

The Lower Colorado River

edited by

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Note: In PDF format most of the images in this web paper
can be enlarged for greater detail.

Introduction

From the Grand Canyon the Colorado River flows into Lake Mead on the border between Arizona and Nevada. From Lake Mead and Hoover Dam the river flows south to Mojave Lake and Davis Dam, completed in 1953, and on to Lake Havasu created by the construction of Parker Dam. Parker Dam spans the Colorado River between Arizona and California, 155 miles downstream from Hoover Dam. Completed in 1938, Parker Dam is operated with Hoover and Davis Dams to bring water and power to residents of the lower Colorado River Basin. From Parker Dam the Colorado flows south to Imperial Reservoir, just north of Yuma, Arizona, created by the Imperial Dam completed in 1935. Water is diverted by the Imperial Dam into the All-American Canal which brings the water to the Imperial Valley.

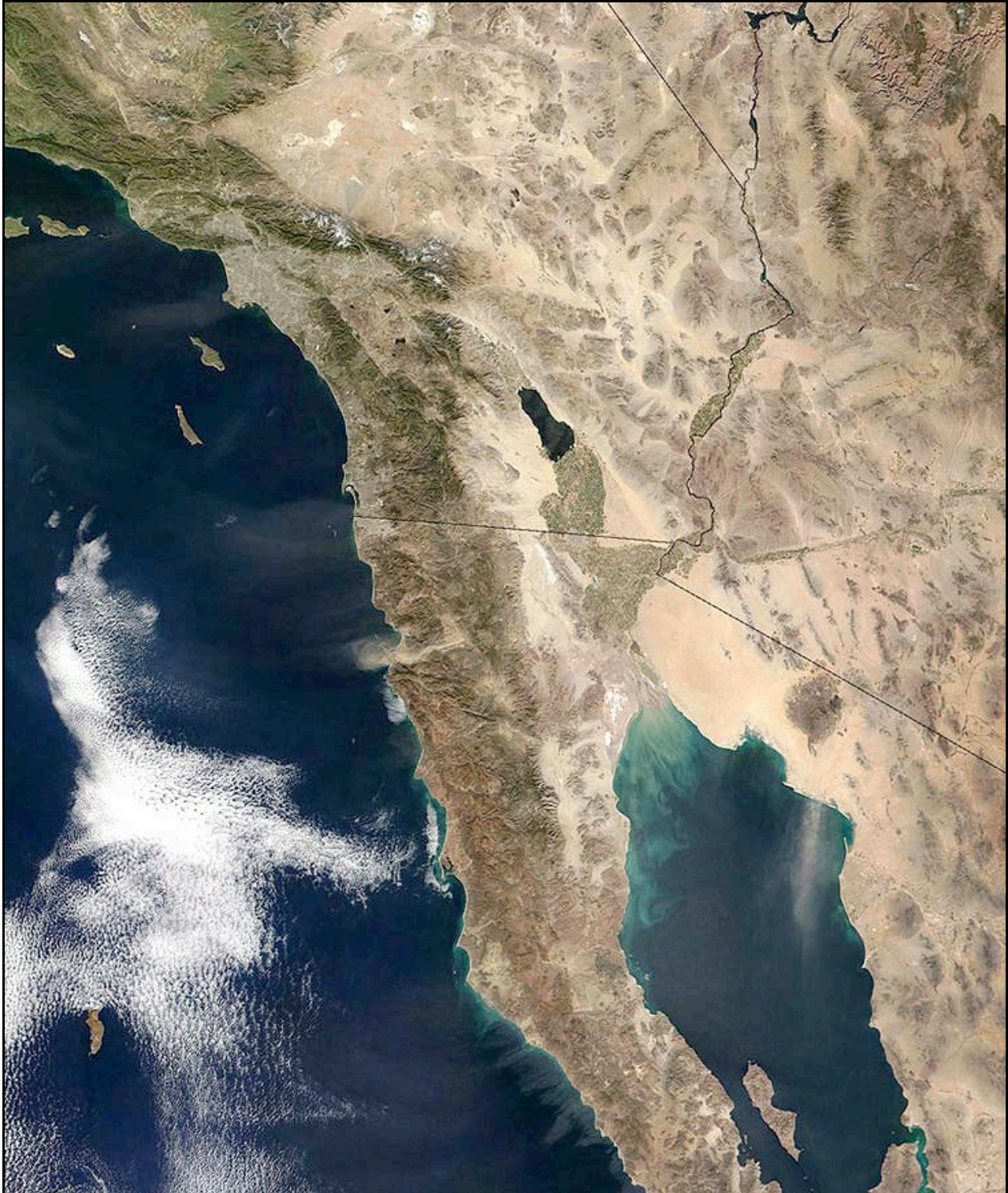
Altogether the chain of lakes along the Colorado River consisting of Lake Powell, Lake Mead, Lake Mojave, Lake Havasu, and Imperial Reservoir hold 63 million acre feet of water. Because of the many reservoirs, evaporation and seepage accounts for between fifteen to twenty percent (over 2.6 million acre feet) of the river's estimated average annual flow of 15 million acre feet.

California's total annual allotment of Colorado River water is 4.4 million acre feet of which 3.1 million acre feet are allotted to the Imperial Valley Irrigation District alone, leaving 1.3 million acre feet for all of municipal Southern California. Only 1.5 million acre feet of the Colorado's total average annual flow is allotted by treaty to Mexico.

