# OPERATION AND MAINTENANCE

# GUIDELINES FOR

# CANALS

**NARMADA WATER RESOURCES WATER SUPPLY & KALPSAR DEPARTMENT**

**GOVERNMENT OF GUJARAT**

**APRIL 2009**

# C O N T E N T S

## *PREFACE*

Guidelines for operation and maintenance of canals are prepared to establish in one primary controlled document (with associated supporting documents) the complete, accurate, current structure-oriented instructions for operation and maintenance of canals. The Guidelines include all applicable operating instructions to adequately, safely, and reliably operate the canals including its structures.

The purpose is to ensure adherence to approved operating procedures over long periods of time and during changes in operating personnel.

The Guidelines are prepared primarily for the use of operating personnel located at or nearest to the canal structures and their immediate supervisors (i.e. section officers) who are assigned the responsibility for the operation and maintenance of the canal.

These GUIDELINES CONTAIN, AS A MINIMUM, ALL INFORMATION AND INSTRUCTIONS NECESSARY FOR OPERATING PERSONNEL AND SECTION OFFICERS TO PERFORM THEIR DUTIES.

Operating procedures shall not deviate from those outlined here in these Guidelines without appropriate authorisation and shall be reviewed and updated periodically by the Government.

# Chapter 1

## Introduction

## Operation

The most important service that the canal operators provide to farmers is the delivery of irrigation water. Ideal from a farmer's point of view is freedom in terms of:

- timing,
- flow-rate, and
- ·duration of irrigation applications.

**Objectives:**

- Water flow control
- Water level control
- Canal control under variable flow conditions

Just as an electrical engineer has to control voltage and amperage, the hydraulic engineer has to control pressure and flow in a piped system, and water level and flow in a free-flow canal. This is the double problem of canal hydraulics.

**Water Flow Control:**

There are four reasons for flow control in a canal system:

- meeting water requirements of crops in order to achieve optimum production;
- water savings;
- safety of operation; and
- Recovery of operating costs.

Water requirements vary with the type of crop, the stage of growth, seasonal variations in climate, and daily variations in weather, especially rainfall. Both too much and too little water affect crop yields, especially at certain critical stages of growth like tillering and flowering for paddy rice. The response of irrigation supply to demand must be accurate and immediate.

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The need to save water is especially important as water is scarce, water wastage in wet season can limit the area under irrigation in both wet and dry season. Systems should be operated so as to accommodate any sudden fall in demand, as at night or during a sudden rainstorm

To ensure safe operation, the flow released into a canal should not exceed its carrying capacity, which decreases from upstream to downstream. Overtopping of canals can be avoided by means of operating escape structures provided to spill excess water into the drainage system. The spilled water can be reused further downstream but at energy cost and with the risk of using water of lesser quality.

The fourth reason for accurate flow control is to provide a basis for sound cost recovery. Farmers can be charged on volumetric basis for irrigation services and application of volumetric quota is feasible.

**Water Level Control**

Control of water level in a canal system is important and the acceptable fluctuations are not very large. The four reasons for water level control are

- to keep command of the service area through gravity,
- canal protection against deterioration,
- canal safety and
- flow control at off-takes

The higher the level in a canal, the larger the area which can be irrigated by gravity without pumping -- an important consideration for the users.

Canals are run only at full supply to ensure a constant water level at each off-take. However, to meet the requirements of modern irrigation, canals have to be operated under variable flow conditions. Since there is a direct relationship between flow and water level in a canal under uniform flow conditions, steps have to be taken to raise the level in the canal by artificial means.

The next reasons for controlling water level are canal safety and protection. The water level should not exceed an upper limit in order to avoid overtopping and wasting water through escape structures.

But if the water level drops too low and too fast, canals may deteriorate because of backpressure on canal lining and the instability of canal slopes in difficult soils. It is important, therefore, to keep the water level between a maximum, which is imposed for safety reasons, and a minimum, which is needed to supply the land by gravity.

By keeping water levels high enough, erosion from rain falling in an empty earth canal is prevented.

The fourth reason for controlling water level variations in a canal is to facilitate the flow control and measurement of water at off-takes.

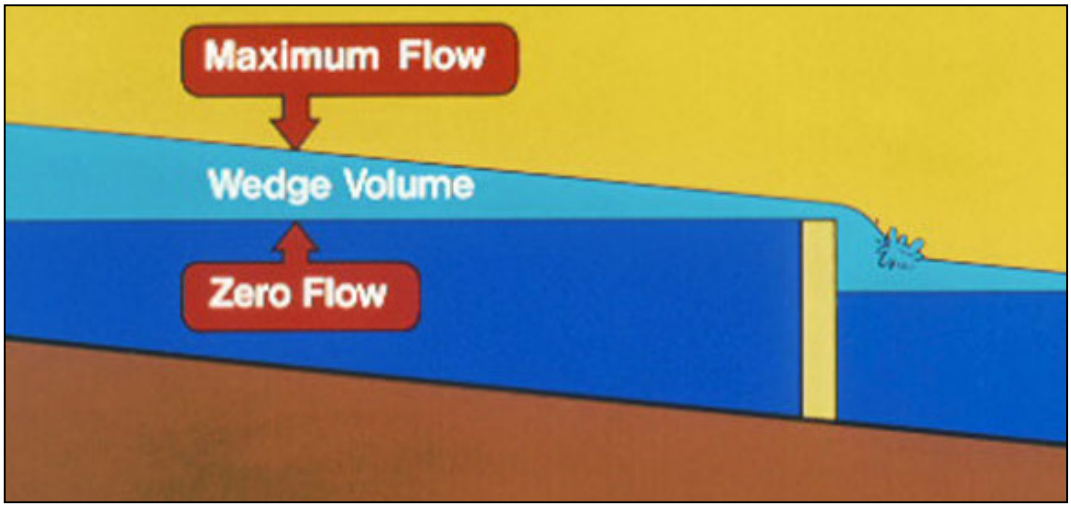
The flow delivered through an off-take depends on the water level upstream. Limiting variations in the water level at canal off-takes to facilitate control of flow releases, therefore, is a crucial task.

Water level control is a basic concept, which has been incorporated into traditional irrigation schemes. Farmers

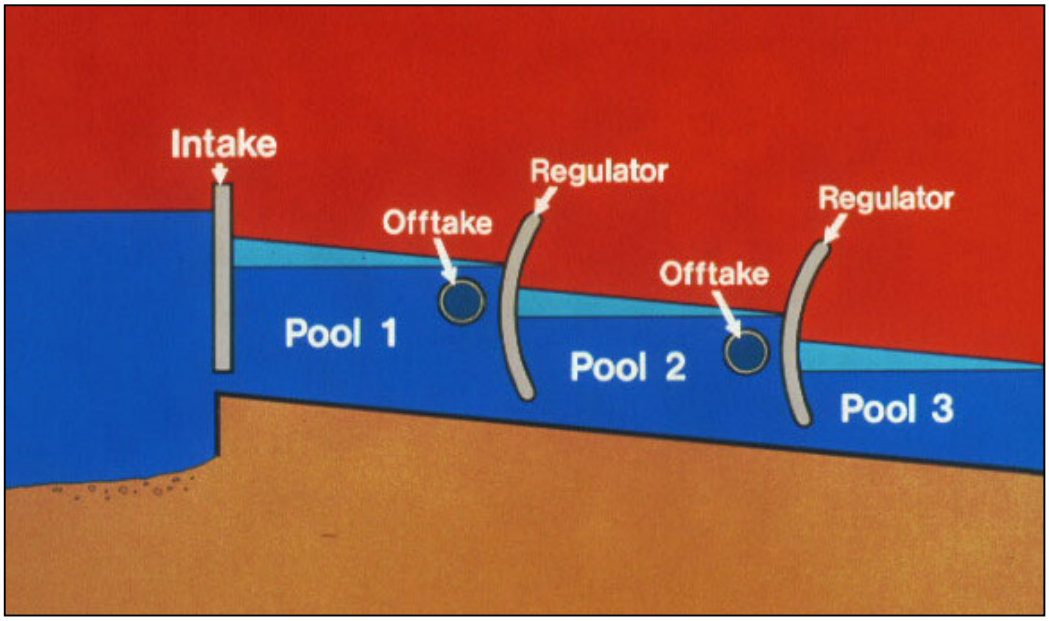
have always known how to dam their streams and canals when and where necessary.

The same concept is used also in the simplest design of new canals: water level is controlled through gated cross-regulators.

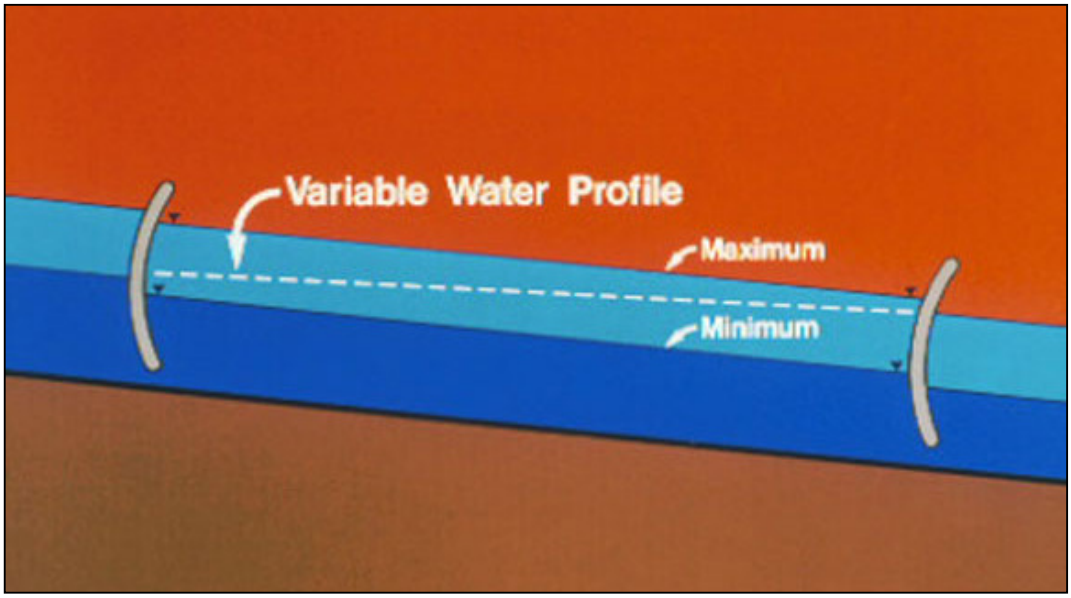
By damming a canal with cross-regulators, the water surface profile varies with the discharge from a line parallel to the canal bed at maximum flow to a horizontal line at zero flow. The volume contained between the two profiles is called the wedge volume.



