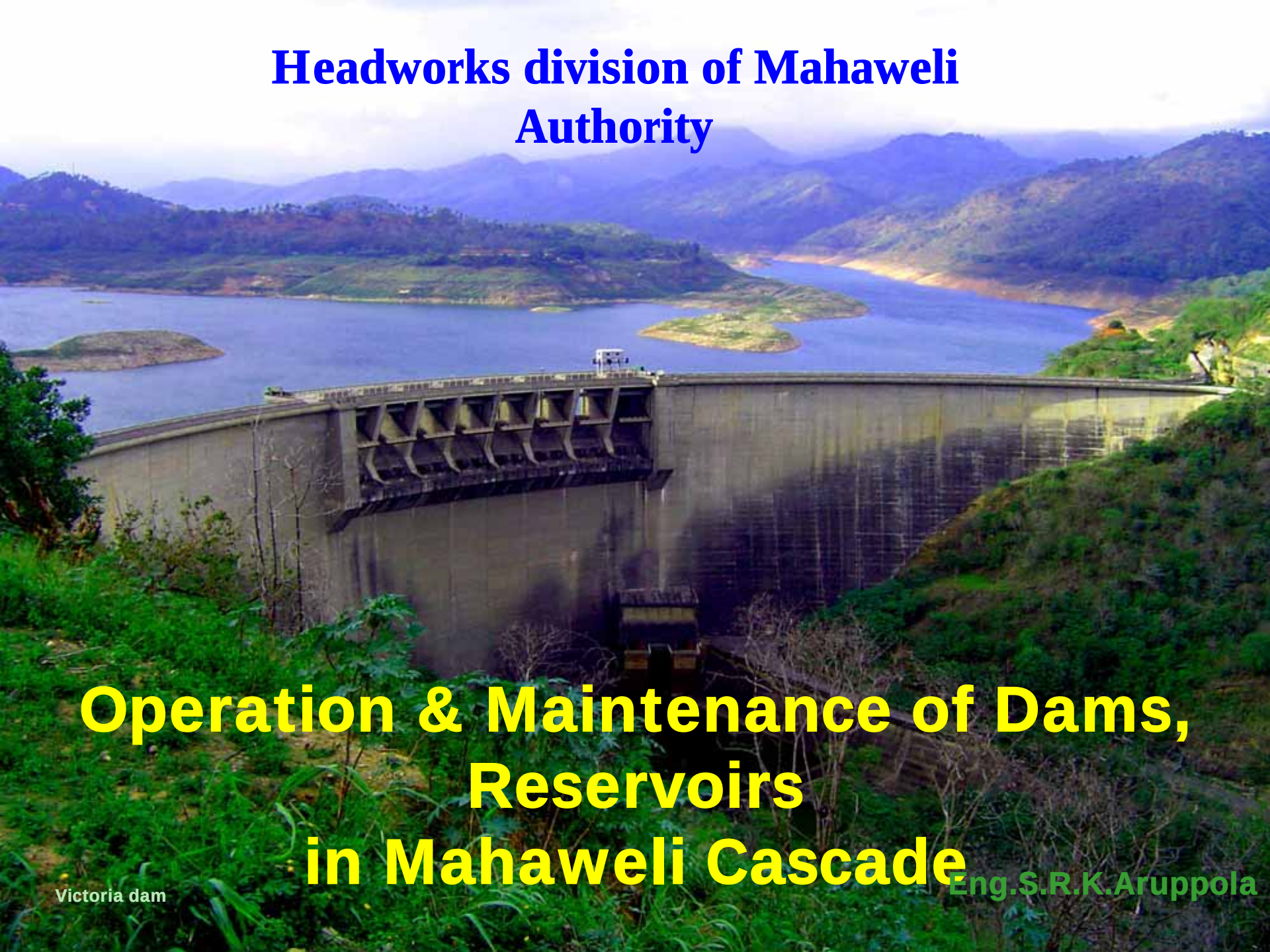
Headworks division of Mahaweli Authority



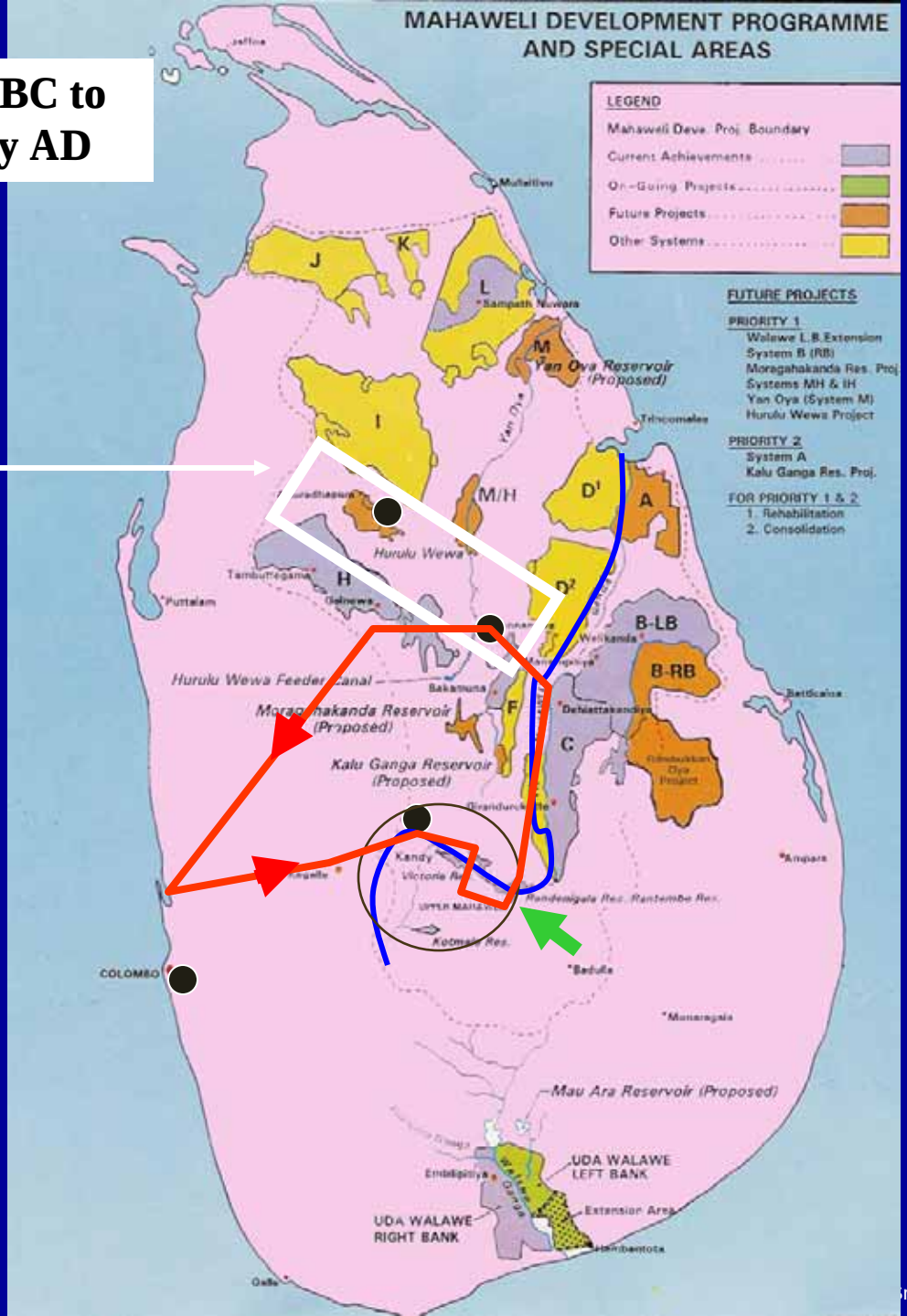
Operation & Maintenance of Dams, Reservoirs in Mahaweli Cascade

Victoria dam

Eng.S.R.K.Aruppola

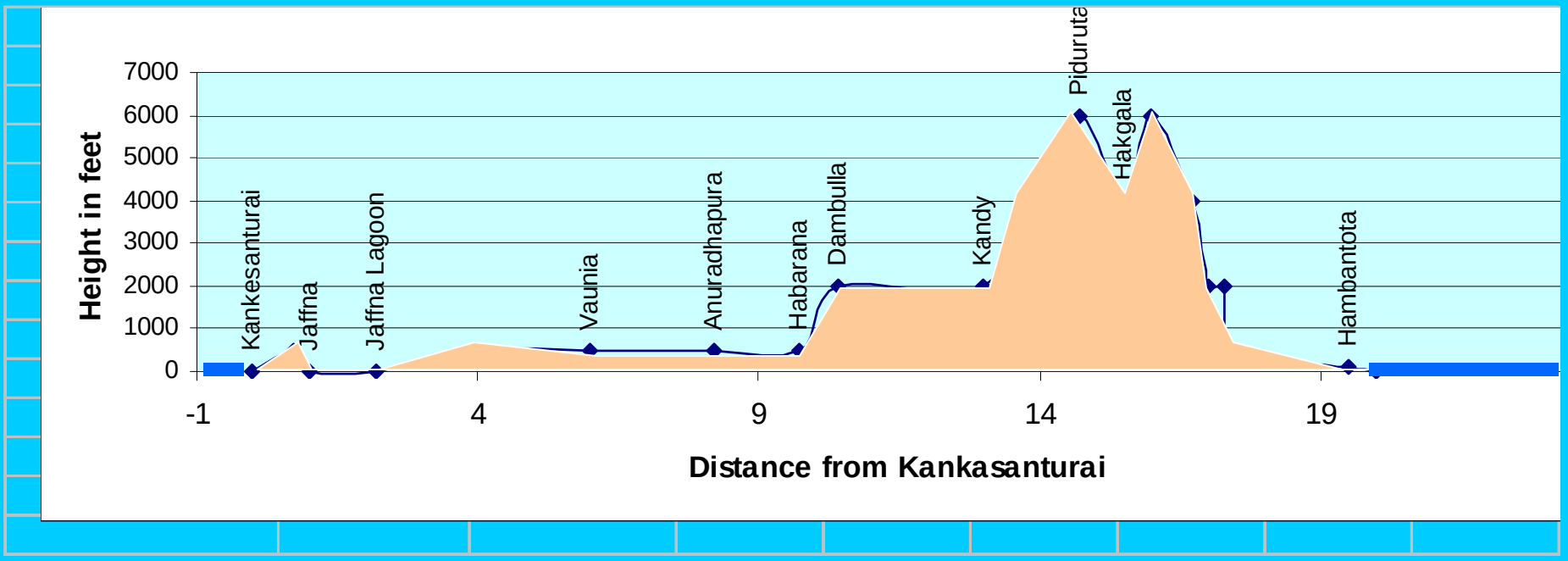

AFGHANISTAN
PAKISTAN
CHINA
NEPAL
BHUTAN
BANGLADESH
MYANMAR
INDIA
SRI LANKA
Srinagar
New Delhi
Jodhpur
Jaipur
Ajmer
Udaipur
Jamnagar
Ahmadabad
Vadodara
Bhavnagar
Surat
Mumbai
Pune
Solapur
Kolhapur
Kurnool
Hubli-Dharwar
Mangalore
Bangalore
Mysore
Kozhikode
Coimbatore
Tiruchchirappalli
Madurai
Thiruvananthapuram
Jaffna
Trincomalee
Kandy
Colombo
Galle
Lucknow
Kanpur
Allahabad
Varanasi
Patna
Jamshedpur
Calcutta
Nagpur
Raipur
Hyderabad
Vishakhapatnam
Vijayawada
Nellore
Cuttack
Chittagong
Dhaka
Imphal
Gauhati
Thimphu
Katmandu
Annapurna
Mt Everest
Yamuna
Chagara
Ganges
Son
Narmada
Brahmaputra
Godavari
Krishna
Mahanadi
Gulf of Kachchh
Gulf of Khambhat
Gulf of Mannar
Mouths of the Ganges
NAGA HILLS
HIMALAYA
GANGDISE SHAN
KARAKORAM
WESTERN GHATS
EASTERN GHATS
ARABIAN SEA
BAY OF BENGAL
INDIAN OCEAN
LACCADIVE IS.
ANDAMAN IS.
NICOBAR IS.
Andaman Sea
Ten Degree Channel
C. Comorin
Ct. Nicobar
0 500 1000 Mi
0 500 1000 1500 Km
©1998, Lattimer Clarke Corp. Pty. Ltd.

5th century BC to 12th century AD

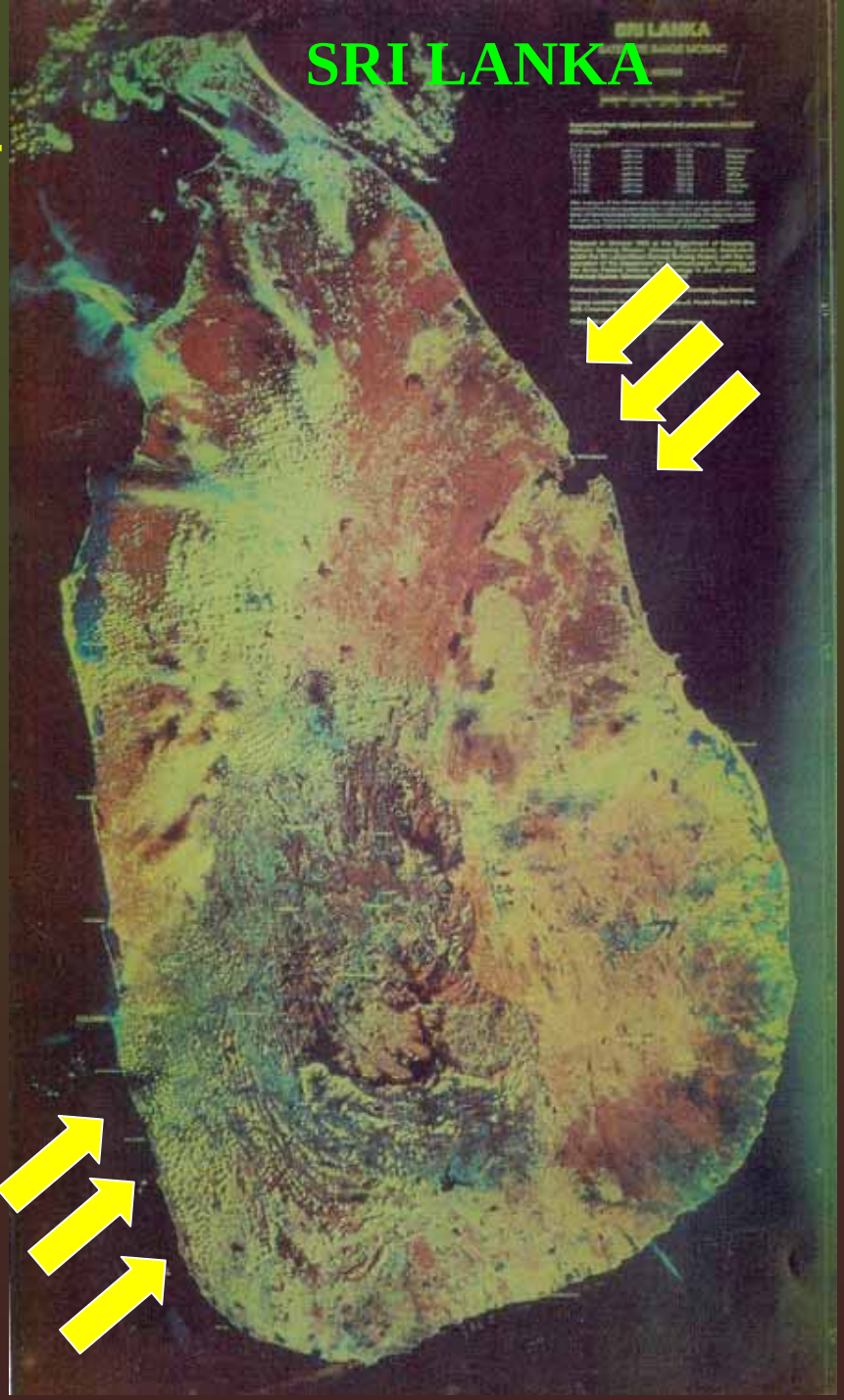



Kambam
Madurai
Point Pedro
Jaffna
Chavakachcheri
Bay of Bengal
10°
Paramagudi
SRI LANKA
laiyam
Sivakāsi
INDIA
TAMIL NĀDU
Rāmanāthapuram
Mullaittivu
Talaimannar
Nedunkeni
Mannar
Surandai
Tuticorin
Vavuniya
Tirunelveli
Horowupotana
Trincomalee
Trivandrum
Tiruchchendūr
Pahala
Anuradhapura
Maragahawewa
Puttalam
Dangollegama
Nāgercoil
Sigiriya
Gulf of Mannar
Galewela
Karadiyanaru
Batticaloa
Hettipola
Kurunegala
Paddiruppu
Narammala
Weragantota
Negombo
Gampola
Kandy
Akkaraipattu
Bibile
Sri Jayawardenepura
Nuwara Eliya
Badulla
Pottuvil
Wadduwa
Bandarawela
Ratnapura
Beruwala
Pitigala
Embilipitiya
Ambalangoda
Baddegama
Beliatta
Galle
Matara
INDIAN OCEAN

Longitudinal section of Sri Lanka



Annual Rainfall
1,900-2,500 mm / year



North – East Monsoon

Maha Season

(November to February)

Heavy Rains

South – West Monsoon

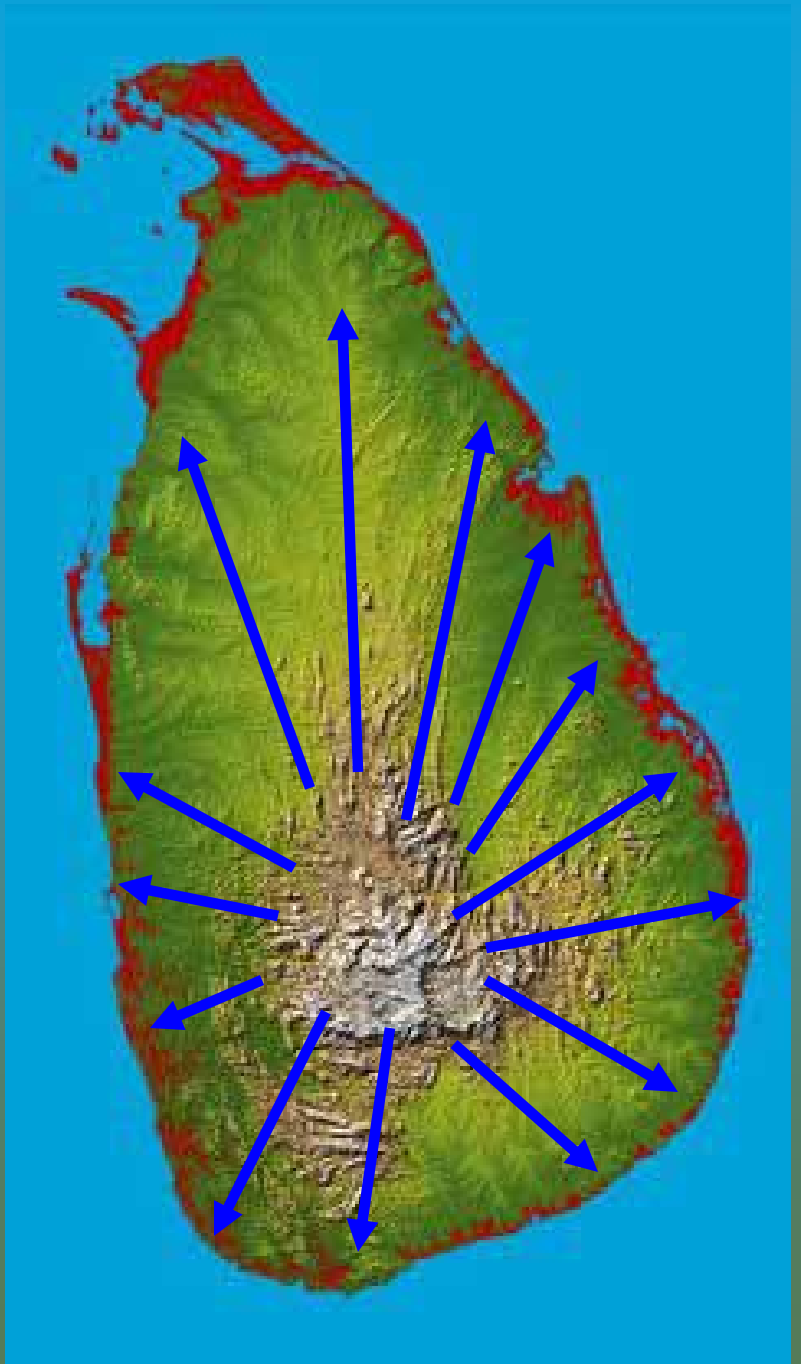
Yala Season

(May to August)

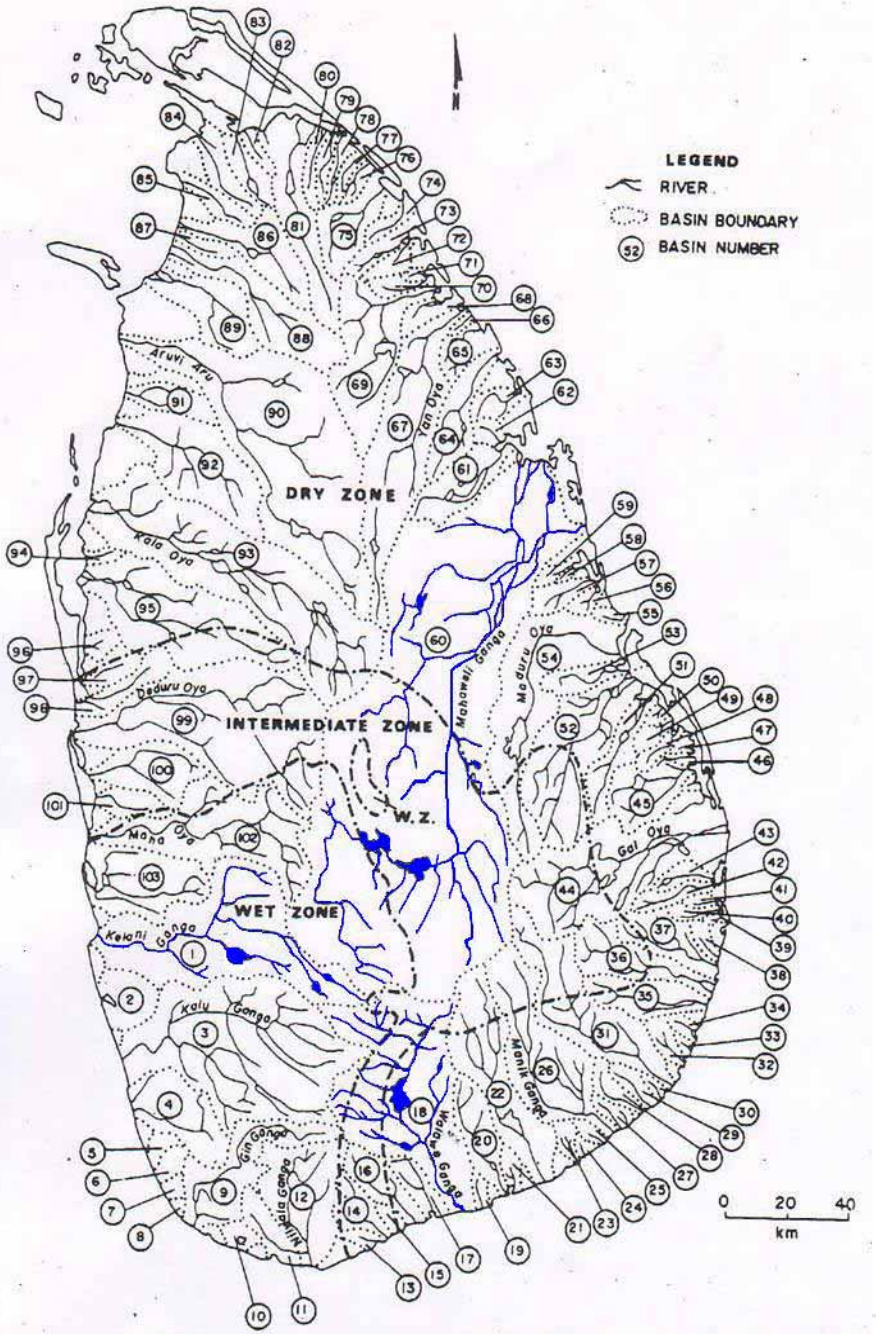
Medium Rains

SRI LANKA

103 rivers originate from the central hills



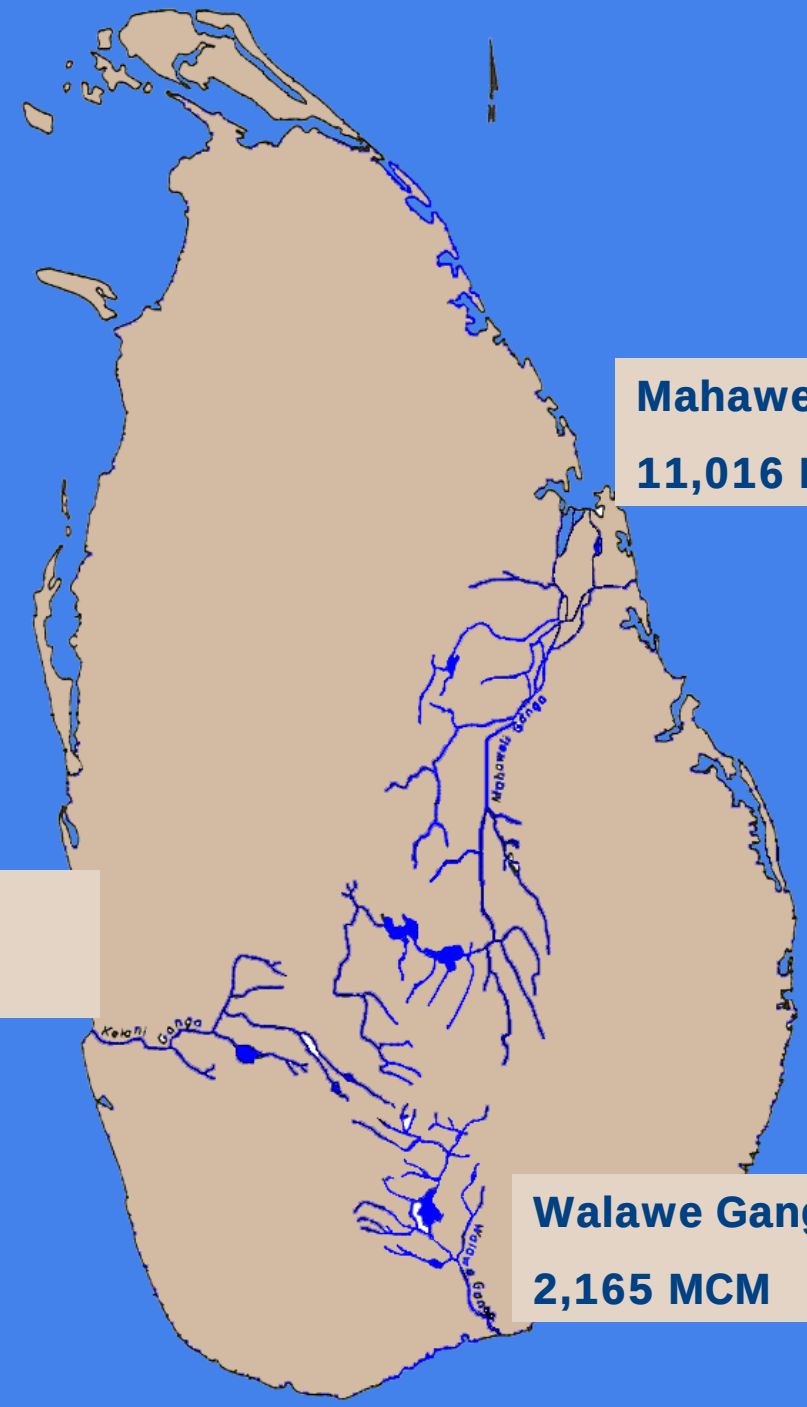
River Basins of Sri Lanka



River Basins

Basin No	Name of Basin	Catchment Area Sq. Km.	Basin No.	Name of Basin	Catchment Area Sq. Km
1.	Kelani Ganga	2278	53.	Miyangolla Ela	225
2.	Bolgoda Lake	374	54.	Maduru Oya	1541
3.	Kaluganga	2688	55.	Pulliyanpotha Aru	52
4.	Bentota Ganga	6622	56.	Kirimechi Odai	77
5.	Madu Ganga	59	57.	Bodigoda Aru	164
6.	Madampe Lake	90	58.	Mandan Aru	13
7.	Telwatte Ganga	51	59.	Makarachchi Aru	37
8.	Ratgama Lake	10	60.	Mahaweli Ganga	10327
9.	Gin Ganga	992	61.	Kantalai Basin Per Aru	445
10.	Koggala Lake	64	62.	Panna Oya	69
11.	Powatta Ganga	233	63.	Palampotta Aru	143
12.	Nilwala Ganga	960	64.	Pankulam Ara	382
13.	Sinimodara Oya	38	65.	Kanchikamban Aru	205
14.	Kirama Oya	223	66.	Palakutti Aru	20
15.	Rekawa Oya	755	67.	Yan Oya	1520
16.	Uruhokke Oya	348	68.	Mee Oya	90
17.	Kachigala Ara	220	69.	Ma Oya	1024
18.	Walawe Ganga	2244	70.	Churian Aru	74
19.	Karagan Oya	58	71.	Chavar Aru	31
20.	Malala Oya	399	72.	Palladi Aru	61
21.	Embilikala Oya	59	73.	Nay Ara	187
22.	Kirindi Oya	1165	74.	Kodalikallu Aru	74
23.	Bambawe Ara	79	75.	Per Ara	374
24.	Mahasilawa Oya	13	76.	Pali Aru	84
25.	Butawa Oya	38	77.	Muruthapilly Aru	41
26.	Menik Ganga	1272	78.	Thoravil Aru	90
27.	Katupila Aru	86	79.	Piramenthal Aru	82
28.	Kuranda Ara	131	80.	Nethali Aru	120
29.	Namadagas Ara	46	81.	Kanakarayan Aru	986
30.	Karambe Ara	46	82.	Kalawalappu Aru	56
31.	Kumbukkan Oya	1218	83.	Akkarayan Aru	192
32.	Bagura Oya	92	84.	Mendekal Aru	297
33.	Girikula Oya	15	85.	Pallarayan Kadu	159
34.	Helawa Ara	51	86.	Pali Aru	451
35.	Wila Ara	484	87.	Chappi Aru	66
36.	Heda Oya	604	88.	Parangi Aru	832
37.	Karanda Oya	422	89.	Nay Aru	560
38.	Simena Ara	51	90.	Malvatu Oya	3246
39.	Tandiadi Aru	22	91.	Kal Ara	210
40.	Kangikadichi Ara	56	92.	Moderagam Ara	932
41.	Rufus Kulam	35	93.	Kala Oya	2772
42.	Pannel Oya	184	94.	Moongil Aru	44
43.	Ambalam Oya	115	95.	Mi Oya	1516
44.	Gal Oya	1792	96.	Madurankuli Aru	62
45.	Andella Oya	522	97.	Kalagamuwa Oya	151
46.	Thumpankeni Tank	9	98.	Pantampola Oya	215
47.	Namakada Aru	12	99.	Deduru Oya	2616
48.	Mandipattu Aru	100	100.	Karambala Oya	589
49.	Pattanthe Aru	100	101.	Ratmal Oya	215
50.	Magalawatavan Aru	346	102.	Maha Oya	1510
51.	Vett Aru	26	103.	Attanagalu Oya	727
52.	Mundeni Aru	1280			

Annual Outflows of Major River Basins to Sea



Mahaweli Ganga

11,016 MCM

Kelani Ganga

5,474 MCM

Walawe Ganga

2,165 MCM

Ancient Sri Lanka

gem & pearl

buddhism

archeology stone carving, frescos

climatic variation

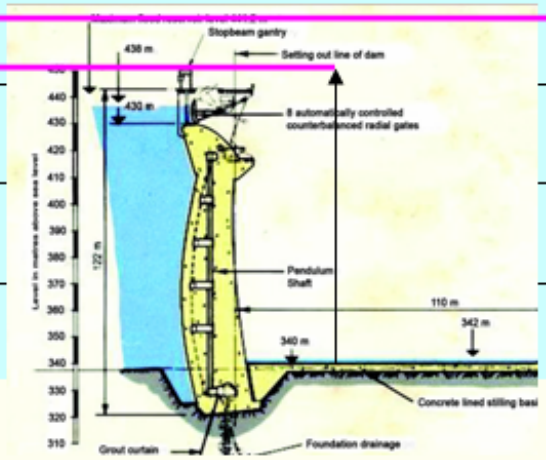
irrigation and hydraulics

Dome and Valve Pit

Heights of ancient and modern structures compared

Victoria dam	Ruwanweli Seya	Jethawanarama
	King Dutugemunu	King Mahasena
1985	140 BC	276 – 303 A.D.
308 ft.	350 ft.	400 ft.

500
400
300
200
100
0

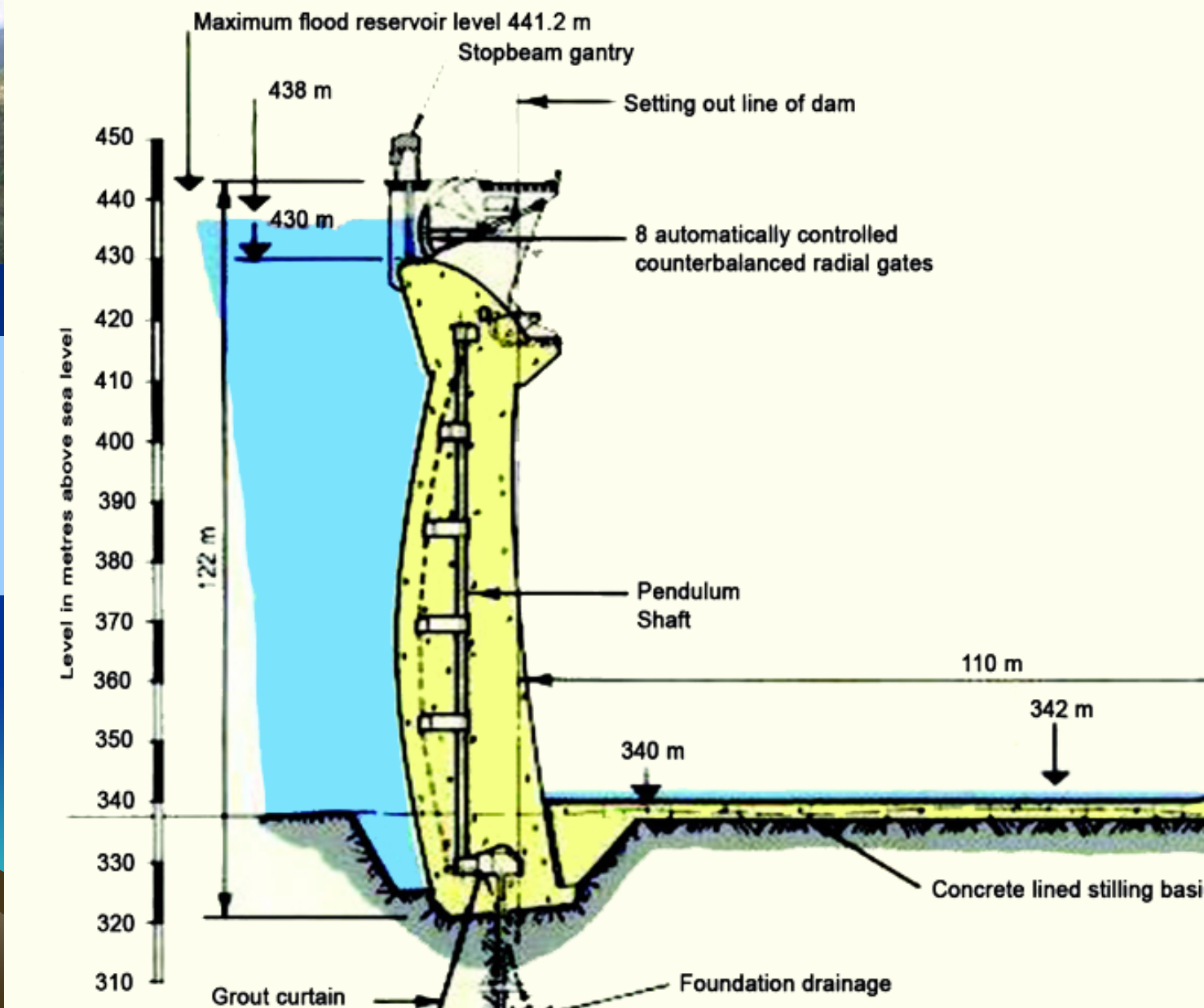


VICTORIA DAM

Victoria dam

1985

308 ft.



