

A HEIGHTENED FOCUS ON PUBLIC SAFETY AT DAMS DOES NOT HAPPEN BY ACCIDENT

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ABSTRACT

The 21st Century has begun as an era of uncertainty, with a heightened focus on security and public safety. ...Gavin Newsom

Located near Leesburg, Virginia in the heart of one of the fastest growing and most affluent areas in the United States, Goose Creek Dam and Beaverdam Creek Dam are important sources for water supply. In the past decade, these dams and their reservoirs have become destinations for public interaction and recreation. Because of increased development and public awareness and usage of these facilities, Loudoun Water decided develop a public safety plan for their dams. These public safety efforts were amplified by strategic partnerships with the county government and regional park authority, both of which own and operate park properties adjacent to the reservoirs. Public engagement and acceptance was enormously successful. The United States Society on Dams (USSD) recognized these efforts by selecting Loudoun Water as the recipient of the *2016 Award for Recognition of Public Safety Around Dams*.

The focus of this paper is to present: (1) the process that was used to develop and document a public safety plan; (2) the specific actions implemented by Loudoun Water to protect the public; (3) the methods used to ensure conformance with the public safety plan; (4) the public safety education, training and outreach programs implemented by Loudoun Water; and, (5) the additional public safety improvements that are planned to be implemented at Beaverdam Creek Dam as part of a major rehabilitation of this dam.

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BACKGROUND

Loudoun County is a rapidly growing jurisdiction located in the northern tip of the Commonwealth of Virginia approximately 25 miles northwest of Washington, D.C. Loudoun County has been one of the fastest growing counties in the country over the past decade. The County is expected to continue to have one of the highest population growth rates in the entire Washington region over the next 20 years. Loudoun Water provides drinking water and wastewater services to over 65,000 households in Loudoun County. Loudoun Water's mission is to sustainably manage water resources in advocacy of health, environment, and quality of life.

Loudoun Water purchased Beaverdam Creek Dam and Goose Creek Dam in January 2014. The dams are located in Loudoun County near Leesburg and are used primarily for water supply. Goose Creek Reservoir and Beaverdam Reservoir are also used for recreation. Beaverdam Creek Dam is a high hazard, earthfill embankment dam located on Beaverdam Creek with a contributing drainage area of approximately 6 square miles. Goose Creek Dam is a run-of-the-river concrete gravity dam on Goose Creek with a contributing drainage area of approximately 347 square miles. Figure 1 shows the location of Beaverdam Creek Dam and Goose Creek Dam.

