FINAL REPORT

MOUNT PISGAH DAM/WRIGHTS RESERVOIR OUTLET WORKS REHABILITATION

WSRA Grant Contract C150505

CWCB Loan Contract C150341

The Applicant

The Pisgah Reservoir and Ditch Company is a mutual ditch company incorporated in 1923. Their decree, dated 1907, is for 2,743 acre feet per year of the natural flow of Four Mile Creek, for irrigation purposes. Water is delivered from Wrights Reservoir down Four Mile Creek to Pisgah shareholders.

Shareholders were assessed $3.00 per share in 2012 as a revenue source for the Company. Rates were doubled between 2011 and 2012 in order to assist in funding this project. Additional rate increases were implemented during the project's duration.

Project Summary

The Wrights Reservoir dam was constructed around 1911. There was an upstream slope failure around 1928. After the slope failure, the upstream ends of the original outlet works were plugged, a new outlet conduit was constructed through the right abutment, and the upstream slope was rebuilt. The spillway is located at the left abutment and was enlarged in 1988.

An SEO Inspection was made in June, 2011, resulting in a possibility of the existing storage capacity of the reservoir being restricted by the State Engineer for safety deficiencies. The existing gate operators had become nearly inoperable.

The Company hired RJH Consultants, Inc. to conduct further analysis of the dam. Their analysis was followed by an evaluation of alternatives to rehabilitate the Mount Pisgah Dam/Wrights Reservoir Outlet Works.

The alternative originally chosen consisted of removing the existing downstream control valves and installing a new upstream control valve on the existing outlet works intake structure located near the upstream toe of the dam. The existing valve house was removed and replaced with a new structure located at the same location. The existing concrete intake structure would be modified as necessary to accommodate the improvements.

The objective of the grant funding was to complete design elements and partially fund construction of the repairs.

In September 2012, the Company received approval for grant funds totaling $161,345: $25,000 in Basin WSRA funds, and $136,345 in Statewide WSRA funds. A CWCB loan in the amount of $161,345 was also approved. The grant and loan together funded approximately 90% of the project total of $362,690.

As the project progressed, it grew, and two revisions were made to the loan funding portion. The final funding summary is as follows:

Grant Funds:	$ 161,345.00	($25,000 Basin, $136,345 Statewide)
Loan Funds:	$1,172,261.00	
Applicant Funds:	$ 40,000.00	(plus)
	$1,373,606.00	

Pisgah Reservoir and Ditch Company incurred additional costs and project wrap-up costs outside the scope of the grant/loan project. Those costs are not included here.

Use of Funds

Grant funds were disbursed between March 2013 and September 2015. Loan funds continued to be disbursed through September 2016.

Grant funds were used for design services, bidding and procurement, construction engineering and management, and the beginning of construction activities.

Project Completion

On June 9, 2016, the Contractor was granted a certificate of substantial completion for rehabilitation of the current functional outlet works by the State Engineer's Office.

The following documents are attached for a more detailed description and illustration of the project:

- Construction Completion Report, by RJH Consultants, Inc.
- Appendix C – Selected Photographs

GEOTECHNICAL AND
WATER RESOURCES ENGINEERING

CONSTRUCTION COMPLETION REPORT

MT. PISGAH DAM OUTLET WORKS REHABILITATION PROJECT

TELLER COUNTY, COLORADO

Submitted to

Pisgah Reservoir and Ditch Company

917 Elm Street

Rocky Ford, Colorado 81067

Submitted by

RJH Consultants, Inc.

9800 Mt. Pyramid Court, Suite 330

Englewood, Colorado 80112

303-225-4611

www.rjh-consultants.com

January 2017

Project 12120

Michael L. Graber, P.E.

Project Manager

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

SECTION 1 - INTRODUCTION

1.1 Purpose

The purpose of this Construction Completion Report (Report) is to summarize general construction information, construction methods and procedures, design modifications, problems encountered and solutions implemented, and results of field and laboratory testing for the Mt. Pisgah Dam Outlet Works Rehabilitation Project (Project) in Teller County, Colorado. This Report is based on data taken from Project daily reports, Project correspondence, field observations, field and laboratory testing, and information provided by the Contractor. The Report contains information required by the Colorado Office of the State Engineer (SEO) in Rule 10.2 of the Rules and Regulations for Dam Safety and Dam Construction (Rules) (SEO, 2007).

1.2 Scope of Work

RJH Consultants, Inc. (RJH) performed the following services during construction of the Project:

- Reviewed submittals for conformance with the intent of the design, construction drawings, and technical specifications.
- Provided clarifications and technical assistance regarding the intent of the design and contract documents.
- Responded to Requests for Information (RFIs).
- Composed Change Orders to increase the Contract substantial completion date.
- Provided an on-site Resident Project Representative (RPR) to observe and document construction activities related to the dam, prepare daily field observation reports, coordinate quality assurance testing performed by Kleinfelder, lead construction progress meetings, and assist with construction administration. The RPR was on site full-time during abandonment of the partially abandoned outlet works, filter diaphragm construction, construction of the sluice gate attachment structure, existing concrete tunnel grouting efforts, valve chamber rehabilitation, and other major construction activities. Minor site work performed was observed part time.
- Concluded and documented that completed work to rehabilitate the current functional outlet works was in general conformance with the intent of the design,

construction drawings, and technical specifications based on construction observations and field and laboratory testing.

- Developed a concept to mitigate ongoing seepage concerns at the partially abandoned current non-functional outlet works.
- Coordinated site visits with personnel from the SEO at key points in construction.
- Prepared Record Drawings and this Construction Completion Report.

1.3 Project Personnel

Project Manager	Michael Graber, P.E.
Resident Project Representative	Micah Smidt, P.E.
Technical Review	Robert Huzjak, P.E.

1.4 Statement of Project Completion

On June 9, 2016, the Contractor submitted and was granted a certificate of substantial completion for rehabilitation of the current functional outlet works, which was considered substantially complete by the SEO following an operational test on May 19, 2016. Based on RJH observations and results of quality assurance testing, it is the opinion of RJH that the construction was completed in substantial conformance with the SEO-approved drawings and specifications.

The attempt to abandon the 16-inch pipes was not completely successful. The current condition of the partially abandoned 16-inch pipes and potential dam safety risks it represents are being evaluated. If additional work is warranted to address this risk, remediation construction will be performed under a separate construction contract.

SECTION 2 - PROJECT OVERVIEW

2.1 Project Location and Objective

Mount Pisgah Dam impounds Wright's Reservoir approximately 6 miles northwest of the Town of Cripple Creek in Teller County, Colorado. The dam is located in Section 31 of Township 14 South, Range 70 West. The location of the site is shown on Figure 2.1.

