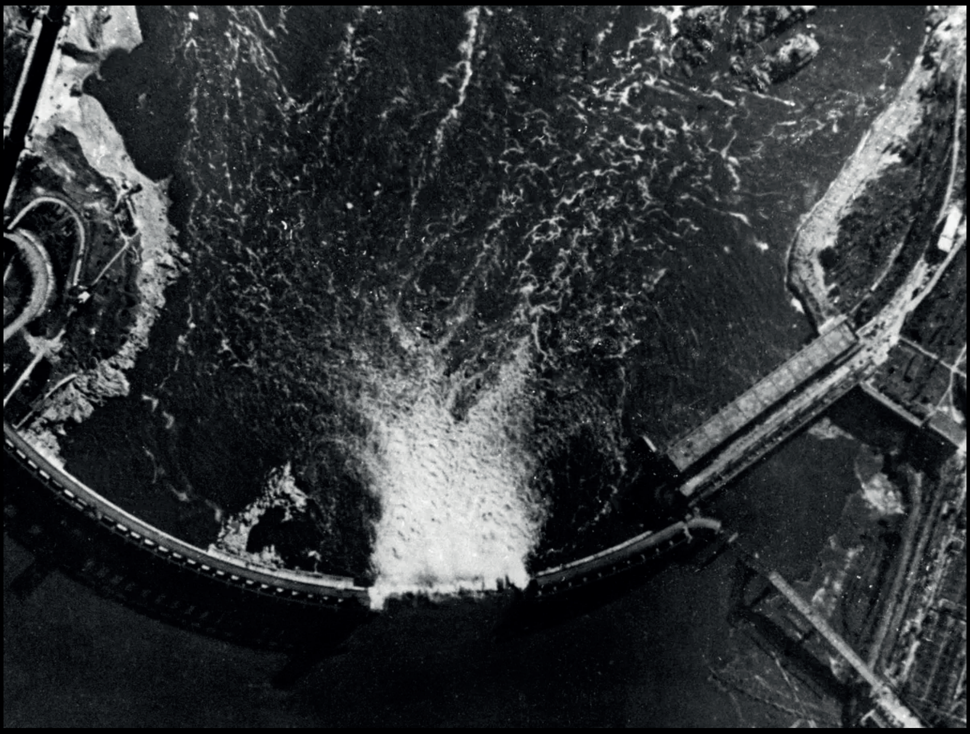
Fall 2023

CONTROLLING NATURE



Marta Krawczynski

“Life has few pleasures to compare with dam building... The pleasure comes from the elegance of the compromise you strike between where the water wants to go (guided by gravity and the medium it’s moving over), and what you want to do with it.” –Banks (1984)

introduction

In a free flowing river, fish can swim up and downstream at will. Groundwater and aquifers naturally refresh the water, silt and other natural materials move along freely. The water moves out onto the floodplain in harmony with the seasons. The free flow of water is governed by the connectivity of pathways that enable the movement and exchange of water and of the organisms, sediments, organic matter, nutrients and energy that it conveys throughout the riverine environment. River connectivity extends in four dimensions: longitudinally (up- and downstream in the river channel), laterally (between the main channel, the floodplain and riparian areas), vertically (between the groundwater, the river and the atmosphere) and temporally (seasonality of flows). River connectivity is also spatially and temporally dynamic, driven by the natural flow regime, enabling and regulating hydrological, geomorphic and ecological processes in river networks and providing the aquatic medium for matter and species to move along the river and into adjacent habitats. Rivers constitute vital fountains of environmental vitality, economic prosperity, and human welfare. However, a recent investigation has unveiled a concerning reality: about two-thirds of the planet's 242 longest rivers have lost their natural free-flowing state, primarily attributed to human interventions, with the detrimental impact of dams standing out as a significant contributor.

Historically, humans have viewed water as a threat, seeking methods to manipulate nature, promising the creation of a world that would better serve humanity's needs. Dams emerged as the means by which humans could exert control and engineer nature, imparting the belief that they could effectively store vast quantities of water, wastewater, or liquid-borne materials for various purposes. These purposes include flood control, the provision of human water supply, irrigation, livestock water supply, energy generation, containment of mine tailings, recreation, and pollution control.

Dams have been around for all of history, with construction increases during the introduction of concrete. Among the myriad characteristics of concrete that could be deemed revolutionary, its most crucial attribute has arguably been its role in facilitating rapid change. This research paper delves into this revolutionary moment in history that demanded swift or urgent transformations – be it the implementation of five-year plans in the Soviet Union, the New Deal in the USA, or the Great Leap Forward in China, – dams emerged as the go-to solution. Each of these ambitious political programs envisioned infrastructural developments on an unprecedented scale, surpassing existing industrial and labor capacities. Concrete, owing to the accessibility and relative affordability of its raw materials, coupled with the notion that a significant portion of the work could be carried out by unskilled labor, held the promise of turning the otherwise implausible into reality.

As a planner and environmentalist, dams are my greatest enemy. This research serves as a response to the ongoing global struggle against water, which poses a continuous threat to its natural flow. The study commences with a section dedicated to hydropower and provides a concise overview of the historical context of dams. Following this, the paper delves into the examination of three countries pivotal to the proliferation of dams: the U.S., China, and Ukraine (formerly part of the USSR). These case studies were selected for their interconnected relevance. Dams, beyond being environmental hazards, also function as tools of political strategy, shaping how communities engage with their environment. As an environmental planner, it is imperative for me to understand the impact of dams on global transformations. The question that guides my exploration is: How will dams shape the trajectory of change in the world?

hydropower

Potential Benefits of Hydroelectric Power

Renewable, clean energy: Hydropower relies on the renewable energy source of the water cycle, which is powered by the sun. In 2022, hydroelectricity generation experienced a nearly 2% increase, producing almost 70 terawatt-hours (TWh) and reaching a total of 4,300 TWh. It remains the most substantial renewable electricity source, surpassing the combined output of all other renewable technologies.

Flood control: Dams constructed with support from the Natural Resources Conservation Service deliver approximately $1.7 billion in annual benefits by mitigating flooding and erosion damage. These benefits extend to recreation, water supplies, and wildlife habitat. For example, dams managed by the Tennessee Valley Authority play a dual role, generating electricity and averting an average of around $280 million in flood damage annually.

Water storage: Dams play a crucial role in creating reservoirs that serve diverse purposes, including fire control, irrigation, recreation, domestic and industrial water supply, and more.

Irrigation: Water stored behind dams facilitates the irrigation of 10% of American cropland, contributing significantly to agricultural productivity.

Navigation: Navigation projects led by the U.S. Army Corps of Engineers cover 41 states, maintaining 12,000 miles of channels. These projects handle 15% of the country's freight transported via inland waterways, featuring 275 locks and overseeing 926 harbors.

Recreation: Dams serve as key hubs for recreational activities across the United States. An impressive 10% of the U.S. population visits at least one U.S. Army Corps of Engineers facility annually, highlighting the widespread appeal of these recreational amenities.

Hydropower is the oldest and cleanest form of renewable energy, providing the U.S. with a total of 28.7% renewable electricity generation and about 6.2% of total electricity generation. At first sight, the concept of hydropower is a simple one. Flowing water is trapped in front of dams, then directed through turbines, which spin to generate electricity. But this process of harnessing the water usually blocks the water streams in natural environments which causes a number of undesirable social and environmental impacts. These hydroelectric systems emit GHG, endanger species, uproot communities, lead to deforestation, and contribute to other destructive impacts that intervene with nature.

Because the source of hydroelectric power is water, hydroelectric power plants are usually located on or near a water source. A fundamental understanding of water and the water cycle is crucial for comprehending hydropower and its impacts. The quantity of water flow and the elevation change, known as head, between two points are key factors in determining the energy available in moving water. Generally, a higher water flow and greater head result in increased electricity production in hydropower plants. The availability of water for hydropower generation is contingent upon the amount of precipitation draining into rivers and streams within a specific geographic area. Seasonal variations and long-term precipitation pattern changes, such as droughts, can significantly affect hydropower production.

The process of hydropower, while entirely man-made, disrupts the natural order while relying on the natural water cycle, which consists of three steps:

1. Solar energy heats water on the surface of rivers, lakes, and oceans, which causes the water to evaporate.
2. Water vapor condenses into clouds and falls as precipitation – rain and snow.
3. Precipitation collects in streams and rivers, which empty into oceans and lakes, where it evaporates and begins the cycle again.

Hydropower plants utilize a pipe or penstock through which water flows, exerting pressure and turning blades in a turbine. This spinning motion powers a generator to produce electricity. Various types of conventional hydroelectric facilities include run-of-the-river systems, where the river's current applies pressure on a turbine, and storage systems, where water accumulates in reservoirs created by dams. Pumped-storage hydropower facilities involve pumping water from a source to a higher-elevation reservoir, releasing it later to generate electricity. However, these facilities often have a net negative electricity generation balance as they consume more electricity for pumping than they generate during release. The strategic location of hydroelectric power plants near water sources and considerations of water flow and elevation are pivotal in optimizing electricity production.

historical overview

Throughout history, dams have served many roles: providing hydroelectric power, civilizing communities, providing employment, but also, controlling nature, colonizing communities, destroying almost every aspect of ecological life. The destruction caused by dams has been so major that in 2005, NASA scientists calculated that the Three Gorges Dam, located in China, has caused the Earth to alter its rotation, increasing daylight hours by 0.06 milliseconds. Scientists explain that the large volume of mass dispersed over a large territory tends to reduce the rotation speed.