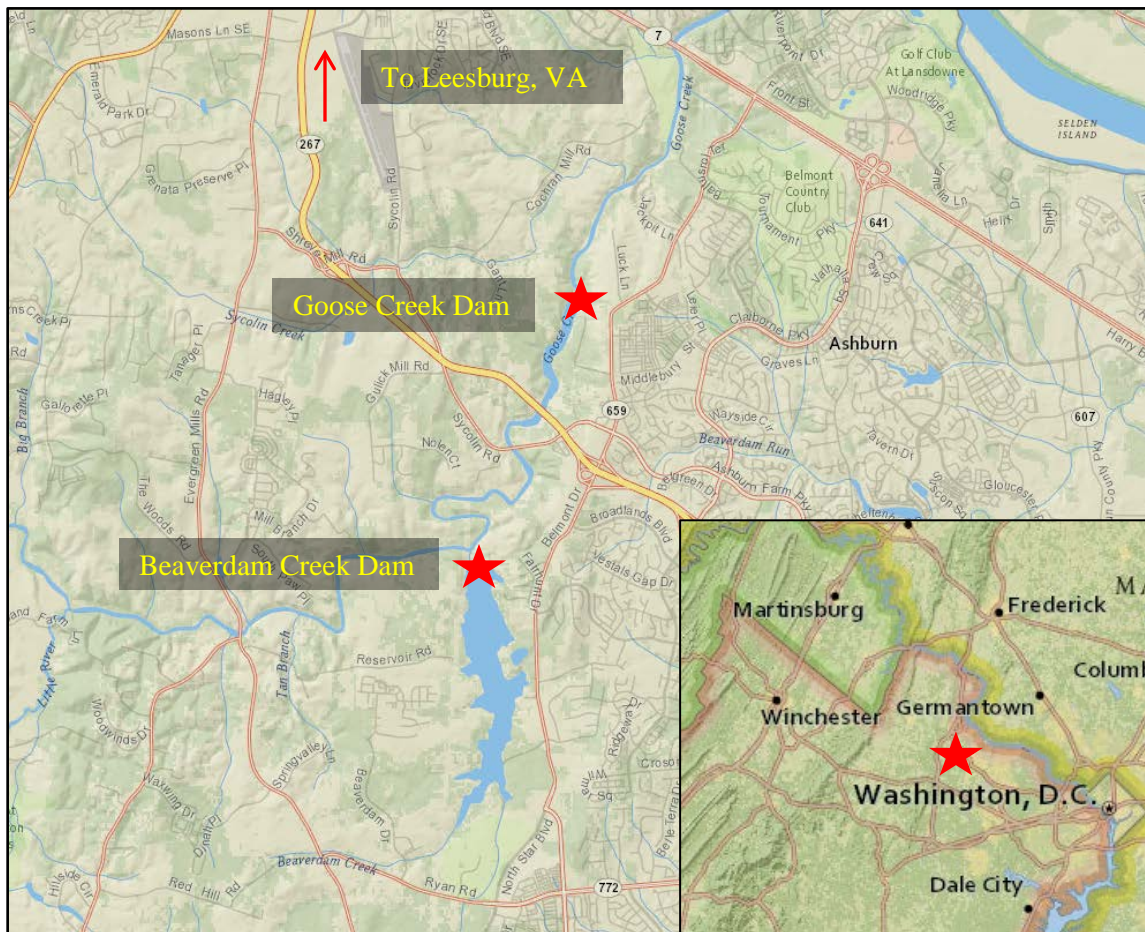
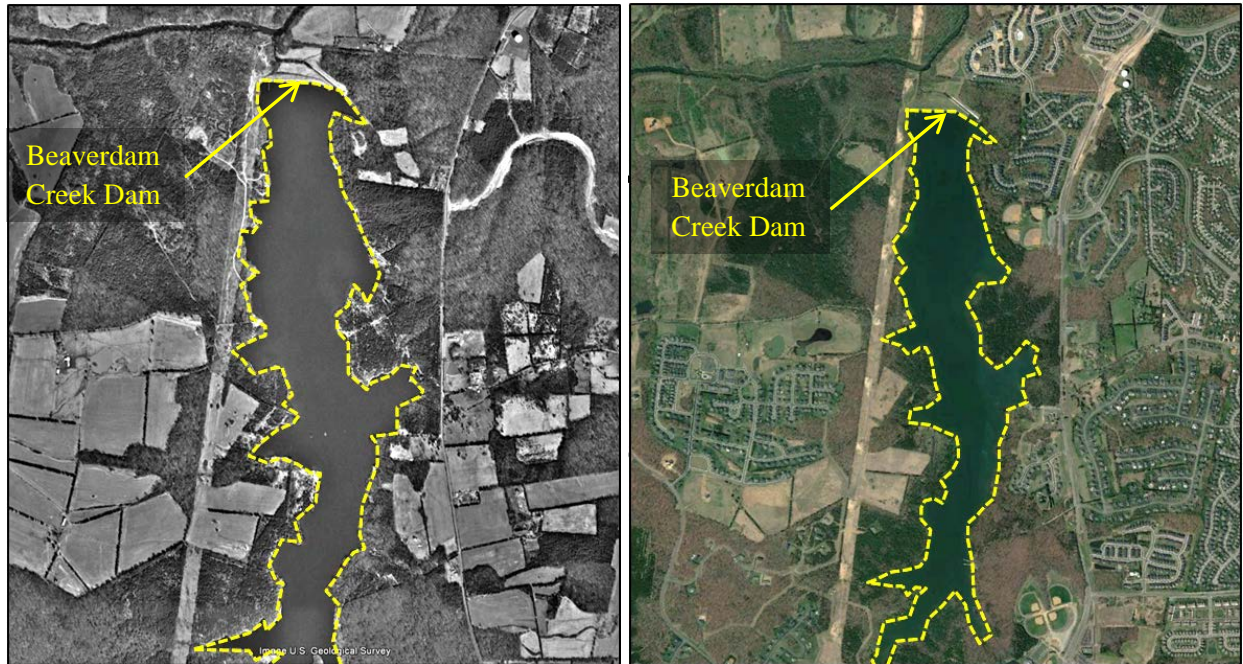


Figure 1: Beaverdam Creek Dam and Goose Creek Dam Location Map

Since construction of Beaverdam Creek Dam in 1972, significant development has occurred in the area surrounding Beaverdam Reservoir. The aerial images of the dam site shown in Figure 2 illustrate the extensive development that has occurred in the area around the reservoir in the past 20 years.



Imagery Source: Google Earth

Figure 2: Beaverdam Reservoir 1995 (Left) Beaverdam Reservoir 2016 (Right)

DEVELOPING THE PUBLIC SAFETY PLAN

Shortly after the purchase of the two dams, Loudoun Water closed the facilities to the public for a period of approximately one year to allow for condition assessment and interim repairs. Loudoun Water recognized the need to address public safety at their facilities and decided to develop a public safety plan. Unfortunately, as of the date of this paper, there were no guidelines for public safety around dams published in the United States. Only recently (February 2017) has the National Dam Safety Review Board formed a Task Force to address this important need. In the absence of national guidelines, the Canadian Dam Association (CDA) *Guidelines for Public Safety Around Dams* published in 2011 were used to prepare the public safety plan for Goose Creek Dam and Beaverdam Creek Dam.

The CDA *Guidelines for Public Safety Around Dams* (CDA Guidelines) do not consider the risks to the public from failure of a dam, or situations related to passage of floods. Rather, the CDA Guidelines address the risks of accidents or incidents, in which a member of the public encounters a hazard created by the presence or operation of a dam. The CDA Guidelines also do

not address the risks associated with operations other than the actual functioning of the dam. The CDA Guidelines follow a risk management process whereby the analysis of risk associated with public interaction at a dam involves the determination of:

- Exposure of people to hazards
- Likelihood of adverse consequences occurring
- Consequences

The CDA risk assessment approach that was used to develop a public safety plan included the following nine (9) steps to evaluate risk and assign a risk level:

STEP 1: Gather Information: In order to obtain a good understanding of the dam sites, Step 1 included collecting existing records, performing site visits, reviewing operating procedures, interviewing stakeholders and persons familiar with the dam sites, and conducting a hydraulic assessment of the facilities.

