Hydrologists Registration Board
Enhancing Professionalism & Competence

DRAFT GUIDELINES FOR THE PREPARATION OF HYDROLOGICAL ASSESSMENT REPORTS

MAY, 2025

Table of Contents

Table of Contents 1
1.1 Rationale for the Preparation of Hydrological Assessment Reports 3
1.1.1 Inform the design of hydraulic structures 3
1.1.2 Equitable allocation of water resources 3
1.1.3 Risk Mitigation 3
1.1.4 Ecological Balances for Environmental Protection 3
1.1.5 Mitigating Effects of Urban Development on Natural Waterways 3
1.2 Objectives 4
1.2.1 Understanding Water Dynamics 4
1.2.2 Policy Development, Regulation and Compliance 4
1.2.3 Hydrological Impact Assessment 4
1.2.4 Supporting Decision Making 4
1.3 Legal Requirements for Undertaking Hydrological Assessments 6
1.5 The Qualification/Certification Required to Prepare a Hydrological Assessment Report 6
1.6 Application of Hydrological Assessment Reports 6
1.6.1 Design of Hydraulic Structures 6
1.6.2 Water Balance Assessment (Ecological Balance and Ecosystems) 7
1.6.3 Flood Assessments 7
1.7 Fees for Hydrological Assessment Reports 7
2.0 HYDROLOGICAL ASSESSMENT REPORT FORMAT 8
2.1 Background to the Study Area 8
2.2 Catchment Characteristics 8
2.2.1 Topography and Physiography 8
2.2.2 Climatic Characteristics 8
2.2.3 Land Cover and Land Use 9
2.2.4 Geology and Soils 9
2.2.5 Ground Water Characteristics 9
2.2.6 Hydrological Characteristics 9
3.0 METHODOLOGY 10
3.1 Data Requirements and Reliability 10
3.2 Data Collection 11
3.3 Data Analysis – Pre-Processing 11
3.3.1 Data Reliability and Consistency 11
3.4 Historic Review of Hydrological Events 12
3.5 Hydrological Analysis 12

3.5.1 Study Area Delineation 12
3.5.2 Flow Analysis 12
3.5.3 Flow Frequency Analysis 12
3.5.4 Flood Frequency Analysis 13
3.5.5 Rainfall Analysis 13
3.5.6 Rainfall Frequency Analysis 13
3.5.7 Catchment Rainfall 13
3.5.8 Probable Maximum Flood/Precipitation 14
3.5.9 Design Flood 14
3.6 Description of Hydrological Models Input and Output 14
3.7 Model Calibration 15
4.0 FINDINGS & DISCUSSION 16
5.0 RECOMMENDATIONS & CONCLUSION 17
6.0 REFERENCES 17
7.0 ANNEXES 17
7.1 Annex 1: Information of Hydrology Professional and the Client. 17
7.2 Annex 2: Details of qualifications for certification. 17
7.3 Annex 3: Procedure for submission of the reports. 17
7.4. Annex 4: Fees for development and certification of Hydrological Assessment Reports. 17

1.0 INTRODUCTION

Hydrological Assessment Reports refer to any written documentation submitted by a licensed Hydrology professional describing the status of water resources in a particular area, including but not limited to, sources, extent, quantity, quality, hydraulic properties, drainage characteristics, abstractions and any other pertinent information.

1.1 Rationale for the Preparation of Hydrological Assessment Reports

1.1.1 Inform the design of hydraulic structures

The design of hydraulic structures includes careful consideration of various factors to ensure their functionality, safety, and sustainability as informed by the Hydrological Assessment Report.

1.1.2 Equitable allocation of water resources

A Hydrological Assessment Report shall inform the equitable allocation of water resources. The Assessment should guide the water use allocation plan for a particular catchment. This should involve balancing the needs of agriculture, industry, domestic use and environmental conservation.

1.1.3 Risk Mitigation

A Hydrological Assessment Study will mitigate hydrological related risk by recommending a series of strategies and practices designed to reduce the negative impacts of water-related hazards such as floods, droughts, and water contamination.

