

FLOOD EARLY WARNING SYSTEM

NZOIA RIVER BASIN SHORT SUMMARY

MAINA, Johnson Muturi
HYDROMETEOROLOGICAL INFORMATION SERVICES
KENYA METEOROLOGICAL DEPARTMENT

FORECAST: HIGH RISK OF FLOODING

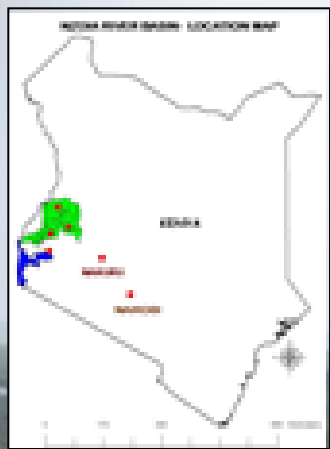
Date	Level (m)	Trend	Flood Risk Category
Yesterday's Max. Level	5.63	-	High
Yesterday's Avg. Level	5.48	Rising	High
Today's "Morning water level" - 8am	5.42	Rising	High
Forecast average water levels	8 th May 2013	Falling	High
	9 th May 2013	Falling	High
	10 th May 2013	Rising	High

TOM OTIENO | NATION

A resident of Bukhoba village, Budalang'i constituency leaves his flooded home yesterday. Below: A woman prepares a meal for her children at an evacuation centre after their homes were submerged in floodwaters. Many families were displaced when River Nzoia burst its banks, causing massive flooding in the area and parts of Siaya County. (Daily Nation, 13 May 2013)



PROBLEM STATEMENT









More misery: Roads damaged, farms swept away by floods with no signs of rains subsidising

Families moved to higher grounds as River Nzoia bursts its banks

BY STANDARD TEAM

There is anxiety among Bunyala South residents after water levels at River Nzoia rose due to the ongoing heavy downpour.

Already, the Provincial Administration and the National Water Conservation and Pipeline Corporation (NWPC), the firm tasked with the rehabilitation of dykes, have asked residents to seek refuge on higher grounds.

They say the water level of the river has risen to 6.12 metres, threatening to burst the river's banks.

On Thursday, locals spent sleepless night as they frantically fought off floods by raising the height of the dykes, using gunny bags as the water level kept rising.

According to experts, any level of water above 4.8 metres is considered dangerous since it was a traditional sign of impending floods.

Residents' safety

"At the moment, we cannot guarantee residents' safety because the water levels have reached an abnormally high level and the dykes may not withstand the pressure. It is important that people move to higher grounds to avert any losses," said Lucy Mbutia, the NWPC site engineer.

Mbutia expressed disappointment that despite the worrying situation, some locals have refused to leave their homes thus endangering their lives. Signs of the dykes crumbling began two weeks ago when water started sipping under-

“We cannot guarantee residents' safety since water levels are high

Rising water level

The water level of the river has risen to 6.12 metres, threatening to burst the river's banks.

On Thursday, locals spent sleepless night as they frantically fought off floods by raising the height of the dykes, using gunny bags as the water level kept rising.

neath the dykes near Igigo, Sibuka, Sisinga and Bukoba points, displacing about 35 families and destroying crops in over 2000 acre farms.

Elsewhere, transport along Kisii-Migori Road has been paralysed after heavy rains destroyed a section of it. The busy road was destroyed near Kamagambo Adventist Teachers Col-



Pupils in Kano, Kisumu County, cross a small river created by floods in the area, yesterday. [PHOTO: COLLINS ODUOR/STANDARD]

lege, about 15 kilometres from Kisii town. The damage caused a heavy traffic snarl-up, with more than 300 vehicles stuck on the road as there was no alternative road.

Officers lost

Heavily affected were Public Service Vehicles (PSVs) that ply the Isebania - Nairobi route. Many of the buses heading to Nairobi used the Rongo - Etago - Kisii murrum road.

In Baringo, over 300 families have been affected by floods and more than 10 acres of crops destroyed as

mudslides hit six villages in Baringo County. Villagers in Sangarau, Ngetmoi, Emom, Sigowo and Timboiwo are living in fear after the hilly areas started experiencing cracks and fissures. This, they say indicates more landslides should the heavy rains continue. Transport along Ngetmoi-Kibonjos-Kaptich road has been cut-off after falling rocks blocked the road, rendering it impassible for motorists and pedestrians.

- Reports by Benson Buluma, Robert Kiplagat and Stanley Ongwae

Western Kenya Red Cross coordinator Emmanuel Owako said the situation was pathetic and the organisation overwhelmed.

"The number of the affected families is increasing daily and the more the rains continue, the more we are getting overwhelmed," said Mr Owako.

Catholic University of Eastern Africa staff and students donated relief food and drugs worth Sh200,000 to flood victims in Nyando District yesterday.

In Budalang'i, evacuation of those whose homes have been submerged began at the weekend.

High water levels

Lorries have been dispatched to the flood-prone area to ferry victims to safer ground.

Budalang'i district commissioner Khalif Ali Abdi and National Water Conservation and Pipeline Corporation site engineer Lucy Mbuthia regretted that residents were reluctant to move despite water levels reaching a record 6.12 metres.

Mr Abdi said six more boats bought by the Ministry of Special Programmes were on standby to evacuate families stranded in flooded homes.

"We have established a camp where the victims will have to put up."

Ms Mbuthia said NWPC was introducing measures that could solve the problem including use of gunny bags filled with sand to reinforce the strength of dykes.

NWPC has constructed two mega dykes at River Nzoia to control flooding.

"Realignment of dykes that kept them much stronger than before equally played a critical role in containing the water as they are cushioned from pressure of flowing water," she said.

Locals have petitioned the government to seek long term solutions to the floods menace.



"We want to know what happened to the World Bank multi-million-shilling project on River Nzoia that would have seen construction of dams to address this crisis once and for all," said Mr Pius Mukola.

Water started sipping under the dykes at Igigo, Siginga, and Sibuka and Bukoba recently and displaced several families besides destroying houses and crops on over 2,000 acres.

Heavy rains continued to wreak havoc in Matungu and Mumias districts in Kakamega County, where several families have been forced out of their homes and learning disrupted in some schools.

Villagers evacuated

A bridge was swept away in Munsanda, Mumias, making it difficult for residents to travel.

More than 100 houses and 20 toilets were destroyed in Matungu at the weekend.

In Murang'a, hundreds of Kirikoini villagers have been evacuated in anticipation of a landslide.

More than 200 villagers have

abandoned their homes after huge cracks appeared on the ground and on the floors of their houses.

Several houses have also been brought down and roads rendered impassable.

Governor Mwangi wa Iria ordered the village to be sealed off to avert loss of lives after huge and deep gulleys appeared on farms.

Yesterday, Kahuro district commissioner Fred Muli confirmed that the residents had all moved and were putting up with relatives, friends and neighbours while others were staying at a church compound.

"Those who do not have a place to live in are being housed at ACK Church Gatuya," said Mr Muli.

"We have also given them space to safely keep some of their household items," he added.

Speaking to the *Nation* by phone, the DC said the residents' livestock were still in the villages, adding to the nightmare of having to feed them during the day and leaving them alone at night.

The cracks appeared following

Nyando Basin has worsened and more than 1,000 people downstream are displaced.

