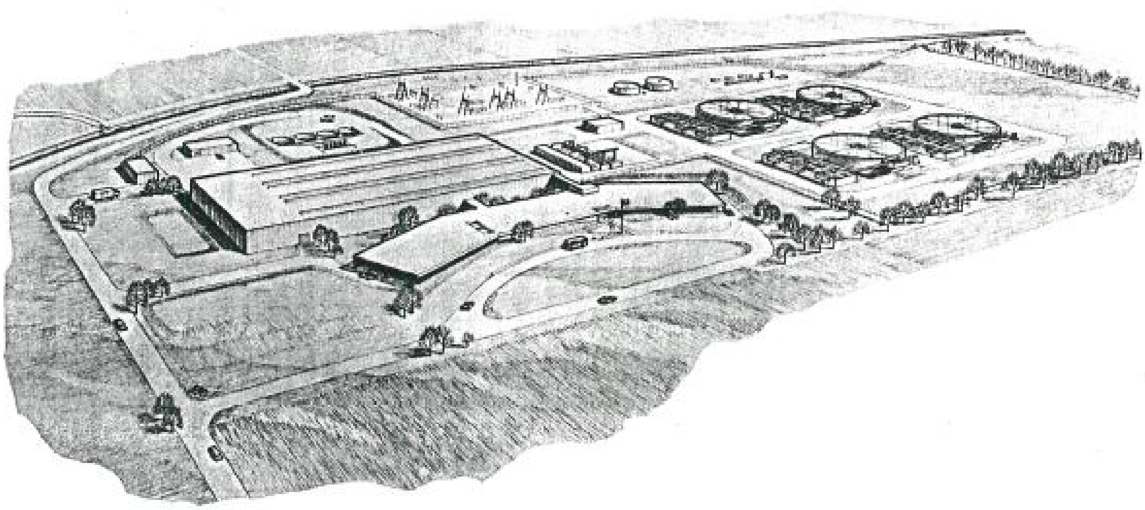
BUREAU OF RECLAMATION

A Very Short History of Yuma Desalting Plant

Yuma Desalting Plant, Arizona
Lower Colorado Basin Region



YUMA DESALTING PLANT
Artist's Conception

Colorado River Basin Salinity Control Project
Title I Division, Desalting Complex Unit, Arizona

U.S. Department of the Interior

January 2021

Mission Statements

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

A Very Short History of Yuma Desalting Plant

Yuma Desalting Plant, Arizona
Lower Colorado Basin Region

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Cover Art: Artist's Conception of Yuma Desalting Plant, 1976. Reproduced in *Project History, Colorado River Basin Salinity Control Project, Title 1,* Vol. II, Calendar Year 1976, p. v.

Acronyms and Abbreviations

1944	Water Treaty 1944 United States treaty with Mexico
1973 Special Report	United States Department of the Interior, Reclamation, OSW, and IBWC, *Colorado River International Salinity Control Project, Special Report,* (Washington, D.C, Denver, CO, Boulder City, NV, and El Paso, TX, 1973),
BRSC	Burns and Roe Services
cfs	cubic feet per second
CRBSCP	*Colorado River Basin Salinity Control Project*, *Title I (or Title 2) Division*
DAS	data acquisition system
EA	Environmental Assessment
ED	electrodialysis
E&RC	Engineering and Research Center
FY	fiscal year
GAO	General Accounting Office
gpm	gallons per minute
HVAC	heating, vacuum, and air conditioning
IBWC	International Boundary Water Commission
ICS	intentionally created surplus credits
KTS	KCorp Technology Services
kV	kilovolts
M	million
Mexico	The United States of Mexico
Mgal/D	million gallons per day
mg/L	milligrams per liter
MODE	Main Outlet Drain Extension
NARA	National Archives and Record Administration
NIB	Northerly International Border
O&M	operations and maintenance
OSW	*Office of Saline Water*
P3	Public Private Partnership
Ppm	parts per million total dissolved solids
PSMC	Programmable Master Supervisory Control System
Reclamation	Bureau of Reclamation
RO	reverse-osmosis
Salinity Control Act	*Colorado River Basin Salinity Control Act of 1974*
SIB	Southern International Boundary
TDS	total dissolved solids
UOP	Universal Oil Projects
USACE	U.S. Army Corps of Engineers
VP	Value Planning
WMIDD	Wellton-Mohawk Irrigation and Drainage District
WAPA	Western Area Power Administration
WQIC	Water Quality Information Center
WPRS	Water and Power Resources Service
YDP	Yuma Desalting Plant
YDTF	Yuma Desalting Test Facility
YPO	Yuma Projects Office

Contents

Page

1. Introduction and Overview

Approximately four miles west of Yuma, Arizona, and about 4,000 feet from the Northerly International Border (NIB) with The United States of Mexico (Mexico) and the Colorado River, sits the Bureau of Reclamation's (Reclamation) Yuma Desalting Plant (YDP). Set on approximately 78 acres of former agricultural fields, YDP is one the world's largest reverse-osmosis (RO) desalination plants. Completed in 1992 for approximately $250 million, its purpose is to reduce salinity levels of brackish Wellton-Mohawk Irrigation and Drainage District (WMIDD) pumped drainage before that water is directed to the Colorado River and south to Mexico. The plant's historic authorization and operation record, however, is much more complex than mere brackish water treatment and conveyance.

From 1983 to 1992, Reclamation constructed YDP pursuant to Title I of the *Colorado River Basin Salinity Control Act of 1974* (Salinity Control Act) or Public Law 93-320, as amended.[1] This law authorized construction, operation, and maintenance of certain works in the Colorado River Basin to control salinity levels of water delivered in accordance with the 1944 United States treaty with Mexico (1944 Water Treaty).[2] Title I Division of Public Law 93-320 mandates various salinity control programs downstream from Imperial Dam, located on the Colorado River about 30 miles north of Yuma. This law also formally implemented provisions of the International Boundary Water Commission's (IBWC) Minute 242 of the 1944 Water Treaty, among them YDP and the 242 Well Field, to account for water lost through drought and other reasons. In implementing these provisions, and with agency and stakeholder enthusiasm and optimism, YDP arose from the once-verdant agricultural fields it displaced.

Shortly after completion, YDP operated at one-third capacity for 168 days. Mother Nature, however, had other plans. Heavy Gila River flooding in January 1993 damaged the Main Outlet Drain Extension (MODE), the plant's main source of WMIDD feed water, interrupting desalting operations. And it would continue interrupted. From the damaging flood to the present, except for a three-month-long demonstration run when YDP ran for 90 days at one-tenth capacity in 2007, and for 328 days as a Pilot Run at one-third capacity in 2010 and 2011, the plant has never functioned as designed. Over time, management pointed to budgetary constraints, as well as surplus conditions on the lower Colorado River that temporarily slaked extended drought—and the success of other Title I (and Title II salinity control measures upstream from Imperial Dam) desalination reduction measures—as primary reasons for plant inactivity beyond ready reserve.

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[1] While the Salinity Control Act authorized construction of YDP and other salinity control measures above and below Imperial Dam, all Title I and II division projects authorized under the act are referred to in official Reclamation and Water and Power Resources Service documents, including all project histories, as the *Colorado River Basin Salinity Control Project*, *Title I (or Title 2) Division* (CRBSCP). For the sake of consistency with official project and other documents, CRBSCP will be used to refer to each project associated with and authorized by the Salinity Control Act, including YDP and related measures under both divisions.

[2] Also known as the "Utilization of the Waters of the Colorado and Tijuana Rivers and of the Rio Grande."

While the demo and (stakeholder co-funded) Pilot runs in the twenty-first century allowed Reclamation and its operations and maintenance (O&M) contractors to update the RO and other plant system technologies, and prove its production capabilities, the plant has never operated beyond ready reserve status for more than 600 days since January 1993.

