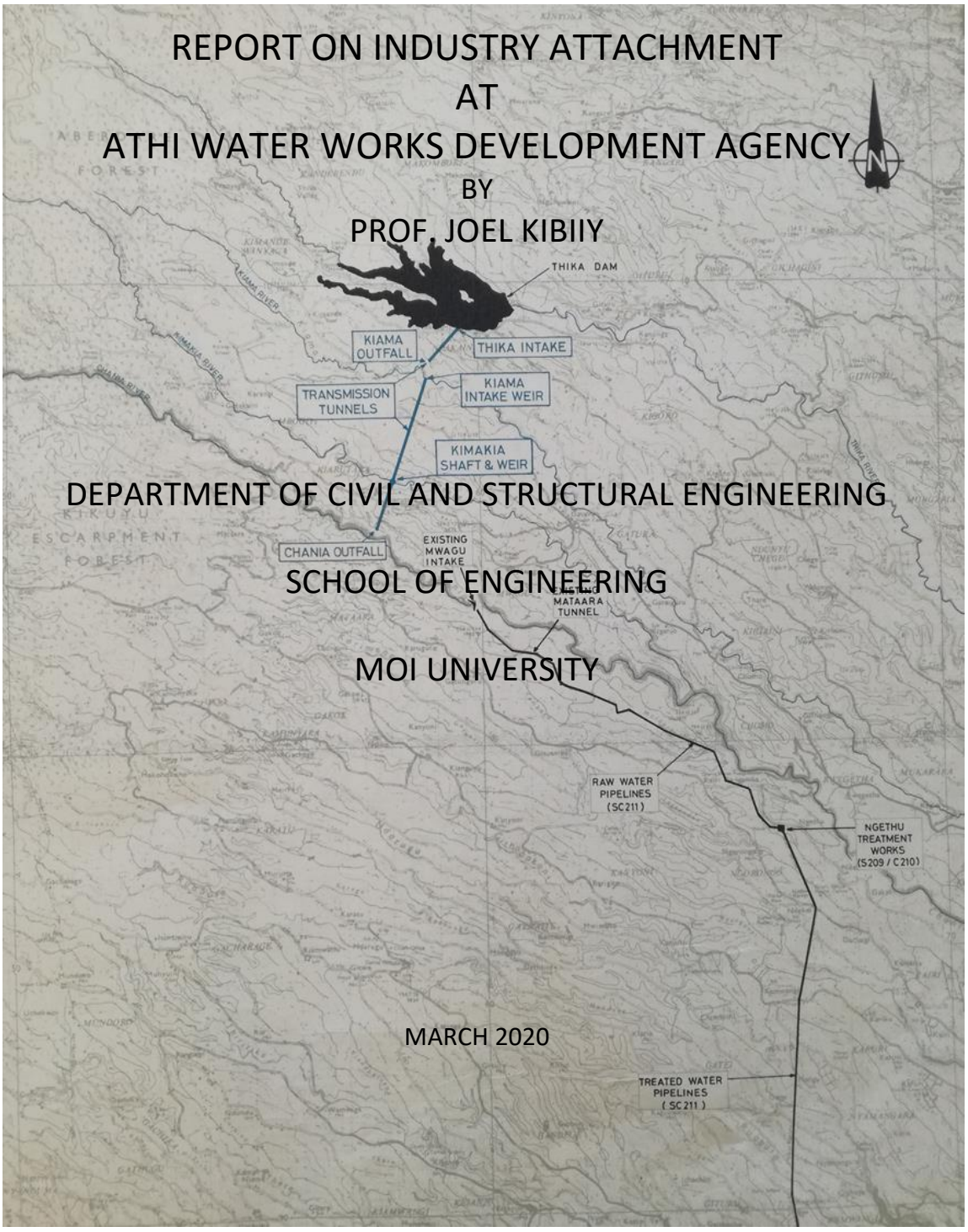
REPORT ON INDUSTRY ATTACHMENT
AT
ATHI WATER WORKS DEVELOPMENT AGENCY

BY

PROF. JOEL KIBIIY



DEPARTMENT OF CIVIL AND STRUCTURAL ENGINEERING

SCHOOL OF ENGINEERING

MOI UNIVERSITY

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1. INTRODUCTION

1.1 Person Attached to Industry

The member of staff on attachment, Prof. Joel Kibiiy, is from the Department of Civil and Structural Engineering, School of Engineering, Moi University.