STEP 2: Establish Boundaries of Site Components: The geographic boundaries of the facility components were identified and documented where hazards were known to be created as a result of the dams' presence or operation. The six component boundaries identified included: (1) upstream areas, (2) reservoirs, (3) the dams and their appurtenant structures, (4) outlet works, (5) spillways, and (6) downstream areas and access roads. A scaled plan and aerial photograph of each dam were annotated to clearly indicate the boundaries of the different components.

STEP 3: Identify Public Activities within Each Component: For each component the assessment identified and documented activities that take place within the boundary of the each component identified in Step 2. The types of public interactions observed included the following:

- Canoeing and kayaking
- Pleasure craft boating
- Sport fishing
- Biking
- Motor bike and all-terrain vehicle motoring
- Camping and hiking
- Wading
- Swimming and diving

Particular attention was given to identifying land and water access routes that lead the public to the hazardous areas. In addition to interviewing persons familiar with the sites, a search of the Internet was made using the names of the dams. This yielded accounts of four fatalities at the dams and several incidences of

hazardous activities at the dams. Several examples of some of the information that can currently be obtained from an Internet search follow:

Internet Example #1. Article from Leesburg Today showing children who trespassed onto the dam and bypassed the security gate and chain-link fence on the access bridge to the intake tower at Beaverdam Creek Dam. The article describes the teens ignoring the signs and rules and shows them jumping from the handrail on the access bridge into the reservoir.

LEESBURG Today

HOME NEWS PUBLIC SAFETY BUSINESS OPINION COMMUNITY LIFE OBITUARIES SPORTS

LOUDOUN LEESBURG ASHBURN TOWNS & VILLAGES SCHOOLS POLITICS SUBMIT A TIP

Home News

Heat Relief: Despite Rules, Teens Cool Off At Beaverdam Reservoir

Advanc

Internet Example #2. Article describing how a mother and her two children drowned at Beaverdam Reservoir.

Mother, 2 children drown in reservoir

By The Associated Press

LEESBURG—A mother and her two children drowned at Beaverdam Reservoir, and investigators are trying to determine why the three were in the water.

The Loudoun County Sheriff's Office identified the victims as Lorena Lima, 28; Ashley Hernandez, 8; and Oscar Lima, 6, all of Manassas.

The three were last seen about 3 p.m. Saturday on the bank of the reservoir in an area where swimming is not allowed, said sheriff's spokesman Ed Pifer.

"We don't know if they were swimming or fell in," he said.

Interviews with witnesses indicated that people nearby became aware of the incident when they heard screams.

Some witnesses "were in there

'We don't know if they were swimming or fell in.'

— Ed Pifer
Loudoun County sheriff's spokesman

while awaiting rescue personnel.

Lorena Lima was pronounced dead at Loudoun Hospital Center in Leesburg. The children were transferred by helicopter to Children's Hospital in the District of Columbia, where they were pronounced dead on arrival.

A soccer game was going on nearby, and the woman's husband

ASHLEY C. HERNANDEZ
SEPT. 11, 1988
AUG. 2, 1997

LORENA LIMA
OCT. 14, 1969
AUG. 2, 1997

OSCAR B. QUINTEROS
APR. 14, 1991
AUG. 2, 1997

Internet Example #3. Article about drowning in Beaverdam Creek Reservoir.

UPDATE: Man's body found in water day after boat capsizes on Beaverdam Creek Reservoir

f t e + 125

Sunday, Nov. 27, 2011 by John Geddie and Matt Vecchio | 33 comments | Email this story

Internet Example #4. Article about family of five being rescued from their boat perched on the crest of Goose Creek Dam.

REPLAY CBS 6 NEWS AT 7 CBS 6 TV SCHEDULE SEARCH CONTACT US

NEWS PROBLEM SOLVERS COMMUNITY EVENTS HEALTH HEROES ON-AIR CONTESTS TRAFFIC WEATHER 65

★ WATCH & WIN: \$1200 GIFT CARD WINNER REVEALED THURSDAY AT 6:30 A.M.

Family rescued from boat dangling on edge of Virginia reservoir

POSTED 11:02 PM, APRIL 11, 2017, BY VERNON FREEMAN JR., UPDATED AT 12:46 AM, APRIL 12, 2017



Onsite information regarding public activities was also obtained and photographed and included the following:

- Garbage (Bottles, cans, bait containers, discarded fishing line, etc.)
- Condition of fencing that showed evidence of climbing
- Signs of vandalism
- Evidence of camping
- Hiking or portage trails
- ATV Tracks
- Vehicle Tracks
- Swinging ropes

STEP 4: Identify the Hazards within Each Component: For each component, potential public safety hazards were identified and documented. The hazards included:

- Rapidly increasing reservoir water levels
- Rapidly increasing reservoir outflows
- Strong currents and undertows
- Submerged hydraulic jumps
- Steep, slippery banks or surfaces
- Floating debris
- Missing or inadequate handrails
- Confined spaces
- Strainers
- Vertical drops from walls and other structures
- Entrapment
- Overflow spillways and spillway channels
- Impact basins
- Gated structures
- Conduit openings

STEP 5: Identify Existing Risk Treatments and Their Effectiveness: Existing control measures were identified and evaluated for their effectiveness. Existing control measures included signs, fences, gates, and patrolling.