In other words, the basic design of an irrigation system operated continually with variable flows is to divide the canals into successive pools and to locate the regulators and the off-takes in such a way that the differential water level variations remain within certain limits.

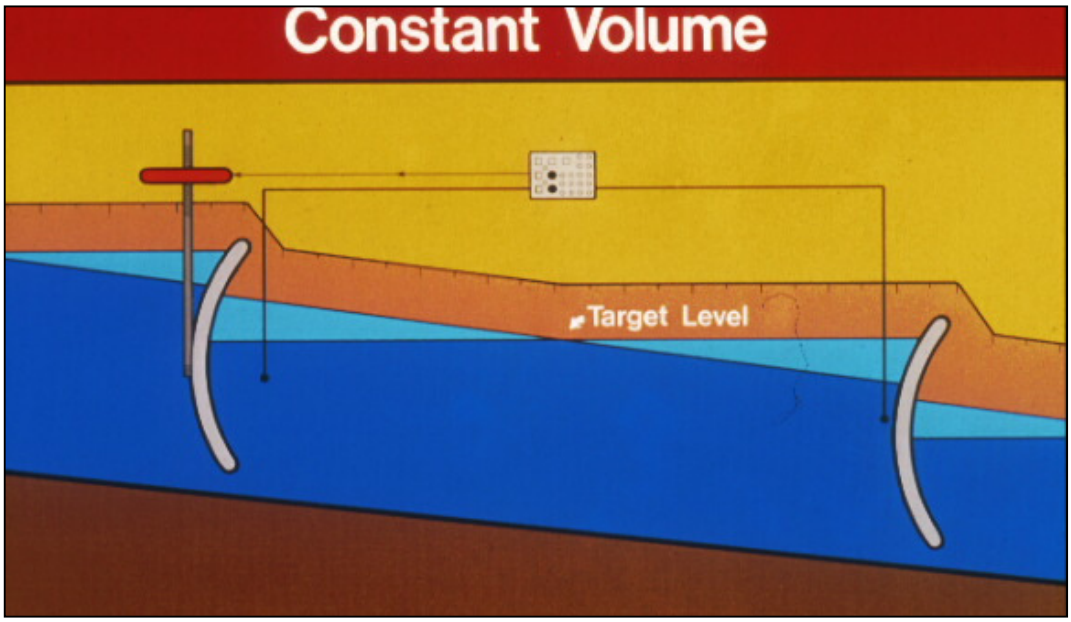



In each pool, the water level should remain within a maximum and minimum level but the surface profile can take any position within the two extreme lines.

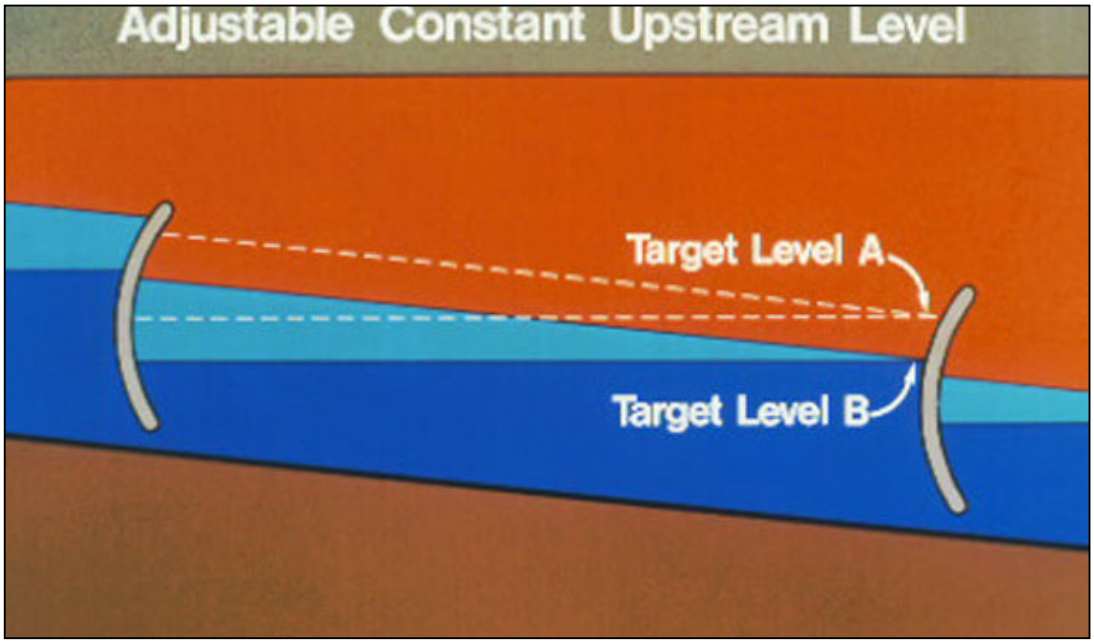


Target levels can be fixed or may even be adjustable.

Adjustable target levels offer some flexibility in operating canal carrying silt-laden water. This prevents sedimentation during periods of low flow demand, for example, during the early stage of project development.




The target level in any section could also be between two regulators. When the control point is approximately in the middle of a pool, this method is called constant volume.



## Working principle

Farmers in an irrigation scheme cannot just open and close their gates as they wish. If too many farmers who are located closer to the source are irrigating, the downstream users will receive no water. If farmers stop irrigating, the canal will overtop.

In an open canal scheme, the flow entering the scheme must equal the sum of the flows delivered to the farms.

The discharge at each minor off-take is regulated through an adjustable flow-control device. The discharge at each distributary's off-take is regulated with a vertical slide gate, according to the irrigation water requirement of that distributary. A gate at the head of the distributary allows adjustment of the flow size entering that distributary to the sum of the flow rates delivered through the minor's off-takes. Similarly a gate at the head of the branch or sub-branch canal allows adjustment of the flow size entering the branch or sub-branch canal to the sum of the flow rates delivered through the distributary's off-takes. Cross regulators along the branch canal maintain sufficient water depth at the off-takes when the canal is operated at lower than design capacity.

The design allows delivery of water to the minors in accordance with the actual irrigation needs of each minor and the water supply available to the scheme. Because of the difficulties involved in setting the gates to the required discharge, it is not recommended to reset the gates more

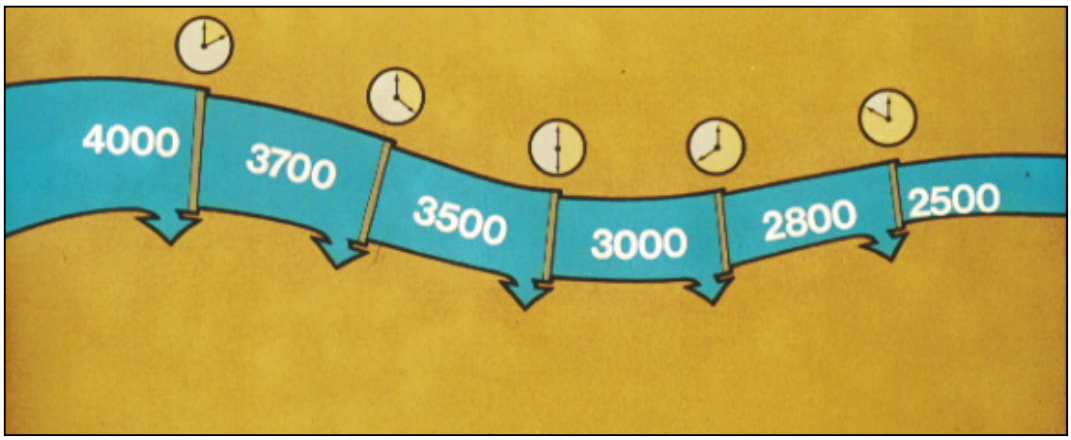
often than once a week. As an example, a procedure is presented for weekly irrigation scheduling for a scheme.

