High Country news

December 12, 1983 *Vol. 15 No. 22* *The Paper for People who Care about the West* *$1.00*

1984 may be a Wilderness Year

by Ed Marston

Ronald Reagan could become known as the Wilderness President. He could easily end up signing more wilderness legislation into law than any other chief executive. He would set this record for historic reasons -- 1984 is ripe for a flood of state wilderness bills to pass the Congress -- whoever is president.

States as geographically distant as New Hampshire and California, as ideologically different as Wisconsin and Utah, as climatically different as Arizona and North Carolina -- could all have wilderness legislation before 1984 is over.

This ripeness for action was created mainly by an irritated reaction to repeated looks at roadless, potential wild lands, first in RARE I, then in RARE II, and most recently in 50-year plans for 154 National Forests. Elected officials especially would like to clear away the issue. For example, Wyoming's conservative Republican congressman, Richard Cheney, said recently: "My main desire in life is to get one (a Wyoming wilderness bill) done."

Generic impatience with the slow wilderness pace was reinforced last year by a California court ruling that the nation's second roadless area review - RARE II - was fatally flawed. The federal Circuit Court of Appeals in California decreed that the RARE II EIS gave short shrift to wilderness values. The court said the Forest Service had rejected prime wilderness candidates.

The ruling brought a quick response from John Crowell, the assistant secretary of agriculture in charge of the Forest Service. He said that a defective RARE II naturally required RARE III. He told the 154 National Forests to stop work on their Fifty Year Plans and begin re-examining all roadless areas.

That made state wilderness bills very popular in some circles because a state wilderness bill represents a vaccination against RARE III. A part of each state wilderness bill is a statement saying that RARE II was legal and sufficient for that state. The states of Colorado, New Mexico, Missouri and Alaska -- which have state wilderness bills - will not be subjected to RARE III. Nor will states that pass wilderness bills in the next session of Congress.

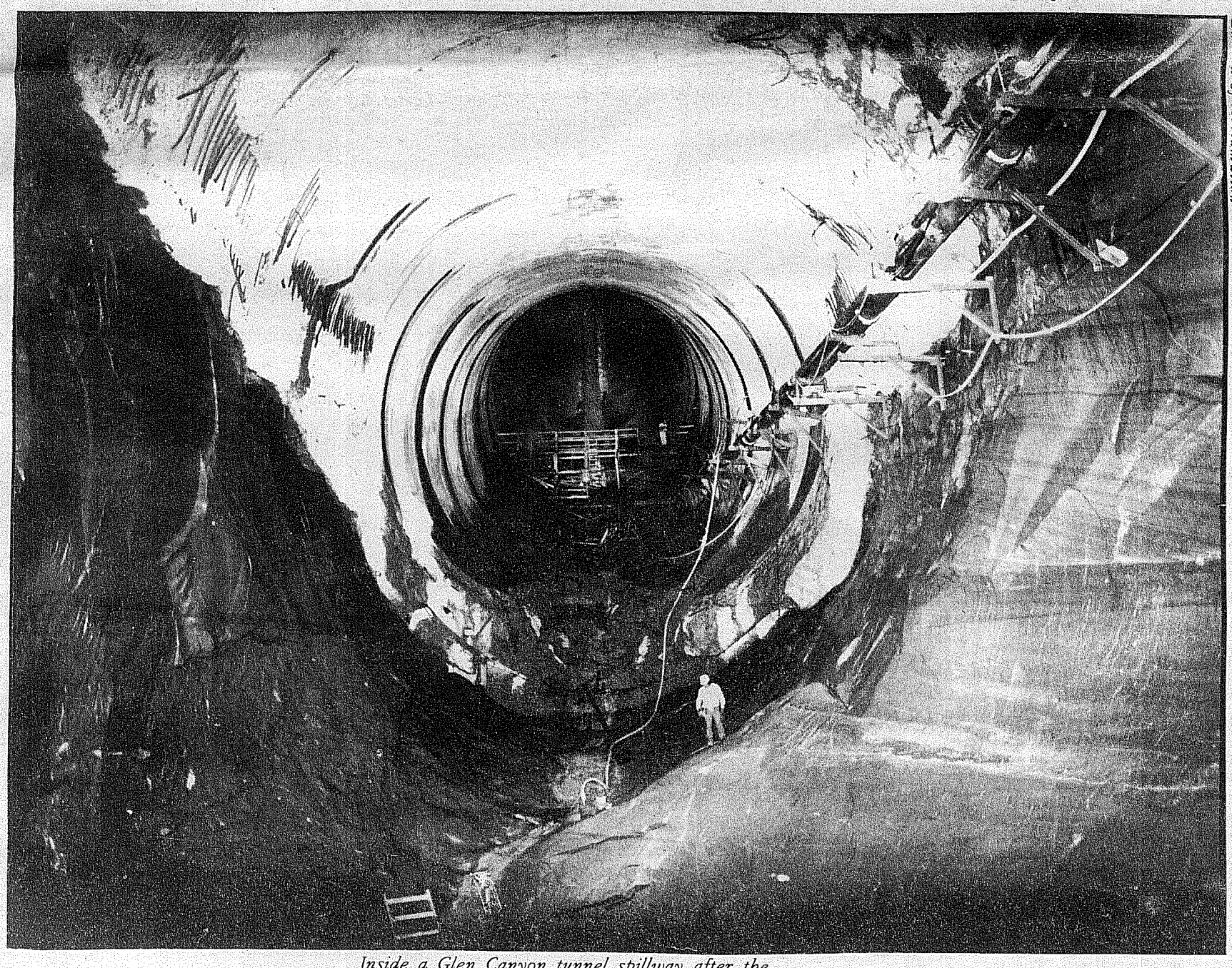
RARE III is a horrifying specter to all sides of the wilderness question. It would cost the Forest Service millions, and cause industry, citizen groups and local and state government to attend yet more rounds of public hearings and prepare yet more reams of testimony and maps.