Dams emerged as pivotal symbols of urbanization and societal advancement, embodying the pursuit of control over water resources. The sentiment expressed by French politician Clemenceau encapsulates this drive, highlighting that "the best politician was one that could bring water into the city," producing a "hygienic" city. In medieval times, water posed challenges, asserting its influence over cities and shaping their landscape. Dams became the solution that liberated cities from this dependency. Furthermore, the widespread use of concrete marked a significant milestone, enabling the construction of dams at an increased frequency. The Romans' invention of concrete facilitated progress in dam construction, exemplified by the enduring functionality of Diocletian's arched dam near the city of Homs, which remains operational even after 1,700 years. Prior to this, 'gravity dams' were the prevailing approach, relying on accumulating massive amounts of material. In contrast, arches offered a more lightweight alternative, redirecting the force of water into the dam's abutments. These innovations facilitated the establishment of expansive, long-lasting reservoirs, addressing water scarcity challenges for cities.

During the era of the Industrial Revolution, advancements in scientific engineering, coupled with a growing demand for electricity, paved the way for the construction of dams on an unprecedented scale. In the year 1900, approximately 600 significant dams were in existence, with more than half of them located in Britain and its empire. The colonization efforts in Canada, Australia, and India were facilitated by the strategic use of dams. An exemplary illustration was the completion of the Aswan Dam in Egypt by the British in 1902, marking the onset of large dams, classified as those exceeding a height of 15 meters. This 2-kilometer structure, consisting of buttressed masonry, effectively regulated the Nile River, altering the natural rhythm that had long defined ancient Egyptian cosmology. The introduction of such dams meant that human control extended even to the seasons themselves.

In the year 1900, the construction pace surged to thirty large dams annually, eventually escalating to 250 by 1950. This era marked the zenith of mega dam projects, with major global powers demonstrating their engineering prowess through these ambitious undertakings. The initial phase of this dam-building competition reached its peak with the completion of the Dnieprostroi Dam on the Dnieper River in 1927-32 and the Hoover Dam on the Colorado River in 1931-36. These two dams hold crucial significance in understanding the politicized nature of dam projects, where dams served as strategic tools in war and governance, albeit at a considerable human cost. The construction of the Hoover Dam, in particular, witnessed the tragic deaths of over 100 workers, concluding with the somber coincidence of the last fatality being the son of the first. The Dnieprostroi Dam, on the other hand, was a victim of war, a theme we will delve into later in this research.

Interestingly, these two dams also symbolize the relationship between the Soviet Union and the U.S. in their joint construction efforts. By 1920, 40 percent of the U.S.'s power was derived from water, influencing the Soviet Union's decisions to increasing hydroelectric plants. Both nations contributed to the building of each dam, with the arched concrete Hoover Dam adorned with Art Deco elements by Gordon B Kaufmann, while the turbine hall of Dnieprostroi followed a Constructivist design. These monumental structures were conceived as symbols of power, standing tall to showcase the malleability and artistry achievable with concrete. Despite receiving congressional approval in 1928, the damming of the Colorado River for irrigation, water control, and electricity generation had been planned much earlier. Across the world, the Soviet Union took inspiration from the endeavors of the U.S. and established a seven-year goal to “catch up and overtake the USA” in concrete construction, particularly focusing on dam projects.

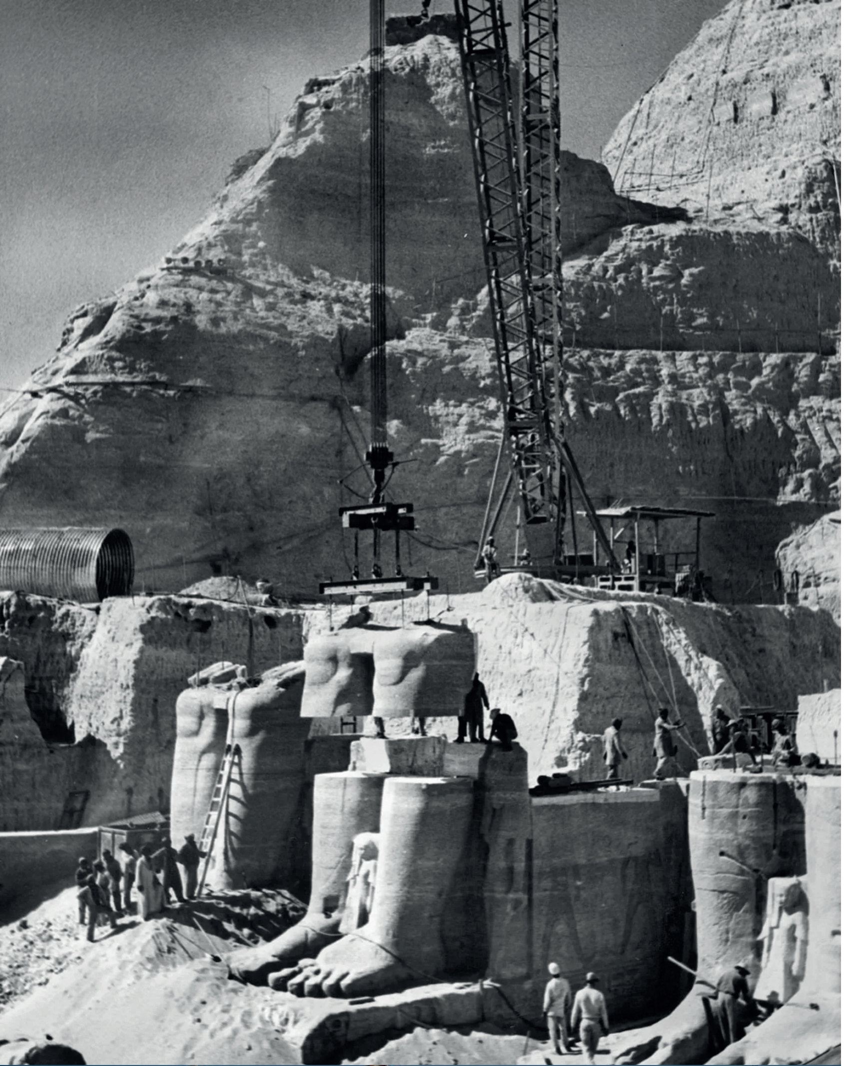
Following the Second World War, the process of decolonization prompted newly formed nations to seek control over their resources, leading to the initiation of a new era of mega dam construction. Up until 1980, India allocated 15 percent of its national expenditure to such projects, while China, in the three decades post-revolution, constructed approximately 600 dams annually. Presently, China boasts over 22,000 large dams, constituting half of the world’s total, whereas the United States has around 7,000.

This surge in dam construction was further fueled by the ideological struggle of the Cold War, manifested through international development agencies that strongly advocated loans for dam projects. Notably, after the 1952 Egyptian Revolution, the Aswan High Dam became a priority for the new regime, receiving financial and technological support from the USSR. Diplomatic maneuvers between superpowers ensued, culminating in the dam’s construction between 1960 and 1970. This endeavor necessitated the rescue of several ancient sites, including the temple of Abu Simbel, relocated to higher ground by an international team of archaeologists.

In response to the Cold War dynamics, the World Bank increased its involvement in dam construction, with its first loan outside Europe directed towards a dam project in Chile. Subsequently, the World Bank has provided over $60 billion in loans for dams. However, from the 1970s onwards, dam construction slowed and dwindled to a trickle by the 1990s. As early as 1958, leaders like Khrushchev and Nehru questioned the worth of such projects, increasingly viewed as having dubious benefits for national economies. The exorbitant construction costs, exemplified by Itaipu in Brazil ($20 billion) and the Three Gorges Dam ($37 billion), further contributed to a reevaluation of the utility of large dams.

Additionally, opposition towards dams rose through realization of environmental destruction, land submersion, and population displacement prompted indigenous protests and drew the attention of international conservation bodies. Critics argue that the destructive impact of large dams outweighs the power they generate, which is often channeled to big industries rather than benefiting the population. Moreover, the substantial funds allocated to dam projects tend to benefit multinational corporations and politicians on an extensive scale, fostering corruption. In response to mounting opposition, the World Bank and other entities established the World Commission on Dams in 1997. This bipartisan body highlighted issues such as the displacement of 40-80 million people by dams, systematic overestimation of dams’ productivity, and unexpected greenhouse gas emissions from these ostensibly green energy sources. Despite these concerns, large dams are experiencing a resurgence, partly due to the appeal of renewables. However, the environmental impact of dams remains questionable, and the preference for dams over coal is acknowledged as a means to alleviate poverty in countries like China and India. The global dam boom, led by China, is prompting increased investment from Western proxies like the World Bank.

