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Stormwater and Pollutant Runoff Management

Document Owner: **NEOM Environment Department**

This document was prepared by Buro Happold on behalf of the NEOM Environment Department with consideration of review input from relevant NEOM Sectors and Functions.

Document History

Version	Date	Reason for Change	Author
Rev 00.0A	10.08.2020	Issued for internal review and coordination before first official issue	NEOM Environment Department

Approvals
The document requires the following approvals:

Name		Signature (required)
Martina Konrad, Environmental Quality Manager, NEOM	Author	
Alf Ziegler, Director Environmental Quality, NEOM	Reviewer	
Peter Kretschmer, Regulation and Resource Lead, Water Sector, NEOM	Reviewer	
Paul Marshall, Chief Environment Officer, NEOM	Approver	

Distribution
This document has been formally distributed to:

Name	Title	Date of Issue	Version
All NEOM Sector and Department heads	NEOM project-wide	10.08.2020	00.0A

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Executive Summary

The purpose of the following Standard is to provide all Proponents with guidance to manage stormwater and pollutant run-off within the NEOM Region. This Standard sets out the interim solution and guiding principles for stormwater and pollutant run-off management for NEOM. This Standard may be updated once the Founding Law is in place to reflect changes in Authority and stakeholder responsibilities as well as updates to related management procedures and/or water quality parameters.

NEOM as a region has a diverse geography and it is therefore vital that stormwater runoff is managed judiciously to maintain existing conditions where necessary and improve otherwise the state of the existing landscape. This document sets out the minimum performance and compliance requirements that all Masterplan, Superplot and Plot Proponents are obligated to meet at the different project approval gateways. This document should be read in conjunction with other supporting guidelines and regulatory procedures being developed by NEOM.

The primary objectives for this Standard are to manage stormwater and pollutant run-off from the site in such a way as to maintain the existing hydrological regime for NEOM and to not cause an adverse impact on the groundwater, surface and/or coastal environment or culturally valued places. The objectives that Proponents are expected to achieve are mapped against the NEOM Sustainability Code, Nature Conservation Standard, NEOM Integrated Water Management Principles and international best practice guidance. All Proponents are thus required to:

- Maintain the existing discharge locations into the wadi, sea or neighbouring plots or Superplot/ Masterplan areas.
- Safeguard existing wadis and overland flow paths.
- Maintain pre-development discharge rates, volumes and velocities.
- Protect people and property from stormwater flooding and not increase flood risk elsewhere.
- Maximise infiltration of stormwater and capture of rainwater for re-use or aquifer recharge.
- Treat the first flush volume at source prior to discharge to the approved water quality.

Compliance with the key criteria noted above will have to be demonstrated by Proponents as they seek approval of development proposals at each design project gateway. This Standard provides guidance on the information that will be required from the Regulatory Approval Body.

This document has been organised as follows:

Section Title	Contents
1. Introduction	Overview of the intent and setting out of roles and responsibilities for Proponents and the Regulatory Approval Body.
2. Vision and Objectives	Sets out NEOM's environmental vision for the region and the objectives each Proponent should target as part of their development proposals.
3. Design Requirements	Design criteria for quality improvement and quantity control of stormwater runoff from the development sites.
4. Design Philosophy	Guidance on how to achieve the objectives and design criteria stipulated within Section 2 and Section 3.
5. Compliance Documentation Requirements	Documents what Proponents are required to submit as part of their design submissions to the Regulatory Approval Body for approval.
6. Regulatory Framework	Outline regulatory structure for operating within the NEOM region.
7. Examples and Case Studies	Examples of best practice approaches to managing stormwater runoff and restoring natural ecosystems particularly affected by flooding, erosion and loss of habitats.
8. Appendices	Supporting information and checklists to assist Proponents in design of stormwater management strategies.

1 Introduction

1.1 Overview and Intent

The purpose of the following Standard is to provide all Proponents with guidance to manage stormwater and pollutant run-off within the NEOM Region. This document sets out the minimum performance and compliance requirements that all Masterplan, Superplot and Plot Proponents are obligated to meet at the different project approval gateways. This Standard sets out the interim solution and guiding principles for stormwater and pollutant run-off management for NEOM. This Standard may be updated once the Founding Law is in place to reflect changes in Authority and stakeholder responsibilities as well as updates to related management procedures and/or water quality parameters. This document should be read in conjunction with other supporting guidelines and regulatory procedures being developed by NEOM.

This document provides guidance to Proponents on the following:

- Roles and responsibilities
- Vision and objectives for managing stormwater within NEOM.
- Requirements regarding quantity and quality control and operation and maintenance.
- Step by step guidance on data, methodologies and strategies to be adopted.
- Compliance documentation required at different project approval stages.
- Case Studies

This Standard focuses on the managing of stormwater from the development plots within the NEOM Region and the mobilisation of pollutants from stormwater run-off. Proponents are recommended to refer to other NEOM guidelines related to but not limited to wadi flood risk, wadi management and irrigation.

This Standard sets out the minimum requirements based on best practice guidance at the time of writing this document. Proponents should also consider the latest research, data and emerging technologies available at the time of their development. The Proponent shall confirm with the Regulatory Approval Body the requirements required prior to commencement of design.

This Standards set out the interim solution and guiding principles for stormwater and pollutant run-off management for NEOM. This Standard may be updated once the Founding Law is in place to reflect changes in Authority and stakeholder responsibilities as well as updates to related management procedures and/or water quality parameters.

1.2 Roles and Responsibilities

The following section provides a summary of the roles and responsibilities of the key parties and Proponents for the design, construction and operation and maintenance phases.

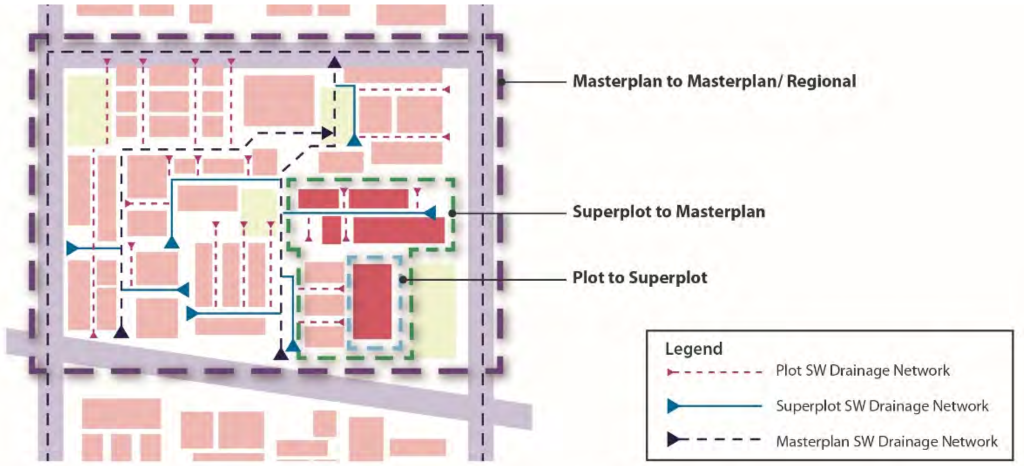
Table 1—1 Definitions of the roles and responsibilities

Organisation	Responsibility	Phase			
		Masterplan Design	Building Design	Construction	Operation & Maintenance
Regulatory Approval Body	Responsible for overall stormwater management strategy and all necessary approvals to assist its delivery	√	√	√	√
Masterplan Proponent	Responsible for masterplanning of the Masterplan zones including the overall stormwater strategy for the Masterplan areas	√			
	Responsible for design, construction and approvals of primary stormwater infrastructure within the Masterplan zones.		√	√	
	Responsible for design, construction and approvals of all stormwater infrastructure required to serve public realm areas within the Masterplan Development Zones.		√	√	
Superplot Proponent	Responsible for masterplanning of the Superplot zones including the overall stormwater strategy for the Superplot areas.	√			
	Responsible for design, construction and approvals of all secondary stormwater infrastructure within the Superplot zones.		√	√	

Organisation	Responsibility	Phase			
		Masterplan Design	Building Design	Construction	Operation & Maintenance
	Responsible for design, construction and approvals of all stormwater infrastructure required to serve any public realm areas within the Superplot Development Zones.		√	√	
Plot Proponent	Responsible for design, construction and approvals of all stormwater infrastructure within the Plot zones.		√	√	
Operator	Organisation to operate and maintain the stormwater infrastructure and recover costs.				√

Each Proponent will be responsible for all aspects of the management of stormwater runoff within their development boundary. The interfaces between the Masterplan, Superplot and Plot infrastructure systems are provided in Figure 1—1. The relevant Proponent will be responsible for the design and construction to the specified standards of:

- The necessary stormwater treatment.
- Any wadis or wadi edges falling within the plot boundary.
- The siting of development outside areas at risk of flooding.
- The incorporation of flood risk management principles in the design, construction, operation and maintenance of buildings, roads, landscaped areas and other infrastructure.
- Minimising impact in areas of nature conservation concern, according to Nature Conservation Standards.



Interface	Responsibility	Measure Required at Interface	Proponent Responsibilities
Masterplan to Masterplan / Regional	Masterplan Proponent for Masterplan development areas. NEOM for Regional development areas.	Stormwater flow paths discharging from the Masterplan to another Masterplan area or Regional area will require coordination with the Masterplan Proponent or NEOM. The Masterplan Proponent/ NEOM will need to provide a formalised overland channel from the boundary to allow the stormwater to be discharged and conveyed through the Masterplan/ Regional area. Stormwater flow paths discharging either into a wadi within the Masterplan or into the ocean will require approval from the Regional Approval Body.	The Masterplan Proponent will be responsible for the design of stormwater management up to and including the boundary of the masterplan, including the treatment, and limiting discharge. The Masterplan Proponent/ NEOM will then be responsible for either discharging into an existing wadi channel, the sea or a neighbouring plot in the closest outfall location in order to maintain the planned overland flow routes. It is the responsibility of both the Masterplan Proponents and NEOM to liaise with necessary stakeholder(s) to ensure all flow path discharge requirements are met and approved.
Superplot to Masterplan	Superplot Proponent for Superplot development areas. Masterplan Proponent for Masterplan development areas.	Stormwater flow paths discharging from the Superplot to the Masterplan will require coordination with the Masterplan Proponent. The Masterplan Proponent will need to provide a formalised overland channel from the boundary to allow the stormwater to be discharged and conveyed through the Masterplan. Stormwater flow paths discharging either into a wadi within the Superplot or into the ocean will require approval from the Regional Approval Body.	The Superplot Proponent will be responsible for the design of stormwater management up to and including the boundary of the Superplot, including the treatment, and limiting of discharge. The Masterplan Proponent will then be responsible for either discharging into an existing wadi channel, the sea or a neighbouring plot in the closest outfall location in order to maintain the planned overland flow routes. It is the responsibility of both the Superplot and Masterplan Proponents to liaise with necessary stakeholder(s) to ensure all flow path discharge requirements are met and approved.
Plot to Superplot	Plot Proponent for the Plot development area. Superplot Proponent for the Superplot development area.	Stormwater flow paths between the Plot and Superplot will require coordination with the Superplot Proponent. The Superplot Proponent will need to provide a formalised overland channel from the boundary to allow the stormwater to be discharged and conveyed through the Superplot. Stormwater flow paths discharging either into a wadi within the plot or into the ocean will require approval from the Regional Approval Body.	The Plot Proponent will be responsible for the design of stormwater management up to and including the boundary of the plot, including the treatment, and limiting discharge. The Superplot Proponent will then be responsible for either discharging into an existing wadi channel, the sea or a neighbouring Superplot in the closest outfall location in order to maintain the planned overland flow routes. It is the responsibility of both the Plot and Superplot Proponents to liaise with necessary stakeholder(s) to ensure all flow path discharge requirements are met and approved.

Figure 1—1 Responsibility split between different Proponents

2 Vision and Objectives

2.1 Vision

NEOM is a project in north western Saudi Arabia with a vision to change the way human civilisation co-exists with its natural environment. Its vision is guided by the principle of living in harmony with nature and is underpinned by five core environmental values that are synonymous with stormwater management and thus become the founding principles for this document:

Understand: Science to action

NEOM is committed to undertaking comprehensive studies and assessments, partnerships with leading scientific institutions with a resolve to learn from its actions. Baseline assessments and biodiversity surveys have identified that NEOM's landscapes, marine ecosystems and islands are home to habitats and species of global significance. NEOM is thus committed to protecting and nurturing natural ecosystems through a comprehensive network of protected areas and rigorous environmental controls on all developments. NEOM's actions to understand and enhance the environment are intending to set new benchmarks for innovative conservation, adaptive management and constant improvement.

Protect: Do no harm

NEOM will comprise a development footprint of less than 4% of the entire NEOM land and seascape, with Environmental Performance Management Systems that aim to exceed international best practice to ensure all development activities meet and exceed key international standards. The remaining 96% of NEOM holds outstanding and critical habitats and features that will be managed to ensure critical habitats such as coral reefs and wadis are protected. NEOM developments will be subject to rigorous assessment and approval processes that achieve or exceed the Environmental and Social Sustainability Performance Standards of the International Finance Corporation of the World Bank.

Enhance: Restore, repair, rewild

Through a progressive program of habitat restoration, threat reduction and species recovery efforts NEOM will lead a renaissance of Arabian wildlife.

Sustain: Wise resource use

Through innovation, investment and a deep commitment to sustainability, NEOM's developments – cities, industries and buildings – will be among the most sustainable on Earth. Harnessing technology to use renewable power for all of NEOM's energy needs, produce water and goods without harmful emissions to lead the revolution to circular economy and cradle-to-cradle as operating principles. Additionally, NEOM´s natural resources such as fish stocks, arable and grazing lands will be best practice models of sustainable use through conservation partnerships with land users and fishers.

Inspire: Learn, share, showcase

NEOM paves the way for the future development of the Kingdom of Saudi Arabia. In order to succeed in this mission, NEOM will aim to constantly learn, share lessons and innovations, and use ideas and technological advances to inform and help the rest of humanity. NEOM aspires to inspire the world to re-imagine the relationship between people and nature through commitments and actions that will establish itself as global showcase for sustainability and conservation innovation.

2.2 Objectives and Targets

The objectives noted below have been mapped against those mandated in the NEOM Sustainability Code and the vision set out in the preceding section, with additions that are specific to stormwater management. Proponents will have to demonstrate how proposed strategies align with the objectives detailed below in order to comply with the project gateways noted in Section 4 of this Standard.

Table 2—1 Design objectives for managing stormwater

Water	
Protect the proposed development from flooding and provide resilience to climate change;	• All developments to be designed to protect property and life from a 1 in 100 year storm event with an allowance for 20% increase in rainfall intensities due to climate change. • Safeguard existing wadis and overland flow paths.
Maximise use of passive storm water treatment	• Utilise water sensitive design to capture, treat, infiltrate and convey stormwater e.g. maximise permeable surfaces, utilise green and blue roof systems for buildings etc.
Maintain the existing hydrological regime	• Protect the natural framework by preserving the existing, major overland flow routes. • Encourage infiltration into the ground to mimic existing conditions. • Minimise the need for pumped systems and leverage the existing topography for routing stormwater flows to reflect existing conditions and minimize energy and maintenance requirements. • Reduce flow velocities before entering the wadis to minimise impact of the development on the hydrological regime. • Mimic the existing regime by maintaining pre-development run-off rates and volumes. e.g. Implement soft landscaping features to treat, encourage infiltration and slow down the rate of rainwater runoff to wider networks from hardscaped areas.
Protect the natural environment from contamination	• Remove contaminants at source where possible. • Apply appropriate pollution control measures to stormwater before it is discharged to the wadis and sea. • Treat stormwater runoff to remove pollutants and mobilised particles so as not to cause an adverse impact on the receiving watercourse.