STEP 6: Assign Incident Likelihood Rating: For each activity and associated hazard, an estimate was made regarding the maximum reasonable public safety likelihood. This required extensive subjective judgment based on knowledge of the site. A rating of increasing likelihood on a scale of 1 to 5 was used. The CDA definition of likelihood was adopted and varied from “Very Frequent” = 5, “Frequent” = 4, “Occasional” = 3, “Possible” = 2 to

“Remote” = 1. For example, the CDA definition for “Very Frequent” is more than 10 occurrences in the hazardous area in any one of the last 3 years or 25 or more occurrences in total in the last 3 years. For “Remote,” the CDA definition is no known occurrence in the last 10 years.

STEP 7: Assign Incident Consequence Rating: The incident consequence rating was assigned for each activity and the hazard. This was achieved by assigning a rating to the most likely outcome of exposure to the hazard that could reasonably be experienced as a result. A 5-point rating was assessed to each that factored in existing risk treatments that varied from “Fatality” = 5, “Critical” = 4, “Major” = 3, “Minor” = 2 to “Insignificant” = 1.

STEP 8: Determine Risk Rating: The risk rating for each hazard was computed by taking into account both the incident likelihood and the incident consequences using the 5-point rating. This risk assessment methodology is mainly qualitative and subjective because the data necessary to support the calculations is unavailable. Steps 1 to 8 were performed for each known activity and component at both dams.

STEP 9: Evaluate Risk and Assign Risk Level: After the risks were rated in the above manner, an evaluation was made to determine whether the risks were acceptable or if risk treatment measures were required. It is ultimately the dam owner’s responsibility to manage risks within the criteria determined by the owner’s policies or the regulatory requirements. The CDA Guidelines provide the following policies that a dam owner may establish to manage the risks:

1. **High risks** should be addressed immediately in order to bring down the risk to at least the Medium level.
2. **Medium risks** should be reviewed and risk control measures implemented in order to bring the risk down to a Low level.
3. **Low risks** do not require further reduction, but reasonable and obvious measures should be implemented as appropriate.

After the risks were identified, a decision was made on the most appropriate means to mitigate each risk, either by reducing the likelihood and/or by reducing the consequence. The risk treatment and control options included: (1) eliminating the hazards, (2) mitigating the hazards, (3) controlling exposure to the hazards, (4) educating the public, (5) and preparing for emergency response.

RISK TREATMENT MEASURES IMPLEMENTED IN PUBLIC SAFETY PLAN

The following risk treatment measures were taken by Loudoun Water as part of their Public Safety Plan:

- Established restricted areas and exclusion zones in the vicinity of dams and spillways. The exclusion zone at Beaverdam Creek Dam was developed to protect the public from potentially unsafe conditions that can be present during pumped refill or reservoir release operations. The exclusion zones at Goose Creek Dam were developed to alert and warn boaters on the river upstream and downstream of the dam about potentially dangerous conditions that exist in the vicinity of the dam, which mainly relate to the drop over the spillway and the hydraulic roller at the toe of the spillway.



Figure 3: Exclusion Zone / Restricted Area at Beaverdam Creek Dam

- Installed warning signs consistent with the Public Safety Plan recommendations. The general public is not always aware of the potential dangers that may be present around dams. Boaters upstream of Goose Creek Dam may not be aware of the presence of the dam and could potentially be carried over the ogee weir of the concrete gravity dam. Signs such as the one shown below were placed in the vicinity of the dams to alert the general public of the dangers associated with the facility.



