For a while in 1983, sheets of plywood were all that kept the mighty Glen Canyon Dam from overflowing

The first public sign that something was up came in the form of a short story in the Arizona Daily Sun in Flagstaff. It was only six paragraphs, but it appeared on the front page above the fold:

"Glen Canyon Dam Water Releases to Increase," the headline read.

It was June 2, 1983, and the story didn't even begin to hint at the drama that was about to unfold.

"PAGE — Early snowmelt due to higher than normal temperatures is forcing the earlier than normal release of water from Glen Canyon Dam here, authorities said Thursday."

Almost every word was an understatement.

"The water releases were to begin at noon today and (Glen Canyon recreation area superintendent John) Lancaster said they could go as high as 38,000 cubic feet per second," the story said.

The releases were likely to continue for the next month and campers along the Colorado River were advised to seek higher ground and secure their boats.

Two weeks earlier, embattled Interior Secretary James Watt had paid a visit to Glen Canyon, the nation's second highest concrete arch dam, to celebrate the 20th anniversary of its completion.

Soaring 710 feet and anchored in Navajo sandstone, the dam was conceived in desert thirst, born into controversy, and swaddled in argument.

The debate over Glen Canyon Dam was not just emblematic of the new American West, but part of its fabric.

On one side, Native Americans and environmentalists decried the loss of a pristine canyon filled with sacred and historic sites and an ecosystem as beautiful and enigmatic as the Grand Canyon. On the other, developers and chambers of commerce argued for the need to protect downstream users from flooding and to provide the water and power needed to turn small desert cities into the sprawling metropolises they've become today.

By June 1983 the debate had long been settled in favor of growth, but there was a new question looming: Could people safely control nature? It was a question fueled by nature's unpredictable wrath as 8 trillion gallons of water in one of the nation's largest reservoirs bore down on 10 million tons of concrete in one of the nation's largest engineering marvels.

It was uncharted territory for both people and nature, and the stakes were high.

Within a month of the AP news story, water in Lake Powell would come within inches of topping the dam's massive spillway gates as engineers frantically tried everything they could think of, rigging 4-by-8 sheets of plywood to extend the top of the gates and releasing more than half a million gallons per second into the Colorado River.

Before it was over, the force of the water releases would gouge house-size holes in the dam's crippled concrete spillways. The white water would tinge red from the bedrock sandstone, and ominous rumbling sounds would be heard as boulders the size of cars belched from one of the spillways into the river.

The more water the engineers released, the more damage they did. But they had no choice.

“We were sitting on a pretty good catastrophe waiting to happen,” said Art Grosch, an electrician who worked at the dam and ran electrical cable into the mangled spillways.

“That lake (Powell) is 190 miles long and has something like 2,300 miles of shoreline,” he said. “And it was rising a foot a day.”

The looming 'Black Swan' event

These days it’s hard to imagine what Lake Powell would look like full. More than 20 years of historic drought brought water levels down 145 feet below the capacity, leaving a visible reminder in the form of the chronic white “bathtub ring” on the canyon walls showing where levels were before the drought.

Growing demand for water and the effects of drought have raised the question of whether Lake Powell will ever reach its full capacity again, but an unusually snowy winter and a wet spring this year have pushed water levels higher, to within about 80 feet of capacity. And though they're nowhere near 1983 levels, scientists,engineers and Reclamation officials are once again talking about “what-if” scenarios, particularly as climate change triggers extreme, unpredictable shifts in weather patterns.

A new report from the Colorado River Research Group, a consortium of scientists dedicated to providing "an independent, scientific voice" about the future of the river, notes that while much of the focus of the last two decades has been on drought, "(p)erhaps less appreciated are the risks of catastrophic flooding in the basin."

"Although weather prediction and water resource management plans have improved and been revised following the events at Glen Canyon Dam, there is nevertheless the possibility that an unusually large flood might occur in the basin headwaters," the report states.

"Even if Lake Powell and Lake Mead remain low, megaflood risk persists and is likely to be increasing. Precipitation intensity, and the amount of precipitation falling in the most intense events, are increasing globally and across the United States, in large part because sea surface temperatures and atmospheric water vapor content are both rising, increasing the odds of more extreme precipitation events. These trends will continue as long as emissions of greenhouse gases to the atmosphere continue."

Such a flood would be a longshot, what's called a “black swan” event — something so incredibly rare as to be almost unimaginable. But the thing about a black swan is that you never see one until you see one, and in the late spring of 1983, the engineers at the U.S. Bureau of Reclamation were about to get a close-up look.