**General Practice for operation of canals:**

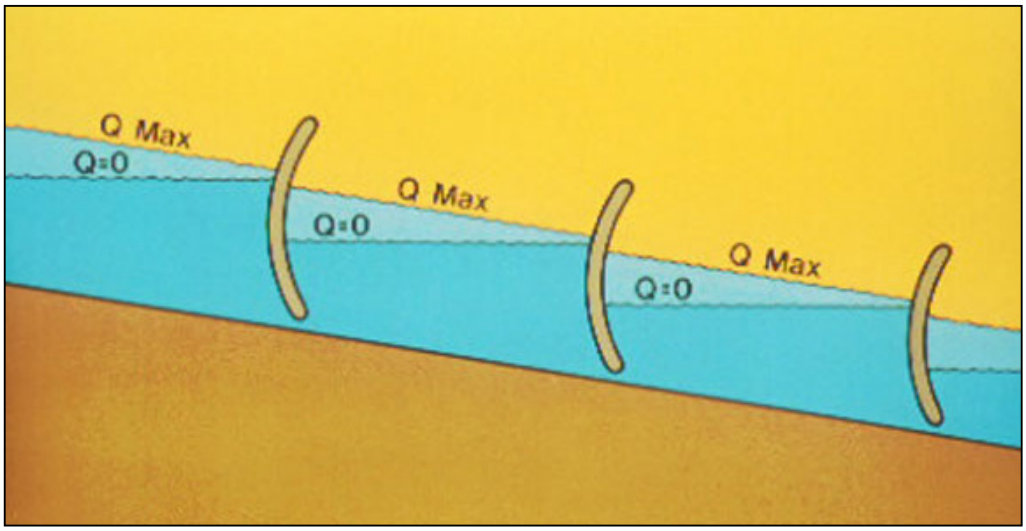
The typical management of a surface irrigation system is as follows:

The operators add up the daily or weekly individual water needs for each minor whether requested by group of farmers or determined by the project management. The information on total demand is then transmitted further upstream to distributary's Head Regulator.

The daily demands for each minor are transmitted SEVEN days in advance to the Section Officers responsible for the operation of the distributary. These Section Officers, in turn, report to the next higher level taking into account the distribution efficiency. The process is repeated up to the head regulator at the Head of the Branch canal, accounting for the conveyance efficiency. Estimates are then made of the transmission time needed for the change in flow rate to travel from the head regulator to various off-takes. These computations must also account for the change in wedge storage volumes. The flow rate is then changed at the branch canal's head regulator.




The canal is divided into successive pools by means of cross regulators.




If the cross regulators are manually operated, each one should be adjusted at frequent intervals as the flow change moves downstream. Many small adjustments may be necessary because the change in flow rate arrives gradually at various regulators. It is difficult to make predictions of the necessary adjustments in control gates because of the large number of hydraulic variables. It is almost impossible to set the flow released at the head regulator of the branch

canal to exactly the amount needed to meet cumulative demand and to compensate for seepage and evaporation losses on the way. To ensure that the lowest off-take is adequately supplied, the flow released at the head regulator of the branch canal must include an additional amount as a safety margin. When there is an unscheduled fall in demand due, for example, to a rainstorm, the off-takes are closed to avoid crop damage from over-watering. Water stored in the wedge volumes is then lost through the tail escape to the drains.

The off-take gate can be locked in the required position with a pin. Larger capacity off-takes would have to be operated with a hand-wheel. Immediately downstream of the off-take gate there is a measuring flume. A rating table can be calculated for measuring flume.

# *Chapter 2*

# *General Operating Practices*

## **1.0**. **Outlet Works Gate Exercising**

(1) Each gate or valve that releases canal water through an outlet work, including those designated as emergency and regulating gates or valves will be exercised through a complete opening and closing cycle at least annually under a balanced-head condition or with the outlet works dewatered.

(2) Unbalanced-head (flow) condition exercising of emergency gates and valves is to be performed on a 6-year frequency. All scheduling of unbalanced-head (flow) condition exercising of emergency gates will be coordinated with area office personnel prior to being performed.

(3) All gate and valve exercising operations will be documented in the operating log or other appropriate means to serve as a permanent record for reference purposes. A copy of data related to unbalanced-head exercising of emergency gates and valves will be sent to the Superintending Engineer Design Circle, Gandhinagar for inclusion in a project-wide database for gate and valve tests.

(4) Any site-specific variances from these exercise requirements will be reflected and documented in the SOP

for the facility after receiving approval from Chief Engineer (QC & Designs).

Exercise requirements are also to include the use of emergency or backup power sources.

Guidance on gate and valve exercising is also outlined in Chapter 3.

**2.0 Escape Gate Exercising**

(1) Escape gates will be exercised annually to confirm that the gates will open and close satisfactorily.

(2) All gate exercising operations will be documented in the operating log or other appropriate means to serve as a permanent record for reference purposes.

(3) Any site-specific variances from these exercise requirements will be reflected and documented in the SOP for the facility; however, such variances will be subject to appropriate approval.

Exercise requirements are also to include the use of emergency or backup power sources. Guidance on gate and valve exercising is also outlined in Chapter 3.

## 3.0 Operation and Maintenance Log (Logbook)

### 3.1 Requirements

A bound operation and maintenance log or logbook will be maintained at each regulating structure. Previously completed logbooks will be kept in a secure and dry location that will allow for ready reference by the operating personnel (or by Design office). At part-time attended facilities, records will be kept for the period of attended operation. At unattended facilities, records will cover each visit made to the facility. A permanent logged record (paper or electronic) will be maintained by either the section officer or the designated alternate on duty.

### 3.2 Content

The log will contain chronological entries of all important events to provide a continuing record of operating activities for future reference. Entries in the operating log will include the documentation of the following activities, as a minimum:

(1) Normal and emergency modes of operation of outlet works and/or escapes including individual gate position changes.

(2) Water elevations and discharges

(3) Startup and stopping of mechanical equipment.

(4) Test of standby equipment or gate controls.

(5) Test and exercise of outlet and escape control devices (gates and valves).
(6) Minor and major maintenance activities, including scheduled maintenance e.g. lubrication, cleaning, painting, clearing debris, tree removal, repairs, erosion etc.

(7) Canal surveillance e.g. areas of embankment and other structural irregularities, including location of settlement, sloughs, erosion, tilting of walls, jacking of slabs, etc.

(8) Records of seepage, including volume, clarity, and damp spots at the abutments, on the downstream face of the embankment/structure etc. All seepage measurements should be accompanied by the corresponding canal water surface level.

(9) Initial acknowledgment of an emergency or unusual condition.

(10) Acts of vandalism or other security incidents.

(11) Request and concurrence to change from normal operation during an emergency or unusual conditions.

(12) Communications network checks and emergency exercises conducted.

(13) Record of names, addresses, and purposes of visitors.

(14) Acknowledgment of SOP/EPP review by operating personnel and supervisor.

(15) Verification of annual site inspections, facility reviews, and special examinations.

(16) Documentation of receipt of operators training (onsite and/or classroom).

(17) Miscellaneous items pertinent to operation, emergency, or unusual conditions at the structures.

### 3.3 Operating Log (Logbook) Entries

All entries in the bound operating log will be made legibly in ink, dated, and signed. Neither erasures nor ink eradicators are to be used to make the corrections. Errors are to be lined out lightly, so that the incorrect notation is still legible after the correct entry is made. If electronic logs are used, they are to be password protected or other appropriate actions taken to prevent loss or alteration of past records. A sample log is illustrated in ***Appendix-A***

### 4.0 Forms

Forms for Telephone Report of Water Interruptions and Facility Failure (emergency or unusual conditions) or other approved daily record, where needed, will be considered part of the operating personnel's operating log. They will be available at all times. A listing of these additional forms will be recorded in the front of the operating log.

## 5.0 Procedure of operation and assignment of duties & responsibilities

- All canals shall be operated as per the schedule decided by the Executive Engineer in charge before commencement of each irrigation season.
- Generally during any rotation the canal shall flow at its Full Supply Level (FSL).
- In case for some reason it is not possible to run the canal at its design FSL, the water level in the canal shall be controlled by operating the gates of Cross Regulators so that sufficient head of water is available at the Head Regulators of all off-taking canals.
- As per approved project report, no canal shall run for irrigation during summer i.e. after 15th of March every year except for _____ projects.
- In designated canals where the Government has entered into water supply agreements, water shall be supplied during summer for drinking supply as well as industrial supply.
- Section Officers in charge of the Minors) shall place firm indent of their daily water requirement a week in advance in prescribed proforma to the Section Officers in charge of Distributaries, indicating:
- The number of hours per day for which they want to receive irrigation water in their minor;
- The flow rate that they want to receive at the minor off-take.

- The Section Officers in charge of the Distributaries shall prepare the irrigation schedule on the basis of these requests.

Estimates should then be made of the transmission time needed for the change in flow rate to travel from the head regulators of Distributaries to various off-takes of minors. These computations must also account for conveyance efficiency as well as the change in wedge storage volumes. The flow rate is then changed at the distributaries' head regulators.

- If the available water supply is not sufficient to meet the requested volumes, the Executive Engineer can impose restrictions on the flow rates and hours of operation after consulting the Farmers/ Water Users' Associations in respective command area. These restrictions should be announced before the farmers make their weekly requests. In times of constrained water supply, the Section Officers can indicate these restrictions on the request forms before they are distributed.
- The Section Officers in charge of Distributaries shall place firm indent of their daily water requirement in prescribed proforma to the Section Officer in charge of branch canal who in turn shall repeat the process and place indent at HR of the main canal.
- All downstream Section officers responsible for operation of branch canal shall communicate the

requirement of their respective sections to the section officers located immediately upstream.

- The section officer in charge of head regulator of main canal should then work out the estimates of transmission time needed for the change in flow rate to travel from the head regulator to various off-takes of Distributaries. These computations must also account for the change in wedge storage volumes. The flow rate is then changed at the main canal's head regulator.
- Depending upon the discharge required to be released in the distributary, the Section officer in charge of respective section of branch canal should adjust the gate opening of the cross regulator downstream so as to ensure the availability of sufficient head.
- In order to factor in actual site conditions, all the gates of canal shall be calibrated every year and corresponding gauge—discharge tables shall be prepared and kept at each structure.
- Any discrepancy in design discharge and actual one be investigated, analysed and reported to SE (CDO), Gandhinagar.
- While operating gates, care should be taken to ensure that at no point of time, the gates get overtopped.
- Both the gates of Cross Regulator should be opened equally to ensure uniform flow and hence the safety of the structure.