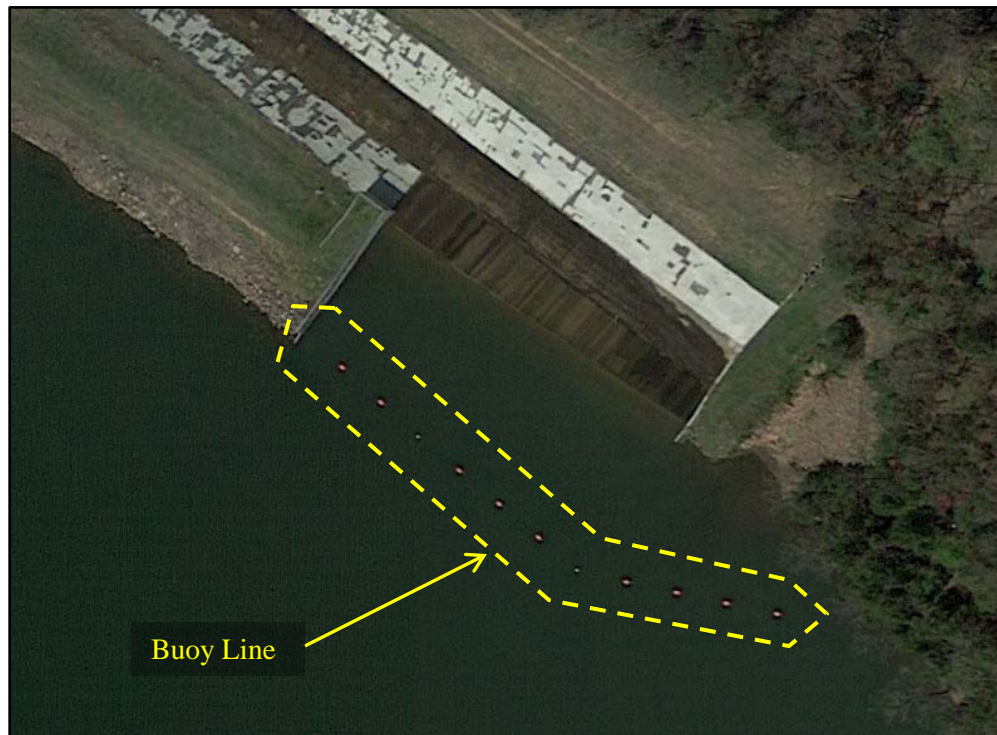
Figure 4: Warning Sign

During certain flow conditions, dangerous hydraulic conditions can develop at the toe of a run-of-the-river concrete gravity dam. Persons swimming, wading, canoeing, or boating at the toe of the dam can become trapped in the hydraulic roller. Loudoun Water installed warning signs in the area downstream of Goose Creek Dam to alert the public of the dangers associated with the recirculating currents present at the downstream side of the dam.



Figure 5: Warning Sign Installed at Goose Creek Dam

- Installed warning buoys and a buoy line in the spillway approach channel at Beaverdam Creek Dam to alert boaters on the reservoir of the presence of the spillway and to create an exclusion zone upstream of the spillway. Dam warning buoys are also positioned on Goose Creek upstream and downstream of Goose Creek Dam.



Imagery Source: Google Earth

Figure 6: Buoy Line at Beaverdam Creek Dam



Figure 7: Safety Buoy at Beaverdam Creek Dam



Figure 8: Warning Buoy at Beaverdam Creek Dam

- Initiated partnership with Northern Virginia Regional Park Authority (dba NOVA Parks) to manage recreational uses on the reservoir and share in enforcement of rules and other safety protocols.
- Engaged and worked closely with law enforcement and other first responders to aid in patrolling the facilities and the effective implementation of the Public Safety Plan.
- Installed surveillance cameras at Beaverdam Creek Dam.
- Repaired and added fences at Beaverdam Creek Dam.
- Altered Standard Operating Procedures to promote public safety: As an example, the 24-inch guard gate on the Beaverdam Creek Dam outlet conduit is maintained in the 95 percent closed position when reservoir discharges are not being performed in order to prevent pets and people from crawling into the pipe.

- Removed graffiti by painting the spillway walls at Beaverdam Creek Dam to discourage loitering and new graffiti.



Figure 9: Graffiti Removal at Beaverdam Creek Dam Spillway

Loudoun Water also implemented the dam safety related measures described below, which affect public safety at and around the dams.

- Developed a formal Operation and Maintenance Manual.
- Programmed regular maintenance into Loudoun Water’s Enterprise Resource Planning Program.
- Updated the Emergency Action Plan (EAP) for Beaverdam Creek Dam and Goose Creek Dam and conducted face-to-face EAP tabletop exercise with applicable local and state emergency management agencies.
- Established a mowing contract to manicure Beaverdam Creek Dam embankment and downstream areas and Goose Creek Dam abutment areas on a bi-weekly basis.
- Performed temporary repair of a non-waterstopped, leaking concrete joint at Beaverdam Creek Dam triangular-shaped spillway weir approach slab to reduce downstream seepage and potential for failure.
- Replaced deteriorated gate valves in Beaverdam Creek Dam control tower to reduce risk of gate failure.
- Added fill to low spot at non-overflow abutment contact at Goose Creek Dam.
- Established emergency and maintenance access to the left abutment of Goose Creek Dam.

ENSURING CONFORMANCE WITH THE PUBLIC SAFETY PLAN

Loudoun Water is committed to organization-wide safety. Loudoun Water ensures conformance with the Public Safety Plan through organizational support, public outreach, partnership with law enforcement and emergency responders, and through the practice of continual assessment of the effectiveness of the Public Safety Plan and the need for additional safety improvements, as described below.

Organizational Support:

The preparation and implementation of the Public Safety Plan around the dams was highly supported by Loudoun Water's upper management; funding needed to implement the safety improvements recommended in the Public Safety Plan was not questioned.

Public Outreach:

Through the strategic partnership with NOVA Parks, Loudoun Water was able to more effectively disseminate information on public safety to recreational users of the reservoirs.

Partnership with Law Enforcement & Emergency Responders:

Loudoun Water has actively worked to engage law enforcement personnel and emergency responders to raise awareness of the Public Safety Plan and to familiarize these personnel with the potential safety hazards present at and around the dams and reservoirs. Some examples of these activities are listed below.

