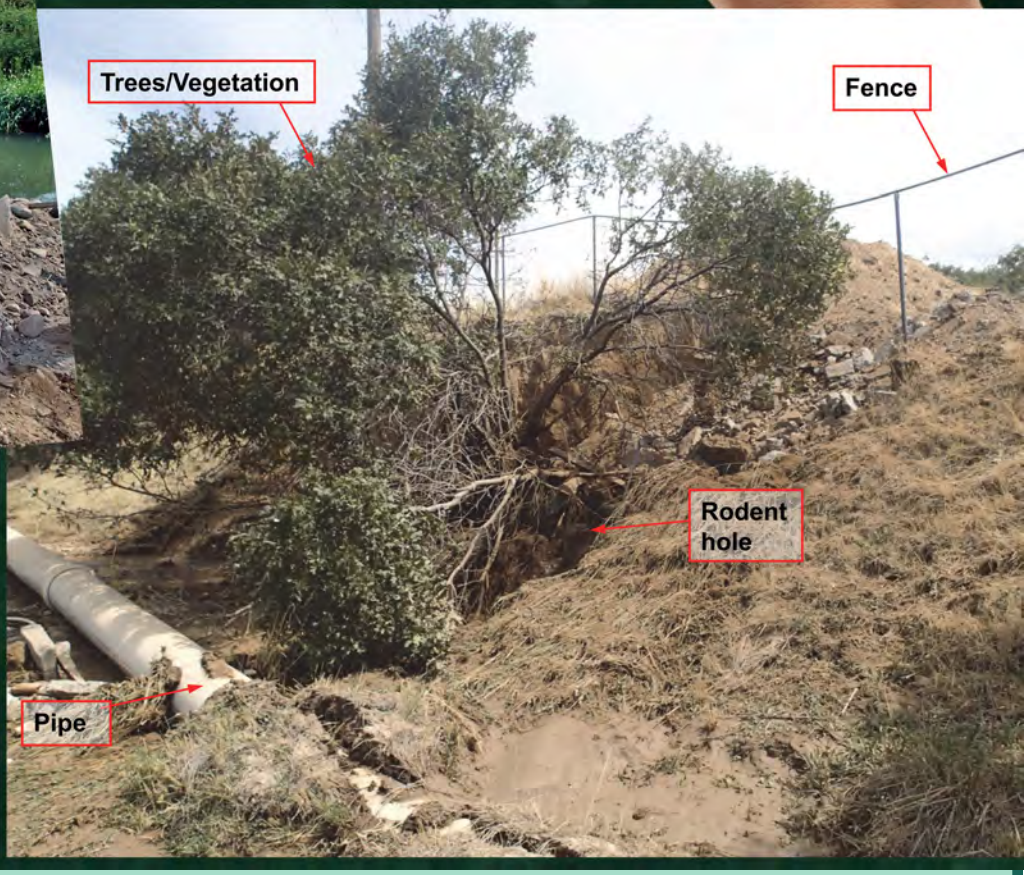
RECLAMATION
Managing Water in the West
Issue No. 241–Spring 2017

Water Operation and Maintenance Bulletin

WHAT WE LEARNED!



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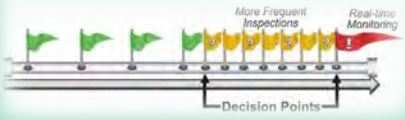

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Thank you.

On the Covers:

Front: Collage of photographs of lessons learned from previous failures.

Back: What to do in a breach.

CONTENT

Haste Makes Wasteway Failures

A Failed Attempt at Hydropower

A low-head small conduit hydroelectric project at the Lewis Wasteway was planned to combine wasteway functions with a small power generating facility. However, this project experienced a breach just as it came online in the V-Line Canal, a Newlands Project feature near Fallon, Nevada. The canal breached in the early morning of April 30, 2015—less than a day after it was first filled. The canal failed from internal erosion caused by scour and backwards erosion along the right side of the penstock unit. All water released through the breach was contained within the wasteway. There was no known property damage except for the damage to the facility itself. As a result of the incident, water releases from Lahontan Dam to the Carson Diversion were terminated.