- A continuous record of all such operations and measurements shall be kept in an Operating Log as described vide section 3 of this chapter.
- When there is an unscheduled fall in demand due, for example, to a rainstorm, the off-takes shall be closed to avoid crop damage from over-watering. Water stored in the wedge volumes is then required to be released through the escapes to the drains after ensuring adequate safety of downstream area. Simultaneously, water demand at the head regulator of main canal should be reduced with a view to preventing wastage of water. However, in no case the drinking water supply should get adversely affected.
- Respective sections shall establish continuous communication amongst themselves so that flow in any canal is not increased/ decreased suddenly without prior knowledge and preparation on either side. In case of difficulty the Deputy Executive Engineer in charge shall be contacted for intervention.
- The idea is to ensure smooth flow alterations resulting into efficient irrigation water management so that the customers i.e. the end users do not suffer from any hardship and quality of service is maintained. Executive Engineer in charge shall be fully responsible to ensure that the system functions as intended.
- Legible gauge marking shall be painted on piers and upstream and downstream of structures. This should be so done as can be clearly visible from a distance.

## 7.0 Water supply for drinking, industrial purposes

**7.1** Government might have entered in to an agreement to supply water to various State Government agencies like GWSSB/ GWIL / GIDC/GUVNL /PGVCL/ MGVCL / DGVCL/UGVCL and also with the private parties for providing drinking as well as industrial water supply. In all such cases management of supply at the respective Head Regulator situated in the canal owned by the Government shall be the responsibility of the concerned Section Officer. He shall ensure that quantity of water as decided or agreed upon is supplied to the user agency promptly and that the measurements of water so drawn from Govt canal by the user agency are appropriately taken through a calibrated measuring device and properly recorded. Monthly data shall then be reported to the Deputy Executive Engineer for each unit separately for preparing bills.

Demand for water supply at each such outlet is required to be placed by the section officer in charge on daily basis a week in advance as in the case of irrigation demand. Any shortfall in quantity should be immediately brought to the notice of section officer in the upstream reach as well as the Deputy Executive Engineer in charge. The deficiency should be tracked to the location of its occurrence and should be corrected immediately by the officer in whose reach the quantity has reduced.

**7.2** A section officer shall ensure that all monies due to the Government are promptly recovered from all units drawing water. He shall also take appropriate action as laid down in each agreement signed with Government so as to enforce discipline.

# *Chapter 3*

# *Special Instructions*

Conformance to special instructions is important for continuing safety and economical operation of the structures.

## 1.0 Overtopping Radial Gates

Radial gates have *not* been designed to support an appreciable water-flow over the gate tops. It should therefore be ensured while operating the radial gates that the inflow and outflow in a given section of the canal is so adjusted that there should be no overtopping of radial gates at any point of time.

## 2.0 Multiple Gate Openings

Optimum operating condition is produced usually when water--flow is distributed uniformly across the glacis of a fall when it enters the basin/cistern. A hydraulic control structure having more than one control gates produces flow distributed uniformly into the stilling basin/cistern when all gates are opened equally. Where all gates cannot be opened equally, the most desirable flow patterns usually are produced by equally opening gates located symmetrically about the centerline of the structure.

## 3.0 Gates and Valves - Exercising and Testing

**3.1** Safety of the structure and good operation and

maintenance practices require that each gate (of head regulator, cross regulator and escape and any other outlet) be tested to confirm that it will operate as designed. Each gate that releases canal water through an outlet work, including those designated as emergency and regulating gates will be exercised through a complete opening and closing cycle at least annually under a balanced-head condition or with the outlet works dewatered.

Circumstances at each structure will govern the extent and frequency of testing. Any site-specific variances from these exercise requirements will be reflected and documented

A note of caution:

> ***CAUTION:*** *If - during any test - the gate will not close from any position or otherwise malfunctions stop the test and determine the cause of the malfunction and correct it. Contact the responsible officer in Design Office before further testing.*

**3.2** Exercising and testing machinery should be done by using *normal* and *auxiliary* power sources to ensure the operation of each.

All exercising and testing results should be recorded and dated in the *Operating Log* at the structure to serve as a permanent record for reference purposes.

**3.3** A differential-head test should be performed annually on each s gate (if possible) while subjected to the maximum head expected for the season. Testing confirms that the

gates will open and close satisfactorily. Testing should be conducted in the following sequence:

Open the gate 10 percent - then close. If the gate has not been operated in the past year, the 10-percent test should be made in progressive steps as follows:

a. Barely open (crack) the gate so that it will produce additional leakage - then close.
b. Open the gate 1 inch - then close.
c. Open the gate 6 inches - then close.
d. Open the gate 10 percent - then close. If 10-percent gate opening is impossible because of downstream restrictions, open it as far as possible -then close.

If the gate passes this test successfully, a routine test should be scheduled for the following year.

**3.4** At scheduled intervals, each gate should be raised to the fully open position and closed while in a balanced-head condition. This part of the test should be scheduled during the season at proper canal conditions. Postponement of maximum gate operational testing should not exceed a 6-year period. If the gate has not been operated in 6 years, it should be exercised first in a balanced condition prior to any differential-head test.

**3.5** Each gate that releases water through an outlet work, including those designated as emergency gates and regulating gates or valves, shall be exercised through a complete opening and closing cycle annually under a

balanced head condition or with the outlet works unwatered. An operational test shall be performed on emergency gates once every 6 years. The test shall be developed for each specific emergency gate installation. At most facilities, raising the gates from 1 to 3 Inches - from the closed position - with the downstream conduit unwatered will suffice.

> **CAUTION:** *OPERATIONAL TESTING OF AN EMERGENCY GATE UNDER AN UNBALANCED HEAD SHOULD NOT BE PERFORMED UNLESS THE CONDUIT DOWNSTREAM FROM THE GATE IS EQUIPPED WITH EITHER AN AIR INTAKE VENT OR AN AIR INLET AND AIR RELEASE VALVE.THIS APPLIES TO CLOSED LONG CONDUITS.*

**3.6** All required lubrication and maintenance of equipment should be done prior to operational testing and exercising.

## 4.0 Fluctuating Releases

**4.1** At escapes where changes in the releases could endanger commuters, hikers, or others along the river downstream from the escape, public notices in the local newspapers or frequent spot announcements in the local radio and television channels/ through cable operators should be used to warn of the danger. Signs warning of the hazards of a fluctuating water level should be placed at river access points throughout the reach where the danger exists.

**4.2** Where a permit for fishing, boating, hiking, picnicking,

camping, or other public use of the river or adjacent area is required, the material issued with the permit should include information indicating and illustrating the hazards of a fluctuating river.

**4.3** Other methods of informing the public should be utilized, including speeches before the local community and service organizations, Water Users' Associations presentation of water safety programs to school pupils, and employee involvement in youth organizations such as the NCC, Boy Scouts and Girl Scouts.

**5.0 Posting of Operating instructions**

As a general rule, operating instructions for gates and generator sets should be posted near the control of these facilities. This, to assure that operating personnel use the facilities according to prescribed procedures and to provide instructions to other less familiar who may have to operate facilities during emergencies. Operating instructions should be posted within protective coverings, such as clear plastics, near associated equipment so that equipment can be operated as intended. Each operating device should be permanently and clearly marked for easy identification.

However, the posting of operating instructions may be potentially dangerous if unauthorised personnel gain access to controls and then have instructions for operating. To minimise this possibility, precautions should be taken to prevent access to controls by such persons.

In any event, the instructions should be clear, in readable condition and in logical sequence. Printed matter often deteriorates rapidly in adverse environment.

**6.0 Standby power facility**

The need for and adequacy of standby power should be evaluated periodically. Periodic trials should be made to ensure reliability. Fuel supply should be checked for volume and freshness. Exterior exhaust system is necessary for all standby system.

**7.0 CONTROL OF FACILITIES**

Only the employees entrusted with the task of operation by the Government in Water Resources Department will operate all gates, meters and other control devices. No person shall willfully open, close, change or interfere with any lawfully established gate without authority. Any person who interferes in any way with the setting or adjustments of said gates shall be held strictly liable for any damage resulting from such interference. All gates are locked to protect both the water users and the area.

**8.0 Restricted Areas**

Restricted areas are those which are potentially hazardous to or subject to damage by public such as

- Public entry into chutes, stilling basins and hoist platforms for gates at Head Regulators, Cross Regulators, outlets, siphons, escapes should be restricted.
- Warning signs and signs prohibiting rock throwing into chutes, stilling basins, cisterns should be posted adjacent to the structure.
- Public access should be limited from area surrounding hydraulic structure intakes and reaches of outlet channels adjacent to discharge structure subject to surging or rapid changes in water surface elevation during releases.

Operating personnel should ensure that public entry is restricted in above area. Section Officers shall ensure that the instructions given are promptly adhered to. Cases of tempering with gates shall be promptly brought to the notice of local police and appropriate complaint shall be registered.

**9.0 Security**

Adequate physical security should be provided to preclude unauthorized tampering with and operating of equipment. Such security may include chaining and locking outside gate operators and constructing and locking adequately restrictive barriers, covers, or enclosures.

**10.0 Rock Removal from Chutes, cisterns and Basins**

Medium and large rocks do not wash from a stilling basin/chute - even during high discharge. Instead, they are swirled by water and pounded against the concrete walls and floor of the stilling basin/chute, causing damage. It is important to remove all rocks in the stilling basin/chute.

Since most rocks which enter the chute and stilling basin are thrown or rolled there by people, signs should be clearly displayed near the structures prohibiting throwing rocks into them. Before release of water through the structures, those rocks that can be reached without draining the basin be removed from the chute, cistern and basin annually. Basin/cistern examination should be conducted at 6-year intervals until experience indicates a schedule more consistent with local operating conditions.

