Watering the West

Executive Summary

Since the dawn of civilization, diversion of water from areas of plenty to areas of scarcity has been a defining feature of human ingenuity. The history of the western United States has been shaped by both water scarcity and impressive projects to alleviate it. The best illustration of this is the California State Water Project (SWP), with dams and reservoirs built to capture precipitation in the north, and over 700 miles of canals, pumping stations, and aqueducts that have made the semi-arid Central Valley into the garden of the United States.

The winter of 2022-23 saw a series of "atmospheric rivers" dumping abnormally high levels of rain and snow in the state, a respite from a multi-year drought that saw the SWPs reservoirs shrinking to critically low levels. At the same time, the Colorado River—which provides water for some 40 million people in seven states—got so low that it could rightly be characterized as a crisis. The above-average snowpack of the winter of 22-23 and a snowpack of approximately historical averages in 23-24 has dampened the Colorado River crisis somewhat, but the water levels in Lake Mead and Lake Powell are still far below historical averages, necessitating negotiations among the various states involved that utilize that river's water.

Ideas about how to deal with these issues have included desalination on a hitherto undreamed-of scale and desperate projects to shuffle scarce water around in a hydrological shell game in California. But the millions of acre-feet of water that could solve these problems will never materialize from such projects. There is, however, a solution: The ORCA Project.

ORegon and CAlifornia (hence ORCA) can collaborate in a project that could immensely benefit both states, and even help to ameliorate the Colorado River water crisis. A critical component of this plan would involve raising Shasta Dam, in northern California, to its original design height of 800 feet. America's entry into WWII happened as the dam was being built, and consequent constrained supplies of both steel and manpower resulted in stopping the dam construction at 600 feet. Raising the dam to its intended height would result in more than a tripling of Shasta Lake's volume to about 14 million acre-feet, more than all other northern California reservoirs put together. Shasta Lake would thus anchor the SWP with a reliable source of water for the farms and cities to the south.

Despite the fortunate precipitation levels of these past two winters, harsh historical experience makes it all but certain that in many future years, precipitation in the winter months in the Shasta Lake watershed will fall short of filling that prodigious reservoir. That's where the ORCA Project comes in. This plan would divert water from two of the twenty-two turbines at the Dalles Dam on the Columbia River into a canal system to be built along the eastern slope of the Cascade Mountain Range, terminating at the McCloud River near Mount Shasta, and flowing from there into Shasta Lake. The Dalles Dam is the second-to-last dam on the Columbia River, and the last dam that doesn't experience substantial tidal flows that could cause brackish water in the future. This diversion could be managed in a way that never diminishes the water level in the Columbia below normal levels, and which would have no impact on fish in the river. This is water that would just be flowing to the sea, intercepted from that course at the last opportune location.

Oregon would reap tremendous benefits from such a project. The eastern 60% of the state is mostly arid or semi-arid, much like the Central Valley of California that was transformed into the garden of the USA by the SWP. Oregon landowners east of the Cascades would be able to build spurs off the main canal to transform eastern Oregon into another bounteous agricultural powerhouse that would consistently bring billions into the state's economy for the foreseeable future. And the multi-year construction of the aqueduct system would provide thousands of high-paying jobs to Oregon's citizens and businesses. In addition to all that, future revenues from the sale of the water to cities and farms could also contribute to Oregon's coffers for decades. And all this by simply diverting water that would otherwise flow unused to the sea, to no one's benefit.

Finally, the ORCA Project's provision of the needed water to California's SWP would allow that state to voluntarily relinquish its substantial claim to water rights from the Colorado River, which is a major drain on that system. It would also make two very costly planned water projects in California irrelevant. Unlike the ORCA Project, neither the Delta Tunnel nor the Sites Reservoir would add a drop of water to the system, only shuffle it around at immense cost. The ~$40 billion that would be saved by abandoning those two ill-advised schemes could instead be applied to this project that will actually solve the state's water problems indefinitely, regardless of the fickle swings in annual precipitation that likely will become even more severe with the progress of climate change.

We used to build big things in the United States. We still can.

Watering the West

The critical water shortage from which Californians got a welcome respite thanks to a succession of "atmospheric rivers" dousing the state in the winter of '22-23 (and, to a lesser extent, the winter of 23-24) is reflective of a recurring pattern for the state—a multi-year severe drought with occasional years of ample—even abundant—precipitation. It would be naïve to think this recent relief ends California's water problems.[1] The unlikely possibility that such a drought will not happen again soon won't come close to solving the state's water future, for the population of California is expected to reach 60 million by mid-century, about double its 1990 population. Desperate for the water the state water project was unable to provide in most years, farmers continue to drill ever-deeper wells (as deep as 3,500 feet![2]), draining aquifers around the state even more dramatically than they have in the past. Even prior to the severe conditions of the past few years, pumping had caused the ground to subside almost thirty feet in some areas of the state. As the ground sinks, the subsurface areas that were once saturated with water become compressed, making recharge of such aquifers nearly impossible, even in good years with plenty of water.

Like it or not, the future of California will require an ever-greater reliance on surface water sources, portending even greater economic and social disruption when future inevitable droughts occur. The state water project has made California the garden of the USA. It is a marvel of engineering, a testament to the foresight of those policymakers who laid the groundwork for what is arguably the most impressive such system in the world. But for all its virtues, the system is insufficient to meet future demand, especially during serious droughts, and woefully incapable of supplying the water needs of California's increasing population and agricultural production in the decades to come.