1.1.4 Ecological Balances for Environmental Protection

The Hydrological Assessment Study should inform the environmental reserve for maintaining ecological balance which is crucial for environmental protection and involves managing natural resources and human activities in a way that preserves biodiversity, ecosystem functions, and overall environmental health.

1.1.5 Mitigating Effects of Urban Development on Natural Waterways

The Hydrological Assessment Study should inform on the effects and mitigation measures of urban development on natural waterways essential to maintain water quality, reduce flood risks, and protect aquatic ecosystems. Urban development often leads to increased impervious surfaces, storm water runoff, and pollution, which can degrade natural waterways

1.2 Objectives

A Hydrological Assessment Report will clearly indicate the objectives of the proposed hydrological study based on the following:

1.2.1 Understanding Water Dynamics

Hydrological studies should provide an understanding of the movement and behavior of water in various systems, including oceans, rivers, lakes, groundwater and the atmosphere.

The key concepts and factors involved in water dynamics are:

i. Hydrological Cycle - Evaporation, Condensation, Precipitation, Infiltration and runoff.
ii. Fluid Mechanics - Laminar Flow, Turbulent Flow and Viscosity.
iii. River Dynamics - Discharge, Sediment Transport, and Erosion and Deposition.
iv. Groundwater Flow - Aquifers: Water Table and Porosity and Permeability.
v. Climate Impact - Global Warming, El Niño and La Niña.
vi. Modeling and Simulation - Hydrological Models.

1.2.2 Policy Development, Regulation and Compliance

Hydrological Assessment Reports should provide scientific evidence and insights to inform the development of water-related policies, regulations, and management plans.

Decision-makers can use the hydrological report to set standards and establish water use permits, and to formulate sustainable water management strategies aligned with societal needs and environmental objectives.

1.2.3 Hydrological Impact Assessment

Hydrological Assessment Reports should provide a technical assessment of probable impacts on the environment that the project is likely to cause and explain the significance of predicted impacts and as a result, it indicates the scope for modification or mitigation. It also provides impetus for the concerned agencies to undertake assessment of the potential results of the project before a decision is given.

1.2.4 Supporting Decision Making

Hydrological Assessment Reports should provide information on the decision support intended in the following areas:

i. Flood Forecasting and Warning Systems

Hydrological Assessment Reports will be used to identify flood prone areas and implement emergency response measures, such as evacuations, road closures, and deployment of flood defenses, to minimize potential damage and protect lives and property.

ii. Water Resources Management

Hydrological Assessment Reports will be used to optimize water allocation among various users, such as agricultural, industrial, and domestic sectors, considering factors like seasonal variability and environmental requirements.

iii. Infrastructure Planning and Design

Engineers and planners use Hydrological Assessment Reports to design hydraulic structures such as dams, pans, reservoirs, canals, levees, bridges, culverts, storm water and drainage systems to effectively manage and control water flow.

By simulating different scenarios and assessing the performance of infrastructure under varying hydrological conditions, decision-makers can make informed choices about the design, operation, and maintenance of water-related infrastructure.

iv. Climate Change Adaptation

Hydrological Assessment Reports can be used in assessing the potential impacts of climate change on water resources, including changes in precipitation patterns, temperature, and extreme weather events.

Decision-makers use Hydrological Assessment Reports in modifying water management practices, enhancing water storage capacity, and implementing measures to reduce vulnerability to floods and droughts.

v. Environmental Management

Hydrological Assessment Reports can be used to understand the ecological impacts of water management decisions on aquatic habitats, wetlands, and riparian ecosystems.

Decision-makers can use the hydrological assessment reports to design environmental flow regimes that maintain minimum water levels and flow patterns necessary to sustain biodiversity and ecosystem services.

vi. Risk Assessment and Mitigation

Hydrological Assessment Reports can be used in quantifying the probability and potential consequences of hydrological hazards, such as floods, landslides, and droughts.

Decision-makers can prioritize mitigation measures and investments in infrastructure, land use planning, and disaster preparedness based on the assessment of risk and cost-effectiveness.

