	Site verification	Once off at end of construction	Transnet
	Number of flooding events where storm water exceeded design capacity	Records	Every 5 years	Transnet
Transnet to undertake routine inspection, clearance and maintenance of all storm water channels at	Number of inspections, clearance and maintenance activities undertaken at Berth 203 to 205 for the	Records	Every 5 years	Transnet

Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring
Berth 203 to 205;	period.			
As the Port stormwater channels are influenced by stormwater management at the catchment level, Transnet to meet with eThekweni to discuss potential partnerships for stormwater channel monitoring between eThekweni and Transnet where eThekweni would be responsible for monitoring at a catchment level and Transnet would be responsible at the Port; and	Evidence of meeting with eThekweni to discuss stormwater management at a catchment level.	Meeting records (Minutes/Attendance Registers)	5 years after construction has finished.	Transnet
Objective 4	Increased temperature, frequency of heatwaves and potential droughts are adequately taken into account in the operation of Berth 203 to 205. (Long Term in the next 30 to 50 years)			
Material specifications should take into account increased temperature predictions (including Expansion joints which will provide for thermal considerations, and corrosion protection and all concrete specifications to Transnet specifications S420).	Material specifications for berth infrastructure have been assessed and take into account increased temperature	Specifications	Once off at end of construction	Transnet
The associated buildings on Berth 203 to 205 should take into account green building design techniques as per the TPT Green Building Requirements.	Landside infrastructure incorporates green building designs where possible as per TPT Green Building Requirements.	Site verification	Once off at end of construction	Transnet
	Heating and cooling costs reduction	Records	Every 5 years	Transnet
Grey water system should be implemented where possible to reduce reliance for potable water.	Grey water system in place	Site verification	Once off at end of construction	Transnet
	Decreased volume of potable water use at Berth 203 to 205	Records	Every 5 years	Transnet

Key Activities	Indicators	Means of Verification	Frequency of Data Collection	Person Responsible for monitoring
Transnet is to meet with eThekweni to discuss the potential inclusion of the Port of Durban in eThekweni's existing Disaster Management Strategy. Based on the outcomes of these discussions, Transnet should develop a contingency plan for disasters at Berth 203 to 205.	Evidence of meetings with eThekweni regarding Disaster Management Plan.	Meeting records (minutes/attendance registers)	5 years after construction has finished.	Transnet
	eThekweni Disaster Management Plan to include Port of Durban or if necessary contingency plan for disaster management is in place.	Early warning system is in place	5 years after construction has finished.	Transnet
Altered work regimes in compliance with Transnet OHSAS Procedures.	Altered work regimes system in place for heatwaves in line with Transnet OHSAS Procedures.	Altered work regimes system/ Contingency Plan	At start of project	Transnet
	Number of injuries related to increased temperature	Transnet records	Every 5 years	Transnet
	Evidence of work stoppage/altered work regimes when temperatures exceed Transnet OHSAS Levels	Transnet records	Every 5 years	Transnet

## 8 CONCLUSION

This Climate Change Adaptation Monitoring and Evaluation Plan aims at ensuring proper implementation of all requisite Climate Change Adaptation measure required for the Berth 203 to 205 Expansion during construction and operation. The plan provides an overview of the baseline climatic conditions as well as an overview of Climate Change scenarios (obtained from international, national and local sources). It explains that adaptation measures adopted as part of the development in light of the Durban Climate Change Strategy and provides a framework for monitoring evaluation.

With the successful implementation of the adaptation measures (assessed through proper and detailed monitoring and evaluation), it is possible to ensure that Berth 203 to 205 will not be vulnerable to Climate Change.

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# **Appendix 1**

## **Stormwater Management Plan**



**TRANSNET SOC LTD**  
**FEASIBILITY STUDY (FEL 3) FOR THE DEEPENING OF**  
**BERTHS 203 TO 205**  
**PORT OF DURBAN**  
**STORM WATER MANAGEMENT PLAN**

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**ZAA 1370 | RPT | 023 REV A**

**September 2012**



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## 1.0 INTRODUCTION

The Port of Durban Container Terminal at Pier No 2, Berths 203 to 205, is being deepened and refurbished to accommodate Post Panamax container vessels up to 9,000 to 12,000 TEU (fully laden) and 14,000 TEU (partially laden). ZAA Engineering Projects and Naval Architecture (Pty) Ltd has been appointed under Contract No TCP CON-041-2011-005 to carry out a FEL 3 Study to this end.