Crowell says his RARE III order was simply a way to obey the court decision. Environmental opponents of the former lumber company executive view his decision more darkly. Some say he wants to reopen the roadless area question so the Forest Service

[*Continued on page 6*]

INSIDE

How Lake Powell almost broke free of Glen Canyon Dam



Bureau of Reclamation

Inside a Glen Canyon tunnel spillway after the summer's flooding. The white concrete tunnel lining is intact at the top and the rear. But in the foreground, the lining has been torn away and the river has been excavating the sandstone 'bedrock.' The pipes and scaffolding are part of the repair process.

See pages 10-14

The Bureau showed the Right Stuff

How Lake Powell of Glen Canyon Dam

by T.J. Wolf

As a Bureau brat growing up in Denver in the 1950s, my favorite critter was the beaver, my contributions to 'show and tell' at school were Bureau scale models of dams, and my idea of a vacation was a family trip out into the desert where I could see the river kicked in the teeth by one or another dam. I knew about Chuck Yeager and the other heroes of *The Right Stuff*. But my heroes weren't flyboys or cowboys. They were engineers.

That was only natural since my father was the Bureau engineer (in my world, there was only one 'Bureau') who designed the powerplant at Glen Canyon Dam on the Colorado River. It was also natural that I would grow up thinking Glen Canyon Dam was a thing of beauty and a joy forever.

"Just think of it from an engineer's point of view!" my father would say. Six hundred feet of acutely angled, dazzling white concrete walls arching up from the frothy white and deep green Colorado running in its red sandstone bedrock, up into the cloudless blue sky that caps the desert.

What a dam! What a site for a dam! With its crest at an elevation of 3,715 feet above sea level, the dam backs up the river to create a marvelous hydropower head. From that man-made height the water zooms down stainless steel tubes to drive $200 million worth of turbines -- enormous, delicately balanced turbines housed in the powerplant nestled in the shelter of the dam's arch.

Smoothly spinning turbines, pollution-free power, a blooming desert. What more could anyone want? And to cap it off, as if to defy the Sierra Club's sensitivities, my father and his friends threw in a surrealistic twist. Between the base of the dam and the powerplant there is a fertile crescent -- a flat, football-field-sized area sown with the finest Kentucky bluegrass, thriving on cold Colorado River water, and carefully tended by Bureau personnel. It's the meticulous touch of the engineer. The sign that everything, but everything, has been thought of and is under control.

The symbolism of that grassy field was put to hard use this summer. For a time, there was a man haying that peculiar meadow all day, every day. It was a war-time routine calculated to keep everyone calm; to show that everything was under control.

But above that calm and scripted scene, above the putt-putt of the two-cycle Briggs and Stratton lawnmower engine, Glen Canyon Dam was in trouble. Glen Canyon Dam was shaking, vibrating madly. Tremendous rumblings from the galleries -- the hollow passages in the dam's otherwise solid interior -- sent security guards scurrying to close the top of the dam to visitors.

The shuddering had its origin in Glen Canyon's spillways. Most dams spill their excess water over the top, over specially designed concrete waterfalls that present onlookers with a show when a reservoir fills and spills.

Glen Canyon Dam is different. It spills inside, down spillway tunnels that take the water from upstream, pass it beneath the dam itself, and discharge it downstream from 41-foot diameter spillway mouths.

For two decades, those spillway mouths gaped dry and empty, ever since Lake Powell had begun to fill. But on June 28, 1983, early in the morning, those spillway tunnels were at work -- work that was not going well. You could hear loud, fearsome noises in the left gallery within the dam and also on top, where the rising sun was warming the white concrete.

If you were on the bridge that spans the canyon below the dam that June morning, perhaps enjoying the spectacle of the water jetting white out of the spillway mouths, perhaps worrying about what the spillage would do to your river-running friends downstream, you would have seen a sight terrifying enough to put the fear of God into anyone, but especially into an engineer.

You would have seen the steady sweep of the spillway mouths suddenly waver, choke, cough, and then vomit forth half-digested gobbets of steel reinforced concrete (bad, very bad), spew out blood-red water (My God, it's into bedrock), and finally disgorge great red chunks of sandstone into the frothy chaos below the dam.

You would have seen the Colorado River going home, carving rock, moving deeper, as it has always done.

If we can say a river is wrathful, then we can say Glen Canyon Dam was the object of the Colorado River's wrath last summer, when flow into the Colorado River basin grew from the normal 6.96 million acre-feet to 14.6 million acre-feet during the April to July runoff.