RUWANWELI SEYA

King Dutugemunu 140 BC

Foundation

compaction

consolidation

reinforcement

JETHAWANARAMAYA RUINS

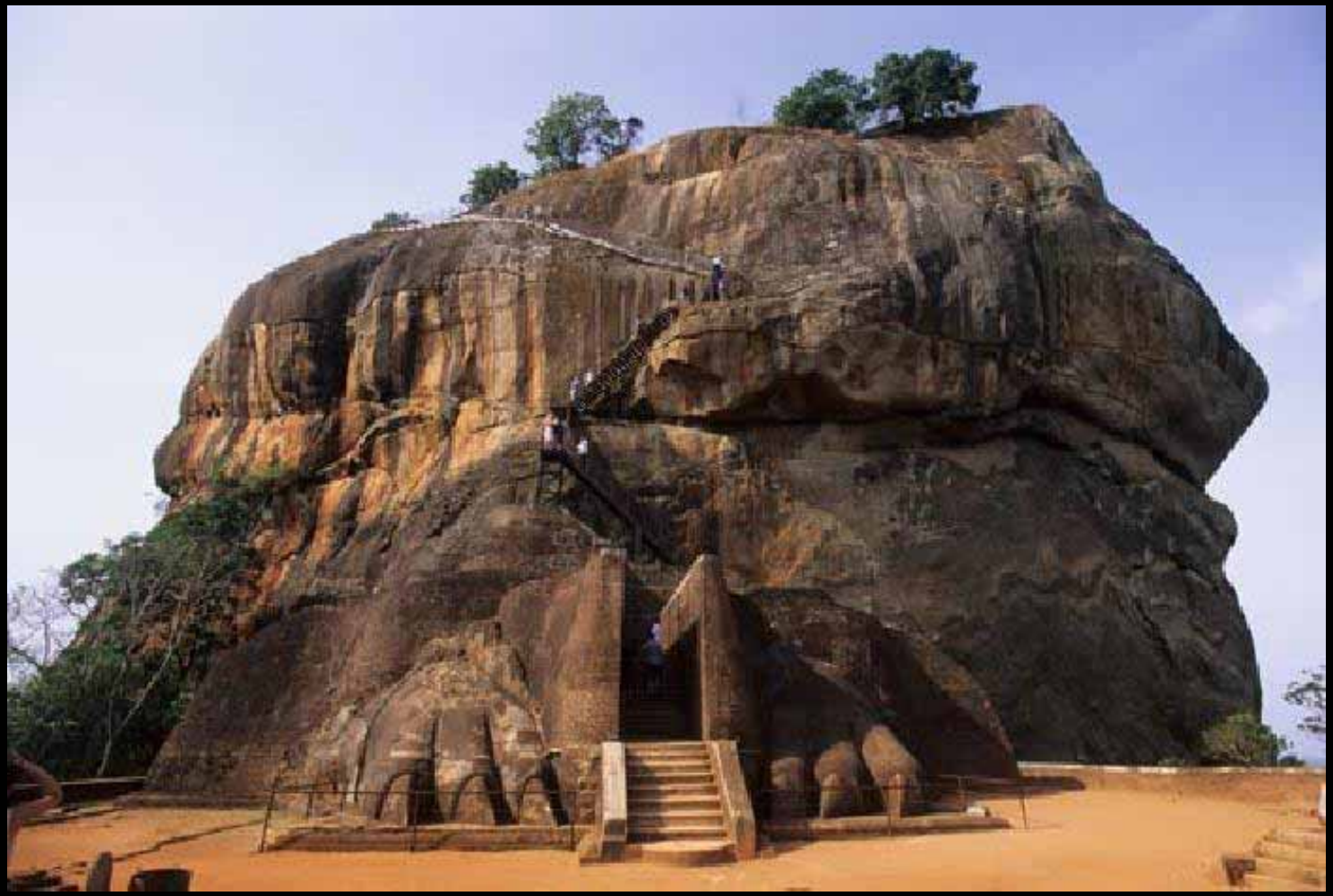
King Mahasena 276 – 303 AD (400ft)

JETHAWANARAMAYA RUINS
King Mahasena 276 – 303 AD (400ft)

King Kassapa

477 - 495 AD

The Rock Fortress Sigiriya



The rock Fortress Sigiriya

King Kassapa 477 - 495 AD

The rock Pool, Sigiriya

Sigiriya - One of the Gardens Gardens

View from the top of Sigiriya

Sigiriya Frescoes

Kasyapa (473- 491 A.D)








Sigiriya Frescoes

Kasyapa (473- 491 A.D)

Yapahuwa Lion

King Buvanaikabahu 1 (1273-1284)

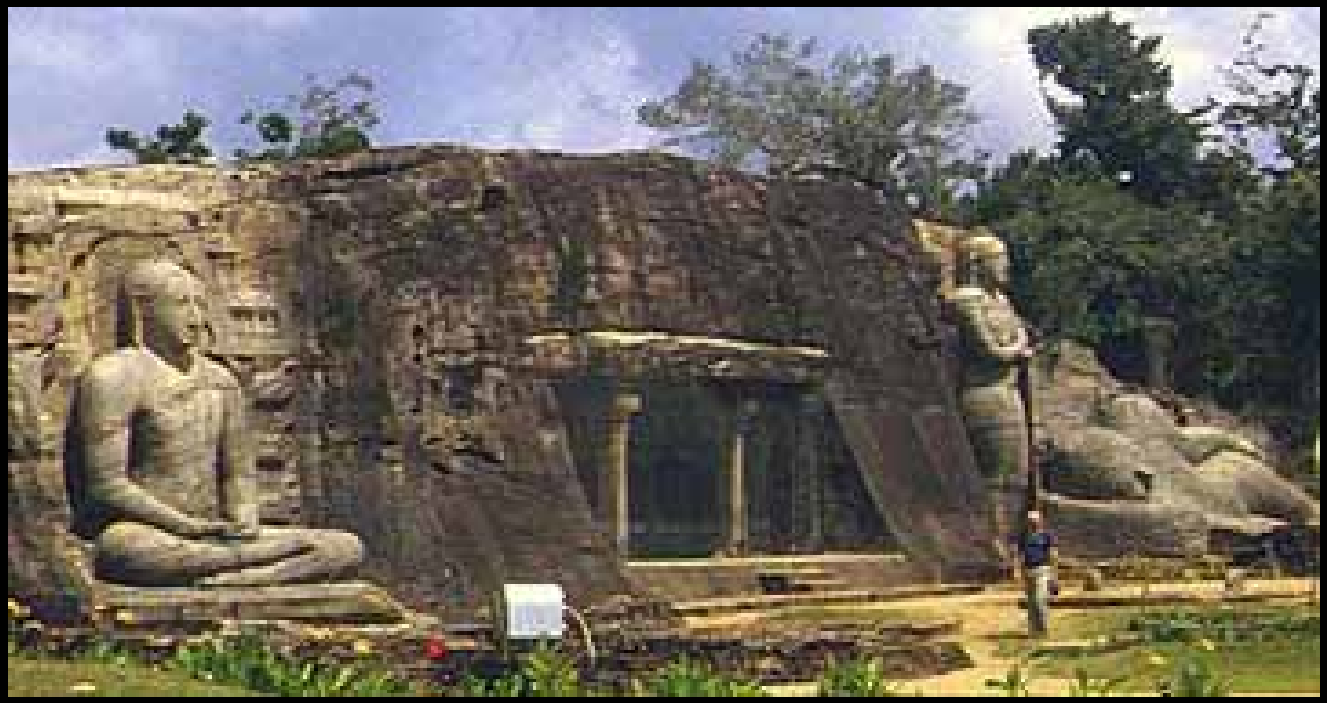
Yapahuwa

Kandy - A pageant of vibrant colour

Gal ViharayaPolonnaruwa

Parakramabahu the Great (11 - 13 AD)

Polonnaruwa Gal Viharaya



Polonnaruwa - Gal Viharaya

Gal Viharaya - Polonnaruwa

Polonnaruwa

Sath Mahal Prasada Polonnaruwa

(11 - 13th Century AD)

Isurumuni lovers Anuradhapura

6th century AD

Vejayanta Pasada Polonnaruwa

(11th Century AD - 13th Century AD)

Sandakada Pahana - Moonstone

Meanings of Arcs

- Flower petals motif - Fires of worldly existence
- Four beasts Elephant, lion, horse and bull - Four mortal perils birth, disease, decay and death
- Liyavela motif 1 - Desire or craving
- Swans - Ones who have left their worldly abodes
- Arc of liyavela motif 2 - Heavenly worlds
- Lotus petals - Nirvana

Sandakada Pahana - Moonstone

Samadhi Pilimaya

Aukana Pilimaya

Aukana Pilimaya

King Dhatusena (459-477 AD)

Abhayagiri Dagoba Anuradhapura

King Vattagamini Abhaya 88 BC

Kuttam Pokuna (Twin Ponds) Anuradhapura

King Vattagamini Abhaya 88 BC

Elephant Wall Anuradhapura

Thuparama dagoba Anuradhapura

King Devanampiyatissa 3rd century BC

Alahana Pirivena
(Alahana University) Polonnaruwa
11 – 13th century AD

OTHER STRUCTURES

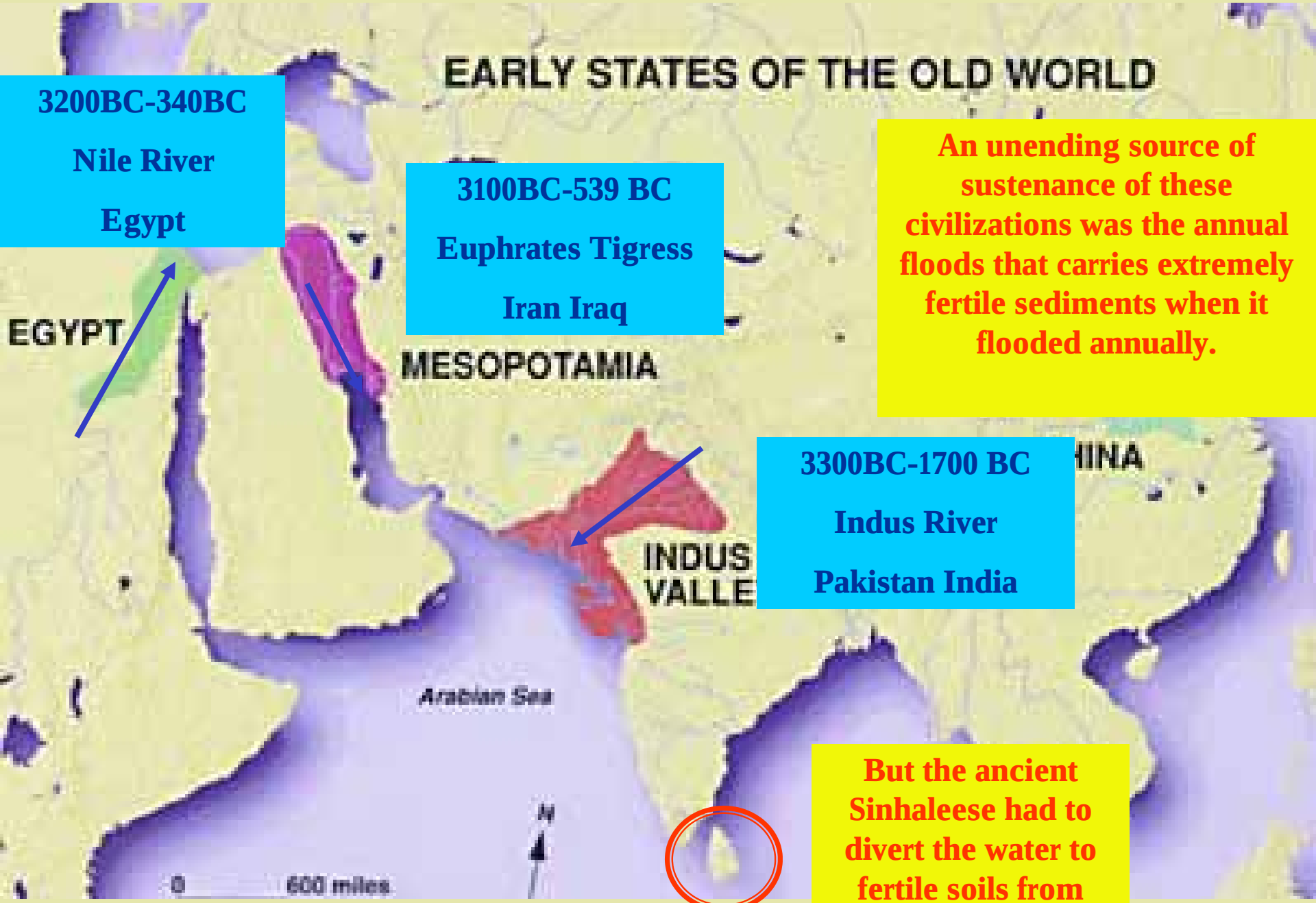
Dagaba is only one of a set of masterpieces. Each of those served various purposes.

The '**Lovamahapaya**‘ was a nine story building in King Parakaramabahu era built for Bhikku's.

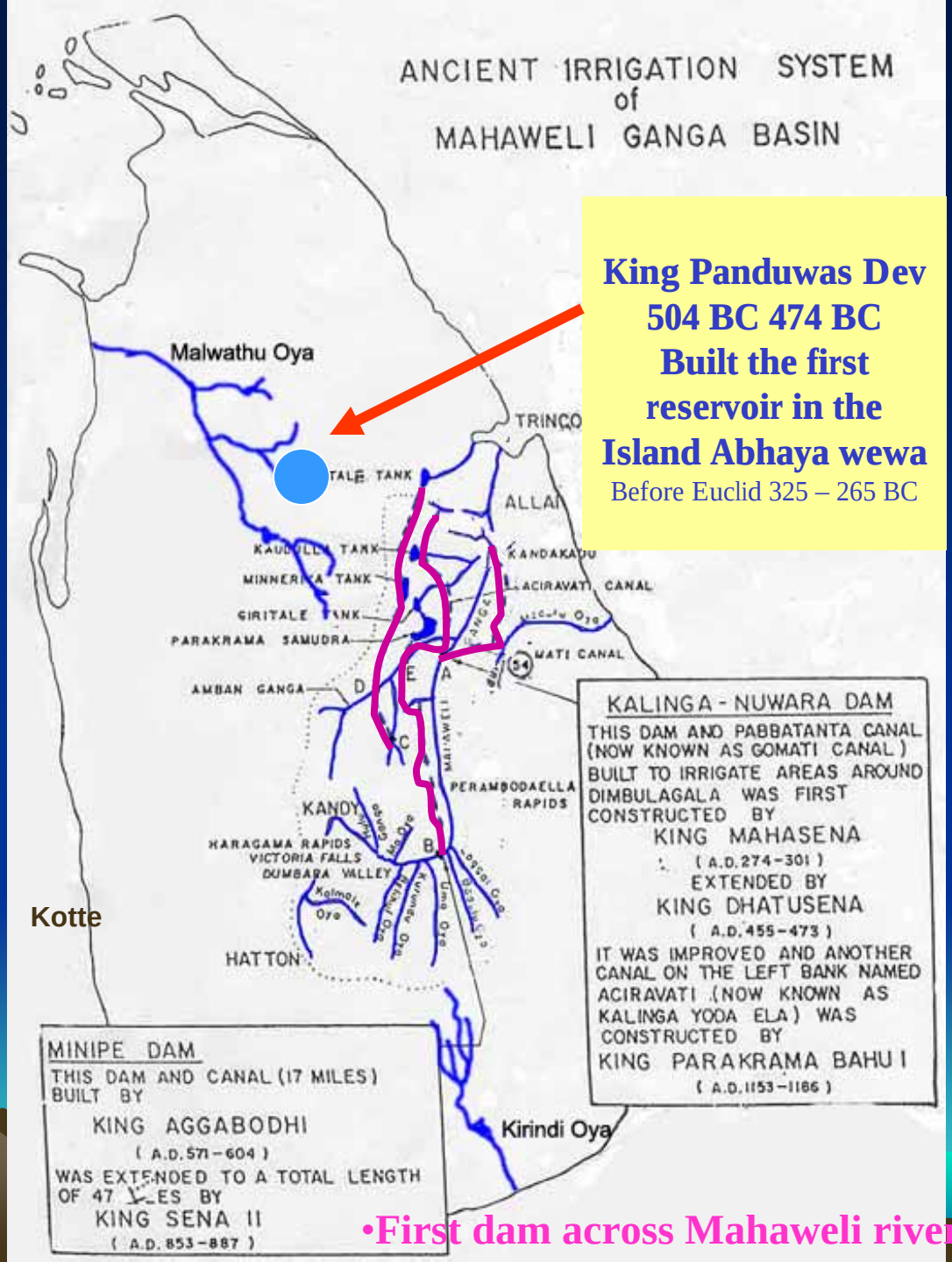
Isn't it a great testimony that Buddhism nurtured the development of technology at that time.

Ancient Hydraulics in Sri Lanka at a glance

water have to be diverted to lands
valve pit
sediment control
canal bed
express and slow canals

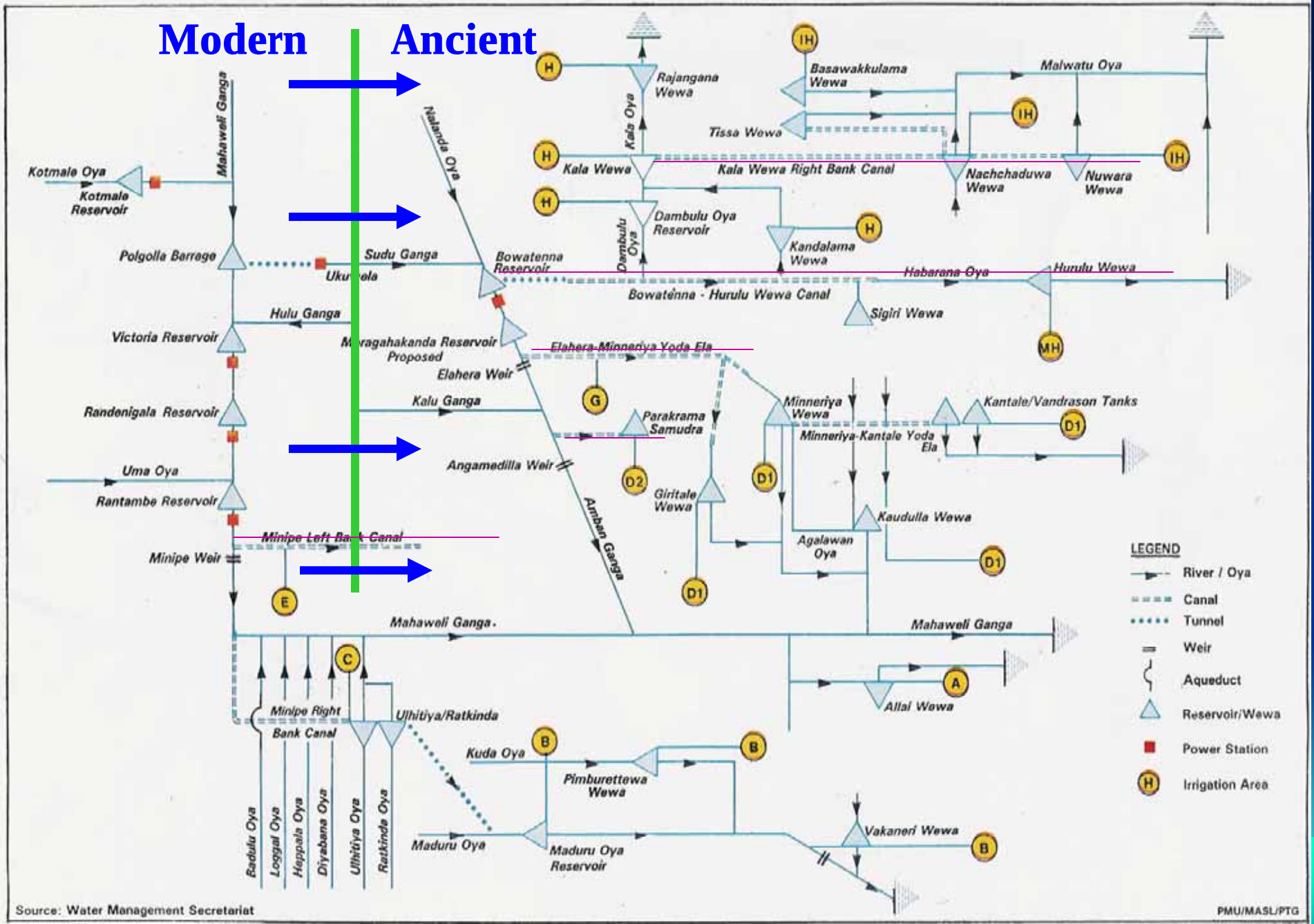


General Map of Ancient Civ



•First dam across Mahaweli river was built in 1 BC

SCHEMATIC REPRESENTATION OF THE MAHAWELI SYSTEM

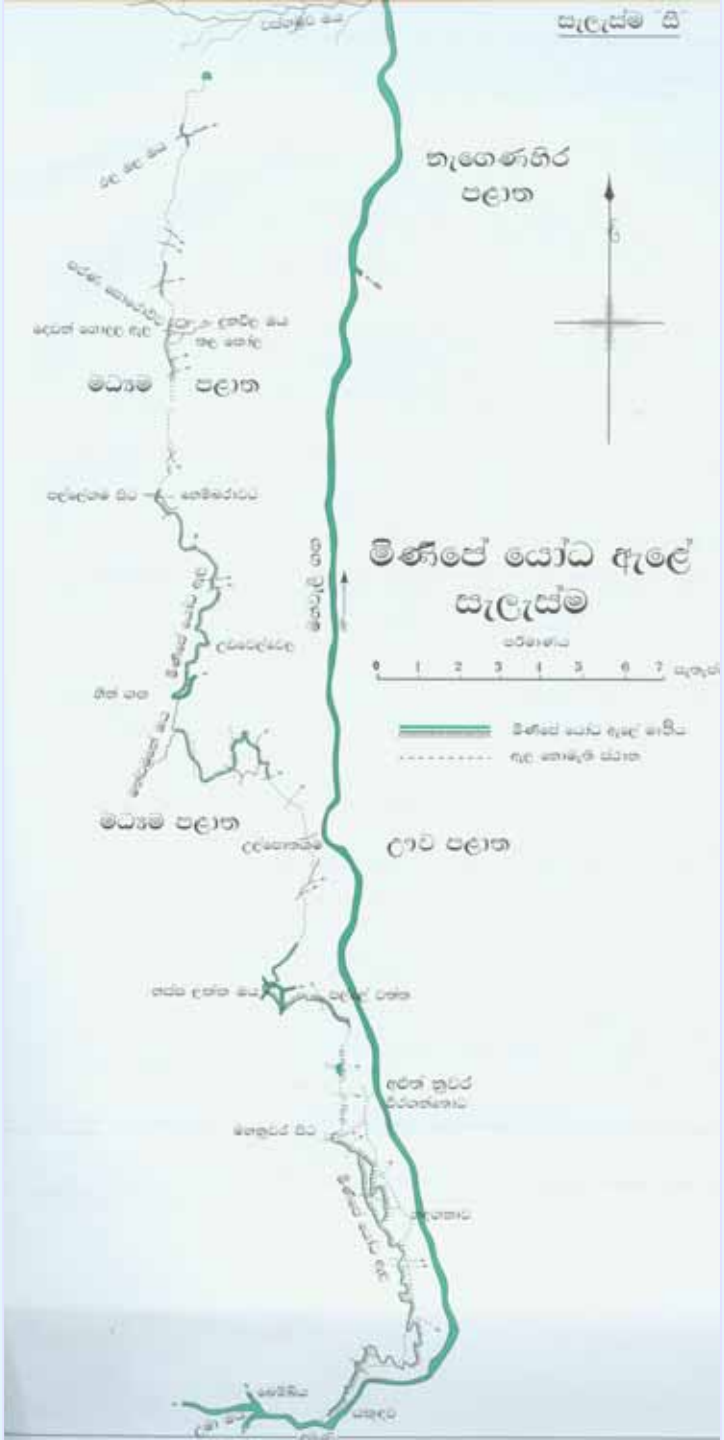


Source: Water Management Secretariat

PMU/MASL/PTG

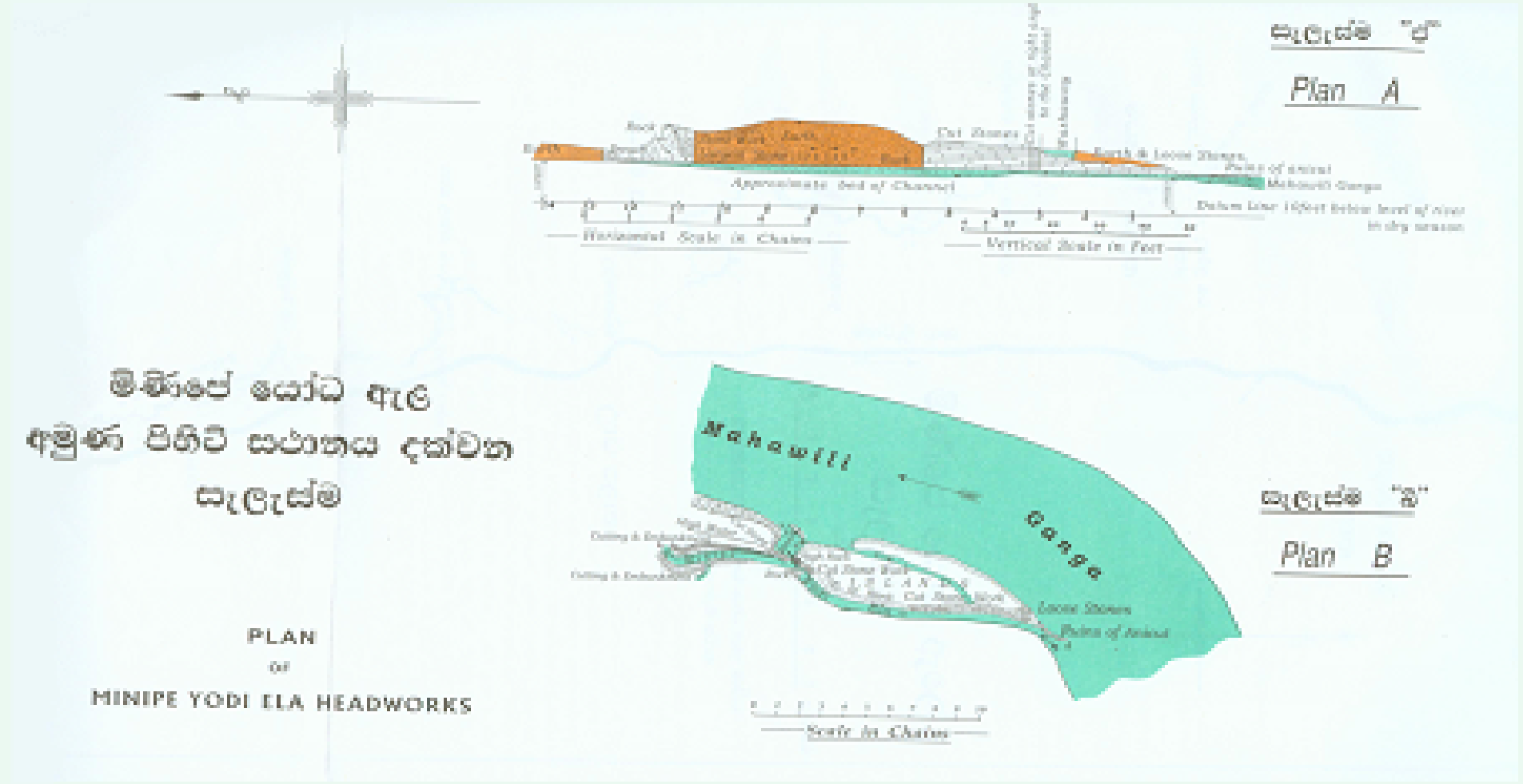
Plan

Minipe Yoda Ela

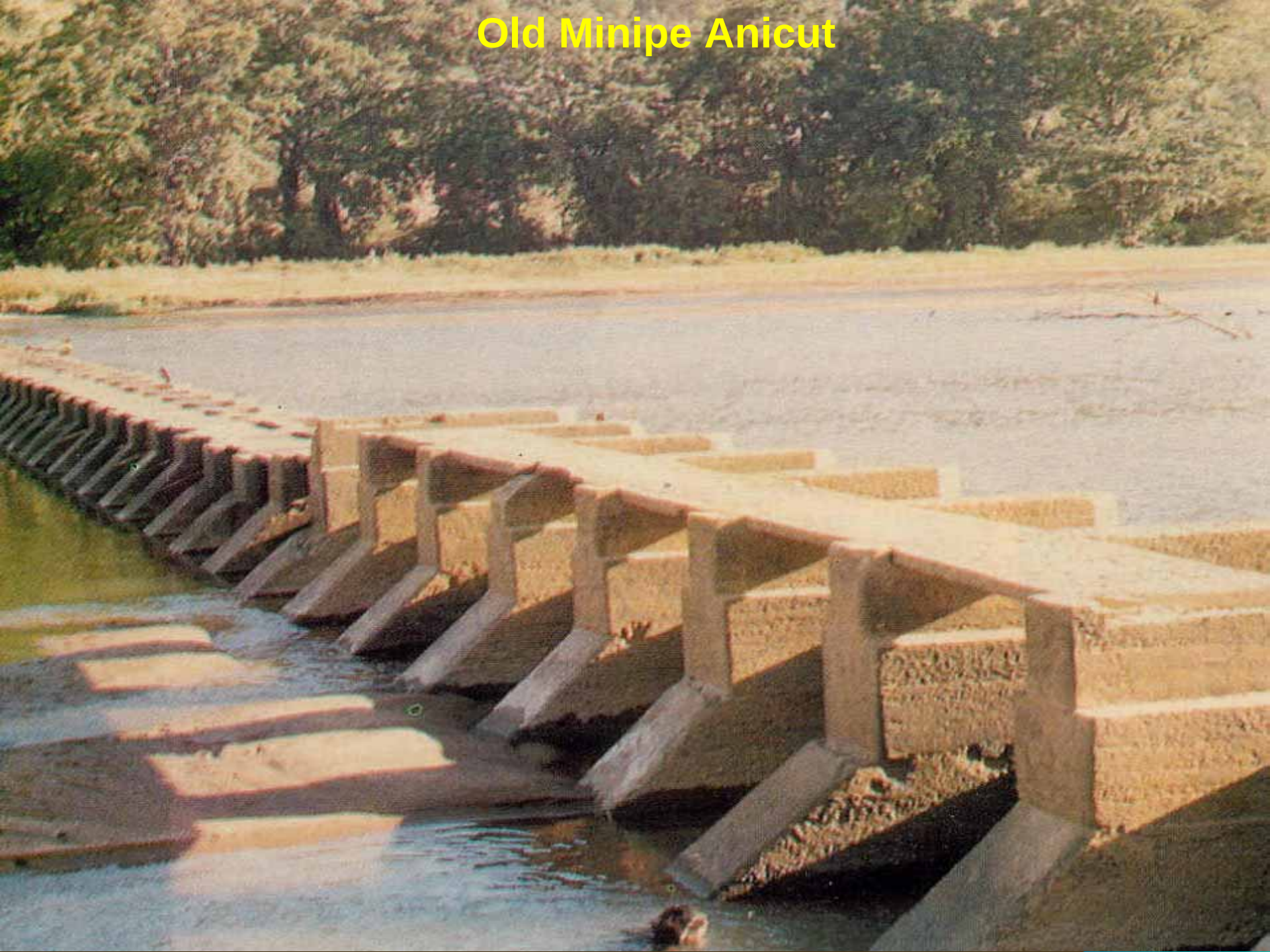


Plan

Minipe Yoda Ela Anicut



Old Minipe Anicut



New Minipe Anicut

Biso Kotuwa

(the valve pit)

dealt with high heads

sub to super critical flow

Brohier, 1934.

It is the equivalent of the **valve pit**, and is therefore essentially an invention made by the Sinhala irrigation engineers **more than 2200 years ago**

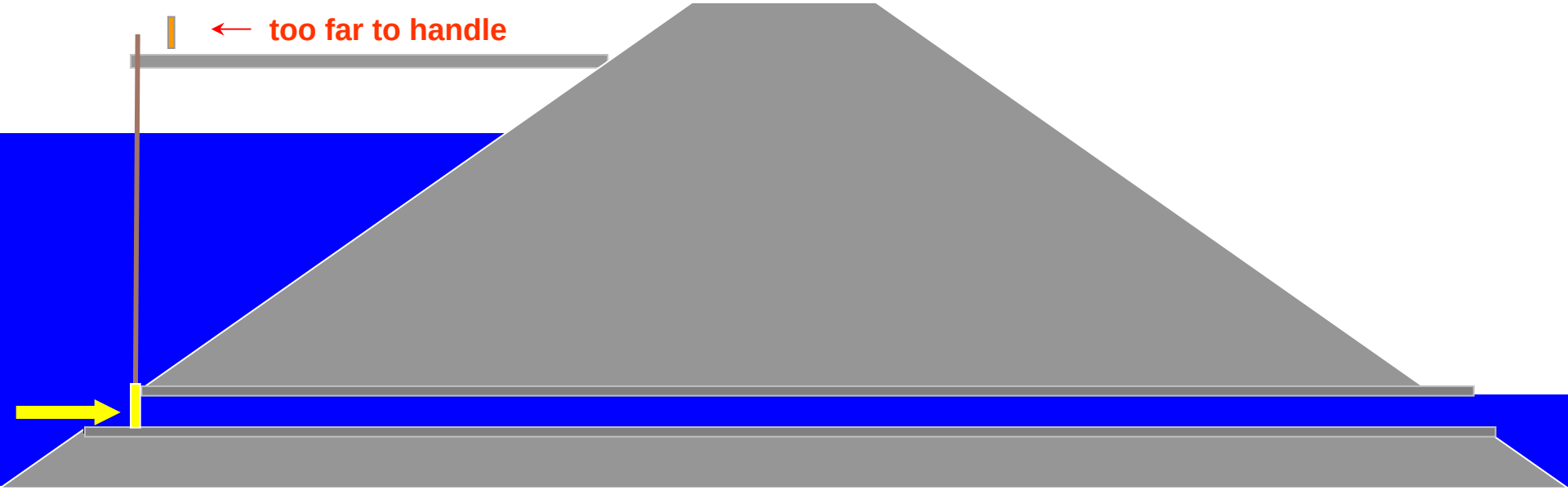
engineering marvels of a bygone era, the valve-pit or ‘Bisokotuwa’, the prototype of sluices regulating water flow from modern day reservoirs had already been invented in 3rd century BC

Parker, 1909.