Marine and Land Conservation	
Natural systems audit, management and enhancement	• Identify areas of ecological importance through the assessment and analysis of geology, hydrology, ecology, topography and contextual climatic patterns and create a protection plan. • Document site conditions prior to the start of work, in terms of environmental health and quality, and identify the type, size, and location of project's "reference habitat(s)." • Document site conservation values, including the potential influence on adjacent sites which may have species or habitats of conservation concern. • Possible habitat types include, but are not limited to: forest, desert, mountains, wadis, sand sheets and dunes, gravel plains, sabkhas and, lakes. • Before the start of the design process and site clearance, an assessment of the natural systems is required to be carried out. • Based on the analysis, identify opportunities and constraints associated with the development. Opportunities for enhancement should be sought, as well as opportunities for raising awareness. Key Performance Indicators (KPIs) must be prepared to guide the design of the development, based on the results of the opportunities and constraints analysis.

Zero pollutant run-off	• Landscapes must be designed to avoid adverse impact to the receiving water courses (directly and indirectly) from stormwater runoff. Some of the ways in which this can be achieved:
	  ◦ Only organic fertilizers, pesticides or herbicides may be used and must be carefully contained. No non-organic pesticides used across the development.
	  ◦ Treating the first flush volume of all rainfall events from all development areas prior to discharge to the wider drainage infrastructure.
	  ◦ Project teams will be required to demonstrate how pollutant run-off will be managed through construction and project's operational life.
	  ◦ Project teams will be required to investigate geophysical pathways of pollutant transfer and demonstrate that these have been adequately mitigated to avoid contamination of groundwater sources.
	  ◦ Project teams will coordinate with conservation departments regarding sites of conservation importance.
	  ◦ Operators of the infrastructure will be required to demonstrate ongoing water quality compliance.

Circular Economy	
Project-specific Circular Economy Strategy	• Project Teams are required to develop a circular economy strategy for the projects and consider circularity of water and the selected materials that: o Optimise the use of water and reduce environmental impacts of the construction of stormwater management infrastructure to complement the NEOM Circular Economy Strategy. o Increase durability and lifetime of the stormwater network through resilient planning and preventive maintenance.
Promote sustainable material use	• Stormwater management solutions should have low embodied carbon, support local economy, reduce transportation costs and emissions through sourcing local materials.

Biophilic City	
Celebration of Nature	• Project teams to set a strategy for biophilic design that integrates nature with public realm spaces and provides a presence for water in order to deliver wider community benefits. • Sustainable urban drainage systems are utilised in conjunction with habitat features in urban environment and to improve native biodiversity.
Access to Nature	• Landscapes should be designed to be perceived as wild, spatial landscapes, not cultivated, surface landscapes, and should use locally appropriate native plant species as their biological basis with habitat complexity (multiple vegetation heights or 'stories') part of the design. Planting should consider Future Climate and potential vulnerability and sensitivity of existing flora and fauna and establish urban landscapes that accounts for probable climate change.

3 Design Requirements

3.1 Overview

The following section provides the minimum requirements that all Proponents are required to meet to manage stormwater and pollutant run-off from their developments. This chapter covers the requirements to replicate as far as possible the existing hydrological regime and to avoid adverse impacts on the wadi and marine environment. Further information is set out in Section 4 which outlines how these requirements can be achieved.

3.2 Quantity Control

3.2.1 Discharge Locations

Stormwater will be discharged into an existing wadi or the sea in a manner that replicates the existing hydrological regime. This requires Proponents to maintain the pre-development natural discharge locations into the wadi or the sea. Existing wadis should be preserved, and the existing pre-development overland flow routes maintained. Any modifications to existing overland flow routes will need approval from the Regulatory Approval Body. The design will need to replicate the existing flow rates and velocities and not increase flood risk elsewhere.

In some instances, the plots will naturally drain into a neighbouring plot or via land within the Superplot or Masterplan prior to discharge into the wadi or sea. Where this is the case, the downstream Proponent will be required to provide a formalised overland route to allow the stormwater to be discharged and conveyed through their site. The downstream Proponent will be responsible for either discharging into an existing wadi channel, the sea or a neighbouring plot in the existing pre-development outfall location in order to maintain the existing overland flow routes.

Overland flow paths with a catchment which is contained in its entirety within the one Plot may be realigned and modified, provided it is not a detriment to the environment and approval is obtained from the Regulatory Approval Body. The pre-development outfall location and the catchment area will be required to be maintained to help preserve the existing hydrological regime.

Where the ground conditions allow infiltration, all Proponents are required to maximise infiltration of stormwater to help maintain the existing hydraulic regime and to limit point discharge volumes and velocities. This should also be carried out to encourage aquifer recharge within the NEOM region.

Prior to discharge of stormwater into wadis, the sea or into the ground, the stormwater will be required to meet the treatment requirements set out in section 3.3.3.

3.2.2 Discharge Rates

To replicate the existing hydrological regime within the NEOM Region, all stormwater run-off discharging into the wadis or the sea, is required to be maintained at the pre-development discharge rates. All Proponents will need to demonstrate that the proposed run-off from their developments into wadis or the sea matches the pre-development run-off rates for the following events:

- 1 in 1 year
- 1 in 25 year
- 1 in 100 year
- 1 in 100 year including allowance for climate change.

To achieve this, the following will need to be considered:

- Maximising infiltration within the development where the ground conditions allow
- Capturing and re-using stormwater on site from roofs and hard landscaping for non-potable uses
- Using water sensitive measures to capture, infiltrate and attenuate run-off
- Minimise the hard landscaping within the developments
- Using groundwater recharge if feasible, to capture stormwater to recharge aquifers.

In some instances, the existing pre-development natural overland flow paths for stormwater will be via an adjacent plot or via land within the Superplot or Masterplan before discharging into the sea or wadi. Where this is the case, the Proponent will be required to discharge at existing rates of run-off for the aforementioned events unless otherwise agreed with the Superplot and Masterplan Proponents. If a relaxation on this requirement is agreed to, for example, due to limited space on the plot, additional measures would be required downstream of the plot prior to discharge into the wadis and the sea to maintain pre-development rates of run-off at these downstream locations.

3.2.3 Volume Control

Proponents are required to match the pre-development volumes of run-off from the development within the NEOM Region for the 1 in 100 year 6 hour event including allowance for climate change prior to discharge into the sea or wadi.

To achieve this, the Proponent will need to consider maximising infiltration and capturing rainwater for either re-use within the development or recharge of groundwater where appropriate.

In some instances, the existing natural overland flow paths for stormwater will be via an adjacent plot or via land within the Superplot or Masterplan before discharging into the sea or wadi. Where this is the case, the Proponent will be required to meet the pre-development volumes of run-off prior to discharge from their site unless otherwise agreed with the Superplot and Masterplan Proponents. If a relaxation on this requirement is agreed to, additional measures would be required downstream of the plot prior to discharge to maintain pre-development volumes of run-off at these downstream locations.

Under certain circumstances, matching pre-development volumes of run-off may not be able to be achieved for example, due to the local ground conditions. The Proponents will need to demonstrate to the Regulatory Approval Body:

- Justification as to why matching pre-development volumes is not possible and
- Evidence that there is no adverse impact downstream such as to the environment and to flood risk.

Proponents will need to present any mitigation measures required to minimise the impact downstream. This may include but not be limited to providing long term storage within the development for the additional volume and discharging at a lower than the pre-development, or greenfield, rate of run-off. Such measures will require agreement with the Regulatory Approval Body.

3.2.4 Velocity Control

Proponents are required to match the pre-development velocities as far as possible when discharging into the wadis and the sea for events up to the 1 in 100 year including climate change event. Increasing or decreasing the velocities could alter the natural deposition of sediments, in terms of volume and location of deposition and pose a risk to habitats particularly in the marine environment. This is likely to require Proponents to incorporate interventions which slow the conveyance of water through the site and at the discharge location. Techniques such as check dams installed within swales and the use of detention basins at outlet locations could be utilised. These are described further in section 4.5.

The Proponents will provide scour protection to prevent erosion at all points of discharge where the stormwater discharge presents an erosion risk. Scour protection design is to follow the guidance provided in section 4.6.4 of the report.

3.2.5 Flood Risk Management

The flood risk management strategy for each Masterplan will need to be set out in the ESIA and design documents following the below principles:

- Safeguard existing wadis and overland flow paths;
- Make allowance for wadi channels and new drainage corridors to capture and convey upland flows safely through the development in coordination with the landscape strategy;
- Re-profile the plot landscapes to direct overland flows away from development and towards treatment areas, before discharging to the wadi corridors.

All Proponents will need to demonstrate that the developments are designed such that there are no adverse impacts on property and people up to the 1 in 100 year with climate change allowance event. Proponents will also need to demonstrate that the stormwater run-off does not increase the flood risk elsewhere by maintaining existing flow routes, run-off rates and volumes.

Proponents will be required to accommodate flows from upstream overland flow routes which naturally convey through their plots for a minimum of the 1 in 100 year event including climate change.

The stormwater network and landscaping will need to be designed to protect the development from stormwater flooding following the below requirements:

- No flooding of the development plots as a consequence of surcharging up to a 1 in 25 year with climate change allowance events.
- No flooding of buildings and emergency routes (Rights of Way) up to and including the 1 in 100 year with climate change allowance events.

For exceedance events beyond the 1 in 100 year with climate change events, the Proponents will need to identify and integrate flow routes into the landscaping to convey water safely towards the site-wide conveyance system.

Proponents will be required to set finished floor levels and development levels at a minimum level to provide protection against stormwater, coastal and wadi flooding. The Proponent shall refer to the ESIA and other NEOM guidance for these requirements.

Any modifications or works to wadis will require prior consent by the Regulatory Approval Body. The Proponent will be responsible for demonstrating that any works such as road crossings across the wadi, do not increase flood risk elsewhere.

3.3 Quality Control

The NEOM development has the potential to adversely affect groundwater and ultimately the highly sensitive coastal environment due to increases in nutrients, sediments, particulates, dissolved pollutants and hydrocarbons from untreated stormwater runoff. The vision is to ensure pollutant runoff is maintained to a minimum of pre-development levels to ensure that there is no net increase in pollutants entering the watercourses (indirectly or directly) and ultimately, no adverse impact on the coastal environment.

3.3.1 Pollution and Contamination Requirements

The risk of contaminants in the stormwater entering the groundwater and into the coastal environment should not be addressed by stormwater treatment alone. All Proponents are required to reduce the sources of pollutants as much as possible through the lifetime of the development including construction. Examples of how to reduce sources of stormwater contamination are provided in section 4.4.2.1.

All Proponents will be required to submit a full quantitative risk assessment to the Regulatory Approval Authority to assess the risks of pollutants entering the groundwater or seawater from their proposed development. This should include mitigation measures to reduce the sources of contamination from the development.

3.3.2 Discharge Requirements

Proponents will be responsible for capturing stormwater run-off from hard landscaped areas, multiuse hard surface areas, buildings, and soft landscaping and directing towards treatment areas prior to discharge off-site or into an existing wadi or sea environment. Treatment areas should be located where possible, on plot as close to the source of the run-off as possible.

The water quality discharge should meet, as a minimum the requirements of the National Ambient Water Quality Standard for KSA and where identified meet the water quality parameters identified in Appendix C for surface water runoff to groundwater, inland water bodies and costal environments. These parameters have been proposed considering international best practice guidance in order to preserve the existing water bodies.

The Proponent shall confirm with the Regulatory Approval Body the discharge water quality requirements prior to commencement of design. This shall be informed by the investigations and modelling to determine the thresholds for groundwater and marine environment.

3.3.3 Treatment Requirements

Stormwater run-off from small, regular rainfall events and the first flush from larger rainfall events contain higher concentrations of contaminants. As a minimum, Proponents will be required to treat the first 20mm of rainfall on their plot prior to discharge unless otherwise agreed with the Regulatory Authority Body. This is based on treating the entire volume of run-off from small, regular rainfall events up to the equivalent of the 1 in 5 year 60 minute rainfall event and from the initial rainfall volume from larger order events.

The above guidance of 20mm is provided as a minimum standard for Proponents and is subject to site specific assessments undertaken by the Proponents.

It is the responsibility of each Proponent, through hydraulic modelling, to demonstrate the pathways for pollutant run-off from their site and to demonstrate that there is no adverse impact on the groundwater and coastal environment. This will require experts in hydrogeology to advise on pollutant transport pathways through the sub-surface geology and to advise on the water quality threshold levels to be achieved prior to discharge.

Proponents are required to treat the stormwater run-off from the plots, and in order to do so should deploy passive treatment techniques. These measures will need to be designed to treat the first flush volume while bypassing later runoff, without washing out the material retained from the first flush.

Temporary treatment of stormwater discharge will also be needed to be provided during the construction phase. These will be required to be detailed in the Construction Environmental Management Plan (CEMP) for approval by the Regulatory Authority Body.

Proponents are also required to undertake modelling and submit the model and outputs to the Regulatory Approval Body to demonstrate that the treatment systems introduced meet the required water quality prior to discharge from their site.

Existing wadis and overland flow paths, which convey stormwater runoff from a catchment that extends beyond a single plot boundary are not permitted to be used for the treatment of stormwater. Any discharge of stormwater runoff into these wadis shall be treated to the required standards prior to its discharge.

3.4 Stormwater Infrastructure

3.4.1 Infrastructure Requirements

Water sensitive design measures are required to be used to capture, treat, infiltrate and convey stormwater through the site. Examples are discussed in section 4.5 and include swales, detention ponds and bio-retention basins.

Proponents will be required to demonstrate the resiliency of the methods utilised to treat stormwater runoff in the event that there is a failure in the system such as a blockage. Treatment solutions should be located outside the ecological setbacks for wadis and coastal environment as set out in the ESIA and confirmed by the Regulatory Approval Body.

Infrastructure should be selected and designed to minimise maintenance issues, including frequency, and sediment accumulation and avoid blockages and surcharging of the system.

Proponents are also required to avoid stormwater pumping systems and leverage the existing topography for routing stormwater flows to reflect existing hydrological conditions. Any pumping within the network will require approval by the Regulatory Approval Body.

Closed systems such as pipes and long culverts should be avoided to capture and convey stormwater and overland flow through the developments as it is more difficult to replicate existing flow and sediment conditions. Closed systems often have maintenance issues, including ease and frequency of inspection and sediment accumulating in the closed network may lead to blockages and surcharging of the system.

3.4.2 Design Life

The design life for the stormwater infrastructure is required to be as follows, unless otherwise agreed by the Regulatory Approval Body:

Infrastructure	Design Life
Primary Infrastructure	100 years OR Design Life of Assets the Primary Infrastructure is serving, whichever is greater.
Secondary Infrastructure	100 years OR Design Life of Assets the Secondary Infrastructure is serving, whichever is greater.
Tertiary Infrastructure	Design Life of Assets the Tertiary infrastructure is serving.

3.5 Design against Mosquitoes

Water Sensitive Design (WSD) systems, such as bioretention gardens and wetlands, can serve as breeding grounds for mosquitos if allowed to hold stagnant water for an extended period. Due to this, permanent wetland systems are not recommended without mitigation measures.

Bioretention and ephemeral wetland systems (seasonal) shall ideally be designed to hold water for less than 48 hours from the end of the event to prevent mosquitos reaching adulthood.

3.6 Operation and Maintenance

All Proponents are responsible for designing the stormwater system such that it can be safely constructed, operated, maintained and also removed and reused or recycled at the end of its intended design life. The Proponents are required to comply with the Health and Safety regulations set out by NEOM that will require provision of safe access, manholes, monitoring stations etc. that allow stormwater infrastructure to be maintained appropriately.

All Proponents will be required to submit an Operation and Maintenance Manual at the project handover to include As-Built information and the maintenance plan. The Operation and Maintenance responsibilities for the Proponents and the Operator will be provided in separate guidance by NEOM.