The lower Colorado River separates two great deserts, the Mojave on the California side and the Sonoran on the Arizona side of the river. South of the Mojave Desert lies the Salton Basin, a large structural depression 278 feet below sea level. In 1905, floodwaters caused a levee to break on the Colorado River near Yuma; its waters rushed into the Salton Basin. This created the Salton Sea, which today is 35 miles long, and 15 miles wide, making it the largest lake in California. It has an average depth of 30 feet and contains ~7.3 million acre feet of water. The sea has no outlet and would quickly evaporate under the desert sun but is maintained today by agricultural wastewater runoff from the Imperial Valley.

Web Reference

http://www.desertusa.com/colorado/explorriver/du_explorrv.html



Above is a satellite image of southern California and the Baja Peninsula acquired February 9, 2002, by the MODIS instrument aboard NASA's Terra satellite.



This enlarged view of the February 9, 2002, MODIS image, shows the Colorado River from Lake Mead to the Gulf of California, with the major cities and features of the lower Colorado River basin labeled.



The Las Vegas Valley, Nevada, 1998

The city of Las Vegas is in the center of this picture with Lake Mead bottom center. Hoover Dam is just visible as a white dot on the bottom left of Lake Mead.

Web References

http://en.wikipedia.org/wiki/Las_Vegas,_Nevada

http://geochange.er.usgs.gov/sw/changes/anthropogenic/population/las_vegas/

(Space Shuttle photograph courtesy of NASA)



Suburban Las Vegas 2002

In spite of the desert climate of the Las Vegas Valley, water conservation has never been widely practiced in the region. The result of wasteful consumption coupled with growth has been a dramatic increase in the demand for freshwater.



Suburban Las Vegas 2007

Las Vegas is finally trying to conserve water. Above crews are removing grass along a golf course and replacing it with xeric landscaping.

Regional demand for the fresh water from the Colorado River has increased dramatically in the last decades. In 1960, the Las Vegas Valley had a population of only 127,000. The Valley's population is now 1.8 million. And Las Vegas was still one of the fastest growing cities in the U.S., that is until the housing bubble crash of 2008. Now the future of Las Vegas is as vague as the future of the United States economy.

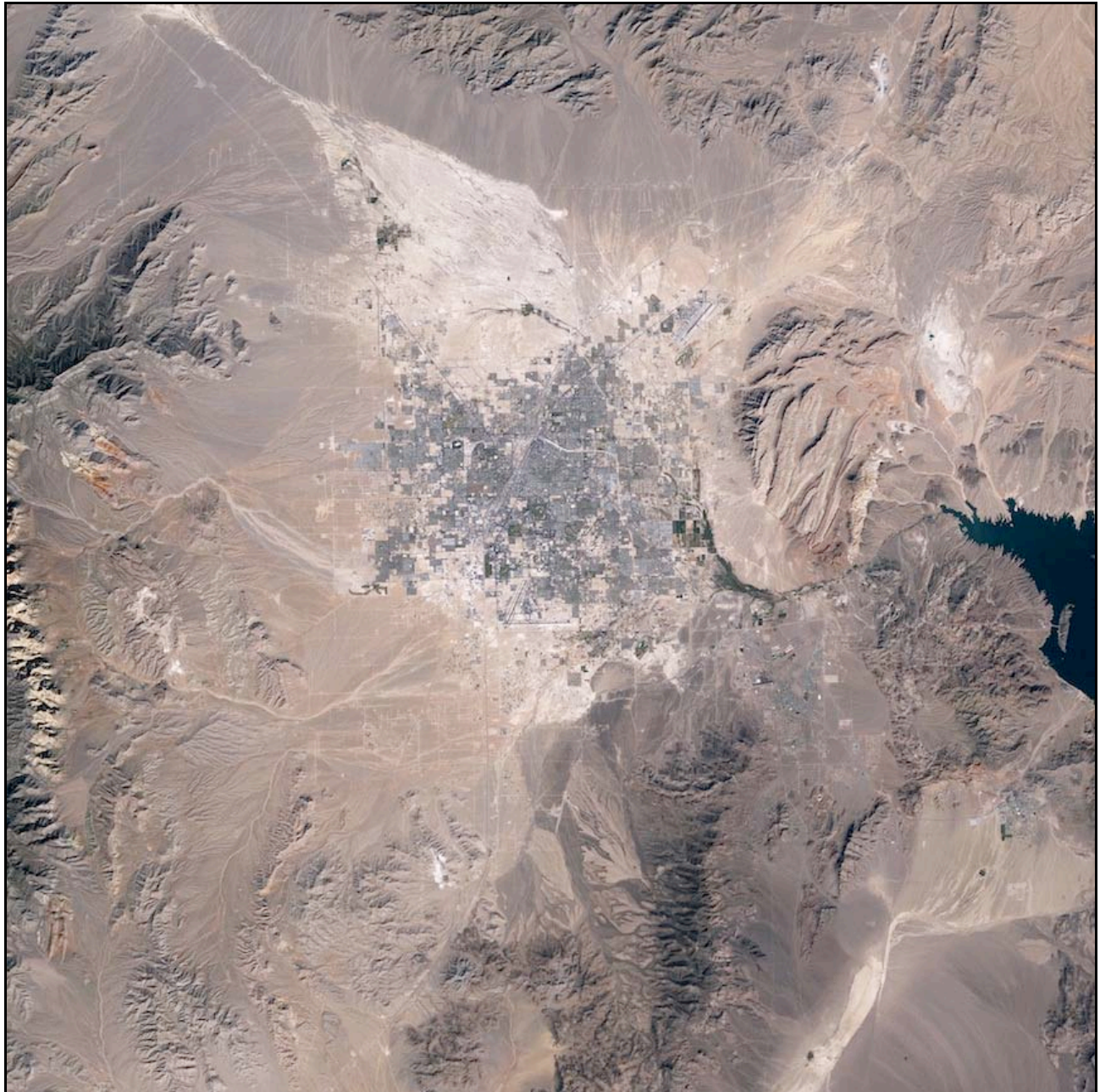
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<http://www.npr.org/templates/story/story.php?storyId=10939792>