The proposal is to extend the cope edge of these berths 48.5m seaward. The cope will have a final length of approximately 1200m.

## 2.0 LOCATION

The proposed site (see figure 1) for the new extended quay is located at Berths 203 to 205.



**Figure 1: Pier 2, Berths 203 to 205**

## 3.0 OBJECTIVES

The stormwater management plan serves the following objectives:

- To quantify the stormwater that will be generated by the proposed berth deepening during and after construction, and
- To propose any mitigation measures, where the development increases the current stormwater run-off.

The following considerations have been taken into account:

- Provision of a reliable stormwater drainage system
- Environmental and water pollution considerations
- Temporary diversions during phased construction program at Pier 2 and Lot 10. Adequate temporary drainage systems for all 3 phases of construction
- Prevent erosion and siltation
- Minimizing costs through Pre and Post development conditions
- Maintenance issues relating to pipes, inlet and outlet structures
- Stormwater discharge positions through the wall of caissons
- Surface slopes of the existing quay and the existing minor system
- Tides for the levels of the discharge from the outlet pipes.



#### 4.0 CONSTRUCTION SEQUENCING

The proposed berth deepening will be completed in three phases/stages viz. first Berth 205, then Berth 204 and finally Berth 203. [Refer to the drawings in Annexure 1].

During the construction phase of the extension of Berths 205 through to 203, cut-off drains are to be provided to collect stormwater in the affected areas which will be routed temporarily and drained into adjacent stormwater system of the existing quay. This stormwater system will apply to the sequence of three stages so that the existing stormwater system at Berth 204 will accommodate the stormwater of the affected areas of Berth 205. Likewise, the affected areas of Berth 204 will be accommodated by the existing stormwater system of Berth 203.

The existing outlet pipes are to be blocked off separately during each construction stage to ensure that the majority of the existing outlet pipes are operational at all times. Sufficient additional temporary stormwater drain pipes will be provided to accommodate extreme events.

#### 5.0 METHODOLOGY: HYDROLOGY AND HYDRAULICS

The rainfall data used for this assessment corresponds to an annual rainfall of 1009mm. The total extension area of the new quay is approximately 5.82 ha and zoned as industrial. The entire area will be paved and this rainfall area will drain as surface run-off into slot drains and then into outlet pipes in the cope face, via sandtrap manholes. The surface runoff area has been subdivided for calculation purposes, into smaller areas that are centred at each manhole with outlet pipe, thus to consider the flow per outlet pipe.

The stormwater system is divided into major and minor systems. The major system is the paved surface area of quay and minor systems comprise of the pipes, inlet and outlet structures. The major system caters for the surface run-off of the new quay with relevant slopes that route surface water into the minor systems such as the new slot drains previously mentioned. The major and minor systems have been checked to accommodate an extreme flood condition such as the 1:50 year storm. Should further unforeseen extreme events occur, the surface stormwater would run off the quay to the water side of the structure.

The existing stormwater system that has been affected by the extension of the new quay has been modified to suit.

The stormwater system for the new quay has been integrated into the stormwater system of the existing quay and modifications were made to the existing stormwater system to accommodate the additional flow conditions. The modification to the existing stormwater replaces relevant existing manholes with sandtrap manholes and the existing pipes are replaced with HDPE pipes. The number of pipes has not been increased over the existing number. Modifications have only been made to the relocation, material type, size and length of pipes that accommodate the additional works.

Slot drains are located between sandtrap manholes. These manholes collect the stormwater which flows into the outlet pipes of the new quay. The sandtrap manholes are located at every low point of the slot drains.

The Rational Method of analysis has been adopted to determine the stormwater of the new quay. Run-off peaks for a 1:50yr storm event has been considered. The following assumptions have been used to quantify the stormwater:

##### Assumptions

- Time of concentration value not less than 15min
- An area width of 30.5m seaward from existing cope would drain into the new slot drains
- The modified section of existing stormwater would be able to facilitate part of the run-off of the extended area ( 15m width)



## 6.0 STORMWATER SYSTEM CAPACITY

Capacity checks have been completed for the existing and proposed new stormwater networks. Calculation flows are given in Annexure 2.

