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NEW BUGESERA INTERNATIONAL AIRPORT
ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT REPORT-WATER RESOURCES

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12. WATER RESOURCES

12.1 Introduction

This chapter of the ESIA Report considers the potential impacts of the Proposed Project on water resources. The assessment includes a review of the existing water environment, including surface and groundwater resources. It predicts and evaluates the potential impacts of the Proposed Project and the associated likely impacts on water resources, arising from the construction works, and operation of the completed Proposed Project.

12.2 Policy, Legal and Administrative Framework

12.2.1 Rwandan Policy

12.2.1.1 The Rwanda Environment Policy, 2003[1]

The Rwanda Environmental Policy aims to conserve, preserve and restore ecosystems and maintain ecological and systems functioning, particularly the conservation of national biological diversity; and to create awareness among the public to understand and appreciate the relationship between environment and development. With regard to the water environment, the Policy refers to the need to manage water resources sustainably and incorporate this into new development.

12.2.1.2 The National Policy for Water Supply and Sanitation Services, 2010[2]

The National Policy for Water Supply and Sanitation Services aims to ensure sustainable and affordable access to safe water, sanitation and waste management services for all, as a means of contributing to poverty reduction, public health, economic development and environmental protection. The policy includes specific objectives in relation to improving rural water supply and increasing sanitation services.

12.2.2 Legal Framework

12.2.2.1 Organic Law No. 04/2005[3]

The legislative framework for environmental management establishes modes of protecting, safeguarding and promoting the environment in Rwanda, including water resources. In particular, it states that impact studies must be efficiently conducted before any activity is undertaken in wetland areas and includes decrees, statutory instruments and ministerial orders concerning underground waters, lakes and streams and their usage and pollution and contamination of surface water bodies.

12.2.2.2 The Water Resources Management Act, 2014[4]

The Water Resource Management Act provides for the application and management of water resources in Rwanda and ensuring that water resources are utilised sustainably. It includes specific measures to prevent pollution of water resources and provision of drinking water and sanitation services.

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[1] Republic of Rwanda Ministry of Lands, Resettlement and Environment, 2003. Rwanda Environmental Policy.

[2] Republic of Rwanda Ministry of Infrastructure, 2010. National Policy and Strategy for Water Supply and Sanitation Services.

[3] Republic of Rwanda, 2005. Organic Law No 04/2005 of 08/04/2005 Determining the Modalities of Protection, Conservation and the Promotion of the Environment in Rwanda. Official Gazette of the Republic of Rwanda.

[4] The Water Resources Management Act 2014.

12.2.2.3 Ministerial Order N° 002/16.01 of 24/05/2013 Determining the Procedure for Declaration, Authorisation and Concession for the Utilisation of Water[5]

This Order Determining the Procedure for Declaration, Authorisation and Concession for the Utilisation of Water sets out the procedure for the declaration, authorisation and concession for the lawful use of water. Every person has the right to use water resources in accordance with provisions of this order and other laws. Written permission must be obtained from the Ministry of Environment.

12.2.2.4 Ministerial Order N° 004/16.01 of 24/05/2013 Determining the List of Water Pollutants[6]

A water pollutant is any substance that may contaminate a water body which is directly or indirectly discharged into such a water body and produces harmful effects to aquatic life. Water pollutants referred to in the Order Determining the List of Water Pollutants shall be established in accordance with the national standards established by a competent authority.

These limits must be considered during the construction and operation of the Proposed Project. Where required, water samples must be obtained and analysed in order to confirm compliance with the order.

12.2.3 International Standards

12.2.3.1 International Finance Corporation Guidelines[7]

The IFC has various social and environmental criteria for the projects it finances, which include criteria that specifically relate to resource efficiency and pollution prevention. Specifically, IFC Performance Standard 3 (PS3) – Resource Efficiency and Pollution Prevention recognises that increased economic activity and urbanisation often generate increased levels of pollution to air, water and land and consume finite resources in a manner that may threaten people and the environment at local, regional and global levels. IFC PS3 outlines a project-level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices.

Further guidance on resource efficiency and pollution prevention is provided in the following IFC documents:

- IFC Guidance Note 3: Resource Efficiency and Pollution Prevention;
- IFC EHS Guidelines for Airports; and
- IFC General EHS Guidelines.

The guidelines are technical reference documents with general and industry-specific examples of GIIP. The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities.

Within the scope of the Proposed Project, these international requirements and the guidance have been and will continue to be taken into account during planning, design, earthworks, construction and operational activities. Relevant measures have been developed during the planning phase in the context of the ESIA Report and the master planning and design studies to mitigate and, where necessary, compensate for adverse impacts on water resources. These measures have been developed in line with national requirements and international standards.

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[5] Republic of Rwanda, 2013. Ministerial Order N° 002/16.01 of 24/05/2013 Determining the Procedure for Declaration, Authorisation and Concession for the Utilisation of Water.

[6] Republic of Rwanda, 2013. Ministerial Order N° 004/16.01 of 24/05/2013 Determining the List of Water Pollutants.

[7] International Finance Corporation EHS Guidelines.

12.2.3.2 African Development Bank Integrated Safeguards System[8]

As specified in Chapter 2: Policy, Legal and Administrative Framework, the African Development Bank Integrated Safeguards System (AfDB ISS) includes the following safeguards considered directly applicable to the water environment:

- Operational Safeguard 3: Biodiversity and Ecosystem Services, which aims to conserve biological diversity and promote the sustainable use of natural resources; and
- Operational Safeguard 4: Pollution Prevention and Control of Hazardous Materials and Resource Efficiency, which covers the industry-specific, regional and international standards regarding pollution, waste and hazardous materials.

Operational Safeguard 4 refers back to IFC EHS Guidelines as the recognised standard and good practice guidance for pollution prevention and control with a requirement for implementation of measures prevent discharge of pollutants into air, surface water, groundwater, land and soil. This Operational Safeguard also calls for emergency preparedness and response where there is a potential identified operational risk of accident and emergency events.

12.3 Assessment Methodology

12.3.1 Scope

The assessment considered the potential effects of the Proposed Project on the water environment. This includes:

- Impact upon water quality to surface water bodies and downstream receptors;
- Impact upon flood risk to watercourses and downstream receptors;
- Impact upon groundwater;
- Impact upon water supply; and
- Impact of wastewater management.