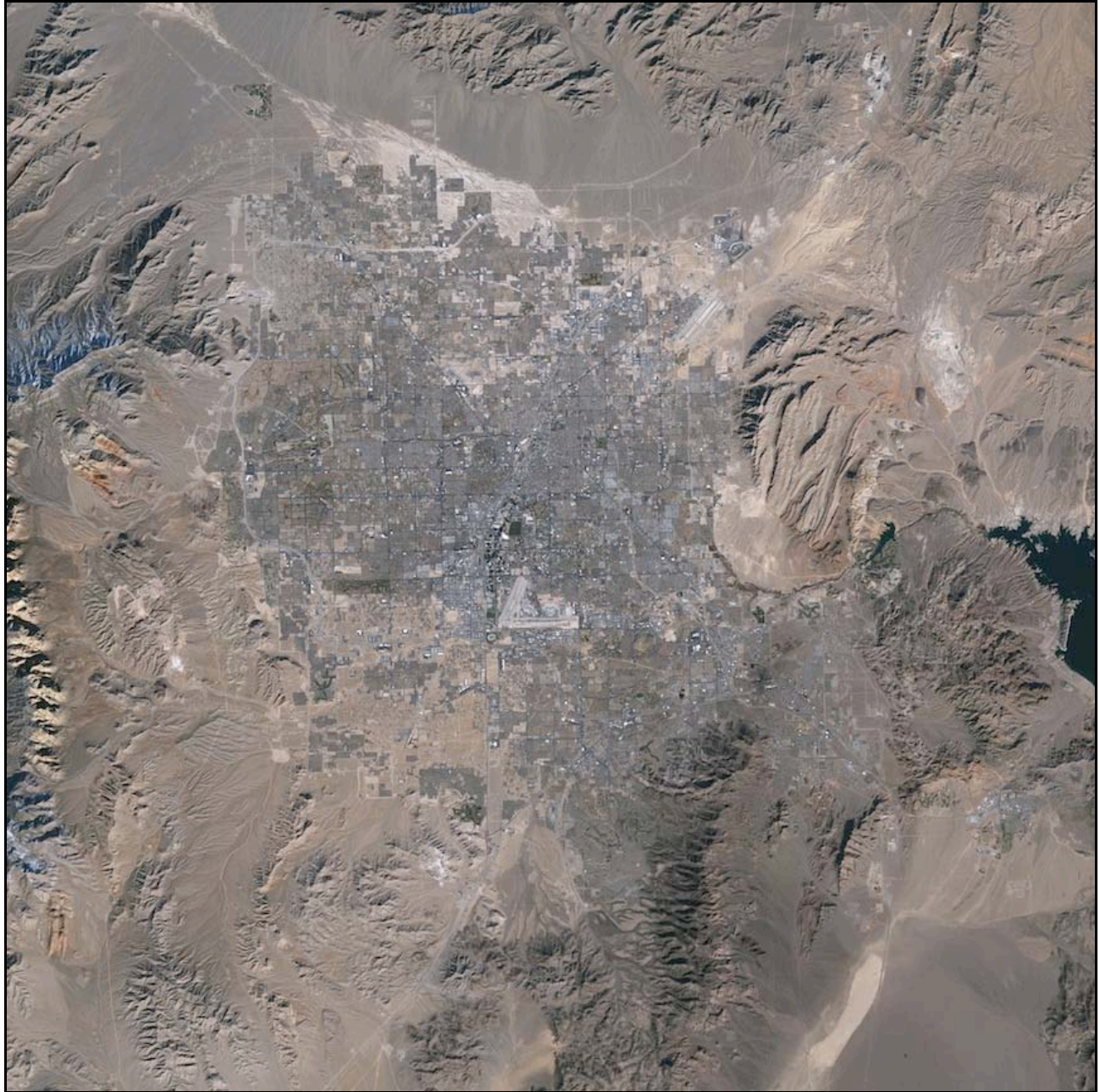
Tanner, A. (2007, August 21) Reuters.

[Las Vegas growth depends on dwindling water supply](#)

Las Vegas growth 1984 to 2009



Las Vegas in 1984, city population ~ 200,000



Las Vegas in 2009, city population ~ 550,000

Earth Observatory article and images on Las Vegas growth from 1984
<http://earthobservatory.nasa.gov/IOTD/view.php?id=37228>



This International Space Station (ISS) photograph shows Lake Mead on the upper left and Hoover Dam just below center, with the Black Canyon of the Colorado River running diagonally lower right.

