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Big Canoe® POA

LAKE PETIT DAM

Pickens County, Georgia

State ID No. 112-009-00462

NID No. GA00685

Operation and Maintenance Plan

Prepared for:

Big Canoe® Property Owners Association, Inc.
10586 Big Canoe
Jasper, GA 30143
Pickens County

Prepared by:

Geosyntec Consultants, Inc.
835 Georgia Avenue, Suite 500
Chattanooga, TN 37402

Project No: TN8667

Document No. GA220392

December 2022

This Operation and Maintenance Plan is NOT an Emergency Action Plan.

Refer to the Emergency Action Plan if there is a potential failure at the dam.

COMMON INDICATORS OF POTENTIAL DAM FAILURE:

- Muddy water flowing from the downstream slope or toe.
- Significant cracks or depressions forming on the embankment.
- Movement or sliding of the surface of the embankment.
- Water flowing over the top of the dam, or rapidly approaching overflow.

IF DAM FAILURE IS IMMINENT:

- Contact 911
- Activate the Emergency Action Plan
- Call Georgia Environmental Protection Division Safe Dams Program (404-463-2461)

REVISION LOG

Revision No.	Effective Date	Affected Page Numbers	Description of Revision/Change	Performed By
0	14 July 2021	All	Initial Issue	Geosyntec
1	01 December 2022	All	Inclusion of Maintenance Repair Information and Update Lake Volumes	Geosyntec

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1. INTRODUCTION

This Operation and Maintenance Plan (O&M Plan or document) was prepared by Geosyntec Consultants, Inc. (Geosyntec) of Chattanooga, Tennessee on behalf of the Big Canoe® Property Owners Association, Inc. (POA or Owner), Jasper, Georgia with guidance from the Rules for Dam Safety of the Georgia (GA) Safe Dams Act of 1978.

This O&M Plan provides routine procedures and recommendations to be performed during normal operation and maintenance of Lake Petit Dam (Dam). The objective of this document is to provide a manual for current and future owners and/or operators of the Dam, and to enable anyone (POA personnel, Engineers, Inspectors, etc.) new to the Dam to easily become familiar with its operations. The O&M Plan should be reviewed and updated annually, and on an as-needed basis when modifications are completed on the Dam that would affect routine operations and maintenance procedures.

1.1 Ownership Information

Contact information for the Owner and Primary Operator of the Dam, as well as the Engineer, are provided in this Section of the O&M Plan. In the event of a potential dam failure, refer to the list of emergency contacts in the Emergency Action Plan (EAP).

Owner Information

Owner and Primary Operator: Big Canoe Property Owners Association, Inc.
Address: 10586 Big Canoe, Jasper, Georgia 30143
Daytime Phone #: (706) 268-3346

Dam Owner's Representative

Dam Owner Representative: Scott Auer
Address: 10586 Big Canoe, Jasper, Georgia 30143
Daytime Phone #: (706) 268-2400
Emergency Phone #: (770) 940-3758

Additional Contacts

Engineer: Wesley MacDonald, P.E.
Address: 835 Georgia Avenue, Suite 500, Chattanooga, Tennessee 37402
Daytime Phone #: (423) 385-2312
Emergency Phone #: (615) 830-5139

1.2 Dam Data Sheet

This section provides high-level categorical data with regards to the Dam. For descriptions of the dam's pertinent features refer to Section 2 of this document.

Table 1 – Dam Data

Dam Name:	Lake Petit Dam	
State ID:	No. 112-009-00462	
NID:	GA00685	
Classification:	Category I	
Purpose of Dam:	Recreation and Water Supply	
Year Constructed:	1972	
Year(s) Modified and Construction History:	1974, 1976, 1997, 1998, 2008, 2009, and 2022	
Original Design Engineer/Firm:	Baldwin & Cranston Associates	
GPS Location:	34.4625 (North)	-84.2903 (West)
County:	Pickens	
Access to Dam:	The Dam is located within the private development owned and operated by Big Canoe Property Owner Association, Inc., which is a gated, private residential community. The Dam can be accessed from the crest via Wilderness Parkway and from the toe via Wolfscratch Drive.	

2. DESCRIPTION OF PERTINENT DAM FEATURES

2.1 General Description

The Dam was constructed in 1972 as a zoned earth embankment consisting of a central clayey silt core and predominantly silty sand embankment shells. The Dam was constructed to supply water and provide recreation for the Big Canoe development and is permitted as a Category I Dam under Chapter 391-3-8 of the Georgia State Code Rules for Dam Safety. The Dam is owned, operated, and maintained by the POA. The original design drawings for the Dam were prepared by Baldwin & Cranston Associates (Baldwin & Cranston, 1971).

The Dam is located in Pickens County, Georgia, within the Big Canoe development on Petit Creek, approximately 5.8 miles upstream of Marble Hill, Georgia. An access map of the Dam and its surrounding facilities was prepared by the POA and is provided in Attachment A – Big Canoe Street Map (Big Canoe POA, 2019). The Dam can be accessed from the crest via Wilderness Parkway and from the toe via Wolfscratch Drive. A topographic and feature survey of the site was completed in April 2021 and is provided in Attachment B – Topographic and Feature Survey (Jordan Engineering, 2021).

2.2 Embankment

According to the United States Army Corps of Engineers (USACE) National Inventory of Dams (NID), the Dam has a maximum height of 126 feet (ft) measured as the vertical difference from crest to the current streambed.

The core of the Dam was designed to be centered on the axis of the Dam, measuring approximately 15 ft wide at elevation (EL.) 1637.0 ft National Geodetic Vertical Datum of 1929 (NGVD29), and inclined at one (1) horizontal to two (2) vertical (1H:2V) on both the upstream and downstream sides. Borings conducted in 1998 indicate the slope of the downstream side of the core is actually 1H:1.5V (Geosyntec, 2020). A keyway along the centerline of the Dam and underlying the core was designed to be extended to bedrock. The keyway is approximately 40 ft wide at its base.

The crest of the Dam is composed of a two-lane asphalt road (Wilderness Parkway) that runs in an approximately east-west direction. The crest is at approximately EL. 1647.0 ft North American Vertical Datum of 1988 (NAVD88), has a span (i.e., length) of approximately 908 ft, and a crest width of approximately 35 ft.

2.3 Upstream Face

The upstream face of the Dam borders Lake Petit (reservoir) and was designed to be an inclined slope at 3.5H:1V. The surface of the upstream face is vegetated and is used for recreational purposes (e.g., fishing, outdoor activities, etc.). Pertinent features located on the upstream face are: (i) shoreline; (ii) low-level discharge conduit gate operator vault; (iii) left and right groins; and (iv) reservoir.

2.3.1 Shoreline

The shoreline of the Dam is located on the upstream face and is composed of rip rap extending from the left to right abutments of the Dam. A shoreline protection repair was conducted in 2022, which involved the replacement of the existing rip rap with Georgia Department of Transportation

(GDOT) Type 1 rip rap, mixed with select pieces of the original rip rap, to existing grades atop of approximately 6 inches (in.) of GDOT #4 coarse aggregate. The rip rap extends from El. 1632.5 ft NAVD88 up to approximately El. 1639.5 ft NAVD88.

Upon completion of the shoreline protection repair, construction entrances on the left and right sides of the shoreline were regraded and dressed to allow access to the shoreline. GDOT #4 coarse aggregate was left in place for access if future maintenance of the shoreline is required.

2.3.2 Low-Level Discharge Conduit Gate Operator Vault and Inlet

The gate operator vault for the low-level discharge conduit is located on the upstream face, near the center of the Dam at Station (STA) 4+70. This is just north of the present-day flagpole. A 30-inch (in.) x 30-in. heavy-duty sluice gate (inlet) was designed (Baldwin & Cranston, 1971) to be mounted on the low-level inlet structure that connects the low-level discharge conduit to the reservoir (Figure 1). The low-level discharge conduit, and associated structures, are classified as the emergency spillway. The lift used to operate the heavy-duty sluice gate is located under the hatch cover of the low-level discharge conduit gate operator vault. To facilitate future maintenance repairs at the Dam, Big Canoe POA may elect to lower the reservoir via a siphon system located left (east) of the concrete spillway (see Section 2.3.4 for additional details).

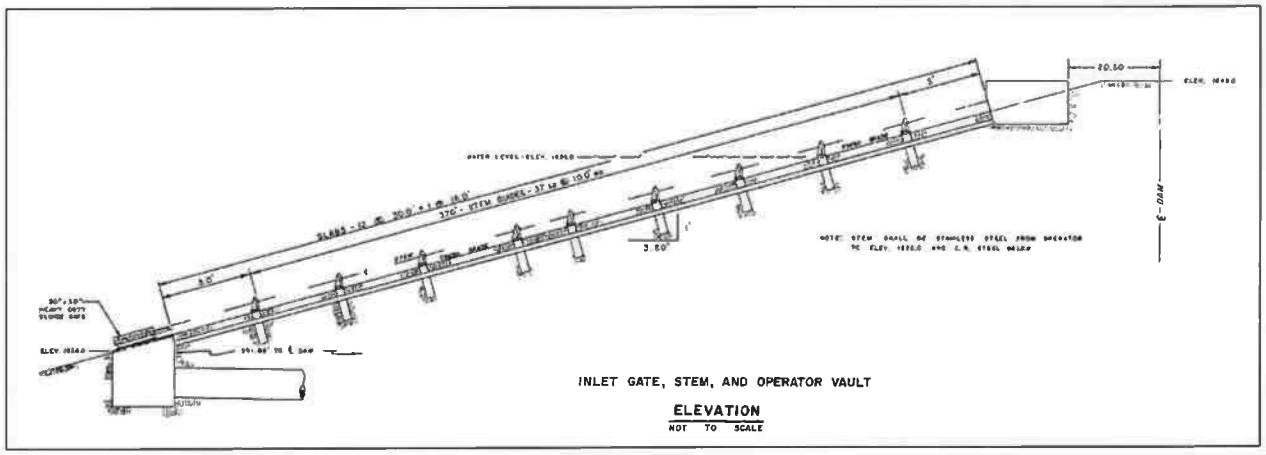

Figure 1 – Cross-Sectional View of the Low-Level Discharge Conduit Gate Operator Vault, Stem, and Inlet Gate. (Baldwin & Cranston, 1971)

In March 2022, while conducting the shoreline protection repair, the vent pipe for the low-level discharge conduit was uncovered, which consists of a 5-in. diameter pipe. The pipe was observed to be comprised of two distinct materials and damaged. The lower sections (in the direction of the sluice gate for the low-level outlet) of the pipe appeared to be asbestos cement. The upper section of the pipe appeared to be steel and was connected to the valve stem operator vault. After jetting the vent pipe (i.e., cleaning of the vent pipe via a jetting truck) and it was reconnected to the vault using a 6-in. PVC Schedule 40 pipe connected to the existing steel and asbestos-cement pipe via 6-in. to 5-in. reducer rubber gasket coupler.

2.3.3 Upstream Left and Right Groins

On the left and right ends of the upstream face, where the upstream face meets its respective abutment are the left and right groins of the Dam. These groins have historically been used for access to the Dam by the public and wildlife.

2.3.4 Reservoir

According to a bathymetric survey conducted at Lake Petit in March 2022, the deepest elevation is approximately 1538.3 ft NAVD88 (i.e., approximately 97.2 ft below normal pool level). The maximum possible fetch (i.e., the average horizontal distance, perpendicular to the axis of the dam, across the reservoir subject to wind forces) of approximately 3,700 ft across the extent of the reservoir. The reservoir is controlled by the sill elevation (EL. 1635.5 ft NAVD88) at the spillway. To facilitate future maintenance repairs at the Dam, Big Canoe POA may elect to lower the reservoir via a siphon system located left (east) of the concrete spillway. The siphon system is composed of a 12-inch raw water main for the intake and an 8-inch ductile iron pipe for the outlet. The siphon system is controlled via a valve system located within a drop manhole located on the downstream side of Wilderness Parkway and left of the concrete spillway.

2.4 Downstream Face

The downstream face of the Dam was designed and constructed with an inclined slope at approximately 2.5H:1V with 10-ft wide benches at approximate 20-ft vertical intervals (Figure 2). Pertinent features located on the downstream face are: (i) downstream benches; (ii) instrumentation; and (iii) the left and right groins.

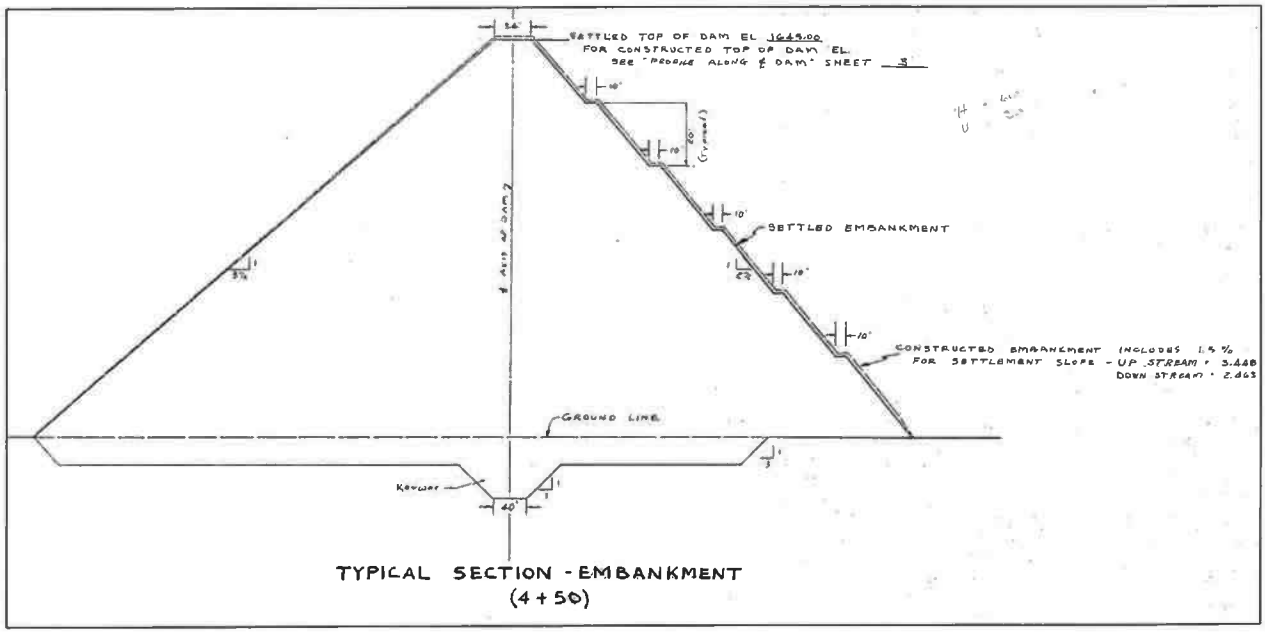

Figure 2 – Lake Petit Dam Typical Section Showing Design Surficial Geometry (Baldwin & Cranston, 1971)

2.4.1 Benches

There are five (5) benches on the downstream face of the Dam, excluding the roadway bench at the downstream toe. The benches are numbered in ascending order, with the lowermost bench being identified as Bench Number (No.) 1. The upper three (3) benches (Bench Nos. 3 to 5) are vegetated with grass, while the lower two (2) (Bench Nos. 1 and 2) are partially paved with concrete channels that are intended to collect and convey both surface water and interceptor drain seepage off the face of the Dam. On the left and right ends of Bench No. 1 (in their respective

groins), two (2) makeshift weirs were constructed and are used to monitor the qualitative flow of water leaving the lowermost concrete channel on the downstream slope.

Nuisance seepage was observed upslope of two paired interceptor drains located on the left side of the downstream face (see Section 2.5.3 for information on the interceptor drain system). The nuisance seepage was first observed and documented in the 2nd Quarterly Inspection of 2020, dated 12 May 2020. The apparent point of origin of the nuisance seepage was approximately 19 ft upslope of the concrete channel located on Bench No.1. To prevent the migration of dam material, construction of a two-stage filter was conducted in February 2022, which involved the placement of GDOT No. 10 FM sand on exposed Dam shell material, which was overlain by GDOT #89 coarse aggregate, with a thickness of approximately 18 in. for both filter materials. 24 linear ft of 18-inch Contech A2000 corrugated PVC pipe was installed atop of the concrete channel and wrapped with TenCate Mirafi S1000 nonwoven geotextile. After placing the PVC pipe in the concrete channel, a buttress composed of GDOT #57 coarse aggregate was placed over the PVC pipe, extending onto Bench No. 1.

2.4.2 Instrumentation

Instrumentation at the Dam primarily relies upon the piezometers installed across the downstream face. Two types of piezometers have been installed on the Dam: (i) conventional standpipe piezometers that consist of PVC pipes with screened sections strategically located to facilitate direct measurement of water levels within the shell of the Dam; and (ii) vibrating wire piezometers (VWPZ) that consist of electrical pressure transducers that provide a means of measuring water pressures at discrete locations within the shell and core. Changes in water levels and pressures measured from these instruments provide useful information regarding the effectiveness of a dam's internal drainage system. As discussed in the section above, there are also two (2) makeshift weirs constructed on the left and right ends of Bench No. 1.

The maintenance required for the instrumentation at the Dam is discussed in further detail in Section 4 of this document. A description of the currently measured instrumentation, along with reading frequency is presented in Section 6 of this document.

2.4.3 Downstream Left and Right Groins

On the left and right ends of the downstream face, where the downstream face meets its respective abutment are the left and right groins of the Dam. These groins have historically been used for access to the Dam by wildlife and are typically not accessed by the public. Surface water collected on the benches drain from the centerline of the dam towards the right and left groins.

2.5 Outlet Works

The outlet works consist of three (3) major features: (i) a spillway; (ii) a low-level discharge conduit; and (iii) an internal drainage system.

2.5.1 Spillway

The Dam has an approximately 15-ft wide concrete cascading channel spillway, located east of the earthen dam's left abutment, that currently serves as the primary spillway outlet of the reservoir. Based on design drawings, the cascading channel spillway is made of reinforced pneumatically placed concrete (i.e., shotcrete) placed against the excavated face of soil. The shotcrete was

designed to be at least six (6) in. thick with No. 3 rebar reinforcement spacing varying between nine (9) and 18 in. on center. The cascades were designed to drop between one-half (0.5) to three (3) ft from one to another from EL. 1633.1 ft NAVD88 (converted from NGVD29) at the crest to approximately EL. 1510.1 ft NAVD88 (converted from NGVD29) at the tailwaters of Petit Creek. The overall channel depth was designed to be maintained at four (4) ft minimum to seven (7) ft maximum with an excavation from the existing ground.

The reservoir elevation was originally designed to be controlled by a concrete sill just upstream of the double box culvert bridge located on the roadway (i.e., Wilderness Parkway) running along the crest of the Dam. At least three (3) utility pipes are visible running through the box culvert (longitudinally to the Dam, and perpendicular to the flow of the spillway).

2.5.2 Low-Level Discharge Conduit

The low-level discharge conduit (discharge conduit or low-level outlet) is shown on original design drawings (Baldwin & Cranston, 1971) as an 814-ft long, 36-in. diameter, concrete pressure pipe with deep spigots and bells that meets American Water Works Association (AWWA) Specification C301 (AWWA, 2014).

The low-level discharge conduit runs perpendicular to the Dam baseline/crest near STA 4+70 along the north-south centerline of the Dam for approximately 400 ft to the intersection with the east-west centerline of the Dam. At approximately this point the discharge conduit curves and intersects the internal drainage system where two (2), 8-in. diameter asbestos-cement pipes begin, parallel the discharge conduit, and extend to the exit at the downstream toe of the Dam, in the tailwater creek. The collector box for the discharge conduit and the internal drainage system consists of an 18-ft by 10-ft reinforced concrete energy-dissipating outlet structure (i.e., impact basin).

2.5.3 Internal Drainage System

The internal drainage system for the Dam was designed to be an 8-in. diameter asbestos-cement perforated pipe embedded in a 4-ft square trench drain filled with coarse-grained soil (i.e., graded "bank drain" from original drawings). The 8-in. diameter pipe traverses the valley bottom downstream of the core, approximately 230 ft from the east-west baseline of the Dam. Two (2), 4-ft bank drains, without piping, extend partially up both abutments at the abutment-core intersection. Two (2) outlets running along either side of the low-level discharge conduit extend to the impact basin and consist of 8-in. diameter solid asbestos-cement pipes. The perforated 8-in. pipe is shown on original design drawings as being 220 ft in length, while the solid 8-in. pipes are shown as being 184 ft and 197 ft in length.

Additionally, approximately 13 interceptor drains have been located on the lowermost bench (i.e., Bench No. 1) above Wolfscratch Drive at the downstream toe. The interceptor drain outlets are a series of corrugated plastic pipes, which empty into the concrete channel on Bench No. 1. These pipes appear to have been installed post-construction of the dam, likely in the late 1970s, in response to observed seepage. These pipes generally appear to be inclined approximately horizontally with a slight slope to provide positive drainage.

3. OPERATION PROCEDURES

The Owner (i.e., Big Canoe POA) is responsible for routine operations at the Dam. Routine operations are described in the sections below, which include: (i) reservoir operations; and (ii) operation of the low-level discharge conduit.

3.1 Reservoir Operations

The reservoir is controlled by the sill elevation at the spillway. To facilitate future maintenance repairs at the Dam, Big Canoe POA may elect to lower the reservoir via a siphon system located left (east) of the concrete spillway. Operating data for the reservoir is presented in Table 2.

Table 2 – Lake Petit Dam Operating Data

Feature	Data
Normal Pool Level	EL. 1635.5
Top of Dam Elevation (settled)	EL. 1647.0
500-Year Flood Elevation at Dam	EL. 1638.4 [2]
100-Year Flood Elevation at Dam	EL. 1637.7 [2]
Normal Storage	4,235 acre-ft [3]
Maximum Storage	5,635 acre-ft [3]
Reservoir Surface Area (normal pool)	107 acres [3]
Spillway Crest Elevation	EL. 1635.5
Spillway Discharge Capacity	(To be determined)
Low-Level Discharge Conduit Inlet Elevation	EL. 1536.1 *
Low-Level Discharge Conduit Outlet Elevation	EL. 1517.6 *
Drainage Area (upstream)	1.53 square miles

Notes:
EL. – elevation (ft NAVD88)
* – Converted from NGVD29 to NAVD88

1. Feature data based on a survey from 2021. A survey from 1998 indicates the top of dam elevation is approximately EL. 1647.0 ft NGVD29 and spillway crest is EL. 1633.2 ft NGVD29. Original design drawings (Baldwin & Cranston, 1971) indicate the top of dam elevation was to be approximately EL. 1646.1 ft NAVD88 and spillway crest was to be approximately EL. 1635.1 ft NAVD88.
2. Based on a scenario where the low-level discharge conduit is not utilized.
3. The value reported is from a bathymetric survey conducted in March 2022, which was formally accepted Georgia Safe Dams Program in August 2022.

If reservoir operating conditions are observed to differ considerably from those presented herein, please refer to the EAP for the appropriate contacts and consult the Engineer of Record (EOR) for further guidance.

3.2 Low-Level Discharge Conduit Operations

NOTE: As of the writing of this document, there is no record of the low-level discharge conduit sluice gate being operated in its history. The POA does not presently plan to utilize this feature of the Dam due to its perceived risk and possibility of not being able to shut it. This perceived risk was communicated to the GSDP in May 2005. On 16 August 2005, GSDP agreed that it was "not wise at this point to test the gate valve." Based on a meeting on 18 June 2021, GSDP was still in agreement it should not be operated without proper engineering measures. As of Revision 1 of this document, the POA is planning to coordinate a test of the low-level discharge conduit sluice gate with the assistance of a dam safety engineer and a specialty contractor. The POA is coordinating the findings of this test with the GSDP, and results should be available in 2023.

The 30-in. x 30-in heavy-duty sluice gate for the low-level discharge conduit was designed to be mounted on the low-level inlet structure that connects the low-level discharge conduit to the reservoir (Figure 3). The low-level discharge conduit, and associated structures, are classified as the emergency spillway. To facilitate future maintenance repairs at the Dam, Big Canoe POA may elect to lower the reservoir via a siphon system located left (east) of the concrete spillway.

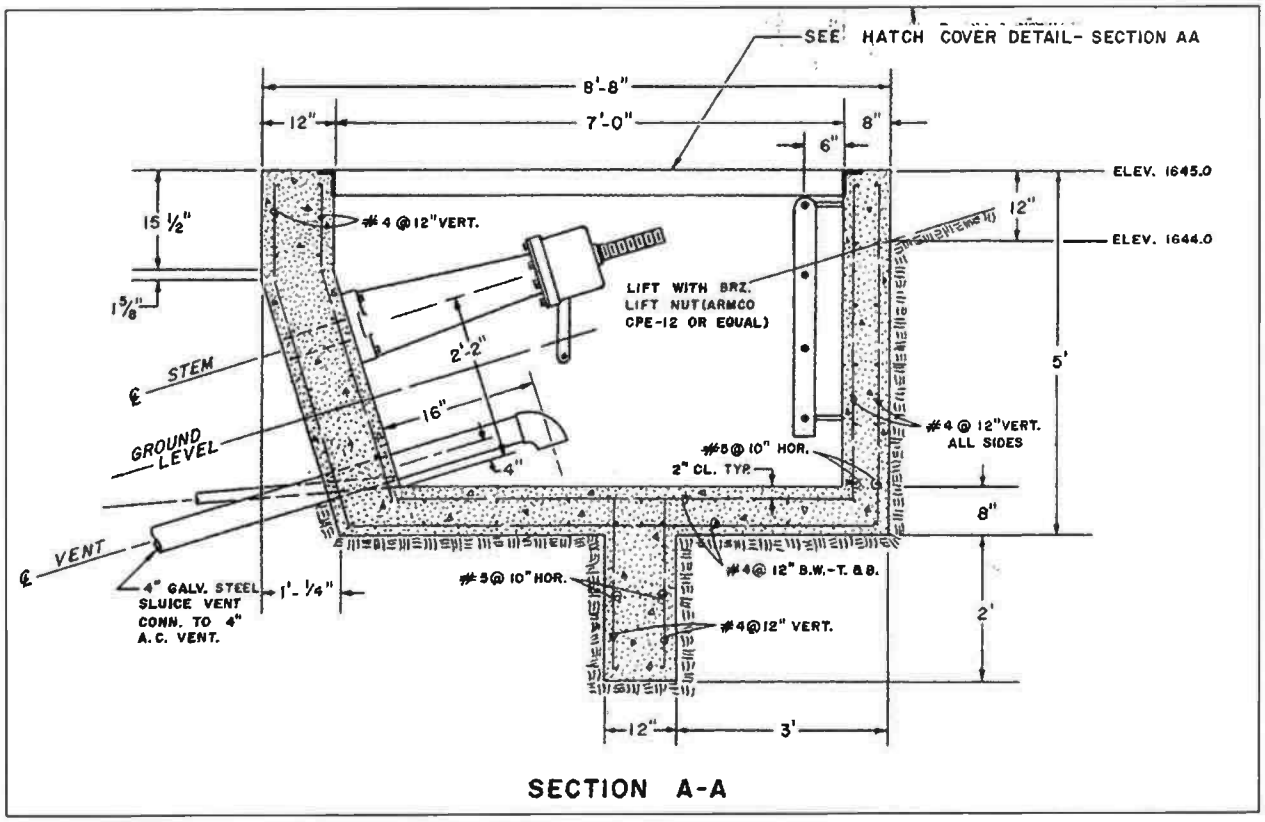

Figure 3 – Cross-Sectional View of the Low-Level Discharge Conduit Gate Operator Vault (Baldwin & Cranston, 1971).

There are no records of the specific model of heavy-duty sluice gate installed at the Dam, however, it is believed that the sluice gate was designed by the same manufacturer (ARMCO) of the sluice gate at Lake Disharoon Dam (a dam owned and operated by POA that was constructed in 1974). ARMCO is no longer in service; however, Hydro Gate® (a brand of Mueller Water Products)

provides operation and maintenance guidance for Cast Iron Slide Gates that are similar in design to the one believed to be installed at the Dam.

The following procedures are included should the low-level discharge conduit ever be operated for emergency purposes.

3.2.1 Manual Handcrank

The lift used to operate the heavy-duty sluice gate is located under the hatch cover of the low-level discharge conduit gate operator vault. A manual handcrank is required to operate the lift. The location of the crank is believed to be on the handcrank that is currently utilized and installed on Lake Disharoon Dam. A backup handcrank should be procured and both handcranks should be stored onsite at the Big Canoe property at a location that can be accessed at any time should an emergency occur, and their locations should be documented in this manual.