Wastewater management is also discussed under Chapter 16: Waste Management.

12.3.2 Baseline Characterisation

A desk-based review of available information was undertaken to establish the baseline conditions for the Proposed Project and its immediate surroundings. This included the following:

- Drainage report for the Proposed Project[9];
- Water and wastewater report for the Proposed Project[10];
- Analysis of weather conditions in Bugesera, Rwanda[11]; and
- Calculations provided by BAC relating to the extraction of water from Lake Kidogo during the construction phase of the Proposed Project[12].

12.3.3 Method of Assessment

The methodology for assessing the effect on the water environment, both during construction and operation, was as follows:

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[8] African Development Bank Group, 2013. Integrated Safeguards System.
[9] Flussbau iC GesmbH prepared for Airport Design Management GmbH. Report Reference: NBIA-524-I-010, March 2017.
[10] Airport Design Management, New Bugesera International Airport Conceptual Design: Water and Wastewater, 2017.
[11] UBIMET GmbH, Analysis of Weather Conditions in Bugesera, February 2017.
[12] Internal document developed by Bugesera Airport Company Limited, September 2017.

- Identification and description of surface water bodies, hydrology, hydrogeology and geology, and establishment of the baseline conditions;
- Identification of potential sensitive receptors both within the baseline water environment (existing situation) and future potential receptors as a result of the Proposed Project in relation to the water environment;
- Determination of the sensitivity of each receptor identified;
- Assessment of the potential effects from the construction and operation phases of the Proposed Project on the identified sensitive receptors; and
- Identification of necessary mitigation measures, where required.

12.3.4 Significance Criteria

The impact significance was determined as the combination of the sensitivity and/or value of the affected environmental receptor and the predicted extent and/or magnitude of the impact or change. The assessment of significance depends on complex interactions and ultimately relies on professional judgement, although comparing the extent of the impact with criteria and standards specific to each environmental topic can guide this judgement. Details of criteria specific to this assessment are defined in Tables 12-1 and 12-2.

The methodology applied is consistent with that outlined in Chapter 3: Impact Assessment Methodology.

12.3.4.1 Receptor Sensitivity/Value

The sensitivity of the receptor is dependent on a number of factors, such as its protection status through legislation and/or policy; the ability of the receptor to absorb changes to the environment without significant effects on the function, services or health of that receptor; the uniqueness or rarity of that receptor either on a local, regional, national or international scale; existing pressures on the receptor from other sources; and its current quality.

It is important to note that a receptor can be equally sensitive to change if its status or current quality is low and hence it may not be resilient to environmental changes; or of very good status or quality in which case it may be resilient but also of very high value as a resource. This highlights the need for professional judgement in each case rather than an absolute application of fixed criteria.

Table 12-1 defines the criteria for each receptor sensitivity/value with regard to surface water bodies.

Table 12-1: Sensitivity / Value – Surface Water

Receptor Sensitivity / Value	Description
High	A water resource making up a vital component of a protected habitat or assemblage of species, which may have designated conservation status at an international and national scale. The water resource supports important (e.g. protected and/or large populations) of flora and fauna. The water resource is highly important and relied upon locally or is important at a regional or transboundary level for providing services.

Table 12-1: Sensitivity / Value – Surface Water	
Medium	The water resource supports populations of flora and fauna. The water resource has a local importance in terms of providing services, but there is ample capacity and/or adequate opportunity for alternative sources.
Low	The water resource has limited or no role in supporting flora and fauna. The water resource has little or no role in terms of providing services for the local community.

12.3.4.2 *Impact Magnitude*

Magnitude can be described as the level of change against the baseline conditions. Also included within the assessment of magnitude are the likelihood of whether an effect will occur and the spatial or temporal spread of such an effect. For an effect to occur in relation to water quality, a pathway must be established between the source pollutant/activity to the receptor.

Table 12-2 defines the criteria for each magnitude of impact with regard to surface water bodies.

Table 12-2: Impact Magnitude – Surface Water

Magnitude of Impact	Description
High	The potential for natural recovery of water quality, quantity and/or physical disturbance through natural processes is limited and the impact is predicted to be long term (several years or permanent). Predicted to affect an entire watercourse downstream of the landfall section.
Medium	Water quality, quantity and the condition of the watercourse is likely to recover through natural processes and the impact is predicted to be medium term (a year). Predicted to affect multiple or elongated stretches of a watercourse.
Low	Water quality, quantity and condition is predicted to recover rapidly through natural processes and the duration of impact is short (limited to the construction phase). Predicted to affect a limited stretch of a watercourse.
Very Low	No changes distinguishable from natural variability.

12.4 Assumptions and Limitations

This chapter is based upon secondary baseline data. No primary data has been collected, for example, with regard to stream flow rates, ephemerality or direct variations in water levels in the lakes in proximity to the Project Area.

The engineering design controls specified with respect to surface water control and flooding, and the protection of onsite and offsite watercourses correspond to standard Good International Industry Practice (GIIP) and the final engineering specifications are to be detailed at the time of the detailed design and construction to meet the criteria specified in this chapter. It has not been possible to specify exact engineering detail at this stage as this has yet to be finally decided, based upon the site conditions that are encountered as part of the preparatory works.

12.5 Baseline Conditions

This section summarises the characteristics of the existing water environment conditions of both the Proposed Project Area and the surrounding area. It is based on available secondary

information derived from publicly available sources. This includes the Proposed Project setting in relation to watercourses and surface water features, and the geological and hydrogeological settings.

12.5.1 Hydrology

The Proposed Project is located within the Kagera River basin upper catchment area. This catchment covers an area of approximately 3,053 km^2 and is defined as a national transboundary (with Burundi and Tanzania) downstream catchment that drains the area from the confluence of the Nyabarongo and Akanyaru rivers down to the Rusuma Falls. The catchment features numerous lakes. The Kagera River ultimately forms a tributary of the Nile, via Lake Victoria (White Nile).

The weather data for the Bugesera District has been sourced from a 36-year historical reanalysis of the European Centre for Medium Range Weather Forecasting (ECMWF) numerical weather prediction model along with representative weather station data within the vicinity of Bugesera. Mean temperatures range from 15 – 16 °C during night time hours to 26 – 28 °C at noon. The warmest temperatures occur towards the end of the main dry season from July to mid-September and also during the short wet season break in January to mid-February. The average maximum temperatures can reach 32°C in July, 27-28°C in February and September-October. Overall, however, there is little seasonal variation in temperature throughout the year.