The organisation says accommodation of displaced families is a nightmare since most evacuation centres are schools that are now being used by pupils.

Kisumu Governor Jack Runguma and the County commissioner Lorna Odero yesterday toured the area to assess the situation.

days of heavy rains, raising fears of a landslide.

Mr Muli said geologists were expected any time to assess the extent of the damage and declare if it was safe for the villagers to return to their homes.

Some of the residents told the *Nation* that they had never seen such an occurrence before and described how they were woken up by the rumbling sound of the moving earth and the cracking walls.

Ms Catherine Wanjiru said she heard some rumbling noise last Wednesday night and later saw huge cracks on the walls and floor of her house.

Full of cracks

"I decided to evacuate my family after the cracks deepened and have been living in a friend's house," she said. The story is the same for her neighbour, Mr Phillip Muchumbi.

"I was awakened by what sounded like thunder only to see my house full of cracks which are widening by the day," said Mr Muchumbi.

The government through the Disaster Centre has offered food aid while Governor Mwangi has set aside Sh500,000 to help the victims with food, bedding and drugs.

Reported by Angela Oketch, Everline Okewo, Linet Wafula, John Shilita and Samuel Karanja

Nandi County leaders have criticised the Cabinet list unveiled by Governor Cleophas Lagat a week ago, saying it does not reflect regional balance. The 30 county assembly members and MPs, led by women representative Zipora Kering, said they had asked the governor to observe the regional balance rule but were surprised when the list was released. Mrs Kering said the elected leaders' views should be respected.

NAKURU

County official sacked for disobeying orders

Nakuru County acting director of social services Pamela Osano has been sent home for "gross misconduct and insubordination". She failed to summon subordinate staff to Nakuru's main market during Governor Kinuthia Mbugua's tour where a head count was to be done to weed out ghost workers and establish why services at the market had collapsed.

LAIKIPIA

Leaders want police reservists recalled

Laikipia County Assembly members have asked the government to bring back Kenya Police reservists to curb cattle rustling. The leaders said reservists in Baringo, Samburu and Isiolo counties had helped curb rustling. "We cannot continue losing lives every day. We are demanding to be allowed to train our own reservists," Security and Home Affairs Committee chairman Dan Ndegwa said. Last Wednesday 10-year-old Joyce Muthoni was killed by cattle rustlers at Kieni village.



FLOOD MITIGATION

Why “Flood Mitigation”

Key to improving livelihoods and resilience to floods

- Reduce losses (lives, property and livestock, economic, ...)

The recurrent floods in the lower reaches of rivers Nzoia and Yala:

- disrupted economic activities,
- caused loss of assets (exacerbating poverty)
- Caused loss of lives/death
- led to the diversion of scarce resources from more developmental uses to support recovery and relief for flood victims.

➤ Build community resilience to environmental (Flood) hazards

- A functional **flood early warning system (FEWS)** is a core component of Flood Mitigation. It entails real-time Monitoring, forecasting and timely dissemination of warnings
- Other elements of integrated flood management include structural controls and non-structural measures such as:
 - Catchment management
 - Multi-purpose dam (flood control, hydropower generation, irrigation, water supply)
 - Floodplain management (dykes, river training, channel management, ...)
 - Building Community-based disaster management capacity
 - Making good use of flood waters

SOME FACTS ABOUT THE NZOIA RIVER BASIN

RAINFALL: AVG CATCHMENT RAINFALL =1100mm; Min=600mm;
Max=2,700mm

FLOW: AVG=3,755 MCM at Rwambwa Bridge Gauge; Min=28m³/s; Max=3,380 m³/s; TC≈3days

FLOOD MAGNITUDES, $Q_{T(\text{YEARS})}$: Q_{10} =2,367 m³/s; Q_{20} =2,671 m³/s; Q_{50} =3,073 m³/s and Q_{100} =3,381 m³/s

Upper reach, 135-257 km, slope=1 to 240 ≈0.42%

Middle reach, 20-135km, slope=1 to 390 ≈0.26%

Lower reach, 0-20km, slope=1 to 3400≈0.0294%;

110km² area affected by flooding from the Yala and Nzoia rivers, almost every year.

Flood depth = 0.5m to 1m lasting about a month.

MAJOR FLOODS:1937,1947,1951,1957-58,1961,1978,1988,1997-98 El

Nino,2002,2003,2007, and 2009. During the 1997-98 El Nino, Oct-Dec rainfall was 300% of the normal; 12,000 people displaced, dykes were extensively damaged due to overtopping and breaching.

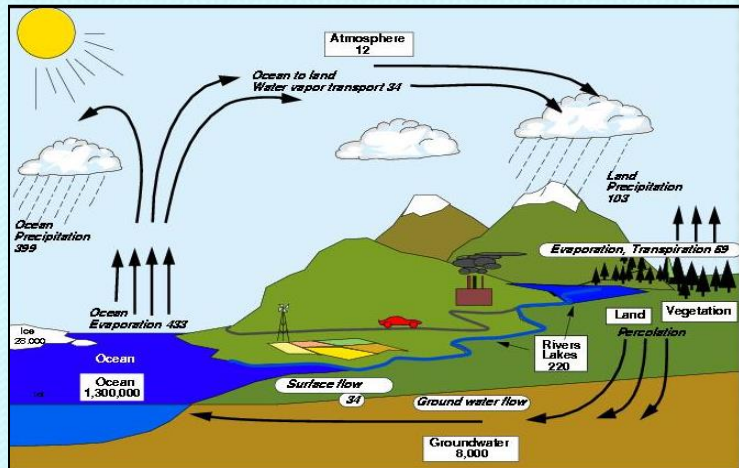


FLOOD EARLY WARNING SYSTEM

SCIENTIFIC BASIS OF THE FLOOD EARLY WARNING SYSTEM

FLOODS CAUSE-EFFECT

HYDROLOGICAL /WATER CYCLE



HEAVY RAINFALL IN RIVER BASIN GENERATES RAPID RUNOFF, WHICH SOMETIMES CAUSES FLOODS;

- The **climate system** transports water vapour from moist surfaces, (e.g. oceans, lakes, Congo forest) into the basin;
- The water vapour is **lifted** to the “condensation level” to form **clouds** that precipitate/ yield rainfall;
- Due to **climate variability**, sometimes we get **floods** while at other times we experience **droughts** depending on available moisture/ water vapour;
- Floods are characterized by river **levels higher than the river bank elevation** leading to overtopping and the flood plain is **inundated/ swamped**.