(ISS image courtesy of NASA)



Hoover Dam and Lake Mead

Photograph courtesy of Philip Greenspun <http://photo.net/philg/>

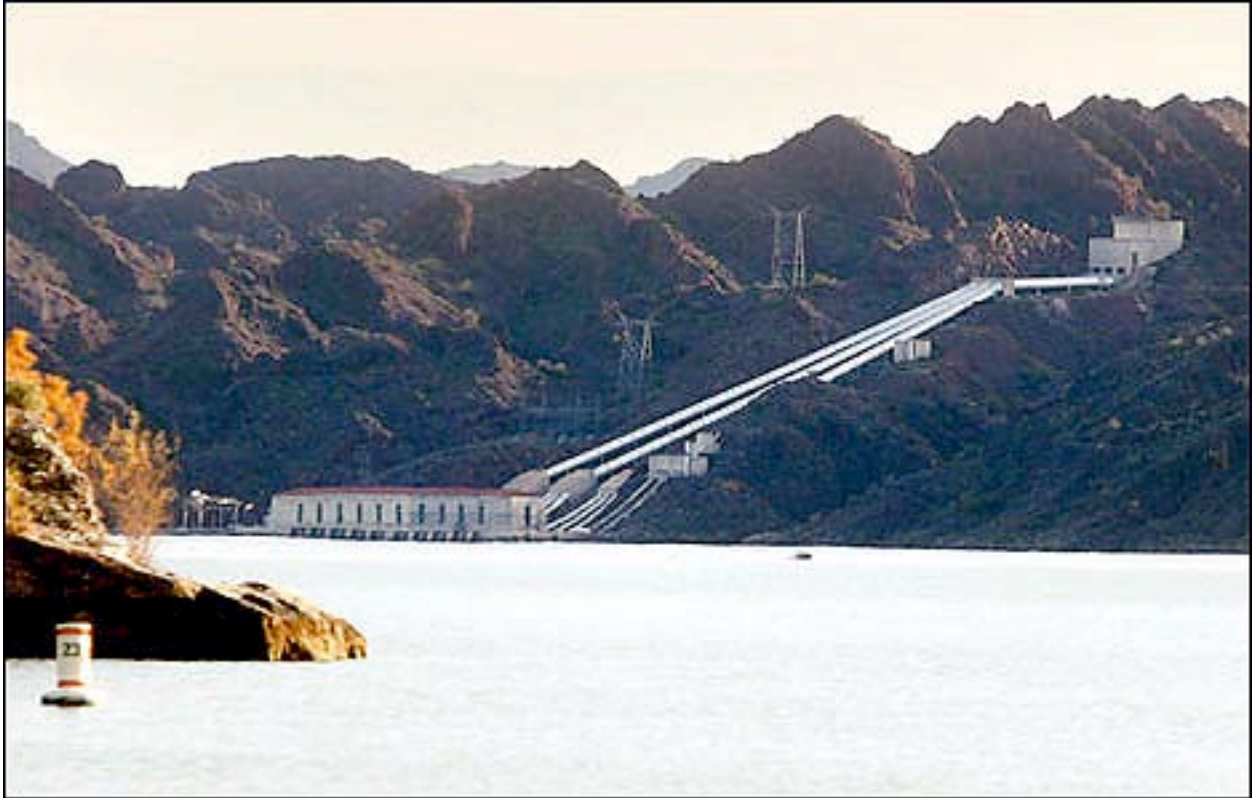


Below Hoover Dam (shown above) the Colorado River flows south to Lake Mojave and Davis Dam and then to Lake Havasu and Parker Dam.



Black Canyon below Hoover Dam

Note the tailings from the original construction of the dam on both sides of the river.



Lake Havasu and the Colorado River Aqueduct

Parker Dam's primary purpose is to provide reservoir storage for water to be pumped to the Los Angeles metropolitan area via the Colorado River Aqueduct and to cities in Arizona via the Central Arizona Project Aqueduct. Lake Havasu, the reservoir behind Parker Dam, is about 45 miles long and can store nearly 211 billion gallons of water. Parker Dam was constructed with funds advanced by the Metropolitan Water District of Southern California. The Colorado River Aqueduct has delivered water from Lake Havasu to the Los Angeles metropolitan area since 1941. The Aqueduct is also tapped by the San Diego Aqueduct, which takes water to that city's water system. Currently a minimum 1.3 million acre feet of water are delivered annually to Southern California through this system.

(Photograph courtesy of the New York Times)



Looking west to the Salton Trough

From Lake Mead the Colorado River travels due south until just north of Yuma, Arizona (bottom just right of center). It then turns sharply west into the Salton Trough (the Salton Sea is far right) before turning south again to the Gulf of California (far left). San Diego is in the upper right corner.

Without the Colorado River and its sediments the Gulf of California would now extend northwest into the United States almost 87 miles (139 km) from the border. The Colorado River began to fill the Salton Trough with sediments 5.5 million years ago. The enormous thickness of the Colorado sedimentary now forms a natural dike between the waters of the Gulf of California and the Salton Sea.

(January 10, 2002, ISS image courtesy of NASA)

For more on the Salton Trough go to:

<http://fire.biol.wvu.edu/trent/alles/GeologySaltonTrough.pdf>



Looking southwest from the Salton Sea to the Colorado River Delta

The surface of the Salton Sea is nearly 230 feet below sea level. As a result, water taken from the Colorado river at Imperial Dam can flow downhill west and then north into the Salton Sea and can be easily drawn off on the way to irrigate the dark green fields of the Imperial Valley. The main canal that brings water from the Colorado River is the All-American Canal and can be seen above as a thin dark line crossing from left to right in the center of the image.