Importantly, the rainfall in Rwanda is controlled by the passage of the Intertropical Convergence Zone (ITCZ) over the region resulting in strongly bi-polar rainfall distribution over the year with two marked rainy seasons. Most precipitation falls between mid-September and December and mid-February to mid-May. There is a pronounced dry season between mid-May and mid-September and a smaller, less pronounced drier period from January to mid-February. The driest months occur from June to August with the transitional periods in February, May, September and January. There is a tendency for the highest precipitation intensities to occur in the February to May wet season reaching a maximum towards the end of March and in April. During the wet season months, annual rainfall falls between the hours of 06:00 – 17:00. The area receives an average of 1,028 mm of rainfall per year (approximately 85.7 mm per month). On average, there are 122 days per year with more than 0.1 mm of rainfall (precipitation) or 10.2 days with a quantity of precipitation.

Precipitation intensity duration and recurrence data within the area were sourced from the neighbouring station in Mayange, using 10-minute precipitation data from the years 2013 to 2016. Greatest intensity of rainfall generally falls for a duration not exceeding 60 minutes. These intense rainfall events occur on a frequent basis and fall for a duration of approximately 15 – 30 minutes on average. Precipitation intensity duration frequency and reoccurrence periods are indicative of short-lived convection weather events such as thunderstorms and squall lines. This results in significant surface water runoff with the strong potential for flash flooding on steeper slopes and scouring of stream and river channels, as well as the possibility of generating increased sediment load to catchments as a result.

The Proposed Project is situated on a plateau, broadly oriented northwest to southeast, between two tributaries of the Akanyaru/Nyabarongo rivers, namely the Mwesa and Kibilizi rivers, located within the northern and southern parts of the Proposed Project Area respectively. The Mwesa and Kibilizi rivers are at least partly ephemeral streams and run dry between mid-May and mid-September, and between January to mid-February. The ephemeral streams may also possibly flow during periods of less intense rains.

The plateau on which the Proposed Project Area sits forms the watershed between two sub-catchments; that of the Akanyaru to the west, itself a tributary of the Nyabarongo; and the Nyabarongo to the east, specifically the network of wetlands and lakes associated with the Nyabarongo River Wetlands. Maps of the area indicate that the Mwesa River arises in the eastern part of the Proposed Project Area, from whence it flows north and northwest. The Mwesa River confluences with the Kibilizi River, before discharging via a series of wetlands to the Nyabarongo, approximately 10 km downstream to the northwest (south of Kigali).

The Mwesa and Kibilizi rivers, as ephemeral streams, may be prone to seasonal flash floods, and are therefore considered to be at risk of flooding, particularly during the maximum precipitation period of March and April. However, observations onsite imply that the flood risk of the Mwesa stream is likely to be limited by its location on an upland plateau. Conversely, seasonal rainfalls are likely to create an inherent risk of surface water flooding. Similarly, potential exists for flash floods to occur within the Proposed Project Area, especially in the months of March and April across the Project area.

Owing to the lack of availability of groundwater as a resource (with the possible exception of ephemeral, perched and highly localised groundwater pockets above clayey lenses in the surface geology), the majority of rivers and lakes in the area are understood to be used for a variety of uses including bathing, cooking, drinking (people and livestock), fishing and as receivers for various wastes, including sewage. It is also understood from secondary sources that watercourses in the region also receive industrial wastes. This latter is particularly so for the Nyabarongo River which flows south of Kigali City and is understood to collect a pollution loading (of unknown concentration and type) resulting from operations in and around Kigali City.

Maps indicate that the far south-eastern part of the Proposed Project Area is located within a separate catchment, that of minor tributaries, which discharge to Lake Kidogo, which is part of the Nyabarongo River Wetlands. Mapping indicates a single, likely highly ephemeral, unnamed stream within the project site boundary (though not crossed by the airport infrastructure itself) which appears to flow from the site to the southeast toward Lake Kidogo.

The Nyabarongo River, is crossed by the northern end of the proposed Expressway, before passing around the site to the north and then southeast, passing 7 km within the site boundary to the southeast as it flows through wetlands to the east and southeast of Lake Kidogo.

A summary of the watercourses and surface water bodies within proximity of the Proposed Project are presented in Table 12-3.

Table 12-3: Water Bodies Surrounding the Proposed Project Area

Feature	Direction from Proposed Project	Distance from Proposed Project
Mwesa River (ephemeral stream)	North and east	Onsite: upper reach of stream crossed by edge of the runway infrastructure and flows northwards out of the Airport Area.
Kibilizi River (ephemeral stream)	West	Onsite: small section crossed by western edge of Airport Area but not by airport infrastructure; is crossed by the Expressway to the north west of the Airport Area.
Kigogoma River (ephemeral stream)	West	Approximately 3.5 km
Lake Kidogo	Southeast	Approximately 2 km*

Table 12-3: Water Bodies Surrounding the Proposed Project Area		
Lake Gashanga	East	Approximately 4.8 km
Lake Rumira	South-east-south	Approximately 5 km
Nyabarongo River	South-east-east (but is also crossed by the northern end of the proposed Expressway)	Approximately 7 km
Lake Birara	South-east-east	Approximately 8 km
Lake Miravi	South-east-south	Approximately 8 km
Lake Mugesera	East	Approximately 9 km
Lake Cyohoha Nord	Southwest	Approximately 11 km

*Note: The Water Pipeline from Lake Kidogo to the Proposed Project Construction Camp will be approximately 5 km in length.

The Nyabarongo wetlands follow the course of the Nyabarongo River which flows around the Airport Area in a wide arc broadly from northwest to southeast. They, and the river itself, are crossed by the northern end of the proposed expressway. The wetlands are more extensive to the south east of the Airport Area and are fringed along their north western edges by a series of lakes. The closest of these to the Airport Area is Lake Kidogo. Lake Kidogo's western edge is approximately 2 km for the Airport Area's eastern boundary.