Many factors contributed to this breach, including:

- Parts of the facility were not constructed as designed. This led to three Stop Work orders by Reclamation, which contributed to project delays that adversely impacted water deliveries.
- The embankment was not fully constructed prior to filling the canal.
- The design engineer was also the contractor and did not have the required experience to design and construct a water-retaining structure.
- The drawings and specifications lacked detail, requiring significant field direction and modification to construct the facility. The contractor was in charge of many competing aspects, which created conflicts of interest and unclear roles and responsibilities.
- The Quality Control Plan was not fully developed.

Original construction was not to Reclamation standards. For example, plastic sheets were used on the right side of the gate structure. (Photo 2/17/2015 by Reynaldo Garcia).

Rebuilding the Canal

At Truckee-Carson Irrigation District (TCID)'s request, Reclamation led the repair design and construction efforts. TCID provided resources for the repair effort. Canal operations were restored two weeks later on May 14th, 2015.

Reclamation and TCID discussing the next phase of the repairs.

Reclamation and TCID installing geotextile liner during the repair operations.

Reviewing Responsibilities

This failure underscores the need for Reclamation, irrigation districts, and contractors to establish clear roles and responsibilities when engaging in projects that result in substantial change to Reclamation owned facilities. Numerous requirements and guidance documents (both Reclamation and industry standards) address projects that represent substantial change to both Transferred and Reserved Works. It is Reclamation's Project Office's responsibility to ensure that these requirements and guidance are adhered to during the design and execution of the project. If circumstances dictate a deviation from Reclamation standards or the approved design, the deviation must be closely coordinated with and accepted by the appropriate Reclamation office. Roles and responsibilities should be clearly delineated in the Project Management Plan that is signed by all the stakeholders. These roles and responsibilities should include:

- Who will ensure compliance with specifications and drawings?
- What quality control and assurance will there be (e.g., information, data requests, testing, control, inspections, oversight, reviews, approvals)?
- What approvals will be provided and by whom before construction and filling begin?
- Who will monitor construction?
- What will the change order process be (submittals, approvals, oversight)?
- Who will be onsite to oversee testing, construction, filling, and operations?

Rebuilding Relationships

After the 2015 V-Line Canal failure, Nevada, Reclamation worked with the Truckee-Carson Irrigation District (TCID) to improve planning, communication, and coordination.

To ensure quality designs, Reclamation's Mid-Pacific region added requirements for Quality Assurance/Quality Control (QA/QC) within its MP620 permit process (Reclamation's Mid-Pacific region-specific permit to add or alter Federal facilities). Now, —districts with transferred or reserved works need to have Reclamation as well as an independent third party review their designs or have Reclamation design and oversee the modification. "*The bottom line is that Reclamation still owns the facility and has a responsibility to ensure quality design and construction,*" says Jack Worsley, Deputy Area Manager, Lahontan Basin Area Office.

TCID and Reclamation have since worked together on several projects, which has helped to repair credibility and trust on all sides. This trust was thrust into action when Derby Dam was threatened in a severe storm in early January of this year. Derby Dam was completed in 1905 and was Reclamation's Design Specification Number 1. Derby Dam can safely pass 10,200 cfs, but storm flows reached 13,000 cfs and threatened to overtop the dam. Reclamation and TCID had planned for emergencies by building a soft plug (a sand core about 200 feet long, 40-60 feet wide, and 12-14 feet high to bypass the primary embankment and spillway, rather than overtopping the dam). Reclamation's Area Office and TCID agreed to remove the plug preemptively to provide a path around the dam for the water. The core turned out to contain frozen clay, which would not have given way easily to the incoming water. So by working together, TCID and Reclamation prevented problems.