During the operation of the developments, Proponents will be required to undertake compliance monitoring and reporting. This may include water quality monitoring results for the stormwater infrastructure and providing maintenance certificates. The frequency of monitoring should be in line with the type of land use. For instance, land uses that pose a greater risk of contamination to surface water runoff may require continuous monitoring of discharge off site whereas lower risk uses could implement a less frequent annual or bi-annual regime for flow monitoring. The requirements by the Regulatory Approval will need to be confirmed and will be subject to the findings of the Regulatory Approval Body.

3.7 Summary of Requirements

For All Proponents, below is a summary of the requirements listed above:

- Maintain the existing discharge locations into the wadi, sea or neighbouring plots or Superplot/ Masterplan areas.
- Safeguard existing wadis, overland flow paths and near shore coastal water inputs.
- Maintain pre-development discharge rates, volumes and velocities.
- Protect people and property from stormwater flooding and not increase flood risk elsewhere.
- Maximise infiltration of stormwater and capture of rainwater for re-use and /or aquifer recharge.
- Treat the first flush volume at source prior to discharge to the approved water quality.

4 Design Philosophy

4.1 Overview

Information provided in the following section outlines the key steps that all Proponents should consider as they progress the design of the stormwater management strategy for the site in consideration. This section gives guidance that should assist Proponents in satisfying the requirements at each gateway during the project's design timeline. To reflect the development timeline, key project gateways have been split into three main design stages – Masterplan, Asset Design, and Construction and Handover (Figure 4—1). The design of stormwater systems is integral to these three overarching project stages and the milestones that will be contained within them. As Proponents seek compliance with the Regulatory Approval Body, they will have to demonstrate progression in their design of stormwater management systems.

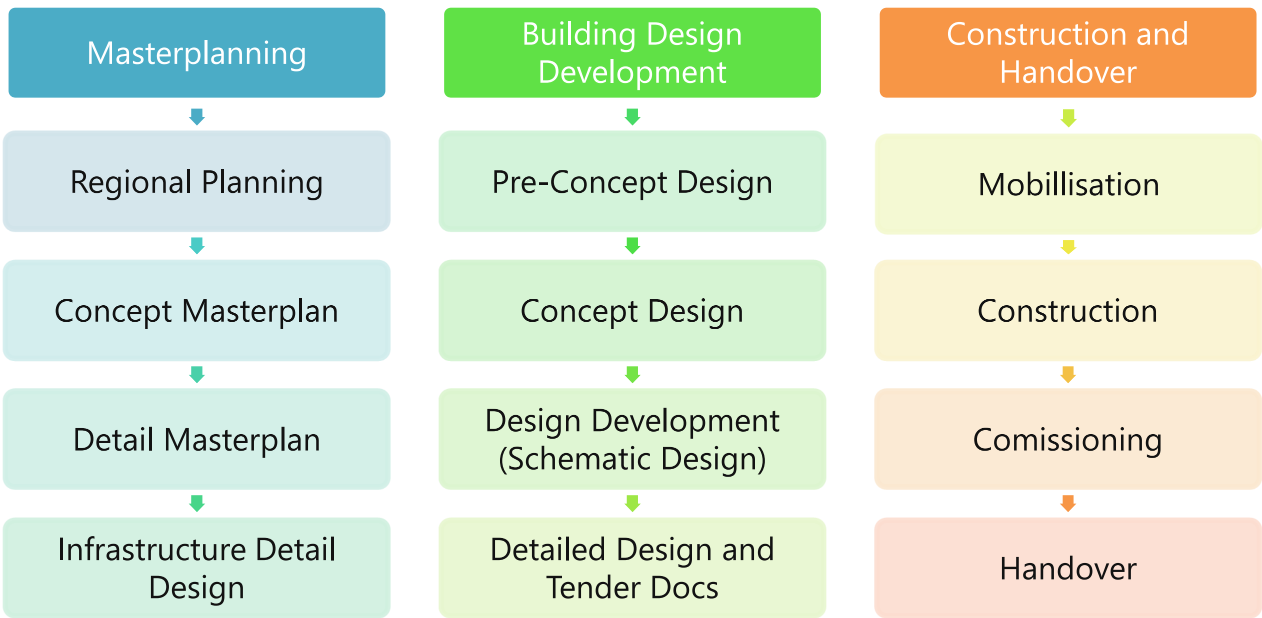


Figure 4—1 Project pathway and design gateways

4.2 Design of Stormwater Management Systems

The design of stormwater management systems should be undertaken while being cognisant of the project constraints and the wider design objectives for the NEOM region. This section outlines the design philosophy that Proponents developing stormwater management solutions should go through as they progress though the design gateways. The purpose of these guidelines is to outline the key steps and considerations that designers of stormwater networks should account for in the development of stormwater management systems.

The guidance given on design methods in this section should be read in conjunction with design codes and international best practice reference documents noted in Section 6.3 of this document. The requirements set out in this guidance document (Section 3) should be applied in conjunction with Kingdom of Saudi Arabia design codes unless agreed otherwise with the Regulatory Approval Body. Where appropriate this guidance makes reference to international best practice such as the CIRIA C753 Sustainable Urban Drainage Manual and Proponents are expected to follow the design procedures outlined within such documents.

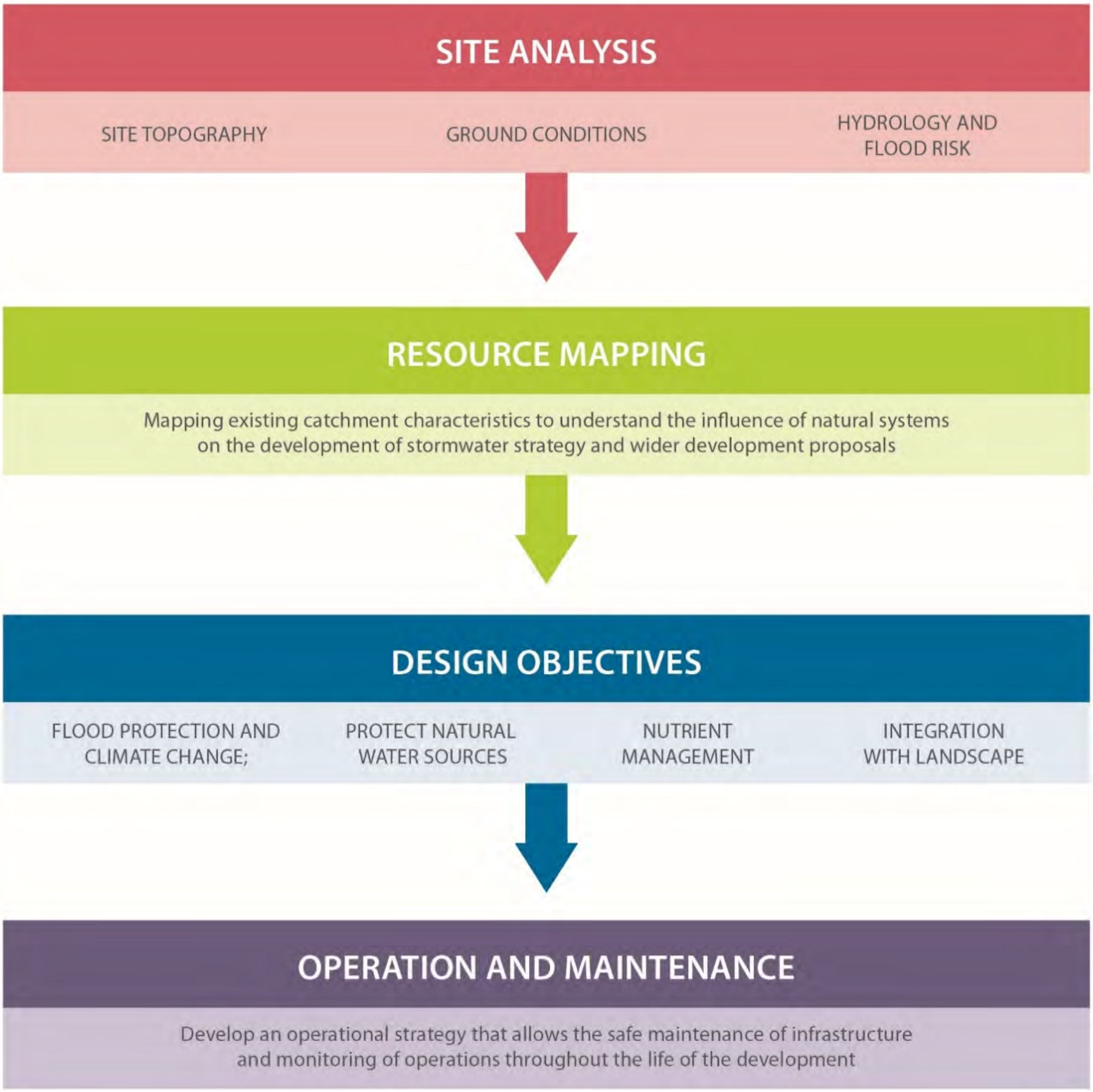


Figure 4—2 Key steps to follow when developing a stormwater management strategy

4.2.1 Site analysis

Site assessments should be carried out at the earliest opportunity within the design programme. A site comprises of a number of physical layers that can be illustrated through the attributes such as geology, topography, ecosystems, and hydrological patterns (Figure 4—1). Desktop surveys and site visits will help inform the need for further technical assessments, such as specialist environmental surveys. Development proposals should take account of the entire range of factors that impact the design of stormwater management systems. The site assessment should include an assessment of:

- Site topography
- Existing environment and ecology
- Site hydrology (climate and rainfall)
- Hydrogeology of the site (ground conditions)
- Other sources of flood risk in context of the site such as tide levels, existing below ground sewers or other drainage infrastructure.

Alongside undertaking a site assessment, reference documentation available by NEOM and other regulatory stakeholders should be given consideration when assessing site conditions. Where site information required to complete initial site investigations is unavailable from the Regulatory Approval Body, it will be the responsibility of the Proponent to undertake the necessary investigations to complete the site analysis.

Early assessments should be utilised to engage with both the Regulatory Approval Body and external stakeholders in order to inform the thinking on stormwater runoff management. The two key elements of the site analysis stage include:

1. A study of the site attributes undertaken via site surveys and desk studies.

2. Developing an understanding of the site resources that can be mapped to inform the baseline condition of the site and their influence on stormwater management.

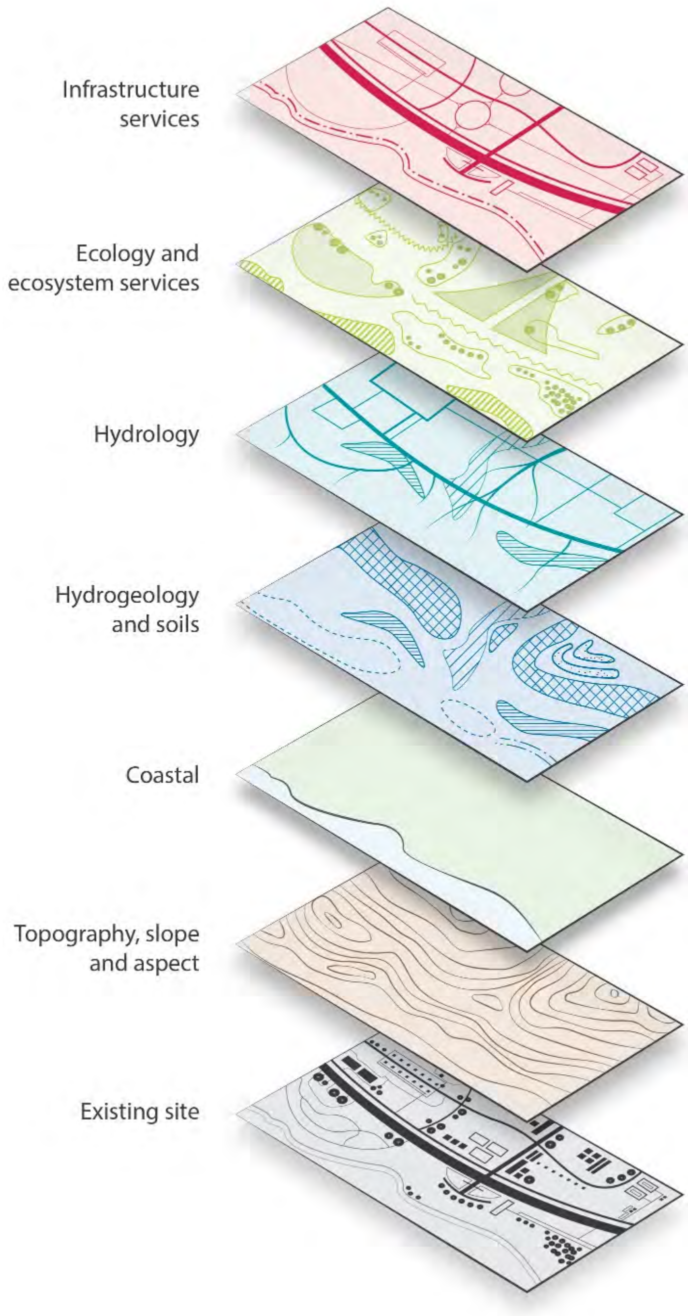


Figure 4—3 Bio-physical layers of assessment for the site

4.2.2 Site topography

The topography across the site is varied, ranging from coastal plain to mountainous areas. Elevations across the site range from 0m at sea level and coastal plains to 3000m at Jabal Al Lawz and other mountainous regions as shown in Figure 4—4. Topographic data in the form of 2m contours is available for the NEOM region and can be requested by the Proponents from the Regulatory Approval Body. This is based on data derived from 1.5 m resolution Spot 6-7 (2016) stereo imagery produced in 2017 by Public Investment Fund (PIF). The Proponents will be responsible for undertaking site specific topographic survey information to inform their stormwater design strategies.

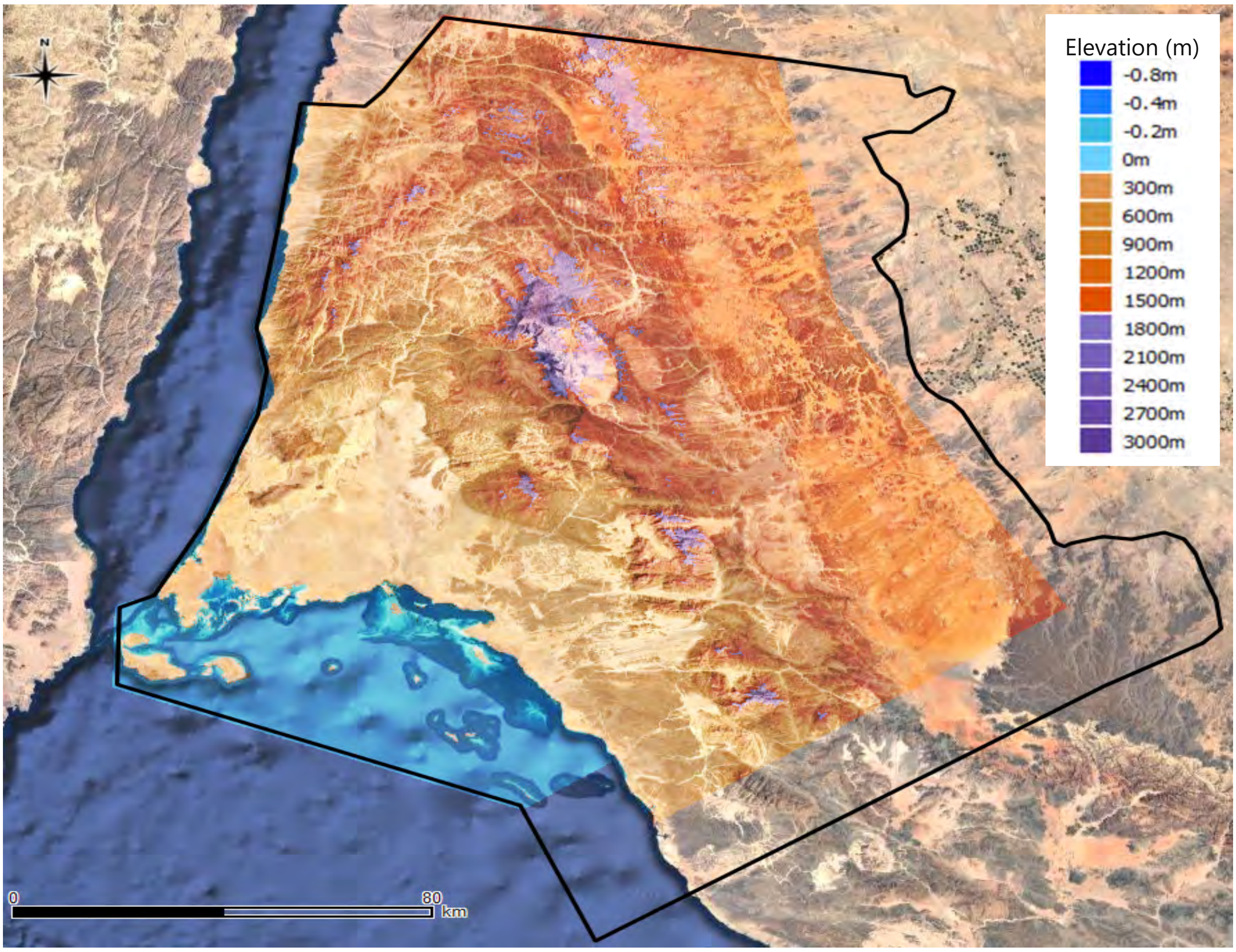


Figure 4—4 LiDAR topographical model for the NEOM Region.