The wetland has an important role in the water balances of Rwanda by acting as a buffer, which subsequently reduces the maximal flow rates during the rainy seasons and sustains a relatively high flow rate during the dry season. Some of the land uses in and around this wetland include agriculture production, collection of leaves to make handicrafts, extensive grazing and brick making. Water from Lake Kidogo is proposed to be abstracted during construction as a source of water for concrete; however, as described above, the majority of surface water onsite is likely to drain in a north-westerly direction. The Nyabarongo River Wetlands are classified as an Important Bird Area (IBA) and Key Biodiversity Area by Birdlife International, and are considered important for a range of wildlife and plants, as well as for water resources.

12.5.2 Hydrogeology

Based on a paper entitled A Case Study of a Precambrian Basement Aquifer in Bugesera Region, 2016 by Bakundukize[13], investigating the Burundian portion of a transboundary aquifer, which stretches over north-eastern Burundi and south-eastern Rwanda (i.e. the Bugesera area), it is believed that the aquifer system underlying the Proposed Project Area is characterised by a relatively deep groundwater level, with a thick clayey weathered overburden (saprolite) followed by fractured/weathered basement rock overlying granite bedrock.

The fractures in the fractured/weathered substratum are characterised by a network of fractures and fissures resulting from weathering processes, lithostatic decompression, cooling stresses or tectonic activity. The typology of the basement aquifers is complex. They are generally considered as unconfined aquifers, but may respond in a leaky (semi-confined) fashion when the groundwater table rests in the uppermost clayey layer of the weathering profile (Carruthers et al. 2010)[14]. Groundwater was not reported to have been encountered in the intrusive

[13] Charles Bakundukize, 2016. Hydrogeological and hydrogeochemical investigation of a Precambrian basement aquifer in Bugesera Region, Department of Geology and soil science, Ghent University, Belgium.

[14] Carruthers, R, Heidke, K., Collins, D., 2010. Groundwater for life! (A case study for sustainable groundwater management), Department of Environment and Resource Management.

investigations reviewed as part of the Proposed Project baseline. However, it is understood that groundwater within the localised area is present within deep aquifers situated within bedrock layers. A reasonable (>10 m) thickness of clays/silts (generally considered to be low permeability deposits) is understood to lie above the deeper groundwater and are likely to limit the infiltration or downward migration of contaminants if present within soils.

Typically, the water of these regional fractured crystalline aquifers is not used as potable water supplies owing to their depth and strong salinity. The maximum drilling depth achieved during the GEG (2017) investigation at the Airport Area was 31.5 mbgl and groundwater was not recorded to have been encountered. However, perched or shallow isolated and highly localised pockets of groundwater could be present in the Proposed Project Area. Further information regarding the surface geology and clayey nature of sub-surface strata is presented in Chapter 13: Geology and Soils.

On the basis of the above data, the depth of the basement aquifer groundwater in the Proposed Project Area, is expected to be significant and this is verified by the lack of groundwater contact in deep geotechnical boreholes on the Proposed Project. This, together with its regionally understood strong salinity, will negate its use as a potable water supply by local communities. In addition, the significant attenuative properties of the clayey, silt rich, weathered igneous rock geology underlying the site for some significant depth to the surface of highly crystalline quarzitic rock formations above the basement aquifer mean that any potential contaminants from the Proposed Project Area would be significantly attenuated and/or prevented from reaching the deep aquifer. As a result, groundwater is not considered a receptor of impacts in the Proposed Project Area, neither is a likely pathway for impacts to the deep groundwater identified.

12.5.3 Identified Receptors

The Area of Influence in relation to the water environment is defined as follows:

- Surface water bodies or hydrological receptors either within the Proposed Project Area or a direct hydrological receptor within a water catchment shared with the Proposed Project Area;
- Surface water bodies adjacent to the Expressway; and
- Water resources to be utilised as a water supply for the Proposed Project.

Potential receptors in relation to the water environment within the Area of Influence of the Proposed Project are as follows:

- Mwesa and Kibilizi seasonal streams, located partially on the Airport Area, as well as an unnamed tributary discharging to Lake Kidogo (see Table 12-3);
- The Nyabarongo River. This is crossed by the northern end of the proposed Expressway. The river flows around the Airport Area broadly from north west to south east at some distance, passing approximately 7 km southeast of the Airport Area at its closest point.;
- Lake Kidogo (as a result of it being the source of abstracted water during the construction phase); and
- The Nyabarongo Wetland Area, partially crossed by the northern end of the Expressway corridor.

12.6 Potential Impacts

12.6.1 Construction Phase Design Controls

The Airport Area and Expressway will be constructed in accordance with Rwandan legal requirements and international best practice. Construction and operation phase Environmental and Social Management Plans (referred to as C-ESMP and O-ESMP respectively) will be prepared and implemented as part of the Proposed Project planning process to ensure that good site practice is followed.

It is assumed that all necessary measures to control pollution during construction will be in place. This includes details of temporary drainage infrastructure to be installed to manage overland flows and wastewater during the construction of the Proposed Project and details of where surface water runoff will discharge to offsite. Temporary drainage infrastructure has been designed to ensure that surface water runoff volumes and silt will be managed throughout the construction period. The temporary drainage infrastructure will include standard pollution mitigation measures, such as oil interceptors and silt traps.

The Expressway and proposed crossings over the Nyabarongo and Mwesa rivers will be designed and constructed such that there is no increased risk of flooding upstream, and no significant effect on the associated wetlands. This will include avoiding the use of scaffolding and temporary structures in the river, design of the bridge piers will be such that there are no significant effects with regards to scour, erosion and therefore no significant effects on silt and flood risk, and no effects on the wetland vegetation or the hydrological function of the wetlands. Any culverts for passage of minor unidentified watercourses will be designed such that there is no increased risk of flooding to upstream receptors and the effects on the biological function of the watercourse minimised. Construction of the Water Pipeline to Lake Kidogo will be conducted such that all risks from construction and installation of the pipe and attendant pumping infrastructure, including pollution, silt runoff and silt/sediment disturbance, are controlled.

During extraction of water from Lake Kidogo for construction use, water levels within the Lake will be monitored on a weekly basis. There are no proposals for discharge to the lake of any kind. Measures will be incorporated into the construction phase elements of the C-ESMP to reduce water demand on the lake in the event that a significant drop in water levels due to the Proposed Project are detected. This will be achieved by the establishment of a threshold lake water level, which will be the determination point for review and reduction of abstraction rates with alternative sources of water only being sought in an extreme event and in agreement with the Client/Developer. The threshold will be based on the results of lake water level monitoring, which is currently underway.

