



GOVERNMENT OF MALAWI

**MINISTRY OF AGRICULTURE, IRRIGATION AND
WATER DEVELOPMENT**


SHIRE VALLEY IRRIGATION PROJECT

**Environmental and Social Impact
Assessment (ESIA) and Pest
Management Plan (PMP) for the
Shire Valley Irrigation Project (SVIP)**

Volume 2: Impact Assessment report

May 2017

BRLi, Nîmes France

	<p>BRL ingénierie</p> <p>1105 Av Pierre Mendès-France BP 94001 30001 NIMES CEDEX 5</p>
---	--

Date	March, 2017
Contacts	Eric Deneut, Gilles Pahin

Document title	Environmental and Social Impact Assessment (ESIA) for the Shire Valley Irrigation Project (SVIP) Vol.2: Impact Assessment Report
Reference	800816
Version	V.6 Final Version

Date	Version	Comments	Written by	Validated by
October 21 st 2016	Impact Assessment V.1	Draft version	Eric Deneut: Terrestrial Ecologist with contributions from :	Gilles Pahin, Team Leader / ESIA/ESMP Expert
January 22 nd 2017	Impact Assessment V.2	Pre Final version	Noemie Arazi: Cultural Heritage Specialist Arie Rimmelzwaal: Soils Specialist	
March 8 th , 2017	Impact Assessment V.3	This section includes the new design of the Tiger fish (designed by KRC and provided by the World Bank). In addition, upon request from SVIP this version integrates the hydrological data from the MoAIWD V.4 includes the final comments from the WB	Robert Matengula: Rural Sociologist specialist Alfred Maluwa: Aquatic ecology expert	
April 12 th , 2017	Impact Assessment V.4		Pierre Gazin: Environmental Health Specialist Stephane Delichere: Hydrologist	
May 24 th , 2017	Impact Assessment V.5	Last set of comments from the WB Regional Safeguards Advisor (RSA)	Dominique Olivier: Integrated Pest Management Specialist	
May 26 th , 2017	Impact Assessment V.6		Eric Verlinden: Drainage and flood control specialist	

**ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT
(ESIA)
FOR THE SHIRE VALLEY IRRIGATION PROJECT (SVIP)
VOL.2: IMPACT ASSESSMENT REPORT**

Table of Contents

1. INTRODUCTION	1
2. MITIGATION WORKSHOPS.....	3
3. RELATION BETWEEN THE IMPACT ASSESSMENT REPORT AND OTHER SVIP STUDIES	4
4. PROJECT LOCALISATION AND DESCRIPTION.....	10
4.1 Water Intake	10
4.1.1 Construction and characteristics	11
4.1.2 Operation	11
4.2 Canals	11
4.2.1 Construction and characteristics	13
4.2.2 Operation	13
4.3 Command areas	14
4.3.1 Construction and characteristics	14
4.3.2 Operation	14
4.4 Natural Resources Management (NRM) component	16
5. IMPACT ASSESSMENT METHOD.....	19
5.1 Method for the determination of impact significance	19
5.2 Description of impacting activities	21
5.2.1 Pre-construction	21
5.2.2 Construction	21
5.2.3 Operation	22

5.2.4 Impact assessment of the Natural Resources Management (NRM) component	22
5.3 Impact Assessment Limitation	22
6. PHYSICAL ENVIRONMENT IMPACT ASSESSMENT.....	23
6.1 Introduction	23
6.2 Impact identification matrix on the physical environment	24
6.3 Affected component value	26
6.4 Geomorphology of rivers	26
6.4.1 Description of impacting activities	26
6.4.2 Mitigation measures	27
6.5 Hydrology	28
6.5.1 Description of impacting activities	28
6.5.2 Mitigation measures	34
6.6 Water quality	36
6.6.1 Description of impacting activities	36
6.6.2 Mitigation measures	37
6.7 Soil & groundwater	38
6.7.1 Description of impacting activities	38
6.7.2 Mitigation measures	39
7. IMPACT ON SOCIOECONOMIC, CULTURAL AND NATURAL HERITAGE	42
7.1 Introduction	42
7.2 Impact identification matrix on socioeconomic, cultural and natural heritage	43
7.3 Affected component value	47
7.4 Settlement, community organization and land tenure	47
7.4.1 Description of impacting activities	47
7.4.2 Mitigation measures	48
7.5 Infrastructures	51
7.5.1 Description of impacting activities	51
7.5.2 Mitigation measures	52
7.6 Economics	54
7.6.1 Description of impacting activities	54
7.6.2 Mitigation measures	56
7.7 Health and safety	58
7.7.1 Description of impacting activities	58
7.7.2 Mitigation measures	59

7.8	Gender aspect and Vulnerable people	66
7.8.1	Description of impacting activities	66
7.8.2	Mitigation measures	67
7.9	Cultural heritage	72
7.9.1	Description of impacting activities	72
7.9.2	Mitigation measures	73
7.10	Natural heritage	74
7.10.1	Description of impacting activities	74
7.10.2	Mitigation measures	86
8.	ECOLOGY IMPACT ASSESSMENT	100
8.1	Introduction	100
8.2	Impact identification matrix on ecology	101
8.3	Affected component value	103
8.4	Land cover	103
8.5	Terrestrial habitats and wildlife	111
8.5.2	Mitigation measures	118
8.6	Wetland habitats and wildlife	125
8.6.1	Description of impacting activities	125
8.6.2	Mitigation measures	132
8.7	Aquatic habitats and fish	135
8.7.1	Description of impacting activities	135
8.7.2	Mitigation measures	140
9.	IMPACT ASSESSMENT CONCLUSION	152
9.1	Conclusion on infrastructures to build to mitigate impacts	154
9.2	Residual impacts	157
10.	BIBLIOGRAPHY	162
ANNEXES		165
	Annex 1: Minutes of Mitigation Workshops	167

List of Figures

Figure 1 Workshop at Nsanje (left) and Chickwawa (right).....	3
Figure 2 Water intake location inside MWR	10
Figure 3 Diagram of irrigation canal.....	14
Figure 4 Farm Land Composition and Irrigation and Drainage Canals.....	15
Figure 5 Furrow irrigation	15
Figure 6 Areas concerned by the Natural Resources Management component.....	17
Figure 7 Hydrological impacts.....	29
Figure 8 Water availability and demand at Kapichira Dam (using same hydrological data from DWR used in TFS).....	30
Figure 9 By passed river section	35
Figure 10 Peak flow of right bank Shire tributaries	35
Figure 11 Poor oil management.....	36
Figure 12 Borrow pit with dangerous steep slopes (left) and typical impact from blasting (right).....	39
Figure 13 Suitable borrow pit for the creation of a wetland.....	40
Figure 14 Stuck cow in a lined canal	52
Figure 15 Trucks and pedestrians sharing construction roads & rubbish in construction camps.....	58
Figure 16 Working in damp condition around a pumping station	60
Figure 17 Canal in Kasinthula with still water and aquatic vegetation along the banks	62
Figure 18 Communal pit latrine in Kasinthula, an elegant but rarely used structure.....	63
Figure 19 "Invisible" falls at 5m³/s (November 2016)	80
Figure 20 Example of the micro topography along one km of the Feeder canal (between KP 2.8 and 3.6).....	87
Figure 21 Exact alignment of the Feeder canal inside MWR according to the FS.....	88
Figure 22 Elevation constraints in LNP.....	93
Figure 23 Mobile noise barrier	96
Figure 24 Wildlife casualties in Grootfontein – Omatako Canal.....	116
Figure 25 Inefficient escape structure.....	116
Figure 26 Overpass in Namibia.....	117
Figure 27 Cost for keeping wildlife out of canals	122
Figure 28 Examples of rock in concrete matrix from MWR and Ng’ona Lodge.....	122
Figure 29 Earth offers better grip than concrete	123
Figure 30 Prefabricated concrete mats (Armorflex ©).....	124
Figure 31 Armorflex ©	125
Figure 32 Inadequate culverts in an earth dike across a seasonal river.....	135
Figure 33 The tiger fish	138
Figure 34 Poor design of a culvert	141
Figure 35 Flood risk area (in red).....	143
Figure 36 Example of under construction large fish screen for water intake (left)	143
Figure 37 Small scale automatic debris removal screens	144
Figure 38 Large-scale automatic debris removal (traveling belt screen).....	145

Figure 39 Smaller scale examples of fish barriers	147
Figure 40 Examples of fish weir and rack	147
Figure 41 KRC proposal for a Tiger Fish barrier	148
Figure 42 Armorflex mats.....	154

List of Tables

Table 1 Relations between studies.....	4
Table 2 Main canals characteristics	12
Table 3 Siphons of MWR	12
Table 4 Water Demands for SVIP and Escom at Kapichira Dam	30
Table 5 Number of months when the flow is (will be) lower than 50m ³ /s.....	32
Table 6 Number of months when the flow is (will be) lower than 40m ³ /s.....	32
Table 7 Number of months when the flow is (will be) lower than 30m ³ /s.....	32
Table 8 Number of months when the flow is (will be) lower than 20m ³ /s.....	33
Table 9 Number of months when the flow is (will be) lower than 10m ³ /s.....	33
Table 10 Estimation of the number of trucks.....	78
Table 11 Number of months when the falls will be "invisible" (below 10m ³ /s).....	80
Table 12 Land cover changes	104
Table 13 Land cover that shall be set aside for protection.....	106
Table 14 Lands to be set aside	107
Table 15 Options to avoid drowning of wildlife in LNP	124
Table 16 Impact on wetland	126
Table 17 Maximum changes in vegetation types per area with two scenarios on Elephant marsh vegetation.....	129
Table 18 Average vegetation changes in Elephant marsh.....	130
Table 19 Residual impacts	157
Table 20 Minutes of Nsanje Workshop.....	169
Table 21 Minutes of Chikwawa workshop.....	170

List of Acronyms

ADD	Agricultural Development Division
Ca	Calcium
CC	Construction contractor
CBOs	Community Based Organizations
CMIP	Common Management Information Protocol
COB	Coyne et Bellier Study
DNPW	Department of National Parks and Wildlife
EC	Electrical Conductivity
EFR	Environmental Flow Requirement
EIA	Environmental Impact Assessment
Escom	Electricity Supply Commission of Malawi
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESP	Exchangeable Sodium Percentage
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Discussion Group
FS	Feasibility Study
GCM	Global Climate Model
GIEMS	Global Inundation Extent from Multi-Satellites
GoM	Government of Malawi
Ha	Hectares
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
ITCZ	Inter-Tropical Convergence Zone
JICA	Japan International Cooperation Agency
KRC	Korea Rural Corporation

LNP	Lengwe National Park
Masl	Meters above sea level
Mg	Magnesium
MWK	Malawian Kwacha (1\$ US equals +/-715 MWK)
MoAIWD	Ministry of Agriculture, Irrigation and Water Development
MWR	Majete Wildlife Reserve
N	Nitrogen
NWDP	National Water Development Project
P	Phosphorus
PAPs	project-affected people
PCCPLTRPF	Preparation and implementation of a Communications, Community Participation, Land Tenure and Resettlement Policy Framework
pH	Soil Reaction
PMP	Pest Management Plan
PPE	Protective Personal Equipment
PPP	Public Private Partnership
RoW	Right-of-Way
SRBMP	Shire River Basin Management Program
SVIP	Shire Valley Irrigation Project
SVTP	Shire Valley Transformation Program
TORs	Terms of Reference
UNESCO	United Nations Education Scientific and Cultural Organization
WASVIP	Water Availability for Shire Valley Irrigation Project
WESM	Wildlife and Environmental Society of Malawi
WRB	World Reference Base for Soil Resources

1. INTRODUCTION

This report is the final Impact assessment report. The Impact assessment report, Environmental and Social Management Plan and baseline report (May, 2016) constitute the Environmental and Social Impact Assessment report (ESIA) for the Shire Valley Irrigation Project (SVIP). It is presented in 3 volumes:

- Volume 1: Baseline report (including the regulatory analysis)
- Volume 2: Impact assessment report (this report)
- Volume 3: Environmental and Social Management Plan (ESMP).

In addition, an Executive Summary was produced as a standalone document.

The client is the Ministry of Agriculture, Irrigation and Water Development (the "Client"). Korea Rural Corporation (KRC) is the consultant in charge of the Feasibility Study (FS). BRLi is the consultant in charge of the ESIA. In addition, two stand-alone reports, the Inception report (June 2015) and the Pest Management Plan (PMP, September 2016) were produced by the consultant.

This report is the Consultant's final version provided for public disclosure. However, it is likely that the Government of Malawi will update this report in response to further public and stakeholder comments as well as any new technical project information that may become available.

OBJECTIVE OF THE PROJECT

The Project objective is to provide access to reliable gravity-fed irrigation and drainage services, secure land tenure for smallholder farmers, and strengthen management of wetlands and protected areas in the Shire Valley.

OBJECTIVE OF THE ESIA

The objectives of the ESIA and PMP are well defined in the ToRs (through a list of 37 requirements). This assignment complies with the national policies regarding impact assessment as well as the World Bank triggered safeguard policies. In addition, the AfDB environmental and social standards, the International Finance Corporation (IFC) Performance Standards are applicable, when relevant. Measures developed under this assignment has informed the Client and technical studies about ways to mitigate impacts and enhance positive effects of the Project. The ESIA is based on the FS description of the Project.

Mitigation measures are based on the BRLi experience in canals in Africa not only in designing canals but also in monitoring impacts during construction. Fieldwork and discussions with stakeholders have helped identifying risks and impacts.

This ESIA is not only intended for funding agencies who financed the ESIA but also for the construction contractor, the designer of the Project the future operator as well as national institutions and the SVIP.

SHIRE VALLEY TRANSFORMATION PROGRAM - I

SVIP is part of the Shire Valley Transformation Program – I.

The SVTP is a 14-year program (2017-2031) structured around three coordinated pillars:

- (i) Providing reliable, professionally managed and sustainably financed irrigation service to a large number of irrigators in a phased construction of the Shire Valley Irrigation Project (SVIP) scheme and providing multiple services including water supply;
- (ii) Support farmer organization within a comprehensive land use plan; supporting land tenure strengthening and consolidation; as well as natural resources management; and
- (iii) Establishment of smallholder owned commercial farm enterprises transitioning into commercial agriculture from subsistence farming and integrating them into commercial value chains.

In general terms, SVTP-I initiates the process on all pillars with a major focus on irrigation service provision to the SVIP-I area, land tenure, farmer organization and natural resource management as these precede any downstream development.

The sub-component of the SVTP called “Sub-component 2.2 Natural Resources Management” will be supported largely with GEF-6 funding and will promote an inter-sectoral approach to the management of the Lower Shire landscape by addressing biodiversity conservation, protecting and enhancing the role that forests, woodlands, rangelands and wetlands play in mitigating climate change; and promoting sustainable approaches to forest management that protect forest resources and deliver benefits to local communities.

At landscape and park level, this sub-component would:

- (i) Invest in community-level natural resource management in areas adjacent to the irrigation and conservation areas (Lengwe National Park, Mwabvi and Majete Wildlife Reserves, Matandwe Forest Reserve and the Elephant Marsh proposed Community Conservation Area) and in wildlife corridors,
- (ii) Provide targeted support to these conservation areas to strengthen conservation and community management and encourage private sector investments (e.g. by tourism concession investors) that could boost revenues for re-investment in local community development and conservation management,
- (iii) Invest in establishment of the Elephant Marsh Community Conservation Wetland Area, with a strong emphasis on community-based natural resources management strategies, based on the wetland management plan currently being finalized with the support of the Shire Basin Management program (SRBMP) phase 1.

Activities that will be implemented as part of this sub-component are separate from, and additional to, the mitigation measures specified in this ESIA.

2. MITIGATION WORKSHOPS

After the draft Impact Assessment report was produced, a mitigation workshop was carried out by the Consultant in November 2016. The objective was to present the mitigation measures to stakeholders and collect their opinions. In addition, a presentation to the Task Force, World Bank and the Feasibility Consultant was done to discuss about several key issues: the tiger fish, the impact on Majete Wildlife Reserve and on Lengwe National Park and impacts on Elephant marsh.

WORKSHOPS WITH LOCAL COMMUNITIES

Two workshops with communities in Nsanje (November 10th 2016) and Chickwawa (November 11th 2016) Districts were held and presented by the Consultant. The objective was to expose the main conclusions from the impact assessment and the set of mitigations. Opinions and questions raised are presented in annex of this report; some of them are dealt with in the main text whenever relevant. In Nsanje, 50 people attended the workshop and in Chickwawa 37.

Other meetings were held at several occasions, their outcomes are presented in relevant sections: meeting with African Parks, meeting with Jambo Africa (in charge of tourism in LNP), meeting with Wildlife and Environment Society of Malawi (WESM) and meeting with Escom.

Figure 1 Workshop at Nsanje (left) and Chickwawa (right)



Source: BRLi, 2016

WORKSHOP WITH TASK FORCE AT LILONGWE

A Workshop with Task Force (SVIP), the FS consultant team, with the World Bank and national stakeholders was held. It was the opportunity to exchange on the latest development of the FS, and on the key technical issues to address such as the tiger fish barrier and type of canal inside MWR.

OUTCOME OF DISCUSSIONS

In the draft impact assessment report, BRLi had developed several scenarios for the canal inside MWR (and estimated their cost). In parallel, the FS consultant had developed a new canal alignment that was not specifically presented in its report. The outcome of the discussion was that:

- The FS Study proposes a canal that is partially underground inside MWR and crosses the Mwembezi River using a siphon (more detail is provided in this report under section 4). The rationale for the latest canal alignment route and mix of open and buried canal is the presence of topographic and terrain constraints. The high cost for the buried sections do not leave much place for a completely buried canal.
- The FS Study did not have the correct boundaries of the reserve and confused the electric fences with MWR boundaries; in fact, the fences are not MWR boundaries.
- BRLi needs to take into account this new canal alignment, however the FS consultant (or Design consultant) also need to study the shortest possible way out of the reserve.

The Tiger fish issue had been given serious consideration by the World Bank. Discussion revolved under the most efficient location for a Tiger fish barrier which is on the Feeder canal and inside MWR (see section 8.7). The FS consultant has been required to incorporate in its design a fish weir at this location.

INCEPTION AND BASELINE CONSULTATIONS

The Consultant had carried out other consultations in the framework of this ESIA at inception and baseline, their outcomes are presented in the Inception and Baseline reports (Vol.1):

- Inception mission (June 2015)
- Baseline mission (January 2016)
- Public consultations (June 2016) two consultation with stakeholders : one in Chikwawa and one in Nsanje

PREVIOUS PUBLIC CONSULTATIONS

In the framework of the 2005 EIA, the consultant in charge of the EIA (Coda and Partners in association with Ninham Shand for the former Ministry of Irrigation and Water Development, 2005) carried out public and stakeholder consultations between September and October 2005.

3. RELATION BETWEEN THE IMPACT ASSESSMENT REPORT AND OTHER SVIP STUDIES

The ESIA/ESMP has many links with other studies. These links can be distinguished in three different categories:

- Relations with the Project technical studies (feasibility and design study);
- Relations with Shire River Basin Management Programme (SRBMP) funded by the World Bank;
- Relations with other studies under the SVIP.

The following table presents these relations.

Table 1 Relations between studies

Project technical studies	Relation
Feasibility Study reports (several versions were produced during the writing of the ESIA, the final version is dated December 2016)	The ESIA is based on FS project definition. The ESIA provides to the FS study the series of mitigations that need to be technically tested. These mitigations only relate to infrastructures or changes in the Project design that will be required to mitigate or avoid impacts.

Design Study (after the FS). This study has not started yet.	The ESIA proposes many measures which technical and economic feasibility have to be studied at the Design Study phase. The Design has to make a final decision on the fate of mitigations presented in the ESIA. Tender documents after the Design phase have to include measures from the ESMP
SRBMP studies	Most of SRBMP studies were not available at time of Vol.1 Baseline report. Their conclusions are used in this final version of Vol.2
<p>Component A – Shire Basin Planning Sub-components: A1-Basin planning framework A2-Institutional capacity A3-Water resources information systems A4-Program management monitoring & evaluation</p> <p>Component B – Catchment Management Sub-components: B1-Catchment planning, monitoring and learning B2-Rehabilitation targeted catchments B3-Alternative rural livelihoods B4-Ecological management</p> <p>Component C – Water related infrastructure Sub-components: C1- Kamuzu Barrage C2-Flood management C3-New water investment</p>	<p>In the framework of these components and sub-components, several studies were made available to the consultant, they are presented hereunder.</p> <p>This ESIA stresses out that recommendations of SVIP and SRBMP should be harmonized since there is a chance that SRBMP studies recommend actions that could interact or impact SVIP or cumulate with SVIP impacts. Most activities of the SRBMP relate to catchment management and rehabilitation. <u>However, they seldom take into account the future presence of the SVIP.</u></p> <p>Most studies under the SRBMP were not finalized at time of ESIA finalization.</p>
Implementation Service Provider (ISP) for Flood Risk Management (SRBMP-1)	<p>This report deals with risk from floods. In some sections, it presents measures to minimize flood impacts on human safety from:</p> <ul style="list-style-type: none"> • Ruo River • Thangadzi East River • Mwanza River • Lalanje River • Tombokamwa River
Lengwe National Park, General Management Plan 2016-2020 work document (Component B, Sub component B4)	The ESIA refers to this document has it defines new objectives for the LNP as well as identifies current issues with wildlife and infrastructures of the park.
Shire River Basin Management Program (Phase I) Project Final Environmental and Social Assessment Report (July, 2013)	The overall assessment of impact of SRBMP planned activities is dealt with in this report (except for the impact of Kamuzu barrage).
Independent Environmental Impact Assessment for the Upgraded Kamuzu Barrage (December 2011)	An ESIA was carried out under the Component C.1: upgrading of the Kamuzu Barrage. The barrage is a key element which has many interactions with SVIP as the current objective of the upgraded barrage is to raise the water level up to 40 cm in Lake Malawi.

<p>Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi. Ministry of Water Development and Irrigation. P117617. <u>Description of the livelihoods in the area of the Elephant Marsh Report</u> November 2016</p>	<p>This study addresses the following objectives (MRAG, 2016):</p> <ul style="list-style-type: none"> • Describe local livelihoods, including spatial and temporal use of resources; • Assess the past, present and potential future influence of human livelihoods on the Elephant Marshes, and what effect these will have on the functional resilience of the Marshes in the future, and the implication for climate change; • Identify the socio-economic impacts of livelihoods and how climate change might affect these livelihoods; • Describe the risks to livelihoods (e.g. flooding or overfishing), and current strategies to increase resilience to these risks that will be exacerbated by climate change; and • Provide an assessment of the support mechanisms for community welfare in line with possible flood mitigation measures and disaster management strategies.
<p>Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi <u>Management Plan for the Elephant marsh</u></p>	<p>The management plan objectives are to:</p> <ul style="list-style-type: none"> • To improve understanding of the functional ecology of the Elephant Marsh; • To assess the feasibility of designating the Elephant Marsh as a community-managed protected area and a Ramsar site; and • To identify strategies and development options that would build the resilience of local communities to environmental change <p>At time of final Impact assessment writing, the management plan was not available (not published)</p>
<p>Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi <u>Hydromorphology study</u></p>	<p>The hydromorphology study objectives are to :</p> <ul style="list-style-type: none"> • To establish the current status and recent trends of the hydromorphology of the Elephant Marshes. • To establish a hydraulic model predicting flooding patterns in the Elephant Marshes since flow records began. • To evaluate historic land-use change (especially deforestation and agriculture) and its effect on sedimentation and siltation. • To map historic changes in the channel patterns in the marshes. <p>At time of final Impact assessment writing the hydroorphology report was not available (not published)</p>
<p>Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi Sub-Study 4: <u>Biodiversity of the Elephant Marsh</u> (2016)</p>	<p>“This sub study forms part of a larger study on the Elephant Marsh which also includes studies of the hydrodynamics, local communities and ecosystem services, in order to inform a management plan for the marshes and in order to prepare an application for Ramsar status as a wetland of international importance” (Anchor, 2016).</p>

	<p>This sub-study aimed at describing (through surveys), biodiversity of Elephant marsh. Specialized surveys and studies of several taxonomic groups were carried: plants, aquatic invertebrates, dragonflies, butterflies, reptiles, amphibians, fish, birds and mammals.</p> <p>This report was not available at time of the Baseline report (Vol.1) and at time of draft Impact Assessment report (Vol.2). However, main conclusions from it were used to update this Vol.2 final version.</p>
<p>Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi Analysis of the potential effects of alternative future scenarios of flow and/or management on the ecological condition of the Elephant Marsh (<u>Ecosystem Functional Model (DRIFT)</u> (2016)</p>	<p>This sub study explores the potential effects of alternative future scenarios of flow and/or management on the ecological condition of the Elephant Marsh.</p> <p>This report was not available at time of the Baseline report (Vol.1) and at time of draft Impact Assessment report (Vol.2). However, main conclusions from it were used to update this Vol.2 final version.</p>
<p>Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi. Sub-Study 3. <u>Ecosystem Services of the Elephant Marsh.</u> (December 2016).</p>	<p>This study is a desktop study which :</p> <ul style="list-style-type: none"> • Describe the ecosystem services provided by the Elephant Marsh in physical terms and provide desktop estimates of their economic and social value; • Draw comparisons with other wetlands in Africa of a similar nature; • Discuss how capacity of the system to deliver these services responds to hydromorphology how this has changed over time; • Discuss the wetland's sensitivity and adaptive capacity to multiple pressures, with a description of those pressures. <p>This report is relevant for Baseline information and this impact assessment report.</p>
Other SVIP studies	
<p>Public-Private Partnership (PPP Feasibility study) (on going)</p>	<p>The PPP study informed the ESIA about public-private partnership arrangements for irrigation services for SVIP. The ESIA also makes recommendations about what arrangement and what are the responsibility of the scheme operator in terms of maintenance and what is the relationship between parks management (Lengwe and Majete) and the scheme operator. The ESIA also helps to identify environmental and social risks regarding the scheme operator.</p>
<p>Hydraulic model study at the headpond of Kapichira dam</p>	<p>Although the title of the study is hydraulic modeling, the main objective of this study is to assess the impact of the Project on the reservoir sedimentation pattern. The study's objectives are also to avoid negative impact on sediment flushing operations at the power station and to minimize the entry of sediment into the proposed feeder canal system of SVIP.</p> <p>The ESIA will not rely on conclusion of this study, as the progress of the study is not as advanced as the ESIA. The ESIA is therefore referring to this study for these topics.</p>

<p>Preparation and implementation of a Communications, Community Participation, Land Tenure and Resettlement Policy Framework (PCCPLTRPF) (on going)</p>	<p>Many elements on socioeconomics are dealt with in the PCCPLTRPF. The ESIA make references to it. This assignment is divided in several studies:</p> <ul style="list-style-type: none"> • Communication strategy: This study describes the main stakeholders and presents a SWOT analysis. It also presents the communication strategy toward stakeholders. • Gender and Youth Strategy Study: This study describes the current challenges that women and young people face. This report also recommends a series of measures and guidelines aiming at these two groups. In addition, roles of various stakeholders and monitoring actions are defined. • Grievance redress mechanism: This study describes the current method for grievance redress (revolving around traditional leaders). This study also implements the Grievance Redress Mechanism (GRM) and Grievance Redress Committee (GRC) to ensure that people's opinions and grievances regarding the project are documented and addressed. In addition, monitoring of complaints will be carried out under this mechanism. • Resettlement Policy Framework This document provides the basis for the Resettlement Action Plan (regulatory review, gap analysis, etc.). It deals with impact of resettlement but also the issue of access to sources of livelihood and to impact on cultural heritage. The ESIA refers to this study, especially when it comes to the number of affected villages and the number of bridges that shall be built to cross canals (and footpaths for people). • Stakeholders' views report This report presents the main conclusions from various stakeholder's consultation. It discusses stakeholders views on several topics: land tenure, access to irrigated land, resettlement, agricultural development, access to water for livestock and gender vulnerability. • Socio-economic baseline report This report presents the main socio-economic figures of the SVIP area and discusses about health, land tenure, livestock, agriculture, etc. It also includes a chapter on communities' views of the Project.
<p>Agricultural Development Planning Strategy (2016)</p>	<p>This study describes the crops of SVIP. Many elements related to agriculture and fisheries are dealt with in this report. It discusses about mitigation for smallholder livestock farmers and assesses the potential for fish farming. In addition, this study describes efficient organization of producers that shall be implemented</p>
<p>Pest Management Plan (2016)</p>	<p>The PMP identifies the main pest based on the type of crops and proposes measures to fight pests.</p>
<p>A Cultural Heritage Impact Assessment Report (2016)</p>	<p>This report provides information on cultural heritage sites based on surveys around Phase I of SVIP. Forty-six sites were identified by the MDoA in addition to those identified by the consultant.</p>
<p>Other report</p>	

Majete Wildlife Reserve, 5 years business plan 2016-2020	This document, written by African Parks, describes the reserve's objectives and presents its zoning. It also describes the various infrastructures of the reserves.
--	---

4. PROJECT LOCALISATION AND DESCRIPTION

Construction work of the SVIP is expected to start in 2018 after a tendering process for a designer, a construction contractor and a scheme operator. The water will start to flow inside the water intake at Kapichira Dam towards the end of year 2022. The total cost of SVIP taking into account direct and indirect construction costs is estimated at 519,250,000 USD. (KRC final report, 2016). This excludes the mitigation measures recommended in this Impact assessment report and detailed in the ESMP.

As mentioned in the latest version of the FS (Korea Rural Corporation, 2016), the Project consists of several key infrastructures as presented in the following sections. The Project design and construction will be phased according to the phases of the Project (Phase I will be designed and built separately from Phase II). Phase I is supposed to start in 2018. Phase II will start at an unknown date, most likely after Phase I.

In addition to these infrastructures, based on the latest information, this ESIA takes into account that dams of tributary rivers were not retained as options to increase available water for SVIP.

The Feasibility Study (FS) was finalized in December 2016. It was undertaken by Korea Rural Corporation in Joint Venture with Dasan Consultants co., LTD., GK Works Civil and Structural Engineers.

4.1 WATER INTAKE

A water intake will be built at Kapichira reservoir, the highest topographic point of the scheme (145.5~146.5masl), on the right bank of the Shire River, upstream from Escom training dike and the fuse dike, on the opposite side of the water intake of Escom hydropower station.

The SVIP water intake will extract a certain amount of water from the Shire River (the reservoir) to distribute water by gravity to the scheme. The value will be between 20.5 and 51.3 m³/s depending on the season. Based on the Hydraulic Modeling study, a bathymetric survey was carried out to select the adequate location which is shown in the following figure.

Figure 2 Water intake location inside MWR



Source: KRC, 2016

The SVIP intake structure will comprise a 46.5 m long intake sill, with 12 sluice gates each 3 m wide.

Escom powerplant as a capacity of 132 MW. The by-passed section between the reservoir dam and the powerplant is very short (900 meters). An unformal environmental flow of 30-50m³/s is currently released from the dam spillway to sustain Kapichira falls during the rainy season, important touristic attraction of Majete Wildlife Reserve. However, during the peak of the dry season, this environmental flow is not guaranteed.

4.1.1 Construction and characteristics

No information regarding the construction of the intake is available (quantity of material needed, localization of quarries, RoW, duration of work, etc.), most of these details will be provided at Design stage. One element can be highlighted: in order to prepare the passage for the water intake, part of the reservoir may be dredged (using a dredger).

4.1.2 Operation

The gates will be operated by an automatic control system. When the operator inputs the required amount of water into the system, the system will automatically operate the gates based on the relation between the flow rate, gate opening and water level variation. The 12 sluice gates will be installed into two partitions, the first one comprising 8 gates and the second one 4 gates. The second partition will allow abstraction of 18 m³/s, and will be operated when the water requirements at the scheme is less than 18 m³/s. The first partition will allow abstraction of up to 32 m³/s and will be operated when the water requirements at the scheme are between 18 m³/s and 32 m³/s. Both partitions will be operated for scheme water requirements above 32 m³/s to the maximum requirement of 50 m³/s (KRC, 2016).

The SVIP water demand per month is presented in section 6.5 (hydrology impact assessment).

The water intake is not a pumping station as water enters the intake passively (gravity).

4.2 CANALS

There will be three main canals:

- A Feeder canal, also called Main canal 1, with a total length of 33.8 km (conveying water from the water intake),
- The Supini canal, also called Main canal 3, with a total length of 10.7 km (previously called Illovo canal) mainly irrigating Phase I,
- The Bangula canal, also called Main canal 2, with a total length of 88.0 km mainly irrigating Phase II but also some Zone in Phase I (before Lengwe National Park).

Each main canal will be lined with concrete. Bangula canal could potentially be an earth canal (not lined) in the 14 km stretch along Lengwe National Park. However, feasibility of an earth canal still needs to be assessed at Phase II.

The following are the main characteristics of the canals based on the feasibility study (lined canal). RoWs are estimated.

Table 2 Main canals characteristics

	Slope	Length (km)	Depth (m)	Average Velocity (m/sec) at max. capacity	Peak flow (m ³ /s)	Bed width (m)	Upper width (m)	Total Right of Way (RoW) (m)
Feeder Canal (also called Main Canal 1)	1H/1.5V	33.7	2.5	1.51	50	12.7	22.6	40-45
Supini Canal (also called Main canal 3 and Illovo Canal)	1H/1.5V	10.6	1.3	1.35	14	6.7	13.0	+/-40
Bangula Canal (also called Main canal 2)	1H/1.5V	78.7	1.9	1.13	29	9.1	17.2	30-45

Source: KRC TF final version, 2016

Each of these canals separate into Branch canals.

Siphons are planned to cross large valleys and rivers with important floods. In total, 11 siphons are planned for a total length of about 4 km. Culverts are planned where topographic changes are high but floods are small. Culverts are also planned to cross small-scale rivers and roads.

INSIDE MAJETE WILDLIFE RESERVE

Due to topographic constraints, the Feeder canal inside MWR is going to be partially underground along 1.25 km inside MWR boundaries. It will be open (open lined canal) along 1.20 km inside MWR.

The following are the characteristics of the underground canal (siphon) in MWR.

Table 3 Siphons of MWR

Chainage location of siphons	Length (m)	Length in MWR (m)	Size (m)	Name
0+64 to 0+817 (entirely in MWR)	755.40	755.40	8.0 x 3.0	Intake and #1 Siphon
1+237 to 1+430 (entirely in MWR)	195.40	195.40		#2 Siphon
2+710 to 2+890 (partially in MWR)	181.70	100		#3 Siphon
3+400 to 3+800 (partially in MWR)	406.80	200		#4 Siphon
Total length of buried canal inside MWR		1250.8		

Source: adapted from KRC TFS Final (2016)

According to the FS, the thickness of concrete will be sufficient to allow large wildlife to pass (50 cm). This thickness shall not be compromised at Design phase.

This report takes into account that the buried canal is fully buried and does not represent an impassable obstacle for wildlife. In case if the canal is not fully buried than 3 wildlife overpasses shall be installed inside MWR as presented in the Draft Impact assessment report.

NIGHT WATER STORAGE

In addition, night water storages will be built, their locations are not provided in the FS. Their size is as follow: between 90 and 270 meters long and 40 to 180 meters wide with a depth of 3.5 meters.

4.2.1 Construction and characteristics

Not much information is provided in the FS reports about the construction of canals. Usually canal construction is done with an excavator to remove earth which is then either stored or transported by trucks. Important elements for ESIA are lacking such as quarries location and duration of work (except for work in LNP which are mentioned in the Option report to last 2 years). The FS report provides with name of 8 borrow pits and quarries, but does not provide with location nor does mentioned whether these are existing or not. Sometimes the name reveals an existing pit: borrow pits are Tomali, Nyaika, Sibale old pit, Nyamithuthu old pit, Chikhama, Moroko, Chikalumphu and Namiche. Quarry sites investigated are Kajawo, Thabwa existing quarry, Nzongwe and Ngabu (KRC, 2016). Detailed information will be provided in the Design study.

4.2.2 Operation

All canals are gravity canals bringing water from the Feeder canal to the Supini and Bangula canals, each of which will lead to Branch canals. In some area, canals may be replaced by siphons (when crossing large rivers such as Mwanza River).

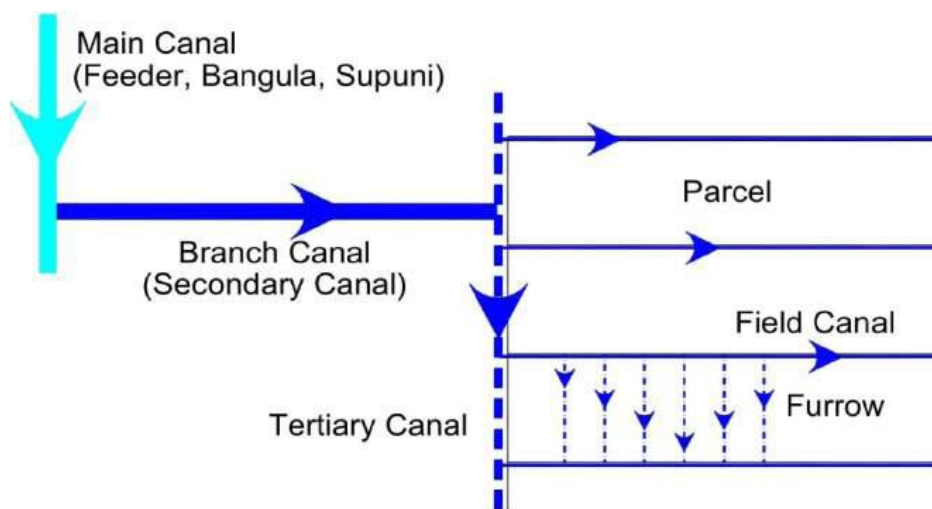
The daily time for irrigation depends on the irrigation methods. For pivot irrigation system, irrigation time is 24 hours, a whole day. For furrow irrigation, water application is normally 12 hours, during the daytime. Therefore, Branch canals shall be used only for 12 hours based on furrow irrigation methods. The main canals are designed for 24-hour continuous supply, for the whole year. Therefore, there is an operating time gap between the main canals and the Branch canals. Night storages will allow to store water (KRC, 2016).

Regarding drainage, the FS report considers using existing rivers and streams as drainage channels. However, it does not provide much information except channelizing some minor rivers to become drains and connecting them to larger rivers (KRC, 2016).

In addition, the FS foresee to modify Mwanza and Nkombedzi Wa Fodya Rivers to reduce the impact of floods. According to the FS report, river training works should be done on these two river channels (KRC, 2016).

The following figure summarizes the system.

Figure 3 Diagram of irrigation canal



4.3 COMMAND AREAS

The project is made of several irrigated areas as shown in the figure next page: Phase 1 consists of three zones:

- Zone I-1: 9,631ha (total area, including access roads and right of ways)
- Zone I-2: 11,250ha (total area, which is made of Illovo estate)
- Zone A: 5,199ha (total area)
- Phase 2 consists of three zones:
 - Zone B: 9,925ha (total area, which is partly made of Illovo estate)
 - Zone C: 10,749ha (total area)
 - Zone D: 4,076ha (total area)

The total area is 50,830ha of land. The irrigation land covers 43,370ha (without road, canals and infrastructures).

With current layout, the Feeder canal will cross about 2450m of Majete Wildlife Reserve (most of it inside the reserve fences) and about 14km of Lengwe National Park.

4.3.1 Construction and characteristics

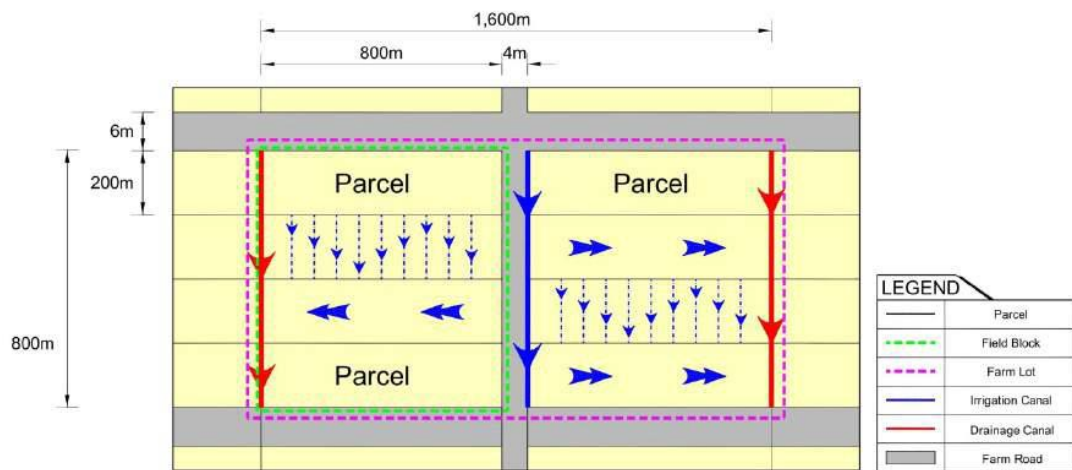
The command area will be made of parcels, drainage channels and farm roads (between 4 and 6m wide). Work will involve land leveling and major earthwork.

4.3.2 Operation

The irrigation and drainage system and roads in a unit parcel of land shall be based on its size. Typically, roads inside the farmland have been planned to be spaced at every 1.5 km distance. In this regard, several parcels comprise a single block around which roads have been planned. A field block shall comprise 6 parcels, and a farm lot shall comprise 2 field blocks (KRC, 2016).

A farm lot=2 field blocks, 1 field block=6 parcels.

Figure 4 Farm Land Composition and Irrigation and Drainage Canals



Source: KRC, 2016

The field canal will supply irrigation water directly to the parcel through furrows.

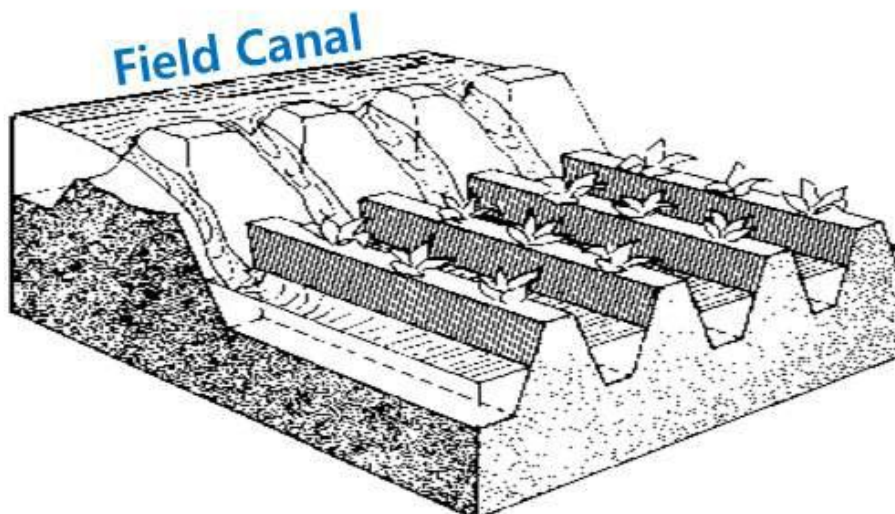
APPLICATION EFFICIENCY

The various efficiency coefficients are:

- Application Efficiency E_a (furrow irrigation): 64%
- Distribution Efficiency E_d : 90%
- Conveyance Efficiency E_c : 90%

Multiplying the three coefficient shows how much irrigation water will return to the system either to the watertable, to drain canals or evaporates. The overall Application efficiency is 52 %, which means that about half of the water is returned to the natural environment (or evaporates).