The following guidance language covers the general operating procedures associated with manual-operation systems of the lift (handcrank) recommended from Hydro Gate, based on present-day models, and may be applicable to the existing system at Lake Petit Dam:

> To open this Cast Iron Slide Gate (i.e., sluice gate) observe the direction of rotation noted on the lift housing. Crank in the direction of opening.
>
> - If the gate has been closed for an extended period, the gate may be difficult to "unseat."
> - If, after several turns of the handcrank, the rotation becomes increasingly difficult, stop rotation when moderate pressure is achieved.
>
> Allow the pressure in the stem to unseat the gate (a "POP" sound typically signals the gate has begun to travel. Continue to turn the handcrank until the desired gate position has been achieved. During the opening procedures, **do not** over-open the gate. Serious damage to the gate stem and sealing surfaces can result.
>
> - To close this Cast Iron Slide Gate, turn the crank in the direction opposite of the Open indicator until the stopnut on the stem has moderately seated on the top of the lift. After the gate has been closed as noted on the indicator, the gate is considered to be [fully] closed. Then reverse the rotation of the crank and relieve the pressure on the stem and lift. Should the gate or actuator require adjustment, refer to the appropriate section of the Installation, Operation, and Maintenance Manual or call Hydro Gate before any adjustments are made. During the closing procedures, **do not** attempt to adjust the position of the stopnut to achieve additional closing stem travel. Serious damage to the gate stem and sealing surfaces can result (Hydro Gate, 2016).

A copy of the Installation, Operation, and Maintenance Manual (Hydro Gate, 2016) is provided in Attachment C – Installation, Operation, and Maintenance Manual for Cast Iron Slide Gates.

4. PERIODIC MAINTENANCE PROCEDURES

The Big Canoe POA is responsible for conducting routine maintenance of the Dam. The following outline lists, by relative priority, the various problems or conditions that might be encountered at the Dam.

4.1 Emergent Maintenance

The following conditions are critical and call for immediate attention:

- The Dam has overtopped or is being overtopped;
- The Dam is about to be breached (by progressive erosion, slope failure, or other circumstances);
- The Dam is showing signs of piping or internal erosion indicated by increasingly cloudy seepage or other symptoms;
- The Dam's spillway is being blocked or otherwise rendered inoperable, or having normal discharge restricted;
- Evidence of excessive seepage appearing anywhere at the Dam site (e.g., the embankment becoming saturated or seepage exiting on the downstream face of the Dam) and increasing in volume; or
- A sinkhole (i.e., a depression greater than the dimensions specified in Section 4.2.1).

If the conditions above are observed at the Dam, refer to the EAP for the appropriate emergency classification and appropriate course of action and contact the EOR so that appropriate recommendations can be made.

4.2 Corrective Maintenance

The following sections outline maintenance activities that should be completed as soon as possible after the relevant defective condition is first documented. In certain instances, immediate corrective actions may not be feasible due to safety concerns, material limitations, and/or regulatory requirements. Similarly, a period of observation may be warranted prior to performing corrective maintenance.

4.2.1 Depressions

Depressions are sunken areas with respect to their surrounding grades and are typically observed in dams in the abutment, toe area, or sloped surfaces. They may be created during construction, decay of buried organic materials, thawing of frozen embankment material, internal erosion of the embankment, by animal burrows, or settlement (consolidation) of the embankment or its foundation. Depressions can also create low areas along the crest, cracks through the embankment, structural damage to spillways or other appurtenant structures, damage to internal drainage systems, or general instability of the embankment. They can also inhibit the maintenance of the Dam and make the detection of stability or seepage problems difficult (ASDSO, 2021a).

If a depression is observed at the Dam, photograph and record the location, size or extent, and depth of any depression or animal burrow. Note that the depression should be inspected frequently

to ensure it is not continuing to settle or enlarge. If after several months of inspection, it is determined that the depression is stable, then the depression should be addressed in accordance with the following guidelines of this section. If the depression continues to grow and exceed the dimensions mentioned in the guidelines in this section, they will be categorized as sinkholes and the EOR should be contacted for the appropriate recommendation.

The following guidelines are intended for minor depressions (i.e., maximum of three (3) ft in depth with a maximum diameter of three (3) ft). Where larger depressions may be observed, the depression should be evaluated by the EOR on a case-by-case basis so that appropriate recommendations can be made.

- Remove the vegetation and any unsuitable or loose fill from the area. Backfill the depression with cohesive soil (i.e., similar to the material the shell of the embankment is composed of). Spread and grade the soil in the depression to conform to the original embankment ground line and compact the backfill.
- If the depression exceeds six (6) in. in depth from the original grade, the backfill of the depression should be completed in 6-in. lifts. Each lift should be compacted using hand-operated or mechanical tamping tools intended for the compaction of the soil.
- Repaired areas should be seeded to re-establish vegetative cover. Examples of appropriate vegetation cover include, but are not limited to, Bermuda, tall fescue, centipede grasses, bluegrass, alfalfa, clover, and redtop. Per the Association of State Dam Safety Officials (ASDSO), "one suggested seed mixture is 30% Kentucky Bluegrass, 60% Kentucky 31 Fescue, and 10% Perennial Ryegrass. Once the seed is sown, the area should be mulched and watered regularly. Erosion control blankets should be placed over re-graded areas following re-seeding" (ASDSO, 2021c).

4.2.2 Erosional Features

Erosional features can commonly occur along the upstream and downstream face, groins, and other sloped surfaces of the Dam. Erosion normally appears in the form of rills (i.e., shallow channels) and gullies (i.e., larger and deeper eroded channels) and is formed by concentrated flow of stormwater runoff, especially on bare slopes or where vegetation is sparse. If left untreated, the rills and gullies can progress in size and could lead to slope instability or other adverse issues. General guidelines for the repair of rills and gullies are provided below. The following guidelines are intended to be applicable for minor to moderate cases of rill/gully erosion. Where widespread or extensively deep gullies features may be observed, the features should be evaluated by the EOR on a case-by-case basis so that appropriate recommendations can be made.

- Dump and spread cohesive soil to fill, re-grade, and shape affected areas to conform to the original ground line. Tracking and blading material with a dozer should be performed until the original ground line is reformed and the material is reasonably compacted.
- If using grass, the topsoil should be prepared with fertilizer and then scarified before sowing seed.

- Repaired areas should be seeded to re-establish vegetative cover. Erosion control blankets should be placed over re-graded areas following re-seeding. Once the seed is sown, the area should be mulched and watered regularly.

4.2.3 Seepage

Seepage can emerge on the downstream face, beyond the toe, or on the downstream abutments of the Dam, at elevations below normal pool. Seepage may vary in appearance from "soft", wet surfaces to a flowing "spring," and also may potentially only be observed as an area where the vegetation is more lush and darker green (hydrophilic). Wet areas on the downstream face of the Dam are typically not natural springs, but seepage areas. Even if natural springs exist, they should be treated with suspicion and carefully monitored. Flows from groundwater springs in existence prior to the reservoir would probably increase due to the pressure caused by a pool of water behind the Dam. All dams have some seepage as the impounded water seeks paths of least resistance through the embankment and its foundation. Seepage must, however, be controlled in both velocity and quantity to prevent the seepage from eroding dam material (North Carolina Department of Environment and Natural Resources, 2007).

Seepage areas should be evaluated by the EOR on a case-by-case basis so that appropriate recommendations can be made.

4.2.4 Tree Removal

Trees and heavy brush growth should be controlled at the Dam. If left in place, trees can result in the creation of seepage paths within the embankment. Allowing vegetation to become overgrown restricts the level of inspection that can be performed on the structure and provides protection and food sources for burrowing animals. General guidelines for the removal of trees and maintenance of vegetation are provided below. Evaluations other than those outlined below should be made by the EOR on a case-by-case basis so that appropriate recommendations can be made.

- All trees with a diameter less than four (4) in. should be cut level with the ground and the cut tree and branches discarded (FEMA, 2005b). The stumps should be treated with a waterproof sealant such as asphalt, polyurethane, or wood preservative to prolong stump decay. For trees with a diameter greater than four (4) in., the removal should be designed and overseen by the EOR based on the trees' location on or around the dam.

4.2.5 Animal Burrows

Animal burrows are relatively common along slopes of dams. If left untreated, these burrows can result in the creation of seepage paths through the embankment. Additionally, tunnels may eventually collapse resulting in surface irregularities in the embankment. General guidelines for the repair of animal burrows are provided below. However, if the burrow extends more than three (3) ft below the embankment surface, extends across a dam, or there are signs of embankment stress surrounding a burrow, the repair of these features should be evaluated by the EOR on a case-by-case basis so that appropriate recommendations can be made.

- Animals should be captured and removed from the area. It is recommended that a local conservation representative be consulted prior to this action;

- For observed burrows without signs of embankment distress, the area can be filled in with an impervious material or cementitious grout. This method of filling requires one length of pipe vertically placed in the burrow and sealed. Then introduce a slurry with 90% to 10% soil to cement ratio, with enough water to make it flow into the pipe and hole (ASDSO, 2021c). Alternatively, the animal burrow could be excavated and cleaned of excess soil along its pathway up to a depth of three (3) ft. With this type of repair, an isolated excavated area of the embankment is exposed; and
- The excavated area should be backfilled with compacted cohesive material (as outlined in Section 4.2.1).

4.2.6 Spillways and Appurtenant Structures

The proper operation of spillways, inlet and outlet structures, and stilling basins requires regular and thorough cleaning and removal of debris. Cleaning is especially important after storms and large precipitation events, which tend to send more debris into the reservoir.

- To the extent practical, small debris should be removed by hand or via hand tools;
- Debris across the entrance to the cascading channel spillway should be removed immediately; and
- If the debris cannot be removed safely (e.g., requiring confined space entry, requiring submersible equipment, etc.) or without the aid of heavy machinery, the cleanup of these features should be evaluated by the EOR on a case-by-case basis so that appropriate recommendations can be made.

4.2.7 Internal Drainage System Maintenance

Proper operation of the internal drainage system of the Dam is imperative for long-term performance of the Dam. Corrective maintenance associated with the internal drainage system of the Dam involves the removal of vegetation or other growth to ensure flow is releasing freely. The outlet of the two internal drains should be observed quarterly for the growth of iron bacteria. If growth is observed, it should be cleaned out. When the low-level discharge conduit is not being used, the amount of flow exiting from the concrete impact basin should be estimated and tracked, and the EOR should be notified if this flow rate changes. The 13 interceptor drains should be observed quarterly for blockages. If blockages are observed, the corresponding interceptor drain should be cleaned out.

4.2.8 Concrete Structures and Metal Components

Maintenance should be performed on all concrete surfaces (i.e., concrete cascading channel spillway and the impact basin) and exposed, bare ferrous metal (i.e., low-level discharge conduit operator vault and lift system) to repair deteriorated areas. Repair deteriorated concrete immediately when noted using a concrete patching compound; it is most easily repaired in its early stages. Deterioration can accelerate and, if left unattended, can result in serious problems or dam failure. Seal small joints and cracks (i.e., less than ¼ inch) in concrete structures to avoid damage beneath the concrete using a concrete crack filler/sealant. If the concrete structure has heavily deteriorated, the repair should be evaluated by the EOR on a case-by-case basis so that appropriate recommendations can be made.

Exposed, bare ferrous metal on an outlet installation, whether submerged or exposed to air, will tend to rust. To prevent corrosion, exposed ferrous metals must be either appropriately painted (following the paint manufacturer's directions) or heavily greased per Attachment C. When areas are repainted, ensure that paint does not get on gate seats, wedges, or stems (where they pass through the stem guides), or on other friction surfaces where paint could cause binding. Use heavy grease on surfaces where binding can occur. Because rust is especially damaging to contact surfaces, remove existing rust before the periodic application of grease.

4.2.9 Instrumentation

The following sections outline maintenance activities that should be completed as soon as possible after a defective condition with the instrumentation is first documented.

4.2.9.1 Piezometers and VWPZ

The piezometers and VWPZ at the Dam are critical for monitoring the performance of the Dam. Therefore, maintenance on the instruments should be conducted at the earliest date after a defective condition is observed.

- Access to the piezometers and VWPZ should be maintained, and grass mowed as outlined to allow the flush-mount piezometers to be easily located. Ensure that monument covers are bolted on and that VWPZ caps are locked to prevent tampering; and
- If the readout box (model GEOKON® GK-401) stops functioning, refer to the manual from the manufacturer for maintenance and troubleshooting which is provided in Attachment D – Instruction Manual Model GK-401 (GEOKON, 2003).

4.2.9.2 Weirs

The left and right weirs on Bench No.1 and concrete channels on Bench Nos. 1 and 2 are important for monitoring qualitative changes in flow and provide a means to monitor the amount of sediment that may accumulate from flows. The weirs may become clogged with debris (e.g., leaves, grass cuttings, and sediment) on a routine basis, therefore cleaning of the weirs should be conducted at the earliest date after the defective condition is observed.

4.3 Routine Maintenance

The following sections outline continued maintenance that should be performed continually throughout the life of the Dam.

4.3.1 Routine Maintenance for Vegetation

Vegetation at the Dam should be mowed regularly, at least once every two (2) months to allow for appropriate inspection of embankment slopes, observation of any changes in conditions, to prevent the growth of trees, and to deter animals from burrowing. Grass should be mowed to between three (3) to six (6) in. in height. If areas lacking vegetation are observed during mowing operations or subsequent inspections, the areas should be seeded to re-establish vegetation as soon as practicable. Mowing activities should extend across the vegetated surfaces of the dam and onto the abutments, as well as around the low-level discharge basin and at least 100 ft downstream the

tailwater creek. Mowing should be conducted so that trees are prevented from growing within 50 ft of the embankment dam (upstream, downstream, or along the abutments).

A figure depicting areas to be routinely mowed once every two (2) months is provided below as Figure 4. In general, the areas include the upstream and downstream slope, toe, and areas near the low-level discharge outlet.

Figure 4 – Lake Petit Dam Mowing Plan

4.3.2 Low-Level Discharge Conduit

Maintenance of the low-level discharge conduit and its appurtenant structures should be completed in accordance with the Installation, Operations, and Maintenance manual from Hydro Gate provided in Attachment C. The intake to the low-level discharge conduit is protected via a trash rack mounted on the surface of the intake structure. The trash rack must be regularly cleaned, preferably at the same time as conducting a low-level discharge conduit inspection. It is recommended that the low-level discharge conduit be inspected every five (5) years.

In the Rules of the Georgia Safe Dams Act of 1978 (GA EPD, 1978), it is stated a dam owner must perform an annual exercise of the low-level discharge conduit sluice gate to ensure the gate is operational. Any operation of this structure should be observed and documented. During the annual exercise, lubrication of the Hydro Gate stem threads and the lift should also take place.

NOTE: As of the writing of this document, there is no record of the low-level discharge conduit sluice gate being operated in its history. The POA does not presently plan to utilize this feature of the Dam due to its perceived risk and possibility of not being able to shut it. This perceived risk was communicated to the GSDP in May 2005. On 16 August 2005, GSDP agreed that it was "not wise at this point to test the gate valve." Based on a meeting on 18 June 2021, GSDP was still in agreement it should not be operated without proper engineering measures. As of Revision 1 of this document, the POA is planning to coordinate a test of the low-level discharge conduit sluice

gate with the assistance of a dam safety engineer and a specialty contractor. The POA is coordinating the findings of this test with the GSDP, and results should be available in 2023.

4.3.3 Weirs

As noted in Section 4.2.9 the weirs may become clogged from foreign debris on a routine basis. Cleaning of the concrete channel and weirs should be conducted once every two (2) months. This routine operation should be completed after the routine mowing activities from Section 4.3.1 are completed to prevent cuttings and debris from immediately clogging the weirs.

4.3.4 Cascading Channel Spillway

The entrance to the concrete cascading channel spillway should be observed daily to confirm there is no debris blocking the main passage of water at the crest of the spillway. Large debris blocking this area can accumulate additional debris, and lead to a backup of the water flow, and inadvertently raise the reservoir.

5. INSPECTIONS & MONITORING

As part of the routine inspection and monitoring program in the state of Georgia, dam owners and operators shall ensure their dam is inspected, and reports are submitted to the GSDP. Inspection and maintenance plan requirements are provided in Rule § 319-3-8-.10 of the Rules for Dam Safety of the Georgia Safe Dams Act of 1978 (GA EPD, 1978). For periodic maintenance procedures, refer to Section 4 of this document.

5.1 Quarterly Inspections

In the Rules of the Georgia Safe Dams Act of 1978, it is stated a dam owner shall inspect the dam each calendar quarter. This inspection may be conducted by the dam owner, or the dam owner may hire someone to do the inspection on their behalf. This inspection is not required to be conducted by an engineer. Calendar quarters are as follows:

- Quarter 1 – 1 January through 31 March;
- Quarter 2 – 1 April through 30 June;
- Quarter 3 – 1 July through 30 September; and
- Quarter 4 – 1 October through 31 December.

The quarterly inspections are to be performed based on the techniques provided by GSDP in the Inspection of Embankment Dams Instructions (GA EPD, n.d.a) and documented using the Embankment (Earth) Dam Inspection Form, presented in Attachments E – Inspection of Embankment Dams Instructions and F – Embankment (Earth) Dam Inspection Form, respectively.

5.2 Engineer Led Inspections

The dam owner shall have the dam inspected by a professional engineer (P.E.) at least every two (2) years. The engineer-led inspection should be conducted between 1 October and 31 March and shall satisfy the inspection requirement in Section 5.1, for the Quarters 4 and 1 inspections. The engineer-led inspection report must provide a summary of findings including outlining areas that need additional maintenance and those areas requiring additional investigation or design by an engineer.

5.3 Reporting

Quarterly and engineer-led inspection reports are to be submitted to GSDP as one (1) package for the entire year provided there are no findings requiring immediate notification of GSDP. The entire yearly package of the inspections conducted between 1 April of the prior year through 31 March of the current year must be mailed to GSDP by 30 April of the current year. The mailing address for GSDP is:

- 2 Martin Luther King Drive, S.E., Suite 1362, Atlanta, Georgia, 30334.

These reports can also be hand-delivered to the above address if a meeting is set with GSDP.

5.4 Pertinent Features and Corrective Actions

As part of this document, inspection guidance for pertinent features located at the Dam along with associated corrective actions are presented in the following sections. In general, the corrective actions described below are largely observational and may be used to initiate and direct the relevant corrective maintenance activities described in Section 4.2 of this document.

It should be noted that the following is guidance extracted from Attachment E for performing inspections; however, pertinent features at the Dam are dynamic and should be reassessed as changes to the Dam arise. If new features are constructed and/or implemented at the Dam, refer to Attachment E for applicable inspection instructions and corrective actions. If during the inspection any questions or concerns arise, refer to the EAP for the appropriate contacts and contact the EOR for further guidance.

5.4.1 Crest

The crest of the Dam is the top surface which is relatively flat and is composed of a two-lane asphalt road (Wilderness Parkway) that runs in an east-west direction (i.e., longitudinal direction). The following items should be noted when inspecting the crest:

1) **Road:** The road on the crest of the Dam should be relatively flat, with no major ruts, depressions, or cracking.

   Corrective Action: For solid surface roads (i.e., asphalt or concrete), identify any excessive cracking, ruts, or depressions. Note that the cracks must be sealed and that ruts and depressions should be filled in to prevent ponding of water on the road.

2) **Depressions/sinkholes:** Depressions or low spots in the crest and may be localized or widespread. A good technique for distinguishing between localized settlement and sinkholes is to look at their profiles:

   i) Localized settlement usually has gently sloping, bowl-like sides.

   ii) Sinkholes usually have steep sides from the soil shearing as it collapses into an underlying void.

   The bottom of depressions should be probed to determine if there is an underlying void, which would be caused by the removal of subsurface material by internal erosion or piping.

   Corrective Action: Photograph and record the location, size or extent, and depth of any depression. Have a survey performed of the crest if there is a concern about the loss of freeboard. Note that the depression should be inspected frequently to ensure it is not continuing to settle or enlarge. If the depression continues to settle or enlarge, refer to Section 4.2.1 of this document for the corrective maintenance required.

3) **Cracks:** Cracking in an embankment dam falls into the following three (3) major categories:

   i) Longitudinal cracking occurs in a direction roughly parallel to the length of the Dam. It is an indication of a potentially unstable slope.

   ii) Transverse cracking appears in a direction roughly perpendicular to the length of the Dam. Deep transverse cracking can provide a pathway for water into the core of the Dam.

iii) Desiccation cracking is caused by the drying out of certain types of embankment soils, and usually develops in a random, honeycomb pattern.

Corrective Action: For longitudinal and transverse cracking, photograph and record the location, depth, length, width, and offset of each crack observed. Monitor these cracks for any changes. Note that GSDP and the EOR must be contacted for major cracking, or if the cracks are changing. For desiccation cracking, probe the more severe cracks to determine their depth, especially if they are oriented in an upstream/downstream direction. Photograph and record the location, length, width, depth, and orientation of any severe cracks observed. Compare these measurements with any past measurements to determine if the condition is worsening. Note GSDP must be contacted if the desiccation cracking continues to worsen.

5.4.2 Upstream Face

The upstream face is the inclined surface of the Dam on the reservoir side of the crest. The following items should be noted when inspecting the upstream slope of the Dam:

1) **Reservoir Level:** The reservoir level affects many areas of the Dam. It is important when inspecting the Dam to determine if it is at normal pool, above normal pool, or below normal pool. If the reservoir is above or below normal pool, the difference in elevation should be estimated (in ft) and included on the inspection form.

   Corrective Action: If the reservoir is above normal pool, it should be monitored to make sure it returns to normal pool. Note that the concrete cascading channel spillway may be blocked and may need to be cleaned out. If the reservoir is below normal pool, the downstream slope and spillway should be monitored for flow which may indicate pending failure of the Dam. If such flow is noted, GSDP and the EOR must be immediately notified to determine if the reservoir needs to be drawn down further to prevent failure. Additionally, contact the EOR to inspect the internal erosion of the Dam and if repairs will be needed.

2) **Slope Cover:** The upstream slope of the Dam should have a good cover of a low-growing grass. This vegetation should be regularly mowed to allow for easy identification of problems with the Dam. Alternatively, there may be slope protection, such as rip rap, on the slope.

   Corrective Action: Note any areas that need to be reseeded or need to have maintenance performed on them (e.g., additional rip rap for slope protection).

3) **Vegetation:** Although a healthy cover of grass is desirable as erosion protection, the growth of deep-rooted vegetation, such as large shrubs and trees, is undesirable.

   Corrective Action: Note any trees or large shrubs which are located on the Dam. For removal of the deeply rooted vegetation, refer to Section 4.2.4 of this document for the corrective maintenance required.

4) **Depressions/Burrows:** Depressions are low spots in the upstream face of the Dam and may be localized or widespread. Refer to Section 5.4.1, Item 2 of this document for a description of localized and widespread depressions. An additional issue on the slope of the Dam are holes, such as animal burrows. In Georgia, groundhogs, muskrats, or beavers typically cause these burrows. Beavers are of particular concern because of their habit of building dams in spillways to raise water levels.

Corrective Action: Photograph and record the location, size or extent, and depth of any depression or animal burrow. Note that the depression should be inspected frequently to ensure it is not continuing to settle or enlarge. If after several months of inspection, it is determined that the depression is stable, then the depression should be addressed accordingly with the corrective maintenance in Section 4.2.1 of this document. If the depression continues to settle or enlarge, then note an EOR must be contacted. If animal burrows are observed, note the size and location of the burrows. Remove or eradicate the animals causing the problem. Note that the holes must be filled with soil, compacted, and reseeded. Refer to Section 4.2.5 of this document for the required corrective maintenance for animal burrows.

5) **Erosion:** Erosion on the upstream slope has several different causes, which at the Dam may include but is not limited to wave action on the shoreline, wildlife traversing on the slope, and recreational activities.

   Corrective Action: If erosion is found, note the size of the area and depth, location, and severity of the eroded areas. If the erosion is caused by wave action on the shoreline, note that additional slope protection, such as rip rap, may be required. The EOR must be contacted prior to the installation of rip rap to determine the acceptability of the material proposed to be used. If the erosion is caused by traffic (pedestrian and vehicular) on the upstream face of the Dam, note that the eroded areas must be filled in, compacted, and grassed. Additionally, if possible, access to the upstream slope of the Dam should be limited to prevent future erosion. The slope must be monitored for further erosion, and erosion found must be repaired as soon as possible.

6) **Cracks:** A description of longitudinal, transverse, and desiccation cracks typically found on dams and the appropriate corrective actions can be found in Section 5.4.1, Item 3 of this document.

7) **Sloughs/Slides:** Of additional concern on the slopes of dams are sloughs or slides. These usually fall into two (2) categories: (i) shallow slides; and (ii) deep-seated slides. Shallow slides in the upstream slope are often the result of an overly steep slope combined with a rapid lowering of the reservoir. Deep-seated slides are serious threats to the safety of the Dam, and are typically characterized by a steep back slope, a soil bulge near the bottom of the slide, and arc-shaped cracks in the slope (which may also be signs of developing deep-seated slides).

   Corrective Action: For shallow slides, photograph and record the location of the slide, including dimensions. Note any cracks which have developed uphill from the slide which could be signs of potential development of a deep-seated slide. The slide should be regularly monitored for changes in size or development into a deep-seated slide. For deep-seated slides, contact GSDP and the EOR to discuss the potential need of lowering and restricting the reservoir.

8) **Shoreline Protection:** Slope protection, in which rip rap is typically used, is used along the shoreline of the reservoir to prevent wave action erosion along the upstream face of the dam. It is important that rip rap is large and durable enough to not be moved or broken down by wave action. Additionally, irregular-sized and shaped rocks create an interlocking mass that decreases wave energy as it passes between the larger rocks and decreases erosion of the underlying material. Look for beaching, scarping, or degrading of the slope protection to determine if it is adequate. Additionally, vegetation should be regularly removed from the rip

rap to allow for easy inspection of the slope and to ensure the vegetation does not displace the rip rap.

Corrective Action: Note if maintenance needs to be performed to remove vegetation from the rip rap slope protection. Note any areas of the slope which are not adequately protected (slope protection is easily moved by the water, there is not enough to protect the Dam from erosion, etc.) Additionally, note any areas where the slope protection has settled, as this is a sign that erosion may be occurring below its surface. Document the dimensions of all areas of inadequate protection. Note that all areas of inadequate protection must be repaired. Contact the EOR to discuss the recommended approach to addressing this issue.

5.4.3 Downstream Face

The downstream face is the inclined surface of the Dam on the opposite side of the crest from the reservoir. The following items should be noted when inspecting the downstream slope of the Dam:

1) **Slope Cover:** The downstream slope of the Dam should have a good cover of low-growing grass. This vegetation should be regularly mowed to allow for easy identification of problems with the Dam. Refer to Section 5.4.2, Item 2 for descriptions of grass cover and corrective actions.

2) **Depressions/Burrows:** A description of depressions, ruts, and holes can be found in Section 5.4.2, Item 4. Refer to Section 5.4.2, Item 7 for a description of shallow and deep-seated slides, and the associated corrective actions. Of additional concern on the downstream slope are bulges which may indicate the beginning of slope instability and can be caused by seepage through the Dam and may lead to a shallow or deep-seated slide.

   Corrective Action: Note the location and dimensions of the bulge and notify the EOR. Additionally, note any wetness in the area of the bulge. Note the bulge should be monitored regularly for any changes.

3) **Erosion:** A description of erosion and its causes are discussed in Section 5.4.2, Item 5. Of additional concern on the downstream slope is erosion near the groins of the Dam, which is where the Dam makes contact with the natural river valley/abutments. This can be caused by runoff or seepage through the contact between the Dam and natural ground.

   Corrective Action: If erosion is found, note the size of the area and depth, location, and severity of the eroded areas. If the erosion is believed to be caused by runoff, note that the eroded area should be filled with soil, compacted, and grassed. If the area continues to erode, note that additional protection may be needed. The EOR must be contacted prior to the installation of additional protection to determine the acceptability of the material proposed to be used. If the erosion is caused by traffic (pedestrian or maintenance equipment) on the groin of the Dam, the eroded areas must be filled in, compacted, and grassed. Additionally, if possible, access to the downstream slope of the Dam should be limited to prevent future erosion. Note that the slope should be monitored for further erosion, and erosion found must be repaired as soon as possible.

4) **Cracks:** A description of cracks typically found on the slopes of dams and the appropriate corrective action can be found in Section 5.4.1, Item 3.

5) **Wet Areas:** Seepage is the passage of water through a dam. Seepage passes through all embankment dams. Many embankment dams have internal drains to intercept this seepage and discharge it safely. Of greater concern is uncontrolled seepage, which can carry with it soil from within the dam, leading to erosion from the inside of the dam and eventual failure of the dam. This seepage may exit the ground through the dam, or it may appear downstream of the dam.