4.2.3 Ground conditions

The NEOM region demonstrates a significant variability in ground conditions and specific desk and site based studies should be undertaken to determine the opportunities and constraints for the development. Proponents shall be responsible for these studies including the specification and procurement of ground investigation at their site. Investigations should be used to understand ground conditions, groundwater levels and infiltration potential on the site to inform the stormwater design strategy.

4.2.4 Hydrological conditions

The climate in the north western region of the Kingdom of Saudi Arabia is characterised by hot temperatures and rare, irregular rainfall throughout the year. Despite the arid climate, intense rainfall (usually falling in the winter months) can lead to fast overland flows as a result of the unsaturated and steep ground. Snowfall can be observed on rare occasions in the winter throughout the region at the higher elevations.

The Proponents may wish to request the following information from the Regulatory Approval Body to inform their understanding of the site's hydrology:

- Detailed climate data in order to determine the micro and macro climatic conditions affecting the proposed development area including rainfall data local to the site. This is to allow the development of Intensity, Duration and Frequency relationships for the different storm return periods. An example of such data from the rainfall gauge in Tabuk has been included in Appendix B of these guidelines.
- Major catchments and stormwater flow routes throughout the NEOM Region with flood maps that define the inundated areas in the 1 in 100 year return period storm event with a 20% allowance for the impact of climate change.

4.2.5 Coastal flood risk

Catchments that have an interface with the Red Sea and Gulf of Aqaba coastline should give due consideration to coastal flood risk. Tide data, information on sea level rise etc. should be requested from the Regulatory Approval Body when commencing design to develop an understanding of the coastal flood risk. A key constraint on coastal developments will be the sensitive marine ecology in near shore conditions. Proponents will therefore have to review the requirements detailed in the ESIA with the NEOM marine conservation division for such catchments to understand requirements in order to be compliant with stormwater discharge conditions that protects the sensitive marine ecology.

4.3 Resource and environmental constraints mapping

The site assessment should be integrated with undertaking an exercise to map existing resources. This analysis should focus on the land use plans for the site and aim to evaluate the influence that proposed land uses may have on the existing ecological landscape.

Resource mapping should be used to inform discussions on the interventions necessary in order to maintain the existing environmental conditions that support the catchment characteristics of the proposed development area. Information specific to the site where available should be requested from the Regulatory Approval Body, but where such information does not exist, a combination of desks studies and site investigations should be undertaken to get a comprehensive of overview of resources within the site boundary.

4.4 Achieving design objectives

In developing the strategy for managing stormwater runoff from the site, Proponents will have to demonstrate that strategies are aligned to the objectives set out in Section 3 (Vision and Objectives). Proponents will have to provide evidence of compliance in order to receive the relevant approvals from the Regulatory Approval Body.

This section of the Standard details how the compliance requirements detailed in Section 3 (Design Requirements) can be achieved in order to demonstrate that the stormwater management strategy is aligned to the NEOM objectives for water management (Section 2 Vision and Objectives).

4.4.1 Quantity Control

4.4.1.1 Flood risk and climate change

As detailed in Section 3 (Design Requirements), in assessing the flood risk from the design storm event, Proponents should ensure that the peak runoff rate and volume of stormwater discharge from a site is controlled. Runoff conditions should be maintained to reflect existing conditions within the catchment and where possible demonstrate an improvement on pre-development conditions.

Existing catchment conditions for each development area should be determined through the use of hydraulic modelling. To ascertain catchment response to the design storm event (Section 4, Design Requirements), 2D hydraulic modelling techniques are recommended to determine the stormwater flows, depths, velocities, flood extents and discharge locations. Discharge rate and velocities for the storm return periods noted in Section 3.2.2 should be determined for storm durations that are critical to the site in consideration. Discharge locations for the existing catchment are of specific importance as these will have to be maintained as close to existing, post development. The modelling of existing catchments may either be undertaken by the Proponent or provided by the Regional Approval Body.

4.4.1.2 Controlling peak runoff

To establish the peak rate of runoff for storm return periods noted in Section 3.2.2, The Rational Method is a commonly used method to determine flow rates from the design storm event. The use of this method should however be restricted to catchment sizes less than 1km^2. For catchments greater than 1km^2 the Soil Conservation Service-Curve Number (SCS-CN) method is suggested as an alternate method that can be utilised for determining the peak rates of runoff. The choice of method for determining the peak rate of runoff and volume is for the Proponent to agree in conjunction with the Regulatory Approval Body to best understand the existing catchment characteristics.

In order to determine the peak runoff, rainfall data local to the site that allows the development of Intensity Duration and Frequency relationships for the different storm return periods should be requested from the Regulatory Approval Body. An example of such data from the rainfall gauge in Tabuk has been included in Appendix B of these guidelines.

See Section 4.5 for solutions that can be implemented to reduce peak runoff from the site. Noted below are recommended methods for reducing peak runoff off site for the design storm event:

- Encouraging rain falling on site to infiltrate.
- Implementing rainwater capture techniques for reuse on site where sensible.
- Slow down the velocity of flow by using natural conveyance channels as opposed to piped systems and hard infrastructure e.g. precast concrete channels.
- Utilise detention features like dry ponds to attenuate stormwater runoff.
- Allow low impact areas like car parks and public amenity spaces to hold stormwater from extreme storm events. Maximum depth of storage to not exceed 300mm.

Proponents will be expected to contain and discharge flows at pre-development run-off rates for a 1 in 100 year storm + 20% climate change 24 hour duration rainfall event. Where outfall from the stormwater networks discharge directly to a wadi or the sea, Proponents should verify the impact of high tide levels or extreme flood levels in the wadi on outfall performance. A joint probability analysis is recommended to ascertain the site specific risk.

Proponents will have to demonstrate that for events that exceed the design capacity of the stormwater infrastructure, suitable exceedance routes have been provided that match predevelopment overland drainage routes as closely as possible and do not exacerbate downstream flood risk.

4.4.1.3 Controlling runoff volume

As shown in Figure 4—5, attenuation features help control the discharge rate by flattening the peak runoff from managed catchments. Attenuating stormwater in lieu of infiltrating or re-use does not reduce the volume of stormwater leaving the site. As post development site conditions typically increase the volume of runoff being conveyed offsite, curtailing the rate through attenuation only results in peak rate being capped but allows an increased total volume of water to enter the receiving watercourse.

When discharging to natural watercourses such as wadi systems this may result in greater degradation as watercourses cope with greater volumes of runoff in extreme storm events for an extended period, albeit at a controlled rate of discharge. This effect is amplified as multiple smaller catchments each attenuating their own flow are contributing to a common wadi, thus resulting in a net increase in overall peak volume and worsening the flood risk to downstream catchment areas.

Proponents will therefore have to use strategies that reduce the rate of runoff and techniques that hold back the flow in order to allow it to infiltrate to protect downstream water receptors.

The difference in volumes between the anticipated post development runoff volume and the estimated greenfield runoff volume for the 1 in 100 year + 20% climate change 6 hour rainfall event should be stored and released at the average annual peak flow rate (mean annual flood, QBAR). Refer to Appendix D for checklist that Proponents will be required to complete in order to demonstrate that they have calculated the necessary parameters for surface water runoff and volume in order to meet the compliance criteria set out by the Regulatory Approval Body.

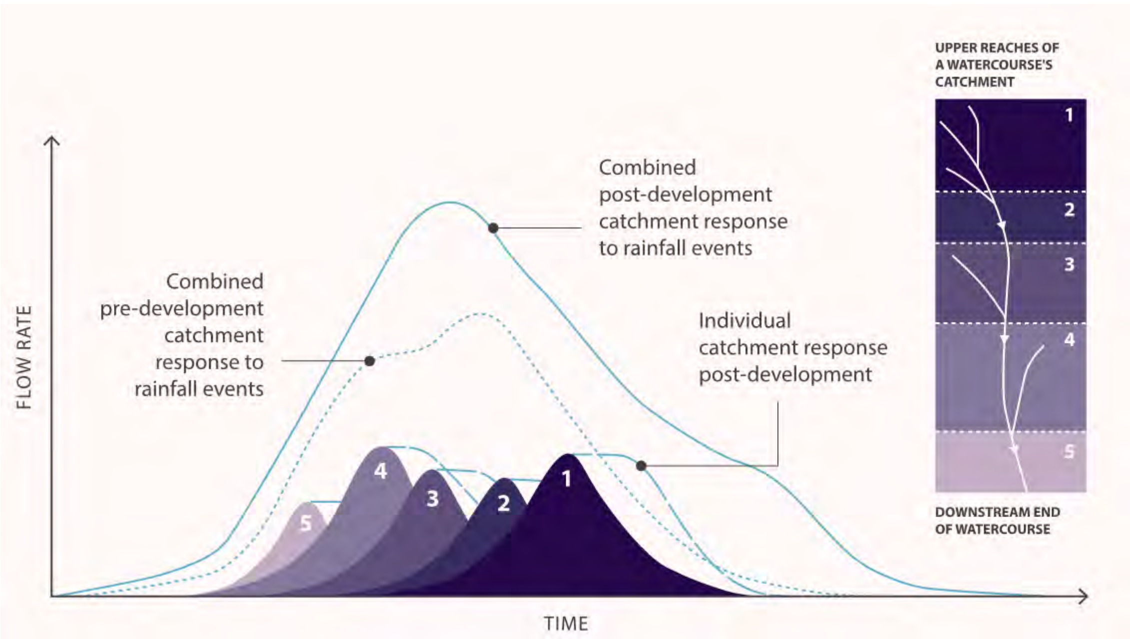


Figure 4—5 Impact on downstream catchments from increased volume resulting from attenuation in individual catchments

4.4.2 Quality Control

Section 3.3 of these guidelines details requirements for mitigating the impact of pollutants reaching natural water courses, groundwater and subsequently the sea. Stormwater within the development boundary will have to be captured and treated prior to discharge except for runoff originating from land that is not being developed. The level of treatment necessary will be dependent on the type of contributing surface and land use.

The guidance provided within this section assumes that as part of the Site Analysis stage, Proponents have undertaken the necessary studies to develop an understanding of the baseline conditions within receiving waterbodies and the sub surface geology. The key objectives of these assessments should be:

- Numerical modelling to establish the probability that baseline thresholds will be exceeded once the developments are in place with an interpretive report submitted to the Regional Approval Body that explains the sub-surface geological conditions.
- Determining the pollutant pathways through nutrient emission modelling based on landscaping and land use proposals for masterplan area.
- Recommendations for mitigation measures and optimisation of development proposals

Refer to Section 4.5 for technologies that Proponents can adopt in order to treat stormwater runoff.

4.4.2.1 Pollutant runoff control

Typically, at the start of a rainfall event, a peak load of pollutants enters the stormwater conveyance system as relatively small amounts of rain are sufficient to mobilise pollutants from the surface (Figure 4—6). The pollutant load then tends to diminish before rising again as discharge from parts of the catchment that are further away reach the discharge location. Pollution prevention should follow the below hierarchical approach:

- Avoid materials that generate pollutants and develop construction method statements that prevent the generation of pollutants.
- Prevent pollutants from mixing with stormwater runoff.
- Intercept pollutants by deploying the appropriate removal, treatment and solution in the design stormwater drainage network.
- Use of organic fertilizers, pesticides and herbicides only.

As noted in Section 3.3.3, the target for treatment solutions will be to treat the equivalent of the 1 in 5 year 60 minute rainfall event which should require Proponents to treat the first 20mm of rainfall. This guidance is provided as a minimum standard for Proponents and is subject to conclusions from the ESIA and modelling undertaken by the Proponents.

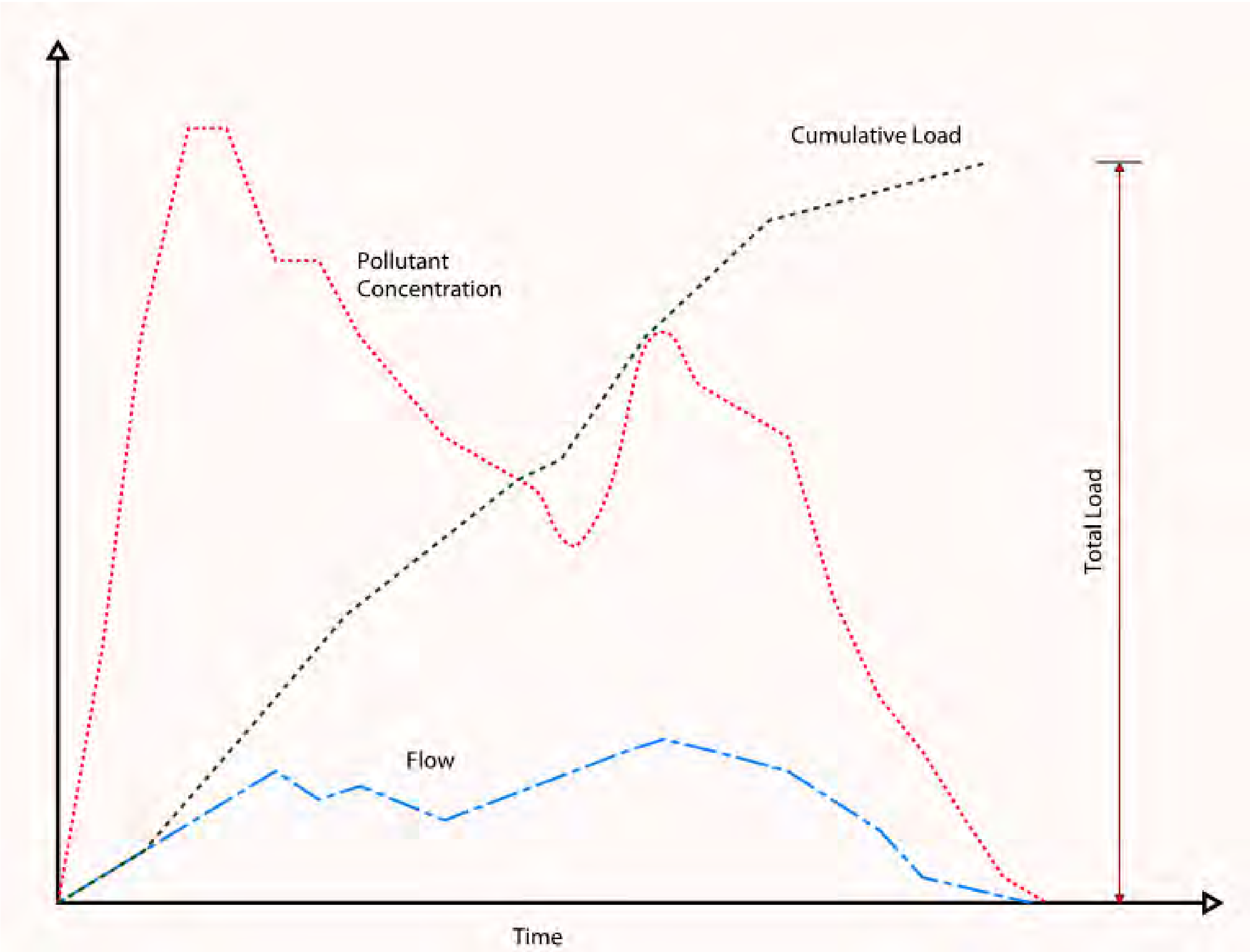


Figure 4—6 Flow, pollutant concentration and load increase during rainfall event (Source: CIRIA SuDS Manual 2015)

The following steps should be followed to contain pollutants from entering watercourses and mitigate the impact of pollutants being transported through stormwater runoff:

Manage stormwater close to the source

Quality improvement solutions should be designed close to the source of runoff. This will allow the treatment solutions to tackle lower pollutant loads and thus work more effectively. If poor treatment performance is observed, treatment trains can be isolated from the wider network and impact on the wider drainage network mitigated.