1.1. Source and Interpretive Limitations/Focus [3]

It is obvious that three brief runs at maximum one-third capacity over the course of almost three decades is not what Reclamation or project stakeholders envisioned for a desalting plant once touted as state-of-the-art. Plant history, however, provides for a compelling story of that roller-coaster journey between authorization and current status. This (reconceptualized) historic overview contextually examines YDP as a product of its time, when the Federal government and Reclamation were not only was dipping their toes into nascent, large-scale desalination (and other) alternative technologies, but also felt enormous pressure from its southern neighbor to remedy rising salinity levels of a shared, bi-national river basin.

Given these limits, there is no way to examine every major aspect of facility history within a 40-page limit. After contextual explanations of Colorado River Basin salinity and international relations with Mexico, the narrative will examine RO/desalination technological history in general, the roles of YDP and other Title I measures, the Yuma Desalting Test Facility, plant design options and modifications, plant construction, and post-construction operations. The interpretive goal here, given source material and length limitations, is to outline and synthesize YDP history into narrative-geared sectional "snapshots" for possible expansion at a later date.

Key questions will guide the narrative:

- What environmental factors brought on this international attention and diplomacy?
- What were other Title I measures, and what drove implementation of YDP as part of Title I? How did the test facility help influence plant siting and design?
- Why was plant capacity frequently revised downwards during the design and construction phases?
- What made brine waste disposal such a controversial issue?

[3] When this supplemental history to the YDP "Special Study" was conceived in early February 2020, it was assumed that detailed research into Yuma Area Office and National Archives files would be possible to look for Title I project correspondence, including decision letters and other valuable original sources, and to examine the records of Interior's defunct *Office of Saline Water*, a major player in the plant's creation. The coronavirus pandemic, however, resulted in non-essential travel restrictions and closure of National Archives to researchers. As such, materials are restricted to what had already been scanned from limited sources, mostly Reclamation-generated Title I project histories and reports, O&M contractor reports and summaries, secondary sources published by the private sector, and websites.

- Finally, beyond the 1993 flood, why was the plant's operation curtailed, despite successful demo and Pilot runs?

This brief history may not answer some of these questions nor suggest solutions, but it can provide a roadmap for further research and interpretation.

1.2. Colorado River Basin Salinity and International Relations

In the wake of widespread continued and proposed development of water storage and power resources along the Colorado, Rio Grande, and other international boundary-shared watercourses, and to ensure that Mexico received its fair share of this water, in 1944 the two countries agreed to a "Treaty for the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande." For the Colorado, this treaty allotted 1.5 million acre-feet of water annually "…of the waters of the Colorado River, from any and all sources…" While the treaty permitted the United States to include agricultural drainage waters from projects below Imperial Dam as part of this allotment, it did not resolve water quality issues associated with this water. Delivery of treaty waters to Mexico began in 1950 with the completion of Morelos Dam, a Mexican diversion structure on the Colorado River located a few thousand feet south of the desalting plant's future site. Eleven years later, by 1961, Mexico was receiving highly saline WMIDD drainage waters averaging 6,000 parts per million total dissolved solids (ppm TDS) annually; the district did so to maintain ground water levels below the crop root zone.

Additionally, due to drought and increased municipal and agricultural use upstream in the post-World War II era, excess flows to Mexico that had existed before 1961 came to a near end. These flows had diluted the saline drainage waters discharged to the river below Imperial Dam. The result was annual average salinity increase delivered to the NIB from 800 ppm TDS to nearly 1,500 ppm TDS.[4] In 1961, Mexico filed a formal protest claiming that increased salinity levels violated provisions of the 1944 Treaty. In response, in 1963 the United States altered water operations to reduce salinity levels of water delivered to Mexico, and on March 22, 1965, both governments signed IBWC Minute 218.[5] This Minute stipulated practical measures to further reduce salinity levels of water reaching Mexico, including construction of the MODE, a twelve-mile-long channel to allow the discharge of WMIDD drainage waters to the Colorado River above or below Morelos Dam, and installation of additional drainage wells in the Wellton-Mohawk valley to allow selective pumping of drainage waters. These measures, and the gradual improvement of WMIDD drainage waters, improved to the point that average annual salinity levels of water delivered to Mexico improved to about 1,245 ppm TDS. Yet this was not enough. Mexico asked the United States under terms of Minute 218 to bypass an

[4] United States Department of the Interior, Bureau of Reclamation, Office of Saline Water, and International Boundary Water Commission, *Colorado River International Salinity Control Project, Special Report,* (Washington, D.C, Denver, CO, Boulder City, NV, and El Paso, TX, 1973), 1. (*1973 Special Report*).

[5] See https://www.ibwc.gov/Files/Minutes/Min218.pdf for details. Accessed September 1, 2020.

additional 40,000 to 75,000 acre-feet of WMIDD drainage flows annually; this resulted in further reduction of saline levels in 1971 at Morelos Dam to about 1,160 ppm TDS.[6]

The clock, however, was ticking on Minute 218, which was slated to expire on November 15, 1970. To ensure improved water deliveries to Mexico, the Nixon administration, spearheaded by Secretary of State Henry Kissinger's desire for better relations with Mexico, proposed a new 5-year agreement. This proposal offered to bypass additional volumes of WMIDD drainage and to substitute equal volumes of better water delivered to Mexico to about 1,140 ppm TDS at the NIB; this salinity level would approximate that of waters delivered to Mexico above Morelos Dam if all projects below Imperial Dam operated in salt balance. While Mexican President Gustavo Diaz Ordaz agreed to this extension, he deferred to his successor President Luis Echeverria, who assumed office in December 1970 along with a one-year Minute 218 extension. And after yet another extension to November 1972, Mexico requested a prompt and permanent settlement.[7]

On July 14, 1972, in an agreement to further improve the water delivered to Mexico north of Morelos Dam, both governments signed Minute 241 of the IBWC. This new agreement provided for the bypass of 118,000 acre-feet of WMIDD drainage waters without charge against the treaty—more than twice the volume under Minute 218—and their replacement by other waters above Imperial Dam and wells on Yuma Mesa. This resulted in the average annual salinity of waters made available to Mexico from 1,245 ppm TDS in 1971 to 1,140 ppm TDS by June 1973. Mexico also requested that the United States to bypass without replacement the remaining WMIDD drainage waters, about 100k acre-feet annually, to the Colorado River below Morelos Dam. This further reduced the average salinity of water at Morelos Dam to less than 1,000 ppm TDS by June 1973. Operations under this Minute continued until August 30, 1973, when they were terminated and replaced by Minute 242.[8]

1.2.1. Minute 242: A "Permanent and Definitive Solution"

Formally approved that same day by the two governments, IBWC Minute 242, also known as the "Permanent and Definitive Solution to the International Problem of the Salinity of the Colorado River," centered on the stipulation that, subject to congressional authorization for the necessary work, the United States will assure that waters delivered to Mexico upstream from Morelos Dam "will have an annual average salinity level of no more than 115 ppm +/- 30 ppm TDS greater than the annual average salinity of Colorado River waters arriving at Imperial Dam." [9]

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[6] United States Department of the Interior, Bureau of Reclamation, *Project History: Colorado River Basin Salinity Control Project Title I,* (Yuma: Yuma Area Office, Volume I, 1975), 2-3. (Hereafter *CRBSCP Title I Project History*, Volume (Vol.) # / Year / Page).

[7] 1973 Special Report, 3-4

[8] *CRBSCP Title I Project History*, Vol. 1, 1975, 4-5.

[9] 1973 Special Report, 8.