Figure 5 Furrow irrigation



Source: KRC, 2016

DOMESTIC WATER SUPPLY

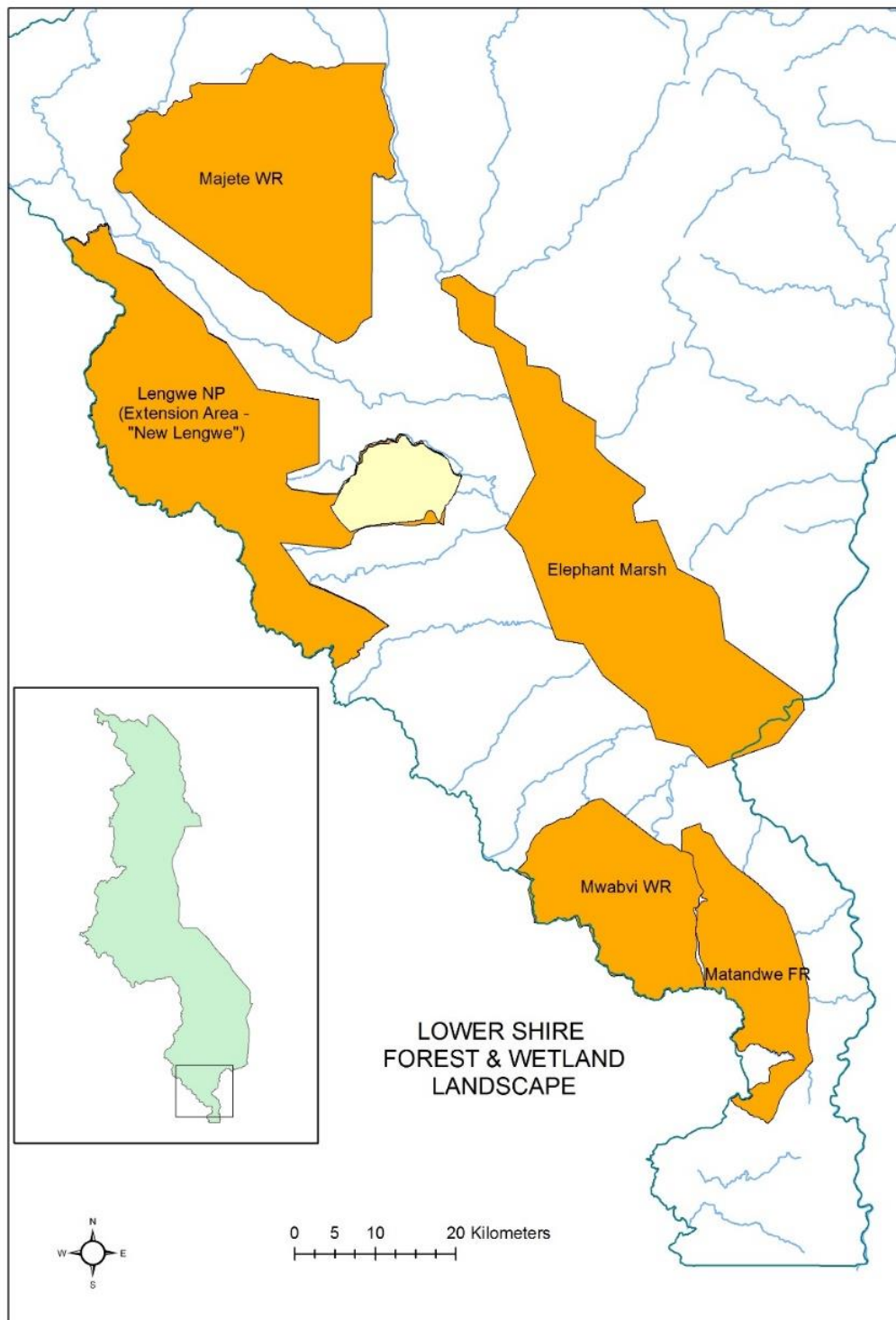
From the Feeder canal at Chikwawa, a pipeline for Chikwawa town (as described in the latest FS report) will divert up to 1,240 m³ per day to supply drinking water to Chikwawa.

4.4 NATURAL RESOURCES MANAGEMENT (NRM) COMPONENT

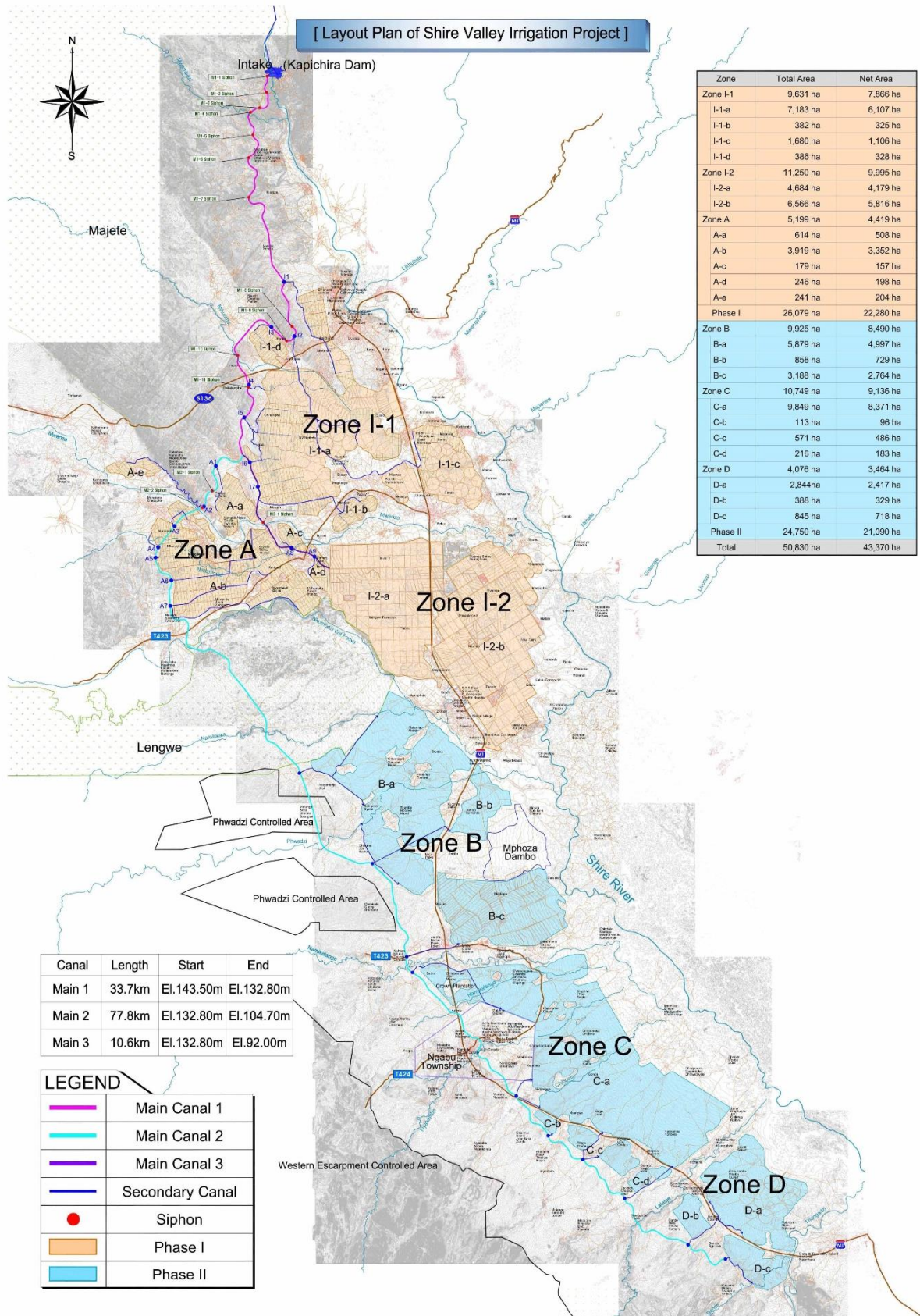
The Sub-component 2.2 Natural Resources Management will include site level support for Conservation Areas of the Lower Shire Landscape aiming at :

- Mwabvi Wildlife Reserve and Matandwe Forest Reserve:** Support will strengthen inter-agency planning and implementation between DNPW, DoF and develop nature-based tourism to deliver livelihood benefits for local communities and revenues to sustain landscape management. Support would also extend ongoing participatory forest management and linkages to wider tourism packages for the Lower Shire that includes a selection of sites. At Matandwe Forest Reserve, The project will support village-level income generating activities, (such as beekeeping, livestock production, timber/firewood harvest and sale, tree seedling production and sale), the establishment of woodlots and tree-based systems on customary land, and the establishment and management of Village Savings and Loan Schemes.
- Elephant Marsh:** Government of Malawi is planning to establish the Elephant marsh as Malawi's first 'Community Conservation Wetland Area' with the intention of balancing local livelihood needs with the longer-term, sustainable management of the marsh ecosystem. The Project will support start-up management of the wetland management plan for the Elephant Marsh with a strong focus on building resilience of local livelihoods given the impacts of climate variability. This will include the establishment and implementation of a monitoring program covering marsh hydrology, biodiversity and livelihoods. In the context of the park management plan, support would also enable the implementation of the first phase of the Community-based Management Plan for the Elephant Marsh. The project will support conservation measures for the remaining fish biodiversity and wildlife populations through support for participatory planning and identification of areas of usage and non-usage zones, the introduction of community fisheries management regimes and development of community-based ecotourism.
- New Lengwe** (the Lengwe "Extension" in the Western par of LNP): the Project will support for the extension of the park management plan to cover New Lengwe, including the development of co-management arrangements with local communities – building on an existing platform of Community-based Organizations around the Park, support for measures to reduce Human Wildlife Conflicts, development of access routes and support for day-to-day Park management, including survey, monitoring and patrolling activities. Support will also be provided to prepare a feasibility for a possible landscape corridor that could protect ecological linkages between New Lengwe and Majete Wildlife Reserve, perhaps through the introduction of a community conservancy-based approach.
- Majete Wildlife Reserve:** The Project will provide additional support to expand and consolidate existing community livelihood initiatives from African Parks as well as for investments in Park management – for example, maintenance and management of parts of the perimeter fence by local to prevent and reduce Human Wildlife Conflicts within the surrounding communities.

Figure 6 Areas concerned by the Natural Resources Management component



Layout Plan of SVIP



5. IMPACT ASSESSMENT METHOD

The ESIA relies on the following method for impact assessment.

Cumulative and induce impacts are dealt with directly in the text (and not in a separate section). This eases understanding of issues at stake especially those related to flow reduction.

5.1 METHOD FOR THE DETERMINATION OF IMPACT SIGNIFICANCE

Impacts significance is assessed using a standardized method based on the integration of 4 criteria:

1. Affected components' value
2. Impact intensity
3. Impact extent
4. Impact duration

In addition, in order to separate risks from actual impacts, the probability of impact occurrence is assessed in all cases

CRITERIA #1 ENVIRONMENTAL AND SOCIAL COMPONENTS VALUE

Each component of the socioeconomic and biophysical environment is analysed according to its value in the study area. Value assessment is based on experts' knowledge on the component, field surveys, public consultations, discussions with NGOs, bibliographical sources, safeguards policies from the World Bank, etc. It is also a mean to put in writing stakeholders opinion about a component and to take them into account.

Value analysis does not take into account foreseen impacts, it is purely based on the component intrinsic value.

Three threshold levels are defined during the assignment: Low, Moderate and High values. A low value component does not represent an important socioeconomic or cultural feature for local communities or it does not have a high ecological value. A high value component is a significant feature for communities; it is either an important livelihood source or an element of cultural significance for communities. A high value component can also possess an important ecological value (rare plant, sensitive habitat, etc.). A high value component is also an element of particular significance for funding agencies (and presented in safeguard policies).

A moderate value is between low and high.

CRITERIA #2 IMPACT INTENSITY

Impact intensity refers to level of disruption on the component. Disruption of natural component refers to death of species, displacement, fragmentation and loss of habitats. Disruption of socioeconomic components refer to loss of income, erosion of traditional ways of life, etc. The resilience of each component to changes is also taken into account.

Three threshold levels of intensities are defined: Low, Medium and High.

A low intensity refers to an impact that will not disturb significantly livelihood and ecological elements and that will not affect the function of the component or its characteristics. High intensity refers to an impact that takes place during a critical phase of biophysical components (breeding period, migration, spawning, etc.) or socioeconomic components (harvest, etc.). It is an impact that affects a component beyond its resilience.

A medium intensity is between low and high.

CRITERIA #3 IMPACT EXTENT

Each impact is defined by its geographical extent. Three levels are established: punctual impact, local impact and regional impact.

Punctual impacts affect a component on a very small scale of the study area, i.e. a small proportion of the study area population (people or wildlife).

Local impacts affect a component on the entire or the majority of the detailed study area in opposition to regional impacts that affect a component on a larger scale and outside the detailed study area boundaries (see delineation of study areas in the Vol. 1 Baseline report).

CRITERIA #4 IMPACT DURATION

Each impact is described according to its duration. Temporary and permanent impacts are distinguished based on their reversibility: temporary are reversible and permanent are irreversible (or last throughout the Project lifespan).

IMPACT SIGNIFICANCE DETERMINATION

Impact significance is based on the four previous criteria. The following table presents the impact importance determination. Positive impact is assessed using the same four criteria.

Intensity	Extent	Duration	Environmental and Social Component value					
			Positive impact			Negative impact		
			Low	Moderate	High	Low	Moderate	High
High	Regional	Permanent	High	High	High	Low	Moderate	High
		Temporary	High	High	High	Low	Moderate	High
	Local	Permanent	High	High	High	Low	Moderate	High
		Temporary	High	High	High	Low	Moderate	High
	Punctual	Permanent	High	High	High	Low	Moderate	High
		Temporary	High	High	High	Low	Moderate	High
Medium	Regional	Permanent	High	High	High	Low	Moderate	High
		Temporary	High	High	High	Low	Moderate	High
	Local	Permanent	High	High	High	Low	Moderate	High
		Temporary	High	High	High	Low	Moderate	High
	Punctual	Permanent	High	High	High	Low	Moderate	High
		Temporary	High	High	High	Low	Moderate	High
Low	Regional	Permanent	High	High	High	Low	Moderate	High
		Temporary	High	High	High	Low	Moderate	High
	Local	Permanent	High	High	High	Low	Moderate	High
		Temporary	High	High	High	Low	Moderate	High
	Punctual	Permanent	High	High	High	Low	Moderate	High
		Temporary	High	High	High	Low	Moderate	High
Impact significance	Major -	Major +						
	Moderate -	Moderate +						
	Minor -	Minor +						
	Negligible	Negligible						

Major impacts represent high level of perturbation of the component, these impacts are seldom mitigable and most of the times require compensation or Offsets, followed by measurable monitoring measures.

Moderate impacts represent noticeable perturbation of the component, however these impacts can be mitigated and need to be monitored.

Minor impacts, most of the time, only require mitigation measures without the need for monitoring.

Negligible impacts do not require any particular measures.

IMPACT OCCURRENCE PROBABILITY

Assessment of the probability that an impact will take place is based on consultant experience on similar assignments and each expert knowledge. It allows to develop preventive measures for risks and mitigation measures for impacts. Three thresholds are used.

High probability	Analysis of the baseline coupled with Project characteristics concludes that the impact will take place.
Potential occurrence	Based on previous experiences, it is possible that the impact will occur.
Risk (low probability)	Analysis of baseline coupled with Project characteristics only reveals a risk of impact occurrence.

5.2 DESCRIPTION OF IMPACTING ACTIVITIES

The current FS report does not provide much information about the construction of the Project. The following description of impacting activities are based on consultant experience in irrigation schemes and literature review. Quantity of required material, localization of borrow pits and other figures are therefore not provided in this ESIA.

5.2.1 Pre-construction

Pre-construction phase: this phase included all technical studies (including the ESIA and the design) as well as the tender process for the selection of a construction contractor and scheme operator. Decisions that will be taken at this stage are important milestones that could influence the environmental and social soundness of the Project.

Before construction, the command area and right-of-ways have to be planned and the study area will be subject to important changes in term of land ownership. Resettlement is an important impact-generating activity for which Resettlement Action Plans (RAP) shall be written.

5.2.2 Construction

Construction phase: is the construction of the water intake in the reservoir and the Feeder canal, Supini and Bangula canals and Branch canals as well as all other infrastructures.

Water intake, canals and command area construction will require major workforce and machinery deployment, waterworks, earthworks and land leveling, rock blasting, vegetation removal, concrete production and quarrying for material. These are impacting-generating activities.

Rock blasting will be carried out in MWR due to the presence of rock outcrops (granite).

5.2.3 Operation

Operation phase: is the operation of the irrigation scheme through the water intake (irrigation of the command area in the valley)

Operation of the scheme will generate impacts and will require overpassing many challenges. Most impacts during operation will come from the flow reduction in the Shire (due to water abstraction), the presence of a long open canal, and the challenges that people will face due to radical changes in their livelihood strategies. However, the purpose of the Project is to bring positive economic benefits.

Phase I will be separated from Phase II as the former will only be built when Phase I is operational.

5.2.4 Impact assessment of the Natural Resources Management (NRM) component

Activities planned under this component will have minimal or no negative environmental impacts, in fact most activities aim at conservation activities or sustainable use of natural resources. In some cases, minor works under this Project component will have to follow the mitigation measures presented in the ESMP (Vol. 3) aiming at the construction contractor such as proper delineation of work and best management practices regarding health and safety, waterworks, earthworks, etc. Social impacts involving local livelihoods will be addressed in the forthcoming Process Framework, a separate safeguards report.

5.3 IMPACT ASSESSMENT LIMITATION

At time of writing of Impact Assessment, some information was not available or not sufficiently detailed in the FS various reports. Additional impacts may be discovered once the Design Study is available. Whenever there is a risk of new impacts, this Impact assessment report has highlighted it. However, in such cases, mitigations can only be presented by their overall principle and goals but their implementation would still need to be detailed at some points.

In addition, this ESIA proposes measures that have never been tested in Africa such as large wildlife overpasses or fish barriers. Most proposed infrastructures to mitigate impact are based on return of experiences from other continents. Regarding the fish barrier, the World Bank will contract a Panel of Experts to review in depth the design and specific location of this fish barrier to ensure that it would function effectively, with little or no required maintenance over the long term. This expert review will be conducted in parallel with the final design of the Main Canal, and well before the start of canal construction.

Lastly, many studies of Elephant marsh (under the SRBMP) are dealing with Elephant Marsh future management: the Ramsar application study, the Management Plan for Elephant marsh, the Hydromorphology study, the Ecosystem services study and the Livelihoods study. Therefore, the ESIA is not making any statement about future management of Elephant marsh.

6. PHYSICAL ENVIRONMENT IMPACT ASSESSMENT

6.1 INTRODUCTION

The impact assessment starts with the Physical environment, as most impacts derive from changes to physical components: water, soil, flow, etc.

LIMITATIONS

One important limitation that needs to be addressed by the FS consultant is the precise localization of unsuitable areas for irrigation due to soil properties (mainly the heavy Vertisols). Since, in these areas, grazing sites could be developed for livestock. The ESIA has localized some heavy Vertisols based on field work of the ESIA Soil Specialist and based on photointerpretation.

6.2 IMPACT IDENTIFICATION MATRIX ON THE PHYSICAL ENVIRONMENT

An impact identification matrix crosses components with phases of the Project to highlight impacts.

Components	Pre-construction	Construction	Operation
Geomorphology of rivers	No impact during pre-construction phase	<p>Impacts from water works: canals and water intake construction will necessitate crossing rivers and will involve water works such as building small dams and weirs, culverts, siphons and installing gabions to stabilize rivers. These will affect the geomorphology and water quality of rivers</p>	<p>Siltation of Elephant marsh: waterbodies, including Elephant marsh, erosion and sedimentation pattern will be modified because of changes to flow</p> <p>Reservoir sedimentation pattern: the water intake will impact reservoir sedimentation pattern</p>
Hydrology			<p>Water abstraction : Up to 50m³/s will be extracted from the Shire system at Kapichira reservoir</p> <p>Hydraulic transparency: where a canal crosses a river, if culverts are not adequately designed and installed they can act as dam and flood villages upstream. Flash flood phenomenon can damage hydraulics infrastructure</p>

Components	Pre-construction	Construction	Operation
Water quality		Impacts from water works: canals and water intake construction will necessitate crossing rivers and will involve water works such as building small dams and weirs, culverts, siphons and installing gabions to stabilize rivers. These will affect the geomorphology and water quality of rivers	Water quality impairment : the scheme will impair water quality (including groundwater)
Soil and groundwater		Impacts from earthwork and land leveling : canal construction will necessitate important excavation of earth and rocks and the command area will be levelled	Changes in soil properties and rising water table: irrigated agriculture can lead to several changes in soil properties (salinization, soil sodicity, waterlogging, etc.). Irrigation can rise water table (leading to salinization and waterlogged soil)

6.3 AFFECTED COMPONENT VALUE

The following table shows the value of components.

Component	Component value
Geomorphology of rivers	River geomorphology is a moderately valued component. Most rivers geomorphology are subject to important natural changes due to flash floods and erosion. Siltation of the reservoir is however an important issue
Hydrology	River hydrology is a highly valued component. Communities are directly dependent on river flow and, based on historical records, any change in the past has led to significant economic and social changes
Water quality	Water quality is a moderately valued component as there is not much attention provided to water quality in the study area although it is an important element for aquatic life
Soil & Groundwater	Soil is a highly valued component in the study area as people depend directly on its properties for agriculture

6.4 GEOMORPHOLOGY OF RIVERS

6.4.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction of the scheme, canal and water intake construction will necessitate crossing rivers and will involve water works such as building small dams and weirs, culverts, siphons and installing gabions to stabilize rivers. These will affect the geomorphology, hydrology and water quality of rivers (**Impacts from water work**). As observed during the baseline mission and confirmed by satellite imagery analysis, tributary riverbeds are very mobile: river beds can move of several tens of meters after severe floods.
- During operation of the scheme, waterbodies, including Elephant marsh, erosion and sedimentation pattern will be modified (**Siltation of Elephant marsh**). Flow reduction will affect the marsh capacity to transport fine sediment that will settle in the marsh. There is a possible shrinkage (blockage) of some of Shire River channel in the marsh. Siltation of the marsh, which is already taking place due to erosion of surrounding hills and intense agricultural activity, is therefore expected to worsen. In addition, drainage of irrigated field will bring additional loads of sediment (see impact on water quality next section). Siltation tends to have negative impacts on aquatic life (smother insect larvae and fish eggs) and may create levees and plugs affecting the marsh outlets.
- During operation of the scheme, the water intake will change sedimentation pattern in the reservoir (**Reservoir sedimentation pattern**). This change could lead to impact on Escom powerstation water intake.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impacts from water work. During construction, some actions and infrastructures will modify geomorphology of rivers	Siltation of Elephant marsh. During operation of the scheme, erosion and sedimentation pattern will be modified	Reservoir sedimentation pattern. The water intake will change sediment deposition pattern in the reservoir
Value of the affected component	Moderately valued		
Intensity	Low	Low	This impact is the subject of an independent study for the SVIP "Hydraulic Modeling of Intake for the SVIP (Artelia)". Impact assessment and mitigation will be dealt with in this report.
Extent	Punctual	Local	
Duration	Temporary	Permanent	
Significance	Negligible	Minor	
Occurrence probability	Potential occurrence (as the type of water works in tributary rivers are not known)	High probability	

6.4.2 Mitigation measures

Impacts from water work

The following mitigations are recommended to limit impact on geomorphology of river:

- Any work across a river will have to take its mobility into account to avoid having rivers shifting and no longer flowing through canals. Therefore, design of the river passages shall involve installing gabions or riprap on riverbanks. In addition, it is recommended not to cross a tributary river in a meander but rather where the river is flowing in a straight line.
- When finetuning the command area in the Design phase, it is recommended to avoid developing irrigated fields too close to any river and to take into account river mobility. It is proposed to avoid all areas that are in the 1 in 10 year floods of rivers and to stabilize sharp meanders with gabions and riprap. These important aspects shall be taken into account in the Design study to safeguard rivers from being channelized and crops from floods.

Siltation of Elephant marsh

Two important mitigation measures could be implemented to reduce the impact on Elephant marsh. However, both actions would necessitate involving other capacities and actors than those related to SVIP:

- One is related to the Lower Shire River watershed management or the forestry department, by limiting erosion and clear cutting of forests in the surrounding mountains, siltation will be reduced.
- In addition, the existing Kamuzu barrage could release more water, thus mitigating the impact. Kamuzu barrage regulates Lake Malawi water level and its outlet on the Shire river, it is located in Liwonde. The feasibility of releasing more water from Kamuzu barrage is discussed in the hydrology section.

Although average flows will be reduced, there will still be periods of high flow during the rainy season.

Other mitigations are related to best management practices in the command area such as good maintenance of drains, proper stabilization of dikes and banks, etc. Some of these will be the responsibility of the scheme operator. It is also expected that the SRBMP will define and implement appropriate conservation measures that will also control soil erosion in the upper and middle catchment area (hills and pediments), in particular along drainage lines and other watercourses, in order to protect the lower lying Project area from flooding and water logging.

Reservoir sediment pattern

The Hydraulic Modeling of Intake for the SVIP will, once finalized, provide with mitigation measures.

6.5 HYDROLOGY

The flow data presented in this report are based on Chickawawa gauging station only and the data from gauging station in Liwonde were not used.

6.5.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During operation of SVIP, canal capacity will be 50m³/s, and this amount will be extracted from the Shire system at Kapichira reservoir (**Water abstraction**). This is a consumptive demand as this amount will not be released directly back in the system (about half will be released back to drains and to the water table). This will lead to environmental impacts (on Elephant marsh) and social impacts (on tourism at Kapichira) and :
 - although the proposed SVIP represents a significant new consumptive demand in the Shire River, the Escom Hydropower Station has a much larger non-consumptive water demands which are likely to take precedence over irrigation requirements at times of low flows. This means that, at times of low flows, irrigation demands from the SVIP would not be exercised and flows would be maintained for power generation demands.
 - the high demand for the Kapichira Hydropower Stations also gives to rise to issues regarding sharing of water.
 - the impact of water abstraction is a transboundary impact since part of the amount that will be withdrawn from the Shire will be lost to Mozambique.
 - The presence of a water intake conveying water from the reservoir close to villages will likely create, on the long-term, new expectations and new water demands from people, industries, etc. For example, Chikwawa will receive 1,240 m³ daily through a pipeline for drinking water. Therefore, discussions on water allocation and water rights could become more significant although the maximum capacity is set at 50 m³/s and this will not increase over time. Based on our social surveys carried out at baseline, there was a general feeling from communities in Paramount Lundu and TA Maseya that conflicts would arise on water distribution and allocation between private companies such as Illovo and the communities. The village headmen indicated that they fear that private companies would monopolize water use on the expense of local communities.

Hydrology impact assessment can be divided in three:

- Hydrological negative changes downstream of Escom Powerstation tailrace, which will lead to impacts on Elephant marsh;
- Hydrological positive changes due to the significant reduction of the use of existing pumping stations along Elephant marsh. This will partially counter balance the flow reduction in the marsh;
- Hydrological negative changes below the dam and upstream of the hydropower tailrace, which will lead to impacts on tourism in Majete Wildlife reserve (falls at Kapichira).

Impacts from water abstraction on tourism and the Elephant marsh are dealt with in separate sections (sections 7.10.1.6 Impact on Kapichira falls attractiveness and 8.6. Changes in plant composition in Elephant marsh).

The following figure illustrates these three types of impacts.

Figure 7 Hydrological impacts



Impact downstream of Escom tailrace

- The water demands for the SVIP and for the Escom power generation (Kapichira I installed capacity: 64.8 MW and Kapichira II, 64.8 MW) are presented in the table below (source: KRC, 2016). The flow reduction downstream the hydropower tailrace is presented (in percentage). With the Project, flow reduction will represent up to 9.4% downstream of the tailrace during normal year and up to 12.4% during the dry years (consumptive demand) (Source data & results: MoAWI Chickwawa Gauging station (1L12), 2017). Kapichira I and II although they borrow large amount of water, are not affecting Elephant Marsh since the hydropower scheme is a run-of-river scheme where all turbinated water is released downstream of the tailrace (non-consumptive demand). Figures show the “without Illovo scenario” since at time of ESIA writing, it was not certain whether Illovo would join or not the SVIP.

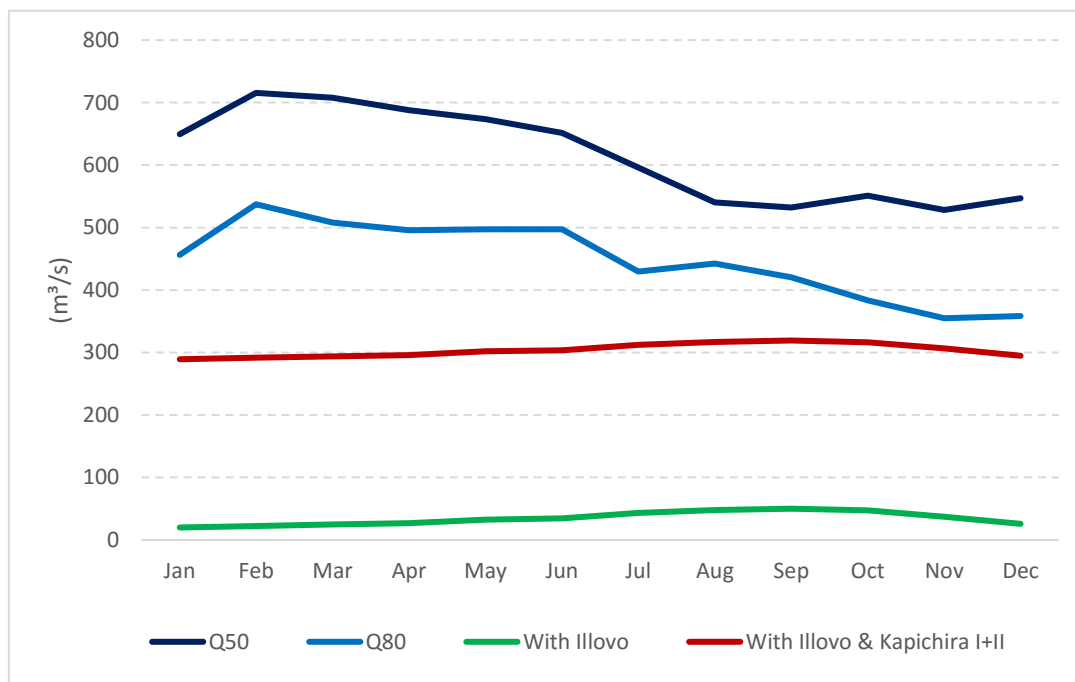
Table 4 Water Demands for SVIP and Escom at Kapichira Dam

(m ³ /s)	SVIP	% of average flow (Median year)*	% of average flow (dry year)	Escom Kapichira I+II
Jan	20.0	3.1	4.4	269.2
Feb	22.3	3.1	4.2	269.2
Mar	24.8	3.5	4.9	269.2
Apr	26.8	3.9	5.4	269.2
May	32.7	4.8	6.6	269.2
Jun	34.5	5.3	6.9	269.2
Jul	43.1	7.2	10.0	269.2
Aug	47.8	8.8	10.8	269.2
Sep	50.0	9.4	11.9	269.2
Oct	47.4	8.6	12.4	269.2
Nov	37.2	7.0	10.5	269.2
Dec	25.6	4.7	7.2	269.2

Source data & results: MoAWI Chickwawa Gauging station (1L12), 2017

- The Figure below presents the availability of water by showing the 50% (Median Q50) and 80% (Quinquennial dry year Q80%) dependable monthly flows as well as the water requirement for SVIP without or with Illovo and with Kapichira I and II.

Figure 8 Water availability and demand at Kapichira Dam (using same hydrological data from DWR used in TFS)



Source data & results: MoAWI Chickwawa Gauging station (1L12), 2017

The previous graph shows that:

- The water supply exceeds largely the irrigation requirement for SVIP without or with Illovo when taken alone.

In addition to prevision on impact, the risk of having illegal motor pumps along the stretch of the feeder canal will create additional small consumptive demands and could affect tail enders. Illegal water connection by communities has to be given consideration, as it has been known to lead to closure of canals as shown by this example from Namibia.

Namibia Water Corporation (NamWater)...came under scathing criticism earlier this week from traditional leaders and farmers in Omusati, angered by the water utility's plan to close the Calueque-Oshakati canal. ... the proposed closure of the canal was necessitated by the high costs that come with the maintenance of the water canal, illegal water connections by community members and the apparently loss of human lives due to drowning in the canal (New Era newspaper, 2015)

Partial closure of existing pumping stations along Elephant marsh

The FS report mentions that existing pumping station could be operated when drought is expected (around once every 5 years). Occasional use of the existing pumping stations (by opposition to constant use) will reduce the effect of hydrological impact on Elephant marsh since water that will be brought by irrigation will no longer be pumped. Most stations utilization, except for Kaombe, could be reduced significantly during Phase I (sugar cane fields irrigated by Kaombe pumping station are concerned by Phase II). According to the FS report, the total amount of water pumped per average year is 9 m³/s. During the wettest months, pumps are taking 6m³/s and during the driest months, pumps are taking 13 m³/s.

The "positive" impact from partial closure of pumps is small but noticeable. It represents 30% to 25% of the flow in comparison to the 20.5 to 51.3 m³/s that will be withdrawn from the Shire system.

Impact below the dam and upstream of the hydropower tailrace: impact on Kapichira falls

This area is the most severely impacted area.

The following tables show different situations with the number of months when the flow at Kapichira falls (below the dam and upstream of the hydropower tailrace) is and will be inferior to 50, 40, 30, 20 and 10 m³/s with actual management of Kamuzu barrage (Liwonde barrage), these figures are based on 2013, 2014 and 2015 data. These figures take into account the variability of needs for SVIP based on season (dry versus rainy). It is clear from these figures that the factor influencing the most the fate of the falls is Kapichira I+II. Therefore, not only the impact is significant but the cumulative impact will even be more severe.

Table 5 Number of months when the flow is (will be) lower than 50m³/s

Nb Months	Kapichira I+II (current situation)	Kapichira I+II & SVIP without Illovo	Kapichira I+II & SVIP with Illovo
2013	0.4	8.8	9.2
2014	0.2	10.8	10.9
2015	5.3	10.3	10.4
<u>Mean</u>	<u>2.0</u>	<u>10.0</u>	<u>10.2</u>
<u>Min</u>	<u>0.2</u>	<u>8.8</u>	<u>9.2</u>
<u>Max</u>	<u>5.3</u>	<u>10.8</u>	<u>10.9</u>

Table 6 Number of months when the flow is (will be) lower than 40m³/s

Nb Months	Kapichira I+II (current situation)	Kapichira I+II & SVIP without Illovo	Kapichira I+II & SVIP with Illovo
2013	0.4	8.4	8.8
2014	0.0	10.6	10.7
2015	3.8	10.3	10.3
<u>Mean</u>	<u>1.4</u>	<u>9.8</u>	<u>9.9</u>
<u>Min</u>	<u>0.0</u>	<u>8.4</u>	<u>8.8</u>
<u>Max</u>	<u>3.8</u>	<u>10.6</u>	<u>10.7</u>

Table 7 Number of months when the flow is (will be) lower than 30m³/s

Nb Months	Kapichira I+II (current situation)	Kapichira I+II & SVIP without Illovo	Kapichira I+II & SVIP with Illovo
2013	0.4	7.5	8.2
2014	0.0	10.2	10.4
2015	2.8	10.2	10.3
<u>Mean</u>	<u>1.1</u>	<u>9.3</u>	<u>9.6</u>
<u>Min</u>	<u>0.0</u>	<u>7.5</u>	<u>8.2</u>
<u>Max</u>	<u>2.8</u>	<u>10.2</u>	<u>10.4</u>

Table 8 Number of months when the flow is (will be) lower than 20m³/s

Nb Months	Kapichira I+II (current situation)	Kapichira I+II & SVIP without Illovo	Kapichira I+II & SVIP with Illovo
2013	0.4	6.5	7.6
2014	0.0	9.8	9.9
2015	2.4	10.1	10.2
<u>Mean</u>	<u>0.9</u>	<u>8.8</u>	<u>9.2</u>
<u>Min</u>	<u>0.0</u>	<u>6.5</u>	<u>7.6</u>
<u>Max</u>	<u>2.4</u>	<u>10.1</u>	<u>10.2</u>

Table 9 Number of months when the flow is (will be) lower than 10m³/s

Nb Months	Kapichira I+II (current situation)	Kapichira I+II & SVIP without Illovo	Kapichira I+II & SVIP with Illovo
2013	0.4	5.8	6.6
2014	0.0	9.2	9.5
2015	1.5	10.0	10.1
<u>Mean</u>	<u>0.6</u>	<u>8.4</u>	<u>8.7</u>
<u>Min</u>	<u>0.0</u>	<u>5.8</u>	<u>6.6</u>
<u>Max</u>	<u>1.5</u>	<u>10.0</u>	<u>10.1</u>

- During operation of the scheme, where canals or new farm roads cross a river, if ever culverts are not adequately designed, they can act as dam and flood villages upstream. Careful design of canals also has to take into account flash flood phenomenon that can damage the hydraulic infrastructures (**Hydraulic transparency**). All tributary rivers are reactive and have small watershed (except Mwanza and Ruo) originating in hilly areas, flowing through the plain and then to the Elephant Marsh where Shire flows. Flash floods in these rivers lead to sudden increase of water level, with high bedload transport capacity, especially right bank rivers where topography is more pronounced. When these rivers reach the plain, their currents become weaker and sediment deposit are finer, ultimately silt plumes reach the Elephant Marsh. Erosion on hill slopes increases the phenomenon. In the plain, these tributary rivers can easily flood villages due to diffuse river beds. In addition, tributary river beds are mobile, within a few years, river bed can move of several tens of meters.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Water abstraction. Up to 50m ³ /s will be extracted from the Shire system	Hydraulic transparency. When crossing the canal tributary rivers can flood upstream village if culverts are not properly sized
Value of the affected component	Highly valued	
Intensity	Medium	Low
Extent	Regional	Punctual
Duration	Permanent	Temporary
Significance	Major (and cumulative)	Minor
Occurrence probability	High probability	Potential occurrence

6.5.2 Mitigation measures

Water abstraction

The main feasible action to mitigate impact from reduced flow would be to release more from Kamuzu barrage. Kamuzu Barrage could increase dry season flows enough to partially offset the SVIP irrigation abstraction, although this cannot be guaranteed at this time, it will depend upon Lake Malawi water levels (which naturally fluctuate over time) and upon the Kamuzu Barrage operating rules (which will be developed and refined in due course by Malawi's recently-established Shire River Basin Authority).

Therefore, at present, there is no possible management adaptation of Kamuzu barrage that could compensate for flow reduction.

Other mitigation measures are proposed in the FS, they related to water use efficiency (adjustment of farming program, adjustment of cropping pattern, etc.). Until Phase II is constructed, there is time for a gradual improvement of water use efficiency in the scheme. This ESIA does not re-discusses these efficiency measures.

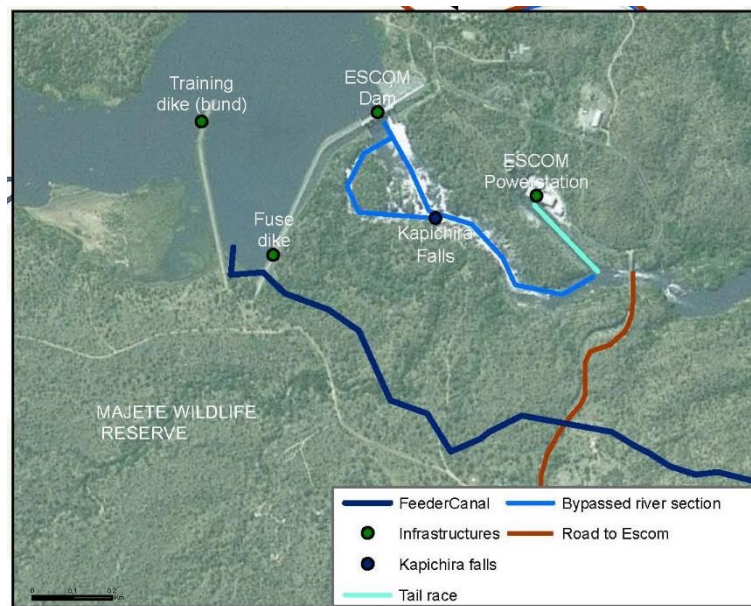
One potential impact needs to be highlighted, it is the risk of having illegal pumping taking place along the western part of the canal where no field will be irrigated. Illegal pumping using motor pumps needs to be addressed by the scheme operator, integrated in a bylaw and enforced by authorities in order to ensure that it does not take place. Illegal pumping will affect downstream water users.

Regarding the environmental flow, it has been reported that there is currently no formal requirement for discharge of environmental flow at the sluice gate of the Escom dam on the Shire River (ATKINS, 2011 and NORPLAN, 2013) (the current environmental flow is controlled by Escom by opening sluice gates). The actual environmental flow is usually around 30m³/s but in case of draught such as the 2016 drought, there is no environmental flow at the falls.

There are two elements to consider:

- The by passed river section at the dam toe is 900 m long, after 900 m, the tailrace from the hydropower station releases all flow without much differences from the natural flow of Shire since Kapichira hydropower is a run-of-river hydropower (what comes in goes out quickly). It is in this by-passed section that tourists from Majete Wildlife Reserve come and enjoy the view of falls, since currently, an environmental flow is release from two sluice gate (see current situation in previous tables).

Figure 9 Bypassed river section



- The project will withdraw from the system up to 50m³/s and there are no possible compensation or mitigation.

The question of environmental flow is presented in a separate section (7.10.1.6 Impact on Kapichira falls attractiveness).

Regarding transboundary impact, Shire River is part of the Zambezi commission and the commission have been contacted through a Riparian Notification Letter to the governments of all the other Zambezi River Basin countries (Mozambique, Tanzania, Angola, Botswana, Namibia, Zambia, and Zimbabwe).