The project objective was to rehabilitate the existing marginally functional outlet works and to reduce the potential dam safety risk the abandoned original outlet works conduits represent. The existing functional outlet works facilities were completed in 1929 and the existing manual flow control gate valves were only marginally functional. The rehabilitation work consisted of replacing the existing control valves, installing a new trash rack, adding an upstream guard gate, repairing cracks in the concrete outlet conduits tunnel, lining existing steel outlet works pipes, providing a hydraulic actuation and control system for all gates and valves, and constructing a new valve house.

2.2 Background

Mount Pisgah Dam is a large, significant hazard, earth embankment dam. The dam is located on Fourmile Creek and impounds Wright's Reservoir, with a capacity of approximately 2,192 acre-feet (ac-ft). The embankment has an approximate upstream slope of 3H:1V, a crest width of about 10 feet, and a downstream slope of approximately 2H:1V.

The dam was originally constructed in 1911 and is used to store and release irrigation water. According to original design documents provided by the SEO, the upstream slope of the embankment was originally 1.5H:1V and was capped with a reinforced concrete face. The original outlet works consisted of parallel 16-inch-diameter cast iron pipes and two 16-inch gate valves located near the downstream toe of the embankment. In 1928, an upstream slope failure sheared off and blocked the entrance to the original outlet works. In 1929, the upstream slope was reconstructed at a flatter slope and a new outlet works was constructed through the right abutment. The original rock-cut spillway is located at the left abutment and was enlarged in 1988. The dam crest elevation provides more than 10 feet of freeboard above the spillway invert elevation based on the June 2011 SEO Engineer's Inspection Report.

The existing current functional outlet works extends from Wright's Reservoir through Mount Pisgah Dam at the right abutment. The outlet works consists of a concrete inlet structure with trash rack connected to an approximate 100-foot-long concrete tunnel that transitions to a rock-cut tunnel extending approximately 400 feet through the right abutment of the dam and discharging into Fourmile Creek. An existing concrete bulkhead wall is approximately 140 feet downstream of the inlet structure within the rock-cut tunnel. Two parallel 16.7-foot-long, 30-inch-diameter steel pipes penetrate the bulkhead wall. A 30-inch-diameter gate valve was fixed to the downstream side of each 30-inch diameter pipe and the gate valves discharged to atmosphere in the rock-cut outlet tunnel. The gate valves were manually operated with valve stems that extended up a vertical rock-cut shaft to a small valve house above near the dam crest.

The abandoned 1911 outlet works consists of parallel 16-inch pipes, 16-inch valves, and a concrete outfall structure. The valves and the structure are located at the toe of the dam in the vicinity of the downstream tunnel entrance of the current functional outlet works. The 16-inch pipes terminate about 230 to 260 feet upstream of the downstream toe within the embankment. The pipe slope and upstream limits are unknown.

2.3 Summary of Rehabilitation Construction

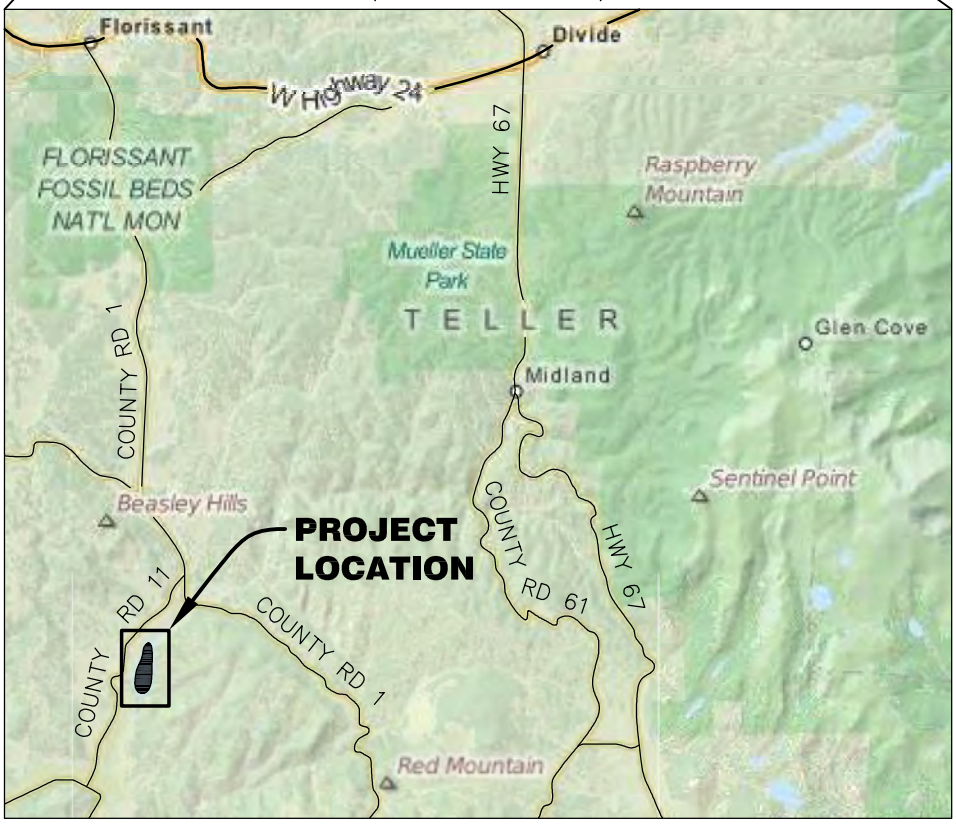
The Project was developed to address identified dam safety issues and to meet requirements and guidelines of the SEO. The design of the Project was presented in the Design Summary Report – Mount Pisgah Dam/Wrights Reservoir Outlet Works Rehabilitation Project (RJH, 2014). The primary elements of the project include:

- Replacement of the existing inlet structure trash rack and supports.
- Construction of a concrete and steel sluice gate attachment structure within the existing inlet structure for attachment of a new guard gate.
- Installation of a new heavy-duty, 30-inch by 30-inch slide gate, hydraulic actuator, and associated piping at the inlet structure. The new slide gate will function as a guard gate and was intended to remain fully open during normal operations.
- Removal of two existing 30-inch-diameter gate valves and associated valve stems and supports.
- Installation of 24-inch-diameter steel pipe liners within the existing parallel, 30-inch-diameter steel pipes.