Minute 242 also required that from September 1, 1973, and until Congress authorized appropriations for the necessary works, the United States would discharge to the Colorado River downstream of Morelos Dam an annual rate of 118,000 acre-feet of WMIDD drainage waters and substitute an equal amount of other water to be discharged to the Colorado River above Morelos Dam. After January 1, 1974, "or the authorization by the Congress, whichever comes later and until the necessary measures under the permanent solutions are completed," the United States would bypass all WMIDD drainage and replace it with water of Imperial Dam quality to maintain the differential.[10]

The "permanent solutions" mentioned in Minute 242 formed the genesis of the Colorado River Basin Salinity Control Project, with a proposed desalting plant as the key feature to "maintain the differential." As the 1973 Reclamation/Office of Saline Water *Special Report* stressed:

> …the only method acceptable to United States interests is to treat the Wellton-Mohawk drainage waters so they will have the same salinity as waters from above Imperial Dam. This can be done by constructing a complex to desalt a portion of the drainage and blending the product water with remaining drainage to achieve the desired salinity. The reject stream from the plant, amounting to between 40,000 to 50,000 acre-feet per year, will constitute a loss of water from the Colorado River system, but it may be reduced by increased efficiency of operations.[11]

In order to bypass all WMIDD drainage and replace it with water of Imperial Dam quality, Reclamation suggested replacing the first 49-mile stretch of the (unlined) Coachella Canal in Imperial County, California, with a new concrete-lined canal. In its estimates, this new canal would save 132,000 acre-feet of water annually, water that could "be used as a replacement water for the bypassed water until needed by other priority users in the Lower Colorado River Basin." Other measures looked at lowering the quantity of WMIDD drainage by improving irrigation efficiencies and reducing the amount of irrigated areas, which could decrease the annual amount of drainage water to 175,000 acre-feet, as well as Gila River control measures below the U.S. Army Corps of Engineer's Painted Rock Dam near Gila Bend.[12]

1.3. Desalting Plant Preliminaries, Project Authorization

Between ratification of Minute 242 and authorization of the Salinity Control Act in 1974, Reclamation drafted preliminary plans and requirements for the new desalting plant. Situated about 4 miles west of Yuma, and operated at 90 percent plant factor, the plant would accept

[10] Ibid.

[11] Ibid., 9. A key aspect of future YDP research are the *Records of the Office of Saline Water* (OSW) located at the National Archives and Record Administration (NARA), Rocky Mountain Branch in Broomfield, Colorado. This research is of paramount importance once the archives reopens, because OSW, not Reclamation, was a major influence in Interior's decision to go with a desalting plant. Created in 1955 as the successor to Interior's *Saline Water Conversion Program*, OSW was abolished in 1974—the same year as the Salinity Control Act's authorization. Source: OSW records at https://www.archives.gov/research/guide-fed-records/groups/380.html, accessed July 16, 2020.

[12] Ibid. Painted Rock Dam is a Gila River flood control facility constructed in 1959 by the U.S. Army Corps of Engineers (USACE), and is located about 20 miles northwest of Gila Bend, AZ.

brackish WMIDD drainage waters via the MODE. Reclamation calculated the plant's maximum treatment capacity at 100 million gallons per day (Mgal/D), 90 Mgal/D of which would be treated water, and the remaining 10 Mgal/D for system maintenance "without interruption of normal operation." Treated WMIDD flows, estimated at 240 ppm TDS, would be conveyed via pipeline to the Colorado River above Morelos Dam via MODE extension #2, and blended with water in MODE #2 to produce water with identical salinity levels arriving at Imperial Dam. Reclamation also proposed to replace a deteriorated metal flume where the MODE bisects from the main WMIDD conveyance with a concrete siphon "to assure continuous operation." [13] The plant's reject stream would be returned to the MODE.

To prevent this water from entering the Colorado River and degrading groundwater in both countries, however, Reclamation proposed to extend the bypass drain (from its terminus at Morelos Dam) approximately 53 miles south through the United States and Mexico to empty into the Santa Clara Slough upstream from the Colorado River Delta. Reclamation stressed this bypass drain would be constructed to convey the same capacity as the MODE, so all the WMIDD drainage could be discharged south to the Santa Clara Slough in an emergency. The United States would assume financial responsibility for their stretch, and assist the Mexican government with their much longer stretch.[14] Reclamation estimated the desalting plant's installation cost, including all infrastructure and land acquisition costs, at $62,080,000, while the rebuilt MODE siphon, bypass drain extension, Wellton-Mohawk irrigation efficiency improvement and acreage reduction programs, and the (as-yet unexplained) Gila River control measures below Painted Rock Dam, tacked on an additional $35,970,000.[15]

As expected, on June 24, 1974, barely six weeks before he resigned from office, President Richard Nixon signed into law the *Colorado River Basin Salinity Control Act* (Salinity Control Act). Split into two titles under the official project name *Colorado River Basin Salinity Control Project* (CRBSCP), Title I covered salinity reduction measures downstream of Imperial Dam, while the more geographically-expansive CRBSCP Title II Division covered desalination measures upstream from Imperial Dam. Title I included:

- Constructing Yuma Desalting Plant and all appurtenant features (including expanding the OSW test facility)
- Extending the concrete-lined bypass drain from Morelos Dam to Mexico's Santa Clara Slough
- Rebuilding the MODE drain extension from metal flume to concrete siphon
- Replacing the first 49 miles of Coachella Canal from Imperial Dam with a concrete-lined conveyance

[13] Ibid., 10-11.

[14] Ibid., 11-12.

[15] Cost breakdown in Ibid., Appendix, A, A-48.

- Installing a protective and regulatory well field near the Arizona-Sonora Southern International Boundary (SIB)
- Implementing the Wellton-Mohawk Irrigation Efficiency Improvement and Acreage Reduction Program to reduce district drainage flows.

Measures regarding Gila River control downstream of Painted Rock Dam discussed earlier were not mentioned as part of CRBSCP Title I Division. Title II Division, which is not part of this history, authorized construction of four salinity control units and completion of planning reports on 12 other salinity source-point areas in the upper basin states, specifically Colorado and Utah. Seven days later, Congress made first-year appropriations of $26,000,000 available for activities beginning in fiscal year (FY)1975.[16]

1.4. Reverse Osmosis: Historic Overview

A brief overview of the scientific history underlying something Reclamation had never attempted—the application of brackish water reverse-osmosis (RO) desalination technology on a large scale with international implications—will help provide a technical context for the eight-year period between CRBSCP Title I/YDP authorization/funding and plant construction. Much like Reclamation's expensive and equally ambitious experiments with alternative wind-power generating and cloud-seeding water supplementing technologies,[17] desalination was not much different—the agency was charting a new course into the unknown. While desalination ended up as a more enduring technology than cloud-seeding and wind power, mostly due to the project's water quality and other treaty-defined international mandates, it was nonetheless a learn-as-we-go process rife with obstacles and challenges to design, apply, and maintain a technology dating back at least two centuries. And it all started with a French clergyman and a pig bladder.

While many technologies can remove salt from water, thermal distillation—boiling and re-condensing seawater to leave salt and other impurities behind—is the oldest, one mostly used to desalinate seawater. Although using little more than makeshift contraptions borne out of necessity, ancient Greek sailors applied this method to increase freshwater supplies at sea. By the 16th century, and until after World War II, a wide range of seagoing vessels, military and civilian, used evaporation-based thermal distillation systems on long ocean journeys; this ensured self-sufficiency in emergencies. Other distillation techniques included multi-stage flash and multi-effect distillation, the first processes incorporated on an industrial scale.[18]

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[16] *CRBSCP Title I Project History,* Vol. 1, 1975, viii. For more on proposed (and implemented) Title II projects see https://www.usbr.gov/uc/progact/salinity/, accessed July 15, 2020.

[17] For more on Reclamation's *Medicine Bow Wind Power Project* and *Project Skywater*, see James M. Bailey, *The Medicine Bow Wind Energy Project* (Denver: Bureau of Reclamation History Program, 2014), at https://www.usbr.gov/history/ProjectHistories/Wind%20Electric%20Power%20Project.pdf, and Jedediah S. Rogers, *Project Skywater,* Andrew H. Gahan, Ed. (Denver: Bureau of Reclamation History Program, 2013), at https://www.usbr.gov/history/ProjectHistories/Project_Skywater_D1[1].pdf, both accessed July 15, 2020.

[18] "A Short History of Desalination," at http://www.theenergyofchange.com/short-history-of-desalination, accessed July 16, 2020.