   Wet areas on or at the toe of the Dam can be caused by seepage or an area poorly graded to drain surface or seepage water. Wet areas can be identified either by water on the surface, areas of hydrophilic vegetation (such as cattails, reeds, lovegrass, and mosses), or areas of vegetation which are much greener than the vegetation around it.

   Corrective Action: Note the size and location of the wet areas. If the wet area appears to be caused by a low area, note that the area should be drained, filled with soil, compacted, and grassed.

6) **Seepage Color:** In Georgia, seepage through the Dam will typically appear rust-colored or stained, which will cause the seepage to have what appears to be an oily sheen on its surface. Seepage color should be carefully monitored for changes from the typical seepage colored observed or if the seepage contains sediment.

   Corrective Action: Note the size and location of any areas of seepage which exhibit any of the signs listed in this item and estimate the flow rate. Note if the area is new or existing. If it is a new area, document the extent of the area. If it is an existing area, note if the size of the area or the appearance of the seepage has changed.

7) **Seepage, Springs, or Boils**: Seepage visibly flowing out of the slope or beyond the toe of the Dam is of great concern. These areas can appear to be springs or sand boils and may appear to have a cone of sediment around them. This sediment is most likely being eroded from within the Dam. Of additional concern is water flowing along the outside of the principal spillway pipe or other drains, which can be a sign of a leak in the pipe or water using the outside of the pipe as a conduit. Seepage flowing through the Dam, whether through the embankment or along a pipe, can lead to a type of dam failure called piping, a form of internal erosion of the dam which can lead to failure.

   Corrective Action: Contact GSDP and the EOR to discuss the potential need of lowering and restricting the reservoir. Provide approximate size, location, description if the flow appears to contain soil particles, and estimate of the flow rate. Additionally, note the EOR must perform an investigation to determine the source and severity of the seepage.

5.4.4 Plunge Pool

The plunge pool is a natural or artificially created pool at the base of a dam that dissipates the energy of free-falling water. It is the location where the principal spillway exits the dam, and the water is returned to the natural flowing stream. At the Dam there is no plunge pool at the base of the principal spillway, however, there is an impact basin out of which the water from the low-level discharge conduit flows. Inspection guidance for concrete structures is provided in Attachment G – Inspection of Concrete Structures (ASDSO, 2021b). The vegetation in the area

of the impact basin should be kept cut and clear of obstructions to allow for inspection and monitoring.

5.4.5 Principal and Emergency Spillways

A principal (also known as primary) spillway is a pipe, channel, etc. which is designed to provide continuous or frequent releases from a reservoir in order to maintain the normal pool. An emergency spillway is designed to provide additional protection against overtopping of a dam intended for use under extreme conditions such as malfunction of the principal spillway or extreme rainfall. Water flowing through the emergency spillway should be a rare occurrence. Generally, the principal spillway should be able to carry most normal storm events.

1) **Primary Spillway:** At the Dam, the primary spillway is the concrete cascading channel located east of the earthen Dam's left abutment, and the emergency is the low-level discharge conduit (discharge conduit of the low-level outlet). The concrete cascading channel should not be cracked or have holes in it. Cracks and holes can allow water to get under the concrete and erode away the material beneath the concrete, thus undermining the spillway. Also, this water can lead to uplift which can possibly break the concrete.

   Corrective Action: Note the current condition of the concrete cascading channel and low-level discharge conduit. Note if the concrete cascading channel has foreign debris (i.e., rocks, branches, trash, etc.). Note any separations, cracks, or holes in the concrete cascading channel, including location, the dimensions of the damage, and if water is flowing through the damaged area. These areas must be monitored for any changes. Note if there are any obstructions within the spillway. If there are obstructions, note that they must be removed.

2) **Emergency Spillway:** The low-level discharge conduit, and associated structures, are classified as the emergency spillway at the Dam. The emergency spillway should not activate regularly; however, there are occasionally storm events that may cause the need to activate this spillway.

   Corrective Action: Note if there has been flow in the emergency spillway since the last inspection. Note the date(s) it occurred, what caused the spillway to flow, and how deep the flow was in the spillway. Maintain the vegetation in and around the area of the emergency spillway outlet to allow for inspection, observation, and maintenance. Remove debris and growth that accumulates in the bottom from the concrete impact basin.

5.4.6 Internal Drainage System

The internal drainage system for the Dam was designed to alleviate porewater pressure within the embankment and mitigate the potential for seepage to daylight on the downstream face. The internal drainage system consists of the two (2) outlet pipes associated with the bank drain that traverses the valley bottom downstream of the core and the 13 interceptor drains daylighting at the lowermost bench (i.e., Bench No. 1).

Corrective Action: Note if there is observable flow out of the interceptor drains. Note the relative flow from the internal drainage system by measuring the flow over the sill in the impact basin, and look for changes in flow during each inspection. Note if the flow is clear or turbid. If turbid water is observed flowing out of an interceptor drain or the internal drainage system drains, use the EAP to contact the EOR and any appropriate personnel.

6. INSTRUMENTATION

The locations and general layout are presented in Attachment H – Lake Petit Dam Features. Available boring logs and piezometer construction details were documented in the Evaluation of Stability and Rehabilitation Measures (Geosyntec, 1998); refer to relevant sections, figures, tables, and appendices of that report for further details regarding instrumentation installed by Geosyntec at the Dam.

6.1 Piezometers and Vibrating Wire Piezometers

A piezometer is an instrument that measures fluid pressures within an earthen dam. At the dam, they typically have been installed in the dam with a ground surface cover similar to a groundwater well. The instruments used to monitor the fluid pressures are: (i) the four (4) nested sets (12 instruments total) of VWPZ installed by Piedmont in 1997 and 1998; and (ii) the seven (7) standpipe piezometers installed by Geosyntec in 1998 (Table 3).

The VWPZ instruments are monitored by taking readings using a readout box (model GEOKON® GK-401). The instruction manual for the readout box is provided in Attachment D. VWPZ are generally located in stick-up, metal instrument casings. The readout box must be connected to the applicable wires for each specific instrument, and a readout value is then recorded and subsequently entered into a spreadsheet maintained by Geosyntec to convert the reading to the piezometric head elevation. The readout box is stored in the POA Maintenance office and requires charging prior to using.

The piezometers are measured by using a water level indicator, which is not stored on-site but is generally brought on-site by Geosyntec when performing quarterly inspections. Piezometer casings vary in size so water level indicators should generally be less than one inch in diameter. The water level indicator provides a direct measurement from the top of the piezometer casing to the piezometric water surface (depth), and this measurement is subtracted from the top of casing elevation specific to each instrument to determine the piezometric head elevation. Piezometers are located in flush-mount metal surface completions and protected by a metal lid and each piezometer has a plastic cap to prevent water or other debris from fouling the instrument. Caps should always be kept on the piezometers, except when reading. At least 15 minutes should transpire between removing the cap and taking a reading of these instruments to let any pressure difference equilibrate to get more reliable readings.

6.2 Weirs

The instrumentation on the abutments of the Dam is limited to two (2) makeshift weirs, one (1) on each abutment, which are used to monitor the flow of water leaving the lowermost concrete channel on the downstream slope (i.e., the cumulative flow coming from the interceptor drains which outlet on this bench). The weir on the right abutment is located near the toe of the Dam, just prior to a corrugated metal drop inlet which directs water to the downstream channel (adjacent to the impact basin). The weir on the left abutment is located in the woods at the end of the concrete channel, where water flows down the abutment hillside.

Table 3 – Piezometer Installation Details

Piezometer No.	Installation Date (Year)	Type	Soil Unit	Elevation or Screen Interval (ft NAVD88)*
P-2A	1997	VWPZ	Shell/Core	1622.1
P-2B	1997	VWPZ	Core	1587.1
P-2C	1997	VWPZ	Core	1558.4
P-4A	1997	VWPZ	Shell	1582.1
P-4B	1997	VWPZ	Shell	1557.1
P-4C	1997	VWPZ	Shell	1537.1
P-6A	1998	VWPZ	Shell	1550.9
P-6B	1998	VWPZ	Shell	1525.6
P-6C	1998	VWPZ	Shell	1541.6
P-7A	1998	VWPZ	Shell	1531.6
P-7B	1998	VWPZ	Shell	1512.6
P-7C	1998	VWPZ	Saprolite	1521.4
G-1A Shallow	1998	Standpipe	Core	1607.0 – 1587.0
G-1A Deep	1998	Standpipe	Core	1572.0 – 1567.0
G-1B	1998	Standpipe	Saprolite/Core	1521.5 – 1516.8
G-2 Shallow	1998	Standpipe	Shell	1574.9 – 1554.9
G-2 Intermediate	1998	Standpipe	Shell	1534.9 – 1529.9
G-2 Deep	1998	Standpipe	Saprolite	1519.4 – 1516.4
G-3	1998	Standpipe	Shell	1522.1 – 1517.1

Notes:
VWPZ – Vibrating Wire Piezometer
* – Converted from NGVD29 to NAVD88

The history and origin of these weirs are unknown. They are not calibrated, as they have a flat top and pass flow through an approximately 1-in. diameter PVC pipe in the bottom of the weir. The pipes routinely get clogged. The weirs are used to qualitatively measure relative changes in flow and provide a means to see the amount of sediment that may accumulate from flows.

6.3 Instrumentation Data

6.3.1 Reading Frequency

Instrumentation at the Dam should be read, at a minimum, on a quarterly basis on the same day that the quarterly inspections are conducted. A seasonal fluctuation is evident in both traditional standpipe piezometers and VWPZs. If an increase in the phreatic surface is observed in the instrumentation readings which exceeds the typical seasonal fluctuations, contact the EOR for further guidance. GSDP requires piezometer readings to be conducted at least quarterly, however, the EOR may increase the reading frequency based on site observations or changes in piezometer levels.

7. DEFINITIONS

Orientation

The following is a list of terms and definitions that are frequently used for orientation purposes relative to the Dam:

Upstream – the opposite direction of the native stream flow. This shall refer to the northern side of the Dam that borders Lake Petit. For orientation purposes at the Dam, the upstream direction is a northerly direction.

Downstream – the direction of native stream flow. This shall refer to the area on the southern side of the Dam; south of the crest (i.e., Wilderness Parkway). For orientation purposes at the Dam, the downstream direction is a southerly direction.

Left – the area to the left when looking in the downstream direction. For orientation purposes at the Dam, the left direction is an easterly direction.

Right – the area to the right when looking in the downstream direction. For orientation purposes at the Dam, the right direction is a westerly direction.

Dam Definitions

The following is a list of terms and definitions that are frequently used when discussing the physical characteristic of the Dam. This list is an abridged version of the definitions from the Rules for Dam Safety §§ 391-3-8.02, and the Safe Dams Glossary from the GA EPD website (GA EPD, n.d.):

Abutment – the bordering area of the dam site which functions as a support for the ends of the dam structure.

Appurtenant works – structures located either in or separate from the dam such as spillways, low-level outlet works, access bridges, and other structures.

Berm – a horizontal step in the slope of an embankment dam usually for the purpose of reducing erosion or to increase the thickness and stability of the embankment.

Category I – the classification where the improper operation or dam failure would result in probable loss of human life. Situations constituting "probable loss of life" are those situations involving frequently occupied structures or facilities, including, but not limited to, residences, commercial and manufacturing facilities, schools, and churches.

Conduit – any closed waterway such as a cast-in-place cut-and-cover culvert, a precast or prefabricated pipe embedded in the dam or foundation, or a tunnel bored through the abutment used for the purpose of regulating or releasing water impounded by a dam.

Corrective actions – a set of actions, which may include but are not limited to measurements, photographs, and continued monitoring, aimed to address a defect or nonconformity observed at the Dam.

Crest – the top of the surface of the dam.

Dam – shall mean the following:

1. Any artificial barrier, including appurtenant works, which impounds or diverts water and which the improper operation or failure of such would result in probable loss of human life as determined pursuant to the Act, and which:
   - is 25 ft or more in height from the natural bed of the stream or watercourse measured at the downstream toe or the lowest elevation of the outside limit of the barrier (whichever is lower) to the maximum water storage elevation; or
   - has an impounding capacity at a maximum water storage elevation of 100 acre-ft or more.
2. Any artificial barrier, including appurtenant works, constructed in conjunction with the reclamation of surface-mined land, and meeting the requirements of Item 1 from the definition above, and when an improper operation or failure would result in probable loss of human life.

8. REFERENCES

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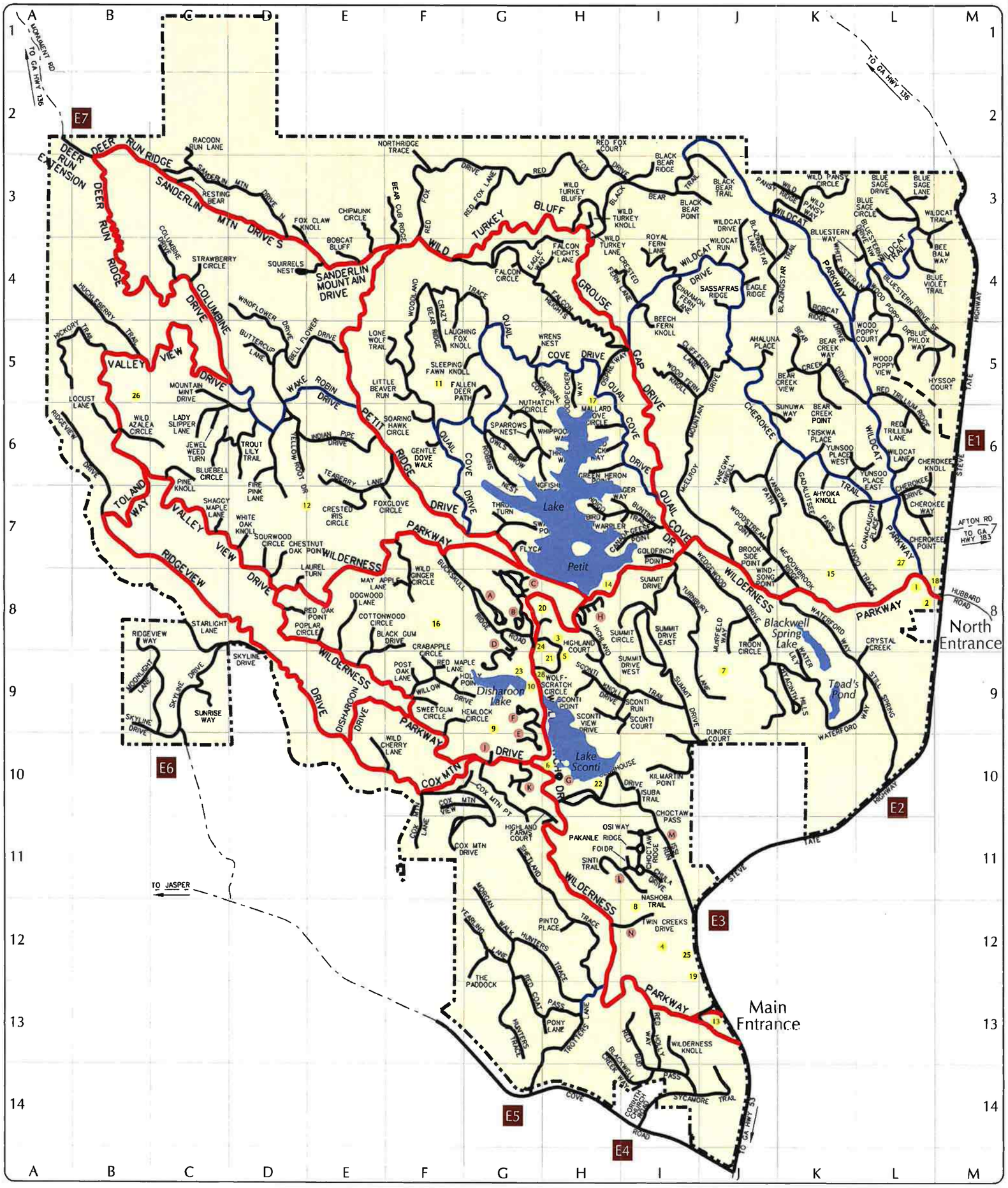
ATTACHMENT A

Big Canoe Street Map

THE MOUNTAINS OF Big Canoe®

Big Canoe Street Map

January, 2019



EMERGENCY Entrances / Exits:

- E1 Wildcat
- E2 Waterford
- E3 Choctaw Village
- E4 Blackwell Creek
- E5 Equestrian
- E6 Bluffs at Ridgeview
- E7 Monument Road

Streets:

- Primary Street
- Secondary Street
- Local Street
- Emergency Exit

Points of Interest:

- Amenities / Facilities
- High Density Residential (See Lists on Reverse Side)

North West East South

TerraMark

ATTACHMENT B

Topographic and Feature Survey

SUBJECT PROPERTY INFORMATION:
CURRENT OWNER (COMMON AREAS): BIG CANOE PROPERTY OWNERS
TAX RECORD: PICKENS COUNTY, GEORGIA, TAX PARCEL 046D 001 004

FIELD DATA FOR INVERT SURVEY WAS COLLECTED USING A TOPCON GPT3002W ELECTRONIC TOTAL STATION AND A JAVAD TRIUMPH-LS+ DUAL-FREQUENCY RTK GLOBAL POSITIONING SYSTEM RECEIVER REFERENCING THE eGPS STATEWIDE NETWORK AND HAVING A RELATIVE POSITIONAL ACCURACY OF LESS THAN 0.04 FEET.

THE INVERT FIELD SURVEY WAS COMPLETED IN APRIL 2021.

EASEMENTS OR RIGHTS-OF-WAY EXIST WHICH ARE NOT SHOWN HEREON. THIS DOCUMENT IS NOT INTENDED TO REFLECT OWNERSHIP RIGHTS OF ANY KIND.

HORIZONTAL COORDINATE SYSTEM: GEORGIA STATE PLANE, WEST ZONE, NAD83(2011) IN US SURVEY FEET.

VERTICAL DATUM: NAVD88 IN FEET.

THE GROUND SURFACE TOPOPGRAPHY AND SOME SITE FEATURES WERE MAPPED BY eGPS SOLUTIONS USING UAV LIDAR DATA COLLECTED IN APRIL 2021 USING A MATRICE 600 Pro UAV.

GROUND SAMPLING DISTANCE WAS APPROXIMATELY 0.086 FEET PER PIXEL. TWELVE 3D GCPs WERE USED FOR REFERENCING. HORIZONTAL RMS ERROR AVERAGE WAS 0.0275 FEET FOR 10 CHECK POINTS. VERTICAL RMS ERROR AVERAGE WAS 0.05 FEET FOR 10 CHECK POINTS.

IMAGERY COVERAGE AREA WAS 37.41 ACRES.

PHOTO #1

LEGEND

○	OPEN-TOP PIPE FOUND	P.O.B.	POINT OF BEGINNING
●	SOLID ROD (REBAR) FOUND	P.O.R.	POINT OF REFERENCE
○	½" SOLID ROD (REBAR) SET	NOF	NOW OR FORMERLY
⊗	BEARING CHANGE (NO PIN SET)	D.B.	DEED BOOK
△	SURVEYOR'S TRAVERSE NAIL SET	P.B.	PLAT BOOK
△	SURVEYOR'S PK NAIL SET	LL	LAND LOT
	POWER POLE	OTP	OPEN-TOP PIPE
		CMF	CONCRETE MON. FD

ADJOINING PROPERTY LINE
EASEMENT
OVERHEAD POWER

JORDAN ENGINEERING
144 N. WARREN ST. MONTICELLO, GA 31064
TELEPHONE: (706) 468-8999
Land Planning • Surveying • Soils Classification

GEORGIA REGISTERED No. 2902 LAND SURVEYOR ROBERT Q. JORDAN

Topographic and Feature Survey with Orthomosaic Image

Lake Petit Dam
Pickens County, Georgia

Rev	Revision Description	Date
0	Initial Issue	04/27/21
1	Addressed Geosyntec comments	05/04/21

Sheet No.
1i

ATTACHMENT C

Installation, Operation, and Maintenance Manual for Cast Iron Slide Gates

REVISED 4-7-16

HYDRO GATE

Installation, Operation, & Maintenance Manual

DO NOT DISASSEMBLE GATE FOR INSTALLATION

HG560 Cast Iron Slide Gates

G1000

12000 E. 47th Ave., Suite 200 • Denver • Colorado • 80239 • 1-800-678-8228 • FAX (303) 287-8531
www.hydrogate.com

TABLE OF CONTENTS

CAUTIONARY STATEMENT FOR INSTALLATION, OPERATION, & MAINTENANCE MANUAL

This manual describes the recommended procedures for installation, adjustment, operation and maintenance of Hydro Gate gates. When it is used in conjunction with installation drawings that have been supplied by Hydro Gate, this manual will be sufficient for most installations. Proper care and precautions must be taken in handling and storing the gates at the delivery site. For further details on the handling, storing, and installation of a specific project, contact Hydro Gate's headquarters.

PRECISE AND ACCURATE INSTALLATION IS CRITICAL TO SATISFACTORY OPERATION. HYDRO GATE ASSUMES NO LIABILITY, EXPRESSED OR IMPLIED, FOR INTERPRETATION OF THE CONTENTS OF THIS MANUAL. IF YOU HAVE ANY QUESTIONS CONCERNING THE INTERPRETATION OF THE CONTENTS OF THIS MANUAL OR INSTALLATION PROCEDURES IN GENERAL, YOU SHOULD CONTACT HYDRO GATE'S COLORADO FACILITY. HYDRO GATE EXPRESSLY DISCLAIMS ALL LIABILITY, EXPRESSED OR IMPLIED, FOR FAULTY INSTALLATION OF ANY GATE OR ASSOCIATED EQUIPMENT AND FOR ANY DIRECT, CONSEQUENTIAL, OR INCIDENTAL DAMAGES THAT MAY RESULT.

FOREWORD

The purpose of this Installation, Operation, and Maintenance Manual is to provide information on the correct procedures for installation, adjustment, operation and maintenance of Hydro Gate Cast Iron Slide Gates and their component parts.

The gate, lift, and accessories were accurately machined, assembled, adjusted, and inspected before leaving the Hydro Gate factory. For best results, read and follow the applicable parts of this Manual carefully, including thorough cleaning and lubrication of moving parts and final wedge adjustment. If the equipment will not be installed immediately, consult the long-term storage instructions following.

Installation

Do not disassemble the gate or lift for installation.

Warranty

Installation and/or operation of the gate lift and stem without proper lubrication will void the equipment warranty. Thorough cleaning of the stem, seating faces, and wedging surfaces is required before gate operation. Details are described in the appropriate sections of this manual.

Notes

Spare Parts – Hydro Gate does not recommend the stocking of spare parts. If spare parts are required see Table 1(last page). Replacement parts are readily available for worn or broken parts. Contact Hydro Gate or our representative in your area.

Special Tools – Special tools are not required to operate and/or maintain the equipment supplied by Hydro Gate on this project.

Price List – Prices for individual parts and/or assemblies may be obtained from Hydro Gate at the time that they are needed.

Disassembly – Hydro Gate does not recommend the disassembly/reassembly of any of the equipment on this project.

Emergencies – Emergency/shutdown procedures do not differ from normal operating procedures for this project. If you should need assistance, please contact Hydro Gate's Field Service Department at (303) 288-7873.

INSTALLATION

Safety Precautions

To help ensure your workers' safety, Hydro Gate recommends the personnel responsible for installation, operation, and maintenance of the gates for this project read and study the instructions and precautions in the Installation, Operation, and Maintenance Manual, and follow all directions carefully. The following are major items associated with safe installation, operation, and maintenance of the Cast Iron Slide Gates.

- **Do not** operate equipment before carefully reviewing the Installation, Operation, and Maintenance Manual.
- Always use proper equipment when lifting or unloading heavy items.
- **Do not** stack equipment too high for storage. Always use heavy wood blocking between equipment. Refer to the storage instructions contained herein for details.
- Adequately support and brace heavy items during placement of equipment.
- Wear proper personal protective equipment (PPE) and clothing when working on or around gates, (e.g., hard hats, heavy boots, safety glasses, and breathing apparatus, if necessary).
- **Never** place bodily obstructions in the path of moving parts. When operating gates and accessories, stand clear of all moving parts. Serious injury can result from contact with moving parts.
- Use caution when performing operations and maintenance. Watch for loose or damaged parts. Stop all functions until any damage has been corrected.
- **Do not** use any mechanical devices other than the factory-supplied equipment to operate the gates for this project.
- **Do not** attempt operational procedures other than set forth in the Operation and Maintenance Manual.
- Contact your Hydro Gate representative with any questions you may have regarding safety in installing, operating, and handling Hydro Gate products.

Things To Do and Not To Do during Installation of This Gate

To properly install this gate, Hydro Gate recommends that personnel study these instructions and installation drawings and follow the installation directions carefully. This gate is precision machined, shop adjusted, quality checked, and designed for low leakage. Attention must be given to proper storage, careful handling, and accurate location of embedded items for this gate to operate as designed.

Some DO'S and DON'TS to ensure proper gate installation.

- ✓ DO – Read and follow the Installation instructions and drawings in this Manual.
- ✓ DO – Carefully inspect the gates and accessories when received, before unloading trucks or cars. Report **ALL** shortages or suspected damage by marking the Bill of Lading and Receiving Reports at this time. Latent shortages must be reported in writing within 30 days of shipment.
- ✓ DO – Store gates evenly on planks or timbers. Even the heaviest castings are subject to permanent warpage if unevenly blocked during storage.
- ✓ DO – Support full length of stems and protect threads during storage and handling.
- ✓ DO – Accurately locate and brace embedded items during placement of concrete.
- ✓ DO – Contact your Hydro Gate representative with questions regarding this gate. Hydro Gate and its related companies have 100 years combined experience in the water control industry.
- ✓ DON'T – Stack gates without heavy wood blocking between gates.
- ✓ DON'T – Disassemble the gates for installation.
- ✓ DON'T – Allow excess concrete to overlap gate thimble or frame.
- ✓ DON'T – Tighten nuts for studs or anchors unevenly, or try to pull a gate frame tightly against an uneven wall surface. This, in most cases, will cause excessive leakage.
- ✓ DON'T – Operate gates with concrete and debris on them.
- ✓ DON'T – Operate gate stems dry (without grease).

Wall Thimble Installation

1. Place the wall thimble in the correct position in the forms and block it in this position. The top centerline of the thimble is stamped on its machined face. The bottom centerline is also marked.

2. Plumb the front face of the thimble using the marks indicating top and bottom centerline. This face should be plumbed with respect to final location of the gate, stem, and lift.

3. Studs furnished for attaching of the gate may be used in the attachment of the thimble to the forms. If these studs are not used, threaded holes in the thimble must be plugged to prevent concrete from entering them.

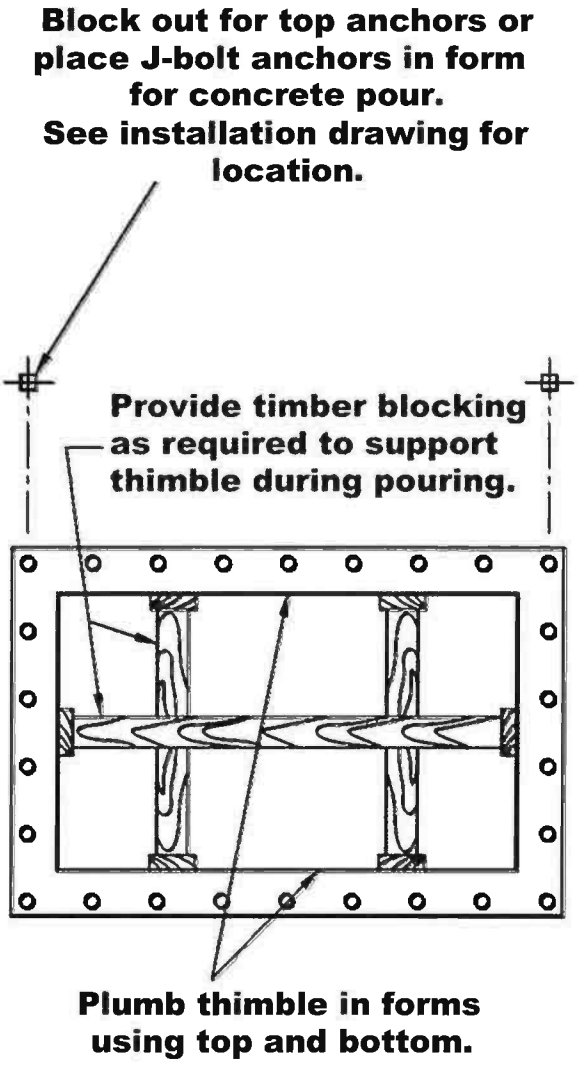
4. Use timbers or other bracing material on the inside opening of the thimble while concrete is being poured **(Figure 1**).