Furthermore, no vehicles will access the lake or any other watercourse or surface water body during construction. Any temporary attenuation provided during construction has been designed so as to minimise the risk of mosquitoes and waterborne/mosquito-borne disease.

Site compounds and storage areas will be situated well away from surface water receptors and all storage of materials and wastes will be in accordance with good international industry practice (GIIP).

12.6.2 Construction Phase Impact Assessment Prior to Mitigation

The potential impacts associated with the construction phase of the Proposed Project are outlined below for each identified receptor. Typical potential pollutants from construction sites include suspended solids, oils and hydrocarbons, cement and concrete products, heavy metals and metalloids, bentonite, dust and solvents/paints. Sources of these pollutants can include

excavations, stockpiles, fuel storage tanks, general bitumen and batching-plant use, maintenance of machinery, equipment and vehicles, and accidents and spillages. The risk of impact from enhanced sedimentation loading of watercourses, as well as flood risk enhancement resulting from disturbances to watercourses from passage of machinery (and possible temporary damming operations), will be a particular factor during the construction phase. Such effects will be particularly enhanced during the rainy seasons.

12.6.2.1 The Nyabarongo River and Mwesa River (seasonal stream)

The Nyabarongo Wetlands IBA and Key Biodiversity Area (KBA), are fed by the Nyabarongo River and its tributary, the ephemeral Mwesa River. The use of the river by communities for activities such as bathing, as a water source, fishing and other provisioning services, as well as the biodiversity that these water features support (despite existing pollution loading), means that these identified receptors are considered to be sensitive to significant change in terms of changes to pollution and sediment loading, flood risk and bank and riverbed scour potential. An important receptor within the habitat, which is spread variously along the Nyabarongo River course, and more widely within the wetlands to the south east of the airport area, are ecologically important papyrus wetland habitats.

The great majority of wetland and swamp habitats in the area lie outside the Proposed Project Area. The part of the Proposed Project Area closest to these sensitive habitats is the proposed Expressway, which fringes the Typha swamp habitat for much of its length and two patches of papyrus swamp in the north western section.

During the construction phase, however, in accordance with good international industry practice for control of water pollution from linear construction projects[15], the key methods of control and protection of the adjacent wetland areas from indirect impacts from surface water flow will be careful and regular visual monitoring (and the keeping of attendant visual inspection reports) along each newly stripped construction section, and ensuring only the minimum area required for construction is stripped at any one time. The standard practice of construction of surface flow cut off ditches, catch pits, soakaways, bunds and silt traps will be intrinsic to the construction process. In addition, regular visual inspections and monitoring of these, any stream crossing points and either side of the Expressway construction area will be undertaken for signs of siltation and or uncontrolled surface water escape towards the fringing wetland habitat. Swiftly applied remedial works will be the primary elements of effective 'design' control of potential impacts along the length of the Expressway.

Such careful monitoring and application of remedial works will be a constant feature of the construction works along the Expressway, especially during and just after heavy rainfall events in the main rainy seasons. These measures will also be applied, as part of standard construction good practice, at the most sensitive locations i.e. where short segments of Typha swamp must be crossed directly and where the construction works fringe two patches of papyrus swamp habitat in the north western portion of the Expressway route.

The risk that surface water pollution from construction of the Expressway may adversely affect water quality would constitute adverse, short term, reversible and both direct and indirect impacts. On the basis of the design control and monitoring measures outlined above, to be implemented throughout the construction phase of the Expressway, the magnitude of these potential impacts is considered to be very low and therefore the impact significance is considered to be **Minor Adverse.**

[15] CIRIA guidance C649 on Control of Water Pollution from Linear Construction Projects – Site Guide, 2006. ISBN-13: 978-0-86017-649-1.

With regard to the physical effects on the rivers, the construction and physical presence of bridge piers within the river will inevitably have some degree of effect on the river and associated wetlands, and the construction of the road on minor tributaries which it crosses.

With regard to the direct effect of proposed crossings of the Nyabarongo and Mwesa rivers on hydrology and flood risk, and any associated minor tributaries, on the basis of the design control measures outlined above the magnitude of these impacts is considered to be low, and therefore the impact significance is considered to be **Minor Adverse**.

12.6.2.2 Lake Kidogo

This receptor is considered sensitive because of its important role as part of the ecologically sensitive adjacent wetland habitats and the aquatic fauna it supports (notably the IUCN Endangered Ningu fish species), as well as its importance to local communities for water supply, fishing and other important ecosystem provisioning services. It also supports areas of papyrus swamp wetland, which are an important functional part of the local Nyabarongo wetlands habitat and Important Bird Area (see also Chapter 11: Biodiversity). Its sensitivity to additional sediment and contaminant load inputs as well as to draw-down effects as a result of water abstraction during the construction phase is therefore high. However, the only likely impact source from the Project, given the lake's remoteness from the Airport Area and the lack of a clearly identifiable direct pathway for sediment or contaminant input from the Project, is that related to water draw-down as a result of water abstraction for construction purposes.

Water quality samples from Lake Kidogo were taken from four locations around the lake in early 2017 and analysed for a range of characteristics, including pH, alkali, chlorides, sulphates, lead, nitrates, phosphates sugars, zinc, colour, detergent, humic matter, oils and greases and odour. The results showed an average pH of around 7 and expected background nominal values for chlorides, nitrates and phosphates, as well as some metals including zinc (average value 0.154mg/l). Lead was not detected. This was primarily undertaken to assess the suitability of the lake water for concrete manufacture on site.

On the basis of the design control measures outlined above, and the lack of a clear and viable pathway for the delivery of contaminants, the magnitude of impact with regard to risk of surface water pollution are considered to be very low and therefore the impact significance is considered to be **Minor Adverse**.

Significant reduction in the water level of Lake Kidogo could have adverse effects on the biodiversity supported by the lake, including patches of ecologically important papyrus wetland habitat which fringe it, as well as upon ecosystem provisioning services to local communities, including fishing and water supply, as well as other forms of provisioning and food supply.