1.3 Legal Requirements for Undertaking Hydrological Assessments

i. The Water Act (2016) provides the Water Resources Authority (WRA) with the mandate to authorize the abstraction of water for projects that have significant impact on water resources.
ii. Part III Section 14(1) of the Water Resources Regulations provides details on the water permitting process. It specifies that application for a water permit requires a Hydrological Assessment Report.
iii. The Hydrologists Act, 2017 provides for the certification by the Board of Directors, of the hydrological studies and reports necessary for the design of hydraulic structures.
iv. The Third Schedule of the Water Harvesting and Storage Regulations makes provisions for a hydrological assessment report as one of the technical reports required for a final Dam Design Report.
v. The Practice Manual for Small Dams, Pans and other Water Conservation Structures in Kenya provides for the Hydrological Assessment Report as one of the mandatory reports in the planning and design of structures.
vi. Section 21A of the draft Hydrologists (Amendment) Bill, 2025 Act makes provisions for the submission to the Board of hydrological reports prepared by hydrology professionals.

It is important to note that, under WRA, Hydrological Assessment Reports are required for permitting purposes only. In contrast, the Hydrological Assessment Reports that will be submitted by Hydrology professionals and certified by HRB will be for various purposes such as informing the design of hydraulic structures (Infrastructure Planning and Design), Flood Forecasting and Warning Systems, Hydrological Impact Assessment and Water Allocation, among others.

1.5 The Qualification/Certification Required to Prepare a Hydrological Assessment Report

A Hydrology professional shall be registered and licensed by the Hydrologists Registration Board. The Hydrologists Act, 2017 under Sections 18-21 provides for the registration and licensing of Hydrology Professionals, and the practice of hydrology. Hydrological Assessment Reports should be submitted to the Board for certification prior to implementation of projects.

1.6 Application of Hydrological Assessment Reports

1.6.1 Design of Hydraulic Structures

Hydrological Assessment Reports will inform the planning of hydraulic structures by providing parameters such as peak flows that are crucial in the design of such structures. These structures

are used to positively control storage, water velocity, direction and depth, the elevation and slope of the streambed and general configuration of a waterway including its stability and maintenance characteristics. They include: dams, water pans, weirs, reservoirs, canals, bridges, culverts, irrigation schemes, flood control structures, water supply systems and drainage systems.

1.6.2 Water Balance Assessment (Ecological Balance and Ecosystems)

This is an assessment done for each catchment to understand surface and ground water interactions. The assessment provides guidance in water allocation for multipurpose uses and for environmental flow.

Recharge Areas Assessment

Recharge areas are defined as areas where surface water infiltrates into the ground to replenish an aquifer. Methods of recharging an aquifer include both natural methods and Artificial Aquifer Recharge (also known as Managed Aquifer Recharge), which involves augmenting natural surface water flow into groundwater reservoirs using civil construction techniques.

1.6.3 Flood Assessments

Flood assessments are done to assess and identify the source of flood risks and evaluate all its sources and provide each a description for planning purposes, especially for the construction of hydraulic structures.

1.7 Fees for Hydrological Assessment Reports

On presentation of Hydrological Assessment Reports by the client to the Board for approval, the Board shall charge such fees as provided for in the Hydrologists Regulations.

2.0 HYDROLOGICAL ASSESSMENT REPORT FORMAT

2.1 Background to the Study Area

Project overview – Detailed context underlying the hydrological study to be undertaken, to include;

i. Justification/Rationale of the study – The statement of the reason(s) for the study, including the significance and gaps that the study intends to fill.
ii. Scope and Objective of the study – a clear and concise statement of the specific goals and aims of the hydrological study. The objective should outline what the study intends to accomplish/achieve. The purpose/objective should be smart (Specific, Measurable, Attainable, Realistic and Time Bound).

NB: Clear objectives will guide the methods to be employed for study data collection and analysis.

Terms of Reference – the hydrological assessment report will provide the TOR's of the study.

Study Area – Details of the specific geographical location where the study is to be conducted, encompassing various characteristics including but not limited to Hydrological Characteristics, Climatic Characteristics, Topographic and Physiographic Characteristics, Geology, Soils, Vegetation and Land Use. It serves as the primary field for data collection and analysis.