- Installation of two new 24-inch knife gate valves, hydraulic actuators, and associated piping.
- Demolition and removal of the existing valve house structure located near the dam crest and preservation of the concrete foundation.
- Construction of a new valve house on the existing concrete foundation and installation of a hydraulic power control unit (HPU) and associated controls to operate the new sluice gate and knife gate valves.
- Pressure grouting of cracks within the concrete portion of the outlet works tunnel.
- Installation of a new aluminum ladder from the new valve house floor to the bottom of the discharge tunnel.
- Full-length grouting of the parallel 16-inch-diameter abandoned outlet works pipes and installation of a diaphragm filter at the location where the pipes daylight. The full-length grouting was not completely successful.

VICINITY MAP

(NOT TO SCALE)



SITE LOCATION MAP

(NOT TO SCALE)

RJH CONSULTANTS, INC.	CONSTRUCTION COMPLETION REPORT MT. PISGAH DAM OUTLET WORKS REHABILITATION PROJECT	SITE LOCATION
	PROJECT NO. 12120	January 2017 **Figure 2.1**

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SECTION 3 - CONSTRUCTION ADMINISTRATION

3.1 Contract Documents

The contract for construction of the Project was initially defined by the following Contract Documents:

- Issued for Bid Construction Specifications (includes Contract Documents and Technical Specifications), dated October 2014.
- Issued for Bid Construction Drawings, Sheets 1 through 12, dated October 2014.
- Addendum No. 1 to Contract Documents, dated April 14, 2015.
- Addendum No. 2 to Contract Documents, dated April 29, 2015.
- Addendum No. 3 to Contract Documents, dated May 04, 2015.

Notice to Proceed was issued on May 26, 2015 and construction began the same day.

3.2 Responsibilities

3.2.1 Owner

The Pisgah Reservoir and Ditch Company is the Owner of the dam and reservoir. The Owner contracted with Inland Potable Services, Inc. (Inland) to complete the work and contracted with RJH to provide construction engineering services for the rehabilitation. Financing for the Project was provided by the Colorado Water Conservation Board (CWCB). The Owner's responsibilities during construction included:

- Review and approval of applications for payment.
- Review and approval of change order proposals.
- Participation in construction progress meetings.

3.2.2 Contractor

Inland Potable Services, Inc. of Centennial, Colorado was awarded the construction contract to construct the Project in accordance with the contract documents. General responsibilities included:

- Development, planning, scheduling, and execution of the means and methods for construction necessary to complete the work.
- Preparation of submittals.
- Preparation and periodic updates of the construction schedule.
- Management and construction of the work.
- Procuring materials.
- Engaging subcontractors to perform selected work, and overseeing the subcontracted work.
- Preparation of RFIs to receive clarification from RJH when needed.
- Quality control of the work.
- Site safety and general site work.

3.2.3 Engineer

During construction, RJH was retained to provide construction engineering services and to fulfill the role of Engineer as defined in the Contract Documents and as defined by the SEO. General RJH responsibilities included:

- Provided office and field engineering support to evaluate if identified conditions were consistent with anticipated conditions and contractor compliance with design intent.
- Reviewed submittals and RFIs.
- Evaluated proposed design modifications to accommodate encountered field conditions or Contractor-requested changes.
- Provided an on-site RPR to observe and document the construction work and testing for the purposes of assessing the progress and quality of the construction work relative to conformance with the Contract Documents and to assess acceptability of the work for payment.
- Reviewed Contractor pay requests and provided recommendations for payment.
- Performed quality assurance (QA) as generally described in the Construction Quality Assurance Plan, by RJH, June 2015. In addition to RPR activities described above, RJH retained Kleinfelder to perform selected Quality Assurance testing.

- Prepared closeout documentation at completion of project needed for State Engineer acceptance and Owner records.
- Provided coordination between project team members, the Owner, the State Engineer, the CWCB, and the Contractor.
- Provided continuity between design intent and construction.

3.3 Contract Modifications

Significant modifications to the design drawings and technical specifications were not required for the Project. Various minor modifications that did not require changes in contract time, contract price, bid item quantities, or SEO-approved design are shown on the Record Drawings and documented in daily reports. Change Orders (CO) were issued to implement changes to the contract time. Change orders are summarized in Table 3.1.

TABLE 3.1
PROJECT MODIFICATIONS

Name	Date Issued	Date Accepted by all Parties	Description	Cost Change ($)	Time Change (days)
CO No. 1	9/30/2015	10/01/2015	Increase contract substantial completion date	0	8
CO No. 2	11/12/2015	12/14/2015	Increase contract substantial completion date	0	90

3.4 Record Drawings

The approved construction drawings were updated during the Project to reflect actual site conditions and changes made during construction. RJH developed Record Drawings at the completion of construction to document construction and changes or modifications to the contract drawings made during the course of construction. RJH developed the Record Drawings based on field records of RJH and Inland. Record Drawings are provided in Appendix A.

SECTION 4 - SUMMARY OF CONSTRUCTION

4.1 Construction Schedule

Inland divided the work into three phases. Phase I consisted of grouting the original 16-inch diameter outlet works pipes and installation of the filter diaphragm. Phase I started on May 26, 2015 and was generally complete in July 2015. Phase II consisted of rehabilitation of the upstream concrete inlet structure, and installation of a vent pipe and conduit encasement pipe on the upstream reservoir slope. Phase II was generally constructed between late September 2015 and the end of November 2015. Phase III consisted of installation of new knife gate valves and conduit liners, tunnel repairs, valve house replacement, and installation of hydraulic control equipment. Phase III was generally constructed between December, 2015 and May, 2016.

The general sequence of construction activities is summarized in Table 4.1.

TABLE 4.1
GENERAL CONSTRUCTION SEQUENCE DATES

Activity	Start Date	Finish Date
Phase I		
Mobilization, erosion control, miscellaneous site work, and demobilization	May 26, 2015	July 13, 2015
Dewatering	May 26, 2015	July 11, 2015
Excavation	May 26, 2015	June 29, 2015
16-inch diameter pipe abandonment	June 11, 2015	June 26, 2015
Filter Diaphragm and Berm Fill Construction	June 10, 2015	July 13, 2015
Phase II		
Mobilization, miscellaneous site work, and demobilization	September 28, 2015	November 24, 2015
Sediment excavation and Surface Preparation	October 1, 2015	October 14, 2015
Steel bulkhead plate, thimble, and steel plate formwork (steel form plate) assembly and installation	October 6, 2015	October 16, 2015
Class A concrete placement	October 12, 2015	October 19, 2015
Trash Rack Installation(1)	October 26, 2015	November 19, 2015
Underwater installation of vent and encasement pipe and anchorage	October 30, 2015	Work continued during phase III.
First installation of the 30-inch slide gate(2)	November 5, 2015	November 9, 2015
Phase III		
Mobilization, miscellaneous site work, and demobilization	December 11, 2015	July 06, 2016
Valve chamber and rock-cut outlet tunnel demolition	October 27, 2016	January 15, 2016
Valve house demolition	November 19, 2015	December 07, 2015
Valve house construction	December 17, 2015	April 2016(3)
Concrete tunnel repairs	December 11, 2015	December 14, 2015

