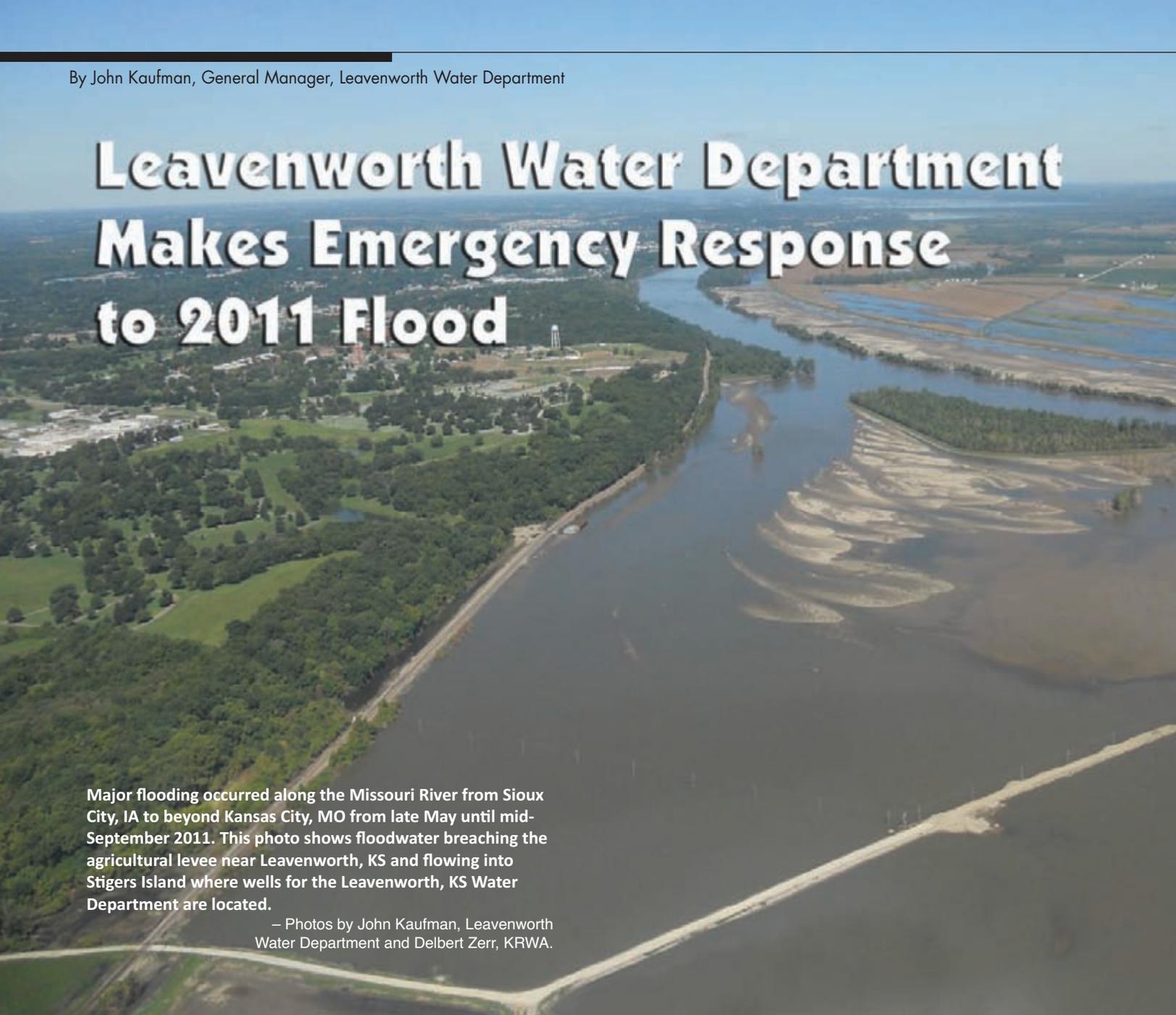


Leavenworth Water Department Makes Emergency Response to 2011 Flood



Major flooding occurred along the Missouri River from Sioux City, IA to beyond Kansas City, MO from late May until mid-September 2011. This photo shows floodwater breaching the agricultural levee near Leavenworth, KS and flowing into Stigers Island where wells for the Leavenworth, KS Water Department are located.

— Photos by John Kaufman, Leavenworth Water Department and Delbert Zerr, KRWA.

Leavenworth, founded in 1854, was the first incorporated city in Kansas. The city is located south of Fort Leavenworth, which is the oldest active Army post west of the Mississippi. Leavenworth is the largest city and county seat of Leavenworth County. The city is located in the northeast part of the state on the west bank of the Missouri River. While most of Kansas was suffering from drought conditions during the summer of 2011, the city of Leavenworth was dealing with more water than it needed, due entirely to its proximity to the Missouri River.