**11.0 Safety procedures**

Particular importance should be attached to tagging controls for equipment being serviced to prevent operation which could endanger other employees. Equally important is the requirement that two employees be in attendance while servicing gates to avoid openings or closing that could injure the workers. Section officers should be familiar with the identity, location and telephone numbers of nearby hospitals, doctors, ambulances, rescue units which can provide medical assistance. A directory containing all these details should be readily available.

# *Chapter 4*

## *Operation during emergency situation*

Detailed guidelines are issued for operation of canals during emergency situation. Each canal shall have its detailed Emergency Preparedness Plan (EPP).

# *Chapter 5*

## *Schedule of Duties*

Operation of the canal during normal conditions shall be the responsibility of the section officer in charge of the canal. It shall be ensured that unauthorized encroachments do not occur, that existing or potential conditions do not lead to public criticism or injury to the public and that nothing is done which conflicts with the primary purpose of the project. Following gives schedule of duties to be performed by the Section officer:

### ***Daily***

1. Record water surface elevation in canal
2. Record discharge released into various canals/ direct outlets off-taking from the canal within his jurisdiction
3. Record releases from escapes
4. Record seepage measurement at embankment toe
5. Check security and safety devices
6. Make required changes in gate openings
7. Record pertinent information in Operating Log
8. Check escape tail channel for debris

### ***Monthly***

1.Run generators for minimum one hour
2. Keep batteries charged
3. Replace light bulbs if required
4.Check signs that warn public of hazards near falls, escapes, Head regulators and siphons
5. Check fence conditions and caution signs
6. Check condition of :
   Top of canal embankment
   Upstream and downstream faces
   Abutment contacts
   Downstream cisterns
   Rodent problems
   Measuring devices
   Toe drains, L-drains
7. Inspect and repair animal burrows, eliminate animals
8. Inspect, remove and repair encroachments

## ***Quarterly***

1. Operating instructions—upto date & legible
2. Clean gate control switchboxes
3. Check & clear bridge drains
4. Clean inside of motor control cabinet
5. Inspect and repair settlement, sloughs, slumps, bulges, cracks and depression.

## ***Semiannually***

1. Lubricate gate rollers
2. Lubricate hoist cables
3. Replace grease in gear case of hoist
4. Change oil in generator
5. Check hydraulic oil lines
6. Check oil reservoir level in hydraulic gate system
7. Check rubber seals and seal clamps
8. Check paint on gates
9. Check mechanical hoist bearings and flexible coupling bearings
10. Spur gear units and gear motors
11. Inspect embankments and channels for trees, vegetation, shrubs, brush, growth and remove deep rooted vegetation and shrubs
12. Inspect embankment for erosion. Also look for erosion around and under structures.
13. Inspect and record quality and clarity of seepage and corresponding water level in the canal
14. Inspect end of each outlet for breaks, undercutting

## ***Annually***

1. Check and repaint metal works of bridge, gates, fence
2. Review Standing Operating Procedure
3. Exercise gates and valves
4. Check electrical pull boxes, conduits & switches
5. Check condition of exterior and interior of siphon barrels
6. Examine approach and tail channels of siphons, tail channels of escapes and carry out repairs, clear drainage-way of all debris/ obstructions.

7. Examine apron, downstream cistern of escapes, falls & outlets and carry out repairs and report evidence of structural instability, erosion, cavitation etc.
8. Inspect canal lining and repair and replace the same in deficient areas
9. Inspect concrete and masonry surfaces for deterioration including scaling, pitting, spalling, pop outs, crumbling , cracking
10. Inspect ends of drainage pipes at or near upstream toe of embankment and clean out debris/ material that might choke the drain.

***After Heavy rains***

1. Inspect and repair embankments
2. Inspect and repair escapes and drainage structures

***After Each Watering***

1. Inspect, measure and record seepage; compare with previous records
2. Report uncontrolled seepage immediately

***Every three years***

1. Inspect and repair conduits/barrels over 90 centimeters in diameter.

- Each **Section Officer** shall perform all above duties for the entire reach of canal including structures within his jurisdiction.
- The **Deputy Executive Engineer** shall ensure that all Section Officers working under him perform their duties properly. He shall carry out

the inspection of entire reach of canal including structures within his jurisdiction every six months i.e. in March and October.

- The **Executive Engineer** shall do the same every year in May and October.
- The **Superintending Engineer** shall carry out inspection every year during May and November in respect of all escapes, aqueducts, canal siphons, drainage siphons as well as the vulnerable reaches of canal.
- The **Chief Engineer** shall randomly select within his jurisdiction the canal as well as canal structures for inspection in June and December, however the selection shall be so done as to ensure that the system as a whole would be running satisfactorily.
- A checklist for inspection of canals and canal structures is given at ***Appendix – B.***

# *Chapter 6*

## *MAINTENANCE OF CANALS AND STRUCTURES — AN OVERVIEW*

Maintenance activities for a canal fall into three categories:

- Routine maintenance.
- Emergency works.
- Scheme improvement.

These are discussed in the following two sections. The last section deals with management of maintenance activities.

### 1.0 Routine maintenance

Routine maintenance activities have to be repeated throughout the lifetime of canals to keep them functioning. Some of these activities are daily routines which do not require special skills:

- greasing of gates;
- removing vegetation from embankments of canals and drains;
- removing silt from canals, drains and structures.

Other routine maintenance activities require skilled artisans, such as a mechanic, a mason, a carpenter and a painter. They may be needed to do routine maintenance work such as:

- repairs to gates and measuring structures;
- repainting of steel structures;
- installation of water level gauges;
- maintenance and small repairs of pumps and engines.

Larger routine maintenance jobs are usually done between irrigation seasons, when the canals are drained. These include:

- major repair or replacement of gates, pumps, and engines;
- large-scale silt clearance from canals and drains;

- Large-scale maintenance of roads and embankments.

## 2.0 Emergency works

Emergency works require immediate action by irrigation staff, to prevent or reduce the effects of unexpected events such as:

- Breach or overtopping of canal embankment or river dike/afflux bunds/guide bunds, causing flooding;
- A severe slope failure.
- Deterioration of the outlet culvert.
- Critical failure of pumps , causing interruption of irrigation water supply;
- Increasing uncontrolled seepage through the embankment.
- A blocked escape or outlet channel
- Natural disasters such as floods, earthquakes or cyclones.

Operational staff of SSNNL as well as of the contractor must be trained so that they know what to do as soon as they arrive on the scene, such as cutting off the power to a overheated pump, and closing the head regulator or operating escape in case of a canal breach. A good communication system can do much to reduce the damage.

## 3.0 Scheme improvement

The routine maintenance and emergency repairs described above are all aimed at keeping or restoring the technical infrastructure in the condition it was in when it was newly built. There are a number of reasons, however, not just to maintain the scheme *in its original condition,* but to gradually *improve* it. The main reasons are:

- A newly constructed scheme is hardly ever perfect. Some alterations are usually necessary to make it fully operational.
- It is sometimes better to construct a scheme at minimum capacity, with low cost structures. Then, if

the scheme proves to be a success, it can be gradually expanded and the structures replaced with more permanent ones.
- Conditions change, both inside and outside the scheme. Improvements are necessary to ensure that the scheme continues to deliver services that correspond with farmers' needs.

Each of these reasons is discussed in more detail below.

### 3.1 Alterations in newly constructed schemes

In the design of an irrigation scheme, many assumptions are made. Examples are:

- The expected seepage and percolation losses for a rice irrigation scheme
- The expected irrigation efficiency
- The expected roughness of the canal bed and sides.
- The bearing capacity of the soil.

Even with extensive field research in the area at the planning stage, it is not possible to be absolutely accurate in predicting these values. If actual seepage and percolation losses in a particular section of a rice scheme are much higher than was assumed, the capacity of the canals and/or turnouts serving this area may have to be increased. An underestimate of canal roughness may be corrected through either enlarging the cross-section, or by canal lining.
Similar actions may be needed if estimates of irrigation efficiencies were too optimistic. Overestimating the bearing capacity of a soil may result in collapse or sinking of structures, which then have to be replaced or adjusted to the original design level.

### 3.2 Gradual scheme development and improvement

When a scheme is first built under pioneer conditions the canal system as originally built may be constructed of minimum capacity or might be left unlined, with the idea of enlarging/lining it as the demands for water increase. It is frequently not economical to build a full sized/fully lined canal at first when it only carries a reduced supply in the first few years. Due to the small demand, the full

sized/lined canal would fill up rapidly with sediment, whereas due to the higher flow velocity in a smaller canal it can be more easily kept clean."

### 3.3 Adapting to change

A design that is well adapted to farmers' needs, at the time of construction can become inadequate due to changes that occur both inside and outside the scheme. A few examples are given below:

- A change in prices for agricultural crops can result in a different cropping pattern.
- Job opportunities outside agriculture may reduce the availability of farm labour.
- A change in lifestyle may result in farmers no longer wanting to irrigate during the night.
- Increased demand for water for domestic and industrial purposes can reduce the volume available for irrigation.

In order to cope with these changing conditions, it may be necessary to change the water distribution practices in the scheme. For example, a scheme that was originally designed for rice cultivation, on the basis of proportional water distribution to the tertiary units during 24 hours a day, is no longer adequate when farmers prefer to grow vegetables and only want to irrigate during the daytime. In such a case, the scheme's infrastructure may need to be upgraded to enable a more appropriate method of water distribution.

## 4.0 Management of maintenance activities

The objectives of maintenance management for a canal are:

- to keep the canal in good operating condition so that it will provide uninterrupted service;
- to extend the useful life of the canal;
- to achieve the above at the lowest possible cost.

In order to keep the costs down, in irrigation maintenance, an attempt should be made to reduce the need for costly repairs. The need for repair by the irrigation maintenance unit may be the result of:

1. Routine inspection by operator.
2. Periodic inspection by maintenance unit.
3. Breakdown.
4. Emergency (flood, pump failure).