Calculations on the recharge capability of Lake Kidogo have been undertaken. The lake volume is calculated at 7,051,520 m^3 (lake area 1,410,304 m^2 x 5 m average depth). Recharge from rainfall alone, based on annual precipitation across the calculated drainage basin area for the lake, and utilising standard calculation factor for runoff over turf terrain, yields 471,976 m^3/yr or 1,297,934 m^3 total over the construction period of 33 months. Abstraction for all uses over the term of the construction period (33 months) is estimated to be 398,690 m^3, at a rate of 465 m^3/day. Although these figures do not take account of evaporative losses from the lake or its limited supply as irrigation water, it is nevertheless considered that additional seasonal seep-recharge from localised groundwater sources, as well as the hydraulic balancing effect of connectivity with the adjacent Lakes Rumira and Gashanga, will more than compensate for such losses. Importantly, the rainfall recharge of the lake alone far exceeds the rate of abstraction.

Two aspects of management during the construction phase will be applied to the abstraction of water from the lake. Firstly, the provision for ongoing monitoring of the Lake Kidogo water levels, particularly in the area of papyrus wetland habitat, will be applied with the objective of defining a threshold point at which abstraction must be reduced or stopped. On the basis of current data, and until a more accurate numerical level can be established from lake level monitoring data, as described in the construction phase mitigation measures for biodiversity (Section 11.7.1 of Chapter 11: Biodiversity), the maximum level threshold point should be defined as the base of the papyrus swamp vegetation in the lake to ensure that this habitat does not dry out. Secondly, the installation of a fish excluder at the intake of the abstraction pipe to protect from entrainment of fish, particularly the endangered Ningu species will be ensured. These elements will be included in the Project Biodiversity Management Plan to ensure execution.

On this basis and based on the daily water demand of the Proposed Project during construction operations versus estimated recharge, it is assessed that a temporary effect of low magnitude would occur to the lake from water abstraction during construction, and only during the dry season. The lake water levels are being monitored on a weekly basis as described under design controls and it is expected that this can be managed and/or water sourced from elsewhere in the unlikely event of a severe water level drop and in agreement with the Client/Developer if necessary to prevent any significant change in the lake levels. The impact significance is therefore considered to be **Moderate Adverse**. Possible effects on wetland vegetation within the lake are also assessed in detail within Chapter 11: Biodiversity.

12.6.2.3 Mwesa River

The Mwesa River is in fact a seasonal stream which, if it experiences flash flooding in the rainy seasons, will be a receptor of moderate sensitivity to enhanced sediment and/or contaminant loading, with resultant pathway effects downstream to the wetlands receptor as well as communities.

The risk that surface water pollution from construction of the Proposed Project may adversely affect water quality would constitute adverse, temporary or permanent and both direct and indirect impacts. On the basis of the design control measures outlined above, the magnitude of impact is considered to be very low and therefore the impact significance is considered to be **Minor Adverse**. Effects on the lower sections of the Mwesa River as a result of the Expressway are considered above.

12.6.2.4 Kibilizi River

For the reasons given for the Mwesa seasonal stream, the Kibilizi River is also considered a receptor of moderate sensitivity.

The risk that surface water pollution from construction of the Proposed Project may adversely affect water quality would constitute adverse, temporary or permanent and both direct and indirect impacts. On the basis of the design control measures outlined above to be implemented throughout the construction phase of the Expressway, the magnitude of impacts is considered to be very low and therefore the impact significance is considered to be **Minor Adverse.**

12.6.2.5 The Nyabarongo Wetlands Area

The Nyabarongo Wetlands are designated as a KBA and IBA. The receptor supports important populations of birds, as well as mammals, flora and fish. It is therefore a receptor which will be highly sensitive to change in terms of sediment or contaminant loading which could change the nutrient and sedimentology regime of the wetland habitats. The wetlands are also important to

local communities, in turn dependent upon the wetlands' ability to support diverse flora and fauna populations.

It should be noted that the great majority of wetland habitat areas lie outside of the Proposed Project Area. Therefore, potential impacts will be indirect and, with respect to water resources, will be related to runoff and potential pollution loading in terms of chemical contaminants and/or sedimentation via the pathway of surface water flow.

The risk that surface water pollution and runoff from construction of the Proposed Project may adversely affect water quality and quantity would constitute adverse, temporary or permanent and both direct and indirect impacts on the wetlands. On the basis of the design control measures outlined above, the magnitude of impacts is considered to be low, though the quality of the water in the wetlands will be sensitive to any change and therefore the impact significance is considered to be **Moderate Adverse**. Possible effects on wetland ecosystems are assessed within the Chapter 11: Biodiversity.

12.6.3 Operation Phase Design Controls

Surface water drainage infrastructure will be included in the design of the Proposed Project to manage surface water runoff across the Proposed Project Area. This infrastructure will ensure the following:

- That the drainage infrastructure serving the Proposed Project will have sufficient capacity to accommodate/attenuate surface water runoff generated within the Airport Footprint and along the Expressway. This will ensure that there is no surface water flooding across the Proposed Project Area for high rainfall events, and the drainage network will be modelled to demonstrate that is has sufficient capacity to accommodate the calculation 1-in-100 year return period storm, estimated based on extrapolation of available rainfall data;
- That there is no increase in surface water flows offsite that may impact upon flood risk or alter the hydrological regime of surface water bodies that could affect downstream receptors, such as people and property. Given the Proposed Project Area currently comprises undeveloped greenfield land, impermeable areas within the Proposed Project Area will increase significantly following development, resulting in an increase of surface water runoff. Therefore, to ensure that there is no increase in surface water flows offsite, these flows will be restricted prior to discharge offsite, to equivalent greenfield rates, i.e. in line with existing peak runoff rates across the Proposed Project Area. To allow for these restricted flow rates, surface water attenuation storage will need to be provided onsite for storm events where peak flows are expected to exceed the maximum allowable discharge rate. Attenuation storage will be provided for the calculated 1-in-100 year return period storm, estimated based on extrapolation of available rainfall data. Attenuation is proposed in the form of detention basins with a restricted outfall. Detention basins will be designed to minimise the potential risks from waterborne and mosquito-borne disease;
- That there is no material alteration in base surface water flows offsite to each hydrological catchment area within the Proposed Project Area that may impact upon the hydrological characteristics of wetland areas, surface bodies and water supply availability to downstream receptors. To meet with this requirement, surface water discharge offsite will be appropriately distributed across all catchment areas that fall within the Proposed Project Area, in line with the existing hydrological regime;
- That there is no discharge of contaminated water offsite to surface water bodies, which may impact on water quality of surface water bodies and also downstream receptors, such as people who utilise surface water bodies for drinking water and sanitation purposes. Therefore, in addition to managing surface water volumes and flow rates, the Proposed