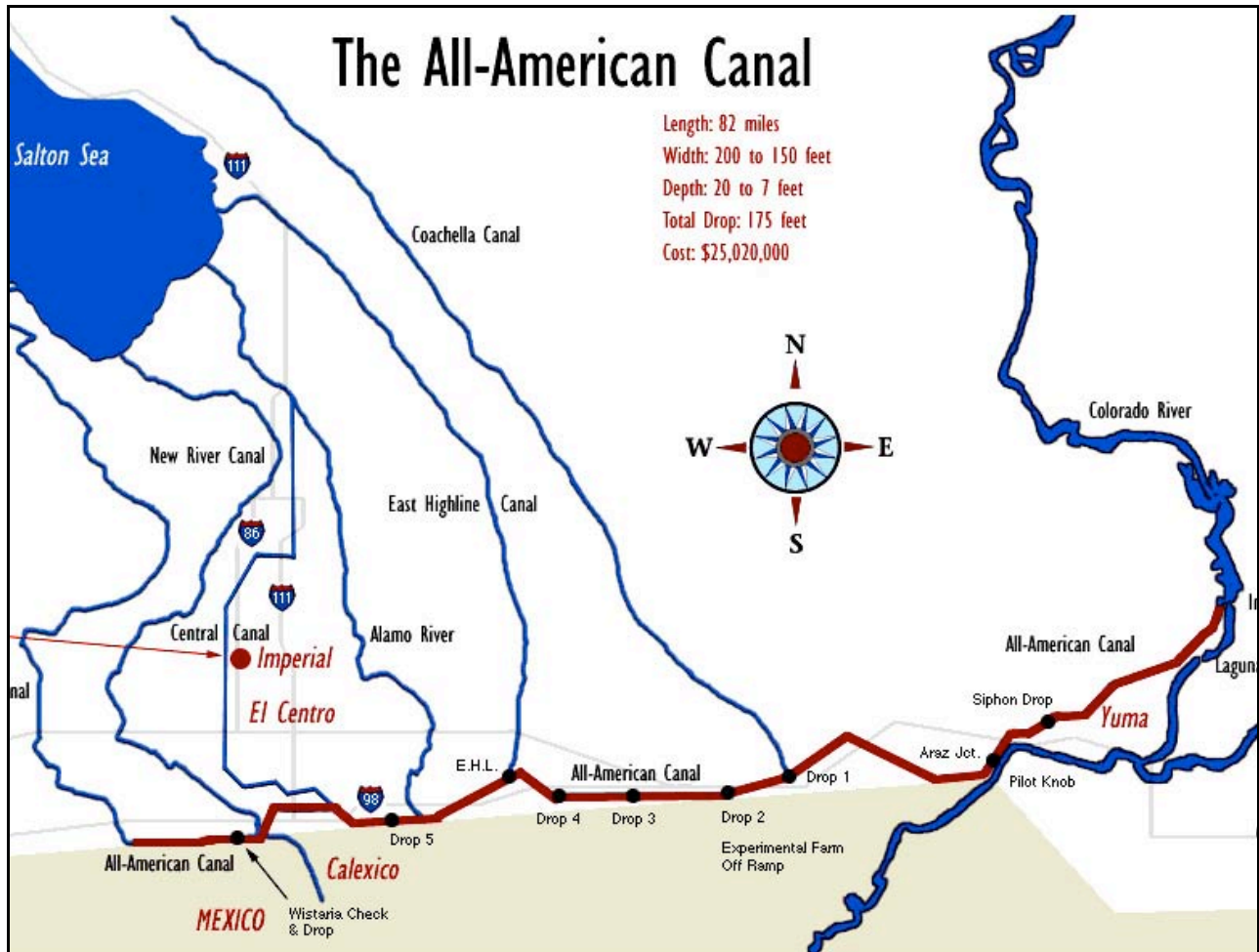
(May 1991, Space Shuttle image courtesy of NASA)



The All-American Canal

Approximately 3.1 million acre-feet of Colorado River water is delivered annually through the All-American Canal to nine cities and 500,000 acres of agricultural lands throughout the Imperial Valley. The gravity flow All-American begins at Imperial Dam on the Colorado River about 20 miles northeast of Yuma, Arizona. It drops a total of 175 feet along its 82 mile length from Imperial Dam to the Westside Main Canal in the southwest corner of the Imperial Irrigation District's delivery area. The All-American Canal was built during the 1930s as part of a larger project that included building the Hoover, Parker, and Imperial Dams on the Colorado River. The All-American first delivered water to the Imperial Valley in 1940.

(Photograph courtesy of Los Alamos National Laboratory)



Through this gravity flow canal, Colorado River water is carried to several canals branching off the All-American. Irrigation water to the Imperial Valley is provided from the main western canals or from the tributary lateral canals that they supply. In total, the Imperial Irrigation District controls and maintains 1,675 miles of irrigation canals in the Imperial Valley.

(Map courtesy of the Imperial Irrigation District)



Flood Irrigation in the Imperial Valley

Above is a field in the Imperial Valley that has been freshly plowed and shaped for flood irrigation. The ditch the farmer is walking in will carry the flow of water, and the raised flat between the ditches will be planted with crops.

But of all the uses along the length of the Colorado River, agriculture is where the most water is wasted because most Colorado River crops are grown using flood irrigation, a method in which only a small percentage of the water is used by the plants. The balance that is not evaporated or absorbed into the soil returns to the river, or flows to the Salton Sea in the Imperial Valley, contaminated with salts, pesticides, fertilizers, and other toxins.

Reference

Barringer, F. (2011, October 23). Empty Fields Fill Urban Basins and Farmers' Pockets. *The New York Times*, National.