Activity	Start Date	Finish Date
24-inch pipe installation within existing 30-inch pipes	January 04, 2016	January 19, 2016
Primary Grouting of the annular space between 24-inch and 30-inch pipes	January 19, 2016	January 26, 2016
Ladder and encasement pipe installation in the vertical rock-cut shaft	January 22, 2016	February 24, 2016
HPU and hydraulic tubing installation	January 27, 2016	July 06, 2016
Knife gate valve installation	January 30, 2016	January 30, 2016
Concrete cradle placement	February 03, 2016	February 09, 2016
Underwater installation of vent and encasement pipe and anchorage	February 11, 2016	June 21, 2016
Secondary Grouting of the annular space between 24-inch and 30-inch pipes	February 17, 2016	February 19, 2016
Transition from the existing concrete bulkhead wall to the 24-inch diameter pipes utilizing waterproof epoxy grout	February 19, 2016	June 21, 2016
24-inch diameter pipe support installation	April 28, 2016	June 21, 2016
Foundation wall vent installation	February 24, 2016	February 24, 2016
Second installation of the 30-inch slide gate[2]	May 02, 2016	May 07, 2016
Reinstallation of the 30-inch slide gate hydraulic cylinder	May 05, 2016	May 07, 2016
Operational test and SEO inspection	May 19, 2016	May 19, 2016

Notes:
1. The trash rack was removed and reinstalled during Phase III to facilitate work in the existing concrete inlet structure.
2. The first 30-inch slide gate frame failed in tension on March 1, 2016 and was replaced in May 2016.
3. Exact date not known.

Based on the Contract Documents, Substantial Completion is defined as the time at which the work can be utilized for the purposes for which it is intended, and it requires inspection and written acceptance by the SEO. A Project completion inspection was performed at the contractor's request on May 19, 2016. Attendance included personnel from RJH, Inland, the SEO, the Owner, and Hydro Gate. After the inspection, the SEO and RJH provided a list of remaining work items required for acceptance of the work. Items on the list included: installation of 24-inch diameter pipe supports, completion of the transition between the existing concrete bulkhead wall and the 24-inch diameter pipes, and sealing a springer leak between the 30-inch slide gate and the upstream thimble face. The complete list of remaining work items is attached to the May 19 daily report. Inland completed the remaining work between May 19 and July 6, 2016. RJH observed the progress of work intermittently over this period. The SEO granted partial acceptance on May 19, 2016 of Phase II and Phase III construction – excluding Phase I construction – subject to the completion of the punch list items.

The original contract specified 160 days from the notice to proceed to the substantial completion deadline and 205 days from notice to proceed to the final completion deadline. Change Order No. 1 increased the contract duration 8 days and Change Order

No. 2 increased the contract duration 90 days. Inland was unable to effectively work for two days in February due to inclement weather but did not request a contract extension for these days. The substantial completion deadline as defined by the contract and the change orders was February 8, 2016 and the final completion deadline was March 24, 2016.

Inland requested and was granted a certificate of substantial completion on June 9, 2016. The deadline for Substantial Completion defined by the contract and change orders was February 8, 2016. The Project was determined to be substantially complete approximately 4 months after the required substantial completion deadline.

4.2 Monthly Summaries

RJH submitted monthly construction reports to the SEO during the course of the Project through January 2016. The monthly reports include descriptions of problems encountered and solutions implemented during the work, and descriptions of design modifications. A summary of work completed between February 2016 and May 2016 is provided in this Report. Monthly reports are provided in Appendix B.

4.3 Daily Reports

RJH prepared daily field reports for days when an RJH Engineer was onsite or to document communications and information provided by Inland when RJH was not onsite. These reports include observations of the work, correspondence and communications, directions given, visitors, administrative tasks, and photographs.

Copies of the daily reports are provided in Appendix E.

4.4 Description of Dam Rehabilitation Construction

4.4.1 General

Information on the progress of the work through January 2016 is provided in the monthly reports in Appendix B. A summary of work completed between February 2016 and May 2016 is provided in Section 4.4.6. Significant issues, solutions, and results are summarized below.

4.4.2 Mitigate Potential Dam Safety Risks from 16-inch Diameter Outlet Works Conduits

The design intent was to completely grout both 16-inch conduits and construct a diaphragm filter and drain system at the discharge end of the conduits. The contractor failed to completely fill the pipes with grout, which was required by the approved contract documents, and did not satisfy the design intent.

The grouting operation was performed on June 26, 2015. Fremont Paving and Redi-Mix supplied the grout, adjusted slump, and added the specified anti-washout admixture; Kodiac Concrete Pumping, Inc. provided pumping services, and Inland coordinated and provided direct oversight. Approximately 8-cy was pumped into the left (east) pipe and 4.5-cy was pumped into the right (west) pipe. Fremont estimated the volume pumped into each pipe by observing the concrete remaining in the concrete trucks. Based on the estimated volume of grout pumped, the left pipe is considered to be approximately 66 percent filled and the right pipe is considered to be approximately 33 percent filled. Several unsuccessful attempts were made to pump additional grout into each pipe. The left conduit downstream bulkhead plate was dislodged from the end of the pipe during the attempts to pump additional grout. Additional grout pumped into the furthest upstream grout port in the right pipe resulted in an approximate equal volume of grout discharging from a vent pipe.

RJH developed a concept plan to address concerns of having partially grouted pipes. The concept plan was reviewed and accepted by the SEO in a letter to Pisgah dated April 1, 2016. The concept plan included a geotechnical investigation, installation of piezometers, and data collection to evaluate potential dam safety risks represented by not fully grouting the pipes. RJH collected geotechnical data and installed instrumentation at Mt. Pisgah Dam as documented in a geotechnical data report dated January 2017. Monitoring and data collection of the dam embankment phreatic surface is ongoing.

If it is determined that additional remediation measures are required to mitigate potential dam safety risks associated with these 16-inch diameter pipes, a supplemental application for review and approval of any proposed dam modifications will be made under the current project construction file number C-1690B. A contractor with the required specialized construction experience will be selected to perform the work.

