= Spring Creek Dam =

Spring Creek Debris Dam is an earthfill dam on Spring Creek , a tributary of the Sacramento River , in Shasta County in the U.S. state of California . Completed in 1963 , the dam , maintained by the U.S. Bureau of Reclamation , serves primarily to collect severe acid mine drainage stemming from the Iron Mountain Mine . The dam forms the Spring Creek Reservoir , less than 1 mile (1 @.@ 6 km) long . Spring Creek and South Fork Spring Creek flow into the reservoir from a 16 @-@ square @-@ mile (41 km2) watershed . The dam is directly upstream from the city of Keswick , California and the Keswick Reservoir . The operation is part of the Trinity River Division of the Central Valley Project .

The primary purpose of the Spring Creek Dam was to collect acid mine drainage from the old Iron Mountain Mine , which was heavily polluting Spring Creek and its tributaries . The dam was built in response to these pollutants that were contaminating the Sacramento River , the primary water supply for millions of Californians . Although the watershed is small in comparison to that of the Sacramento River , the stream is among the most polluted and acidic in the world .

The dam and reservoir , along with other treatment structures built at and below the mine , have successfully reduced the dry weather pollution of Spring Creek by up to ninety @-@ five percent . Problems , though , still occur mainly in the form of large uncontrolled spills from the reservoir . Several concerns about the structural integrity and safety of the dam , both physically and biologically , arose in the 1990s . Emergency releases from Shasta Lake , often in the value of thousands of acre feet of water , have occurred from time to time to dilute massive acid spills from the Spring Creek drainage .

= = History = =

= = = Mining = = =

The Iron Mountain Mine , the most productive copper mine in California in at least one point along its history , operated along the banks of two Spring Creek tributaries , upstream from the current dam site , from 1879 to the 1960s . The mine extracted iron ore , silver , gold , copper sulfide ore , and pyrite from a rock formation dating to approximately 780 @,@ 000 years ago . The potential of a mine at the site was discovered in 1860 , when two men , surveyor William Magee and settler Charles Camden , discovered an extensive iron ore deposit along one of the tributaries of Spring Creek . In 1879 , silver was also discovered at the site , and the mine was begun . The ownership was transferred to Mountain Mines Ltd . , a London company , in 1894 . At the very end of the 19th century , Iron Mountain Mine took blames for several fish kills in the Sacramento River . Nevertheless , mining activity continued , and by 1928 , 600 tons of ore were being extracted from the site per day .

The still continuing problem of Iron Mountain Mine runoff has once been described as :

... [acid mine drainage is] most vividly illustrated by the problems at the Iron Mountain Mine in California .

... release of this waste resulted in virtual elimination of aquatic life in many of the creeks surrounding the Iron Mountain Mine site .

... work is continuing on what is possibly the largest and most difficult acid mine drainage problem in the United States .

-P . Aarne Vesilind . Controlling Environmental Pollution , 2005

= = = Events prompting construction = = =

The construction of Shasta Dam and its afterbay (regulating downstream dam) , Keswick Dam , in 1943 and 1950 , respectively , severely impaired the capability of the Sacramento River to flush away pollutants from the mine . Acid mine drainage flowed , unfettered , down Spring Creek directly

into the Keswick Reservoir , depositing contaminated sediment and turning a portion of the water a rusty red shade . Previously , the water would have continued down the creek into the river , and flushed to the Pacific Ocean . The pooling of the water , however , made it extremely difficult for the pollutants to be removed . From 1955 to 1962 , open pit mining began on the site . At its peak , the mine discharged 5 tons of iron , 650 pounds (290 kg) of copper , and 1 @,@ 800 pounds (820 kg) of zinc into the stream per day . By then , the water flowing down the drainage was so contaminated that it necessitated the construction of a holding dam , the Spring Creek Dam .

Spring Creek Dam was begun in 1961 , when a company named Gibbons and Reed was awarded the contract . The clearing operations began in July of that same year , and the dam was officially dedicated by the Bureau of Reclamation on September 12 , 1961 . Construction of the dam began on October 20 , 1961 , with the placing of the dam embankment , which at least partially consists of acidic sediment dredged from Spring Creek . Riprap was laid on the upstream face of the dam beginning November 9 of that year . In 1962 , a series of labor strikes impacted communities in the Central Valley , also affecting construction of the dam , which was temporarily halted on May 3 of that year . After work restarted on June 26 , pervious core material for the dam was soon out of supply , so impervious material was used to complete the dam core .