California has already tapped virtually every surface water source that might be channeled into the state's system. Over 700 miles of pipelines and aqueducts carry water from far-flung sources into the thirsty Central Valley, the cities of the Bay Area, and southern part of the state. Even before the most recent drought, the demands of agriculture and cities across the state stressed the system to such an extent that salmon, smelt, and other aquatic species endured serious impacts due to low water levels; sometimes too low to provide the environment required to maintain their life cycles.

All the way back in 1957 the California Department of Water Resources suggested a "Trans-Delta System" to divert water around the Sacramento-San Joaquin Bay Delta to south Delta pumps for export to farms and cities in the south. Variations on this plan have been proposed ever since, the most recent being the Delta Conveyance project (aka Delta tunnel), a 45-mile-long tunnel to move water under the delta and allegedly improve the current situation. This is a highly contested assertion, however. What we do know is that current incarnation would cost in the range of $30-40 billion by the time it's finished in 2035, yet it would not add a single drop to the state's water supply. In a candid admission of this fact, the director of the California Department of Water Resources commented when discussing the water tunnel project, "We're not going to drought-proof California."

[1] https://archive.ph/mbXzg
[2] https://archive.ph/20Tv

But we can, with a different plan.

The last several years of the most recent drought saw an unusually high number of acres lying fallow for want of water. Many fruit and nut groves, which take years to develop, died for lack of water. By late November 2022, California had experienced the state's driest three-year period on record. In a report on the drought's economic effects, university researchers in the state[3] estimated that California's irrigated farmland shrank by 752,000 acres, or nearly 10%, in 2022 compared with 2019 — the year before the drought. They found that water deliveries in the Central Valley were cut by nearly 43% in both 2021 and 2022. Gross crop revenues fell $1.7 billion, or 4.6%, and revenues of the state's food processing and manufacturing industries declined nearly $3.5 billion, or 7.8%. An estimated 12,000 agricultural jobs were lost, representing a 2.8% decline. Of course the knock-on effects just within the farming communities are also severe. And since California normally produces about half of the fruits, vegetables, and nuts for America's tables, the inevitable rise in prices for these products has an economic impact that ripples across the nation.

As bad as this sounds, it is but a microcosm of a global situation that is far worse in many countries. Billions of people already live in water-stressed circumstances today, and aquifers from the Great Plains to the Middle East are being pumped dry to provide for an ever-increasing population and rising standards of living. With over eight billion people on the planet today, demographers predict a mid-century global tally of at least nine billion and, very possibly, ten billion or more. Providing water for not only the personal needs but also the agricultural requirements of a further two billion people is a challenge that can only be met by desalination on a scale hitherto undreamed of.

If one were to ask an agriculturalist if it's possible to provide food for ten billion people, the answer will almost certainly be, "Yes, if you can provide the water." Similarly, if one asks a hydrologist how to provide the water required by ten billion people, the answer is likely to be, "Yes, we can supplement existing resources with desalination if you can provide the energy." In the end, it all comes down to energy. With sufficient affordable energy, desalination on a massive scale—and moving water to where it is needed—is certainly possible. But with the threat of climate change being one of the probable causes of severe drought in many parts of the world, it's critical for that energy to be provided by carbon-free sources. That, too, is certainly doable.

Desalination technology has improved dramatically in recent years. Middle Eastern nations such as Saudi Arabia, the UAE and Israel have pioneered ever larger and more efficient desalination plants. The Saudi Saline Water Conversion Corporation (SWCC) reports[4] seawater desalination can be done for as little as 2.271 kWh per cubic meter, or less than 25¢ per cubic meter when the requisite electricity costs 10¢/kWh. In US cities water costs from $1 to as much as $6 per cubic meter, averaging from $1.50 to $2. The Saudis have been highly motivated to reach such an impressive cost milestone, since there, as in so many other areas of the world, increased pumping from aquifers has resulted in estimates predicting their deep groundwater reserves will be gone in 25 years.

This is the shape of things to come. Barring some unforeseen cataclysm, we'll have ten billion people on the planet within a few decades. Providing for their necessities—much less a comfortable standard of living—will be an unprecedented challenge of epic proportions. California's current and future dilemma is but a foretaste of the sort of challenges that have to be met on a global scale.

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[3] https://archive.ph/qrFWf

[4] https://tinyurl.com/jsjra25a

The good news is California can again take the lead in demonstrating a solution to the problem of water and agricultural plenty. We already have the technologies to drought-proof California. Such an accomplishment would stabilize not only the economy of the nation's garden state, but the entire country's food supply. This would demonstrate a path forward enabling every nation's standard of living to rise even as we finally reach what is projected to be the planet's peak population. The fact this can be accomplished in an environmentally benign manner is all the more encouraging.

Making Use of What We Have

The California State Water Project (hereinafter SWP) is an invaluable resource that would need only modest modification to manage a great deal more water. Seemingly out of desperation, there are calls for more dams and water storage to corral more water in wet years for use in the dry ones. But it doesn't take a prophet to imagine the hue and cry arising from even the suggestion of building more dams.[5] When the snowpack in the mountains doesn't materialize, having more reservoirs just means having more empty reservoirs.

The anchor of the SWP lies in the north. Three reservoirs there—Oroville, Shasta, and Trinity Lakes—comprise half the water storage capacity of the entire SWP (and some of the smaller ones are simply holding water that's been channeled from those three). This makes the entire system overly dependent on the snow and rain that fall in the northern part of the state. The two largest reservoirs in the state—Lake Shasta and Lake Oroville—are as full as flood control considerations will allow after the ample precipitation of these two most recent winters. But in 2021 and 2022 they were only about half as full at this time of year when they should have been at their maximum levels, and the snowpack to provide further later inflow was likewise well below normal levels. Even with twice the capacity in those reservoirs, it would have done no good then, or in most other years. Trinity Lake—the state's third largest reservoir—was still only 38% full even after the deluges of 22-23, but thankfully the rain and snowfall of 23-24 has, for now, brought it up to its historical average level.