In this same flood, Reclamation and TCID worked together to ensure that the canals could handle the storm surge. Before the storm, TCID and Reclamation had conducted a risk assessment of the canal system. During the storm, the canal started breaching at four sites from cross flows. TCID and Reclamation consulted on this risk assessment and determined how to safely draw down the canal. This event ended up requiring only minor repairs and overtopping events in the canal did not result in losses or breaches.

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Yuma Storms Pack a Wallop

Early Tuesday afternoon, September 8, 2015, a severe thunderstorm struck the Yuma, Arizona, area with nearly six inches of rain. Runoff overpowered the mostly empty canal and breached the canal embankments in several locations.

The Yuma County Water Users' Association (YCWUA) is Reclamation's operating entity for the East Main Canal Yuma Project, Valley Division system. At about 7:00 pm that same evening, YCWUA operations center was notified of a breach of the East Main Canal within the East Cocopah Reservation near County 18th Street and Avenue C½. YCWUA management immediately deployed heavy machinery and employees to the scene, where they and tribal officials battled against the rapid water and debris flow in the housing development to rescue and evacuate residents. Thanks to the quick action by the YCWUA personnel and tribal law enforcement as well as the availability of heavy equipment that could be used to transport residents out of harm's way, nobody was harmed by the breach.

The YCWUA worked with the Cocopah Tribe and used large pumps to remove pooled water from the surrounding areas. YCWUA personnel performed excavation of debris and material that was washed into the canal, rebuilt and repaired embankments at several locations that were damaged or breached from the flood waters. YCWUA was prompt in rebuilding the canal embankments, restoring the canal capacity, and returning the farmland to service by Sunday, September 13, 2015 at 4:00 pm.

Facing southerly observing YCWUA O&M personnel repairing a breach in the East Main Canal on September 9, 2015, the day after the storm event occurred.

Facing southerly observing a breach in the East Main Canal embankment about ½ mile downstream of the Yuma County Water Users' Association Headquarters near County 15th Street and Avenue C in Somerton, Arizona. Sediment, storm and canal waters flowed into agricultural fields to the right (west).

A question and answer session with Reclamation's Yuma Area Office and partners revealed some powerful lessons learned from this storm:

1. **What lessons could we pass on to other districts about this canal breach?**

An incident such as this highlights how critical it is for operating entities to have up-to-date emergency management plans (EMPs) for their canal systems. The YCWUA had recently updated their EMP, which included information on emergency causes and progression of decisions, response levels, verification measures, canal evacuation objectives and measures, canal operational information and evacuation planning, equipment and materials availability, agency contacts and a communications directory, as well as canal reach information (descriptions, flow rate information, maps, etc.). The YCWUA reached out to local agencies listed within the EMP for assistance and notification. Due to the YCWUA's diligence, they were able to cut scheduled water orders immediately, adjust operations, work with the Cocopah Tribe to coordinate prompt evacuations, remove water from pooled areas, and repair damaged portions of the canal.

The YCWUA also used their official website and Facebook page to notify the public of the issues and current status of events. The YCWUA continued to keep the public apprised up until the time the canal was placed back into full operation. Being transparent and providing stakeholders with updates helps to minimize uncertainties and concerns, and informs them that a plan is in place to address the issue. This also provided the public with an opportunity to comment and ask questions should the need arise.

2. **How were the repairs made? Could other districts use these methods and benefit from this work?**

Heavy construction equipment such as front-end loaders, excavators, road graders, and dump trucks, was used to remove debris from within the canal embankment and to rebuild damaged portions of the canal. No state-of-the-art equipment was used nor were new types of construction methods used. Having direct access to equipment facilitated the repair process and minimized the need to rent or purchase equipment and materials, which could have slowed down the process.

3. **What should irrigation districts do to minimize damage from storms like this?**

To prevent or minimize the impacts from storms such as these, measures should be taken when possible to redirect runoff away from canals and into over-chutes, under-shots, retention/ detention basins, or other storm systems. Runoff will become more of an issue as the land around a canal is developed due to the increase in impervious ground cover (concrete, asphalt, structures, etc.). Rights-of-way, land ownership, and other information would need to be reviewed prior to any such planning/improvements as this could affect the types of improvements that could take place on the adjacent lands. If there are excessive storm inflows, operations should be adjusted to make space in the canal for incoming storm waters.