Treat stormwater runoff on the surface

As far as practical avoid the use of buried proprietary products to treat stormwater runoff and use natural vegetation to provide the required treatment. Exposing sediments to natural sunlight allows the breakdown of contaminants such as oils and hydrocarbons.

Treat stormwater to remove a range of contaminants

The different land uses within development proposals will result in varied pollutants. The treatment solutions being developed should therefore be aimed addressing a broad range of contaminants.

Minimise the risk of sediment remobilisation

The design of treatment solutions should avoid the risk of sediments being remobilised and washed into receiving water bodies during events greater than those for which the treatment solution has been designed. Proponents are referred to the guidance within the CIRIA SuDS Manual 2015 for detailed strategies that can be adopted in order to mitigate the risk of sediment remobilisation.

Minimise impacts of accidental spills

Proponents will have to demonstrate that the treatment solutions being proposed are able to deal with accidental spillages through robust treatment design that manages the risk to sensitive downstream ecologies.

Plan land uses with the least risk pollution adjacent to sensitive environments

Land uses such as golf courses or farming have a tendency to contribute high nutrient loads during rainfall events. Such land uses should therefore be allocated within zones that minimise the likelihood of pollutants being transferred to groundwater, watercourses or marine environment. Where such land uses are being proposed, they should be approved by the Regulatory Approval Body and aligned to the requirements identified within the ESIA. In such situations, setbacks from wadis and marine environment should be considered. Detailed modelling should be undertaken to inform the setback distances to respect ecological considerations and to meet buffer zones in the conservation standards. Where no information is available, for initial development planning, all proposals should be set back by a minimum of 50m until investigations are undertaken to confirm pollutant transfer pathways and calculations for determining suitable application quantities and practices for nutrients etc depending on vegetation quality as part of the ESIA assessment process.

Minimise the risk of network failure

Proponents will be required to demonstrate the resiliency of the methods utilised to treat stormwater runoff in the event that there is a failure in the system such as a blockage.

4.5 Stormwater Technologies – Water quantity and quality management

This section provides guidance on the design of stormwater quantity and quality management technologies. It explores different options available for use and outlines general design considerations. It will be the responsibility of the Proponent to ensure the technologies listed below are suitable for the site, and to make the necessary arrangements to ensure they adhere to processes set out by the Regulatory Approval Body. Infiltration Systems

Infiltration systems are designed to facilitate the flow of stormwater runoff back into the ground, reducing the overall volume of stormwater runoff and aids the regeneration of the natural water cycle.

- Soakaways – soakaways are excavations that are made to be filled with void forming material that allows the temporary storage of water before allowing it to soak into the ground. These usually incorporate geocellular units wrapped in geotextiles. Geocellular units provide a much larger capacity for water storage and are easy to install.
- Infiltration trenches – these can be described as linear soakaways. As these can be installed across a long length, their benefit is that they can be kept much shallower than regular soakaways. A perforated pipe can also be installed at the bottom of the infiltration trench to aid water distribution along the trench.

- Infiltration blankets – typically constructed using permeable aggregate or geocellular units, these are large shallow systems that allow for temporary storage. Examples of infiltration blankets include car parks surfaced with porous materials and that use the pavement build up layers for the storage of stormwater runoff.
- Infiltration basins – these are flat bottomed, shallow landscape depressions that can be used to store runoff before infiltrating back into the subsoil and then into the ground water. Infiltration basins can also allow pollutants to settle and filter out prior to infiltrating back into the sub-soil. This is beneficial for areas with higher numbers of pollutants and for areas with sensitive ground water environments.

General design considerations

To ensure there is no risk of groundwater contamination, all infiltration systems will require a level of filtration before infiltrating into the sub-soil. As a minimum, a distance of 1m should be adopted between the base of any infiltration system and the maximum likely groundwater level including for the effects of climate change. This will also decrease the risk of groundwater contamination.

To ensure infiltration systems function effectively, specific pre-treatment and sediment removal strategies should be implemented, and infiltration systems should be regularly maintained. The overall performance of infiltration systems is dependant of the infiltration capacity of the underlaying sub-soil in the areas where the infiltration systems are proposed. Infiltration tests should be carried out to verify that the soil infiltration rate is sufficient to percolate the required volume of stormwater runoff.

As part of the design process for any infiltration system, the following issues should be assessed:

- Risk of insufficient infiltration into the ground due to impermeable sub-soil layers
- Risk of pollution from infiltration of polluted stormwater runoff
- Risk of groundwater or (downstream) soil contamination due to existing site contaminants
- Risk of contamination of marine environment and conservation areas
- Risk of ground and slope instability due to infiltration
- Risk of groundwater flooding due to infiltration
- Risk of groundwater leakage into sewers and other below ground drainage systems
- Risk of infiltration systems not functioning effectively due to lack of appropriate maintenance mechanisms and procedures

Hydraulic design

Infiltration systems should be able to drain from full to half full in a 24-hour period. Where infiltration systems are designed for storm events larger than the 1 in 25 year event, it results in large storage volume being required and infiltration systems should be supported by detention features like dry ponds to accommodate the required storage volumes.

It may be appropriate to make an allowance for longer half draining times, but an assessment should be made based on volumes available for storage, the required performance of the system, and the risk and consequences of flooding events or consecutive flood events.

Volume control and exceedance design

Infiltration reduces the volume of runoff from a site, therefore reducing the need for attenuation storage volumes. A temporary overflow storage area should be considered to manage flows that exceed the capacity for storm events larger than standard of service designed for, or for flows stemming from consecutive storm events. This can be carried out by installing an overflow pipe at a level higher than the infiltration system, conveying runoff to the dedicated flood exceedance area. Dedicated flood exceedance routes will be required to lower risk non sensitive areas that do not cause significant issues if temporarily flooded. It will be the responsibility of Proponents to identify and agree specific flood exceedances routes and areas that reflect the existing conditions.

4.5.2 Filter Strips

Filter strips are uniformly graded sloping strips of dense vegetation (typically grass) that are designed to treat runoff from adjacent polluted impermeable areas and are designed to filter and treat stormwater runoff and to promote sedimentation and infiltration (where possible). Filter strips function best for flows moving at a low velocity and typically as a pre-treatment system where there is an additional downstream component such as a swale or a bioretention system. Filter strips are usually vegetated as vegetation also further promotes the removal of free soluble pollutants.

Filter drains are suitable for use on a variety of different sites but are well suited for managing runoff from linear infrastructure components, such as roads or public transport tracks due to their linearity. They also provide adequate preliminary treatment for runoff pollutants from roads and industrial sites as pollution can be identified relatively easily.

General design considerations

The contributing drainage area being conveyed into the filter strip system should incorporate a shallow slope that falls towards the filter strip. Typically, as filter strips require a consistent sheet flow for best performance, longitudinal slopes should be kept to a minimum. Small changes in longitudinal slopes can be accommodated for using broad crested weir arrangements.

Filter drains should be designed to extend the entire length of the area being drained. They should be effectively incorporated into public open spaces and landscaping areas to ensure their functionality is not compromised by the activity of the sites they are used on (such as damage from parking or pedestrians).

Key issues that typically cause failure within a filter strip system include the following:

- Clogging at the vegetation interfaces and disturbing sheet flow
- Inappropriate landscaping, omitting the drop from the hard surface to facilitate flow of run-off
- Inaccurate grading of bottom of filter strip slope (too little resulting in lack of sheet flow, too much resulting in soil erosion)

Filter strip systems are a relatively simple technology, but best practice construction and maintenance procedures should be adhered to ensure they function as required. Regular maintenance plans are required to ensure vegetation/grass is trimmed back regularly. Occasional sediment removal will also be required to maintain the filter strips effectively.

Hydraulic design

It is essential that sheet flow conveyed to the filter strip is maintained to ensure the filter strips function effectively. To maintain this, filter strips should be designed with a minimum longitudinal slope of 1%. Maximum longitudinal slopes should not be larger than 5% to prevent flow channelling reducing the risk of erosion. Where longitudinal slopes are greater than 5%, a series of weirs may be used to maintain sheet flow.

It is recommended that maximum flow velocities across filter strips should be no greater than 1.5 m/s to stop soil erosion.

4.5.3 Filter Drains

Filter drains are shallow trenches filled with selected granular or other porous materials and provide temporary attenuation for stormwater runoff from adjacent hardscaped areas. Filter drain fill material can also be replaced by geocellular storage; these offer a greater void ratio for storage but have limited treatment capabilities. Filter drains should ideally receive lateral flows from adjacent hardscaped areas, where pre-treatment has been carried out via a vegetated filter strip or equivalent system.

Depending on infiltration requirements/capabilities of the site, filter drains can either be lined or unlined. In the case of a lined filter drain, this is usually carried out through the use of a geotextile membrane. Perforated pipes should also be installed at the bottom of the filter drain trench to facilitate the collection and conveyance of water through the length of the filter drain. Suitable bedding materials should be selected for the perforated pipes.

Filter drains can help to reduce pollutant levels in runoff by filtering out sediments and other pollutants.

General design considerations

Typically, filter drains depths should be 1-2m. To ensure reasonable levels of pollutant removal, the maximum depth of filter medium under any pipe distribution/outfall collection system should be 0.5m. Where infiltration is possible, the maximum groundwater level should be a minimum of 1m below the level of the bottom of the filter drain trench including an allowance for increase in groundwater levels due to climate change.

To minimise risks of blockages, the void ratio and porosity of the granular fill materials selected should be high enough to allow sufficient percolation rates and control the risk of blockages. The type of fill material selected will also depend on the type of site the filter drain will be installed on and the surface loadings the filter drain will have to withstand (i.e. vehicular traffic).

Filter drains are best located adjacent to impermeable surfaces such as car parks or roads with effective upstream pre-treatment systems. An effective pre-treatment option for filter drains could be a small length of filter strip to remove pollutants and facilitate silt removal and sedimentation. Regular maintenance and inspection are required to ensure filter drain systems function effectively.

Hydraulic design

To facilitate low conveyance velocities and stable flows, filter drains should be restricted to sites without significant slopes. Longitudinal slopes should be limited to 2%, and filter drains should be installed parallel to contours if possible.

The rate of percolation through the filter drains should be sufficient to meet the design criteria for the site. The storage of water volume is dependent on the materials selected and the specific site requirements. Proponents will be required to make an assessment of this during the design stage.

4.5.4 Swales

Swales are vegetated open channels, typically flat bottomed and relatively shallow. These are designed to convey, treat, and typically store stormwater runoff. Additionally, they can also enhance public spaces and landscaped areas on sites – offering biodiversity and aesthetic benefits. Swales are best suited to a variety of sites, including paths, roads, and car parks. They can also replace conventional pipework systems as a means of conveying runoff from contributing areas, and the use of adjacent filter strips in conjunction with the swales can also eliminate the need for kerbs and gullies.

Standard swale channels are usually broad and shallow and could be covered with vegetation suitable for local conditions – this slows the slow of water and facilitates the filtering and sedimentation of the runoff. Depending on the slopes found across the site, swales can also incorporate check dams or berms installed along the flow path to slow down the velocity of the runoff.

Swales can be used for a variety of applications and are well suited to managing runoff from roads as they can easily be incorporated as a linear roadside feature.

There are three types of swales typically used, these are as follows:

- Conveyance swale – this is a shallow potentially-vegetated channel, designed to treat and usually attenuate stormwater runoff. For small rainfall events, mini swales can be used. These usually incorporate effective overflow facilities that convey to alternative downstream components.
- Dry swale – also a shallow potentially-vegetated channel, but usually also incorporates a filter bed of prepared soil that overlays an underdrain system. This provides additional treatment and prevents waterlogging. The dry swale is usually wrapped in a geotextile, and if infiltration is not permitted, an impermeable liner at the base.
- Wet swale – this system is comparable and equivalent to the conveyance swale but is designed to be best suited to wet and marshy conditions and for sites with poorly drained soils. The base of wet swales will be planted using specific wetland planting. Wet swales are unlikely to be suitable of the climatic conditions within NEOM and Proponents should give consideration to risks like growth of mosquitoes arising from using such solutions.

All swales require regular maintenance to ensure long term performance. This typically involves removal of litter and debris, and maintenance of the vegetated area.

General design considerations

Swales are easiest to construct when they have a trapezoidal or parabolic cross-section, so it is best practice to design them this way. This shape also offers ease of maintenance and provides good hydraulic performance. Generally, swales should be designed with a bottom width of 0.5-2m, allowing for shallow flows and preventing flows creating erosion channels. For swale widths >2m, consideration should be given to diving the cross-section width with a flow divider in circumstances where width of flow may lead to flow channelling.

Swales should be designed to incorporate longitudinal slopes in the range of 0.5-6%, with check damns being incorporated for swales with slopes greater than 3% (allowing slopes to increase up to 10%). For slopes <1.5%, underdrains may also be required for the swales. An assessment of the appropriate side slope arrangement should also be made during the design stage.

Generally, the maximum swale depth should be in the range of 400-600mm. There may be opportunities for this to be increased following appropriate health and safety risk assessments. Swales should be designed with a min. 300mm freeboard above the design flood event

It is the overall responsibility of the proponent to carry out the necessary assessments and make the appropriate swale selection.

Hydraulic design

Swale design is based on open channel design. The three types of swales described above will all have specific hydraulic design criteria that will to be assessed and achieved, it is the responsibility of the proponents to make the necessary assessments and design assumptions to ensure acceptable hydraulic performance of the swale.

4.5.5 Bioretention Systems

Bioretention systems are shallow landscaped depressions that intercept pollutants and can provide effective management and treatment of stormwater.

Runoff collected by the bioretention systems usually temporarily ponds at the surface of the bioretention system before eventually infiltrating into the underlaying fill materials, where it is filtered by vegetation roots and the underlaying soils. Depending on site conditions, filtered runoff can then either be infiltrated into the subsoil below the bioretention system or collected and conveyed by an underdrain system.