Hydraulic transparency

The estimates of the frequency peak flows for the sub-basins of right-bank tributaries intersecting the SVIP canals are given in the table below (calculations based on the flood frequency relationship established by Mkhanda & Kachroo, 1998). Based on these data, culverts and under passages have to be carefully designed and super sized to allow dry passage of wildlife, the Q100 shall be taken into account to size box culverts and culverts. Another rationale to make large culverts is that larger culverts are less likely to result in flooding of the main irrigation canals; such flooding can lead to the entry of Lower Shire/Zambezi fish species into the canal system, posing an invasive species risk for Lake Malawi. In addition, tributaries that are crossed by the primary canal have to be stabilized with gabion or rip rap and the primary canal shall always cross a river perpendicularly and in a place where the river is flowing in a straight line (to reduce the impact of river mobility). The Design study shall take this measure into account.

Figure 10 Peak flow of right bank Shire tributaries

Tributary rivers name	Catchment Area at SVIP Canal (km ²)	Peak Flow (m ³ /s)				
		Q2	Q10	Q20	Q50	Q100
Mwambezi	160	41	111	138	171	195
Masakale	102	34	91	113	140	160
Nthumba	70	29	77	96	119	136
Mwanza	1621	112	304	377	467	535

Tributary rivers name	Catchment Area at SVIP Canal (km ²)	Peak Flow (m ³ /s)				
		Q2	Q10	Q20	Q50	Q100
Nkombedzi Wa Fodya	418	62	168	209	259	297
Namitalala	65	28	75	93	116	132
Phwadzi	219	47	127	158	196	224
Namikalango	140	39	105	130	161	184
Nyakamba	78	30	81	101	125	143
Mikombo	47	24	65	81	100	114
Mafume	61	27	73	90	112	128
Lalanje	77	30	81	100	124	142

6.6 WATER QUALITY

6.6.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction of the scheme, canal and water intake construction will necessitate crossing rivers and will involve water works such as building small dams and weirs, culverts, siphons and installing gabions to stabilize rivers. These will affect the geomorphology and water quality of rivers (**Impacts from water works**). In addition, concrete wash water can seriously pollute water by increasing its pH. Water works could increase turbidity, especially during construction of the water intake in the reservoir. There is a risk of oil spill from refueling of machinery and storage of fuel barrel. The following picture shows an example of inadequate oil storage taking place when machinery is working in river.

Figure 11 Poor oil management



Source: BRLi, 2015

- During operation of the scheme, drainage from irrigated fields will impair water quality (including groundwater) (**Water quality impairment**). Drainage will transport pesticides, fertilizers and silt. The chain of consequences will be long, as these pollutants will impact aquatic life in many ways:
 - Pesticides are known to induce mutation in herpetofauna and fish species and affect the food chain up to piscivorous birds and fishes;
 - Fertilizers are known to induce eutrophication and changes in plant communities especially when flow is low. This could worsen invasive plant colonization of Elephant marsh;

- Silt are known to transport pollutants (as they cling on silt) and to impact fish by smothering eggs and affecting gills of many species (impacts on fish are discussed in a separate section).

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impacts from water works. Construction activities will bring silt and other pollutants to rivers	Water quality impairment. Drainage in watercourses will impair water quality
Value of the affected component	Moderately valued	
Intensity	Low	Medium
Extent	Punctual	Local
Duration	Temporary	Permanent
Significance	Negligible	Moderate
Occurrence probability	Potential occurrence (as the type of water works in tributary rivers are not known)	High probability

6.6.2 Mitigation measures

IMPACTS FROM WATER WORKS

Several mitigations are possible to limit impact from water works on water quality, they apply to the construction contractor:

- Work close to tributary rivers shall be carried out during the dry season when rivers are dry
- Best management practices shall be implemented for water work, such as :
 - Mandatory use of silt floating fences in the reservoir when building the water intake;
 - Mandatory use of silt fences when working close to rivers;
 - Refueling activities away from any waterbody (at least 100 m);
 - No evacuation of concrete wash water in waterbodies;
 - Emergency spills containment kit in all vehicles and machinery.
- Request in tender documents that companies develop a method for environmentally friendly water work (reservoir and river) and spill containment. Selection criteria shall include a scoring system for the water work method.

WATER QUALITY IMPAIRMENT

Several mitigations are possible to limit impact from drainage:

- Since the command area will remain at a certain distance from the marsh (to avoid floods), several settling pond could be designed to allow silt and attached pollutants to settle in ponds rather than reaching the marsh. However, this would also reduce the amount of water that returns back to the marsh and these ponds would be washed away during floods. This mitigation is therefore not recommended.
- The Integrated Pest Management Plan has developed measures to ensure that only authorized pesticides are used.
- Measures presented in section 6.4. to limit erosion will also bring benefits to water quality.

6.7 SOIL & GROUNDWATER

6.7.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction of the scheme, canal construction will necessitate important excavation of earth and the command area will be levelled (**Impacts from earthwork and land leveling**). Based on the current feasibility study (KRC, 2016), earth work for the canal is as follow (for an lined canal, estimated based on information provided from the Feasibility study):
 - Feeder canal excavation for the canal bed: +/- 1 Mm³
 - Feedar canal backfilling for embankment: +/- 1 Mm³
 - Supini canal excavation for the canal bed: +/- 0.2 Mm³
 - Supini canal backfilling for embankment: +/- 0.2 Mm³
 - Bangula canal excavation for the canal bed: +/- 0.8 Mm³
 - Bangula canal backfilling for embankment: +/- 0.8 Mm³
- Excavated material may not always be suitable for backfilling material, therefore there will be needs for space to deposit spoil material and to exploit borrow pits. Opening of borrow pits and quarry will lead to numerous risks on safety of local population (see section 7.7) and possibly on habitats (see section 8.5).
- Irrigated agriculture can lead to several changes in soil properties. Salinization, soil sodicity, waterlogging, loss of soil are common risk under gravity irrigation (**Changes in soil properties and rising water table**). In addition, there is a risk associated with the presence of poorly drained Vertisols in Zone B and C (heavy Vertisols).
 - Salinisation and Alkalinisation: soils with a high risk of further salinisation or alkalinisation need special attention. However, available analytical data sets indicate that such areas are limited in size and can be sustainably managed with good management. Salinity levels in the project area are generally low and if levels should go up, soils can be easily flushed with excess drainage water. Alkalinity is in fact a more serious problem but occurrence of alkalinity at any serious scale is not indicated by available analytical data. Impact of the Project on soil salinisation is not expected as the Project is supposed to ensure good management levels.
 - Soil erosion: with respect to a possible increase of erosion in irrigated land, the Project is not expected to cause an increase of runoff, flooding and erosion as most land is currently already under cultivation, in a rather flat area and because it is anticipated that Project infrastructure and conservation measures will further control erosion. The great majority of land included in the Project is already used as rainfed arable land and this land will only change to another agricultural use, namely irrigated land. In fact, the project will improve the quality of land wherever possible in order to construct economically sized land parcels.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impacts from earthwork and land leveling. Construction of the canal system will lead to important earth movement	Changes in soil properties and rising water table. Several changes in soil properties could take place in the command area
Value of the affected component	Highly valued	
Intensity	High	Medium
Extent	Local	Punctual
Duration	Temporary	Permanent
Significance	Moderate	Minor
Occurrence probability	High probability	Risk (low probability)

6.7.2 Mitigation measures

IMPACTS FROM EARTHWORK AND LAND LEVELING

Several measures can be implemented during construction, they apply to the construction contractor:

- Some spoils from excavation could be used as soils for agriculture, soils could be given back to communities to level land or spread in the command area. Soil cannot be sold by the contractor to surrounding communities;
- No spoils can be stored even temporarily close to waterbodies including Elephant marsh or parks;
- Unusable spoils shall not be left in mounds but shall be flattened at the end of construction and revegetated;
- Borrow pits shall have gentle slopes to minimize the risk of injuries and death;
- Borrow pits and quarries location shall be done in consultation of local authorities to minimize impacts on land users;
- Borrow pits and quarries shall not be left unrestored at the end of work (unless requested by local authorities) and shall be filled with unusable soil to reduce their depth or shall be transformed into wetlands or livestock drinking ponds where appropriate;

Figure 12 Borrow pit with dangerous steep slopes (left) and typical impact from blasting (right)



Source: BRLi, 2015

Suitable borrow pits to be transformed into wetlands are those that are impermeable and filled with water even during the dry season. The following pictures shows a borrow pit where slopes could be transformed and native plant could be planted. Ideally, the wetland creates different habitats with different depth of water and limits the access to cattle.

Figure 13 Suitable borrow pit for the creation of a wetland



Source: BRLi, 2017

CHANGES IN SOIL PROPERTIES

Monitoring of soil properties is highly recommended. Soil water levels and salinity will require very close monitoring to provide early warning of problems. It is recommended to follow typical parameters that help detect acidity or alkalinity of the soil such as pH, Cation exchange capacity (CEC), Magnesium (Mg²⁺), Calcium (Ca²⁺), Organic matter (OM), Organic carbon (OC) and Exchangeable Sodium Percentage (ESP).

Areas rated as non-suitable for irrigation within the Project area can be evaluated for other land uses, such as infrastructures but also for settlement, amenities, grazing, set aside conservation land and forestry. It is expected that, after the land evaluation exercise of the FS or the Design study, such unsuitable areas have been identified and mapped with a definition of their characteristics. Future uses should be determined in land use plans at design phase, in which community preferences, e.g. as for forestry and woodlots can be reflected.

The planning of multi-purpose areas has also to be incorporated in overall land use planning, both inside and outside the Project area. However, it is presently not yet possible to precisely map these areas since the FS has not identified non-suitable areas. This ESIA has identified some lands that could be designated as set aside lands. They are described in a section hereunder.

Encompassing land with serious limitations or risks, such as very poorly drained areas with severe risk of flooding, will also have certain limitations for other uses. Future use of such land will have to be carefully planned for. Sustainable land use planning may help to establish a balance between all intended land uses, including large-scale agro-industry, small-scale irrigation, settlement, forestry and nature conservation.

For poorly drained Vertisols, rice could be included as a crop, for which use the current Project areas of Zone B and C could even be slightly enlarged, extended down slope or sideways. The use of rice with associated irrigation infrastructure and constructions will also help to control current severe erosion by flooding (sheet and gully erosion).

7. IMPACT ON SOCIOECONOMIC, CULTURAL AND NATURAL HERITAGE

7.1 INTRODUCTION

This section focuses on two elements: cultural heritage and natural heritage impact and mitigation. Natural heritage refers to the two parks: Majete Wildlife Reserve (MWR) and Lengwe National Parks (LNP). Natural heritage impact assessment deals with every impacts on these parks that are not related to biodiversity such as impact on tourism, infrastructures and landscape. Impacts on biodiversity are studied in the last two chapters of this report. Other socioeconomic impacts are presented and assessed and some mitigations are provided. However, to avoid repetition with the Communications, Community Participation, Land Tenure and Resettlement Policy Framework study, many references are made to this study.

7.2 IMPACT IDENTIFICATION MATRIX ON SOCIOECONOMIC, CULTURAL AND NATURAL HERITAGE

Components	Pre-construction	Construction	Operation
Settlement, community organization and land tenure	<p>Village reorganization and resettlement: the project will lead to major changes in terms of land occupation and will necessitate physical and economic displacement</p>	<p>Workers influx: the project will require important workforce consisting of foreign workers. Land will also be required for machinery storage and workers camps. There is a risk that buildings and amenities do not respect quality standards</p>	<p>Rapid social changes: there is a risk that people do not change their lifestyle and develop skills rapidly enough to adapt to the new irrigated environment</p> <p>Hinterland effect: the development of irrigation may be associated with an increase in human activity and local economy, which may lead to additional pressure on resources (wood for charcoal, fish, etc.)</p>
Infrastructures		<p>Permanent loss of buildings and other infrastructures: canals could necessitate destroying buildings and other infrastructures</p> <p>Disruption of access : canals will cross roads, trails, path disrupting access for communities and cattle to grazing sites or to urban centers</p>	<p>Inadequate maintenance of canals and infrastructures: there is a risk that the irrigation system is not adequately and regularly maintained</p>

Components	Pre-construction	Construction	Operation
Economics		<p>Disturbance to existing agriculture: work will disturb cropping practices since some households will control physically different areas of land</p> <p>Job opportunities: work will require unskilled and skilled labour for construction</p>	<p>Potential delays in irrigated agriculture development: any delays in the project completion or skills acquisition could delay the benefits</p> <p>Over supply of crops: increase in production could reduce prices and affect rain fed producers</p> <p>Benefits of irrigated agriculture: the project overall goal is to benefit local communities</p> <p>Reduction of fisheries: with less water in Elephant marsh, fishery could be impacted</p> <p>Impacts on livestock rearing: the Project will require adaptation of this livelihood strategy</p>
Health and safety		<p>Construction risk and nuisances: communities and workers are at risk from important works along canals and quarries</p>	<p>Bilharzias: the Project will lead to an increase of bilharzia in the command area</p> <p>Drownings: the presence of primary canals may lead to drownings</p>
Gender aspect			<p>Increase workload for women: with increasing yield, the project may add to the workload of women</p>

Components	Pre-construction	Construction	Operation
			<p>Improved access to water: with the presence of canals, women will travel shorter distance to fetch for domestic water (<u>although canals are not intended to provide safe drinking water</u>)</p> <p>Risk of unfair distribution of benefits: access to financial services is a strong barrier to women and youth empowerment</p>
Vulnerable people			<p>Impacts on vulnerable people: landless people could be disadvantaged by the Project and land distribution</p>
Cultural heritage		<p>Loss of physical cultural heritage: the canal alignment route and borrow pits will affect some known and unknown cultural heritage sites (mainly pottery)</p>	
Natural heritage	<p>Decision on the type of canal and its alignment: decisions regarding the canal layout during the design stage will have long term impacts on parks</p>	<p>Impact on tourism: construction activities in MWR and LNP and close to Ng'ona lodge will have deleterious impacts on tourism</p>	<p>Loss of ownership of park management on the western side of LNP: with the canal severing the park in two and the weak presence of rangers in the western part of the park, management may lose "ownership" of the western part of the park</p>

Components	Pre-construction	Construction	Operation
	<p>Decision on the status of canals inside parks: the presence of canals inside parks will require a clear definition of their status</p> <p>Tender process and selection of a construction contractor: the tender process for the selection of the Project construction contractor represent a high risk for parks as it is a crucial step in the development of binding environmental measures</p>	<p>Impact on Majete buildings, roads and infrastructures : Malaria research camp, Heritage center, Entrance gate, Wildlife research camp, Community camp site, electric fences, access road to the park, access to Kapichira falls viewing site will all be disturbed by construction of the Feeder canal</p> <p>Impact on Lengwe roads and infrastructures: the fence and park roads will be impacted</p>	<p>Impact on Kapichira falls attractiveness : the viability of the falls as a sight to see for tourists may be compromised on long term with reduced flows</p> <p>The presence of canals inside parks will be long-term agent of changes: the presence of canals and other infrastructures inside parks will require additional efforts and inputs from park management in order to maintain parks' integrity. Canals may become agents of negative changes in parks as their management will have to deal with a new stakeholder (the scheme operator), whose decision and actions may negatively impact parks. In LNP, the maintenance road along the canal may be used by communities as "travel path" as it is the case with an existing road inside the park</p>

7.3 AFFECTED COMPONENT VALUE

Component	Component value
Settlement, community organization and land tenure	This component, as most socioeconomic components, is highly valued since it relates to important topics for communities, stakeholders and funding agencies
Infrastructures	Infrastructures are moderately valued components. Outside of the Kapichira dam, the study area does not have buildings nor any construction of high interest.
Economics	These components, as most socioeconomic components, are highly valued since they relate to important topics for communities, stakeholders and funding agencies
Gender aspect	
Vulnerable people	
Health and safety	
Cultural heritage	
Natural heritage	

7.4 SETTLEMENT, COMMUNITY ORGANIZATION AND LAND TENURE

Most impacts on these topics are addressed in the study called “Preparation and implementation of a Communications, Community Participation, Land Tenure and Resettlement Policy Framework (CCPLTRPF, COWI, 2016)” and its various components: Communication strategy, Gender and youth strategy study, Grievance redress mechanism, Resettlement Policy Framework, Stakeholders’ views report.

This ESIA does not repeat the impact assessment and the proposed mitigation on gender and vulnerable people, land tenure and resettlement carried out by COWI.

7.4.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During pre-construction, the project will lead to major changes in terms of land occupation and will necessitate physical and economic displacement including acquisition of land for the canal and other infrastructures. According to COWI (2016), economic and/or physical resettlement will concern for Phase I 21,000 households and for Phase II 27,367 households (**Village reorganization and resettlement**). However, only 10 settlements will be directly impacted by the canal alignment and will have to be physically resettled. During construction, some lands will also be temporarily be required. The experience with Illovo and land acquisition is still, 50 years later, in people’s mind and local communities are suspicious of the government and SVIP trying to alienate customary lands. Construction will also disrupt existing access patterns.

- During construction, the Project will necessitate important workforce consisting of foreign workers. Land will be required for machinery storage and workers camps. There is also a risk that buildings and amenities do not respect quality standards (**Workers influx**). Worker influx from other regions in Malawi and from Mozambique can also lead to impacts and conflicts with local communities because of settlement, development of shanty towns, employment, sexual transmitted disease, and disrespectful behavior toward women. In addition, both Mwabvi Wildlife Reserve and LNP are at risk by people migrating to the command area and using them as sources of wood to build new houses. The same risk could come from the important resettlement activities that will take place and the need for new building material for resettled communities. Mwabvi is not surrounded by the irrigation scheme but only at 3 km from Phase II Zone D. The Matandwe Forest Reserve, close to Mwabvi Wildlife Reserve, suffers from logging and gardens from surrounding forest dependent communities. It is also at risk also from increase logging for building material because of its lack of official management (it is actually managed by Traditional Authorities). Mwabvi is accessible by road while the forest reserve is only accessible by trails. The two small reserve: Nyasa and Nyala wildlife reserve are privately owned and are not at risk.
- During operation of the scheme, there is a risk that farmers do not change their lifestyle and develop skills rapidly enough to adapt to the new environment (**Rapid social changes**). The entire agricultural system including its livestock components will be forced to make dramatic adjustments. These changes may overwhelm local coping mechanisms and may generate social resistance.
- During operation of the scheme, the development of irrigation may be associated with an increase in human activity and local economy, which may lead to additional pressure on resources (wood for charcoal, fish, etc.) and land (**Hinterland effect**).

ASSESSMENT OF IMPACT SIGNIFICANCE

	Village reorganization and resettlement. Major changes are foreseen in terms of land occupation	Workers influx. Land will be necessary and there is a risk that infrastructures do not respect quality standards. Influx could be associated with social impacts	Rapid social changes. There is a risk that people do not change their lifestyle and develop skills	Hinterland effect. Increase in human activity and local economy may lead to additional pressure on resources (wood for charcoal, fish, etc.) and land
Value of the affected component	Highly valued			
Intensity	High	Medium	Medium	Medium
Extent	Local	Punctual	Local	Local
Duration	Permanent	Permanent	Temporary	Permanent
Significance	Major	Moderate	Minor	Moderate
Occurrence probability	High probability	Potential occurrence	Risk (low probability)	High probability

7.4.2 Mitigation measures

VILLAGE REORGANIZATION AND RESETTLEMENT

The current CCPLTRPF assignment aims at collecting people grievances and communicate about the Project. The Communication strategy report provides a tool to ensure social acceptability of the Project.

Regarding resettlement, with current knowledge, some avoidance measures were proposed by COWI at the Resettlement Policy Framework stage, the complete set of measures will be developed in the Resettlement Action Plan (RAP) which is still to be produced once the Design study will start.

The Resettlement Policy Framework includes a method for valuation for compensation of agricultural produces, forest and fruit trees.

WORKERS INFLUX

Recruitment policies

Recruitment policies will need to consider social issues and project acceptability. Considering the high local impact of the Project in terms of land and disruption of existing lifestyles, it is recommended to maximise local employment. Local benefits would be maximised and some of the negative impacts of construction mitigated if local residents, especially the most severely project-affected people (PAPs), are given priority for recruitment. This will require:

- That the tender document for the construction contractor specifies that a method for local employment shall be developed by bidding firms. This method shall involve consultation of Traditional Authorities (TAs) with the list of required non-qualified work force. The need to have women and youth employment was also highlighted in the Gender and Youth Strategy (COWI, 2016). In addition, in the area, there are local capabilities thanks to past experiences with Illovo schemes. Ideally people would get employed in the vicinity of their homes and some transport arrangement would be provided when feasible.
- Social preparation and the incorporation of eligibility for priority in employment into the RAP Entitlement Matrix, together with an official mechanism for providing names to the construction contractor and for follow-up to track the numbers of PAPs employed.
- The inclusion of appropriate wording in the construction contract.

Land occupation

LNP shall be aware of the risk of workers influx and encroachment and increase logging activities in the park as some its western parts are already occupied by settlements, this risk also applies for Mwabvi Wildlife Reserve and the Matandwe Forest Reserve. These reserves are located outside the Project area but close enough to be affected by population influx and associated need for building material (wood) and land (3 km from Phase II Zone D). There is a risk of increase land occupation in Elephant marsh as well. To mitigate impact, additional rangers provided by the DNPW shall be present in Mwabvi during the construction phase, the DNPW shall be aware of the risk in order to take the precautionary measures. Funding could be provided once Phase II is implemented to hire additional rangers in Mwabvi and to patrol the area to keep illegal loggers away from the Matandwe Forest Reserve.

Avoiding the creation of shantytowns from people attracted to the site to find work is difficult when local enforcement are limited in number. Local law enforcement have to be aware of the risk and shall be ready to answer any complaints about illegal settlement and collaborate with traditional authorities on a regular basis to rapidly take action.

Workers code of conduct

The project developer and construction contractors will be expected, in advance of any construction work, to promulgate this code of conduct for workers (and related visitors), including local workers, workers from other region or countries, and expats. Induction training shall include a cultural induction, delivered with the help of Traditional Authorities.

The following is the code of conduct, it shall be taught during the induction training:

- Prior to entering a village for the first time, the village headman shall be met for the construction contractor to show his respect and present works and activities and to describe the safety risk.
- No alcohol or any form of drugs shall be consumed in the communities by any project employees. The contractor/developer should have and enforce an alcohol and drug-free policy (in the work place and while driving vehicles and machinery).
- Workers and visitors should not make any disrespectful gestures or use any swearing words to anyone either in the community, or along the access road.
- No unlicensed person shall drive work vehicles. Drivers shall be tested prior to starting work on the project, and have a valid license. International workers shall be responsible to provide a translation into English of their driver license.
- Construction company vehicles or trucks shall not be permitted to pick up anyone who is not an employee of the Project, except in case of an emergency.
- Heavy machinery shall only be operated by those who have the license and proven skills to use those types of machines. This shall be embedded in the recruitment and other policies of the contractor. International workers shall be responsible to provide a translation into English of their machinery license. This will help avoid health and safety problems.
- Workers and visitors shall drive slowly when passing villages that are very close to the access roadside or pedestrians walking along the side of the road.
- Drivers and passengers shall watch out for domestic animals, cattle or people crossing the access road. In case of collision with an animal, full compensation shall be paid in consultation with the village headman.
- Workers who will engage in prostitution, sexual harassment and poaching shall be fired and brought to the police for legal prosecution.
- Induction training about sexual harassment shall be given to all workers. During these induction trainings, the police law enforcement shall be present to explain the national laws that make sexual harassment and gender-based violence a punishable offence.
- It is forbidden for all workers to purchase bush meat, any animal parts, any living animals or any mineral (gold, stones). It is forbidden to fish, hunt, capture wildlife, free-roaming pets, engage in trading activities in or outside the Project area. Any worker engaged in such activities shall be laid off.

Sexually transmitted diseases

Reducing this risk will start by sensitizing staff and neighbouring population as well providing an easy access to condoms. Prohibition of prostitution will be enforced (see code of conduct).

Outside abstinence, the only proven method for preventing the spread of HIV during sexual intercourse is the correct use of condoms. Sexual education is one of the most efficient action against HIV diffusion. It cannot be done without reference to culturally values for its social acceptance. Peer-to-peer education is necessary to obtain results. Poverty, difficulties to have enough food and gender inequalities favour HIV transmission. Preventing HIV transmission shall be done in the field with general education and sensitization of workers by health workers.

Increased risk of contracting HIV often correlates with other sexually transmitted infections. Their treatments reduce the risk of infection by HIV. The treatment of the HIV-infected by anti-retroviral drugs reduces their viral load and accordingly the risk of transmission to sexual partner(s) or from mother to child. The knowledge of personal viral status is important to reduce the risk of transmission and initiates change in the behaviour. Sensitization and induction training shall be provided to all new workers as well as referrals to the appropriate services.

Grievances during construction

It is recommended that the CCPLTRPF grievance redress mechanism encompasses the construction phase to allow community to communicate with the construction contractor about their concerns and grievances (and behavior of workers). The role of the contractor in this activity shall be formalized in its contract. This could be done by holding mandatory monthly meetings between the contractor and village headmen, by providing a mailbox at the contractor camp site to collect grievances and a billboard so that communities can read answers from the contractor.

RAPID SOCIAL CHANGES

The current CCPLTRPF assignment aims to collecting people grievances and communicate about the Project. The Communication strategy report provides a tool to ensure social acceptability of the Project.

HINTERLAND EFFECT

Providing for adequate woodlots and grazing land set-aside areas, as part of the SVIP's participatory land use planning process for the irrigated farming communities, will reduce pressures to encroach upon nearby protected areas to obtain construction wood, fuelwood, or livestock forage. Some measures of the SRBMP will also aim at improving use of natural resources especially in Elephant marsh.

7.5 INFRASTRUCTURES

7.5.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction, canals could necessitate destroying buildings and other infrastructures (**Permanent loss of buildings and other assets**). At current stage, the number of infrastructures is not precisely known as the Design study has not started. The Resettlement Policy Framework and the future Resettlement Action Plan will provide details about affected infrastructures. The risk to infrastructures could also come from blasting activities.
- During construction, the canal will cross roads, trails, path disrupting access for communities and cattle to grazing sites and urban centers (**Disruption of access**). The estimated number of affected roads and footpaths is provided in the Resettlement Policy Framework (RPF). According to the RPF, 10 tarred roads, 57 gravel roads and 17 footpaths will be severed by canals for Phases I and II. In addition, most canals (except at plot level) will become a barrier to walking and a serious hazard for cattle and people trying to cross. Personal observations from the Consultant of people and domestic animal crossing an underconstruction lined canal with slope 1H/1.5V reveal that:
 - in the absence of a nearby bridge, during construction, people are forced to cross lined canal, some of them slip especially elderly people.
 - many juvenile cows try to fetch for stagnant water and end up stuck and sometimes wounded in the canal, this happens regardless of the presence of cattle bridge. It is very difficult to take them out;
 - mature cows do not usually take risks;
 - goats have no problem entering and exiting a dry canal.

It is probable that given the time necessary to rescue the cow on the following pictures (more than 15 minutes and the help of three people and a rope), if the canal would have been filled, the animal would have probably drawn.

Figure 14 Stuck cow in a lined canal



BRLi, 2017

- During operation, there is a risk that the irrigation system and infrastructures proposed in this ESIA to mitigate impacts are not adequately and regularly maintained (**Inadequate maintenance of canals and infrastructures**). The risk may also come from the fact that water hyacinth is present in Kapichira reservoir and may invade canals, that silt will be deposited in canals and that community may use canals as waste dumps.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Permanent loss of buildings and other assets. Canals could necessitate to pass through several buildings and assets	Disruption of access. Canals may sever footpaths and cattle paths	Inadequate maintenance of canals and infrastructures. There is a risk of canals and water intake siltation and invasion of plants in canal and drainage channel
Value of the affected component	Moderately valued		
Intensity	Low	Medium	Medium
Extent	Punctual	Local	Local
Duration	Permanent	Permanent	Permanent
Significance	Minor	Moderate	Moderate
Occurrence probability	High probability	High probability	Risk (low probability)

7.5.2 Mitigation measures

PERMANENT LOSS OF BUILDINGS AND OTHER ASSETS

As mentioned in the Resettlement Policy Framework, a number of locations where impact of the canal can be reduced considerably without any additional construction work has been identified. Changes were proposed to avoid village areas and graveyards as much as possible. The result of the proposed changes is a reduction of affected villages from 19 to 6 and affected houses from 121 to 26 in Phase I (a similar investigation has not been done for phase 2 yet.) (COWI, 2016).

During construction, before blasting, it will be important to assess risk to infrastructures by doing a groundtruthing survey of well, houses, churches, buildings, etc. Groundtruthing shall involve local authorities and the construction contractor.

DISRUPTION OF ACCESS

Bridges shall be built to allow for access across canals where existing footpaths and roads are impacted (10 tarred roads, 57 gravel roads and 17 footpaths will be severed by canals). In addition, these footpaths and bridges shall be strong enough to allow cattle to pass. It is recommended that they be built as the canal progresses to avoid forcing people and cattle to travel long ways to cross the canal or crossing the trench affecting the canal banks and leading to safety risks.

People/cattle bridges shall be built every km of main canals. Therefore, the Project may require up to 133 people/cattle bridges. As discussed in the baseline report, there is no identified livestock route, movement of cattle is diffused in the Study area, therefore sufficient provision for additional livestock bridges shall be planned. Sensitization to livestock owner is also recommended so that they take less risk for their livestock by:

- not using canal maintenance roads with their livestock ;
- carrying out with them ropes in case of juvenile cows entering the canal

In the command area, some footpaths shall also be designed to allow people to cross secondary canals, these shall be 1.5 m wide. Spacing between these footpaths shall not be more than 1 km.

In addition, whenever a canal crosses a seasonal river, box culverts shall be large enough to allow people to walk under the canal.

It is not recommended to build people/cattle bridges in Branch canals or smaller canals as the presence of livestock in the command area will lead to conflicts with farmers.

INADEQUATE MAINTENANCE OF CANALS AND INFRASTRUCTURES

In many irrigation schemes, the scheme operator is in charge of maintenance of main canals (lined canals) and the water intake while the water user associations are in charge of maintenance of tertiary canal and small drains. However, due to the nature of the Project and the need to install many mitigation infrastructures, it will be important that the SVIP determines the responsibility of each actors in order to allow these infrastructures to function on the long term. Such structures include:

- Bridges (cattle, pedestrian and vehicle) ;
- Safety stairs and ladders for villagers to bath and wash and to exit in case of falls ;
- Wildlife passes ;
- Tiger fish barriers ;
- Wildlife fences;
- A trash rack against water hyacinth and debris at the water intake.

This ESIA recommends that wildlife passes and tiger fish barriers do not become public infrastructures and therefore be at risk of poor maintenance but be the responsibility of the scheme operator as privately owned infrastructures.

Creation of bylaws to regulate the use of the canal shall also be made to avoid people throwing garbage in the canal, building informal (and often dangerous) bridges, or degrading the canal. Therefore, maintenance shall be accompanied by some form of law enforcement.

It will be also important to train farmers and management entities in maintaining their drains and canals as well as not to use the canal as a waste dump. This is a major responsibility and requires a significant level of managerial and technical skills and physical resources (facilities and equipment). Fees will be collected and in-kind contributions will be compulsory (maintenance of on-farm channels). The creation and training of such water management entities is a major task and will require (i) enactment of the relevant legislation, (ii) significant social preparation, and (iii) intensive hands-on support and training at start-up and over the initial years of operation, and (iv) provision of facilities and equipment. Failure, or delay, in operationalising the on-farm management will result in inefficient use of water and poor system maintenance, with lower crop yields, wasted water, an increased risk of impeded drainage, groundwater rise and secondary salinisation, and significantly reduced project benefits.

In addition to trash rack sized to stop the water hyacinth, the current method to remove the water hyacinth at Kapichira reservoir (biocontrol using insects) shall continue on a regular basis to avoid having the plant invading canals and night storages.

7.6 ECONOMICS

Most impacts on these topics are dealt with in the study called “Preparation and implementation of a Communications, Community Participation, Land Tenure and Resettlement Policy Framework” and its various components: Communication strategy, Gender and youth strategy study, Grievance redress mechanism, Resettlement Policy Framework, Stakeholders’ views report.

7.6.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction, work will disturb cropping practices since some households will control physically different areas of land (**Disturbance to existing agriculture**). New lands may not be ready for cropping immediately because of timing, lack of water, or the need for land preparation including levelling, boundaries and drains.
- Work will require unskilled and skilled labour for construction creating local employments (**Job opportunities**).
- During operation of the scheme, people will have to change their habits in terms of livelihood strategies. People in the valley, while incredibly poor, adapt to their situation by having flexible livelihood choices depending on the environment. They grow cotton and maize if there is adequate rainfall. They have goats, cattle and chickens and move the cattle and goats around to whatever pasture is available. They fish in the river and floodplains. They grow maize (dimba farming) on the floodplain, following the river down so that the crops get the moisture in the soil and survive long enough to be harvested before the water table drops too low. This livelihood strategies will be profoundly modified with SVIP as people will rely mainly on irrigated agriculture. Any delays in the Project completion, adaptation from people to irrigated agriculture or skills acquisition could delay the benefits (**Potential delays in irrigated agriculture development**). The project relies on a knowledge-, inputs- and labour- intensive model of production at the field and household level. This model is untested at household level under the environmental, social, economic and institutional conditions prevailing in the study area. If the model is not feasible, there will also be a delay in project benefits as potential solutions are tested and applied.
- During operation of the scheme, increase in production from irrigated fields could lower price at local markets and affect rain fed producers (**Over supply of crops**).
- The project overall goal is to benefits local communities (**Benefits of irrigated agriculture**). The Project positive impact in term of income will bring indirect changes such as improved health and education, new agribusiness investments, economic development and increase in wage labor.

- During operation of the scheme, with less water in the Shire River, fishery in Elephant marsh could be impacted (**Reduction of fisheries**). Currently, fisheries are already declining due to rapid human population growth, there is also an issue with regulation and use of illegal gears. The project impact will create an additional pressure on this resource. Fishing is a particularly important livelihood activity in the eastern and southern parts of the marsh. The value of the fish caught from the marsh could be between US\$1.5 – 8.8 Million per year (Anchor Environmental Consulting, 2016). The DRIFT report (Ecosystem Functional Model by Southern Waters in association with Streamflow Solutions, Anchor Environmental and MRAG for the SRBMP, 2016) does not foresee a reduction of open water surface (but depth) in the marsh (where most fishery takes place) however it foresees a reduction in rooted vegetation where spawning takes place.
- The project construction and operation will require adaptation of livestock rearing activities (**Impacts on livestock rearing**). The canals and command areas will represent obstacles to movement of cattle mainly toward Elephant marsh and will reduce the land available for grazing. The presence of vast irrigated areas could lead to conflict between cattle owners and farmers. In addition, smallholder livestock farmers fear that they might be deprived of access to crop residues from SVIP which are likely to be sold to the highest bidder. Other grievances collected from livestock farmers by COWI (COWI, 2016) are as follow:
 - The proposed schemes with large contiguous command areas will block livestock accessing the Shire River and other watering points.
 - Access to the few ponds currently used as watering points for livestock may be blocked by the schemes or may be located inside the schemes.
 - There is a fear among livestock owners that irrigation water could introduce new diseases or enhances and perpetuates existing ones.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Disturbance to existing agriculture. New lands may not be ready for cropping immediately because of timing, lack of water, or the need for land preparation including levelling, boundaries and drains	Job opportunities. Work will require unskilled and skilled labour for construction	Potential delays in irrigated agriculture development. Any delays in the project completion or skills acquisition could delay the benefits
Value of the affected component	Highly valued		
Intensity	Medium	Medium	Medium
Extent	Local	Local	Local
Duration	Temporary	Temporary	Temporary
Significance	Minor	Minor (positive)	Minor
Occurrence probability	High probability	High probability	Potential occurrence

	Over supply of crops. Increase in production could lower prices and affect rain fed producers	Benefits of irrigated agriculture. The project overall goal is to benefits local communities	Reduction of fisheries. Fishery could be impacted by SVIP	Impacts on livestock rearing. The project will require adaptation of livestock rearing activities
--	---	--	---	---

Value of the affected component	Highly valued			
	Intensity	Medium	High	Low
Extent	Regional	Local	Punctual	Local
Duration	Permanent	Permanent	Permanent	Permanent
Significance	Major	Major (positive)	Minor	Moderate
Occurrence probability	Risk (low probability)	High probability	Potential occurrence	High probability

7.6.2 Mitigation measures

DISTURBANCE TO EXISTING AGRICULTURE

According to the Resettlement Policy Framework (RPF), loss of annual crops would be avoided by starting the project after the harvest. In addition, the RPF has recommended the construction of bridges and footpaths across canal to allow people to continue accessing their field or to commute. These passages shall be built as the canal progresses and not at the end to avoid creating a long trench with dangerous embankments.

Land acquisition and land consolidation shall be planned in advance of construction, so that farmers have some time to adjust to their farming condition before the additional stress of physical construction. Land acquisition shall be phased according to the Project (Phases I and II).

JOB OPPORTUNITIES

As mentioned in the previous section, job creation shall bring benefits to the community as long as local employment is favored.

POTENTIAL DELAYS IN IRRIGATED AGRICULTURE DEVELOPMENT

Resources shall be provided to support the delivery of advisory services, adaptive research and development, the strengthening of research-extension-farmer linkages, the improvement of market linkages, and increased pluralism in market delivery. These resources could be provided by the Ministry of Agriculture, Irrigation and Water Development and the Proposed organizational setup presented in the Agricultural Development Planning Strategy study (PWC, 2016). Pilot trials shall also be put in place and Phase I success shall be tested prior to implementing Phase II.

OVER SUPPLY OF CROPS

In order to avoid oversupply of crops at local market, the project shall focus on exporting crops. In addition, the Project shall study the possibility to transform vegetable for the food industry (tomato sauce, etc.). Measures to mitigate the impact are developed in the in the Agricultural Development Planning Strategy study (PWC, 2016).

BENEFITS OF IRRIGATED AGRICULTURE

The overall goal of the Project is to increase livelihood of communities. The benefit from the Project will also influence several other socioeconomic indicators: general health and education level of the community, etc. These positive side-effects can be numerous and relatively easily achieved:

- Greater food security than rain-fed production and increase in the monetary income will reduce poverty and food shortage.

- Change in behaviour and acceptance of new mentality particularly associated with health.
- Increased access to efficient health system.
- Better access to schools.
- Development of agribusiness in the area.

Enhancement measures are well detailed in the Agricultural Development Planning Strategy where efficient organization of producers are proposed. Institutional measures will also be developed as well as assistance and training to producers once the Project starts. Creation of water users associations is another example of an enhancement measure.

REDUCTION OF FISHERIES

Impacts on fisheries could be compensated by creating fish farms. Factors to consider for fish farming are presented in the “Agricultural Development Planning Strategy” study (PWC, 2016). In addition, the current study under the SRBMP called “Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi” will provide (once available) more details on institutional measures to implement to ensure proper natural resources management, including fisheries.

IMPACTS ON LIVESTOCK REARING

Mitigation for smallholder livestock farmers were discussed in consultation meetings by the consultant in charge of the Agricultural Development Planning Strategy (PWC, 2016). The following mitigations reflect smallholder grievances:

- Construction of drinking spots along the main canals. Drinking spots shall take the form of pipes or cattle troughs. One cattle trough should be installed at each village at a location outside of it and on both side of the main canals. A first estimate would be 40 cattle troughs (20 on the western side and 20 on the eastern side). These troughs shall be made of concrete to limit seepage and the quality of concrete shall be equal to the quality of the lining for the canal. Their size shall be around 5 by 5 meters.
- Phasing the installation of people/cattle bridges as canal construction progresses is recommended to avoid creating a long trench without any passage for cattle.
- Construction of people/cattle bridges. People/cattle bridges shall be installed at each km along the main canals (a total of 133 people/cattle bridges), but Project proponents shall make provisions for additional bridges. Bridges shall be made of concrete and include high walls to avoid accident. From the consultant experience in irrigation schemes in Africa, along a 22km main canal, 3 people/cattle bridges were initially installed, after complaints from livestock owners, a dozen additional bridges were built. Today local government are requesting more people/cattle bridges. Based on this example, it is seems important to provide one people/cattle bridge per km.
- Establishment of conflict management structures at village level and guidelines to deal with farmer’s conflicts.
- Formalization of the marketing of crop residues and organic manure to foster strong collaboration between livestock and irrigation farmers and to ensure reciprocal gesture in the disposal of crop residues by crop farmers in exchange of manure.
- In order to ensure that crop residues are available to smallholder farmers, small scale farmers shall have access to the crop residues realized from crops grown on their traditional land parcels.
- Some lands that cannot be farmed (see section on set-aside land) shall be designated as grazing areas and, if possible, planted with grass in consultation with livestock owners.

- Command areas from vast contiguous patches of land and outside of roads, urban places and rivers they offer very few direct access to Elephant marsh grazing sites. It will therefore be important to designate cattle corridors so livestock can access the marsh. This will not only reduce the risk of conflicts between farmers and livestock owners but also the risk of conflicts with people living in urban place (Nchalo, Ngabu, Chikwawa). At this stage, these corridors cannot be proposed, but the Design study shall take this measure into consideration.

7.7 HEALTH AND SAFETY

7.7.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction, the public and workers are at risk from important work along canals (**Construction risk and nuisances**). The main risks are related to collision with vehicles and trucks as people will inevitably use construction road; with dust and speed the risk is non-negligible. Other risks related to workers safety including:
 - Risk of workers not wearing any Protective Personal Equipment (PPE). From experience of the Consultant in construction sites in Africa and China, most workers (particularly daily workers) never wear any PPE either because the construction company does not provide any equipment to save money, because workers sell them on the local market, or because the weather is too hot to wear a helmet and safety shoes. Without complete review of the common PPE management approach, SVIP construction sites will not be different.
 - Risk due to poor hygiene and general state of workers camps when surplus material, wreckage and rubbish are found everywhere on site and when toilettes and used water are not correctly evacuated out of the site.
 - Risks due to workers lower standards in terms of safety precaution especially when working close to water and the risk of electrocution at the water intake when welding.
- During operation of the scheme, an increase of waterborne disease in the command area, mainly bilharzia, is expected (**Bilharzias**). Other diseases could see their prevalence increased due to the Project.
- During operation of the scheme, the presence of main canals and night storage may lead to drownings (**Drownings**). Branch canals whose depth are between 0.4 and 1.1 meter are not drowning hazards but still represent a risk for children.