1.2 Place of Attachment

The attachment was offered by Athi Water Works Development Agency (AWWDA). However, two of the three field stations visited were facilities of Nairobi City Water Supply and Sanitation Company (NCWSC). The Nairobi City Water and Sewerage Company is a wholly owned company of the County Government of Nairobi. The good working relationship between AWWDA and NCWSC, and by extension, the County Government of Nairobi, made it possible for the attachment to be extended to their facilities.

1.3 Period of Attachment

The attachment was for a period of 14 days from 16th February 2020 to 1st March 2020.

1.4 About AWWDA

Athi Water Works Development Agency is a government agency under the Ministry of Water and Irrigation. It was established in 2019 under the Water Act 2016 as a successor to the same agency earlier established in 2003 under the Water Act 2002. Its area of operation is limited to the three counties of Kiambu, Murang'a and Nairobi (Figure 1). It has its headquarters in Upper Hill, Nairobi. The agency is headed by a Chief Executive Officer working under a board of management. The agency has the wide mandate in the area of water and waste water services that includes undertaking the development, operation, maintenance and management of national public water works in its area of operation.

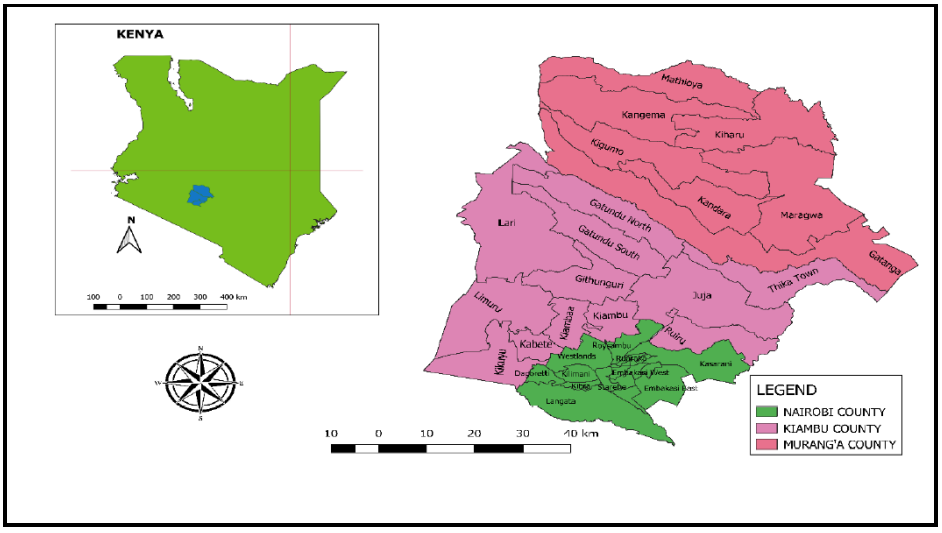


Figure 1. AWWDA operation area

1.5 Objectives of the Attachment

The objectives of the attachment were:

i. Familiarise with current practice, technology and procedures in industry
ii. Identify challenges at the place of attachment and propose solutions
iii. Foster links and networks with industry colleagues
iv. Explore possibilities for collaboration with industry.

1.6 Attachment Programme

The programme of the attachment was discussed and agreed with AWWDA at the start of the attachment. It was later reviewed to fit with changing circumstances. The programme as realized is given in Table 1. Time was shared between AWWDA Headquarters and three field stations, namely, Thika Dam, Karimenu II Dam and Sasimua Dam and Water Treatment Works. The first two dams are in Murang'a County and Kiambu County respectively while the latter is farther afield in Nyandarua County.