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A Very Unlucky Friday the 13th

On Friday the 13th, May 2016, a 17.5 foot-diameter prestressed concrete pipe (PCCP) failed in the Navajo Nation near Farmington, New Mexico. This PCCP featured a double-wire wrap with a 16-gauge steel liner. The pipe was manufactured in the field and installed in 1972. Previous electromagnetic inspections indicated 30 broken wires in 2002 and 60 broken wires in 2010 at this section of pipe.

The pipe rupture blew concrete 100 to 200 feet away, with debris damaging an overhead powerline. 75,000 acres of irrigated land were suddenly out of service. The Navajo Agricultural Products Industry (NAPI) and farmers had just planted their crops, so recovering from this break quickly was vital to save their crops.

Corroded wires on PCCP.

The pipe failure discharged about 1,000 cfs into the San Juan River, with approximately a million gallons of water spilled into the nearby wash. Luckily, the San Juan River flows were not high. Had this happened a month later, the operational consequences would have been even more severe. Even with priority watering and quick response, crop losses were still an estimated $17.5 million.

Emergency Repairs

Reclamation's Four Corners Construction Office, the Navajo Nation, and Bureau of Indian Affairs sprang into action for an emergency repair and replacement. After the pipe failed, the Navajo Agricultural Products Industry (NAPI) immediately closed radial gates near the break. The pipeline was dewatered and the situation assessed. Only two companies could replace the pipe, and Ameron could produce the pipe the fastest. Reclamation's Technical Service Center (TSC) designed the steel pipe replacement sections and worked directly with Ameron to develop manufacturing details and welds.

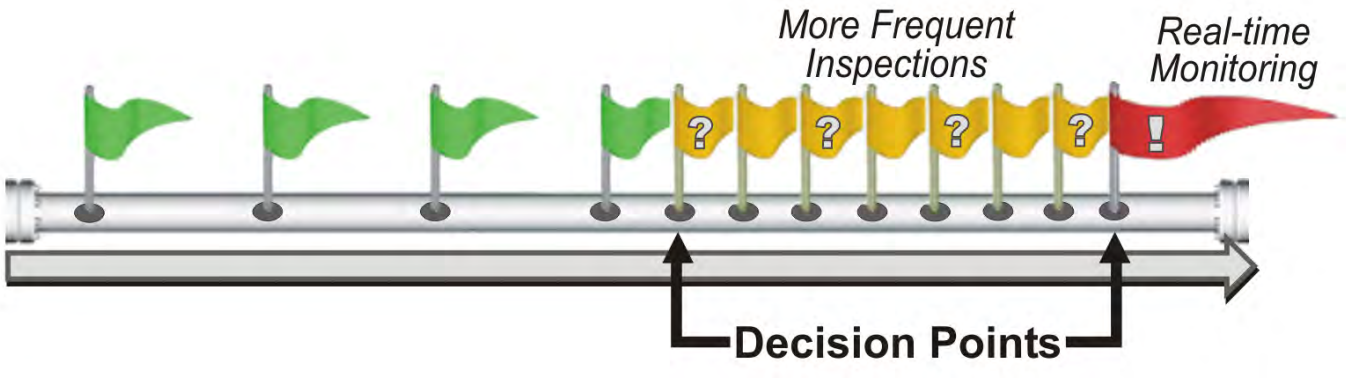
Welders working outside the siphon piping right of centerline.

NAPI spent $1.5 million in emergency repairs to address the breach. The Navajo Nation hired an emergency contractor to perform the work. Crews started pipe repairs immediately, working 24 hours a day to replace the pipe. Replacement steel pipe was used, with a ¾ inch steel plate with a yield strength (F_y) of 36 ksi, where F_y is the allowable yield stress and ksi is thousand pounds per square inch. Four 10-foot sections were welded together and put in place. Reclamation designed a backfill, with service being restored on June 11th, less than 30 days after the break.