> ***Installation***
> *Use care in placing of these supports to prevent warping of the thimble.*

5. Pour concrete, being careful not to tilt the thimble from its original position in the forms.

6. Remove forms and bracing.

Figure 1 – Front View of Thimble Showing Bracing



Installation of Gate on Wall Thimble

1. Clean machined face with scrapers and wire brush so that no sand, concrete, dirt, or foreign material is present **(Figure 2).**

2. Check flatness and plumb of thimble face to verify that it did not move or shift during concrete pour. Flatness must be within 1/64 inch of true flat plane. The thimble should be plumb within 1/8 inch. Use good quality plumb level, or plumb lines, at each vertical side. Both sides should be plumb or parallel to each other within 1/32 inch over the total height.

3. After verifying thimble flatness and alignment, install thimble stud bolts.

4. Check the installation drawings for use of anchor bolts to stabilize the upper frame guides or extensions. If shown on the installation drawing, install a nut on these anchors and run on as far as possible before installing the gate.

5. Trowel a thin layer (1/16 inch to 1/8 inch thick) of mastic on the face of the thimble or two ½ inch diameter beads of mastic from a caulking gun; one bead midway between the inner edge of the face (opening) and the row of studs and the other bead just outside the row of studs. Place a circular bead around each stud. These beads should be of size and placement so they will flow out and substantially cover or wet the flange joint. Trowelable grades of asphalt roof cement, or polyurethane sealants (Sika-Flex 1-A or equivalents), work well as mastic.

6. Although Hydro Gate does not recommend using rubber gaskets in place of mastic, they may be used at the discretion of the owner or consulting engineer. They should be no more than 1/8 inch thick and the thimble must be flat within the 1/32 inch total maximum warping allowed. Use of thicker gaskets may result in a spongy foundation for the gate or blowout under high unseating heads.

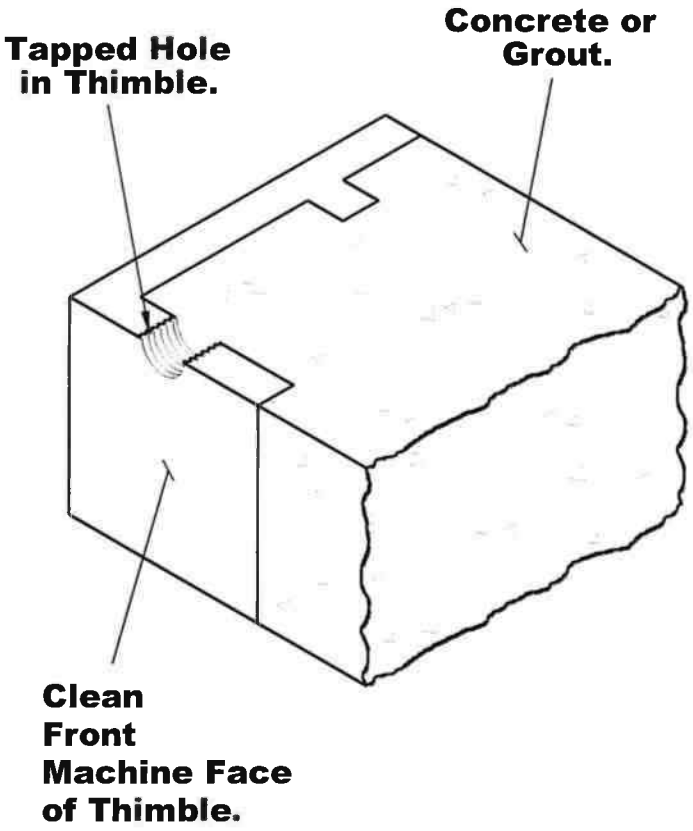
7. Tighten all stud nuts uniformly. See the torque table shown below. It is not mandatory that nuts be tightened precisely to these values. Repeated tightening with a torque wrench will be required to squeeze mastic to a thin layer for metal-to-metal contact.

8. Use caution when mounting gates on nonmachined steel structures, round flanges, or existing thimbles. The rules of flatness discussed above apply. Severe distortion of the gate and subsequent excessive leakage results when torque tightening gate mounted on uneven/non-flat surfaces. Do not torque tighten a gate to an uneven non-flat surface.

Torque Table for Tightening Nuts

Capscrew Diameter (Inches)	Torque Specifications (Pound Feet)
5/8	90
3/4	128
1	285
1 1/4	500
Use "Anti-Seize" Lubricant on All Threads.	

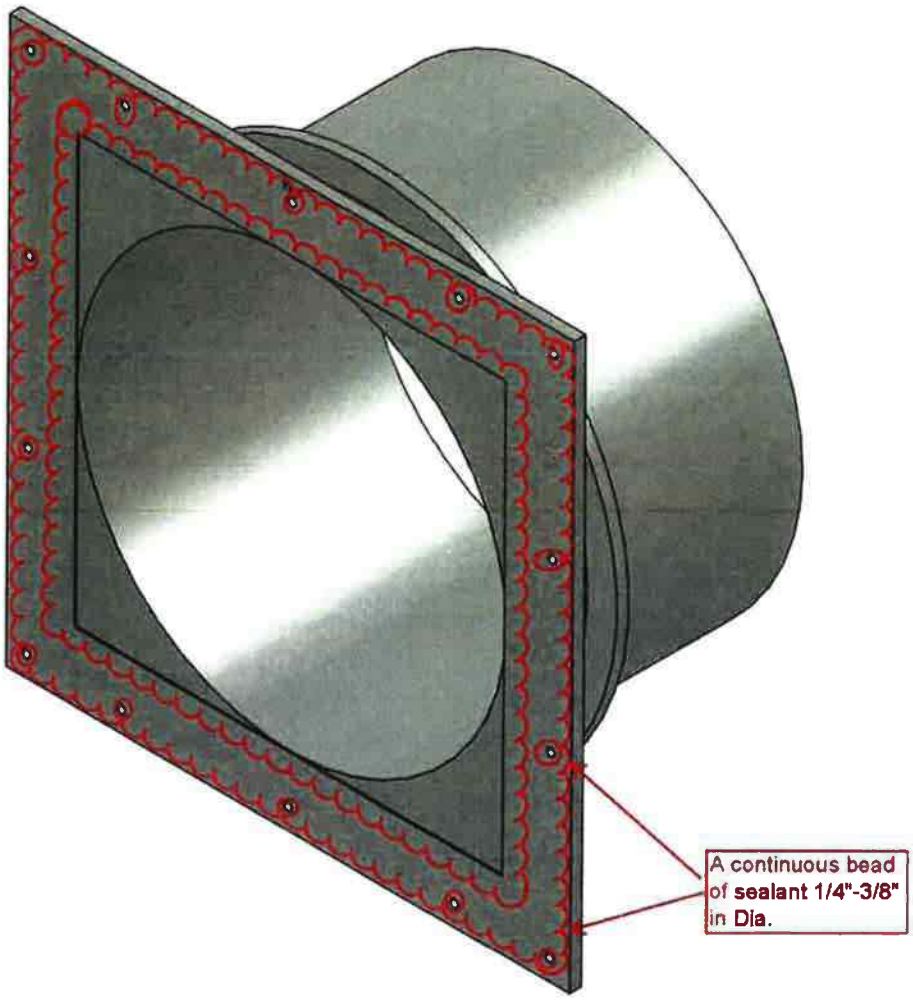
Figure 2 – Front Cross Section of Thimble Showing Machined Front Face



"F" Wall Thimble
Typical Thimble Installation

Application of sealant on Thimble

1. Thoroughly clean both mounting face of the slide gate and the wall thimble mounting flange.
2. Install of the mounting stud bolts into the wall thimble
3. Apply two continuous beads of sealant around the wall thimble flange and around each stud.
4. Install the gate over the mounting studs and thread on the flat washers and hex nuts.
5. Utilizing a torque wrench tighten all of the mounting stud bolts evenly. Tighten the mounting bolts in accordance with the torque table.
6. In approximately 24 hours after the sealant has begun to set, re-tighten the mounting evenly again with the torque wrench.



Correcting and Compensating for a Warped Thimble

If the vertical faces are out of parallel more than 1/32 inch, the thimble is warped or twisted excessively and the gate may exhibit sealing problems. Warping can be corrected in one of the following ways:

1. Remove thimble from concrete and try again. This requires substantial demolition and risks damage to the structure and thimble.

2. The preferred correction involves mounting the gate on the thimble with shims between gate and thimble flanges to restore gate seat faces to a good contacting condition. The resulting gap between gate and thimble flange can be sealed with mastic such as polyurethane seal-like Sika Flex 1-A.

   There is a limit to how wide a gap the chosen mastic will seal. Consult the mastic supplier for gap limit and cure times. Sika Flex 1-A with Sika Flex primer claims to bridge and seal up to 1/2-inch gaps. Sika Flex 1-A requires a 1-week cure for water immersion; Sika Flex-2C NS/S1 requires a 3-day cure. Hydro Gate recommends not exceeding 1/4-inch gap with polyurethane considering uncertainties such as water pressure.

   When the twist or warp exceeds 1/4 inch or operating heads are high (more than 20 feet of water), Hydro Gate recommends that the gap be filled with injectable epoxy to both form a watertight joint and provide a solid mounting for the gate. This work is best performed by an Adhesive and Sealing Contractor who can dam up the gap and inject the material.

   The recommended steps to shim a gate frame are as follows:

   A. Dry mount the gate (i.e. without mastic.) If the gate has been wet-mounted with mastic, remove the gate and clean off all mastic, then dry-mount the gate. Do not tighten stud bolts.

   B. Determine where and what thickness shims are needed between the frame and thimble, which will produce gate seat contact that excludes a .004-inch feeler gage. Shims may be stainless steel washers placed on stud bolts between the gate and thimble flange or "C"-shaped shims cut from stainless shim stock. Place the "C" straddling the stud bolts.

   C. Tighten all stud nuts, then verify that the gate seat is contacting within .004 inch all around the opening.

   D. Remove the gate, keeping track of what shims go where.

   E. Apply a thick layer of mastic on the thimble or gate flange sufficient to seal the gap resulting from the shimming action or prepare for epoxy injection by Adhesive/Sealing Contractor.

3. If the thimble face is flat but is out of plumb, or racked, consult Hydro Gate's Engineering Department for suggestions. The axis of movement of the slide must be parallel to the axis of the stem within certain limits, depending on the gate size. Hydro Gate's Engineering Department can determine these limits for the specific installation and offer suggestions.

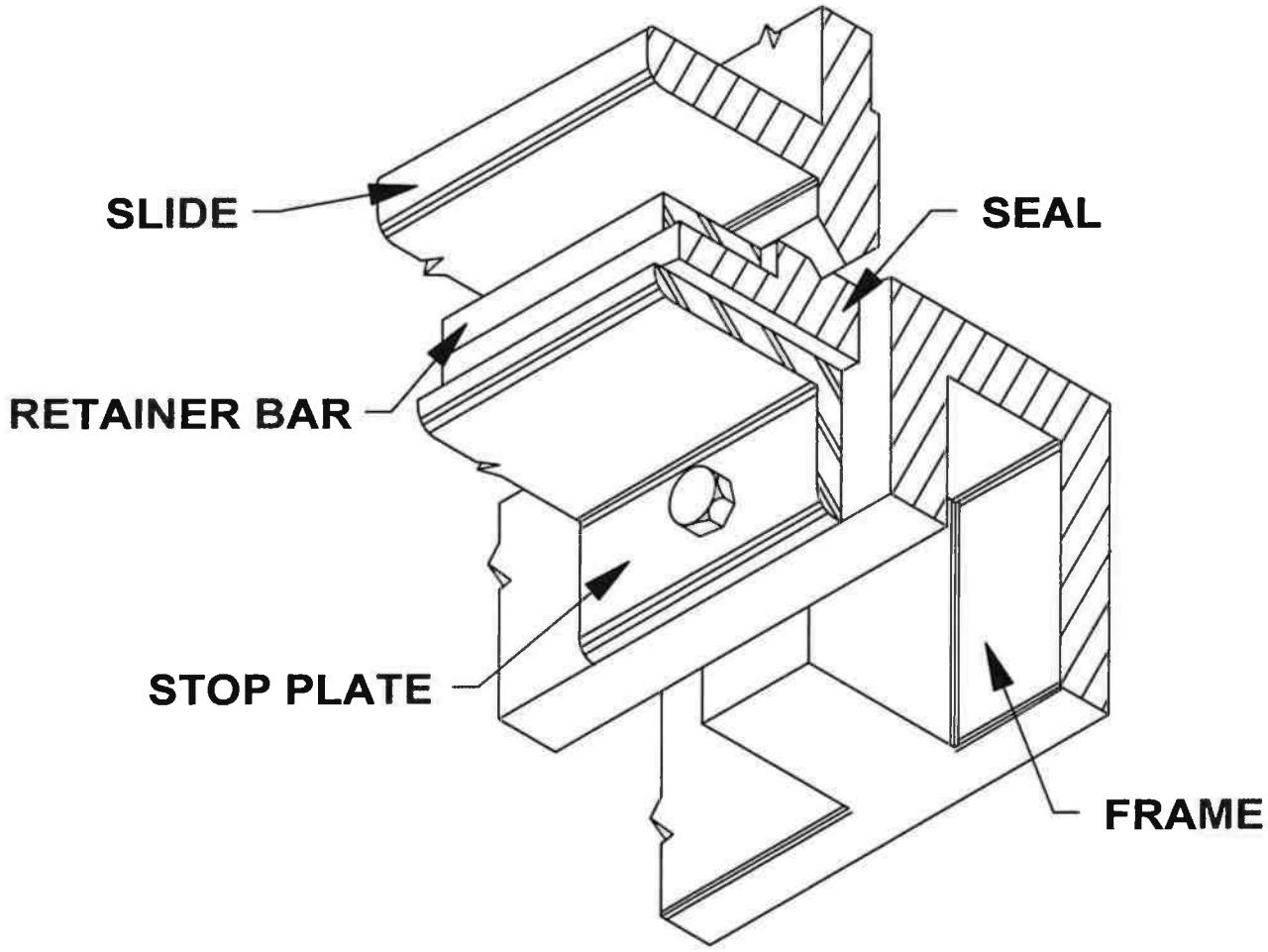
Installation of Flush Bottom Closure Gates

Gates that are to be installed with bottom frame members embedded in the concrete are furnished with a rubber seal attached to the invert of the gate frame **(Figure 3).** The top surface of the rubber seal is installed at the same elevation as the invert of the gate opening. Refer to the Hydro Gate installation drawing.

1. Form a recess for the bottom of the gate in the original pour of concrete. The dimensions of this recess are shown on the installation drawing.

2. After the forms are stripped, install the gate as shown for other types of installations in this manual.

Figure 3 – Bottom View of Gate Slide and Invert Interface



Installation of Flange Back Gates on Concrete without a Thimble

1. Secure all anchor bolts in proper position in the forms. For proper size, length, projection and spacing, see Hydro Gate installation drawing.

> ***Installation***
> *An upper anchor is often required for supporting the upper gate frame.*

2. Two nuts and washers are provided per bolt. Grout space must be left for adjustment of the back nut on the anchor bolt as shown in **Figure 4.** The anchor bolt projection shown on the installation drawing provides for the suggested thickness of the grout shown.

3. Pour concrete and strip forms.

4. Coat threads with anti-seize lubricant. Place one nut on each anchor bolt and adjust them to establish a true flat and vertical plane. Starting with the nuts on the corner anchors, taut string lines (horizontal) and plumb lines (vertical) to bring all nuts around the opening to a flat vertical plane. Place the completely assembled gate into position on the anchor bolts, straightening them as required. Install a second nut and washer on each anchor bolt. Bring the front nuts into light uniform contact with the gate frame, aligning the gate as required. Check for firm contact at the back of the nut, then uniformly tighten all of the front nuts around the opening. Check for proper seating tolerance with a .004-inch feeler gauge.

> ***Installation***
> *To ensure the gate frame has not been distorted during this process, attempt to insert a .004-inch feeler gauge between the seating faces around the entire perimeter of the opening. If the gauge can be inserted between the faces, then adjust the anchor bolt nuts to eliminate the gap. Refer to the "Excessive Localized Leakage" section of this manual.*

5. Carefully grout in the gate, using "Five Star" non-grout, or equal.

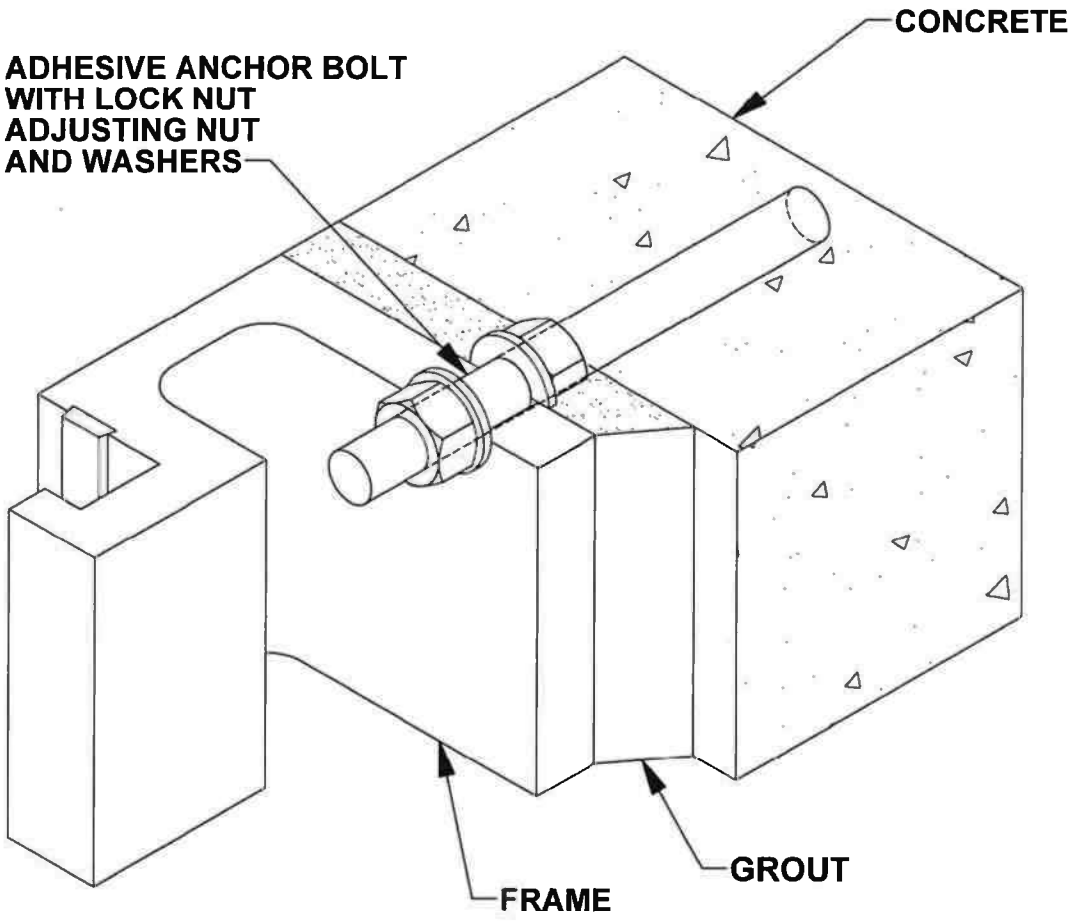
6. After the grout has set, make certain there are no voids between the gate frame and the concrete. Because of possible shrinkage of certain types of grout, it may be necessary to loosen the gate and apply a sealing compound between the gate seat and the wall.

7. Lubricate all nuts and anchor bolts with anti-seize lubricant and tighten uniformly.

> ***Installation***
> *Do not force the gate to conform to any uneven surfaces.*

8. To complete the gate assembly, install nuts on the anchor bolts located on the upper frame extension. Bring both the front and back nuts in firm contact with frame. Tighten both without distorting the frame.

Figure 4 – Top View of Anchor Bolt Mounting with Flanged Back Gate



Gate Stem and Guides Installation

1. Install the stub for the lift and stem guides as shown on the installation drawings. Check for proper alignment of the lift, stem guides, and gate. The lift stem and gate stem block must be in vertical alignment within 1/8 inch per each 10 feet of distance.

2. Provide opening with adequate clearance in the lift platform for the gate stem.

3. Install stem guide brackets on studs, but do not tighten nuts; leaving them loose so the bracket can be moved for later alignment. Loosen all assembly bolts holding the collars to the bracket. Stem guide collars are 2-piece construction.

4. When more than one gate is to be installed, stems may be of different diameters or lengths. Stems are marked and/or tagged for each installation. Separate the stems per individual gate installation.

> ***Installation***
> *Exercise care when handling and installing threaded stems; nicks or burrs will damage lift nut threads.*

5. Insert the stem block into the gate slide pocket or attach with the one or two assembly bolts thru the slide plate and stem.

   Lower the bottom section of the stem into place through the hole of the gate slide and thread it all the way into the block and align the keyways (**Figure 6**).

> ***Installation***
> *Immediately insert the key to lock the bottom section of the stem to the block. (The key is omitted on non-rising stem gates as the turning motion is between the block and the stem.)*

6. Stems may be in more than one piece to facilitate shipment and installation. If two or more pieces are furnished for an installation, they must be installed in their proper order from bottom to top to place splices in correct location so that they will not interfere with the stem guides when the gate is opened or closed. Measure the stem section lengths and install.

7. Place all of the succeeding stem sections. Double-check the installation drawings to ensure that one-piece stem guide collars are in place. Join together with splices as provided (**Figure 7**).

> ***Safety***
> *Insert all bolts or keys in each stem splice immediately after sections are installed and aligned to prevent one section disconnecting from another when the gate is operated.*

8. Immediately before lowering the lift over the threaded portion of the stem, remove the protective wrapping from the stem and thoroughly clean off all foreign material.

9. Lubricate stem threads with recommended lubricants as noted in the "Lift and Stem Maintenance" section of this manual. Do not leave lubricated stem exposed to contamination before completing the installation.

Figure 6 – Stem Block and Key

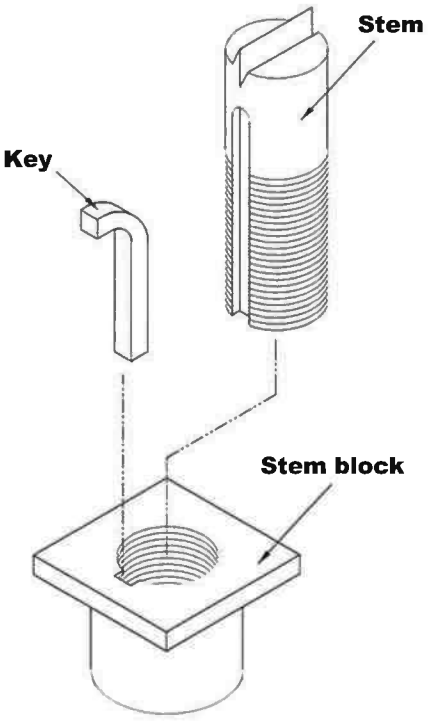
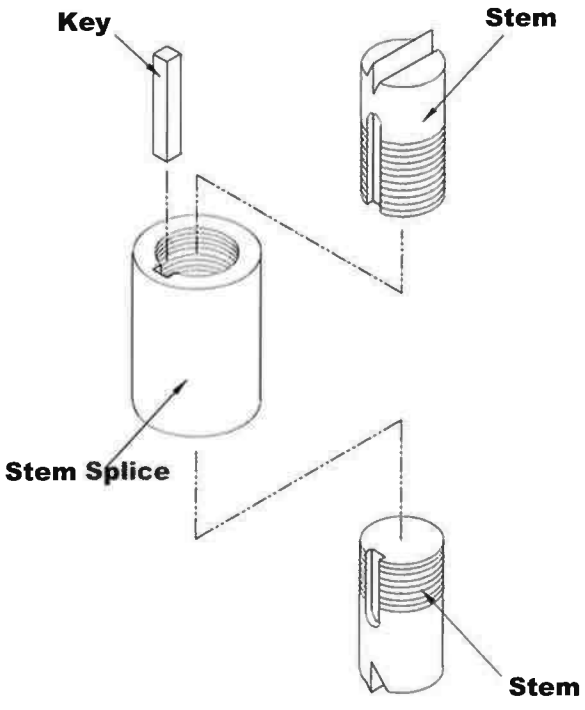


Figure 7 – Stem with Splice



Lift Installation and Adjustment of Stem Guides

1. Clean the interior threads of the lift nut.

> ***Installation***
> *Foreign material in the nut threads may cause damage and make the gate harder to operate. Each threaded nut should be carefully swabbed out even if it appears to be clean.*

2. Clean the threaded section of the stem, removing all foreign material, and lubricate with recommended lubricant as described in the "Lift and Stem Maintenance" section of this Manual.

> ***Warranty***
> *Operation of the gate assembly without proper lubrication of the stem will damage the lift nut threading and void the equipment warranty.*

3. Raise the lift and lower it over the previously installed and lubricated threaded stem section. When starting threaded stem into the bottom of lift nut, care must be taken to avoid damage to the threads. Rough handling may result in damage to the bottom edge of the threaded lift nut and prevent the stem from being threaded into the lift nut freely. Hold the lift to prevent its rotation. Turn the handwheel or crank to lower the pedestal onto its anchor bolts.

> ***Installation***
> *When all parts are cleaned, the threaded lift nut will turn onto the threaded stem with very little effort.*

4. The gate is shipped with a steel clip or clips attached to the frame at the top corner of the slide **(Figure 8),** which held the slide closed during shipment. The clip(s) should now be removed and discarded.

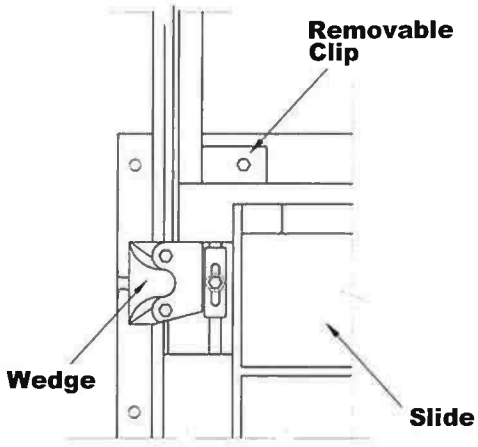


Figure 8

> ***Installation***
> *Do not attempt to operate gate without removing shipping clips.*

5. Using shims, double nuts on anchors, or other leveling devices under the lift, align the centerline of the lift nut until parallel with the stem centerline. Vertical alignment of gate stem and the gate slide stem block must be within 1/8 inch per 10 feet of distance. Tighten nuts on the anchors uniformly.

6. The crank should turn freely for two or three turns in each direction until the clearance between the top or bottom of the stem block in the gate slide is taken up. If any binding occurs during operation of the lift with the slight vertical movement of the gate slide, the stem alignment should be checked. Slight misalignment will cause undue wear to the threaded lift nut. When binding is not caused by misalignment, recheck to be certain all threads on the stem and in lift nut are clean.

7. Place the two-piece stem guide collars around the stem above each bracket. Place the bolts through the projection of the bracket and the ends of the collars. Do not tighten the bolts.

8. Grout under the lift (if required). After the grout has set, tighten the anchor bolts uniformly.

> ***Installation***
> *Before opening the gate, clean all grout, stones or other foreign material from the top of the gate (or bottom in the case of a downward opening gate) and recheck the projection of the anchors or studs across the top of the gate opening. Excess bolt projection will damage the top corrosion-resistant metal seating face on the slide when it is opened.*

9. Turn the lift crank or handwheel to open the gate, until the gate slide is pulled from its wedges. The stem is now in tension. Check the stem to be certain it is straight. Tighten the nuts on the anchors through the stem guide brackets, center the stem guide collars around the stem, and tighten the assembly bolts holding the collars in position on the brackets.

10. Move the gate to its fully opened position and check the position of the stems. If the stem is being deflected by the collars, a stem alignment problem exists and must be corrected, indicating the gate may not be plumb. Consult Hydro Gate for ways to correct or compensate for this condition.

11. Lower the gate to fully closed position and check the wedges and the seating faces as described below. Run the stop nut down on top of the projecting threaded stem until it contacts the top of the lift nut or stem cover flange. Back the nut up until 1/8-inch gap appears between the lift and the stop nut to allow complete gate closure as sliding and bearing surfaces wear in.

12. Tighten the setscrews through the stop nut to hold it in place (**See Figure 13 or 14**).

13. Install the stem cover, decal, indicator, etc., as required. Stem cover and decal installation detailed on the stem cover submittal drawing.

Cleaning and Final Adjustment of Gate

1. Move the slide to the fully opened position.

2. Clean all dirt, grit, paint or other foreign material off of the gate seating faces and wedging surfaces on both the slide and frame.