Figure 15 Trucks and pedestrians sharing construction roads & rubbish in construction camps



Source: BRLi, 2015

ASSESSMENT OF IMPACT SIGNIFICANCE

	Construction risk and nuisances. The public and workers are at risk from important works along canals	Bilharzias. An increase of bilharzia in the command area is expected	Drownings. The presence of main canals may lead to drownings
Value of the affected component	Highly valued		
Intensity	Medium	Medium	High
Extent	Punctual	Local	Local
Duration	Temporary	Permanent	Permanent
Significance	Minor	Moderate	Major
Occurrence probability	Risk (low probability)	High probability	Risk (low probability)

7.7.2 Mitigation measures

CONSTRUCTION RISK AND NUISANCES

Dust and pedestrian on construction roads

All gravel roads used by trucks shall be sprayed on a regular basis. Due to low availability of water, it is recommended that the construction contractor pays Illovo to spray road with sugar molasses as it is done along Illovo roads. Molasses offer long lasting dust control. It is recommended that roads be sprayed three times a day (morning, mid-day and evening), except when a heavy rain takes place. Molasses is 3 to 4 times more efficient than water in dust deposition rate (Gotosa et al., 2014). Spraying molasses will however not be accepted in LNP and MWR due to its strong smell and associated increase in Biological Oxygen Demand (BOD) in nearby watercourses.

It is also required that the construction contractor provides transportation to a designated place for workers at the end of their day of work. This will help reduce the number of pedestrian walking on construction roads.

Risk of workers not wearing any PPE

- In the call for tender document, bills of quantities shall request that answering firms provide cost estimates for helmets, clothes and safety boots (and other safety equipment). For each proposal, the foreseen budget has to be verified by the authority in charge of proposal analysis to make sure that figures are coherent as PPE are in fact expensive.
- In call for tender document, the method to ensure that PPE are returned to the employer shall be provided. This method could be a deposit on equipment, which shall be recovered at the end of the contract by the worker or penalty fees for workers losing their equipment, etc.

Risk due to poor hygiene and general state of workers camps

It is recommended to:

- Require the tendering contractor to develop measures for the safe evacuation of wastewater and wastes from the various camps, to forbid the evacuation of wastewater in watercourses and forbid burning wastes.

Risks due lower standards among workers

- In the call for tender document, a Health and Safety specialist shall be required. He/she shall have a certificate in H&S and a copy of his certificate shall be provided in the proposal (with the translation if it is in a foreign language), he/she shall be mobilized at beginning of contract.
- Working close to water shall be subject to very high H&S standards given the fact that : the water intake is located in MWR, that there are a lot of crocodiles on site, and that the risk of electrocution is high when welding in a damp environment. Return of experience from the consultant has highlighted that many workers around pumping stations or water intakes are welding in damp condition due to poor sheet piling installation and poor drainage around the construction site where water intrusion from the river and stagnant water from rain become hazardous situations. In fact, sheet piling will also keep crocodiles from entering the site.

Figure 16 Working in damp condition around a pumping station



Source: BRLi, 2016

Other generic measures regarding health and safety on site are:

- Request in the call for tender document that tendering firms develop a Code of Practice to manage health and safety risks associated with excavation work.
- Ensure that the project proponent and financiers signal that best H&S standards should apply to this project (policy leadership).
- Include standard best practice health and safety provisions in the construction contract (and tender), together with :
 - appropriate Bills of Quantities items so that at least some elements of H&S are pay items (financial incentive),
 - a mechanism for withholding payments if the contractor is not compliant with the H&S provisions (especially PPE). Note that the provisions should include insurance to enable the contractor to pay for treatments required by his workers including those of all sub-contractors, together with any subsequent disability payments.
 - Include a specific task in the supervision contract concerning H&S supervision and compliance, together with the staff resources to carry this out, and including a training task for the employer's staff.
 - Require the contractor to implement an H&S program and training throughout the construction period including an induction training.
- The construction contractor shall establish and enforce the code of conduct for drivers and suppliers. An induction training shall be provided (see previous section).

- Require the contractor to install speed breakers in all access roads. These shall be made of soil spoils and shall be compacted to last. One speed bump shall be installed every 200 meters.
- Require the contractor to install construction fences around excavators and trucks loading excavated earth.
- Require the contractor to have a small clinic and nurse available on-site all the time with first aid kits. This would also entail that a replacement nurse is available (on-call). In addition, one vehicle shall remain available at all time to drive wounded staff to Blantyre.
- When using dynamite for blasting, local population shall be warned ahead through radios, public posters, churches and local authorities. A safety patrol with an alarm has to ensure that all individuals are evacuated from quarries area prior to blasting.

As highlighted throughout this ESIA, the selection of the construction contractor will require a conscious decision by the Project proponent and financing agencies prior to tendering for a construction contractor. In many observed cases by the Consultant, the terms of references and contracts for construction contractors do not include measures developed in the ESIA (and ESMP). In addition, many measures proposed in this ESIA involve a cost for the construction contractor, call for tender shall be clear on the requirement to quantify health and safety measures in the Bills of Quantities (PPE, speed breakers, construction fences, etc.).

Lastly, in the call for tender for the scheme operator, it is recommended to require that firms provide a health and safety protocol for work in canals.

BILHARZIAS (ALSO CALLED SCHISTOSOMIASIS)

In order to reduce the burden of schistosomiasis, the following actions shall be implemented:

- 1) reduction of the contact between water and human by the use of boots and protective clothes. This reduction of contacts with water is feasible with farm workers but not with children and adolescents.
- 2) reduction of the infection of the snail's fauna by avoiding defecating in or near water and avoiding urinating in water. Health sensitization is the only efficient way to reduce the release of feces or urine in water. It only can be obtained by a long-term strategy of education including scholar education.
- 3) the elimination of the snails by molluscicides. This action is neither realistic nor sustainable at the scale of thousand hectares of irrigated area and hundreds kilometers of canals. However, thorough and regular maintenance of the canals by the scheme operator and farmers, particularly the elimination of aquatic plants, reduces the proliferation of snails. Drying up canals during several weeks is also efficient. This will be done for secondary and tertiary canals after the dry season.
- 4) preventive mass campaigns of chemotherapy with praziquantel. To be efficient, these campaigns have to be done with the entire population and repeated each year. Praziquantel is not an expensive drug and it is well-tolerated. It is effective against both urinary and intestinal schistosomiasis, resulting in a reduction of the severe forms but not in an interruption of their transmission.

The workers of Illovo estate benefit from protective clothes and boots and from sensitization. In case of symptoms of schistosomiasis, they are treated in one of their clinics. Their relatives have also access to free treatment. The workers of outgrowers and also the neighbouring population can be treated for free at Kasinthula bilharzias health post. A microscope examination of urine is done there but not an examination of feces because of the lack of knowledge regarding intestinal schistosomiasis in the area. Seven hundred patients were tested in this health post in 2015 and 400 were treated.

In order not to increase the schistosomiasis burden and to ensure its sustainable reduction, the control of the intermediate hosts shall be aimed by the reduction of the contacts between human skin and water, by the sanitation to reduce defecation and urination in or near canals and drains, by preventive treatments of the human population and by curative treatments of infected people. This integrated control is an aim but it is not easy to realize:

- The gastropods intermediate hosts still need water or slow current and aquatic vegetation to settle (next figure). The maintenance of the primary, secondary, tertiary and also drainage canals free of vegetation and solid debris is of great importance to limit the mollusk's proliferation. "Canals regular emptying" is theoretically efficient but the *Bullinus* are able to support desiccation buried in the mud. Hence, to have some results, emptying should persist during many weeks. This is not an appropriate measure for agricultural production. The molluscicides products are not efficient on a long term and on a large scale and they have various negative effects on the environment.

Figure 17 Canal in Kasinthula with still water and aquatic vegetation along the banks



Source: BRLi, 2016

- The reduction of contacts with infected water is possible for the farmers using boots and protective clothes but at the same time, children and adolescents appreciate to play in water. In addition, many daily activities will be done in canal like clothes washing. Therefore, a true reduction of water contacts is not really realistic neither.
- The reduction of the infestation of the gastropods by human excreta is possible for feces (intestinal schistosomiasis) and more difficult to obtain for urine (urinary schistosomiasis). It can be obtained by health education to sensitize people on the use of pit latrines. To be really used, the latrines should be clean and easily accessible and communal latrines are rarely clean. Private latrines near the households are more useful. The actions of sensitization and health education have to be repeated during many years to obtain the beginning of a result. Collaboration with the education sector is crucial for health education.

Figure 18 Communal pit latrine in Kasinthula, an elegant but rarely used structure



Source BRLi, 2016

- Treatment of the patients by oral praziquantel is neither difficult nor expansive. It is better to do a microscopic diagnosis to confirm the cause of the symptoms (parasites eggs are easily observed in urine or faeces). At present time, this observation is performed at Kasinthula health post but only in urine. In fact, intestinal schistosomiasis is unknown by the health workers and consequently underestimated. Existing capacities for diagnosis and treatment should be strongly reinforced.
- Systematic mass treatments by praziquantel are given to the primary school pupils in Chikwawa district as in other districts of the country. To be efficient, this treatment should be repeated yearly. It would be of interest to extent this mass treatment to adolescents and young adults outside the school system.
- The increase in cash income thanks to the Project associated with awareness may also lead to increase in the use of praziquantel.

LEPTOSPIROSIS

Leptospirosis is prevented by the use of protective clothes and boots and avoiding contact with fresh water in the canals. Thus, this prevention is not different from that of schistosomiasis. Leptospirosis, however, is much rarer and much less transmissible. Before any excessive concern for this disease, it would be of interest to conduct a serological survey among the cane workers.

OTHER WATERBORNE DISEASES NOT DIRECTLY LINKED TO IRRIGATION SCHEMES

Soil-transmitted helminthiasis

Measures against **soil-transmitted helminthiasis** are:

- use of pit latrines for defecation
- washing hand after defecation
- protection of the feet by shoes
- protection of the food from flies

These measures are possible with the workers and generally with adults but more difficult to obtain from the children and adolescents. Systematic mass treatment with a deworming drug is not useful because of the apparently low level of parasitism in the area. Surveys among pupils would be of interest to confirm this low prevalence.

Cholera

Regarding **Cholera**, its prevention is similar with intestinal schistosomiasis but with a stronger implication: schistosomiasis is a chronic disease which does not kill (or rarely after a long delay without treatment) while cholera can kill in few hours. Defecation in pit latrines, hand washing with soap, access to clean water are the main weapons to prevent cholera transmission.

Cholera transmission is prevented by sanitation and by personal hygiene actions:

- Use of latrines for defecation or at least, defecation away from houses, paths, water pools and supplies, places where children play, etc. and covering feces with earth or sand ("The cat method" for ending open defecation).
- Handwashing with water and soap after defecation and before any contact with food or drink. Washing is efficient with any ordinary soap even with dirty water.
- Drinking safe water and safe water use for cooking, teeth brushing, children bathing. The easiest way to obtain safe water is to put 2 at 3 ppm of chlorine (five to ten drops of bleach for 10 liters of water). The disinfecting power of free chlorine persists from 24 to 48 hours.

To reduce the risk of cholera and at the same time of other infectious diarrheas, providing people with safe drinking water is one of the most useful action. From the Feeder canal, a main pipe can conduct the water by gravity to a treatment center (decantation and chlorination) then to the main villages and settlements (as developed in the FS). The biggest difficulty is not to construct this water transport network but its maintenance. To be sustainable, the water delivery by standpipes should be lucrative for the operator in charge of the distribution and also economically accessible for this poor population. Conversely, free distribution of water will never be sustainable because the lack of maintenance of the network and of the treatment center. Everywhere in the world, payment of water is a sensitive issue, especially with traditional farmers. This issue exists also for the water used in irrigation scheme. It should be part of health education to make people accept the principle of paying for this service.

To increase sanitation, it is also necessary to develop the use of pit latrines. To be useful, the latrines should be a part of the household and remain clean and private. Building useful pit latrines can be only be the result of health education and of appropriation of hygiene messages by the majority of the population.

Malaria

As mentioned in the Baseline report, **Malaria** is not directly linked to irrigation schemes as the area is already surrounded by puddles, wetlands and dambos. Suppressing its transmission, given the environmental conditions of South Malawi lowlands, is not possible at the present time. However, the incidence of malaria attacks and their severity can be reduced.

The main action to minimize the incidence is to reduce the contacts between Anopheles mosquitoes and human beings by the use of insecticide treated bed nets during the night. The nets should be in good condition, well bordered. Depending on the insecticide, the fabric and the manner of impregnation, this impregnation is efficient to repulse mosquitoes during six months to two years at best. Selling nets is more effective than distributing them for free (often, free mosquito nets end up being sold as fish nets for quick cash). The increase in cash income associated with awareness can promote these purchases. The irrigation project may be a good opportunity to promote health education and use of bed nets for all, not only for children and pregnant women. House-spraying is not realistic, less efficient and use much more insecticide than the impregnation of the nets.

The best way to reduce malaria attack severity is a prompt and exact diagnosis and a prompt treatment by an effective drug. The Malawian ministry of health guidelines prescribe to use an oral artemisinin combined therapy like arthemeter plus lumefantrine for uncomplicated attacks and parenteral artesunate for the severe ones. These drugs are highly effective. The prevention of the effects of malaria during pregnancy on the foetus is done by a preventive intermittent treatment with sulfadoxine-pyremithamine. At present time, various health structures in the Study area do not have any anti-malarial drugs. Improvement of the health structures in staff and in equipment is absolutely necessary to reduce malaria burden. However, nothing can be done regarding canal or drain design or the irrigation techniques to reduce the prevalence of malaria.

Onchocerciasis

Regarding **Onchocerciasis**, because of the strong link between the *Simulium* blackflies and running water in streams and rivers, there is no risk of invasion by these vectors of onchocerciasis in the lowlands along the bank of the Shire River and canals. The possible presence of *Simulium* larvae at the tiger fish barrier (if it involves a weir) is more anecdotic than of health interest.

DROWNINGS

It is recommended to carry out sensitization at primary schools to inform children about the danger of canals. Children are curious and will inevitably "test" the canal; sensitization shall be on going, shall use simple illustrations and involve teachers.

It is also recommended to build large concrete stairs at each village crossed by a main canal (Feeder, Bangula and Supini). The primary purpose of these stairs would be to allow people to access water without danger. These stairs shall be large enough so that people can use them to fetch for water and clean their clothes (10 meters wide). An estimate, based on density of villages around main canals, gives about 40 stairs for the whole scheme (20 on the western bank and 20 on the eastern bank). It is not recommended to:

- build stairs on both side of a canal at any location, it could be interpreted as an invitation to cross the canal (especially at time of low low).
- build stairs north of Chikwawa as the area has very little population density (although this may change in the near future).
- to decrease the slope of the canal bank as the canal could become available to cattle. Return of experience from a long canal in Namibia has revealed that not much could be done to evacuate a drowning adult cow anyway. In area where ramps with gentle slope will be built for canal maintenance, the concrete shall have a higher coefficient of friction or shall be textured to improve grip (with a broom), gritty material can also be added to the surface. This way, if a cow comes to drink it will have a better grip to exist the area. Access for cattle to these ramps shall not be encouraged (fence, etc.).

Stairs shall only be built at village level to maintain a certain level of control over the use of canal. To reduce the incidence of drowning, fixed ladders shall be fixed every 500 m on both side of the canal along the full length of the Feeder, Bangula and Supini canals (with alternating position as well). Fixed ladders shall be installed in night storages as well (as mentioned in the FS). Due to their greater depth night storages shall also be fenced.

It is also recommended that the general population be informed about the presence of the canal and the restriction of access and use that apply to people (no fishing, no canoe, no motor pump, etc.).

The water intake shall never operate rapidly; gates shall be opened progressively to avoid creating a sudden increase of water in the canal.

Discussions with irrigation specialists have raised one limitation with fixed ladders : as they are made of iron they often are stolen. Alternatives to iron shall be studied such as hard plastic (replaceable plastic railing) or recycled half rubber tires embedded in the concrete lining (with holes to avoid retaining stagnant water). Notches can also be made directly in the concrete to offer some grip to people trying to exit the canal.

7.8 GENDER ASPECT AND VULNERABLE PEOPLE

7.8.1 Description of impacting activities

- With increasing yield, the project may add a burden to the workload of women (**Increase workload for women**). However, on the other hand with **improve access to water** thanks to the presence of canals, women will travel shorter distance to get domestic water (fetching for water is “traditionally” done by women). Water shortage and distance to travel to collect water are serious constraints in the study area.
- Access to financial services is a strong barrier to women and youth empowerment (**Risk of unfair distribution of benefits**). Women often depend on their own capital and other informal sources of capital. In the study area, businesses owned by women are less likely to be registered by government authorities compared to those operated by men. This makes women less likely to access credit from formal banks as they would not have certificates of registration.
- Landless people and squatters could be disadvantaged by the project (**Impacts on vulnerable people**).

	Increase workload for women. The Project may become a burden to the workload of women but on the other hand time spent to get water should decrease with Improved access to water	Risk of unfair distribution of benefits. Access to financial services is a strong barrier to women and youth empowerment	Impacts on vulnerable people. The Project benefits may not reach vulnerable people
Value of the affected component	Highly valued		
Intensity	Low (the negative impact is counterbalanced by the positive effect)	Medium	Medium
Extent	Local	Local	Local
Duration	Permanent	Permanent	Permanent
Significance	Minor (positive)	Moderate	Moderate
Occurrence probability	Potential occurrence	High probability	Potential occurrence

7.8.2 Mitigation measures

The Gender and Youth Strategy Study (COWI, 2016) has developed a series of measures to mitigate impacts from the Project in the “Proposed guidelines and activities” section. These measures aim at the preparatory phase as well as the Project implementation stage.

The following are mitigation measures that are developed in the Gender and Youth Strategy Study (COWI, 2016).

PREPARATION PHASE

Preparation phase are measures that were already implemented by the consultant (COWI, 2016).

Recruitment and capacity of consulting /project teams/missions

- Ensure that all terms of reference for consultants and staff have a gender aspect/expert in them ;
- Train/orient all project staff and consultants on gender and youth issues, including orienting them on SVIP ;
- Where possible, ensure that the composition of staff at all levels is at least 50% women, to be in line with the 50:50 policies.

Implementation of stakeholder consultation process, community mobilisation and engagement for the SVIP

- Implement communication activities at all levels in the project area (ADC and VDC levels)
- Develop community mobilisation guidelines that incorporate gender issues.
- Ensure information education and communication materials are accessible to the illiterate, especially women.
- Ensure women, youth and the poor are included in all field level activities, meetings and capacity building processes.

Preparatory studies, baselines data collection, analysis and reporting

- Orient all enumerators on gender and youth issues related to Chikwawa and Nsanje
- Ensure that all data collection instruments are able to collect gender and youth disaggregated data.
- Ensure that all data collection tools are gender/youth-audited by the CCPLTRPF Gender and Youth Expert
- Ensure that data is analysed and disaggregated by sex and age to capture gender and youth issues.

Institutional development and formation of irrigation options, water user institutions, SVIP governance and management committees

- Ensure that gender and youth issues are used as criteria for choosing the SVIP irrigation institutional model.
- Ensure that women, youth and poor people are represented and actively participate in irrigation management entities
- Train all irrigation management entities on gender and youth issues
- Ensure women, youths and poor are included in the management, governance, implementation and technical teams of SVIP

- Build capacity of individual farmers on gender and youth issues, including decision making at household level
- Ensure no discriminatory practices are being used to limit participation of women and youth.
- Ensure that voices of women, youths and poor are heard by management of the water management entity
- Implement positive discrimination, if the irrigation or water users committees do not have representation from women, youths and the poor

Land redistribution, resettlement policy framework and grievance mechanism

- Ensure that PAPs are gender, age and poverty defined, so that it is known who is most affected by resettlement
- Ensure that women, youths and poor are also provided with land in the schemes. Government can lease off land and reallocate equitably amongst beneficiaries.
- Ensure that women and youths and poor who lose land are appropriately compensated. During compensation, ensure that all household members have access and control of the compensation by adopting a household livelihood and planning approach that is being implemented in Chikwawa by the Ministry through IRLAD project.
- Ensure that District Council teams, Committees and experts that value lost assets during compensation, value land as well, not just structures on it.
- Ensure that District Council teams, Committees and experts that value lost assets during resettlement planning do not sexually abuse women or girls (or any form of gender based violence)
- Ensure that land assessment teams include women and youths and ensure that land losses of female headed households are assessed by female officials/experts. Whoever does the valuation should be gender trained.
- Ensure that gender and youths sensitive spaces are created for women to lodge their grievances on unfair practices.
- Ensure that grievances by women are handled by women. Traditional leaders should ensure that women are included in any primary justice structures that they have in place or are to be created.
- Encourage land being registered jointly in the name of the woman and the man.

Monitoring and evaluation of gender and youth activities

- Ensure that the intervention logic of any project being designed has SMART and gender and youth sensitive indicators and take into account poverty
- Ensure that monitoring the progress made in applying gender and youth approaches in irrigation projects is regularly undertaken.
- Ensure that all indicators at input, output, outcome and impact level are disaggregated by gender, age, household headship, location and marital status, where necessary. Indicators that can be used are included in the annexes.
- Ensure that programme targets are gender and youth disaggregated
- Ensure that monitoring and evaluation terms of reference and teams have gender and youth expertise.

PROJECT CONSTRUCTION AND OPERATION PHASE

Policy level commitment to mainstream gender and youth issues in the SVIP

- Promote SVIP as multiple-use (irrigation, domestic and livestock uses) irrigation and water programme.
- Ensure that women enjoy de jure and de facto equality in access to land and other property, including inheritance and purchase.
- When water management institutions do not have any or few women and youth, introduce appropriate institutional measures, such as minimum quotas for women and youth to increase participation of women and youths
- Provide improved coordination among concerned water management institution to facilitate the implementation of multiple-use water projects.
- Support equal employment opportunities in water management institution for both genders and for youth and older people.
- Provide and support capacity building around gender and youth issues in water management entities with particular attention to extension staff.
- Ensure effective linkages with gender and youth ministries and CSOs

Land administration, allocation and tenure arrangements for women, youth and poor people

- Conduct participatory assessments to understand the social organization of agricultural production and the specific gender and youth division of labour in the project area.
- Implement mechanisms to ensure that the landless are also provided land and participate in irrigation activities
- If irrigation schemes involve land titling or retitling, new land titles should be granted to women or to husbands and wives jointly. Youth should also be included.
- Disaggregate land ownership data by gender and age to understand land ownership issues amongst women and youth.
- Conduct local/grassroots advocacy work with traditional leaders to improve land ownership by women and jointly by woman and man
- Ensure that irrigation schemes have both commercial as well food security objectives by adopting integrated farming systems, nor jus commercial mono-cropping

Construction of various irrigation infrastructure and installation of equipment

- Ensure that women and youth are involved so that they also benefit from the employment created, where feasible.
- Ensure gender sensitive resettlement in terms of targeting, compensation and provision of services to new locations.
- Provide social safeguards to protect women and girls from being sexually abused

Gender and youth division of labour

- The irrigation scheme should provide labour for irrigation activities in the farm. The irrigation model should not allow farmers to work using their own labour in the blocks.
- Ensure that planners involved in the projects are aware of women's and youth contributions to farm and household production to enable them design plans that are appropriate for women.
- Irrigation designs should carefully evaluate the availability of women's and men's work in the family and expected impacts of intervention on women's and men's income, time use, and social power.

- Community labour contribution to irrigation projects should take into consideration the contribution of women and men at household level. Where possible, this labour should be for to compensate for time lost.
- Provide appropriate labour and time saving technologies to those beneficiaries, especially those who are already overburdened with labour at household level.

Access and control over economic and social benefits from participation irrigation services

- Income from irrigation at household level should be transparently used by adopting a participatory expenditure management at household level
- Provide equal access to training, finance/credit and related irrigations services for men, women and youths.
- Provide training opportunities for the youth and women in advocacy and engagement and inclusion
- Provision and promotion of (agriculture-related) vocational skills for youths which will enhance the growth of the sector
- Monitor use of irrigation income/earnings at household level

Water user organizations and other institutional arrangements.

- Ensure that by-laws of irrigation schemes/WUAs or its constitution provide equal opportunities for all members. Ensure that it has some affirmative actions that favour the disadvantaged groups.
- Ensure that there are no discriminatory practices that are being used to limit participation of women and youth, even when bylaws provide for equal opportunity. These may include high membership fees, landlessness, access to water etc.
- Implement positive discrimination, if the criteria for irrigation scheme or WUA membership is discriminatory

Socio-economic empowerment of women and youths in and around irrigation schemes

- Improving access to finance to enable women and youths participate in irrigation technology and value addition
- Integrate/promote village loans and savings and income generating activities in irrigation schemes
- Training women and men on human rights and the importance of women's participation in decision making at all level
- Introducing functional literacy classes in water management institutions to improve women's and illiterate men's ability to read and write so that they can effectively participate in agricultural decision making processes

Designing and implementing multiple use irrigation services

- Implement a strong consultation process during the planning and implementation stages to understand gender dynamics
- During implementation, conduct training programs addressed to women to help them manage and maintain the points of supply will also be necessary. Ensure that planners understand women's and girls' water needs as women and girls will be the main users of those watering points
- Translate multiple water needs into affordable small- and medium-scale technical irrigation designs
- Ensure that water points are created for domestic and other social uses, especially livestock.

- Introduce community water points because tap water may not be feasible as houses are not mostly permanent.

Irrigation scheme management and farmer management

- Ensure that all farmers aggregate their land so that no single farmer is identified by or works on their own land.
- When forming groups, ensure that membership fees are affordable and those that cannot afford are supported with cash transfers to be able to pay
- Adopt management arrangements that have been used for the Phata Irrigation Schemes where possible
- Ensure that farmers are organised in a way that ensure women and youth participate in the activities of the scheme and benefit from it
- Implement gender training programmes for staff and communities around the schemes
- Implement gender sensitive transparent and accountable irrigation revenue management
- Adopt agronomic principles that use technology other manual labour and ensure that farmers are paid when they provide labour.

Reaching the poorest and most vulnerable groups

- Ensure that the vulnerable and often-overlooked groups such as women, youths, PLHIV, elderly, landless workers and poor women farmers are included in all stages, including during consultation, resettlement and land reallocation, during implementation and monitoring and evaluation.
- In order to know who vulnerable rapid vulnerability assessments should be included in the consultation processes.

Monitoring and evaluation of gender and youth activities

- Ensure that the intervention logic of any project being designed has SMART and gender and youth sensitive indicators
- Ensure that monitoring the progress made in applying gender and youth approaches in irrigation projects is regularly undertaken.
- Ensure that all indicators at input, output, outcome and impact level are disaggregated by gender, age, household headship, location and marital status, where necessary. Indicators that can be used are included in the annexes.
- Ensure that programme targets are gender and youth disaggregated
- Ensure that monitoring and evaluation terms of reference and teams have gender expertise.

Gender and youth capacity building and sensitization at various level

- Cabinet level:
 - Presidential directives
 - Gender and youth briefings and awareness sessions
 - Policy briefs on gender and youth
- Ministries and departments :
 - Establish focal points in ministries
 - Train planning and monitoring and evaluation officers on gender and youth
 - Joint planning and monitoring teams
 - Technical support on gender and youth

- District Executive Committees Members :
 - Allocate resources for gender and youth analysis, gender and youth training and mainstreaming
 - Train of the District Executive Committee on gender and youth
 - Establish focal points in sectors
 - Joint planning and monitoring teams
 - Technical support on gender and youth
- Community structures :
 - Orient local leaders (such as Councillors, Traditional Leaders, Religious Leaders on gender and youth issues and women's and youth' rights
 - Train of the ADCs, VDC and AECs on gender and youth
 - Conduct gender and youth analysis together with District and Community Teams
 - Train community-based volunteers in gender and youth issues such as gender and youth participation in decision making
 - Conduct participatory gender and youth analysis, planning and monitoring at community level
 - Establish local gender and youth forums or advocacy groups
- Household level :
 - Sensitisation of men, women and youth on the roles and importance of women and youth and women's and youth' rights

In addition, impact on landless and vulnerable people is addressed in the Resettlement Policy Framework (COWI, 2016), this will be further be studied once the Resettlement Action Plan is produced.

7.9 CULTURAL HERITAGE

7.9.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

- During construction, excavation of the canal will affect some known and unknown cultural heritage sites mainly pottery (**Loss of physical cultural heritage**). Identification of affected pottery sites is in annex of Vol.1 (Baseline report). No sacred sites will be affected by the canals. Based on COWI work (2016):
 - The actual main canal alignment is not running through graveyards with the exception of one case where a branch canal is crossing a graveyard. The canal alignment is proposed to be modified to avoid this situation.
 - Religious structures, such as local churches and other places of worship, were also recorded as points of special interest during the land use mapping by COWI. A significant number of religious structures were identified, but none will be affected by the main canal or the branch canal alignments.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Loss of physical cultural heritage. During construction, excavation of the canal will affect some known and unknown cultural heritage sites.
Value of the affected component	Highly valued
Intensity	Low
Extent	Punctual
Duration	Permanent
Significance	Minor
Occurrence probability	High probability

7.9.2 Mitigation measures

Due to the identification of 87 cultural heritage sites (46 by the MDoA and 41 by BRLi), of which more than half might be impacted by the Project's land-transformation activities, mitigation measures will be necessary in the form of a Cultural Heritage Management Plan (CHMP). The CHMP allows avoiding or limiting adverse impacts and looking for opportunities to maximise the benefits of those resources. This management plan is included in the ESMP (Vol.3).

The World Bank's Operational Policy 4.11 on Physical Cultural Resources states that "as an integral part of the EA process, the borrower develops a physical cultural resources management plan that includes measures for avoiding or mitigating any adverse impacts on physical cultural resources, provisions for managing chance finds, any necessary measures for strengthening institutional capacity, and a monitoring system to track the progress of these activities". According to OP 4.11, this management plan needs to be consistent with the country's overall policy framework and national legislation and needs to take into account institutional capabilities with regard to physical cultural resources.

Concerning the institutional capabilities of managing physical cultural resources, it is important to mention that Malawi has limited financial and professional resources to implement holistic cultural heritage management projects. Under these circumstances, a conventional North American CHMP strategy, with avoidance of all sites as the primary goal of the project, does not appear appropriate to the circumstances at hand. The fact that considerable numbers of archaeological sites have been discovered and many more sites may be buried underneath the surface, constitutes another important finding of this study, indicating the high probability that the sites buried underneath the surface will be revealed once land-transformation activities start.

Furthermore, the IFC's Performance Standard 8 states that "the client will identify and protect cultural heritage by ensuring that internationally recognized practices for the protection, field-based study, and documentation of cultural heritage are implemented".

At this early stage, the following mitigation measures are recommended by the consultant, which comply with national legislation and internationally recognized practices concerning heritage protection. The MDoA should also be directly involved in the implementation of the Project's CHMP. However, as the staff of the MDoA is equally tied up with a lot of administrative responsibilities, there should be room to engage professional individuals and/or a structure active in cultural resource management that can assist in the implementation of the Project's CHMP. The training of University students and representatives from the MDoA should also be carried out during all stages of this CHMP in order to strengthen the national capacity in cultural heritage management in the context of development projects.

PHASE 1: PRE-CONSTRUCTION DATA COLLECTION (FOR DETAILS SEE ESMP)

The following measures shall be implemented before construction starts:

- **Artifact collection** using hand excavated shovel pits or augers to assess the depth of sites and range of artifacts and controlled excavation of high priority sites (see Vol. 1 Baseline report and Vol. 3 ESMP). One element is to be noted: many of these sites were identified in or along rivers in 2016 by the consultant and there is a chance that flash floods have washed them away;
- All artifacts collected shall be catalogued and described, and curated in Malawi through a governmental institution (MDoA). Artifacts could be exposed in the valley at the Tisunge! Lower Shire Heritage Centre at the entrance of LNP;
- Appropriate analyses of collected artifacts such as ceramics, copper objects and slag, etc. will be completed as they are collected;
- A report will be issued describing and interpreting the cultural resources found and placing them within a broader cultural-historical framework; and
- Publication of results in peer-reviewed journals.

PHASE 2: MITIGATION PLAN DURING CONSTRUCTION (FOR DETAILS SEE MANAGEMENT PLAN)

During construction, the following mitigations shall be implemented:

- Contractor training and awareness program based on identified cultural sites, sacred sites and graveyards;
- An initial one or two months period of selective archaeological monitoring of surface clearing and earth work during construction in areas with poor surface visibility and/or a high probability for cultural resources buried below the surface; assessment of artifacts recovered during land transformation activities; training of Malawian students in archaeological monitoring;
- Salvage excavations at sites deemed as of high priority (see annex of Vol.1 Baseline Report and Vol. 3 ESMP);
- Once the initial period of archaeological monitoring and salvage excavations is over, the Project will apply Chance Find Procedures (see Vol.3 ESMP for the details). Personnel from the MDoA should decide about necessary management measures;
- Avoid/minimize construction-related impacts to known cultural resources (see Vol.1 Baseline report).

7.10 NATURAL HERITAGE

This section describes impacts on parks on a socioeconomic aspect (tourism, management and infrastructures). The section on “Terrestrial habitat and wildlife” discusses impacts on parks from an ecological point of view (wildlife movement, etc.).

Measures have been developed in close consultation with concerned park management.

7.10.1 Description of impacting activities

The impact matrix has identified several activities and impacts presented in the following sections.

7.10.1.1 Decision on the type of canal and its alignment route

During pre-construction stage (design stage), decisions regarding the canal layout will have long term consequences on parks. The current canal alignment route (based on the FS) is 2.45km inside Majete Wildlife Reserve and 14km inside Lengwe National Park (Bangula canal). Technical studies shall evaluate the feasibility of several options inside two parks to minimize impacts. This section presents some case scenarios as an introduction for other sections.

OPEN VERSUS CLOSED CANAL

Majete Wildlife Reserve (managed by African Parks)	Lengwe National Park (managed by the Government)
<p>An open canal leads to significant impacts as:</p> <ul style="list-style-type: none"> • An open canal is not compatible with touristic activities as the Feeder canal passes in the “High Intensity Tourism Zone” and that it will have to be heavily fenced or walled to keep large animals (elephants, hippo, crocodiles, etc.) from entering the canal and : <ul style="list-style-type: none"> - Risking their life (the canal will be a death trap) - Damaging the canal - Using the canal as a pathway to access areas outside the reserve and entering in conflict with communities <p>An open canal will represent a physical and aesthetic barrier for tourists; MWR will lose its attractiveness in the eastern side of the Park.</p> <p>From discussion with African Parks, a closed canal is the favored of the two options as it will minimize impacts on several level (tourism, wildlife movement, risk of drowning, etc.)</p>	<p>An open canal leads to impacts as:</p> <ul style="list-style-type: none"> • The open Bangula canal will pass through the “Central Wildlife Viewing Area” which is the area where most wildlife are located and tourists are visiting the park. An open canal may lead to, depending on its layout, significant wildlife drownings. <p>However, in LNP, an open canal can be seen as an opportunity to provide water for wildlife since the park suffers from water shortage.</p>

EARTH VERSUS LINED

Majete Wildlife Reserve (managed by African Parks)	Lengwe National Park (managed by the Government)
<p>Earth canals look more natural than lined canals. Therefore, having a lined canal has an impact on landscape. Lining in canal is one of the factor that leads to drownings as concrete gets slippery and the smooth surface of concrete does not allow animal to have a good grip.</p>	

CURRENT ALIGNMENT ROUTE OF THE CANAL

Majete Wildlife Reserve (managed by African Parks)	Lengwe National Park (managed by the Government)

The current alignment route of the canal which runs along a 2.45 km route inside MWR could be optimized to short cut the reserve as it leads to numerous impacts (as presented in sections hereunder).	The current alignment route of the canal which runs along a 14 km route inside LNP leads to numerous impacts. However, there is no possible short cuts for a gravity canal (as presented in sections hereunder). A canal may become an opportunity for wildlife if properly designed, as water is scarce in LNP.
--	--

ASSESSMENT OF IMPACT SIGNIFICANCE

	Decision on the type of canal and its alignment. Decisions regarding the canal layout during the design stage will have long term impacts on parks
Value of the affected component	Highly valued
Intensity	High
Extent	Local
Duration	Permanent
Significance	Major
Occurrence probability	Potential occurrence (as no decision will probably be made before the Design study)

7.10.1.2 Decision on the status of canals inside parks

During pre-construction stage, the presence of canals inside parks will require a clear definition of their status. Decisions regarding the canal and (water intake) status may have long term impacts on MWR and LNP as it will influence how their access inside these parks is managed and how park management will be consulted in the Project decision making process.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Decision on the status of canals inside parks. The presence of canals inside parks will require a clear definition of their status
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	Potential occurrence

7.10.1.3 Tender process and selection of a construction contractor

During pre-construction phase, the tender process for the selection of the project construction contractor represents a high risk for parks (and all other social and environmental components) as it is a crucial step in binding environmental measures. This tender process represents a high risk for MWR and LNP for several reasons:

- The construction contractor may not have any environmental sensitivity nor a proactive attitude (no environmental policies or no expert among its staff, etc.), or may not have any experience in work in sensitive areas such as parks.
- The tender document and the contractor's contract may not include sufficient binding environmental measures or may not have any leverages in case of non-compliances.

- Parks management may not have any official supervision role of construction activities within the parks and may not have any authority over the contractor in cases of non-compliances. Whenever a serious non-compliance is observed by park managements, the long chain of communication toward decision may hinder quick actions.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Tender process and selection of a construction contractor. The tender process for the selection of the Project construction contractor represent a high risk for parks as it is a crucial step in the development of binding environmental measures
Value of the affected component	Highly valued
Intensity	High
Extent	Local
Duration	Temporary
Significance	Major
Occurrence probability	Risk (low probability)

7.10.1.4 Impact on tourism

Construction activities in MWR and LNP will have very serious deleterious impacts on tourism on a financial point of view especially at MWR since:

- Aesthetic aspects of tourism will be compromised at the Kapichira dam with the water intake structure and make this location no longer viable for tourism.
- Work will create visual disturbances to visitors and impact the natural experience during the construction process. Physical excavation, blasting and terracing along the path of the canal and access roads will affect landscape.
- Noise from equipment will impact visitors experience at day visitor center, headquarters and Thawale lodge. The path of the canal passes close to the community campsite and during construction will make this a very unattractive destination and as a result affect business at the campsite. The revenue from this campsite goes directly to the community which they utilize for social welfare and community projects. This revenue will be significantly impacted due to loss of business during construction.
- Work will lead to intense truck traffic inside MWR, most likely along Mkulumadzi Road (because of topographic constraints and cliffs, the access road along the Feeder canal route will most likely not be practicable for trucks). An estimate of 100,000 m³ will be excavated for the canal in addition to the 560,000 m³ to 640,000 m³ of dredged sediment at the reservoir (water intake) (Artelia, 2016). Depending on the duration of work inside MWR, this will lead to a tremendous amount of trucks passing inside the reserve as shown in the following table.

Table 10 Estimation of the number of trucks

Indicative work duration inside MWR*	Number of trucks passing through the reserve (given a load of 25 m ³ per truck) for a total of 100,000 m ³ of earth (canal excavation in MWR) + 560,000 m ³ to 640,000 m ³ of dredged sediment
1 year	<p>26,400 to 29,600 trucks travelling on week days represents about 100 to 116 loaded trucks per day or about 12 to 15 trucks per hour or about 1 loaded truck every 5 minutes.</p> <p>Trucks will travel back, therefore the number of loaded and unloaded trucks passing through the reserve will be about 1 truck every 2-3 minutes</p>
2 years	<p>26,400 to 29,600 trucks travelling on week days represents about 50 to 58 loaded trucks per day or about 6 to 8 trucks per hour or about 1 loaded truck every 10 minutes.</p> <p>Trucks will travel back, therefore the number of loaded and unloaded trucks passing through the reserve will be about 1 truck every 5 minutes</p>

* at time of the ESIA the work duration inside MWR was not known.

- Loss of revenue from tourism business due to visual, aesthetic and noise impacts which will make MWR a less attractive destination during the construction process (the number of paying tourists was around 8000 for the year 2015).
- LNP will be affected but to a lesser extent since construction will take place far from the main activities which are concentrate at the eastern end of Old Lengwe. In addition, in LNP the access to construction site can easily be done by the existing road outside the Park (the road used by communities that surrounds the park). Lastly, LNP does not actually attract much tourists and incomes from tourism are low (see Vol. 1 Baseline report: "in 2015, the number of paying visitors had remained steady at 556).

Boat trips in MWR will not be affected during the construction process since the jetty is located on the other side of the spur dike (training dike) opposite to the water intake.

Ng'ona lodge (also called Mwembezi lodge) is a private property (the land tenure was not verified by the consultant, the owner of the lodge declared she owns the land around the lodge) that will be affected by work as the road that leads to the lodge will be used by machinery and trucks, this road follows flat land and cannot be diverted due to changing topography. The owner of the Lodge was met at time of the Consultant last mission to present the impacts.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impact on tourism
Value of the affected component	Highly valued
Intensity	High for MWR, Low of LNP and Ng'ona lodge
Extent	Local
Duration	Temporary
Significance	Moderate (MWR) / Minor (LNP and Ng'ona lodge)
Occurrence probability	High probability

7.10.1.5 Impact on Majete buildings, roads and infrastructures

Construction of the Feeder canal may have impacts (dust, vibration, etc.) on several buildings and infrastructures of Majete Wildlife Reserve: Malaria research camp, Heritage center, Entrance gate, Wildlife research camp, Community camp site, electric fences, access road to the park, access road to Kapichira falls viewing site are the closest infrastructures to the future canal. Certain tourism roads will no longer be viable during construction because they will be used by construction machinery or very close to the construction site (Hall-Martin, start of Mkulumadzi road along Shire and Kapichira falls road). Chikwawa to Majete main road (D135) condition will be affected due to regular use of heavy construction equipment and passage of trucks. Many electric fences will directly be affected in areas where the canal crosses (exit point of reserve close to office, entrance and exit points at the entrance gate complex and along Mwambezi river), shutting down electric fences during construction may lead to animal escape outside MWR. Boreholes for drinking water (for reserve staff housing) could be damaged due to blasting. The following figures are buildings that are relatively close to open section of the canal (based on information provided by the FS report).

- Office building: 120 meters
- Entrance gate: 400 meters
- Heritage center: 425 meters
- Community camp site: 225 meters (and 200 from the buried section of the canal)
- Wildlife research camp: 290 meters

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impact on Majete buildings, roads and infrastructures. Infrastructures will be disturbed by construction of the Feeder canal
Value of the affected component	Highly valued
Intensity	Medium
Extent	Punctual
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

7.10.1.6 Impact on Kapichira falls attractiveness

The small reservoir is created by Escom dam to feed the hydropower plant. At the dam wall, an environmental flow is currently released by sluice gates.

During operation of the scheme, the feasibility of the falls as a sight to see for tourists may be compromised on long term with reduced flows especially during the dry season. The following table shows the number of months when the flow at Kapichira falls (below the dam) is and will be inferior to 10 m³/s with actual management of Kamuzu barrage. Under 10 m³/s, due to the presence of large boulders, falls become “invisible” to visitors as shown in the following figure. The following table takes into account the variability of needs for SVIP based on season (dry versus rainy), it applies to Phase I and II.