In 1748, French clergyman and physicist Jean-Antoine Nollet discovered what would (much later) become the other primary method of desalination: osmosis. Nollet replicated the human body osmotic process by using a pig's bladder as a membrane through which solvent molecules from low solute water could flow through the bladder wall into a higher solute concentration made of alcohol. He proved that a solvent could pass through a semi-permeable membrane through natural osmotic pressure, and the solvent will continually enter through the cell membrane until what scientists call "dynamic equilibrium" was reached on both sides.[19]

While Nollett's discovery was a technological breakthrough, it was not until 1959 that researchers at the University of Southern California developed a functional synthetic RO membrane from cellulose acetate. They pressure-forced high solute water through the cellulose membrane, which acted as a filter that allowed only water molecules to pass through while rejecting salt and other TDS. This process produced purified, drinkable water via a durable and reusable membrane that could operate under normal water pressure and conditions. Since this new technology worked in reverse of the natural osmotic process, it soon became known as reverse osmosis. Six years later, in 1965, the first commercial desalting plant was built in Coalinga, California, to use RO processes to desalinate brackish water, which attracted scientists from around the world.[20] The YDP would soon follow Coalinga in their efforts to desalinate incoming brackish water flows for the Wellton-Mohawk valley.

1.5. Post-Authorization Preliminaries

In the wake of Salinity Control Act and CRBSCP Title I Division authorization, Reclamation forged ahead with their desalting plan specifics. After reviewing the 1972 Office of Saline Water and Bureau of Reclamation document "Desalting Handbook for Planners" and the various methods available—distillation, electrodialysis, RO, and ion exchange—they initially settled on a combination of RO and electrodialysis (ED). Planners based this decision on anticipated salinity levels from WMIDD amounting to around 3,200 ppm TDS (distillation was better for TDS amounts exceeding 10,000 ppm TDS, while ion exchange better suited 2,000 ppm TDS and lower). ED and RO fell into the middle of the range, averaging 5,000 ppm TDS.[21]

By this time Reclamation also settled on the process. The plant would be divided into two "distinct systems": pretreatment and membrane desalting. Flows to pretreatment facilities would pass through a MODE diversion structure to grit sedimentation basins for chlorination, then to sludge reactors. Overflows from these reactors would be percolated through gravity sand filters then pumped to clear wells to await the membrane desalt process. Any TDS

[19] "Dynamic Equilibrium" is defined as "the reaction rate of the forward reaction is equal to the reaction rate of the backward reaction." https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Equilibria/Chemical_Equilibria/Principles_of_Chemical_Equilibria/Dynamic_equilibrium, accessed July 16, 2020.

[20] "History of Reverse Osmosis Filtration," at https://www.freedrinkingwater.com/reverse-osmosis/knowledge-base/history-of-reverse-osmosis-filtration.htm, accessed July 16, 2020.

[21] *CRBSCP Title I Project History,* Vol. 1, 1975, 18.

remaining in the water after passing through pretreatment would be removed using a thin membrane process: ED or RO, or a combination of both. Planners also focused on the plant's "most desirable" location, "Yucca Site" adjacent to the MODE about four miles west of Yuma in the Yuma Project's Valley Division. Having two service roads on each side of the MODE, as well as extending a Southern Pacific Railroad spur on the adjacent Yuma Valley Levee, (eventually) helped finalize this decision, despite concerns over seismic suitability.[22]

Another major construction item associated with YDP and CRBSCP Title I was the Bypass Drain that would carry reject stream discharged into the existing MODE from Morelos Dam south to Mexico's Santa Clara Slough. The 53-mile-long, 353 cubic feet per second (cfs) capacity drain would have wasteways and check structures built for emergencies. Reclamation indicated that while the United States would fund and build their stretch to the border, Mexico, with financial assistance from the IBWC, would construct and maintain their stretch.[23]

Other plant-related infrastructural items that remained under discussion: where the plant would get the enormous amount of power to operate the desalting process, and how the plant would dispose of the large quantities of waste product (concentrate) generated by this process. While truck, rail, and pumped pipeline options were initially suggested, as will be discussed later this waste disposal issue generated its share of public controversy, especially proposals to send it west to California.

The first order of business, however, was replacing the deteriorated metal MODE flume adjacent to the river near Prison Hill to provide a reliable flow to the desalting plant. Planned as a 3,300-foot-long, 120-inch-diameter concrete structure, Reclamation would place it next to the old flume on the south side, then tie it into the existing concrete-lined drain channel about 300 feet upstream from the beginning of the present structure. It would extend downstream along the bank of the Colorado River and terminate at the present structure's outlet. Because the new siphon right-of-way encroached upon sites associated with the Yuma Crossing and Associated Sites National Historic Landmark (established in 1966), Reclamation worked the National Park Service under Section 106 of the National Historic Preservation Act to determine if the new siphon would have adverse effects on the historic landmark. After extensive public and interagency consultations, the Advisory Council of Historic Preservation in Washington, D.C., determined that there were no adverse effects due to this proposed construction.[24] With this ruling, Reclamation began siphon construction.

[22] Ibid., 18-19. Other plant sites considered were Pilot Knob, Dome Narrows, Fortuna Wasteway, Prison Hill, and Yuma Valley Section 30. All were eventually rejected due to location and extensive infrastructure preparations that the Yucca Site did not need, along with distance to the Colorado River and other factors.

[23] Ibid. 37-39.

[24] *CRBSCP Title I Project History,* Vol. 1, 1975, 49-50. This national historic landmark is now known as the Yuma Crossing National Heritage Area. https://en.wikipedia.org/wiki/Yuma_Crossing, accessed July 16, 2020.

2. Yuma Desalting Test Facility

Originally set up in 1971 as a mobile test facility by Interior's Office of Saline Water (OSW) east of Yuma adjacent to the Wellton-Mohawk Main Conveyance, the Yuma Desalting Test Facility (YDTF) was crucial in producing design and construction data regarding YDP's desalt process and capacity. Reclamation expanded it two years later from its original output of 100 gallons per minute (gpm) to over 1,100 gpm, and from six membrane test units to ten. Reclamation also enhanced this test system to represent the size and type of membranes to purchase for YDP. Pretreatment methods were also investigated. Several types of different pretreatment methods, among them filtration, diatomaceous earth, potassium permanganate, manganese zeolite, and alum flocculation all produced the best and most reliable results.[25]

The test facility also allowed different equipment manufacturers to test and gain confidence in their products and systems. Reclamation invited RO manufacturers: Envirogenics, Dupont, Westinghouse, and Hydranautics, as well as ED and Ion-exchange suppliers Aqua Chem, Dow Asahi, and Ionics (Westinghouse dropped out in 1974). The only overriding constraint on testing was for benefit of YDP, so units inappropriate for the larger plant were not tested. Burns and Roe Services, Paramus, New Jersey, operated YDTF under a cost-plus-fixed-fee contract[26] (Burns and Roe would also secure YDP's initial O&M contract).[27]

3. Wellton-Mohawk Irrigation Efficiency Improvements and Acreage Reduction

Another crucial aspect to (future) YDP operations was to decrease brackish WMIDD drainage flow through irrigation improvements and acreage reductions. The objective was to reduce these flows from about 204,000 acre-feet in 1974 to 167,000 acre-feet in 1981 to reduce plant costs. To accomplish this, Reclamation teamed up with three other entities, the WMIDD, the Soil Conservation Service, and the Agricultural Research Service, to look at on-farm system improvements, irrigation management practices, and research demonstrations. Additionally, Section 101 (f) (2) of Public Law 93-320, required an additional 10,000 acre reduction in the district's authorized irrigable acreage. Reclamation and project stake holders initially identified about 20,000 acres that met possible irrigable acreage reduction criteria; as these lands would have required expensive constructing improvements and were enough to initiate the on-farm improvement program. About 7,500 acres were initially offered for sale, with most of this land planted as citrus on Wellton Mesa.[28]

[25] *CRBSCP Title I Project History*, Vol. 1, 1975, 35.

[26] Ibid, 36.

[27] The current Water Quality Information Center (WQIC) is a miniature version of the original test facility.

[28] Ibid., 43-45. The Soil Conservation Service is now known as the Natural Resources Conservation Service.