2011 Flood warning from the Corps of Engineers

In May 2011, the Corp of Engineers began forecasting record-high and sustained reservoir releases in response to the excessive snow pack in the upper reaches of the Missouri River basin and record rainfall in Wyoming, Montana, and the Dakotas. Initially, the forecast river stage for Leavenworth was 27 to 33 feet, not including precipitation runoff; in June it was increased to the range of 28 to 34 feet. The river stage at the top of the walkway at the intake for the north water treatment plant is

28.5 feet. Flood stage is 20 feet. The base of the main entrance to the intake is just a couple of inches above this level. The communication and grounding-wire conduits to the intake are below the walkway elevation. A river stage of 29 to 30 feet would overtop the levee that protects the South Plant well field at Stigers Island. The levee is made of non-cohesive soils (sand and silt) and its structural integrity is questionable over a sustained period of flooding.

Choosing to avoid the events and consequences of the 1993 flood which caused considerable damage to the raw



Floodwater flows over the access road to the well field on Stigers Island. The wells are located in the far background along the tree line.



This photo shows a cut being made in the 24-inch transmission line north of the channel scour taking out 340 feet of 24-inch line. The purpose of the cut was to install a by-pass around the failed section of transmission line using 2 parallel lines of 8-inch HDPE pipe. The by-pass is now operational and is allowing us to pull water directly from our wells and deliver the water to the South Plant for treatment.



A worker moved a pipe section with isolation valve into place to prepare for possible flood damage. This valve was eventually closed to prevent surface water from flowing back to the wells when the emergency system which was pumping surface water was activated.

water infrastructure and resulted in significant and extended interruption of water service including strict water rationing, the Water Department designed and constructed emergency backup pumping systems for both of its water treatment plants. These systems and the actions taken are described below.

Overview of Leavenworth Water Department

The Leavenworth Water Department (LWD) provides potable water to the citizens of the city of Leavenworth, Kansas, the Federal Penitentiary, the Veterans Administration medical facility, two community hospitals, and seven neighboring rural water districts, including the city of Lansing. The total population served by the Water Department is about 50,000. The Water Department also provides potable water to Fort Leavenworth and the Lansing Correctional Facility (LCF) whenever emergencies occur. The annual average day

demand normally ranges from 4.3 to 4.8 MGD and the peak day demand occurring in the summer commonly ranges from 6 to 7 MGD. The additional water demands of Fort Leavenworth and the LCF during a water emergency are about 1.0 and 0.5 MGD, respectively.

The Water Department owns, operates, and maintains two water treatment plants (North and South). The Water Department diverts water from the Missouri River at two locations – directly from the Missouri River through a river intake located at the northeast corner of the city, and indirectly through nine wells constructed in the alluvial aquifer located adjacent to the Missouri River southeast of the city. Ground water pumped from the alluvial wells comes from the Missouri River.

The Department’s operations are governed by a five-member elected board comprised of citizens of the city pursuant to state law (K.S. 13-2414 through K.S. 13-2429).

North Plant and Intake

The North Plant is a conventional 5.4 MGD peak capacity lime-softening water treatment plant that is designed to treat surface water. The plant is located near and about 100 feet above the elevation of the Missouri River between the city proper and Fort Leavenworth. The intake structure is located along the western edge of the Missouri River about two blocks south of the North Plant. Raw water is pumped from the intake up to the North Plant through a buried 24-inch diameter transmission line.

Because of past experience with record high floodwaters in the Missouri River, there was every possibility that damage would occur to the North Plant Intake structure by floating debris, causing interior flooding, and loss of electrical power. Knowing that a backup pumping system was needed and used during the 1993 flood, the Water Department constructed an emergency backup surface water diversion and pumping system near the



This photo shows the connections for the by-pass system that is now operational and allowing us to pump ground water from the wells to the South Plant. The surface water diversion and pumping system served its purpose is being dismantled.



The access road to the well field on Stigers Island is under water.



The wellhead shown in this photo is 18 feet above ground.

intake structure. The pumping station is located just west of the intake structure near the Union Pacific railroad tracks. Piping modifications with two isolation valves were made to the raw water line to the North plant. Above a sump pit, a pump header platform equipped with two high-capacity (4 MGD total) vertical turbine pumps was erected. Floodwater can enter the sump pit through a large storm water conduit or overland. The emergency backup pumping system was tested and was fully operational in the event it was needed.

The 2011 flood began in Leavenworth on May 31 and reached a peak river stage of 30.8 feet on June 30 with a corresponding flow of about 240,000 cubic feet per second. Floodwater overtopped the walkway to the North Plant Intake. Water Department staff inspected the intake twice per day for leaks and damage. A fire department boat was used to ferry staff to and from the intake. Access into the structure was achieved by climbing an exterior ladder and entering through a hatch in the roof. Flooding caused minor seepage into the structure, which drops three stories below the river level. This seepage was managed by using sump pumps. On one occasion, a 2-inch conduit into the building was punctured overnight by debris in the river causing the intake to accumulate five feet of water. The

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three high-capacity centrifugal pumps were flooded, but one pump managed to keep operating. Water was quickly removed from the building using a high-capacity sump pump. Once the structure was dewatered, Water Department staff and contractors were summoned to inspect the pumps and other equipment for damage and to dry the electric motors. Quick action by Water Department staff and others narrowly prevented the intake from being shut down and therefore, the backup pump station was not activated.