MAIN COMPONENTS OF THE NZOIA FLOOD EARLY WARNING SYSTEM

- ❑ **A Real-time monitoring system:**
 - Network of hydro-meteorological stations: rainfall, evapotranspiration and river levels
 - Rapid transmission of data
 - Meteorological Satellite images and Rainfall estimates; fast internet facility
- ❑ **A Flood Diagnostic and Forecasting Centre**
 - Real-time data acquisition: rainfall, river levels/flow, evapotranspiration,.. **Receivers: Central Base Stations**
 - Data processing
 - Analysis
 - Quantitative rainfall forecasts
 - River flow forecasting (models)
 - Decision making: Warning or No Warning?
 - Preparation of “Bulletin”: Warning message!!
- ❑ **A Warning dissemination System**
 - **Mailing list**, through Internet
 - Disaster/emergency management agencies (Government, Red Cross, NGOs, CBOs..),
 - Local leadership,
 - Schools, Hospitals
 - **Community FM Radio Station (RANET):** broadcasts warnings in local language
 - **SMS (Mobile phones)**

FLOOD EARLY WARNING SYSTEM

□ FLOOD DIAGNOSTIC AND FORECASTING CENTRE (FDFC)/CONTROL CENTRE

- REAL-TIME MONITORING SYSTEM : NETWORK, EQUIPMENT AND TELEMETRY**
- AUTOMATIC DATA ACQUISITION SYSTEM: CENTRAL BASE STATIONS**
- DATA PROCESSING AND ANALYSIS**
- FORECASTING TOOLS/MODELS: DECISION SUPPORT SYSTEM**
- FORECASTING EXPERTS**
- WARNING DISSEMINATION SYSTEM**

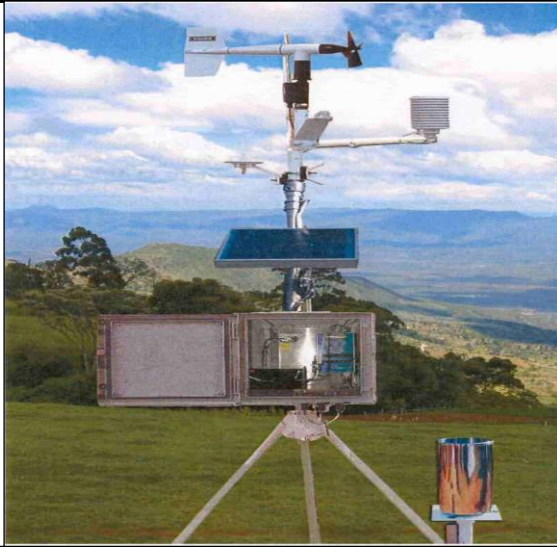
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- NATIONAL/INTERNATIONAL EMERGENCY RESPONSE AGENTS**
- COMMUNITY DISASTER MANAGEMENT: AWARENESS , FLOOD RISK MAPS, RESPONSE TEAMS, ...**
- DISASTER EVACUATION ROUTES, SHELTERS, DYKES, FLOOD DIVERSIONS**



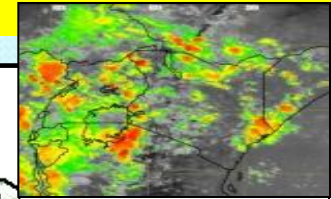
FLOOD MONITORING NETWORK AND EQUIPMENT

NZOIA BASIN REAL-TIME MONITORING SYSTEM: STATE-OF-THE-ART EQUIPMENT



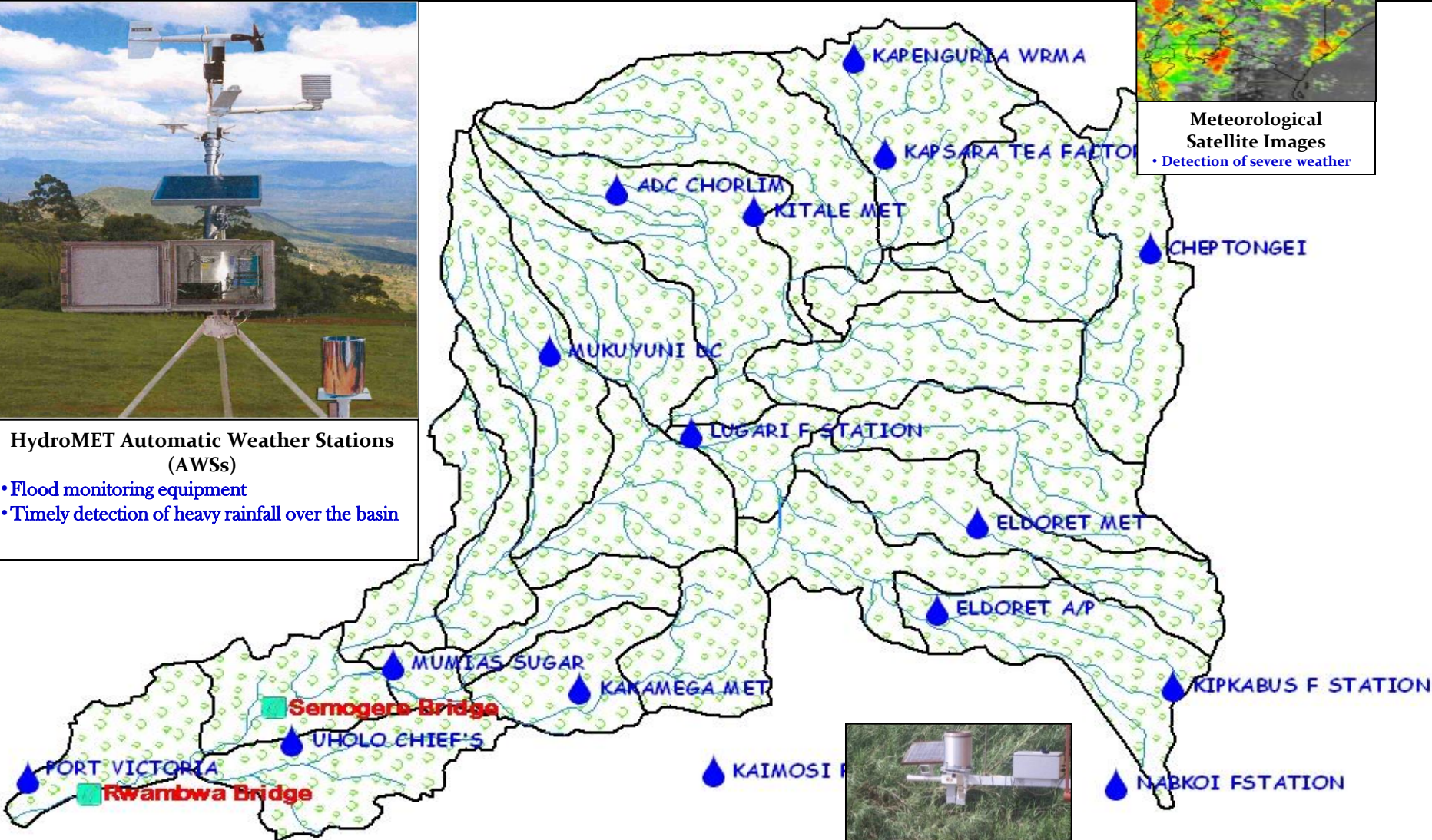
HydroMET Automatic Weather Stations (AWSs)

- Flood monitoring equipment
- Timely detection of heavy rainfall over the basin



Meteorological Satellite Images

- Detection of severe weather



Automatic Radar River Level Stations

- Flood monitoring equipment
- Early detection of dangerous water levels

LONGIANT

TELEMETRIC AUTOMATIC STATIONS: HYDROMET AWSs AND RGSs



MANUAL RIVER LEVELS MEASUREMENT

STAFF GAUGE



Description

A staff gauge is used for measuring water levels in lakes, rivers, reservoirs, irrigation channels, flumes and other bodies of surface water.