- Facilitated a tour of Goose Creek Dam with Loudoun County Department of Fire, Rescue, and Emergency Management Heavy Technical Rescue (HTR) squad to increase awareness and preparedness in the event that the squad needs to rescue someone trapped in the hydraulic roller of Goose Creek Dam.
- Granted Loudoun County Department of Fire, Rescue, and Emergency Management formal permission to hold open water training activities.
- Paid for Loudoun County Sheriff patrols during peak season (foot, ATVs, vehicles) to discourage trespassing and other illegal activities.
- Worked closely with Virginia Department of Game and Inland Fisheries to facilitate patrols around the reservoirs.

Continual Assessment:

Loudoun Water performs continual internal review of the Public Safety Plan to evaluate the plan's effectiveness and to assess whether the components of the plan are being properly implemented based on prevailing conditions at the dams and reservoirs. A Public Safety Assessment (PSA) for each dam and its appurtenant facilities is performed no less than once every three years to identify potential public safety hazards; however, the PSA is reviewed annually or at any time a safety incident occurs.

EDUCATION AND TRAINING FOR PUBLIC SAFETY AROUND THE DAMS

Internal to the Organization:

All divisions of Loudoun Water were involved in development of the Public Safety Plan and continue to be involved in its implementation and in the continual assessment of the plan's effectiveness.

External to the Organization:

Loudoun Water provides safety training opportunities at the dams for emergency responders. Loudoun Water also provides safety education to the public using various avenues of communication as described below.

- Posting new signage at park entrances, which contain restricted area maps, as well as the rules pertaining to public safety around dams. This arrangement was hugely successful during the first season of implementation (2015). The public's reaction was overwhelmingly positive.
- In the fall of 2015, Loudoun Water and NOVA Parks held the first in a series of community engagement open houses, with the goal of educating the public about dam safety and the ongoing Beaverdam Creek Dam rehabilitation project, as well as solicit feedback for planning future recreational uses and facilities on Beaverdam Reservoir.
- An additional meeting with the community was held on December 14, 2016, during which conceptual-level plans for recreational facilities at Beaverdam Reservoir were presented to the community in order to obtain feedback.
- Loudoun Water engages and educates the public at open houses and through the websites <https://www.loudounwater.org/news/beaverdam-reservoir-temporarily-reopens-may-30> and <http://www.nvrpa.org/park/Beaverdam>.



Figure 10: Open House and Open House Advertisement on Loudoun Water’s Website

ADDITIONAL PUBLIC SAFETY RISK TREATMENT MEASURES FOR BEAVERDAM CREEK DAM

Construction for the rehabilitation of Beaverdam Creek Dam began in November 2016. The project consists of replacing the existing spillway, flattening the embankment and adding an internal drainage system, construction a new transfer pump station, construction of an electrical building, and construction of a permanent stream crossing. The primary objectives of the project were to bring the dam up to current dam engineering standards as required by the Virginia Department of Conservation and Recreation Dam Safety Program for high hazard dams and to improve reservoir release and pumped refill operations. The project also involves the implementation of numerous new public safety improvements, which include the following:

- Removal of an existing access bridge that extends from the dam embankment to the control tower. This is in response to the public using the bridge as a platform for diving into the reservoir, which is extremely unsafe. Attempts were made by the previous owner of the reservoir to install a security gate to prevent trespassers from

accessing the bridge; however, the trespassers where able to bypass the security gate. Based on continued issues with trespassers, Loudoun Water decided the best alternative would be to remove the access bridge.