Project drainage strategy will include oil separation systems for all runways, aprons, taxi-ways, cargo areas, maintenance yards, car parks and high traffic areas to control pollutants within surface water runoff across the Proposed Project Area. This will ensure that pollutants do not flow off the site and impact on the wider water environment. Emergency shut offs for the surface water drainage system will also be installed where necessary in order to prevent fire-fighting foam and other pollutants from reaching watercourses in the event of an emergency. This will include as a minimum the runway, aprons, taxi-ways, cargo areas, maintenance yards, car parks and high traffic areas;

- Foul wastewater will be treated at an onsite treatment plant to levels that will meet discharge consent conditions. If the treated sewage effluent is discharged to a permanent body of water measures will be taken to ensure that the receiving water can accommodate the flows without a substantial change to its characteristics. This will be monitored on a regular basis via the Pollution Prevention Plan;
- The Expressway and crossings over the Nyabarongo and Mwesa Rivers will be designed such that there is no increased risk of flooding upstream, and no effect on the associated wetlands. This will include avoiding the use of scaffolding and temporary structures in the river, design of the bridge piers will be such that there are no significant effects with regards to scour, erosion and therefore no significant effects on silt and flood risk. This will also minimise the effects on the wetland vegetation and the hydrological function of the wetlands. Any culverts for passage of minor unidentified watercourses will be designed such that there is no increased risk of flooding to upstream receptors and the effects on the biological function of the watercourse minimised;
- The Expressway will be designed with features to control the quantity and quality of water leaving the road prior to discharge to receiving watercourses. These may include ponds and swales, which will provide settlement of silt, removal of pollutants through chemical and biological means, and control of peak flows during storm events, both in terms of water volume and velocity. Bridges will include drainage systems to carry water off the bridge and into the drainage network. Catch pits will be maintained and emptied on a regular basis to remove contaminated silt and maintain their functionality in the long term. The exact design of the drainage features will be determined at a later stage and will includes measures to minimise the potential risks from waterborne and mosquito-borne disease.

12.6.4 Operation Phase Impact Assessment Prior to Mitigation

The level of sensitivity of the identified potential receptors for the operation phase will be the same as described in Section 12.6.2 above for construction phase impacts. The potential sources of impact during the operation phase will be directly related to the enhanced surface water runoff potential created by the extensive hard surfacing of the Expressway, airport, runways and aprons. Typical potential pollutants from the development will likely include (but not be limited to) suspended solids, sewage residues, oils and hydrocarbons, heavy metals and metalloids, fuels and fire control. Sources of these pollutants can include wash-off from runway and apron surfaces, general aircraft, plant and vehicle use and maintenance including solid and liquid waste management, as well as accidents and spillages and firefighting residues and liquids. The risk of impact on sensitive receptors will depend upon a viable pathway for pollutants being present from the operational infrastructure to the identified receptor/s. As in the construction phase, such potential impacts will be particularly enhanced during the rainy seasons.

12.6.4.1 The Nyabarongo River and Mwesa River

The Nyabarongo and the seasonal stream which is the Mwesa River feed a complex of wetlands within the vicinity of the Expressway to the north of the Airport Area. There is the potential for the pollution of the Nyabarongo River from contaminated surface water runoff generated across the Expressway, during operations.

Whilst the Nyabarongo River is large, the river already carries some background pollution loading, and would be expected to absorb some degree of diffuse pollution from roads. The Nyabarongo River and Mwesa ephemeral stream are considered of high sensitivity due to the informal and unregulated nature of use for drinking water and domestic use, the possibly ephemeral nature of much of the Mwesa ephemeral stream, and due to the sensitive wetland habitats and ecological receptors present. On the basis of the design controls detailed above, the magnitude of impact with regard to both water quality and surface water flood risk is considered to be low and therefore the significance of impact is considered to be **Minor Adverse.**

With regard to the physical effects of the road and bridges within the rivers, the physical presence of bridge piers within the river will inevitably have some degree of effect on the flow hydrodynamics of the river.

12.6.4.2 Lake Kidogo

There is a risk of surface water pollution of this highly sensitive receptor from the Proposed Project Area via an unnamed seasonal stream located to the south-eastern edge of the Airport Area, which could affect water quality within the lake if there is sufficient flow in this seasonal stream during the rainy seasons. If connectivity with the lake occurs, this could constitute adverse, long term, irreversible or reversible and both direct and indirect impacts on the lake. The risk of increased surface water flows from the Proposed Project Area to the lake catchment area impacting upon flooding to downstream receptors, such as people and property, during high rainfall events, would constitute adverse, short term or long term, reversible and both direct and indirect impacts.

On the basis that direct connectivity to the lake from the Airport Area via this stream is not fully established together with the design controls detailed above, the magnitude of impact with regard to both water quality and surface water flood risk, are considered to be very low and therefore the significance of impact is considered to be **Minor Adverse.**

12.6.4.3 The Mwesa River

There is a risk that surface water pollution both from the Airport Area and the proposed Expressway may affect water quality in the Mwesa River when this ephemeral stream flows. This would constitute adverse, long term, irreversible or reversible and both direct and indirect impacts. The risk of increased surface water runoff from hardstanding areas across the Proposed Project Area to the stream could result in potential flooding during high rainfall events, which could constitute adverse, short term or long term, reversible and both direct and indirect impacts.

On the basis of the design controls detailed above, the magnitude of impact with regard to both water quality and surface water flood risk is considered to be very low and therefore the significance of impact is considered to be **Minor Adverse**.

12.6.4.4 The Kibilizi Stream

There is a risk that surface water pollution of the Kibilizi Stream from the Proposed Project Area may affect water quality, which would constitute adverse, long term, irreversible or reversible

and both direct and indirect impacts. Risk of increased surface water runoff from hardstanding areas across the Proposed Project Area to the stream resulting in potential flooding during high rainfall events, will constitute adverse, short term or long term, reversible and both direct and indirect impacts.

On the basis of the design controls detailed above, the magnitude of impact with regard to both water quality and surface water flood risk is considered to be very low and therefore the significance of impact is considered to be **Minor Adverse.**

12.6.4.5 The Nyabarongo Wetland Area

There is a risk that surface water pollution from the Proposed Project Area may affect water quality and the hydrological setting of the wetland area, which would constitute adverse, long term, irreversible or reversible and both direct and indirect impacts. Risk of increased surface water flows from the Proposed Project Area impacting upon the hydrological regime and biodiversity of the Wetland area would also constitute adverse, long term, irreversible or reversible and both direct and indirect impacts.