[5] https://archive.ph/AaV0M

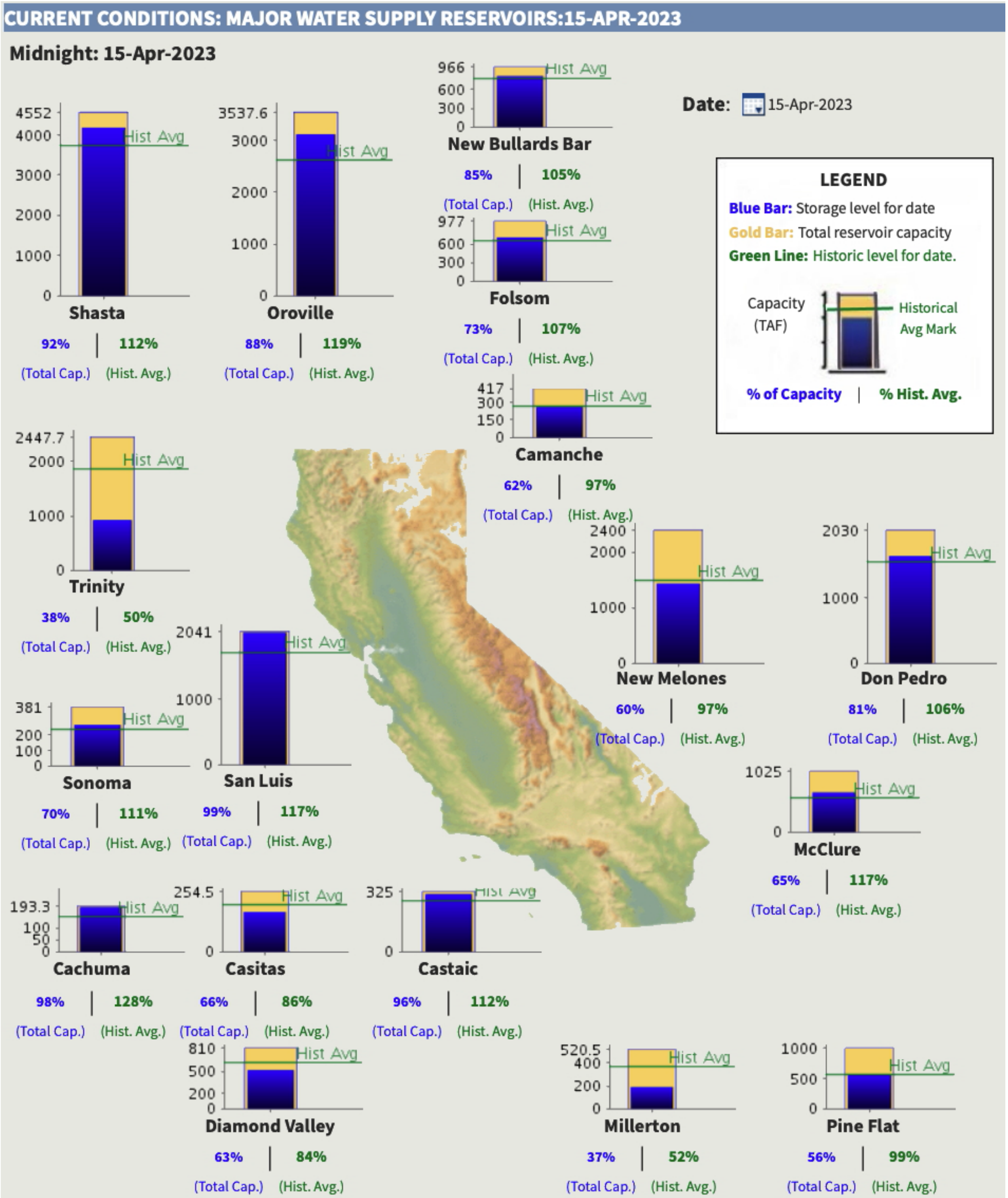

Image courtesy of California Department of Water Resources tinyurl.com/22h353fe

After the last abnormally wet winter relieved a long drought in 2016, California lapsed into yet another multi-year drought that was finally ameliorated by 2023's succession of "atmospheric river" deluges. It remains to be seen just how much this latest precipitation will remedy, at least temporarily, the dire water situation in the state. A look at the history of precipitation in California—especially in the last decade—

reveals a predictable pattern of multi-year droughts interspersed with a year or two of adequate precipitation.

The SWP has long-term delivery contracts for about 4 million acre-feet (MAF) of water per year, though in most years it is incapable of providing that much. Shasta Lake, the largest of the SWP reservoirs by far, holds about 4.5 million acre-feet when it's full, which isn't often. We can see from the illustration, though, that in the spring of 2023 the reservoirs were being maintained at historically high levels, though even with these rains Trinity Lake wasn't able to recover. Trinity Lake and Lake Oroville together hold another six million acre-feet. Of course, much of the water in those reservoirs, for environmental reasons, necessarily runs down the Sacramento and Trinity/Klamath Rivers to the sea. In drought years especially, the allotment of what available water remains creates an almost inevitable conflict between agriculture and thirsty cities on one side and environmental necessity on the other. Unless we can provide a lot more water in the future—no matter the precipitation—something's got to give.

The logical approach to the stabilization of the system would be to "create" a substantial amount of new fresh water and use our existing reservoirs to impound it for use by both farmers and cities. It so happens this can be done without building a single new dam!