There are many different approaches adopted for the design of bioretention systems, but as a minimum all bioretention systems should consist of the following components:

- Inlet – designed to prevent scour and erosion
- Depth of extended detention – this is where the runoff is temporarily stored at the surface of the bioretention system before infiltrating into the underlaying soils. Normally at a maximum depth of 150-300mm.
- Vegetation – this influences the performance of the system and should be selected carefully. Proponents should ensure that the type of vegetation selected is non-invasive and appropriate for the site and for the specific type of bioretention system used. Aside from facilitating pollutant removal, vegetation is essential in preventing erosion of the surface soil layers and maintaining the permeability of the system. Vegetation selection should be carried out alongside ecologists, horticulturist specialists, and landscape architects.
- Filter medium – this is normally sand-based with additional organic matter to promote plant growth. It also filters out pollutants and maintains permeability through the bioretention system so is a key influence on the performance of the system. Filter medium layers are normally 750-1000mm deep depending on contributing catchment sizes (with an absolute minimum of 400mm).
- Transition layer – this layer assists in the prevention of washing of fines from the filter medium and should be at least 100mm deep. Alternatively, a geotextile may be used instead providing the pore size selected is appropriate for the site.
- Drainage layer – the purpose of this layer is to collect stormwater runoff and from the above layers and to assist it in flowing into the perforated pipes easily. This is typically at least 100mm deep, but the exact depth is usually determined by the length of the system, the slope of the underdrain, the underdrain pipe diameter, the depth of cover over the pipe, and the levels of the outfalls or connection pipe.
- Perforated pipes – these will collect the stormwater runoff off and convey it to the downstream system and should be sizes appropriately for the site and for the type of bioretention system used. If infiltration is specified, a perforated pipe may not be required.
- Overflow – this component is designed to aid the conveyance of additional runoff when the limit of the system’s storage volume has been exceeded.

Examples of typical bioretention systems used widely in the industry include:

- Bioretention tree pits – these are similar to regular tree pits but include additional components to enhance performance. These include additional planting to dissipate the energy of runoff, intercept rainfall and allow water to evaporate from leaf surface, facilitate infiltration, provide shade and reduce runoff temperatures, and other amenity and biodiversity benefits.

- Bioretention swales – these are typically located at the base of a swale and can run along the entire length of a swale or can just be a portion before the outlet of the swale. During events up to the design event, runoff will soak into the filler layers and be carried away by the underdrain as normal. Therefore, the type of filler material and vegetation should be selected carefully to ensure it isn't susceptible to erosion and water inundation.
- Anaerobic bioretention systems – these systems have a pipe designed to ensure that there is a permanent water level within the drainage layer. This water storage area is then accessible for vegetation during dry periods. This system also aids in filtration through plant and tree roots, which can assist in the treatment of pollutants.

General design considerations

Bioretention systems are best suited to draining relatively small areas close to the source of the runoff. They can be designed for management of a wide range of rainfall events and their limiting factors are usually the size of the catchment and the available space for the system. For larger catchments, a series of cascading bioretention systems should be used to ensure the best performance.

Typically, Bioretention systems can be used in most ground conditions so are suited to most types of sites. In order to ensure there is no groundwater contamination, the maximum groundwater level should be assessed to ensure the bioretention system is designed to protect any polluted runoff from entering the groundwater. Where the groundwater cannot be protected from polluted runoff through effective treatment systems, infiltration from polluted runoff should be prevented through the use of an impermeable membrane and positive drainage systems to convey runoff from site.

Hydraulic considerations

Depending on the type of system selected, an assessment of the following key hydraulic criteria should be made to ensure the system functions accordingly:

- If the system will be required to infiltrate, determine the required permeability of filter medium material to sustain effective treatment of runoff for given site constraints (minimum percolation rates of 100-300mm/h).
- Sufficient surface area and depth of system to maintain required runoff treatment for required treatment volumes (normally 150-300mm).
- Inflow velocities as to not cause scour to the bioretention surface, and therefore should be below 0.5 m/s (or 1.5m/s for the 1:100-year rainfall event). This will also ensure that flows are uniformly distributed over the filter medium surface area.
- Filter medium depths to be a minimum 1m above the ground water table.
- Drainage area storage if required for attenuation
- Suitability of medium to support vegetation growth

Depending on the bioretention system selected, proponents should ensure the design meets the required hydraulic design criteria.

4.5.6 Detention Basins

Detention basins are landscaped depressions that provide stormwater attenuation and treatment. They are typically dry except during and immediately following storm events. These can either be online or offline systems. Online systems provide attenuation through a restriction to the onward continuation flow, whereas off-line systems divert excess runoff into the basin once flows exceed a specified design threshold.

Online detention basins can also be vegetated and provide treatment for the design treatment volumes during storm events. Off-line detention basins tend to be hard-landscaped storage areas that tend to provide attenuation without any treatment as the storage is mobilised less frequently.

General design considerations

Where there is no specified pre-treatment, on-line detention basin systems should also include a forebay area to provide maximum pollutant removal.

Off-line detention basins will typically be designed to have an alternative use, either as a public amenity or recreational facility or as part of the wider urban hard landscaping plan for the site. As these basins are offline detention systems, their alternative use usually tends to be the principal use for the detention basin.

Other typical design considerations for a detention basin are as follows:

- Aesthetic considerations for basins should be made, taking into account their surrounding urban landscape
- Maximum depth of water of 2m. Usually this will be less for safety reasons, and Proponents are expected to ensure that these features remain safe and accessible if placed in publicly accessible areas.
- Bottom of basin to be relatively flat, with a gentle slope of no more than 1:100 (draining towards the specified outlet)
- Recommended length/width ratios to be between 3:1 and 5:1.
- Recommended side slopes should not exceed 1 in 3 unless specific site safety arrangements have been made and agreed for steeper slopes
- Access and maintenance considerations should be made throughout the design of the basin.

Hydraulic considerations

Depending on the type of system selected, the necessary assessments should be made to ensure the systems meet the required hydraulic criteria. Detention basins should be designed to attenuate and treat stormwater runoff for the required storm events as in line with the standard of design required both for volume and discharge restrictions.

4.6 Drainage for Urban Areas

Provision of hard infrastructure solutions is discouraged and passive or natural methods that encourage infiltrations should be prioritised. In certain circumstances though these may be permitted subject to approval form the Regulatory Approval Body.

4.6.1 Linear Drainage

In regard to drainage strategies for inner city areas, proponents should make the necessary assessments to ensure adequate drainage systems are designed to attenuate and convey stormwater in a controlled, safe, and effective manner. This may include the use of channel drains, kerb drains, slot drains, and other drainage mechanisms.

4.6.2 Pervious Paving Systems

Permeable paving systems are suitable for both pedestrian and vehicular loading and can be used on a variety of sites. These paving systems allow stormwater to infiltrate through the surface and be and be stored in the underlying structural layers temporarily before either infiltrating into the ground or being conveyed to a below ground drainage system via an under drain.

There are two types of pervious paving systems available for use, as follows:

- Porous paving systems – these allow stormwater to infiltrate across the entire surface material. Examples include reinforced grass, gravel surfaces, resin bound gravel surfaces, or porous concrete or asphalt.
- Permeable paving systems – these systems are composed of a surface material that is typically impervious, but the water is allowed to infiltrate into the paving systems via voids or joints between the surface. Examples include standard concrete or natural stone paving blocks.

Regardless of the type of pervious paving system selected, there are three types of water management options for use. Following an assessment of the site opportunities and constraints, the following water management options for selection are:

- Type A – total infiltration. This system allows water to infiltrate through the pervious paving system and into underlying soil. Depending on the design of the system, the stormwater can either be temporarily stored within the underlying structural layers or it can infiltrate directly into the underlying subsoil. Normally, no stormwater will be discharged into a sewer or nearby waterbody. However, an emergency overflow may need to be considered for events exceeding the design storm designed for.
- Type B – partial infiltration. Similar to system Type A, system Type B will allow a portion of the stormwater to infiltrate into the underlying subsoils, while the remainder of the stormwater runoff will be collected via a pipe connection. Normally, these systems are designed when the expected volume of stormwater exceeds the infiltration capacity of the soil.
- Type C – no infiltration. In this case, the system is usually wrapped in an impermeable, flexible, membrane to prevent stormwater from infiltrating into the underlying soils. Stormwater is then conveyed to an outfall via perforated pipes or fin drains. These systems are typically used for the following reasons:
  - The underlying soils have low permeability and cannot accommodate for stormwater infiltration (i.e. clay based soils).
  - The stormwater is to be harvested for re-use
  - The underlying ground is of low strength, making infiltration not possible
  - The underlying groundwater requires protection
  - The site has a high-water table (within 1m of the sub-base).
  - The site is contaminated and therefore not suitable for infiltration into the underlying soils/groundwater to minimise risk of contamination.

Design Considerations

Specific site conditions should be assessed to allow a decision to be made regarding the suitability of the use of pervious paving systems. This includes (but isn't limited to) an assessment of the expected site use and layout, site specific conditions and constraints, ground and groundwater conditions, expected site pollutants and the risk of contamination of the groundwater below, space requirements required for the pervious systems, compatibility with other solutions on site (if applicable). Proponents should make the necessary assessments and agree the design rationale with the required stakeholders to ensure adequate selection of pervious paving systems.

4.6.3 Proprietary Treatment Systems

In addition to the treatment systems described in the sections above, proprietary treatment systems can also be used to remove specified pollutants from stormwater runoff. Proprietary treatment systems are manufactured products, typically used as additional treatment devices to aid in the pollution management train. While these systems may be beneficial in aiding treatment, they typical require more routine maintenance schedules.

Treatment systems tend to use a variety of treatment processes that may suit different types of sites. Some typical proprietary treatment system examples can be found in the following table:

Table 4—1 Examples of Proprietary Systems:

Proprietary System	Description	Treatment Processes
Treatment Channels	Channels designed to collect and treat water as opposed to conveying it along the channel. These can include proprietary filter media within the channel as well as baffles of weirs at regular intervals to trap pollutants such as oils and other floatables.	Removal of sediment, oils and floatables as well as wetting and drying to promote degradation of waste.
Hydrodynamic/Vortex Separators	These structures use gravity and centrifugal force to separate out and collect particles, sediment, and debris (medium sized: 63-250µm). By varying the flow rate across the system, smaller particles can also be collected and removed.	Physically removing sediment through the use of gravity.
Oil Separators	Proprietary structures which separate oil and large suspended solids (> 250µm) from water. Oil separators do this by allowing non-aqueous phase liquids (LNAPL) to float and large sedimental particles to sink. Baffles, coalesces, and oil skimmers can also be used to speed up and enhance performance.	Physical removal of floatables and the use of gravity to physically remove sediment.

Proprietary Filtration Systems	Devices that filter and clean water by passing it through various selected filter media. These systems do not support vegetation as they are typically constructed below the ground within chambers.	Filtration and adsorption
Proprietary Bioretention Systems in concrete (/other material) structures	These are filtration devices that use soil or other filtration media (which also support plants or bacterial biofilms).	Filtration, adsorption, bioremediation
Multi-process	Systems that include multiple treatment processes, typically placed in series.	Various.

Proponents should make the necessary assessments when specifying proprietary treatment systems and ensure they are suitable for the site.

4.6.4 Scour Protection

Scour protection will be required in order to mitigate the risk of damage, reduce maintenance costs, and protect the stability of proposed wadi's and channel geometries receiving high flow velocities (greater than 1m/s).

Examples of scour protection interventions recommended for channels, swales and wadis include:

1. Rock steps to protect the geometry of the excavated low flow channel (LFC) during frequent flood events.
2. Mortared rock revetments (or similar) at the base of embankments up to the 1 in 100-year flood water level to provide local scour protection and increase the stability of the slope.
3. Mortared rock stepped terraces.
4. Groynes at right angles to the wadi walls.
5. Rock armour to cover wadi or channel beds under any bridge structures, to prevent flood events undermining the bridge foundations. Any remedial works, or works requiring the removal of rock armour, shall replace the armour on completion.

Scour protection location and material shall be chosen according to the estimated severity and probability of scour. Protection shall be designed to focus on areas at highest risk of scour to reduce the volume of materials required. Location and material choice will also affect ease of construction. Mortared rock beds of varying size (rip rap) are potentially easier to install, especially in areas of reduced access. Larger, squarer and more spacious areas of scour protection could be better served by the bedding of limestone slabs (or similar). The choice of scour protection provided should give be cognisant of the ecological constraints posed by local site conditions.

Erosion to mortar is more likely to occur in rip rap than slabs due to the higher mortar to material surface area. Repair of mortar is potentially quicker and cheaper after a storm event, whereas damage to limestone slabs could require the replacing of the slab, depending on the severity of the damage. Rip rap also has a higher energy absorption due to the geometries of protruding rock. In this respect, rip rap could be better suited to intermittent flow channels and limestone slabs to dry weather flow channels.

Therefore, selection of scour material is dependent on the flow and type of channel or obstruction to be protected. Consistency in choice along the network will accelerate future development design and provide more tailored maintenance schedules.

4.7 Ownership, Operation and Maintenance Plans

Proponents will be required to develop monitoring and maintenance plans for all stormwater conveyance infrastructure. Proponents will have to ensure:

- Stormwater conveyance systems can be economically maintained, with safe access available for maintenance.
- Natural systems deployed for conveyance and treatment of stormwater will require occasional or remedial maintenance and maintenance plans should detail the nature and frequency of intervention needed.
- Maintenance plans should be treated as live documents and should be reviewed at regular intervals to make any necessary adjustments to suit operational performance.
- Inspection chambers or other such access provisions should be available for the Regulatory Approval Body in order to inspect the performance of quality improvement solutions being implemented on site.

Stormwater conveyance infrastructure that resides outside the Plot boundary components may be offered for adoption by the Regulatory Approval Body. In such cases Proponents will have to provide the documentation noted in Table 5—4 to allow the handover of infrastructure assets to the Regulatory Approval Body.

5 Compliance Documentation Requirements

5.1 Overview

This section of the Standard provides a summary of the minimum documentation that Proponents will be required to be submitted by the Regulatory Approval Body at each of the Design Gateway stages in relation to stormwater infrastructure design.

Proponents are urged to engage with the Regulatory Approval Body to understand requirements and discuss any deviations necessary from the prescribed documentation to address specific site constraints. These guidelines are not aimed at being prescriptive and Proponents are encouraged to propose alternate solutions where appropriate that may better achieve the project outcomes in discussion with the Regulatory Approval Body.

5.2 Documentation Required

Table 5—1 Documentation Required by each type of Proponent to be submitted

Stage		Key Documentation	Masterplan	Superplot	Plot
Masterplan	Regional Planning	Landuse permit	√		
	Concept Masterplan	Masterplan ESIA	√		
		Masterplan Hydrology Study	√		
		Masterplan stormwater drainage Strategy	√		
		Specification of additional surveys and investigations	√		
	Detailed Masterplan	Updated Masterplan ESIA	√		
		Detailed Masterplan Sustainability compliance submission including: Updated Masterplan Hydrology Study	√		
		Updated stormwater drainage Strategy	√		
		Plot Guidelines for Superplot and Plot Proponents	√		

Stage		Key Documentation	Masterplan	Superplot	Plot
		Water quality quantitative risk assessment, design note and model outputs	√		
	Infrastructure Detail Design	Detailed Design Sustainability compliance submission including: Updated stormwater drainage Strategy	√		
		Stormwater infrastructure detailed design calculations, drawings and specifications within masterplan area and water quality modelling outputs to demonstrate compliance with water discharge requirements.	√		
Building Design Development	Pre-Concept Design	Stormwater management outline principles statement		√	√
	Concept Design	ESIA		√	√
		Outline stormwater drainage Strategy		√	√
		Specification of additional surveys and investigations		√	√
		Water quality quantitative risk assessment		√	√
	Design Development (Schematic Design)	ESIA		√	√
		Stormwater drainage Strategy		√	√
	Detailed Design and Tender Documents	Updated ESIA Compliance Checklist		√	√
		Detail Design Sustainability compliance submission including: Stormwater infrastructure detailed design		√	√

Stage		Key Documentation	Masterplan	Superplot	Plot
		calculations, drawings and specifications and water quality modelling outputs to demonstrate compliance with water discharge requirements.			
Construction and Handover	Mobilisation	None			
	Construction activities	Construction Environment Management Plan	√	√	√
		Stormwater Infrastructure Construction Drawings, specifications and Calculations	√	√	√
		Contractor Method Statements	√	√	√
		Forms and documentation to support building and construction permits	√	√	√
	Completion/ Commissioning/ Handover	As-built drawings of all stormwater infrastructure	√	√	√
		CCTV surveys for any pipe infrastructure	√	√	√
		Commissioning and testing results and reports for stormwater infrastructure	√	√	√
		Operation and Maintenance Manual	√	√	√
		Health and Safety File	√	√	√
		Building and Construction Permits	√	√	√
		Forms and documentation for handover of stormwater infrastructure	√	√	√

Stage		Key Documentation	Masterplan	Superplot	Plot
	Operational Stage	Operation Environment Management Plan	√	√	√
		Sustainability Compliance Monitoring and Reporting	√	√	√

5.3 Information Required

The following sections provide a more detailed list of requirements for each of the Design Gateway stages.