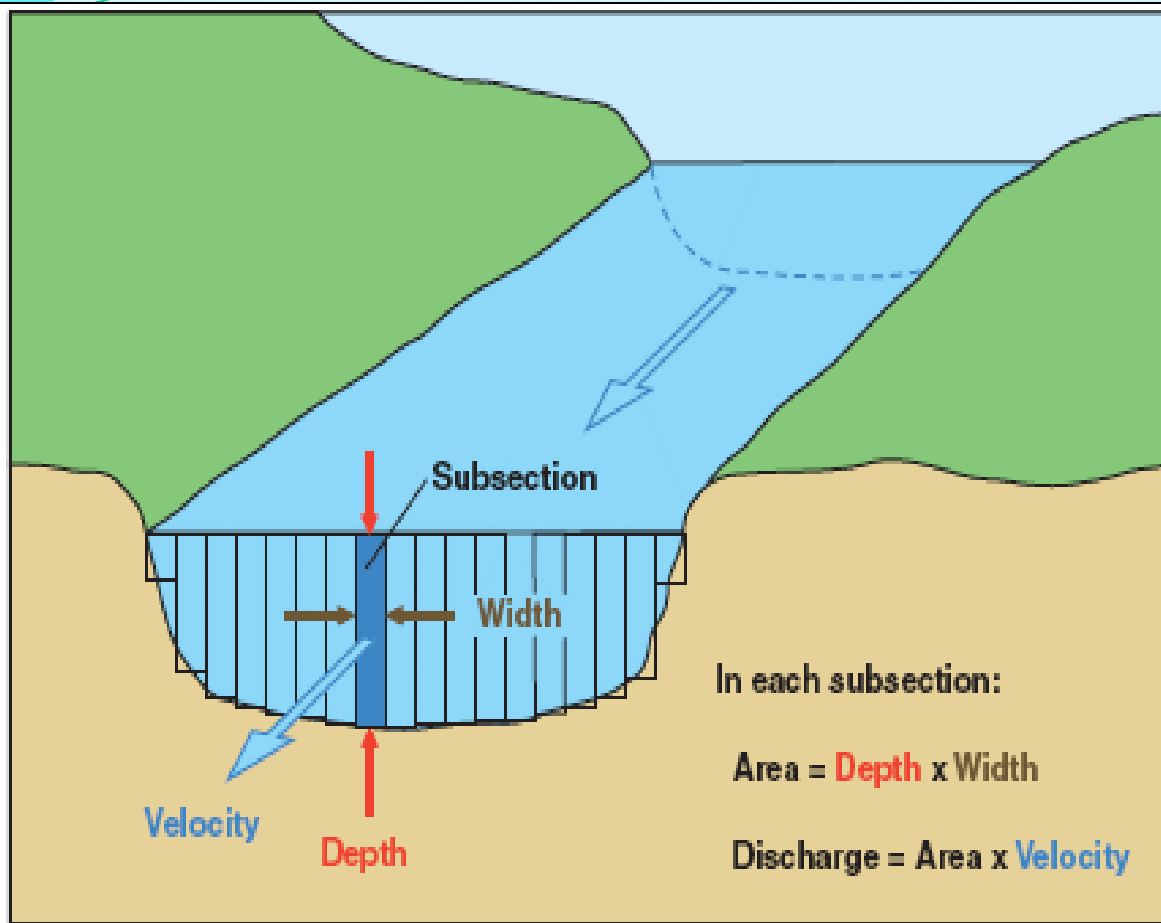
Designed for high accuracy & excellent readability. Special porcelain enamel coating offers rust & discoloration protection. It is a graduated plate (usually in centimeters) mounted on a pillar, pier or on a bridge beside and/or in the river or lake. Each plate is fixed relative to a datum determined using benchmarks (points of known elevation). Several staff gauges are installed depending on the expected/known range of river/lake/reservoir levels.

AUTOMATIC RADAR WATER LEVEL SENSOR



The measuring principle is based on the pulsed radar principle. Measurement is done in pulses, the so-called pulse procedure, where a transmitter sends out a short microwave pulse, followed by a period when the receiver picks up the signals reflected by the water. The received signal is conveyed to the integrated evaluation system. The time travelled by the pulse corresponds with the distance travelled to and from the surface of the water.

RIVER DISCHARGE/ FLOW MEASUREMENTS



Required measurements:

River flow velocity -
CURRENT METER, (v m/s)
at section

River depth (h m), sounding
rod or staff gauge

River width (w m)

River cross section area (A m²)

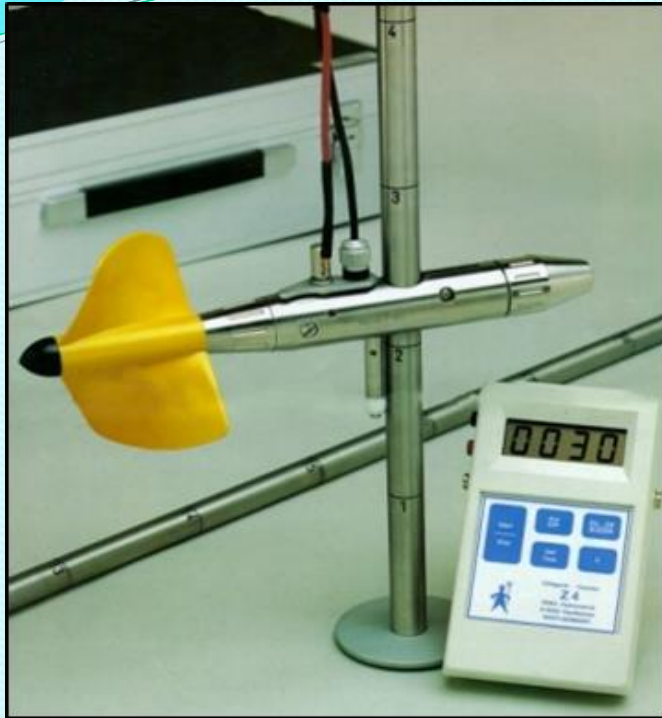
Discharge, $Q = \sum A_i v_i$
(m³/s ≡ cumecs)

Discharge measurements are
used to develop a **stage-
discharge relationship**, also
known as a **rating equation or
curve**. Usually of the form,

$$Q = a(h \pm c)^b$$

Current-meter discharge measurements are made
by determining the discharge in each subsection of a channel
cross section and summing the subsection discharges to obtain
a total discharge.