Table 1. Programme of attachment at AWWDA

S/N	Day	Date	Activity	Remarks
1	Sunday	16-2-2020	Travelling, Eldoret - Nairobi	
2	Monday	17-2-2020	Reporting at AWWDA Headquarters. Discussions and review of programme. Transport arrangements. Courtesy call on the CEO.	Africa Re Building, Kenya Road, Upper Hill, Nairobi
			Transfer to Thika Dam, Ndakaini, in Murang'a County.	This is a facility of NCWSC. Host – Mr. Job Kihamba, Dam Coordinator.
3	Tuesday	18-2-2020	Tour of the dam installations and instrumentation	Guided by Mr. Solomon Mogire, (Hydrology Office) Operations Section.
4	Wedn.	19-2-2020	Study of the *Operation Rules of Thika Dam* and other materials	
5	Thurs.	20-2-2020	Visitors from Global Environmental Fund, IFAD and Nairobi Water Fund.	
			Fieldwork: weekly readings of gauges and instruments	
6	Friday	21-2-2020	Field visit to the Thika-Ng'ethu WTP System	
7	Sat. and Sunday	22 & 23-2020	weekend	
8	Monday	24-2-2020	Reporting AWWDA Hqs. Review of programme. Study of Strategic Plan and drawings of Karimenu II Dam.	
9	Tuesday	25-2-2020	Site visit Karimenu II Dam	Under construction
10	Wedn.	26-2-2020	Visit to Sasimua Dam and Water Treatment Plant	

11	Thurs.	27-2-2020	AWWDA Hqs. Recap and preparation for presentation on 28-2-2020.	
12	Friday	28-2-2020	Presentation to staff, AWWDA Hqs.	
13	Sat.	29-2-2020	Report writing	
14	Sunday	1-3-2020	Travelling Nairobi-Eldoret	

2. ATTACHMENT EXPERIENCE

2.1 Thika Dam

2.1.1 Location

Thika Dam was constructed between 1989 and 1994. It is located on River Thika at an altitude of 2045 m above sea level (m.a.s.l.) and about 100 km north of Nairobi. However, it is commonly referred to as Ndakaini Dam because it is located at Ndakaini area in Murang'a County.

2.1.2 Features

Thika Dam is an earth-fill dam with a clay core. It has a height of 65 m and a maximum volume of 69.46 million m^3. The reservoir has a water surface area of 275 Ha when full. The dam and its reservoir, with sparkling clear blue water, the undulating hills, with the Aberdare Range in the background form a beautiful and serene environment (Plate 1). It has a catchment of 71 km^2.

Plate 1. Thika Dam and reservoir

Thika dam is provided with two water intakes. The first intake is located on the right bank of the reservoir incorporates a hydro-electric power house that was not equipped with turbines. It takes water to Ng'ethu Water Treatment Plant through an ingenious transfer system referred to as the Thika-Ng'ethu WTP System. The second one is an intake tower in the reservoir just upstream of the dam embankment (Plate 2). Pipeline works are in progress to connect it to the recently completed Kigoro Water Treatment Plant meant to supply Ruiru, Juja and parts of Nairobi.

Plate 2. Main spillway with intake tower in the background

The dam has two free spillways: a main spillway and an emergency spillway. The main spillway is a bellmouth or morning glory type dug into the ground in the reservoir near the left abutment. It discharges through a tunnel into the parent river downstream of the dam. The reservoir was full at the time of the visit and the main spillway was active (Plate 2). The emergency spillway is meant to augment the main spillway in times of high flood. It is on natural ground away from the embankment and provided with gabion jute (Plate 3) to direct any spill to the parent river downstream of the dam. This uniquely designed jute has not had the opportunity to undergo the test of usage.