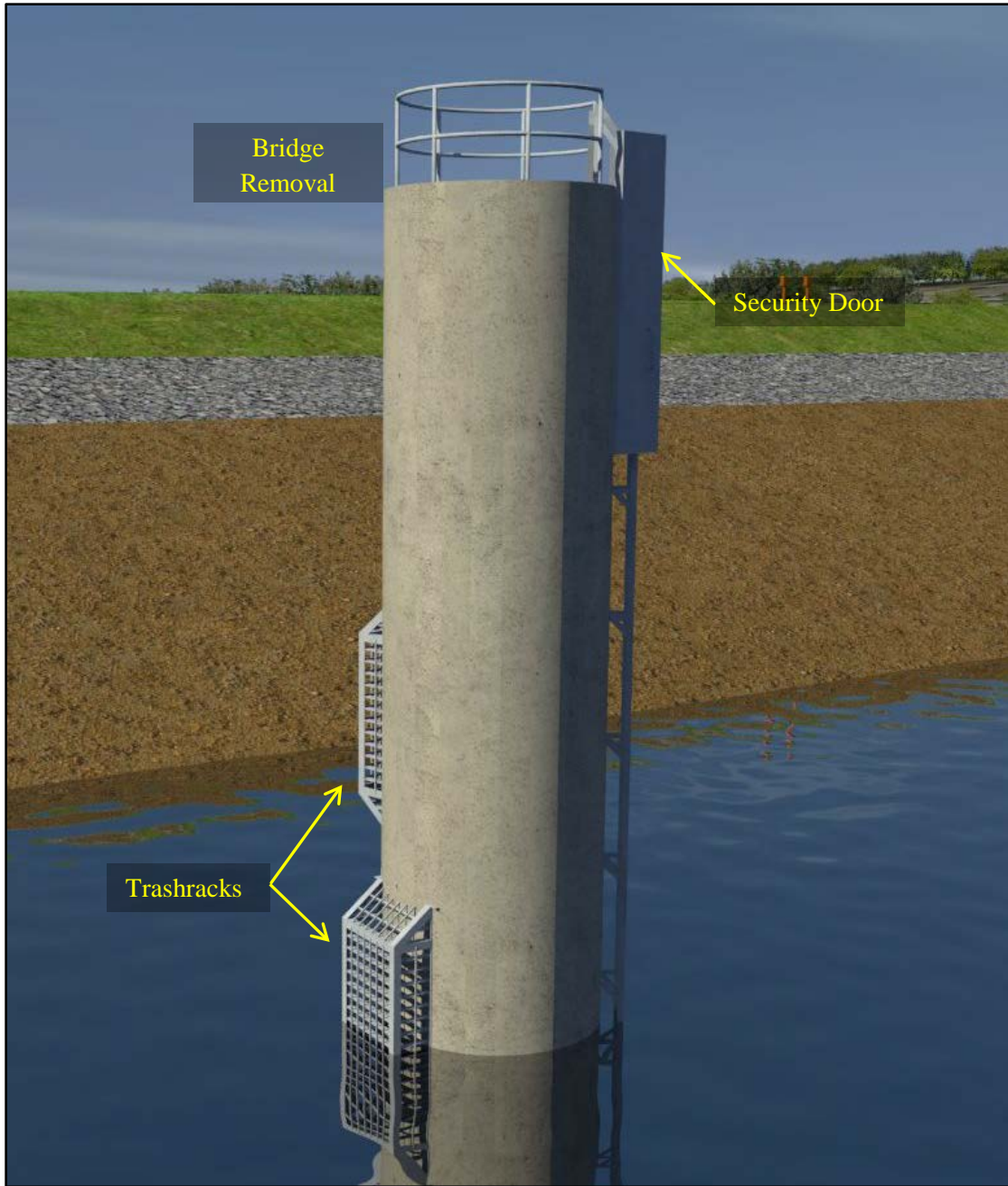


Figure 11: Existing Access Bridge and Security Gate at Beaverdam Creek Dam to be Removed



Figure 12: Close-up of the Existing Security Gate

- Adding a ladder to the exterior of the control tower to allow access to the tower via boat and over a range of reservoir levels. Access to the top of the tower will be restricted to Loudoun Water personnel with the addition of lockable security covers installed at the upper portion of the ladder.
- Trashracks will be added on the exterior of the control tower at two of the gated inlets. The trashracks are sized and designed to maintain safe entrance velocities during reservoir releases.
- The discharge location of pumped refilling operations is being changed to minimize the attraction to the public. The pumping operations currently discharge in a “geyser-like” fashion into the atmosphere from the top of the inlet control tower. The new pumped discharge location will be from the end of a new, submerged 30-inch diameter refill/release pipeline into the new spillway approach channel. A grate will be installed on the end of the reservoir release segment of the pipeline to restrict public access at the location where the pipeline discharges into the new spillway chute.



Note: Reservoir level shown below normal pool for visualization purposes.

Figure 13: Rendering of Control Tower Modifications at Beaverdam Creek Dam



Figure 14: Existing Reservoir Refill Pumping Operations through Inlet Control Tower at Beaverdam Creek Dam

- 13 new security cameras (bullet type and pan tilt zoom type) will be added at the dam site, with remote control and monitoring capability.
- Security lighting will be installed at the dam crest, new labyrinth spillway, and new electrical building.
- Security fencing will be installed around the perimeter of the new labyrinth spillway structure, outlet works impact basin, and spillway valve chamber and pump station facilities to discourage access. Within the fenced areas, secure grating and hatches will be installed to minimize the potential for falling into openings.