5.3.1 Masterplanning

Table 5—2 provides a summary of the information to be provided for the masterplanning stage for the Masterplan Proponents. This is related to the technical information to be provided to the Regulatory Approval Body and should be read in conjunction with any other guidelines including Health and Safety to advise on documentation required.

Table 5—2 Detailed compliance requirements for stormwater for Masterplanning Stage

Design Stage	Key Documents to be submitted for Approval	Information to be provided at each design stage
Regional Planning	• Regional strategies, landuse permit application	• None

Concept Masterplan	• Outline Masterplan ESIA Submission.
	• Sustainability submission including:
	  • Outline stormwater drainage strategy
	  • Masterplan Hydrology Study
	  • Specification of surveys and investigations required to inform design (e.g. infiltration tests, ground investigations etc.).
		• Strategy for discharge of water (considering hierarchy of discharge)
		• Opportunities for stormwater capture and feasibility of infiltration based on available site information
		• Determine exceedance pathways, pre-development overland flow routes and catchments.
		• Concept strategy to manage and treat stormwater within the masterplan to meet discharge requirements (water quality and quantity) with proposals for interventions at Masterplan, Superplot and Plots.
		• Requirements for Superplot and Plot developers to conform for stormwater discharge into the masterplan area (water quality and quantity - rate and volume).
		• Preliminary sizing to inform land take and location of stormwater infrastructure required at masterplan level with supporting outline calculations, considering impacts of climate change.

Design Stage	Key Documents to be submitted for Approval	Information to be provided at each design stage
		• Where pre-development overland flow routes are not being maintained, justification for why they haven't been respected, and what mitigation measures have been developed. • Options appraisal of proposed stormwater infrastructure at Masterplan level and identification of preferred water sensitive design measures for quality improvement.
Detail Masterplan	• Updated Masterplan ESIA Submission to include outcomes of surveys and site specific investigations. • Sustainability submission including Updated stormwater drainage strategy providing approach to stormwater management and treatment based on geological surveys, groundwater investigations and other data acquired within the Concept Masterplan stage. • Masterplan Hydrology Study updated to include results of surveys and site investigations. • Water quality risk assessment, water quality design note and model outputs • Plot Guidelines for Superplot and Plot developers	• Strategy for discharge of water (considering hierarchy of discharge) • Conclusions on opportunities for stormwater capture and feasibility of infiltration. • Exceedance pathways, overland flow routes and proposals for mitigating any changes to the existing hydrological regime. • Developed strategy to manage and treat stormwater within the masterplan to meet discharge requirements (water quality and quantity), considering interventions at Masterplan, Superplot and plots. • Water quality quantitative risk assessment to assess the risks of pollutants entering the groundwater or seawater from the proposed development • Demonstration through design note and hydraulic modelling, the pathways for contaminant run-off from the site and the mitigation measures required so that there is no adverse impact on the coastal environment and groundwater. • Requirements for Superplot and Plot developers for discharge limits into the masterplan area (water quality and quantity - rate and volume). • Plot Guidelines for Superplot and Plot developers. • Updated infrastructure sizing to inform land take and location of stormwater infrastructure required at masterplan level with supporting calculations. • Management strategy of overland flow routes.
Infrastructure Detail Design	• Detailed Design Sustainability submission Updated stormwater drainage strategy	• Summary of hydrological calculations including rainfall data used, allowances for climate change and methodology for run-off calculations.

Design Stage	Key Documents to be submitted for Approval	Information to be provided at each design stage
	• Stormwater infrastructure detailed design calculations, drawings and specifications within masterplan area and water quality modelling outputs to demonstrate compliance with water discharge requirements. •	• Pre-development run-off rates, volumes and discharge locations with and without climate change allowance with detailed calculations. • Hydraulic model outputs for network infrastructure for proposed runoff rates, volumes, velocities and discharge locations. • Identification, location and sizing of stormwater infrastructure within the Masterplan to meet discharge requirements (quantity and quality) with detailed calculations. • Updated water quality quantitative risk assessment to assess the risks of pollutants entering the groundwater or seawater from the proposed development • Demonstration through design note and hydraulic modelling, compliance with the water discharge requirements so that there is no adverse impact on the coastal environment and groundwater. • Identification of exceedance routes for managing water in excess of 1 in 100 +cc event • Depths and location of any flooding expected and the return period event. • Operation and Maintenance strategy for proposed stormwater infrastructure.

5.3.2 Building Design Development

Table 5—3 provides a summary of the information to be provided for the Superplot and Plot Proponents for the Design Development stage for the stormwater infrastructure design for their sites. This is related to the technical information to be provided to the Regulatory Approval Body and should be read in conjunction with any other guidelines including Health and Safety to advise on documentation required.

Table 5—3 Detailed compliance requirements for stormwater for Building Design Development Stage

Design Stage	Key Documents to be submitted for Approval	Information to be provided at each design stage
Pre-Concept Design	• None	• None

Design Stage	Key Documents to be submitted for Approval	Information to be provided at each design stage
Concept Design	• ESIA (depending on project type) • Sustainability submission including Outline stormwater drainage strategy • Specification of additional surveys and investigations • Water quality risk assessment,	• Description of existing catchments within site boundary and Masterplan Hydrology Study • Strategy for discharge of water (considering hierarchy of discharge) • Opportunities for stormwater capture and feasibility of infiltration based on available site information • Determine exceedance pathways and pre-development overland flow routes and catchments to inform Concept Design. • Water quality quantitative risk assessment to assess the risks of pollutants entering the groundwater or seawater from the proposed development • Concept strategy to manage and treat stormwater within the site boundary including any stormwater flows to meet discharge requirements (water quality and quantity). • Concept strategy to manage and treat stormwater within the site boundary including any stormwater flows from off-site to meet discharge requirements (water quality and quantity). • Conformance to requirements developed for Superplot and Plot developers for stormwater discharge into the masterplan area (water quality and quantity - rate and volume). • Preliminary sizing to inform land take and location of stormwater infrastructure required with supporting outline calculations, considering impacts of climate change. • Where pre-development overland flow routes are not being maintained, justification for why they haven't been respected, and what mitigation measures have been developed. • Specification of surveys and investigations required to inform design (e.g. infiltration tests, ground investigations etc.). • Options appraisal of proposed stormwater infrastructure and identification of

Design Stage	Key Documents to be submitted for Approval	Information to be provided at each design stage
		preferred water sensitive design measures for quality improvement.
Design Development (Schematic Design)	• Updated ESIA to include outcomes of surveys and site specific investigations. (depending on project type) • Sustainability submission including Outline stormwater drainage strategy based on geological surveys, groundwater investigations and other data acquired within the Concept Design stage.	• Strategy for discharge of water (considering hierarchy of discharge) • Updated stormwater drainage strategy providing approach to stormwater management and treatment based on geological surveys, groundwater investigations and other data acquired in the Concept Design stage. • Exceedance pathways, overland flow routes and proposals for mitigating any changes to the existing hydrological regime. • Description of pre-development catchments within site boundary. • Summary of hydrological calculations including rainfall data used, allowances for climate change and methodology for run-off calculations. • Pre-development run-off rates, volumes and discharge locations with and without climate change allowance with detailed calculations • Post development run-off rates and volumes with detailed calculations (prior to mitigation measures) • Hydraulic model calculations for stormwater networks, proposed runoff rates, volumes, velocities and discharge locations. • Identification, location and sizing of stormwater infrastructure with a focus on water sensitive design measures to meet discharge requirements (quantity and quality) with detailed calculations. • Updated water quality quantitative risk assessment to assess the risks of pollutants entering the groundwater or seawater from the proposed development • Demonstration through design note and hydraulic modelling, compliance with the water discharge requirements so that there is no adverse impact on the coastal environment and groundwater. • Depths and location of any flooding expected and the return period event.

Design Stage	Key Documents to be submitted for Approval	Information to be provided at each design stage
		• Identification of exceedance routes for managing water in excess of 1 in 100 +cc event • Operation and Maintenance strategy for proposed stormwater infrastructure.
Detailed Design and Tender Documents	• Updated ESIA compliance checklist (depending on project type) • Sustainability submission including Stormwater infrastructure detailed calculations, design drawings and specifications and water quality modelling outputs to demonstrate compliance with water discharge requirements	• Summary of hydrological calculations including rainfall data used, allowances for climate change and methodology for run-off calculations. • Pre-development run-off rates, volumes and discharge locations with and without climate change allowance with detailed calculations. • Hydraulic model outputs for network infrastructure for proposed runoff rates, volumes, velocities and discharge locations. • Updated water quality quantitative risk assessment to assess the risks of pollutants entering the groundwater or seawater from the proposed development • Demonstration through design note and hydraulic modelling, compliance with the water discharge requirements so that there is no adverse impact on the coastal environment and groundwater. • Identification of exceedance routes for managing water in excess of 1 in 100 +cc event • Depths and location of any flooding expected and the return period event. • Operation and Maintenance strategy for proposed stormwater infrastructure.

5.3.3 Construction and Handover

Table 5—4 provides a summary of the information to be provided for the Masterplan, Superplot and Plot Proponents for the Construction and Handover stage for the stormwater infrastructure design for their sites. This is related to the technical information to be provided to the Regulatory Approval Body and should be read in conjunction with any other guidelines including Health and Safety to advise on documentation required.

Table 5—4 Detailed compliance requirements for stormwater for Construction and Handover Stage

Design Stage	Key Documents to be submitted for Approval	Information to be provided at each design stage
Mobilisation	• None	• None
Construction activities	• Construction Environment Management Plan (CEMP) • Stormwater Infrastructure Construction Drawings, specifications and Calculations • Stormwater Infrastructure Construction Drawings, specifications and Calculations • Forms and documentation to support building and construction permits	• Construction Environment Management Plan to provide mitigation measures to mitigate impacts on the environment due to construction activities (in compliance with ESIA, may include water quality monitoring) • Construction drawings (plans, details, sections), specifications and calculations • Contractor Method Statements (in compliance with CEMP and ESIA) • Any documentation/ forms required to support building and construction permits e.g. stormwater discharge consents, connection to wider stormwater network. To be confirmed by Regulatory Approval Body.
Completion, Commissioning and Handover	• As-built drawings of all stormwater infrastructure • CCTV surveys for any pipe infrastructure • Commissioning and testing results and reports for stormwater infrastructure • Operation and Maintenance Manual • Health and Safety File • Building and Construction Permits • Forms and documentation for handover of stormwater infrastructure	• As-built drawings (plans, sections, details) for all stormwater infrastructure • CCTV surveys for buried stormwater infrastructure • Commissioning and testing certification • Operation and Maintenance manual including maintenance plan and product information and warranties. • Health and Safety File including residual risks. • Building and Construction Permits • Any documentation/ forms required to support handover. To be confirmed by Regulatory Approval Body.

6 Regulatory Framework

6.1 NEOM Regulatory Approvals Process

The Regulatory Approval Body will be responsible for approving the design, construction, handover and operation of all stormwater infrastructure within the NEOM Region. Guidelines on the approvals process for NEOM are currently under development and will be supplied to the Proponents upon request.

The Proponents will be responsible for submitting all required information to the Regulatory Approval Body at each of the required stages for Environmental Permitting purposes. A list of the information required is provided in section 5.3 but should be confirmed with the Regulatory Approval Body prior to submittal.

6.2 Key Stakeholders

It is important that all Proponents consult with the key stakeholders for the development to understand specific development constraints and to meet approval requirements. This includes, but is not limited to the following:

- NEOM Environmental Department
- NEOM Water Sector
- NEOM Urban Development

A full list will be provided by the Regulatory Approval Body on request.

6.3 Codes and Standards

All Proponents are required to adhere to the Standard set out in these NEOM Stormwater and Pollutant Management Run-off Standard and other supporting guidelines provided by NEOM. As a minimum Proponents are to meet the KSA standards and codes in all instances but where these requirements are exceeded by these guidelines, this document should take precedence.

Prior to the NEOM Regulatory Framework being in place, all Proponents are required to meet the Saudi Codes and Standards as a minimum. These include the codes and standards set out in Table 6—1. Additional International codes and standards have also been provided in Table 6—2 for information.

Table 6—1 KSA Applicable Codes and Standards

Subject	KSA Base Codes & Standards
Stormwater System Design	National Committee for the Saudi Building Code, Saudi Building Code, 2018 SBC 701 - Sanitary
	The Kingdom of Saudi Arabia Ministry of Communications Highway Design Manual (HDM)
Stormwater Quality Requirements	The Kingdom of Saudi Arabia Presidency of Meteorology and Environment Ambient Water Quality
Climate Change Allowance for Flood Risk Management	Impacts of Climate Change on water resources in Saudi Arabia, 3rd International conference on Water Resource and Arid Environments, Al Zawad, 2008

Table 6—2 International Applicable Codes and Standards

Subject	Recommended International Codes & Standards
Stormwater Design Principles	Water Sensitive Design for Stormwater - GD04 WSD March 2015
	Water by Design (2014.) Bioretention Technical Design Guidelines. Healthy Waterways Ltd, Brisbane
	CIRIA C697 The SUDS Manual
	WRc Sewers for Adoption - A design and Construction Guide for Developers
	Building Regulations Approved Document H – Drainage and Waste Disposal
Rainfall Calculation Methods	HR Wallingford - Manual for the Design of Roof Drainage Systems
Erosion Control	Drainage Design Manual for Maricopa County, Volume III, Erosion Control
Flood Protection	National Planning Policy Framework, Planning and Flood Risk, UK, 2019
Water Quality	• Australia and New Zealand Guidelines for Fresh and Marine Water Quality • Queensland Water Quality Guidelines 2006, Australia Great Barrier Reef Water Quality Guidelines • Florida Water Quality Standards Chapter 62-302 • Hawaii Administrative Rules, Chapter 54: Water Quality Standards • EU Groundwater Directives Document 2006/118/EC – UK • Proposed System of Surface Water Quality Standards for Moldova • Arizona Department of Environmental Quality - Water Quality Standards (Chapter 11)

7 Examples and Case Studies

Figure 7—1 Wadi Hanifah

7.1 Wadi Hanifah

A Wadi Hanifah flood management and restoration scheme was put in place to manage the frequency of flood events in the region and to mitigate the effects of flooding in the wadi.

The objective of the flood management plan was to of nd significantly reducing the damage caused. This included the implementation of a catchment wide flood management and monitoring system as well as a flood warning system.

As part of the wadi restoration scheme works, a bioremediation scheme was also put in place as a way of improving the quality of the wadi environment to improve the amenity and biodiversity value of the wadi.

The Wadi Hanifah project saw overall improvements in the state of the wadi, in terms of the mitigation of high frequency flooding events and improved stormwater management. The Wadi Hanifah scheme also integrated the wadi design into the urban environment, creating high quality public amenity and recreational spaces for residents of the city (Refer to Figure 7—1 and Figure 7—2).