Maps and charts will be used to illustrate the study area's climatic, land use, land cover, soil, hydrological and geological characteristics.

2.2Catchment Characteristics

2.2.1 Topography and Physiography

Topography of an area is regarded to as the study of physical features of a designated area. It should include a detailed description of location, elevation, contours and water bodies using topographic maps or other means.

2.2.2 Climatic Characteristics

The climatic characteristics can be defined as the assessment of weather parameters over time. These include precipitation, temperature, evaporation and wind patterns.

During this assessment a Hydrology Professional will be required to describe the climatic zone and characteristics in terms of:

i. Precipitation-Rainfall data depth (annual, monthly and seasonal), Rainfall intensity (duration and frequency), Rainfall distribution over the study area using rainfall charts and maps.
ii. Temperature (mean maximum temperature and mean minimum temperature).
iii. Evaporation and evapotranspiration (Pan evaporation - daily, monthly, annual).
iv. Wind Patterns (Wind speed).

2.2.3 Land Cover and Land Use

Land cover is defined as the physical cover of the earth's surface including vegetation and human construction while land use is characterized by the arrangements, activities and inputs people undertake in a certain land cover type to produce change or maintain it. The hydrological report will contained a detailed description of the land use and land cover classification using land use land cover maps which will describe: farmland, forest range, scrubland and human development in a certain catchment.

2.2.4 Geology and Soils

The detailed description of the geological formations and soil classification of the study area will be provided. This includes rock formation and types, the soil types and their characteristics

2.2.5 Ground Water Characteristics

A detailed description of the surface-ground water interaction will be provided in the Hydrological Assessment Report. Occurrences of natural and artificial recharge areas, springs, existing boreholes and shallow wells will be recorded.

2.2.6 Hydrological Characteristics

Hydrological characteristics can be described using historical data and modelling to predict future stream flow conditions. The Hydrological Assessment Reports will describe the following hydrological parameters;

i. Details of the catchment including hydro-meteorological stations.
ii. Hydrometric data (flow measurements, flow patterns).
iii. Sediment transport data.
iv. Water quality data.

3.0 METHODOLOGY

Data is necessary for a Hydrology Professional to make Hydrological computations to establish design criteria and to do forecasting. This section will entail a detailed description of Data Requirements, Data Collection and Data Processing.

3.1 Data Requirements and Reliability

The quality of the hydrological analysis will depend in part on the availability of reliable data. The categories of data requirements for hydrological study include hydrometric data, climatological data for hydrological purposes, groundwater data, soil moisture data, physiographic data and anthropogenic data.

Table 1 below will be filled to provide information on hydrological and meteorological data types, pertinent details and sources. However, the information provided will be specific for each hydrological study.

Table 1 Hydrological and Meteorological Data Requirements

Data Type	Detail	Data Sources	Comments
Rainfall	Location of rainfall stations within or neighboring the catchment area and the length of the records		
	Daily (24 hour) rainfall		
	Mean monthly rainfall		
	Mean annual rainfall.		
	Annual 24 hour maximum		
	Rainfall-duration-frequency		
Evaporation/ Evapotranspiration	Mean monthly open water evaporation		
Discharge	Location, reference number of river gauging stations and duration of the record		
	Approved discharge rating equation(s) for selected RGS		
Catchment	Catchment boundaries		
	Contours		
	River drainage network		
	Land use map		
	Vegetation cover		
	Soil map		
	Geological formation maps		

	Cadastral maps		
Water use data	Existing authorized/non-authorized use within the catchment		
Water Demand	Population, per capita water demand, Water use (Industrial, Domestic, Commercial)		

3.2 Data Collection

This will include a description of the primary and secondary data collection methods used for the study, as well as the data analysis tools used in the study.