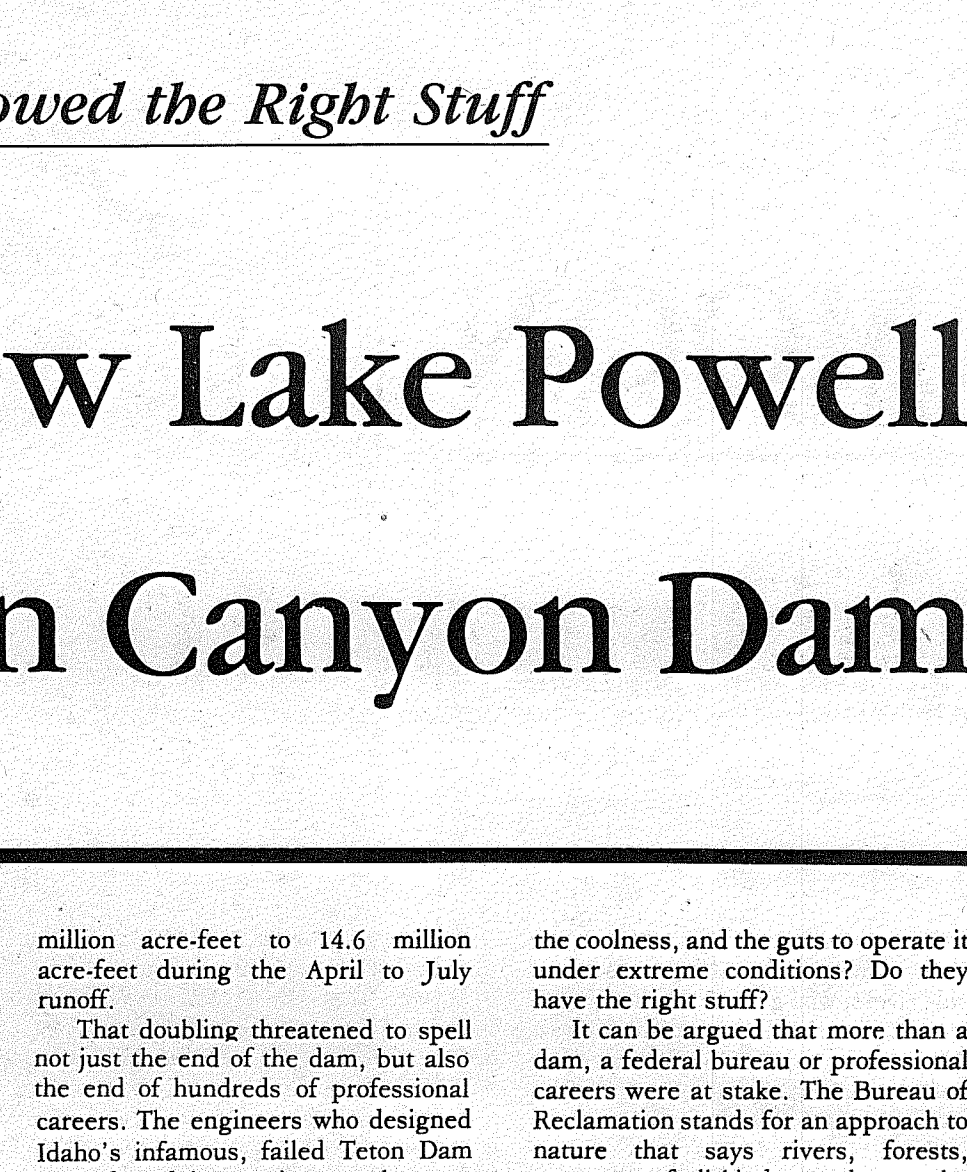
That doubling threatened to spell not just the end of the dam, but also the end of hundreds of professional careers. The engineers who designed Idaho's infamous, failed Teton Dam were forced into retirement because the dam's failure was actually their failure. Some of them died soon after.

But if the Bureau lost Glen Canyon, it would be more than a dozen or so engineers forced out in disgrace. It might be the end of the agency. The flooding Colorado was posing the same question to the Bureau engineers that space posed to those who would navigate it. Did they design their technology correctly? Assuming their design is right, do they have the skills, the knowledge, the coolness, and the guts to operate it under extreme conditions? Do they have the right stuff?

It can be argued that more than a dam, a federal bureau or professional careers were at stake. The Bureau of Reclamation stands for an approach to nature that says rivers, forests, resources of all kinds are there to be changed, transformed and reworked, until they respond to flicks of switches, until they go on and off at will, until they produce exactly what man wants.

Glen Canyon Dam provides a clear example of this dominance over nature. Glen Canyon and Hoover are where the undisciplined "useless" rushing of the river is turned into electricity -- a form of energy that can do all the things engineers want energy to do.

The Bureau's approach to rivers is



A photo of one of the radial gates is at upper right. The upper left box shows a gate in the shut position. Note the 8-foot-steel flashboards above the gate. The cross section in the main diagram shows a gate partially open. It also shows where the old, plugged diversion tunnel meets the spillway. The numbers are feet above sea level.

almost broke free this summer

as opposite as can be to that of the river runner or kayaker. Those who ride rivers, who go with the flow, want to master a river without breaking it. They want to experience the river without putting their mark on it. The river people, and those who share their world view, had as large a stake in the drama that played out this summer in Glen Canyon Dam as the Bureau did.

At stake was the way our society looks at nature. If that had been known, all sorts of people would have been standing on the bridge below the dam -- a bridge that provides a wonderful view of the dam and its spillway mouths, the grassy crescent, and the powerhouse. It would have been a great place for the river runners to stand and cheer on the river. And just as great a place for those who feel they and society lost at Three Mile Island or Teton Dam to stand and cheer for the Bureau to show it has the right stuff.

If you had stood with me and my father on that same bridge at its dedication in 1959, you would have been peering down into the narrow canyon as he explained why the river disappeared from view for a stretch. You would have heard him say that the Bureau engineers had routed the river in a tunnel around and under the damsite so that they could pour concrete for the dam's foundations.

Carefully boring through the soft red sandstone that must do here for bedrock, Bureau engineers had designed two concrete-lined diversion tunnels that led through the canyon walls, around the places where the dam would be married to the canyon walls (the abutments), and down into the canyon below, where the tunnels spilled the Colorado back into its accustomed bed.

If you had returned with us four years later, in 1963, to witness Lady Bird Johnson dedicate the completed dam, you would have seen a different sight. The diversion tunnels were plugged now, and the dam had already trapped enough of the Colorado's flow to create an infant Lake Powell -- small, but showing signs that over the next two decades it was going to become a very large reservoir indeed.

This time, you would have heard my father explain how the engineers had not wasted the diversion tunnels. They had poured concrete plugs into the upper section of those tunnels, cutting them off from the river.

But then they had made the downstream sections of the two diversion tunnels part of the new spillway system. They had built new tunnels down from above. They had married the downstream part of the diversion tunnel to these new slanting concrete tubes coming down from above, with the connection point upstream of the dam, right below the concrete plugs.

Those new slanting spillway tunnels rise at a 55 degree angle from their merger with the old diversion tunnels at the bottom of the reservoir. Then they open out into the reservoir, 600 feet upstream from the face of the dam, up against the canyon walls on each side. Water gets to the 41-foot-wide tunnel intakes by flowing through concrete approach-channels.

The lips of the spillway tunnels are at an elevation of 3,648 feet above sea level. But even when Lake Powell reaches that height, the spillways don't necessarily take on water. They are each guarded by two curved radial gates, 52.5 feet high. Those gates are raised and lowered by booms anchored into the canyon walls. When the gates are down, the water level must rise another 52.5 feet before it can flow over the gates and get to the spillway. That means Lake Powell can rise to 3,700.5 feet before it can spill. If water flows into the reservoir faster than the spillways can take it away, and the reservoir continues to rise, the ultimate spillway is the dam itself, which is at 3,715 feet of elevation.