4.4.3 Concrete Tunnel Repairs

Inland attempted to grout and seal cracks and holes in the concrete tunnel on two occasions (December 11 and December 14, 2015) using hydrophilic polyurethane grout. The attempts were generally unsuccessful because water temperatures flowing from the cracks and holes was cold and the phreatic surface in the dam embankment was higher than typical in December (reservoir water surface was at about El. ± 7985). The colder water temperature delayed the set time of the resins and the elevated pressure head increased the water flow rate from the cracks and holes. These conditions tended to eject the injected grout from cracks and holes before it could properly cure and seal the leak. Additionally, mechanical injection ports inadequately sealed against the concrete because of the friable nature of the concrete tunnel walls after drilling.

The concrete tunnel repair work was terminated and not completed as part of this Project because a) the tunnel is normally operated in a near balanced condition with the reservoir (upstream guard gate open) and the concrete tunnel filled with water, b) the cracks and holes are a long-term maintenance issue and not a dam safety concern, and c) the repair would have required more material, effort, and cost than if performed during warmer weather at lower reservoir levels. RJH documented the conditions of the concrete tunnel on December 14, 2015, which is provided in the daily report for this date.

4.4.4 Annular Space Grouting

New 24-inch diameter steel pipes were placed into the existing 30-inch diameter steel pipes between January 15 and January 19, 2016 and grouting bulkeads were installed between January 18 and January 21, 2016. Casing spacers located at each end and center of each 30-inch pipe provided an approximate 2- to 3-inch-wide annular space. Annular space grouting operations were performed on January 21, 2016. Fremont Paving and Redi-Mix supplied the Type 1 cementitious grout, Kodiac Concrete Pumping, Inc. provided pumping services, and Inland coordinated and provided direct oversight and added intraplast N admixture to the grout mix in the Redi-Mix delivery truck. During and subsequent to the grouting process, grout leaked from the upstream bulkhead through Aquatapoxy sealing material that was not fully set. The largest grout leak occurred when the annular space was momentarily pressurized by the grout pump. Leaks were plugged with Ramnek, which worked well initially to stop the flow of grout but after grouting operations were terminated, additional grout leaks developed from around the upstream annular space bulkhead. The upstream end of the annular space was inspected on January 26 and a void was observed at the crown of both pipes. The void in the right (west) annular space was 3/16-inch wide, about 1-foot 4-inches long and at least 5-feet

deep. The void in the left (east) annular space was 1-inch wide about 1-foot 4-inches long and at least 16-feet deep.

Secondary grouting was performed on February 18, 2016 and the voids in the annular spaces were successfully filled with Mountain Grout R-20S – a two component expansive hydrophobic polyurethane grout. The polyurethane grout material expands about three times the initial volume to form a hard and strong cellular plastic. Inland provided low pressure pumping equipment and performed the grout operation. Approximately 4 gallons of grout was pumped into the left void and approximately 2 gallons of grout was pumped into the right void. During pumping operations, a relatively small volume of grout leaked from the left and the right bulkheads. The upstream end of the annular space was inspected on February 19 and the voids were completely filled with polyurethane grout. In our opinion, the grouted annulus was in general conformance with the contract documents and design intent following secondary grouting.

4.4.5 Second Installation of the 30-inch Slide Gate

The 30-inch slide gate frame installed by Inland (first installation) in November 2015 failed in tension on March 1, 2016. The existing gate was removed and a replacement slide gate (second installation) was installed in May 2015. The failure surface of first slide occurred along the slide gate frame between the connection to the yoke and the slide approximately 15 inches above the upper most wedge. The thickness of the gate frame casting at the failure surface cross section differed as much as 5/16-inch between the left and right sides. Additionally, following the failure of the slide gate, the yoke anchor bolts were bent and pulled from the sluice gate attachment structure. The resulting voids were filled with Aquatapoxy and Oakum (Avanti 202 hydrophilic polyurethane resin mixed with jute fibers). The second slide gate was reinstalled between May 3 and May 4, 2016. Aquatapoxy was used to seal the slide gate to the thimble. The yoke was attached to a 3/4-inch stiffener plate that was attached to the steel form plate.

The hydraulic cylinder was tested underwater on May 6, 2016 and found to be in acceptable condition for operation; the seals did not appear to leak and the cylinder rod appeared unbent and unmarred. The hydraulic cylinder was reinstalled on May 6, 2016.

The second slide gate was tested in balanced head conditions and then the outlet works upstream of the knife gate valves was dewatered on May 7, 2016. Following dewatering of the tunnel, water was observed leaking into the outlet works between the slide gate and the thimble. Inland reduced the leaks by tightening the nuts connecting the slide gate to the thimble and installing Oakum in leaks. The slide gate was inspected on July 21, 2016

and leaks were not present. In our opinion, the completed slide gate was in general conformance with the contract documents.

4.4.6 Site Work between February and May 2016

The following is a summary of work between February and May 2016. Except where indicated, it is our opinion that the following work was completed in substantial conformance with the Contract Documents:

- Existing Concrete Bulkhead wall Transition (taper) to the 24-inch Diameter Steel Pipes: Inland attempted to use Aquatapoxy to form the transition from the existing concrete bulkhead wall to the 24-inch diameter pipes. The Aquatapoxy did not maintain the necessary thickness of material to produce an acceptable taper. After several unsuccessful attempts to modify installation procedures – including the use of a thickening agent supplied by the manufacturer – Inland used NuMetal Epoxy Putty to successfully complete the tapered transition. NuMetal is a two component waterproof epoxy putty that cures underwater and has a compressive strength of 12,000 psi, a tensile strength of 4,000 psi, and a bond strength of 375 psi. The transition was inspected on June 21, 2016 and, in our opinion, in general conformance with the contract documents.
- 24-inch Steel Discharge Pipes Concrete Cradle: Inland constructed the concrete cradle on February 9, 2016. Class A concrete (underwater concrete) was used instead of Class B (conventional concrete) because it has a smaller aggregate size but provides equal strength. The anti-washout admixture was not added to the concrete because the placement was not underwater. Concrete was supplied by Fremont Paving and Redi-Mix and pumping services were provided by Kodiak Concrete Pumping.
- 24-inch Steel Discharge Pipes - Stainless Steel Pipe Supports: Inland installed stainless steel pipe supports approximately 1 foot downstream of the 24-inch diameter knife gate valves. Pipe supports were installed by removing rock, placing concrete to level the rock subgrade, anchoring the pipe supports to the placed concrete, and attaching the pipe support to the 24-inch diameter pipes.
    - Rock was removed to at least 9 inches below the bottom of the pipe supports to provide appropriate clearance for the pipe supports and embedded items. The supports were cast into concrete with four 6-inch long 1/2-inch diameter bent anchor bolts embedded beneath each pipe support baseplate. The concrete extended approximately 2 inches above the top of the support baseplates. The baseplate was not anchored using post-installed epoxy anchors

because the rock broke apart into boulders and cobbles when attempting to drill the bolt holes.