CURRENT METER



Methods

- Wading, for small rivers
- Boat, medium size rivers
- Cable Way, large rivers

Current meter parts

- **Sounding rod** with scale to measure depth of river and depth of the current meter
- **Propeller**
- **Connecting cable**
- **Digital Display Counter**, indicates the number of propeller revolutions (N) over a given duration. N will be higher for high velocities and low at low velocities. Current meter calibration equation relates N to velocity (of the form, $v=a+bN$)

ACOUSTIC DOPPLER CURRENT PROFILER (ADCP)

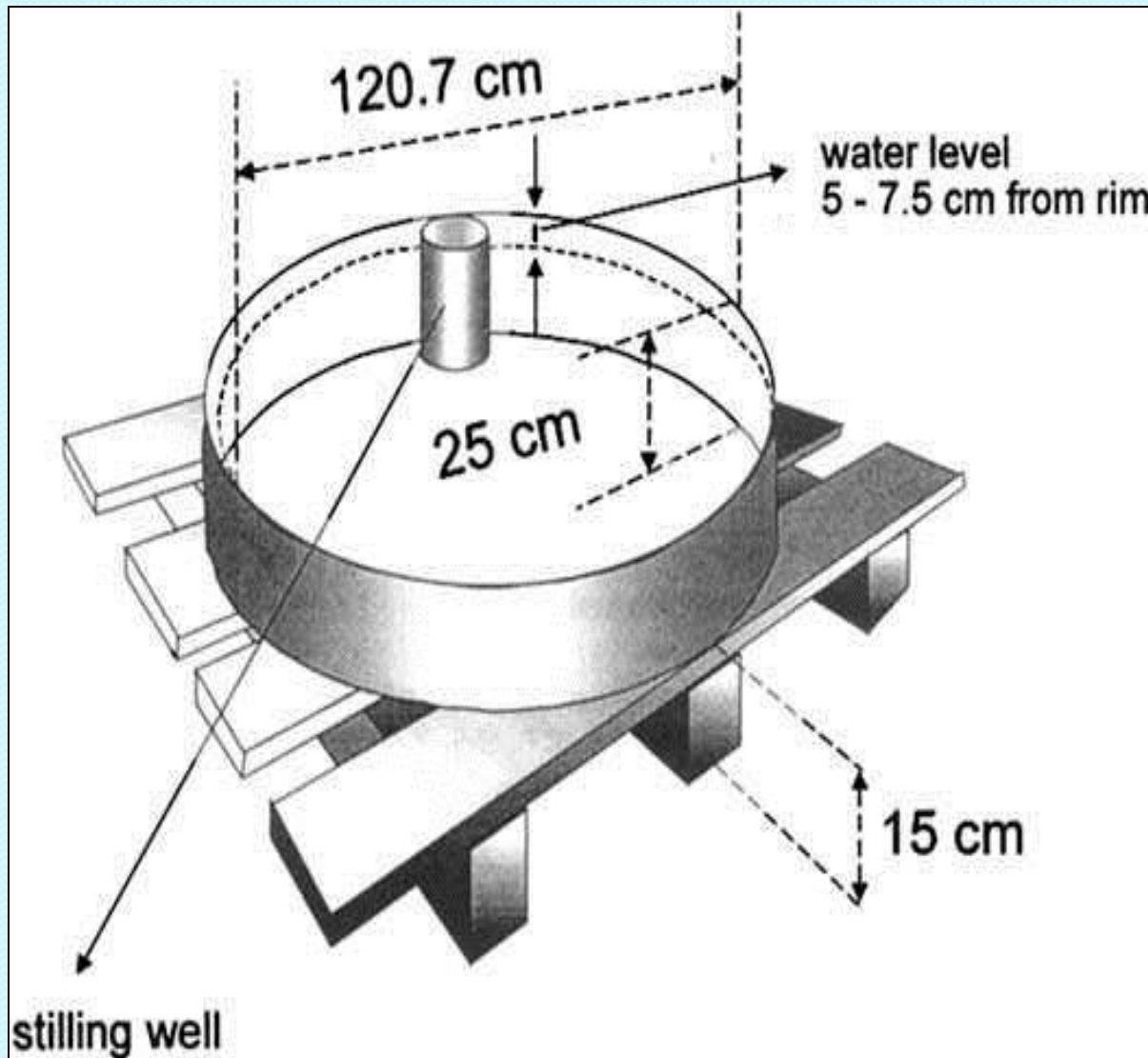


The ADCP measures water currents with sound, using a principle of sound waves called the Doppler effect. A sound wave has a higher frequency, or pitch, when it moves to you than when it moves away. You hear the Doppler effect in action when a car speeds past with a characteristic building of sound that fades when the car passes.

The ADCP works by transmitting "pings" of sound at a constant frequency into the water. (The pings are so highly pitched that humans and even dolphins can't hear them.) As the sound waves travel, they ricochet off particles suspended in the moving water, and reflect back to the instrument. Due to the Doppler effect, sound waves bounced back from a particle moving away from the profiler have a slightly lowered frequency when they return. Particles moving toward the instrument send back higher frequency waves. The difference in frequency between the waves the profiler sends out and the waves it receives is called the Doppler shift. The instrument uses this shift to calculate how fast the particle and the water around it are moving.

Sound waves that hit particles far from the profiler take longer to come back than waves that strike close by. By measuring the time it takes for the waves to bounce back and the Doppler shift, the profiler can measure current speed at many different depths with each series of pings.

EVAPOTRANSPIRATION



Evaporation pan

SOIL MOISTURE

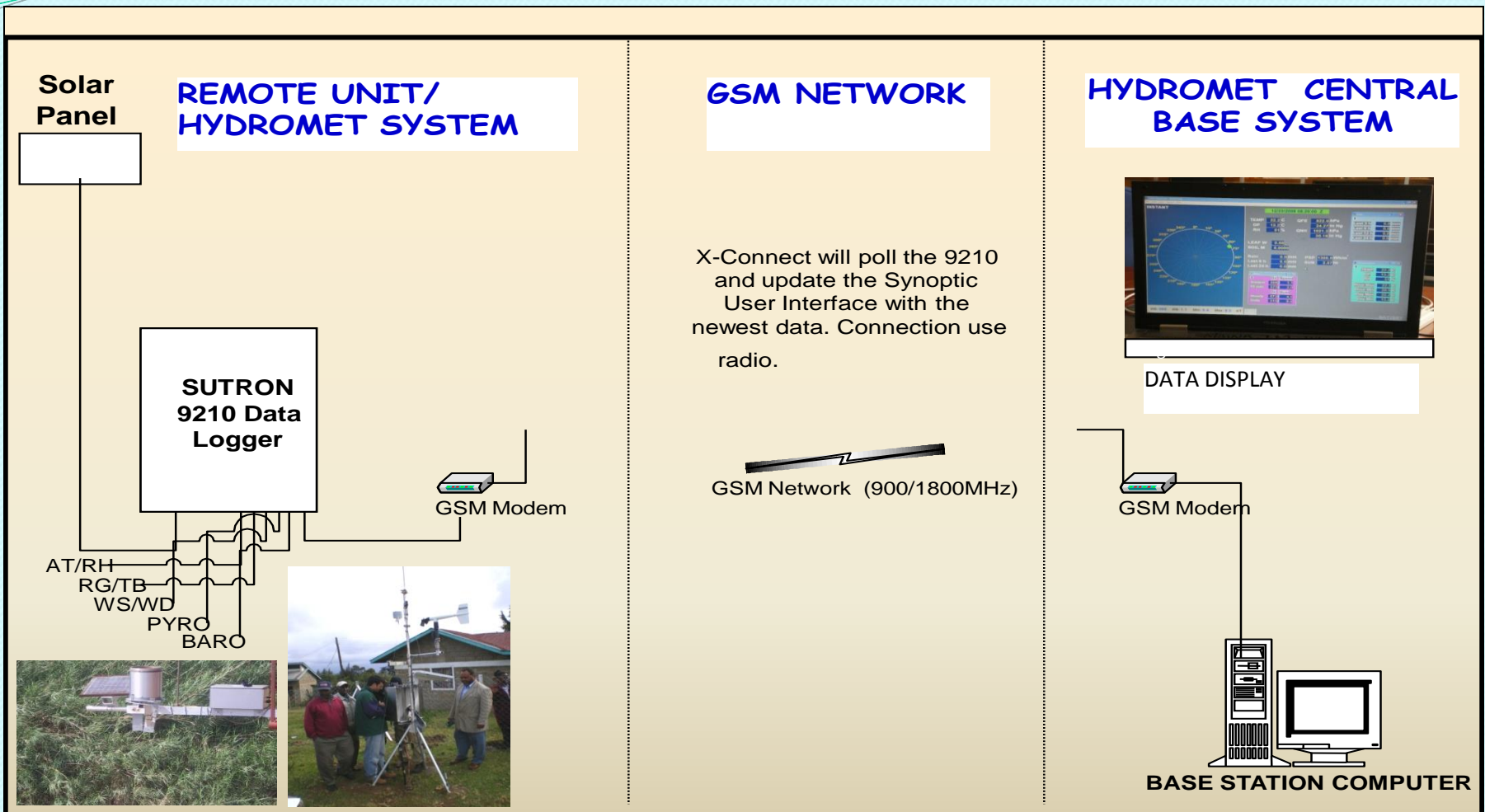
Why Monitor Soil Moisture?