Eventually , the Iron Mountain Mine closed , but pollution continued and still continues , and in 1983 , the Iron Mountain Mine was listed on the National Priorities List . The Iron Mountain Mine is known for having the most acidic naturally found water content on Earth , with samples having up to a ? 3 @.@ 6 pH value when tested in the early 1990s , which is roughly 100 times the acidity of battery acid . However , this pH value is only found inside and near the mine , as the average pH of water entering the Spring Creek Reservoir is 4 @.@ 12 .

= = = Storage expansion = = =

The Spring Creek Dam was later deemed " undersized " for the Spring Creek watershed , as the large flows of both natural drainage and acid mine drainage caused frequent uncontrollable spills at the dam . The spills contain many volatile components in acid mine drainage , which include the most acidic naturally occurring (i.e. not in a laboratory) water on Earth . Several alternatives were considered for remediating this problem :

Enlarge the Spring Creek Dam to create a reservoir three times its original size : This plan was considered , but never built , as the cost of it was estimated at US $ 75 million .

Partial capping (covering) of the site : The ore body in Iron Mountain was determined to be shallow , so this alternative was considered . However , the recurring high occurrence of fractures in the mountain made this inefficient , so it was also never implemented .

Construction of dams upstream : This proposal called for several dams upstream that would " reduce the watershed by 40 percent " , including a dam on Slickrock Creek , a branch of Spring Creek . This plan was implemented , removing the need for the dam enlargement .

Waste rock removal : Rock extracted from the mine was removed from tailings piles and disposed of in a compacted cell . In Boulder Creek , another tributary of Spring Creek , the acidity level has lowered slightly .

= = = Recent history = = =

In 1985 , it was found that water seepage into the foundations of the Spring Creek Dam could possibly cause its collapse . Shortly after the discovery , a controversy over the irregular spills of mine toxins from the dam began in the 1990s . Two years later , in March 1992 , an uncontrolled , unexpected spill of acidic water rushed from the dam down Spring Creek . This spill heavily contaminated the Keswick Reservoir and threatened the water supply of Redding , California . Despite the fact that the region was suffering from a drought , 77 @,@ 000 acre feet (95 @,@ 000 dam3) of water were released from Shasta Lake , which was only half full , to dilute the pollution . The loss of the water , which was badly needed by Central Valley agricultural users , was estimated at US $ 18 million .

A water treatment plant was built on a site named Minnesota Flats near the Iron Mountain Mine , using lime to balance the pH of the acid mine drainage . Water is also diverted from Slickrock Creek to the treatment site . Altogether , over 95 percent of toxins in the water are removed by the treatment process . Roughly 8 @.@ 5 miles (13 @.@ 7 km) of specialized acid @-@ resistant pipeline , with a cost of over US $ 1 million per mile , are included in the treatment process . Most water flowing directly from the mine has a pH level close to 1 ; the ? 3 @.@ 2 pH mentioned earlier is only found in small amounts . Water is further diluted by natural flow in the tributaries and water diverted from nearby Clear Creek , however , the acidic water still requires treatment .

= = Hydrography = =

Spring Creek is a southeast @-@ flowing , 9 @-@ mile (14 km) long tributary of the Sacramento River , receiving water from approximately 16 square miles (41 km2) of land . The creek begins in the Klamath Mountains above the Sacramento River drainage , and flows in a generally south @-@ east direction before turning south and sharply west into the Spring Creek Reservoir . From the reservoir , it continues due west until it empties directly into an arm of the Keswick Reservoir . The creek never actually runs by the mine . The acid mine drainage found in the creek is actually carried in by two smaller tributaries , which are Boulder Creek and Slickrock Creek . The former stream runs southeast from the north side of Iron Mountain Mine to Spring Creek , while the latter stream drains the south side of the mine and also flows southeast into Spring Creek . South Fork Spring Creek is a small tributary that flows west and north the Spring Creek Reservoir , but since its basin lies far from the mine , it receives no acid mine drainage . The inflow and outflow from the reservoir are highly erratic , ranging from 0 cubic feet (0 m3) per second to roughly 225 cubic feet (6 @.@ 4 m3) per second in a particular 10 @-@ day period from March to April .

Flat Creek , a small southeast @-@ flowing stream , rises in two forks and empties into the Sacramento River upstream of Spring Creek . The stream receives contaminated runoff from the Minnesota Flats Tailing Pile , but is not nearly as polluted or acidic as Spring Creek . Another stream , Rock Creek , rises in three forks and flows east to meet the Sacramento River downstream of Spring Creek and the Keswick Reservoir .