The Bureau engineers are sure the dam can spill without suffering any damage. But the $200 million powerhouse and turbines at its base, to say nothing of the fertile green crescent, would be washed away like a log.

In addition to the tunnel spillways, the dam has two other ways to release water. One is through the river outlet works (ROW, if you like acronyms) -- four steel conduits, each eight feet in diameter and controlled by huge valves.

The third way is the only one the engineers ever want to use -- through the steel tubes that lead to the turbines themselves. For water that goes through the spillway tunnels or the river outlet works does not generate electricity. The Bureau tries to only use the power plant, so that every drop of water produces a bit of electricity.

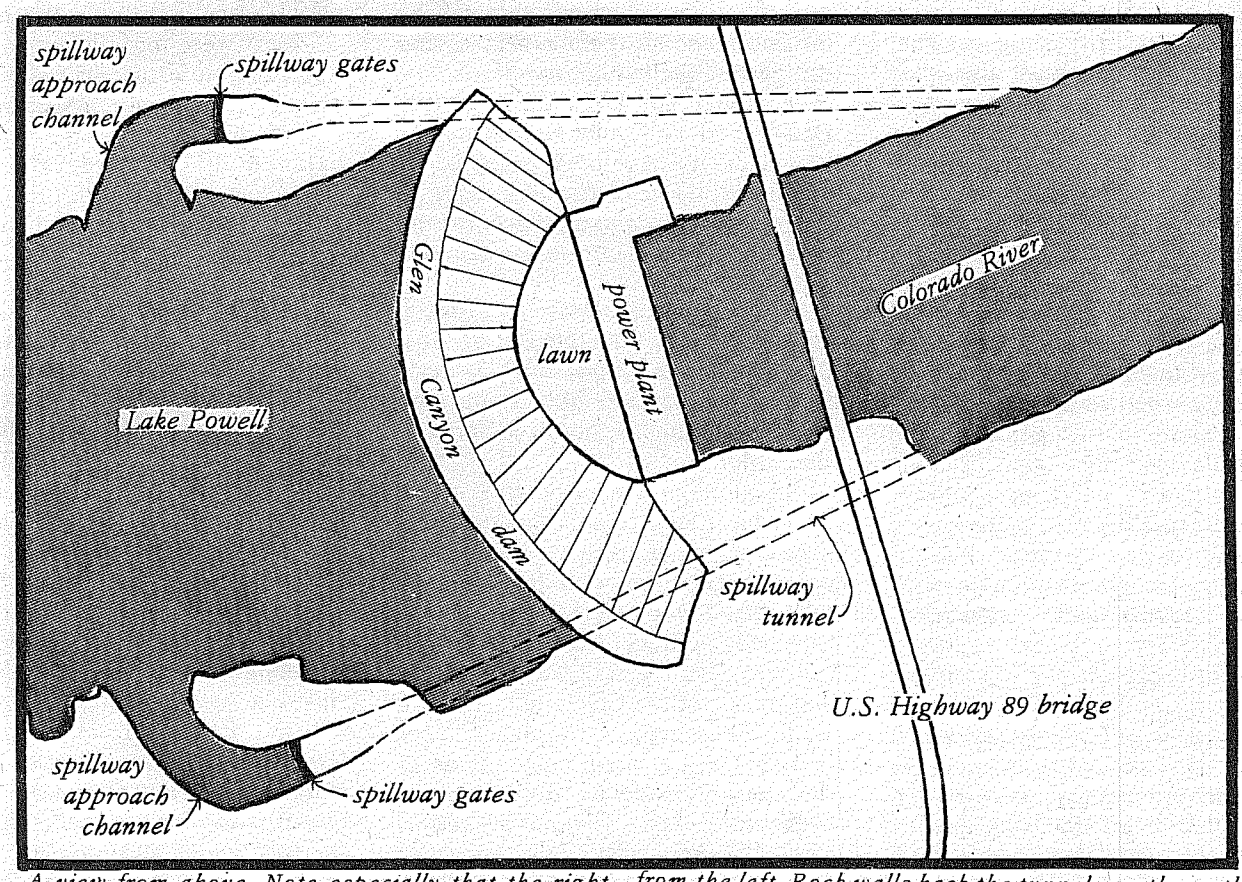
This summer, as everyone knows, the Bureau had to waste water. It had to send water through the tunnel spillways and the river outlet works -- water that didn't produce a watt of energy. In normal times, that would have been a scandal. But this summer, waste was the least of the Bureau's worries.

The real worry was that, because of this peculiar design, the Colorado River came close to beating the Bureau, close to showing that it and its people didn't have the right stuff, by getting in at the ground floor and blowing out the dam's soft sandstone foundations.

The underground spillways came close to providing a route for the reservoir to rush under the dam and down the river, to overwhelm Hoover Dam, and to continue the process, toppling the other dominoes in the system -- the dams at Davis, Parker, Headgate Rock, Palo Verde, Imperial, Laguna, and Moreles, each of which was already dealing with desperate conditions. Suddenly, the Salton Sea in extreme southern California could be some fifty million acre-feet bigger. Or the Colorado River might find a new outlet, a new way to the sea. A river once more.

Ironically, the changes Glen Canyon could have caused might have spared the visible part of the dam itself. The river might have carved itself a new path downstream by ripping open the diversion tunnels, but the dam might

[Continued on page 12]



A view from above. Note especially that the right (lower) spillway tunnel passes beneath the dam. Note also that water can flow into the spillway tunnels only from the left. Rock walls back the tunnel mouths on the three other side. The radial gates guard them from the front (left).

Glen Canyon...

[Continued from page 11]

have stood, whatever was going on beneath it.

Certainly, it would stand if water spilled over it, or piled up behind it in even greater quantities than it did this summer. Glen Canyon is a tough structure, a gravity dam that is also curved. Most gravity dams, such as the Grand Coulee on the Columbia, are straight and set at right angles across the river.