When Shasta Dam was partially built, World War II intervened. Suddenly both steel and manpower were being diverted to the war effort. So even though Shasta Dam was designed to be 800 feet high, it ended up only 600 feet high. There has been much discussion about raising Shasta dam either 100 feet or the full 200 feet to its 800-foot design height. Raising it 100 feet would nearly double Shasta Lake's capacity to 8.5 MAF. 200 feet would more than triple it to nearly 14 MAF. (As a point of comparison, Oroville Dam is 770' high, and Hoover Dam is 726'.)

Since the SWP contracts to deliver (when possible) four million acre-feet of water per year, raising Shasta Dam just an additional 100 feet would add about that much more in extra capacity, but if the project is undertaken the most sensible option would be to raise it to its originally intended height of 800 feet. If such an expanded Shasta Lake could be reliably at or near full by the end of every winter, it would guarantee that the entire agricultural sector of California would be supplied while assuring plenty of flow in the Sacramento River for environmental stability. A dependable water supply would provide economic stability for the many employees and owners of agricultural enterprises. It would also smooth out the roller coaster of price swings due to water shortages and the resulting lack of produce, which our whole country experiences when the agricultural system is disrupted.

After the exceptional precipitation of this 2022/23 winter, snowpack in the Sierra Nevada mountains presented a bit of a double-edged sword. On the one hand, it promised to fill at least the Shasta and Oroville reservoirs to the brim for the first time in years. But dams are built not just for irrigation but for flood control. The possibility of sudden substantial water flows (especially from snow melt if the weather in the mountains turns hot quickly) requires water managers to lower the level of reservoirs in anticipation, to prevent serious or even catastrophic flooding. It's common for reservoirs in such situations to be lowered to as little as 65% of capacity. Imagine the alternative situation if Shasta's volume were to be tripled by simply building it up to its design height. Allowing it to be full at this point to about 13 million acre-feet would still allow sufficient flood control leeway for any future winter's exceptionally heavy snowpack. Instead, the current situation allows millions of acre-feet which could otherwise be kept in the expanded reservoir to be released. If Shasta Dam had been built to its intended height, the precipitation of these two recent winters could almost certainly have filled it from just its normal sources of inflow, providing abundant water for the coming year.

When the SWP started delivering water to the farms in the state, groundwater pumping diminished considerably, along with the resulting subsidence. Land subsidence has, predictably, increased in drought years and slowed in good water delivery years. Because the aquifers get compacted when the land subsides, years of heavy pumping such as we've seen recently—and can expect to see again in future low-water years—will only exacerbate this problem, which can't be reversed. Already subsidence is so serious it's affecting the flow of the SWP aqueducts in some areas. They've been designed with a sufficient gradient to move a substantial amount of water at a certain speed. This aqueduct system has begun sinking as much as 25 inches in places. It will not be easy (or cheap) to rebuild or re-route the aqueduct. In the short term, we may well be facing groundwater pumping restrictions to minimize the subsidence problem, even though such regulation would almost certainly result in the loss of even more orchards and vineyards, a loss of decades of effort and investment in each case. In the long term, we must plan to provide the needed water from the surface to minimize pumping so subsidence can be stopped and aquifers can recharge where possible. Alas, many aquifers have been irredeemably shrunken or damaged.

Designing the Future

Shasta Lake is the key to the future of California agriculture. Trinity Lake—the third largest reservoir in the state at almost 2.5 million acre-feet, could likewise be involved, albeit without any modification. Lake Oroville would not be affected, since its location on the east side of the Central Valley restricts its catchment to the Sierra Nevada Mountains.

The west side of Trinity Lake is approximately 120 miles from the Pacific. Its surface water level is over a thousand feet higher than Shasta Lake. A desalination system could produce fresh water at desalination plants along the coast in the vicinity of Eureka, then pump the water up over the Coast Range and into Trinity Lake. With Trinity and Shasta Lakes only about twelve miles apart at their closest points and Shasta Lake so much lower, a simple overflow canal without any pumps would be able to fill Shasta Lake as water is pumped into a full Trinity Lake.

Whenever a major infrastructure project is built, it's incumbent upon its designers to assure it will be used to its optimal potential. It should be quite possible (albeit expensive) to produce and transport up to 4.5 million acre-feet per year. That's about the same amount as Shasta Lake's volume will increase if the dam is raised one hundred feet, as described earlier. This extra storage volume would all but guarantee in most years the Eureka Project (an apt name both for the location of the water source as well as the allusion to Archimedes' bathtub) could run full-out and maintain both Trinity and Shasta Lakes at or very near their design volumes.

It's important to look at how the SWP moves water today. The major pumping stations are all modular. In other words, they have multiple pumps and multiple pipelines to transport the water. The Eureka Project would not have to be built all at once, so long as the pumping stations are designed with expansion in mind. The only portions of the system to be built at maximum capacity would be the gravity-flow aqueduct sections (including any water tunnels that might be cut through ridges in the Coast Range).

Most of the pumping stations and pipelines serving the SWP were built 40-60 years ago. Several pumps have been replaced since, undoubtedly with greater efficiency. No new technology would be required for such a system, but the logistics—both physical and political—would be daunting. The production of 4.5 million acre-feet of water per year would require the construction and continuous operation equivalent to fifteen[6] of the largest desalination plants ever built. The sheer amount of power needed to operate the desal plants, and then to pump the water over the Coast Range, would be considerable, as would the other costs of operation. The political battles over such a massive project can only be imagined.

The ORCA Project

At this point one is tempted to look at a map to imagine the geographical aspect of such a plan. If the map extends a bit northward from California it's nearly impossible to ignore the fact that just about 350 miles to the north there is a vast quantity of perfectly good freshwater constantly flowing to the sea via the Columbia River, which delineates the border between Oregon and Washington. It's easy to visualize this water mixing with the salty ocean water, flowing down the coast, and then being desalinated at great expense to pump into California's reservoirs.

