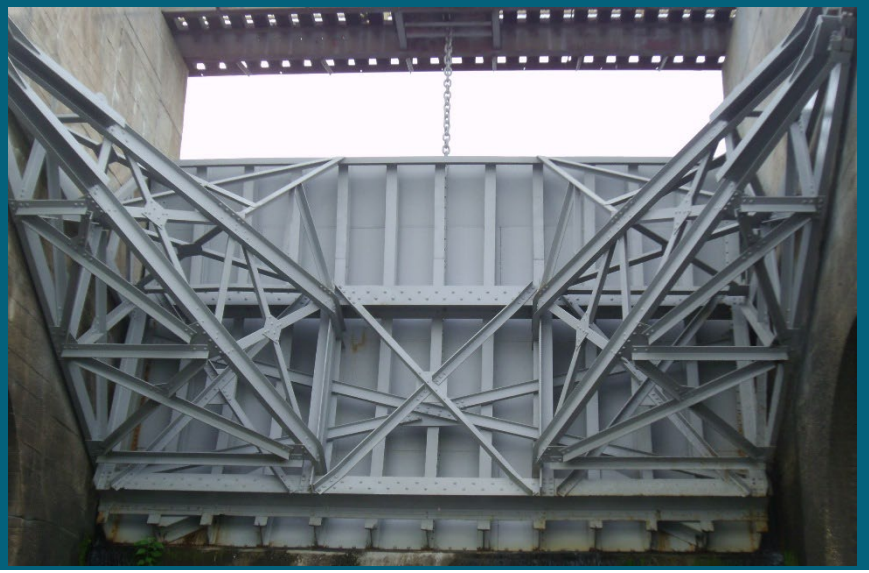
Extending Life of Gates



Kleinschmidt

Life Extension of Gates

Useful Concepts

- Confirm the Gate's Current Design Conditions
- Determine the Risks and Actual Condition of the Gate
- Consider the Technology Constraints of the Original Construction

Gate Safety Program

Step 1 - Establish *baseline* conditions

- Comprehensive system description
- Define design criteria
- Define hazards and risks
- Determine Probable Failure Modes
- Determine and Document Actual Condition

Gate Safety Program

Step 2 - Establish a site specific *inspection, monitoring, and documentation plan*

- Different portions of a gate will have different critical components
- Skin thickness & pitting assessment
- Concentrate on operator connections points, member connection points
- Thickness measurements
- Critical to have repeatable observation locations
- Inspection checklist can be useful to maintain consistency and completeness

Gate Safety Program

Step 3 - Implement a documented *maintenance and repair program*

- Document all records for future trending analyses

Step 4 - Periodic comprehensive independent *condition assessments*

- Frequency 5 to 15 years and after special events (e.g. major flood)

Condition Assessment

Types of Inspection

- Cursory Inspection:
  - Purpose is to note any observable change in condition
  - Typically performed by operation or maintenance personnel weekly, monthly, or quarterly
  - Changes in condition noted for further investigation

- Comprehensive Inspection/Evaluation
  - Purpose is to review the condition, safety, and risk of the existing gate
  - Performed by engineers who understand the design basis and actual condition of gate
  - If deficiencies are noted they can be resolved by repair, rehabilitation or replacement