  - The steel lockout nipple on each pipe support was shortened 2-inches to reduce the amount of rock removal beneath each base plate while maintaining an operable pipe support.
  - The operational range of the pipe supports is 0.5-inches downward and several inches upward.
  - Concrete was placed in May 2016 on two different dates. The first placement secured the baseplates and embedded items into position. Concrete for the first placement was batched in the valve chamber by hand. The second placement consisted of mass concrete to fill the remainder of the excavation. Concrete for the second placement was supplied by A.C. Concrete and pumping services were provided by Kodiak Concrete Pumping.

- Vent Pipe: The remainder of the 6-inch diameter galvanized steel vent pipe for the 30-inch slide gate was installed. The vent pipe extended from the reservoir and attached to the east wall of the valve house and was generally complete on February 5, 2016. Additional efforts to install conduit anchors in the reservoir and the rock outcrop east of the valve house continued until about June 21, 2016.
- Installation of Flexible Hydraulic Tubing: Flexible hydraulic tubing was inserted into the 3-inch galvanized steel encasement pipes located on the upstream reservoir slope and in the vertical rock-cut shaft. Flexible tubing in the reservoir was pushed into the encasement pipe from the inlet structure to the reservoir surface on February 6, 2016. Flexible tubing in the vertical rock-cut shaft was inserted from the valve chamber up to the valve house on January 31, February 3, and February 6, 2016. The instrumentation cable was inserted with the tubing.
  - During insertion of the tubing in the valve chamber one of the portable heaters burned a short length of one of the flexible hydraulic tubes. The tubing was removed and replaced with new tubing.
  - During installation of the instrumentation cables the sheathing was nicked and an electrical short developed in the cables. The instrumentation cable to the 30-inch slide gate was abandoned and not reinstalled because the slide gate will be operated in either a fully open or fully closed position and will be operated infrequently. The instrumentation cables to the knife gate valves were reinstalled in PVC conduit attached to the exterior of the encasement pipe following July 6, 2016.

- Valve Chamber Ice Fall Shield: A stainless steel shield was installed in the vertical rock-cut shaft to protect critical outlet works components including the knife gate valves and hydraulic equipment from ice and falling debris. The shield was installed by a separate contractor under a separate agreement with Pisgah. The shield is removable to facilitate future removal of the knife gate valves.
- Aluminum Ladder: The aluminum ladder was installed in the vertical rock cut shaft. The ladder was mounted to the east wall of the rock-cut shaft and to the galvanized steel struts (that support the encasement pipe). The ladder was installed between February 08 and was complete on February 24, 2016.
- Riprap Placement: Additional riprap was placed on February 11, 2016 downstream of the drain outlet structure on the left bank of the outlet works channel.
- Valve House: Construction of the valve house progressed intermittently and was generally complete in April 2016.
- Foundation Wall Vent: Installation of the foundation wall vent occurred on February 24, 2016.
- Reservoir Bubbler Line Instrumentation: The reservoir bubbler line was disconnected on October 26, 2015 to facilitate construction of the valve house and was reconnected on March 1, 2016.
- Flume Instrumentation: The flume instrumentation used to measure reservoir discharge was disconnected on October 26, 2015 to facilitate construction of the valve house and was reconnected on March 8, 2016.
- Hydraulic Cylinder Support Bracket: The hydraulic cylinder support bracket was installed and inspected on June 7, 2016.
- Operational Test: An operational test of the rehabilitated outlet works was conducted on May 19, 2016. The test consisted of operating the upstream 30-inch slide gate, and then fully opening and fully closing each knife gate flow control valve under full reservoir head. A video of the operational test for each valve is presented in Appendix H (electronic only).
- Subdrainage Pipe Inspection: A video inspection of the subdrainage pipe was performed on June 7, 2016. Seepage water was flowing in the pipe and the slotted pipe was partially filled with water. The subdrainage pipe was free of sediment and debris, the joints appeared tight and the grade was sloped generally uniformly downstream. There was an accumulation of iron ochre within the pipe. Flushing the pipe with water appeared to remove some of this accumulation. A

copy of the subdrainage pipe video inspection is presented in Appendix G (electronic only).

- Flap Gate: A flap gate was installed on the subdrainage pipe at the drain outlet structure. Fourmile Creek was below the invert of the PVC pipe during reservoir releases observed in July and September 2016.

SECTION 5 - RECOMMENDATIONS

5.1 General

This section provides general recommendation for the operation, maintenance, and monitoring of Mt. Pisgah Dam.

Pertinent operation and maintenance (O&M) excerpts for the hydraulic equipment, the slide gate and knife gate valves are included in Appendix D. Pertinent submittals are included in Appendix F (electronic copy only).

5.2 Operation

The following general procedures are recommended when operating the outlet works under normal conditions:

- Maintain adequate supply of hydraulic fluid. If the supply of hydraulic fluid becomes too low, the low-level system alarm will activate and the HPU will not be operational. Information for the hydraulic fluid furnished by Inland is provided in Appendix D.
- The Hydraulic Power Control Unit (HPU) pump begins to operate when the HPU is activated (power is on and red mushroom push button are on). Deactivate HPU when not adjusting slide gate or valve positions.
- The 30-inch slide gate (guard gate) (valve number 1) should remain in the fully open position. Utilize either or both (as appropriate) of the 24-inch knife gate valves to provide flow control for outlet works releases.
- Exercise caution when adjusting the position of knife gate valves or the 30-inch slide gate. Track gate positions utilizing multiple methods.
    - 30-inch slide gate: Track position during operation using hydraulic power control unit (HPU) system pressure and elapsed time. Refer to Table 5.1.
    - Knife gate valves: Track position during operation using transducer readings, hydraulic power control unit (HPU) system pressure, and elapsed time. Refer to Table 1.
    - Operate slide gate and valves independently (one at a time).
    - If system pressure, transducer reading, and elapsed time do not correspond the slide gate or valve could be blocked by debris, the initial position could have

been misunderstood, or the transducers could be incorrectly reporting gate position.

Additional information of the HPU operation can be found in the *Sun Source Operation Manual for Hydraulic System* provided in Appendix D.