The construction of dams represents one of the most impactful ventures in human history. However, the juxtaposition of these structures with the natural environment, from a design perspective, has been the impetus behind some of the most catastrophic man-made disasters in our collective past. The deeper question revolves around our capacity to rectify these errors and restore the symbiosis between rivers and ecosystems. Neglecting this imperative transformation could exact a higher toll on our future, as the enduring consequences of dam-related damages persist and accumulate.



The Aswan Dam completed in 1902 in Egypt by the British, marked the onset of large dams, classified as those exceedingaheightof15meters.
Figure 1: Art Forum
Figure 2: Georg Gerster (Nat Geo)

“On Occasions Like This, I Envy the Dead”

A crack in the St. Francis Dam afer one of U.S.’s deadliest dam failures.

Fatalities: 400 people
San Francisco Public Utilities Commisions’s Engineering Archives (2013)

dark side of dams

When a dam collapses, the terrain disappears, taking with it ancient ruins, sacred sites, and valuable farmland. The flood engulfs human activity, carrying downstream animals and homes. In this new natural order, fish become integral, and the only audible sound is the rush of waves, sweeping away everything in their path. Amidst the devastation, the towering dam silently observes as the world is submerged.

Often mistaken as acts of nature, these man-made disasters have caused an unparalleled level of devastation, escaping the same level of condemnation as nuclear disasters such as Fukushima and Chernobyl. According to international law, dams fall under the classification of “installations containing dangerous forces,” making them one of the most disruptive forms of infrastructure failure. Dams can fail for various reasons. The overflow of water, causing the dam to be eroded away as it descends with force, is one such cause. Seepage, if undetected and unaddressed, can lead to the gradual erosion of dams, culminating in the “sudden” phenomenon known as ‘piping’ of the supporting soil. The appearance of a whirlpool is often a harbinger of imminent collapse. Additionally, when the soil in a dam is unable to drain, ‘static liquefaction’ may occur, causing the dam materials to lose their strength. Dams have been destroyed due to factors such as poor maintenance, human or computer errors, and severe storms. Practices like “sequential raising” (incrementally increasing the dam’s height each time it approaches full capacity) and inadequate maintenance also contribute to dam collapses. Other common causes include:

- Foundation Defects
- Earthquakes
- Extreme inflow/ Flooding
- Structural Failures
- Internal erosion or piping, especially in earthen dams
- Sliding of a mountain into the reservoir
- Spillway Capacity
- Deliberate Breaching

These failures are frequently interpreted as errors, categorized as natural disasters, opportunities for learning, or even strategic moves in times of war. It is crucial to acknowledge that dams, in their very existence, fall under the classification of “high-hazard structures.” In the United States alone, there are around 92,000 dams, with a significant subset of 14,000 falling into the high-hazard category according to the U.S. Army Corps of Engineers. This classification implies that the failure of these dams could potentially lead to the loss of human lives.

Environmental consequences of large dams are numerous and include direct impacts to the biological, chemical and physical properties of rivers and their surrounding environments. What is commonly thought as a green solution is destroying the planet through short-term and long-term effects:

Dams Alter Ecosystems: Water is life–and since dams block water, that impacts life downstream, both for ecosystems and people. Ecosystems have adapted to natural flooding, which is taken away from dams.

Dams Reduce Biodiversity and Cause Extinction: Habitat loss is the leading cause of extinction. Aquatic species, particularly fish, are vulnerable to the impacts of dams. Large dams have led to the extinction of many fish and other aquatic species, the disappearance of birds in floodplains, huge losses of forest, wetland, and farmland, erosion of coastal deltas, and many other unmitigable impacts.

Dams Contribute to Climate Change: As reservoirs fill, upstream forests are flooded, eliminating their function as carbon sinks. As the drowned vegetation decomposes, decaying plants in man made reservoirs release methane, a powerful GHG. That makes reservoirs sources of emissions–particularly those in tropical forests, where there is dense growth. It's estimated that greenhouse gas emissions from dams amount to about a billion tons annually, making it a significant global source. And as the climate changes, more frequent and prolonged drought means dams will capture less water, resulting in lower electricity production. Countries dependent on hydropower will be especially vulnerable as temperatures keep rising.

Dams Reduce Water Quality: Man-made reservoirs trap fertilizers that run into the water from surrounding land. In addition, in some developing countries, sewage flows directly into the reservoirs. This kind of pollution can result in algae blooms that suck the oxygen out of the water, making it acidic and potentially harmful to people and animals. Still water in large man-made lakes is warm at the top and cold at the bottom, which can also affect water quality. While warm water promotes the growth of harmful algae, the cold water that is often released through turbines from the bottom of a reservoir may contain damagingly high mineral concentrations. In some cases, water in man-made reservoirs is of such bad quality that it is not even fit to drink.

Dams Waste Water: Since more surface area of the water gets exposed to the sun, reservoirs result in much more evaporation than the natural flow of the river before that dam existed. Reservoirs are also a haven for invasive plant species, and weed-covered reservoir banks can lead to evapotranspiration – or the transfer of water from the land to the atmosphere through evaporation from soil and transpiration from plants. Such evapotranspiration amounts to six times more than the evaporation from the water's surface. And there is even evidence that dams increase water use and promote water waste by creating a false sense of water security.

Dams Increases Displacement: The available evidence indicates that individuals displaced by dam projects often experience a decline in their overall well-being compared to their pre-displacement status. Common negative consequences include alterations in household size and structure, diminished housing quality, reduced employment and income prospects, limited access to education, land, and water resources, fractured social networks and communities, as well as heightened health and psychosocial risks. Additionally, the absence of consideration for the political environment, historical land relations, local grievances, and non-compliance with international standards may lead to tensions, violence, and conflict during dam-induced displacements.

life and death at the hoover dam

Location: Clark County, Nevada

Project Year: 1931-1936

Type of Dam: Concrete Gravity-Arch

Architectural Style: Art Deco

Creates: Lake Mead

Impounds: Colorado River

Installed Capacity: 2,080 MW

Construction Cost: $49 million ($760 million in today's day)

There are 17 main turbines in the Hoover Powerplant; 9 on the Arizona wing and 8 on the Nevada wing. On average, the Dam generates around 4 billion kilowatt-hours of hydroelectric power each year for use in Nevada, Arizona, and California, enough to serve 1.3 million people.

Figure 1: AP Photo-Lennox McLendon; Figure 2: Mathew Reamer (NYT); Figure 3: Mike O'Callaghan (2019)

The World's Largest U.S. Flag displayed at
the Hoower Dam. (May 1996)

death, destruction

Construction Deaths

Drought

Change in Water Flow

Decline in Ecosystem

Endagering Species

Displacement of Native Tribes

Increasing GHG emissions

"They died to make the desert bloom"
photographed by Dawn Bowen (June 22, 2007)

Human ingenuity once shaped a civilization in an arid landscape, bending nature to their will. However, the very human activity that electrified the West now poses a threat to those ambitious dreams. Lake Mead, the expansive artificial reservoir created by the Hoover Dam, has reached a level near its historic low, signaling significant changes in the world facilitated by the damned Colorado River. The Hoover Dam stands as a prime example of America's quest for influence and power.

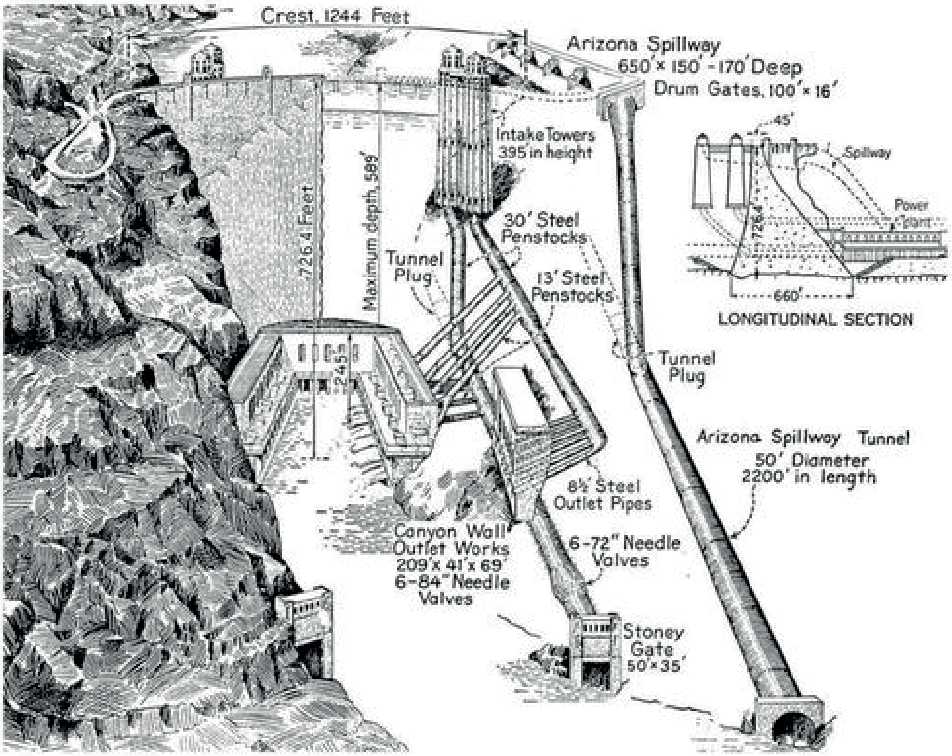
In 1928, the U.S. Congress authorized the Boulder Canyon Project, later known as the Hoover Dam, marking the beginning of several decades of major water projects funded by the U.S. government. Positioned on the border between Arizona and Nevada, within Black Canyon on the Colorado River near Las Vegas, the construction of the Hoover Dam commenced in 1931. By its completion in 1936, the dam stood as a remarkable engineering achievement, towering at a height of 221 meters (726 feet) with a crest width of 379 meters (1,244 feet). The reservoir created behind the dam, Lake Mead, ranks among the world's largest artificially formed bodies of water, covering an expansive area of 603 square kilometers (233 square miles) and boasting a shoreline stretching 885 kilometers (550 miles). Hoover Dam's hydroelectric generators, capable of supplying nearly 4 billion kilowatt-hours on average each year, play a crucial role in providing electricity to Arizona, southern California, and Nevada.