4. Construction

4.1. Pre-construction and Other Activities[29]

In the six years before plant construction, Reclamation and its partners made great strides in preparing for actual desalting plant construction. Among these accomplishments were final plant design and preconstruction infrastructure activities, completion of plant-connected siphons and drains, more analysis of test facility data, and further acreage reduction and irrigation efficiency efforts in the Wellton-Mohawk valley. While the MODE siphon and bypass drain construction and irrigation reduction measures proceeded fairly smoothly, issues regarding plant size and capacity, bidder protests over RO membrane contract awards, and controversies surrounding brine disposal, stretched out investigations longer than expected.

4.2. MODE Siphon and Bypass Drain

The MODE Siphon and bypass drain were the first two YDP-centered features completed, both within three years after Title I authorization. Working under Specifications No. DC-7140, contractor Sully-Miller, Brea, California, worked throughout 1975 and into 1976 on the new, 3,941-foot-long concrete MODE siphon. No major obstacles or delays were reported by the contractor or Reclamation, and on June 9, 1976, Reclamation accepted the contract as completed—nearly 14 months ahead of schedule.[30]

Similar rapid progress was also made on the United States portion of the bypass drain that ran from its new bifurcation at Morelos Dam south to the Southerly International Border (SIB). Specifications No. DC-7210 was opened June 29, 1976, with award of contract and notice to proceed to low bidder Contri Construction Company, Reno/Las Vegas, Nevada, with 450 days allowed for completion. Much like the MODE Siphon rebuild, the contractor finished this job early, with work accepted for completion on September 19, 1977. On the Mexico stretch below the SIB, the Mexican government issued two contracts for their portion of drain construction. Reimbursed with $21,850,000 in IBWC funds, in spring 1977 Mexico completed their stretch of the bypass drain to Santa Clara Slough. Reclamation Commissioner Gilbert Stamm viewed the bypass drain as symbolic of linking "together of our two countries in our effort to improve the quality of water delivered to Mexico here at Morelos Dam."[31]

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[29] This section is condensed to only include major highlights directly related with YDP design and site work, connected plant features like the MODE siphon and bypass drain construction, and the brine disposal controversy. Complexities behind WMIDD flow and irrigation reduction efforts are only mentioned as they relate to plant capacity and size.

[30] *CRBSCP Title I Project History,* Vol. 3, 1977, 55.

[31] *CRBSCP Title I Project History,* Vol. 3, 1977, 41-42; Stamm quote from *Salt Talk, a Quarterly Newsletter about Title I Features* (hereafter *Salt Talk*), October 15, 1976, reproduced in *CRBSCP Title I Project History,* Vol. 2, 1976, 130. Salt Talk was published by Reclamation's Lower Colorado Regional Office, Boulder City, NV.

4.3. Desalting Plant: First Stages

While most of the early stage work on YDP consisted of assorted planning studies and reports, by the end of 1976 refinements and modifications to original designs were taking shape, including finalizing the site. Reclamation decided on a preferred site 4 miles west of Yuma, due to its close proximity to the MODE, Colorado River, Morelos Dam, and Arizona Public Service's Yucca-Axis Powerplant. Plant capacity would be "about" 100 million gallons per day (Mgal/D). WMIDD drainage was projected to total about 167,000 acre-feet per year at 3,200 ppm TDS, of which the plant would desalt up to 102,700 acre-feet to 386 ppm TDS while producing 43,400 acre-feet of reject at 8,874 ppm TDS; approximately 100 additional acre-feet would be consumed in the pretreatment process. When plant product is blended with the remaining 20,900 acre-feet from the MODE, 123,600 acre-feet of total blend water at 834 ppm TDS will be returned to the Colorado River annually. Reclamation also mentioned that final plant characteristics would be determined pending final design after awarding membrane contracts in 1977.[32]

A major concern with plant siting, however, was seismic load on sandy soils. After extensive testing, Reclamation deemed the low density soils at Yucca site inadequate as foundational material for a large water treatment structure. Complicating matters was the site being close to three major earthquake fault zones; engineers theorized the sandy soil would liquify under seismic stress. To remedy this, engineers proposed to remove and recompact all the silty materials under each major structure and provide gravel pads to reduce differential settlement. They also proposed to build up the entire plant area three feet to make the sands less susceptible to liquification and reduce future settlement. Using raft-type foundations for major structures would also reduce foundation pressures and minimize differential settlements.[33]

In 1977, Reclamation's Lower Colorado Regional Office released a YDP sizing and design production capacity study report. It recommended a 96 Mgal/d plant size based on operational characteristics for a spiral-wound RO desalting process capable of producing 254 ppm TDS product water when the feedwater salinity is 3,200 ppm TDS, with a 70 percent plant recovery rate. Also, since the plant may not be adequate for all possible hydrologic conditions, drainage flows should be bypassed to the Santa Clara Slough when necessary to maintain the 115 ppm TDS salinity differential. But the primary factor affecting YDP size was WMIDD drainage flow; more improvement in saline reductions on that end equaled smaller plant size, so Reclamation proceeded on that assumption and stressed this program "must continue."[34]

Yet plant sizing and capacity seemed modest compared to the disposal controversy that an estimated 85,000 *tons* of calcium carbonate waste engineers estimated YDP would annually produce. It is generated by pretreatment of drainage water with a lime-softening process, where

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[32] *CRBSCP Title I Project History,* Vol. 2, 1976, 19. As will be later mentioned, these contracts would be delayed over a year due to alleged unfair bidding practices.

[33] Ibid., 19-21.

[34] Bureau of Reclamation, *Sizing Study, Yuma Desalting Plant, Arizona, Interim Report,* (Boulder City, NV: Lower Colorado Regional Office, 1977), ii-iii.

the water is treated with lime ferric sulfate and polyelectrolyte. These additives act as coagulants, resulting in the extraction of large quantities of waste solids that require proper disposal. Early on, Reclamation decided the most viable method of sludge disposal was by transporting the waste—via pipeline, truck, or rail—and burying it in a landfill. Environmental studies in 1977 focused on three sites for burial, all on Federal land: Cactus and Pilot Knob sites in nearby California, and the Border Site southeast of the plant near San Luis, Arizona.[35]

4.4. Yuma Desalting Test Facility

Reclamation's top priority at that time was the continued research-oriented operation and maintenance of YDTF to gather information and data for plant design, construction, and operation. The next priority was to discover the best type of commercially-available RO membranes to use in the plant. The YDTF provided Reclamation and equipment suppliers with the opportunity to evaluate the performance of contractor equipment on actual WMIDD drainage water on a scale large enough to produce meaningful data, and to provide a good basis for manufacturer proposal preparation. Since 1976, the test facility used more redesigned and refined membranes called "large modules" to examine a more economic size of equipment for large-capacity desalting plants. The main problem Reclamation noted was rapid membrane deterioration over time caused by physical changes, chemical reactions with the water and its constituents, biologic attacks on the membrane, scale formation, and clogging. Physical change of membrane materials over time and under constant high pressure complicated membrane evaluation, including membrane compaction that reduced flow (aka flux). To dependably predict product flow of a unit after several thousand hours of operation was a base requirement for plant design.[36]

Another important aspect of the test facility was to deal with various aspects of the water pretreatment process, to meet the quality specifications of feed water set by respective membrane equipment manufacturers. By 1978, and after unsuccessful dalliances with other pretreatment processes, including flocculation and coagulation, Reclamation settled on the partial lime softening process to reduce alkalinity, remove scale-forming materials like calcium and particulates, eliminate organic and biologic material, and remove transitional metals like iron and manganese before the feed water reached the delicate RO membrane process. Reclamation concluded the partial lime process, controlled by a process pH, was "very reliable" provided the hardware functioned properly.[37]

While research continued on pretreatment, and would so for another couple years, in 1977 Reclamation selected two companies involved in RO membrane evaluation: Fluid Systems Division, Universal Oil Projects (UOP), Inc., San Diego, California, and Hydranautics, Goleta, California. After selection, however, there was a year-long delay regarding unfair practice protests filed by RO membrane manufacturers DuPont and Ionics with the General Accounting Office (GAO). The GAO eventually ruled their protests held no merit, and that Reclamation

[35] *CRBSCP Title I Project History*, Vol. 3, 1977, 33-34.