A summary of the peak flow rate is tabulated below:

Table 6-1: Proposed development conditions for new quay

Return Period	Ft	C	Tc(min)	I (mm/hr)	A (ha)	Q (m <sup>3</sup> /s)
1:50 yr	N/A	0.95	15	230	0.259	0.157

The peak flows for the area of the new quay exceed 0.12m<sup>3</sup>/s flow by 0.037m<sup>3</sup>/s

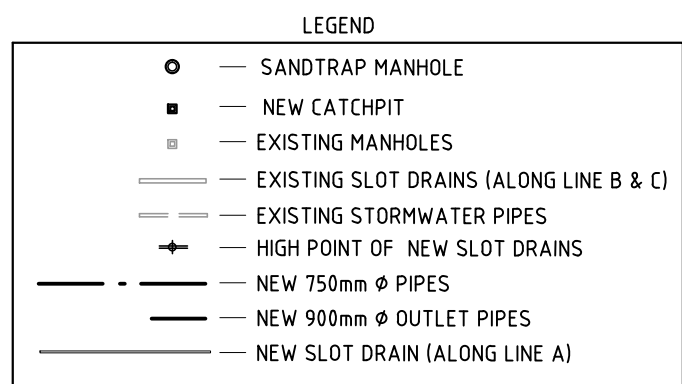
## 7.0 CONCLUSION AND RECOMMENDATION

The objectives of the SWMP are met. Based on the estimated maximum/peak rate of run-off, a 1:50 yr storm event will have no real impact on the proposed development. Since there are no significant changes to the existing stormwater layout, no mitigation measures are required. The difference in the flow of 0.037m<sup>3</sup>/s will have no significant impact on the environment.



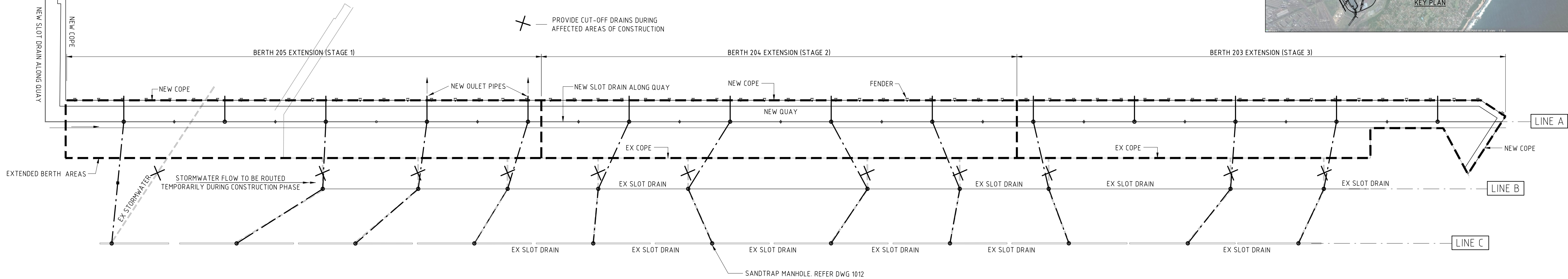
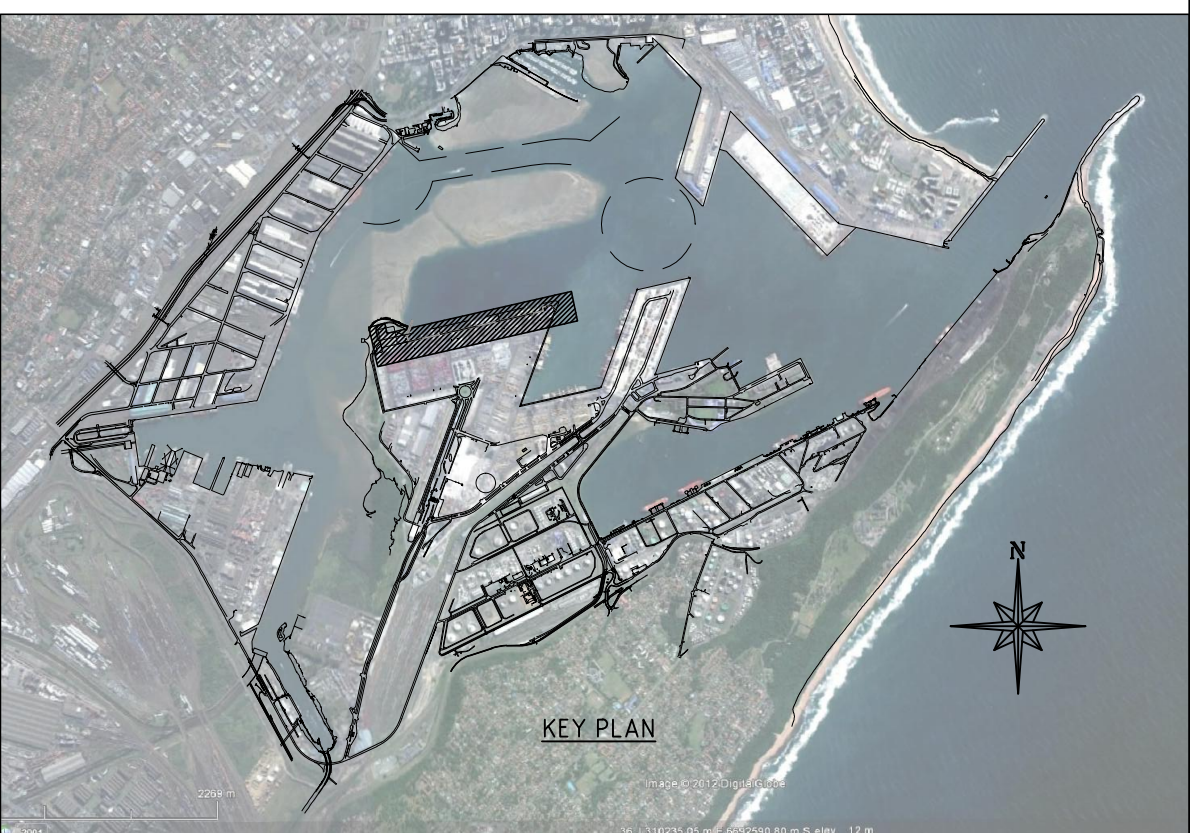
## **ANNEXURE 1   DRAWINGS**