Drought Threatening The West

Prolonged drought in the Western region and the diversion of water for human use, primarily through dam construction, are leading to sections of the Colorado and Mississippi rivers experiencing depletion and running dry. However, the drought intensified by climate change, combined with the overuse of water from the Colorado River, is causing Lake Mead to recede, posing a threat to the dam's hydroelectricity production. As of June 2022, declining water flow has significantly reduced the dam's power generation capacity to approximately 1,076 megawatts. The impact of climate change and global warming has heightened the frequency and severity of droughts, prompting the U.S. Bureau of Reclamation to establish a Drought Contingency Plan in 2019. By 2021, water levels had dropped to a critical point, leading to the declaration of a water shortage and subsequent cuts in water supply to Arizona, Nevada, and Mexico. Measures to alleviate the shortage included transferring water from Flaming Gorge Reservoir to Lake Powell, but the primary solution underscored the urgent need to reduce water consumption.

Lake Mead, the massive reservoir fed by the Colorado River and located atop the Hoover Dam, is currently at a mere 39% capacity – down more than 130 feet since 2000. The looming threat is that if the water level falls below 1,075 feet, a major water conservation plan will be activated for the first time. The Bureau of Reclamation anticipates this threshold being breached soon, necessitating adjustments to water allotments for states relying on Colorado's water. Lower river states, including Arizona and Nevada, are poised to face significant cuts. David Palumbo, the Bureau of Reclamation's deputy commissioner of operations, highlights the impact of climate change on the West – a region experiencing hotter and drier conditions where the ground absorbs more runoff before reaching reservoirs. Even in high snow years, low runoff has become a concerning trend. The prospect of a "dead pool" scenario looms, potentially transforming dams from a regulator of national importance into a concrete plug obstructing the Colorado River – an ominous doomsday scenario. To avert such dire outcomes, the Biden administration has urged the seven states along the Colorado River to reduce water consumption by 2 to 4 million acre-feet, approximately one-third of the river's annual average flow. This measure aims to safeguard power generation and mitigate the impending water crisis.

A parallel challenge confronts Lake Mead's upstream neighbor, Lake Powell, the second-largest reservoir in the country. Water levels at Lake Powell are approximately 44 feet away from reaching a point where the Glen Canyon Dam would be unable to generate hydropower. In 2022, the Bureau of Reclamation announced its support for studies exploring whether physical modifications to Glen Canyon Dam could allow water to be released below critical elevations, including the dead pool. This implies investigating costly and time-consuming construction projects such as drilling tunnels through the Navajo sandstone at river level. Jack Schmidt, a Colorado River expert at Utah State University, notes that contemplating such measures represents a significant departure from previous norms in dam management.



The Hoover Dam by Gordon Kaufmann & Henry John Kaiser (ArchEyes)

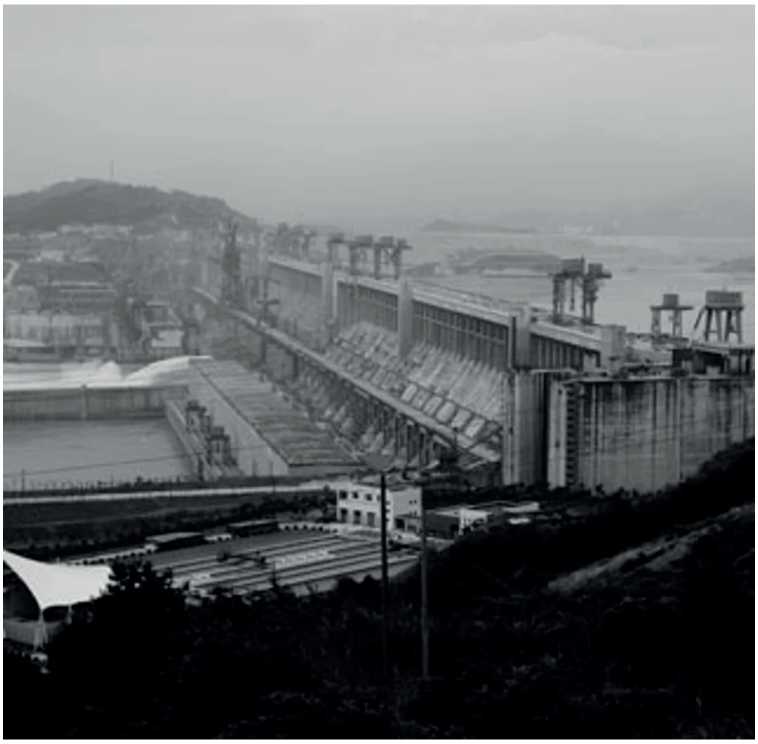
The politics surrounding the construction of dams, levees, and other structures are integral to the policies shaping the management or mismanagement of American rivers. The well-being of the nation is intricately linked to the health of these rivers and the measures taken to secure them against various threats. The conditions of dams in the U.S. are maintained in a national database, but its secrecy prevents Americans from knowing whether nearby dams pose any dangers or are federally regulated. While smaller dams can be found on the online federal database, notable structures like the Hoover Dam on the Nevada-Arizona border and California's Oroville Dam, the tallest in the country, remain absent from the database. The Hoover Dam impounds one of the nation's largest reservoirs, and recently, the Oroville Dam underwent a significant $1 billion makeover after its spillway failure.

The U.S. Army Corps of Engineers declines to disclose information about dam conditions, citing concerns stemming from the 9/11 terrorist attacks. In the post-9/11 era, the U.S. Department of Homeland Security has prioritized the protection of vulnerable and valuable national resources and infrastructure from potential threats. Dams, as crucial national resources, require safeguarding, given the substantial threat that terrorism poses to U.S. water infrastructure. This infrastructure is vulnerable to physical destruction, biological and chemical contamination, and cyber-attacks, influencing government and private security spending decisions, consumer costs, and confidence. However, concerns regarding terrorist attacks on dams existed even before the 9/11 attacks. In the 1990s, the U.S. bolstered security at dams to address the potential for attacks, despite no actual threats materializing. This heightened control over infrastructure for increased security against potential terrorist attacks on dams inadvertently led to internal attacks on ecosystems, communities, and energy.

In the United States, the politicized nature of dams has fueled resistance to hydropower projects and an uptick in protests, underscoring the contentious nature of these initiatives. Recently leaked documents suggested that environmental activists influenced the consideration of removing dams on the Lower Snake River by proposing alternative energy projects in the event of dam failure. Despite the unique nature of the four dams, the government spent $17 million to rectify errors and ensure the dam's continued operation. This substantial amount could have been allocated to completely remove and restore the dam. However, this process faces challenges, as even reports that could potentially lead to dam removal are often disregarded or dismissed.

One may ponder: What conditions or circumstances would be necessary for a dam, like the Hoover Dam, to be dismantled or entirely shut down?

china: the leader of dams



Three Gorges Dam (Popular Mechanics)

May 15, 2006

July 17, 2000

Three Gorges Dam 2000 - 2006 (NASA)

China is the leader of Hydropower.

Over 98000 dams/reservoirs

40% of the largest dams in the world

Total Hydropower Installed: 390.9 GW

Displaced approximately 23 million people over the years

Largest Dam in the World: Three Gorges Dam

Displaced approximately 2 million people

Impounds: Yangtze River

Installed Capacity: 22,500 MW

Height: 594 ft

Construction Cost: $31.765 billion

focus: Banqiao Dam

The Three Gorges Dam in China under Construction in 2005. (Edward Burtynsky)

Destruction Type: Dam Failure During Typhoon Nina

Fatalities: 26,000 (official); 230,000 (Human Rights Watch estimate)

Built: Collaboration between Chinese and USSR Supervision–"The Iron Dam"; Chen Xing

Type of Dam: Earthfill Embankment

Height: 80 ft

Property Damage: $513 million

Creates: Huai River Basin

Banqiao Dam after the catastrophe.