Plate 3. Emergency spillway

2.1.3 Dam and discharge monitoring

The dam is well instrumented for routine safety and operations monitoring. Readings are taken weekly for horizontal and vertical movements, seepage pressure and seepage discharge. Data for seismic activity is downloaded annually from the seismograph by an external agency.

The water level in the reservoir is read off a staff gauge mounted on the intake tower using a pair of binoculars from the dam crest. The water level on the main spillway is similarly read from a staff gauge on the spillway. The dam also hosts a fully-fledged weather station with telemetric capabilities to KMD on some parameters. There are two river gauging stations on streams feeding the reservoir and one downstream to monitor the outflow from the reservoir. It was noted, however, that River Kaihuri which joins Thika River just downstream of the dam and upstream of the gauging station is not gauged thus giving the impression that the flows measured are releases from the dam.

The water transferred from the reservoir to Ng'ethu WTP through the Thika Dam – Ng'ethu WTP System is monitored for discharge at four points before it is discharged

into the Chania. All these monitoring stations were initially fitted with telemetric discharge monitoring devices, which, unfortunately no longer function.

2.1.4 Dam Operations

Thika dam currently serves as a supplementary source to Ng'ethu WTP. It only receives and stores water during the wet season. Excess water is allowed to spill. Water is released Ng'ethu WTP only during the dry season when Chania, Kiama and Kimakia rivers cannot meet the water requirement at the plant. However, on some occasions when the turbidity of water arriving at Ng'ethu is very high, water is released from the reservoir to provide dilution and thus reduce water treatment costs.

The Thika Dam – Ng'ethu WTP System transports water through a series of three tunnels from the reservoir to Rivers Kiama, Kimakia and Chania from where it is abstracted to Ng'ethu WTP.

2.1.5 Other activities

Large parts of the catchment of Thika dam are private farmland under different land use and crop cover. NCWSC has teamed up with different agencies to encourage enhanced catchment conservation. During the stay at Thika dam, a combined team of stakeholders from Global Environmental Fund, IFAD and Nairobi Water Fund visited (Plate 4). A presentation on the results of their support was made followed by a site visit to a telemetric river gauging station.

Plate 4. Thika Dam Coordinator hosting a group of visitors

2.1.6 Observed challenges

a. The river bank protection provided at the dam outlet area consisting of gabions has failed (Plate 5). The failure may be attributed to the energy of water released from the outlet as overflow and/or sediment scoring. It can be seen in Plate 5(b) that the point of failure lies in a straight line with the flow path of water from the outlet. This is, therefore, a problem with origins in the design of the outlet area.


(a) (b)

Plate 5. Damaged river bank protection at the outlet area of Thika Dam

b. The weather station at Thika Dam is bordered by trees that have overgrown the fence (Plate 6) and impact negatively on the functioning of some of the equipment at the station. The World Meteorological Organization (WMO) standards prescribe the distance and height of vegetation or other obstructions.

Plate 6. Weather station at Thika Dam

c. Discharge measuring installations at the various points along the Thika dam – Ng'ethu WTP System seem to suffer from a common defect that brings into question the reality of the readings. Flow measurement is based on energy principles for flow over weirs or flumes. The situation is explained below.
    i. The plan for the gauging installations at the Chania outfall is shown in Figure 2. It incorporates an outfall chamber which is essentially a stilling basin, and a measuring weir – which has been drawn as a flume.