3. Grease the seating faces and wedge surfaces with water-resistant grease such as the following:

    - Conoco's All Purpose Superlube
    - Texaco's Multi-Fak Heavy Duty No. 2
    - Shell Oil Company's Alvania No. 1
    - Lubriplate No. 630 AAA
    - BP Energrease LS 2

> ***Safety***
> *Lubriplate Super FML2 has a vegetable base and is recommended for use on gates in potable water treatment plants.*

4. Close the gate completely and check for proper wedge adjustment per the "Wedge Adjustment" section of this manual.

Wedge Adjustment

All wedging devices were adjusted for proper metal-to-metal contact before shipping. Vibration during shipment or normal handling during installation may cause some loosening or changing of these settings.

After installation with the slide in the fully closed position, use a .004-inch feeler gauge to check excess clearance between the seating faces. For best results, make this check from the backside of the slide.

If a .004-inch feeler gauge is admitted between the seating faces along the top near the stem, excess compression on the stem may be causing a slight deflection of the slide. To relieve and correct this problem, turn the crank or handwheel in the direction to open the gate until it turns freely. Re-check the clearance with a feeler gauge. If the wedge settings have been changed during installation or if it is necessary to readjust all wedging devices, a suggested order of adjustment is shown in **Figure 9.** The number of wedges may vary, but the pattern of adjustment should be similar.

Top and Bottom Wedge Adjustment

1. Loosen adjusting screw "H" and then loosen cap screws "F" a fraction of a turn until tapping lightly can move the wedge block **(Figures 10 and 11).**

> ***Installation***
> *Do not loosen adjusting screws too much as leakage or damage to the wedges can occur when the wedge is readjusted and tightened.*

2. Tighten adjusting screw "H" (The torque on the adjusting screw is variable, but should not normally exceed values in the torque table for fasteners).

3. Tighten the cap screw "F".

4. Tighten the lock nut "G".

5. Open the gate approximately 1 inch and retighten capscrew F.

Figure 9 – Gate Wedge Adjustment Sequence

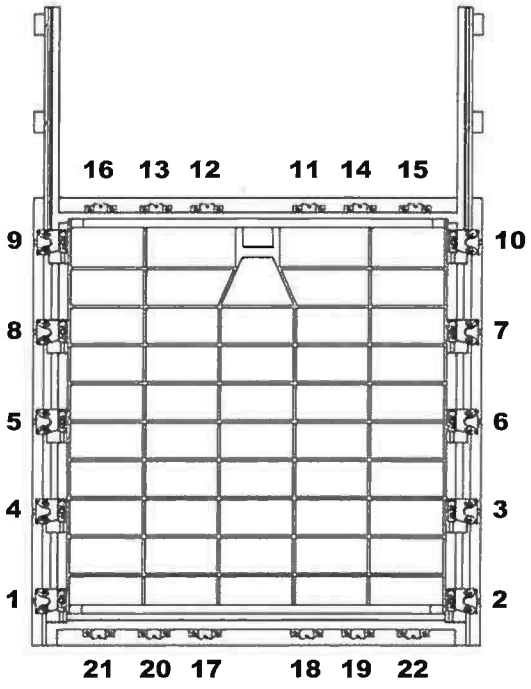


Figure 10 – Top Wedge Adjustment

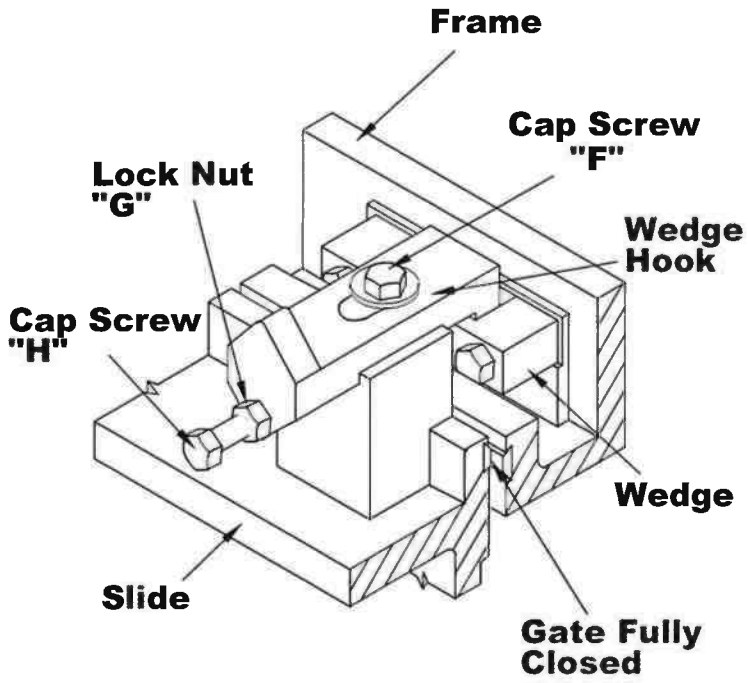
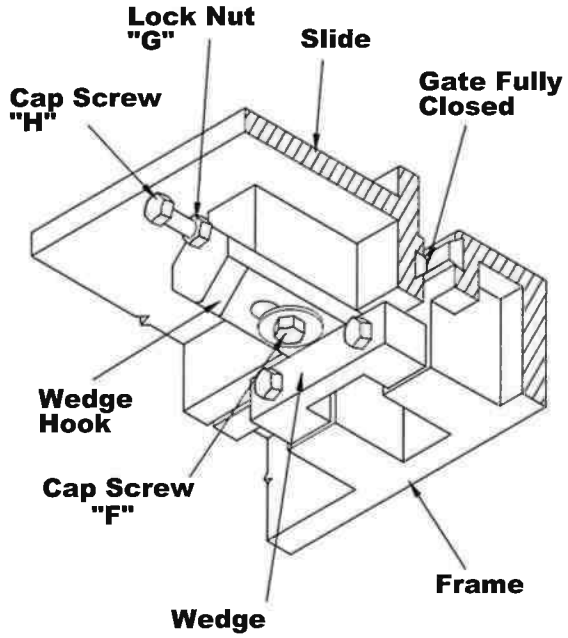


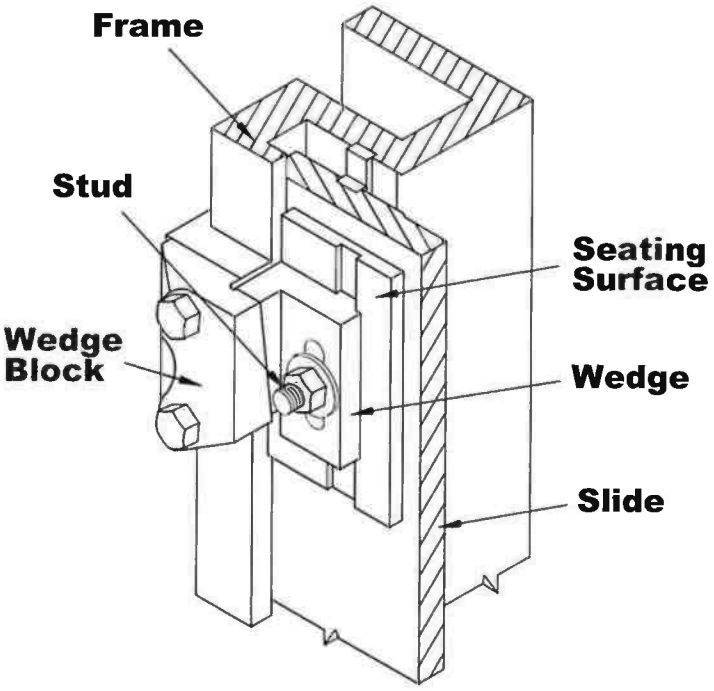
Figure 11 – Bottom Wedge Adjustment



Side Wedge Adjustment

1. Loosen the nut on the stud through the wedge until tapping lightly can move wedge **(Figure 12).**
2. Be certain that the bolts holding the wedge block to the frame are tight. See the torque table below.
3. With a punch or discarded bolt, drive the wedge down until firm contact is made with the overhang portion of the wedge block and the seating faces are pushed together. Do not over-drive any wedge, because it may cause premature engagement when closing. Check all wedge faces for uniform and simultaneous contact during closing.
4. Tighten the nut on the stud through the wedge. (See torque table below for proper tightening.)

Figure 12 – Side Wedge Adjustment



Flush Bottom Closure Adjustment

All flush bottom devices were factory adjusted for proper contact before shipment. Shipment and normal handling may have caused loosening or changing of the settings. Use the following procedures to readjust.

1. On those gates having flush bottom closure, move the gate slide to its fully closed position by applying force on the handwheel or the crank of the lift. Uniform contact between the bottom lip of the gate slide and the top surface of the rubber seal must be made for the full width of the gate opening. Check for proper contact with a .004-inch thickness feeler gauge.

2. If full closure is not being made, open the gate a fraction of an inch to relieve pressure on all of the wedges. Loosen all of the nuts on the studs through the side and wedges and top wedges (if used), as explained the "Top and Bottom Wedge Adjustment" section of this manual.

3. Re-close the gate until uniform contact is made between the bottom of the gate slide and the rubber seal. A slight deformation of the seal is required for the full width of the gate. Re-check contact surface with 0.004 in feeler gauge.

4. Adjust and retighten all wedges, as explained in the "Side Wedge Adjustment" and "Top and Bottom Wedge Adjustment" sections of this manual.

5. Grout or fill the bottom recess around the flush bottom closure as required.

Manual Lifts, Parts, and Assemblies

Typical assemblies of manual lifts are included for reference. These lifts may be either bench-mounted or pedestal-mounted. All Hydro Gate's lifts have housings that can be removed from the pedestal, leaving the lift nut in place supporting the gate weight. If inspection or service of the gears and bearings is necessary, unbolt the lift from the pedestal or benchstand and pull the housing off. The nut and retaining ring should stay in place.

Hydro Gate's lifts may be arranged in tandem. These lifts are connected with an interconnecting shaft, sometimes called a tandem shaft. See the gate installation drawing for more information.

The assembly of tandem lifts requires the following:

1. Reference is made to Hydro Gate's installation drawing.
2. Two stems are provided in two thread directions "left hand" and "right hand", refer to installation drawing for correct stem placement.
3. The stems and lifts are synchronized so that the gate lifts evenly.

Synchronization is accomplished with the interconnecting shaft coupling, (make up the coupling, per the installation drawing, when the gate and stems are even and level.)

(See Figure 13 or 14 for detail information)

Installation of Hydraulic Operating Cylinder, Stems and Stem Guides to Gate

The preferred method of installing and adjusting the operating cylinder to the gate is through the use of the hydraulic power system.

1. Ensure the gate slide is in the fully closed position. See appropriate sections for wedge and seat face check, and adjustments.

2. Locate the stem block/nut and clean the internal threads. Also, clean the threads on the cylinder rod thread and stem extensions where the nut will attach. Prior to final assembly thread the parts together to verify ease of assembly.

3. Bolt the cylinder to the operating platform as required. Prepare to connect cylinder rod to stem extensions as required per the installation drawings.

4. When more than one gate is to be installed, stems may be of different diameters or lengths. Stems are marked and/or tagged for each installation. Separate the stems per individual gate installation.

Installation Note
Exercise care when handling and installing threaded stems; nicks or burrs will damage lift nut threads.

5. Stems may be in more than one piece to facilitate shipment and installation. If two or more pieces are furnished for an installation, they must be installed in their proper order from bottom to top to place splices in correct location so that they will not interfere with the stem guides when the gate is opened or closed. Measure the stem section lengths and install.

6. Attach the upper most stem section to the cylinder rod. Join together with splices as provided (Figure 7).

Safety Note
Insert all bolts or keys in each stem splice immediately after sections are installed and aligned to prevent one section disconnecting from another when the gate is operated.

7. Lubricate stem threads with recommended lubricants. Do not leave lubricated stem exposed to contamination before completing the installation.

8. Place the anchor bolts for the stem guides as shown on the installation drawings. Check for proper alignment of the cylinder rod extension, stem guides, and gate. The cylinder rod extension and gate stem block must be in vertical alignment within 1/8 inch per each 10 feet of distance.

9. Install stem guide brackets on anchors, but do not tighten nuts; leaving them loose so the bracket can be moved for later alignment. Loosen all assembly bolts holding the collars to the bracket. After each collar is installed, re-bolt it to its bracket, but do not tighten.

10. Connect the hydraulic lines to the appropriate port on the cylinder. Refer to the operation and maintenance manual for the hydraulic system.

> *Installation Note*
> *Take care to not leave the cylinder ports uncovered during installation as contaminants can enter the hydraulic system causing premature failure.*

11. Supply hydraulic fluid to extend the cylinder rod and stem assembly toward the gate slide stem block pocket. If the cylinder rod does not align with the center of the stem block pocket it will be necessary to make adjustments to the cylinder mounting.

12. Place the stem block/nut in the gate slide stem block pocket. Refer to the installation drawing provided to confirm the correct location.

13. Carefully extend the rod and stem assembly into the block pocket and rotate the stem block/nut to engage the threads.

14. The stem block/nut will have multiple holes in its circumference. A straight piece of rod can be used to rotate the nut.

> *Installation Note*
> *The cylinder must be fully extended, at the same time the gate must be completely closed. Care must be taken not to over close the gate which creates distortion across the top of the gate slide.*

15. Alternately extend the cylinder rod and rotate the nut until the cylinder rod is fully extended. Verify that the cylinder rod or stem extension thread fully engages the stem nut, and the nut is in contact with the bottom of the block pocket.

16. Tighten the screws that lock the stem block/nut to the matching rod and stem assembly.

17. Bleed the hydraulic lines to remove trapped air. Refer to the operation and maintenance manual for the hydraulic system.

18. Cycle the gate several times to verify proper function.

19. Re-check with feeler gauge across the top of gate opening. Verify that the cylinder is not over-closing the gate, causing the slide to bend open at the stem block pocket. Back up the stem block slightly on the rod to alleviate this problem.

OPERATION

General Operation Information

Cast Iron Slide gates are used to control flow of or retain a volume of water, effluent, or other fluids. Typical applications include industrial water treatment facilities, municipal water treatment facilities, irrigation, dams, flood control, and many other applications that require accurate control of liquid flow.

The simplicity of a Cast Iron Slide Gates makes it a popular choice when designing flow controls. From the basic hand-cranked manual model to the microprocessor-controlled, fully integrated electric Cast Iron Slide Gates, actuation consists of the basic open or closed operation. An open gate allows flow and a closed one does not.

Depending on size, most Cast Iron Slide Gates can operate without error in diverse conditions. Some extenuating circumstances may include large amounts of ice or other solids that will obstruct the travel path of the gate. In most cases, when the obstruction is removed, normal operation can be resumed without adjustment to the gate.

Cast Iron Slide Gate Operation Procedures

The following sections cover the general operating procedures associated with two manual-operation systems (handwheel and handcrank) and an electrical-operation system. Read and follow the operating procedures for the applicable system. If you have any questions concerning safe operation of this Hydro Gate Cast Iron Slide Gates, contact Hydro Gate immediately.

Manual Handwheel Model H2B or Tee Wrench

Opening – To open this Cast Iron Slide Gate observe the direction of rotation noted on the handwheel. Turn in the direction of opening. If the gate has been closed for an extended period the gate may be difficult to "unseat." If, after several turns of the wheel, the rotation becomes increasingly difficult stop rotation when a **moderate** pressure is achieved. Allow the pressure in the stem to unseat the gate (a "POP" sound typically signals the gate has begun to travel. Continue to turn the hand wheel until the desired gate position has been achieved. Observe the relative position of the top of the stem in relation to the Mylar decal on the stem cover (if equipped.) When the top of the stem is equal to the OPEN or 100% indicator the gate is considered to be FULL open and should not be opened further.

> ⚠ ***Operation***
> *Do not over-open the gate. Serious damage to the gate stem and sealing surfaces can result.*

Closing – To close this Cast Iron Slide Gate turn the handwheel in the direction opposite of the Open indicator until the stopnut on the stem has **moderately** seated on the top of the lift. When the top of the stem is equal in height to the bottom/zero height indicator, the gate is considered to be FULL CLOSED and should not be closed further. Should the gate or stop nut require adjustment, refer to the appropriate section of the Installation, Operation, and Maintenance Manual or call Hydro Gate **before** any adjustments are made.

> ⚠ ***Operation***
> *Do not attempt to adjust the position of the stopnut to achieve additional closing stem travel. Serious damage to the gate stem and sealing surfaces can result.*

Manual Handcrank Type IB

Opening – To open this Cast Iron Slide Gate observe the direction of rotation noted on the lift housing. Crank in the direction of opening. If the gate has been closed for an extended period the gate may be difficult to "unseat." If, after several turns of the handcrank, the rotation becomes increasingly difficult stop rotation when a **moderate** pressure is achieved. Allow the pressure in the stem to unseat the gate (a "POP" sound typically signals the gate has begun to travel. Continue to turn the handcrank until the desired gate position has been achieved.

> ⚠ ***Operation***
> *Do not over-open the gate. Serious damage to the gate stem and sealing surfaces can result.*

Closing – To close this Cast Iron Slide Gate turn the crank in the direction opposite of the Open indicator until the stopnut on the stem has **moderately** seated on the top of the lift. After the gate has been closed as noted on the indicator, the gate is considered to be FULL CLOSED. Then reverse the rotation of the crank and relieve the pressure on the stem and lift. Should the gate or actuator require adjustment, refer to the appropriate section of the Installation, Operation, and Maintenance Manual or call Hydro Gate **before** any adjustments are made.

> ⚠ ***Operation***
> *Do not attempt to adjust the position of the stopnut to achieve additional closing stem travel. Serious damage to the gate stem and sealing surfaces can result.*

MAINTENANCE

Field Cleaning and Painting

Hydro Gate's standard paint system on Cast Iron Slide Gates is commercial grade blast and Hi-build epoxy paint. It does not require top coating. Should blast cleaning be needed to condition the gate for top coating, the gate should be fully closed and any exposed metallic seating faces, wedges, and wedge blocks protected from blast and paint. Before painting, blow all grit off gate, particularly in and around the seating faces. Do not remove any wedges or disassemble the gate except as described in the next paragraph.

Hydro Gate does not usually recommend removing the slide from the frame to apply finish/top coats because of the risk of damage to the seating faces during handling. If sufficient reasons exist for removal of the slide, (e.g., badly deteriorated paint on an old gate or a complete change of paint system that is incompatible with the existing paint) then completely disassemble and thoroughly blast clean all surfaces to obtain a quality recoated product.

When disassembling the gate or gates, keep parts segregated and match-marked so that parts are not mixed gate-to-gate because interchangeability between gate parts is not always certain. Protect all seating surfaces on the slide and frame with duct or masking tape. Use special care in handling the slide and frame to avoid damage to the seating faces.

Blast clean and paint the frame and slide as required by the specifications or the paint manufacturer's recommendations. Do not paint the contact faces of the wedges or metal seat. Remove masking tape or other material used to protect machined faces. Clean all faces thoroughly and relubricate. Reinsert slides in the proper frame.

With the gate in the fully closed position, recheck maximum clearance between the seating faces with .004-inch thickness feeler gauge. Readjust wedges, if required, per the instructions in the “Wedge Adjustment” section of this manual.

Maintenance and Lubrication

Occasional adjustment, lubrication, and painting of Hydro Gate Cast Iron Slide Gate components will be required. The frequency will depend upon how often the gate is used, location, and operating conditions. Periodic inspection, adjusting, cleaning, and repainting are recommended as conditions at the site permit.

When excess leakage through the gate seating surfaces occurs or when the gate has been in the closed or opened position for long periods of time without movement, the seating faces and wedging surfaces should be cleaned and greased and the wedges should be readjusted per the instructions in this manual.

Lift and Stem Maintenance

Maintenance of the threaded operating portion of the gate stem is critical and should be performed as frequently as the operating environment requires.

> ⚠ ***Maintenance***
> *Failure to maintain stem thread lubrication causes operating difficulties and premature failure of the lift nut and stem threads.*

Recommended inspection frequency and procedures are listed on the maintenance schedule:

- Initial inspection at time of installation and again at the date of commissioning.

A "cycle" of gate operation is operation of the gate slide from closed to open to closed position. At each inspection, verify the following items:

- Inspect the stem threads and lift nut threads for wear. Using a threaded stop nut as an example of the original thread, verify the amount of wear on the lift nut and stem.
- Check the amount of lubricant remaining and add if necessary.
- Relubricate if necessary - threads should be cleaned and relubricated with fresh lubricant.

More severe conditions or operating modes require a slightly different schedule of inspection and service. For example: Modulating gates with electric motor operators may make position changes several times a day but seldom go full stroke. There is a portion of the stem that gets a lot of use. These stems should be inspected at least weekly. The lubricant on the stem threads should be monitored closely. As the lubricant is depleted and becomes contaminated, it should be cleaned away and replenished.

When excess dried grease or other foreign material is carried into the threads of the lift nut, extremely hard operation will result. If serious binding occurs, the only way to correct it is to remove the threaded stem from the lift nut and clean the thread interior. If this foreign material is not cleaned from the interior threads of the lift nut, heavy pulls on the handcrank or seizure will result.

Stem threads may be cleaned with solvent, rags, and brushes. Run the gate open. While in the process of opening (running the stem out above the lift nut), clean off the old grease. Inspect the threads for roughness. If the threads are rough, they may be filed and polished. Be careful to keep filings and grit out of the lift nut. Rough stem threads accelerate the wear of the lift nut threads.

Relubricate the stem threads by brushing or smearing grease onto/into the threads as the gate is closing (the stem is going into the lift). This puts fresh lubricant into the lift nut and carries out the old contaminated grease.

It is recommended that the contaminated grease be cleaned from the stem as it exits underneath the lift where the stem is accessible from below. Of course, replenish grease on the underside stem.

The recommended stem thread lubricant is Schaeffer's 238 Ultra Supreme.

An equivalent lubricant can be made from a mixture of "La Co Slic-Tite Paste" and Fiske Bros. "Lubriplate No. 630 AAA" in the ratio of 24 ounces of paste per gallon of grease. "Slic-Tite Paste" is a pipe dope with Teflon fibers and is available from most plumbing supply stores.

An equal alternate for La Co's "Slic-Tite" is "ANTI-SEIZE Pipe Thread Sealant Paste with Teflon", Stock Nos. 4X222 or 5X998, which is available at W. W. Grainger Inc. stores in major cities nationwide.

Equivalent lubricants to Fiske Brothers' "Lubriplate 630AAA" include:
- Texaco's "Multifak EP 2"
- Sta-Lube "Sta-Lube" No. 3121
- Shell Gadus Grease (formerly known as Alvania grease)
- Mobil's "Mobilux EP2"
- Mobil's "Ronex MP"
- Fiske Brothers' "Lubriplate No. 630 AA"

Recommended for potable water is a vegetable-based lubricant such as Schaeffer's 195 Food Grade.

Lifts may be furnished with a stem lubricator Zerk Fitting which is located in the "stem cover adapter" to facilitate lubrication of stem threads with pressure greasing equipment. To be effective, lubricant should be injected while the stem is moving through the lift.

Manual crank lifts have sealed thrust bearing and do not require lubrication.

Exercise of infrequently operated lifts and gates is recommended. An annual exercise will ensure the gate is operable when needed and the lubrication condition will be maintained.

Removal of the stem nuts for thread inspection of frequently modulated gates is recommended. This avoids "surprise" when the nut threads have worn so thin they strip out and drop the gate. Replacement or spare nuts can be ordered from Hydro Gate. Spare parts are usually not needed or recommended, since they are readily available on short notice from Hydro Gate. In those cases where equipment operation or downtime is critical and the gate is operated extremely often, a spare lift nut may be wise to have on hand.

Maintenance Schedule and Lubrication Summary

Activity	Frequency	Lubricant
General Cleaning and Inspection	Every 6 months, more frequently as conditions and use require.	N/A
Stem Thread and Lift Nut Wear Inspection	Every 6 months, more frequently as conditions and use require.	N/A
Stem Thread Lubrication and Cleaning Inspection	Every 6 months, more frequently as conditions and use require.	Schaeffer's 238 Ultra Supreme*
Clean and Grease Seating Faces and Wedge Surfaces	Annually or whenever the gate is dewatered. Exercise gate, at least partially, every 6 months if dewatering is not possible.	*Schaeffer's 238 Ultra Supreme*
		*See text for equivalent lubricants.

Notes

- ***Inspect crank lift and/or electric actuator for the collection of moisture beneath the stem cover housing. Unthread the stem cover housing and examine the space surrounding the stem. A convenient method of removing the moisture is by utilizing a Squeeze Bulb, Siphon or Baster.***
- For potable water treatment plants use a vegetable-based lubricant such as Schaeffer's 195 Food Grade.

Lubrication Equivalents

The recommended stem thread lubricant is Schaeffer's 238 Ultra Supreme.

Hydro Gate considers any of the following greases/lubricants to be acceptable equivalents when combined with a pipe thread sealant:

A. Fiske Brothers "Lubriplate" No. 630 AAA or AA
B. Sta-Lube "Sta-Lube" No. 3121
C. Texaco "Multifak EP 2"
D. Shell Gadus Grease (double check grade)
E. Mobil "Mobilux EP2"
F. Mobil "Ronex MP"

Hydro Gate recommends the following pipe thread sealants with Teflon:

A. La-Co Slic-Tite Paste
B. ANTI-SEIZE Pipe Thread Sealant with Teflon\
C. Loctite 561 Pipe Thread Sealant with PTFE
D. Any other commercially available pipe thread sealants containing Teflon

For water treatment plants, Hydro Gate recommends using a vegetable-based lubricant such as Schaeffer's 195 Food Grade. The following lubrications are considered acceptable equivalents:
Lubriplate Super FML-2.
Rocol Foodlube Multi-Paste (European product)
Petro-Canada Purity-FG
Loctite 561 Pipe Thread Sealant with PFTE

Leakage

The most frequent cause of excess leakage through a newly installed Hydro Gate Cast Iron Slide Gate is improper installation and/or failure to make final adjustments before the gate is put into operation. When you encounter this problem, first verify that Hydro Gate's installation instructions have been carefully followed and that final adjustment and greasing have been accomplished. If not, then complete the applicable step-by-step procedures of adjusting and greasing as outlined in the appropriate sections of this manual.

An important note: ensure the Cast Iron Slide Gates were not disassembled for installation. The cover of this Installation, Operation, and Maintenance Manual states **"DO NOT DISASSEMBLE GATE FOR INSTALLATION"**. This is repeated in the text of this manual at several critical locations.

> ⚠ ***Installation***
> *When the Cast Iron Slide Gate is disassembled for installation, all of the fine adjustments that were made by Hydro Gate are lost. It is then necessary for you to clean all of the contact faces, reinstall the slide, and adjust all wedging devices in strict accordance with our instructions.*

As pointed out above and in our installation instructions, the amount of leakage through the Cast Iron Slide Gate is highly dependent upon the quality of installation. The gate seat, or frame is somewhat flexible and is easily pulled out of line if incorrectly installed, resulting in leakage. The amount and location of leakage depends upon the deflection of the castings by improper tightening of the nuts on the anchors.

To minimize leakage through Cast Iron Slide Gates and meet or exceed the AWWA C560 Cast Iron Slide Gate Standards, installation must be precise. Our instructions not only call for careful installation of gates, but also emphasize the importance of final cleaning and lubrication of seating faces and wedge contact surfaces before operating the gate. We also recommend a water-resistant grease be applied to all surfaces, which allows proper seating of the gate in the last turn or two of the hand crank.

> ***Example***
> *When the slide is moved downward by as little as 1/64 of an inch, the wedges cause it to move toward the seating surface by .002 inch. This almost negligible horizontal movement can cause a considerable difference in the amount of leakage.*

The American Water Works Association's (AWWA's) leakage rate for Cast Iron Slide Gates is 0.1 gallon per minute per foot of seating perimeter for seating heads and 0.2 gallons per minute per foot of perimeter for unseating heads up to unseating head of 20 ft. Unseating heads above 20 ft. require the allowable leakage to be calculated. Maximum allowable leakage for unseating heads above 20 ft. (gallons per minute per foot of seating perimeter) = .10 + 0.005 x (unseating head in feet).