(The Ohio State University)

china: the country that slowed down the earth through dams

China stands unrivaled as the global powerhouse in hydroelectric infrastructure, boasting a greater number of dams in operation than all other countries combined. According to the Ministry of Water Resources, China hosts a staggering 98,000 dams, surpassing any other nation in this regard. The roots of this hydro-dominance delve deep into China's history, with a legacy dating back 2,600 years when the earliest dams were constructed for flood control and irrigation. The narrative of the Great Flood, a prominent theme in Chinese mythology, underscores the historical importance of reengineering landscapes to overcome natural challenges. Yu, also known as Yu the Great, was appointed by legendary emperors Yao and Shun to lead the transformative efforts, earning rulers the highest praise by being compared to the virtuous Da Yu. In the historical context of China, river management was a solemn state responsibility, tightly regulated to "maintain harmony with nature." The belief prevailed that the battle against floods was not a defiance of the heavens but a pursuit of harmonious coexistence, aligning human actions with the laws of nature.

Early Chinese industrialization, supported by Soviet engineers and foreign aid, saw dams becoming a crucial component of the Five Year Plans. They played a pivotal role in realizing Mao's vision by controlling floods, providing water storage, symbolizing industrialized progress, and generating hydroelectric power to meet the emerging electricity needs. One of the pioneering dam projects under this developmental framework was the Banqiao Dam, constructed in 1951. Initially considered unbreakable with rigorous technical specifications, its success led the Communist party officials, including Mao, to view water storage as a key element for collectivized agriculture and industrialization. Over a hundred dams were subsequently built in the Henan region alone, contributing to a saturated network of dams and reservoirs in the confined Huai river valley. Unfortunately, the lack of flood mitigation measures and oversight in the development process led to catastrophic consequences, as witnessed in the Banqiao Dam failure.

In the realm of China's hydro-engineering achievements, the Three Gorges Dam serves as a testament to the nation's confidence in ambitious technological solutions. Initially proposed in 1919, its approval came to fruition in 1992 under Premier Li Peng's bold declaration. However, the dam's success is not without controversy. Contemporary assessments from geologists, biologists, and environmentalists highlight concerns regarding the construction of a massive hydropower dam in a densely populated area. The region's ecological sensitivity, home to endangered species and crisscrossed by geologic fault lines, underscores the intricate balance between technological ambitions, power requirements, and environmental preservation. This delicate interplay remains a critical consideration in the ongoing dialogue surrounding China's hydroelectric endeavors.

A similar Chinese reservoir's dam and spillway, completed in 1954. (Popular Mechanisms)

Banqiao Dam

Commencing in April 1951 and concluding 14 months later in June 1952, the construction of the Banqiao Dam marked a monumental undertaking in human engineering along the Ru River in Henan Province, China. Originally envisioned as a masterpiece, the dam aimed to serve as a multifaceted solution, providing flood control, irrigation water, and electrical power to the entire region. However, the very structure that was meant to epitomize engineering prowess became infamous as the site of the deadliest dam failure in recorded history. The Chinese government asserted that the Banqiao Dam had been designed to withstand a 1,000-year storm, but the catastrophic events unfolded when Typhoon Nina struck on August 5, 1975 – a storm categorized as a 2,000-year event. Described by survivors as a terrifying onslaught, the dam burst unleashed a deafening cacophony that resembled the collapse of the sky and the fracturing of the earth. The storm, colliding with cold atmospheric air, lingered over the Huai River Basin, inundating the region with an unprecedented deluge. In just three days, Typhoon Nina deposited over 55 inches of rain, nearly double the annual average. This deluge pushed the reservoir's water level to 370 feet, surpassing the dam's design limit by approximately 14 feet.

The failure of the Banqiao Dam unleashed a massive wave, measuring 10 kilometers (6.2 miles) in width and 3-7 meters (9.8-23 feet) in height, hurtling downstream at a speed of 50 kilometers per hour (31 mph). This torrent of rapidly moving floodwaters inundated the lower region. The disaster resulted in the collapse of some 5,960,000 buildings and impacted 11 million residents.

The aftermath of the disaster was devastating, rendering three million acres of land uninhabitable and resulting in a staggering loss of human life, estimated between 85,600 and 240,000 people. The immediate flooding claimed the lives of approximately 26,000 individuals, while an additional 145,000 succumbed to epidemics and famine in the aftermath. Shockingly, the Banqiao Dam failure claimed fifteen times more lives than the infamous Chernobyl incident, a grim statistic that fails to garner adequate attention. Hydrologist Chen Xing, who served as the Chief Engineer of the dam projects, had forewarned against complacency and advocated for additional safety measures. Regrettably, his cautionary advice was disregarded, leading to his eventual resignation. Government officials chose to keep information about the dam failure under wraps until 2005, adding to the tragic narrative. The dam was immediatley reconstructed. Examining the technical specifications, the Banqiao Dam, as documented in the World Register of Dams, boasts a spillway capacity of approximately 530,000 cubic feet per second (cfs) and a reservoir capacity of 547,000 acre-feet. The dam's spillway is now equipped with eight large radial gates and a substantial stilling basin, reflective of post-disaster enhancements aimed at fortifying the dam against potential future challenges.

from hydro-terrorism to ecocide: weaponising water in war

Kirov Reservoir with Lenin figure in Kyrgyzstan
(Senses Atlas)

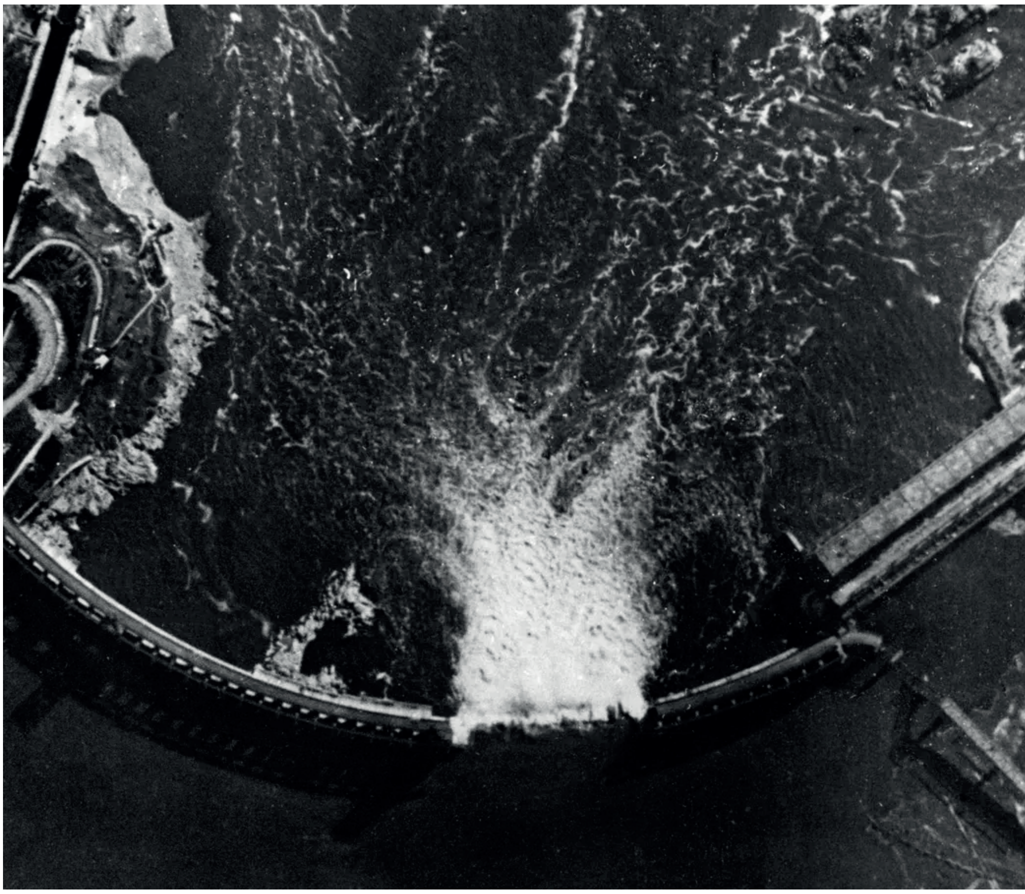
Gustav Klutsis' 1932 poster for the Dneprostroi Dam in Russia

(Heritage Image Partnership/Alamy)

kakhovka dam

Figure 1: Dam Breach at Dnipro Hydropower Plant (WWII)

Figure 2: Satellite Images of Nova Kakhovka (CNN)



Destruction Type: Deliberate Breaching by Russian Army

Fatalities: 58

Built: Collaboration between USSR and U.S.

Type of Dam: Earth-fill Embankment with Gravity Sections

Height: 30 m (98 ft)

Length: 3272 m (10,738 ft)

Creates: Kakhovka Reservoir

location: Kakhovka, Ukraine, Former USSR

Between 2:15 and 3:00 A.M. on June 6, 2023– Ukrainian and Russian sources reported explosive-like sounds that appeared to come from the Kakhovka Hydroelectric Power Plant in the dam located on the Dnieper River. A dam, built as a Cold War construction project and was designed to withstand almost any attack imaginable, was predicted to have been blown up from within by Russian aggression. In order to understand this tragedy, it is important to understand the major role that Dnieper River played in historical warfare.