It was this invention alone which permitted the Sinhalese to proceed boldly with the construction of reservoirs that still rank among the greatest work of its kind in the world

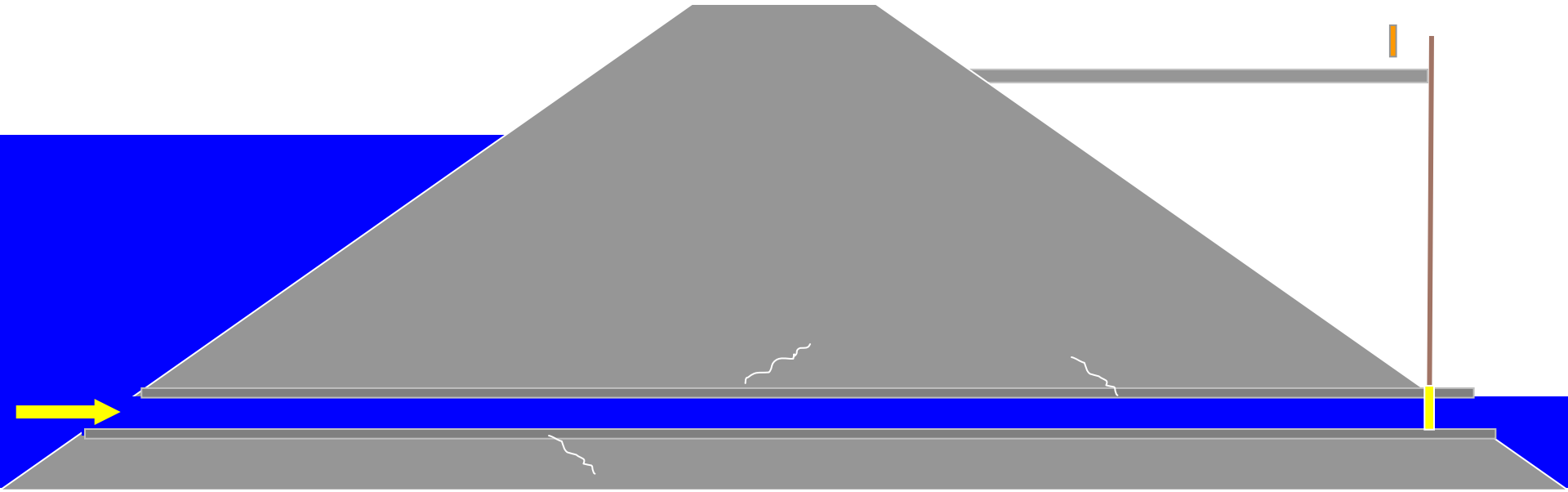
Gate at upstream without Bisokotuwa

GATE OPENING & SUDDEN CLOSING



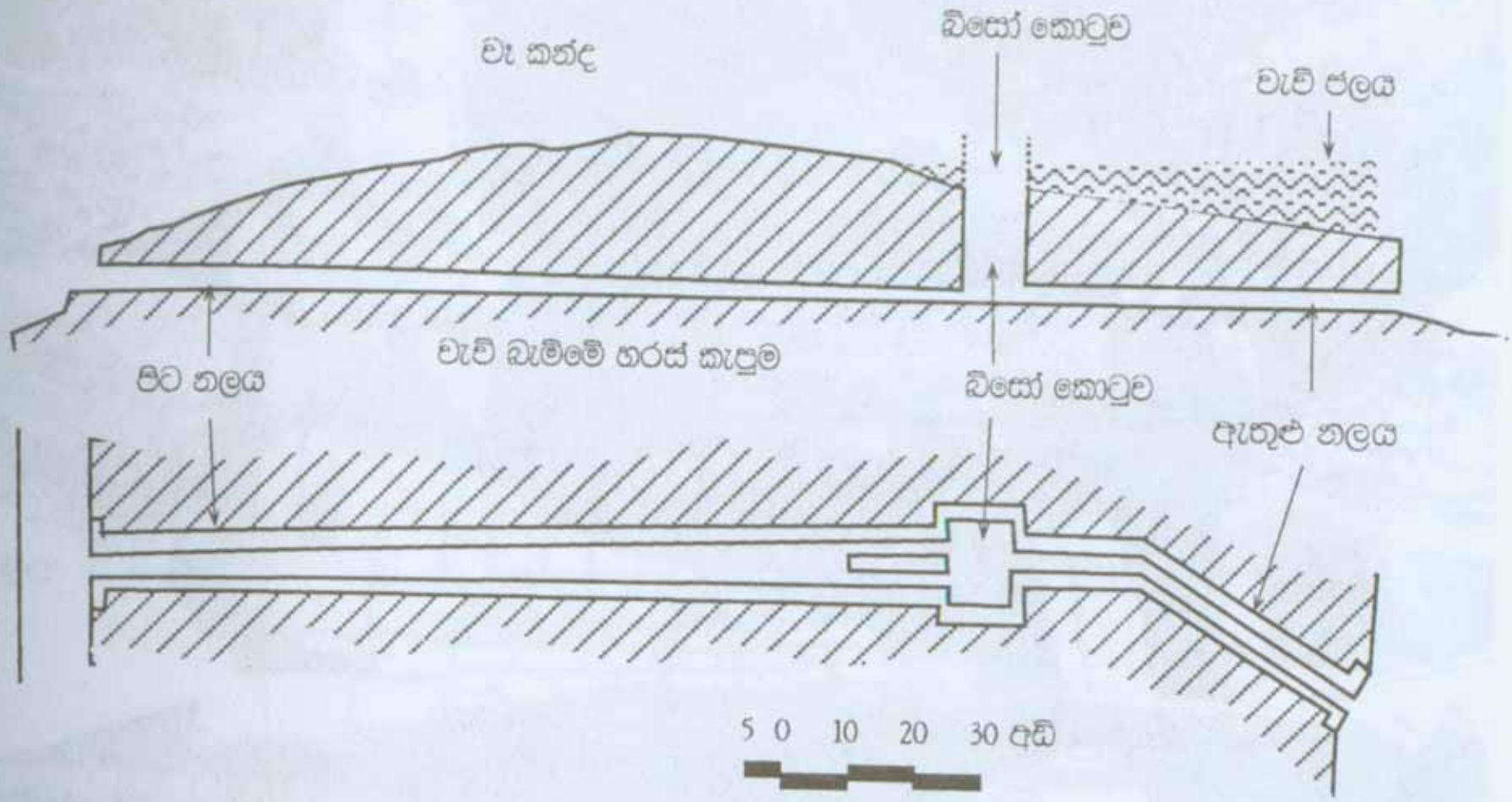
Gate at downstream without Bisokotuwa

GATE OPENING & SUDDEN CLOSING



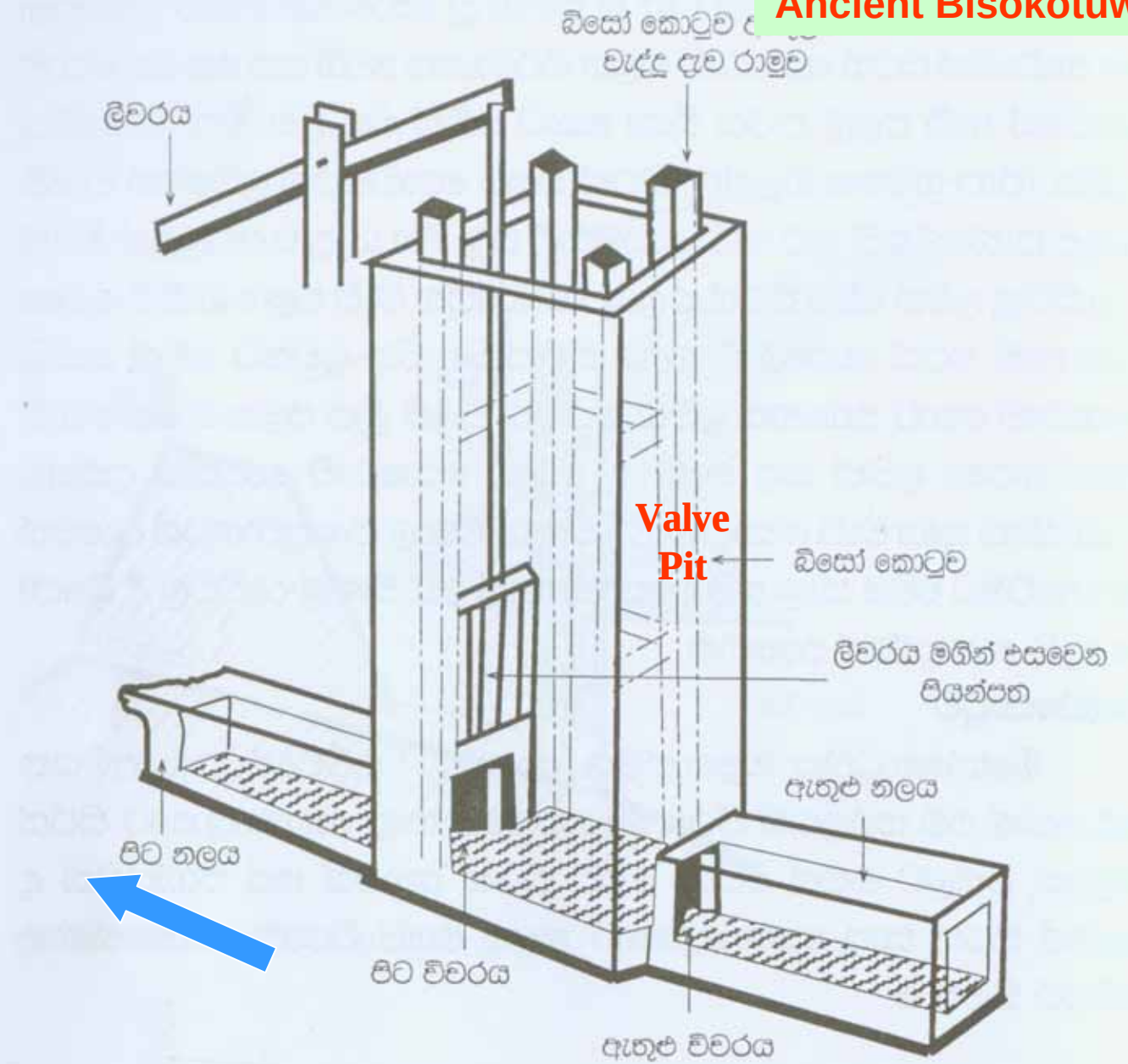
activate water hammer mechanism

Ancient Bisokotuwa (Valve Pit)



බිසෝ කොටුවක සැලැස්ම (පාවටි කුලම)

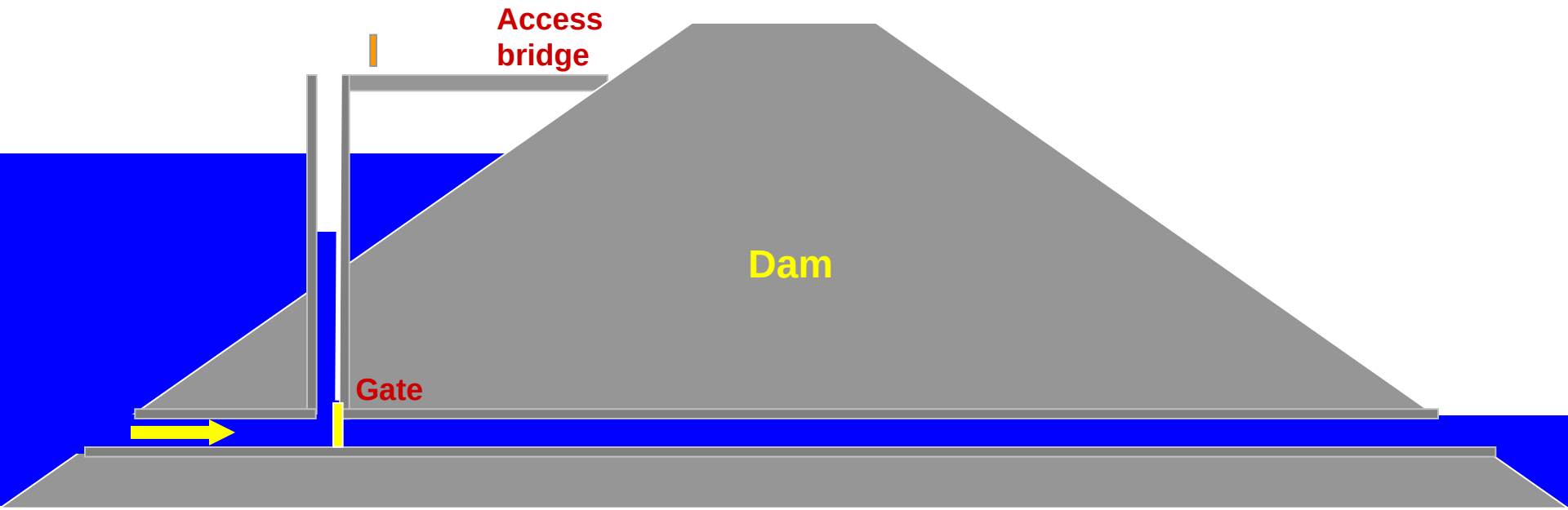
Ancient Bisokotuwa (Valve Pit)



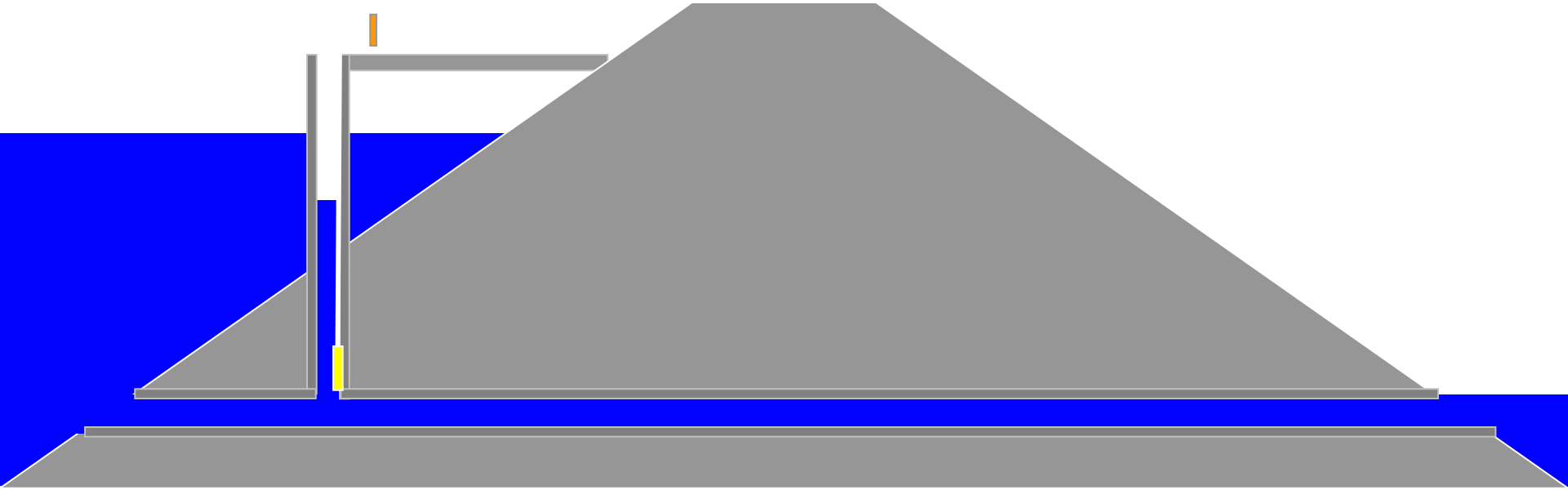
බිසෝ කොටුවක සරල ජ්‍යාමිතික නිරූපණය - 2

Modern surge tank technology

GATE OPENING



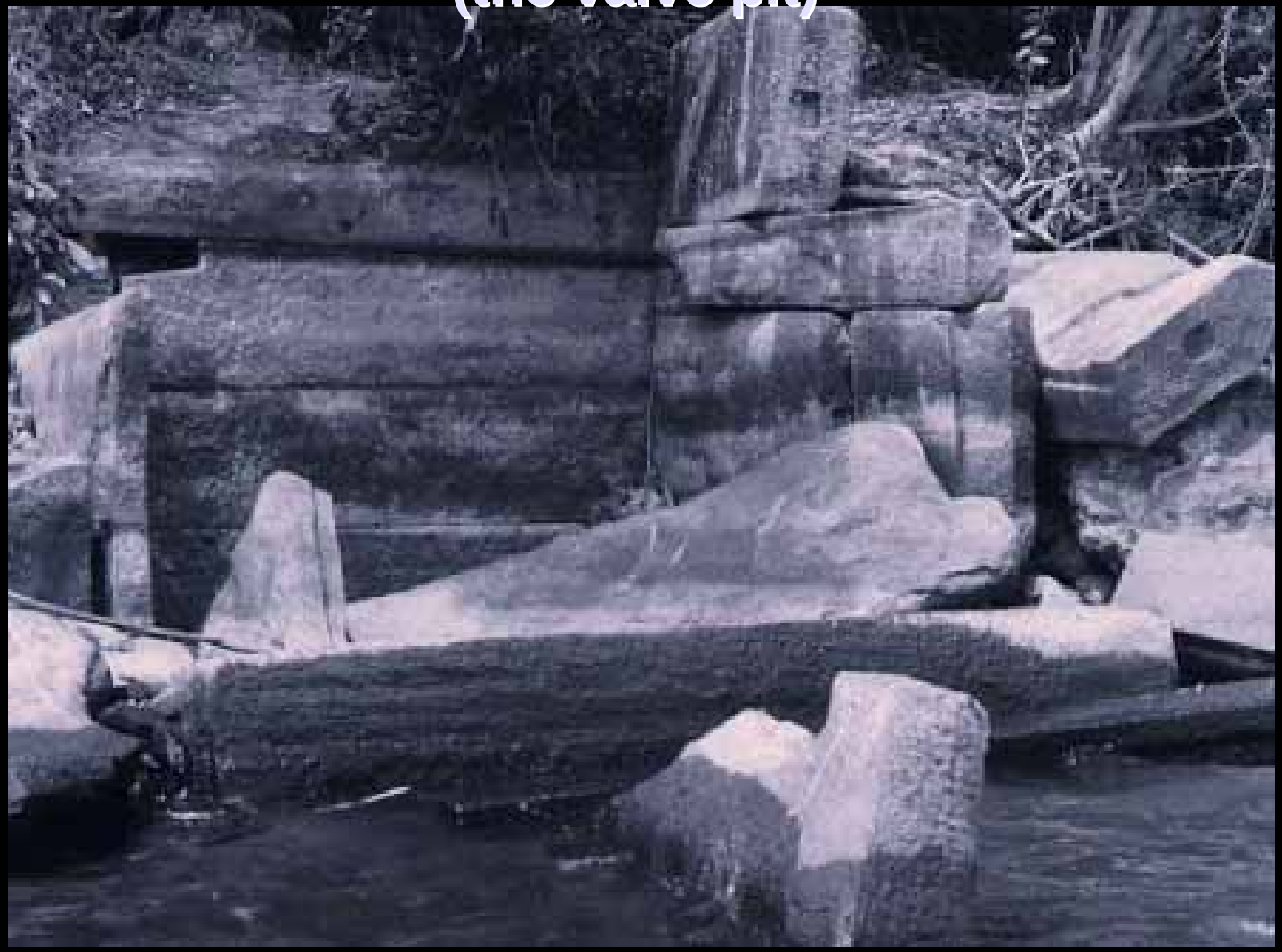
SUDDEN GATE CLOSING



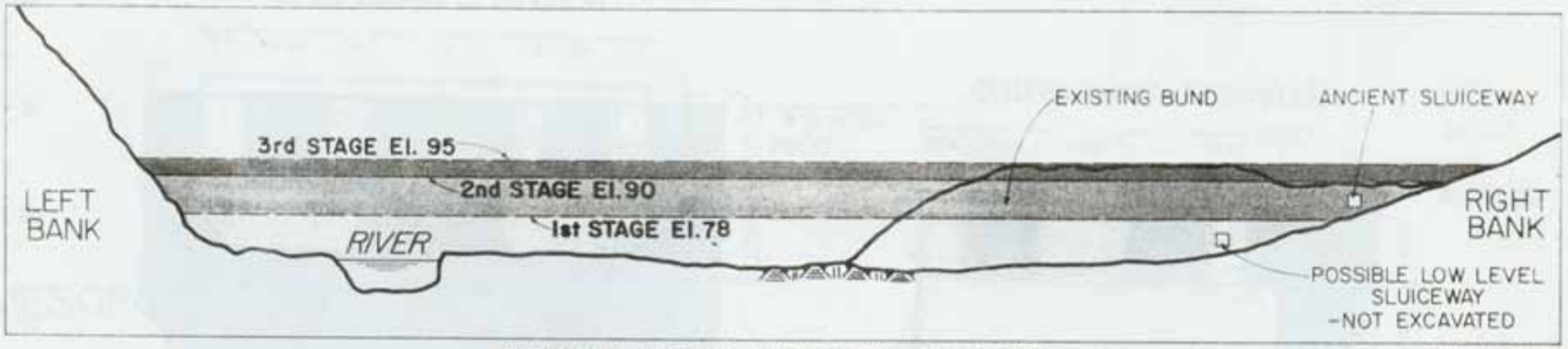
Ancient Bisokotuwa (Valve Pit)

SUDDEN GATE CLOSING

Biso Kotuwa
(the valve pit)

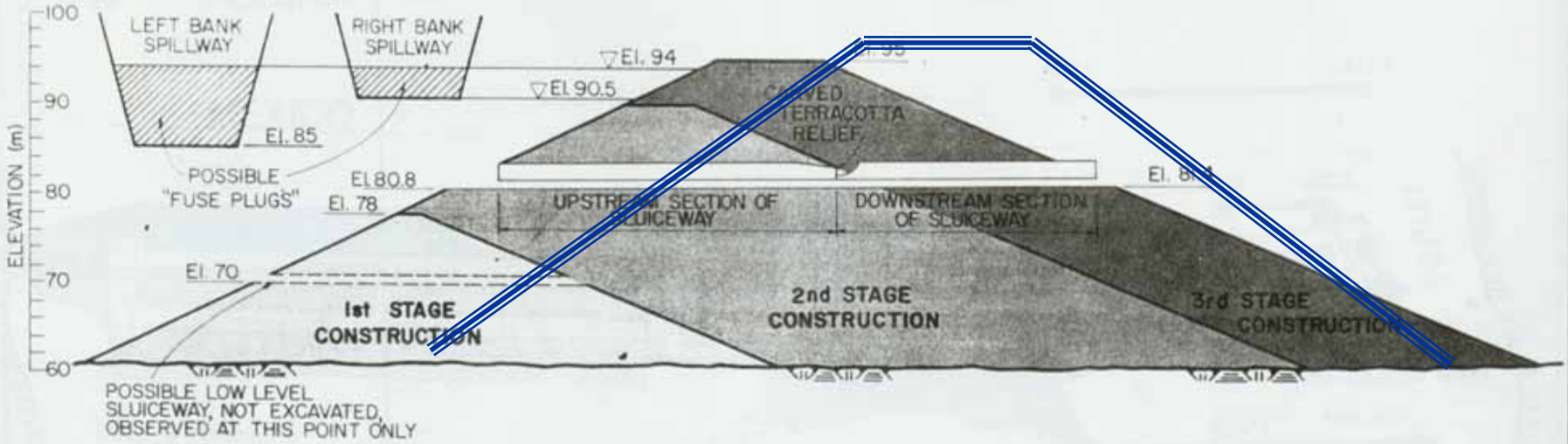


3rd century BC and improved 12th century AD
(Topawewa-Parakrama Samudra)



SECTION ALONG CENTRELINE OF BUND

(NOT TO SCALE)



SECTION OF BUND AT VALLEY BOTTOM

FIG. 2B – 3rd STAGE CONSTRUCTION OF OLD BUND AND ANCIENT SLUICEWAY

Ancient and modern Maduru Oya Reservoirs

Ancient

Modern

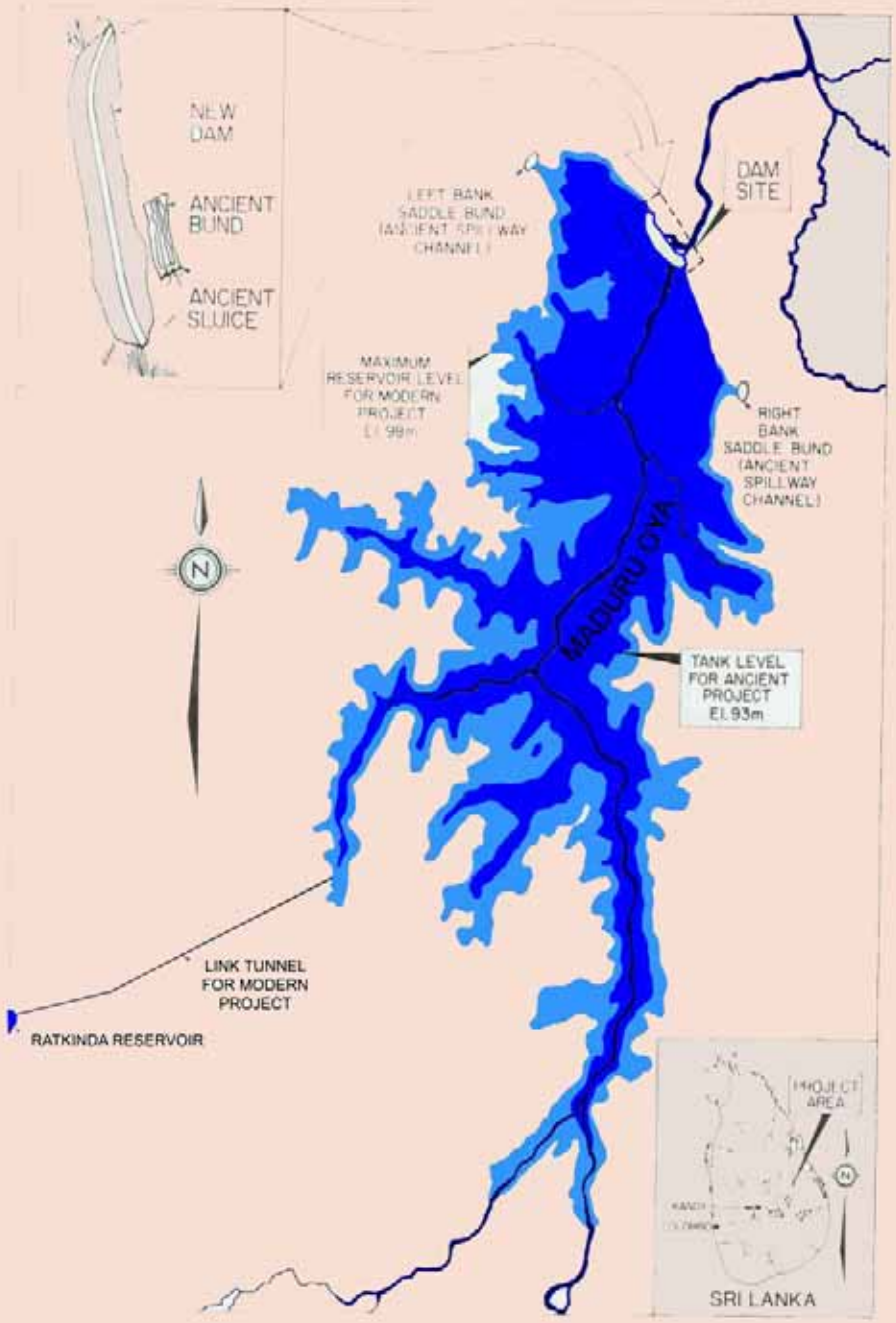
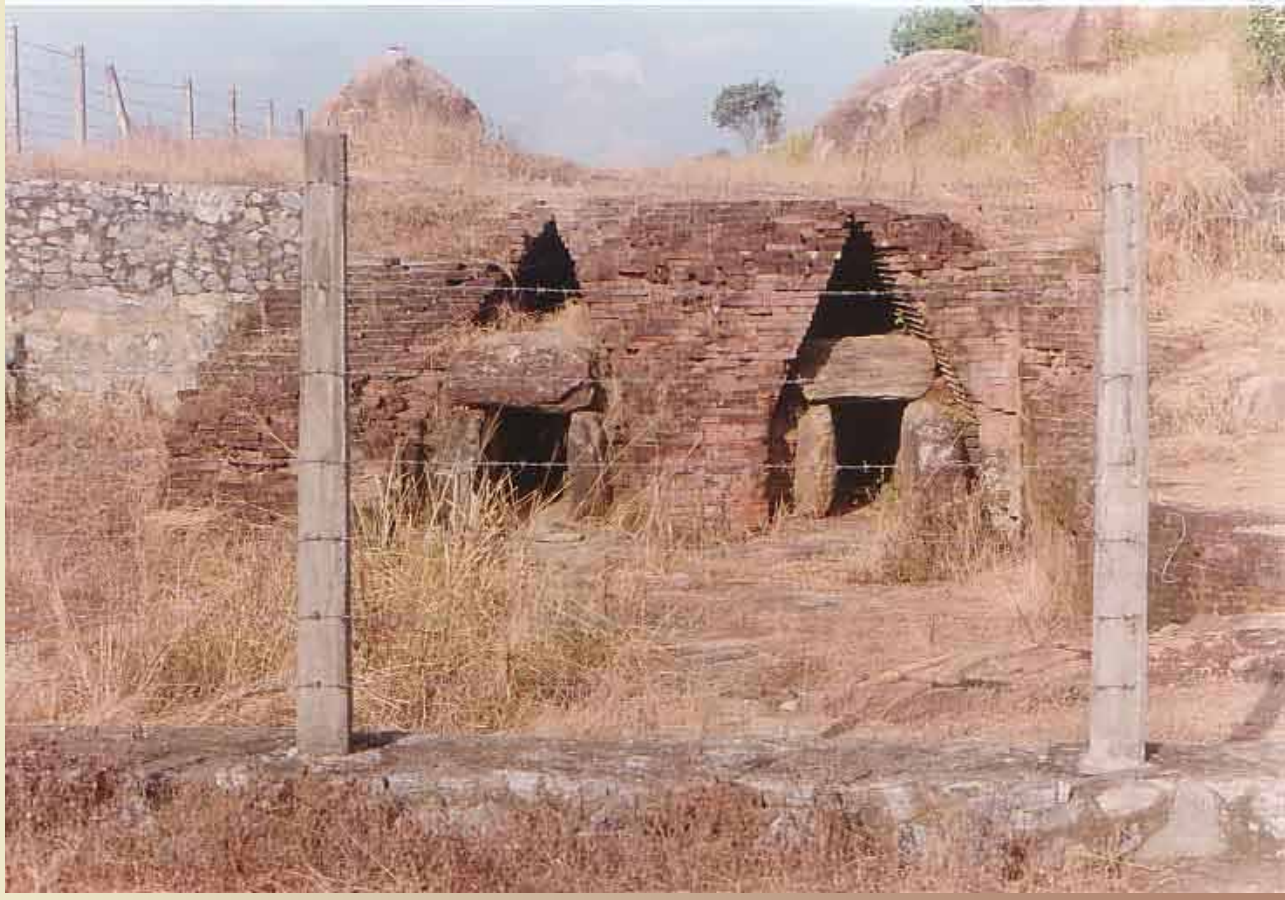


FIG. 1– ANCIENT AND MODERN MADURU OYA RESERVOIR

Ancient Sluice - Maduruoya



- Constructed in 300 BC
- Sluice lined with fabric stones
- Load transferred via arches
- Sluice barrel end elevated to make the flow subcritical
- Dam - height 40m, length 1 km
- Concept of rip rap (relapanawa) applied

Ancient Sluice of Maduru Oya Reservoir

Ancient Sluice of Maduru Oya Reservoir

3rd century BC

This was about the time Euclid was working with Elements of Geometry

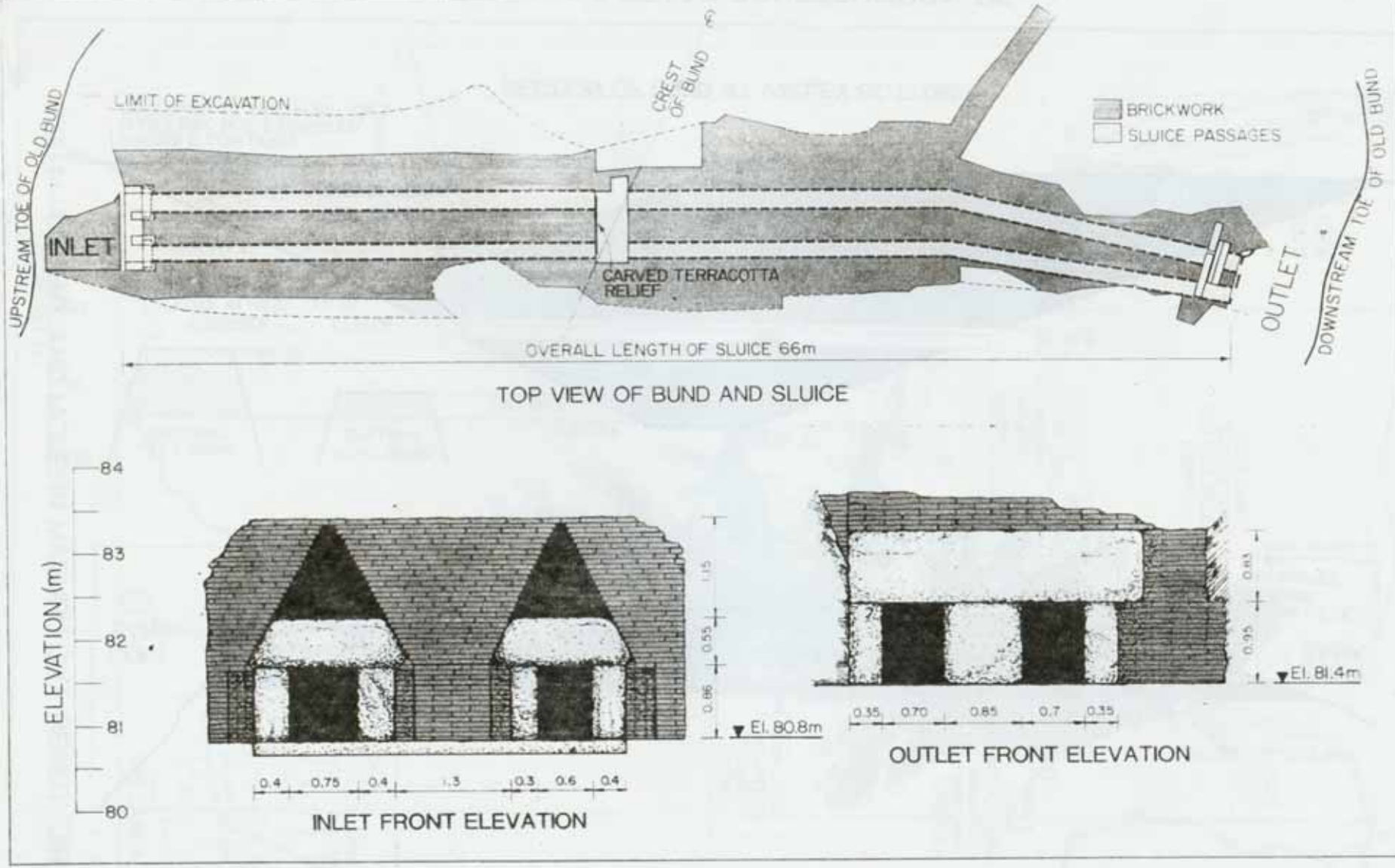
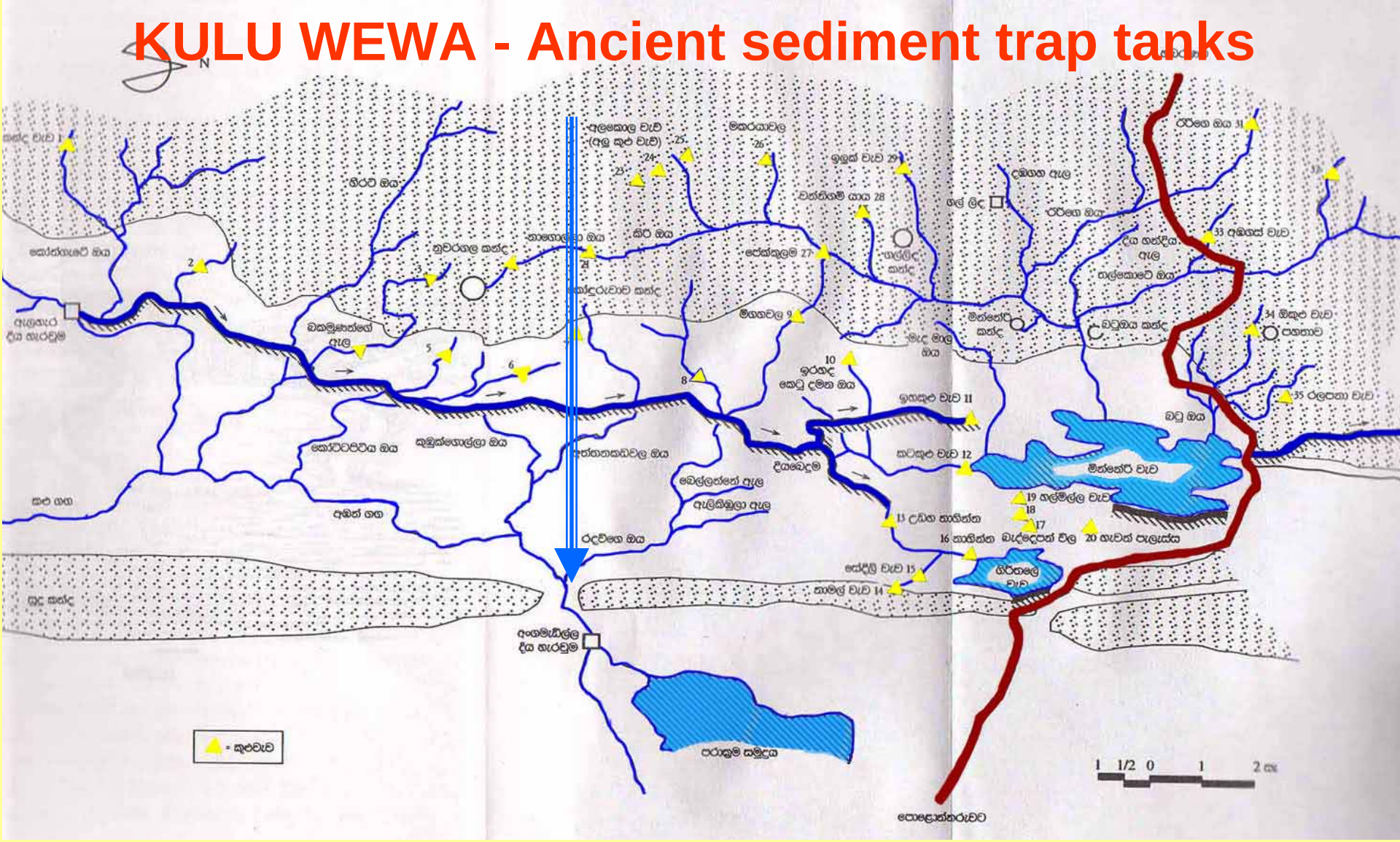


FIG. 3– SLUICE OPENINGS AND BUND

Nuwarawewa Outlet

KULU WEWA - Ancient sediment trap tanks

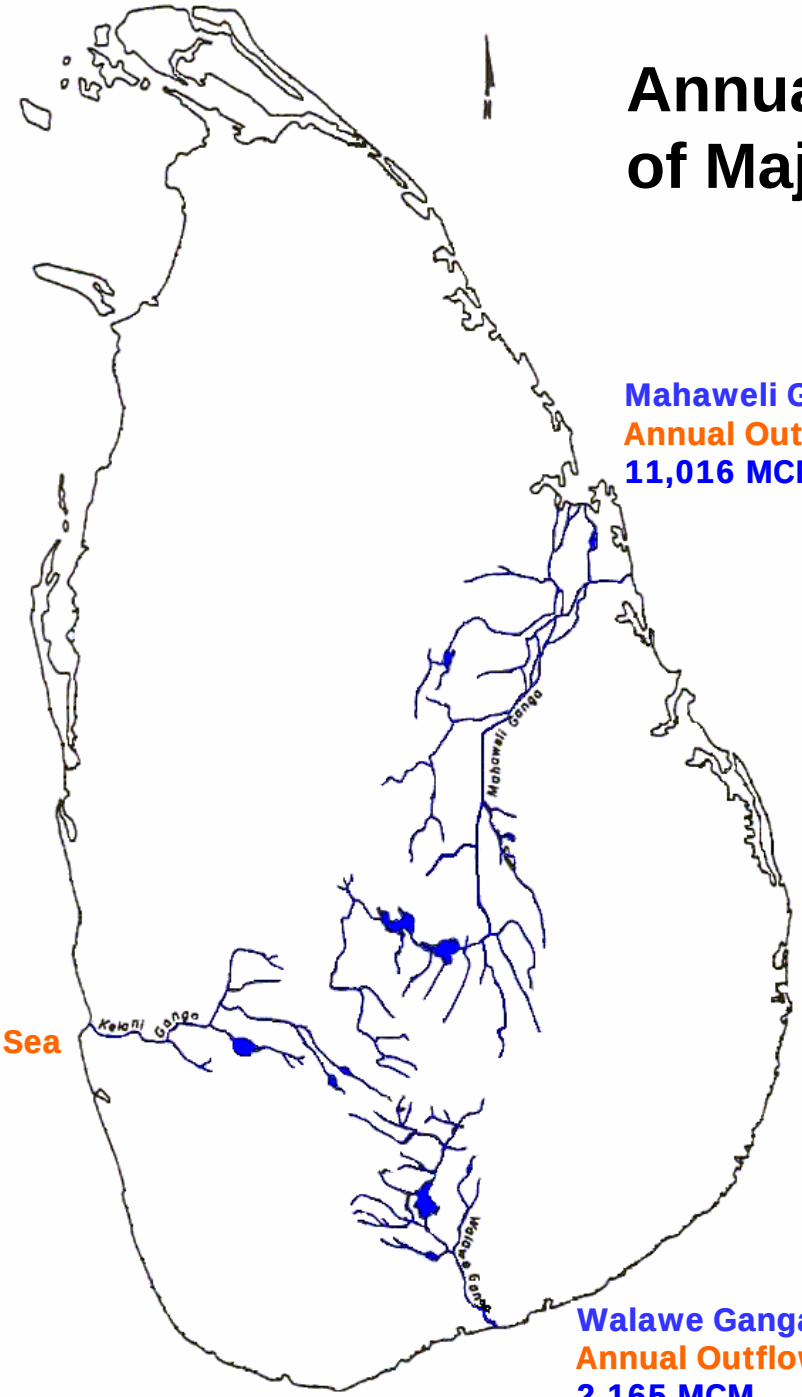


Kulu Wewas were constructed at upper reaches of the major tanks to stop sediment flows.