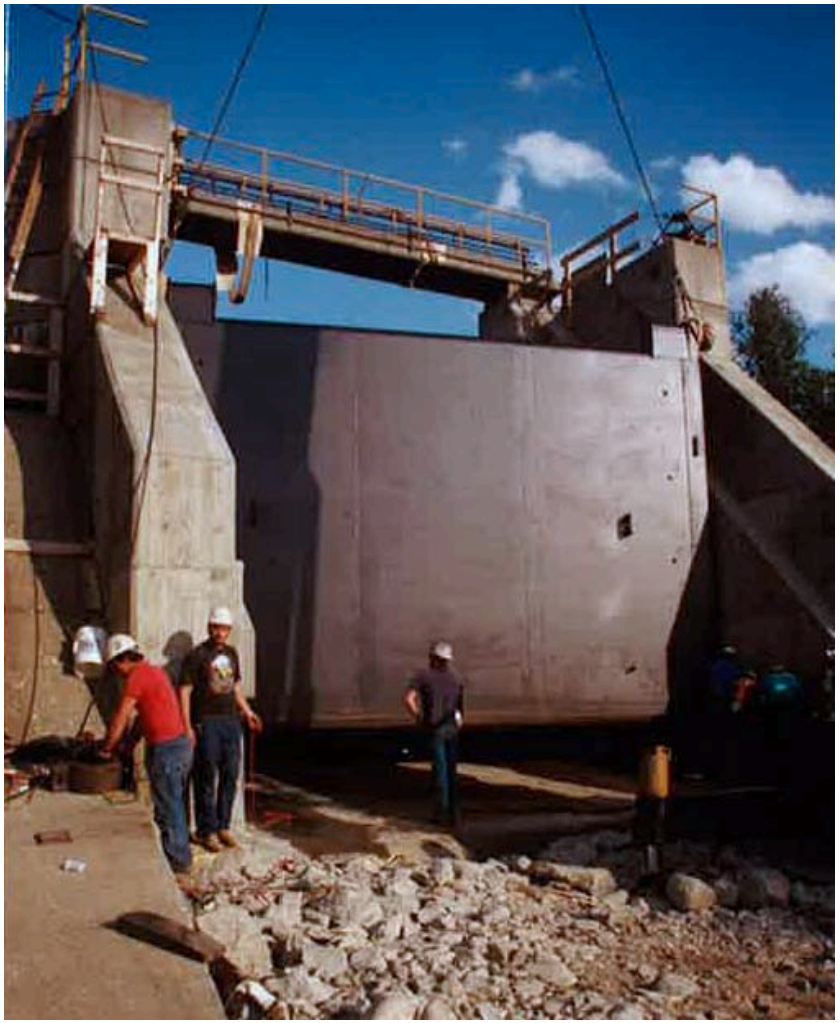
How Serious Is This Observation

Risk = Probability x Consequence

How Important is this Observation?

Example 1 – Evaluating Early Warning Signs

- Tensile rupture initiated at downstream flange of RH vertical member



LESSONS LEARNED

- **Objectively Consider Early Warnings**

- Small initial local flange weld cracking was observed previous to gate general failure, but incorrectly attributed exclusively to faulty workmanship and not a design inadequacy.

- Evaluations should use "*brutal candor*"