Monitoring soil moisture can help growers manage soil moisture. Choosing the right times and the right amounts to irrigate can lead to:

- higher yields
- better product quality
- improved plant vigour
- reduction in disease
- more effective use of water (water efficiency)
- reduced irrigation costs

The soil moisture also influences the catchment response to rainfall i.e. runoff generation.

DATA TELECOMMUNICATION SYSTEM/ REAL-TIME TELEMETRIC SYSTEM

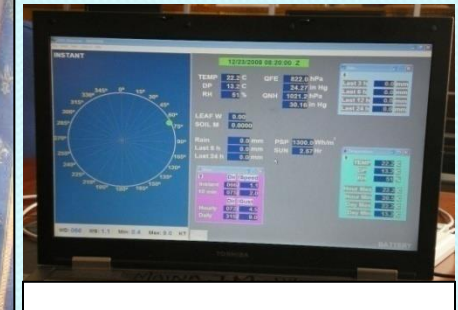
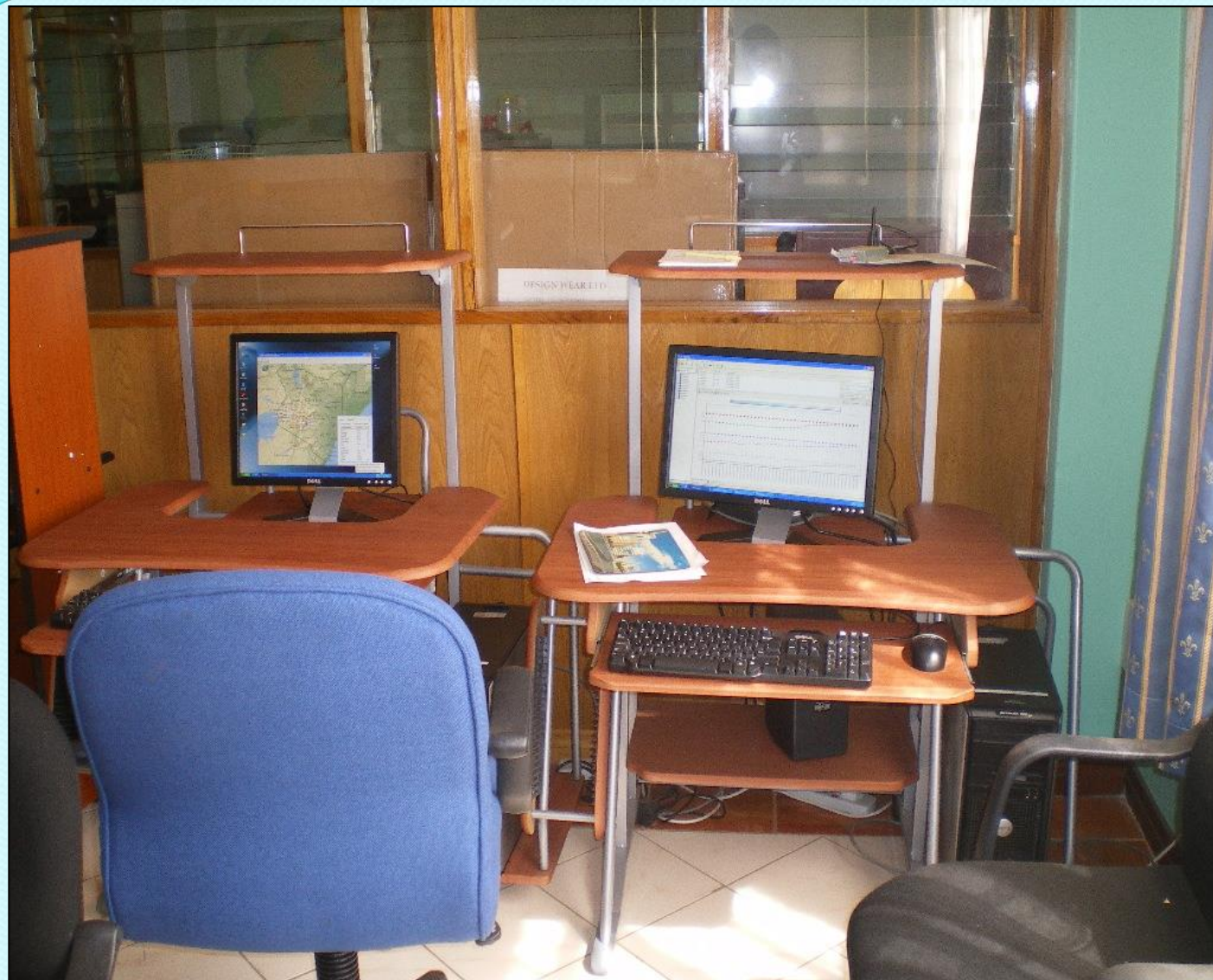


Telemetric system for real-time meteorological and river level data acquisition at the Flood Diagnostics and Forecasting Centre (FDFC)

**AUTOMATIC DATA ACQUISITION AND
VISUALIZATION
AT
FDFC/CONTROL CENTRE**

DATA COLLECTION AND DISPLAY AT THE FORECASTING (WARNING) CENTRE (FDFC)

CENTRAL BASE STATION AND MODELING SYSTEM



DATA DISPLAY - RIVER LEVEL



RWAMBWA BRIDGE



River Level: **1.534 m**
 Last Updated: 11/18/2010 9:00:00 AM
 Logger Temperature: 29.48 degC