Figure 19 "Invisible" falls at 5m³/s (November 2016)



Source: BRLi, 2016

Table 11 Number of months when the falls will be "invisible" (below 10m³/s)

Nb Months	Kapichira I+II (baseline situation)	Kapichira I+II & SVIP
2013	0.4	6.6
2014	0.0	9.5
2015	1.5	10.1
<u>Mean</u>	<u>0.6</u>	<u>8.7</u>
<u>Min</u>	<u>0.0</u>	<u>6.6</u>
<u>Max</u>	<u>1.5</u>	<u>10.1</u>

Based on this table, falls will be invisible from 6.6 months of the year to 10.1 months upon completion of Phase I and II. This is a noticeable difference from the baseline situation (where falls are only “invisible” at the peak of the dry season between October and November). In fact, an accurate statement is that SVIP will withdraw what is currently released as an environmental flow, leaving only room for a flow during the peak of the rainy season (January to Mars). However, in terms of tourism, the most impressive flows over the falls are during the rainy season which will be less impacted by SVIP.

See section 6.5 for the full set of calculation for different scenarios (50, 40, 30, 20 and 10 m³/s).

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impact on Kapichira falls attractiveness. The viability of the falls as a sight to see for tourists may be compromised on long term with reduced flows
Value of the affected component	Highly valued
Intensity	Medium
Extent	Punctual
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

7.10.1.7 Impact on Lengwe roads and infrastructures

Construction of Bangula canal will have an impact on fences and access roads of Lengwe National Park. The canal crosses paths inside the park at 4 locations:

- North Thicket Drive,
- South Thicket Road,
- Makanga Drive
- Tsanya Drive

These paths are used by tourist to travel in Old Lengwe. They were upgraded with World Bank funds (SRBMP) in 2015.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Impact on Lengwe roads and infrastructures. The fence and park roads will be impacted
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Temporary
Significance	Moderate
Occurrence probability	High probability

7.10.1.8 Loss of ownership of park management on the western side of LNP

Construction and operation of Bangula canal will split the park in two and could aggravate the weak message of ownership that management sends due to low presence of rangers in the western part of the park. The park has porous boundaries and surrounding villages do not fully accept the presence of a park (personal communication with park staff, 2015) as many use it as grazing area (personal observation, 2015, LNP General Management Plan GEF, 2016), as a source of timber (personal observation, 2015, satellite imagery interpretation, 2016) and as a source of bush meat (WESM, 2016). Deforestation, poaching and village encroachment are identified as the most threatening ecological issues of LNP by the general management plan (GEF, 2016). If the canal crosses the Park, a new infrastructure inside the Park, it may be interpreted by villages as a message that park management is “letting go” the western part of the park, leading to increasing occupation in this area and utilization of the Park resources. The presence of a canal could also become very attractive for livestock owner as watering point, further increasing the presence of cattle in the park.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Loss of ownership of park management on the western side of Lengwe. Construction and operation of the Bangula canal will split the park in two, this could be interpreted as a message of weak ownership
Value of the affected component	Highly value
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	Potential occurrence

7.10.1.9 The presence of a canal inside parks will be long-term agent of changes

Three new situations will bring challenges to park management:

- the presence a linear infrastructure inside parks ;
- the presence of new stakeholders with different interests ;
- new chains of responsibilities in decision making process.

The presence of a canal and the water intake will require additional efforts and inputs from MWR and LNP management in order to maintain parks' integrity. Negative impacts from linear infrastructures crossing natural habitats are well documented in Africa and the Feeder and Bangula canals will probably not be the exceptions. These canals may become agents of negative changes as management will have to deal with new stakeholders (the construction contractor and the scheme operator during operation), who's interests and actions may negatively impact them. Operation may also bring unexpected impacts from surrounding communities with increase encroachment as it is the case with linear infrastructures. In addition, there is a possibility that new impacts arise due to changes in layout, changes in scheme operator and unexpected events. If any such unexpected event takes place, the decision making chain of responsibilities may be too complex to allow parks to rapidly take action because of the presence of new stakeholders with fundamentally different interests:

- the construction contractor who's interest will be to deliver infrastructures within the delays and the allocated budget;

- the scheme operator who's interest will be to ensure delivery of water to water user associations within its budget (and, without proper sharing of information, may not be aware of all environmental and social risks);
- park management who's interest is the safeguard of wildlife and habitats while maintaining tourism financially viable.

Other risks may come from mitigation measures themselves as they may not work on the short and long terms since they are no or few return of experiences in Africa for many of the proposed mitigations (see other sections on the tiger fish and wildlife passes). The maintenance road along the canal will also represent an agent of change especially in LNP where communities will use it as a travel path as it is the case with an existing "unformal" road inside the park (see Vol.1 Baseline report). The following are examples of unpredictable impacts that could arise:

- Changes in wildlife behaviors regarding the canal: wildlife entering the canal to travel (causing damages to structures, leading to wildlife-human conflicts, etc.);
- The canal becoming very attractive to wildlife as drinking spots, as the quality of water will be better than in the reservoir or puddles from boreholes;
- Accident involving wildlife: what will happen if an antelope falls in the canal, breaks its legs and needs assistance to be extracted from the canal? What will happen if an animal drowns and dies in the canal? Who will pay for such unexpected impacts, who will extract the dead animals from the canal? How will maintenance interventions on the canal be planned? Who will pay for maintenance of wildlife passes? An animal in distress in a canal could give parks a bad image if the situation is filmed and published on social media, etc.
- Poaching from maintenance staff: what will happen if an employee of the irrigation operator is caught poaching?

All these represent risks that are difficult to assess.

In LNP, there is a risk that the Project aggravates existing issues in the Park:

- There is a risk that livestock use wildlife passes or drink from the canal, as currently in some areas cattle rearing takes place inside the park and law enforcement do not seem to efficiently fight this (farmers are even burning grazing sites inside the park to prepare for the rainy season!);
- There is a risk that poachers have an easier time hunting wildlife close to the canal as it may become a drinking spot;
- There is a risk that the canal may be used by villagers either to shortcut their travels (to the other side of the park) or to fetch for water.
- There is a risk that buffalos be tempted to exit the park and enter in surrounding fields. It has been reported that, in 2013, buffalos entered Illovo fields and remain there for a while causing damages to crops.

ASSESSMENT OF IMPACT SIGNIFICANCE

	The presence of a canal inside parks will be long-term agent of changes. The presence of canals and other infrastructures inside parks will require additional efforts and inputs from park management in order to maintain parks' integrity
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	Potential occurrence

7.10.1.10 Summary of impact significance

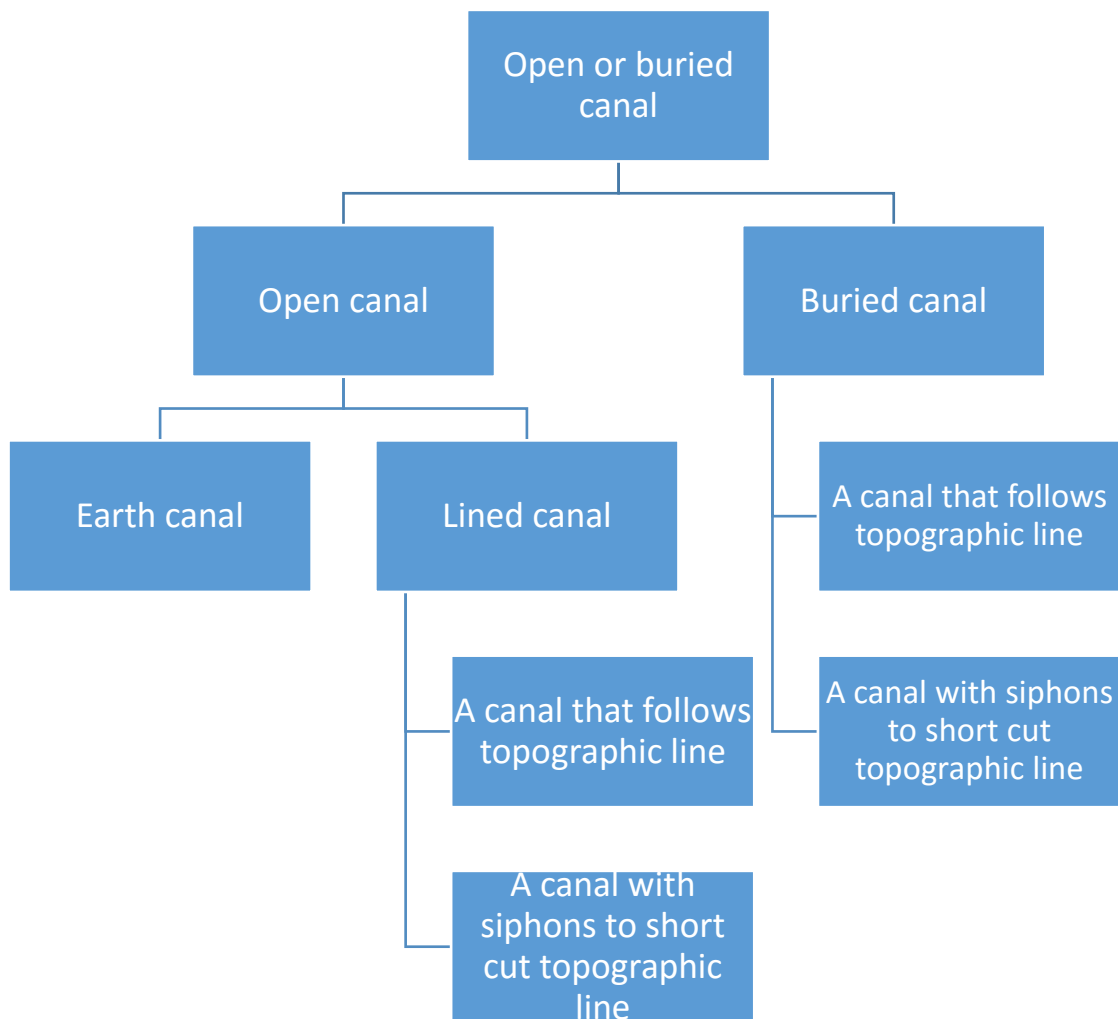
Impacts	Significance	Occurrence probability
Decision on the type of canal and its alignment route: Decisions regarding the canal layout during the design stage will have long term impacts on parks	Major	Potential occurrence
Decision on the status of canals inside parks: the presence of canals inside parks will require a clear definition of their status	Moderate	Potential occurrence
Tender process and selection of a construction contractor: the tender process for the selection of the project construction contractor represent a high risk for parks as it is a crucial step in development of binding environmental measures	Major	Risk (low probability)
Impact on tourism: Touristic activities will be compromised during construction activities across MWR and LNP and Ng'ona lodge	Moderate (MWR) / Minor (LNP and Ng'ona lodge)	High probability
Impact on Majete buildings, roads and infrastructures: Infrastructures will be disturbed by construction of the Feeder canal	Moderate	High probability
Impact on Kapichira falls attractiveness: The viability of the falls as a sight to see for tourists may be compromised on long term with reduced flows	Moderate	Potential occurrence
Impact on Lengwe roads and infrastructures: Construction of the Bangula canal will have an impact on fences and access roads of Lengwe National Park	Moderate	High probability
Loss of ownership of park management on the western side of Lengwe: Construction and operation of the Bangula canal will split the park in two, this could be interpreted as a message of weak ownership	Moderate	Potential occurrence
The presence of a canal inside parks will be long-term agent of changes: The presence of canals and other infrastructure inside parks will require additional efforts and inputs from park management in order to maintain parks' integrity	Moderate	Potential occurrence

7.10.2 Mitigation measures

7.10.2.1 Decision on the type of canal and its alignment route

There are several avoidance and mitigation measures when it comes to the layout of the canal. The following sections show the different options that could optimize the canal.

CANAL OPTIONS INSIDE MWR



Open versus buried canal

MWR: An open canal should be avoided as much as possible and the Design shall favor a buried canal or at least a closed canal in the area where the canal runs within the park fences. The canal route is important for tourists (viewpoint of the Kapichira falls, etc.) and for wildlife (access to drinking spots along the river).

A buried canal should be designed in order to mitigate the serious impacts on MWR. For the 50m³/s, underground pipelines will not be technical easy and difficult to access for maintenance, however underground concrete box culverts is a feasible option as presented in the FS. They would have to be designed to sustain the passage of vehicles and large animals such as elephants. This is why the term “buried canal” is more appropriate than “closed canal” as it implies a higher resistance to heavy loads.

LNP: there is less incentive to have a closed canal in Lengwe mainly because wildlife suffers from water shortage, a well-designed canal could even be an opportunity to have more water available for wildlife. More water could event lead to an increase of the carrying capacity of the Park.

Earth versus lined canal

MWR & LNP: an earth canal looks more natural than a lined canal. Therefore, having a lined canal has an impact on landscape. According to the FS, since soil permeability is very high in MWR water leakage will be very high if an earth canal is chosen. Therefore, the canal will be lined with concrete. In addition, given the presence of large mammals in MWR who enjoy using watercourses to bath such as elephant and hippopotamus, an earth canal will quickly be destroyed by these animals.

The FS has stated that soil properties allow for an earth canal in LNP with two permeability tests. However, fieldwork by the consultant along the canal alignment revealed that some areas are sandy. In-depth assessment would be required before stating that an earth canal will be implemented.

Changing the alignment route to reduce impacts (MWR)

The canal has to follow topographic contour lines. The question of changing the alignment route to short cut topographic lines were addressed and the FS has identified areas where an inverted siphon will allow to short cut topographic lines.

A section of the Feeder canal is passing close to building, this will call for mitigation measures (see section hereunder).

In addition, in many areas, the micro topography is very irregular as shown in the following figure along the canal foreseen alignment route (this was taken following the topographic pegs).

Figure 20 Example of the micro topography along one km of the Feeder canal (between KP 2.8 and 3.6)

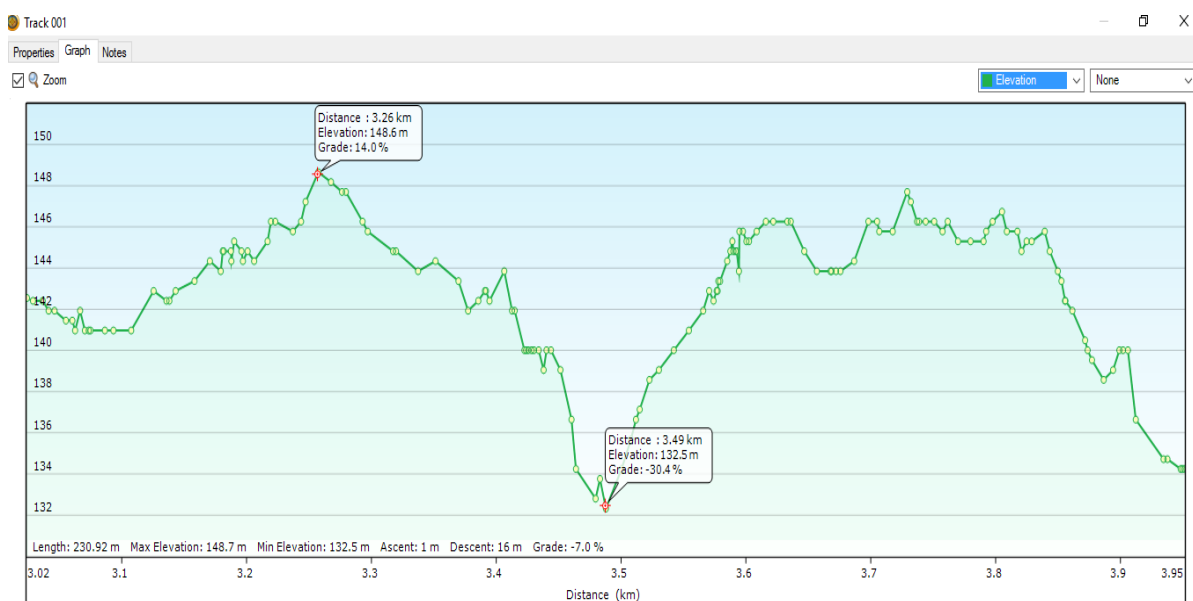


Figure 21 Exact alignment of the Feeder canal inside MWR according to the FS



A topographic peg is visible on the tree on the right photo. Source: BRLi, 2016

Summary of options for a canal inside MWR

The following sections highlight the differences between open and buried canal inside MWR. The current Final FS has optimized the Feeder canal based on technical and economic criteria with sections both open and buried (see project description). During the ESIA process, several options were studied by the FS, some were adopted others rejected:

- (i) location of the intake at Kapichira Dam, rather than Hamilton Rapids to greatly reduce the impact on MWR (adopted);
- (ii) location of the intake on the Left (East) Bank of the Shire River, completely out of MWR (rejected due to high cost and significant technical limitations with a canal crossing the Shire);
- (iii) location of the intake below Kapichira Dam (rejected, because pumping stations would be required, which would substantially raise the operating costs for the new irrigation farmers and make the project less financially viable); and
- (iv) locating all of the Main Canal underground within the Majete Reserve (rejected because it would complicate construction of the invasive fish barrier, because the planned decorative walls will effectively prevent most wildlife from entering the canal, and because of the high investment and maintenance costs associated with underground canal).

This ESIA also highlights the need to study ways to optimize the canal based on environmental (under section 8.5.2) and touristic issues (under section 7.10.2). Whether the Feeder canal layout from the FS is final or not, the Design study shall further develop ways to minimize as much as possible impacts on MWR.

One guiding principle is that the canal alignment shall be optimized to have as much as possible buried section and to short cut to the maximum possible the distance inside MWR and to remain as far as possible from the reserve buildings (entrance gate, etc.).

CANAL OPTIONS OUTSIDE MWR

A water intake on the left bank of the reservoir beside Escom water intake

The relevance of having a canal inside MWR has been given consideration due to the major impacts on tourism and wildlife (chapter 8). During mitigation workshops (November 2016), it was requested that the FS studies the possibility of having a water intake on the left bank of the reservoir with an aqueduct crossing Shire River around the Escom tailrace. The riverbed and banks at this location are made of large rocks, and seems to be stable. Having an intake on the other side of the reservoir would keep MWR intact. This water intake could be located beside the current intake for the hydropower station. Unfortunately, due to the lower topography on the east bank of Shire, this option would represent a significant economic expense for an irrigation scheme that revolves around gravity irrigation. In addition, Escom has the intention to develop more infrastructures on this site. This option has been assessed in the final FS and proven not to be feasible.

CONCLUSION

These options have been presented to African Parks as part as stakeholder consultation, according to them a buried canal would be better than a lined canal, if stretched of the canal are open, African Parks has requested that vehicle and wildlife passes be installed as well as walls to avoid drowning.

In areas where the canal is lined and open, major impacts on wildlife are to be expected, and mitigation measures should be implemented, their feasibility is studied in this report in the section on Ecology Impact (chapter 8). Therefore, in the final Design, the entire length of the Main Canal within Majete must be either buried, covered, or walled off to prevent wildlife (including all large mammals) from falling into the canal.

African Parks has plans to develop two areas impacted by the Feeder canal

It must be noted, that there is a large portion of MWR that is not fenced, but still falls under the MWR management to the East of the main road where the proposed canal will now run through. MWR reserves the right to develop this area and has a plan to do so. African Parks has approved one project within MWR boundary: a small area for non-dangerous wildlife observation (antelopes, etc.) for school trips and children. This area is located on the Feeder canal alignment route between KP 1.25 and 1.65. In this area, the canal will be open and will require mitigation to avoid children and animal drowning. On the other hand, at this location, an open canal can provide water for wildlife by creating a small wetland which would become an important asset. The wetland could be around 30 meters in diameter and shall be lined with concrete to avoid seepage, with a depth of 0.5 m, it would require about 350 m³ of water from the canal, filled every two days, this would be the equivalent of 1230 m³ per week (or 0.002 m³/s) which is negligible in regard to the volume of water in the canal. Another project is under study along the canal alignment route: the development of housing and lodge units at the southern tip of MWR. These two areas are presented in the map hereunder.

Buried canals reduce aesthetical impacts and erase the need for wildlife passes. However, a buried canal does not mitigate all impacts such as those related to construction activities since it requires blasting activities.

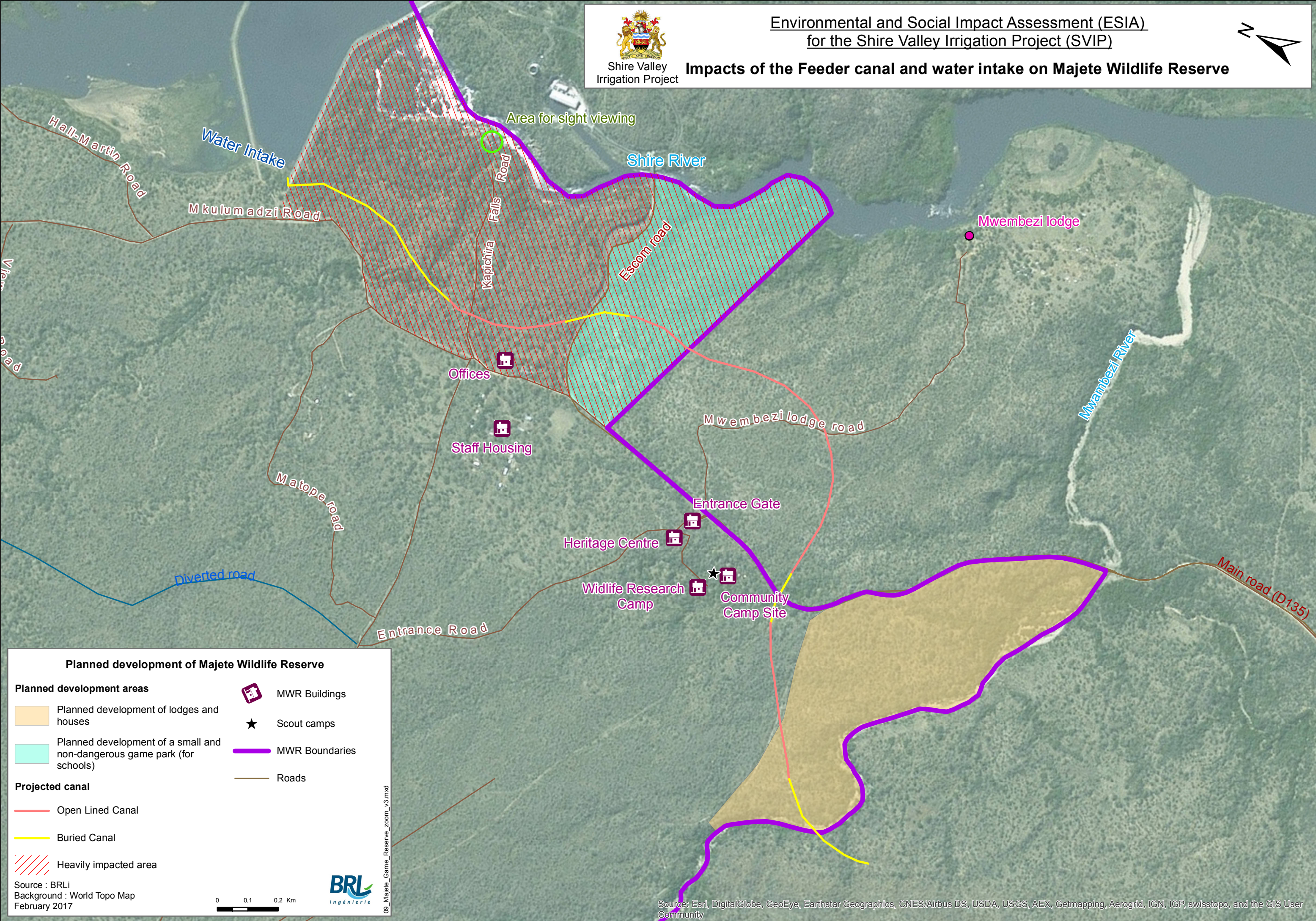
All have to be studied in depth at the design stage, in consultation with African Parks. In addition, all options have to be studied in light of recommended mitigations for ecological impacts (see chapter 8).



Shire Valley Irrigation Project

Environmental and Social Impact Assessment (ESIA) for the Shire Valley Irrigation Project (SVIP)

Impacts of the Feeder canal and water intake on Majete Wildlife Reserve



Planned development of Majete Wildlife Reserve

	Planned development of lodges and houses		MWR Buildings
	Planned development of a small and non-dangerous game park (for schools)		Scout camps
	MWR Boundaries		Roads

Projected canal

	Open Lined Canal
	Buried Canal
	Heavily impacted area

Source : BRLi
Background : World Topo Map
February 2017

0 0,1 0,2 Km

09_Majete_Game_Reserve_zoom_v3.mxd

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

CHANGING THE ALIGNMENT ROUTE TO REDUCE IMPACTS (LNP)

Due to topographic constraints illustrated on the topographic map and characterized on the field, the canal cannot shift further westward from the Old Lengwe to minimize impact on thicket habitat (see chapter 8). The next figure illustrate topographic changes across the canal section (from BRLi field work). Therefore, there is no possible measures to change the alignment route, siphons are not necessary since there is not steep slopes inside the park.

Figure 22 Elevation constraints in LNP



7.10.2.2 Decision on the status of canals inside parks

The canals shall remain within the MWR and LNP “administration” and the right-of-way of canals shall not be alienated from MWR and LNP. Access to the intake and canals for maintenance will be managed in accordance with African Parks and LNP access restrictions (and inspection to avoid poaching). This means that there shall not be any independent access gate to canal maintenance road inside MWR and LNP. Scheme operator staff shall enter and exit parks as every visitors entering the parks.

In case of wildlife passages (and other civil engineering infrastructures within the park), their status shall be clearly defined in order to clarify who will be responsible for maintenance of such passages and infrastructures. A Memorandum of Understanding between the project operator and African Parks/LNP will be necessary to ensure long-term commitments.

African Parks/LNP management need to become important stakeholders in the project next steps including in the design review phase and advice on the tender process for the construction and operation of the scheme.

7.10.2.3 Tender process and selection of a construction contractor

The tender process for the pre-selection and selection of a construction contractor is a crucial step, it is at this stage that risks can be partly managed. It is therefore strongly recommended that:

- the tender document requires that the construction contractor has several references in work in parks or environmentally sensitive areas and that these references be verified to ensure that work went well (reputation of the contractor shall be checked before the selection). In order to verify the contractor’s reputation the following method shall be applied:

- The bidding document and contract shall reflect the new requirements of the World Bank as highlighted in the document “Summary of Environmental, Social, Health and Safety (ESHS) Enhancements Standard Procurement Documents (SPDs) & Standard Bidding Documents (SBDs)” One of its requirement is that: “Applicants/Bidders/Proposers are now required to make a declaration listing any civil works contracts that have been suspended or terminated by an employer and/or performance security called by an employer, for ESHS reason/s.”
 - The bidding process shall be a two-step one with pre-selection and selection
 - The Procurement specialist shall include “special pre-selection criteria” such as :
 - Number of past failures to complete the contract.
 - Length of time in business.
 - Self-assessment of past client relationship
 - Self-assessment of other relationships (surrounding communities and stakeholders) presenting past claims by NGOs, claims by traditional authorities, etc.
 - Description of past injuries where the bidder is required to provide with a list of past injuries and deaths on construction site
 - Past projects concerned by an ESIA, ESMP and RAP and monitoring and auditing activities. A reputation
 - A “Tender Panel” shall be put in place for the pre-selection process. This panel shall assist the Procurement Specialist in the evaluation of each criteria. This panel shall be composed of NGOs, and important stakeholders such as DNPW, African Parks, etc.
 - For each of these criteria, the bidder shall provide answers and the procurement specialist shall set thresholds. Investigation could be done by the procurement specialist in compliance with national regulation.
- the tender document for short-listed firms includes all applicable environmental and social measures from the Environmental and Social Management Plan (Vol. 3, ESMP).
 - the tender document quantifies needs in terms of mitigation to ensure that the contractor adequately budgets mitigations such as rehabilitation of areas affected by earth work.
 - African Parks and DNPW be involved in proof reading the tender document and the contractor’s contract (or at least parts of it that relate to work within their boundaries) and shall be part of the Tender Panel.
 - the tender document requires the contractor to have a wildlife or environmental specialist in its staff (in addition to a health and safety specialist) that reports to and consults with African Parks and LNP on a daily basis.
 - the contract includes sufficient leverages in cases where the contractor does not respect the various site sensitivities. Delays in payment or reduction of payment shall be applied for non-compliances.
 - local law enforcement be involved in cases of serious unlawful activities such as poaching and prostitution.
 - that the tender document and the contract clearly state roles and authority of African Parks and LNP (DNPW) as well as chains of responsibilities during construction.
 - the contract includes obligation of termination for work in a set timeframe (and compensation for African Parks in case of delays).
 - In addition, African Parks and the DNPW should have a right to review the Design for the upcoming Phase I and to propose improvements, as Phase I will soon start.
 - African Parks and the DNPW shall have the full authority to stop work and take quick actions in cases of serious non-compliances and offences without having to go through long processes of communication. This authority shall be formalized before construction starts and shall be added in the contractor’s contract.

In order to benefit from the return of experience of the work inside MWR, it will be important that environmental measures regarding Bangula canal in LNP be adapted once work has reached Phase II.

7.10.2.4 Impact on tourism

The following mitigations will reduce impacts on tourism:

- The most important mitigation is the provision of funds for compensation due to loss of business. With about 1 truck passing every 1 to 5 minutes, tourism will be affected and, even if work is confined, wildlife will probably hide further inside the reserve (this leads to other impacts as detailed in Chapter 8). A fund for losses shall be provided for the time of construction in addition to fund to produce pamphlets or online advertisements prior to work and after work is over to present the work and to advertise the reserve after work (distribution of vouchers, etc.). These compensations are detailed in the ESMP (Vol.3).
- Regarding transportation of dredged sediment, discussion shall be engaged at Government level about ways to dispose of this large amount of sediment and about the need to avoid storing them within MWR.
- African Parks wishes that construction of the Feeder canal starts and finishes between January and February the same year (in the quietest time of year), or at least that the core of the work takes place during these two months. For noisy operations (blasting, dredging, etc.), the contractor and African Parks shall define times for construction. Noisy processes will be preplanned with warnings and shall not take place during Friday through Sunday and holidays (days which receive a majority of the overall tourist visitation). To minimize disturbance to wildlife as well as tourists, blasting will only be allowed during 11 am to 2 pm (the hottest hours of the day, with generally the least wildlife activity).
- Earth works shall be limited to the path of the canal and all bare soil shall be rehabilitated at post construction in consultation with African Parks. The same rule applies to LNP and rehabilitation shall be done in consultation with DNPW.
- Excavated materials shall be dumped in predetermined area such as a quarry, outside MWR/LNP or only in designated areas specified by African Parks/DNPW.
- Surplus materials suitable for road surfacing shall be used for upgrade of road surfaces in MWR/LNP under the supervision of MWR management/DNPW.
- The contractor will have to restore the road from Chickwawa to the reserve and budget this restoration.
- Temporary construction roads and tracks shall be limited to immediately adjacent site along the canal in the predefined footprint (10m) from the canal path, these roads and tracks shall be rehabilitated upon completion of construction based on decision by AP (either decommissioned or kept and upgraded for visitors).
- The dredger for the water intake (as part of the preparation for the water intake) shall operate at night, if possible (between 9pm to 5am), dredged spoils cannot be stored in MWR (even temporarily).
- The FS report has recommended that noise and dust barriers be installed close to MWR offices and community camps to reduce visual, air quality and noise impacts. In fact, the barrier shall be moved as construction progresses (using mobile noise barriers). These noise barrier must be absorbent (non reflective) and have to be high enough to absorb noise from blasting (at least 3 meters high). Only certified absorbent noise barrier shall be used. Whenever blasting will be used, the best method shall be used. In South Africa, several firms have developed environmentally friendly technics for rock blasting in sensitive areas. An example of such method is called "precision rock blasting" in which cartridges are introduced in drill holes. This technic leads to minimal vibration, noises and flying debris (CN Plant Hire & Rock Blasting, 2016).
- Other compensation proposed by MWR management include:
 - Paving the actual road from Chickwawa to the reserve. This will not lead to impacts as the existing road is already graded

- Providing a pipeline to extract some water from the canal for water supply for our staff village of around 30 households. The actual borehole for the staff village gives yield issues in the dry season.

Figure 23 Mobile noise barrier



Source : Sound Fighter © System, 2016

All specific equipment required to mitigate impacts shall be installed and on-site prior to beginning of work. The schedule of work shall be agreed upon before beginning of work.

Ng'ona lodge (also called Mwembezi lodge) is a private property and compensation shall be paid to the owner for the impact from the canal construction and the canal RoW, these shall be developed in the RAP. Mitigation and compensation includes dust control (with the same frequency as MWR), access road repair, compensation for loss of business, production of information pamphlet for clients, compensation for loss of tree, etc. The lodge will however probably not be affected by noise (as it is located 30m lower than the canal).

Phasing the work inside MWR and Ng'ona lodge private property in three distinctive confined areas is absolutely necessary (so that no work takes place in several areas):

- "Heavily impacted area" (first phase)
- Mwembezi lodge private property (also called Ng'ona lodge) (right outside MWR) (second phase)
- Southern MWR (third phase) from Siphon #2 to Siphon #3

This three phases shall be completely fenced, in order to completely isolate work and to keep wildlife away.

The Design study has to study ways to phase the Project, this would require that excavation is done in one area and followed directly by concrete lining work before reaching the next phase.

Phasing the work shall be mentioned in the call for tender of the construction contractor so all interventions are planned.

7.10.2.5 Impact on Majete buildings, roads and infrastructures

Since the Feeder canal is passing very close to many MWR buildings, mitigation and compensation in case of damages to building and infrastructures should be planned:

- To avoid causing disturbances to reserve buildings (and to keep canal as far as possible from them), an inverted siphon is designed in the FS to short cut the reserve as much as possible (as discussed above).
- Destruction of building is not likely to take place. However, if for any reason it is necessary, the developer has to compensate African Parks for all buildings that will be destroyed to complete rebuild of facility in agreed upon location to a minimum of a similar standard and extent the cost of replacement of such building (according to OP 4.12 on involuntary resettlement). New buildings will have to be completed before the start of construction of the canal so that there is seamless transition to the new facilities before the existing facilities are affected. Costs are in the ESMP (Vol.3).
- All reserve infrastructures shall be assessed prior to machinery deployment. Groundtruthing site visit with African Parks and the contractor shall be done in order to ensure that the contractor repairs all damages to road, water boreholes, building, fences, etc. Pictures shall be taken to assist groundtruthing visit. The main road to Chickwawa should be inspected prior to construction by African Parks, the contractor and Escom to determine a baseline status and to inform any damages that are incurred during the construction process.
- Roads (Hall Martin drive and beginning of Mkulumadzi road) will not be usable by tourists during and after construction due to disturbance and the changed environment. Compensation will be necessary to reroute roads and provide alternatives for tourists to avoid the Hall- Martin road and alternative routing to access southern portion of Mkulumadzi road. The previous map shows a proposed alternative road for tourists (diverted road). In addition, a vehicle bridge shall be installed at Kapichira falls road and on the road to Ng'ona lodge (outside MWR property). Alternative roads and the diverted road shall be finalized prior to all other activities inside the reserve.
- The Contractor shall regularly maintain Chikwawa to Majete main road (D135) in good condition, and the possibility of upgrading this road to asphalt should be considered.
- At a minimum, daily dust control interventions must be put in place along Chikwawa to Majete main road (and within the park). During the dry season (May to November), dust control shall be done every two hours (with water only). This will also ensure that villages close to the road are not impacted by dust. The source of water for dust control shall be taken from outside MWR and outside the Kapichira reservoir and in consultation with local communities. If water is pumped from the Shire, the access shall be stabilized to limit erosion in the river (concrete access ramp).
- Areas where fences will be affected will have to be compensated. Contractor will ensure there is no breach of the fence during construction. All repairs and newly required fence sections will be for the cost of the contractor but done by approved African Parks contractors.
- African Parks also proposed as a compensation for impacts that a pipeline be built to bring water to the rangers housing compound (about 30 houses).

7.10.2.6 Impact on Kapichira falls attractiveness

An interesting mitigation would be to implement timed releases at the sluice gates and to inform MWR visitors on time and season where the falls will be visible. Timed releases of flow is however not recommended since:

- effective coordination of timing of flow releases between ESCOM and African Parks would entail high transaction costs and limited likelihood of real success (visually impressive flows at a guaranteed, pre-arranged time of day are not very likely to happen in practice);

- daily flushing of the falls would be harmful to aquatic and terrestrial wildlife adapted to the dry season Kapichira Falls environment of relatively dry falls with numerous dry boulders and some trickles and pools of water.

As mentioned above, the most impressive flows over the falls will remain during the rainy season which will be less impacted by SVIP.

7.10.2.7 Impact on Lengwe roads and infrastructures

Where Bangula canal crosses roads, a vehicle bridge shall be installed. Based on available map of the park, there are four areas where a bridge shall be installed:

- North Thicket Drive,
- South Thicket Road,
- Makanga Drive
- Tsanya Drive

The map on impacts on LNP shows these roads.

In addition, the project may impact boreholes for watering point that were funded by the SRBMP (still underconstruction). These will have to be avoided or rebuilt to a new location if necessary since Bangula canal may also be utilized to create watering points.

Access to the canal RoW by the construction contractor shall be done from the side of the Park (northern and southern part) and not from existing touristic roads. However, during operation, access to the canal service road shall be done by the Park's entrance only and not by an independent road.

7.10.2.8 Loss of ownership of park management on the western side of Lengwe

The activities of the current Shire River Basin Management Program and the new General Management Plan under SRBMP (GEF, 2106) have developed their own measures. Since the ESMP (Vol.3) only addresses Phase I, Phase II ESMP shall be coherent with SRBMP.

LNP could receive long term funding to improve its governance in the Park, this would include funding for additional staff on field. As part of mitigation for SVIP impacts, a permanent ranger scout for a team of rangers should be installed along the Bangula canal to keep poachers and settlers away. In that case, it is suggested to install this scout close to a wildlife pass as presented in the next sections. Park management also has to require its staff to move further west from their usual rounds.

7.10.2.9 The presence of a canal inside parks will be long-term agent of changes

In order to prepare for long term risks and to ensure that stakeholders interests and mainly those of parks are not affected by others, clear chain of responsibilities have to be defined taking into account all possible situations and "worst case scenarios". A Memorandum of Understanding (MoU) shall be signed between African Parks and the scheme operator for MWR and between the Department of National Parks and Wildlife (DNPW) and the scheme operator for LNP to ensure long-term commitments. It is recommended that this MoU clearly states that African Parks and the DNPW shall never be responsible for animal damages to project infrastructures and that maintenance of all wildlife passes and other infrastructures proposed in this ESIA shall be done (and budgeted) by the scheme operator (including the fences or walls around the canal).

Regarding LNP, it is recommended to:

-
- Install a ranger scout along the canal close to a wildlife overpass ;
 - Install an artificial wetland on the eastern side of the canal (as presented in Chapter 8) ;
 - To sort out all existing issues as described in the General Management Plan of LNP (GEF,2016) (poaching, illegal wood clearing, lack of reliable fence and buffalo entering Illovo field, current issue with Bailey Bridge that has collapsed, lack of field equipment, vehicles and communication equipment, etc.) before implementing any sort of mitigation or compensation measures as these existing issues could aggravate with the Project implementation. This implies that compensation for LNP due to impacts from SVIP could also be oriented to solve current issues:
 - Installing fences to keep buffalos from entering Illovo estate (part of SRBMP funds is currently oriented at installing new fences) and future irrigated lands.
 - Building a new bridge across Nkembedzi Wa Fodya River to replace the current Bailey Bridge (however this may be done before Phase II because it is completely destroyed).
 - Improving existing infrastructures and equipment of the park.
 - Improving existing drinking spots for wildlife.
 - etc.

For both the LNP and the MWR and in fact for all other risks presented in this report, the PPP report shall clearly highlights the environmental and social risks in order to properly inform the future scheme operator and investors.

8. ECOLOGY IMPACT ASSESSMENT

8.1 INTRODUCTION

This section deals with impacts of the Project on biodiversity.

CRITICAL NATURAL HABITAT

Under the World Bank Operational Policy 4.04 on Natural Habitats, critical natural habitats are “area either legally protected, officially proposed for protection, identified by authoritative sources for their high conservation value, recognized as protected by traditional local communities or areas of high ecological value where rare or endangered species are highly depended of their features to complete critical phases of their life cycle”.

Two elements have to be highlighted regarding the safeguard policy on Natural Habitats (OP 4.04):

- the Elephant Marsh could be considered a Critical Natural Habitat because it is proposed for Ramsar Wetland status, while the rare thicket ecosystem is contained within the Lengwe National Park which is a Critical Natural Habitat by definition under OP 4.04.
- the SVIP Program (both the upcoming Phase I Project and the proposed Phase II Project) complies with OP 4.04 because it would not cause the “significant conversion or degradation” of Elephant marsh, MWR and LNP thickets as demonstrated in this chapter.

MWR and LNP are both Critical Natural Habitats as they correspond to all criteria of OP 4.04: legally protected or officially proposed for protection, identified by authoritative sources for their high conservation value and recognized as protected by local communities.

As presented in this chapter, the Project will impact these critical natural habitats but not a point where significant conversion or degradation of natural habitats will take place as severe impacts are socioeconomic impacts (see impact assessment on Natural Heritage). Regardless, as required by OP 4.04, mitigations must be implemented.

MWR is affected by Phase I while LNP will mainly be affected by Phase II. MWR has elephants and the presence of such animal will be an issue for the integrity of the canal since elephant are known to “sabotage” infrastructures when searching for clean water (Elephant Specialist Advisory Group, 2013). This is why the canal in MWR will either be buried or walled.

Given the current issues with LNP (see Vol.1 Baseline report): poaching, lack of human resources, lack of equipment, etc. and the fact another program from the World Bank aims at improving the Park (SRBMP), this ESIA highlights that impacts on LNP could be minimized to an acceptable level as long as recommended mitigations are implemented and that the canal is used as an opportunity to provide drinking water for wildlife. In fact, the presence of water in LNP may increase the park carrying capacity for wildlife.

For both parks, the amount of cleared trees and thickets shall be fully compensated by replanting native species in degraded areas inside parks. This would involve installing a local tree nursery as soon as possible (for LNP) and providing funds to MWR for its existing nursery.

8.2 IMPACT IDENTIFICATION MATRIX ON ECOLOGY

	Pre-construction	Construction	Operation
Land cover	No impact during pre-construction phase	Rapid change in land cover: the Project will lead to significant changes in land cover	
Terrestrial habitats and wildlife		Disturbances of wildlife and vegetation: work will generate noise and necessitate forest and thicket clearing in the right-of-way destroying some habitats and startling wildlife	Habitat fragmentation: with the canal passing through MWR and LNP, wildlife habitats will be fragmented Drowning hazard for wildlife: open canals represent a drowning hazard for wildlife
Wetland habitats and wildlife			Changes in plant composition in Elephant marsh: reduction of flow due to abstraction of 50m ³ /s will affect plant composition Wildlife-human conflict: There is a risk that hippos and crocodiles enter the drains and cause wildlife – human conflicts (and casualties). Irrigated field will become very attractive for wildlife.