3.3 Data Analysis – Pre-Processing

To be able to make good use of data, it has to be stored in such a way that all possible errors are removed and that the data is accessible when required. Processing of data requires the following:

i. Data screening
ii. Data correction and completion
iii. Data aggregation

It is generally considered good practice for a hydrology professional who is using hydro-meteorological data to verify the location and on-site conditions for the data that is being used. No analysis of any data sets should be undertaken until the data has been pre-processed and there is confidence that the data provides an accurate record of the measured parameters.

3.3.1 Data Reliability and Consistency

The Hydrology professional should prove the reliability and consistency of any data sets obtained and used, and should demonstrate the reliability and consistency of data using tools and methods such as the Double Mass Curve.

Use of a data availability chart will provide a visual presentation of the available data. The length and consistency of the record can be visualized. This helps in the selection of the data for further analysis. Further investigation of the data is required to determine data gaps and to assess the usefulness of the dataset.

Where data gaps are detected, the report should describe tools and method used to fill the gaps.

3.4 Historic Review of Hydrological Events

These are extreme events which have occurred overtime, mostly droughts and floods. A detailed description of these events such as their severity, duration, frequency and type will be given. In order to interpret these extreme events, it is necessary to have records for a long period of time of river flow and other variables.

Review of existing flood and drought reports of the study area will be necessary to inform the proposed hydrological study.

3.5 Hydrological Analysis

Hydrologic analyses are performed to quantify the volumetric flow rate of water draining from a watershed (i.e. drainage area) over time. This aspect is based on a digital elevation model (DEM) raster data to establish a water system model which is used to study the hydrological characteristics. Hydrological analysis will be performed based on the purpose of the study and the available data. Hydrological analysis uses different techniques to obtain the desired outputs. The level of hydrological analysis required will depend on the scope and nature of the study being proposed.

3.5.1 Study Area Delineation

To undertake a hydrological study, it is important for the Hydrology professional to define the geographical boundary of the study area. Computerized methods for study area delineation use digital elevation models (DEMs), data sets that represent the height of the earth's land surface. The delineation may be done using specialized hydrologic modeling software such as Watershed Modelling System (WMS), Geographic Information System software like ArcGIS or QGIS or with programming languages like Python or R.

3.5.2 Flow Analysis

To assess the potential surface water availability, the Hydrology professional requires to estimate the flow within the catchment area at any given time. Flow estimation can be achieved using rainfall or discharge data.

3.5.3 Flow Frequency Analysis

Time series flow data is generally used to create Flow Duration Curves (FDC's) that show the percentage of time during which specified discharge were equaled or exceeded over a historical period of time, which is a standard way of understanding the flow dynamics of a water course. A description of the tools used for the computation of the flow duration curves will be provided.

3.5.4 Flood Frequency Analysis

The objective of flood frequency analysis is to estimate a high (peak) flow corresponding to a specific return period of occurrence. The design of spillways, diversion works and storm water channels require an estimation of the peak discharge for a given return period.

The determination of the expected peak flows should be based on actual and accurate stream flow data. When such data are available, a flood frequency analysis based on the annual maximum discharge series should be/can be undertaken. Care should be taken to use the hydrological year (October – September), not the calendar year (January – December) to establish the annual maximum series. Statistical software can be used to fit different probability distributions to the annual maxima data series. Care should be taken to select probability distributions appropriate for discharge analysis. The Hydrology Professional should state why the preference of the selected probability distribution.

3.5.5 Rainfall Analysis

Rainfall analysis should be conducted to provide three simple outputs:

i. Mean monthly rainfall - This is used to determine the longest and driest periods and is used to estimate storage requirements and to select the best time to schedule construction activities. Median monthly rainfall, being less influenced by extremes, can also be used.
ii. A time series of mean annual rainfall and the long term mean value.
iii. Rainfall frequency.

3.5.6 Rainfall Frequency Analysis

Rainfall frequency analysis is an important component in the estimation of peak flows for specific return periods, especially where there are no stream flow records. A basic assumption is made that the return period for a storm corresponds to the return period for flows.