An El Niño stronger than any other

This particular black swan originated more than a year earlier in the Western Pacific Ocean in the form of an El Niño, a cyclical weather pattern that typically occurs every five or so years.

It’s known in climatological terms as a southern oscillation. In normal years, high pressure along the coast of South America and low pressure near Australia cause the trade winds in the tropics to blow from east to west across the Pacific, pulling colder water from deep in the ocean to the surface.

In an El Niño year, those pressure systems shift, causing the trade winds to subside and sometimes even reverse direction, which pushes warm ocean currents eastward, toward North and South America. When those warm currents interact with high or low pressure systems, it can produce storms with massive amounts of energy — and rainfall.

WHAT ARE THEY? El Niño and La Niña and what they mean for Arizona weather

The 1982-83 El Niño was the strongest ever recorded at the time. The tales of its fury were recounted in newspaper headlines of the day — and later in books and scientific journals — as it unleashed disaster on virtually every continent, from searing droughts in Australia, Africa and south Asia, to violent floods in South America.

It was even linked to an increase in shark attacks off the coast of Oregon and a spike in bubonic plague in New Mexico.

The 1982-83 El Niño punished islands in the tropics with torrential rains that lasted for weeks on end, and as it pushed eastward, it lashed Hawaii with its first hurricane in more than a quarter of a century.

As it reached North America, the warm, moist air pushed by the currents collided with the jet stream, unleashing storm after torrential storm, battering the California coast, swamping off-shore oil rigs, and spawning deadly mudslides.

Normally, the storms play themselves out as they cross the coastal mountain ranges, and spend their last hurrahs on the western side of the Sierra Nevadas, leaving little moisture for the arid West.

But there was nothing normal about this El Niño.

In the winter of 1982-83, the jet stream pushed the Pacific moisture well into the Rocky Mountains and other ranges in the West, where it fell in the form of unprecedented snowfall that was three times the average. Some places in Colorado recorded total snow accumulations of nearly 70 feet.

In a normal spring, the last major snowfall in the Rockies occurs around the end of March. As temperatures rise in the lower elevations, the snowpack melts slowly and creates a steady stream of runoff as temperatures rise into the higher elevations.

But there was nothing normal about the spring of 1983.

The late-winter snowfall of January and February was actually below normal, but in early March it accelerated and didn't quit until May. And then, instead of increasing gradually, temperatures skyrocketed.

Instead of a slow, steady flow down from the mountains, the runoff gushed.

The black swan had spread its wings and taken flight.

There was so much water from the Wasatch Range in Utah that the Great Salt Lake rose 4 feet, and officials in Salt Lake City literally turned two downtown streets into canals to handle all the runoff.

In the Rockies, every tributary of the Colorado River was running high and fast, and the Colorado itself was running at 100,000 cubic feet per second — enough water to cover the entire 517 square miles of Phoenix in 6 inches of water in less than a day.

And all that water was barreling into Lake Powell toward a choke point only a quarter of a mile wide. The only thing in its way was Glen Canyon Dam, which had only been completed 20 years before and had only been filled close to capacity once.

A scenario grows worse – and then 'worst'

Tom Gamble remembers standing on a platform watching the water burst from the spillway into the river.

He was the chief of dam operations for the Bureau of Reclamation at Glen Canyon. He'd been there for seven years and had never seen that much water coming into Lake Powell.

"I get a call from the water people saying we're going to get another 400,000 acre-feet," Gamble recalls.

"That in itself is not a killer," says Gamble, who is now retired and living in Northern California.

“Then a few days later we get a call saying there’s an additional 400,000 acre-feet on the way. Then they kept increasing the estimates. At one point 400,000 became 800,000. The forecast kept going up and up.”

An acre-foot is the amount of water it would take to cover an acre one foot deep. There are nearly 326,000 gallons in an acre-foot. That initial forecast of 400,000 acre-feet meant an additional 130 billion gallons of water was about to flow into the lake. That’s enough to fill 13 million backyard swimming pools. Then 13 million more. Then 13 million more and 26 million more, enough to make the lake's water level rise about a foot a day.

Dams don’t just control floods in wet years, they also store water for dry ones, and a big part of the bureau’s job is to manage water for the arid West. It’s a tough balancing act. Release too much water downstream and you might not have enough for the future. Release too little and the downstream users — farmers and ranchers, cities and towns — may not have what they need.