The logical approach would be to forego the herculean challenges of a desalination solution, replacing it with a system to divert water from the Columbia River just before it flows to the sea, routing it through a canal system to provide abundant water first to the arid and semi-arid land of eastern Oregon, then on to California. Such a project would benefit primarily ORegon and CAlifornia (though the entire country would enjoy more stable food supplies and prices). So we'll call it The ORCA Project.

Neither the distance from the Columbia River to Lake Shasta nor the technology needed to divert water directly from the Columbia to eastern Oregon and then on to Shasta are deal-breakers. The length of the canal system would be about half the 700-mile length of the existing California water system aqueducts. The pumping stations to move the water would be substantial, but once in place, the operational costs of a Columbia diversion project would be trivial compared to the massive desalination system described above. Remember that the desal proposal as described would require at least 135 miles of aqueducts and a lot of pumping power in addition to the hefty power requirements of the desalination process.

The electricity required to pump water through the ORCA system's pumping stations would be considerable. It's possible to estimate the power requirements based on the historical data from California's system. A one-gigawatt (1,000 megawatt) power plant would likely suffice, and some of that energy would be recovered when the water exited the turbines of Shasta Dam. Given the advanced nuclear reactor systems in development today, a practical solution to the power demand would be to build a nuclear power plant (or a small number of the newer passively-safe small modular reactors) at Hanford, Washington, a site already licensed for nuclear power production. In this way Washington could likewise benefit from the ORCA Project, with high-paying jobs and community income from the new power plant.

Let's look at the actual environmental (and other) challenges. Would a Columbia diversion project make sense?

Any time a water diversion project is contemplated there's always the legitimate concern about how it affects whatever and whoever is downstream. Since the Columbia River has many dams in place, diverting water is going to affect the reservoirs and dams downstream, at least to some degree. Even if that effect is small, the very perception of someone downstream getting shortchanged will make upstream diversion a difficult political prospect, so the logical solution would be to divert the water from below the last dam on the Columbia, after which the river flows unhindered to the sea. The last dam on the Columbia is the Bonneville Dam, located just west of the Cascade Range and about 40 miles east of Portland.

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[6] tinyurl.com/2p8kdz8n

Though politically it would be easiest to make the case for withdrawing water from the last dam on the river, there's a potential problem with using the Bonneville Dam. Even though it's quite far inland from the sea, the Columbia River in the vicinity of the Bonneville dam has surprisingly large tidal fluctuations, up to eleven feet. Even if the water there currently isn't brackish because of such considerable tidal flows, one must consider a future of sea level rise and/or diminished Columbia River flow due to potential droughts.

It would be eminently more sensible to withdraw the water from the next dam upriver, the Dalles Dam, about fifty miles east of the Bonneville Dam. There the tidal fluctuation is only about a foot or two, so the potential issues of brackish water with Bonneville wouldn't be a problem. The Dalles is located right about at the eastern slope of the Cascade Range, which is the best place to locate the canal needed to move the water south.

The Dalles Dam & Locks Photo credit: U.S. Army Corps of Engineers

Contrary to the conventional type of dam which holds back an entire river, the Dalles Dam (like the Bonneville Dam downstream) is what's called a run-of-the-river dam. It holds back very little of the water, with the upriver portion only about 85 feet above the lower river level. In the photo above, you can see the spillways releasing their white water on the left. From the other perspective in the photo below, the powerhouse comprises a line of 22 turbines which generate electricity. Fish ladders and a lock for river navigation are also part of the system.

Photo credit: U.S. Army Corps of Engineers & Pacific Northwest National Laboratory

Environmental Impact

Any time water is pulled out of a river in substantial quantities, there's always a concern about the environmental impact, especially for the fish and other aquatic creatures which could be sucked in and killed in the process. For the Columbia River this issue has added salience, since the river is home to a substantial commercial salmon fishery. This fact led the builders of the Dalles Dam and other dams on the Columbia to mitigate the impact by installing an impressive fish ladder system to protect the salmon. To this day the fish ladders are a tourist attraction during the summer salmon migration.

The Dalles Dam has been operational for many decades and the Columbia River salmon fishery is none the worse for it. Efforts to minimize the loss of fish in the turbines have been aided by extensive studies which confirm minimal impact on fish passage.[7] Those turbines are the key to eliminating the environmental impact of diverting water to the ORCA Project's proposed canal system.

The environmental impact of water diversion is certainly a serious and legitimate concern. Since the output of the turbines doesn't contain live fish, the trick is to divert water directly from just two of the twenty-two turbines' outflows into a pumping station designed to send water into the aqueduct system. That way there would be no question of such a diversion affecting the salmon or any of the other creatures that might otherwise be impacted by pumping water out of the river. This turbine outflow approach would be far easier, more economical, and less complicated than the way water is diverted from the Sacramento River as it is withdrawn to send south through California's Central Valley. By pulling water directly from only two of the Dalles 22 turbines this potential problem is eliminated. Unless such an