Items 1 and 2 are *preventive maintenance* activities.
*While preventive maintenance represents efforts and costs, it costs much less than repair of breakdowns.*

## 5.0 Planning maintenance

Planning maintenance activities means deciding *what* activities should be done, *who* should do them, and *when*. T*he preventive maintenance programme* - has to be developed for each individual canal. The activities performed under the preventive maintenance programme can be planned in advance, indicating for each task when it should be done and by whom. Inspections for identification of maintenance needs can also be scheduled in advance, indicating when inspections will take place and by whom. Of course, it is not possible to predict which maintenance needs will be identified through these inspections. A practical solution is to have an annual inspection as a basis for drawing up the maintenance programme for the next year.

The maintenance needs identified at this annual inspection will not all have the same degree of urgency. For example, erosion of the embankment of a canal must have top priority and be corrected without delay, because failure of the canal would have serious consequences. Other activities, such as silt or vegetation removal from a canal, may safely be planned a few months later. The main factors to consider when setting priorities are the consequences of not doing the maintenance work, in terms of:

- safety; risk to human life and risk of structural failure;
- effect on crop production due to interruption of water deliveries.

The maintenance needs identified will then be scheduled into the maintenance plan according to their priority, together with the preventive maintenance activities.

# *Chapter 6*

## *GENERAL GUIDELINES FOR MAINTENANCE*

### 1. EMBANKMENTS

The embankments considered herein are of earth-fill construction

**a. Erosion:** Erosion involves the loss of embankment material due to wind and water action. It reduces the cross section and undermines structures, thereby impairing the safety and stability of the embankment and structures. Erosion can be in the form of gullies down side slopes, benching due to wave action, or undercutting of structures. The gullies and benching may be initiated by animal and/or manmade traffic.

**Semiannually and after heavy rains, inspect for erosion** and replace lost material. Inspect groins, berms, slopes for erosion and channelisation. Inspect washout of material below pitching. Check for bald areas where turfing is provided. Earth materials used to repair eroded areas should be tamped, compacted into places, and reseeded when appropriate. If trails have contributed to the erosion, the traffic causing the trails should be prevented, if possible, or controlled to minimize the creation of such trails. The use of gravel and stones/metal may be appropriate to repair minor erosion. Other embankment materials, normally of the kind removed by erosion, will be required to repair areas of extensive erosion. Rock

protection on the surface of the repaired areas may be required to prevent or minimize future erosion.

**b. Trees and Vegetation:** Trees and deep rooted vegetation on embankments create voids and provide seepage flow paths when the roots decay. Upon reaching maturity, trees are also susceptible to being toppled and shortened seepage paths in the embankment.

**Semi-Annually inspect embankments and flow channels for tree, brush, and shrub growth** and remove such growth by cutting at the ground line and removing the cuttings. The vegetative removal should provide for clear openings to escape and siphons inlet and outlet channels and extend a minimum distance of 50 feet downstream from the toe of the embankment and 15 to 20 feet from the groins to allow proper surveillance of the embankment toe and any seepage areas which might otherwise be concealed. After removal the area shall be backfilled and compacted to prevent development of piping action. These guidelines should be applied to drains and pipes also.

**c. Animal burrows:** Animal burrows in embankments can create seepage paths and weaken the integrity of the structure. Often, animals burrow deep into the embankment which allows water to travel freely to the downstream face, thus allowing piping to occur and ultimate failure of the dam.

**Monthly inspect for animal burrows**, excavate burrows to the maximum extent possible, fill excavation with earth material tamped and compacted into place, and eliminate the burrowing animals, if possible. Beaver activity will become apparent through visual observation of tree cuttings. Animals should be removed immediately upon detection. Woodchucks, squirrels, rabbits, moles and muskrats can be exterminated or flushed out with smoke. Beavers must be relocated. The animal burrow must be filled with soil or a mixture of water to 9 parts soil and 1 part cement. The soil mixture should be placed as deep as possible and compacted with a pole

**d. Encroachments:** Encroachments may occur in various ways, including buried utilities, utility lines and poles on the embankment top and side slopes of embankments, construction of buildings on embankments, and removal of embankment material to accommodate construction or to obtain material for other use. Encroachments weaken embankments and may seriously jeopardize the integrity of the structure.

**Weekly inspect for encroachments.** Require removal of the structure or installation if it affects the integrity of the embankment. Removed material should be replaced with tamping and compaction efforts. No encroachments should be permitted.

**e. Stability and settlement:** Sloughs, slumps, bulges, depressions in the top of the bund, cracks, or other irregularities are often signs of instability and settlement of

the embankment or foundation, or both. Significant settlement of the embankment may diminish the full supply depth and freeboard and increase the possibility of overtopping. Signs of instability and settlement should be reported promptly through Superintending Engineer in charge of the work to Design Circle who can assess significance and suggest appropriate action to be taken. In critical situation such as imminent overtopping or failure, implement the emergency preparedness plan.

**Quarterly inspect embankments for sloughs, slumps, bulges, depression, and cracks.** Where traffic is permitted on the top of the embankment, the top should be surfaced with gravel or similar material, crowned, and well maintained. Ruts from vehicular traffic should be filled so that the top will be well drained and access along the top is possible at all times. Where there is settlement, the top should be rebuilt to the original design level using appropriate earth materials and sound construction particles. Inspect for slides. Sketch, Measure, Photograph and Locate (SMPL) the extent and displacement. Look for surrounding cracks uphill. Probe entire area for knowing condition of surface material. Make sure there is no seepage area near the slide.Monitor continuously.

**f. Seepage**: Seepage occurs to some extent at almost all embankments. The monitoring and control of any seepage are essential to proper maintenance. The amount of seepage may vary from wet spots to large quality flows. Uncontrolled

seepage (large flows or flows that carry sediment) indicates internal erosion, which weakens the embankment, foundation, or abutments; creates voids; and leads to embankment failure. Where possible, the quantity of seepage should be measured and recorded in a log book. Water measurement weirs and devices may need to be constructed and installed. Guidance pertaining to water measurement may be found in the U.S.Bureau of Reclamation Water Measurement Manual. Other characteristics such as the clarity of seepage (that is, whether clear or carrying sediment) or discoloration of concrete and staining should also be noted. Seepage may occur at the abutments, at the downstream slopes of the embankment, or downstream from the embankment.

**At least semiannually and especially during periods of canal carrying heavy discharges, inspect and record the quantity and clarity of seepage and the corresponding reservoir level in the log** Uncontrolled seepage, significant increase in seepage, and seepage which is carrying sediment should be reported promptly through Superintending Engineer in charge of the work to Design Circle who can assess significance and suggest appropriate action to be taken. Inspect downstream slope for piping, sloughing, sand boils. Watch for vortex in canal water. That is the sign for piping. Watch out for growth of vegetation /greenery. It is sure sign of seepage.

In critical situation such as imminent failure, implement the emergency preparedness plan.

**g. Slope protection**: The canal lining must be protected against destructive action. The canal lining is sometimes distressed, displaced, and impaired by various causes, including deterioration of concrete surface, settlement, or removal by man for use elsewhere, or to accommodate recreational use such as building a seat for placing a pump or a windbreak for fishing.

**Annually inspect the canal lining and repair and replace the same in deficient areas.**

## 2. CONCRETE/MASONRY CONSTRUCTION

The construction considered herein is that of concrete or masonry, including combination of concrete and masonry work.

The condition of concrete and masonry works is generally dependent on the quality of materials used, circumstances or quality of construction, and severity of weather exposure. Poor quality materials and deficient composition of concrete and mortar will be evidence by scaling, spalling, pop-outs, crumbling, and other forms of deterioration. Likewise, poor quality construction, such as the use of too much of water in mixes or finishing and/or permitting exposure to freezing condition before adequate curing and hardening of concrete or mortar, will lead to early and accelerated concrete deterioration.

Cracking is usual and normal in concrete works. Most cracks are superficial and not very deep or wide, and some cracks in concrete where damp or high humidity

atmospheric conditions prevail, as in conduits, may self-heal or seal by chemical action as with calcium carbonate formation. In mild climates, this type of cracking is usually not a problem or detrimental to the integrity of the structure. Cracks that are deep or through a structure may be of significant concern as they can be signs of settlement, structural movement, and distress and may permit seepage or leakage of water. Sometimes when seepage or leakage occurs, staining of concrete may be noted. This may be indicative of reinforcing steel corrosion or chemical reaction of water with foundation materials or concrete and may or may not be of a serious nature. Seepage and leakage through cracks most commonly occur at portions of structures below the water level and in case of barrels of a conduit.

Expansion, contraction, and construction joints may be of concern when they become "open" and permit seepage or leakage of water. Opening of joints can be a signal of structural movement or disbanding of concrete if at construction joints. In the case of contraction joints, seepage may indicate the failure of the water-stops. Some opening or closing of joints normally occurs with temperature changes.

**Annually inspect concrete and masonry surfaces for deterioration including scaling, spalling, pop-outs, crumbling, and cracking**. This type of deterioration may be relatively slow, and recordkeeping in the form of photographs, sketches, or notes indicating location, size,

and depth of deterioration will be helpful in evaluating the severity and rate of progression. When concrete deterioration reaches embedded reinforcing steel, immediate repair is usually required.

**Semiannual inspection and measurement of seepage should be performed.** The quantity of seepage should be recorded in a log book. The clarity of seepage (that is, whether clear or carrying sediment) and any staining or discoloration of concrete should also be noted. Seepage may occur not only at cracks and joints but also at the abutments and downstream from the construction.

## 3. EMBANKMENT DRAINS

Many embankments have drainage systems installed for collection and safe exit of seepage. Often, such systems have drain pipes terminating at or near the downstream toe of the embankment. Visible ends of such drain pipes provide easy exit of any seepage and allow observation and possible measurement of seepage flows. Such drains and exist points may become clogged with chemical deposition, sediment, or debris such that the drains cannot function effectively.