[36] Ibid., 222-223.

[37] Ibid., 227-231.

could proceed with contract issuance. But there was a domino effect: this delay in awards slowed contracts with plant site preparations, including switchyard, powerlines, control systems, sludge disposal, and plant design.[38] Still, the Yuma *Daily Sun* was ecstatic the plant was about to become a reality—although contracts would not be formally ruled on and awarded for another year:

> Under the proposal, it would desalt 100 million gallons of water daily from the bypass drain. Although desalinization plants have been operating in water-short areas worldwide, Yuma's would be the largest on earth. It would be the prototype for others to follow, and would significantly advance the field of desalinization. While the plant would probably not have a large operating staff, its construction would certainly help pump some extra money into the local economy. And it would be another first for Yuma and another interesting draw for tourists, and no doubt lure visiting engineers, water experts and politicians from all corners of the world. It was almost too good to be true, particularly in a period of recession, government belt-tightening and serious scrutiny of big federal public works projects by the Carter Administration last winter. But Wednesday's announcement that the choice of suppliers for some $35 million in desalting equipment will soon be made is welcome evidence of life in the desalting project. It was originally planned for completion by 1981.[39]

Despite fervent proclamations by the local paper—and the favorable editorial in the *New York Times*—this delay would be one of the first in many that would push back the plant's completion by eleven years.

4.5. Plant Pre-Construction Begins

Once the GAO resolved RO membrane contract disputes, in early 1979 Reclamation took the first steps in plant site preparation by securing land acquisitions and issuing bid notices for site infrastructure work. Land acquisition for the rights-of-way access to the proposed plant site was completed under Land Purchase Contact No. 8-07-34-L0153 for 6.7 acres of land valued at $56,010. Total land acquired for the desalting plant, including access road, was 91.4 acres valued at $445,010. On December 20, 1979, Reclamation issued Specifications No. DC-7401, Yuma Desalting Plant, Pretreatment I and Site Improvement, with a low bid of $7,046,798, thirteen percent below engineering estimates, to ACS Constructers, Boise, Idaho, with notice to proceed on February 1980. Work included for the plant's first on-site contract included access roads, preparatory earthwork and fencing, intake piping, sedimentation basins, the intake pumping plant, and various intake and discharge structures.[40]

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[38] *Salt Talk*, in *CRBSCP Title I Project History,* Vol. 4, 1978, 76.

[39] "World's Largest Desalt Plant Moved One Step Closer to Reality," *Yuma Daily Sun*, September 18, 1977; "Spurring World's Desalting Projects," *New York Times*, September 14, 1977.

[40] *CRBSCP Title I Project History,* Vol. 5, 1979, 13-14, 122-123; *Salt Talk*, June 13, 1980.

And, pending a request by the Water and Power Resources Service (WPRS)[41] to Congress to raise the Title I appropriations budget ceiling by $113.5 million, a reassessment was conducted of time required to finish Pretreatment II specifications and complete plant construction. Assuming in-house design to be restarted March 1, 1980, WPRS optimistically estimated that invitations for bids could be issued in two years, resulting in a revised plant completion date of June 1986. [42]

Sizing of incoming plant power was also finalized. Studies conducted by the Department of Energy's Western Area Power Administration (WAPA) revealed that upgrading from 69 kilovolts (kV) to 161 kV showed a significant cost savings to the government with no loss of system reliability. The study proposed one 3.8-mile-long 161 kV transmission line from Knob Substation northwest of the plant site. This was in lieu of two 69 kV lines, one fed 27 miles from the Gila Substation and another much shorter, 0.2-mile-long 69 kV line from Arizona Public Service's Yucca-Axis Switchyard. Construction for the 161 kV line would be included in the plant's switchyard specifications. Discussions were also suggested about the possibility of solar energy powering the plant, which reflects the WPRS quest to investigate alternative energy means such as wind power around this time.[43]

The June 13, 1980, issue of the Lower Colorado Region's *Salt Talk* newsletter also discussed the possibility of a smaller plant, due to a higher-than-expected reduction of WMIDD drainage flows since the implementation of Title I irrigation efficiency measures a few years previous. Estimates placed the WMIDD flow reduction at around 108,000 acre-feet annually, much less than previous projections of up to 157,000 acre-feet—even with efficiency and land reduction programs in place. Because of this, while WPRS analysts theorized plant size could be reduced to 73 Mgal/D, it would not be a redesigned, smaller physical plant, it only reduced the amount of desalting and other associated equipment. Redesigning a smaller plant would further increase costs, create more delays, and would cost more if the plant required future expansion. So the original plan remained in place. *Salt Talk* mentioned Spring 1982 for issuance of construction contracts and a new plant completion (and fully operational date) of January 1986. But beyond optimistic projections the hard reality was there. An FY1980 Summary Cost Progress Report showed "probable" total costs of plant construction (now 20 percent complete) at $328 million, a $68 million increase over the official project estimate of $260.9 million.[44] It is safe to assume the decision in retaining current plant design, while reducing desalting equipment costs, may have something to do with this projected increase.

4.6. Test Facility "Proof Failures" and Sludge Disposal

Despite President Jimmy Carter approving the Title I appropriations ceiling request in September 1980 to $356.4 million (from $155 million authorized in 1974), it was clear that changes in project plans and record-high inflation and interest rates were having a negative

[41] Reclamation's controversial temporary two-year-long name change from 1979 to 1981.

[42] *CRBSCP Title I Project History,* Vol. 5, 1979, 13-14, 122-123; *Salt Talk*, April 1, 1979.

[43] *CRBSCP Title I Project History,* Vol. 5, 1979, 65.

[44] *Salt Talk*, June 1, 1980. Project Summary and Cost Report in *CRBSCP Title I Project History,* Vol. 6, 1980, 89.

impact. While preparatory plant site work continued throughout 1981, problems with the desalting testing process, among them “proof failures” of Fluid Systems- and Hydranautics-supplied RO membranes at YDTF, along with the ongoing sludge disposal controversies, impeded progress. The only good news around this time was ACS Construction nearing its completion of its YDP site preparation work, doing so in September.[45]

In late 1980, WPRS’s Engineering and Research Center (E&RC, precursor to the Technical Service Center) in Denver sent formal notice to Fluid Systems and Hydranautics that their proof test membrane units, which went online a few months previous, failed to meet requirements set forth in their contract solicitations. In March 1981, the WPRS announced delays of the Desalting Test Program due to greater than expected decreases in desalting performance in the membrane proof test equipment furnished by the two companies; proof testing was required under contract to identify and correct problems on the same kind of equipment slated for plant installation. The failures revolved around flux (desalting productivity) declines after cleaning membranes. However, after researching and testing new cleaning technologies, proof testing was soon back online and deemed successful enough that, by August 1981, Fluid Systems and Hydranautics were given the go-ahead by (again renamed) Reclamation to proceed with supplying spiral-wound RO membranes and basic plant desalting equipment. Reclamation Commissioner Robert Broadbent remarked that completion of this first phase confirms the project’s “technical viability.”[46] It was viable enough that, in February 1982, Broadbent announced the test facility’s closing and dismantling effective in April.[47]

It is interesting to note that Reclamation, in its news release announcing the test facility’s closure, was still optimistically fixed on not just the plant being built by 1986, but being operational. In addition to site preparation being barely completed, the agency still had not sorted out where to dispose of the plant’s calcium carbonate waste by-product. As noted previously, Reclamation had three sites in mind: two in Imperial County, California, and one near the SIB in Arizona; the agency also decided that a buried pressure pipeline, as opposed to truck or rail, as the best option for conveying this waste. Yet other local governments thought otherwise.

In May 1981, the Imperial County Board of Supervisors denied a permit to Reclamation for use of their top (and closest/cheapest) pick, Pilot Knob site, as a waste disposal facility. Board of Supervisors member James Bucher told the Yuma *Daily Sun* that the main reason for denial was that the area around Pilot Knob was slated for commercial and residential development, and he accused Reclamation of “poor planning” in not thoroughly investigating other sites. He suggested Reclamation look at the “Cactus” site just east of the sand hills 7.5 miles north of

[45] *Salt Talk*, April 1981. *Salt Talk* also mentioned a potential reduction of $7.4 million of the YDP construction budget in FY1982.