Example 2 – Frequently Decisions Need to be Based on Incomplete Information

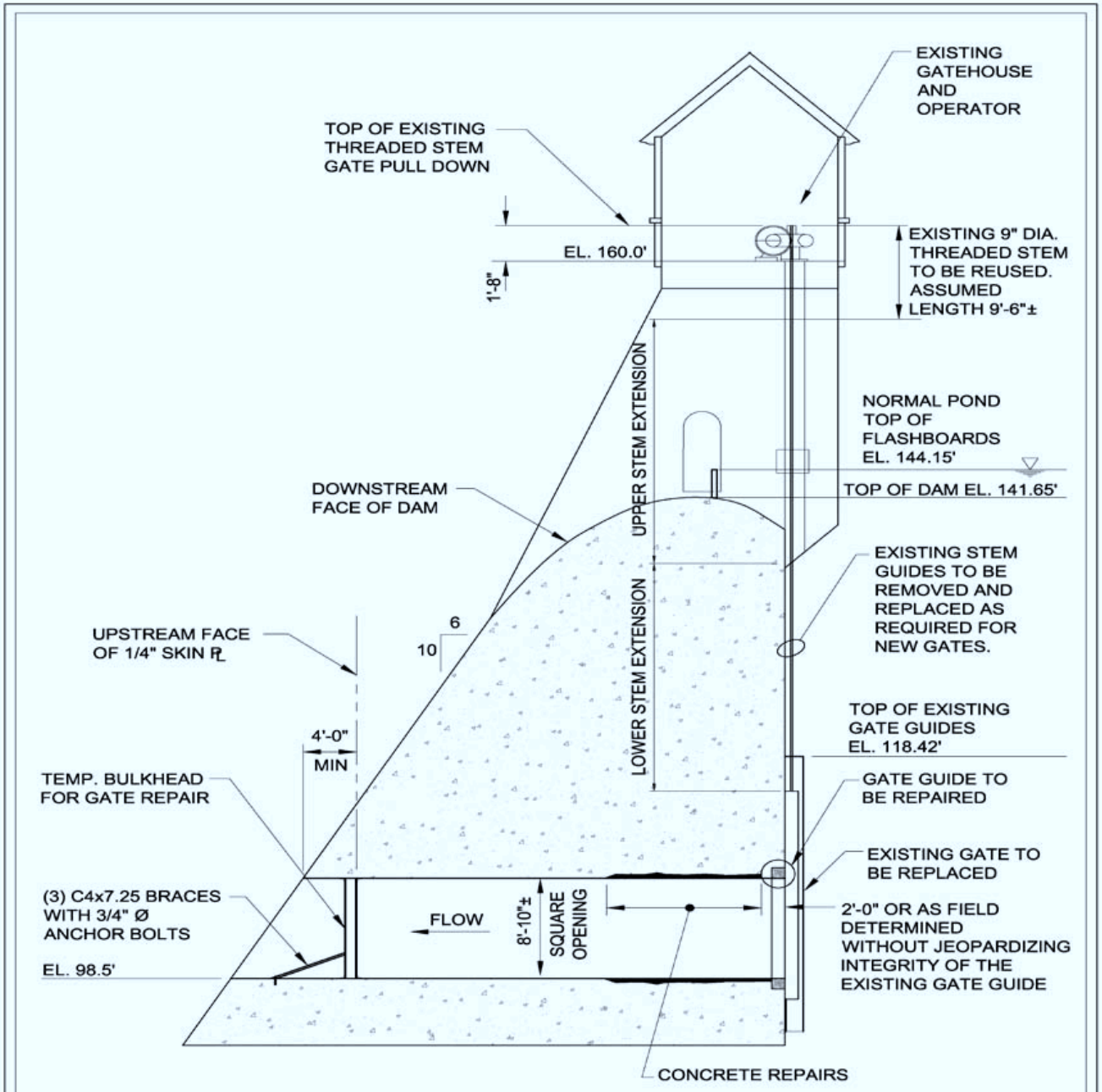

EXISTING GATEHOUSE AND OPERATOR
TOP OF EXISTING THREADED STEM GATE PULL DOWN
EL. 160.0'
1'-8"
EXISTING 9" DIA. THREADED STEM TO BE REUSED. ASSUMED LENGTH 9'-6"±
UPPER STEM EXTENSION
NORMAL POND TOP OF FLASHBOARDS EL. 144.15'
TOP OF DAM EL. 141.65'
DOWNSTREAM FACE OF DAM
EXISTING STEM GUIDES TO BE REMOVED AND REPLACED AS REQUIRED FOR NEW GATES.
LOWER STEM EXTENSION
6
10
UPSTREAM FACE OF 1/4" SKIN PL
TOP OF EXISTING GATE GUIDES EL. 118.42'
4'-0" MIN
TEMP. BULKHEAD FOR GATE REPAIR
GATE GUIDE TO BE REPAIRED
EXISTING GATE TO BE REPLACED
(3) C4x7.25 BRACES WITH 3/4" Ø ANCHOR BOLTS
FLOW
8'-10"± SQUARE OPENING
2'-0" OR AS FIELD DETERMINED WITHOUT JEOPARDIZING INTEGRITY OF THE EXISTING GATE GUIDE
EL. 98.5'
CONCRETE REPAIRS

FIGURE 1

Example 3 - 1948 Vintage Headgate

LESSONS LEARNED

- Incomplete Information - Complete condition of gates commonly unknown until full disassembly
- Initial condition assessment decisions generally need to be made on incomplete information
- Depth of observations need to match consequence of failure

How Serious is This Guide Deterioration?

Operational Review and Assessment

Can your Gate be Raised High Enough?

Types of Gate Failures

- Gates fail to open when directed.
- Gates open from equipment malfunction.
- Gates fail structurally with sudden discharge.
- Debris blockage impedes discharge.
- Gates operated incorrectly.

1.0 Gates Fail to Open When Directed

- Loss of Electrical Power (Tous, 1982: Spokane 1986: Belci 1991)
- Automatic Control Malfunction (San Teresa, 1963)
- Operator Hoist Chain/Rope Failure (Picote, 1966; Tarbela, 1992)
- Wooden Gate Stem Tensile Rupture (Vergennes, 2002)

2.0 Gates Open From Equipment Malfunction

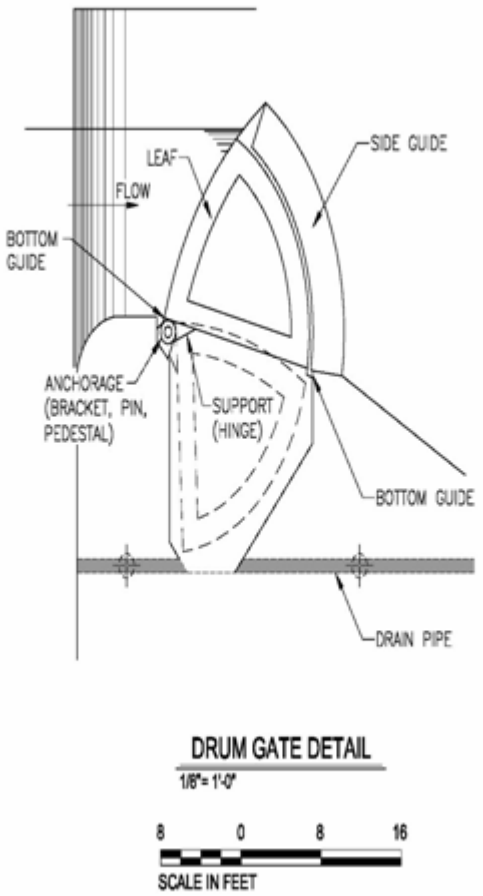
- Uncontrolled automatic start of oil pump (Mavcice Dam, 1993).
- Frozen water in electrical conduit forced contacts closed. (Seton 1989).