THE MIGHTY COLORADO: A journey into the river forever changed by human hands

But there are other risks of not releasing enough water: If the reservoir behind the dam gets too full and the water tops the dam, it can cause catastrophic damage to the hydroelectric generators and other infrastructure below. That effect would cascade downstream, putting pressure on other dams and flooding the low-lying areas those dams were designed in part to protect.

That’s what Gamble saw as the worst-case scenario as the water kept coming.

Others feared even worse.

An article in High Country News, which covered the crisis extensively, suggested that the torrential runoff could lead to the failure of smaller dams upstream, and that the resulting tidal wave could swamp Glen Canyon Dam and then Hoover Dam, hundreds of miles downstream.

Years after the episode, the late environmental author Philip Fradkin voiced the same fear.

In a Los Angeles Times article headlined “The year the dam (almost) broke,” Fradkin said the flooding threatened the dam itself.

“The ghost of the untamed river had almost achieved what Edward Abbey, author of 'Desert Solitaire' and 'The Monkey Wrench Gang,' and his radical environmental followers had fantasized — the destruction of Glen Canyon Dam,” he wrote.

Still others suggested that the concrete failures in the crippled spillways could lead to the erosion of the soft sandstone around the dam, leaving the dam standing alone like a 700-foot-high concrete tooth, with the river flowing around both sides of it.

Gamble said none of those prospects ever entered his mind.

To start with, he'd met the man who designed the dam. Louis G. Puls was a longtime bureau veteran who'd had a hand in building most of the big dams in the West, and Gamble said his confidence in what Puls built was unwavering.

Puls himself had told Gamble that the sandstone around the dam had been extensively pressure tested, and that even with the natural cracks and fissures, it was five times stronger than the concrete in the dam.

As for the concrete, there was nearly 5 million cubic yards of it — 10 million tons — anchored 200 feet below the surface of the river. At the bottom it was 300 feet thick.

If the 555-foot-tall Washington Monument were made of solid concrete, it would take 123 of them to equal the amount of concrete in Glen Canyon Dam.

Glen Canyon was the last of the bureau's big dams to be built, and Puls had been with the bureau since the Great Depression, when there were a lot of engineers looking for work and the federal government had its pick of the best and brightest.

“Those guys didn’t fool around,” Gamble said. One of the things Puls did was calculate how much the dam would move or settle once the water started flowing into the reservoir and putting pressure on the structure.

“Even in retirement, he’d been getting data from the Bureau and plotting the movement of the dam on a chart. He showed up in my office one day — he’s a big guy, chomping on a cigar, and he wanted me to see his chart. He was proud that the dam did exactly what he’d anticipated it would do.”

A dam built for the ages

But just because the dam wasn’t about to break doesn’t mean it wasn’t about to bend, figuratively speaking.

Gamble and his team were already releasing the maximum amount of water possible, about 40,000 cfs, through the eight massive turbines in the dam’s power plant. But as more and more water gushed into Lake Powell, Gamble knew he would have to begin releasing water through the dam’s two spillways, two massive tunnels bored into the sandstone on either side of the dam and running parallel to the river.

The spillways are 41 feet in diameter — picture the height of a Boeing 737 from the runway to the tip of the tail — and extend more than half a mile, beginning about 600 feet upstream of the dam and emptying out a few hundred feet on the downstream side.

Each tunnel is lined with concrete 3 feet thick and is controlled by colossal steel gates at the top — 52 feet tall and weighing 350,000 pounds — that control how much water is released. At the bottom of each is a “flip bucket,” a sort of 40-foot ski jump that sends the water into the air before it hits the river, dissipating its energy and controlling erosion.

The first third of each spillway tunnel drops more than 500 feet in elevation from lake level at a 55-degree angle beforeintersecting with horizontal tunnels that were originally drilled to divert water around the dam while it was being built.

The upstream portions of the diversion tunnels, which connected directly with the reservoir, were sealed with giant concrete plugs more than 150 feet long. Using the original diversion tunnels allowed the bureau to save time and millions of dollars by not having to drill thousands of more feet and line the new tunnels with concrete.

When the spillways are wide open, they are capable of releasing 276,000 cubic feet of water per second, more than 2 million gallons a second, from the reservoir. That number was based on detailed studies of peak flows down the Colorado through history, both the 100 years of recorded history by man and the eons of geologic history recorded in the strata of the canyon walls.