[46] “Technical Information Statement – Yuma Desalting Test Facility,” *CRBSCP Title I Project History,* Vol. 7, 1981, A-38; “Hydranautics Water Systems Completes First Phase of Yuma Desalting Plant Contract” Bureau of Reclamation News Release, August 17, 1981 (Fluid Systems received an identical news release in December).

[47] “Reclamation to Close Test Facility at Yuma,” Bureau of Reclamation News Release, February 9, 1982.

Interstate 8—13.5 miles further away than Pilot Knob. "It may cost $100,000 more a year to operate the Cactus site," Bucher said, "but there aren't any people in the area."[48]

Under California law, if a county board refused a request, Reclamation could appeal the decision to the state water quality board and, if denied there, to a state appellate court. But it had other work to do before it could decide where to store the waste. After the Imperial County denial, Reclamation ordered an engineering geology study comparing Pilot Knob site and another site called "A-22" located about 18 miles south of the plant and north of the SIB and Yuma Well Fields. Arizona, however, seemed more flexible. On November 18, the Arizona Department of Health Services Bureau of Waste Control informed Reclamation of their tentative approval in developing A-22 Waste Disposal Site subject to receipt of final design plans and specifications, including environmental impact studies.[49]

4.7. Second Stage Pretreatment Work, More Disposal Controversy

While Reclamation addressed the waste disposal situation, on August 6, 1982, it awarded (under Specifications No. 3DC7510) a $25,325,000 contract to Brinderson Corporation, Irvine, California, for construction of features associated with the second stage pretreatment (a.k.a. Pretreatment II) of WMIDD feed water. Working on the newly-prepped site by the previous contractor, tasks included drilling an approximately 25-foot-deep water well, all site grading and earthwork for structures including foundation preparation, placing cast-in-place reinforced concrete for the test train, pretreatment plant and test train dual media gravity filters, pretreatment plant and clearwell and test train clearwell, lime slaker building, solids contact reactors, four lime storage silos, and miscellaneous small structures. *Salt Talk* noted that the test train was being installed at the plant site to serve as a "miniature desalting plant." Designed to obtain data for main plant startup, the test train would assess processes and equipment to pinpoint problems and increase plant efficiency. The newsletter also noted that the contract for actual plant construction would be awarded in 1983, with plant completion slated for 1987.[50]

Meanwhile, the waste disposal controversy lingered. Despite the Arizona Department of Health Services approving the A-22 site near Luke Air Force Base bombing range in November 1982, with resolute determination Reclamation not only held on to the Pilot Knob possibility, but it continued to study other sites to save costs and keep it in-state, including one in Somerton and another near San Luis. On April 27, 1983, Reclamation held a public meeting in Winterhaven to outline their Pilot Knob disposal plan. Situated on 600 acres divided into three blocks, each surrounded by a raised berm, Reclamation estimated that over the next 50 years, assuming the plant would produce 236 to 578 tons daily of desalting byproduct waste,

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[48] "Imperial County Battles Desalt Waste," Yuma *Daily Sun,* May 26, 1981.

[49] Barry Abbott, Arizona Department of Health Services, to Merle Turley, Bureau of Reclamation, November 18, 1982.

[50] *CRBSCP Title I Project History*, Vol. 8, 1982, B-6; *Salt Talk*, November 1982.

this would amount to seven million cubic yards conveyed through a 5.5-mile-pipeline (compared to approximately 20 miles for A-22 site) and stored in the three blocks.[51]

To say public pushback was intense is an understatement; the *Imperial Valley Press* termed it as "very, very negative." Winterhaven residents and the Quechan Indian Tribe were furious that Reclamation never contacted them about this plan when discussed over the previous two years. Furthermore, Imperial County refused to issue conditional permits over concerns that the bureau had inadequately studied potentially negative environmental problems and human impacts the project could bring. "They didn't do [the study] right the first time," County Planning Director Richard Mitchell noted, and that "they've been trying to catch up ever since." Project Manager Ken Trompeter admitted Reclamation should have taken measures to better inform the public during the project's initial planning stages.[52]

So waste disposal boiled down to two sites: a shorter, cheaper option with formidable local population and government opposition, or a longer, pricier option with preliminary state support and little to no local opposition. One near proposed residential developments, another adjacent to an Air Force bombing range, far from any planned residential development. One with potentially long and expensive court battles in a state known for strict environmental regulatory compliance, another in a state that already expressed final approval pending submission of final pipeline and storage designs. Since waste disposal was central to plant operations, decision makers felt pressured to make up their minds. The plant could not be built and operated without a means—and more crucially, a location—to dispose of the enormous quantities of waste the RO process generates.

Yet Reclamation pressed forward with both site options. In January 1984 the E&RC sent feasibility-level construction field cost estimates for both options to the Lower Colorado Regional Director. Differences in the amounts were staggering. Including mobilization and contingencies, the ER&C estimated (at October 1983 price levels) that A-22 would cost upwards of $6.3 million, while Pilot Knob came in just over $1 million, with both estimates not including potential pipeline rights-of-way acquisition costs. A-22's largest material cost driver, by far, was the 500 and 300 psi piping, over 200,000 linear feet worth, at $3.27 million. On the other hand, Pilot Knob's modest 28,000 linear feet of (300 to 700 psi) piping came in at $261,000.[53]

Still, no decision had been made by the end of 1984. However, there is a gap in the project record that only further (when available) archival research into critical project decision documents can potentially resolve. The 1985 Title I *Project History* mentions that, sometime in 1985, Reclamation chose the A-22 option. The site at Yuma County Avenue A and Yuma County 22nd street would store all calcium carbonate waste sludge from the plant desalting

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[51] "Reclamation to Conduct Public Discussion of Proposed Disposal Sites at Winterhaven Meeting," Bureau of Reclamation News Release, April 12, 1983. Copy in *CRBSCP Title I Project History*, Vol. 9, 1983, A-45.

[52] Winterhaven Area Opposed to Proposal for Waste Dump," *Imperial Valley Press,* April 28, 1983, copy in *CRBSCP Title I Project History*, Vol. 9, 1983, A-52.

[53] Full cost estimates and explanations in *CRBSCP Title I Project History,* Vol. 10, 1984, A-38 to A-45. One of Reclamation's first "Value Engineering" studies was A-22 (document not available).

process. Also selected was a tentative pipeline alignment along Yuma county road rights-of-way in (then) mostly undeveloped agricultural and desert lands.[54] There was zero mention as to why Reclamation selected A-22; perhaps because plant construction started to accelerate, and given the potential expensive regulatory legal barriers and battles Pilot Knob presented, Reclamation decided on the easiest, yet more expensive path. While further research into one of the biggest controversies in early YDP history may provide answers about this critical decision, it is obvious the regulatory-friendly State of Arizona made Reclamation's decision for them.

4.8. Plant Construction Continues

While the sludge disposal issue dragged on, plant construction moved forward. Most heavy work on the Pretreatment II contract was completed by July 1984, on time and on budget. All reactors were complete, with sand and anthracite added to the dual media fitters. Backfill and grading operations were finished, along with equipment and electrical installation. Reclamation also made contract modifications to the delivery of basic desalting units, requiring that all membrane elements, including spares, be shipped no later than July 1985. Another contract modification reduced the number of membrane spares from 1664 to 576, resulting in a cost reduction of $1.82 million. Fluid Systems and Hydranautics continued to deliver units to a Yuma warehouse to await installation. At the end of FY 1984, a project Summary Cost and Progress Report listed total plant costs to date of $136,168,297, with 36 percent completion, with a probable total cost to complete of $375,432,550.[55]

On March 8, 1985, Reclamation awarded the largest plant contract ever, a $35,419,195 contract (under Specifications No. DC-7610) to Brinderson Corporation, Irvine, California, the contractor who had just successfully completed initial Pretreatment II preparation work. This was the last major contract awarded for plant construction, to build out pretreatment facilities. This included constructing, furnishing, and/or equipping the remaining major features of the Yuma Desalting Plant such as specialized buildings (for example the large building that would house the RO membrane systems), a variety of operating systems, storage facilities, and mechanical, electrical, and chemical equipment, and office space. While Reclamation awarded other smaller contracts, including Fluid Systems and Hydranautics manufacturing and supplying RO membranes, the second Brinderson contract would build out YDP as designed.[56]

Unfortunately, after 1985 there is no narrative in the Title I Project Histories discussing subsequent YDP construction progress under the Brinderson (or other) contracts. While Reclamation mentioned that, in accordance Reclamation Instructions Part 175.2. "Final Construction Report," they would prepare said report within an "expected" three years after construction completion. They stated the report would make available methods adopted and experiences gained during construction and initial operation, as a reference document "useful in the service, maintenance, and possible feature rehabilitation, or design and construction of

[54] *CRBSCP Title I Project History,* Vol. 11, 1985, 26.