Lessons Learned

Insights and lessons learned from pipe inspections on the Kutz siphon include:

- **Determine when more frequent or real-time monitoring is needed.** All pipe, including PCCP, needs to be monitored over its lifetime. More frequent monitoring is needed as the pipe progresses through its lifespan. If there is a history of breaks or if the facility is deemed to be "critical infrastructure," then real-time monitoring may become necessary. As with all infrastructure, decisions must be budgeted for and made as to when a pipeline will require replacing. The figure below shows the inspection frequency over a pipe's lifetime.



Conceptual schematic of inspection requirements over a pipe's lifetime.

Looking at an overall system and planning an inspection and repair program will be easier on budgets than addressing problems piecemeal. Implement a regular inspection program and develop a baseline and then inspect pipes every five to six years. Explore the possibility of obtaining spare replacement sections and materials to address emergency situations quickly.

- **Keep stationing consistent between inspections.** Inconsistent stationing of the testing activities will pose challenges in comparing results.
- **Consider real-time monitoring based upon the findings from previous inspections.** If inspections warrant, install hydrophones or acoustic monitoring systems to provide real-time monitoring.
- **Plan for the eventual repair and replacement.** Use the inspection and monitoring program to determine the extent and location of specific problem areas and identify proactive repairs that can be made to address issues before failures occur. "Run to Failure" is not a recommended practice.

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Coming Together in a Crisis

Strawberry High Line Canal failed in the morning on Tuesday, August 25th, 2015. Reclamation staff in the Provo Area Office and Regional Office responded to reports of a partial breach of the Strawberry Highline Canal in Salem, Utah, at 11:15 am. The cities of Salem, Payson, Spanish Fork, and Utah County worked together and supplied manpower and equipment to help plug the breach and divert water from reaching homes and other structures. Salem City contacted the local High School and church organizations and hundreds of volunteers responded and filled a great deal of sandbags and placed them to channel any potential flows away from homes. Strawberry High Line Canal Company (SHLCC) and Strawberry Water Users Association (SWUA) personnel worked together to obtain material and coordinate the effort.

Breach location and path of water—just upstream of a school, church, and houses.

View of the breach from the crest of the canal embankment. A 2 to 3-inch rodent hole was noticed on the right side of the breach.

Breach in the City

This breach highlights the problems that an urban canal reach can run into. Residences, schools, and other infrastructure have developed downhill from the canal, making potential consequences of a breach greater. Thus, a previously acceptable level of protection provided by canal embankment and routine maintenance practices has become inadequate.

Rodent holes, vegetation on the downhill embankment, and a fence on the downhill embankment that obscured inspections and restricted access likely contributed to the breach. After the breach, the Strawberry High Line Canal Company (SHLCC) has instituted an aggressive system-wide vegetation removal program.

Minimizing risks to people during a breach becomes much more critical in an urban canal setting. Keeping onlookers and bystanders out of the way, while allowing for equipment access presented a challenge. An Incident Command Center was set up near Mt. Loafer Elementary School. Crews went to work filling and placing sandbags in the area of Salem Canal Road and 250 West Road to direct the water away from homes. It was decided that it would be better for the elementary school students to shelter in place. No water reached the Salem Canal Road during the event and no evacuations were required.

Luckily, this breach occurred upstream of very dry orchards near an easy surface street access point. SHLCC, Salem City, and the downstream community acted quickly in their initial response. The breach repairs were completed according to Reclamation and industry standards. Reduced flows were allowed back into the canal after the repairs. An increased monitoring and inspection program was implemented during the first fill of the canal embankment. The new section of embankment performed well for the remainder of the season and continued to be monitored on an increased schedule through the 2016 irrigation season.

Current and future development near the canal demand more actions, to protect the canal and downstream infrastructure, such as a pipe or upgrade of the canal to adequately mitigate the increase in consequences. The SHLCC has been working on plans and a feasibility study to pipe the canal for the last several years.