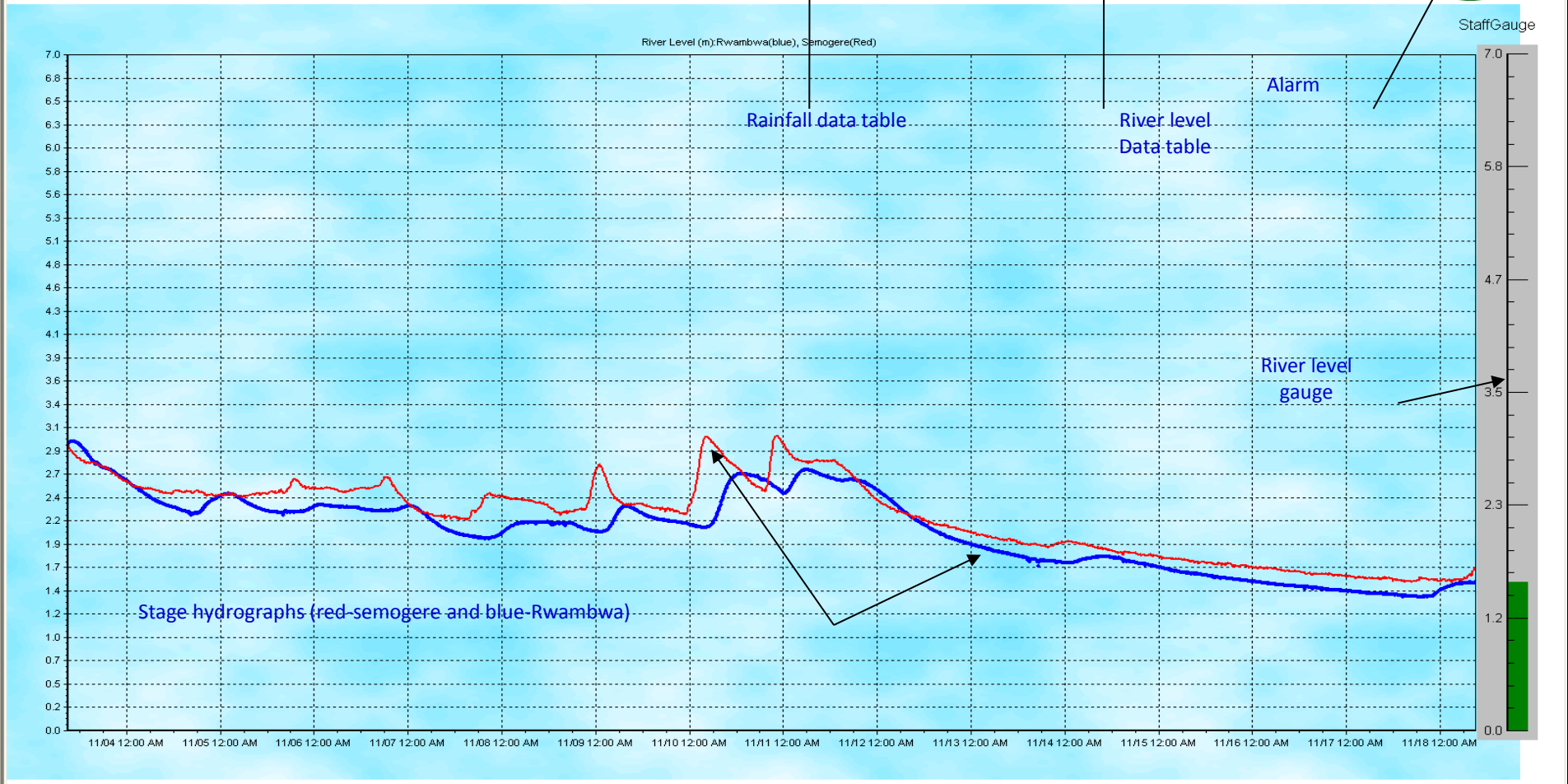
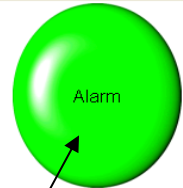
Battery Level: **13.70 VDC**

Rainfall: **0.0 mm (last hour)**
0.0 mm (previous 24hr)

Timestamp	RainFall_Tot
11/16/10 08:00:00	0
11/16/10 09:00:00	0
11/16/10 10:00:00	0
11/16/10 11:00:00	0
11/16/10 12:00:00	0

11/18/10 08:00:00	1.532	13.42	23.64
11/18/10 08:10:00	1.532	13.47	24.78
11/18/10 08:20:00	1.53	13.54	25.92
11/18/10 08:30:00	1.53	13.6	26.93
11/18/10 08:40:00	1.532	13.57	27.75
11/18/10 08:50:00	1.528	13.54	28.69
11/18/10 09:00:00	1.534	13.7	29.48