**Annually inspect the ends of drainage pipes at or near the downstream toe of the embankment** and clean out any debris and material that may clog the drains and exit channels. Material covering unexposed ends of drainage pipes should be removed. If animals occupy the drains, as may be the case when drains are dry, it is appropriate to

clean the pipe and install large-mesh corrosion-resistant screens in the ends of the drains to preclude entry.

## 4. Escapes

Escapes are constructed to release floodwater or water in excess of the storage space in a canal. Escapes are important to the safety of canals, and maintenance to allow proper functioning is essential. These usually are located away from the embankment in order to preclude erosion of the embankment when spilling. Regulated escapes employ gates of various types to control the rate of flow through the escape. Structural instability is evidenced by deep cracks in slabs or walls, slab removal, foundation piping, tilting of walls, and misalignment of walls. Obstructions including debris, trash, trees, brush, and sediment diminish the flow capacities of escape structures, stilling basins, and inflow and outlet channels and may also produce undesirable erosion-producing currents. Weep holes and drainage openings are usually installed in the walls and floors of escape structures, and these often become clogged with sediment and may be occupied by animals or birds.

**Annually inspect the escape structures and channels for instability, deterioration, obstructions, and erosion.** Evidence of structural instability should be reported immediately, through Superintending Engineer in charge of the work to Design Circle who can assess significance and suggest appropriate action to be taken. Structural deterioration that is progressive and endangering the

structural integrity of the canal should be repaired. Obstructions including debris, trash, dead and live trees, and brush and sediment deposits should be removed. (Debris, trash, trees, and brush should be disposed of in accordance with forest and environmental regulations. )

Weep holes and drainage openings should be cleaned and large-mesh corrosion resistant screens installed, as appropriate, to preclude animal and bird entry. Areas of backfill settlement along walls should be repaired. Erosion around and under structures such as undercutting of concrete footings, cutoff walls, and stilling basins at the end of escapes should also be repaired.

## 5. Outlet Works

Outlet works are conduits through or around an embankment used for releasing water. Regulated outlets use gates or valves for controlling the rate of flow. At unregulated conduits, the rate of flow is controlled by the size of the conduit and the height of the water in the canal above the invert, or floor, of the conduit. Conduits at embankments usually have regulating gates or valves within the upstream portion of the conduit so that flows can be shut off to prevent water from eroding the embankment in the event of failure or leakage through the conduit. Outlet works gates are susceptible to plugging with debris and sediment deposition. Thus, it is important that any trash racks in front of the gates be cleaned whenever possible and

that the gates be opened periodically to flush debris and sediment.

**Semiannual1y inspect the end of each outlet**. The outlet end of the conduit should be inspected for breaks in the conduit, erosion of the downstream toe of the embankment, or undercutting of the outlet end of the conduit. Eroded material should be replaced and armored with suitable material. Each gate should be operated sufficiently to ensure that it is fully operable and to flush debris and sediment. Gate stems should be inspected to the waterline, and any misalignment that interferes with operation should be corrected. For gates having a vertical stem and a catwalk for access to the controls, the catwalk should be maintained so that the controls remain accessible even in emergency situations. Downstream cistern of the outlets should be inspected and debris/vegetation should be removed.

**Annually and after unusually high discharges, inspect the channel downstream from the outlet works for erosion, obstructions, and undercutting of the outlet structure or the toe of the embankment.** Erosion should be repaired, and obstructions including tree and brush growth should be removed.

**Every 3 years, internally inspect conduits over 90 centimeters in diameter**. The inspection should be for the purpose of determining the existence of breaks, leaks, cavitations, or other damage.

## 6. Mechanical Equipment

**All accessible parts of mechanical and associated electrical equipment should be given an annual visual inspection for damaged, deteriorated, corroded, cavitated, loose, worn, or broken parts.** Air vents in conduits and pipes should be checked to make sure they are open and unobstructed. Mechanical and electrical equipment should be lubricated at periodic intervals. The service and maintenance procedures prescribed by the manufacturer should be followed for pumps, motors, and other commercial components, where available. Proper lubrication reduces the friction and wears between sliding parts, protects against corrosion, and carries away contaminants. Adequate ventilation should be provided wherever feasible to reduce the occurrence of corrosion. For electrical equipment, the use of desiccants is helpful to increase equipment life and reduce trouble.

All mechanical and electrical equipment with moving parts should be exercised by operating through the full travel range under actual operating conditions, if possible, and at regular intervals. A log of such operations should be maintained. Periodic operation of equipment removes foreign material from sliding surfaces, distributes lubricants, and flexes packing and seals.

AlI exposed metal surfaces (not in sliding contact), other than corrosion resistant materials, should be properly

protected or painted to prevent deterioration. Operating instructions should be posted within protective coverings, such as clear plastics, near associated equipment so that equipment can be operated as intended. Each operating device should be permanently and clearly marked for easy identification.

Adequate physical security should be provided to preclude unauthorized tampering with and operating of equipment. Such security may include chaining and locking outside gate operators and constructing and locking adequately restrictive barriers, covers, or enclosures.

**a. Gates and valves (annually).**

**(1) Visual inspection.** - When water conditions permit, inspect the downstream surfaces of the guard gate leaves and bodies, the upstream and downstream surfaces of regulating gate leaves and bodies, and outlet pipes. Particular attention should be given to signs of cavitations damage to waterway surfaces downstream from gate or valve leaves and flanged joints. Inspect neoprene or rubber gate seals for deterioration, cracking, wear, foreign material deposits, and leakage. Inspect valve and gates metal seats or seals for wear, scratches, foreign material deposits, and leakage. Repairs should be made as necessary to keep the equipment in a safe and reliable operating condition.

**(2) Lubrication** - Apply a suitable lubricant (water resistant, where applicable) at all fittings and sliding surfaces. Clean any foreign material that has collected on threaded stems and re-lubricated. When excess dried grease or other foreign material is carried onto the threads of the lift nut of a gate operator, extremely difficult operation will result. If foreign material is not cleaned from the interior threads of the lift nut, heavy pulls on the hand crank or motorized operator can result. The oil in gear cases should be checked for dirt, water, and proper level and replaced, filtered, or added to as necessary. Inspect grease and oil seals for tightness and leakage.

**(3) Exercising** - After lubrication, operate each valve and gate through a full cycle while under actual operating conditions, if possible. During operation, listen for unusual noises and check for binding or vibration.

**b. Hydraulic and manual operators and control systems for gates and valves (annually)**

**(1) Visual inspection** -

(a) Check hydraulic oil in the tank for proper fluid level (take into account displacement of the gate stem), water, and foreign materia1.

(b) Check all pipe joints, cylinder flanges, packing, and hydraulic equipment for leaks.

(c) Check oil filters and strainers and change or clean if required.

(d) Check hydraulic hoist piston stem for rusting and foreign deposits. Remove deposits and rough areas on stems to prevent damage to packing or seals.

**(2) Lubrication** - Lubricate commercial equipment (motors, etc.) according to manufacturer's recommendations.

**(3) Exercising** - Operate hydraulic control and manual operator systems and check for unusual noises or vibrations. Check motors and hydraulic fluids for overheating, and check pressure switches, pressure gages, and limit switches for proper operation according to operating instructions. Clean manual operators of dirt and foreign material and lubricate as appropriate.

**(4) Physical security** - The physical security should be inspected for adequacy and repairs and improvements made, as necessary, to avoid unauthorized operation and ensure the safety of the equipment.

**c. Traveling crane, hoist, and tracks (annually)**

**(1) Visual inspection** - Examine hoist, crane, and tracks for broken, bent, misaligned, worn, or loose

parts and corrosion and deterioration of protective coatings.

**(2) Lubrication** - Apply a suitable lubricant at all fittings and on all sliding surfaces. Lubricate according to manufacturer's recommendations, if available.

**(3) Exercising** - After lubrication, operate crane and hoist throughout all functions and check for unusual noises, binding, and vibration during operation.

**d. Ventilating equipment (annually) -**

**(1) Visual inspection** - Examine for broken, bent, misaligned, worn, or loose parts and corrosion and deterioration of protective coatings.

**(2) Lubrication**. - Apply a suitable lubricant at all application points. Follow manufacturer's recommendations, if available.

**(3) Exercising** - After lubrication, operate equipment and check for unusual noises, binding, vibration, and overheating of motors and bearings.

This guide for exercising and maintaining mechanical equipment is intended to suggest a thorough periodic lubrication, exercising, and inspection schedule and may be supplemented or modified as good practice or experience dictates.

## 7. Inspection of Canal works Following an Earthquake

If you have felt an earthquake or one having a Richter magnitude of 4.0 or greater has been reported to have occurred in the area, follow these procedures:

a. Immediately conduct a general overall visual inspection of the canal including all the structures.

b. If any portion is damaged to the extent that there is increased flow downstream, immediately implement the emergency preparedness plan. If an emergency preparedness plan is not available, the procedures identified in **appendix C** should be immediately implemented.

c. If visible damage has occurred but has not been serious enough to cause failure of the canal/structure, make the following observations and contacts immediately:

(1) Quickly observe the nature, location, and extent of damage. The description of slides, sloughs, and sudden subsidence should include location, extent, rate of subsidence, and effects on adjoining structures, springs or seeps, and downstream channel water elevations. Also, note prevailing weather conditions and any other facts believed to be pertinent. Evaluate potential danger of failure. Document the damage, as far as possible, with photographs.

(2) As soon as possible, report should be promptly sent through Superintending Engineer in charge of the work to Design Circle who can assess significance and suggest appropriate action to be taken, or if key personnel are not available, report directly to the nodal officer. It is extremely important that the one receiving your report understands your evaluation and description of the potential hazard. A decision on further actions required must be promptly made by one of these officials.