	Pre-construction	Construction	Operation
Aquatic habitats and fish		<p>Disturbance to fish migration to spawning sites: works in temporary rivers could lead to disturbances of fish migration</p>	<p>Risk of Tiger fish invasion in the upper Shire: floods from the Shire in canals could lead to invasion of the Tiger fish in Lake Malawi</p> <p>Reduction of suitable habitat for fish in the Elephant marsh: reduction of flow will lead to decrease of suitable habitats in the marsh</p> <p>Disturbance to fish migration to spawning sites: permanent infrastructures and channelization of tributary rivers could disturb fish migration to spawning sites</p>

8.3 AFFECTED COMPONENT VALUE

Component	Component value
Land cover	Land cover is weakly valued since the area is an agricultural area with heavy pressure on land cover from this activity
Terrestrial habitats and wildlife	These three components are highly valued as natural habitats are fragile and some, as thicket in LNP, are rare and imperiled.
Wetland habitats and wildlife	
Aquatic habitats and fish	

8.4 LAND COVER

DESCRIPTION OF IMPACTING ACTIVITIES

The impact matrix has identified the following activities and impacts:

- The project construction and operation will lead to significant changes in land cover (**Rapid change in land cover**). Based on a right-of-way (RoW) of 45 m around main canals and the extent of the command area (and the definition of land cover types of the FAO, 2013), the project will permanently change approximately 34 571 ha of land cover types to irrigated crops and, to a lesser extent, to canals and maintenance roads. Most lands are already cultivated or urbanized. About 4900 ha of natural or semi natural land classes including rivers will be changed to irrigated agriculture or affected by infrastructures (river crossings, river channelization, etc.). The following table summarizes expected land cover changes (including canal RoW in LNP and MWR). The existing irrigated land for sugar cane (close to 16, 000 ha) will not be modified, therefore it is not presented in the total.

Table 12 Land cover changes

Land Cover types	Command areas and canals	Area (ha)
Built Up Area(s). These are urbanized areas (Nchalo, Ngaba, Chikwawa, etc.)	A	486.6
	B	913.9
	C	570.0
	D	738.4
	I 1	312.6
	I 2	190.0
	Bangula canal	59.0
	TOTAL	3270,5
Closed Broadleaved Deciduous Trees. This class includes dense forested areas (natural or semi natural)	I 1	12.3
	I 2	70.6
	Bangula canal	13.4
	TOTAL	96,3
Closed Herbaceous. This class includes dense grassland with sparse trees and shrubs (natural or semi natural)	B	13.1
	C	1 357.0
	A	19.1
	B	645.5
	C	950.5
	D	201.6
	I 1	208.0
	I 2	29.2
	Bangula canal	10.4
	Feeder canal	10.8
	TOTAL	2088,2
Open Woodland with Herbaceous Layer. This class includes habitats that are mainly covered by trees with open canopy and herbaceous layer. Most of LNP, MWR and hilly areas fall under this category (natural or semi natural)	A	442.5
	B	28.0
	D	988.0
	I 1	648.7
	I 2	199.8
	Feeder canal	120.5
	Supini canal	7.1
	Bangula canal	87.8
	TOTAL	2522,4
Post Flooding Cultivation. Refers to "dimba agriculture" carry out in dambo	A	861.2
	I 1	103.9
	I 2	188.9
	Supini canal	19.5
	Bangula canal	7.1
	TOTAL	1180,6
Rainfed Herbaceous Crop(s). Refers to areas of rainfed agriculture	A	2 886.4
	B	2 037.5
	C	7 736.5

Land Cover types	Command areas and canals	Area (ha)
	D	1 490.8
	I 1	2 732.3
	I 2	255.4
	A	130.7
	B	3 179.3
	I 1	3 114.7
	Feeder canal	70.9
	Supini canal	24.1
	Bangula canal	243.0
	TOTAL	23 901,60
Rivers	A	141.8
	Feeder canal	7.7
	Bangula canal	1.3
	TOTAL	150,8
Other	I 1	3.9
	GRAND TOTAL	34 571,30

ASSESSMENT OF IMPACT SIGNIFICANCE

	Rapid change in land cover. The command area will lead to significant changes in land cover
Value of the affected component	Weakly valued (highly valued land cover types such as those found in LNP and MWR are discussed in the terrestrial habitat section)
Intensity	High
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

MITIGATION MEASURES

Most changes to land cover are inevitable. However, impacts within park shall be compensated by planting the equivalent of affected trees (see next section). In addition, some land could be set apart for protection either because they are the last remaining semi-natural areas, are valuable habitats for small wildlife, because they are grazing sites or because they are flooding area that help to sustain small wetlands. With current information about the canal alignment route, no recommendation can be made for land affected by canal.

Setting aside land as a mitigation measure will not necessarily imply that irrigated land will be lost, as the limiting factor is water not as much as available land. However, it will allow the Design study to fine tune each command area taking into account these sensitive areas and to study the possibility to expend the irrigated land in areas with lesser value. A map next page shows areas worth paying attention.

The following table identifies areas that are worth considering for protection from the irrigation scheme based on FAO (2013).

Table 13 Land cover that shall be set aside for protection

Land Cover types	Command areas and canals	Area (ha)	Land to consider setting aside
Closed Broadleaved Deciduous Trees. This class includes dense forested areas (natural or semi natural)	I 1	12.3	These areas shall be protected as they most likely are valuable sources of logs for communities
	I 2	70.6	
	Bangula canal	13.4	
	TOTAL	96,3	82.9
Closed Herbaceous. This class includes dense grassland with sparse trees and shrubs (natural or semi natural)	B	13.1	These areas shall be protected as they most likely are grazing sites for livestock
	C	1 357.0	
	A	19.1	
	B	645.5	
	C	950.5	
	D	201.6	
	I 1	208.0	
	I 2	29.2	
	Bangula canal	10.4	
Feeder canal	10.8		
	TOTAL	2088,2	2067
Open Woodland with Herbaceous Layer. This class includes habitats that are mainly covered by trees with open canopy and herbaceous layer. Most of LNP, MWR and hilly area fall under this category (natural or semi natural)	A	442.5	These areas shall be protected as they most likely are sources of logs and grazing sites
	B	28.0	
	D	988.0	
	I 1	648.7	
	I 2	199.8	
	Feeder canal	120.5	
	Supini canal	7.1	
	Bangula canal	87.8	
	TOTAL	2522,4	2307
Post Flooding Cultivation. Refers to "dimba agriculture" carry out in dambo	A	861.2	Not necessary to protect as these lands are already cultivated
	I 1	103.9	
	I 2	188.9	
	Supini canal	19.5	
	Bangula canal	7.1	
	TOTAL	1180,6	1154
Rivers	A	141.8	River channelization shall be avoided whenever

Land Cover types	Command areas and canals	Area (ha)	Land to consider setting aside
			possible and their natural flooding areas free from activities
	Feeder canal	7.7	
	Bangula canal	1.3	
	TOTAL	150,8	141.8
Other	I 1	3.9	
	GRAND TOTAL	6042,2	5752,7

By looking at updated satellite imagery, it is clear that tree-clearing activities have already removed much of the “Open Woodland with Herbaceous Layer” and “Closed Broadleaved Deciduous Trees” in the command areas, therefore some of the previous figures (Table 13) are no longer accurate and 5752.7 ha cannot be set aside. A more accurate assessment (than the assessment presented in the previous table 13) based on 2016 imagery shows that valuable open woodland cover about 720 ha of the command areas (this figure does not consider small patches of woodland). The following map, shows the 720 ha of woodland worth considering as set-aside land. In addition to woodland, in Zone A 34.5 ha of a marsh called Thanda marsh and an unnamed grazing area of 29 ha shall be set-aside as well. Among the estimated 4000 ha of heavy vertisols (see Vol. 1 Baseline report), some 2000 ha are well delineated in Zone C, this land shall be given consideration to be set aside. About 430 ha of land are regularly flooded in Zone B along the Nkombedzi Wa Fodya River, this land also shall be considered to be set aside. Lastly, 141.8 ha of river banks with an additional buffer zone of at least 10 meters shall be protected.

The Mphoza dambo is safeguarded from the Project (see Baseline report).

Table 14 Lands to be set aside

Land cover type	Command areas	Approximate area (ha)
Open woodland (including riparian forest)	A	161
	A	181
	A	20.8
	I 1	67.7
	I 1	43.9
	B	88.8
	C (riparian forest)	12.8
	D (contiguous to Nyasa private wildlife reserve beside Kaombe sugar estate)	144 (this surface is the part of woodland beside Nyasa that is affected by the command area)
Marshes and flood prone area	A (Thanda marsh)	34.5
	B (flood prone area)	429
Heavy vertisols	C	1477
	C	672
Grazing area	A	27.8
Rivers	Everywhere	141.8 + 10 meter buffer zone on both banks

In addition, large baobab and small communal forests shall be avoided (not clear-cut) when developing the command area. It is recommended, that before clearing forest or bushes, the following protocol be followed by the Engineer in charge of work plans and supervision of work:

- Make sure that there are no protected trees, shrubs or plants (National Parks and Wildlife Act (Act No. 11 of 1992) by requesting a clearance from the Department of National Parks and Wildlife (DNPW);
- Establish contact with the DNPW to know what is the procedure in case of protected tree in the canal right of way;
- Make sure the forest or bush does not hide a graveyard by talking to village headman (part of the Code of Conduct);
- Make sure that all cut trees return to their owners;
- Make sure that borrow pits, roads and other infrastructures do not destroy protected trees.

The following two pictures show, based on the consultant's return of experience in construction of irrigation schemes, two failed mitigation measures to safeguard protected trees and the reason why they failed. They are shown as examples to avoid.



Source: BRLi, 2017

The construction contractor took the advice from the Engineer to protect the tree at the borrow pit site because of its protected status. However, the contractor's poor judgement and lack of environmental sensitivity has left the tree dead in one season. Roots were dried by exposed sun (the mound is about 5 meters high).

What should have been done: a protection area of at least 10 meters should have been delineated with construction fences, and the slope should have been more gentle to avoid affecting soil property where the tree is rooted.



Source: BRLi, 2017

The protected tree was in the way of the canal, the project spend tens of thousands to avoid it by creating a bend in the canal route.

However, nearby excavation, the drainage ditch on the left, compaction and earth fill to create the maintenance road have left the soil impervious to water and has created drainage. The tree died in one season.

What should have been done: the avoidance measures shall not have been implemented and the tree should have either been cut and the lost compensated in close consultation with authorities or the access road should not have completely surrounded the tree. Any action leading to changes in soil properties will affect vegetation.



Shire Valley Irrigation Project

Environmental and Social Impact Assessment (ESIA) for the Shire Valley Irrigation Project (SVIP)

Set-aside land



Thyolo escarpment

Chiromo

Bangula Lagoons

Bangula

Chikwawa

I 2

Nchalo

D

Feeder Canal

Illovo Canal

B

C

Mwabvi Game Reserve

Majete Game Reserve

Lengwe National Park

B

Ngabu

Bangula Canal

A

Legend

- Roads
- Main rivers
- Study area
- Command areas
- Illovo
- Phase I
- Phase II
- Canals
- Park and reserve
- Elephant marsh
- Towns

Set Aside Land

- Flood Prone Area
- Grazing Area
- Heavy Vertisols
- Nyasa Reserve
- Open Woodland
- Thanda Marsh
- Riparian Forest

Source : BRLi
Background : World Topo Map
December 2016

0 2.5 5 Km



8.5 TERRESTRIAL HABITATS AND WILDLIFE

This section describes impacts on parks on an ecological point of view (wildlife movement, etc.) The section on “Natural heritage” discusses impacts on parks from a socioeconomic perspective (tourism, management and infrastructure).

The impact matrix has identified the following activities and impacts.

8.5.1.1 Disturbances of wildlife and vegetation

During construction of the scheme, work will generate noise and necessitate forest clearing in the right-of-way (RoW) destroying some habitats and startling wildlife. In LNP, the canal RoW will destroy about 24.8 of thickets and 34.9 ha of tree savanna. In MWR, the canal RoW will destroy 25 ha of forest. Construction activities will have several impacts on wildlife and vegetation:

- Scaring of wildlife (and potential casualties) due to construction in an area where they are accustomed to access without disturbance (this will have direct impact on tourism as well, as wildlife observation will decrease). In MWR, animals will most likely move inside the reserve due to the noise, however this area lacks water which will further stress animals. Due to lack of fences in many areas in LNP, some wildlife may be tempted to exit the park and lead to human-animal conflicts (especially buffalos);
- Persecution of slow moving animal (snakes) from workers;
- Changes in habitat quality (risk of invasive plants colonization on bare soil and risk of increasing turbidity in the reservoir due to waterworks). The invasive tree *Prosopis glandulosa* was often observed in the Study area, this tree often colonizes ditches;
- Animals will not be able to cross canals under construction to access Shire river below the Kapichira dam wall (MWR) and to access the western part of Old Lengwe (LNP) as the excavation will create an impassable trench;
- Increased poaching risk with foreign and transient construction crews operating in and adjacent to MWR and LNP.

In addition, resettlement activities will take place in the command area. Resettlements are known to increase pressure on natural resources mainly trees for logs to rebuild houses and on available land to resettle people. This impact is difficult to assess but was raised by a traditional authority during a consultation meeting with COWI consultants (COWI, 2016). LNP, Mwabvi Wildlife Reserve and Matandwe Forest Reserve which are close to the SVIP Phase II are at risk.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Disturbances of wildlife and vegetation. Forest clearing will permanently destroy valuable habitats and work will startle wildlife
Value of the affected component	Highly valued
Intensity	Medium
Extent	Punctual
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

8.5.1.2 Habitat fragmentation

Canal construction and operation will fragmentize wildlife habitats especially in parks. In MWR, open stretches of the Feeder canal will have impacts on wildlife capacity to move toward the Shire below the dam wall where many fetch for water in the river. Elephants however do not use this section of the river to drink due to steep slopes, rock outcrops and high current. Depending on the final layout, it may represent an impassable obstacle and it could isolate 75 ha (0.75 km²) of MWR which represent the area between the fuse dyke, the river, the road to Escom and Mkulumadzi Road. The previous map on MWR shows this area under the title "Heavily Impacted Area". This "Heavily impacted Area" will be subject to intense truck traffic (as discussed in the Impact on tourism section). In addition, 31 ha will be isolated south of the Escom bridge to the limit of the reserve (currently it is an unfenced area).

In LNP, Bangula canal will fragmentize highly valuable thickets mainly:

- 28.74 ha of *Sterculia appendiculata* riverine thickets,
- 260.11 ha of Small-leaved bloodwood thickets, and
- 278.35 ha of *Acacia nigrescens* thicket

These will be separated from their main units as they will no longer form continuous habitats as shown on the next map. Habitat fragmentation can lead to the "edge effects" along forested areas. The edge is the area where natural habitats come in contact with manmade habitats or infrastructures (canal, road, transmission line, etc.). Edge effect causes abrupt changes in vegetation covers and reduces the true surface of forest, leading to colonization of new species. Edge effect also leads to local changes in soil characteristic from a cooler, darker and moister to a warmer, more exposed and dryer environment due to solar radiation. This change brings higher mortality of trees and shrubs along the edge. Habitat fragmentation can lead to changes beyond the line of contact with construction activities.

As far as today, no reliable information is available to determine Nyala movement in and out of Old Lengwe (as there are no telemetric monitoring of animal movement). However, Old Lengwe is subject to floods from Nkombedzi Wa Fodya, during which animal are known to move to the Western part of the Park. In addition, discussion with the Lodge manager (Max Del Bufalo, personal communication, 2016) and field observations have revealed that animal do move westward outside the thicket for grazing, the movement is however believed to be limited.

In LNP, the current command area layout (as received from KRC, 2016) is encroaching on the park boundaries (Zone B is encroaching on about 342.6 ha of NLP on its southern end). Final design of Phase II needs to address this and ensure that park boundary are respected. The following map show impacts on LNP and the issue with its boundaries.

In addition to this, Old lengwe which is surrounded by heavy anthropogenic activities (Illovo scheme) and villages that create pressure on the ecosystem, will be further circumscribed by Zone A (Phase I) and Zone B (Phase II) adding pressure on ecosystems.

ASSESSMENT OF IMPACT SIGNIFICANCE

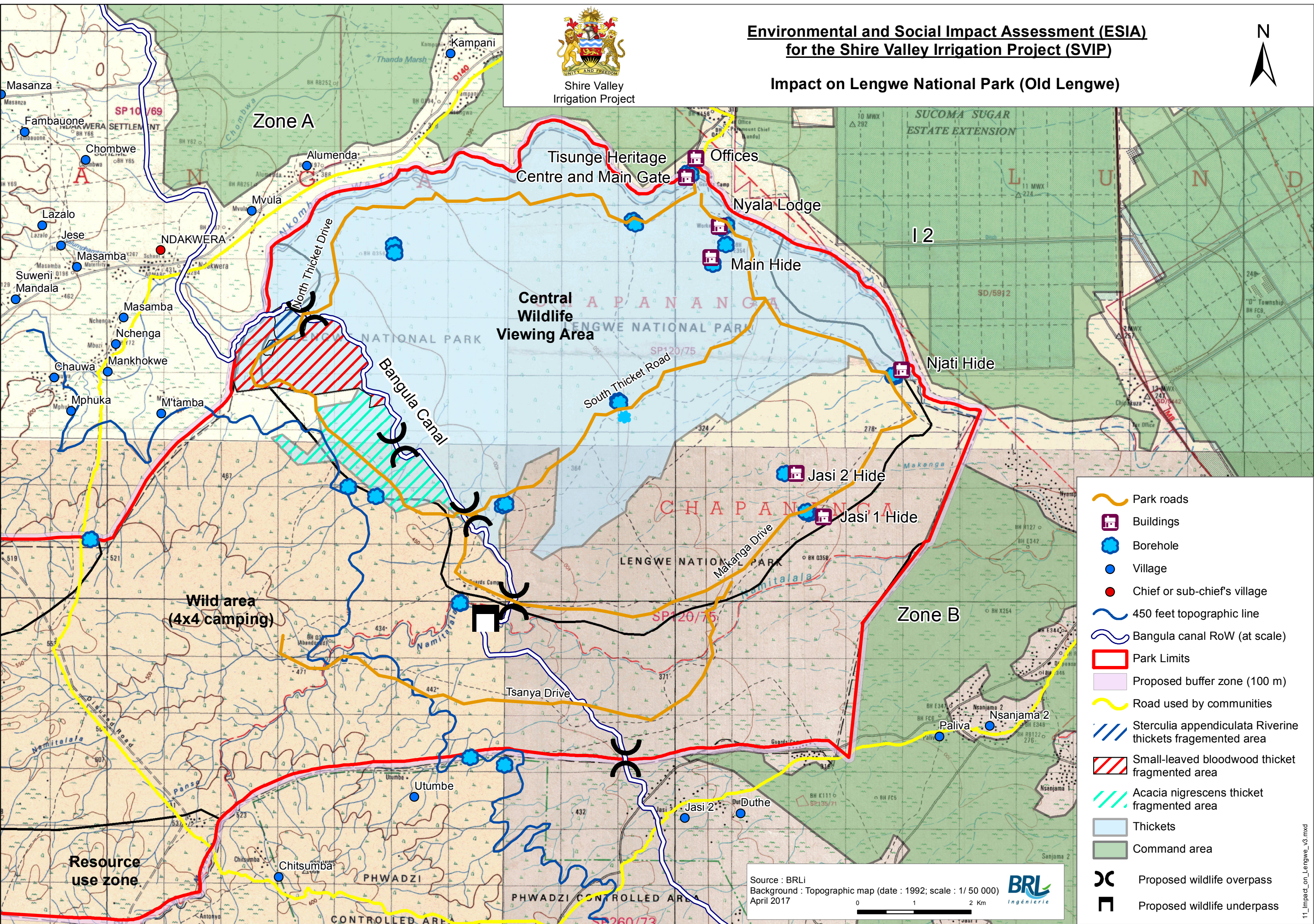
	Habitat fragmentation. Canals will permanently fragmentize habitats especially in parks
Value of the affected component	Highly valued
Intensity	High
Extent	Punctual
Duration	Permanent
Significance	Major
Occurrence probability	High probability



Shire Valley Irrigation Project

Environmental and Social Impact Assessment (ESIA) for the Shire Valley Irrigation Project (SVIP)

Impact on Lengwe National Park (Old Lengwe)



- Park roads
- Buildings
- Borehole
- Village
- Chief or sub-chief's village
- 450 feet topographic line
- Bangula canal RoW (at scale)
- Park Limits
- Proposed buffer zone (100 m)
- Road used by communities
- Sterculia appendiculata Riverine thickets fragmented area
- Small-leaved bloodwood thicket fragmented area
- Acacia nigrescens thicket fragmented area
- Thickets
- Command area
- Proposed wildlife overpass
- Proposed wildlife underpass

Source : BRLi
 Background : Topographic map (date : 1992; scale : 1/ 50 000)
 April 2017

8.5.1.3 Drowning hazard for wildlife

During operation of the scheme, an open canal will represent a hazard for the two following reasons:

- with a lined canal, banks will be slippery and any stocked animals will not be able to escape by climbing up the banks due to lack of grip. This represents a risk for animal health even when water level is low as animals could break their legs, get stuck and die from the heat or starvation. Snakes are known to “fall” and not be able to escape as well (Namibia Environment and Wildlife Society, 2016). Slopes of 1 Vertical / 1.5 Horizontal and 1 Vertical / 2 Horizontal are hazardous for wildlife (and human).
- animals will inevitably fetch for water in main canals as the water will be clearer than in any other water sources and more easily available especially during the dry season. The Feeder canal will convey up to 50m³/s during the peak of the dry season which is also a stressful time for wildlife.

The impact mainly concerns MWR and LNP but also to a lesser extent the whole length of the primary canals as smaller wildlife will be concerned as well (snakes and small mammals especially).

Returns of experience are rare in Africa, however one example in Namibia shows that without proper planning and implementation of mitigation measures, canals can become death traps for thousands of wildlife. The Grootfontein – Omatako Canal (260 km) was built in the 80's, it is an open lined canal with steep and lined slopes (U-shaped canal). This canal is going through game farms as well as other natural habitats severing migration route of grazing animals. The canal was built 30 years ago and is still in operation. A newspaper from Johannesburg (the Star of Johannesburg, 1990) mentioned that the number of dead animal was more than 8,000 per year including endangered species. The estimate annual death is about 4,700 warthogs, 1,500 hares, 300 baboons and scores of antelopes, cheetahs, wildcats, foxes and jackals (large cats are not at risk because of their jumping abilities). Personal communication with the Namibia Environment and Wildlife Society (2016) also revealed that snakes, aardvarks, warthogs, kudu, oryx and eland are amongst the victims of drowning in this canal. The Namibian Afrikaners online newspaper called “Republikein” also reveals that casualties include domestic animals (cow and goats). In addition, the newspaper mentions that the cost of supervising the canal and the effort required to remove trapped wildlife is significant. According to the Republikein, some small animals such as pangolin are known to dig and destroy canal embankment which causes water loses and seepage. According to the article, omission to close fences and gates by maintenance staff as also led to wildlife intrusion in fenced areas (the Republikein, 2016).

The Grootfontein – Omatako Canal is still called the “Killer canal”.

Figure 24 Wildlife casualties in Grootfontein - Omatako Canal



Source: the Republikein, 2016

Discussion with Piet Heyns (personal communication, 2016) who was during planning, construction and management of the canal the Head of the Planning Division and later the Director of the Investigations and Research in the Department of Water Affairs in Namibia has confirmed that the number of casualties was and still is very high and removal of dead animals is very expensive and therefore often neglected. According to him, the largest group were/are snakes and antelopes. According to M. Heyns, many solutions were tested in order to reduce casualties: such as escape gentle slopes (escape structures) with “guides” in the canal to force the animal to use the escape structure. However, most animals when faced with “guides” were swimming on the opposite direction (and up and down the canal) and finally drowning in agony. In parks and reserve, an agonizing animal or an animal in distress is a disturbing experience for visitors and could really affect the image of MWR and LNP (tourists publishing a dying animal on social media will affect the image of parks). The following is a picture from the non-efficient escape structure with the “guide”

Figure 25 Inefficient escape structure



Source: Heyns, 2016

M. Heyns mentioned that regular farm fences were inefficient to keep wildlife from entering due to the fact that many antelopes (oryx, kudu, eland) could jump over 1.6 m high fences. Today, this canal has not seen any efficient action to fight against drowning and the cost of maintenance is affected by this issue. M. Heyns also said that, based on his experience, regardless of the fence many small animals could pass under the fence or across and drown in the canal. According to him, the only way to reduce casualties in parks is to cover or bury the canal. He also mentioned that the structure should be strong enough to allow passage of intruding wildlife. With the presence of elephants in MWR, this issue is rather serious.

M. Heyns sent the consultant a picture of a wildlife pass that was installed in commercial game farms along the Grootfontein – Omatako Canal to reduce the number of drownings. By looking at the picture, the thickness of concrete is not sufficient for large animals or herds. In the case of the Namibian canal, the width of the canal is small (3 meters) so large herds cannot cross at once and exert pressure on the pass. In the case of the Feeder canal (22.6 meter wide), such thin concrete plate would not sustain the weight of elephants.

Figure 26 Overpass in Namibia



Source: Heyns, 2016

A request to NamWater was made to obtain the reports on animal death in the canal, however since these reports are from the 90's there is no electronic version. Scan versions were expected but the consultant never received them (Report on the investigation into the influence of the Grootfontein-Omatako Canal on wild animals and methods to prevent identified problems from the Namibia. Department of Water Affairs. Research Division. Namibia. Ministry of Wildlife, Conservation, and Tourism. Windhoek: The Division: Dept. of Water Affairs, 1992).

The risk of crocodiles and hippopotamus entering the water intake is significant but easily mitigable.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Drowning hazard for wildlife. Open canals represent a drowning hazard for wildlife
Value of the affected component	Highly valued
Intensity	High
Extent	Punctual
Duration	Permanent
Significance	Major
Occurrence probability	High probability

8.5.1.4 Summary of impact significance assessment

	Disturbances of wildlife and vegetation. Forest clearing will permanently destroy valuable habitats and work will startle wildlife	Habitat fragmentation. Canals will permanently fragmentize habitats especially in parks	Drowning hazard for wildlife. An open canal will represent a drowning hazard for wildlife. There is also a risk that hippos and crocodiles enter the canal and cause wildlife – human conflicts
Value of the affected component	Highly valued		
Intensity	Medium	High	High
Extent	Punctual	Punctual	Punctual
Duration	Permanent	Permanent	Permanent
Significance	Moderate	Major	Major
Occurrence probability	High probability	High probability	High probability

8.5.2 Mitigation measures

8.5.2.1 Disturbances of wildlife and vegetation

- It is recommended to phase the installation of wildlife passes as canal construction progresses to avoid creating a long trench without any passage (wildlife passes are presented in the next section).
- Wildlife will have to be contained away from construction to avoid casualties. Construction planning will have to consider and provide for materials and costs for the containment of animals for both LNP and MWR. Such costs include erecting temporary wildlife fences around construction sites. These fences have to be wildlife approved and electrified. They cannot be domestic animal fences.
- An upgrade to existing water points in MWR (Thawale, Nakamba and Nsepete) is necessary because animals will disperse away from the construction and use the existing waterholes which will then need increased capacity. This would be in preference to having a temporary structure that may have its own impacts (water tanker coming every day).
- Slow moving animal (snakes) shall be protected from persecution from workers by providing sensitization induction training to workers.
- In MWR, construction vehicles shall access the water intake site as far as possible from the east bank of the Shire.
- Speed limits shall be set at 15km/hour for all vehicles and trucks in MWR and LNP.
- When working in LNP, the Supervising Engineer will be required to verify construction contractor fridges in their kitchen on a regular basis to ensure that contractors do not purchase any bush meat or animal parts. DNPW should provide technical support if needed (such as to identify suspected bush-meat or animal parts).
- African Parks and the DNPW need to approve all required access roads.
- In MWR, anti-erosion practices shall be put in place. They shall be designed once the Design study available. Silt fences on land and floating silt fence in the reservoir shall be installed.

- Machinery (excavator, grader, etc.) will be checked by reserve and park rangers at entrance to ensure that no mud is present on wheels and caterpillar tracks. This is necessary to avoid invasion of the water hyacinth (or other plants). In case of presence of mud (even dry mud), the machinery or vehicle will be forbidden to enter.
- No construction camp in any parks shall be authorized, workers will have to commute daily to MRW and LNP with a bus and will be subject to inspection at the end of the day (inspection of trunks, bags, ice boxes, etc.). Workers cannot spend the night in MWR nor in LNP. Identification badge of workers shall be mandatory at entrance and exit (including for daily workers). Any workers without a badge will be forbidden to enter parks. Workers cannot spend the night at rangers compounds.
- MWR and LNP shall keep provision of extra law enforcement personnel to increase patrol and law enforcement effort during construction phase and training session for workers (induction training). Costs shall be covered by project financiers.
- In LNP and MWR, the contractor will delineate the required Right-of-Way with African Parks/DNPW and RoW limits shall be marked so that no encroachment takes places. Marking will involve using construction fences (visible plastic fences to ensure that RoW is respected). One of the extra rangers hired for the time of construction will be full time along the construction to ensure that work follows the no encroachment rule.
- Access to the construction site must be restricted through controlled access points managed by African Parks, and operating hours shall be limited to 9am to 6pm. Peak game drive times are 6am – 9am and 3pm to 6pm, ideally work should avoid that timeframe. In LNP, work shall take place between 6am and 6pm.
- Code of conduct for all workers for respectful interactions with surrounding communities, tourists and wildlife will be enforced (a mandatory induction training will be provided by park staff for all workers, see previous section on Code of Conduct).
- Dredged spoils and excavated soils cannot be stored in MWR nor in LNP (even temporarily).
- Vegetation removal shall be limited to the canal path and a pre-agreed footprint either side of the canal during construction. All removed vegetation remains the property of MWR and LNP who will specify where this be stored and how.
- Post construction soil rehabilitation shall be mandatory. It will take place at the end of work in MWR and LNP and not at the end of the contractor's contract to ensure that it is done and budgeted by the contractor (during tender). Delays in payment will be applied if rehabilitation is not done in the set timeframe including removing all rubbish and construction equipment.
- Replanting of trees shall be done by WESM in LNP and by African Parks in MWR to ensure recovery of vegetation and to ensure the use of native species. Costs are presented in Vol 3. ESMP.
- Modification of Nkombedzi Wa Fodya to keep floods from affecting surrounding land is not recommended. The FS consultant in its Interim report (section 5.8.2. Flood Protection of Nkombedzi River) recommends to modify the river to keep floods from affecting irrigated land. However, this river flooding pattern allow riparian thickets to grow in LNP and also causes floods at LNP (flooding of offices and lodges), any channelization upstream of LNP may increase floods in LNP. The General Management Plan of LNP also proposes to build a small dam (a weir) on the Nkombedzi Wa Fodya to create drinking spots in the Western part of LNP and retain floods. Therefore, the proposed modifications to this river shall be discussed with LNP park management as well as WESM (Wildlife and Environmental Society of Malawi) in a concerted approach and to ensure maximum benefits for the park while protecting lands from floods. Regardless if this dam is built or not, the river shall not be modified when passing through riparian thickets and the dam shall have sluice gates to allow for flow release when needed. From personal discussion with Dowsett and Lemaire-Dowsett (2016), it is the best preserved riparian thicket in the area and such communities are scares and rare in the region. The Final Design shall exclude training work of this river, in order to comply with OP 4.04 and generally accepted environmental good practice standards.

- Regarding compensation for the losses of thicket and forest, we recommend the following revegetation measure to ensure no net losses:
 - To compensate for the 25 ha of forest cleared in MWR (mainly broadleaf deciduous trees), an estimate number of trees proposed is 1 per 10meters (144 trees per ha) which represent $144 \times 25 \text{ ha} = 3\,600$ trees (square planting). To ensure conservation gains, this number shall be doubled so every cut tree is replaced by 2 trees. Trees shall be planted inside the reserve by African Parks.
 - To compensate for the 60 ha of thickets and forest cleared in LNP (mainly *Pterocarpus antunesii*), an estimate number of thicket species is 1 per 5meters (484 shrubs per ha) which represent $484 \times 60 = 29\,040$ shrubs (square planting). To ensure conservation gains, this number shall be doubled so every cut shrub is replaced by 2 shrubs. Shrubs shall be planted in consultation with LNP management.
 - Wildlife and Environmental Society of Malawi (WESM) has the experience to carry out such planting and they shall be in charge of planting in LNP, the nursery shall be located in the valley which will require land and irrigated water. For MWR, AP has a nursery inside the reserve. Each plant shall be between 2 and 5 years old to ensure success and shall be protected with cages to keep herbivores away. The full cost assessment is in the Environmental and Social Management Plan (Vol. 3 ESMP).
- No direct action can be proposed against the invasive tree *Prosopis glandulosa*. However, revegetation measures and rehabilitation of affected areas will help minimize the colonization of this tree in parks.

8.5.2.2 Habitat fragmentation

ECOLOGICAL CONTINUITY IN MWR

The fate of the heavily impacted area of 75 ha of the reserve (area that will be isolated due to the Feeder canal, see previous map) and the safeguard of this area and mitigation measures to ensure tourists access and wildlife access is crucial for African Parks. Therefore, the “do nothing option” for the 75 ha (called “Heavily Impacted Area” as shown on the map) is not acceptable as it leads to major irreversible impacts.

Buried canal represent 1.25 km inside the reserve, buried canal will allow animals to pass since the thickness of concrete will be sufficient (50 cm), therefore with current layout of the canal inside MWR there is no need for wildlife overpass.

In section with open canal, designing the canal in order to have gentle slopes and shallow water to allow all wildlife to “ford cross” the canal would, in theory, be a good option. It could allow the canal to be “transparent” and reduces the need of installing fences. The canal could mimic a natural watercourse with gentle slopes and meanders. Reducing the water depth and decreasing current would necessitate a larger right of way (RoW). Unfortunately, whatever the possible reduction of depth, a shallower canal would always represent an impassable obstacle since the current would often discourage wildlife from crossing, and juveniles would always be at risk of drowning (up to $50\text{m}^3/\text{s}$ will flow in the canal). In addition, elephants would use the canal as a pathway and affect its integrity. The drowning hazard and impacts on infrastructures can only be suppressed by restricting all access to section of open canal (on both sides of the Feeder canal).

ECOLOGICAL CONTINUITY IN LNP

In LNP wildlife passes are important because the western side of the canal is a grazing site for wildlife. Even though an earth canal allows wildlife to have a certain grip on the banks, the current of the canal will always discourage many animals to cross especially at the peak of the irrigation season (dry season).

There are two feasible types of passes: underpass and overpass.

Underpasses would require that the canal be elevated. It could also be located where seasonal tributary rivers cross the canal by installing very large box culverts to allow for “dry passage”. An underpass will only offer limited passage since many animals move in herds and the limited size of the box culverts may not allow herds to pass.

Overpasses shall have very mild slopes (1 Vertical / 8 Horizontal), be high enough to pass over the canal wall or fence (2 meters) and be large enough for herds to cross (at least 50 meters wide), its design shall be done by an engineering company with experience in overpasses (and not by the consultant in charge of the canal design). The main issue with overpasses is that in Africa there is no return of experience on this infrastructure.

In LNP, where the canal will be open (see Natural Heritage section), it is suggested to install five wildlife overpass and one wildlife underpass. Overpasses shall be located in open area to minimize poaching and four of them could be shared with vehicle bridges. Discussion with Nyala Lodge management has revealed that a single large wetland would be preferable than several troughs (Max Del Buffalo, personal communication, 2016), water would be brought by the same mechanism. The wetland will allow the park to achieve an overall net gain from a conservation standpoint. This wetland shall be installed on the western part of the canal only to avoid villagers bringing their cattle inside the park to fetch for water, a ranger scout shall be installed there. The wetland could be around 30 meters in diameter and shall be lined with concrete to avoid seepage, with a depth of 0.5 m, it would require about 350 m³ of water from the canal, filled every two days, this would be the equivalent of 1230 m³ per week (or 0.002 m³/s) which is negligible in regard to the volume of water in the canal. It is necessary to install bridges for vehicle at all locations where an existing path crosses the canal. Based on actual map of LNP, the canal will cross paths at 4 locations (see maps on impact in LNP), bridges shall be designed to allow wildlife passage (with very gentle slopes and fences on the side). There is no need to install specific pedestrian passes in LNP.

All options have to be studied in depth at either the current feasibility stage or at the design stage, in consultation with LNP and Nyala lodge management.

BUFFER ZONES AROUND LNP AND ENCROACHMENT

Any encroachment by the scheme inside LNP is to be strictly avoided and park boundaries shall not be subject to any adjustment to accommodate irrigated lands. In fact, the future Zone A and B shall be designed to leave a buffer zone between the park and the scheme (where no land shall be irrigated). The current Zone B is very closed to LNP, it shall be reviewed to leave a buffer zone. The buffer zone shall be large enough to keep LNP from all impacts of surrounding activities and uses. This ESIA recommends a 100m buffer zone.

Since communities in Zones A and B will benefit from the SVIP, and since most illegal wood cutting activities and illegal grazing originate from these communities, part of their inclusion in the scheme shall be conditional on the acceptability of a “no illegal wood clearing rule” and a “no grazing rule” at each village level. Village headmen shall sign a contractual agreement or some form of engagement to respect this rule prior to their inclusion in the scheme. The SVIP shall be used as an opportunity to request some environmental engagement in exchanges of irrigation.

Buffer zone from Zone A

The Nkombedzi Wa Foydya River along the LNP shall be protected from drainage water from the scheme and from any infrastructures. Setting a minimal distance between fields and this river is arbitrary, this report suggests that no irrigated fields should be located less than 100 meters from the river.

Buffer zone from Zone B

Zone B shall be moved back from the park boundary to allow for a buffer zone of at least 100 meters.

8.5.2.3 Drowning hazard for wildlife

- The design of the water intake shall be done to ensure no crocodiles and hippos can enter the canal. For that, the trash rack in front of the water intake shall allow to retain adult and juvenile crocodiles. Spacing shall be 5 cm. However, having juvenile crocodiles entering the water intake will remain a risk. This is why a wall around the canal is also necessary.
- The issue of animal drowning is complex since :
 - fencing the whole canal to avoid wildlife drowning will affect the natural landscape of both LNP and MWR and fences require maintenance. Maintenance of electric fences is a real burden for both MWR and LNP (personal communication with several stakeholders including LNP and MWR management). In addition, in the case of LNP, fences may be stolen or vandalized (as it is the case today). Building a wall, using rocks in a concrete matrix will provide efficient protection against (for) large animals with little maintenance, will last longer and will have a better appearance. Wall with rocks in concrete is actually used to decorate many areas in MWR as shown in the pictures. Although a wall is more expensive than an electric fence as shown in the following table, it is necessary not to underestimate the risk associated with elephants. Electric fences are about

Figure 27 Cost for keeping wildlife out of canals

	Full cost (including installation and quarrying for rocks)
Electric fence in Malawi (based on current prices in MWR)	11 USD per meter
Wall made of rocks in a concrete matrix (based on current prices in MWR) (given a 0.5 cm thickness and a height of 2 meters)	400 USD per meter

Figure 28 Examples of rock in concrete matrix from MWR and Ng'ona Lodge



Source : BRLi, 2016

- Having a shallower and wider canal without fence rather than a narrow and deep canal to ensure that wildlife do not drown could be an interesting mitigation. However, several animals could use this canal as a pathway to travel (and not only to cross it), which in turn could affect the integrity of the canal. Elephants are large and heavy and travel in herds; they could cause damages to the canal. Therefore, some forms of barriers are inevitable to keep elephant from entering the canal in MWR. In addition, regardless of the layout, the lined canal will always represent a drowning hazard because of slippery slopes of concrete.
- Based on return of experience from the Grootfontein – Omatako Canal in Namibia and discussion with M. Heyns, escape structures are not recommended as wildlife do not understand that these are exits (personal communication, 2016). If escape structures did not work with a canal much smaller than SVIP main canals (Grootfontein – Omatako Canal), they will probably not work with the Feeder and Bangula canals.
- If an earth canal is feasible in LNP, it may not lead to drowning as animal who enter the canal may exit it because of the better grip earth offers as shown in the following pictures taken by the consultant. In this case, a wall along the canal will not be necessary. However, with large wildlife such as buffalos, earth canal will be damaged.

Figure 29 Earth offers better grip than concrete



Source : BRLi, 2017

- A solution against animal damaging the earth canal in LNP could be an earth canal lined with prefabricated concrete mats which are flexible matrix of cellular concrete blocks (the registered technology is called the Armorflex ®). The cellular blocks offer good grip for animals to exit canals. It can easily follow meanders of the canal (to mimic a natural aspect) and allows to protect banks from erosion and gullies caused by animals. In order to be efficient, slopes have to be gentle at 1 Vertical / 3 Horizontal. The cost of this technology is, based on a quotation from the firm who produces them in South Africa (including transportation from South Africa to Malawi and taxes), about 1000 USD per meter (Technicrete, 2016) in addition to the 346 USD per meter (cost for Bangula earth canal provided in KRC, 2016). This technology would offer good protection of the canal bank for wildlife. A cost comparison is provided in the next table. These costs exclude the cost of wildlife passes which will still be needed as bridges for tourist roads will have to be built (as mentioned in the previous section, vehicle bridges will be required and these shall be adapted to become wildlife bridges as well). In this case, a wall along the canal will not be necessary as shown in the next table.

Table 15 Options to avoid drowning of wildlife in LNP

Type of canal inside LNP	Earth only	Earth canal + Armorflex ®	Lined canal + fences on both sides	Lined canal + walls on both sides
Unit cost (USD per meter)	346	346 + 1000	439 + 22 (11x2)	439 + 800 (400x2)
Cost for 14 km (USD)	4,850,400	4,850,400 + 14,000,000 = 18,85,400	6,147,600 + 308,000 = 6,455,600 (excluding the cost of fence maintenance)	6,147,600 + 11,200,000 = 17,347,600

Source: KRC, 2016 for the cost of Bangula canal (lined and earth canal), African Parks for cost of electric fences (22 USD per meter for fence on both side of the canal) and for cost of a wall (800 USD per meter for a wall on both side of the canal) and Technicrete, 2016 for the cost of Armorflex ®

Figure 30 Prefabricated concrete mats (Armorflex ®)



Source: ISG Infrastructure Specialist Group, 2016

Figure 31 Armorflex ©



Source: ISG Infrastructure Specialist Group, 2016

WILDLIFE DROWNING OUTSIDE LNP AND MWR

Outside MWR and LNP, little can be done to mitigate impacts on small wildlife such as snakes and small mammals, there are no bridge nor adaptation to canals that could reduce the impact. However, the presence of cattle troughs (see chapter 7) would possibly help to reduce drowning of small wildlife as these would be attracted to troughs rather than the canal.