Small tanks are preferred as they help to bring the water table up.

Modern Dams in Mahaweli Cascade

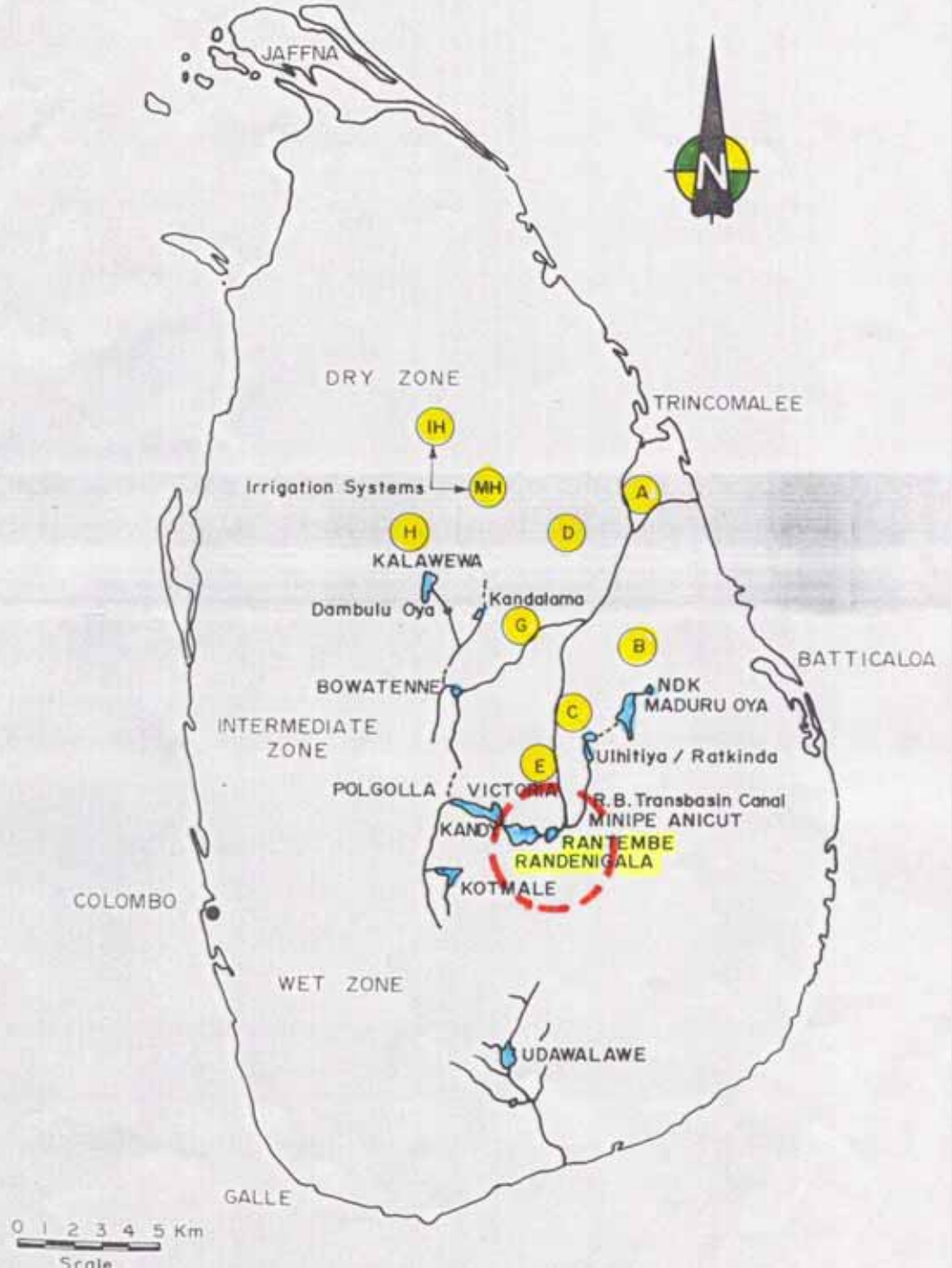
Annual Outflows to Sea of Major River Basins

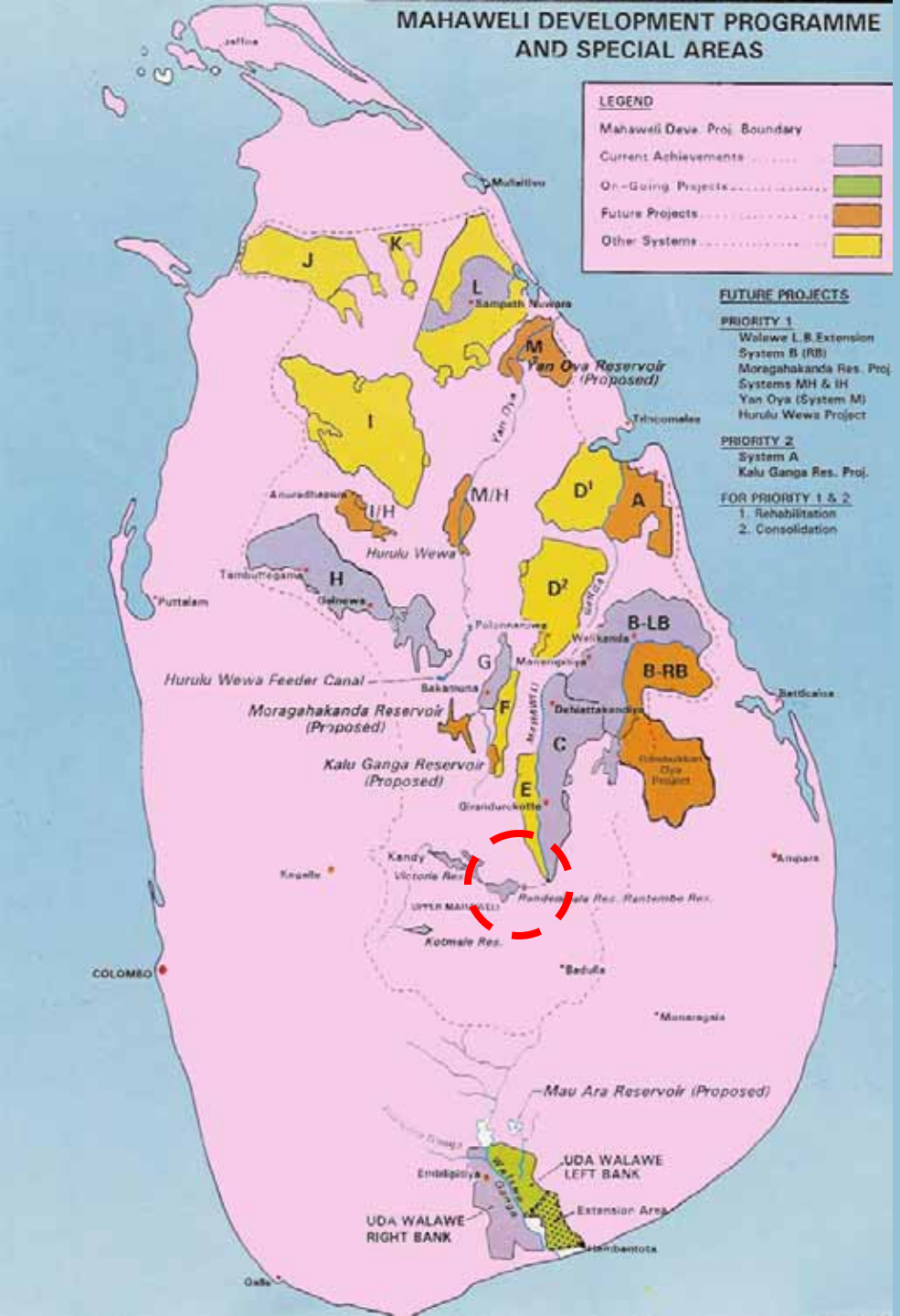


Mahaweli Ganga
Annual Outflow to Sea
11,016 MCM

Kelani Ganga
Annual Outflow to Sea
5,474 MCM

Walawe Ganga
Annual Outflow to Sea
2,165 MCM


JAFFNA
N
DRY ZONE
TRINCOMALEE
IH
Irrigation Systems
MH
A
H
D
KALAWEWA
Dambulu Oya
Kandalama
G
B
BATTICALOA
BOWATENNE
NDK
MADURU OYA
C
INTERMEDIATE
ZONE
Ulhitiya / Ratkinda
E
POLGOLLA
VICTORIA
R.B. Transbasin Canal
MINIPE ANICUT
KANDY
RANTEMBE
RANDENIGALA
KOTMALE
COLOMBO
WET ZONE
UDAWALAWE
GALLE
0 1 2 3 4 5 Km
Scale



System	Project	Irrigable Area (ha)	Institute
H	Dambulu Oya	2,225	MASL
	Kandalama	4,500	MASL
	Kalawewa RB	13,965	MASL
	Kalawewa Yoda Ela	4,720	MASL
	Kalawewa LB	6,000	MASL
	Rajanganaya	7,123	ID
I/H	Nachchaduwa	2,540	ID
	Nuwara wewa	970	ID
	Tisa wewa	520	ID
M/H	Hurulu wewa	4,210	ID
	Hurulu wewa canal	2,250	MASL
G	Elahera	5,400	MASL
D	Girithale	3,075	ID
	Minneriya	8,900	ID
	Kawdulla	5,060	ID
	Kantale	6,782	ID
	Parakrama Samudra	10,420	ID
E	Hasalaka	7,750	ID
C	Sorabora	810	ID
	Mapakada	550	ID
	Dambarawa	610	ID
	Ulhitiya/Ratkinda	21,700	MASL
B	Maduruoya	16,500	MASL
	Wakaneri	3,500	ID
A	Alleya	7,050	ID
Walawa	Walawa RB	12,300	MASL
	Walawa LB	6,110	MASL
	Liyangastota	6,800	ID
	Kaltota	940	ID
Total		**173,280**	

MASL – Mahaweli Authority of Sri Lanka ID – Department of Irrigation

Headworks of Mahaweli – HAO&M

- Our Vision
  - 100% Reliability in Gate Operations
- Our Mission
  - Timely Maintenance for Reliable Operations
- Our Targets
  - 100% Reliability
  - Safety (no fatal accidents)
  - Timely & Standard Maintenance practice
  - State of the Art Developments
  - Emergency Action Plan

O & M PHILOSOPHY

Attitude of the staff

It is the people at the Headworks who have to do the work,

and whether the Works serve a long and useful life, or deteriorate rapidly to an unusable condition,

depends solely on the responsible attitude that the men and women of the site staff develop towards their duties.

-SOP

-Maduru Oya Project

Weekly Diary

It keeps a valuable channel of communications open between the site and the Head Office.

-SOP

-Maduru Oya Project

Things that need doing

If you see something that needs doing,
and if you are capable of doing it properly,
do it.
If you can't do it properly yourself,
report it so that other trained personnel can handle it.

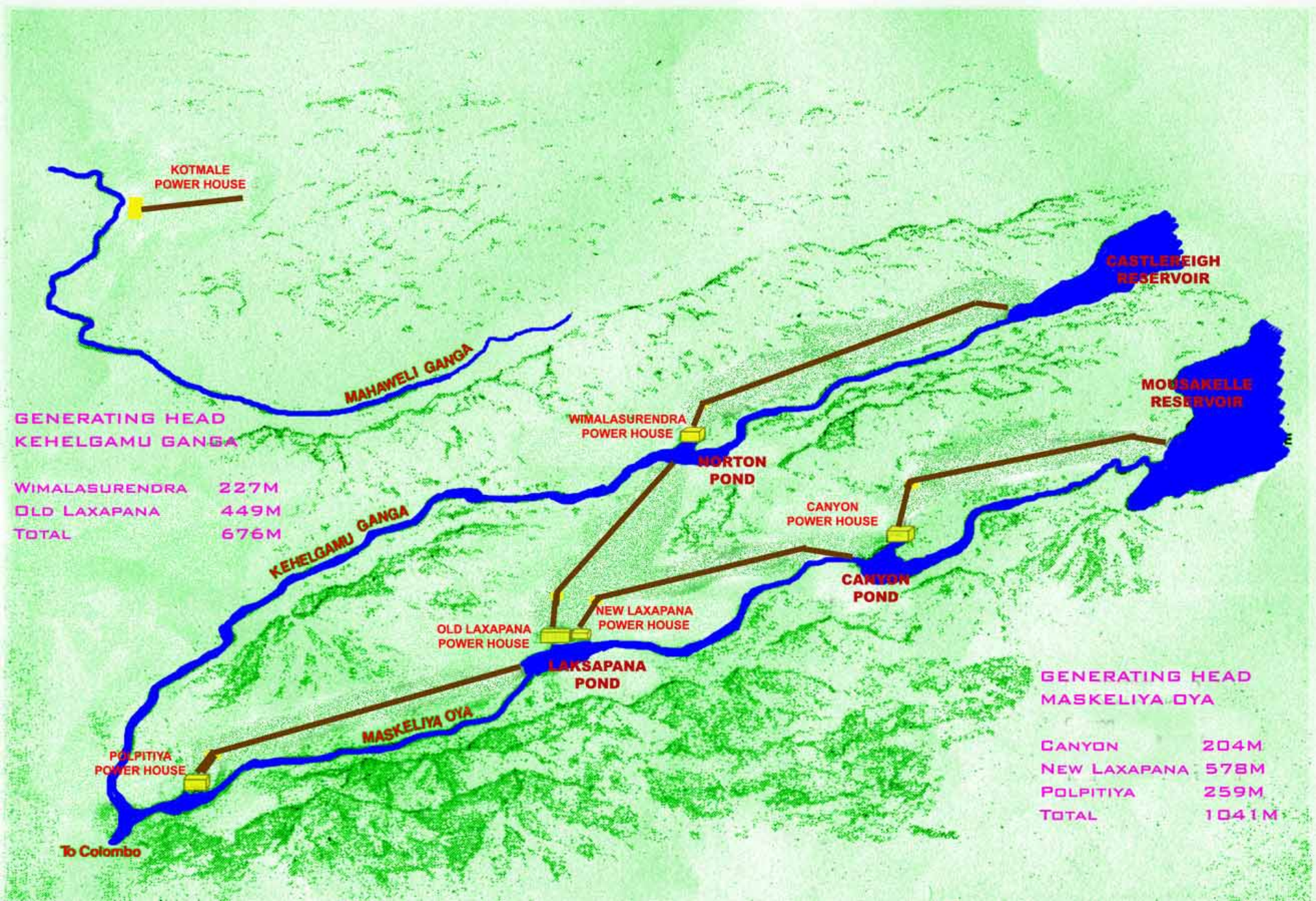
-SOP

-Maduru Oya Project

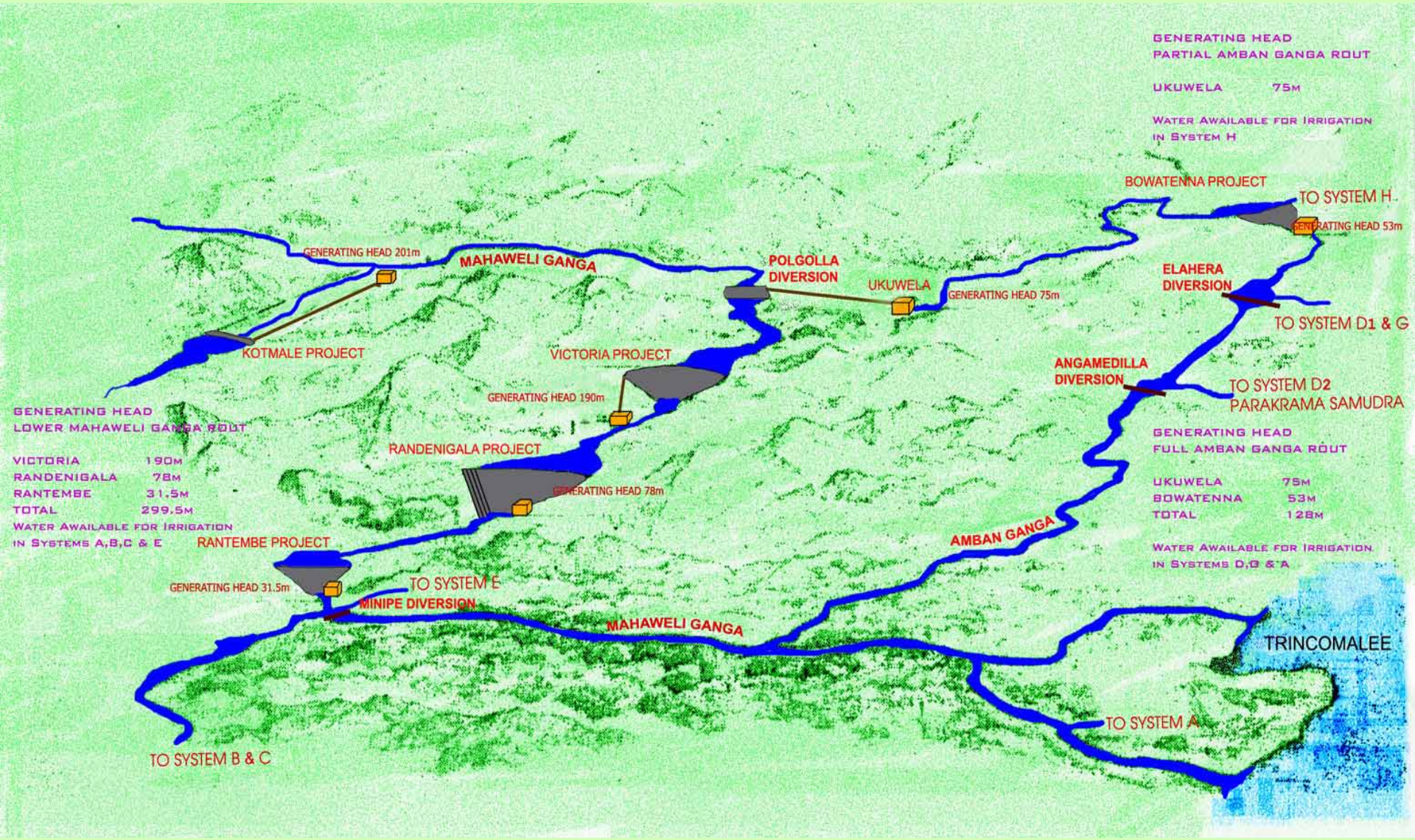
Maintenance crew must have…

an Observant eye connected to an Intelligent brain

KELANI SYSTEM

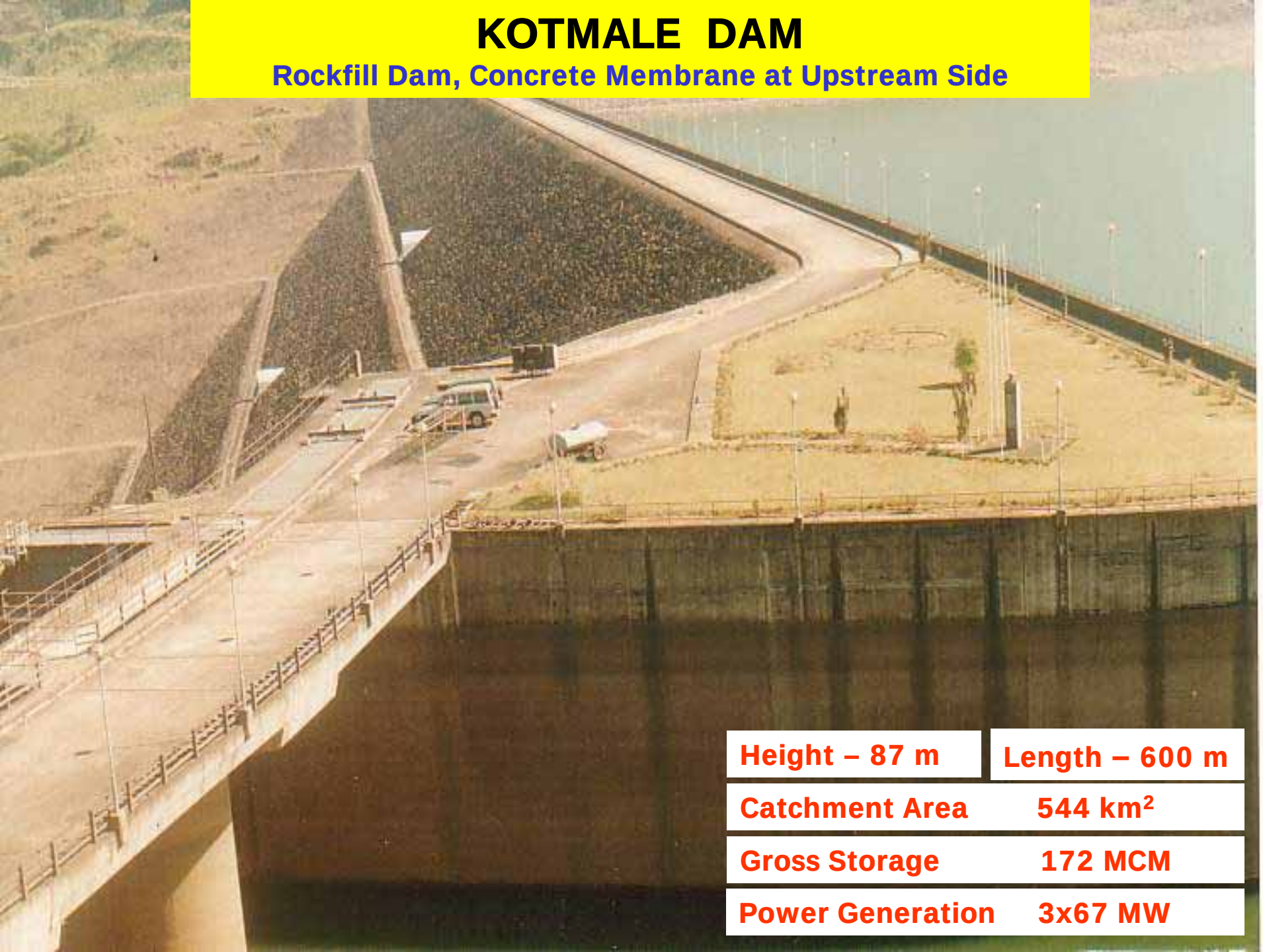


MAHAWELI SYSTEM



KOTMALE DAM

Rockfill Dam, Concrete Membrane at Upstream Side



Height – 87 m	Length – 600 m
Catchment Area	544 km^2
Gross Storage	172 MCM
Power Generation	3x67 MW

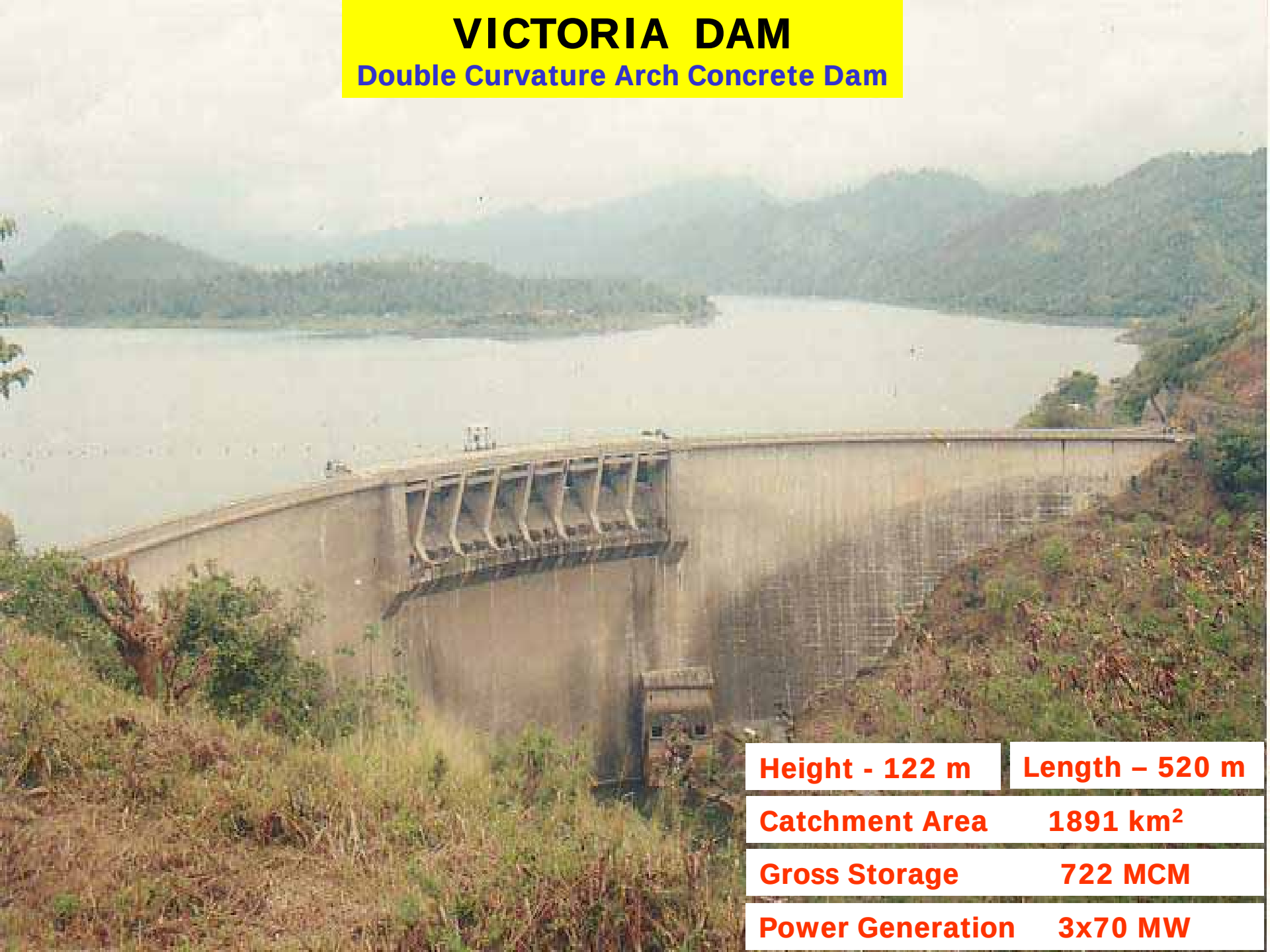
POLGOLLA BARRAGE

Concrete Barrage with 10 Leaf Gates

Height - 15 m	Length - 144 m
Catchment Area	1292 km^2
Gross Storage	2.5 MCM (in 2001)
Power Generation	2x20 MW

VICTORIA DAM

Double Curvature Arch Concrete Dam



Height - 122 m	Length – 520 m
Catchment Area	1891 km^2
Gross Storage	722 MCM
Power Generation	3x70 MW

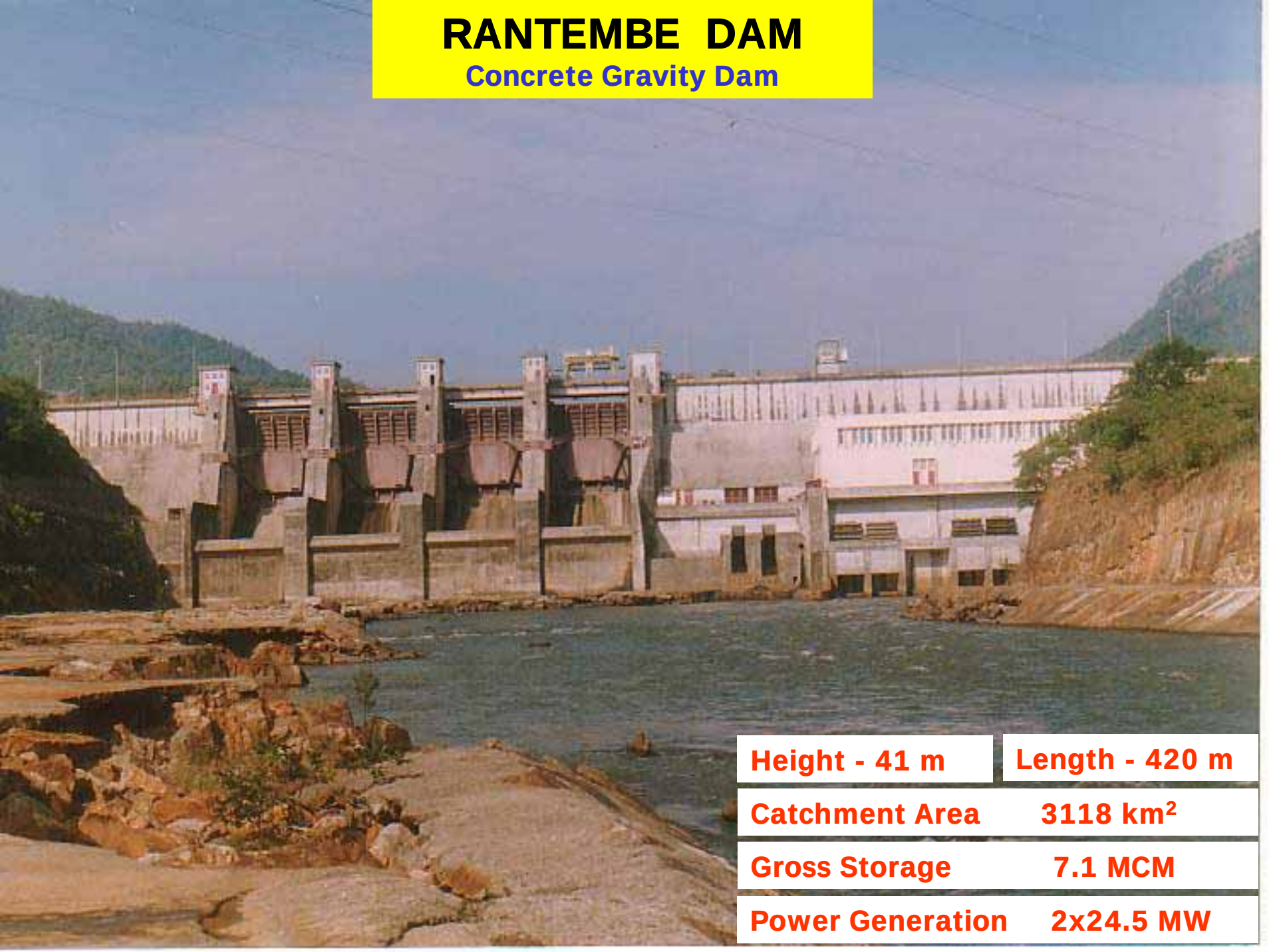
RANDENIGALA DAM

Zoned Rockfill Dam with Central Earth Core

Height - 94 m	Length - 485 m
Catchment Area	2330 km^2
Gross Storage	860 MCM
Power Generation	2x63 MW

RANTEMBE DAM

Concrete Gravity Dam



Height - 41 m	Length - 420 m
Catchment Area	3118 km^2
Gross Storage	7.1 MCM
Power Generation	2x24.5 MW

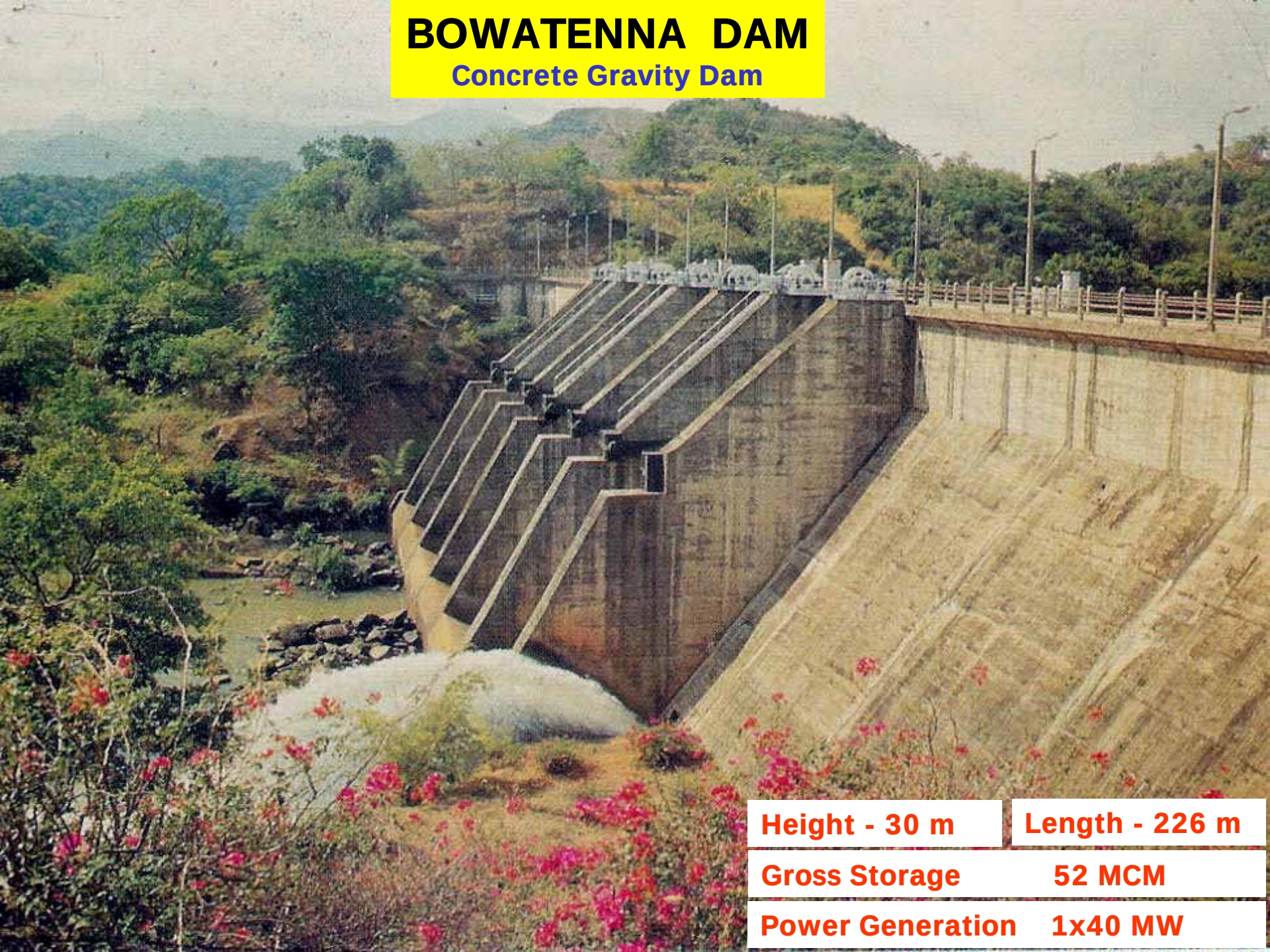
MADURU OYA DAM

Rockfill Dam with Earth Core

Height - 41 m	Length -1090 m
Catchment Area	453 km^2
Gross Storage	597 MCM

BOWATENNA DAM

Concrete Gravity Dam



Height - 30 m	Length - 226 m
Gross Storage	52 MCM
Power Generation	1x40 MW

Lack of Maintenance

Results in disasters

Kantale Dam Failure (20th April 1986)

- **75 People Died**
- **Cost of rehabilitation – Rs 525 million**


U.S. TERRITORIAL ACQUISITIONS
Folsom Dam
Ceded to Great Britain 1818
British Cession 1818
Oregon Territory 1846 (Treaty with Great Britain)
Spanish Cession 1819
Louisiana Purchase 1803 (from France)
Mexican Cession 1848
Territory of the Original Thirteen States (Ceded by Great Britain) 1783
Gadsden Purchase 1853 (from Mexico)
Texas Annexation 1845 (former Republic of Texas)
Spanish Cession 1819
West Florida (Spanish Cession) 1819
East Florida (Spanish Cession) 1819
Hawaii Annexation 1898 (former Republic of Hawaii)
Alaska Purchase 1867 (from Russia)
Porrto Rico Ceded by Spain 1898
Virgin Islands Purchased from Denmark 1917
Albers equal area projection
CANADA
MEXICO
CUBA
THE BAHAMAS
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
NEBRASKA
IOWA
WISCONSIN
MICHIGAN
NEW YORK
MAINE
PENNSYLVANIA
ILLINOIS
INDIANA
OHIO
KENTUCKY
TENNESSEE
NORTH CAROLINA
SOUTH CAROLINA
GEORGIA
ALABAMA
MISSISSIPPI
FLORIDA
UTAH
COLORADO
KANSAS
MISSOURI
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
ALASKA
HAWAII
PUERTO RICO

The Spillway Gate Failure of the Folsom Dam,

California (July 17, 1995)


Dubai Dry Dock Disaster
19 people dead, 27 missing


U.S. TERRITORIAL ACQUISITIONS
Tenton Dam
CANADA
Ceded to Great Britain 1818
WASHINGTON
Oregon Territory 1846 (Treaty with Great Britain)
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
WISCONSIN
MAINE
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
NEW YORK
PENNSYLVANIA
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ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
Hawaii Annexation 1898 (former Republic of Hawaii)
HAWAII
Alaska Purchase 1867 (from Russia)
ALASKA
CANADA
Puerto Rico Ceded by Spain 1898
PUERTO RICO
Virgin Islands Purchased from Denmark 1917
VIRGIN ISLANDS
THE BAHAMAS
CUBA
Albers equal area projection

The Failure of the Teton Dam - Idaho (June 05, 1976)

- 14 People Dead
- Over 1$ Billion of Property Damaged

An Aerial View of the Teton Dam Failure

Teton Dam Failure

4 R philosophy in risk management

Risk

Responsibility

Re solve

Relax !!!