According to a design report from 1961, the 276,000 cfs number was 1.7 times the highest flow ever recorded on the river. In other words, the spillways were built to handle 70 percent more water than had ever been seen before on the Colorado.

It was little wonder then that Tom Gamble's faith in his dam was unshakable.

'That dam did not shake'

On June 2, as the water surged toward the dam, it was just inches below the spillway gates.

Engineers opened the left gate and began releasing 10,000 cfs, enough to fill 450 backyard swimming pools every minute, but still only a fraction of capacity. Three days later, they doubled the flow to 20,000 cfs and planned to open the gates even more.

But early the next morning, on June 6, engineers began to hear strange rumbling noises from somewhere deep in the dam works. Some said they actually felt the dam shake, though the dam's monitors detected no evidence of any unusual vibration.

“I guarantee you the dam did not shake,” Gamble says. “There’s 4.9 million cubic yards of concrete in that dam. If it ever did shake, it means the world’s coming to an end.”

Still, the noises were troubling enough for technicians to call Gamble at home in the middle of the night.

As the sun came up, Gamble stood on a platform above the spillway, which for two days had been sending an elegant arc of white water into the river below.

But in the early morning light, Gamble could see large chunks of something — probably rocks or chunks of concrete the size of office chairs — being ejected into the river. And the white water had taken on a reddish tint, a hint that the spillway’s 3-foot concrete lining had somehow been breached and the native red sandstone that gave the Colorado its name was washing into the river.

Something was clearly wrong, but Gamble didn’t know what.

“I’m not worried about the dam,” he told The Arizona Republic in a recent interview. “I’m worried about what’s going on that I don’t understand.”

Despite the rising river, he ordered the spillway gates closed and placed a quick call to the bureau’s regional headquarters in Denver. A team of experts arrived that afternoon.

What they would find would make the decision to save money by using the original diversion tunnels seem penny-wise and pound foolish.

Too much damage to use the tunnels

Bureau hydraulic engineer Phil Burgi landed in Page just hours after Gamble's phone call and went straight to the dam. To inspect the spillway, he had to be winched down the 55-degree incline in a wheeled cage-like buggy that was tethered by steel cable. Everything looked normal as he followed the contours of the massive tunnel.

As he descended, though, he found a small hole in the lining of the spillway that had been gouged out by water.

Several feet past that hole was another hole, larger than the first, and beyond that one was another that was still larger.

When he got to the bend where the spillway flattened out, he saw "a fairly good hole, 10 to 12 feet long and 2 to 3 feet deep." It was so big his cart could go no further.

Before he entered the tunnel, Burgi had a hunch about what was happening. His observations confirmed it.

Before he left the tunnel, he looked above the first hole and found a quarter-inch bump in the concrete that he described in a later report as a calcite deposit.

That tiny bump, 2,000 times smaller than the diameter of the tunnel, had unleashed a devastating phenomenon known to hydraulic engineers as "cavitation," a testament to the power of water.

Just as water carved mile-deep canyons along the course of the Colorado River, so it gouged huge chunks out of the left spillway, although through a different process and one that took days instead of eons.

Cavitation occurs when water flowing down a smooth surface encounters a bump or rough spot. As it flows over that bump, a vacuum is created. When the vacuum breaks, it sends shockwaves into that surface.

With the water in the spillway moving at more than 100 mph down the steep upper portion of the chamber, it didn't take long for millions of vacuums to form and break with enough force to weaken the concrete and gouge the first hole.

As the water continued to cascade over it, the hole grew, scoured by loose sand, gravel and concrete. That hole in effect became a second bump in the concrete and spawned its own cycle of cavitation destruction.

And that, in turn, created an even larger hole and more cavitation further down the tunnel. With each hole, a new larger hole was gouged further down the tunnel.

The rumbling noises that were heard coming from deep within the damworks were the sounds of water jackhammering progressively gargantuan holes inside the spillway and sending massive chunks of concrete hurtling through the tunnel, the very same projectiles that Gamble had seen shooting into the river.

For Burgi, there was only one thing to do.

"I remember coming back up with another design engineer and saying we can't release any more water through this tunnel," Burgi says.

Sheets of plywood buy engineers time

It was news no one wanted to hear.

"The lake's rising a foot a day," Burgi recalls. "We're inches from top of (spillway) gates."

If water topped the spillway gates, it could result in an uncontrolled flood downriver with potentially devastating consequences.

They had to think of something fast. And, being engineers, they did.