CONCLUSION

The Design shall study options that the ESIA proposes.

It the light of the very high cost for walls, electric fence seems to be the best option for open canal, however they will quickly become a burden for parks management. As cost for maintenance of fences will be the scheme operator responsibility, it is not recommended to have fences, budget cuts may lead to abandonment of their maintenance, leading to breaches and animal drowning. Self-reliant and low maintenance are the two principles that should govern every infrastructures built to mitigate impacts. Therefore, walls mixing concrete and rocks shall be installed whenever the canal is open in MWR not only to preserve the landscape but mainly to reduce the cost and the risk associated with poor maintenance. If in LNP, the main rationale for the flexible matrix of cellular concrete blocks is that it would allow protecting the banks from wildlife. Earth canal may offer possibility of wildlife to exit the canal if they are stuck however, the canal may still require wildlife passes (as presented in a section above) because the canal will always represent a constraint to wildlife movement, especially when filled with water.

8.6 WETLAND HABITATS AND WILDLIFE

8.6.1 Description of impacting activities

The impact matrix has identified the following activities and impacts.

8.6.1.1 Changes in plant composition in Elephant marsh

During operation of the scheme (Phase I and II), reduction of flow due to abstraction of up to 50m³/s will reduce the size of some plant communities in the wetland. The impact is influenced by several factors:

- The higher demand for SVIP will be during the dry season when up to 50m³/s will be withdrawn from the system, which is also the period when the marsh is under more stress due to shortage of water;
- Pumping stations of existing sugar estates will only rarely be used once gravity irrigation is installed. This will locally moderate the impact, since the actual capacity of pumping stations is around 21 m³/s and up to 16 m³/s is pumped in the dry season (Norplan, 2013);
- Many cultivated areas (dimba agriculture) are in the wetlands but are in a transition zone with non-wetland habitats, these may shift from wetlands to “drylands” with flow reduction. This transition is supported by satellite imagery treated by infrared to highlight plant activity (see map on Elephant marsh in Vol. 1 Baseline) as dimba agriculture show less plant activity at the peak of the dry season, because reduction in soil humidity can no longer sustain plant activity. This statement is support by the DRIFT report (Ecosystem Functional Model by Southern Waters in association with Streamflow Solutions, Anchor Environmental and MRAG for the SRBMP, 2016) that states that the western part of the marsh is expected to react more strongly to flow changes in the Shire River than other areas of Elephant marsh.
- The Application Efficiency for furrow irrigation is 64% (KRC, 2016), which means that about one third of the water at each irrigated plot is returned to the natural environment. In this figure, part of the water goes to the watertable along drains (seepage), part of it evaporates and part of it returns to surface water at Elephant marsh (as the marsh is the final receptor of drainage). The percentage of each pathway is not easily assessable.

As mentioned in the baseline report, a wetland is an area where hygrophilous plant species thrive. Hygrophilous plants are those that require a certain moisture level during a certain length of the year. For most wetland plants, there are thresholds under which they can no longer grow and give way to terrestrial plants. These thresholds are unique to each plants and most are not scientifically studied. However, the DRIFT report presents a few thresholds for key species such as reed grass (phragmites), papyrus, etc. Phragmites are internationally known as facultative wetland plants (they can sustain dryness conditions) by opposition to papyrus and other *scirpus* who are internationally known to be obligated wetland plant species (they cannot sustain dryness condition).

Determining how change in flow will affect the area of wetland is rather difficult without long-term follow up. However, several statements can be made to describe what will qualitatively change from baseline to Project.

Table 16 Impact on wetland

Theme	Baseline	Project (Phases I and II)
Sources of water	<p>In the dry season, damp conditions are maintained thanks to several factors:</p> <ul style="list-style-type: none"> • The marsh is a depression, water remain stagnant in many areas, • The Shire and its branches and accompanying alluvial water tables, 	<p>The Project will reduce the level of the Shire and its branches, which will lower their accompanying water tables.</p>

Theme	Baseline	Project (Phases I and II)
	<ul style="list-style-type: none"> Seepages from the Thyolo escarpment on the west bank of the marsh 	
Critical period for wetland plants	<p>The critical periods for wetlands plants are not the rainy season when most areas are damp in the marsh or submerged, the critical period is the dry season when water is irregularly distributed</p>	<p>The project will not change much of the wetland hydrology during the rainy season, since irrigation will be limited.</p> <p>The project will affect the critical period for wetland plants by reducing the Shire flow during the dry season affecting more severely the edge of the marsh where conditions may no longer allow for wetland plants to grow. The eastern edge is the area where water retrieves earlier after the rainy season floods; it will be more severely affected. This area is also intensively cultivated (dimba agriculture). Dimba is also called recession agriculture, therefore with reduced flow people will move further in the wetland to cultivate land at the peak of the dry season, further increasing pressure on wetland plant during a critical period.</p>
Wetland zones	<p>The baseline has described three zones in the marsh:</p> <ul style="list-style-type: none"> Area where dimba agriculture takes place. Dimba takes place in wetland that is the least damp during the dry season Areas where the soil is permanently damp and where dimba agriculture is not taking place thanks to high water level Areas of pools, where water submerges the ground. 	<ul style="list-style-type: none"> Flow reduction will lead to changes in plant communities. The surface that will be affected is however difficult to assess. Dimba agriculture and facultative wetland plants will take more place at the expense of obligated wetland plant species. Some areas where the soil was permanently damp inside the marsh may be encroached by people who lost their dimba field due to reduced wetness at the edge of the wetland and who will find new suitable conditions further inside the wetland. Baseline reports presented historical facts that linked increased dimba agriculture with flow reduction. This statement is also supported by the DRIFT report which has identified the eastern, central and southern part of the marsh as potential new suitable area for dimba agriculture.

Theme	Baseline	Project (Phases I and II)
		<ul style="list-style-type: none"> Water level will be lower in pools during the dry season. This could affect fishing activities and rooted aquatic plants.

The SRBMP Sub-study 4: Biodiversity of Elephant Marsh Final version (Anchor Environmental Consulting Report, 2016) supports our statements about SVIP impacts. The following statements, copied-pasted from the report, supports the reliability of the ESIA assessment on impact on wetland.

“Marsh vegetation will be impacted by reduced flow, as drying will reduce the ability of marsh plants to resprout and therefore to persist and will also make it easier to clear marsh areas for cultivation”

“Reduced flow through the Elephant Marsh will reduce the extent and flooding of lake and permanently inundated habitats as well as lessen the extent (and possibly frequency) to which the flood plain is flooded. These changes will affect the biodiversity of the Elephant Marsh directly as flow, sediments, vegetation and marsh fauna are intricately linked. Reduced flow through the Elephant Marsh will also facilitate encroachment by people and increase the extent of cultivation and natural resource harvesting.”

Wetland reduction could also changes local sources of livelihood as mentioned in the Ecosystem Services of the Elephant Marsh (Anchor Environmental Consulting, 2016), the total annual provisioning value was estimated to be approximately US\$5 million per annum. Most of this value is from fish and thatching grass.

ASSESSMENT OF IMPACT BASED ON THE DRIFT REPORT

The DRIFT report uses water depth reduction to assess impacts on the marsh. It has developed several scenarios to model impacts on the Elephant marsh. Impacts are then studied based on geographical locations in the marsh: the northern part, western part, etc. The 5 scenarios are:

- a. Dry calibration (DryCalib), which includes dry range hydrological regime (1991-2002)
- b. Mid Calibration (MidCalib), which includes middle range hydrological regime (2003-2009)
- c. Wet calibration (WetCalib), which includes wet range hydrological regime (1976-1990)
- d. Development and climate change (DevCC), which includes the maximum proposed water-resource development in the Shire Basin coupled with climate change
- e. Dry - Development and climate change (DryDevCC), which includes dry range hydrological regime (1991-2002) and maximum proposed water-resource development in the Shire Basin coupled with climate change

DryCalib, MidCalib and WetCalib represent the range of historical changes in the Shire River flow regime, and thus the range in vegetation condition that occurred naturally in the past.

The following table, adapted from the DRIFT report shows the expected changes with these scenarios. However, several limitations with the DRIFT report need to be highlighted:

- DRIFT report does not relate to SVIP (DRIFT report is a mandate under the SRBMP not the SVIP)
- the report does not provide the meaning of “proposed water-resource development” under the DevCC scenario.

- Since marsh water levels are key in defining marsh morphology and vegetation communities, and thus in dictating the biotic responses, hydrological data were not used directly in the DRIFT model, but were converted to water depth, which were then used as the main driving variables in the DRIFT assessment.

Scenario d. (DevCC) may be the closest to SVIP since it models a flow reduction due to water-resource development. DryDevCC would include climate change factors. The following tables shows DRIFT model results.

Table 17 Maximum changes in vegetation types per area with two scenarios on Elephant marsh vegetation

Wetland vegetation indicators in Elephant marsh	Parts of Elephant marsh	Percentage changes in area (%) with DevCC and DryDevCC scenarios	
		DevCC	DryDevCC
Rooted aquatics (aquatic plants)	Northern	-15.5	-19.5
	Western	Absent in this area	Absent in this area
	Eastern	-26.3	-33.6
	Central	-33.9	-38.5
	Southern	-37.2	-42.2
Area cultivated floodplain (dimba agriculture)	Northern	+5.6	+2.7
	Western	+6.2	+11.8
	Eastern	0	+1.7
	Central	-6.2	-0.6
	Southern	-4.5	-1.7
Area uncultivated floodplain	Northern	+3.4	-1.6
	Western	-1.2	-4.8
	Eastern	-3.4	-4.1
	Central	-7.5	-10.2
	Southern	-8.1	-7.2
Area reeds <i>Reeds need damp conditions but survives well long dryness condition do not tolerate to be submerged They are facultative wetland species</i>	Northern	+4.7	-3.2
	Western	+10.1	+1.3
	Eastern	-1.3	-13.6
	Central	-5.2	-7.5
	Southern	-2.9	-9.2
Area papyrus <i>Papyrus require to have their foot in the water all year around but not tolerated submersion They are obligated wetland species</i>	Northern	+3.0	-2.9
	Western	+5.8	-1.5
	Eastern	-1.6	-7.3
	Central	-5.2	-7.5
	Southern	-2.9	-9.2
Area uncultivated channel margin	Northern	-8.8	-19.2
	Western	-10.3	-22.6
	Eastern	-10.9	-27.1
	Central	-9.4	-21.2
	Southern	-5.5	-14.3

Source: adapted from the DRIFT report (MRAG for the SRBMP, 2016)

Based on this table, several conclusions can be drawn, these are supported by conclusions of the DRIFT report:

- The Northern and Western part of the marsh are likely to react more strongly to flow changes in the Shire and are more susceptible to conversion to dimba agriculture.
- With flow reduction (DevCC and DryDevCC) there is substantial loss in rooted aquatic vegetation (up to 42.2 %) concomitant with an increase in cultivated floodplains (dimba)
- Reed (phragmites) are facultative wetland plants, meaning that they can thrive with limited wetness; they will take advantage of flow reduction and could occupy more areas.

Table 18 Average vegetation changes in Elephant marsh

Vegetation types	Changes in % from baseline	
	DevCC	DryDevCC
Rooted aquatics	-34.42	-39.61
Area cultivated floodplain	+4,25	+7,74
Area uncultivated floodplain	-2.81	-5.29
Area reeds	-1.52	-9.34
Area papyrus	+0,81	-5.56

Source: adapted from the DRIFT report (MRAG for the SRBMP, 2016)

PRELIMINARY CONCLUSION ON IMPACT ON ELEPHANT MARSH

In the light of this analysis on impacts, the Project will not lead to “significant conversion or degradation” of the Marsh as defined in the OP 4.04 on Natural Habitats. Water abstraction of about 10 % (full development of Phases I and II) at the peak of the dry season is not likely to result in the elimination of the Elephant Marsh, a severe diminution of its integrity, or a substantial reduction in its ability to maintain viable populations of its native species, however some changes in plant communities are expected as demonstrate by the DRIFT report.

Although several recently released SRBMP-supported technical studies on Elephant Marsh were released (or will be released) too late to have their data be fully reflected in this ESIA, enough other information was available for this ESIA to reach the above-mentioned conclusions about SVIP’s limited hydrological impact on the Elephant Marsh. However, projected impacts on the Elephant Marsh from expected Shire River flow reductions (attributable to SVIP) represent a preliminary assessment that will be updated as appropriate with further available information (including from the SRBMP studies) after September 2017.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Changes in plant composition in Elephant marsh. Flow reduction will reduce the size of Elephant marsh
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

8.6.1.2 Wildlife-human conflict

With the Project and associated impacts on Elephant marsh, wildlife-human conflicts will increase leading to death of people, cattle and animals. The actual situation in the Project is already unique, as wildlife human conflict have constantly worsen through time (see Vol.1 Baseline report). The Project will aggravate five existing situations:

- Ongoing degradation of Elephant marsh, as it has been the case in the past, Elephant marsh degradation will put pressure on hippopotamus and crocodiles food resources. The link between wetland degradation and wildlife conflict is well documented in Africa (and North America);
- During the dry season, increase availability of fresh grass for hippopotamus closer to Elephant marsh thanks to irrigation;
- Presence of higher number of aquatic paths for crocodile movement thanks to drainage canals (currently crocodiles occupy Illovo drains as observed during baseline);
- Increase of dimba agriculture thanks to reduction of Elephant marsh area (death toll is high among people cultivating in the marsh, Compass, 2000);
- Impacts on LNP due to canal construction leading to wildlife disturbances and increase risk of buffalos entering surrounding fields;

In addition, there is also a risk that hippos and crocodiles enter the Feeder canal from the water intake then exit MWR and cause wildlife – human conflicts in surrounding villages.

If the current method of the Department of National Parks and Wildlife (DPNW) is used, “shoot to kill”, the wildlife death toll will most likely be high for hippopotamus.

The SRBMP Sub-study 4: Biodiversity of Elephant Marsh Final version (Anchor Environmental Consulting Report, 2016) supports the consultant assessment on risk of aggravation of human-wildlife conflict. The following statements is copied-pasted from the report:

“Crocodile-human interactions will increase if human numbers and encroachment into the remaining uncultivated regions of the Elephant Marsh persist. This will be exacerbated as fish stocks, the natural food of crocodiles, dwindle and crocodiles have to hunt for alternative prey”.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Wildlife-human conflict. There is a probability that hippos and crocodiles enter the drains and cause wildlife – human conflicts (and casualties). Irrigated field will become very attractive for wildlife.
Value of the affected component	Highly valued
Intensity	Medium
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	Potential occurrence

8.6.2 Mitigation measures

8.6.2.1 Changes in plant composition in Elephant marsh

This impact is non-avoidable as withdrawing water from the system is the basis of the Project.

The water intake will be dimensioned to abstract a maximum of 50 m³/s from the Shire River. However, since some of the canal water will simply substitute for irrigation water that is currently pumped from the river, the maximum net abstraction will be 32 m³/s at full development (Phase II) and only 12 m³/s for Phase I. Based on the World Bank's International Waterways Notification Letter, this translates to a net abstraction at full SVIP development of not more than about 10 percent of the Shire River's flow during September, the dry season month of peak irrigation water demand. For Phase I, this maximum seasonal reduction in flows to the marsh would be only about 3 percent.

The Project as part of the SVTP-I will mitigate these impacts and enhance the conservation of the Elephant Marsh through support for:

- hydrological and biological monitoring (building on the baseline data obtained through the ongoing Shire River Basin Management Project, SRBMP);
- designation of Elephant Marsh as a Ramsar Wetland of International Importance; and
- establishment of Malawi's first Community Conservation Wetland Area under the administration of the Department of National Parks and Wildlife (DNPW). This improved protection and management of the Elephant Marsh will begin during the Phase I Project; it will thereby facilitate adaptive management to further mitigate the impacts of reduced flows from the Phase II irrigation expansion, such as through the establishment of different Wetland Area Use Zones that could limit further conversion of the drier wetland areas to flood-recession agriculture (dimba agriculture).

Designation of Elephant Marsh as a Ramsar Wetland of International Importance and establishment of the Elephant Marsh Sustainable Use Wetland Conservation Area are both objectives of the Natural Resources Management component of SVIP, to be completed during the expected 2018-2022 project implementation period.

Elephant marsh shall be monitored to determine the long-term changes due to the Project. SRBMP study of Elephant marsh proposes to monitor key species.

Building weirs in the marsh to maintain a certain level of water during the dry season is not recommended for several reasons:

- the severity of floods has shown how destructive the Shire can be, weirs or dikes may not sustain;
- weirs or dikes will block sediment transport to downstream areas;
- weirs or dikes will locally block fish movement;
- When Ruo River joins with Shire it creates a beneficial backflow that brings water to the marsh. Weirs would block the flow of Ruo into the marsh;
- Weirs and dikes may retain water but may also create dryness conditions downstream and lead to additional dimba agriculture as it was the case when a branch of the Shire was blocked in the marsh by Illovo (see Vol. 1 Baseline report).

During the January 2015 flood, Ruo River changed its course and since then discharges directly into Tomoninjobi pool in Elephant marsh rather than having a confluence with the Shire River downstream of Chimromo Bridge. This situation has led to casualties. However, on an environmental perspective it has allow to provide more water directly into the Elephant marsh. A good way to mitigate impact of SVIP would be to maintain this new channel and to resettle people that are now more vulnerable to floods around Ruo River.

It has to be highlighted that neither SRBMP, nor any other World Bank-supported projects in Malawi, will support diverting the Ruo River channel for flood management (which could reduce inflows to the southern part of the Elephant Marsh). Any future works involving the Ruo River (possibly involving lower-impact flood management approaches) would need to be approved by the Shire River Basin Authority, which has a mandate to consider environmental management (including wetlands conservation) in the planning of new civil works in the Shire Basin. Any Government proposals to alter the course of the Ruo River in ways that might affect the Elephant Marsh will be summarized for further reference in the ESIA after September 2017.

8.6.2.2 Wildlife-human conflict

Elephant marsh is at stake when it comes to wildlife-human conflict. Hippopotamus and crocodiles are the current most conflictual animals and the situation will worsen with the Project's impact on Elephant marsh.

CROCODILES

Crocodiles are present in Illovo drainage, it is unlikely that, with SVIP, the situation will be different. Crocodiles can move on land and in the water therefore there is little direct actions that can be undertaken, the risk will never be eliminated. To reduce the risk it is recommended to implemented the following measures (in increasing order of cost):

- Sensitize people not to use drain canals to bath or to bring cattle for water.
- Design drains with steep bank slopes to keep crocodiles from exiting them and attacking people.
- With the installation of cattle troughs along the canal, the access to the Shire for livestock could be limited to some areas as part of a future wetland management (as developed in the SRMBP study on Elephant marsh).
- Install a crocodile fence across every connecting drains with the Shire. Each crocodile fence shall be fixed to the drain bed and grounded using concrete and shall be high enough to stand out during a flood. Wire mesh shall remain sharp at the top of the fence. On ground, it shall be wide enough to discourage crocodiles from moving on land and circulate around the fence to reach the drain. Such fences would need to be maintained and debris removed on a regular basis to avoid having the fence destroyed, as drains will be maintained by farmers there is a risk that they will be neglected. In addition, any major floods in the Shire River would most likely destroy the fence. Regular replacements are to be foreseen. Chances to see crocodiles climbing fences are also to be expected. All these elements are serious limitations to the success of a crocodile fence. In addition, fences would restrict movement of other species from drains to the wetland.

HIPPOPOTAMUS

Hippopotamus will be attracted to forage in irrigated fields, some measures can be proposed:

- Sensitize people not to stay late in their field, as hippopotamus are known to enter fields at night;
- Adapt crop in the command area so that cotton (non-edible crop) is cultivated closer to the Shire and food crops further away;
- Install along irrigated fields thorny branches (acacia branches) to keep hippopotamus from entering. However, it has been reported that even barbed wire are not efficient against hippos. In fact, walls could be the only efficient measure (UNDP, 2016) given the size of the irrigation scheme, efficient actions are rather limited and death of hippopotamus due to conflicts are likely to take place.

ENVIRONMENTAL FLOW

As with other impacts, the environmental flow with adaptation from Kamuzu barrage has another reason to be implemented, it will safeguard crocodiles and hippopotamus habitat and food supply and will help to minimize conflicts with farmers.

BUFFALOS ENTERING FIELDS

LNP will be surrounded by irrigated fields, to avoid all encounter with buffalos, it will be important to fence the whole Old Lengwe section of the park (or finalize the current fencing process).

STATUS OF THE WETLAND

As long as the wetland does not have a formal status and formal management, impacts on wildlife will continue to take place since dimba agriculture is increasing in the marsh.

The conclusions of the study "Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi (Component B, Sub component B3)" provides with more information on the future management of the marsh.

8.7 AQUATIC HABITATS AND FISH

8.7.1 Description of impacting activities

The impact matrix has identified the following activities and impacts:

8.7.1.1 *Disturbance to fish migration to spawning sites*

During construction and operation of the scheme, works in temporary rivers could lead to disturbances of fish migration. Permanent infrastructures and channelization of tributary rivers could disturb fish migration to spawning sites as well. During construction, the main risk comes from the fact that most rivers are seasonal; the construction contractor may be tempted to ford cross-rivers when they are dry, which with time will destroy the river banks and cause erosion. Some constructors build small earth dikes with culverts to ford cross-rivers, however culverts are often undersized and earth dikes remain even during the rainy season which affects fish migration. Another impact comes from the operation of the scheme where natural rivers will be used as drainage canal collecting polluted water from the scheme and being modified to convey drainage water. River channelization reduces suitable sites for spawning.

Figure 32 Inadequate culverts in an earth dike across a seasonal river



Source: BRLi, 2015

ASSESSMENT OF IMPACT SIGNIFICANCE

	Disturbance to fish migration to spawning sites. Works and infrastructures in temporary rivers could lead to fish migration disturbances
Value of the affected component	Highly valued
Intensity	Medium
Extent	Punctual
Duration	Permanent
Significance	Moderate
Occurrence probability	Potential occurrence

8.7.1.2 Risk of Tiger fish invasion in the upper Shire

The Lower Shire River is an independent ecoregion from the Middle Shire and Upper Shire in terms of aquatic fauna. The Lower Shire River belongs to the Lower Zambezi fish fauna and, since Kapichira falls constitute a barrier to upstream movement, all the totally aquatic 'Lower Zambezi' species of the Lower Shire River are absent upstream from Kapichira falls (Tweddle et al., 1979).

Lake Malawi (Upper Shire) fish fauna is mainly endemic (several species of endemic cichlids) and fish are adapted to lacustrine conditions (low flow conditions).

The separation in fish fauna between the Lower and Upper Shire has always existed. However, now with the presence of the SVIP in the near future, a question is raised: *what if the Feeder canal, a gravity irrigation canal by-passing the Kapichira falls, leads to the upstream movement of the Tiger fish or other species that were historically separated from the Middle and Upper Shire?* In that case, *what would happen to Middle and Upper Shire fish fauna and more importantly to endemic fish fauna of Lake Malawi?*

HOW COULD THE TIGER FISH AND OTHER NON NATIVE FISHES INVADE THE RIVER UPSTREAM OF KAPICHIRA FALLS ?

Lower Shire to Middle Shire

Passage from natural rivers to the canal system and the Feeder canal

During operation of the scheme, floods from the Shire River in secondary canals and the Mwanza River in the Feeder canal could lead to fish colonization of the canal system. Another source of risk is that people may be tempted to carry out fish farming in the canal. Through time, the Feeder canal will not remain free of fishes, as observed in irrigation schemes worldwide, fishes are colonizing canals.

The passage from the Feeder canal to Middle Shire

The passage is probable since gravity canals will have very gentle slopes and the water intake is a passive mechanism not involving any pumps. Buried siphons and inverted siphons, regardless of their slopes are not fish proof since, in case if the water intake closes, the water will remain still in the siphon and fish could simply move up in the water column (the tiger fish is a pelagic fish; it can easily move up and down in the water column).

An example of tiger fish passage in underground and pressurized places was provided by M. Tweddle (personal communication, 2016):

“The Fisheries Offices in Katima Mulilo (Namibia) contain a fish hatchery. The reservoir for the hatchery is a large pond filled by a narrow pipe directly from the town’s water supply, which is pumped directly from the Zambezi River. The offtake to the hatchery pond lies between the pump and the purification plant. The pond contains several species from the river, including a few small tigerfish”.

Middle Shire to Upper Shire and Lake Malawi

Several elements support the statement that other than Kapichira falls, there are no absolute and proven impassable obstacles for fish upstream movement along the Shire:

- **Physical characteristics.** None of Middle and Upper Shire falls are as high as Kapichira falls, they also do not have sudden drops such as those found at Kapichira falls. They are not physical impassable obstacles especially at time of high flows because the falls are not very high at any given point (no sudden drop), therefore they could be transformed into rapids during high flows. In addition, some of these falls have gentle “bypass” channels where water flows more quietly. The following is the path and obstacles that fishes may face after Kapichira falls when moving upstream, rapids are not presented because they are not obstacles to fish movement :
 - After Kapichira falls, going upstream there is Mpatamanga gorge. During the rainy season, falls become rapids as depth of water increases in the gorge without an increase in river width.
 - The next obstacles going upstream are Tedzani and Nkula falls both located in by-passed stretches of Shire River where Escom is generating hydropower (two hydropower stations). Nkula falls are rather small and Tedzani falls look more like a long series of rapids.
 - After the powerstations, there are two other falls: close to Zalewa where, during the rainy season, side channels have gentle slopes and by-pass the falls; and close to Malope which appear to be more difficult to pass. However, these falls are in gorges, thus during the rainy season water level goes up transforming the falls into rapids.
 - the Kamuzu Barrage is not a barrier.
- **Human barrier.** Since both sides of the Kapichira falls and the reservoir are restricted access areas, Kapichira falls are also a “human barrier” to the accidental release of fish upstream. On one side, Escom prohibits all access to the reservoir and on the other side, Majete Wildlife Reserve restricts access to paying visitors only. Both organizations take restricted access to the reservoir very seriously.
- **Proven barriers.** This argument is the most important of the three and the only one that can hardly be scientifically questioned (as there will probably never be any consensus whether other falls are passable or impassable solely based on their physical properties). To really assess whether other falls along the Middle and Upper Shire are impassable or not would require some evidences in terms of differences in fish diversity and the fish fauna “assemblage” is the same along the stretch of Middle Shire and Upper Shire. The only absolute fact is that the barrier between Lower Zambezi fish fauna and Upper Shire fish fauna is, based on extensive fish surveys, Kapichira falls (Tweddle, 1979, 1994). None of other falls can be proven barriers to stop upstream migration since they are all located upstream of Kapichira falls where the “separation” in fish fauna has already taken place.

WHAT IS AT STAKE ?

Lake Malawi shelters rich aquatic biodiversity and fishery, it is a source of livelihood for communities. It is also a World Heritage site.

- **Biodiversity:** more than 800 species in Lake Malawi are endemic (from the cichlid family). They are therefore unique to Lake Malawi. The lake has more known fish species than any other lake in the world (Lewis, 1988). The risk of having new species of fishes in the Middle and Upper Shire is also a concern as Kapichira falls have always separated two distinctive fish fauna assemblages (Upper and Lower Shire).

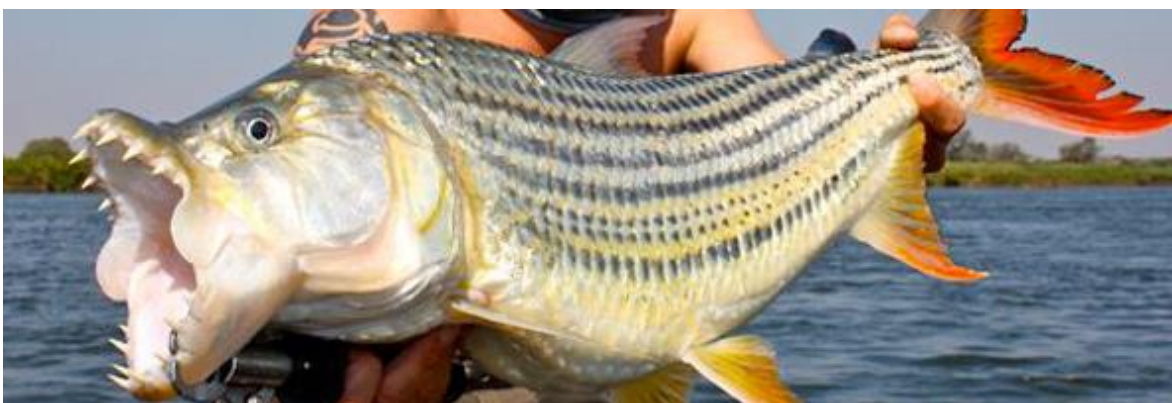
- **International waterbody:** Lake Malawi is shared between three countries: Malawi, Mozambique and Tanzania.
- **Fisheries:** fisheries in Lake Malawi is an important source of livelihoods. In addition, cichlids from Lake Malawi are exported as aquarium fishes.
- **Tourism:** Lake Malawi is an important touristic spot and a diving spot for the colorful cichlid fishes.

WHY IS THE TIGER FISH A RISK ?

- **It is a piscivorous predator and an opportunistic feeder:** the Tiger fish is a piscivorous predator and an opportunistic feeder which preys upon the most abundant prey species (it does not have a strict food regime). Its prey size can reach up to 46% of its body lengths, far beyond the size of cichlids (Lewis, 1988 and Dalu et al., 2012).
- **It preys on cichlids** (fish family found in Lake Malawi): it has been proven by research of stomach contents that the Tiger fish, in other countries such as Zambia and Zimbabwe, preys on cichlids. In Lake Kariba, the Tiger fish takes a substantial toll on the juveniles of commercially important cichlids (Lewis, 1988). In Zimbabwe, a study demonstrated that cichlids are the most important diet of the Tiger fish in a reservoir lake (Dalu et al., 2012).
- **It is a large and powerful fish:** the Tiger fish is known to jump out of the water to catch birds (barn swallows) (O'Brien et al., 2013). It is common in the fast flowing stretches below Kapichira falls (Tweddle et al., 1979).
- **It likes open water with few vegetation** (Langerman, 1984 quoted by Lewis, 1988) which is the typical environment found in Lake Malawi or a canal.
- **It is an aggressive species** and spawning of the Tiger fish takes places earlier than most fishes, juvenile Tiger fish could easily prey on eggs of endemic upstream fishes causing damages to Upper Shire fish fauna.
- **It has never been observed upstream from Kapichira falls:** as the Kapichira falls are effective barriers to passage of all fishes (Tweddle et al., 1979).

If the tiger fish were to reach Lake Malawi, it would lead to a decline in native fish population and in fishery activities of Lake Malawi. The extent of the decline is not predictable, however in some areas in Africa, the Tiger fish, when introduced, had a significant impact on native fish population (Dalu et al., 2012).

Figure 33 The tiger fish



Source: Angle Zambia, 2016

CONCLUSION

The following conclusion summarizes our assessment, the statement in italic is shared by M. Denis Tweddle, renowned fish expert in the Southern Africa Region and highest reputed fish expert of the Shire River.

Kapichira falls are the only proven and absolute barriers to the upstream migration of the Tiger fish. Other falls along the Shire have characteristics that makes them difficult to pass, but are not all-year around absolute barriers to fish. In addition, due to their locations upstream from Kapichira falls they were never proven to be reliable physical barriers to Tiger fish migration.

Regardless of the characteristics of other falls, the impact of the Tiger fish (and other Lower Zambezi fishes) moving to a new ecoregion in the Middle and Upper Shire also needs to be taken into account. Allowing non-native fishes to move up the Middle and Upper Shire, one step closer to Lake Malawi, is also a risk because any future development along the River could provide new paths for fish movement (for example: a new gravity irrigation scheme using another hydropower reservoir, etc.).

The question of which falls other than Kapichira Falls are also absolute barriers is therefore irrelevant, since Kapichira Falls are the only proven barriers to fish passage (there is a clear difference between upstream and downstream fish diversity). Risking the introduction of a non-native fish upstream of Kapichira Falls would go against all precautionary principles since there is no proof that the falls further upstream are absolute barriers. It is the Consultant's opinion that the issues at stake call for serious measures, and should not be influenced by any assessment of physical properties of other smaller falls in the Middle or Upper Shire.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Risk of Tiger fish invasion in the upper Shire. The water intake could lead to Tiger fish invasion of Middle and Upper Shire and Lake Malawi
Value of the affected component	Highly valued
Intensity	High
Extent	Regional
Duration	Permanent
Significance	Major
Occurrence probability	Potential occurrence

8.7.1.3 Reduction of suitable habitat for fish in the Elephant marsh

During operation, reduction of flow will lead to reduction of habitat suitability in the marsh. With flow reduction, especially at Phase II, many areas will be less submerged, leading to reduction of suitable fish habitats. In addition, slower water may lead to more silt being deposited in the marsh, which will further degrade the habitat. The correlation between flow and fish catch was proven to be highly significant, whenever there was a flow reduction, the number of fish declined (Tweddle et al., 1994).

The DRIFT report (Ecosystem Functional Model by Southern Waters in association with Streamflow Solutions, Anchor Environmental and MRAG for the SRBMP, 2016) does not foresee a reduction of open water surface (but depth) in the marsh (where most fishery takes place) however it foresees a reduction in rooted vegetation where spawning takes place.

Lastly, the increase drainage of pollutants (fertilizers and pesticides) will impact aquatic habitats.

ASSESSMENT OF IMPACT SIGNIFICANCE

	Reduction of suitable habitat for fish in the Elephant marsh. Reduction of flow will lead to reduction of habitat suitability in the marsh
Value of the affected component	Highly valued
Intensity	Low
Extent	Local
Duration	Permanent
Significance	Moderate
Occurrence probability	High probability

8.7.2 Mitigation measures

8.7.2.1 Disturbance to fish migration to spawning sites

In order to reduce impact on fishes during construction, it is highly recommended to:

- Design appropriate permanent river crossings instead of earth dikes. The goal would be to foresee needs before the Project is operational and to install permanent crossings;
- Forbid ford crossings of rivers to avoid destroying banks. In case where ford crossing is the best option, banks shall be stabilized and the ford crossing and ramp shall be made of concrete.
- When installing a temporary dike to cross river (for machinery and construction vehicles), the following measures shall be implemented:
 - Install super sized box culverts that allow for hydraulic transparency (see section on hydraulic transparency).
 - Install box culverts with natural bottoms to allow for fish passages by :
 - ensuring that all culverts are installed partially under the river bed level;
 - avoiding creating water falls (perched culvert) or having a steep slope in the culvert;
 - avoiding increasing flow to a point where some fishes can no longer swim;
 - stabilizing the culvert embankment with large riprap or gabion (given the strength of flash floods);
 - avoiding crossing at areas rich in vegetation (trees and tall grasses) or with shallow rocky areas as they often are valued spawning areas.
- All work in temporary rivers shall be prohibited from November to March and shall be concentrated between July and October to minimize impacts on migrating fishes.

Regarding the potential channelization of watercourses inside command areas to become drainage canals or to avoid floods, the FS has identified the Nkombedzi Wa Fodya to be channelized to protect lands from floods. On an environmental perspective, it is recommended to avoid channelizing major seasonal rivers as well as rivers crossing LNP especially Nkombedzi Wa Fodya and Namitalala Rivers. The main reason is that these rivers flooding pattern allow riparian thickets to grow (see previous section on disturbance of wildlife and vegetation). The Final Design shall exclude training work on Nkombedzi Wa Fodya and Namitalala Rivers, in order to comply with OP 4.04 and generally accepted environmental good practice standards.

Figure 34 Poor design of a culvert



Source : Bibliothèque nationale du Québec, 1997

8.7.2.2 Risk of Tiger fish invasion in the upper Shire

“If there is one thing the history of evolution has taught us it’s that life will not be contained. Life breaks free, it expands to new territories and crashes through barriers, painfully, maybe even dangerously...” Professor Ian Malcom, quote from the movie Jurassic Park (1993).

Although the invasion is only potential, the seriousness of the consequences both for fisheries and biodiversity of Lake Malawi in case of a Tiger fish invasion calls for real effective measures (Precautionary Principle). It is therefore recommended to install a fish barrier.

Self-reliant and low maintenance are the two principles that should govern the infrastructure that will be built to stop migration of Lower Shire fish species upstream.

Physical barriers will be more effective than behavioral barriers. This ESIA presents 3 options, all of which shall be studied in depth at Design stage to select the most appropriate option.

Electric fish barrier, sending pulses through the water, is not recommended, as it would involve having a constant electric current in a stretch of the canal, with regular power outages it will not be efficient.

The following options are not based on any return of experience on Tiger fish barriers as this situation is unique. It is only based on bibliographical analysis on invasive fish issues in North America. In addition, the FS report does not provide reliable assessment on canal or siphon infrastructures that are planned and that could be modified to design a physical barrier. The following description of options has been carried out with these limitations and take into account that the Tiger fish is known to jump out of the water to catch birds (barn swallows), it is also known to gain speed deeper before surfacing out of water (O'Brien et al., 2013).

OPTION 1: FISH SCREENS: HIGH RISK IF BUILT BY THE SCHEME CONSTRUCTION CONTRACTOR

Technical aspects

Fish screens are actual screens with small mesh size that retain fishes from moving along a canal or water intake. Fish screens should remain outside of the Shire flood risk zone (this is valid for all options). The following figure overlays flood assessment maps (BRLi, Wems, Aurecon, 2015) with the Project layout to show the area prone to floods. From this map, it is obvious that, in order to minimize the risk of floods overlapping fish screens, they have to be installed upstream from Mwanza River (this is valid for all fish barrier options). Installing fish screens upstream of the scheme reduces the risk of sabotage as people could be tempted to stock fish in the canal, a fish screen could be seen as an obstacle to fisheries. It is not recommended to install the screens along a canal since there is a probability that people use the canal as a waste dumpster (it is observed in many countries where the consultant has worked) blocking the flow at screen location and creating localized floods leading to potential Tiger fish passage around the fish screens;

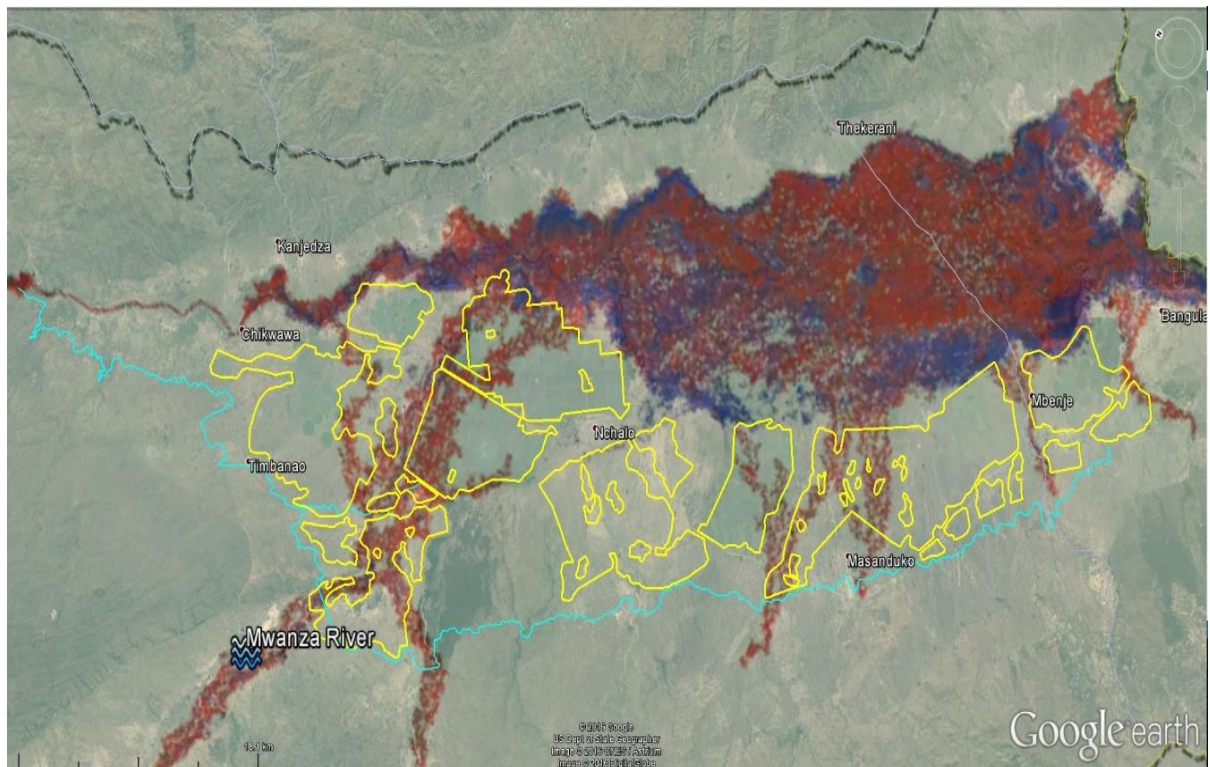
The mesh shall be small enough to exclude all tiger fish life stages except for eggs as tiger fish is not likely to spawn in the canal (especially in the buried canal) and that the risk of passage is based on movement (fish swimming upstream) and not flow (eggs do not swim).

- Fry sizes at hatching varies from 5-8 mm but fry grows very fast in warm temperatures (above 28°C) to reach 15mm in length within 2-3 days (with good nutrition).
- Adult size is up to 1,050mm (standard length, i.e., exclude the caudal fin, only the body) in the wild, in captivity they grow up to 750 mm ; their life span is 10 to 15 years and can weigh up to 28 kg. Males are larger than females.

Fish screens with 5 mm mesh size could be installed at the water intake.

The cost for fish screens varies greatly, but the average price in the US is about 35,000 USD per m³/s (Oregon Department of Fish and Wildlife Fish Screening Program: Fish Screen Types and Costs, 2016). A cost estimate for a fish screen with automatic cleaning device was provided by an USA based firm; based on current design of the Project, the cost of a fish screen would be 1.2 million USD including installation and shipment to South Africa of the screens (IWS International Water Screens, 2016) but excluding land transport to Malawi, which would cost around 25,000 USD (quotation from Savino Del Bene, 2017). Custom fees are unknown. Each replacement screen is 75,000 USD.

Figure 35 Flood risk area (in red)



Source: BRLi, 2016

The fish screens shall have automatic cleaning mechanism to remove debris using a traveling belt, with the belt moving in an endless loop powered by electricity. In front of the traveling belt a trash rack would be installed removing larger debris (logs, etc.). An inspection and maintenance plan shall be developed to ensure that the screens are operating well and that there is no breach.