O & M

What is Maintenance ?

Maintenance (service) of Operating facility and Associated Structures for 100% reliable operation

Daily, weekly, monthly – maintenance schedules

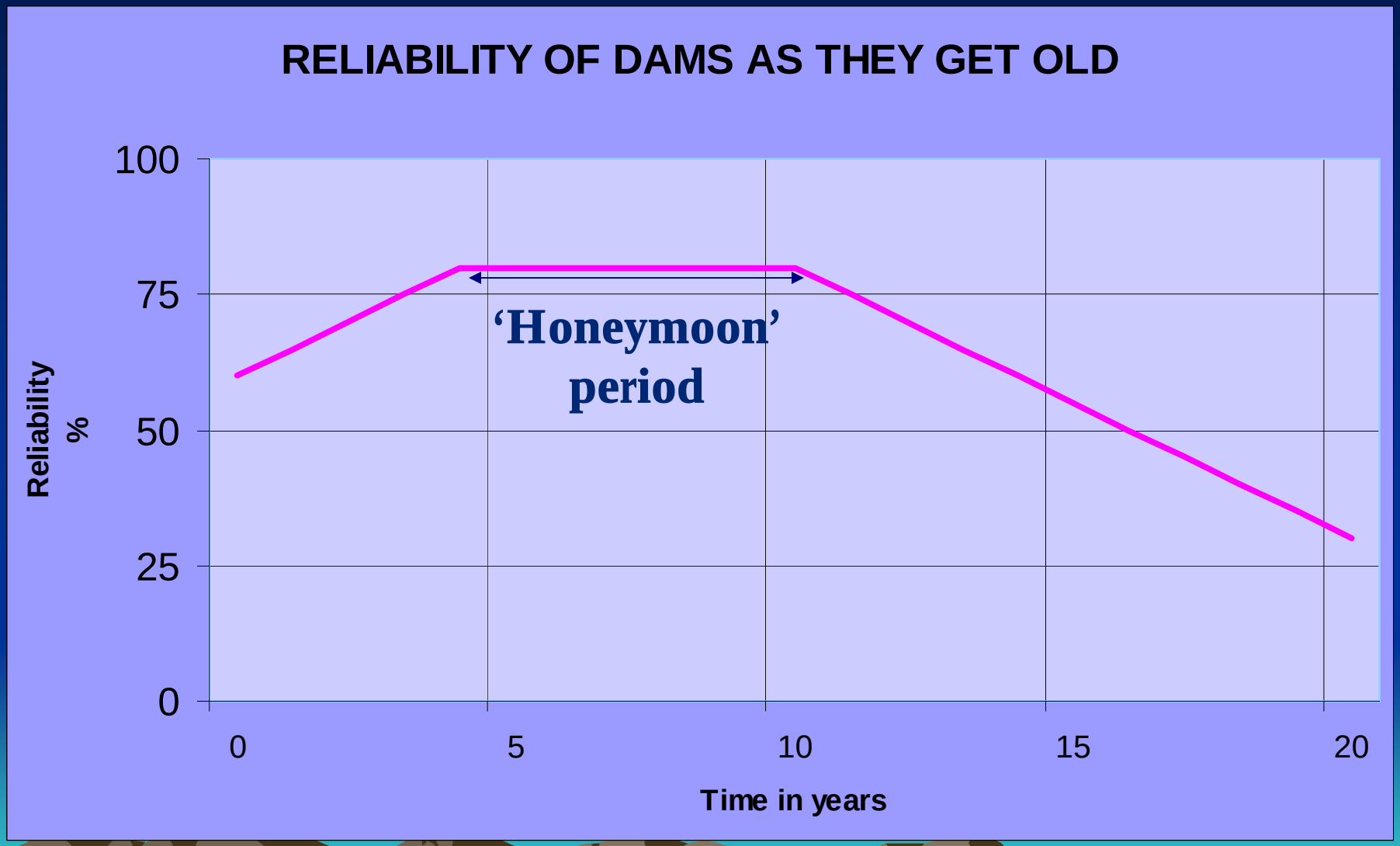
What is Operation ?

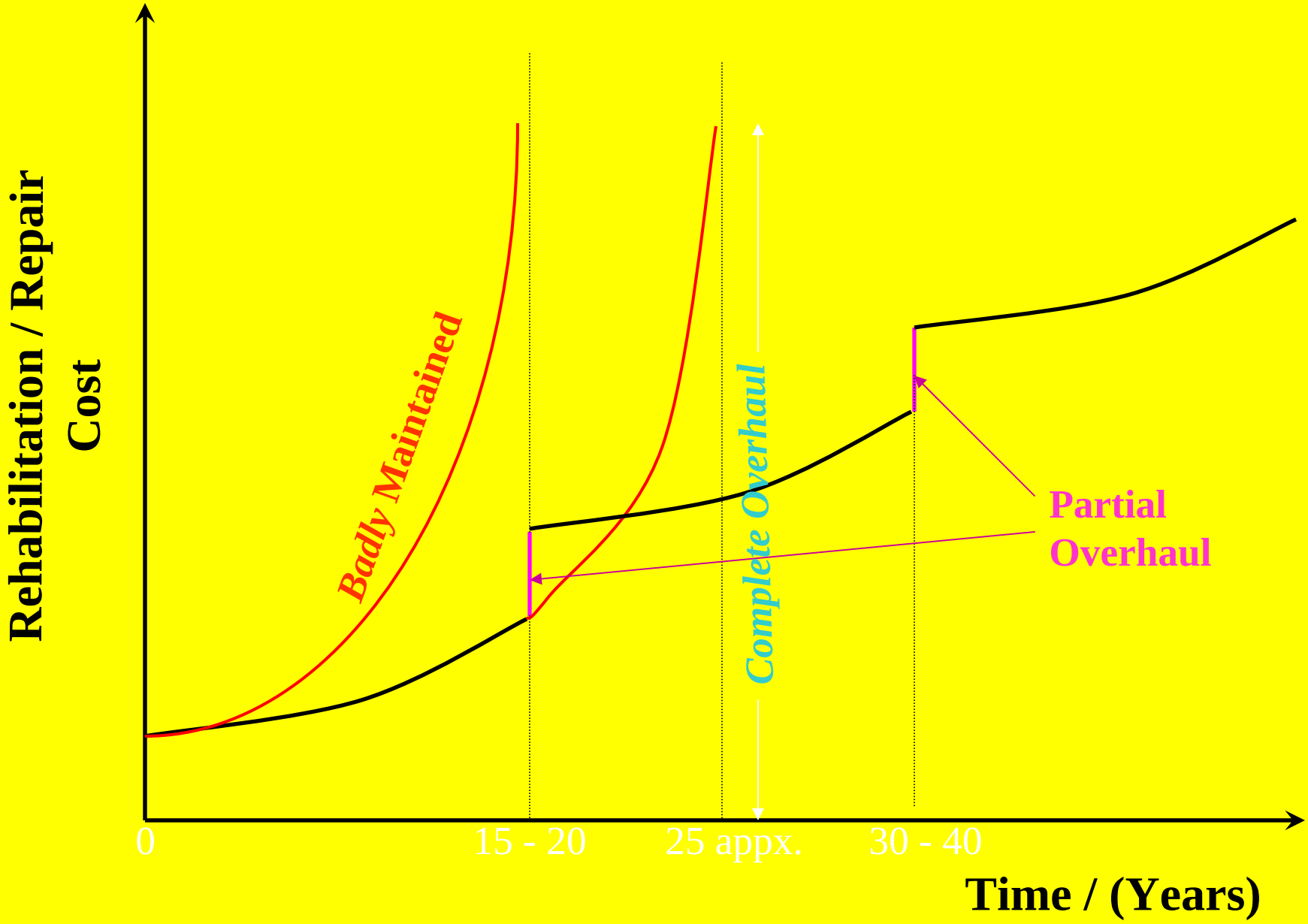
- Regulate the reservoir under control in

Normal Condition

Emergency Condition

- Safely with no danger to Human Life or Property etc.


RELIABILITY OF DAMS AS THEY GET OLD
100
75
50
25
0
Reliability %
‘Honeymoon’ period
0
5
10
15
20
Time in years



Standard Curve for Maintenance

Dam monitoring

Dam Monitoring is mainly two fold

Maintenance & Inspection

- Weekly Maintenance Schedule
- Weekly Inspection Schedule

Instrumentation - Measurements

- Weekly
- Fortnight
- Monthly
- Yearly (two times)

Additionally on daily basis

- Hydrological Data
- Metrological Data

For Good Maintenance Practice

- Follow O&M manuals
- Active management – 5M
  (Material, Machines, Money, Man, Motivation)
- Trained staff
- Sufficient financial resources

Maintenance – Main Areas (Weekly Diary)

- Embankment dams
- Concrete Structures
- Spillways
- Outlet works
- Instrumentation
- Reservoir

WEEKLY DIARIES – RANDENIGALA

Maintenance (Master Document)

RANDENIGALA HEADWORKS - MAINTENANCE

HEDWORKS ADMINISTRATION OPERATION & MAINTENANCE DIVISION - MASL

Week Commencing : September 6, 2004 Week No.:

Name of EIC : ..... Responsible Officer :.....

MAINTENANCE ACTIVITIES	DATE CARRIED OUT	COMMENTS / ACTION REQUIRED
1.0. ROCKFILL DAM & RESERVOIR		
(a). Remove vegetation from surface		
(b). Repair rip-rap and slopes		
(c). Minor repair of crest works & roads		
(d). Clean floors of tunnels and gallary		
(e). Clean drains in tunnels and gallery		
(f). Minor repairs in tunnels and gallery		
(g). Clean foundation drainpipe and sump		
(h). Maintain corrosion protection of dam drainage		
(i). Clean tailwater area from obstruct		
(j). Maintain dam monitoring equipment		
2.0. SPILLWAY		
2.1. STRUCTURES		

WEEKLY DIARIES – RANDENIGALA

Maintenance (Master Document) continued….

3.1. STRUCTURES		
(a). Minor repair of intake tower		
(b). Repaint pressure tunnel lining		
(c). Clean gate chamber incl. drainage		
(d). Repair cavitation in outlet channel		
(e). Clean aeration slots		
(f). Clean flip bucket drainage		
3.2. BOTTOM OUTLET GATES		
3.2. 1. MECHANICAL		
(a). Test run service gates		
(b). Test run revision gates		
3.2. 2. ELECTRICAL		
(c). Replace defective pilot lamps		
3.2. 3. HYDRAULICS		
(d). Operate aeration valves		
(e). Trial run of hydraulic unit		
(f). Laboratory test hydraulic oil		
(g). Relubricate rod and bearings		
(h). Top up brake cylinder oil		

WEEKLY DIARIES – RANDENIGALA

Inspection (Items for a Week)

RANDENIGALA HEADWORKS - INSPECTION

HEDWORKS ADMINISTRATION OPERATION & MAINTENANCE DIVISION - MASL

Week Commencing : June 9, 2003 Week No.: 23

Name of EIC : ..... Responsible Officer : .....

INSPECTION ACTIVITIES	DATE CARRIED OUT	COMMENTS / ACTION REQUIRED
1.0. ROCKFILL DAM & RESERVOIR (f). Judge foundation drain pipe flow* (g). Check functioning of dam monitoring*		
2.0. SPILLWAY **2.2. SPILLWAY GATES** **2.2. 1. MECHANICAL** (h). Check cleanliness of brake discs* **2.2. 2. ELECTRICAL**		


Maintenance of Embankment Dams

Maintenance on Embankment Dams

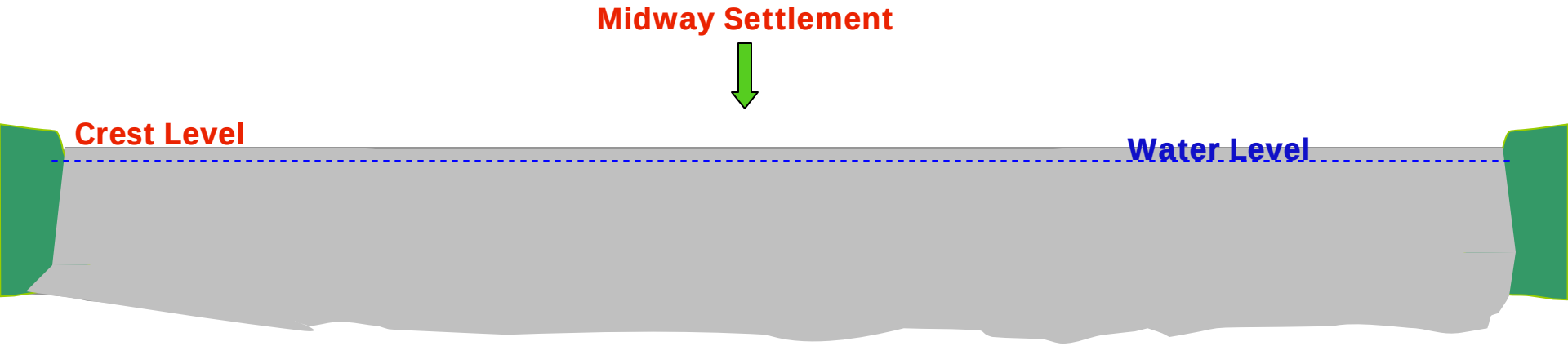
- U/S, D/S slope settlement correction
- Visual inspection around structures
- (outlet ,side walls)

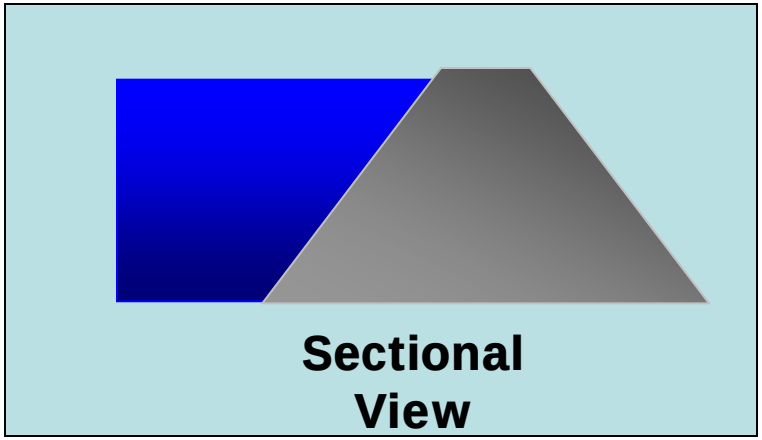
- Dam crest settlement correction

- Seepage arresting structures
  - Toe filters
  - Toe drains

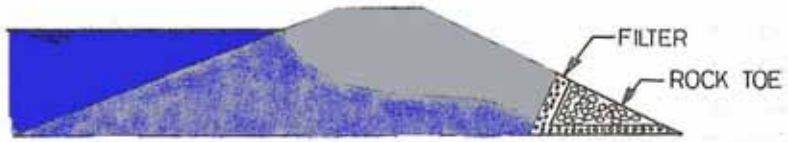
- Drainage systems (cleaning, flushing)
  - Inside the dam body
  - Outside the dam body

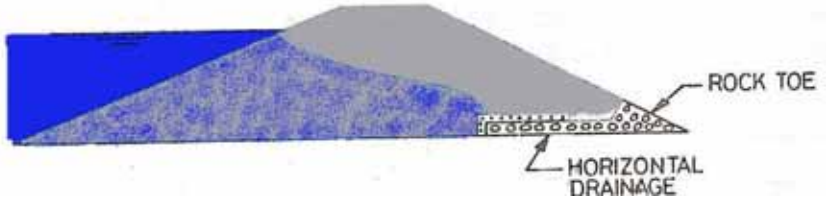
Overtopping due to Settlement of Long Embankment Dam

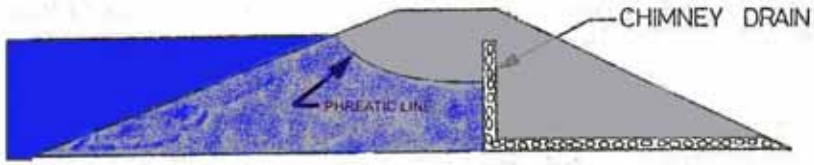


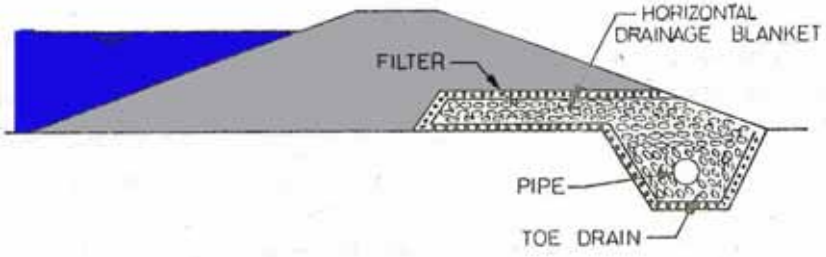


Different type of Toe Filters/Drains









Maintenance on Embankment Dams

- **Slope protection surface drains**

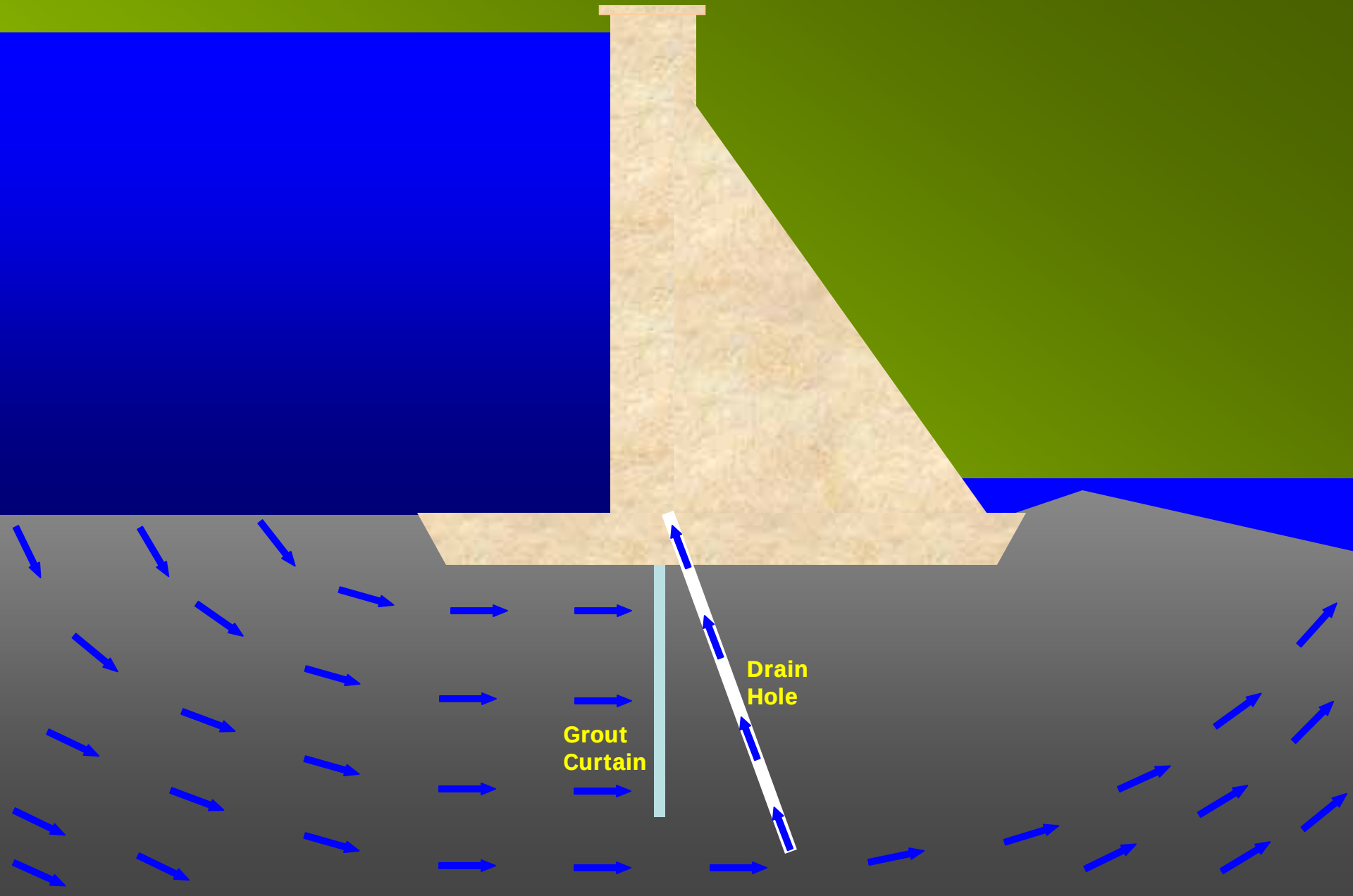
- **Anthills & Trees/Plants growth**


Maintenance of Concrete Structures

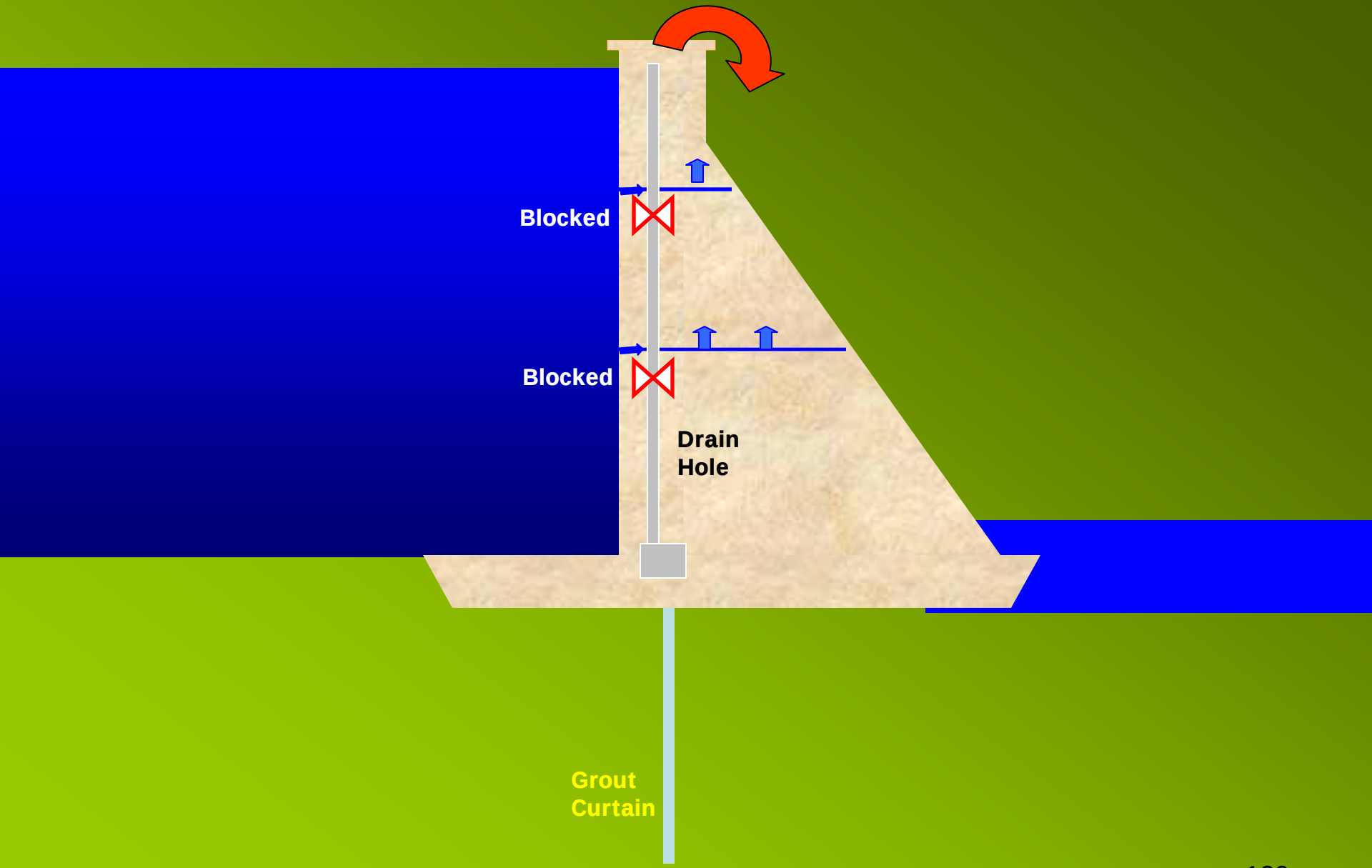
Maintenance on Concrete Structures

- Concrete surface, deterioration, honeycombs (remedy with non-shrink materials)
- Structural cracks – monitoring
- Settlement measurements
- Abutment/Structure Junction (erosion)
- Drains & Pressure Relief Holes
- Joints/Sealant (Construction & Expansion)

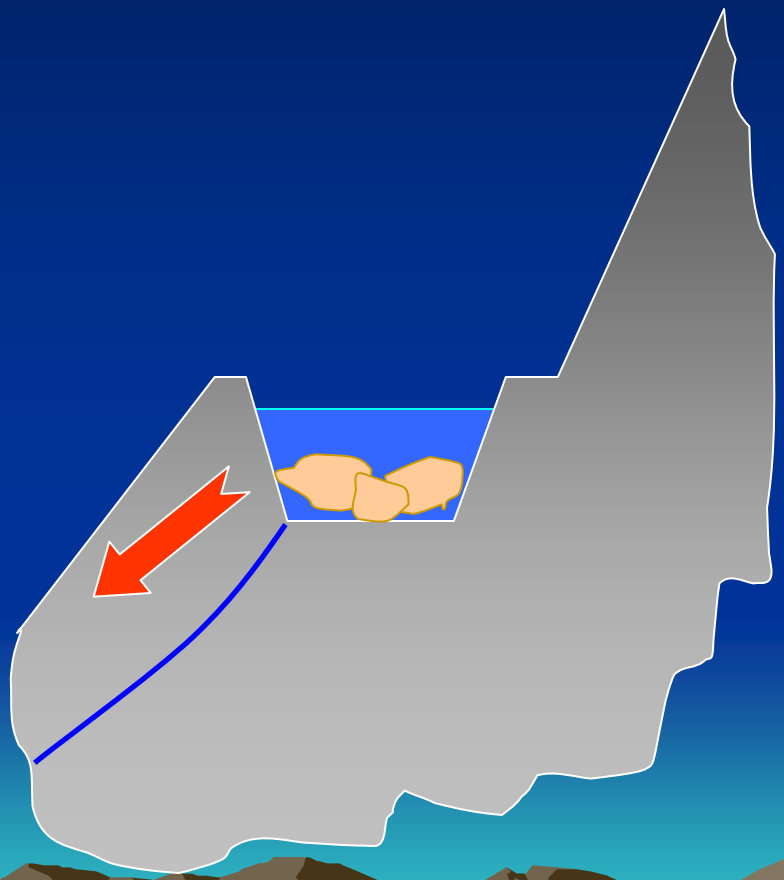
Drain Holes (Normal Condition)



If Vertical Drains are blocked



When side drains are blocked by debris, water retained in the drain, then lower part of the drain can be slipped down due to seepage water

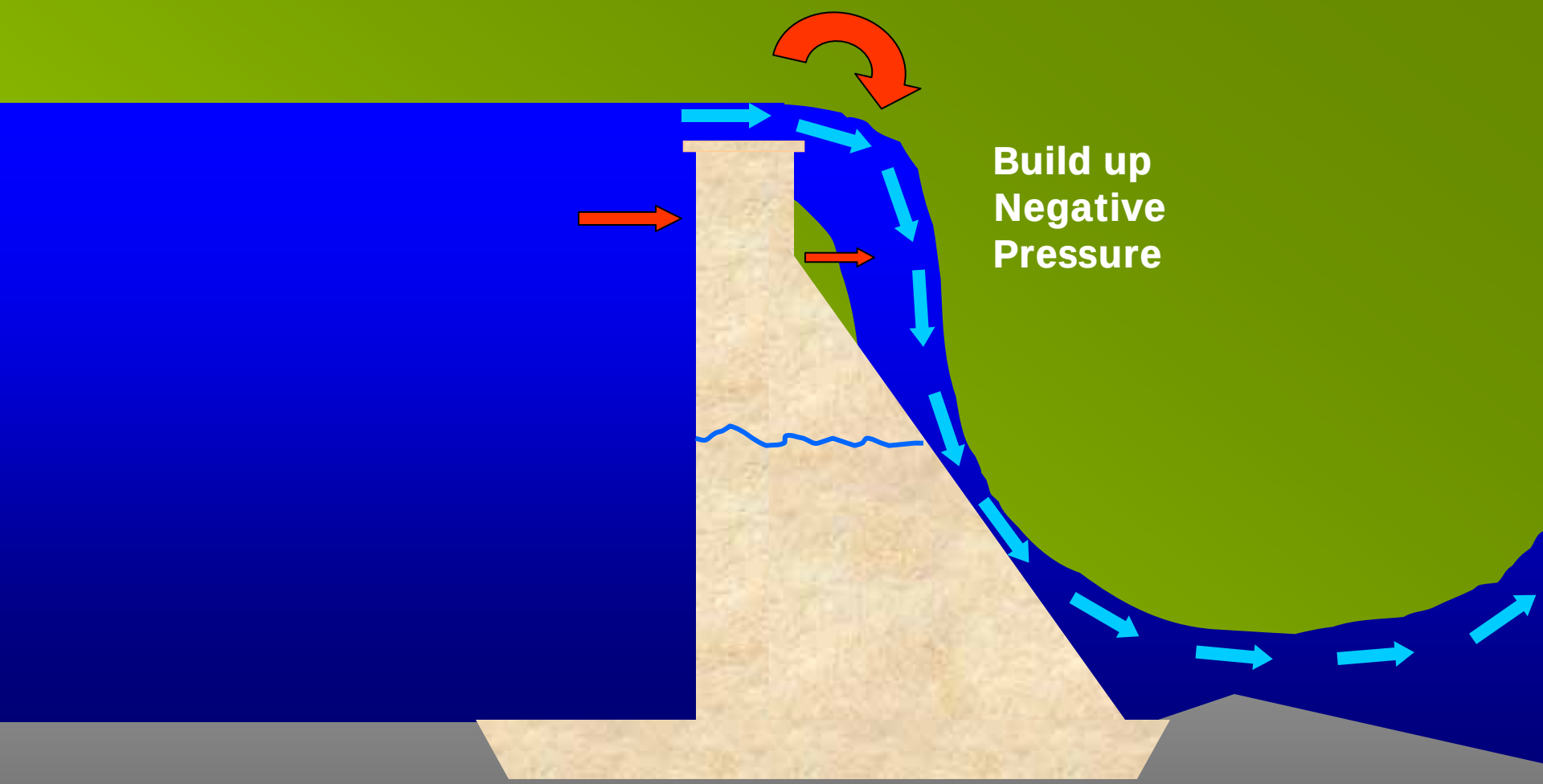



Maintenance of Spillways

Spillway Maintenance

(Concrete, Natural etc.)