South Plant and Well Field

The South Plant, located about five miles south of the north plant, is a conventional lime-softening water treatment plant with a peak capacity of 5.5 MGD. This plant is designed to treat ground water. During normal operations, the treatment duration for a given volume of water at the plant is about four hours; the plant is normally used to meet peak demands in the water storage and distribution system.



These pipes are a part of the emergency pumping system used to move surface water to the South Plant.

Raw water is supplied to the South Plant by ground water diverted from the Missouri River alluvial aquifer. The ground water is pumped from nine high-capacity wells located along the northeast extent of a large fluvial deposit called Stigers Island. Protecting the wells from the Missouri River is an agricultural levee that extends for miles south along the river. Each of the wells in the well field was constructed so that the well head extends to a height of

about 18 feet above the ground surface to protect the electrical components of the well pumps and to prevent floodwaters from directly entering the wells. Raw water is conveyed from the well field to the South Plant through a buried 24-inch transmission line.

Knowing that the South Plant operations were shut down due to the 1993 flood, the Water Department constructed an emergency backup surface-water diversion and pumping

system next to the well field access road. A strategic location was selected that was not damaged by the 1993 flood. Modifications to the raw water pipe line were made to allow the emergency pump system to be connected. In a nearby excavation, a 14-foot gravel-lined and covered sump and 2-MGD submersible pump were installed along with the necessary power pole, power supply, and electrical controls to operate the pump.



The floodwater at the river intake at the North Plant overtopped the walkway. Access to the intake structure was through a hatch in the roof. Flooding of the pumps was the result of damage to a 2-inch conduit that allowed a steady stream of water to enter.

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The Navy ship door that was installed years ago prevented flood water from entering the north plant intake structure. Also note the ladder on the side of the structure that was used by city staff to gain entry during the flood.



This photo shows the relative location of the intake structure to the emergency pumping station for the North Plant. The emergency pumping station is in the foreground near the Union Pacific RR Tracks. The emergency pumping station performed adequately when test operated but was not needed because even though all three raw water pumps were under water, one continued to operate delivering water to the plant.

The emergency backup pumping system was tested and was fully operational in the event it was needed.

Flooding of Stigers Island and the well field began as the Missouri River eroded the ballast beneath the Union Pacific railroad tracks at the northern extent of the levee. Shortly afterward, the levee near the railroad tracks was overtopped. With continued flooding, overtopping led to down cutting and eventual breach of the levee. In less than a day, the northern portion of the Stigers Island filled with water and was dammed on the south by the well field access road embankment. Sand boiling and overtopping eventually caused the road to fail in several locations. Sand boiling also led to deep scour erosion (approximately 40 feet deep) in at least two locations along the road. On the morning of Saturday, August 6, the Water Department lost water flow from the well field. Upon site inspection, one power pole was found bobbing in the torrent of flow cutting through the access road. Although not visible beneath the floodwaters, the 24-inch ductile iron pipeline (slip-joint) likely failed by collapse into the channel scour.

To power up the backup pumping system, Water Department staff worked 24 hours in 15 feet of fast-moving water to close a 24-inch isolation valve to ensure that water produced from the backup system flowed to the South Plant and not back toward the well field. From August 7 to September 27, the Water Department diverted 1.2 to 1.7 MGD of surface water to the South Plant for treatment and pumping into the water distribution system. Treatment was aided by the extensive use of costly polymers to control turbidity. By mid-September, floodwaters receded in the well field area and the water pumped to the South Plant came from a large sand boil believed to be about 40 feet deep and several hundred feet wide. The receding floodwaters also revealed that 340 feet of the 24-inch transmission line was gone. With partial restoration of the access road to the well field completed, a temporary bypass around the transmission line break was installed using two parallel, 8-inch HDPE pipelines; each line is 1,500 feet long. Once again, the water is being produced from the supply wells, which were not damaged by the flood.

It will be some time before the transmission line and levee are repaired and the well field is returned to normal operations. Meanwhile, the Water Department is continuing to produce sufficient water to satisfy the current needs of its many customers. The proactive approach the Water Department undertook obviously prevented a severe water shortage, especially considering the fact that so many entities are dependent on Leavenworth for water. Dedicated contractors, suppliers and staff members of the Water Department are commended for the action taken as the floodwater was approaching the city.

John Kaufman has been manager of LWD since June 30, 2008. He previously worked in the mining industry and in water resources consulting. He also served on the Board of Directors of the East Cherry Creek



Valley Water and Sanitation District in Centennial, CO. He holds a Bachelor's Degree in Geology from the University of Kansas and a Master's Degree in Geological Engineering from the Missouri University of Science and Technology.

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