The straight dam depends on its weight to keep it from sliding downstream. It sets there, squat and ponderous, pushing back against the water behind it. But Glen Canyon is curved like an eggshell, with the convex part of the eggshell pointing upstream. The result is that the downstream force of the water is transmitted along the eggshell to the places where the dam abuts the canyon walls. Instead of resisting the water's force by its own brute force, it enlists the rock of the canyon to hold back the water.

So the dam isn't simply a heavy irrigation rock set into the canyon. It is more like a bathtub plug: the harder the water pushes on it, the more it pushes back.

And in a sense -- a sense the river runners might appreciate -- the Glen Canyon Dam is made to go with the flow. It is built of enormous concrete blocks that are designed to shift, to settle, to drop into openings, should they appear, as the pressure on the dam face shifts or changes.

As we said, this summer, because of the dam's design, the Colorado River came close to beating the Bureau. The defense against such a technological disaster, or victory for the river, whichever you choose, was the lining of the spillway tunnels -- a barrier of concrete reinforced with heavy steel bars. Although the steel tubes of the river outlet works and of the power generating system were designed to take the beating of tons of water falling at 120 miles per hour, the concrete spillways were never meant to withstand such conditions.

When water rushes over concrete, no matter how smooth the concrete, it will erode. The erosion can cascade and multiply when grains dug out upstream become grinding, tearing agents downstream, ripping out ever larger chunks under the double push of air pressure and water pressure.

And beyond the man-made concrete tunnels was something worse -- soft Jurassic Navajo sandstone, composed of quartz grains and a little feldspar. It is both moderately porous and highly absorptive. Not the best bedrock to hold back millions of tons of water, as the Colorado has been proving by millenia of downcutting. But Glen Canyon was the best physical site for a dam -- a site so narrow and with walls so high that Bureau engineers had to put their spillways through the rock because there was no room for them elsewhere.

Spillway damage is nothing new. It even has a special name -- cavitation. Hoover Dam's own tunnel spillways had experienced it in 1941 and Montana's Yellowtail Dam had experienced a 1967 episode which provided the data for designs to correct the potential problem at Glen Canyon. The correction was airslots built into the tunnel walls to bleed off the air trapped with the water and reduce pressure.

Bureau of Reclamation

Adding its overflow to Glen Canyon Dam was the Morrow Point Dam: 468 feet high and the Bureau of Reclamation's first thin-arch double-curvature dam. On June 29, 1983, Tom Fridmann took this picture during "one of the rare moments when the dam spills because of high-water flows."

Cavitation is Bruce Moyes' specialty. An engineer at the Bureau's Engineering and Research Center in Denver, he headed the special team assigned to monitor and manage Glen Canyon Dam last summer. His job now is to make engineering sense out of last summer's near-disaster and to propose design solutions that can be put into concrete before next spring brings an equally high runoff.

Working in a building at the Denver Federal Center so functionally ugly it has to have been designed by engineers, Bruce cultivates a beard, a sense of humor, and a respect for the power of the Colorado River.

When you call Bruce's office, a voice answers, "Concrete Dams!" in a tone reminiscent of one of my father's favorite sayings: "I like people and technical problems, not necessarily in that order."

In addition to his cavitation work, Bruce has a long-term assignment. He keeps track of the evolution, the aging, of Glen Canyon Dam, which he talks about as if it were a living thing, a moody critter that moves and changes, keeping time with the moves and moods of the Colorado.

In the course of the day I spent with Bruce, I related to him some of the charges made by Bureau critics concerning last summer's record spills. He replied, "Hell, we could have just run 100,000 cubic feet per second down the Grand Canyon during June and flushed everyone and everything out. That would have solved our technical problems and saved the dams too.

"But our goal was to save the dams and the people downstream in the floodplains. Not easy. But we believe we succeeded as far as possible under the circumstances."

What were those 'circumstances?' According to Bruce it was an ever mounting flow of water into Lake Powell that required the Bureau to balance off imponderables. The chronology that follows draws on his account of the summer and on Bureau documents.

June 2, 1983. This day can be taken as the start of the crisis. The level of Lake Powell exceeds 3,696 feet above sea level and Bureau officials decide that powerplant discharges alone can no longer control the reservoir rise. They raise the left spillway gates and dump an additional 10,000 cubic feet per second (cfs). Over the weekend, they increase the spill to 20,000 cfs.

June 6. Dam personnel hear rumbling noises and see material shooting out of the left spillway mouth. Engineers fly out from Denver. But before they arrive, the dam manager has shut down the left tunnel and opened both the right spillway gates and the river outlet works. The Denver team boards a contraption called the cart, which is lowered over the left radial gates and down into the intake. They observe some cavitation damage close to the point where the tunnel from above joins the horizontal diversion tunnel -- right at the elbow.

That leaves them with nasty choices. If they reduce flow through the left spillway tunnel, the reservoir will continue to rise. If it rises until it overtops the closed gate, it might jam the gate shut and water will spill uncontrollably over the gate into the tunnel. If there is too much water even for the spillway tunnel, the reservoir will continue to rise and might overtop the dam, washing out the powerplant at its base.

To the engineers on the scene, the maximum reservoir height seems to be 3,700 feet -- the top of the radial gates. But higher authorities in the Bureau overrule them just as the river is overruling the dam. Under orders, the engineers arrange for the installation of four-foot-high sheets of plywood, called flashboards, onto the tops of the radial gates. In effect, the radial gates are now 56.5 feet high, and the reservoir can rise another four feet without flowing over the gates and into the spillway tunnels. It buys time by creating a surcharge pool in Lake Powell.

Along with the flashboard installation order comes disturbing news from the National Weather Service: inflow forecasts for Lake Powell are

Glen Canyon...

(Continued from page 12)

accelerating. Other disturbing news comes from closer by. The team descends into the dam itself, into its hollow insides, the galleries, on the trail of the rumbling noises heard earlier. Since the left tunnel is temporarily down, the noise has ceased. But it doesn't take a close inspection of the watery confusion in the galleries to show that the river outlet-works couplings are leaking, and that manhole covers throughout the dam show increasing signs of pressurization. Everywhere, like corks in shaken champagne bottles, various systems are responding to increasing pressure from the rising wall of water behind the dam and the huge flows through the dam.