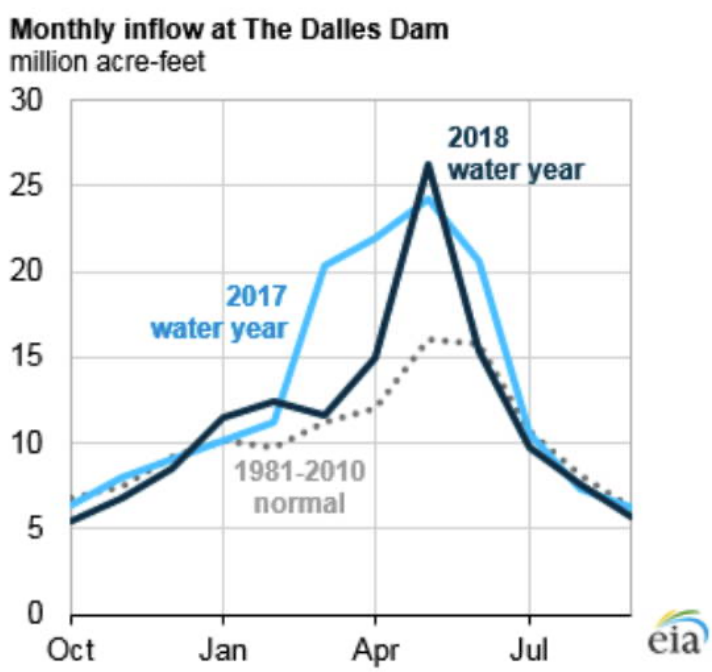
[7] tinyurl.com/57y2kwu6

environmentally-benign method is employed, the impact on salmon and other river life would certainly be one of the biggest objections to this project.

Number Crunching

As we saw earlier, the current capacity of Shasta Lake is about 4.5 million acre-feet. If Shasta Dam were raised another 100 feet, capacity would be increased to about 8.5 million acre-feet. Building the dam up to its original 800' intended level would increase capacity to a whopping 14 million acre-feet, more than triple its current volume. Even if Shasta Lake could be guaranteed to be full every spring at even just its present capacity, it would go a long way toward stabilizing agricultural and other water demands in California. At present, water contracts with the State Water Project (SWP) entitle their holders to 4.2 million acre-feet, close to a full Shasta Lake. In non-drought years these water contractors generally receive only 50-65% of their contracted amount or Table A allocation. The average allocation from 1996-2023 was 45%. For the last decade the allocation dropped to an average of 35%. During the drought of 1991 only a little over 0.5 MAF were delivered, and during the most recent drought the state announced it wouldn't deliver on any of its contracts, after having delivered just 5% for the last couple years of the most recent drought. After the plentiful precipitation brought on by 2023's atmospheric rivers, state water officials exulted as they expected to be able to increase Table A deliveries from 35% to 75% of their contracted amounts,[8] still substantially short of the amounts expected for both the cities and the farms served by the SWP. The last time the system was able to provide 100% of the contracted water was in 2006.

If California were to raise Shasta Dam two hundred feet, to its design height, and manage to keep it nearly full in the spring, California's water troubles would be history. The increased reservoir capacity would allow water managers to cease releasing large amounts of water in the spring as a precaution against potential flooding. In many years (such as 2023) this would amount to additional millions of acre-feet being impounded in Shasta Lake from its natural feeder rivers to augment the water coming in from the Columbia. Such a system would virtually guarantee water stability to the entire California system, both for agriculture and cities, even in multi-year drought conditions. Given the impact of climate change already being experienced, it would be foolish not to plan for such droughts.



Source: US Energy Information Administration, based on US Army Corps of Engineers Dataquery

Let's look at the numbers. First off, it's important to recognize the Columbia's flow past the Dalles varies throughout the year, as seen in the graph on the left.

The average river flow at the Dalles is 155,388 cu ft/sec, or 3.57 acre-feet/sec. This computes to about 112 million acre-feet per year. When the river is flowing at its peak level, each of the dam's 22 turbines has nearly 10% of the river's average flow running through them, about 14,000 cubic feet per second.