Flood irrigation is necessary to leach the salts that build up in the soil with repeated years of growing crops in desert environments, and is used as long as there is enough inexpensive freshwater available. Because the Imperial Irrigation District was established in the early 20th century, the cost of irrigation water to the farmers that belong to the Irrigation District is a fraction of the real market value of the water, and so the practice continues.

Web References

<http://eros.usgs.gov>

<http://earthshots.usgs.gov/Imperial/Imperial>



Because it has no outlets, the Salton Sea is an evaporation basin that concentrates pollutants and salts. In the last two decades the level of pollutants have become a hazard to birds and other wildlife. Anaerobic conditions caused by phytoplankton blooms fed by fertilizers from agricultural runoff have led to massive fish and bird kills. Since 1992, an estimated 200,000 birds have died from avian botulism, cholera, and other diseases. More than 14,000 pelicans died in 1997. The NASA image above shows a massive phytoplankton bloom in the Salton Sea on **July 31, 2006**.

Each year the Salton Sea loses ~1.36 million acre feet of water by evaporation, almost 20% of its volume. This must be balanced by inflow to maintain the sea's water level or the sea will disappear. Agricultural runoff supplies ~ 90% of this inflow. Municipal effluent and storm water that flows into the sea through rivers and creeks supplies the balance. Currently sea levels are stabilized with inflows equaling evaporation, but the situation could change rapidly if the state of California and the Imperial Irrigation District are forced by the federal government to live within their allotment of river water. If that happens, there may be no hope of maintaining the Salton Sea.

What could the future of the Salton Sea look like?



Dust Storm blowing northeast over the Aral Sea May 28, 2008

(MODIS/Aqua Real Time image courtesy of NASA)

The Death of the Aral Sea

The Aral Sea in central Asia was once the world's fourth largest lake, slightly bigger than Lake Huron, and one of the world's most fertile regions. Today it is little more than a string of lakes scattered across central Asia east of the Caspian Sea.

The sea disappeared for several reasons. One is that the Aral Sea is surrounded by the Central Asian deserts, whose heat evaporates 60 square kilometers (23 sq. miles) of water from its surface every year. Second is four decades of agricultural development and mismanagement along the Syr Darya and Amu Darya rivers that have drastically reduced the amount of fresh water flowing into the sea. The two rivers were diverted starting in the 1960s in a Soviet scheme to grow cotton in the desert. Cotton still provides a major portion of foreign currency for many of the countries along the Syr Darya and Amu Darya rivers.

By 2003, the Aral Sea had lost approximately 75% of its area and 90% of its pre-1960 volume. Between 1960 and January 2005, the level of the northern Aral Sea fell by 13 meters (~ 43 ft) and the larger southern portion of the sea by 23 meters (75.5 ft) which means that water can now only flow from the north basin to the south. Evaporation and agricultural runoff have left portions of the Aral much saltier than the ocean, which in turn has killed off most fish. All 24 of the Aral's native species have long since perished. The surrounding region now has one of the highest infant mortality rates in the world, and anemia and cancers caused by chemicals blowing off the dried sea bed are common. Economic mismanagement has turned the area surrounding the sea into a toxic desert.

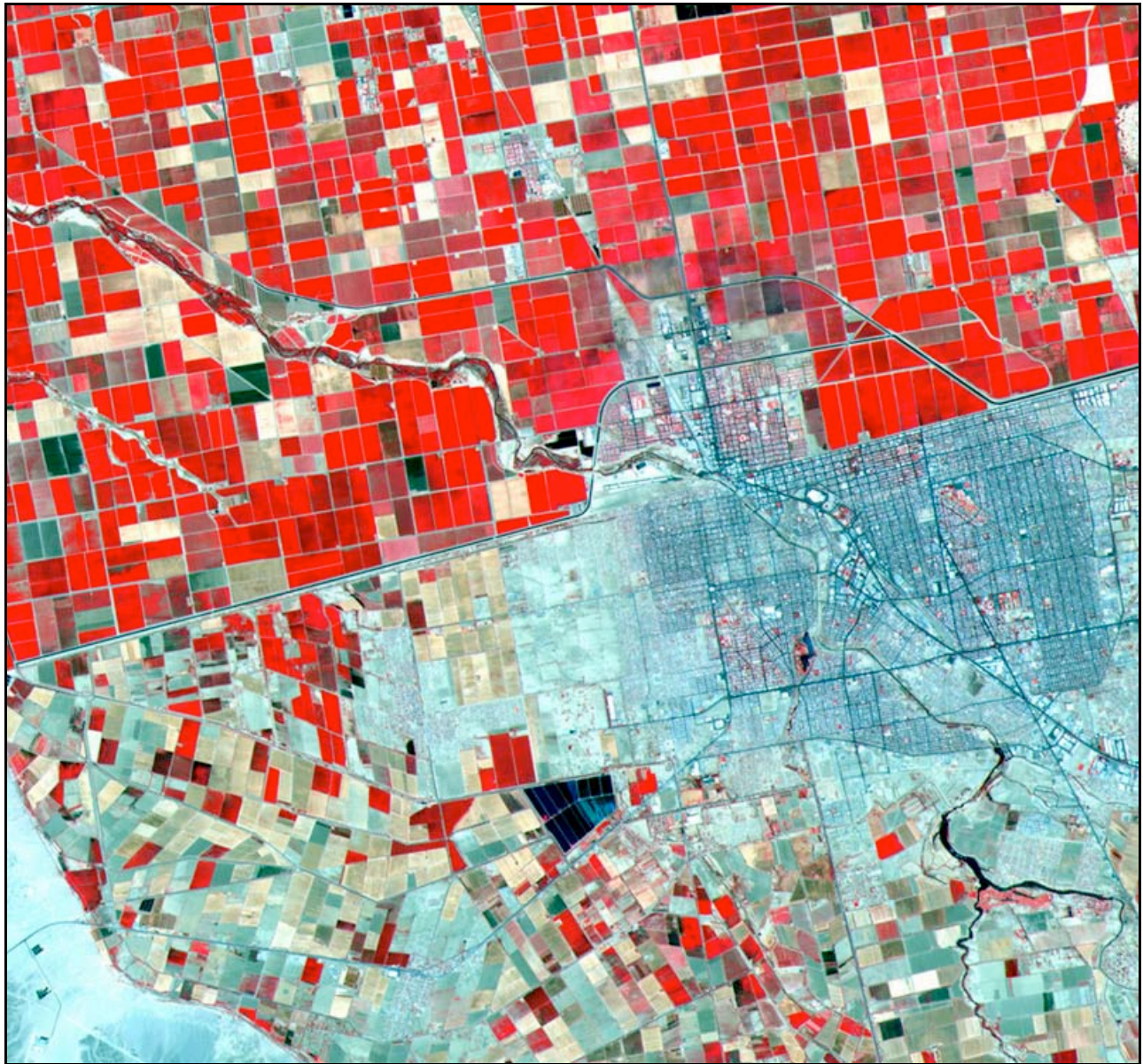
According to Dr. Robert Jellison, a specialist in salt lakes, increasing irrigation is drying up salt lakes all around the world (Pala, 2003). In the U.S., in California's Imperial Valley, it's happening to the Salton Sea. Today the Salton Sea is a closed desert basin into which salt, pesticides, and fertilizers are flushed indiscriminately. The sea does receive enough polluted runoff water to maintain its size for now. But the real issue for the Salton is the future. One projection of the future needs of southern California cities means that the sea will be allowed to dry up to provide more water for the cities. This will leave behind a salt basin filled with pollutants and exposed to the winds.