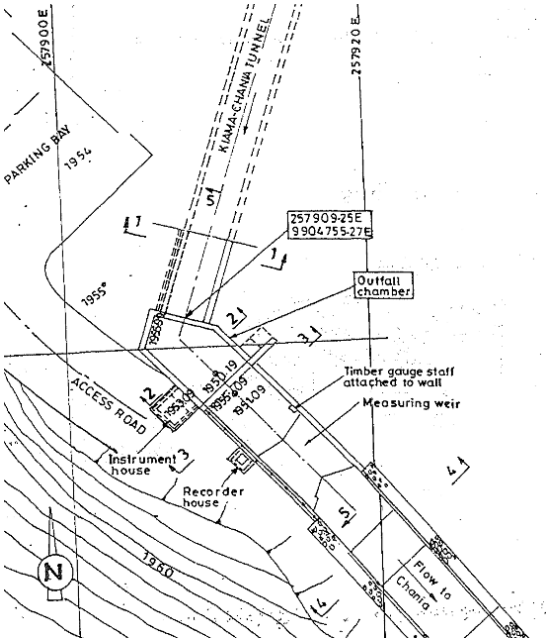


Figure 2. Plan for gauging installations at Chania outfall

The existing gauging installations at the Chania outfall are shown in Plate 7. It can be seen that there is no outfall chamber and that there is also no measuring weir or flume. However, a stilling well is provided from where water levels are read.

(a) (b)

Plate 7. Flow measuring installations at Chania outfall

ii. The situation is exactly the same at the Kiama outfall (Plate 8). A stilling well is provided immediately after the outfall (Plate 8b) for readings of water level but there is no stilling basin and there is neither a weir nor flume for flow measurement.

(a) (b)

Plate 8. Flow measuring installations at Kiama outfall

iii. The intake from River Kimakia into the Thika Dam – Ng'ethu WTP System consists of a sealed chamber that leads the water into a tunnel (Plate 9). The amount of water abstracted was supposed to be monitored automatically and tele-transmitted by a solar-powered system now vandalised. The measuring flume or weir, if any, are enclosed in the chamber and thus precludes the possibility for or means for manual monitoring.

Plate 9. Intake chamber at River Kimakia

The intake from Kiama into the Kiama-Chania tunnel has flow measuring devices which are not capable of providing data for want of maintenance. Plate 10 shows the intake from at River Kiama.

Plate 10. Intake at River Kiama

It would be interesting to know the method used to convert the water level readings into discharge at the gauging stations on the Thika Dam – Ng'ethu WTP System in the absence of weirs and flumes.
It is also worth stating that if indeed there is a problem, it can be remedied by undertaking gauging by current meter and subsequently developing a rating curve. A site for flow gauging by current meter is so chosen that the flows may be assumed to constitute uniform flow.

d. The current dam operation rules for the dam are in essence an assessment on the supply-demand scenarios for Nairobi. It is based on exceedance probabilities for satisfying the demand for the city. It is thus not an operations tool but rather a planning tool.

Dam operation rules should be guidelines that help the managers to decide on the course of action in a given situation. For example, what are the release rates to Ng'ethu WTP at different levels of water demand stress in Nairobi; when the dam is filling beyond main spillway level, should he wait for the auxiliary spillway to discharge, or should he open the bottom gates, and by how much; when should he open the sediment score gates and for how long. It is therefore necessary to develop operation rules for Thika Dam and if possible, transform into a curve for ease of application.

e. There is a good hydro-electric power potential in the Thika Dam-Ng'ethu WTP System that has not been realised. It was explained that the turbines for the power house intake were not installed because they would be running only at those times when water was released to Ng'ethu WTP. However, there an even greater potential at the Chania outfall with a higher constant flow and an even higher physical head.

f. The years 2016 and 2017 were very dry years. By early 2018, water levels in Thika Dam were very low and declining. When the 2018 rainy season came, the rains were very heavy, leading to flooding in different parts of Kenya. However, it took quite some sometime for Thika Dam to fill as compared to Sasimua Dam which filled faster. This attracted negative insinuations from some quarters which were carried in the media. A rainfall-runoff model study of the catchment would provide a better understanding of catchment response to rainfall and also form a basis for water balance studies of the reservoir.

2.2 Karimenu II Dam

A one-day site visit was undertaken on 25th February 2020 to Karimenu II Dam. Karimenu II Dam in currently under construction. It is part of a water supply system being developed for Ruiro, Juja and Nairobi.