Troubleshooting Tips for Hydro Gate Cast Iron Slide Gates

Symptom	Cause	Remedy
Excessive Leakage under Slide on Flush Bottom Closure	Gate not completely closed or bottom seal out of adjustment or debris under seal or damage of seal. Some or all the wedges are too tight and the slide is being stopped short of its fully closed position.	Remove foreign material. Check seal for permanent damage and possible replacement. Check for any mistightened wedges with a .004 inch feeler gauges. Tigh wedges will not permit insertion of the gauge. If only one or two wedges are the problem, then readjust them. It may be necessary to completely loosen and readjust the entire gate per the instructions in the manual.
Excessive Leakage along the sides and/or the top of the Slide with Flush Bottom Closure	Multiple wedges improperly adjusted.	Check the location where the leakage is occurring and adjust the side and top wedges as described under the **Wedge Adjustment** section of the manual.
Excessive Leakage at One Particular Location	A (one) wedge improperly adjusted	Check between the tapered face of wedge and the wedge block with .004-inch thickness gauge. If the gauge passes between these surfaces, readjust that wedge. Even if the gauge cannot be passed between the tapered wedge faces, loosen the nut on the stud through the wedge and adjust the wedge tighter. If you are unable to correct the leakage by readjusting the wedge, it may be caused by foreign material between the gate seating faces. Open the gate an inch or two. If a large piece of foreign material is found, flush it out. If the leakage persists, foreign material such as paint or grit may be on the seating faces. To correct this problem, dewater the gate completely, clean all seating faces and wedge surfaces, and grease the faces. Follow the procedures under the **Clean and Adjust Gate** section of this manual.
Excessive Leakage along Top; Stem Block Pocket Located at or Near Top of Slide	Gate overclosed	With this slide configuration, it is possible to push down on the stem so hard that the stem block is pulling the gate slide from its seating faces at the top. Turn the handwheel, gear crank, or power actuated lift to relieve the compression on the stem and the excess force on the top of the slide. If the slide was being deflected, the excess leakage will diminish or stop when the compression in the stem is relieved.

Excessive Localized Leakage; Gate Installed on Concrete, Wedges Tight	Overtighted anchor bolts	Loosen the bolts in the area of the leak. The frame will usually spring back. Check the seating face with a .004-inch gauge. Check the wedge adjustment. Shim as required between the gate frame and wall. Retighten the bolts. Caulk or regrout to seal off the crack or gap between the frame and wall. If the warp is severe, it may save time to completely remove the gate and reinstall the gate on new grout, or a bead of epoxy or sealant such as Sikaflex 1-A. Be careful so that the gate is installed flat the second time. Review the proper installation and adjustment instructions in this manual.
	Dirty Seating Face	Check for drops of paint, cement runs onto seating faces, or other construction grime. To correct, scrape off the foreign material from the perimeter of the seating faces on both the slide and frame and reseat the gate.
Cast Iron Slide Gates Installed on Wall Thimble - Excessive Leakage	Improper installation Thimble improper seal between the gate back and the thimble face. Improper contact between the gate and the thimble. One or more spots without mastic, or too little mastic	- Check for thimble warp - Clean foreign material - Reapply continuous bead of mastic
Stem Bends	Improper stem guide placement or excessive force on operator	- Check stem guide spacing and alignment - Contact Hydro Gate for new stem
Excess Force Is Required on Handwheel or Crank	Dry and/or misaligned stem or Seating face damage	Lubricated Stem or Contact Hydro Gate with documentation
Noise during operation	The stem threads may be dry and/or the stem guides may be misaligned causing excessive rubbing as stem passes through.	Check thread surface and remove any burrs or damaged areas. Clean and coat with an extreme pressure grease and check stem guides for correct alignment.
Excessive effort to Operate	Dry Stem threads or foreign material is carried into the threads of the lift	Remove the treaded of the lift nut, clean the interior and lubricate

Long-Term Storage Instructions for Cast Iron Slide Gates, Lifts, Stems, and Accessories

1. Gate assemblies must be stored horizontally and flat, with the backside (flange side) down. The storage area must be flat, graded, comprised of compacted soil, concrete, or asphalt. Storage on uneven surfaces can cause permanent distortion of the gate, creating installation problems.

2. Place timber, minimum 4-inch x 4-inch, to provide substantially complete perimeter support under the gate frame assembly. Longitudinal timbers, spaced a maximum of 4 feet, may also be used.

3. Stacking of gates is permissible. The stacked height should not exceed 3/4 of the bottom gate's width or height. Stack gates of different sizes in a pyramid fashion. Do not stack large gates on top of smaller gates.

4. Stacked gates should be separated with timber. The separating timbers should form a flat and level base for the gate above.

5. Wall thimbles may be stored similar to above with machined flange face up or down. Substantial level blocking is essential. Uneven support of gate assemblies and thimbles causes the gate or thimble to warp and voids the manufacturer's warranty.

6. Store the lift assemblies either upright with plastic plugs/caps in place to keep dirt out of the nut threads or leave in original shipping cartons. Do not store the lifts directly on the ground.

7. Stems and stem covers should be stored horizontally on timbers spaced 4 to 8 feet apart. Protective sleeves should be left on all stem threads and stem covers.

8. Miscellaneous accessories and hardware should be stored off the ground.

9. Bronze stem blocks, wedges, lift nuts, and stainless steel accessories are targets for theft and resale as scrap. Report all shortages at once and note same on shipping papers. Hydro Gate cannot be held responsible for theft and loss of equipment stored on the job site.

10. Inside dry storage is the best for all equipment. Covering equipment stored outside with tarpaulins is recommended to minimize degradation of paint from rain and sunlight, until finish paint is applied. Uncovered outdoor storage may result in staining of painted surfaces from rain and sunlight.

HYDRO GATE

12000 E. 47th Ave., #200, Denver, CO 80239 •
Phone: 303-288-7873 • Fax: 303-287-8531 • www.hydrogate.com

WATER CONTROL GATE GUARANTEE

For a period of one year from the date indicated, Hydro Gate hereby guarantees that its water control gates will be free from defects in material and in workmanship and agrees to repair or, at its discretion, to replace any part or parts found defective within such one year, provided the Purchaser gives immediate notice of such defect, and such defect, in the opinion of Hydro Gate clearly demonstrates the existence of defective materials or workmanship.

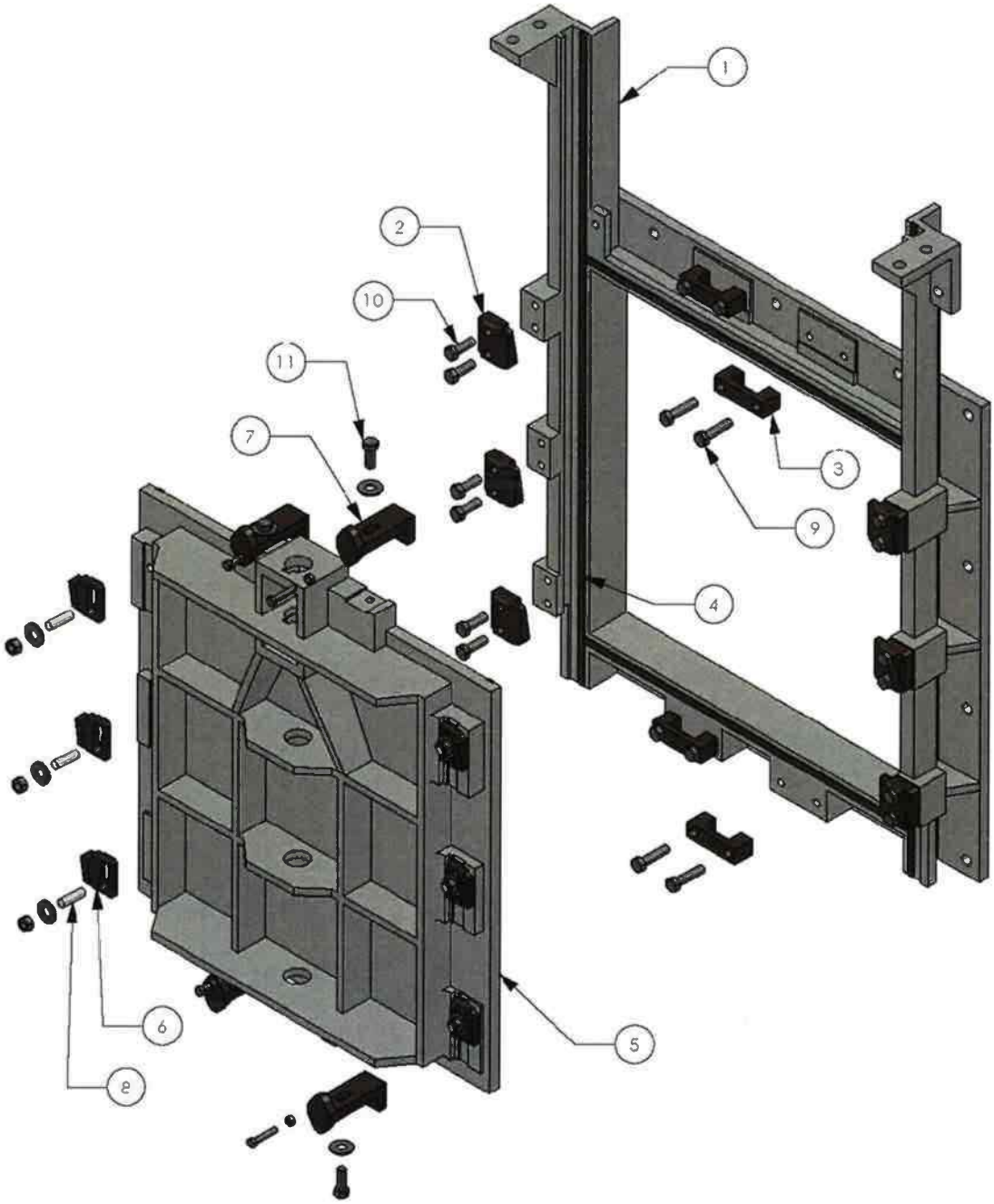
This guarantee is applicable only if the product is properly stored and protected as prescribed by us, between the interval of its receipt by the Buyer and actual installation and if the product is properly installed and lubricated in accordance with our instructions.

The liability of Hydro Gate shall not in any case exceed the cost of repairing or replacing the defective parts. The guarantee and the remedies provided for defective parts set forth above are in lieu of and shall supersede any and all guarantees or warranties, express or implied, or remedies provided by law or otherwise (including those set forth in purchase order forms or other sales documents). In no event shall Hydro Gate be liable for loss of income, any other expenses, consequential damages or incidental damages. At the end of said one year, all liability of Hydro Gate shall cease and terminate.

Hydro Gate guarantees equipment of other manufacturers only insofar as such equipment is guaranteed to it. Information with respect to such guarantees is available on request.

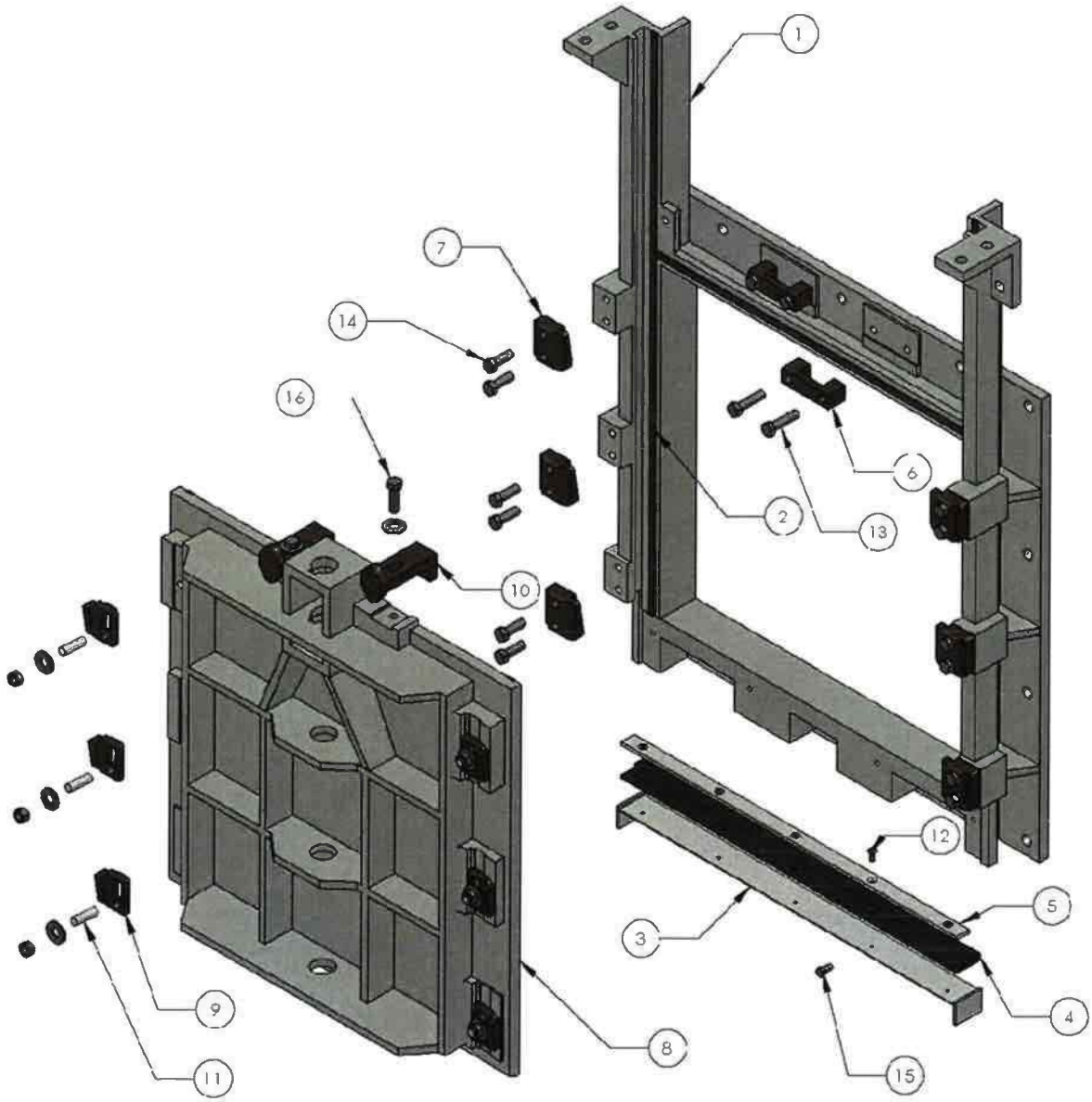
Effective Date: Substantial Completion

Exploded View Series 560 Standard Bottom Configuration

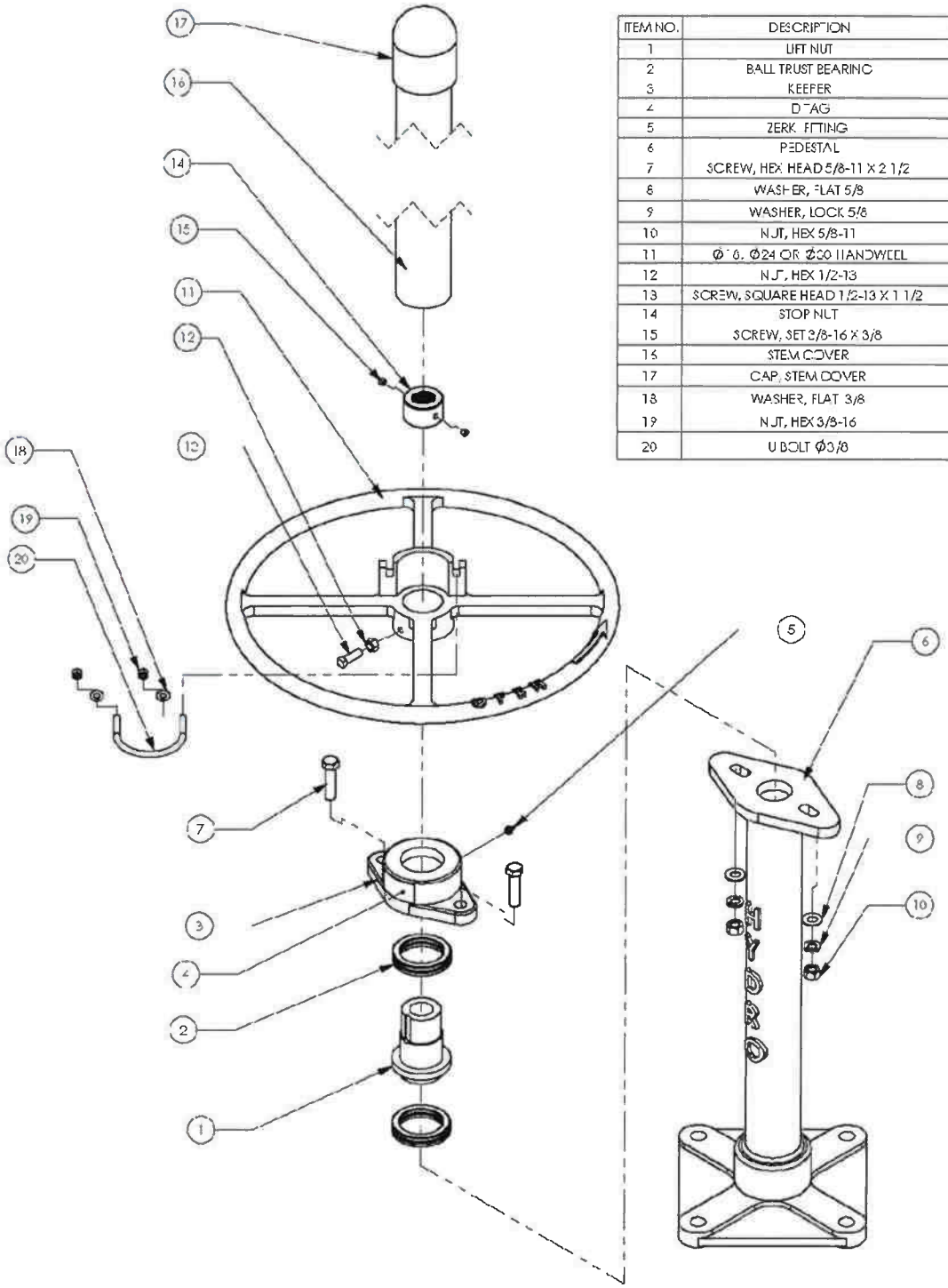


ITEM NO.	STANDARD BOTTOM CONFIGURATION PART LIST
1	FRAME
2	SIDE WEDGE BLOCK
3	TOP & BOTTOM WEDGE
4	DOVETAIL BRONZE SEATING FACES (FRAME & SLIDE)
5	STANDARD BOTTOM SLIDE
6	SIDE WEDGE
7	TOP & BOTTOM WEDGE HOOK
8	SIDE WEDGE FASTENER SET
9	TOP & BOTTOM WEDGE FASTENERS
10	SIDE WEDGE BLOCK FASTENERS
11	TOP & BOTTOM WEDGE HOOK FASTENER SET

Exploded View Series 560 Flush Bottom Configuration

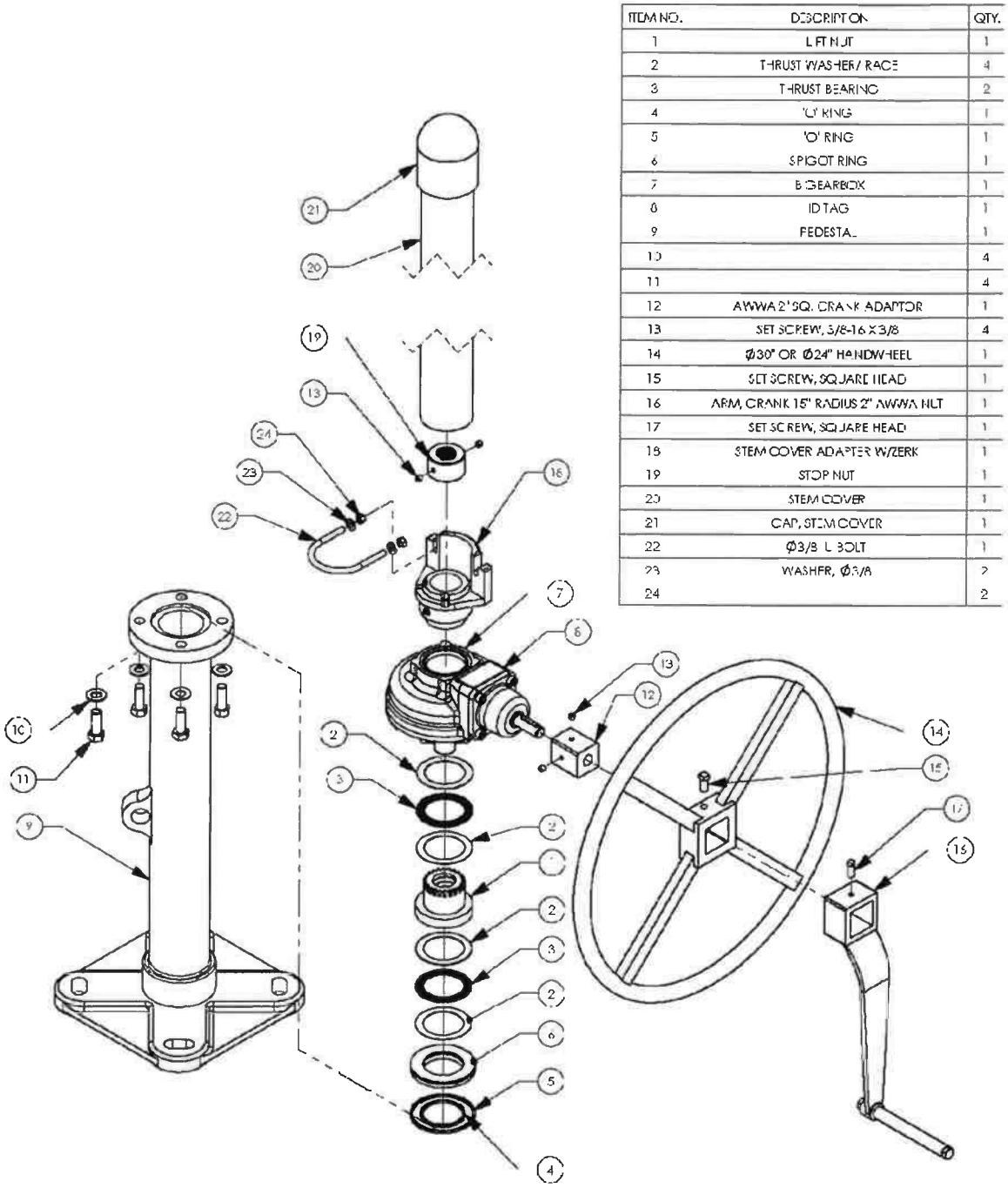


ITEM NO.	UNIVERSAL BOTTOM CONFIGURATION PART LIST
1	FRAME
2	DOVERTAIL BRONZE SEATING FACES (ON FRAME AND SLIDE)
3	FLUSH BOTTOM ANGLE
4	FLUSH BOTTOM RESILIENT SEAL
5	SEAL RETAINER
6	TOP WEDGE
7	SIDE WEDGE BLOCK
8	UNIVERSAL BOTTOM SLIDE
9	SIDE WEDGE
10	TOP WEDGE HOOK
11	SIDE WEDGE FASTENER SET
12	FLUSH BOTTOM SEAL RETAINER FASTENERS
13	TOP WEDGE FASTENERS
14	SIDE WEDGE BLOCK FASTENERS
15	FLUSH BOTTOM ANGLE FASTENERS
16	TOP WEDGE HOOK FASTENER SET



ITEM NO.	DESCRIPTION	QTY.
1	LIFT NUT	1
2	BALL TRUST BEARING	2
3	KEEPER	1
4	DRAG	1
5	ZERK FITTING	1
6	PEDESTAL	1
7	SCREW, HEX HEAD 5/8-11 X 2 1/2	2
8	WASHER, FLAT 5/8	2
9	WASHER, LOCK 5/8	2
10	NUT, HEX 5/8-11	2
11	Ø16, Ø24 OR Ø30 HANDWHEEL	1
12	NUT, HEX 1/2-13	1
13	SCREW, SQUARE HEAD 1/2-13 X 1 1/2	1
14	STOP NUT	1
15	SCREW, SET 3/8-16 X 3/8	2
16	STEM COVER	1
17	CAP, STEM COVER	1
18	WASHER, FLAT 3/8	2
19	NUT, HEX 3/8-16	2
20	U BOLT Ø3/8	1

Figure 13 - *Manual Handwheel Model H2B*



ITEM NO.	DESCRIPTION	QTY.
1	LIFT NUT	1
2	THRUST WASHER/ RACE	4
3	THRUST BEARING	2
4	'O' RING	1
5	'O' RING	1
6	SPIGOT RING	1
7	GEARBOX	1
8	ID TAG	1
9	PEDESTAL	1
10		4
11		4
12	AWWA 2" SQ. CRANK ADAPTOR	1
13	SET SCREW, 3/8-16 X 3/8	4
14	Ø30" OR Ø24" HANDWHEEL	1
15	SET SCREW, SQUARE HEAD	1
16	ARM, CRANK 15" RADIUS 2" AWWA NUT	1
17	SET SCREW, SQUARE HEAD	1
18	STEM COVER ADAPTER W/ZERK	1
19	STOP NUT	1
20	STEM COVER	1
21	CAP, STEM COVER	1
22	Ø3/8 U BOLT	1
23	WASHER, Ø3/8	2
24		2

Figure 14 - *Manual lift Type IB*

SPARE PARTS

Warnings
- Check size of parts before attempting to store them
- Spare parts should be stored in clean, dry and protected warehouse until ready for installation.

HOW TO ORDER REPLACEMENT OR SPARE PARTS

Parts may be ordered from your local Hydro Gate Representative or direct from Hydro Gate.

Please have the following information:

1. Hydro Gate sales information found on the blue anodized tag located on the gate or pedestal.
2. The item and/or tag number must be relayed to Hydro Gate
3. Description of replacement Part(s)

Spare Parts List

1	Stop Nut
2	Stop Collar
3	Lift Nuts
4	Stem Cover
5	Thrust Bearing for Gate lift

Table 1

ATTACHMENT D

Instruction Manual Model GK-401

GEOKON

The World Leader in Vibrating Wire Technology

48 Spencer Street
Lebanon, NH 03766, USA
Tel: 603•448•1562
Fax: 603•448•3216
E-mail: geokon@geokon.com
http://www.geokon.com

Instruction Manual

Model GK-401

Vibrating Wire Readout

(Doc Rev D, 11/03)

Warranty Statement

Geokon, Inc. warrants its products to be free of defects in materials and workmanship, under normal use and service for a period of 13 months from date of purchase. If the unit should malfunction, it must be returned to the factory for evaluation, freight prepaid. Upon examination by Geokon, if the unit is found to be defective, it will be repaired or replaced at no charge. However, the WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion or current, heat, moisture or vibration, improper specification, misapplication, misuse or other operating conditions outside of Geokon's control. Components which wear or which are damaged by misuse are not warranted. This includes fuses and batteries.

Geokon manufactures scientific instruments whose misuse is potentially dangerous. The instruments are intended to be installed and used only by qualified personnel. There are no warranties except as stated herein. There are no other warranties, expressed or implied, including but not limited to the implied warranties of merchantability and of fitness for a particular purpose. Geokon, Inc. is not responsible for any damages or losses caused to other equipment, whether direct, indirect, incidental, special or consequential which the purchaser may experience as a result of the installation or use of the product. The buyer's sole remedy for any breach of this agreement by Geokon, Inc. or any breach of any warranty by Geokon, Inc. shall not exceed the purchase price paid by the purchaser to Geokon, Inc. for the unit or units, or equipment directly affected by such breach. Under no circumstances will Geokon reimburse the claimant for loss incurred in removing and/or reinstalling equipment.

Every precaution for accuracy has been taken in the preparation of manuals and/or software, however, Geokon, Inc. neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damages or losses that result from the use of the products in accordance with the information contained in the manual or software.

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TABLES

1. THEORY OF OPERATION

The GK-401 Vibrating Wire Readout is used to excite and read out vibrating wire gages which include: strain gages, crackmeters, piezometers, total pressure cells, etc. The basic principle is that a wire that is held under tension has a specific natural or resonant frequency of vibration which is dependent on the strain and the length of the wire. If the wire is plucked, as in a stringed instrument, the frequency will always be the same provided that the strain and length do not change. Vibrating wire gages have specific fixed lengths of wire, and the change in strain is measured by measuring the change in vibration frequency. The readout box provides the means of exciting the wire and reading the resultant frequency.

In use, a pulse of varying frequency is generated by the Readout Box and is applied to an electromagnetic coil assembly which is located close to the sensing wire. When a frequency corresponding to that of the wire is generated, the wire is "plucked" and vibrates at that frequency. The wire continues to vibrate after the "pluck" ends and a signal, primarily the resonant frequency, is induced in the coil assembly and transmitted to the readout where it is conditioned and displayed.

The GK-401 amplifies the return signal, converts it to a square wave and counts 255 cycles of vibration. This is then manipulated by the processor to display the required units: period, frequency squared or microstrain. For weaker gage signals the processor counts fewer cycles to try to obtain consistent readings during the signal decay period. The gage factors and arithmetic functions are stored in the EPROM and can be changed for special application by obtaining custom EPROMs from Geokon.