Figure 7—2 Recreational space in Wadi Hanifah

7.2 Wadi Al Aqeeq

Figure 7—3 Recreational space in Wadi Al Aqeeq

Wadi Al Aqeeq is a wadi rehabilitation scheme within the holy city of Medina. The project includes the rehabilitation of Wadi Al Aqeeq to allow it to carry out its natural function within the context of this historic, living and developing city. Aims include:

- Restoration of wadi function as a natural rainwater and storm flow channel
- Re-balance and rehabilitation of the natural landscape
- Value and nurture of its natural resources
- removal of contamination and constraints, and improvement of environmental quality, including water quality
- Restoration and support of indigenous ecology (animal and plant life)
- Coordination of facilities and services, and development of the surrounding areas in accordance with their natural characteristics, historical and urban components

Wadi Al Aqeeq is a great example of designing in harmony with nature – the project's aims also included developing the creation of an integrated series of open public spaces that are available to residents of the city for leisure and recreational use (refer to Figure 7—3 and).

Figure 7—4 Recreational space in Wadi Al Aqeeq

Appendix A Glossary

A.1 Glossary

The glossary has been provided to define the following:

- Definition of areas
- Infrastructure hierarchy
- Responsible parties
- Defined terms/abbreviations

A.1.1 Definition of Areas

Term	Definition
NEOM Project Region	Zone defined by the NEOM regional boundary, incorporating all Development Areas and Nature Conservation Areas.
Masterplan Development Zone	Zone defined by masterplan boundary, containing multiple plots and Superplots
Superplot	Plot with multiple assets that can remain as one plot or can be subdivided into multiple plots.
Plot	Defined area of land for the purpose of construction (building), and/or title. Area of the masterplan that is intended for a specific use. In general, should contain 1 asset

A.1.2 Defined Terms - General

Term	Definition
NEOM	The title of the project. Short form of the words 'New Future'.
Climate Change	A long-term change in global or regional climate patterns, attributed largely to the increased levels of anthropogenic green-house gas emissions and deforestation.
Discharge	The rate of flow of water measured in terms of volume per unit time (e.g. m^3/s)
First Flush	First flush is the initial stormwater runoff generated after a rainfall event. The first flush typically has the highest concentration of pollutants.
Groundwater	Water present within underground strata known as aquifers

Term	Definition
Risk	Risk is the probability that an event will occur, and the impact or consequences associated with that event
Runoff	Water flow over surfaces to the drainage system. Runoff occurs if the ground is impermeable or if permeable ground is saturated.
Wadi	A flood flow route/riverbed in the Middle East and North Africa that remains dry except in the rainy season.

A.1.3 Abbreviations

Term	Definition
BH	Buro Happold
CC	Climate Change
ESIA	Environmental and Social Impact Assessment
GIS	Geographic Information System
MoMRA	Municipality of Municipal and Rural Affairs
MPA	Marine Protected Area
MSL	Mean Sea Level
PIF	Public Investment Fund
WSD	Water Sensitive Design
SuDS	Sustainable Drainage Systems
QBAR	Mean Annual Flood

Appendix B Rainfall Data

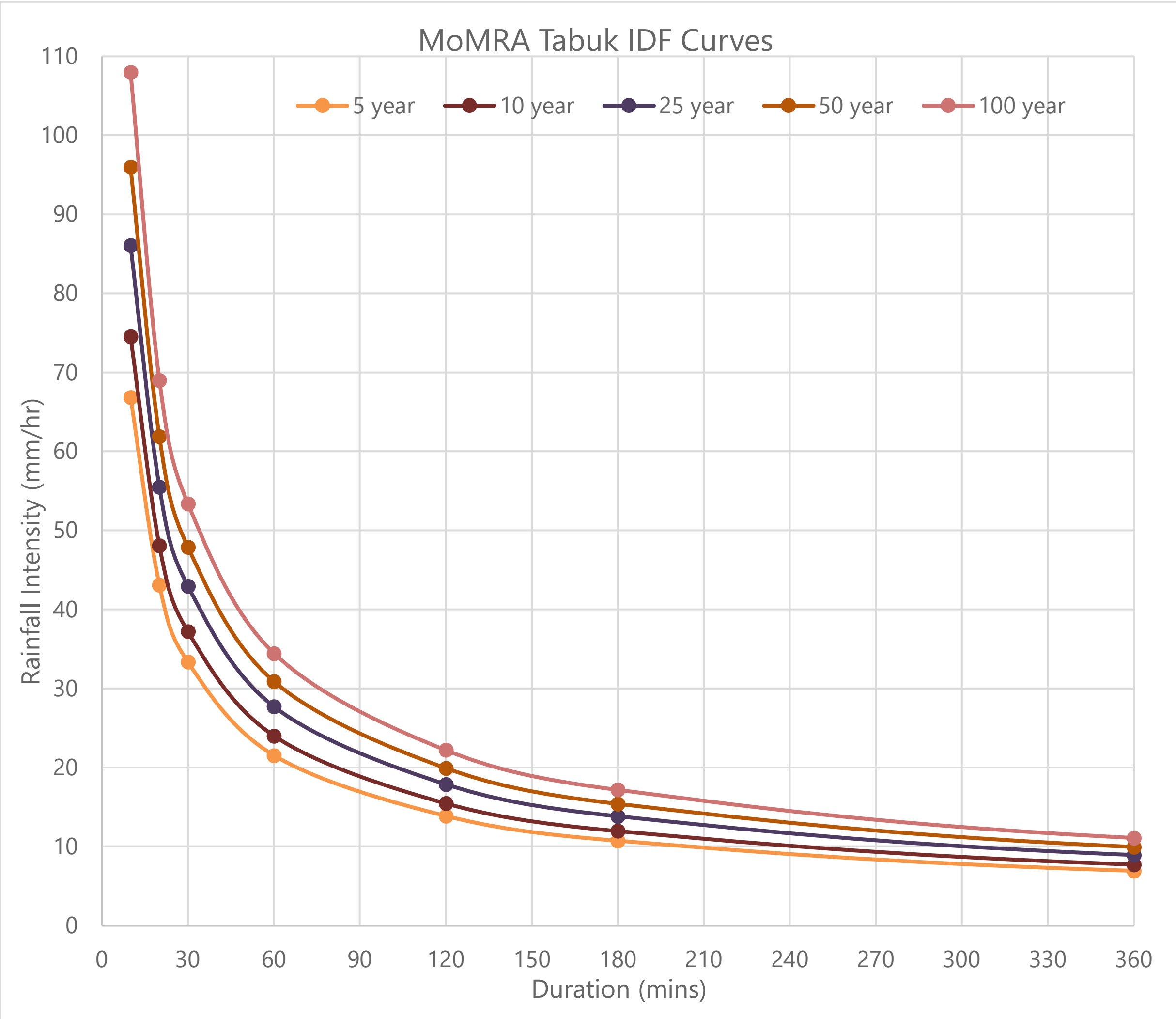


Figure 7—5 IDF curves from the rainfall records collected at Tabuk, provided by MoMRA, for a range of return periods.

Figure 7—5and Table 7—1 show the intensity-duration-frequency relationship derived from the rain gauges in the Tabuk region, illustrating the intensity of rainfall anticipated during a given storm duration for a given return period.

Table 7—1 IDF data from the rainfall records collected at Tabuk, provided by MoMRA, for a range of return periods.

Return Period	Rainfall Intensity (mm/hour) for different durations (mins)						
	10	**20**	**30**	**60**	**120**	**180**	**360**
5	66.85	43.12	33.36	21.52	13.88	10.74	6.93
10	74.53	48.07	37.2	23.99	15.47	11.97	7.72
25	86.06	55.51	42.95	27.7	17.87	13.83	8.92
50	95.96	61.89	47.89	30.89	19.92	15.41	9.94
100	107.99	69.01	53.39	34.44	22.21	17.19	11.09

Appendix C Water Quality Parameters

C.1 Water quality parameters for discharge to coastal bodies

		Saudi Arabia Ambient Water Quality Guidelines		Minimum Requirement
Parameter	Unit	Red Sea		Coastal Waters
		Marine (C1)	High- value (C2)	
Temperature	°C	△3	△2	△1
pH	-	△0.2	△0.1	△0.1
TSS	mg/l	5	2	2
Turbidity	NTU	2	1.5	1
Dissolved oxygen (DO)	mg/l	>5	>5	>5
BOD_5	mg/l	10	10	1.5
COD	mg/l	25	20	20
Phosphorus (total)	mg/l	0.5	0.25	0.0001
FRP (filtrable reactive phosphate)	mg/l	n/a	n/a	0.006
Ammonia (free, as NH_3)	mg/l	0.1	0.05	0.05
Chlorophyll a	mg/l	n/a	n/a	0.002
Calcium (Ca)	mg/l	1,200	1,200	160
Ammonia Nitrogen (NH_4-N)	mg/l	n/a	n/a	0.015
Total Nitrogen	mg/l	n/a	n/a	0.14-0.2
Inorganic nitrogen (as Nitrite and Nitrate)	mg/l	1.5	1.2	0.014
Aluminium	mg/l	0.2	0.2	0.2
Arsenic	mg/l	0.05	0.05	0.05
Barium	mg/l	0.5	0.5	0.5
Cadmium	mg/l	0.005	0.002	0.0007
Chromium (Cr III)	mg/l	n/a	n/a	0.0077
Chromium (Cr VI)	mg/l	n/a	n/a	0.05
Cobalt	mg/l	0.05	0.05	0.000005
Copper	mg/l	0.05	0.05	0.0029
Iron	mg/l	0.5	0.1	0.1
Lead	mg/l	0.05	0.005	0.0022
Manganese	mg/l	0.01	0.01	0.01
Mercury	mg/l	0.0004	0.0004	0.000025
Nickel	mg/l	0.05	0.05	0.0083

		Saudi Arabia Ambient Water Quality Guidelines		Minimum Requirement
Silver	mg/l	0.1	0.07	0.0008
Selenium	mg/l	n/a	n/a	0.071
Zinc	mg/l	0.8	0.2	0.007

C.2 Water quality parameters for discharge to inland bodies

		Saudi Arabia Ambient Water Quality Guidelines	Minimum Requirement
Parameter	**Unit**	**Surface Water**	**Surface Water**
Temperature	°C	-	△1
pH	pH Units	-	6.5-8.5
TSS	mg/l	5	5
Turbidity	NTU	30	30
Dissolved oxygen (DO)	mg/l	>5	≥7
BOD_5	mg/l	10	5
COD	mg/l	25	7
Phosphorus (total)	mg/l	0.5	0.2
FRP (filtrable reactive phosphate)	mg/l	n/a	n/a
Ammonia (free, as NH_3)	mg/l	0.1	0.1
Chlorophyll a	mg/l	n/a	n/a
Calcium (CaCO3)	mg/l	ABD	n/a
Ammonia Nitrogen (NH4-N)	mg/l	n/a	n/a
Total Nitrogen	mg/l	n/a	4
Inorganic nitrogen (as Nitrite and Nitrate)	mg/l	1	1
Aluminium	mg/l	0.2	0.2
Arsenic	mg/l	0.005	0.005
Barium	mg/l	0.5	0.5
Cadmium	mg/l	0.005	0.001
Chromium (total)	mg/l	0.05	0.05
Chromium (VI)	mg/l	0.005	0.005
Cobalt	mg/l	0.05	0.02
Copper	mg/l	0.05	0.05
Iron	mg/l	0.5	0.5
Lead	mg/l	0.005	0.005
Manganese	mg/l	0.01	0.01

		Saudi Arabia Ambient Water Quality Guidelines	Minimum Requirement
Mercury	mg/l	0.001	0.001
Nickel	mg/l	0.05	0.025
Silver	mg/l	0.07	0.1
Selenium	mg/l	n/a	n/a
Zinc	mg/l	1	1

C.3 Water quality parameters for discharge to groundwater

		Saudi Arabia Ambient Water Quality Guidelines	Minimum Requirement
Parameter	**Unit**	**Groundwater**	**Groundwater**
Temperature	°C	N/A	Δ1
pH	pH Units	N/A	6.0-8.5
TSS	mg/l	N/A	2
Turbidity	NTU	N/A	1
Dissolved oxygen (DO)	mg/l	N/A	>5
BOD_5	mg/l	N/A	1.2-1.5
COD	mg/l	N/A	20
Phosphorus (total)	mg/l	0.03	0.03
FRP (filtrable reactive phosphate)	mg/l	N/A	n/a
Ammonia (free, as NH_3)	mg/l	0.3	0.05
Chlorophyll a	mg/l	N/A	N/A
Calcium (Ca)	mg/l	N/A	160
Ammonia Nitrogen (NH_4-N)	mg/l	n/a	0.002-0.015
Total Nitrogen	mg/l	n/a	5
Inorganic nitrogen (as Nitrite and Nitrate)	mg/l	30	0.014
Aluminium	mg/l	0.2	0.15
Arsenic	mg/l	0.005	0.005
Barium	mg/l	1	1
Cadmium	mg/l	0.005	0.002-0.005
Chromium (total)	mg/l	0.1	0.005-0.1
Chromium (VI)	mg/l	0.1	0.1

		Saudi Arabia Ambient Water Quality Guidelines	Minimum Requirement
Cobalt	mg/l	0.05	0.05
Copper	mg/l	0.053	0.053
Iron	mg/l	0.2	0.2
Lead	mg/l	0.005	0.005
Manganese	mg/l	0.1	0.1
Mercury	mg/l	0.001	0.0008
Nickel	mg/l	0.02	0.015
Silver	mg/l	0.1	0.1
Selenium	mg/l	n/a	0.02
Zinc	mg/l	0.02	0.02

Appendix D Design Calculation Checklist

D.1.1 Checklist for stormwater runoff, volume and velocity

This checklist is only to be utilised to record the discharge rate, volume and velocity controls being achieved for the development proposals and does not substitute the need to submit a comprehensive stormwater management strategy statement at the design gateways noted in Section 5 of this document.

1.0 SITE DETAILS				
Total site area (ha)				
2.0 VOLUME AND FLOW DESIGN INPUTS				
Impermeable area drained pre-development (ha)				
Impermeable area drained post development (ha)				
Additional impermeable area (2.3 minus 2.2)				
Predevelopment use		Greenfield	Brownfield	Mixed
Infiltration rate (where applicable)		m/hr		
Rainfall data used (location on local rainfall gauge)				
3.0 CALCULATION OUTPUTS				
Max. discharge for 1 in 5 year rainfall (l/s/ha)				
Max. discharge for 1 in 25 year rainfall (l/s/ha)				
Max. discharge for 1 in 100 year rainfall (l/s/ha)				
Max. discharge for 1 in 100 year plus 20% CC (l/s/ha)				
4.0 ATTENUATION STORAGE TO MANAGE PEAK RUNOFF RATES FROM THE SITE				
Storage - 1 in 5 year (m^3)				
Storage - 1 in 25 year (m^3)				
Storage - 1 in 100 year (m^3)				
Storage 1 in 100 year plus climate change (m^3)				
5.0 CONTROLLING VOLUME OF RUNOFF FROM THE SITE				
Pre-development runoff volume (m^3)				
Post development runoff volume (unmitigated) (m^3)				
Volume to be controlled (does not leave site) (m^3)				
Volume control provided by:				
Separate area designated as long term storage (m^3)				
Interception losses (m^3)				

1.0 SITE DETAILS	
Rain harvesting or other methods to reuse water on site (m^3)	
Infiltration (even at low rates) (m^3)	
Total volume control (sum of above measures)	
6.0 VELOCITY CONTROL	
Predevelopment 1 in 100 year velocity at outfall location (m/s)	
Post development 1 in 100 year + 20%CC velocity at outfall location (m/s)	

END.