3.0 Gate Structural Failure

- Example Failures:
  - Tainter
  - Bascule
  - Sluice

Drum Gate Failures

- Drum gate fills with water (Guernsey, 1986)
- Drum Gate (Cresta, 1997)



Tainter Gate Failures

- Tainter gate trunnion girder weld failure (Singur, 1990)
- Tainter gate arm bracing failure (Folsom, 1995)
- Tainter gate arm to trunnion failure (1994)

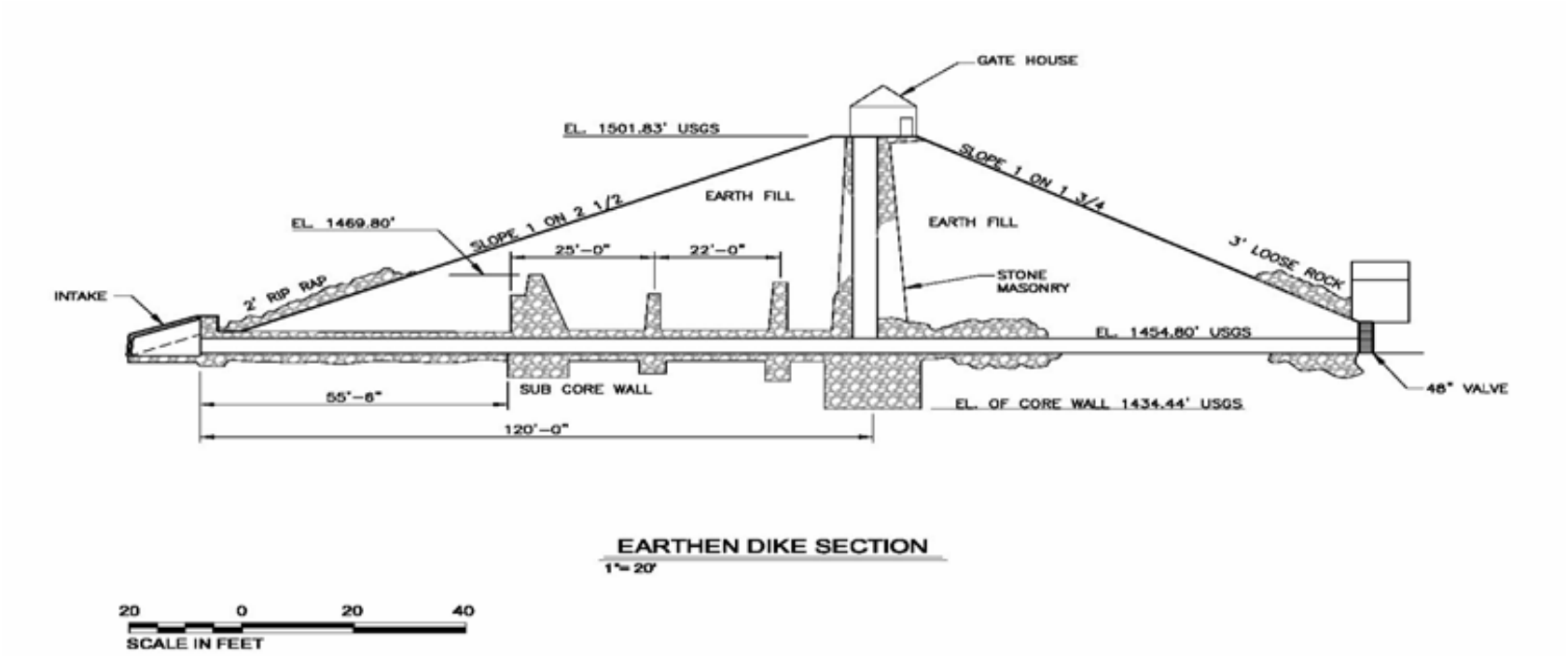
Failed Folsom Tainter Gate

Bascule Gate Failure

- Steel Tensile Rupture Near Bottom Hinge (1991)
- Deteriorated/Missing Bolts in Bottom Torque Tube (1999)

Sluice Gate Failure

- Cast Iron Gate Fracture (2002)
- Corroded 1934 Vintage Steel Deep Sluice (2003)



Preventing Gate Failures

- Focus attention on Critical Gates
- Provide & Practice loss of electrical power operating procedures
- Regularly Field Verify actual condition and operation of electrical & mechanical operator components
- Concentrate Inspection and Maintenance on items where reactions are concentrated and/or lack of redundancy

Preventative Maintenance

Ice Issues

Reducing Ice

New Gate Seals

Modifications to Increase Operational Flexibility