2.2.1 Location

It is located on Karimenu River in Kiambu County about 75 km from Nairobi.

2.2.2 Observations

The Dam is being constructed by a consortium of two Chinese companies under Fund-Design-Built arrangement.
There are various works across the site: site clearing for the dam at the higher elevations; tunnelling; building of office and residential blocks among others.
Works involving different aspects of civil engineering as well as other engineering discipline would be observed.
The site has a well-equipped materials laboratory.

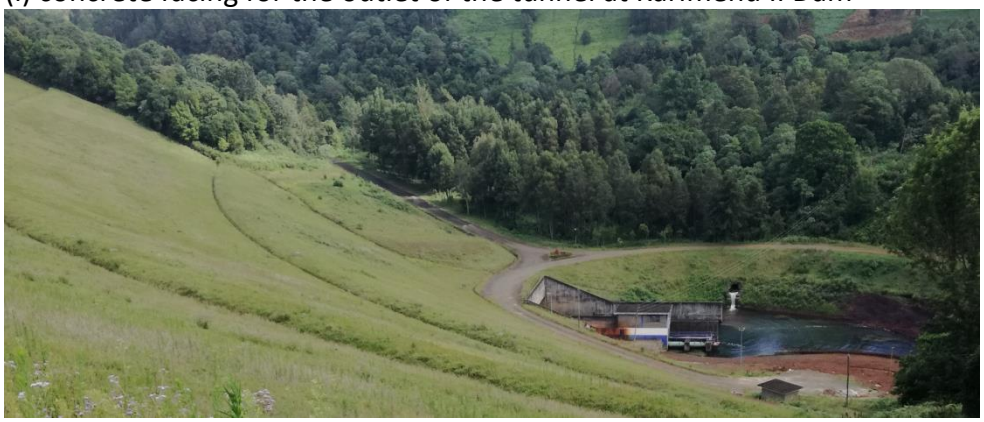
2.2.3 Observed challenges

a. The works are being implemented as a fund-design-built contract. It is thus imperative to review the project for safety and cost management especially if the designs have not been finally approved.

b. The works are on an extensive site and varied in engineering terms of the disciplines. The supervision, however, seems to be thin on the ground. A strong supervisory team is necessary especially given that this is a fund-design and build contract.

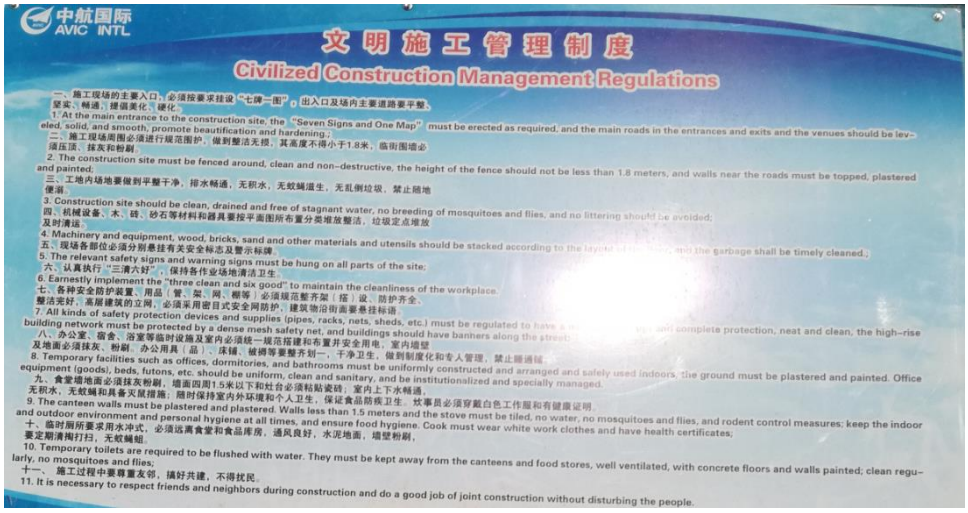
c. The materials laboratory n site is good. It is however, small and inadequate in scope.
d. The natural slopes on the reservoir area are very steep and they raise the prospect of sliding once submerged.
e. Environmental considerations are important for all works. A comparison of two solutions is given in Plate 11 for two finishes to slopes.