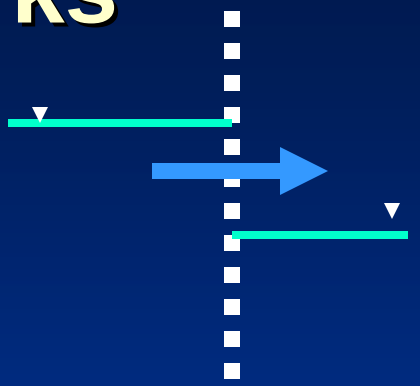
- **Surface erosions, cracks, scouring etc.**
  (Natural spill – better periodical spills)
- **Mechanical part embedded areas**
  (Cracks possible for water leaks)
- **Approach/Outlet canals**
  (Accumulation of tree logs, abutment erosions etc.)
- **Erosions/Scouring around energy dissipaters**



Crack last


Maintenance of Outlet works

Maintenance of Outlet Works



- Collection of derbies – Head loss (Periodical clearing)
- Power/Irrigation intake – scouring/cracks
- Water Passage – Concrete scouring steel liner corrosions
- Bottom Outlets, Lead away pipes, Drain holes (Need periodical cleaning to release the uplift pressure)


Maintenance of Reservoir

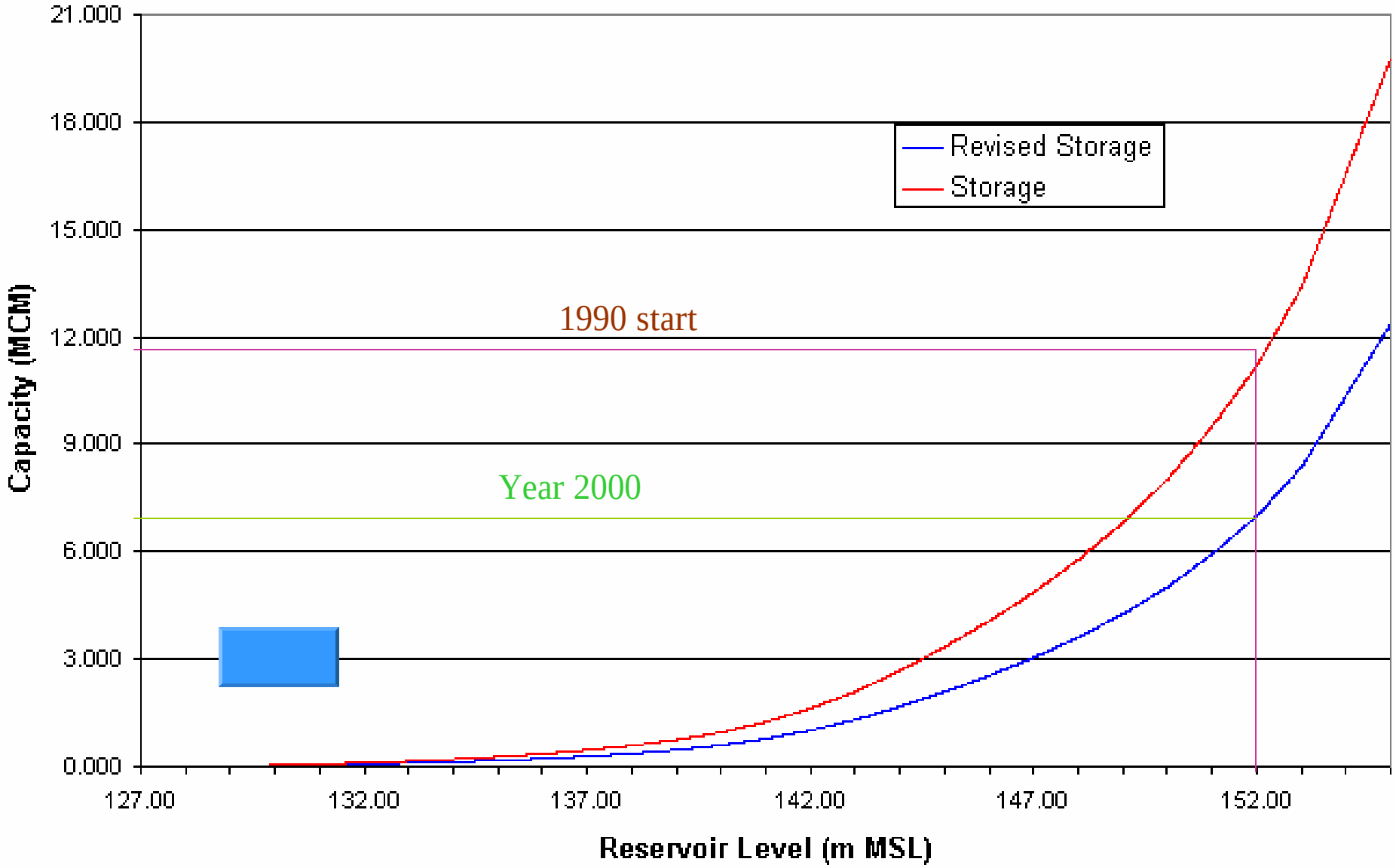
Maintenance of Reservoir

- Periphery – landslide, encroachments
- Earth slips & Land slides

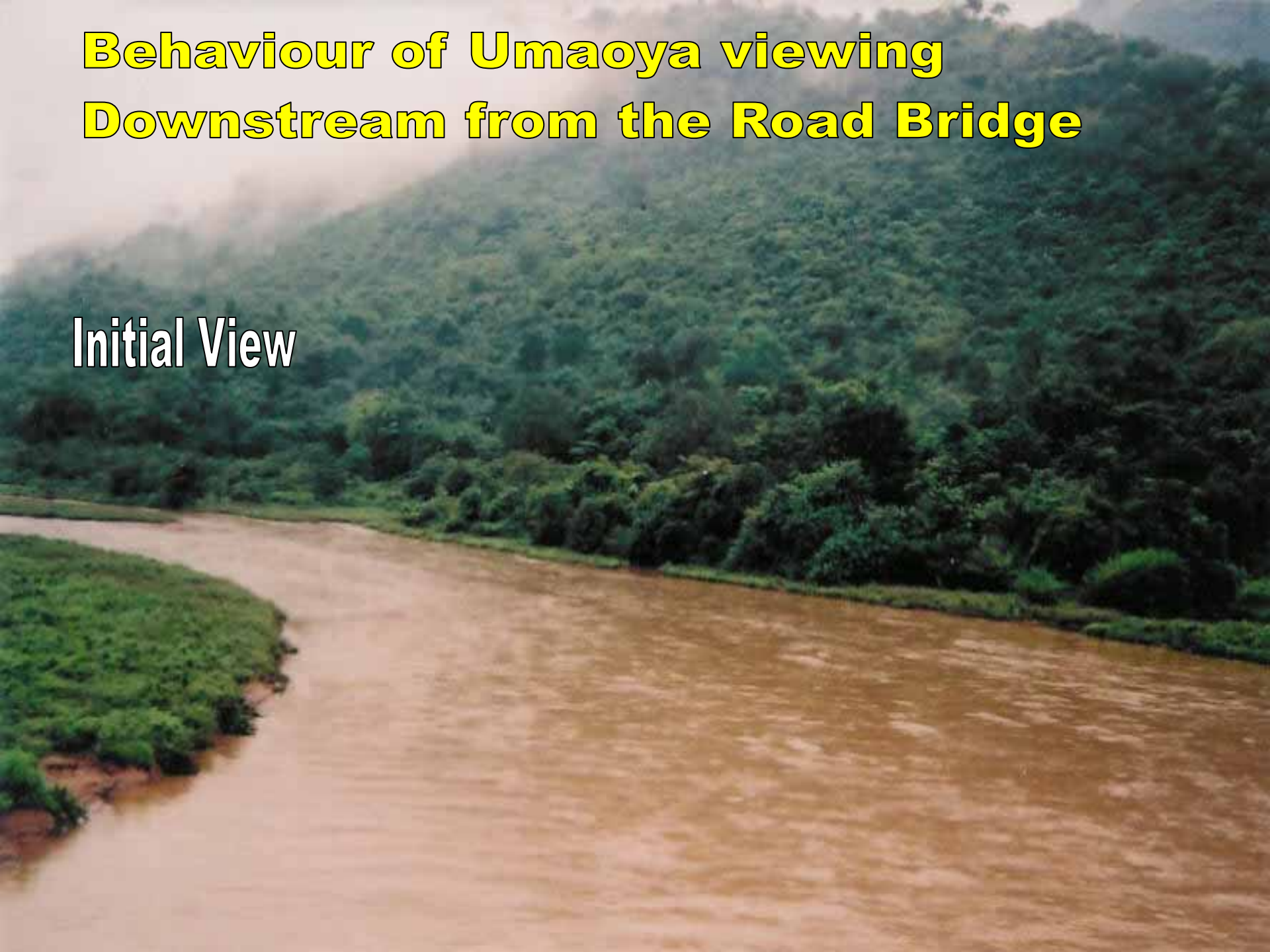
- Upstream water paths cleaning
  (Tree logs, flash floods)
- Water sheds – Human activity, timber cutting coordinating with Environment Department
- Water quality tests etc
- Sediment Controls
- Water Balance – Predictions, 24 hr duty above certain level

REVISED CAPACITY CURVE RANTEMBE

(After Flushing)

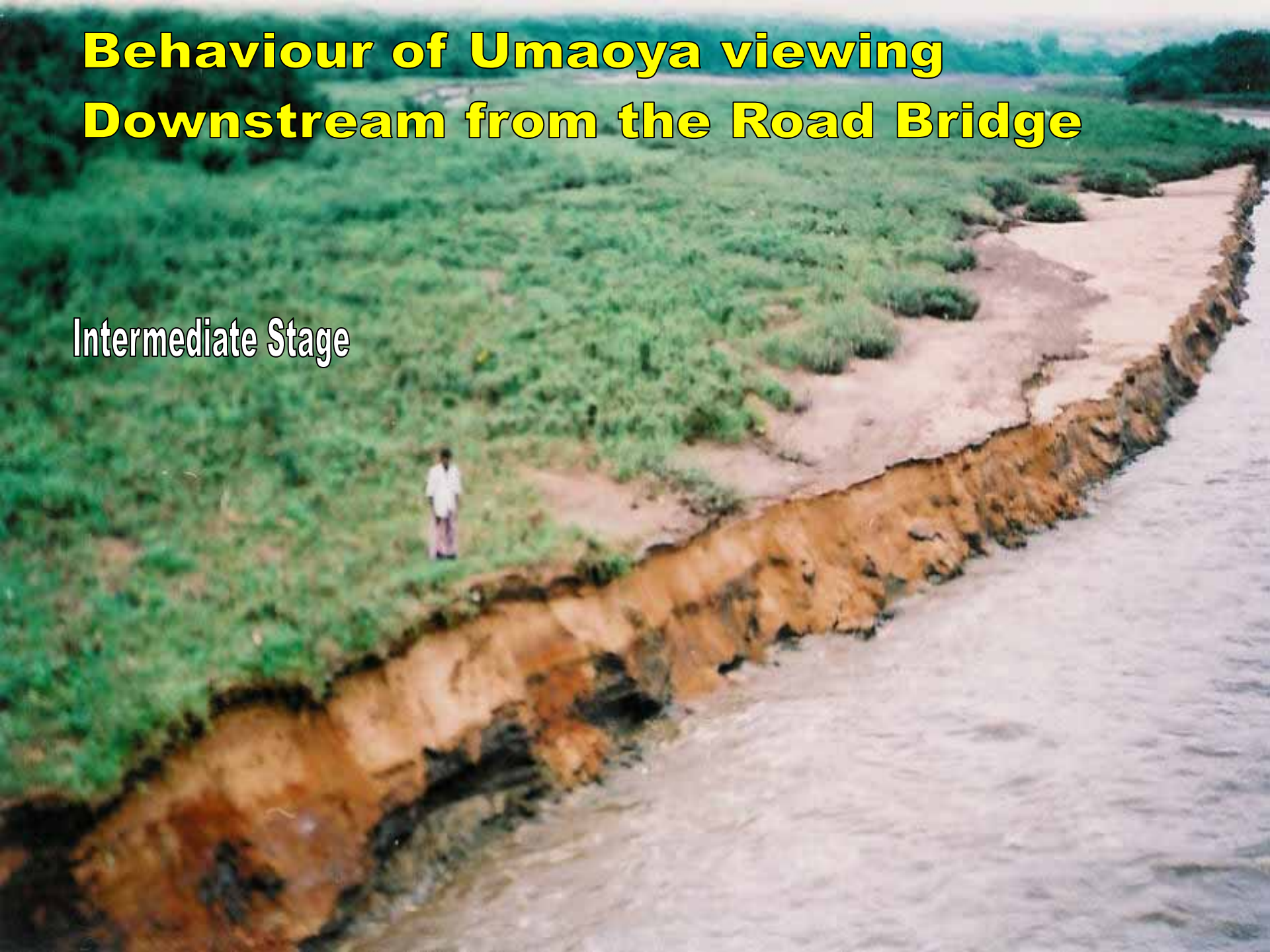


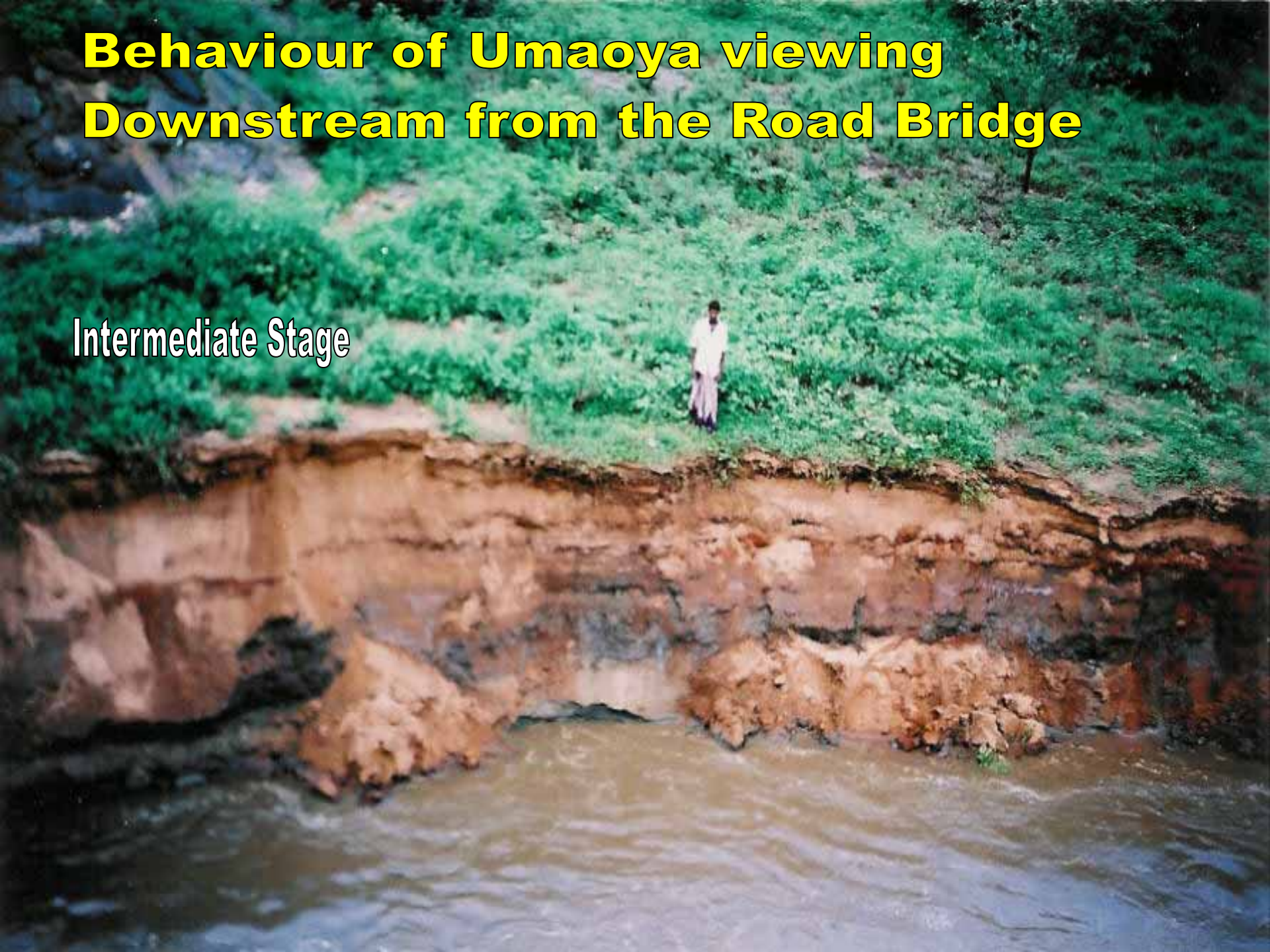
Behaviour of Umaoya viewing Downstream from the Road Bridge



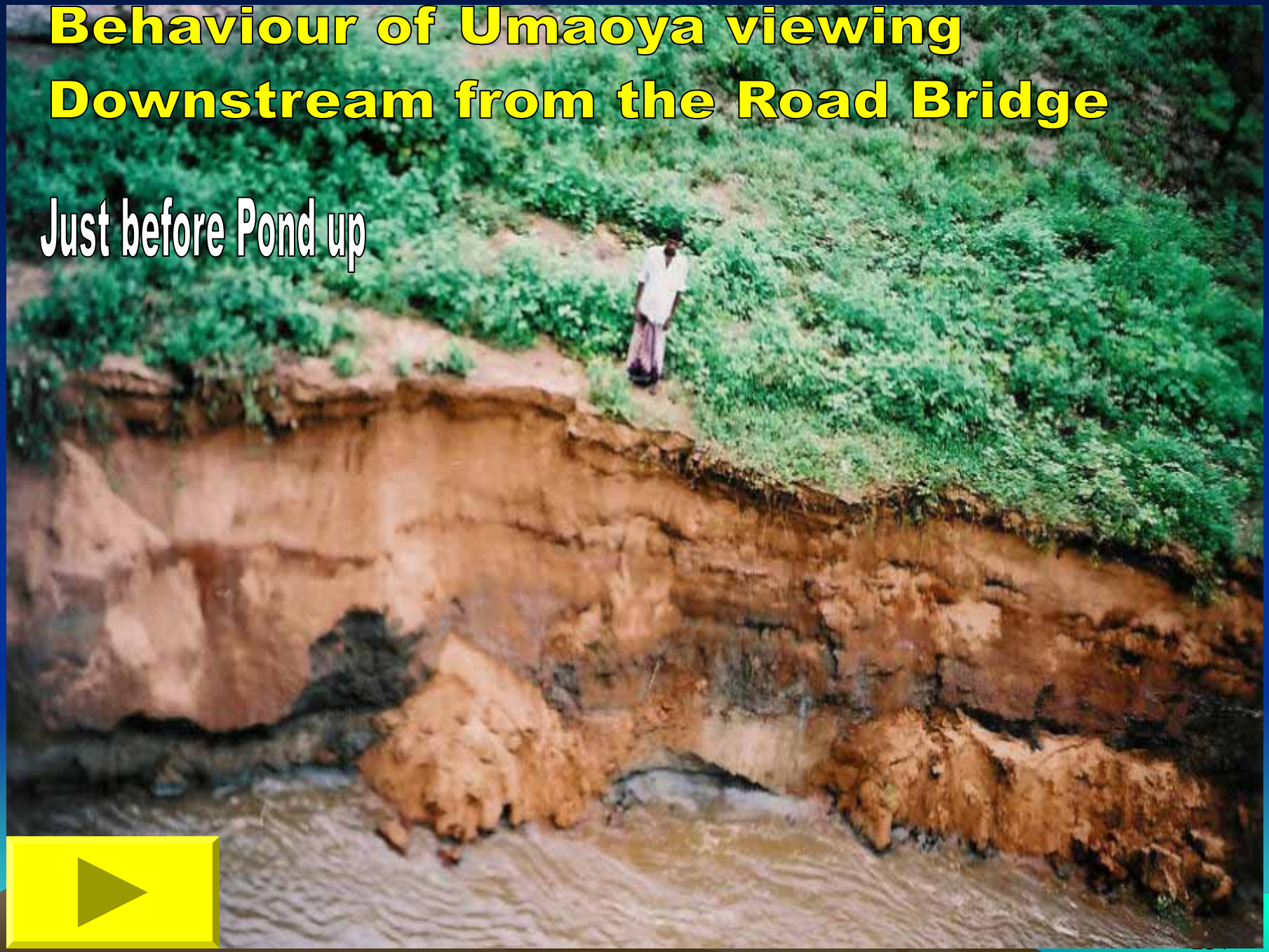
Behaviour of Umaoya viewing Downstream from the Road Bridge

Behaviour of Umaoya viewing Downstream from the Road Bridge



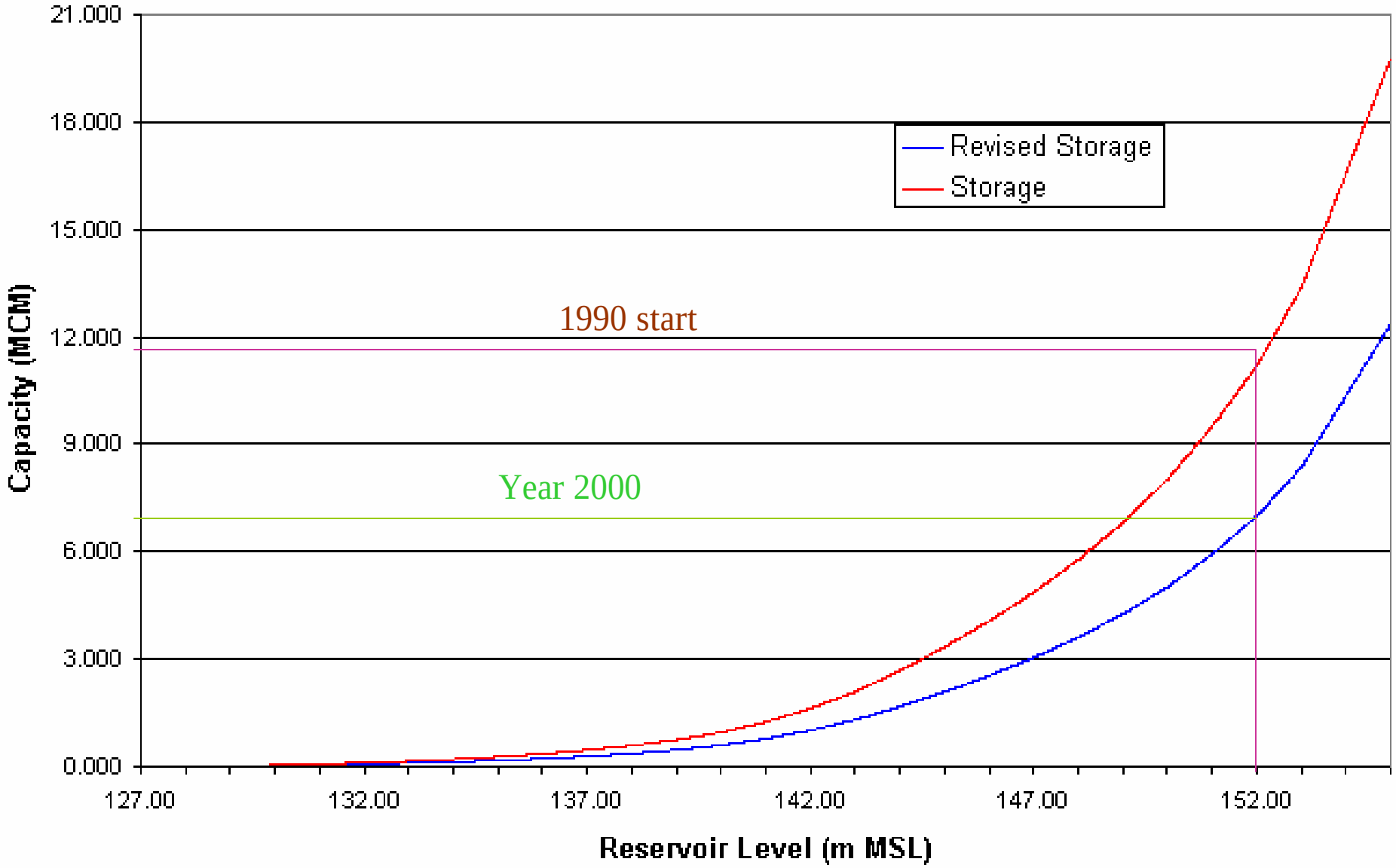

Behaviour of Umaoya viewing
Downstream from the Road Bridge
Intermediate Stage

Behaviour of Umaoya viewing Downstream from the Road Bridge



REVISED CAPACITY CURVE RANTEMBE

(After Flushing)




OPERATION

What is operation ?(of reservoir)

- Regulate the reservoir under control in

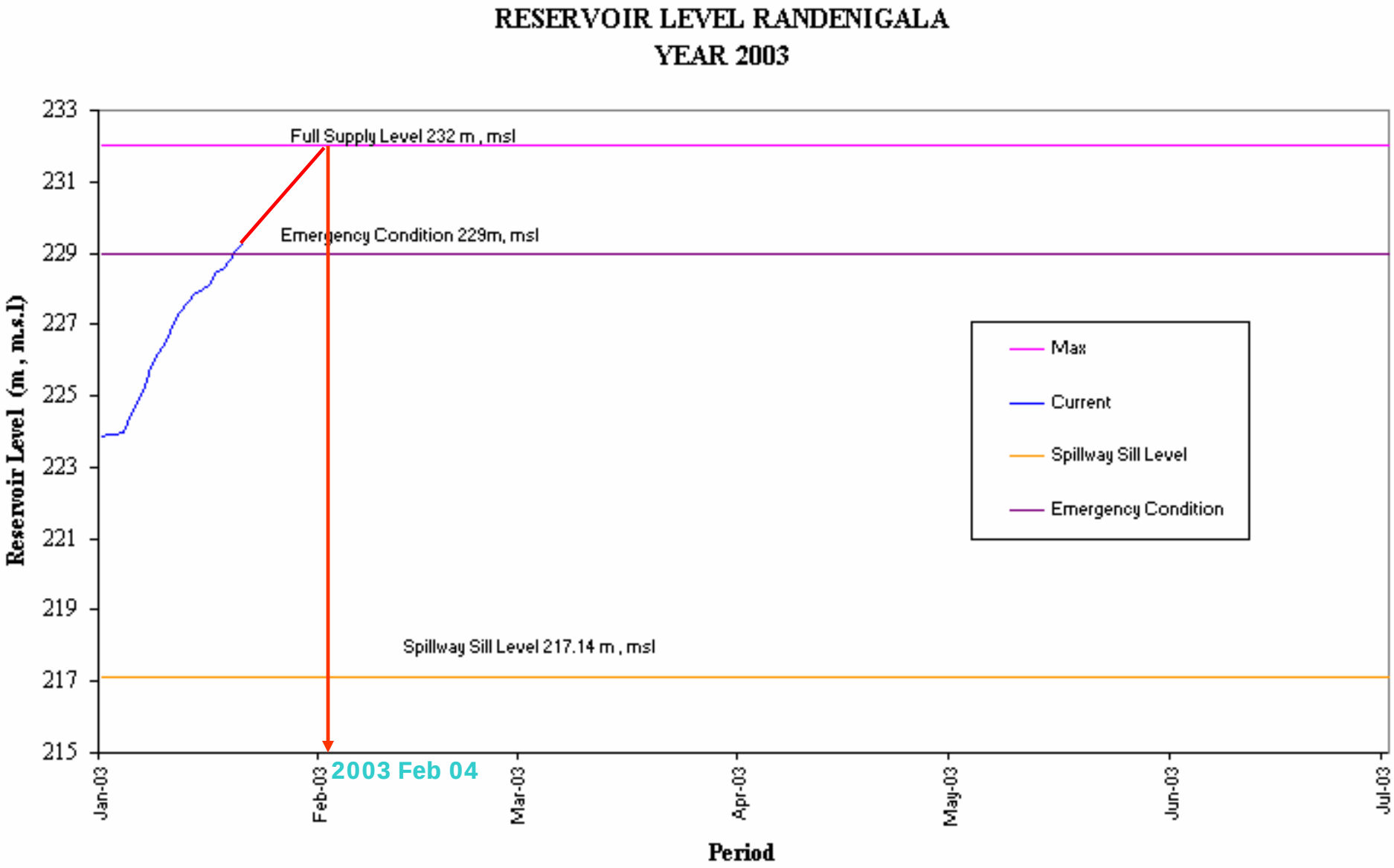
Normal Condition

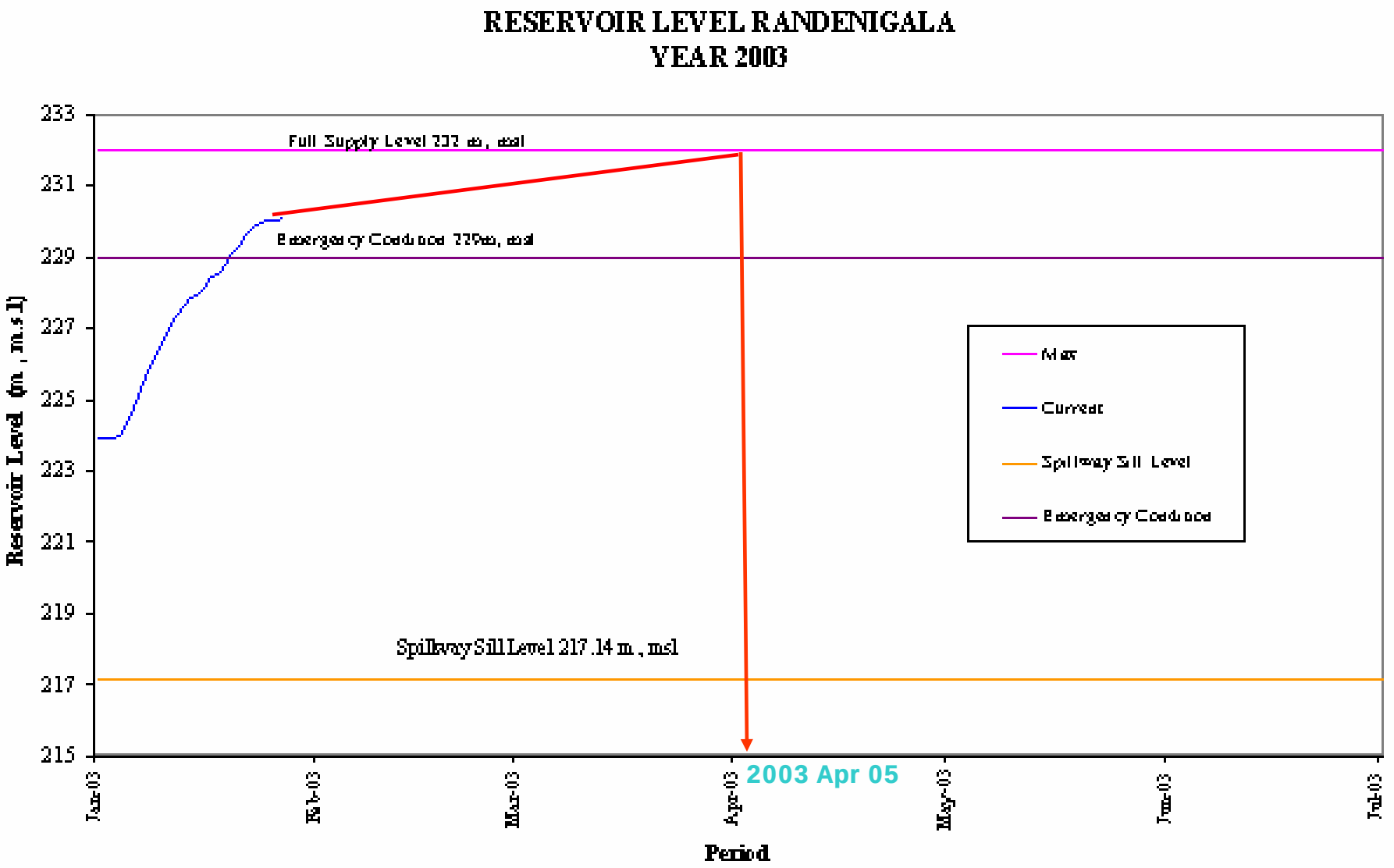
Emergency Condition

- **Safely with no danger to Human Life or Property**

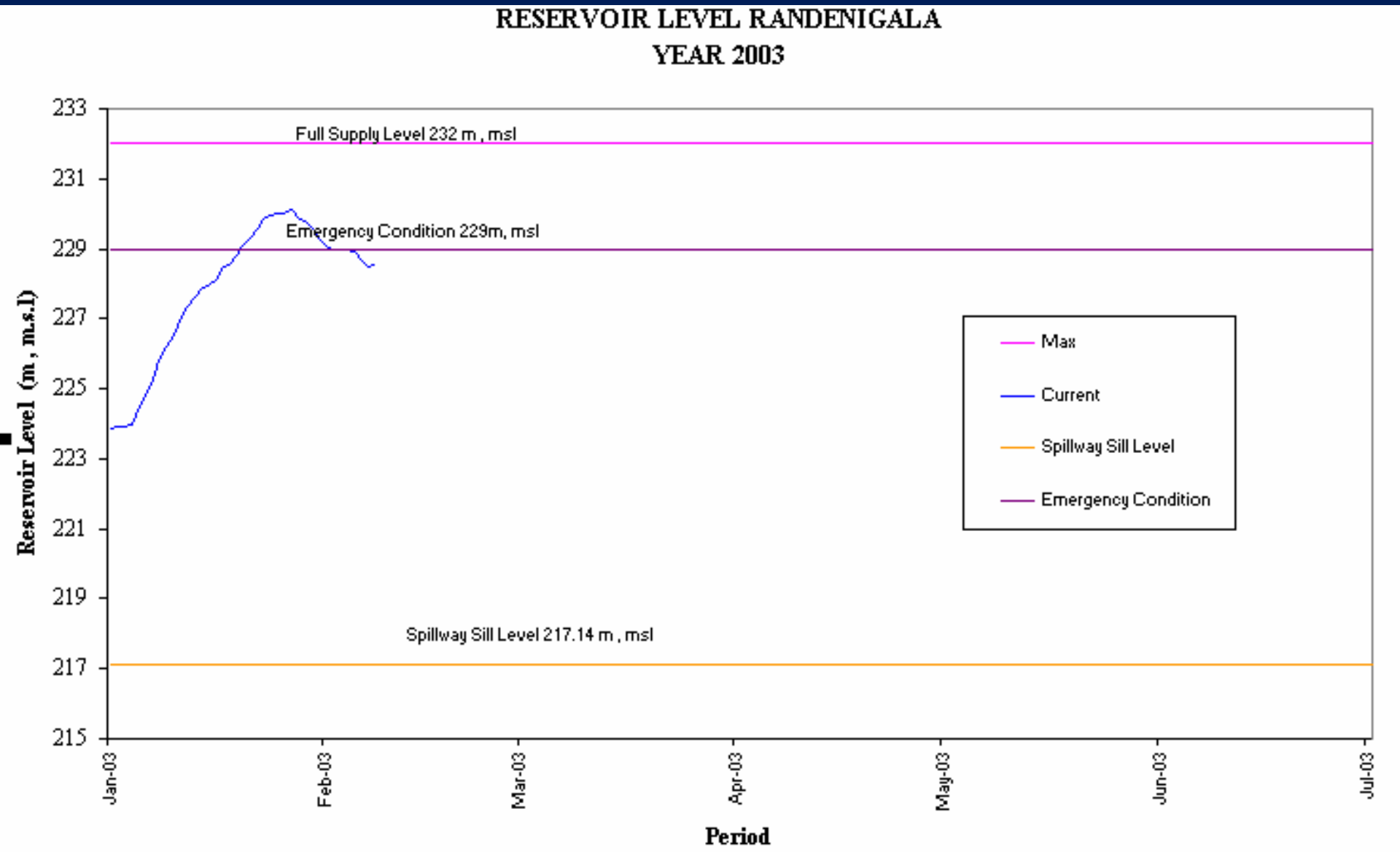
alarm, pre release for buffer signal, be ready, catchments communication

Emergency Condition




RESERVOIR LEVEL RANDENIGALA
YEAR 2003
Full Supply Level 232 m., msl
Emergency Condition 229m, msl
Spillway Sill Level 217.14 m., msl
2003 Apr 05
Max
Current
Spillway Sill Level
Emergency Condition
Reservoir Level (m., m.s.l)
Period
233
231
229
227
225
223
221
219
217
215
Jan-03
Feb-03
Mar-03
Apr-03
May-03
Jun-03
Jul-03

Normal Condition



Special Inspection Report

SPECIAL DAILY INSPECTION REPORT FOR HIGH WATER LEVELS AT RANDENIGALA DAM - (229-232 M MSL)

Date : …….. Water Level : ……..

No	Location	Seepage	Rock fall	Slides/Slips
1	Dam D/S Toe			
2	Dam L/B Area			
3	Dam R/B Area			
4	Instruments Chamber			
5	Inspection Gallery			
6	Bottom Outlet Area			
7	Sump Pumps			

.....

Technical Officer (Randenigala)

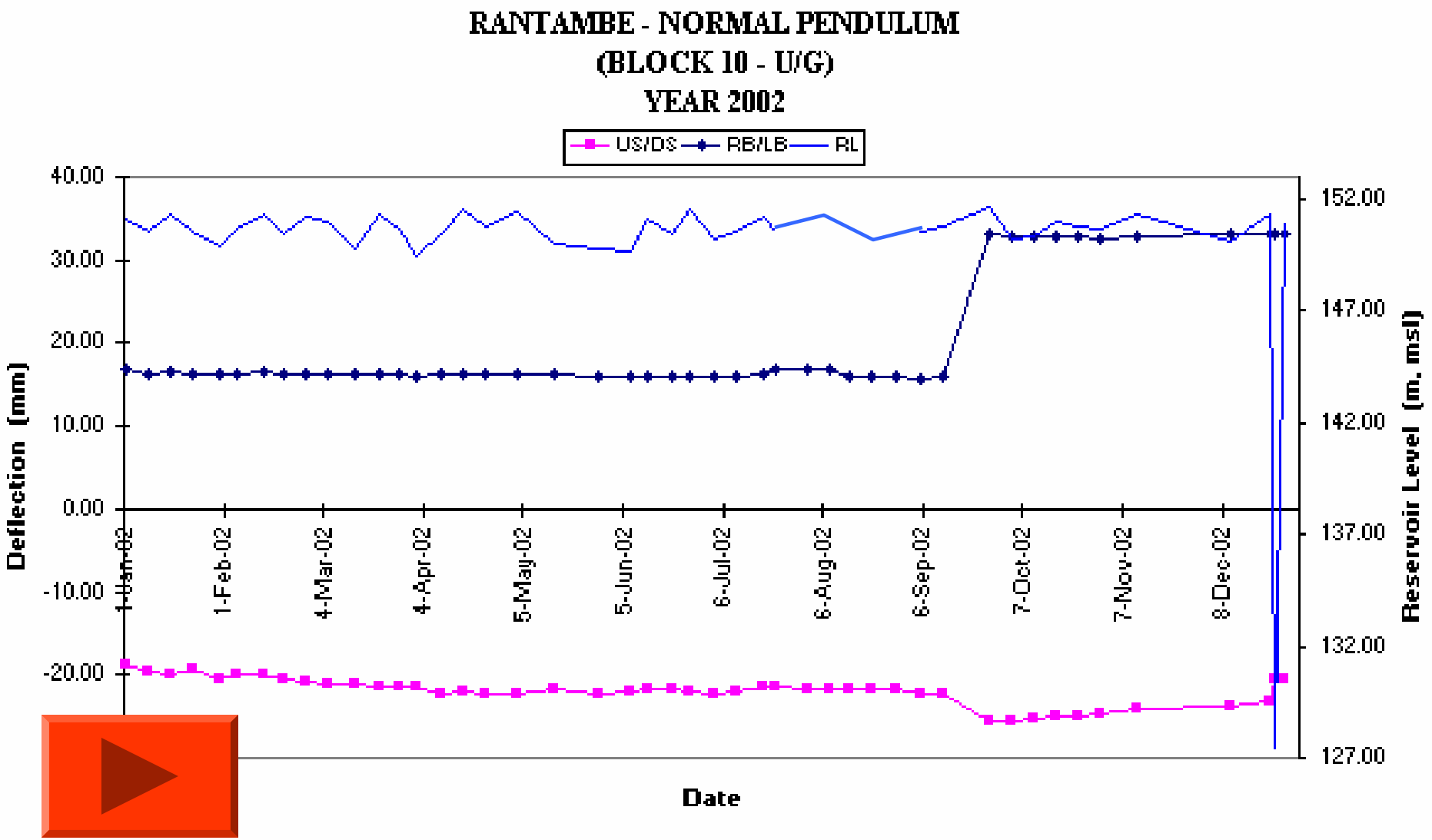

INSTRUMENTATION
SOKKIA

WHY DAM INSTRUMENTATION IS IMPORTANT ?