Soviet Era

The first great Soviet hydroelectric dam, the Dnieprostroi (Dnieper River Dam) project on the Dnieper River, was erected under the direction of Col. Hugh Cooper of the United States Corps of Engineers and was equipped with five huge turbines built by Newport News Engine Company. Built in 1927-39, during Stalin's regime the dam, featuring American design, swiftly evolved into a symbol of socialist modernity. Architects Vesin and Kolli, with the assistance of American engineers, designed the dam to catalyze industrialization in line with Lenin's slogan, 'Communism is Soviet power plus the electrification of the whole country!' The completion of Dnieprostroi was celebrated as a substantial stride toward realizing this goal, and the dam became the focal point of posters, novels, songs, symphonies, and films. By 1941, war was escalating and Stalin–without hesitation–ordered for the immediate destruction of the dam, causing an explosion over 100 meters in length and 20 in height. This explosion propelled water levels downstream, drowning up to casualties in the ten thousands. Post war, Dnieprostroi was fully restored and the casualties and destruction remained a tactic that had occurred in the middle of the war, almost as if destroying something this catastrophic was the appropriate thing to do.

By September 1950, the Soviets decided to build another dam and an additional hydropower station, downstream from Zaporizhzhia, at a place called Kakhovka. The idea was to supply water for the irrigation of the southern Ukrainian steppe and northern Crimea, where the Soviet authorities planned to grow wheat and cotton. The massive engineering feat was completed in 1956, and since then the Kakhovka reservoir has played a key role in the regional economy, including as a source of water for Crimea. Around the same time, the International law surrounding war had changed and attacks on "installations containing dangerous forces," including dams, were restricted in Article 56 of the 1977 Protocol I amendment to the Geneva Conventions.

In the recent war on Ukraine, Russia moved forward with an attack on Kakhovka, blowing up the dam that could stop the advance of a superior army–in this case, Ukraine. The resulting destructive flooding led to the loss of around 10,000 hectares of agricultural land, as stated by the Ministry of Agrarian Policy and Food of Ukraine. The ministry also highlighted that the catastrophe disrupted 31 irrigation systems that serviced fields in Dnipropetrovsk, Kherson, and Zaporizhzhia oblasts. These systems, supporting

Satellite Image (Maxar Technologies)

the cultivation of four million tons of grain and oilseeds valued at approximately US$1.5 billion, provided irrigation for half a million hectares in 2021.

The impact on fish species in the Dnipro River and its adjacent water bodies was particularly severe. Stranded fish, as observed in videos near the village of Maryanske, face a heightened risk of mortality due to their isolation from natural habitats. The agricultural ministry estimates that up to 95,000 metric tons of fish perished, emphasizing the dangers of consuming fish downstream due to potential contamination and the risk of botulism. Birds, reliant on waterways and wetlands, reptiles like the Caspian whip snake, and vulnerable mammals such as Nordmann's mouse were also in jeopardy due to the destruction of their habitats and the disruption of the natural water flow, posing significant challenges to their survival. Additionally, the Kakhovka Dam played a crucial role in supplying cooling water to the Zaporizhzhia nuclear power station, situated approximately 160 kilometers (100 miles) away and currently under Russian control. Cooling water is indispensable for regulating reactor temperatures and ensuring safe nuclear plant operations. The disruption of this cooling water supply raised concerns about its potential impact on the plant's functioning and nuclear safety.

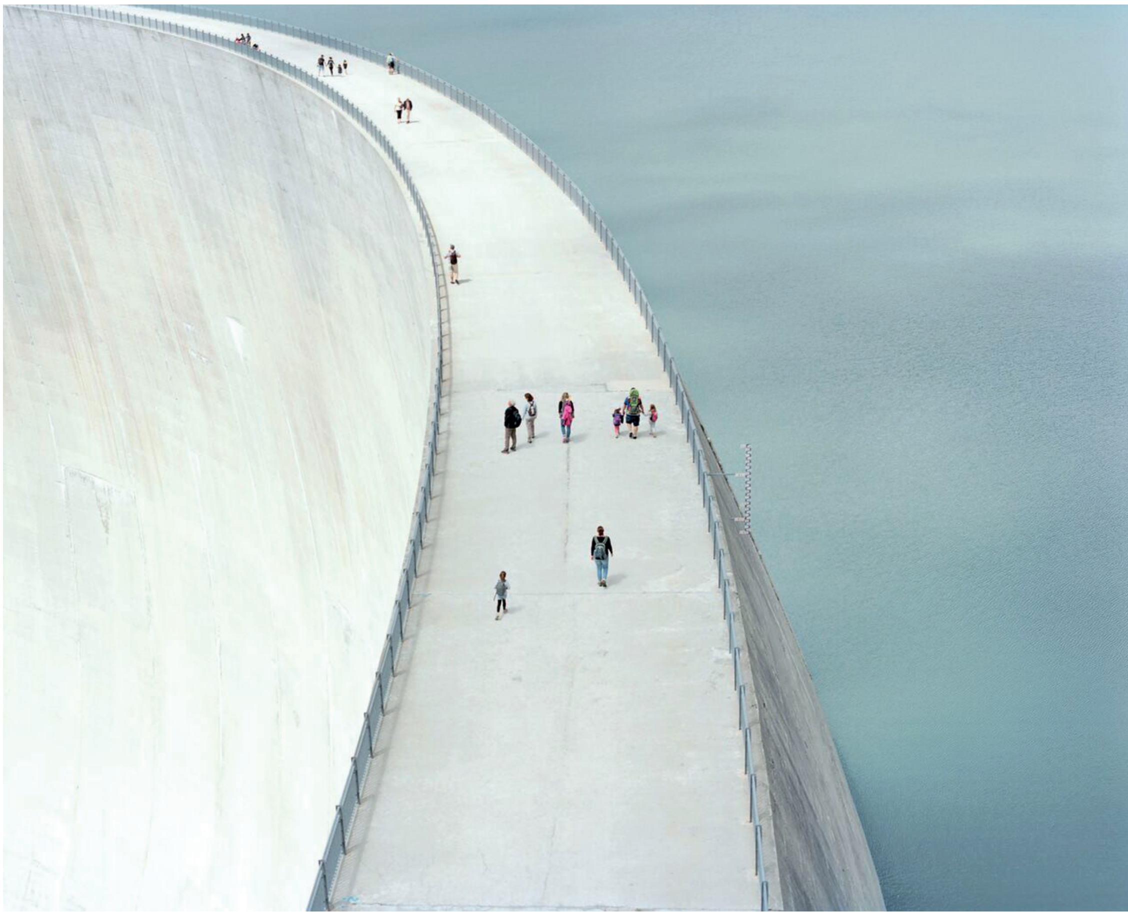
The rupture of the Nova Kakhovka dam in southern Ukraine has raised concerns about a potential ecological disaster, prompting Ukrainian President Volodymyr Zelensky to characterize the situation as "an environmental bomb of mass destruction." The unfolding events carry a certain irony, considering that in 1941, the USSR intentionally destroyed the dam for their own safety, ostensibly "protecting" contemporary Ukraine from German forces. Fast forward to 2023, and Russia has now sabotaged the same infrastructure that historically linked them to present-day Ukraine. The breach of the dam prompts numerous questions about whether this could ultimately be a positive development for Ukraine, potentially eliminating an ecologically harmful hydropower station. Nevertheless, it could take years for Ukraine to assess the full damage and decide whether to restore or remove the dam completely.