1.534M



PROCESSING AND ANALYSIS

Time Series and Spatial rainfall analysis -GIS

Rainfall distribution over Nzoia basin
06 November 2008



□ Districts boundaries

~ River Nzoia

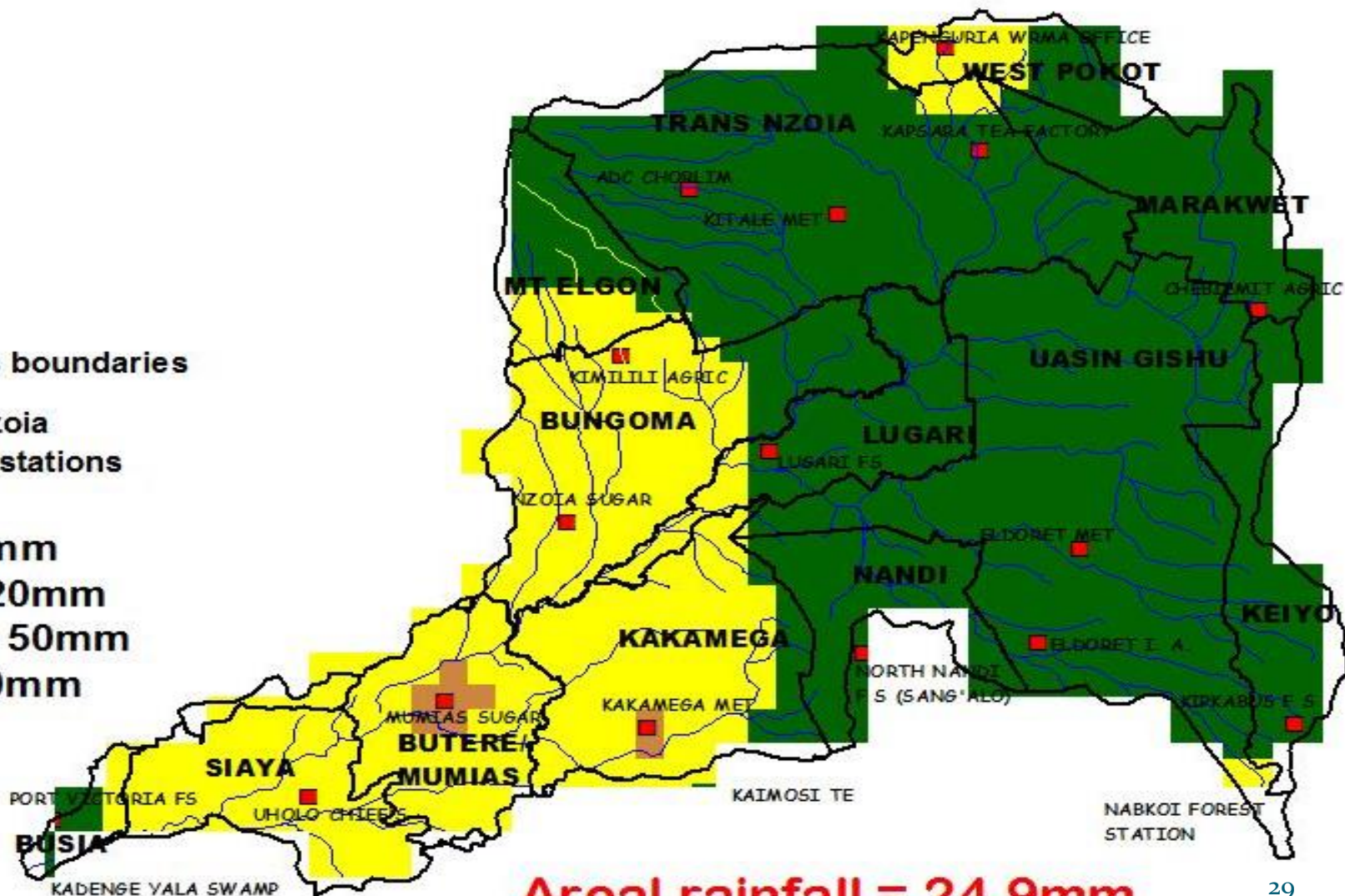
■ Rainfall stations

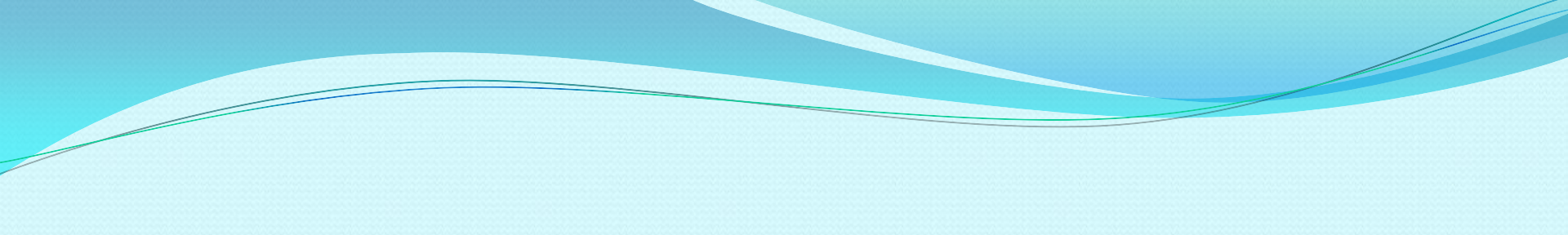
■ < 5mm

■ 5 - 20mm

■ 20 - 50mm

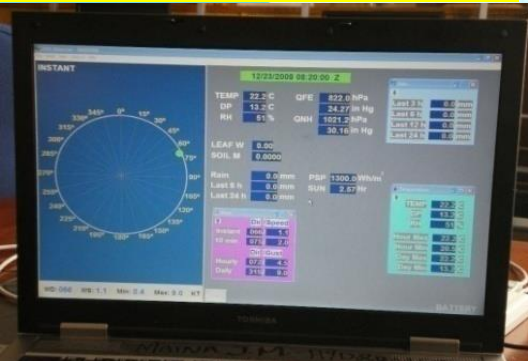
■ > 50mm





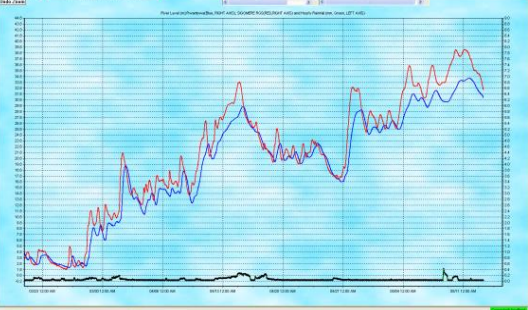
**OPERATIONS AT THE FLOOD
DIAGNOSTICS
AND
FORECASTING CENTRE [FDFC]
SUMMARY**

DATA ACQUISITION



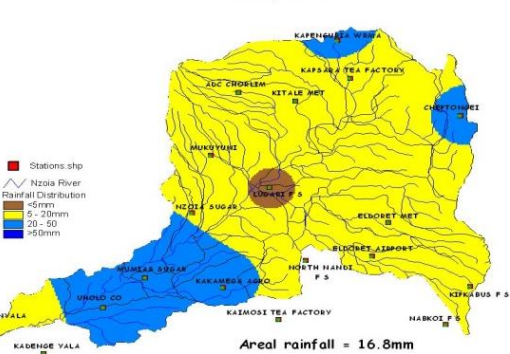
CENTRAL BASE STATIONS

Station Name	Level (m)	Status
RWAMBWA BRIDGE	13.19	OK
...



DATA DISPLAY – RIVER LEVEL

Rainfall distribution over Nzoia basin 06 May 2013



SPATIAL RAINFALL ANALYSIS

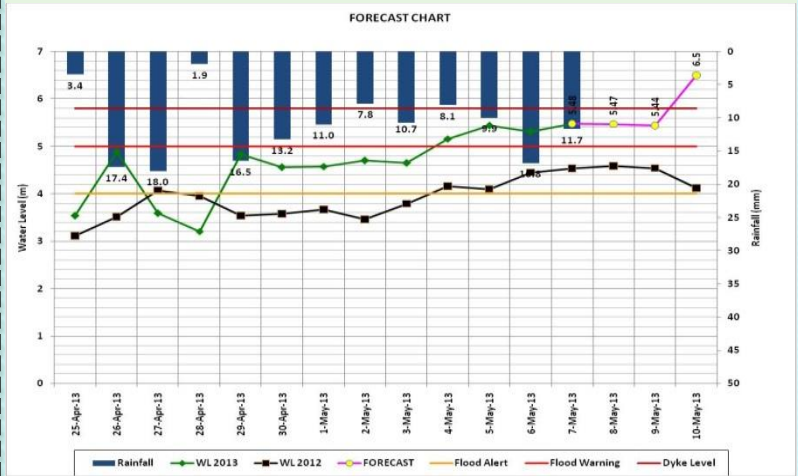
FLOOD FORECASTING

Screenshots of flood forecasting software showing model selection and output parameters.

FLOW FORECASTING MODELS

MODEL INPUTS

- Areal Rainfall
- Discharge/River Flow
- Evapotranspiration
- Quantitative Precipitation Forecast (QPF)



FORECAST RIVER LEVEL CHART

EARLY WARNING BULLETIN (Flood Watch)

- Use of Colour Codes:
 - ✓ Green-No Risk
 - ✓ Amber: Medium Risk
 - ✓ RED: High Risk

Description	Range	Colour codes	Remark
Flood Warning level (m)	>5.0 m	Red	Above this point flooding can occur depending on strength of the dykes
Alert levels	4.0 -5.0 m	Amber	Watch
No risk	< 4.0m	Green	Safe

DISSEMINATION

- Email list
 - ✓ The OP/Devolution Ministry: State Department for Special Programmes
 - ✓ National Disaster Operations Centre (NOC)
 - ✓ Red Cross
 - ✓ Medical/Health/Schools
 - ✓ Religious Org
 - ✓ NGOs
 - ✓ County/District/Community Disaster Management Committees, etc]
- Radio Broadcasts: Bulala RANET

WELL COORDINATED AND TIMELY RESPONSE PLAN



THANK YOU