(i) concrete facing for the outlet of the tunnel at Karimenu II Dam



(ii) grassed downstream slopes of the Thika Dam
Plate 11. A comparison of environmental solutions

f. Working language: there is an element of language barrier noticeable at site. In some cases it may be quite innocuous as in the notice in Plate 12 (a). In others, however, it may have long-term undesirable consequences as illustrated in the lab record on a set of core samples in Plate 12(b).



(a) A signboard at Karimenu II Dam site

(b) A geological log record at Karimenu II Dam site laboratory

Plate 12. Language need not be a barrier

The services of a language expert could be helpful for proper communication and records.

2.3 Sasimua Dam and WTP

A one-day site visit was undertaken on 256th February 2020 to Sasimua Dam. The visit, undertaken from Nairobi, was cut short by rains which started shortly after arrival at the place.

2.3.1 Location

Sasimua Dam and WTP is in Nyandarua County about 85 km from Nairobi.

2.3.2 Observations

Sasimua Dam and WTP supplies water to Nairobi through a 62 km pipeline. It was built in phases between 1956 and 1968. The first phase was built in 1956 and comprised of

the dam, water treatment plant and a three turbine hydro-electric power plant appurtenant to the water treatment plant. The hydropower plant was built for internal use but is now silent for want of repair.
The dam was overtopped and partially destroyed during floods in 2003. It was rehabilitated in 2009-2010 and upgraded in terms of embankment elevation, dam instrumentation and the provision of an emergency spillway.
The dam has its own catchment comprising 12,600 Ha of well-conserved forest.
The water treatment plant has a water quality lab and is partially automated in sampling water for quality testing.

2.3.3 Observed challenges

Due to the limited time and bad weather, it was not possible to visit the weather station, hydrometric stations and dam instrumentation points.
However, it was observed that the dysfunctional hydroelectric power station at the WTP is capable of supplying the energy requirement of the WTP and staff quarters. The challenge of undertaking repairs and that of running it are not insurmountable.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

2.1.1 The attachment at the Athi Water Works Development Agency (AWWDA) was very successful and beneficial.
2.1.2 AWWDA has an excellent inter-institutional cooperation that made it possible for this industrial attachment to be smoothly extended to NCWSC.
2.1.3 Useful contacts were made with staff of AWWDA and NCWSC.
2.1.4 Opportunities for further collaboration in consultancy, research and development exist and can be explored.

3.2 Recommendations

3.2.1 University-industry collaboration can be mutually beneficial and should be encouraged.
3.2.2 Athi Water Works Development Agency should work together with Nairobi Water and other sector players to improve existing data collection networks, data transmission, storage, retrieval and access.
3.2.3 Athi Water Works Development Agency being a lead agency in the development of dams in Kenya should lead the way in capacity building for the construction and management of dams and associated works in the country.

4. ACKNOWLEDGEMENTS

The author wishes to express gratitude to all those who supported and made it possible to undertake the industrial visit, especially to:

a. ACE II Program, Moi University for providing the financial support;
b. Moi University Management and the Dean, School of Engineering for the grant of leave of absence during this period;
c. The CEO Athi Water Works Development Agency, Eng. Michael Thuita Mwangi and all his staff for accepting to be host and for coordinating with NCWSC for placement at Thika Dam and the visit to Sasimua Dam and WTP;
d. The Dam Coordinator, Thika Dam, Mr. Job Kihamba and his staff for being good hosts.
e. The Dam Coordinator and staff at Sasimua Dam and Water Treatment Plant for good reception during the short visit to their facility.

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