Don’t Press Your Luck

The Strawberry High Line Canal Company (SHLCC) in Utah got lucky. The good news is that there was no infrastructure immediately downstream, the breach was identified early, and crews were mobilized quickly. The breach was plugged quickly and did not impact homes, schools, businesses, or other infrastructure.

However, the outcome could have been much worse. The SHLCC Emergency Management Plan (EMP) proved inadequate during the emergency response. Shortly after this, the SHLCC drafted a better plan and had it reviewed by Reclamation and accepted by its Board of Directors.

Don’t wait until you have an unlucky day to test your EMP. Your best bet is to have an EMP in place that all involved are familiar with and can work through step by step. Local emergency responders need to be familiar with the plan and the canal so that proper actions can be taken regarding evacuation and other mitigating measures.

Reclamation can assist during an incident response at a district’s request. The extent of this assistance and any notifications that may be made by Reclamation should be formalized before the emergency.

View of the breach from the uphill side of the canal, 12:06 pm, August 25, 2015.

Look around. Is there a crisis right now? No? Then now is a good time to develop or update your EMP.

EMP plans should include:

- Response levels and specific actions to be taken
- Emergency shutdown procedures for specific canal reaches to minimize consequences
- An accurate and current communication directory to quickly notify district staff, Reclamation, and emergency responders
- A list of materials and equipment that can be called on during an emergency

Address other what-if scenarios that apply to your urban canal reaches. Conduct regular tabletop exercises of the EMP to discuss canal breach scenarios with everyone who needs to be involved (such as Reclamation, local public works and emergency responders). May the luck stay with you.

Once More into the Breach, My Friends

During the peak irrigation season, the Strawberry High Line Canal Company (SHLCC) in Utah faced some pretty large economic consequences if their breach didn't get fixed quickly. So they got right down to work.

SHLCC first attempted to plug the breach with two different loads of sandy/silty materials, but these all washed out. They found that the best way to slow the water down was to place large pieces of concrete in a precise location within the breach. A track hoe with a thumb on it was instrumental in doing this. Once some large pieces of concrete were placed to slow the water down, then other fill materials were able to be placed to continue plugging the breach. At around 12:20 pm, a large load of broken concrete and gravel was dumped into the breach, which primarily blocked it. Next, several loads of sandy/silty material were placed and the breach was entirely plugged by approximately 1:00 pm. The canal continued to drain through open laterals until approximately 7:00 pm that night.

Because of high water demands at that time of year, the emergency repair fill had to be excavated after the canal was drained. The next day, Cary Southworth and Bart Leeflang (Reclamation Engineering Division Managers) and Ed Vidmar (Franson Civil Engineers) designed the breach repair and found acceptable fill material for the repair.

The repair was constructed in three days—from August 26 to August 28. SHLCC removed the temporary plug, rebuilt the breached embankment, and watered up on August 29:

View of the breach from the crest of the canal embankment. 12:02 pm, August 25, 2015. Note the large pieces of concrete used to stop the flow out of the breach.

The emergency fill was excavated and inspected.

A 2-3 foot wide key trench was excavated vertically approximately 10 feet out from the canal bank.

Compacting the embankment foundation after excavating the emergency repair fill material.

Placing the first fill lift of embankment material. —8/27/2015 .

After compacting the foundation, one lift of material was placed over the bottom of the excavation from the downstream catch to the key trench.

Embankment repair—8/27/2015.

Compacted lifts of fill material, about 6 inches thick, were placed and tested. Two compaction tests (percent relative to maximum dry density determined by the Standard Proctor) were completed.

Backfill operations showing neat line of clay liner and fill material —8/27/2015.

A clay liner was placed about 2 feet below the bottom of the canal. The inside clay liner extended 5 feet from the inside wall of the canal into the fill for 4 lifts and then was reduced to 2.5 feet in width for the remaining lifts.