DRAWING NUMBER



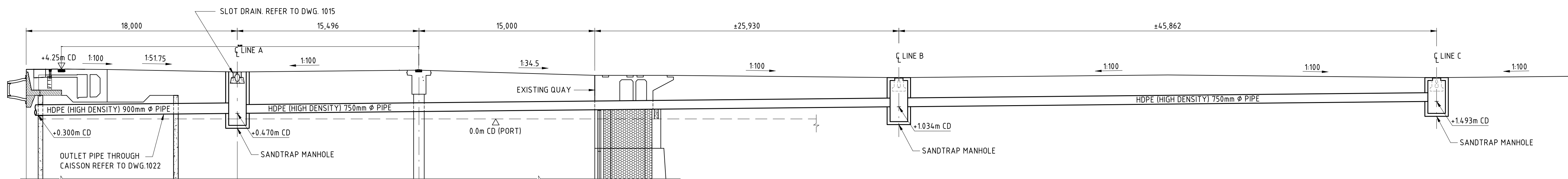
NOTES:

1. THE NEW STORMWATER DRAINAGE ONLY CONSIDERS THE PORTION OF THE EXISTING DRAINAGE SHOWN ON THIS LAYOUT. THEREFORE ANY FURTHER STORMWATER DRAINAGE NOT SHOWN ON THIS LAYOUT BUT LINKS TO THE SAME EXISTING STORMWATER (SHOWN ON THIS LAYOUT) IS PUT ON HOLD.
2. THE EXISTING OUTLET PIPES THROUGH THE EXISTING QUAY TO BE BLOCKED OFF
3. THE EXISTING PIPES LOCATED FROM LINE C TO LINE B THAT ARE LINKED TO THE EXISTING MANHOLES ARE TO BE REPLACED BY THE NEW PIPES. SEE DRAWING LAYOUT.
4. ALL EXISTING MANHOLES ON LINE B AND C FROM THE EXISTING SLOT DRAINS ARE TO BE REPLACED BY SANDPUMP MANHOLES. SANDPUMP MANHOLES ALSO TO BE INSTALLED AT EACH OUTLET PIPE ON LINE A.
5. PIPE LENGTHS ON PLAN LAYOUT ONLY APPLY TO DIMENSIONS IN PLAN (HORIZONTAL)