Burgi and Gamble don't remember who came up with the idea, but it was a textbook example of seat-of-your-pants engineering.

In order to keep the water from topping the massive spillway gates, they would extend the tops of the gates. With plywood.

One set of crews was dispatched to round up all the angle iron they could find, and another was sent to round up all the 4-foot-by-8-foot sheets of marine-grade plywood they could find. Welders used the angle iron to form frames for the plywood sheets, which were then bolted into place. It took less than a day.

The new 4-foot-high flashboards leaked at the seams, but they were enough to hold the water back. They also bought the bureau precious time.

But not much.

Late spring rains had accelerated the runoff even more, the lake level was still rising, and weather forecasters were predicting even more rain in the mountains.

By June 8, they were out of options. They would have to release more water, and both spillways would need to be used.

Burgi and the emergency team calculated that they could release 6,000 cfs through each spillway for several months before incurring serious cavitation damage.

Without knowing when the runoff would slow, the decision was made to keep the right spillway in reserve and push the bulk of the releases through the already damaged left, in effect sacrificing it for the greater good of the dam.

For a week beginning on June 16, the right spillway was held to 6,000 cubic feet per second, while the left went from 12,000 to 23,000 cfs as needed.

During that week, engineers would also increase the height of the flashboard structure to 8 feet from 4 feet, replacing the plywood with metal. That bought 4 additional feet of water storage, or 1.3 million acre-feet, enough to cover the entire city of Phoenix in 4 feet of water.

The river rapids created by the releases were so intense they enticed three daredevils to challenge them in a wooden dory, a tale chronicled by author Kevin Fedarko in his book, "The Emerald Mile."

By June 27, the amount of water flowing into Lake Powell reached 111,500 cubic feet per second, and there was no end in sight.

"It didn't matter if the spillway was damaged or not. We had to get water out," Gamble recalls.

At 7 p.m., the releases from the left spillway were increased to 25,000 cfs, and by the next morning, the rumbling noise from the left tunnel had increased dramatically. The loud thumping sound could be heard all the way at the top of the dam.

At 9 a.m., they increased the flow on the left side to 32,000 cfs.

Burgi and Gamble [described what happened next in a report]() they wrote after the fact:

"Within 50 minutes the left spillway bucket suddenly stopped flipping the jet and the water downstream from the spillway bucket turned an ominous amber color as the jet carried chunks of concrete and sandstone into the river."

As more and more debris broke loose from the cavitation, it had accumulated in the horizontal portion of the left spillway, creating a condition known in fluid dynamics as a hydraulic jump. The phenomenon occurs when fast-flowing water, in this case the water traveling down the steeply angled portion of the spillway at more than 100 mph, either hits a blockage or is routed into a channel that's too small to accommodate it.

That caused the water to back up in the upper portion of the spillway. Instead of a steady flow of white water into the river, the discharge came in pulsating spurts of water and air, sending shockwaves into the already damaged structure.

That created a new "what if": Could the shockwaves be enough to compromise the sandstone around the 150-foot concrete plugs that sealed off the upstream portions of the diversion tunnels? If either of the plugs failed, there wouldbe nothing to stop the 8 trillion gallon reservoir — 180 miles long, 25 miles wide and nearly 600 feet deep — from draining.

With the benefit of 36 years of hindsight, Burgi says that scenario was more of a concern than a fear.

“I don’t think I ever felt we were headed for a disaster, but I knew we were headed for serious damage,” he says. “I didn’t think we’d lose the reservoir, but it was a concern. Once we got to a point where we couldn’t close gates and get in there, we’d be flying blind.“

“Certainly there were days I remember toward the end of June … I would wake up and think, what the heck is going on down there in that tunnel?”

Lake level peaks, inches from disaster

The bureau's team increased flows even more from the left spillway to try to blast some of the debris from tunnel, efforts that were met with varying success. The right side, meanwhile, was increased to 27,000 cfs.

On July 1, ominous rumblings could be heard coming from the right spillway, prompting engineers to dial back the releases to 20,000 cfs.

On July 7, both the spillway gates were closed so the tunnels could be inspected. The right side wasn't as bad as feared, but still the damage was extensive.

"Major damage had occurred in the vertical bend of both spillways," Burgi and Gamble wrote. "Reinforcement steel which looked like 'spaghetti' was observed extending from the damaged tunnel liner."

Nevertheless, they decided to continue releasing water through them for the next two weeks until the runoff began to subside.