Figure 36 Example of under construction large fish screen for water intake (left)



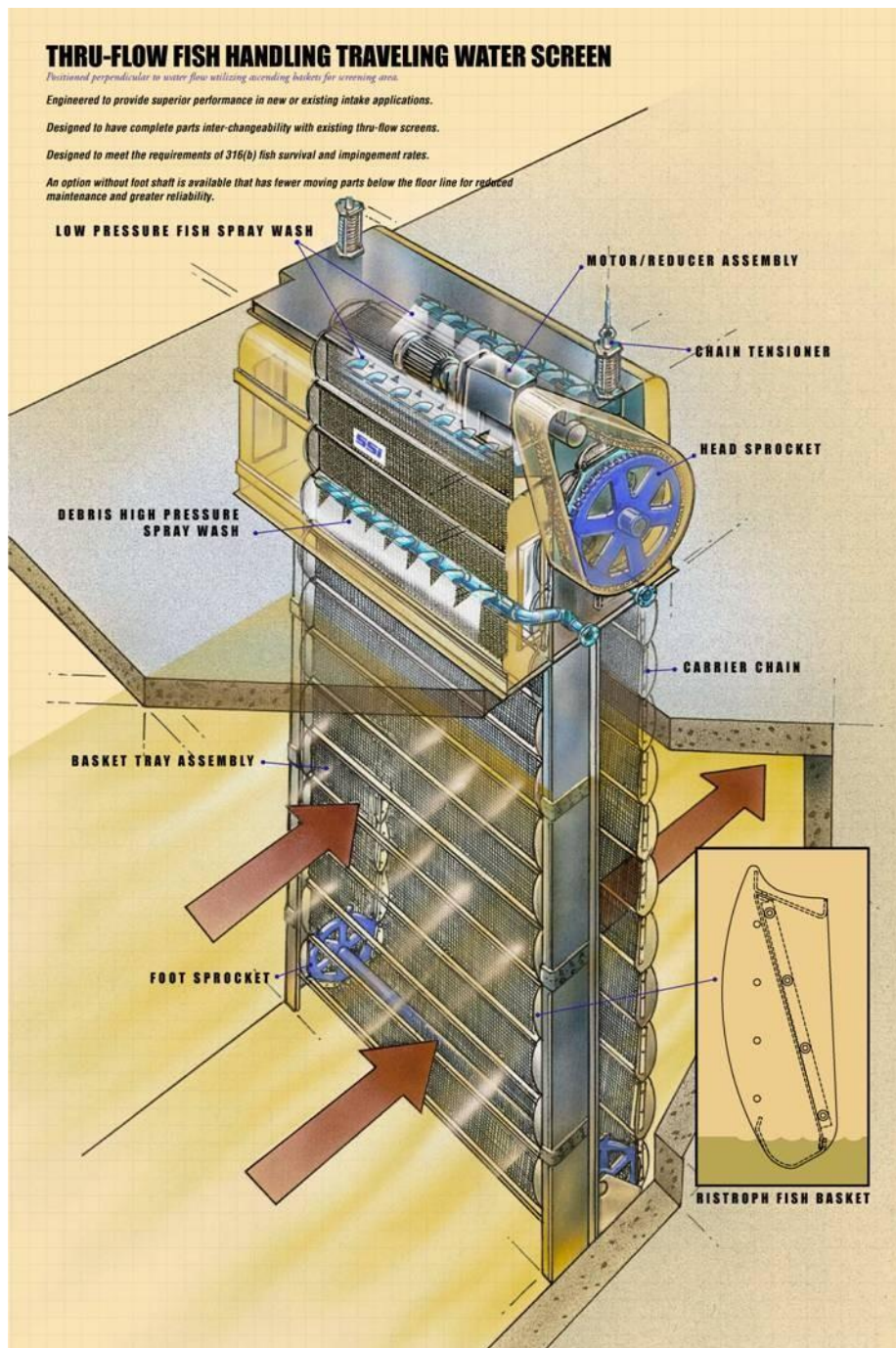
Source: Hendrick Screen Company, Fish diversion screen, 2016

Figure 37 Small scale automatic debris removal screens



Source: IWS International Water Screens, 2016

Figure 38 Large-scale automatic debris removal (traveling belt screen)



Source: Screening Systems International, 2016

Pros

Installing fish screens will have lesser economic impact on the Project than option 1 (due to option 1 head loss) because it will lead to insignificant head loss (about 30 cm head loss, based on actual calculations from IWS with a fish screen at the SVIP water intake, 2016). It will be efficient to prevent the Tiger fish from moving upstream only if a specialized firm is involved in designing and installing the screen.

Cons

The risk of defect, breach or obstruction of the screens is very important for the following reasons:

- There is a high risk of water hyacinth bloom in the Kapichira reservoir leading to blockage of screens at the water intake, unless a reliable trash rack is installed;
- Unless a specialized firm is involved in designing, producing and installing the screen, it will probably have defects and will not prevent fish passage (in fact in many countries such as the US, fish screens have to follow regulations and norms and must be built by certified firms). Many specialized firms are located on the Pacific coast of North America where there are issues with invasive migratory fishes. This expertise is absent in Africa and there is no return of experience in Africa.
- The fish screen is not a simple civil engineer infrastructure and will require constant effort and maintenance. Maintenance of this technology may fail in the medium term for a number of reasons (change in the scheme operator, budgets cut back, lack of spare parts, etc.). Maintenance of the screen at the water intake would require to remove debris (water hyacinth), logs, etc. in an area crawling with crocodiles. A self-cleaning device is highly recommended.

OPTION 2: A LOW CONCRETE WALL WITH A RACK AND AN APRON

This infrastructure shall not be installed outside MWR otherwise people will use it as area to wash clothes (on the apron) to bring cattle to drink and to bath. This will lead to damages to the infrastructure.

To be efficient, the fish barrier shall have the following characteristics from upstream to downstream:

- A waterfall high enough to keep the fish from jumping over. This wall shall be vertical and made of concrete. The height shall be at least 1 meter high.
- A long area of shallow water of about 30 cm deep (called an apron) to keep fish from gaining speed and energy to jump. The length of the apron shall be a few meters. To convey 50m³/s, the apron will need to be several hundred meters wide.
- An area of gradual slope leading to the canal which, at this point, will have its normal shape.
- A rack to offer additional security against jumping fishes

The fish barrier shall be installed in Majete Wildlife Reserve for the following reasons:

- To intercept all risks as the further downstream the structure is installed, the higher the risk of invasion;
- To take advantage of the buried canal or inverted siphons exit and available land to install the fish barrier;
- To take advantage of an area with lesser population density and to avoid having people using it to wash clothes (on the apron), bringing cattle to drink and to bath.
- To rely on African Parks as a well-managed organization for surveillance.

The following figures show two tested fish barriers with their wall and apron.

Figure 39 Smaller scale examples of fish barriers



Source left to right: The Verde Independent | Cottonwood, Arizona (2015) and Trout Unlimited (2013)

Pros

The low wall could be compensated by a rack (fence) along it to keep adult fish from jumping, the height of the wall would still be efficient to keep adults, fry and juveniles away and the apron will keep Tiger fish from gaining speed to jump. The fence could be either vertical or horizontal (as shown in the following pictures). This option is economically advantageous while ensuring high efficiency. However, as the wall is low, any damages to the structure would reduce its efficiency. The fence could simply be repaired in case of damages.

Cons

For this option, the Design or FS consultant has to decide what is an acceptable head loss, canal slope reduction, width augmentation and flow reduction. The height shall however not be lower than one meter.

The rack (fence) shall be designed, produced and installed by a specialized firm.

Figure 40 Examples of fish weir and rack



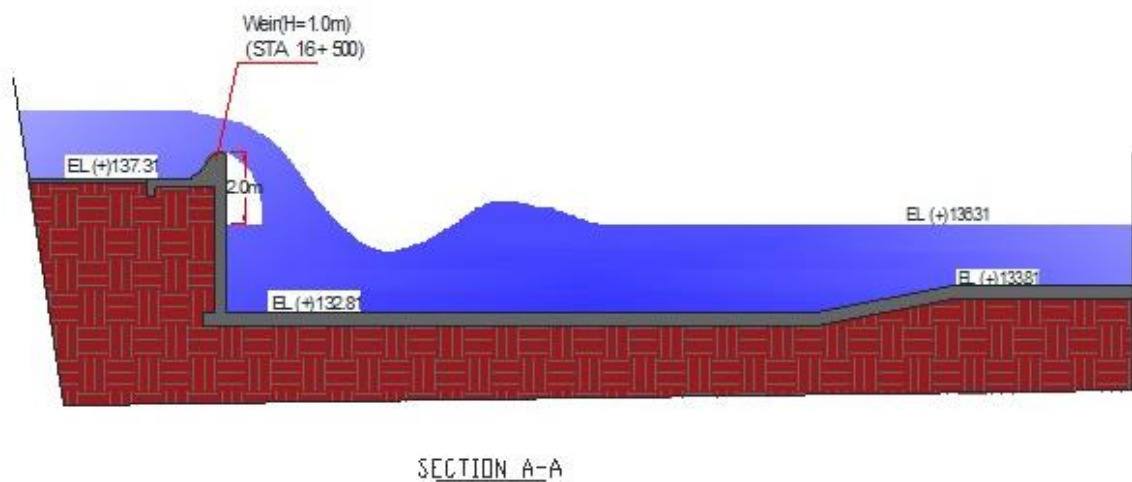
Source: New Zealand department of conservation, 2016

OPTION 3: A HIGH WALL, THE TIGER FISH WEIR DESIGNED BY KRC

Several discussions were held after the ESIA Mitigation Workshop (November 2016) on measures to avoid invasion of the Tiger fish upstream of Kapichira falls. In March 2017, a document called "Second proposal for mitigating the Tiger Fish Issue" was produced by the FS consultant presenting an infrastructure to stop Tiger fish migration upstream. This section presents the infrastructure and its main characteristics.

This option has a higher wall but no apron and no rack. The infrastructure involves a fall with a 1 meter high broad crested weir across the Main canal 1 (feeder canal) combined with a 3.5 meters drop structure as shown in the following figure.

Figure 41 KRC proposal for a Tiger Fish barrier



Pros

The height of the fall provide sufficient protection against fishes trying to jump. The fact that the wall is higher than option 1 makes the apron and the rack not useful.

Cons

The proposal from KRC seems to be efficient; however, it will have to be completed by more detailed plans and technical description in order to assess its efficiency. In addition, a ramp must be installed to allow removing deposited silts to keep silt from clogging the weir and having side flow and to maintain the structure.

KRC has provided in its document two location, one inside MWR and one at chainage 16+600 (as shown in the picture). The chainage 16+600 is too far downstream and will not catch all risks. In addition, at this location, there is a risk of damages from people using the falls for domestic use or to bring their cattle to drink. The weir has to be located inside MWR.

Summary of options

The following table is a summary of options to block Tiger fish invasion in the Upper Shire River system and all other Lower Shire fishes.

	Option 1: Fish screens	Option 2: A low concrete wall with an apron and a rack	Option 3: The Tiger fish weir designed by KRC High concrete wall without apron and without a rack
Land	Does not require additional land than the actual canal RoW	Requires additional land to install the wide apron	Does not require additional land than the actual canal RoW
Maintenance	High level of maintenance required to remove the debris and repair damages to the screens. Even if an automatic debris removal screen is installed it would still require maintenance (and energy for automatic debris removal)	Low maintenance necessary, the structure is a long lasting infrastructure. Silt removal could be necessary if not done upstream (at the water intake). The fence could easily be repaired in case of damages.	Low maintenance necessary, the structure is a long lasting infrastructure. Silt removal could be necessary if not done upstream (at the water intake)
Economic	High initial cost but probably the least expensive on economic implication thanks to minimal head loss. However, expensive to maintain and represent a high risk in case of failure to maintain the screens	Cheap to install and leading to less head loss than the high wall.	Additional cost is, according to KRC, 4.3 million dollars if the structure is installed inside MWR
Technical		The weir could be done by the canal construction contractor as the structure is easy to design. However, the fence requires more technical expertise to sustain the flow	Could be done by the canal construction contractor as the structure is easy to design
		This option would require the feasibility or design consultant to decide on an acceptable head loss to statute on an acceptable wall height. However, less than a meter high is not recommended.	Loss of gravity command area: Dropping the canal by 3.5 meters will keep the following area out of gravity command: 275 ha

	Option 1: Fish screens	Option 2: A low concrete wall with an apron and a rack	Option 3: The Tiger fish weir designed by KRC High concrete wall without apron and without a rack
Efficiency	High efficiency in blocking fish movement (no risk regarding fry and juvenile passage) as long as the screen is design and installed by a specialized firm	High efficiency, but the lowest the wall, the more it represents a risk (in case of damages to the weir or fence)	High efficiency in blocking fish movement (no risk regarding fry and juvenile passage) as long as the weir is inside MWR

CONCLUSION

None of the option shall be installed outside African Parks reserve. African Parks is a reliable organization and the reserve is fenced, this would avoid having damages to the infrastructure.

Investment for mitigation should reflect the issues at stake (invasion of the Tiger fish and other non native fishes in an international lake and world heritage site).

Given the high risk of poor maintenance and clogging of fish screens and the high cost for maintenance for the screens, the ESIA recommends that a weir be implemented, as presented in options 2 and 3) because it is the only realistic infrastructure. Option 2 is only recommended if head loss cannot be compensated by changing the canal slope. **However, option 2 alone represents, on the long-term, a major risk for the future of Lake Malawi if maintenance fails or breaches appear on the screens.**

The wall is therefore the principle to retain, if the wall is low (option 2) it has to be accompanied by a rack and an apron, if the wall is high (option 3), there is no need for a rack and less incentive for an apron. The concept of an apron is interesting but given the volume of water, it is not feasible (it would be 500m wide).

This report highly recommends that the fish barrier be installed inside MWR for the following reasons:

- the fish barrier must catch all risks and be located as far as possible upstream.
- to eliminate the risk of tributary rivers flooding the feeder canal upstream from the fish barrier (such as Mwanza River and other rivers with flash floods) leading to potential colonization of fishes. Tributary Rivers flooding canals is a real risk and has been observed by the consultant in other regions of Africa (most of the time it is caused by the absence of culverts across canals or the improper sizing of culverts).
- outside MWR there is a real risk of damages from people using the falls for domestic use (washing their clothes on the fall, as observed in Illovo) or to bring their cattle to drink.
- inside MWR, there is a better chance that defects or breaches in the fish barrier be detected early enough, thanks to good management of African Parks.

It is not recommended that a fish barrier be installed in the underground section of the canal because of maintenance issues; any breaches would remain undetected for long periods of time. In addition, underground fish barriers were never designed nor tested. An underground fish screen is not feasible neither due to high risk of breaches for debris.

In all cases, further assessment shall be done at Design study stage to ensure that the infrastructure blocks all Tiger fish from moving upstream, the Design study has to prove that at all time and at all flow (especially at high flow), the weir drop is higher than the jumping ability of the Tiger fish which is about 1 meter. The World Bank will contract a Panel of Experts to review in depth the design and specific location of this fish barrier to ensure that it would function effectively, with little or no required maintenance over the long term. This expert review will be conducted in parallel with the final design of the Main Canal, and well before the start of canal construction.

8.7.2.3 Reduction of suitable habitat for fish in the Elephant marsh

In order to mitigate the impact on Elephant marsh not much could be done in terms of civil engineer infrastructures. Installing weirs or dikes to maintain a level of water at some key locations is not recommended as important floods would destroy them. The current study under the SRBMP called "Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi" provides more details on institutional measures to implement to ensure adequate natural resources management which will help to improve biodiversity in the marsh as well. Once again, adaptation of Kamuzu barrage to provide for an environmental flow would be useful.

9. IMPACT ASSESSMENT CONCLUSION

This Impact assessment report is based on several bibliographical researches and consultations with various stakeholders as well as external experts on wildlife behavior.

This report has highlighted several significant impacts all of which can however be mitigated to acceptable levels as long as adequate budget is dedicated to mitigation measures.

Mitigation revolves around four challenging topics:

- the tender process for a construction contractor ;
- work in MWR;
- the type of canal and associated wildlife infrastructures in MWR and LNP;
- the type of fish barrier

These five topics shall be given priority by project financiers in case if budget for mitigation is limited. Although mitigation workshops have revealed that additional release from Kamuzu is not feasible on the short term, the rationale for an environmental flow is still detailed in this section.

TENDER PROCESS FOR A CONSTRUCTION CONTRACTOR

The selection of a construction contractor and the inclusion of appropriate mitigation measures in call for tender and contract is a crucial step as many contractors are not environmentally and socially proactive and most have no experience in working in sensitive areas.

Therefore, the selection of the construction contractor will require a conscious decision by project proponent and financing agencies prior to tendering. In addition, many measures proposed in this ESIA involve costs for the construction contractor, call for tender shall be clear on the requirement to quantify measures in the Bills of Quantities.

It is highly recommended to require that the contractor has experience in work in wildlife parks but most important of all, his reputation must be assessed.

WORK IN MWR

This ESIA has highlighted the need to implement many highly specific mitigation measures inside MWR, some of which should be included in the bills of quantities of the construction contractor. The quality of some mitigations inside the reserve cannot be compromised, and the risk that the contractor intentionally tries to replace highly specific mitigation by cheaper infective measures can be managed by providing funds directly to African Parks prior to work inside the reserve so that some site preparation works can be done by African Parks trusted contractors. This way, African Parks could prepare the site according to its quality standards and manage impacts associated with the "heavily impacted area". The following mitigation could be done by African Parks' regular contractors (and not by the Project construction contractor):

- Construction of the diverted road.
- Purchase and management of certified sound barriers.
- Purchase and installation of the temporary fences and all other infrastructures along the "heavily impacted area".
- Animal containment and transportation outside the temporary fences (including the cost for a veterinary).
- Improvement of existing watering points to provide for water further inside the reserve (because wildlife will be startled by construction noise).

- Funds for monitoring studies on the effect of construction on wildlife.
- Any other activities, equipment or mitigation to completely confine the heavily impacted area during the time of work. It will not be realistic trying to continue any touristic activities during work in the “Heavily impacted area”, as the number of trucks traveling along the Mkulumadzi road across MWR will be very high and constant (mainly due to sediment dredging at the water intake, every few minutes a truck will pass). Therefore, it would be better to completely confine this area at once from Mkulumadzi Road to the Shire River. Mobile sound barriers shall be installed along the road close to the entrance gate and shall surround MWR offices (as offices will have excavating activities in the back and traveling trucks in front in addition to dust). Funds for confinement shall be provided to African Parks before work.

Phasing the work inside or near MWR in three distinctive confined areas so that no work takes place in several areas is absolutely necessary to maintain the reserve integrity:

- “Heavily impacted area” (first phase)
- Mwembezi lodge private property (also called Ng'ona lodge) (right outside MWR) (second phase)
- Southern MWR (third phase) from Siphon #2 to Siphon #3

Phasing the work shall be mentioned in the call for tender of the construction contractor so all interventions are planned.

This ESIA has engaged in many discussions with African Parks and provides cost estimates in the ESMP. However, since the Design is not available yet, this ESIA also suggests that the compensation package be updated once the final layout is known.

TYPE OF CANAL AND ASSOCIATE INFRASTRUCTURE IN MWR AND LNP

In order to achieve maximum efficiency in mitigation while remaining economically feasible (and realistic), we recommend that the canal in MWR shall follow the shortest distance outside MWR. According to the FS, some sections of the canal inside MWR will remain open, in this case, to avoid animal and children drownings; walls shall be built on both side of the canal. This is particularly relevant given the fact that recently African Parks has decided to develop the area where the open canal will pass. The development will consist of a small fenced park with non-dangerous mammals (antelope, etc.) aiming at children (schools trips, etc.). African Parks has also requested that a small wetland be built at this location instead of small troughs (as a compensation measure).

Regarding LNP, in case if an earth canal is feasible, this ESIA recommends that slopes remain gentle (1/2 or 1/3 rather than 1/1.5) and that the option of prefabricated concrete mats made of flexible matrix of cellular concrete blocks be studied at Design phase. These mats would give wildlife a good grip to exit the canal and would safe canal banks from erosion and bank destruction from wildlife. The following is a figure illustrating these mats.

Figure 42 Armorflex mats



Source: Infrastructure Specialist Group, 2016

TYPE OF FISH BARRIER

This ESIA recommends that Option 2 or 3 be implemented, as it is simple to maintain, however it will lead to head loss that will have implication for the area of irrigated land. Installing a fish screens at the water intake with a self-cleaning device (traveling belt) is a very interesting option because it will lead to minor head loss (30 cm). The mesh of the screen shall be small enough to exclude all adult and fry tiger fish (5 mm mesh size). However, given the fact that the screen can only be designed and maintained by a specialized firm (and not just by installing a wire mesh across the water intake), this option is less relevant and maintenance risks are high. Any breach in the screen would require importing a new screen from a foreign country leading to delays.

The cost of a fish screen is about 1.2 million USD (based on calculation for SVIP from International Water Screens Co, 2016). This cost exclude maintenance and electricity, each spare screen is 75,000 USD (International Water Screens Co, 2016). This cost also excludes importation fees.

9.1 CONCLUSION ON INFRASTRUCTURES TO BUILD TO MITIGATE IMPACTS

This section presents all civil engineering infrastructures developed in this ESIA and that need to be studied by technical studies (Design).

Self-reliant and low maintenance are the two principles that should govern all infrastructures that will be built.

Additional infrastructures recommended in this ESIA will allow to engage in discussion with various stakeholders but will most likely evolve based on the evolution of the Project. Depending on the financial arrangements for the Project (who will be the end payer for these mitigations), these infrastructures could affect the overall performance of the Project and may influence the water fees.

Costs for mitigation are provided in the ESMP (Vol.3), they are based on return of experience from the consultant or are provided from specialized firms (quotations). However, in depth economic feasibility has to be done by the Design study. Additional cost estimates are provided in the ESMP for non-engineering measures.

CANAL OPTIONS IN LNP

If the canal is an earth canal, the Design shall study the feasibility of installing prefabricated concrete mats along the 14 km of LNP which are flexible matrix of cellular concrete blocks that safeguard canal integrity from animals while ensuring that canals do not represent a drowning hazard. In addition, in case of an earth canal (with or without the Armorflex), walls are not required as an earth canal offers good grip for wildlife to exit the canal.

FENCE OPTIONS IN MWR AND LNP

Wall made of rock in concrete matrix (with a 0.5 cm thickness and a height of 2 meters) to protect the open sections of the Feeder canal in MWR is the selected option by this ESIA and the Design study shall retain this option.

PASSES

The Design study shall assess the economic feasibility of the following options (with current knowledge this will not be required for MWR thanks to buried sections but will be necessary in LNP):

- Unit cost for a wildlife overpass in concrete able to sustain the weight of a herd of buffalos (20+ individuals) with the following dimensions:
 - Slope for the access ramps: 8 Vertical / 1 Horizontal
 - Width : 50 m
 - Height: 2 m above the canal
 - Length to cross Bangula canal: 17 m (without the length of the ramp on both site of the canal)
 - Wall on the pass: 2 m high
 - Supporting poles
- Additional cost to enlarge a box culvert to allow for dry passages of small to medium size animals (wildlife underpass).
- The unit cost for a vehicle bridge across main canals (5 meters wide)
- The unit cost for a footpath across main canals (and branch canals)
- The unit cost for a people/cattle bridge across main canals

WATERING POINTS

The Design study shall design the following measure:

- MWR and LNP : A concrete lined wetland in the small game area of MWR and on the Eastern part of Bangula canal in LNP with the following dimensions:
 - Diameter : 30 m
 - Depth 0.5 m
 - Concrete lining : 10 cm (to avoid seepage) and a geomembrane
 - Type of pipes to convey water (sluice gates, etc.)
 - Each wetland would require about 350 m³ of water from the canal, filled every two days, this would be the equivalent of 1230 m³ per week (or 0.002 m³/s) which is negligible in regard to the volume of water in the canal.

CROCODILE FENCE

As highlighted in the report, such fence are not recommended.

TIGER FISH BARRIER

The Design study shall further assess option 4 to ensure that it blocks upstream migration

9.2 RESIDUAL IMPACTS

This section presents residual impacts, if mitigations are implemented impacts can reach an acceptable level.

Table 19 Residual impacts

Impacts	Significance	Residual impact	Explanations
Impacts from water work. During construction, some actions and infrastructures will modify geomorphology of rivers	Negligible	Negligible	Impacts will be reduced with mitigation but not suppressed
Siltation of Elephant marsh. During operation of the scheme, erosion and sedimentation pattern will be modified	Minor	Minor	Reduction of flow cannot be mitigated, the impact will remain
Water abstraction. Up to 50m ³ /s will be extracted from the Shire system	Major (and cumulative)	Moderate	Reduction of the impact can be slightly achieved if pumping stations of Illovo remain shut down and if drainage is efficient. However, they are no provision for an environmental flow from Kamuzu barrage
Hydraulic transparency. When crossing the canal tributary rivers can flood upstream village if culverts are not properly sized	Minor	Negligible	If infrastructures (box culvert, etc.) are properly dimensioned, the impact should be negligible
Impacts from water works. Construction activities will bring silt and other pollutants to rivers	Negligible	Negligible	Impact will be reduced with mitigation but not eliminated
Water quality impairment. Drainage in watercourses will impair water quality	Moderate	Moderate	Impact will remain the same as pesticides and fertilizer will inevitably be used
Impacts from earthwork and land leveling. Construction of the canal system will lead to important earth movement	Moderate	Minor	If mitigations are implemented the impact can be reduced
Changes in soil properties and rising water table. Several changes in soil properties could take place in the command area	Minor	Negligible	Proper soil management will reduce the impact
Village reorganization and resettlement. Major changes are foreseen in terms of land occupation	Major	Minor	The RAP report will address impacts from village reorganization
Workers influx. Land will be necessary and there is a risk that infrastructures do not respect quality standards. Influx could be associated with social impacts	Moderate	Minor	If mitigations are implemented, including the strict application of the Code of conduct, the impact can be reduced

Impacts	Significance	Residual impact	Explanations
Rapid social changes. There is a risk that people do not change their lifestyle and develop skills	Minor	Minor	Impact will be reduced with mitigation but not eliminated. The current CCPLTRPF assignment aims to collecting people grievances and communicate about the Project. The Communication strategy report provides a tool to ensure social acceptability of the Project.
Hinterland effect. Increase in human activity and local economy may lead to additional pressure on resources (wood for charcoal, fish, etc.) and land	Moderate	Moderate	Mitigations for this impact are difficult to address in an ESIA
Permanent loss of buildings and other assets. Canals could necessitate to pass through several buildings and assets	Minor	Minor	Impact will be reduced with mitigation but not eliminated, however, the RAP will compensate according to the World Bank OP4.12
Disruption of access. Canals may sever footpaths and cattle paths	Moderate	Minor	If all measures to ensure continuity of access are fulfilled, the impacts will be mitigated
Inadequate maintenance of canals and infrastructures. There is a risk of canals and water intake siltation and invasion of plants in canal and drainage channel	Moderate	Minor	If all measures to ensure proper maintenance of canals and infrastructures are implemented by the scheme operator, the impact will be mitigated
Disturbance to existing agriculture. New lands may not be ready for cropping immediately because of timing, lack of water, or the need for land preparation including levelling, boundaries and drains	Minor	Minor	Impact will be reduced with mitigation but not eliminated, the risk still needs to be addressed
Job opportunities. Work will require unskilled and skilled labour for construction	Minor (positive)	Moderate (positive)	If the employment recruitment policy is implemented, the positive impact can be enhanced
Potential delays in irrigated agriculture development. Any delays in the project completion or skills acquisition could delay the benefits	Minor	Minor	The impact will be reduced with mitigations but not eliminated
Over supply of crops. Increase in production could lower prices and affect rain fed producers	Major	Minor	If this issue is addressed in future studies (agriculture development, agribusiness development), this risk will be significantly reduced
Benefits of irrigated agriculture. The project overall goal is to benefit local communities	Major (positive)	Major (positive)	This major positive impact will be enhanced thanks to training of farmers, creation of water user associations, etc.

Impacts	Significance	Residual impact	Explanations
Reduction of fisheries. Fishery could be impacted by SVIP	Minor	Minor	Reduction in fishery (if it occurs) will hardly be mitigable. The SRBMP will develop more good management measures for fisheries
Impacts on livestock rearing. The project will require adaptation of livestock rearing activities	Moderate	Minor	If appropriate mitigations to ensure that livestock owners have access to grazing areas, the impact will be mitigated.
Construction risk and nuisances. The public and workers are at risk from important works along canals	Minor	Minor	Impact will be reduced with mitigation but not eliminated as they will always remain a level of nuisance (noise, dust) and risks of collision
Bilharzias. An increase of bilharzia in the command area is expected	Moderate	Minor	Impact will be reduced with mitigation such as mass treatment but will not be eliminated
Drownings. The presence of main canals may lead to drownings	Major	Moderate	Reduction of the drowning risk can be achieved with sensitization and safety ladders, but never eliminated
Increase workload for women. The Project may become a burden to the workload of women but on the other hand time spent to get water should decrease with Improved access to water	Minor (positive)	Minor (positive)	Gender and Youth Strategy Study (COWI, 2016) has developed a series of measures to mitigate these impacts.
Risk of unfair distribution of benefits. Access to financial services is a strong barrier to women and youth empowerment	Moderate	Minor	
Impacts on vulnerable people. The Project benefits may not reach vulnerable people	Moderate	Minor	
Loss of physical cultural heritage. During construction, excavation of the canal will affect some known and unknown cultural heritage sites.	Minor	Minor	Reduction of the impact can be achieved, however, they will always remain a certain level of impacts as excavation may unveil (or destroy) unknown cultural heritage material
Decision on the type of canal and its alignment. Decisions regarding the canal layout during the design stage will have long term impacts on parks	Major	Minor	If this issue is given consideration and that the canals remain partly buried inside MWR (and remains an earth in LNP), the impact will be reduced.

Impacts	Significance	Residual impact	Explanations
Decision on the status of canals inside parks. The presence of canals inside parks will require a clear definition of their status	Moderate	Minor	If this issue is given consideration and that the canals is not alienated from MWR and subject to African Parks access restriction, the impact will be reduced.
Tender process and selection of a construction contractor. The tender process for the selection of the Project construction contractor represent a high risk for parks as it is a crucial step in the development of binding environmental measures	Major	Moderate	If the selection of a high quality construction contractor is given consideration, the impact will be reduced
Impact on tourism. Construction activities in MWR and LNP and close to Ng'ona lodge will have deleterious impacts on tourism	Moderate (MWR) / Minor (LNP and Ng'ona lodge)	Minor	If the construction activity is phased and confined in MWR and its vicinity, the impact will be reduced
Impact on Majete buildings, roads and infrastructures. Infrastructures will be disturbed by construction of the Feeder canal	Moderate	Minor	If the mobile noise barrier, sufficient dust control and other mitigation measures are implemented, impact will be reduced
Impact on Kapichira falls attractiveness. The viability of the falls as a sight to see for tourists may be compromised on long term with reduced flows	Moderate	Moderate	As explained in the report, no realistic mitigation can be implemented
Impact on Lengwe roads and infrastructures. The fence and park roads will be impacted	Moderate	Minor positive	If appropriate infrastructures are implemented close to the canal, they could become an opportunity for LNP
Loss of ownership of park management on the western side of Lengwe. Construction and operation of the Bangula canal will split the park in two, this could be interpreted as a message of weak ownership	Moderate	Minor	If appropriate compensations such as a new ranger scout are funded, the impact will be mitigated
The presence of a canal inside parks will be long-term agent of changes. The presence of canals and other infrastructures inside parks will require additional efforts and inputs from park management in order to maintain parks' integrity	Moderate	Minor	If responsibilities are clearly stated in agreements, the impact will be reduced
Rapid change in land cover. The command area will lead to significant changes in land cover	Moderate	Minor	If set aside lands are implemented at Design, the impact will be reduced

Impacts	Significance	Residual impact	Explanations
Disturbances of wildlife and vegetation. Forest clearing will permanently destroy valuable habitats and work will startle wildlife	Moderate	Minor	With compensation measures (planting of trees) and mitigation during work are implemented, the impact will be reduced
Habitat fragmentation. Canals will permanently fragmentize habitats especially in parks	Major	Minor	With a buried canal in MWR and wildlife overpass in LNP, the impact will be reduced
Drowning hazard for wildlife. An open canals represent a drowning hazard for wildlife	Major	Moderate	If the appropriate measure is taken against animal intrusion in the canal (walls on both side of the canal), the impact will be reduced for large animals, however small animals will always be at risk of drowning.
Changes in plant composition in Elephant marsh. Flow reduction will reduce the size of Elephant marsh	Moderate	Moderate	The impact is not mitigable, as they are no provision for an environmental flow from Kamuzu barrage
Wildlife-human conflict. There is a probability that hippos and crocodiles enter the drains and cause wildlife – human conflicts (and casualties). Irrigated field will become very attractive for wildlife.	Moderate	Moderate	The risk is hardly mitigable, however it mainly concerns Phase II as Phase I is far from Elephant marsh
Disturbance to fish migration to spawning sites. Works and infrastructures in temporary rivers could lead to fish migration disturbances	Moderate	Minor	If work is done outside the spawning season and crossings and culverts properly sized, the impact will be reduced
Risk of Tiger fish invasion in the upper Shire. The water intake could lead to Tiger fish invasion of Middle and Upper Shire and Lake Malawi	Major	Nil	If a fish weir is installed upstream from all risks (in MWR and on the Feeder canal), the risk will be nil. Otherwise, the risk will remain
Reduction of suitable habitat for fish in the Elephant marsh. Reduction of flow will lead to reduction of habitat suitability in the marsh	Moderate	Moderate	The risk is hardly mitigable. However, SRBMP may propose measures to mitigate impact

10. BIBLIOGRAPHY

A brief review of the Fish Stocks and dependent Fisheries of Lake Malawi <http://www.fao.org/docrep/005/S7047E/S7047E04.htm#ch4> FAO Fisheries and Aquaculture Department

A Cultural Heritage Impact Assessment Report (Malawi Department of Antiquities, MDoA, 2015)

Agricultural Development Planning Strategy (PWC, 2016)

Armorflex : <http://www.incaconcrete.co.za/armorflex.php>

Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi Management Plan for the Elephant marsh (Anchor Environmental Consultants in association with MRAG and Southern Waters for the Shire River Basin Management Program)

Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi Hydromorphology study (Anchor Environmental Consultants in association with MRAG and Southern Waters for the Shire River Basin Management Program)

Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi Sub-Study 4: Biodiversity of the Elephant Marsh (Anchor Environmental Consultants in association with MRAG and Southern Waters for the Shire River Basin Management Program)

Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi Analysis of the potential effects of alternative future scenarios of flow and/or management on the ecological condition of the Elephant Marsh (Ecosystem Functional Model (DRIFT) (Report Prepared by Southern Waters in association with Streamflow Solutions, Anchor Environmental and MRAG for the Shire River Basin Management Program)

Climate Resilient Livelihoods and Sustainable Natural Resource Management in the Elephant Marsh, Malawi. Sub-Study 3. Ecosystem Services of the Elephant Marsh. Anchor Environmental Consulting Report No1652/2. December 2016.

Climate resilient livelihoods and sustainable natural resources management in the Elephant Marshes, Malawi. Ministry of Water Development and Irrigation. P117617. Description of the livelihoods in the area of the Elephant Marsh Report November 2016 Submitted by MRAG in association with Southern Waters, Anchor and Stream flow solutions.

Comparative Road Dust Suppression Capacity of Molasses Stillage and Water on Gravel Road in Zimbabwe J. Gotosa , G. Nyamadzawo , T. Mtetwa , A. Kanda and V. P. Dudu1. Editor(s): (1) Francisco Marquez-Linares, Nanomaterials Research Group, School of Science and Tech., University of Turabo, USA.: <http://www.sciencedomain.org/review-history.php?iid=695&id=31&aid=6468>

Concrete wall: <http://concreteva.com/what-we-do/walls/>

Elephant crossing fence: <http://www.dailymail.co.uk/news/article-2573840/The-elephant-didnt-forget-avoid-electric-fence.html>

Feasibility Study reports KRC (2016) Final version is dated December 2016

First observation of African tigerfish *Hydrocynus vittatus* preying on barn swallows *Hirundo rustica* in flight G. C. O'Brien, F. Jacobs, S. W. Evans, N. J. Smit First published: 19 December 2013

Fish screen pictures: <http://www.screeningsystems.com/products/316b-Compliant---Fish-Handling-Screens>

Fondriest Environmental, Inc. "Sediment Transport and Deposition." *Fundamentals of Environmental Measurements*. 5 Dec. 2014. Web. < <http://www.fondriest.com/environmental-measurements/parameters/hydrology/sediment-transport-deposition/> >

Full publication history UNDP (2016) Fencing crops against hippopotamus. http://www.gm.undp.org/content/gambia/en/home/ourwork/environmentandenergy/successstories/Sample_Success_Story_2.html

Fury over Namwater's planned closure of water canal: <https://www.newera.com.na/2015/08/07/fury-namwaters-planned-closure-water-canal/>

Guide L'aménagement des ponts et des ponceaux dans le milieu forestier © Gouvernement du Québec Ministère des Ressources naturelles Dépôt légal, Bibliothèque nationale du Québec, 1997 ISBN : 2-550-31791-2

Hydraulic model study at the headpond of Kapichira dam. Artelia (2016)

Implementation Service Provider (ISP) for Flood Risk Management (SRBMP-1)

Independent Environmental Impact Assessment for the Upgraded Kamuzu Barrage (December 2011)

IUCN African Elephant Specialist Group. Barrier against elephant. 2003 <https://cmsdata.iucn.org/downloads/hecfencen.pdf>

Lengwe National Park, General Management Plan 2016-2020 work document (Component B, Sub component B4)

Lewis, D. (ed.), 1988 Predator-prey relationships, population dynamics and fisheries productivities of large African lakes. CIFA Occas. Pap., (15): 154 p. <http://www.fao.org/docrep/005/S7047E/S7047E00.htm#TOC>

Managing the risks of adverse impacts on communities from temporary project induced labor influx from the Environmental and Social Safeguards Advisory Team (ESSAT) of the World Bank 2016.

Mount Kenya Trust. Elephant underpass. <http://www.mountkenyatrust.org/projects/elephant-corridor>

Pest Management Plan for the SVIP (BRLi, 2016)

Precision blasting (2016) CN Plant Hire & Rock Blasting: <http://www.cnplanthire.co.za/rock-blasting/>

Preparation and implementation of a Communications, Community Participation, Land Tenure and Resettlement Policy Framework (PCCPLTRPF). COWI (2016)

Public-Private Partnership (PPP Feasibility study). BRLi (2016)

Shire River Basin Management Program (Phase I) Project Final Environmental and Social Assessment Report (July, 2013)

Some observations on the predatory feeding habits of *Hydrocynus Vittatus* Castelnau in Lake Kariba <http://www.fao.org/docrep/005/S7047E/S7047E09.htm> FAO Fisheries and Aquaculture Department

The feeding habits of an introduced piscivore, *Hydrocynus vittatus* (Castelnau 1861) in a small tropical African reservoir TATENDA DALU, BRUCE CLEGG, LIGHTONE MARUFU & TAMUKA NHWATIWA PANAMJAS *PanAmericanJournal of Aquatic Sciences*

The Republikein (2016) Die 'waterpad' na Windhoek gee problem
<http://www.republikein.com.na/nuus/die-waterpad-na-windhoek-gee-probleme/>

The Star of Johannesburg, 1990

ANNEXES

Annex 1: Minutes of Mitigation Workshops

Table 20 Minutes of Nsanje Workshop

Questions raised during the workshop	Answers from the Consultant
What will happen if there is a need to cut valuable or protected trees?	At this stage, the ESIA could not identify individual protected trees, the Department of forestry will be involved whenever there is a risk of destruction of protected trees (whenever the canal passes across forested areas). This is added in the ESIA/ESMP in addition to the need to protect woodlands as set aside lands
Will canal be accessible for canoe?	No, canal access will be strictly forbidden for canoe
Water level in the Shire is already going down, is the Project feasible?	Indeed, however the ESIA role is not to assess the feasibility of the Project but to assess impacts. The FS has assessed the feasibility of the Project.
Who will maintain the canals?	The primary canal and branch canals will be under the management of an operator. People will have to maintain their plots, tertiary canals and drains
Could the canal overflow and flood villages?	No, water in the canal is controlled by gates at the water intake
Could the canal be fenced to keep children from drowning?	No, fencing will not withstand (stolen, vandalized, etc.), in addition the length of the canal (160 km) would make this very expensive. However, the ESIA/ESMP recommends regular sensitization in school about the risks for children associated with the canal
Will the water be safe to drink?	No, the objective of the scheme is irrigation. Some pipes may be built to provide with drinking water.
There is concerns over the spread of HIV	Ok, the ESIA/ESMP has highlighted this in the Code of conduct
How to ensure that local people will be hired in the construction process?	An Affirmative Action Recruitment Policy will have to be implemented so that contractor hire local people to work
How will the water fees be collected?	Answer by provided by Boniface Nthakomwa (SVIP) : same as PATHA out grower model (participants related to this example)
Can the canal be buried?	No, in Nsanje it will be open and lined (burying a canal is too expensive)
Will there be any school impacted?	Normally not, however if the canal cannot avoid infrastructures, they will be rebuild to good standards (according to the OP 4.12 from the World Bank)
What about transboundary impact?	Shire River is part of the Zambezi commission, they have been contacted (riparian notification)

Table 21 Minutes of Chikwawa workshop

Question raised during the workshop	Answer from the Consultant
Shire water level is low (same level than in 1997), the barrage is managed by the National Water Authority	Ok, this is taken into account
To compensate for lower water level in the Elephant marsh is it possible to build a pipe to bring water to dimba agriculture?	Dimba agriculture cover a vast area, a pipeline would not solve the issue and would cost a lot
If Kamuzu barrage releases more to compensate for impacts of SVIP it will impact Liwonde National Park (inundations)	Ok, this will be taken into account in the ESIA.
Comment on the PowerPoint : WESM has highlighted that Impact on Majete Wildlife Reserve are not acceptable as African Parks has invested millions in a prime touristic area that is now under threat from construction work and the presence of a canal, in order for the World Bank to comply with their policies, it has to give impacts and mitigation a serious consideration.	Impacts and mitigation on MWR are presented in depth in the ESIA
Comment on the PowerPoint : a participant has highlighted the risk from the Tiger fish	Impact from the Tiger fish is dealt with in the ESIA
Comment on the PowerPoint: How to propose more measures to ensure that a good construction contractor is selected?	The best way to ensure that is to verify the contractor reputation
Comment on the PowerPoint : WESM has highlighted that Elephant poaching was major during work close to Liwonde National Park in 2003, bringing a contractor inside a park is a risk	Ok
The water intake shall have a trash rack with appropriate size to keep juvenile crocodiles from entering	This concern is dealt with in the ESIA/ESMP
Comment from WESM: are local people fully aware of the fact that there will be a water fee?	Yes it was presented as part of the Consultation work from COWI
How will the project mitigate risk during construction of the canal (risk of animal falling in the trench)?	In MWR the work area will be fenced (as described in the ESMP)
Slow moving animal (snakes) shall be protected from persecution from workers	A measure has been added in the ESIA/ESMP
Who will have the authority to stop work in cases on non-compliances?	Details are added in the ESIA/ESMP