[8] https://archive.ph/EJKWe

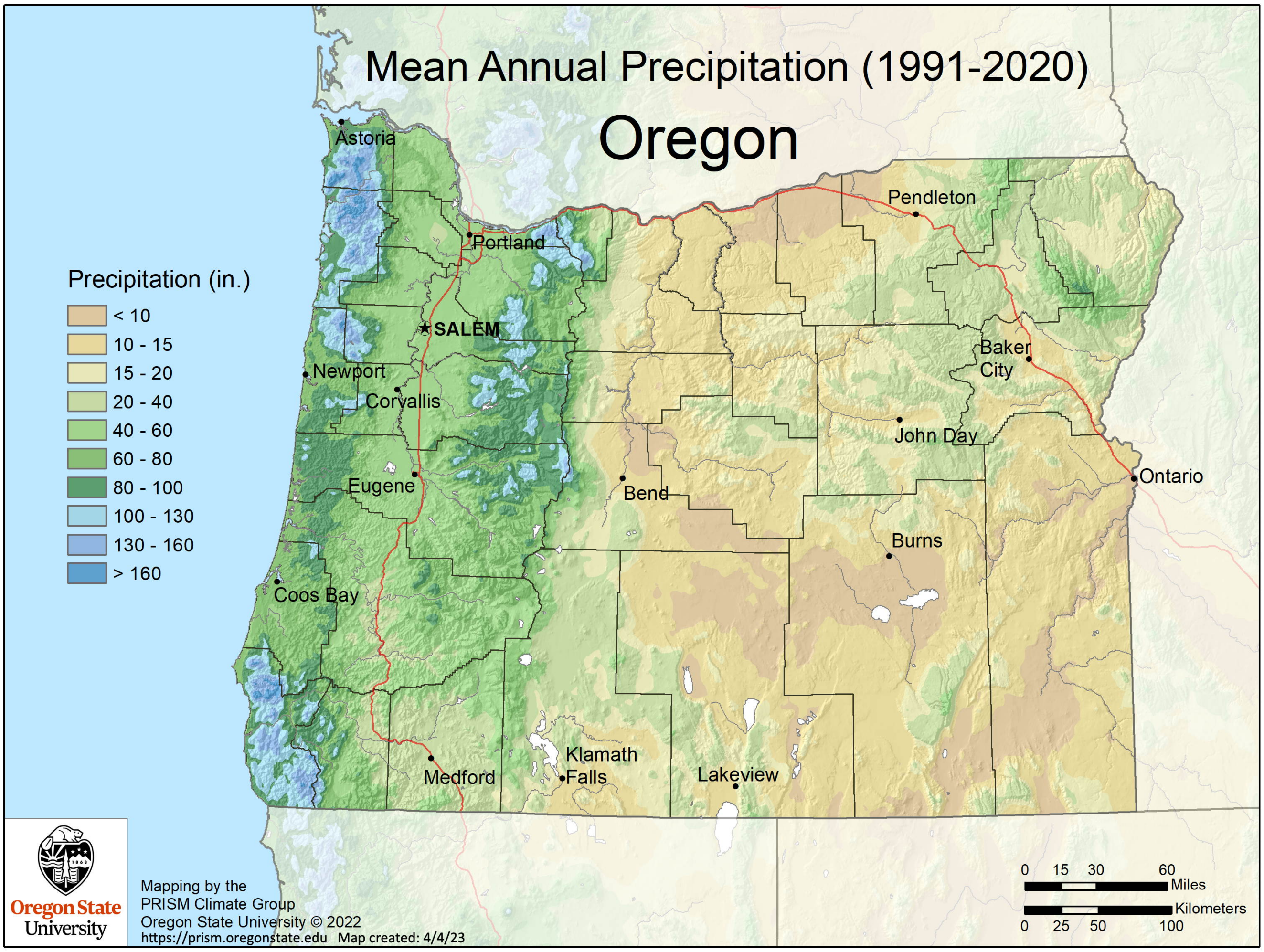
So a single turbine operating at full capacity would be able to provide almost eleven million acre-feet of water per year for a diversion plan like the ORCA Project. But it would be sensible to build the diversion sluices from two turbines rather than one, allowing for more volume when the river is high and for reducing or even halting the flow when the river is low, or if fisheries biologists recommend reducing the flow during peak periods of salmon migration.

The system could be operated so the river level would never fall below its normal lowest level. At the point of lowest flow, it could simply be shut off. As the flow began to pick up, the diversion into the canal system could increase, at first at a level that would simply keep the normal low level for a bit longer than usual. As the river's flow increases, the diversion could increase substantially. Of course, management of the flow would be monitored constantly by fisheries biologists to assure minimal impact. With such a system in place, the environmental impact would be almost nil, yet a substantial amount of water could be diverted south, probably in excess of fifteen million acre-feet per year.

At the risk of sounding repetitive, it's important to recognize that this water is simply flowing to the sea once it passes the Dalles Dam. By the time it reaches the last dam on the river fifty miles downstream, the tidal fluctuations there at the Bonneville Dam are far greater than any water level diminishment which would be seen as a result of the water being diverted at the Dalles. The environmental impact, and any negative economic impact to either Washington or Oregon, would be essentially nil. Yet the economic impact of diverting the water would be immense, with profound advantages for eastern Oregon as well as California and other states.

Who Benefits?

A glance at this precipitation map illustrates in no uncertain terms that the Cascade Range forms the western border of a large dry area comprising about 60% of the state of Oregon, which is predominantly arid or semi-arid (i.e. < 20"/year). The Central Valley of California is also semi-arid, yet it is the garden of the USA. It's all about the water.



Under normal conditions, California's agriculture industry is worth about $40 billion or more. Is there any reason why Oregon's semi-arid land east of the Cascades couldn't bloom like California's Central Valley? Imagine the countless jobs and tens of billions of dollars in annual agricultural revenue that could utterly transform Oregon into a garden state, turning previously barren land fruitful, just as we've seen the SWP transform California.

If the output from just one turbine at the Dalles Dam can keep California's bountiful agriculture industry thriving, why not build the Columbia Diversion Project to divert the output from two of the Dalles' 22 turbines, as suggested above? Yes, it would take a lot of electricity to pump the water through an aqueduct system along the eastern Cascade foothills. But from such an aqueduct system, Oregon farmers (or those who would soon be farmers) could run spurs off to the east to create eastern Oregon's new booming agriculture industry. If California and the federal government offered to pay for the main aqueduct system while permitting Oregon landowners to build (at Oregon's expense) spurs capable of using nearly half the water, it's hard to imagine the project couldn't win the support of most Oregonians. After all, any negative environmental impact would be minimal, and atop all the jobs which would materialize in the new agricultural industry, there would be thousands of good jobs created just building the water system in the coming years. As Oregon's climate warms in the future, lush and bountiful farmland would replace what is now desert land.

It's impossible to get too specific about the costs of all this, since the route would have to be determined and surveyed. As for the electricity to run the pumping stations, it could originally be generated by the Dalles and Bonneville dams, or by a new power plant at Hanford, as suggested previously. In the future, though, economical and ultra-safe modular nuclear reactors (such as the molten salt systems currently under development, or even Oregon's own NuScale small modular reactors) could be built to power the system and surrounding communities. These could be built right along the aqueduct. The water used to cool the reactors—often a point of complaint from environmentalists—could be the same aqueduct water, which as we know from its source would have no fish in it and would return to ambient temperatures rather quickly. Here again, the environmental impact would be nil. No cooling towers would be necessary.

During the most recent drought, farmers in California's Central Valley were contracting for scarce water at prices as high as $2,000 per acre-foot.[9] Even at 1/20th of this price—$100 per acre-foot—ten million acre-feet per year being sluiced down from the Columbia to eastern Oregon and California would bring in a cool billion dollars per year. Sure, the project would be expensive to build, but not nearly as expensive to build, operate, and pump desalinated water from a project like the one described in the beginning of this document The long-term benefits to both Oregon and California would be staggering.