2. TAKING READINGS

Different gages have different frequency characteristics and the GK-401 has a 6-position selector: five positions with specific functions and one general position for period readout.

Generally, positions B, C, D and E are used for all Geokon gages. Position A is used to obtain period of vibration readings for gages in the range of approximately 500 to 5000 Hz. The table in the readout lid instruction panel describes positions for specific model numbers. Table 1 shows the model numbers, readout positions and pertinent information.

Display Position	Geokon Model No.	Display Units	Excitation Range	Gage Factor
A	All[1]	Period in μseconds[2]	450-6000 Hz	None
B	4210 4300BX 4400 4500 4600 4700 4800 4900	$f^2 \times 10^{-3}$ (digits)	1500-3500 Hz	1.000
C	4000	μstrain	450-1200 Hz	4.062[3]
D	4200	μstrain	450-1200 Hz	3.304[3]
E	4100	μstrain	1500-3500 Hz	0.391[3]
F	4300EX	$f^2 \times 10^{-3}$ (digits)	2500-6000 Hz	1.000

Notes:

[1] General position for all gages; possibility of harmonics in 4000 and 4200 gages at very low strain levels.

[2] The period readings can be very useful for greater resolution of strain measurements. Also, measurements as low as 0.1 μstrain can be made (see individual manuals).

[3] Factor multiplies digits ($f^2 \times 10^{-3}$).

Table 1 - GK-401 Display Position vs. Geokon Model Number

To take readings the gage is connected via the patch cord to the readout, the readout display is set to the proper position and the box is turned on. A reading will appear in the display and should remain constant, plus or minus one digit. The readout will turn itself off after approximately 4 minutes. The reading is updated once a second and the display is updated only when the reading changes. Readings should be checked against previously recorded data and any unusual data should be retaken and noted.

3. DATA REDUCTION

Individual gage instruction manuals discuss how data is taken, recorded and reduced, but a few important procedures for taking data are noted here.

1) Always take zero or no load readings and record pertinent data which may include but not be limited to: temperature, barometric pressure, weather conditions, water levels, fill levels, nearby construction activity, etc. Initial readings properly obtained are the baseline for all further measurements.

2) Always obtain stable readings; if a reading fluctuates be sure to note it.

3) Compare current readings with previous readings while at the site; numbers sometimes get transposed in notebooks.

4) Use permanent notebooks or field data sheets whenever possible.

4. MAINTENANCE AND TROUBLE SHOOTING

4.1 Battery

The GK-401 uses one 12-volt rechargeable, lead acid type battery to run the Readout. This battery has an extremely long shelf life and will lose approximately 2% of it's charge per month sitting on the shelf. At 60°F (15°C) the box will operate continuously for a minimum of 20 hours; at -20°F (-30°C) this period is cut to less than 10 hours. At higher temperatures the capacity goes up however, the useful service life decreases.

This battery can be expected to last 3 to 5 years, or between 250 and 500 discharge and recharge cycles.

Recharging is accomplished by a charger which is included with each readout. Overnight (10 to 12 hours) is usually long enough to bring the battery to full charge. The charger can be left plugged in whenever the Readout is not is use (recommended) to ensure full charge on the battery at all times. As the battery ages, the on-time will be reduced, and at some point, will be very short and recharging will not help. At this point the battery will need to be replaced. Battery packs are available from Geokon, or a battery can be purchased locally (see Appendix A for battery specifications) and installed by the user (see Appendix D for battery replacement instructions).

In cases where the battery will no longer operate in the field Geokon should be contacted for remedial measures.

4.2 Readout System

If the readout system fails to operate properly, and the cause is not the battery, Geokon should be contacted. The unit should not be opened in the field. A few checks can be made, however:

- If zeros appear in the display with gages connected, patch cords should be checked for continuity between contacts and clip leads (see Appendix B).
- The gage itself should be checked; see gage manual.
- The processor may need to be reset, which can be accomplished by turning the unit off and on.
- The selector position may be incorrect (see Table 1).
- Noise levels may be excessive; try reading a gage in a different area; try connecting the ground lead (white or green clip) to the shield drain wire.

4.3 Calibration

The readout should be sent periodically (every 12 months) back to the manufacturer for inspection, cleaning, and calibration. A nominal fee will be charged for the service, but it is highly recommended.

APPENDIX A - GK-401 SPECIFICATIONS

Excitation Range:	450 to 6000 Hz, 170 to 2250 µseconds
Measurement Range:	400 to 9500 Hz, 105 to 2500 µseconds
Measurement Resolution:	Period: 0.1 µsecond Strain[1]: 1 µstrain
Accuracy:	0.1% of reading
Excitation:	5 volt square wave
Temperature Range:	–20° to +120°F, –30° to +50°C
Microprocessor:	80C85 CPU operating @ 3.072 MHz 256 Bytes SRAM, 2048 Bytes EPROM
Oscillator Frequency:	6.144 MHz
Display:	5-digit LCD, .7" high
Battery:	(1) 12 volt Panasonic lead acid LC-SD122EU
Battery Capacity:	2.0 Amp Hour
Operating Current:	110 mA
Operating Time:	minimum 20 hours @ 60°F
Quiescent Current:	20 µA
Input Connector, Gage:	Lemo, FGG-1K-303-CNAC470
Input Connector, Charger:	Lemo, FGG-0K-303-CNAC37
Dimensions:	6½×4×8½", 165×102×216mm
Weight:	5 pounds, 2.3 kg.

Notes:

[1] In the strain mode (greater resolution is possible in positions A, B and F).

APPENDIX B - CONNECTOR PINOUTS

Gage Connector

Pin	Description	To
1	Ground	Green Clip Lead
2	Gage Positive	Red Clip Lead
3	Gage Negative	Black Clip Lead

Old Style Gage Connector (6 pin, Lemo ERA-1E-306-CNL)

Pin	Description	To
1	Ground	Green Clip Lead
2	No Connection	NA
3	Gage Positive	Red Clip Lead
4	No Connection	NA
5	Gage Negative	Black Clip Lead
6	No Connection	NA

Charger Connector

Pin	Description	To
1	Charger Negative	Charger Black Lead
2	No Connection	NA
3	Charger Positive	Charger Striped Lead

APPENDIX C - BATTERY PACK REPLACEMENT INSTRUCTIONS

Note the following instructions:

1) Remove the eight phillips-head screws on the face panel.

2) Pull out the face panel (the panel fits very tightly in the box and may have to be pried out carefully with a screwdriver).

3) Remove the four Phillips-head screws from the bottom of the box.

4) Carefully pull the pack from the box (it is a tight fit).

5) If a new pack has been supplied, connect the leads to the readout assembly and reverse the above steps. If just the battery has been purchased, the old battery must be removed from the pack and the new one wired in the same manner, and glued into the pack before putting the pack into the case. (RTV holds it in place very nicely).

NOTE: The only screws that should be removed from the outside of the GK-401 are the 8 screws on the face panel and the four screws on the bottom of the box. All others are meant to remain permanently.

APPENDIX D - THERMISTOR LINEARIZATION

A thermistor (temperature sensing device) is normally encapsulated with all Geokon vibrating wire sensors. Use an ohmmeter to measure the resistance (usually the green and white leads from the gage cable). The following equation or Table 2 can be used to determine the temperature in degrees centigrade.

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3

Steinhart and Hart Log Equation: $$T = \frac{1}{A + B(LnR) + C(LnR)^3} - 273.2$$

where: T = Temperature in °C.

LnR = Natural Log of Thermistor Resistance

$A = 1.4051 \times 10^{-3}$

$B = 2.369 \times 10^{-4}$

$C = 1.019 \times 10^{-7}$

Note: Coefficients calculated over -50° to +150° C. span.

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.1	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342.2	83	107.9	123
77.66K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-34	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	292.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	5692	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	**3000**	**25**	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table 2 - Thermistor Resistance vs. Temperature

APPENDIX E - READING OTHER MANUFACTURERS' SENSORS

Most vibrating wire gages available today have frequency characteristics that are within the range of operation of the GK-401 Readout Box, and if they have the type of electromagnetic coil that is used in the pluck and read system of the GK-401, it can be used to read them.

Gage factors need to be known in order to convert readings to engineering units. The readings can be taken in the period mode, Position A and, conversions to strain, pressure, etc. can be made using the manufacturers' factors supplied with the gages.

The table below lists approximate operating frequency ranges for different wire lengths for reference.

Wire Length	Frequency Range
1"	2500-5000 Hz
2"	1200-3000 Hz
3"	825-2000 Hz
4"	600-1600 Hz
6"	450-1000 Hz
10"	250-650 Hz

Table 3 - Vibrating Wire Length vs. Frequency Range

ATTACHMENT E

Inspection of Embankment Dams Instructions

INSPECTION OF EMBANKMENT DAMS
INSTRUCTIONS

Through regular inspections, you will become more familiar with your dam and better able to recognize changes which could be of concern. Following are general guidelines for completing the Embankment (Earth) Dam Inspection Form. As all dams are different, every situation cannot be included in these instructions. If you have any questions, please contact the Safe Dams Program or the Engineer of Record (EOR) of your choice.

Each item listed below corresponds with an item on the Embankment (Earth) Dam Inspection Form. Within each item listed below, there is a short description which discusses the importance of the item for the inspection and things to observe. There is also a CORRECTIVE ACTION section. When completing the inspection form, make notes of anything that you see concerning that inspection item, and make the appropriate notes on your inspection form based off the CORRECTIVE ACTION section.

If an inspection item requires further action on your part (hiring an EOR, monitoring changes in cracks, etc.), place a check mark to the left of the number of the item on the inspection form. This will provide an easy way for you and the Safe Dams Program to determine items which need to be observed or corrected.

Thank you for taking the time to complete this inspection, as it will proactively help you to maintain your dam while at the same time providing for the protection of fellow Georgians downstream.

A. Crest

The crest of a dam is the top surface of the dam, and is usually relatively flat. The following items should be noted when inspecting the crest:

1. Unless there is a road on the dam (see Item 3 in this section), the crest of the dam should have a good cover of a low-growing grass. The vegetation should be regularly mowed to allow for easy identification of problems with the dam. CORRECTIVE ACTION: Note any areas that need to be reseeded or need to have maintenance performed on them.

2. Although a healthy cover of grass is desirable as erosion protection, the growth of deep-rooted vegetation, such as large shrubs and trees, is undesirable. Note in this section any trees or large shrubs which are located on the dam. CORRECTIVE ACTION: If the trees and shrubs are less than 8" in diameter, note that the trees and shrubs must be removed from the dam, any holes must be filled in and compacted, and the area must be seeded. If the trees and shrubs are greater than 8" in diameter, then an EOR must be hired to determine the best way to safely remove the inappropriate vegetation.

3. If there is a road on the crest of the dam, it should be paved or layered in gravel. It should be relatively flat, with no major ruts, depressions, or cracking. CORRECTIVE ACTION: For solid surface roads (i.e., asphalt or concrete), identify any excessive cracking, ruts, or depressions. Note that the cracks must be sealed, and that ruts and depressions should be filled in to prevent ponding of water on the road. For gravel roads, identify any ruts or depressions. Note that these areas must be filled in with additional gravel to prevent erosion.

4. Depressions are low spots in the crest and may be localized or widespread. They may be caused by settlement in the embankment or foundation or internal erosion or piping and

subsequent collapse of overlying material. Some areas of the embankment surface that look like depressions may be the result of improper final grading during construction, however the cause of depressions should be determined. Depressions can be minor or they can be very serious. Sinkholes are a serious type of depression. A good way of distinguishing between localized settlement and sinkholes is to look at their profiles:

i) Localized settlement usually has gently sloping, bowl-like sides.
ii) Sinkholes usually have steep sides from the soil shearing as it collapses into an underlying void.

The bottom of depressions should be probed to determine if there is an underlying void, which would be caused by the removal of subsurface material by internal erosion or piping.

CORRECTIVE ACTION: Photograph and record the location, size or extent, and depth of any depression. Have a survey performed of the crest if there is a concern about loss of freeboard. Note that the depression should be inspected frequently to ensure it is not continuing to settle or enlarge. If after several months of inspection it is determined that the depression is stable, then note that the depression should be filled with top soil, compacted, and grassed. If the depression continues to settle or enlarge, then note an EOR must be hired.

5. Cracking in an embankment dam falls into the following three major categories:
   i) Longitudinal cracking occurs in a direction roughly parallel to the length of the dam. It is an indication of a potentially unstable slope.
   ii) Transverse cracking appears in a direction roughly perpendicular to the length of the dam. Deep transverse cracking can provide a pathway for water into the core of the dam.
   iii) Desiccation cracking is caused by the drying out of certain types of embankment soils, and usually develop in a random, honeycomb pattern.

   CORRECTIVE ACTION: *For longitudinal and transverse cracking*, photograph and record the location, depth, length, width and offset of each crack observed. Monitor these cracks for any changes. Note the Safe Dams Program must be contacted for major cracking, or if the cracks are changing. *For desiccation cracking*, probe the more severe cracks to determine their depth, especially if they are oriented in an upstream/downstream direction. Photograph and record the location, length, width, depth and orientation of any severe cracks observed. Compare these measurements with any past measurements to determine if the condition is worsening. Note the Safe Dams Program must be contacted if the desiccation cracking continues to worsen.

6. Note here any items on the crest which are not covered above. In particular, note if there is evidence of livestock or recreation vehicles using the crest, which can lead to erosion problems. CORRECTIVE ACTION: If practical, restrict usage of the dam by animals or vehicles which will damage the vegetative cover. Note any areas which must be reseeded to prevent further erosion.

B. Upstream Slope

The upstream slope is the inclined surface of the dam on the reservoir (lake/pond) side of the crest. The following items should be noted when inspecting the upstream slope of the dam:

1. The reservoir level affects many other areas of the dam. It is important when inspecting the dam to determine if it is at normal pool (the normal elevation of the water in the reservoir), above normal pool, or below normal pool. If the reservoir is above or below normal pool, the difference in elevation should be estimated (in feet) and included on the inspection form. CORRECTIVE ACTION: If the reservoir is above normal pool, it should be monitored to make sure it returns to normal pool. Note that the principal or emergency spillway (see Section E) may be blocked and may need to be cleaned out. If the reservoir is below normal pool, the downstream slope and principal spillway (see Sections C and E, respectively) should be monitored for flow which may indicate pending failure of the dam. If such flow is noted, the Safe Dams Program must be immediately notified to determine if the reservoir needs to be drawn down further to prevent failure. Additionally, an EOR must be hired to determine the scope of the internal erosion of the dam and if repairs will be needed.

2. The upstream slope of the dam should have a good cover of a low-growing grass. This vegetation should be regularly mowed to allow for easy identification of problems with the dam. Additionally, there may be slope protection, such as rip rap, on the slope. This is covered in item 7 below. CORRECTIVE ACTION: Note any areas that need to be reseeded or need to have maintenance performed on them.

3. A description of inappropriate vegetation can be found in Section A, Item 2.

   CORRECTIVE ACTION: If the trees and shrubs are less than 8" in diameter, note that the trees and shrubs must be removed from the dam, any holes must be filled in and compacted, and the area must be seeded. If the trees and shrubs are greater than 8" in diameter, then an EOR must be hired to determine the best way to safely remove the inappropriate vegetation.

4. A description of depressions can be found in Section A, Item 4 of these instructions.

   An additional issue on the slope of the dam is holes, such as animal burrows. In Georgia, these burrows are typically caused by groundhogs, muskrats, or beavers. Beavers are of particular concern because of their habit of building dams in spillways to raise water levels.

   CORRECTIVE ACTION: Photograph and record the location, size or extent, and depth of any depression. Have a survey performed of the crest if there is a concern about loss of freeboard. Note that the depression should be inspected frequently to ensure it is not continuing to settle or enlarge. If after several months of inspection it is determined that the depression is stable, then note that the depression should be filled with top soil, compacted, and grassed. If the depression continues to settle or enlarge, then note an EOR must be hired. IF ANIMAL BURROWS ARE FOUND, note the size and location of the burrows. Remove or eradicate the animals causing the problem. Note that the holes must be filled with soil, compacted, and reseeded.

5. Erosion on the upstream slope has several different causes, including wave action on the shoreline, livestock on the slope, and recreational vehicles driving on the slope. CORRECTIVE ACTION: If erosion is found, note the size, location, and severity of the eroded areas. IF THE EROSION IS CAUSED BY WAVE ACTION ON THE RESERVOIR, note that additional slope protection, such as riprap, may be required. The Safe Dams Program must be contacted prior to installation of riprap to determine acceptability of the material proposed to be used. IF THE EROSION IS CAUSED BY TRAFFIC ON THE DAM, note that the eroded areas must be filled in, compacted and grassed. Additionally, if possible, access to

the upstream slope of the dam should be limited to prevent future erosion. Note the slope must be monitored for further erosion, and any erosion found must be repaired as soon as possible.

6. A description of cracks typically found on dams can be found in Section A, Item 5 of these instructions.

   Of additional concern on the slopes of dams are sloughs or slides. These usually fall into two categories: shallow slides and deep-seated slides. Shallow slides in the upstream slope are often the result of an overly steep slope combined with a rapid lowering of the reservoir. Deep-seated slides are serious threats to the safety of a dam, and are typically characterized by a steep back slope, a soil bulge near the bottom of the slide, and arc-shaped cracks in the slope (which may also be signs of developing deep-seated slides.) CORRECTIVE ACTION: FOR SHALLOW SLIDES, photograph and record the location of the slide, including dimensions. Note any cracks which have developed uphill from the slide which could be signs of potential development of a deep-seated slide. Note the slide should be regularly monitored for changes in size or development into a deep-seated slide. FOR DEEP-SEATED SLIDES, contact the Safe Dams Program to discuss the potential need of lowering and restricting the reservoir, and the potential need to hire an EOR.

7. Slope protection is used along the shoreline of the reservoir to prevent wave action erosion, surface runoff erosion, and wind scour. Riprap (broken or angular rock) is typically used. It is important that riprap is large and durable enough to not be moved or broken down by wave action. Additionally, irregular sized and shaped rocks create an interlocking mass that prevents waves from passing between the larger rocks and eroding the underlying material. You should look for beaching, scarping, or degrading of the slope protection to determine if it is adequate. Additionally, vegetation should be regularly removed from the riprap to allow for easy inspection of the slope and to ensure the vegetation does not move the riprap. CORRECTIVE ACTION: Note if maintenance needs to be performed to remove vegetation from the riprap slope protection. Note any areas of the slope which are not adequately protected (slope protection is easily moved by the water, there is not enough to protect the dam from erosion, etc.) Additionally, note any areas where the slope protection has settled, as this is a sign that erosion may be occurring below its surface. Document the dimensions of all areas of inadequate protection. Note that all areas of inadequate protection must be repaired. Contact the Safe Dams Program to discuss the recommended approach to addressing this issue.

8. Note any issues with the upstream slope which are not mentioned elsewhere in this section.

C. Downstream Slope

The downstream slope is the inclined surface of the dam on the opposite side of the crest from the reservoir. The following items should be noted when inspecting the downstream slope of the dam:

1. The downstream slope of the dam should have a good cover of a low-growing grass. This vegetation should be regularly mowed to allow for easy identification of problems with the dam. CORRECTIVE ACTION: Note any areas that need to be reseeded or need to have maintenance performed on them.

2. A description of inappropriate vegetation can be found in Section A, Item 2.

CORRECTIVE ACTION: If the trees and shrubs are less than 8" in diameter, note that the trees and shrubs must be removed from the dam, any holes must be filled in and compacted, and the area must be seeded. If the trees and shrubs are greater than 8" in diameter, then an EOR must be hired to determine the best way to safely remove the inappropriate vegetation.

3. A description of depressions, ruts, and holes can be found in Section B, Item 4. Of additional concern on the downstream slope are bulges which can be caused by seepage through the dam, and may lead to a shallow or deep-seated slide (see Item 5 in this section.)

   CORRECTIVE ACTION: FOR SHALLOW SLIDES, photograph and record the location of the slide, including dimensions. Note any cracks which have developed uphill from the slide which could be signs of potential development of a deep-seated slide. Note that the slide should be regularly monitored for changes in size or development into a deep-seated slide. FOR DEEP-SEATED SLIDES, contact the Safe Dams Program to discuss the potential need of lowering and restricting the reservoir. Additionally, note that an EOR must be hired to perform an investigation to determine the magnitude and the cause of the slide. FOR BULGES, note the location and dimensions of the bulge. Additionally, note any wetness in the area of the bulge. Note the bulge should be monitored regularly for any changes.

4. Erosion on the downstream slope has several different causes, including runoff from the crest, livestock traffic on the slope, and recreational vehicles driving on the slope. Erosion is especially prevalent near the groins of the dam, which is where the dam makes contact with the natural river valley. This can be caused by runoff or seepage through the contact between the dam and natural ground. CORRECTIVE ACTION: If erosion is found, note the size, location, and severity of the eroded areas. IF THE EROSION IS CAUSED BY RUNOFF, note that the eroded area should be filled with soil, compacted, and grassed. If the area continues to erode, note that additional protection may be needed. The Safe Dams Program must be contacted prior to installation of additional protection to determine acceptability of the material proposed to be used. IF THE EROSION IS CAUSED BY TRAFFIC ON THE DAM, note that the eroded areas must be filled in, compacted and grassed. Additionally, if possible, access to the downstream slope of the dam should be limited to prevent future erosion. Note the slope must be monitored for further erosion, and any erosion found must be repaired as soon as possible.

5. A description of cracks typically found on the slopes of dams can be found in Section B, Item 5 of these instructions.

   CORRECTIVE ACTION: FOR SHALLOW SLIDES, photograph and record the location of the slide, including dimensions. Note any cracks which have developed uphill from the slide which could be signs of potential development of a deep-seated slide. Note that the slide should be regularly monitored for changes in size or development into a deep-seated slide. FOR DEEP-SEATED SLIDES, contact the Safe Dams Program to discuss the potential need of lowering and restricting the reservoir. Additionally, note an EOR must be hired to perform an investigation to determine the magnitude and the cause of the slide.

6. Seepage is the passage of water through a dam. Seepage passes through all embankment dams. Many embankment dams have internal drains to intercept this seepage and discharge it safely. These drains are discussed in Section F of these instructions. Of greater concern is uncontrolled seepage, which can carry with it soil from within the dam, leading to erosion from the inside of the dam and eventual failure of the dam. This seepage may exit the ground

through the dam, or it may appear downstream of the dam. Items 6, 7, and 8 in this section are intended to document this uncontrolled seepage.

Wet areas on or at the toe of the dam can be caused by uncontrolled seepage or an area poorly graded to drain. Wet areas can be identified either by water on the surface, areas of water-loving vegetation (such as cattails, reeds and mosses), or areas of vegetation which are much greener than the vegetation around it. CORRECTIVE ACTION: Note the size and location of the wet areas. If the wet area appears to be caused by a low area, note that the area should be drained, filled with soil, compacted, and grassed.

7. Seepage through the dam which is causing erosion will typically appear rust-colored or stained. Additionally, the soils in Georgia will often cause the seepage to have what appears to be an oily sheen on its surface. CORRECTIVE ACTION: Note the size and location of any areas of seepage which exhibit any of the signs listed in this item. Note if the area is new or existing. If it is a new area, document the extents of the area. If it is an existing area, note if the size of the area or the appearance of the seepage has changed.

8. Seepage visibly flowing out of the slope or beyond the toe of the dam is of great concern. These areas can appear to be springs or sand boils, and may appear to have a cone of sediment around them. This sediment is most likely being eroded from within the dam. Of additional concern is water flowing along the outside of the principal spillway pipe or other drains, which can be a sign of a leak in the pipe or water using the outside of the pipe as a conduit. Seepage flowing through the dam, whether through the embankment or along a pipe, can lead to a type of dam failure called piping, which is internal erosion of the dam which can lead to failure. CORRECTIVE ACTION: Contact the Safe Dams Program to discuss the potential need of lowering and restricting the reservoir. Additionally, note that an EOR must be hired to perform an investigation to determine the source and severity of the seepage.

9. Note any issues with the downstream slope which are not mentioned elsewhere in this section.

D. Plunge Pool

The plunge pool is a natural or artificially created pool at the base of a dam that dissipates the energy of free-falling water. It is the location where the principal spillway exits the dam, and the water is returned to the natural flowing stream.

1. Erosion protection is often used around the plunge pool to prevent erosion caused by falling water. Additionally, it provides energy dissipation to the water before it is returned to the natural channel. Riprap is typically used. It is important that it is large and durable enough to not be moved or broken down by the energy of the falling water. It is desirable to have irregular sized and shaped rocks that create an interlocking mass to protect the underlying material. You should look for beaching, scarping, or degrading of the slope protection to determine if it is adequate. Additionally, vegetation should be regularly removed from the riprap to allow for easy inspection of the plunge pool. CORRECTIVE ACTION: Note if maintenance needs to be performed to remove vegetation from the riprap protection. Note any areas of the plunge pool which are not adequately protected (erosion protection is easily moved by the water, there is not enough to protect the plunge pool from erosion, etc.) Additionally, note any areas that the erosion protection has settled, as this is a sign that erosion may be occurring below its surface. Document the dimensions of all areas of inadequate protection.

Note that areas of inadequate protection must be repaired. Contact the Safe Dams Program to discuss the recommended approach to addressing this issue.

2. Erosion at the plunge pool is typically caused by runoff from around the plunge pool or from the energy of the water falling from the principal spillway. Seepage, which is discussed in Section C, Items 6-8, will often come to the surface within the plunge pool. CORRECTIVE ACTION: If erosion is found, note the size, location, and severity of the eroded areas. Note that additional erosion protection is needed to protect the area from erosion. Contact the Safe Dams Program to discuss the recommended approach to addressing this issue. If seepage is found, document the size and any of the signs exhibited in Section C, Item 7. For any seepage which is actively flowing, contact the Safe Dams Program to discuss the potential need of lowering and restricting the reservoir. Additionally, note that an EOR must be hired to perform an investigation to determine the source and severity of the seepage.

3. Note any issues with the plunge pool which are not mentioned elsewhere in this section.

E. Principal and Emergency Spillways

A principal (also known as primary) spillway is a pipe, channel, etc. which is designed to provide continuous or frequent releases from a reservoir in order to maintain the normal pool. An emergency spillway is designed to provide additional protection against overtopping of a dam intended for use under extreme conditions such as malfunction of the principal spillway or extreme rainfall. Water flowing through the emergency spillway should be a rare occurrence. Generally, the principal spillway should be able to carry most normal storm events.

1. Principal spillways on earthen dams in Georgia have typically been made of corrugated metal, concrete, plastic, or iron, and can either be a traditional spillway (where water falls into a riser in the lake and flows out of the pipe) or a siphon spillway (where water is pulled up out of the lake via pressurized flow). The spillway may also be a concrete channel. Emergency spillways are typically an earthen or concrete channel at one or both ends of the dam, but they can take other forms depending on the construction of the dam. While corrugated metal pipe has been used in the past for spillways in earthen dams, it has been determined to not be appropriate in this application and is no longer considered an acceptable option for use in dams. CORRECTIVE ACTION: Note in this section the type of primary and emergency spillways at your dam. If you are not sure what kind of spillways your dam has, please contact the Safe Dams Program to discuss.

2. As indicated previously, the emergency spillway should not activate regularly. However, there are occasionally storm events which cause this spillway's activation. CORRECTIVE ACTION: Note if there has been flow in the emergency spillway since the last inspection. Note the date(s) it occurred, what caused the spillway to flow, and how deep the flow was in the spillway.

3. One concern with pipe spillways is that they can become obstructed by various items, including excessive debris (tree limbs, logs, etc.) This leads to reduced flow through the spillway. It is important that obstructions be removed from pipe spillways regularly so they may carry their full design flow. CORRECTIVE ACTION: Note if there is debris at the entrance to the spillway pipe. If there is debris, note that the debris must be removed.

4. The entrance to pipe spillways should have some form of trash rack to prevent debris from entering the pipe and becoming lodged in the pipe. The trash rack is typically a metal grate. CORRECTIVE ACTION: Note if a trash rack is installed. If a trash rack is not installed, note that a trash rack should be added to the pipe spillway entrance. If a trash rack is installed, note its condition, including if it adequately covers the pipe, if it is broken, etc. If the trash rack is damaged, note that it will need to be repaired or replaced.

5. Pipe spillways are typically shorter lengths of pipes which are joined together in various ways. Over time, these joints can become separated. Additionally, cracks or holes may develop in the pipes due to rusting or damage from outside forces, including heavy equipment. CORRECTIVE ACTION: Note any separations, cracks, or holes in the pipe, including location, the dimensions of the damage, and if water is flowing through the damaged area. Note that these areas must be monitored for any changes. Contact the Safe Dams Program to determine what additional actions must be taken.