- Doctor talk to his patient and diagnose.
- Dam Engineer has to keep on talking with Dam through instrument.
- If the patient has a continuously maintained health record, easy for doctor to trace the origin of disease.
- Similarly, good instrumentation record (history) helps Dam Engineer to trace the troubling areas.
- Each and every Dam has it's own unique behavior.
- Theory has to build on our own.
- Doctor's mistake will kill one person at a time.
- Dam Engineer's mistake will kill thousand of lives and billions of assets at a time

Maintenance of Instruments

- Periodical calibrations
- Battery levels
- Unusual change in readings
- Fixing Points – Base plates, Brackets
- Top covers of standpipe, piezometers


RANTAMBE - NORMAL PENDULUM
(BLOCK 10 - U/G)
YEAR 2002
US/DS
RB/LB
RL
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
Deflection (mm)
152.00
147.00
142.00
137.00
132.00
127.00
Reservoir Level (m, msl)
1-Jan-02
1-Feb-02
4-Mar-02
4-Apr-02
5-May-02
5-Jun-02
6-Jul-02
6-Aug-02
6-Sep-02
7-Oct-02
7-Nov-02
8-Dec-02
Date

Instrumentation - Measurements

- Weekly
- Fortnight
- Monthly
- Yearly (two times)

Type of Instruments

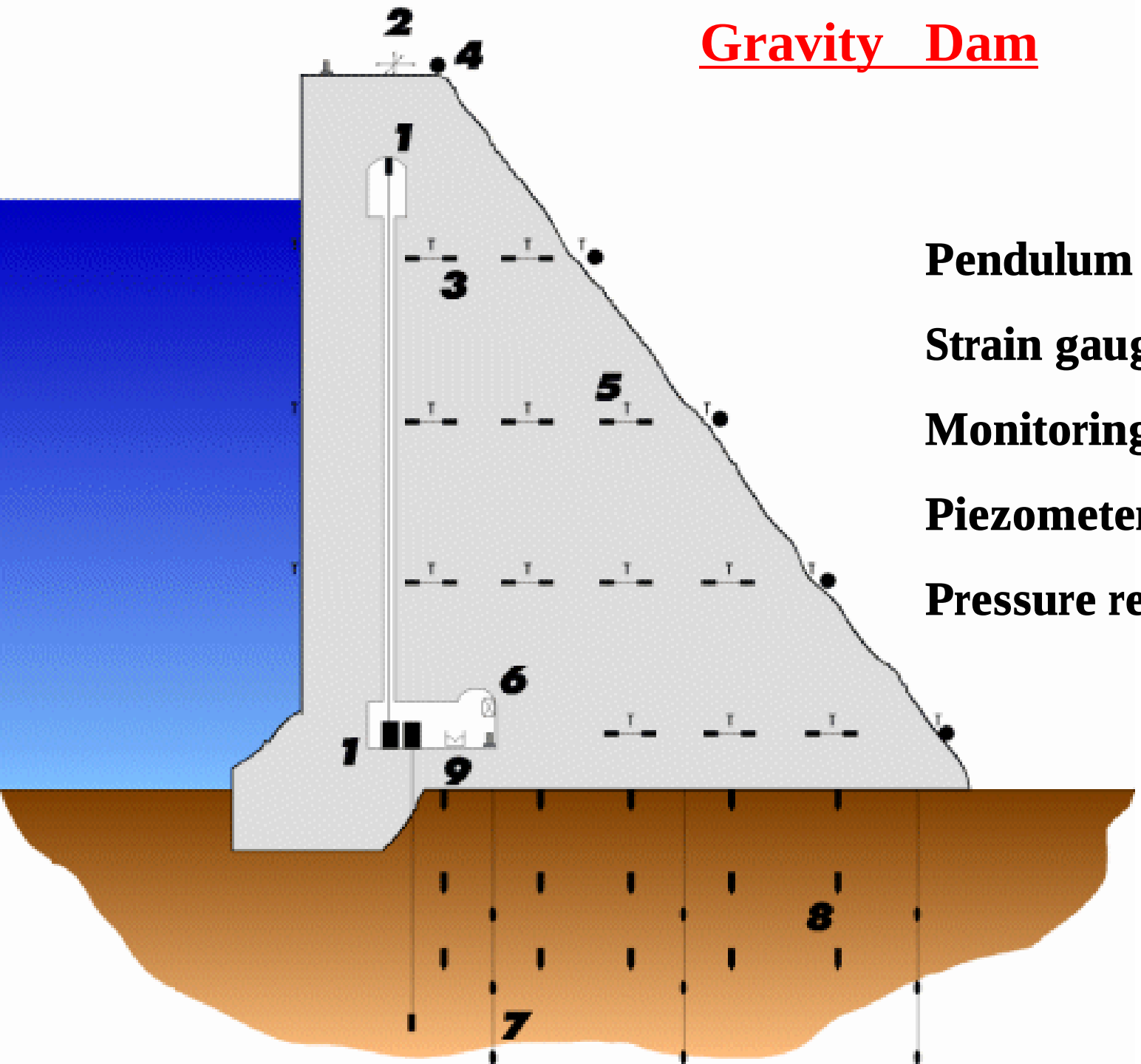
Randenigala

- Inclinometers 07 Nos.
- Extensor Meters 51 Nos.
- Pressure Transducers 74 Nos.
- Pressure Manometers 09 Nos

Rantembe

- Pendulums 09 Nos.
- Tilt meters
- Joint meters 39 Nos.
- Manometers 62 Nos

Gravity Dam



Pendulum

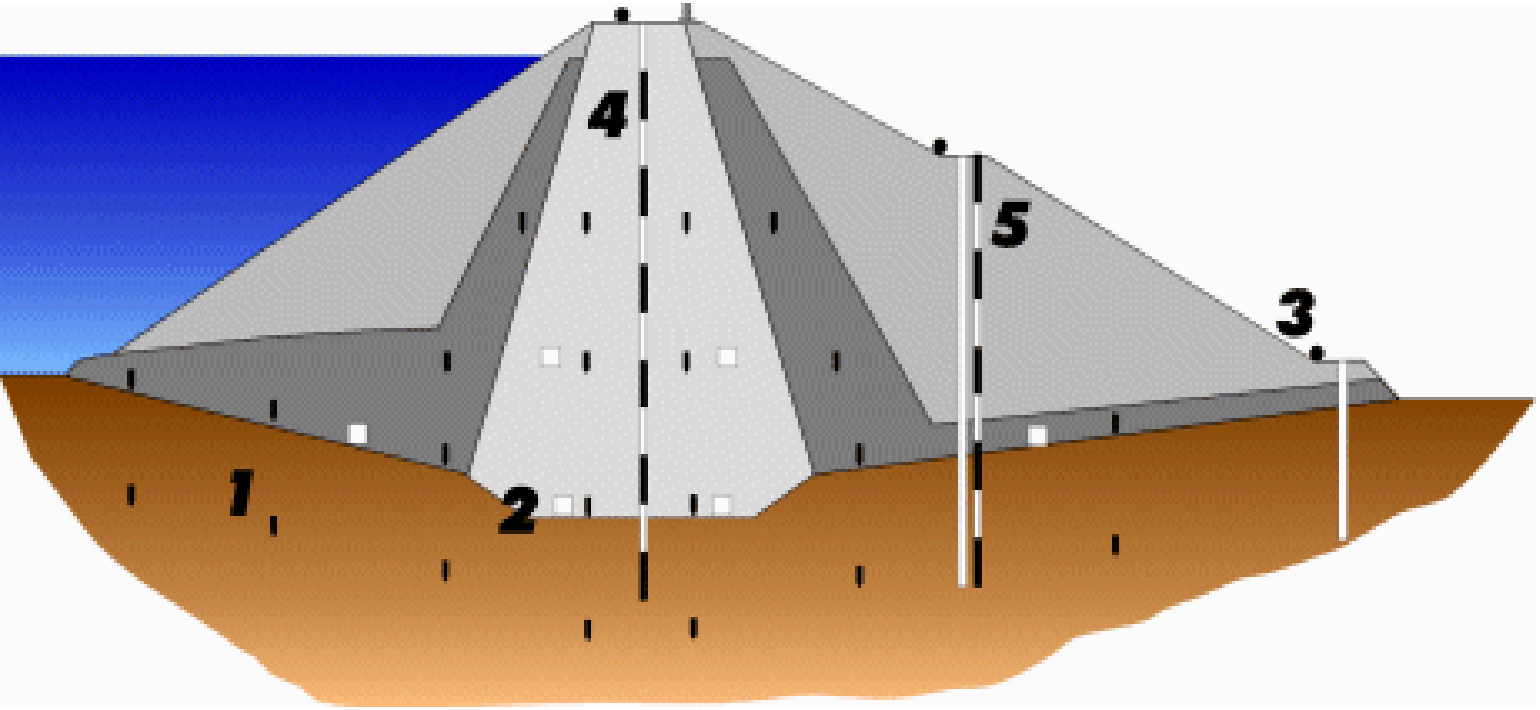
Strain gauge

Monitoring targets

Piezometers

Pressure relief holes

Earth Dam



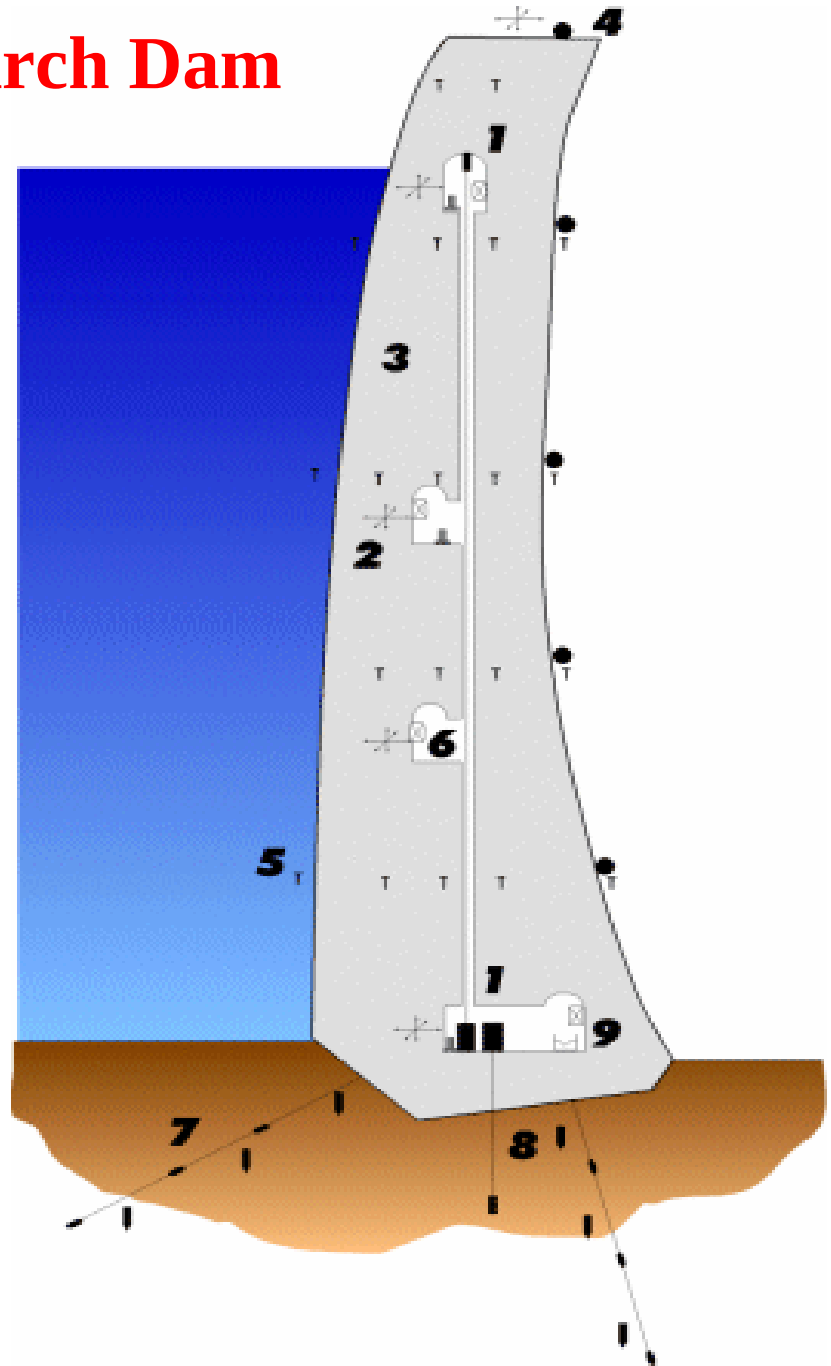
Extensor meters

Settlement gauges

Bottom pressure cell / gauges

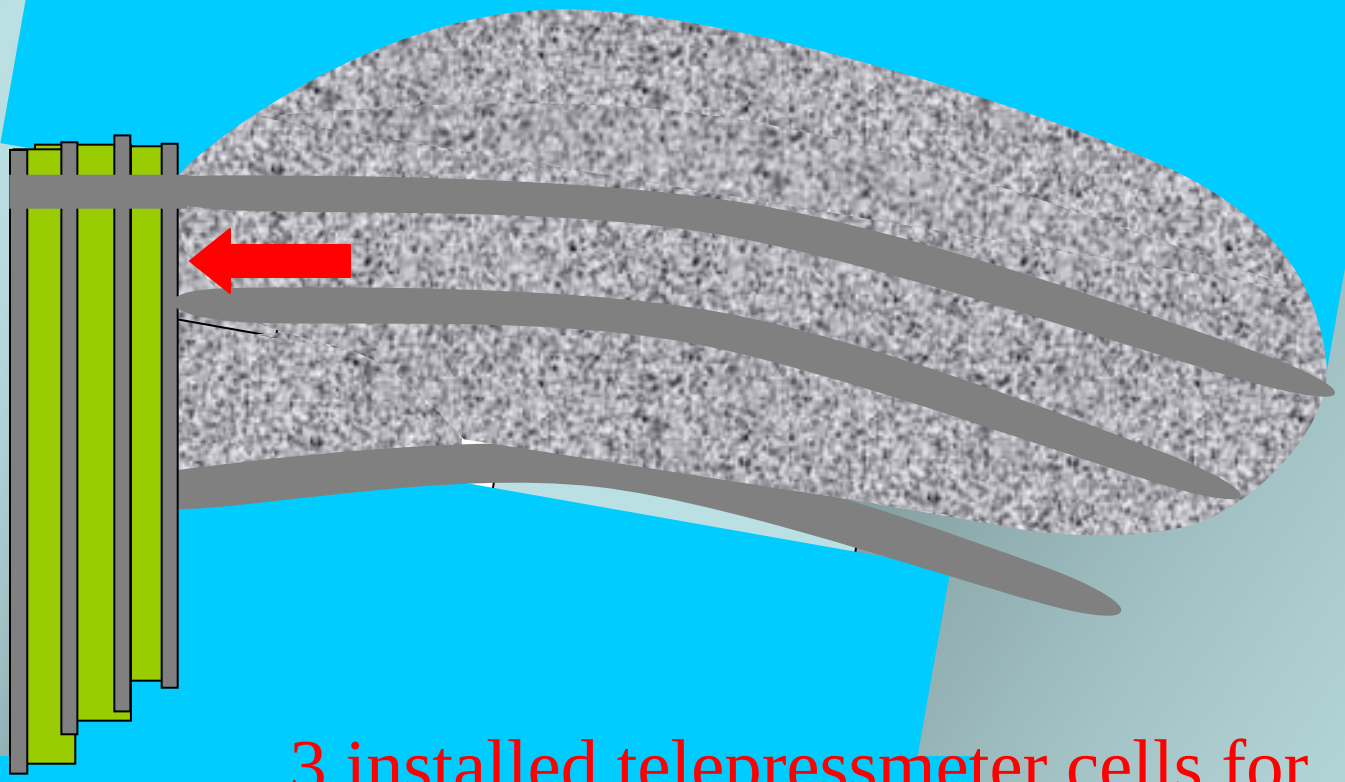
V notch

Arch Dam



Pendulum
Strain gauge
Monitoring targets
Piezometers
Pressure relief holes

Telepressmeters



3 installed telepressmeter cells for lateral pressure of the core against the spillway wing wall

Digital Inclinometer

Applications

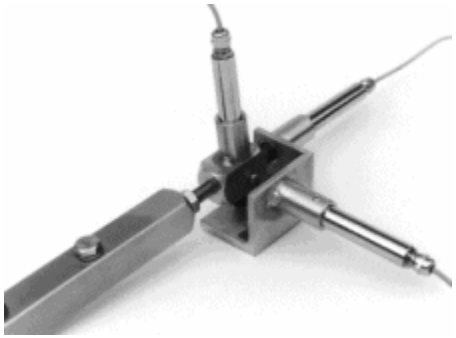
- Slope Indicators
- lateral movements in embankments and landslide areas,
- deflections of retaining walls and piles, deformations of excavation walls, tunnels, and shafts.

Joint meters

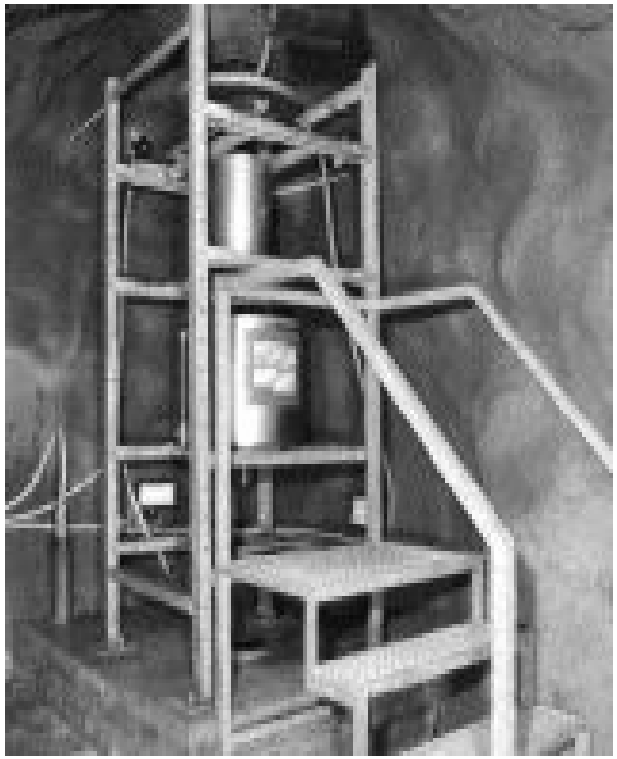
Applications

Displacement monitoring of discrete structures, in particular opening of discontinuities, such as:

- Movement along joints and geologic faults
- Widening of fissures in concrete structure
- Monitoring of cracks in masonry brick walls



Pendulum System



Applications

Typical applications include the displacement monitoring of:

- Tall buildings and structures
- Dams
- Diaphragm walls

Piezometer - probe

Applications

- Monitoring the effects of dewatering systems used for excavations
- Monitoring the effects of ground improvement systems such as vertical drains and sand drains
- Monitoring pore pressures to check the performance of earth fill dams and embankments

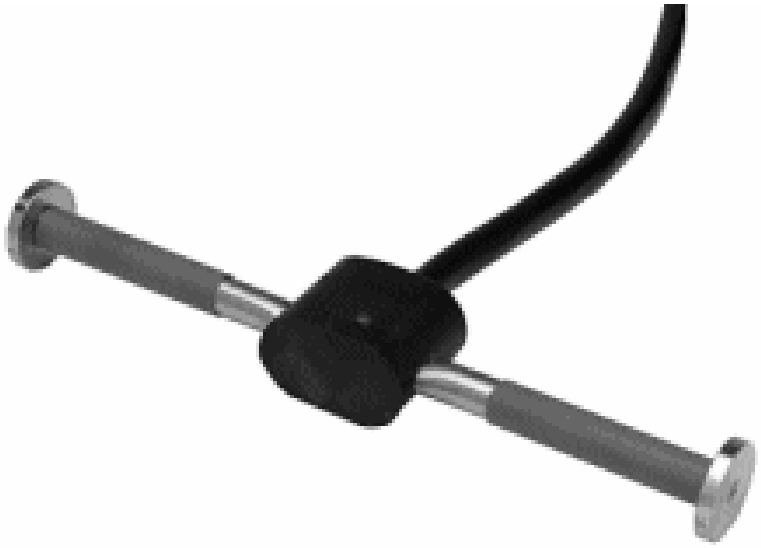
Magnetic Extensometers

Applications

- Displacement and especially settlement along an axis of a measuring tube (or borehole)
- Monitoring settlement in excavation, foundations, earth dams and embankments.

Data from the extensometer provides an indication of settlement per measuring point, as well as total settlement.

Strain Gauges

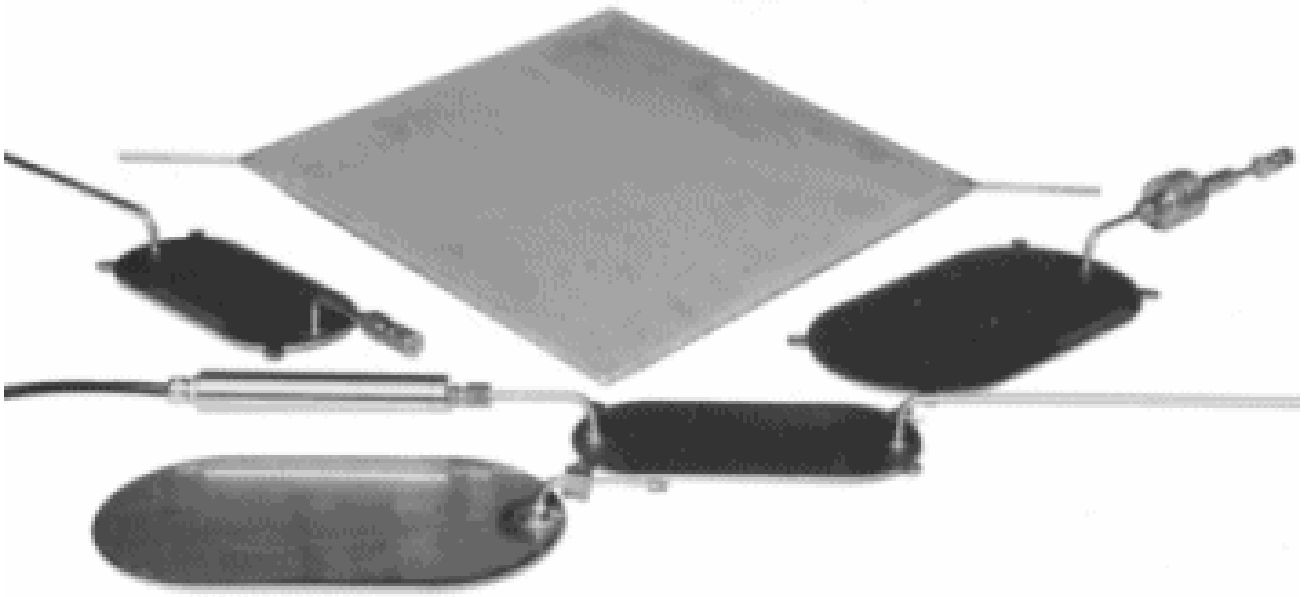


Applications

- used to measure strain in reinforced concrete and mass concrete.

- The strain gauge has a modulus similar to that of typical construction concrete and is suitable for most applications.

Total Pressure Cells

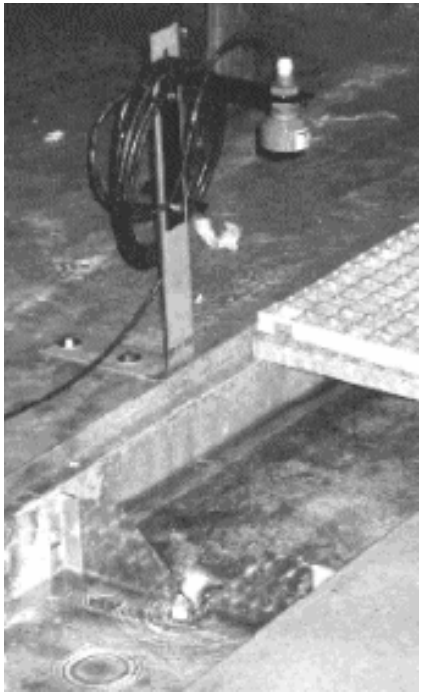


Applications

- monitor stress changes in concrete, soil and fills, contact joints and in boreholes.

- Typical areas of application include the monitoring of:
  - Radial and tangential pressures in tunnels
  - Load measurements at head and toe of pile construction

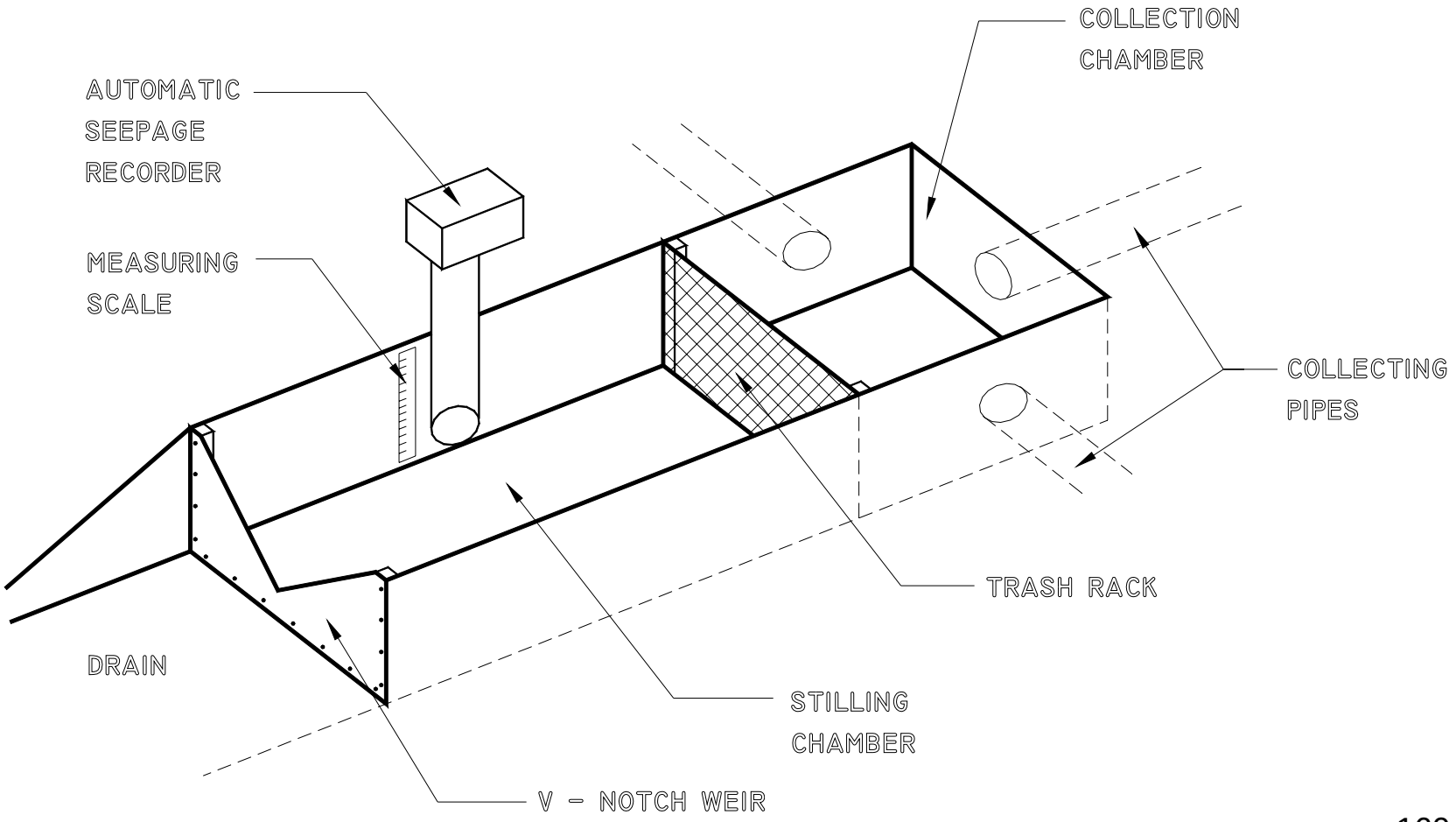
V-Notch Weir



Applications

- Monitor discharge in small open channels.
- Seepage water monitoring inside large dams.
  (The most common application)

Typical seepage collection / stilling chamber

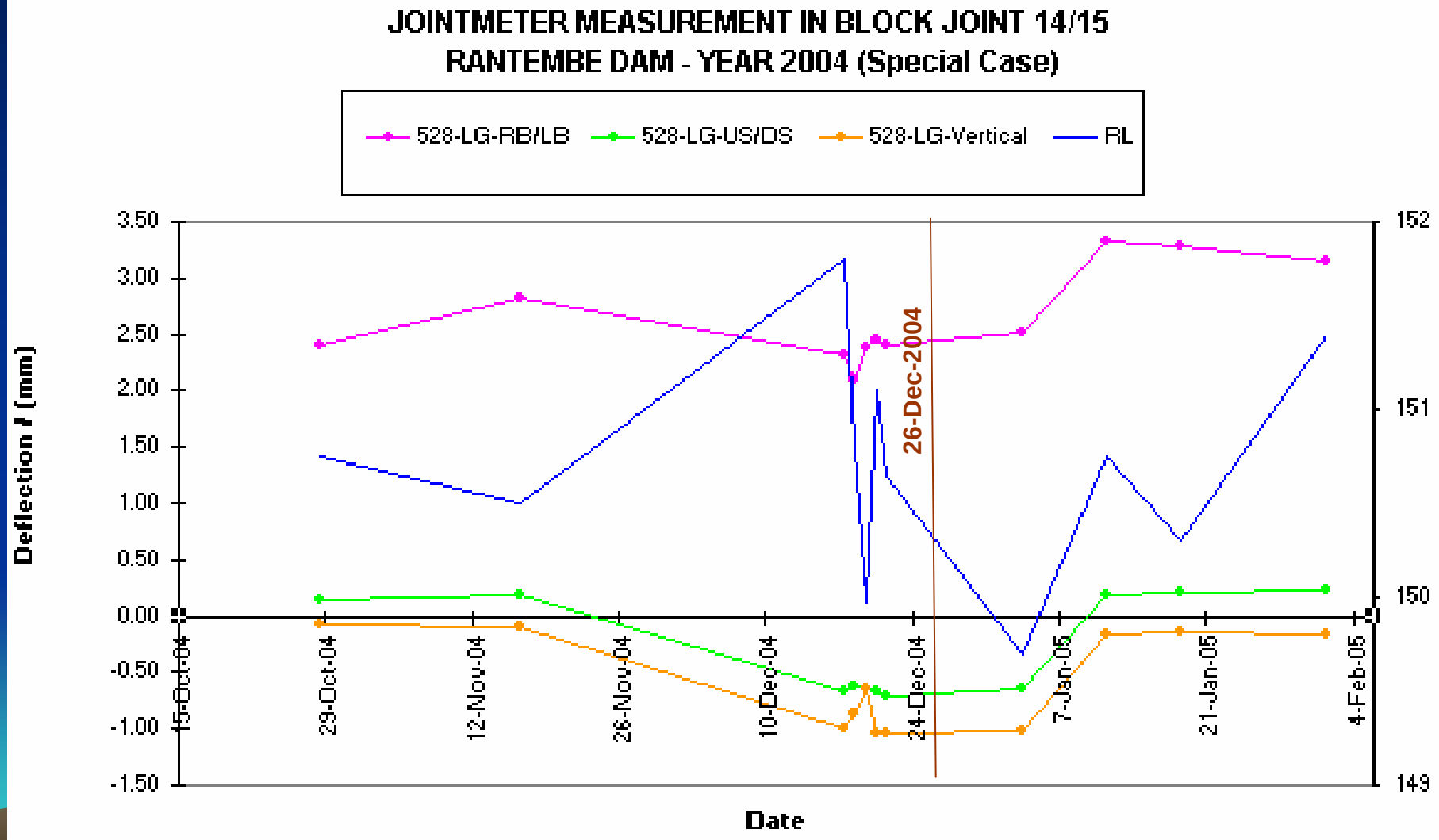


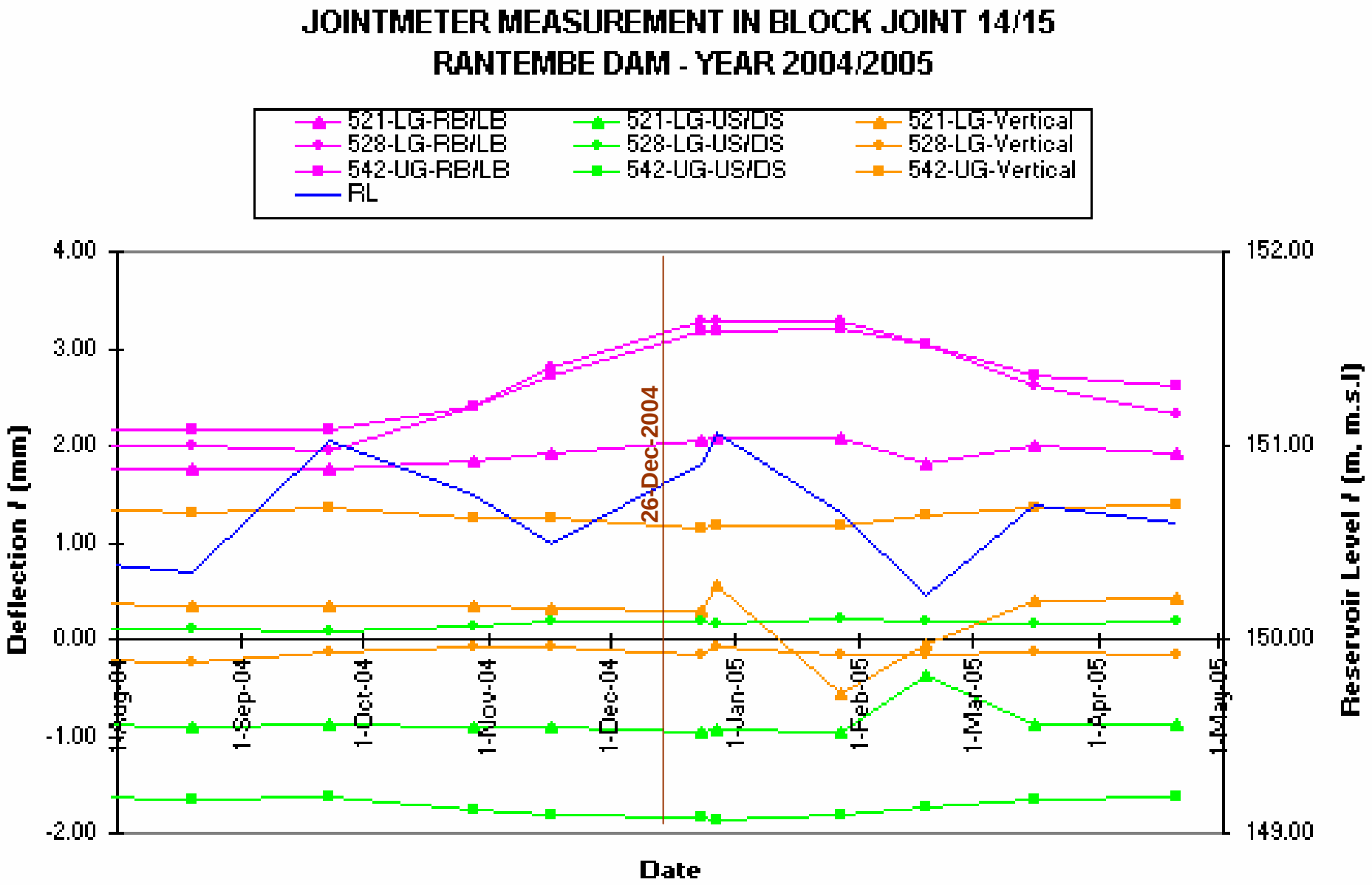
Surface ‘V’ notch construction to trap seepage

A Problem ??