3.5.7 Catchment Rainfall

Rainfall is unlikely to occur equally over a catchment, especially for larger catchments. A single rainfall record has therefore to be adjusted by an area reduction factor (ARF) which is dependent on the size of the catchment. In the event that a number of reliable rainfall records are available for a particular catchment area, then a better estimate of the rainfall over the catchment on a storm, seasonal, or annual basis, can be made by using an area weighting factor as determined by the Isohyet method, Thiessen Polygon method or by the Distance Weighting/Gridded method. Where there are no reliable nearby stations, use of satellite data is employed to obtain a real rainfall with a description of its source and type.

3.5.8 Probable Maximum Flood/Precipitation

Probable Maximum Flood (PMF) is the flood which is a direct result of Probable Maximum Precipitation (PMP) or is the highest flood a region will ever experience or flood that may be expected from the most severe combination of the critical meteorological and hydrological conditions that are reasonably possible in a particular area.

Hydrological studies for the design of hydraulic structures such as dams requires determination of PMP and PMF. To estimate the magnitude of flood peak, various methods are used such as Rational method, empirical method, unit hydrograph technique and flood frequency studies.

A description of the method employed should be indicated in the Hydrological Report.

3.5.9 Design Flood

Design flood is the final value adopted for the design of a structure and could be the entire flood hydrograph or the peak discharge of the flood hydrograph. Methods of estimating design floods may include but not limited to:

i. Rational formula
ii. Design flood estimation using the unit hydrograph method
iii. Statistical methods (flood frequency analysis)

3.6 Description of Hydrological Models Input and Output

Hydrological models are developed to assist in understanding, predicting, and managing water resources. They help generate stream flow estimates and trends over long periods, undertake hydrological prediction and for understanding hydrologic processes. A model consists of various parameters that define the characteristics of the model. The Hydrological Assessment Report will describe the following;

i. The type of models used
ii. Preference of the choice of models
iii. Parameters of the models
iv. The functioning of the model
v. The limitations associated with the use of the model
vi. The model inputs.

The model input is important in determining the results. Use of reliable model input data therefore should be considered in hydrological assessment. The input data required for models includes climatic data such as rainfall, temperature and evapotranspiration; catchment/drainage area data; discharge data; and watershed characteristics such as soil properties and vegetation cover.

Model output data includes steam flow simulations over long periods. Models also provide simulated data on rainfall, surface runoff, soil moisture, evaporation and infiltration, among others. All this is important in development of hydraulic structures, flood forecasting, planning and policy making.

3.7 Model Calibration

Model calibration involves the adjustment of parameters and constants within the model so that the model more accurately simulates measured values.

A description on model calibration should be displayed in the Hydrological Assessment Report indicating the parameters adjustments and the confidence levels attained.

4.0 FINDINGS & DISCUSSION

The Hydrological Assessment Report will provide a description of the findings and discussions on the following;

i. Flow Analysis

Findings on the normal flows, flood flows and the reserve flows as depicted by Flow Duration Curves, availability of water for the proposed use, flood frequency analysis for various Return Periods.

ii. Rainfall Analysis

Findings on the mean monthly rainfall, mean annual rainfall, long-term annual mean and rainfall frequency and reliability.

iii. Probable Maximum Precipitation/Flood (PMP/F) for hydraulic designs.

iv. Impacts of the proposed activities on the flow regime and other abstractors.

5.0 RECOMMENDATIONS & CONCLUSION

The Hydrological Assessment Report will provide descriptive recommendations for the study based on the findings and conclusions.

The Hydrology Professional will provide advice on undertaking the proposed project and the available alternatives.

6.0 REFERENCES

All cited literature sources shall be referenced using the APA formatting and citation style.

7.0 ANNEXES

7.1 Annex 1: Information of Hydrology Professional and the Client.

The details of the hydrology professional:

i. Full Name
ii. Postal Address
iii. Physical Address
iv. Phone Number
v. Email Address
vi. HRB Registration certificate number
vii. Practicing License number.

Client detail:

i. Full Name
ii. Postal Address
iii. Phone Number
iv. Email Address

7.2 Annex 2: Details of qualifications for certification.

7.3 Annex 3: Procedure for submission of the reports.

7.4. Annex 4: Fees for development and certification of Hydrological Assessment Reports.