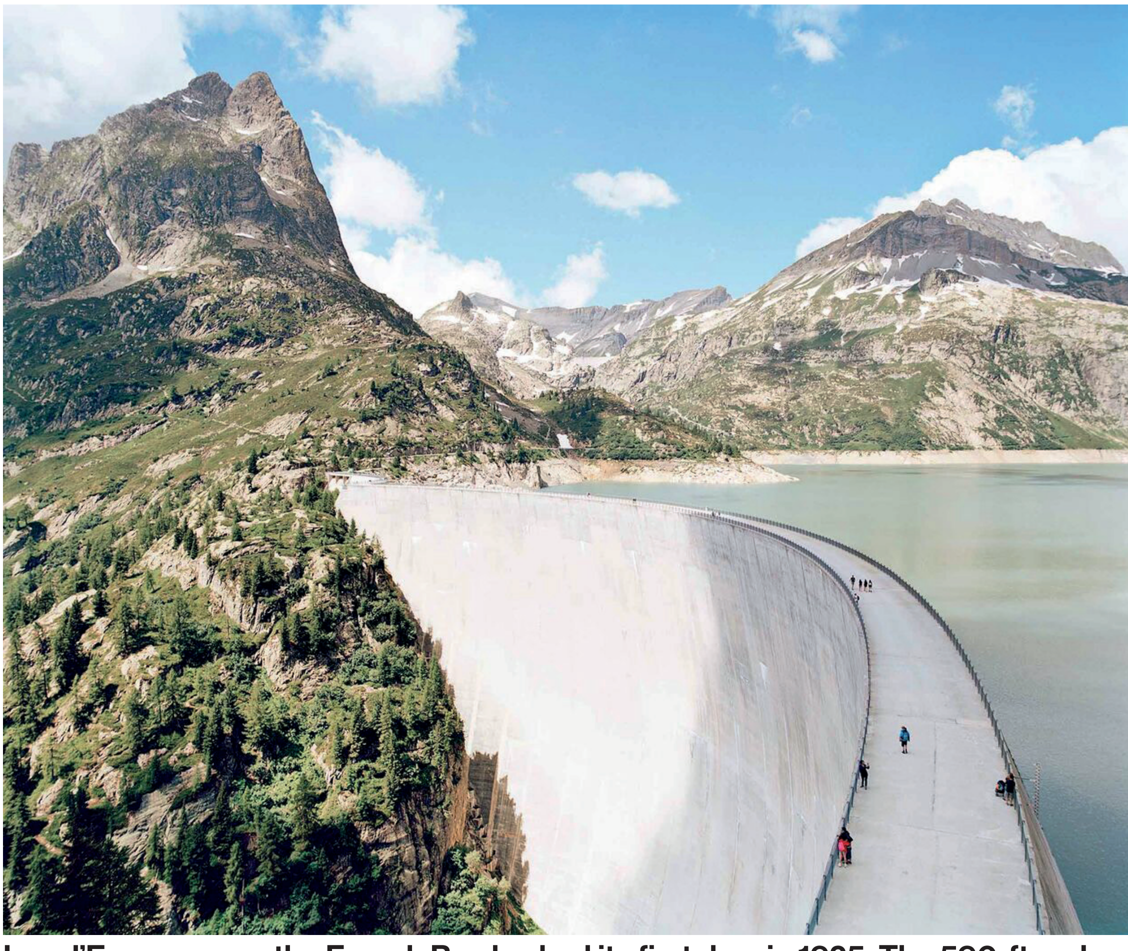
reimagining dams

"We need to make friends with flooding." There is no way to build a dam safely, and it could be decades before we see countries fully–if ever–move away from dams. Climate change is intensifying extreme hazards, exposing the stark reality that both historical and contemporary infrastructure exacerbate our challenges. Ultimately, the natural order of the world will prevail, and no artificial infrastructure can rescue us. Addressing the multitude of dams requires a multifaceted approach, encompassing political, ecological, and philosophical frameworks.

The movement–Slow Water–comes to mind. Its projects and activism advocate for befriending water by conserving or restoring wetlands, river floodplains, and mountain forests. This approach simultaneously safeguards carbon storage and preserves habitats for endangered plants and animals. Rooted in indigenous traditions, Slow Water views water not as a threat but as a living entity, a kin that must be protected at all costs. A crucial aspect of the movement involves compelling planners, engineers, and politicians to construct cities with consideration for how water naturally flowed before urban development. The city-building process requires understanding the water's preferences and adapting human landscapes accordingly. It is essential to grasp how water behaves before generations of humans drastically altered landscapes and waterways – how it interacted with local rocks, soils, ecosystems, and climates before our interventions. While acknowledging the difficulty people face in envisioning space for water, the movement emphasizes that if we neglect to do so, water will inevitably carve out its own space.

As a planner, there are a multitude of ideas that struck out in my research, in responding to the plague of dams. Through my research, I focused on environmentalism and the history of power needed in controlling these huge blocks of concrete. Recently, in the U.S, environmental groups and the energy industry began to agree to work together to bolster hydropower while reducing harm from dams. The environmental movement was so successful in its opposition that it effectively ended all major dam building in the U.S. Dam busting even became a transition of American environmentalism. American environmentalist–John McPhee–explained how the innermost circle of an environmentalist's hell "stands a dam." "Possibly the reaction to dams is so violent because rivers are the ultimate metaphors of existence, and dams destroy rivers."





Lac d'Emosson, on the French Border, had its first dam in 1925. The 590-ft arch dam standing today, ecompleted in 1973, is one of Europe's biggest hydroelectric projects. (Bloomberg 2019)

reimagining dams

Developing a strategy to decommission a dam necessitates a comprehensive plan that not only benefits the local community but also contributes positively to the ecosystem and energy grid. Addressing the global challenge of numerous dams requires close collaboration among planners, architects, and engineers, with a focus on understanding the surrounding land and community dynamics. Envisioning a world without dams acting as barriers to water flow, suffocating natural waterways, becomes essential. In this vision, the entire world relies on renewable energy sources, free from any detrimental impact on our planet. It is a vision where politicians refrain from exploiting nature to assert dominance over the world. Achieving this transformative outcome can take various forms, encouraging innovation and cooperation across diverse sectors.

Eco-Tourism and Education Centers

Revitalizing dams by transforming them into Eco-Tourism and Education Centers holds the potential to not only preserve the ecological integrity of natural sites but also to foster community engagement with the environment. Such endeavors can serve as powerful tools for reconnecting communities with nature, promoting sustainable practices, and offering valuable insights into the significance of river ecosystems. These transformed centers can play a pivotal role in environmental education, shedding light on the intricate web of life within river ecosystems. Visitors can gain a deeper understanding of the importance of biodiversity, the role of waterways in supporting various species, and the overall health of aquatic ecosystems. Interactive exhibits, guided tours, and workshops can be designed to engage visitors of all ages, fostering a sense of responsibility and appreciation for the environment.

Moreover, these Eco-Tourism and Education Centers can serve as platforms for promoting renewable energy alternatives. Exhibits and demonstrations can showcase innovative technologies in hydropower, solar, and wind energy, elucidating the potential for sustainable energy solutions. This not only raises awareness about the environmental impact of conventional dams but also encourages discussions on transitioning to cleaner and more environmentally friendly energy sources. Recreational areas within these centers can be carefully designed to encourage low-impact activities, emphasizing a harmonious coexistence between humans and nature. Trails for hiking, observation points for bird watching, and water bodies suitable for canoeing can provide visitors with immersive experiences in the natural surroundings. Such activities not only contribute to physical well-being but also instill a sense of responsibility for preserving the beauty and ecological balance of the area.

Floating Solar Islands

Transforming reservoirs behind dams into floating solar islands represents an innovative approach to optimizing land, or in this case water, usage while simultaneously harnessing renewable energy. This dual-use strategy not only addresses energy needs but also provides opportunities for additional environmental benefits. For instance, the utilization of floating solar platforms can create a conducive environment for aquaculture, allowing the cultivation of fish and other aquatic species beneath the solar panels. This symbiotic relationship enhances biodiversity and fosters sustainable practices in water management. Furthermore, the space beneath the floating solar islands offers an ideal opportunity for wetland restoration. Wetlands play a crucial role in maintaining ecological balance, serving as habitats for diverse plant and animal species, while also providing essential ecosystem services such as water filtration and flood control. Integrating wetland restoration beneath these solar platforms contributes to the preservation and revitalization of these vital ecosystems. The synergy between floating solar islands, aquaculture, and wetland restoration exemplifies a holistic and sustainable approach to utilizing dam reservoirs. This multifaceted strategy not only addresses energy generation but also promotes environmental conservation and ecosystem resilience, showcasing the potential for harmonizing human activities with the natural world.

Hydropower-Free River Restoration

Investing in Hydropower-Free River Restoration goes beyond energy considerations; it involves comprehensive river rehabilitation projects. These initiatives prioritize habitat improvement, creating conditions conducive to the flourishing of diverse plant and animal life. Erosion control measures are implemented to safeguard riverbanks, preventing sedimentation that can harm aquatic habitats and water quality. Moreover, the restoration efforts incorporate the natural dynamics of floodplains, allowing rivers to meander and shape their courses naturally. Replacing traditional hydropower with solar or wind energy serves as a sustainable energy solution that eliminates the environmental toll associated with dams. Solar and wind technologies offer renewable energy sources that are less invasive, avoiding the disruption of river ecosystems caused by dam construction and operation. By integrating these alternative energy sources, we not only meet energy demands but also mitigate the adverse impacts on riverine environments.