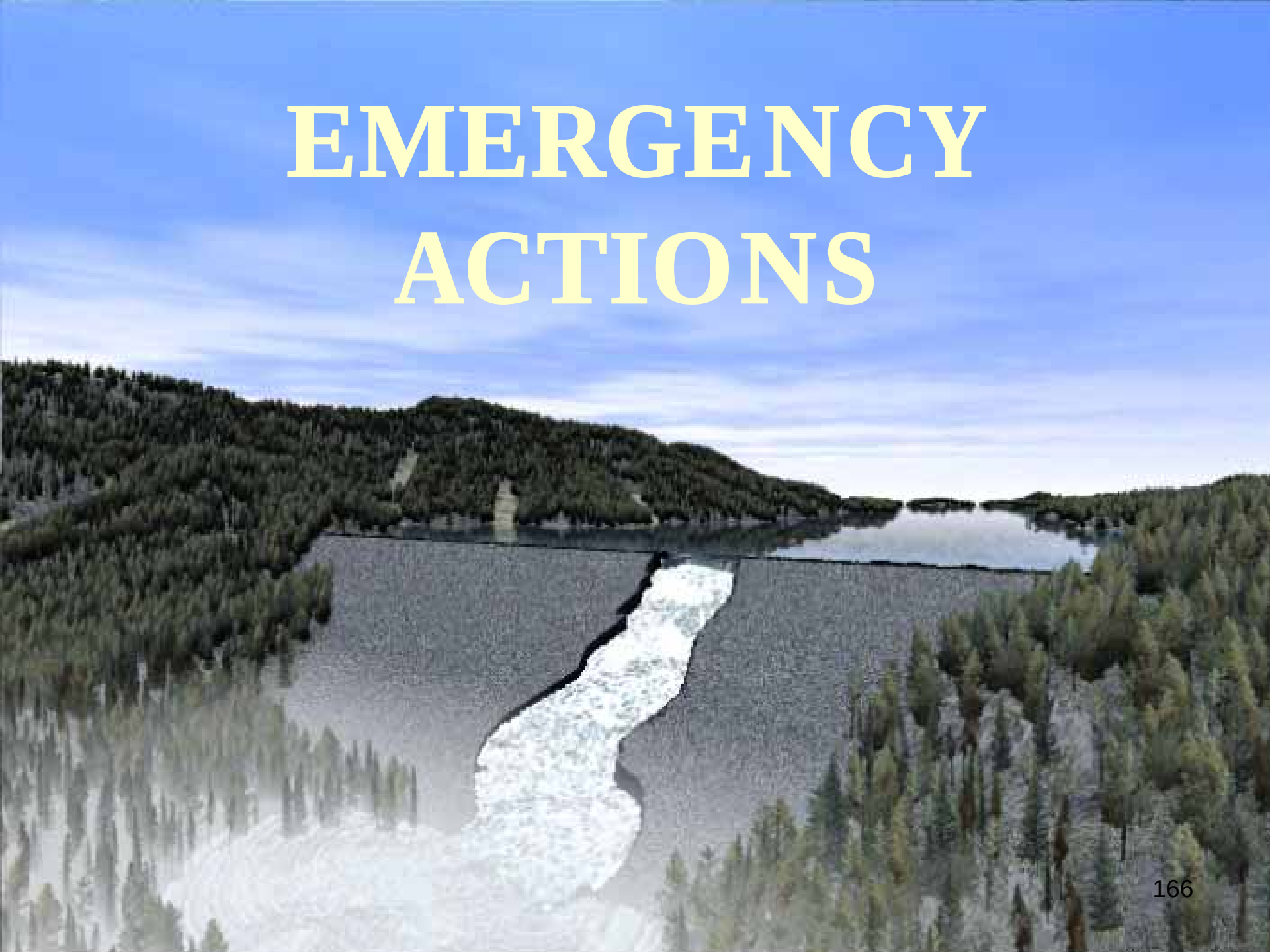
APPLICATIONS IN INSTRUMENTATION READINGS

TREMOR IN 26TH DECEMBER 2004


JOINTMETER MEASUREMENT IN BLOCK JOINT 14/15
RANTEMBE DAM - YEAR 2004 (Special Case)
528-LG-RB/LB
528-LG-US/DS
528-LG-Vertical
RL
Deflection / (mm)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
152
151
150
149
15-Oct-04
29-Oct-04
12-Nov-04
26-Nov-04
10-Dec-04
24-Dec-04
7-Jan-05
21-Jan-05
4-Feb-05
26-Dec-2004
Date


JOINTMETER MEASUREMENT IN BLOCK JOINT 14/15
RANTEMBE DAM - YEAR 2004/2005
521-LG-RB/LB
528-LG-RB/LB
542-UG-RB/LB
RL
521-LG-US/DS
528-LG-US/DS
542-UG-US/DS
521-LG-Vertical
528-LG-Vertical
542-UG-Vertical
26-Dec-2004
Deflection / (mm)
Reservoir Level / (m. m.s.l)
Date
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
152.00
151.00
150.00
149.00
1-Aug-04
1-Sep-04
1-Oct-04
1-Nov-04
1-Dec-04
1-Jan-05
1-Feb-05
1-Mar-05
1-Apr-05
1-May-05

EMERGENCY ACTIONS



DISASTER MANAGEMENT

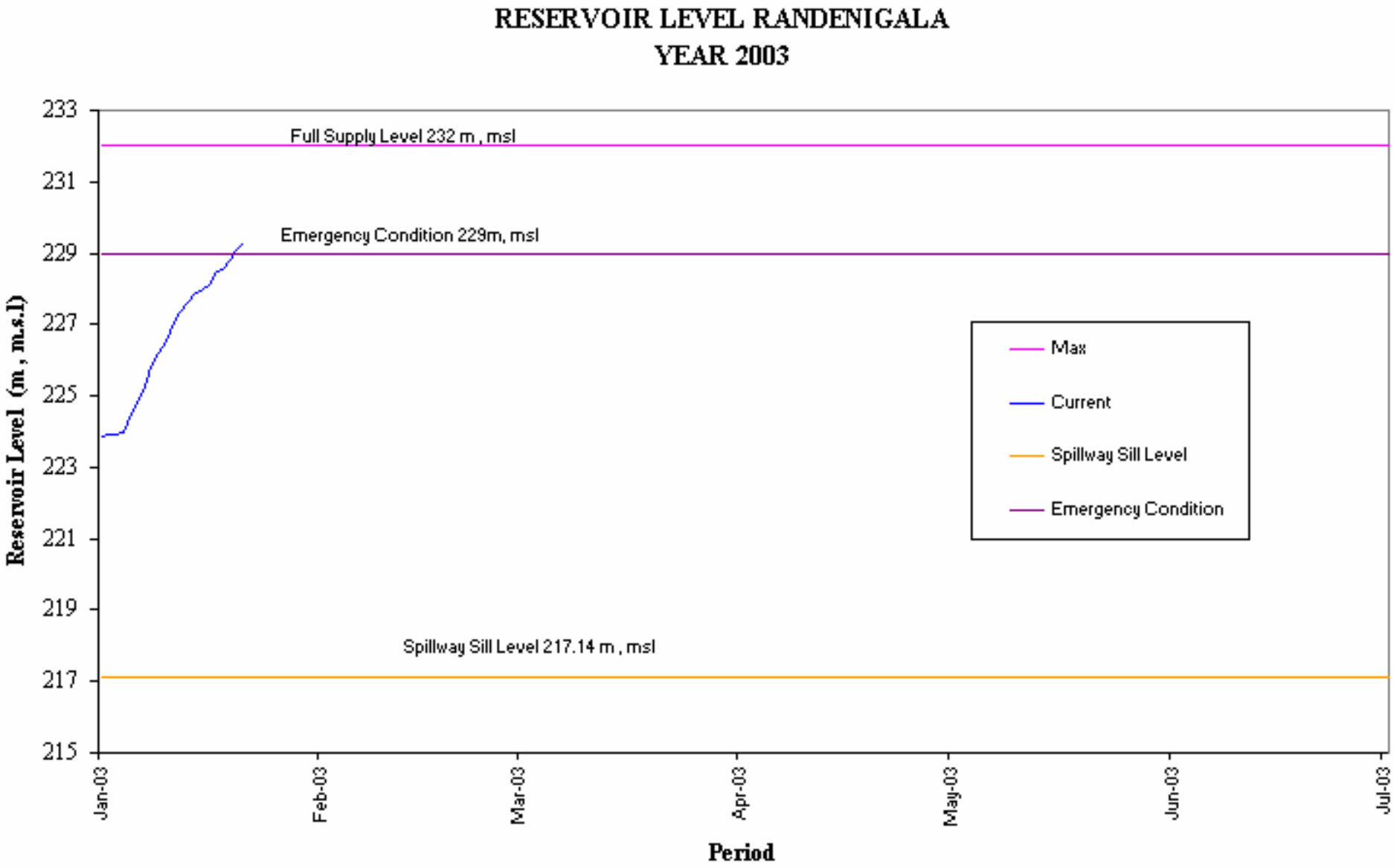
To evacuate the threatened people and property

to the right place

in the right time

to minimize the damage

Emergency Condition

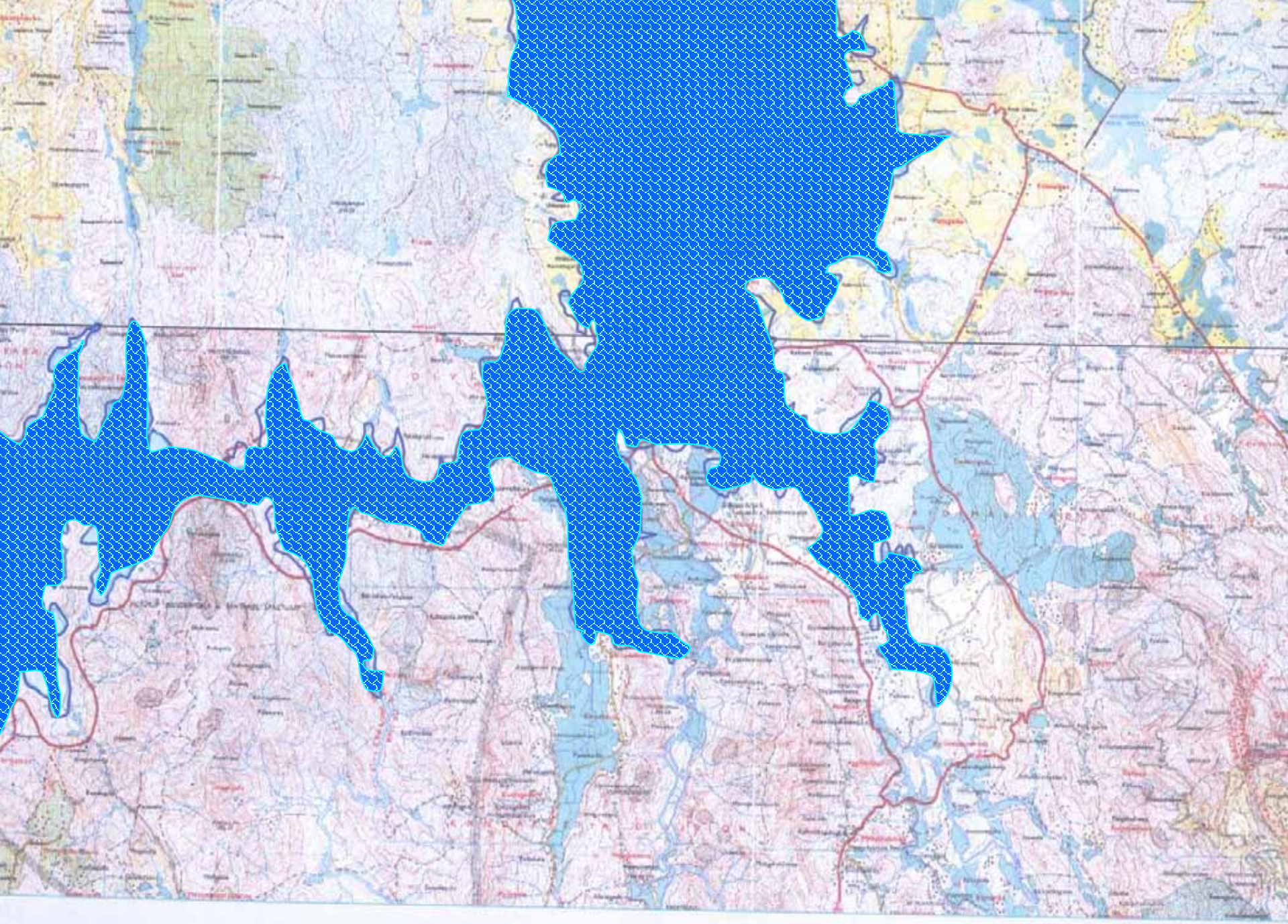


VISION

To save the life of the people living downstream of Randenigala and Rantembe dam

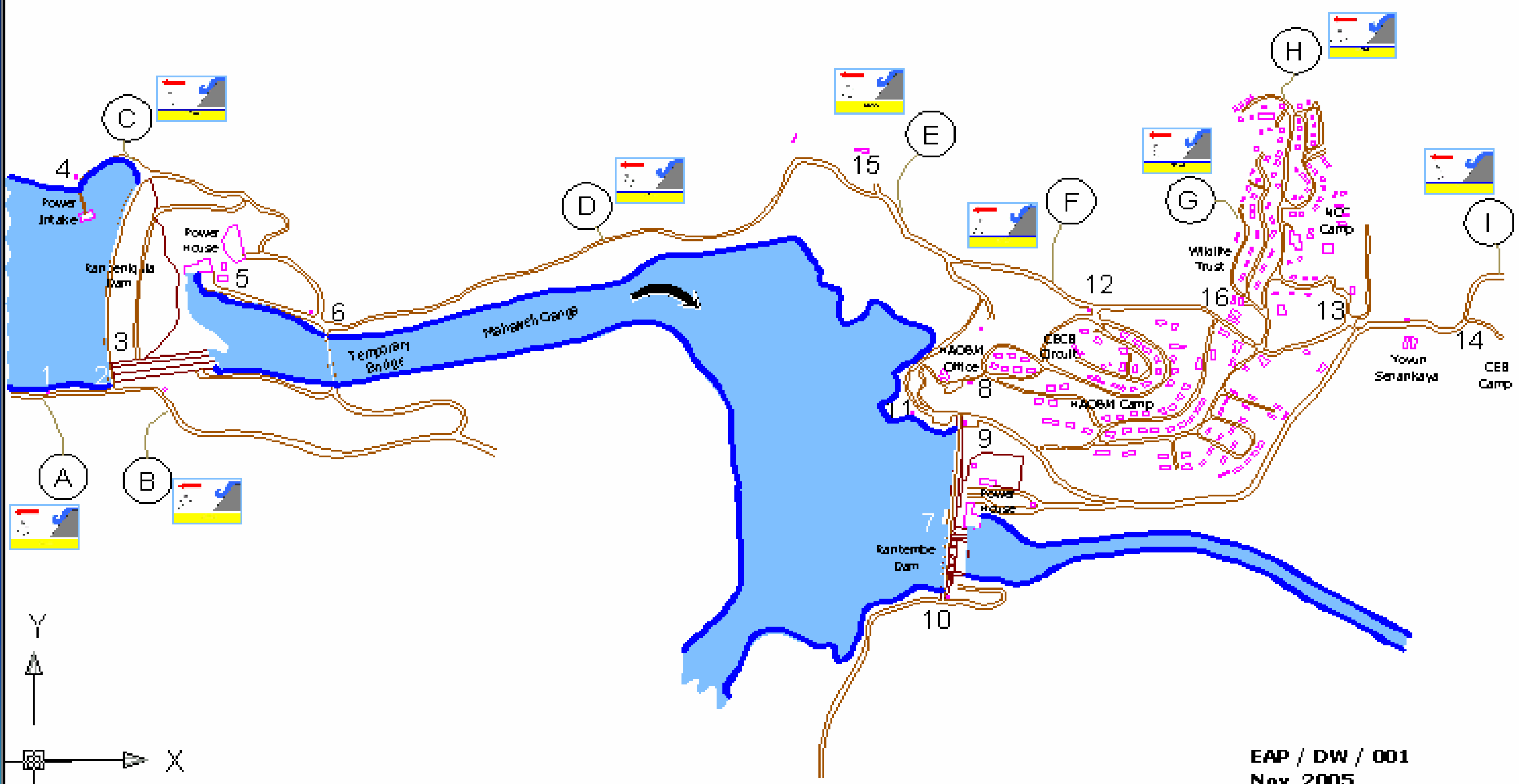
MISSION

To direct the affected people to the right place in the right time



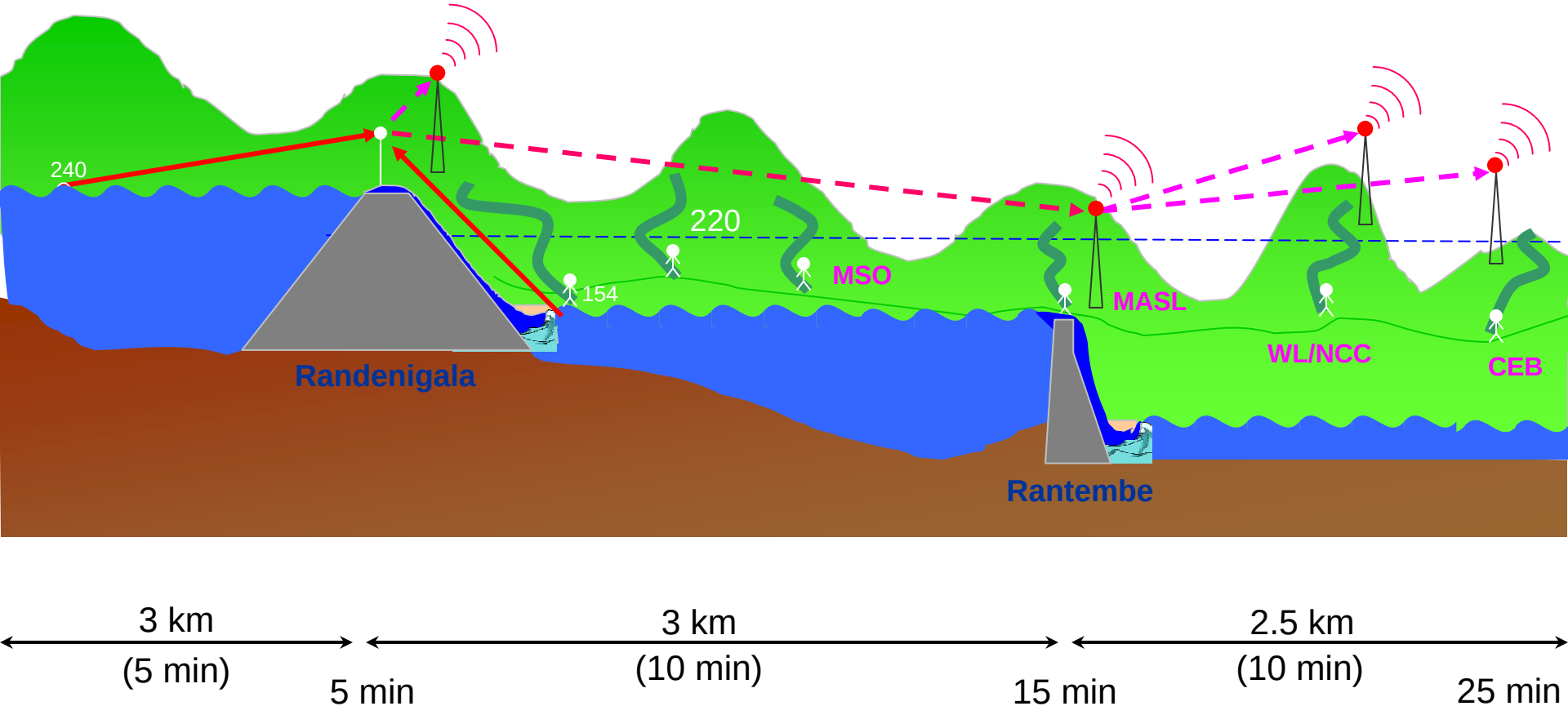
EMERGENCY ACTIONS PLAN

Randenigala -Rantembe Project Area - Evacuation Routes



DIRECTIVE BOARD

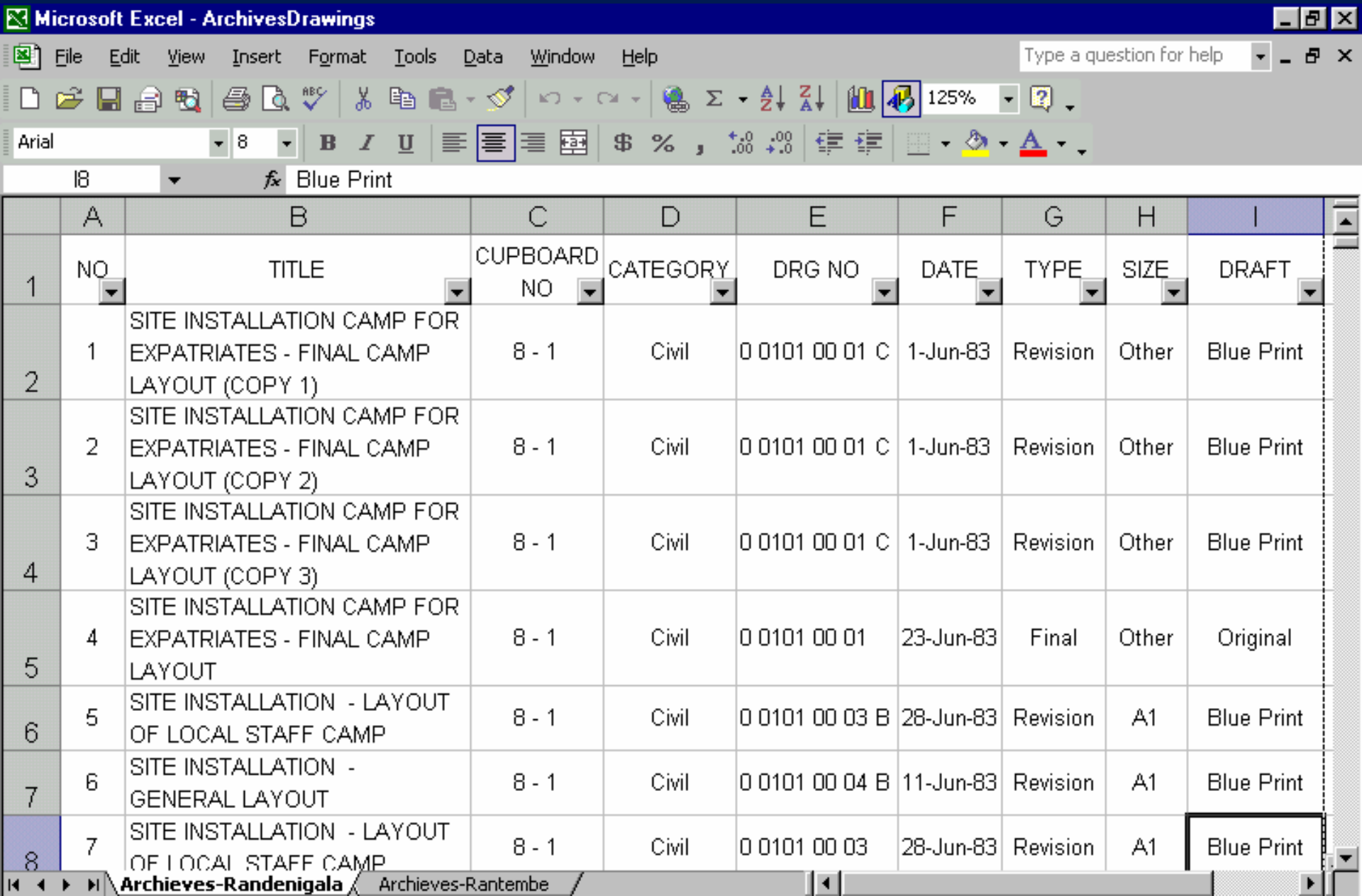
Transmission of Flood Warning Signal



DOCUMENT TRACEBILITY
&
SPARE PART CONTROLS

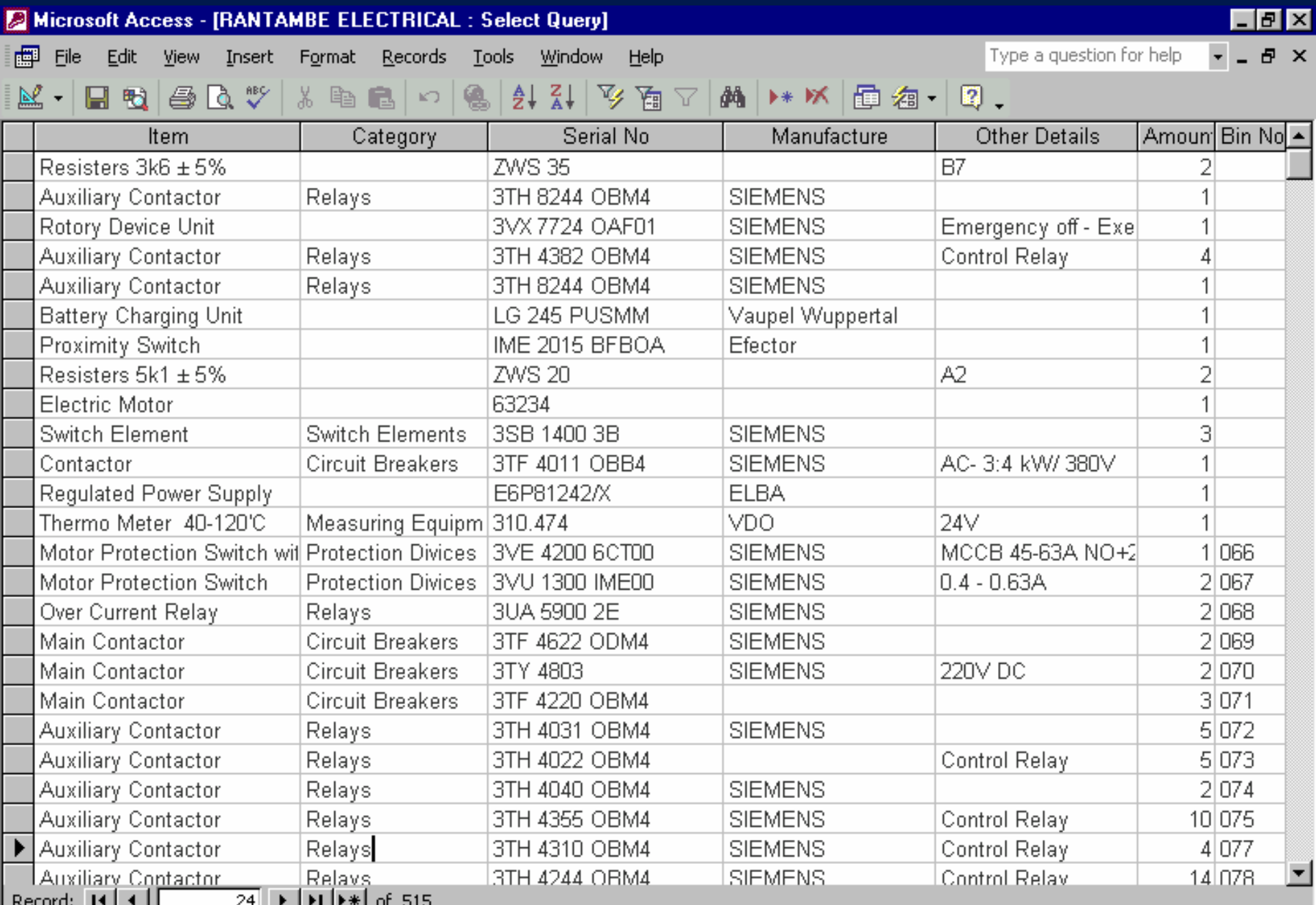
drawings
data (hydrological& instrumentation)
spare parts stock

DRAWINGS DATABASE



	A	B	C	D	E	F	G	H	I
1	NO	TITLE	CUPBOARD NO	CATEGORY	DRG NO	DATE	TYPE	SIZE	DRAFT
2	1	SITE INSTALLATION CAMP FOR EXPATRIATES - FINAL CAMP LAYOUT (COPY 1)	8 - 1	Civil	0 0101 00 01 C	1-Jun-83	Revision	Other	Blue Print
3	2	SITE INSTALLATION CAMP FOR EXPATRIATES - FINAL CAMP LAYOUT (COPY 2)	8 - 1	Civil	0 0101 00 01 C	1-Jun-83	Revision	Other	Blue Print
4	3	SITE INSTALLATION CAMP FOR EXPATRIATES - FINAL CAMP LAYOUT (COPY 3)	8 - 1	Civil	0 0101 00 01 C	1-Jun-83	Revision	Other	Blue Print
5	4	SITE INSTALLATION CAMP FOR EXPATRIATES - FINAL CAMP LAYOUT	8 - 1	Civil	0 0101 00 01	23-Jun-83	Final	Other	Original
6	5	SITE INSTALLATION - LAYOUT OF LOCAL STAFF CAMP	8 - 1	Civil	0 0101 00 03 B	28-Jun-83	Revision	A1	Blue Print
7	6	SITE INSTALLATION - GENERAL LAYOUT	8 - 1	Civil	0 0101 00 04 B	11-Jun-83	Revision	A1	Blue Print
8	7	SITE INSTALLATION - LAYOUT OF LOCAL STAFF CAMP	8 - 1	Civil	0 0101 00 03	28-Jun-83	Revision	A1	Blue Print

SPARE PARTS DATABASE


Microsoft Access - [RANTAMBE ELECTRICAL : Select Query]

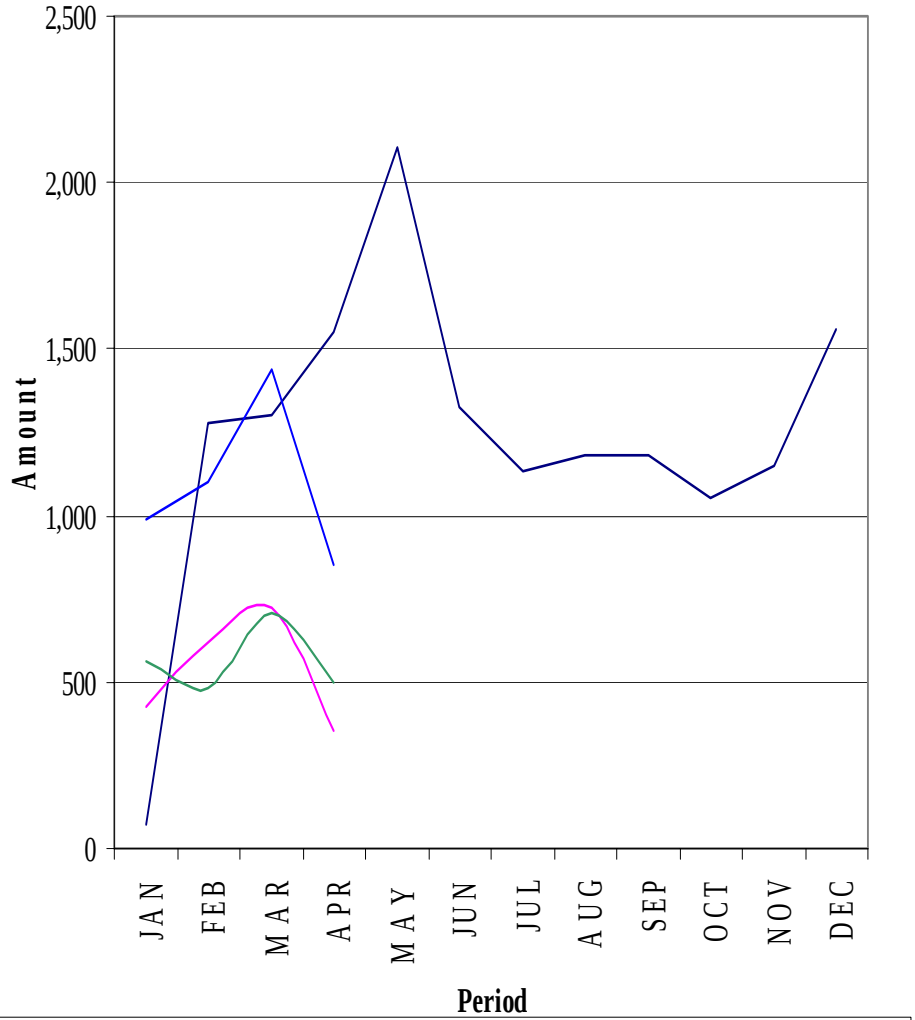
File Edit View Insert Format Records Tools Window Help

Type a question for help

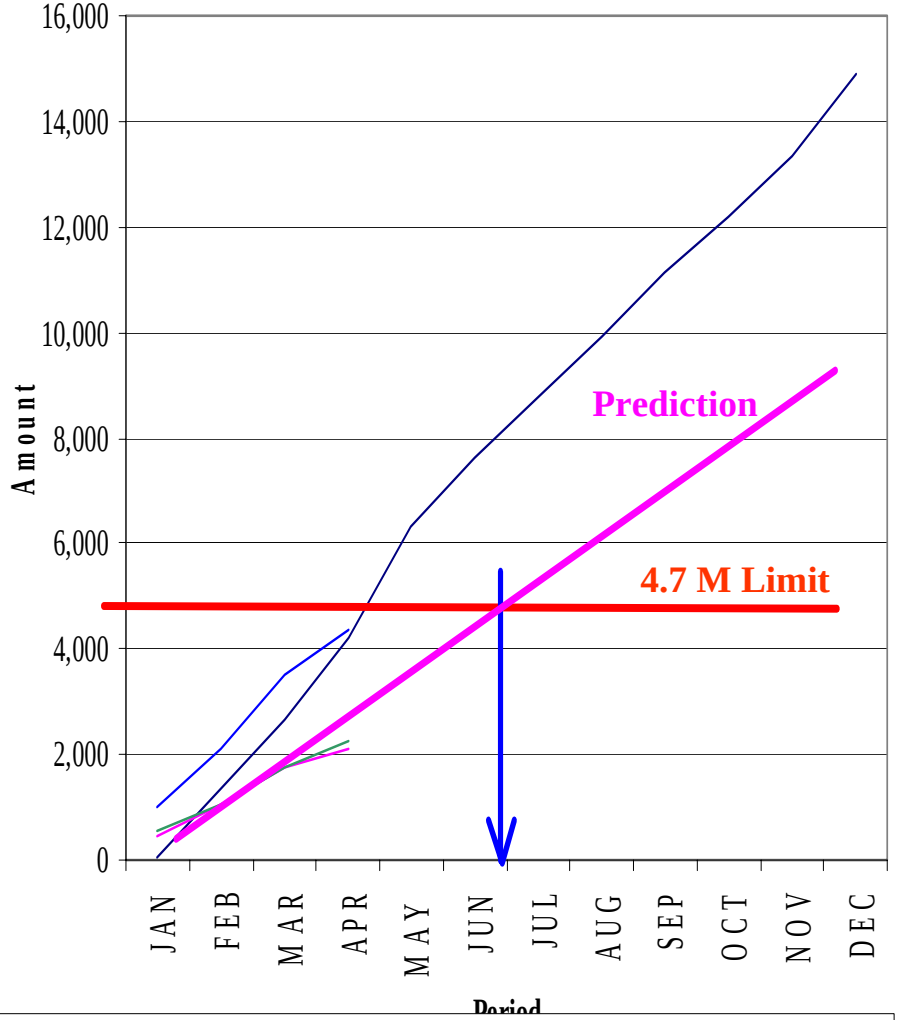
Item	Category	Serial No	Manufacture	Other Details	Amoun	Bin No
Resisters 3k6 ± 5%		ZWS 35		B7	2	
Auxiliary Contactor	Relays	3TH 8244 OBM4	SIEMENS		1	
Rotory Device Unit		3VX 7724 OAF01	SIEMENS	Emergency off - Exe	1	
Auxiliary Contactor	Relays	3TH 4382 OBM4	SIEMENS	Control Relay	4	
Auxiliary Contactor	Relays	3TH 8244 OBM4	SIEMENS		1	
Battery Charging Unit		LG 245 PUSMM	Vaupel Wuppertal		1	
Proximity Switch		IME 2015 BFBOA	Efector		1	
Resisters 5k1 ± 5%		ZWS 20		A2	2	
Electric Motor		63234			1	
Switch Element	Switch Elements	3SB 1400 3B	SIEMENS		3	
Contactor	Circuit Breakers	3TF 4011 OBB4	SIEMENS	AC- 3:4 kW/ 380V	1	
Regulated Power Supply		E6P81242/X	ELBA		1	
Thermo Meter 40-120'C	Measuring Equipm	310.474	VDO	24V	1	
Motor Protection Switch wit	Protection Divices	3VE 4200 6CT00	SIEMENS	MCCB 45-63A NO+2	1	066
Motor Protection Switch	Protection Divices	3VU 1300 IME00	SIEMENS	0.4 - 0.63A	2	067
Over Current Relay	Relays	3UA 5900 2E	SIEMENS		2	068
Main Contactor	Circuit Breakers	3TF 4622 ODM4	SIEMENS		2	069
Main Contactor	Circuit Breakers	3TY 4803	SIEMENS	220V DC	2	070
Main Contactor	Circuit Breakers	3TF 4220 OBM4			3	071
Auxiliary Contactor	Relays	3TH 4031 OBM4	SIEMENS		5	072
Auxiliary Contactor	Relays	3TH 4022 OBM4		Control Relay	5	073
Auxiliary Contactor	Relays	3TH 4040 OBM4	SIEMENS		2	074
Auxiliary Contactor	Relays	3TH 4355 OBM4	SIEMENS	Control Relay	10	075
Auxiliary Contactor	Relays	3TH 4310 OBM4	SIEMENS	Control Relay	4	077
Auxiliary Contactor	Relays	3TH 4244 OBM4	SIEMENS	Control Relay	14	078

Record: 24 of 515

Monthly Cashflow 2002
Randenigala



Cumulative Cash Flow 2002
Randenigala



THANK YOU