6. In general, there should be no leaks in a spillway pipe. Leaks can be visible or can be internal to the dam. If water is flowing into the pipe but not flowing out of it, or if no water is flowing into a pipe but is flowing out of it, there is an issue with the pipe within the dam. CORRECTIVE ACTION. Note if there are any leaks in the spillway pipe. If there are leaks, note their locations, sizes, and the rate of flow. (Rate of flow determination is discussed in Section F, Item 3 of these instructions.) Note that an EOR must be hired to determine if the leaks adversely impact the spillway pipe.

7. This item provides a general overview of the pipe(s). Check the items which are appropriate for the pipes in your dam based on your inspection.

8. For open channel spillways, including earthen and concrete-line spillways, there should be no obstructions to prevent the flow of water in the event the spillway activates. CORRECTIVE ACTION: Note if there are any obstructions within the spillway, including fences, buildings, etc. If there are obstructions, note that they must be removed.

9. Earthen spillway must have a good cover of a low-growing grass. This vegetation should be regularly mowed to allow for easy identification of problems within the spillway. CORRECTIVE ACTION: Note any areas that need to be reseeded or need to have maintenance performed on them.

10. Although a healthy cover of grass is desirable as erosion protection, the growth of deep-rooted vegetation, such as large shrubs and trees, is undesirable. Note in this section any trees or large shrubs which are located within the spillway. CORRECTIVE ACTION: If the trees and shrubs are less than 8" in diameter, note that the trees and shrubs must be removed from the spillway, any holes must be filled in and compacted, and the area must be seeded. If the trees and shrubs are greater than 8" in diameter, then an EOR must be hired to determine the best way to safely remove the inappropriate vegetation.

11. Eroded areas within earthen spillways must be dealt with to prevent further erosion in the event of spillway activation. CORRECTIVE ACTION: Note the location and extent of the damage, including depth of erosion. Contact the Safe Dams Program to discuss options to address the damage.

12. Concrete channel spillways should not be cracked or have holes in them. Cracks and holes can allow water to get under the concrete and erode away the material beneath the concrete, thus undermining the spillway. Also, this water can lead to uplift which can possibly break the concrete. CORRECTIVE ACTION: Note the location and size of any cracks or holes in the concrete. Contact the Safe Dams Program to discuss options to address the cracks and/or holes.

13. As mentioned previously, water under concrete channel spillways can potentially lead to erosion and undermining of the spillway. If water flows in the spillway and then disappears at a crack or joint, or if water suddenly appears at a crack or joint, this is a sign that water is flowing under the concrete. Additional signs could be if a section of the concrete has collapsed or if water is visibly flowing from under the concrete at the end of the spillway. CORRECTIVE ACTION: Note the location and rate of flow of the leak. If unable to measure the leak, note the reason that you believe water is flowing under the spillway. Note that an EOR must be hired to determine the extent of undermining of the spillway and to determine the best method of repair.

14. This item provides a general overview of the earthen or concrete channel spillway(s). Check the items which are appropriate for the earthen or concrete channel spillway(s) on your dam based on your inspection.

15. Note any issues with the spillways which are not mentioned elsewhere in this section.

F. Instrumentation

Instrumentation is defined as any device installed into or near a dam which are used to monitor the performance of the dam. Typical instrumentation on an earthen dam includes piezometers and toe drains. A piezometer is an instrument that measures hydraulic pressures within an earthen dam. They typically will be pipes that extend vertically out of the dam, or they may be set in the surface of the dam with a cover similar to a groundwater well. A toe drain is a system of pipe and/or pervious material along the downstream toe of a dam used to collect seepage from the foundation and embankment and convey it to a free outlet. These typically come out near the toe of the dam, and can often be found near the plunge pool. They are smaller pipes than the spillway pipe.

1. As indicated previously, toe drains are located along the toe of the dam, often near the plunge pool. The area around the drains should be cleaned out to allow for easy inspection and measurement of the flow from the pipes. CORRECTIVE ACTION: Note if there are toe or other seepage drains on the dam. If there are toe drains, describe their condition, including if they are visibly clogged, if water is flowing from them, and if they have deteriorated (rusted, broken, etc.) If the drains are clogged, note that they should be flushed to remove sediment so they flow freely. If the toe drains are overgrown or have sediment built up under them, note that the area around them needs to be maintained. If the drains have deteriorated to the point of having holes in them, then note that an EOR must be hired to determine how to repair the pipes.

2. Animal guards are installed on the ends of toe drains to prevent animals from climbing into the pipe, while at the same time allowing water to freely flow out of the drains. All toe drain outlets should have animal guards installed on them. CORRECTIVE ACTION: Note if all toe drain outlets have animal guards installed. If the drains do not have animal guards, note which toe drains are missing them. Also, note that these toe drains must have animal guards installed on them.

3. Measurements of the flow from each drain are very important to understanding your dam. The flow from the toe drains, when looked at over time, can be indicative of potential problems within the dam. It is good to plot the flow of water over time on a graph to see if there is a sudden change in the flow.

   To measure the flow from a toe drain, choose a container for which you know the volume. Place the container under the toe drain, and time how long it takes for the container to fill. Divide the volume of the container by the amount of time necessary to fill it, and that is the flow rate. For example, if you have a one gallon bucket, and it takes two minutes to fill it, then your flow rate would be (1 gallon)/(2 minutes), or 0.5 gallons per minute (gpm). If your container is measured in ounces or milliliters, then measure the time taken to fill the container in seconds. Divide the container volume (in ounces or milliliters) by the time taken to fill it (in seconds.) If your flow is in ounces/second, then multiply the flow by 0.4688 to get the flow in gallons per minute. If your flow is in milliliters/second, then multiply the flow by 0.01585 to get the flow in gallons per minute.

   In addition to the flow, it is important to look at how clear the flow is. This gives an indication of the amount of erosion within the dam.

   CORRECTIVE ACTION: Take the flow measurement at each toe drain, and convert it to gallons per minute, if necessary. Note the location, flow measurement, and how clear the water is on the inspection form. Compare the flow with previous flows from the toe drains. If the flow has significantly dropped, note that the drains should be cleaned out. If the flow has significantly increased, contact the Safe Dams Program to discuss.

4. Piezometers are usually found on the slope of the dam, and can occasionally be found beyond the toe of the dam. They are used to measure how far the water level in the dam is below the surface of the dam. CORRECTIVE ACTION: Note if there are any piezometers located on or near the dam. Note if the piezometers have been damaged (broken, bent, etc.) If the piezometers have been damaged, note that an EOR must be hired to determine if the piezometer can be repaired.

5. Since the piezometers are used to measure the water level inside the dam, it is important that outside water not be introduced. Therefore, all piezometers must have caps to prevent rain water from entering the pipe. Also, if the piezometers are accessible to the public, the caps should have locks to prevent tampering with them. CORRECTIVE ACTION: Note if the piezometers all have caps with locks. If the piezometers do not have caps, note that caps must be installed. If the piezometers do not have locks and they are accessible to the public, then note that locks must be installed on the caps.

6. It is important that the piezometers be read regularly to ascertain the depth of the water within the dam. Much as the flow from toe drains, the depth of water below the surface of the dam should be looked at over time to watch for any drastic changes. This is best done by plotting the values on a graph over time. It is best to also note the reservoir level on the graph as lake level can impact the readings. CORRECTIVE ACTION: Note the values for the water level at each piezometer and compare it to previous readings. If there has been a drastic change in the level of the water within the dam, contact the Safe Dams Program to determine what steps should be taken. If you do not know how to read the piezometers, please contact an EOR either to take the readings for you, or to show you how to read them.

7. Other monitoring devices may exist on the dam, including monitoring wells and settlement plates. These will vary from dam to dam. CORRECTIVE ACTION: Note any additional monitoring devices located on the dam. Provide readings for the monitoring devices if available. Note the condition of the monitoring device.

8. Note any issues with the instrumentation which are not mentioned elsewhere in this section.

G. Photographs

Photographs provide a good way for the health of the dam to be monitored from inspection to inspection. Often changes will be noticed in photographs that may not be noticed otherwise. Photographs should be taken of the crest, upstream slope, and downstream slope. Additionally, photographs should be taken of any problems which are noted (erosion, cracks, etc.), and an item of a generally known size (a piece of paper, ruler, shoe, clipboard, etc.) should be included in these photographs to provide a perspective on the size of the problem. All photographs should be date stamped. Additionally, it is a good idea to take pictures from the same general area during each inspection, as this allows for easier comparison of photographs between inspections. List the photographs taken, and attach color copies of the photos to the report.

ATTACHMENT F

Embankment (Earth) Dam Inspection Form

Embankment (Earth) Dam Inspection Form

Name of Dam:_____ Date:_____

Location of Dam (County):_____ Weather:_____

pected by (Print Name):_____

If an inspection item requires further action on your part, place a check mark to the left of the number of the item

A. Crest (refer to Glossary for description)

☐ 1. How would you describe the vegetation on the crest? (Check all that apply)

Recently Mowed_____ Overgrown_____ Good Cover_____ Sparse_____

Other/Corrective Action (describe):_____

_____

☐ 2. Are there any trees or other inappropriate or excessive vegetation on the crest? Yes_____ No_____

If yes, describe (type of vegetation, size, location, etc.)/Corrective Action:_____

_____

☐ 3. Is there a paved road or driveway on the crest? Yes_____ No_____

If yes, describe the condition (for example, good condition, numerous cracks, newly paved)/Corrective Action:_____

_____

☐ 4. Are there any depressions, ruts or holes on the crest? Yes_____ No_____

If yes, describe (size, location, etc)/Corrective Action:_____

_____

☐ 5. Are there any cracks on the crest? Yes_____ No_____

If yes, describe (length and width, location, direction of cracking, etc.)/Corrective Action:_____

_____

☐ 6. Other observations on the crest/Corrective Action:_____

_____

B. Upstream Slope (refer to Glossary for description)

1. What is the reservoir level today? At Normal Pool____ Above Normal Pool_____Feet Below Normal Pool_____Feet

☐ 2. How would you describe the vegetation on the upstream slope? (Check all that apply)

Recently Mowed_____ Overgrown_____ Good Cover_____ Sparse_____

Other/Corrective Action (describe):_____

_____

☐ 3. Are there any trees or other inappropriate or excessive vegetation on the slope? Yes_____ No_____

If yes, describe (type of vegetation, size, location, etc.)/Corrective Action:_____

_____

☐ 4. Are there any depressions, bulges, ruts or holes (such as animal burrows) on the slope? Yes_____ No_____

If yes, describe (size, location, etc.)/Corrective Action:_____

_____

☐ 5. Are there any eroded areas on the slope (such as wave erosion along the shoreline)? Yes_____ No_____

If yes, describe (size of area, location, severity, etc.)/Corrective Action:_____

_____

☐ 6. Are there any cracks, sloughs or slides (vertical cliffs) on the slope? Yes_____ No_____

If yes, describe (length, width, height, location, etc.)/Corrective Action:_____

_____

↑ Check if corrective action is noted/required.

Upstream Slope (continued)

☐ 7. Is there any type of slope protection along the shoreline (such as riprap)? Yes_____ No_____

If yes, describe what type and its condition (for example, riprap - adequate, inadequate, sparse)/Corrective Action:_____

_____

8. Other observations on the upstream slope/Corrective Action:_____

_____

C. Downstream Slope (refer to Glossary for description)

☐ 1. How would you describe the vegetation on the downstream slope? (Check all that apply)

Recently Mowed_____ Overgrown_____ Good Cover_____ Sparse_____

Other/Corrective Action (describe):_____

_____

☐ 2. Are there any trees or other inappropriate or excessive vegetation on the slope? Yes_____ No_____

If yes, describe (type of vegetation, size, location, etc.)/Corrective Action:_____

_____

☐ 3. Are there any depressions, bulges, ruts or holes (such as animal burrows) on the slope? Yes_____ No_____

If yes, describe (size, location, etc.)/Corrective Action:_____

_____

☐ 4. Are there any eroded areas on the slope (such as along abutment contacts)? Yes_____ No_____

If yes, describe (size of area, location, severity, etc.)/Corrective Action:_____

_____

☐ 5. Are there any cracks, sloughs or slides (vertical cliffs) on the slope? Yes_____ No_____

If yes, describe (length, width, height, location, etc.)/Corrective Action:_____

_____

☐ 6. Are there any wet areas or areas of hydrophilic (lush, water-loving) vegetation? Yes_____ No_____

If yes, describe (size of area, location, etc.)/Corrective Action:_____

_____

☐ 7. Do any wet areas indicate seepage through the dam (such as rust-colored, stained water)? Yes_____ No_____ N/A_____

If yes, describe (for example, new area of seepage, no change from past observations, size of area, location) /Corrective Action:_____

☐ 8. Are there any leaks (flowing water) from the slope or beyond the toe of the dam? Yes_____ No_____

If yes, describe (location, rate of flow, turbidity of flow)/Corrective Action:_____

_____

☐ 9. Other observations on the downstream slope/Corrective Action:_____

_____

D. Plunge Pool (refer to Glossary for description)

☐ 1. Is there any type of erosion protection around the plunge pool (such as riprap)? Yes_____ No_____

If yes, describe what type and its condition (for example, riprap - adequate, inadequate, obstructed by vegetation) /Corrective Action:_____

☐ 2. Is there any erosion and or seeps around or going into the plunge pool? Yes_____ No_____

If yes, describe (size of area, location, severity, etc.) /Corrective Action:_____

_____

☐ 3. Other observations around the plunge pool/Corrective Action:_____

_____

Name of Dam:_____ Date:_____

Principal and Emergency Spillways (refer to Glossary for description)

☐ 1. What types of spillways does the dam have (such as corrugated metal, concrete or siphon pipe; concrete or earth channel)?
Principal Spillway_____ Emergency Spillway_____
Other/Corrective Action:_____

☐ 2. Has the emergency spillway activated (had flow) since the last inspection? Yes_____ No_____
If yes describe (date(s) of flow, reason for activation, depth of flow) /Corrective Action:_____

☐ 3. For pipe spillways, is the intake obstructed in any way (such as with excessive debris)? Yes_____ No_____
If yes, describe (type of debris, reason for obstruction, etc.) /Corrective Action:_____

☐ 4. For pipe spillways, what is the condition of any trash racks (for example, adequate, inadequate, damaged)? /Corrective Action:

☐ 5. For pipe spillways, are there any visible cracks, separations or holes in the pipe(s) (intake or outlet)? Yes_____ No_____
If yes, describe (location, width of crack or separation, etc.)/Corrective Action:_____

☐ 6. For pipe spillways, are there any apparent leaks in the pipe(s)? Yes_____ No_____
If yes, describe (location, rate of flow from leak, etc.)/Corrective Action:_____

7. For pipe spillways, how would you describe the overall condition of the pipe(s)? (Check all that apply)
Functioning Normally____ Not Functional____ Deteriorated____ Damaged____ Adequate____ Inadequate____

☐ 8. For concrete or earth channel spillways, is the entrance or channel obstructed in any way? Yes_____ No_____
If yes, describe (type of obstruction, location, etc.)/Corrective Action:_____

☐ 9. For earth channel spillways, how would you describe the vegetation in the spillway? (Check all that apply)
Recently Mowed_____ Overgrown_____ Good Cover_____ Sparse_____
Other (describe)/Corrective Action:_____

☐ 10. For earth channel spillways, are there any trees or other inappropriate vegetation in the spillway? Yes_____ No_____
If yes, describe (type of vegetation, size, location, etc.)/Corrective Action:_____

☐ 11. For earth channel spillways, are there any eroded areas in the spillway? Yes_____ No_____
If yes, describe (size of area, location, severity, etc.)/Corrective Action:_____

☐ 12. For concrete channel spillways, are there any cracks or holes in the spillway? Yes_____ No_____
If yes, describe (width of crack or hole, location, etc.)/Corrective Action:_____

13. For concrete channel spillways, are there any leaks or evidence of undermining (flow under the concrete)? Yes_____ No_____
If yes, describe (location, rate of flow from leak, indicators of undermining, etc.)/Corrective Action:_____

↑ Check if corrective action is noted/required.

Principal and Emergency Spillways (continued)

14. For earth or concrete channel spillways, how would you describe the overall condition of the spillway? (Check all that apply)

Functioning Normally____ Not Functional____ Deteriorated____ Damaged____ Adequate____ Inadequate____

15. Other observations on the spillways/Corrective Action:_____

_____

F. Instrumentation (refer to Glossary for description)

☐ 1. Are there any toe drains at the downstream toe or any other seepage drains on the dam? Yes_____ No_____

If yes, describe the condition (for example, clogged, free flowing, deteriorated, good condition) /Corrective Action:_____

_____

☐ 2. For drains, is an animal guard installed at the outlet of each drain? Yes_____ No_____

If no, which drains lack animal guards? /Corrective Action:_____

_____

☐ 3. For drains, measure the rate of flow from each drain and record below (use additional pages if necessary):

Designation/Location of Drain	Flow Rate	Flow Rate in GPM*	Turbidity of Flow (describe – clear, muddy, etc.)

☐ 4. Are there any piezometers on the dam? Yes_____ No_____

If yes, describe the condition (for example, good condition, damaged, etc.)/Corrective Action:_____

_____

☐ 5. For piezometers, does each piezometer have a cap with a lock? Yes_____ No_____

If no, which piezometers need caps (to prevent rain water intrusion) and/or locks (to prevent tampering)? /Corrective Action:_____

☐ 6. For piezometers, are you able to take a measurement (depth to water) in each piezometer? Yes_____ No_____

If yes, record depth to water (in feet) in each piezometer, record on a separate page, and attach to this form.

☐ 7. Are there any other monitoring devices on the dam? Yes_____ No_____

If yes, describe what type and the condition (for example, monitoring wells - good condition, damaged) /Corrective Action:

_____

☐ 8. Other observations on instrumentation/Corrective Action:_____

_____

G. Photographs

At a minimum, photographs should be taken of the crest, upstream slope, downstream slope and any other notable features.

List of photographs (be sure to date stamp the photos): _____

_____

_____

_____

**GPM (gallons per minute): to convert from oz/sec multiply by 0.4688; to convert from ml/sec multiply by 0.01585*

↑ Check if corrective action is noted/required.

ATTACHMENT G

Inspection of Concrete Structures

Dam Ownership
Fact Sheet

TOPIC:
INSPECTION OF CONCRETE STRUCTURES

Dams, dikes, and levees must not be thought of as part of the natural landscape, but as manmade structures which must be designed, inspected, operated, and maintained accordingly. Routine maintenance and inspection of dams and appurtenant facilities should be an ongoing and active process to ensure that structural failures do not occur which can threaten the overall safety of the dam. The information provided in this fact sheet pertains entirely to the inspection of concrete structures used at dams. The intention is to help dam owners become more aware of common problems that are typically encountered with concrete so that they can more readily address the seriousness of a condition whenever it arises.

STRUCTURAL INSPECTIONS

Concrete surfaces should be visually examined on a periodic basis for spalling and deterioration due to weathering, unusual or extreme stresses, erosion, cavitation, vandalism, and other destructive forces. Structural problems are indicated by cracking, exposure of reinforcing bars, large areas of broken-out concrete, misalignment at joints, undermining and settlement in the structure. Rust stains that are noted on the concrete may indicate that internal corrosion and deterioration of reinforcement steel is occurring. Spillway floor slabs and upstream slope protection slabs should be checked for erosion of underlying base material otherwise known as undermining. Concrete walls and tower structures should be examined to determine if settlement and misalignment of construction joints has occurred.

WHAT TO LOOK FOR

Cracking

Concrete structures can exhibit many different types of cracking. Deep, wide cracking is due to stresses which are primarily caused by shrinkage and structural loads. Minor or hairline surface cracking is caused by weathering and the quality of the concrete that was applied. The results of this minor cracking can be the eventual loss of concrete, which exposes reinforcing steel and accelerates deterioration. Generally, minor surface cracking does not affect the structural integrity and performance of the concrete structure. Cracks through concrete surfaces exposed to flowing water may lead to the erosion or piping of embankment or foundation soils from around and/or under the concrete structure. In this case, the cracks are not the result of a problem but are the detrimental condition which leads to piping and erosion.

Example of cracking.

Structural cracking of concrete is usually identified by long, single or multiple diagonal cracks with accompanying displacements and misalignment. Cracks extending across concrete slabs which line open channel spillways or provide upstream slope wave protection can indicate a loss of foundation support resulting from settlement, piping, undermining, or erosion of foundation soils. Piping and erosion of foundation soils are the result of inadequate underdrainage and/or cutoff walls. Items to consider when evaluating a suspected structural crack are the concrete thickness, the size and location of the reinforcing steel, the type of foundation, and the drainage provision for the structure.

Seepage

Seepage at the discharge end of a spillway or outlet structure may indicate leakage of water through a crack. Proper underdrainage for open channel spillways with structural concrete floors is necessary to control this leakage. Flows from underdrain outlets and pressure relief holes should also be observed and measured. Cloudy flows may indicate that piping is occurring beneath or adjacent to the concrete structure. This could be detrimental to the foundation support.
Concrete surfaces adjacent to contraction joints and subject to flowing water are of special concern especially in chute slabs. The adjacent slabs must be flush or the downstream one slightly lower to prevent erosion of the concrete and to prevent water from being directed into the joint during high velocity flow.

Poor Drainage

All weep holes should be checked for the accumulation of silt and granular deposits at their outlets. These deposits may obstruct flow or indicate loss of support material behind the concrete surfaces. Tapping the concrete surface with a hammer or some other device will help locate voids if they are present as well as give an indication of the condition and soundness of the concrete. Weep holes in the concrete are used to allow free drainage and relieve excessive hydrostatic pressures from building up underneath the structure. Excessive hydrostatic pressures underneath the concrete could cause it to heave or crack which increases the potential for accelerated deterioration and undermining. Periodic monitoring of the weep hole drains should be performed and documented on a regular and routine basis to ensure that they are functioning as designed.

Inspection of intake structures, trash racks, upstream conduits, and stilling basin concrete surfaces that are below the water surface is not readily feasible during a regularly scheduled inspection. Typically, stilling basins require the most regular monitoring and major maintenance because they are holding ponds for rock and debris, which can cause extensive damage to the concrete surfaces during the dissipation of flowing water. Therefore, special inspections of these features should be performed at least once every five years by either dewatering the structure or when operating conditions permit. Investigation of these features using experienced divers is also an alternative.

Weep holes with screens to control seepage.

PREPARING FOR AN INSPECTION

Before an inspection of the dam's concrete ıcilities is performed, it is recommended that a checklist be developed that includes all the different components of the spillway and/or outlet works. The checklist should also include a space for logging any specific observations about the structure and the state of its condition. Photographs provide invaluable records of changing conditions. A rapidly changing condition may indicate a very serious problem and documentation of prior inspections is very helpful in making this determination If there are any questions as to the seriousness of an observation the state dam safety agency, or a registered professional engineer experienced with dams, should be contacted.

RESOURCES

ASDSO Resources
The ASDSO website houses national guidelines on dams. Go to:
DamSafety.Org/ManualsandGuidelines

For more information, videos and tools for dam owners go to:
DamOwner.Org

Watch for training in your area sponsored by ASDSO or your State Dam Safety Office.

Access your state's Dam Safety Program by clicking your state at:
DamSafety.Org/States

DHS / FEMA Resources
DHS and FEMA make several publications and videos available to dam owners through:
FEMA.gov and *DHS.gov*
(search "dam safety")

Dam Ownership **Fact Sheet**

TOPIC:
GROUND COVER

The establishment and control of proper vegetation are an important part of dam maintenance. Properly maintained vegetation can help prevent erosion of embankment and earth channel surfaces, and aid in the control of groundhogs and muskrats. The uncontrolled growth of vegetation can damage embankments and concrete structures and make close inspection difficult. Grass vegetation is an effective and inexpensive way to prevent erosion of embankment surfaces. If properly maintained, it also enhances the appearance of the dam and provides a surface that can be easily inspected. Roots and stems tend to trap fine sand and soil particles, forming an erosion-resistant layer once the plants are well established.

Grass vegetation may not be effective in areas of concentrated runoff, such as at the contact of the embankment and abutments, or in areas subjected to wave action.

COMMON PROBLEMS

Bare Areas

Bare areas on an embankment are void of protective cover (e.g. grass, asphalt, riprap etc.). They are more susceptible to erosion which can lead to localized stability problems such as small slides and sloughs. Bare areas must be repaired by establishing a proper grass cover or by installing other protective cover. If using grass, the topsoil must be prepared with fertilizer and then scarified before sowing seed. Types of grass vegetation that have been used on dams are bluegrass, fescue, ryegrass, alfalfa, clover, and redtop. One suggested seed mixture is 30% Kentucky Bluegrass, 60% Kentucky 31 Fescue, and 10% Perennial Ryegrass. Once the seed is sown, the area should be mulched and watered regularly.

Erosion

Embankment slopes are normally designed and constructed so that the surface runoff will be spread out in a thin layer as "sheet flow" over the grass cover. When the sod is in poor condition or flow is concentrated at one or more locations, the resulting erosion will leave rills and gullies in the embankment slope. The erosion will cause loss of material and make maintenance of the embankment difficult. Prompt repair of the erosion is required to prevent more serious damage to the embankment. If erosion gullies are extensive, a registered professional engineer may be required to design a more rigid repair such as riprap or concrete. Minor rills and gullies can be repaired by filling them with compacted cohesive material. Topsoil should be a minimum of 4 inches deep. The area should then be seeded and mulched. Not only should the eroded areas be repaired, but the cause of the erosion should be addressed to prevent a continued maintenance problem.

Footpaths

Paths from animal and pedestrian traffic are problems common to many embankments. If a path has become established, vegetation in this

area will not provide adequate protection and a more durable cover will be required unless the traffic is eliminated. Gravel, asphalt, and concrete have been used effectively to cover footpaths. Embedding railroad ties or other treated wood beams into an embankment slope to form steps is one of the most successful and inexpensive methods used to provide a protected pathway.

Vehicle Ruts

Vehicle ruts can also be a problem on the embankment. Vehicular traffic on the dam should be discouraged especially during wet conditions except when necessary. Water collected in ruts may cause localized saturation, thereby weakening the embankment. Vehicles can also severely damage the vegetation on embankments. Worn areas could lead to erosion and more serious problems. Ruts that develop in the crest should be repaired by grading to direct all surface drainage into the impoundment. Bare and eroded areas should be repaired using the methods mentioned in the above sections. Constructed barriers such as fences and gates are effective ways to limit access of vehicles.

Improper Vegetation

Vegetation that hides the embankment surface, preventing early detection of cracks and erosion, is not recommended. Crown vetch is an example of this type of vegetation. It is a perennial plant with small pink flowers. It is also not effective in preventing erosion.

Vines and woody vegetation such as trees and brush also hide the embankment surface preventing early detection of cracks and erosion. Tall vegetation also provides a habitat for burrowing animals.

All improper vegetation must be removed from the entire embankment surface. Any residual roots that are larger than 3 inches in diameter must be removed. All roots should be removed down to a depth of at least 6 inches and replaced with a compacted clay material; then 4 inches of topsoil should be placed on the disturbed areas of the slope. Finally, these areas must be seeded and mulched to establish a proper grass cover.

MAINTENANCE

Embankments, areas adjacent to spillway structures, vegetated channels, and other areas associated with a dam require continual maintenance of the vegetal cover. Removal of improper vegetation is necessary for the proper maintenance of a dam, dike or levee. All embankment slopes and vegetated earth spillways should be mowed at least twice a year. Reasons for proper maintenance of the vegetal cover include unobstructed viewing during inspection, maintenance of a non-erodible surface, discouragement of burrowing animal habitation, and aesthetics. Common methods for control of vegetation include the use of weed trimmers or power brush-cutters and mowers. Chemical spraying to kill small trees and brush is acceptable if precautions are taken to protect the local environment. Some chemical spraying may require proper training prior to application.

RESOURCES

ASDSO Resources

The ASDSO website houses national guidelines on dams. Go to:
DamSafety.Org/ManualsandGuidelines

For more information, videos and tools for dam owners go to:
DamOwner.Org

Watch for training in your area sponsored by ASDSO or your State Dam Safety Office.

Access your state's Dam Safety Program by clicking your state at:
DamSafety.Org/States

ATTACHMENT H

Lake Petit Dam Features

Legend

- Weir
- Interceptor Drain (#)
- Piezometer

Notes:

1. All locations are approximate.
2. Interceptor drains are numbered starting at the right abutment.

N

0 250 500 Feet

Lake Petit Dam Features

Big Canoe Property Owners Association
Jasper, Georgia

Geosyntec consultants

Chattanooga, Tennessee

July 2021

Figure

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