TABLE 5.1
PERTINENT VALVE DETAILS

Valve	Operation	Transducer Reading	System Pressure[1]	Elapsed time[2]
No. 1 – Slide Gate (Guard Gate)	Open to Close[3] Close to Open[3]	Not Applicable[4] Not Applicable[4]	0→2,000 psi 0→2,000 psi	±1 min 45 sec ±1 min 30 sec
No. 2 – knife gate valve (Right)(West)	Open to Close[5] Close to Open[5]	24.0→0.0 (inches) 0.0→24.0 (inches)	0→2,000 psi 0→2,000 psi	±1 min 25 sec ±1 min 10 sec
No. 3 – knife gate valve (Left) (East)	Open to Close[5] Close to Open[5]	24.0→0.0 (inches) 0.0→24.0 (inches)	0→2,000 psi 0→2,000 psi	±1 min 25 sec ±1 min 10 sec

Notes:
1. HPU builds to 2,000 psi pressure when the gate is fully open and fully seated.
2. Elapsed time after pressing (and holding) raise/lower buttons and when system pressure reaches 2,000 psi.
3. Normal operating position is open. Gate operating range is 30-inches.
4. The guard gate is not equipped with a transducer.
5. Valve is normally used for flow control. Normal operating position varies. Valve operating range is 24-inches.

5.3 Maintenance

5.3.1 Slide Gate and Knife Gate Valves

- Follow all routine and periodic equipment manufacturer's recommended maintenance procedures. Pertinent excerpts are presented in Appendix D, complete documents are presented in Appendix F.
- Exercise the knife gate valves and slide gate at least twice a year
- General Procedure:
  1. Close the knife gate valves (valve number 2 and valve number 3) and verify the slide gate (valve number 1) is in the closed position and the intake tunnel is filled.
  2. Open the right knife gate valve (west, valve number 2) to a full open position and then return it to a full closed position. Opening the knife gate valve will release the water held in the outlet works tunnel between the knife gate valves and the Slide gate.

3. Open the left (east, valve number 3) knife gate valve to a full open position and then return to a full closed position.
4. Crack open the slide gate by pressing and holding the gate 1 open button for 14 seconds. Opening the slide gate will fill the outlet works tunnel between the knife gate valves and the slide gate with water and expel the air.
5. Wait a few minutes for the outlet works tunnel to fill between the slide gate and the knife gate valves. Listen to the 6-inch vent pipe located outside the window on the east wall during this time. The vent pipe will convey air expelled from the tunnel.
6. Finish opening the slide gate.
7. Confirm that knife gate valves have adequately seated and then adjust knife gate valves, as required, for normal flow control.

- Any operational problems should be assessed and any identified damage or poor performance should be repaired immediately in accordance with manufacturer's instructions.

5.3.2 Outlet Works Tunnel

- General – Recommended tunnel dewatering procedure, annual and periodic inspections are provided below. Annual inspection activities may be adjusted to periodic inspections following several years of acceptable performance.

5.3.2.1 Tunnel Dewatering

- General – Dewater the outlet works tunnel between the 30-inch slide gate and knife gate valves to perform inspections. Following inspection refill outlet works tunnel.
  - Outlet works tunnel dewatering procedure:
    1. Close the knife gate valves (valve number 2 and valve number 3) and then close the 30-inch upstream slide gate.
    2. Open the left (east, valve number 3) knife gate valve. Opening the knife gate valve will release the water held in the outlet works tunnel between the knife gate valves and the slide gate.
    3. Verify that slide gate has adequately seated by observing downstream flow rate.
    4. Open the right knife gate valve (west, valve number 2).

- Outlet works tunnel refilling procedure:
  1. Close the right (west, valve number 2) knife gate valve
  2. Close the left (east, valve number 3) knife gate valve
  3. Crack open the slide gate by pressing and holding the gate 1 open button for 14 seconds. Opening the slide gate will fill the outlet works tunnel between the knife gate valves and the slide gate with water and expel the air.
  4. Wait a few minutes for the outlet works tunnel to fill between the slide gate and the knife gate valves. Listen to the 6-inch vent pipe located outside the window on the east wall during this time. The vent pipe will convey air expelled from the tunnel.
  5. Finish opening the slide gate to a fully open position.
  6. Confirm that knife gate valves have adequately seated.
- Note that the outlet works tunnel will also refill slowly as seepage enters the dewatered outlet works tunnel. Seepage flow rates will be dependent on reservoir head.

- Safety: Reduce safety hazards as required. Tunnel is a confined space. Follow Occupational Safety and Health Administration (OSHA) regulations, as appropriate. Engineering control of hazards include: lockout tagout of Hydraulic Power Control Unit (HPU), adequate ventilation of the outlet works tunnel, others as appropriate.
  - Remove personnel, equipment, and supplies from downstream of the knife gate valves before dewatering the tunnel. If the tunnel has been recently dewatered, the knife gate valves are closed, and the slide gate remains closed the tunnel will fill with seepage and could present a safety hazard.

5.3.2.2 Annual Inspections

- Inspect epoxy coating of 24-inch diameter pipes.
  - The epoxy coating consists of three layers of epoxy with a minimum dry film thickness of 16-mils. The color of the epoxy from top to bottom is blue, then white, then red.
  - Record description of the epoxy coating condition and take photographs.

- Repair epoxy coating when red layer becomes visible to reduce the development of corrosion within the 24-inch diameter steel pipes. Refer to Attachment F for product information.
- Move to periodic inspections after several years of acceptable performance.