## PLAN: STORMWATER LAYOUT

1:1750

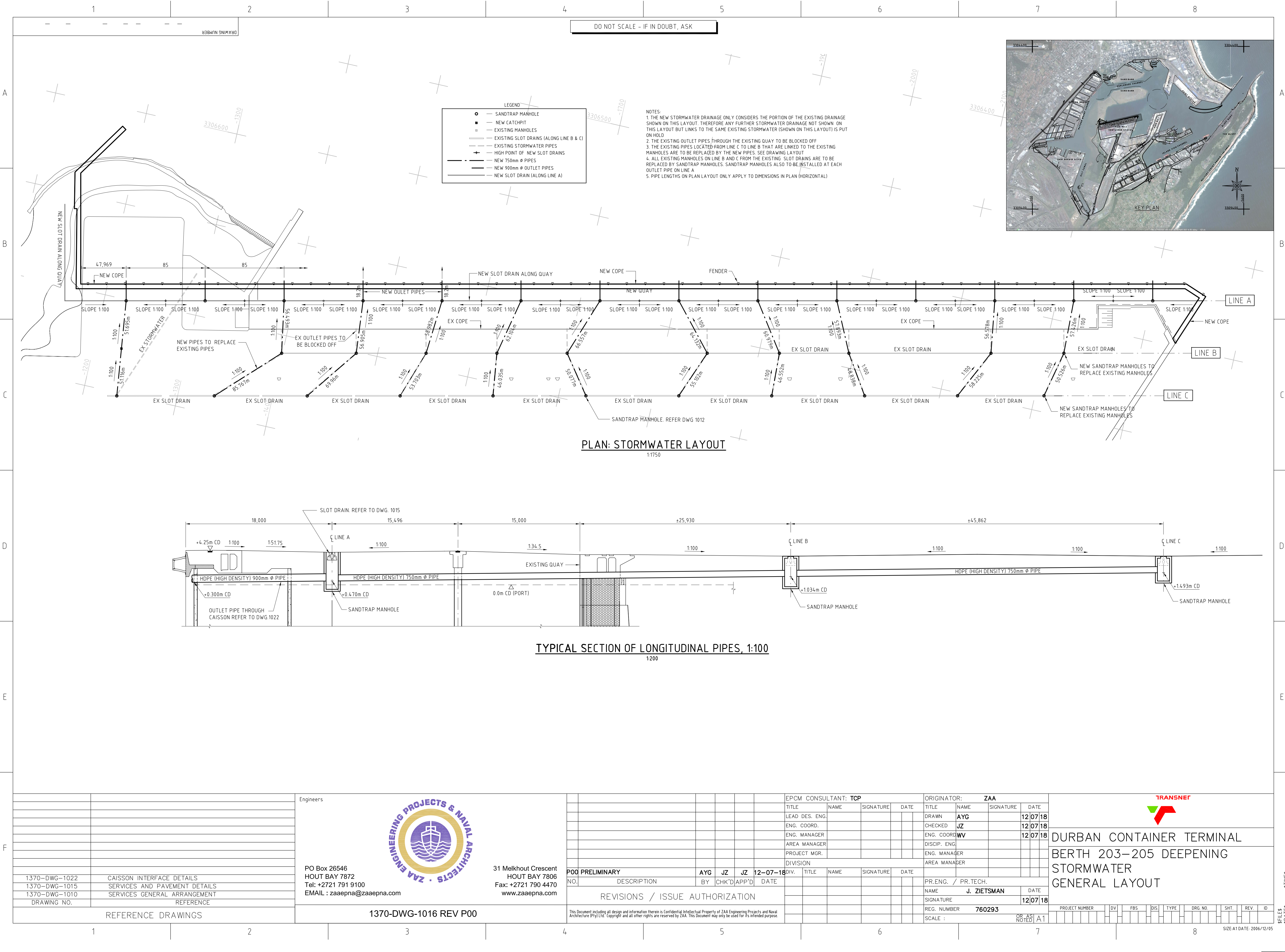


TYPICAL SECTION OF LONGITUDINAL PIPES (AFTER CONSTRUCTION)

1:200

[illegible]







## ANNEXURE 2 PEAK FLOW RATE



## PEAK FLOW RATE

A summary of the peak flow rate are tabulated below:

**Table 6-1: Proposed development conditions for new quay**

Return Period	Ft	C	Tc(min)	I (mm/hr)	A (ha)	Q (m <sup>3</sup> /s)
1:50 yr	N/A	0.95	15	230	0.259	0.157

Where:

Ft = adjustment factor for the recurrence interval storm considered

C = run-off coefficient

Tc = time of concentration in minutes

I = rainfall intensity

A = area of catchment in hectares

Q = the maximum/peak rate of run-off

The existing surface runoff has been estimated from the outlet pipes located through the existing quay. A conservative approach has been adopted to determine the flow conditions with a minimum velocity of 0.9m/s and a full-flow existing outlet pipe size of 750mm in diameter. A summary is tabulated below:

**Table 6-2: Existing development conditions**

Pipe diameter (m)	A1(m <sup>2</sup> )	v (m/s)	Q (m <sup>3</sup> /s)
0.75	0.442	0.9	0.397