On the basis of the design controls detailed above, the magnitude of impact with regard to both water quality and increased surface water flows are considered to be very low and therefore the significance of impact is considered to be **Minor Adverse.**

12.6.4.6 Water Supply Resources

Water will be supplied from a water treatment plant and pipeline that will connect to the project. This is considered as an Associated Facility. More detailed information on Associated Facilities is included in Chapter 6.

12.7 Mitigation Measures

The design and engineering controls specified above, if fully implemented, will be sufficient to reduce the anticipated potential impacts to a level which requires no further direct mitigation measures for surface water protection in both the construction and operation phases.

However, on-going water monitoring, as specified within the design control sections above, will be an essential element of the management system for the site during the operational phase. In particular, monitoring of Lake Kidogo's mean water level during water abstraction in the construction phase, together with reduction (or in an extreme event cessation of abstraction and the finding of an alternative source of water if necessary in agreement with the Client/Developer), and of the Nyabarongo Wetlands KBA/IBA for the presence of additional contaminant loading will be an integral part of the project ESMP.

12.8 Residual Impact Assessment Conclusions

12.8.1 Construction Phase Residual Impacts

On the basis that the construction phase ESMP and the Pollution Prevention Plan are implemented in line with the requirements detailed under the construction phase design controls, the impact significance relating to the water resources (surface and groundwater), including flood risks, are assessed to be **Minor Adverse,** with the exception of impacts on the water level of Lake Kidogo, which will remain **Moderate Adverse** and no further residual impacts are anticipated.

12.8.2 Operational Phase Residual Impacts

On the basis that the drainage strategy is implemented in line with the requirements detailed under the operation phase design controls, the impact significance relating to the water

resources (surface and groundwater), including flood risks, are assessment to be **Minor Adverse** and no further residual impacts are anticipated.

12.9 Summary of Mitigation and Residual Impacts

12.9.1 Summary of Findings

This study focused on water resources within the Proposed Project Area, including surface and groundwater aspects. This included the Mwesa and Kibilizi streams, Nyabarongo River, Lake Kidogo and Nyabarongo Wetland Area. Cognisance was taken of flood risks as well as water supply demand.

Construction and operation phase impacts include contamination to the water resources, increase in runoff flow resulting in flooding and hydrological flow disruptions. Although a change to the water resources exist, with the correct implementation of design controls and mitigation measures, the impact resulting from the Proposed Project is considered to be **Minor Adverse**.

Table 12-4: Summary of Findings

Impact	Receptor	Phase	Impact Magnitude	Receptor Sensitivity	Pre-mitigation Impact Significance	Design, Enhancement or Mitigation Measures	Management Plan	Residual Significance
Surface Water Pollution arising from construction processes	• Mwesa Stream • Kibilizi Stream • Nyabarongo River • Nyabarongo Wetland Area • Lake Kidogo	Construction	**Impact Magnitude:** Very low to low **Nature:** Adverse **Type:** Direct and indirect **Duration:** Temporary and Permanent **Reversibility:** Reversible	Moderate to High	**Minor Adverse** **Moderate Adverse** for Nyabarongo Wetland Area	• Oil interceptors and silt traps; • No discharge to the lake of any kind; • No Contractor vehicles will access the lake or any other watercourse or surface water body; • Site compounds and storage areas situated away from surface water receptors; and • Storage of materials and waste in accordance with international best practice.	C-ESMP Pollution Prevention Plan	**Minor Adverse**

Table 12-4: Summary of Findings

Water Supply Demand	• Lake Kidogo	Construction	**Impact Magnitude:** Medium **Nature:** Adverse **Type:** Direct and Indirect **Duration:** Short term **Reversibility:** Reversible	High	**Moderate Adverse**	• Water levels and quality monitored on a weekly basis; • Reduce, or in an unlikely event, cease extraction if lake levels reduce below nominated trigger level to be defined in the ESMP, and water then sourced from elsewhere if necessary, in agreement with the Client/ Developer.	C-ESMP Pollution Prevention Plan	**Moderate Adverse**

Table 12-4: Summary of Findings

Increased surface water runoff arising from construction processes	• Mwesa Stream • Kibilizi Stream • Nyabarongo River • Nyabarongo Wetland Area • Lake Kidogo	Construction	**Impact Magnitude:** Very low **Nature:** Adverse **Type:** Direct and indirect **Duration:** Short term **Reversibility:** Reversible or irreversible	Moderate to High	**Minor Adverse** **Moderate Adverse** for Nyabarongo Wetland Area	• Temporary drainage infrastructure; • Avoid use of scaffolding and temporary structures in river where possible and practical; • Bridge piers designed so that there are not significant effects; and • Culverts designed so no increased risk of upstream flooding.	C-ESMP Pollution Prevention Plan	**Minor Adverse**

Table 12-4: Summary of Findings

Surface water pollution arising from operation activity	• Mwesa Stream • Kibilizi Stream • Nyabarongo River • Nyabarongo Wetland Area • Lake Kidogo	Operation	**Impact Magnitude:** Very low **Nature:** Adverse **Type:** Direct and indirect **Duration:** Short term or Long term **Reversibility:** Irreversible or Reversible	High	**Minor Adverse**	• Detention basins designed to minimise potential risks; • Oil separation systems where feasible; • Foul wastewater treated onsite; and • Expressway designed to control quantity and quality of water leaving road.	Pollution Prevention Plan	**Minor Adverse**

Table 12-4: Summary of Findings

Increased surface water runoff due to increase in impermeable areas	• Mwesa Stream • Kibilizi Stream • Nyabarongo River	Operation	**Impact Magnitude:** Very low **Nature:** Adverse **Type:** Direct and indirect **Duration:** Short term **Reversibility:** Reversible or irreversible	Moderate to High	**Minor Adverse**	• Sufficient capacity for surface water runoff; • Flows restricted prior to discharge offsite; • Surface water discharge offsite appropriately distributed; • Expressway and crossings designed to not increase flood risk; • Expressway designed to control quantity and quality of water leaving road.	Design Controls to be implemented as per O-ESMP	**Minor Adverse**