Meanwhile, on the 225-mile stretch of the Colorado that winds from Glen Canyon downstream to Lake Mead, Park Service helicopters drop the news about the increasing releases to river runners: "Camp High! Be cautious!"

The Bureau was taking its own advice on 'caution' as this report summarizing the early summer apprehensions shows: "The intial concern upon the June 6 report was noises from the left tunnel was for the safety of the dam and its foundation. This concern predominated throughout the spill period."

June 7. The team brings the powerplant flows up to 28,000 cfs -- 20 percent over normal capacity. They hold the river outlet works to 15,000 cfs. That keeps water speed down to only 50 miles per hour. And they hold the right spillway to 4000 cfs. They want to keep it low because it occupies a dangerous position upstream from the dam's foundation. If the right spillway tunnel broke through to bedrock, it would threaten the dam's foundation.

They also get organized. They set up twice daily inspections of both spillway portals, of dam abutment leakage (water flowing through joints where the dam meets the canyon), and a more technical evaluation of dam noises. They have been using: "Scares the hell out of me!" for serious sounds. From Bruce Moyes' account, you imagine the team members like men in battle, experiencing feelings of elation and camaraderie alternating with convictions of isolation and doom. Noah and Jonah jokes abound.

June 8. The left radial gates are fitted with their flashboards. Attention turns to the right radial gates.

Hydraulic computations give additional reasons to baby the right spillway. So long as the water erodes straight down, everything is safe. But damage patterns, the computations show, also like to spread out laterally, or horizonally. Since the right tunnel elbow is near the dam, horizontal damage spreading out from the tunnels could threaten it.

A related worry is that damage to the concrete plug in the right tunnel could create a direct connection between Lake Powell and the river via the old diversion tunnel.

June 9. Total discharge is at 48,000 cfs and the National Weather Service revises its predictions upward. The team decides that the river outlet-works couplings are going to hold.

June 10-11. The right spillway radial gates have their flashboards. Total discharge is held at 48,000 cfs.

June 11-12. The river outlet works are discharging 17,000 cfs with no problem. But the reservoir continues to rise.

June 13. The National Weather Service ups its predictions by 500,000 acre-feet and the team thinks that its forecasts will always err on the low side. They also realize that they can't totally shut down the spillway tunnels by lowering the radial gates. That would put too much pressure on the jury-rigged plywood flashboards atop the gates. But Bruce Moyes says there was one comfort:

"The inherent stability of the dam and its ability to bridge openings in the foundation gave us confidence that no sudden loss of reservoir was possible. But any direct connection (of the reservoir through the spillway tunnels to the river downstream) could lead to erosion of the sandstone and the potential for uncontrolled release into Lake Mead was a real concern." In other words, the dam could hold but the tunnels could give way.

June 15. Discharge is up to 53,000 cfs, but the reservoir is still rising six inches a day. Babying the crucial right tunnel, the team increases the left tunnel by 7000 cfs, up to 12,000 cfs, and the reservoir as a whole up to 60,000 cfs.

June 16. Someone figures that only 200 feet of soft Jurassic sandstone separate the spillway tunnels from the dam abutments.

June 17-21. Anticipating lawsuits and Congressional investigations, the team establishes a memo system to document how decisions are being reached. That system comes quickly into use when the left spillway discharge falters on June 18 and disappears on June 19. They take a chance and lift the left radial gates further, hoping more water will blast out the obstruction. It works and the water discharge downstream of the dam resumes.

June 22. Bureau Commissioner Robert Broadbent and all the big Bureau chiefs decide in Salt Lake City to go from the present 61,000 cfs up to 70,000 cfs at Glen Canyon and to begin spilling at Hoover. The team is told: "We strongly recommend that discharges from Glen Canyon Dam be immediately raised to 70,000 cfs to protect the safety of the structure. It is imperative that discharges from Hoover Dam be raised to 40,000 cfs a soon as possible. If the extreme forecast of the NWS becomes operational, the discharges from both dams must be increased."

The team, and the dam, is between a rock and a hard place. If the increased flow of water begins to destroy the spillway tunnels, they will have to shut the gates. That will knock down the wooden flashboards and cause a tremendous, uncontrolled surge of water into the already damaged spillways, possibly destroying them.

As if to underscore this concern, the left tunnel's discharge fails again, even at 21,000 cfs, which should sweep blockages away. And noise levels in the dam and spillways are high. So the team lowers the left spillway to 10,000 cfs and increases the right to 15,000 cfs. Noise drops and the left discharge becomes smooth again.

A June 23 memo answers the question: Would overtopping of the radial gates be serious.

"The answer must be a qualified yes... expansion of the damaged area could affect the stability of the canyon walls. This is even more critical in the right tunnel since its elbow is further upstream" and therefore closer to the dam abutments.

June 27. Heavy rains and high temperatures in the upper Colorado River Basin force the team to go from the already high 70,000 cfs up to 80,000 cfs. But raising the spillway gates and actually getting the flow are two different things. The discharge from the left spillway is very weak. And there is booming and vibrating throughout the galleries on the left side of the dam.

Put yourself in the control room that June 27 morning, when you feel frantic about the left spillway discharge, and you are under orders to reduce the dam's noise and vibration before the turbines start to wobble on their axes and spin themselves into destruction, just before the spillways also self-destruct.

You can't shut down the power system, and you dare not shut down the river outlet works. So you turn the dials regulating the left spillway not down, but up -- up from the 25,000 cfs rate that is already performing a tonsillectomy on the left spillway, up to 32,000 cfs. Your other hand revs the right spillway (the one you are really afraid to use) up, up from 10,000 to 15,000 cfs. Counting everything, your dials tell you the total discharge is 92,000 cfs. What the discharge really is you have no idea. There are no flow gauges down in the bedrock.