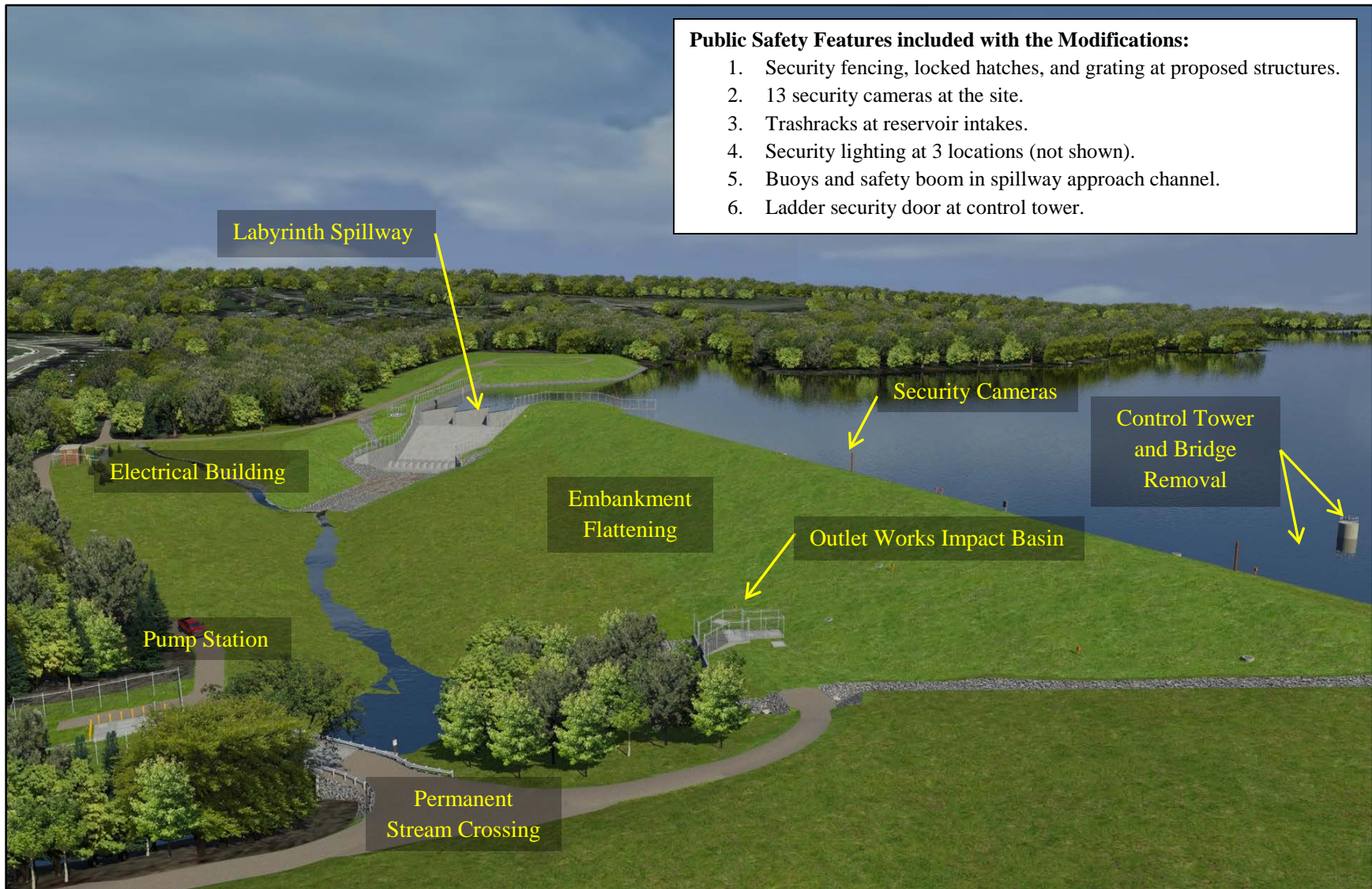


Figure 15: Rendering of Modifications at Beaverdam Creek Dam.

RESPONSE TO AN INCIDENT

Despite the best attempts by an organization to reduce public safety-related dangers at dam sites, unforeseen events can still occur that require reassessment of a Public Safety Plan and public safety features at the dam site.

Loudoun Water installed appropriate signage and buoys to create exclusion zones upstream and downstream of Goose Creek Dam. The signage and buoys allowed boaters to identify the dam and the restricted areas upstream and downstream of the dam. However, in April 2017, a family boating on Goose Creek upstream of the dam experienced engine problems with their small boat, which left the boat disabled and unable to steer clear the dam. Emergency responders were alerted and were able to rescue the boaters before the boat passed over the dam.



Source: LoudounNow.com

Figure 16: 2017 Incident at Goose Creek Dam

Due to the occurrence of this incident, Loudoun Water performed a review of the Public Safety Plan for Goose Creek Dam to assess the effectiveness of the plan and determine the necessary approach to further reduce the likelihood of similar events occurring in the future. Currently a plan is being developed to install a safety boom at the dam to provide a barrier for boaters and to potentially allow boaters in a disabled boat to avoid the dam.

Several previous actions taken by Loudoun Water prior to the incident aided in the rescue of the trapped boaters. The emergency responders had previously been given a tour at the dam site, which allowed them to be familiar with the location of the dam. By maintaining and establishing emergency and maintenance access to both abutments of the dam, the emergency responders were able to access the site respond quickly and effectively to the incident.

CONCLUSIONS

Public safety around dams has become an important topic of discussion due to continuing development around existing dams and increased recreational use of the reservoirs. It is important for dam owners to identify and address public safety concerns at dam sites. An effective public safety plan should be prepared with input from different groups within an organization and the community. The public safety plan should be a “living” document that is consistently reassessed and modified based on new observations at the dam site, new industry standards, and prior experience with public safety-related incidents. Intentionally providing opportunities for emergency responders to become familiar with the dam site, the public safety plan and emergency action plan can prove beneficial if and when an incident occurs. When performing dam safety modifications at an existing dam, consideration should be made to assess and update the public safety features at the dam and reservoir.

REFERENCES

1. Gannett Fleming, “Public Safety Plan for Beaverdam Creek Dam and Goose Creek Dam”, July 2015.
2. Federal Regulatory Commission (FERC), “Guidelines for Public Safety at Hydropower Projects”, November 2011.
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4. LoudounNow, “Family Rescued from Goose Creek Dam”, April 2017.