On July 15, the lake level peaked, just inches from the top of the new 8-foot metal flashboards, and less than 7 feet from the top of the dam.

Finally, on July 23, Gamble and his team were able to close the spillway gates for good.

In August, engineers descended into the spillways to survey the damage.

THE AFTERMATH: Read the 1984 report on the damage to the spillways

Grosch, one of the electricians, helped string the cables to provide power in the crippled tunnels.

“They had no idea of the damage. There were holes so big you could put a house in them. There was rebar the size of hot dogs just all twisted up…it’s the most dangerous job I’ve ever been on.”

Behind the left spillway’s ski jump-like flip bucket, engineers found 300 cubic yards of concrete, sandstone and mangled steel — enough to fill 30 cement mixers. Farther up the tunnel, they found a sandstone boulder the size of a food truck and debris several feet deep.

Still farther up they found the largest of the cavitation holes, 35 feet deep, 134 feet long and 50 feet wide, big enough to fit the entire volume of the Goodyear Blimp with room to spare. Nearly three-fourths of the concrete liner’s circumference had been washed away. The damage in the right tunnel was less severe, but engineers still found a section where 175 feet of the tunnel’s floor had been scoured away to a depth of 12 feet.

'A hell of a job to do'

Even though the danger to the dam itself had passed, the damage elsewhere was just starting to unfold. Three hundred miles from Glen Canyon Dam, Lake Mead, which is fed by the releases from Lake Powell, was also near capacity.

That in turn forced releases from Hoover Dam that proved devastating for low-lying communities in the Lower Colorado basin in far western Arizona.

At least seven people in Arizona and California died in the flooding. The town of Parker’s water system was swamped with fetid river water, the state had to allocate a half million dollars in emergency funds for mosquito control to stave off a public health crisis. The U.S. Army Corps of Engineers was called in to try to keep U.S. 95, the main north-south artery that connects Interstate 10 with Interstate 40, from collapsing into the Colorado.

In Yuma, the floodwaters seeped below the surface of protective dirt levees and bubbled up in low-lying areas, causing roads and sewer mains to collapse and water-logged crops to rot in fields that were too soggy to harvest.

The official files of then-Gov. Bruce Babbitt in the Arizona State Library and Archives are filled with letters to the Reagan administration asking for disaster relief, letters from officials with the Colorado River Indian Tribes chronicling the damage to crops — and their livelihoods — and from William and Betty Flannigan, who included photos of the knee-deep water coursing through the dream home they’d invested their entire retirement savings in.

BABBITT'S LEGACY: [Former gov, Interior chief on why

[conserving wilderness matters]

Like the Colorado's inevitable cycle of drought and deluge, a cycle of finger-pointing rippled through both the political and bureaucratic establishments.

The governor of Nevada blamed the bureau for not releasing enough water early enough, and Babbitt criticized them for not keeping the states well-enough informed. The bureau in turn blamed inadequate projections from weather monitors. And the weather monitors blamed a lack of resources, namely too few monitoring stations — reportedly only 14 for all of the Rockies — upon which to build accurate models.

No one knew it at the time, but there was another contributing factor: institutional inertia. Engineers had known for several years about the potential for cavitation damage in the Glen Canyon Dam spillways and had even developed a fix. It involved installing air channels to aerate the water coursing down the spillway, which eliminates the vacuum effect. In fact, an air slot project had been proposed for the dam several years earlier, but it was moved down the priority list because no one expected a black swan event.

Gamble wasn't interested in litigating blame. He had less than a year to get the crippled spillways up and running again, this time with air slots. It would be a massive effort, and dangerous.

“We had a hell of a job to do," he says. "Those construction guys are a different breed.”

The entire project would cost $37 million. He points out, however, that electricity from the power plant, which ran full bore for 18 months during the crisis, brought in more than $200 million.

And they finished just in time. By the time the newly revamped spillways were ready for operation, forecasters were predicting an even bigger deluge in 1984.

“We were all feeling the pressure there … knowing what was coming,” Burgi recalls.

What was coming was another black swan, winging its way from the west. But this time, the bureau was ready for it.

John D'Anna is a reporter on the Arizona Republic/azcentral.com storytelling team. He's been fascinated with Glen Canyon Dam ever since he read "The Monkey Wrench Gang" as a high school student in Tucson way back in the late '70s. Send feedback or story ideas to john.danna@arizonarepublic.com, and follow him on Twitter, @azgreenday.

PHOTOS: glen canyon dam today