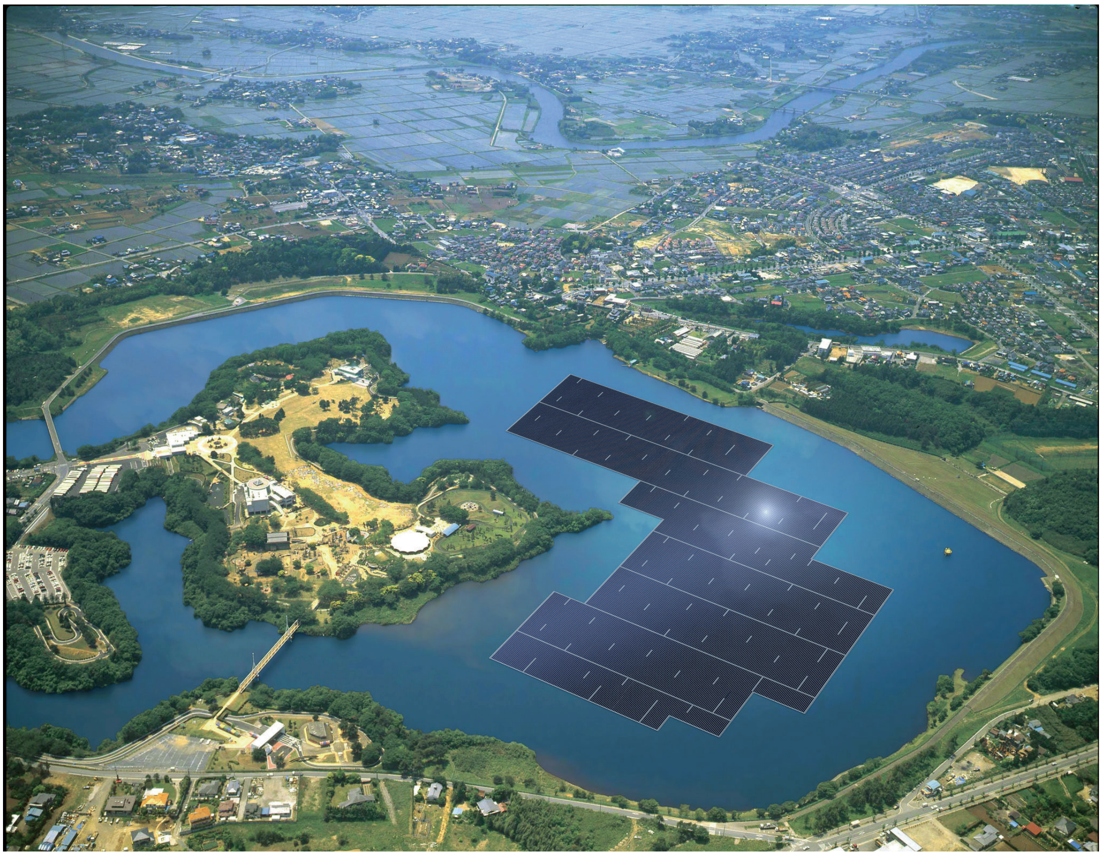
reimagining dams

Artistic Expression and Awareness

Commissioning public art installations on dams presents a dynamic and impactful approach to raising awareness about environmental issues associated with dams and hydropower. These installations serve as powerful visual narratives, conveying messages about the ecological impacts of dam infrastructure and the importance of sustainable energy alternatives. By integrating art into the dam environment, it engages the public in a thought-provoking manner and encourages dialogue about the environmental consequences of dam construction. Examples of such public art installations could include large-scale murals on dam structures that depict the interconnectedness of ecosystems disrupted by dams. These murals might showcase the diverse flora and fauna that inhabit river ecosystems, emphasizing the ecological balance that free-flowing rivers sustain. Incorporating vibrant colors and intricate details, these artworks can captivate the attention of onlookers and serve as a constant reminder of the environmental stakes. Events like environmental awareness festivals near dam sites can bring communities together. Workshops, panel discussions, and educational activities can provide insights into the ecological importance of free-flowing rivers and promote discussions on adopting alternative, eco-friendly energy solutions.

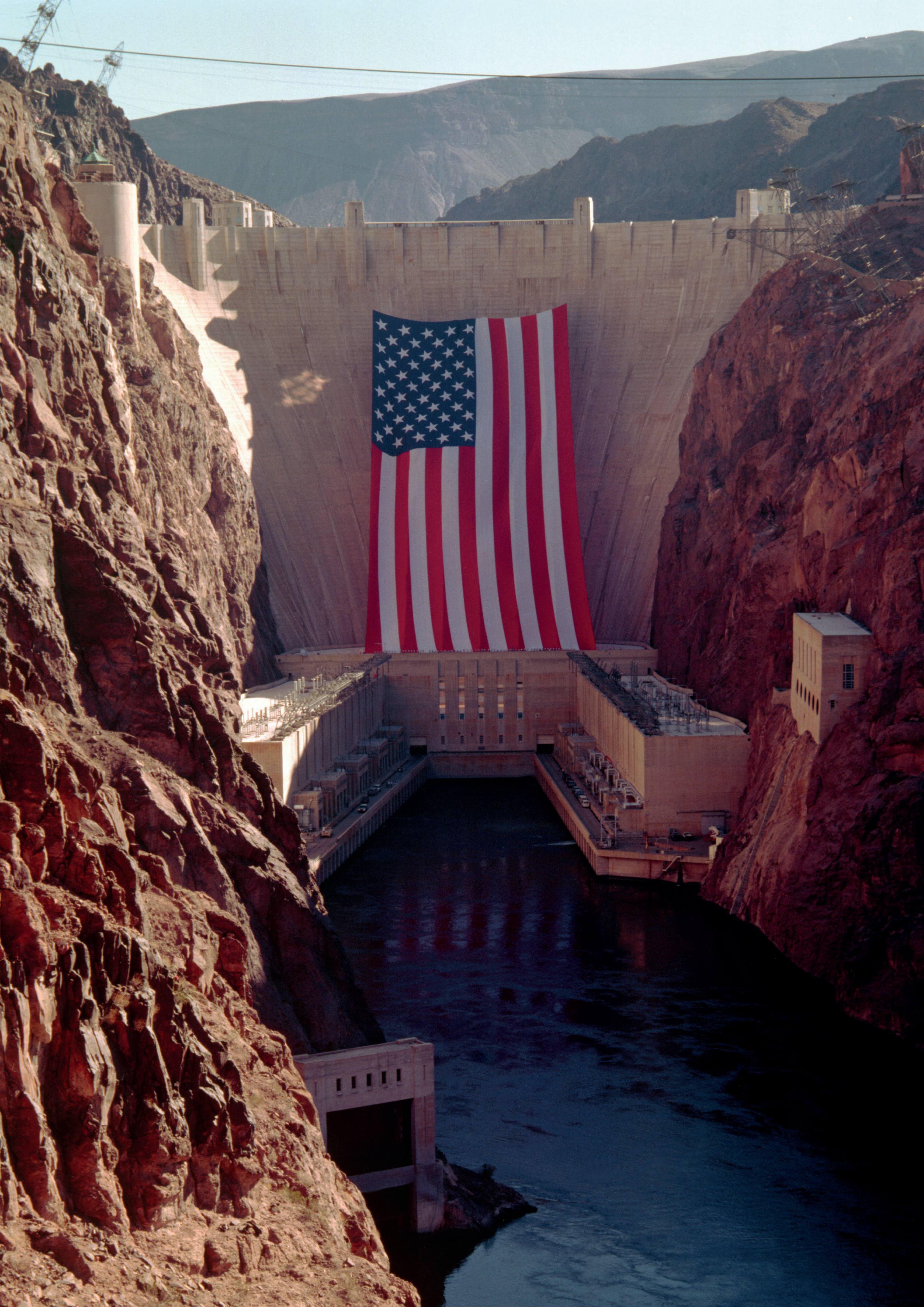
River Centric Planning

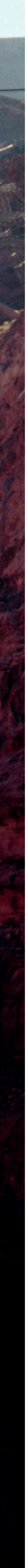
The removal of outdated or environmentally detrimental dams becomes a key focus, as witnessed in successful cases like the Edwards Dam on the Kennebec River in Maine, USA. Such initiatives aim to restore natural river flow and ecosystems, fostering improved fish migration and habitat revitalization. Along the riverbanks, urban planners advocate for the integration of green spaces, creating vibrant parks that serve as recreational areas and enhance the city's aesthetic appeal. Pedestrian pathways and cycling lanes are thoughtfully designed to encourage alternative transportation modes and promote a healthier urban lifestyle. Wildlife corridors are strategically planned along river corridors, fostering biodiversity by connecting fragmented habitats and facilitating the movement of diverse species. Sustainable agriculture initiatives along riverbanks, exemplified by projects such as urban farming along the Milwaukee River, emphasize environmentally conscious practices to promote local food resilience. Community gardens thrive along these waterways, not only contributing to local food production but also fostering community engagement. Riverfront restoration projects, like San Antonio's River Walk, successfully blend ecological revitalization with economic development, attracting tourism and supporting local businesses. Educational and cultural initiatives along rivers aim to raise awareness about their ecological significance and historical importance. Overall, river-centric planning offers a holistic approach to urban development, recognizing rivers as vital components that contribute to thriving, resilient communities coexisting harmoniously with their natural environments.



Solar Panels on the Yamakura Dam Reservoir in Japan. If construction goes as planned, 50,904 panels will float on the reservoir, generating enough electricity to power almost 5,000 homes. (2016, The New York Times)

Guerilla Activists Paint “Cut Here” Scissors on Obsolete Dam (LA Times)





Dams, as engineering marvels, have undeniably played a crucial role in meeting human needs for water supply, flood control, and energy generation. However, their profound influence on ecosystems cannot be ignored.

My examination has revealed that dams often trigger a cascade of ecological consequences, altering river dynamics, disrupting natural habitats, and affecting the biodiversity of aquatic and terrestrial ecosystems. While the negative impacts are evident, it is essential to recognize that the ecological needs of both humans and the environment are intricately interconnected. Striking a balance between meeting human demands and safeguarding ecological integrity is a formidable challenge, but one that demands urgent attention.

To navigate this complex terrain, future dam projects should adopt a holistic and sustainable approach, incorporating comprehensive environmental impact assessments, adaptive management strategies, and the integration of ecosystem-based solutions.

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