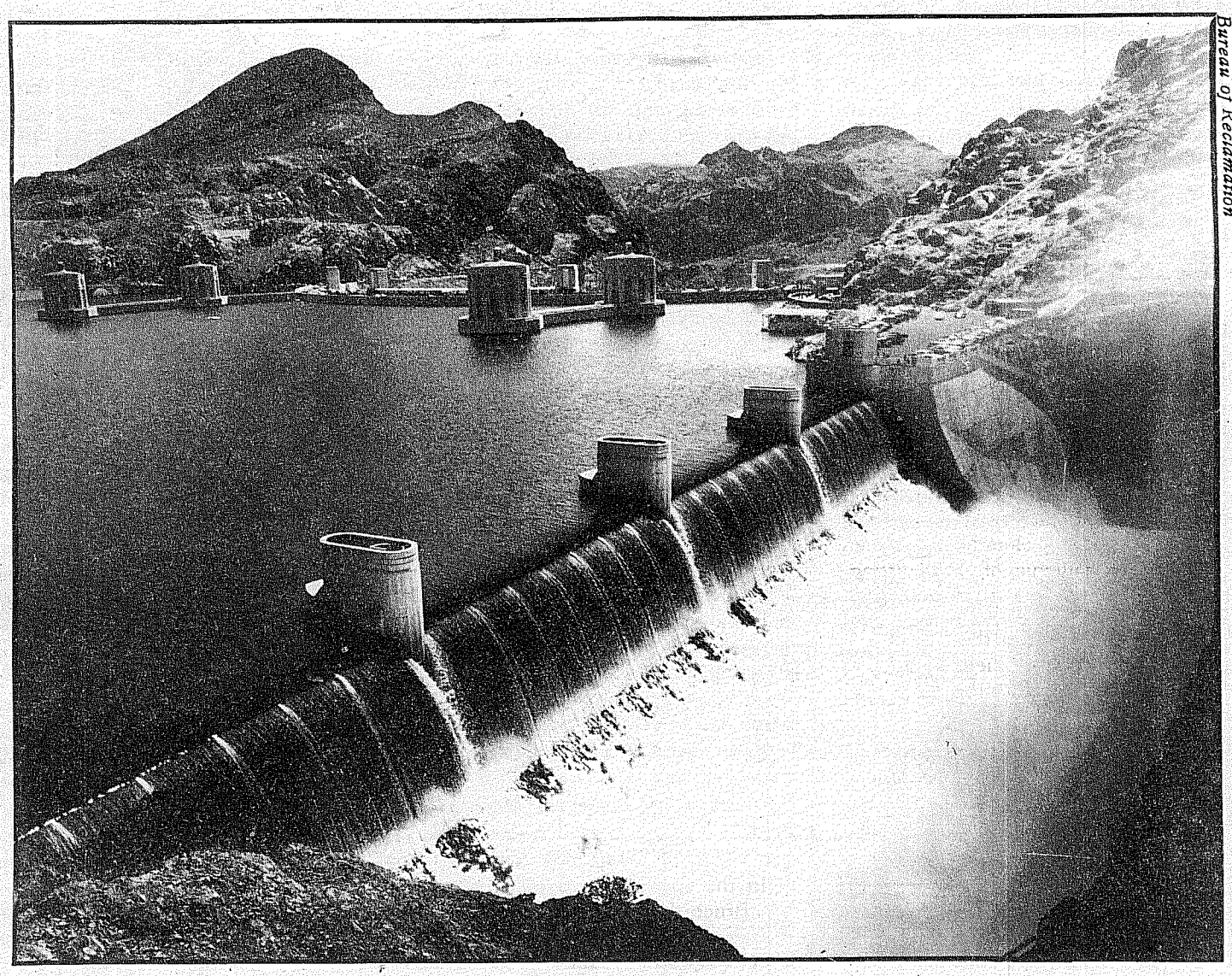
While you play with the dials, maybe your inner video flips far up the channel of the Colorado, far upriver where the waters of the apocalypse creep towards Rainbow Bridge, some eight feet higher than the previous all-time high water mark. Maybe that is where the environmentalists are on this day of doom, saying: "We told you so!" Prophesying from Rainbow Bridge, crying forth in a loud voice to the empty desert, to the rising reservoir: "Make straight the way of the Lord. Let the river flow."

Maybe such voices sound in your mind back in the control room, as you increase the flow in the right spillway up to 27,000 cfs, and wait. Then you hear it. Outside, the little two-cycle Briggs and Stratton lawnmower engine labors on, shaving the bluegrass down to putting green quality. Comforting, especially as you realize you can hear it because the terrible thundering and vibrating has stopped. For now.

Downstream from this sudden peace, the new Colorado has turned deadly serious. Since normal flow is 25,000 cfs, a release at 92,000 cfs moves like a tidal wave through the Grand Canyon. Pontoon rafts forty feet long capsize at Crystal Rapids, providing some passengers with eight-mile-long lifejacket rides through seven other major rapids before they reach shore.

Though helicopters evacuate around 150 people from the Canyon,

(Continued on page 14)



Bureau of Reclamation

Hoover Dam's Nevada Spillway ran at peak capacity this summer, overflowing at 13,944 cubic feet per second and 4.5 feet above the spillway gates. What was amazing, say Bureau of Reclamation officials, is that the spillway had been dry every summer since 1941. This picture was taken by J.E. Kinsley on July 22, 1983.

Glen Canyon...

(Continued from page 13)

dozens are hurt and one drowns. Also drowned out and scoured away is the new (since 1963) riparian habitat made possible by Glen Canyon's once steady releases. The Park Service is mad. River runners are mad.

If the unregulated Colorado was something that had to be controlled with dams, what do you call this?

June 29. Good news. Forecasts say flow into Lake Powell is peaking. So the team drops the Glen Canyon discharge to 87,000 cfs.

July 2. With both spillway tunnels at 20,000 cfs, the right discharge falters. It is upped to 24,000 cfs in an attempt to sweep it clean. But inside the dam, in a gallery, drainholes begin to bubble violently. Great sighs of air and water surge from the drain holes in the gallery nearest the right tunnel -- the tunnel that comes closest to the dam's foundation. The team cuts the right spillway to 15,000 cfs. The surges calm, but no one knows what has happened. Until the plywood flashboards are replaced with eight-foot-high strong steel ones -- a job in progress -- they don't dare shut the radial gates. And until they shut the gates, they can't go into the tunnels and inspect the damage.