As the situation was urgent, compaction tests were limited. The general notes called for a test of every lift—which was not feasible using Sand Cones as the testing method. Despite having a limited number of compaction tests, the inspector documented consistent and acceptable embankment placement, moisture conditioning, and compaction patterns for all lifts. Reclamation's inspector was onsite for the entire reconstruction of the embankment, ensuring consistency in lift thickness, proper materials, moisture conditioning, compaction pattern, and scarification of the compacted initial lift's surface to facilitate bonding with the subsequent compacted lift.

After constructing the embankment, first fill procedures were implemented and the embankment repair was closely monitored. The initial flow rate was 150 cubic feet per second (cfs) (half of the original design capacity), and flows incrementally increased over time.

- SHLCC monitored the canal repair embankment continuously for the first 120 hours (5 days).
- After the initial 120 hours, SHLCC looked at the repair embankment thoroughly (conducted an extensive visual inspection) every 6 hours for the next 72 hours (3 days).
- After the initial 8 days of increased visual observation and inspection, SHLCC reduced visual inspections of the repaired embankment to twice a day for the repair embankment, and this area was identified as a High Priority area for the rest of the 2015 irrigation season until the canal was drained for the winter.

Finished canal embankment— 8/28/2015.

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Connections

Sidney, Montana, breach August 21, 2016

A canal south of Sidney, Montana, breached on August 21. The erosion left a 100 to 150 foot breach and damaged canal embankments.

Lower Yellowstone Irrigation Project Manager James Brower says the final cost for the repairs was more than half a million dollars. Construction crews got the canal operational again in just 12 days to get the canal operational again.

"The amazing thing is, these people moved over 200,000 yards of dirt within only eight days of digging, working 24 hours a day. The quality and the accuracy of what they did is fantastic," says Brower.

More than 30,000 acres were without irrigation, yet Brower was happy to report no farmer lost any crops while the canal was inactive. See the video at:

http://tinyurl.com/sidney-breach

Corrosion Webinar, March 22 at 1 pm MT

Reclamation is providing a webinar on common forms of corrosion, with examples to help you recognize when and where corrosion may occur. We will also review the two main techniques for corrosion control: protective coatings and cathodic protection.

To join on March 22 from 1 to 2 pm Mountain Daylight Time, go to

https://signin.webex.com/collabs/#/meetings/

Enter the Meeting Number: 198 424 840

Audio Call-In: (866) 758-0394
Participant Code: 461 891 0

Various screen shots of the Technical Service Center's Canal Breach Tests videos.

Physical Hydraulic Modeling of Canal Breaches

The Technical Service Center has performed lab and field tests for breaches. You can use a spreadsheet tool for making appraisal-level estimates of canal-breach outflow hydrographs to estimate peak breach outflows for a given canal, using available information on canal hydraulic characteristics, embankment geometry, and embankment soil properties.

See the video of the embankment breach at: http://tinyurl.com/breach-tests

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Kennewick Irrigation District Communicates During Breach

Kennewick Irrigation District has learned quite a bit about breaches, especially after dealing with a rodent-caused breach that inundated three homes. Read about their experiences in the January 2017 issue of the Irrigation Leader at

http://tinyurl.com/Irr-Lead-KID

Watch a video about how they reached out to the public to find out about rodents before the animals caused more havoc at

http://tinyurl.com/NBC-KID

What to do in a Breach?

1. Plan Beforehand

Emergency Management Plan

1. Response Levels
2. Shutdown Procedures
3. Communication Directory

2. Emergency Repair

- Coordinate with officials to handle the emergency
- Stop the flow
- Excavate the repair site
- Place lifts and compact
- Dress the embankment

3. Investigate and Coordinate with Reclamation

Protect Your Infrastructure

- What were signs leading up to the failure?
- What did the embankment look like (seepage, cracks, animal burrows, erosion)?
- What was the loading (earthquake, flood, high water, freeboard)?
- When was the last inspection?

Address the Consequences

- When and what happened?
- Were there injuries, deaths, property damages, or other consequences?
- Are there legal and forensic investigations, and if so, what information do they need?