For more on the Aral Sea go to:

<http://fire.biol.wvu.edu/trent/alles/AralSea.pdf>

Water and Politics along the Colorado River

What follows are examples of Colorado water politics during the last ten years.



Mexicali, Mexico on the U.S. Border

Dramatic differences in land use patterns are highlighted in this image of the U.S.-Mexico border. Lush, regularly gridded agricultural fields on the U.S. side contrast with the more barren fields of Mexico. This June 12, 2000, scene combines visible and near infrared bands, displaying vegetation in red. The city of Mexicali-Calexico spans the border in the middle of the image.

(ASTER image courtesy of NASA)

Excerpts from **Mexicali: Living on Borrowed Water**

by Haley Nolde

"Although it has more Colorado water rights than any other state, California has been taking more than its share for decades. In 1990, California used every drop of Arizona and Nevada's surplus, causing the three states collectively to use their entire apportionment of the river for the first time. But growth is driving Arizona and Nevada to demand more water. In the year 2000, 21,000 new homes went up in the Las Vegas area and 21 new golf courses bloomed in Arizona. Now the federal government is forcing California to cut back on its use of the river.

One of the key components of the state's elaborate plan to live within its legal water limit is to line the All-American Canal with concrete, and pipe the conserved water to coastal cities in Southern California. But what's slipping through the dirt bottom of the canal is not just lost water waiting to be saved. Underground, it flows south to Mexico, where for 60 years, farmers have pumped it from wells to irrigate their crops. In Baja California's Mexicali Valley, 30,000 people rely on it. For these farmers, field workers, cooks, mechanics, clerks and others in some 30 rural towns, the lining of the All-American Canal could mean the end of a way of life."

In the fall of 2000, nine reporters from the Graduate School of Journalism at UC-Berkeley set out on a three-month project to document the tremendous challenges to life on the border. Haley Nolde was one of the nine reporters.

For more on their reports go to:

<http://journalism.berkeley.edu/projects/border/mexicali.html>

Excerpts from: **In a First, U.S. Puts Limits on California's Thirst**

"For the first time since it was given the authority four decades ago, the United States Department of the Interior has said no to California's dipping into the Colorado River for more than its allotted share. Nudged on by six other states that draw from the river, Interior Secretary Gale A. Norton described the enforcement last month as "a turning point in the history of the Colorado River." The circumstances that led to the crackdown involved a failed deal to move water from farms to cities in Southern California, a requirement of a federally brokered armistice along the Colorado two years ago. Though the farms-to-city provision was overshadowed by the consequences for California, it reflected an epic shift in the jostling for water that some water experts say could someday eclipse the rivalries among states. Already as cities across the West look to agriculture to help meet growing water needs, demarcation lines are more likely to have swimming pools on one side and irrigation ditches on the other." (Murphy, 2003)

Excerpts from: **U.S. Backs Reducing California Valley's Use of Colorado River**

A federal agency said today that farmers in the Imperial Valley of California are wasting water from the Colorado River and should have their allotment of the drought-shrunk waterway cut 9 percent next year. The Bureau of Reclamation said the roughly 400 farmers in the valley who use most of the state's supply from the Colorado River should lose 275,900 acre-feet of water. The valley's water board has threatened to challenge any ruling that threatens rights to the water that the region, in California's southeastern corner, regards as its lifeblood. Barring an appeal, the bureau's findings are to become permanent next month. Imperial County pours about one trillion gallons of Colorado River water, about 70 percent of the state's share of the river, across sun-baked fields to produce \$1 billion in food every year. The region's farmers flood fields to allow water to seep to the roots and to flush salt from the desert soil." (Associated Press, 2003, July 3)

Excerpts from: **California Water Pact Is Signed by Interior Secretary**

"U.S. Interior Secretary Gale Norton has signed a deal to divide Colorado River water among seven Western states. Much of the water will go to San Diego. The Imperial Valley, California's biggest user of Colorado River water, will sell as much as 90 billion gallons each year to San Diego — roughly a third of the city's future water needs. In an interview Wednesday, Norton said the "monumental" deal is a roadmap for future water trades in the West, which will face increasing demand for scarce resources in years to come. "This puts in place the basic building block of future agreements to meet water needs," she said.