July 4. Holiday visitors to the dam can watch the construction company working around the clock to install the steel flashboards -- which will be stronger and four feet higher than the plywood ones.

July 6-7. The steel is in place and the left tunnel shut down. The team is swung into the tunnel over the radial gates on the cart. There they find much more damage than expected. In fact, the cart cannot proceed through the tangle of twisted steel and concrete. The water still in the tunnel prevents an exact evaluation. But they know there's a lot.

Most disturbing, they find damage much higher in the tunnel than expected. This suggests that rockfalls have occurred in the tunnel due to horizontal, or sideways, damage toward the dam.

July 8. Today they ride the cart into the now-closed right spillway. They find the damage on this side starts lower down than it did on the left. So they proceed down the slanting elbow of the tunnel into the horizontal section. There they attempt to launch a rubber boat over the small lake filling an eroded portion of the concrete. But they lose the boat to strange currents and decide it makes more sense to return to the surface. They have no desire to be swept out of the tunnel and into the river. Back at the surface they open the radial gates, sending a modest 5000 cfs down each spillway.

"Damage (to the left spillway) includes a massive hole into the sandstone to about 36 feet below the tunnel invert. The upstream-downstream length of this hole was about 150 feet. It extended laterally (horizonally) to about 15 feet beyond the full tunnel width."

In the right spillway tunnel, a large hole extended ten feet horizonally beyond the full tunnel width, according to a report.

July 15. The reservoir finally peaks at 3708.4 -- some sixty feet above the spillway tunnel crest of 3648, and a mere 7 feet below the crest of the dam itself. Discharges can now be dropped from 61,000 cfs to 51,000 cfs, where they remain.

July 23. With the reservoir at 3707.8 feet above sea level, the spillway gates on both sides are slammed shut. The eight-foot-high steel flashboards hold. It is 8 A.M. Crews prepare for immediate descent into the spillway tunnels to begin planning repairs.

Epilogue

When the spillway tunnels were finally completely dewatered in September, inspectors found considerable damage.

I wish to thank Chief Engineer Jim Brown of the Bureau for taking the time to answer my questions and for providing me with access to Bill Anderson and Bruce Moyes. Though all of the Bureau publications and internal documents I have examined for this article are accessible to the public, I never would have been able to sort out key materials without the help of Bureau personnel. I alone, however, am responsible for the interpretation given them.

□

T.J. Wolf is a freelance writer living in Fort Collins, Colorado. This article was made possible by the High Country News Research Fund.

Bureau downplays damage

The U.S. Bureau of Reclamation says it will cost $10 to $15 million to repair the two Glen Canyon Dam spillways damaged last spring. The Bureau expects the repairs to be completed by mid-June, hopefully in time to handle peak spring runoffs.

The repaired spillways should be more resistant to the 120 mile per hour flows. Air slots are being installed to reduce the likelihood of damage caused by cavitation.

Most of the damage was suffered by the left spillway. About 1000 cubic yards of debris -- concrete, steel and bedrock torn out of the spillways and the canyon walls -- will first have to be removed. Large amounts of water will also have to be pumped out of the holes.

The Bureau estimates that 4000 to 5000 cubic yards of concrete will be needed just to fill the holes. An equal amount will be needed to repair the damaged concrete lining. For comparison, a large construction truck can carry about 10 cubic yards of material.

The work requires the boring of tunnels into the canyon walls to gain access to the horizontal section of the spillways. The left spillway repair is to be completed by mid-April 1984 and the less severely damaged right spillway by mid-June 1984.

Clifford Barrett, the Upper Colorado Regional Director, said that the extensive repair work necessary didn't mean the dam had been in serious trouble.

"Despite the damage, which first had been observed early in June, neither the dam nor the spillways were in danger of failing. And while there was serious damage to the spillway lining, it was confined to a small area and at no time would it have caused us to shut down the spillways. Considering all the water that was spilled (4.4 million acre-feet, including the bypass tubes), it was remarkable how well the spillways performed."

Oh! Weatherby (with apologies to Sir Walter Scott's *Lochinvar)*

Oh! Young Weatherby is come out of the West,
Here is his passion, it brings out his best.
And save his good backpack, he gadgets has none,
He hikes all alone and he kayaks for fun.
But when told of danger to a Wilderness free,
He determined to fight, did Young Weatherby.

He stayed not for Watt, he stopped not for Reagan,
He swam the Snake River where bridge there was none.
But ere he alighted at BLM's gate,
They had consented, for the gallant came late.
Laggards in wildlife, dastards in vegetation,
Were to mine Wilderness and damn reclamation!

Boldly he strode into the BLM hall,
Among bureaucrats, miners, loggers, and all.
The craven developers hid 'tween their legs,
When up spake the hearing boss, hands on his regs:
'Oh come ye in peace or come ye in perfidy,
Or to sneer at our permitting, young Weatherby?'

I long wooed your forest, my suit you did doff,
Love swells like the snowpack, but ebbs like run-off.
Now I am come with this lost love of mine,

To quote from *HCN* a very short line.
There are lands in Alaska less sullied, you bet,
That will gladly be home to this hiker and ferret.

So the hearing boss said yes, BLM unwound,
And young Weatherby took the podium with a bound.
So stately his form, and so steady his pace,
That never a hearing such a gallant did grace.
The BLM fretted, the Forest Service scuffed,
The firms sat dangling all their permits and stuff.
For the public whispered, 'twould be a pity,
Not to match our Wilderness to Young Weatherby.'

And then it happened: *HCN* told the tale,
The public read the facts, and did loudly wail;
The permits were pulled, the agency caved in,
Birds, deer, fish, people -- they all did win.

There was noise from Carl Bagge of the giant coal clan,
AMAX and Amoco, they rode and they ran.
There was lobbying and suing throughout all the land,
But the vast Wilderness -- they had to unhand.
Oh! Young Weatherby is come out of the West,
The West is his passion, to save it his test.