(3) Re-inspect the site of the damage and maintain communications with the key personnel who previously received the report.

(4) If there is 'no imminent danger of failure, continue to paragraph (d). If there is imminent danger of failure, follow the emergency action plan. If an emergency action plan is not available, the procedures in appendix C should be immediately implemented.

d. Thoroughly inspect the following for damage:

(1) Both faces of the embankment/structure for cracks, settlement, or seepage.
(2) Abutments for possible displacement.
(3) Drains.
(4) Escape structure.
(5) Outlet works gate structure/chamber.
(6) Visible canal reach filled with water and downstream areas for landslides.
(7) Other appurtenant structures.

(8) Downstream channel for reduced capacity and altered flow characteristics.

e. Report findings to Superintending Engineer in charge of the work or officials reported to previously during the earthquake incident.

f. If no apparent damage has occurred to the canal, embankments, or appurtenant structures, a "No Damage" report must be made to Superintending Engineer in charge of the work.

g. Continue to inspect and monitor the facilities for at least 48 hours, or as instructed by the Superintending Engineer in charge of the work, in the event that unobservable or delayed damage occurs.

h. Some damage to structures may not be readily apparent during an inspection immediately following an earthquake. It is possible that settlement of structures, the reactivation of old slides or the development of new slides may not occur with ground shaking and would manifest themselves after the initial inspection. Another inspection should be made 2 to 4 weeks after the initial inspection.

## 8. Inspection of Canal Following Floods

If a situation develops whereby flooding above normal water surface elevation i.e. water surface encroaching the free-board completely, appears imminent, immediately contact

Superintending Engineer in charge of the work. Information to be reported should include:

a. Current water surface elevation in the canal.
b. Observed rise rate of the water surface.
c. Weather conditions in the vicinity - past, present, and predicted.
d. The flow conditions above and below the canal.
e. Known conditions at upstream or downstream canal sections and position of downstream reservoirs/waterbodies, location of escapes if any exist.

The Superintending Engineer in charge of the work will provide instructions regarding canal operation and further reporting, based on this report.

If all communications from the canal are lost and there is potential for flooding and subsequent failure of the canal, use the following checklist as a guide during a major flood event:

a. Check the canal water surface elevation; if at normal water surface elevation i.e. FSL, increase discharge through the escape gates or outlet works, if possible.

b. If discharge is to be increased, notification of downstream residents is essential, if possible; also, if failure is possible, warnings and alerts are necessary in accordance with the emergency action plan, if available. During a period of communication loss,

warning of downstream residents by the section officer is up to his personal judgment.

c. If increased releases are deemed necessary, they should be staged, if possible, to allow the water level downstream to rise gradually and thus avoid the likelihood of persons being trapped by rising water. However, if in the judgment of the section officer, failure is more likely with gradual increases, larger increases may be appropriate.

## 9. Operation and Maintenance Log

A record should be kept of all canal and structure operation and maintenance activities. The data should be logged by the person responsible for performance of operation and maintenance. The log can be a very useful source of information regarding past problems and solutions and can provide historical project data that may be very valuable when safety inspections and evaluations occur. The log can provide important data regarding performance of the canal, such as seepage, embankment settlement, stability, repairs, maintenance, and modifications.

Information to be recorded in the log includes the following:

a. Date and time of observations.
b. Water elevations and discharges.
c. Normal and emergency changes in operation of outlet works and/or escapes, including gate position and changes.

d. Testing and exercising of outlet and escape gates and valves, controls, and standby equipment.
e. Maintenance activities, including lubrication, cleaning, clearing debris from channels, tree removal, repairing erosion, etc.
f. Miscellaneous items pertinent to operation during emergencies or events of an unusual nature, such as earthquakes or floods.

Entries in the log should be made in ink. Errors should be corrected by crossing out the incorrect entry and adding the correct entry. A sample log is illustrated in appendix B.

Photographs should be taken of any unusual conditions observed. They should be captioned with the photographer's name, date, and descriptive information to assist later recognition and understanding of the event pictured.

# Chapter 7

## Public Relations

In the eyes of public a canal operator and Section Officer are the representative of the Government. The propriety with which one conducts oneself has much to do with the image of the Government and the particular agency. Operators need to be trained in their reactions to the situations that may arise. For example, during drought period recreational possibilities may suffer. The tact with which the operator and section officer handle the complaints will have much to do with acceptance by the public of decisions made. An operator and section officer need to be understanding and on occasion must be the visible support for decisions made by others, whether the decision is perceived as correct or not.

Whenever possible an operator and section officer's conduct should be such that a positive image is projected. Their presence before the press, public officials, local agencies and recreationists (tourists) will then more appropriately evoke favourable and open-minded reactions.

## APPENDIX A

## INSPECTION, OPERATION, AND MAINTENANCE SUMMARY

A summary listing of inspection, operation, and maintenance items and their recommended frequency of performance follows:

| Item | Frequency of inspection |
|---|---|
| | **Weekly** |
| Encroachment | Inspect, remove and repair |
| | **Monthly** |
| Animal burrows | Inspect and repair, eliminate animals |
| | **Quarterly** |
| Settlement, sloughs, slumps, bulges, cracks | Inspect and repair |
| | **Semiannually** |
| Erosion of embankments, around and under structures | Inspect and repair |
| Outlet works | Inspect outlet ends of conduits; clean trash-racks, if possible; operate and inspect gates |
| Seepage | Inspect, measure, record, report, and compare with previous records |
| Trees and vegetation | Inspect embankments and channels, and remove deep-rooted vegetation |
| | **Annually** |
| Concrete and masonry surfaces | Inspect and repair |
| Drains (in embankments, foundations, galleries and spillways) | Inspect and clean |
| Mechanical equipment | Inspect, repair, lubricate, clean and fully exercise |
| Physical security | Inspect, repair and improve as necessary |
| Outlet works – downstream channel | Inspect, repair, remove obstructions |
| Escapes and channels | Inspect, repair, remove obstructions, clean drains, and report evidence of structural instability |
| Slope protection | Inspect and repair |

| | |
|---|---|
| | **After Heavy rains** |
| Canal and escapes | Inspect and repair |
| Embankment | Inspect and repair |
| | **After Each watering** |
| Seepage | Inspect, measure, record, and compare with previous records; immediately report uncontrolled seepage |
| | **Every 3 years** |
| Outlet works – conduits over 90 centimeters in diameter | Inspect and repair |
| | **Every 5 years** |
| Stilling basin/cisterns downstream of the structure | Dewater, remove debris, repair |

**SAMPLE OPERATIONS AND MAINTENANCE LOG**
**FOR _____ CANAL CHAINAGE --------- TO ---------**

| Date | Time | Name of Recorder | Canal water surface elevation | Discharge | Remarks |
|---|---|---|---|---|---|
| 04-06-05 | 9:00 a.m. | A.B.Patel | | Gate open 6 inches | Visited canal. Everything appeared okay. |
| 15-06-05 | 10:15 a.m. | A.B.Patel | | Gate open 10 inches | Opened gate. Canal water surface level rising |
| 19-06-05 | 8:00 a.m. | A.B.Patel | | Gate open 10 inches | 4.5 Richter Scale earthquake reported 30 kms from canal. No damage seen at canal/structures. |
| 26-06-05 | 2:00 p.m. | A.B.Patel | | Gate fully open | 2 inch of water going over escape. Wet area noted at bottom of left abutment looking downstream. Half a cusec of water flowing from left toe drain and right toe drain dry. |
| 03.07.05 | 11:00 a.m. | A.B.Patel | | Gate fully open | 4 inches of water going over escape. Minor erosion occurring escape channel. Wet area at bottom of left abutment unchanged from 26-04-02. 1 cusec water flowing from left toe drain. Right toe drain dry. |
| 07.07.05 | 9:30 a.m. | A.B.Patel | | Gate fully open | No flow over escape. Some repairs needed in escape channel when dry. ¾ cusec flow at left toe drain. None from right toe drain. Trees were cut off of downstream slope of embankment. |

**APPENDIX C**
**FAILURE OR IMPENDING FAILURE OF THE CANAL**

In the event emergency action plans are not available for the canal, the following procedures should be followed:

1. Downstream hazard potential – The canal could present a hazard potential to the downstream area as a result of failure or mis-operation. Should it fail, loss of life and excessive economic loss could probably occur.

If the canal is failing, downstream evacuation of the flood plain must be started immediately by the following procedures:

a. Inform the following using telephone, radio, or automobile: District Collector _____, Police _____, radio station _____,

b. Contact supervisory authorities; they will notify other officials that need to be informed and will take action.

c. Implement all possible efforts, if any, to reduce or minimize resultant downstream flooding.

d. Coordinate efforts with Collector's office in alerting all downstream areas.

e. Maintain contact with supervisory personnel receiving previous reports.

2. If all communications from the canal are lost and there is potential for failure of the canal, use the following checklist as a guide:

a. Quickly inspect the canal and evaluate potential danger of failure.

b. Check for sloughs, slides, slumps, and other signs of distress near canal abutments.

c. If failure is imminent, all measures which can be used to reduce storage in the canal should be used. The emergency action plan for the canal, if available, should be implemented. If no emergency action plan exists, initiate warning of downstream residents. If possible, enlist the aid of Collector's office. Warning of downstream residents by the section officer is up to his/her personal judgment.

Note: Section Officers must be knowledgeable regarding what constitutes "impending failure" of the canal. A false alarm causing panic and possible loss of life during evacuation would be a mistake –

no alarm with subsequent failure of the canal would be a greater mistake. An early notification to the collector's office of possible flooding downstream should be made as early as possible; make certain all officials understand the situation and the questionability of failure.