$100 per acre-foot is a pretty standard price for farmers who get their water from the SWP, though they never get the amounts of water they've contracted for. The majority of the contract is hypothetical water. Residents of cities usually pay about $1-$6 per cubic meter for water[10], a price that the $100/a.f. price would drop to just eight cents. One would hope that sending a billion dollars a year north to Oregon and Washington (for water they wouldn't miss anyway) might placate most of the project's opponents After all, we live in the UNITED States. We should act like it.

What Other Options Are There?

The USA can hardly afford to let its garden state dry up. Using this plan, it would instead add another garden state to fill its larders. There has been a lot of talk about building more reservoirs and dams in California, channeling water this way or that, but none of those plans actually create any new water. When the snowpack doesn't materialize, the state will be as desperate as ever. The fact that over-pumping is making California more dependent than ever on surface water is all the more reason to recognize and embrace a plan to bring in dependable water in great volume even during droughts, ensuring the state's verdant future.

Besides the aforementioned Delta Tunnel which would cost an estimated $30-40 billion, California is planning to build another reservoir, the Sites reservoir, at a cost of about $5 billion. Like the Delta Tunnel, it would add not a drop to the state's system and in drought years would dry up just like the others. The Sites reservoir would be a ground-up project, considerably more involved than an expansion of Shasta Dam to its original design height. A simple comparison of the reservoir volumes tells the story: Raising Shasta Dam would add almost ten million acre-feet of capacity. The Sites project would add less than two million in its best years. Far better to put that $35-45 billion to work raising Shasta Dam and building the ORCA Project. Even if the ORCA project would never be built, abandoning the Delta

[9] tinyurl.com/k32tznyk
[10] tinyurl.com/mvzpwe5e

Tunnel and the Sites Reservoir in favor of raising Shasta Dam is still a no brainer. After all, both of those dubious projects would be getting their water from Shasta Lake anyway.

The fraction of water from the Columbia that ORCA would divert can be easily managed to remain within the range of normal water level fluctuations. Even if the Columbia is lower than normal due to drought, the argument is the same: from here it just flows to the sea. It is highly unlikely that even up to 10% of its flow being carefully diverted would make a meaningful difference to the salmon runs or other aquatic life. The environmental impact report required to accompany the ORCA Project would clarify and confirm a lack of significant biological impact.

The cost of such a project will be considerable, but would pay off handsomely for a century or more. It adds vast amounts of water to the benefit of both Oregon and California, plus the return on investment would be long term and immense.

An ancillary benefit of this system running down the east side of the Cascades involves forest fires. Where the canal would be flowing along relatively open ground, it could be intermittently widened and deepened in such a way as to allow firefighting "scooper" planes to fill when fighting nearby forest fires. Another could be to provide water to tanks along the aqueduct near the fireline. Large, heavy-lift helicopters can fill their water tanks with a snorkel which could, during emergencies, siphon water from the aqueduct. Smaller helicopters carry water in buckets holding between 100-400 gallons of water. Each bucket has a release valve on the bottom controlled by the helicopter crew. When the helicopter is in position, the crew releases the water to extinguish hot spots.

ORCA would also provide an opportunity to improve the water situation in the Klamath Lake/Klamath River. Low water levels in recent drought years have ignited feuds between farmers desperate for water and native American tribes and environmentalists who want the water for the health of the ecosystem. Now that four dams are being removed from the Klamath River, there's a real opportunity to reestablish the salmon run in that river, if only sufficient water for everyone's needs can be provided. ORCA could be the deciding factor.

This brings us to another seemingly unrelated water issue: the crisis in the Colorado River. Its two main reservoirs, Lake Powell, and Lake Mead, are nearly dry at the end of 2022. The water rights of the various states which use the Colorado River's water were negotiated and the Colorado River Compact became effective in 1922, and even then they were unrealistic. This compact was renegotiated resulting in interim guidelines signed in 2007 on how to reallocate Colorado River water. Today California has a claim, under those old agreements, to 4.4 million acre-feet per year (coincidentally the volume of the current Shasta Lake). These interim guidelines expire in 2026 and are now the subject of early negotiations which are already raising hackles in the other states which depend on Colorado River water: Colorado, Utah, Nevada, Arizona, Wyoming, and New Mexico. California's allotment provides water not only to the San Diego area but, importantly, to the farms of the Imperial Valley in southern California, where much of the winter lettuce and other vegetables are grown to supply stores across the country. What will happen when—as seems unavoidable at this point—the water supply from the Colorado River is slashed to insufficient levels for the downstream states?

To be sure, water management in both California and Arizona can be—and should be—overseen and regulated far better than has been the case up to now. Growing a water-intensive crop like alfalfa[11] in the desert makes absolutely no sense, and that's just one glaring example among many of the utterly foolish misuse of much of the Colorado River's water. And Los Angeles discharges into the ocean nearly half a

[11] https://archive.ph/gQasU

million acre-feet of water every year from its publicly owned water treatment plants, water which could be diverted for irrigation.

With the construction of the ORCA project, it would take only modest canal construction south from the Los Angeles area to provide the water farther south, including to the Imperial Valley. This would allow California to willingly relinquish all claims to any water from the Colorado River, considerably easing an ever-worsening water crisis.

The proposed project is admittedly massive and would take several years and lots of money to build. But the payoff for the entire country, and especially for the western states, would be immeasurable. We used to build big things in the United States. We still can.

The best time to plant a tree was 25 years ago. The second-best time is today.

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