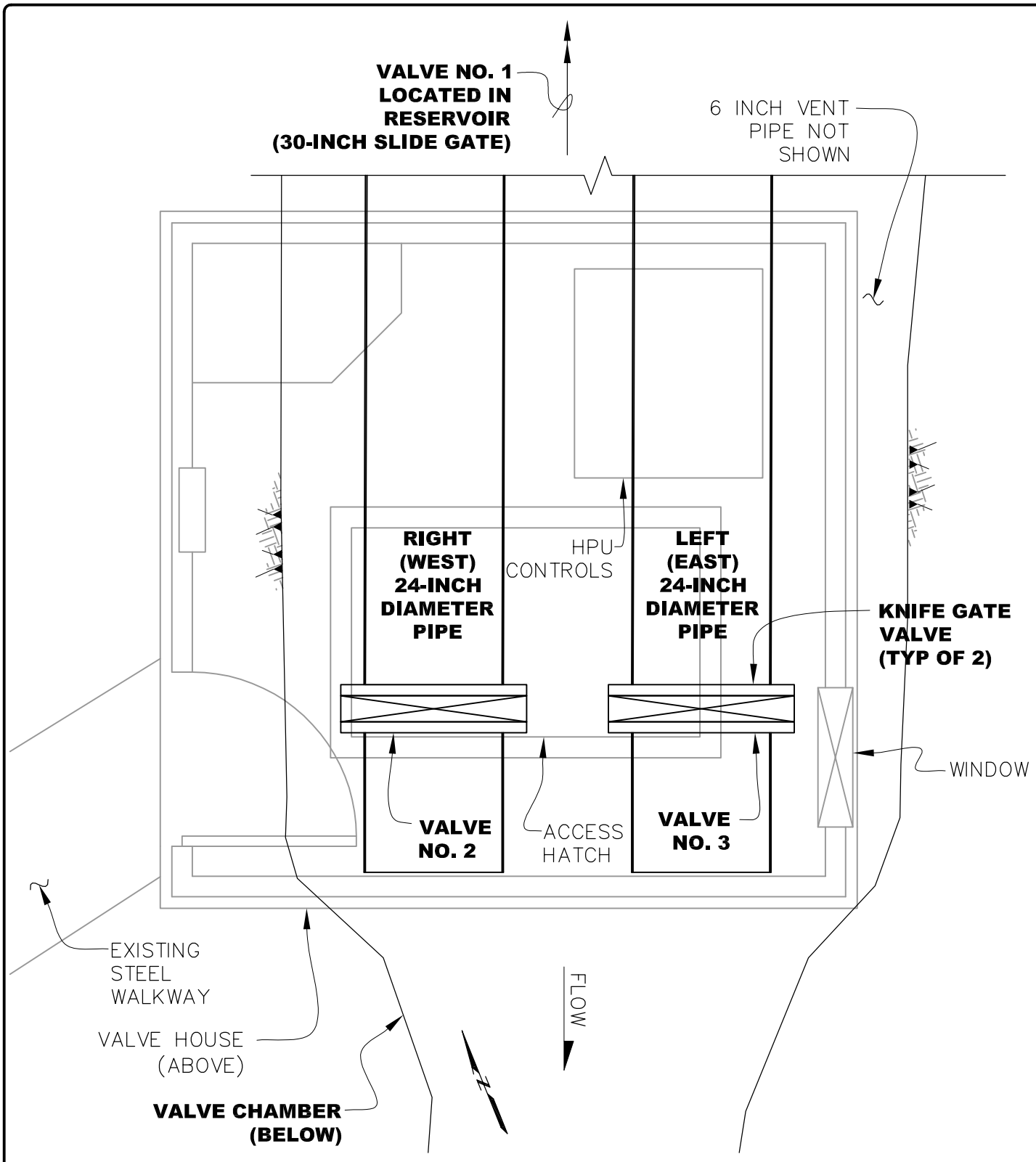
- Inspect waterproof epoxy, which forms the transition (taper) from the existing concrete bulkhead wall to the 24-inch diameter pipes.
  - Check for surface erosion, spalling, or pitted surface of waterproof epoxy. Record description of the taper and take photographs. Repair as appropriate. Refer to Attachment F for product information.
  - Move to periodic inspections after several years of acceptable performance.

5.3.2.3 Periodic Inspections (Every Five Years)

- Inspect concrete tunnel.
  - Repair the tunnel during periods of reduced reservoir levels and favorable temperature conditions.
  - Inspect condition of concrete tunnel. Record description of conditions and take photographs as appropriate. Refer to the daily report for December 14, 2015 to review conditions observed during construction.
- 30-inch slide gate and steel bulkhead plate.
  - Inspect Aquatapoxy coating at downstream side of the steel bulkhead plate. Repair as appropriate.
  - Inspect epoxy coating on the 30-inch slide gate and thimble. Record description of conditions and take photographs. Repair as appropriate. Refer to Attachment F for product information.

5.4 Monitoring

RJH submitted a Monitoring Plan to Pisgah under a separate cover. The Monitoring Plan includes a field data form and a spreadsheet for use by Pisgah to record monitoring data.



RJH CONSULTANTS, INC.	CONSTRUCTION COMPLETION REPORT MT. PISGAH DAM OUTLET WORKS REHABILITATION PROJECT	OUTLET WORKS VALVES OPERATIONAL SCHEMATIC PLAN
	PROJECT NO. 12120	January 2017 **Figure 5.1**

SECTION 6 - REFERENCES

Colorado Office of the State Engineer (SEO) (2007). *Rules and Regulations for Dam Safety and Dam Construction*.

RJH Consultants, Inc. (RJH) (2014). *Design Summary Report – Mount Pisgah Dam/Wrights Reservoir Outlet Works Rehabilitation Project*.

Photograph 1: February 29, 2016 Frozen reservoir water surface.

Photograph 2: February 6, 2016 Installation of flexible hydraulic tubing for the 30-inch slide gate.

Photograph 3: January 31, 2016 Installation of flexible hydraulic tubing in the vertical rock-cut shaft.

Photograph 4: February 16, 2016 ladder installation.

Photograph 5: February 24, 2016. Ladder, encasement pipe, and lighting in the vertical rock-cut shaft.

Photograph 6: February 9, 2016. Forces mobilized to place the concrete cradle for the 24-inch diameter steel pipes.

Photograph 7: March 2, 2016. 24-inch diameter pipes and concrete cradle.

Photograph 8: June 14, 2016. Pipe supports and backfill concrete.

Photograph 9: June 7, 2016. 24-inch steel pipe coated with Aquatapoxy above the concrete cradle.

Photograph 10: February 19, 2016. Annular Space between 24-inch and 30-inch diameter pipes following secondary grouting.

Photograph 11: June 21, 2016. Completed transition from the concrete bulkhead wall to the 24-inch diameter steel pipes.

Photograph 12: May 3, 2016. Knife gate valve hydraulic cylinders, hydraulic manifolds, flexible hydraulic control tubing, and removable shield.

Photograph 13: May 2, 2016. Remains of the 30-inch slide gate (first instllation) removed from the Reservoir.

Photograph 14: April 27, 2016. 30-inch Slide Gate (Second installation) and Stiffener Plate.

Photograph 15: May 4, 2016. 30-inch slide gate (second installation) coated with Aquatapoxy prior to installation.

Photograph 16: March 2, 2016. Downstream face of the steel bulkhead plate, thimble, and 30-inch slide gate (first installation).

Photograph 17: June 21, 2016. 30-inch slide gate under full reservoir head. Springer leaks have been sealed.

Photograph 18: May 12, 2016. Hydraulic cylinder support bracket (30-inch slide gate).

Photograph 19: May 3, 2016. Vent pipe and encasement pipe installed on the east wall of the valve house.

Photograph 20: May 12, 2016. Reservoir water surface and valve house.

Photograph 21: May 19, 2016. Reservoir water surface.