Approval of the long-awaited deal also restores California's privileges to draw additional Colorado water for 15 years. The Interior Department revoked those privileges when California missed a Dec. 31 deadline to reach a deal. Nevada, which was linked to the California deal, also lost 10 percent of its supply. With the new accord approved, Nevada will be allowed to draw water for fast-growing Las Vegas." (Associated Press, 2003, October 16)

But we now know that politics isn't enough.

Excerpt from: **Colorado River Basin Water Management Report 2007**

"Recent studies of past climate and stream flow conditions have broadened understanding of long-term water availability in the Colorado River, revealing many periods when stream flow was lower than at any time in the past 100 years of recorded flows. That information, along with two important trends—a rapid increase in urban populations in the West and significant climate warming in the region—will require that water managers prepare for possible reductions in water supplies that cannot be fully averted through traditional means. Successful adjustments to these new conditions will entail strong and sustained cooperation among the many entities involved in Colorado River water management and science programs." (NRC, 2007)

Excerpt from: **Model Projections of an Imminent Transition to a More Arid Climate in Southwestern North America**

"How anthropogenic climate change will affect hydroclimate in the arid regions of southwestern North America has implications for the allocation of water resources and the course of regional development. Here we show that there is a broad consensus among climate models that this region will dry in the 21st century and that the transition to a more arid climate should already be under way. If these models are correct, the levels of aridity of the recent multiyear drought or the Dust Bowl and the 1950s droughts will become the new climatology of the American Southwest within a time frame of years to decades." (Seager, et al., 2007)

Excerpt from: **An Arid West No Longer Waits for Rain**

"Some \$2.5 billion in water projects are planned or under way in four states, the biggest expansion in the West's quest for water in decades. Among them is a proposed 280-mile pipeline that would direct water to Las Vegas from northern Nevada. A proposed reservoir just north of the California-Mexico border would correct an inefficient water delivery system that allows excess water to pass to Mexico. In Yuma, Ariz., federal officials have restarted an idled desalination plant, long seen as a white elephant from a bygone era, partly in the hope of purifying salty underground water for neighboring towns. The scramble for water is driven by the realities of population growth, political pressure and the hard truth that the Colorado River, a 1,400-mile-long silver thread of snowmelt and a lifeline for more than 20 million people in seven states, is providing much less water than it had." (Archibold & Johnson, 2007)

Excerpt from: **A Pattern of Normal Drought**

It has taken humans awhile to realize that our idea of normal changes as our understanding of history deepens. Over the past couple of decades, climatology has become a deeply historical science. In the American Southwest, climatologists have found a surprisingly detailed record of weather patterns — especially patterns of moisture — in tree rings that show that prolonged periods of drought there are normal.

This evidence — and its implications — have been gathered in a report released last month by a committee of the National Research Council [NRC 2007]. Its conclusions are stark. The Colorado River basin has experienced staggering population growth. Precipitation patterns are changing, in part because of global warming. Nearly every drop of water that flows downstream is already allocated, which means that the only new water source for residential and commercial growth is water that has been allocated to agriculture.

So what is normal? Vast quantities of water devoted to subsidized agriculture? Vast quantities of water devoted to the growth of cities and suburbs that are, in the long historical view, unsustainable? The immediate question this report raises is whether the forces that shape development from Wyoming to California will allow themselves to be guided by the scientific evidence and a starkly different vision than the one that was visible in 1922. Science is capable of changing its mind as the evidence it discovers becomes more precise and more conclusive. The fundamental challenge for us all is to change the way we live as well." (Editorial, 2007, March 3)

Retrospect

“Behind the scramble for water in years past was not only its obvious necessity for survival in a water-shy country, but also an obsession with growth, an obsession that equated progress with obtaining enough water to develop the biggest farms and cities and industries. Many now question that fascination with growth, but even they tend to forget that water is a finite commodity. Ten years or a hundred years or a hundred thousand years from now, the world's supply will remain the same. Such an assertion cannot be made about the world's population or about mankind's capacity for devising technologies to use-and abuse-the limited water supply. Put another way, the fate of all natural bodies of water is inseparably tied to human values about the quality of life and the number of people any part of the world can properly support. Seen from this perspective, the Colorado River is a microcosm of the world's water supply. Lessons learned from its past and policies adopted for its future are of fundamental importance not only for those dependent on the river, but also for people everywhere.” (Hundley, 1996).

Web Reference

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To return to the Colorado River Index go to:

<http://fire.biol.wvu.edu/trent/alles/ColoradoRiver.html>

For the next paper in this series on the Colorado River go to:

<http://fire.biol.wvu.edu/trent/alles/GeologySaltonTrough.pdf>

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<http://fire.biol.wvu.edu/trent/alles/index.html>