= = Dimensions and operations = =

The Spring Creek Dam is 196 feet (60 m) high , 1 @,@ 110 feet (340 m) long along its crest , and 1 @,@ 040 feet (320 m) thick at its base . Its crest stands 816 feet (249 m) above sea level . The reservoir is 795 feet (242 m) above sea level at full pool and spillway crest level . When at full pool , the reservoir holds 5 @,@ 870 acre feet (7 @,@ 240 dam3) of water with a depth of roughly 184 feet (56 m) . One spillway runs over the crest of the dam on the left bank of the canyon . The spillway is 25 feet (7 @.@ 6 m) wide , able to accommodate a water flow of 5 @,@ 260 cubic feet (149 m3) per second . The outlet works of the dam are located at the base , and can accommodate a water flow of 660 cubic feet (19 m3) per second . The Spring Creek Powerplant downstream of the dam generates up to 180 @,@ 000 kilowatts .

= = = Spring Creek Powerplant = = =

The Spring Creek Powerplant is located at the base of the Spring Creek Dam , and is actually supplied by flow from Whiskeytown Lake . The lake , formed by Whiskeytown Dam , is on Clear Creek , a drainage downstream along the Sacramento River from Spring Creek . Both streams run east into the river . The power plant was completed and began operations in 1964 , with a capacity of 150 @,@ 000 kW . The capacity was later upgraded to 180 @,@ 000 kW . The plant is a peaking power plant with two separate generators , generating power for operations and distributing excess power to the local power grid . Water from Whiskeytown Lake is diverted through the Spring Creek Tunnel , a conduit roughly 2 @.@ 4 miles (3 @.@ 9 km) long and 18 @.@ 5 feet (5 @.@ 6 m) in diameter .

The Bureau of Reclamation gives a detailed report on the specifications of the generating plant :
The powerplant houses two 13.8kV generators each rated at 100 @,@ 000 kVA , .90 power factor , along with Francis turbines . Spring Creek Power Conduit conveys water from Whiskeytown Reservoir , located on Clear Creek , to the Spring Creek Powerplant . The Spring Creek power conduit varies in diameter between 5 @.@ 64 metres (18 @.@ 5 ft) and 5 @.@ 18 metres (17 @.@ 0 ft) and is about 4 @.@ 8 km (3 @.@ 0 mi) in length . The power conduit consists of Tunnels No. 1 and No. 2 , and Rock Creek Siphon . Twin penstocks take off from Tunnel No. 2 leading to the powerplant .
? U.S. Bureau of Reclamation , Trinity River Division of the Central Valley Project

= = = Spring Creek Reservoir = = =

Spring Creek Reservoir is the artificial lake formed behind the dam . The reservoir is used mostly for flood control storage , and is rarely filled to its 5 @,@ 870 acre feet (7 @,@ 240 dam3) capacity . During the dry season , water from Spring Creek pools in a small , stagnant pond retained behind the dam , depositing contaminated sediment and acidic mine waste in the reservoir space . When flows from the Shasta Dam , upstream on the Sacramento River , are sufficient to flush contaminated water away , water held in the reservoir is released through the outlet works into the Keswick Reservoir and the Sacramento River . Despite this operation strategy , the reservoir was eventually deemed inadequate for the watershed , and can be filled to capacity by a single heavy storm event . Uncontrollable spills frequently poured into the Sacramento River during floods , through the crest spillway of the dam , which lacks gates . As a result , numerous fish kills have occurred during these sudden releases of contaminants , a major one of which was in 1969 . Due to this consistent acid pollution from the reservoir , most large fish spawn downstream of Red Bluff Diversion Dam , a dam also on the Sacramento River near Red Bluff , California .

= = = Spillway and outlet works = = =

The Spring Creek Dam is able to release up to 5 @,@ 920 cubic feet (168 m3) of water per second from the Spring Creek Reservoir , through a crest spillway and outlet works . The spillway begins on the left bank of the dam at elevation 795 feet (242 m) , and drops roughly 184 feet (56 m) in vertical distance down the face of the dam into a stilling basin , before flowing into Spring Creek and into the Sacramento River . It is roughly 25 feet (7 @.@ 6 m) wide and can carry 5 @,@ 260 cubic feet (149 m3) per second . The outlet works tunnel through the dam from an elevation much lower than that of the spillway ; the conduit terminates at a culvert exit , a design commonly seen on storm drains but rarely seen on dams , at the base of the dam . The maximum capacity of the outlet works is 660 cubic feet (19 m3) per second .