[55] *CRBSCP Title I Project History,* Vol. 10, 1984, B-8-9; Summary Cost and Progress Report in Ibid., D-15.

[56] *CRBSCP Title I Project History,* Vol. 11, 1985, 10-15. Pages 14-16 list specific completion contracts.

comparable structures. Materials to be included will include reports, studies, narratives, drawings, maps, and photographs."[57]

Unless it is in draft form somewhere, or possibly in National Archives/Federal Records Center holdings, it is safe to assume this report was either never done or started then shelved. Contacts in the Yuma Area and Lower Colorado Basin regional offices, including that of the regional engineer, indicated they had never seen such a report. Therefore, the following progress narrative is extrapolated from the outstanding aerial and ground photography taken by Reclamation and contractor photographers from 1986 through 1988—the final *Project History* year—and the captions they wrote for each picture.

4.8.1. 1986 [58]

The most obvious construction going on from photographs taken in 1986 for the official record were the beginnings of what would become the desalting plant building. Photos from February that year show the concrete slab in place for the building's administrative section, along with forms and rebar for the building's processing section, along with other features like the clearwell and sewage ejection station. A March picture shows Brinderson workers placing concrete on the upper deck of the clearwell structure, finishing a job they started under the Pretreatment II contract a couple years previous. Workers also placed the 10 mil thick polyfilm impervious liner that, with the help of an earthen pad, will support the 5,000 gallon test train chemical drain tank. By May, workers started to place backfill, reinforcing steel, and an electrical conduit for the clearwell' s high pressure pumping units. A month later, Brinderson started to erect structural steel for the desalt building's exterior walls, interior supports, and roof, and set the 48-inch diameter aluminum-bronze manifold pipe across the clearwell deck. An aerial photo taken July 10, 1986 showed the progress made the previous 16 months, most notably the activity resulting in the superstructure enclosing the desalting processing area in the main building taking shape, and other features built as part of the Pretreatment II contract, such as the dual media gravity filters, solid contact reactors, and larger outbuildings.

Other July activities by contractor's personnel at the desalting building include constructing reinforced concrete masonry walls for rooms between the building's west wall and the "B" Line pipe trench, continued erecting the building superstructure including roof decking, placing and installing 36-inch to 24-inch diameter aluminum bronze pipe, and setting the plumbing feed line piping for RO pressure vessels. By mid-August, under Specifications No. DS-7549, Brinderson workers began installing 17 energy recovery units and their turbine sections manufactured by Toshiba International. Work on A-22 disposal site picked up by Fall 1986. Contractor Copper Cliff Corp., Inc started excavating disposal cells, which would eventually be fine graded, lined with 10 mil thick polyvinyl chloride material, and covered with a layer of earth backfill to protect the liner. By January 1987 the plant started to take shape, with walls erected and the RO membrane systems being assembled on the roof.

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[57] Ibid., 14. This same phrase was repeated in every single *Project History* until they ended in 1988. What they wished to do is similar to the "Technical Record of Design and Construction" documents produced until the early 1970s.

[58] Excerpted from *CRBSCP Title I Project History,* Vol. 12, 1986, Appendix F.

4.8.2. 1987 [59]

With the plant inching closer to completion, the only non-construction news in 1987 was the Yuma Projects Office (YPO) preparing to move staff from their current office complex at 3800 Avenue 3 in Yuma to new offices at the plant, street address 7301 Calle Agua Salada (Salt Water Street). Desalting personnel moved in March, followed by warehouse operations in May, Water Lab and Inspection personnel in August, shop personnel by December, and office and administration personnel in February 1988. Inside the desalting building, Brinderson continued to construct, furnish, and install aluminum bronze piping for the Fluid System product water line, with installation of pipe to the RO vessels; outside, contractors completed installation of the clearwell energy recovery unit pumps. By June, the inside of the desalting plant was taking shape, with the Fluid Systems pressure vessels for the RO control blocks set in place on both sides of the "D" trench. Working under a separate contract, later that summer subcontractor Cannon Structures started work on a sludge handling area. Cannon built this area as a temporary means of dewatering and storing calcium carbonate sludge pending completion of the A-22 pipeline and storage facility.

However, Burns and Roe Services (BRSC), the O&M contractor in charge of getting the plant up to operational standards, reported that while some smaller systems were performing well, such as the test train and its data acquisition system (DAS), cancellation of the primary Production Plant DAS—along with deferral of other construction projects scheduled for FYs 1987 and 1988—would delay plant production operations until "at least" 1991. BRSC explained that because of the large number and remoteness of local control panels, integrated operation of the production plant systems was not possible without a central information center. And while the plant's heating, vacuum, and air conditioning (HVAC) systems were part of the DAS contract, their operation was required for the YPO move.

5. Documentation Drops Off

Notwithstanding the absence of (available) official government records for plant pre-production period, BRSC annual reports are good sources for the problems and issues YDP faced as it crawled towards eventual operational status. 1988 marked the final year of official CRBSCP Title I *Project Histories,* as construction of the desalting plant, along with most of Title I activities, were complete or nearly so. The quality of information also dropped off. The last three Title I Project Histories were little more than FY-activity updated cut-and-paste jobs, including the same CRBSCP Title I filler found in the Reclamation/Water and Power Resource Service's *Project Data* book, published seven years earlier.[60] From here on, until further research can be conducted, most of the plant's story becomes one-sided.

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[59] Excerpted from *CRBSCP Title I Project History,* Vol. 13, 1987, 3, Appendix G; Burns and Roe Services, *Fourth Quarter FY87 Report,* (Yuma: Burns and Roe, 1987) in Ibid. Hereafter Burns and Roe Services, report/year/page.

[60] This approach was common with other Reclamation Project Histories written after the mid-1980s, especially those projects nearing completion.

A major problem noted by BRSC their FY88 annual report was that Production Plant operation was not possible due to excessive algae accumulation in the grit basins. This MODE canal algae, combined with mud, formed mud and grass bales which overtorqued grit rakes and plugged grit intake piping. While BRSC tried a fence diversion in the MODE to redirect algae downstream, this proved unsuccessful. And even without the algae problem, BRSC stressed that the grit pumping system could not handle mud and sand in the grit basin without plugging the pump intake piping. The Denver E&RC suggested designing replacement trash rakes and traveling screens, and implementing a biomass handling system for the MODE plant intake.[61]

Another problem area was procuring, installing, training, and operating the Programmable Master Supervisory Control System (PSMC) before YDP could begin integrated testing or placed into production. BRSC did not take this delay lightly. They stressed the PMSC system was not a simple, "turnkey-type contract," that it would take considerable time after installation for development of control parameters and philosophy, calibration values, installation of output boards for the test train, and personnel training. They warned Reclamation to closely monitor this operational-essential contract to prevent further delays beyond the established operational target date of 1991.[62]

And to complicate matters even further, BRSC questioned Reclamation's desire to remove them from plant O&M contracts to perform plant O&M themselves. The contractor disagreed, stating a division of responsibility would be "detrimental" to plant O&M, that interfaces between operations, information/commands, and sensor maintenance and control equipment would be so extensive, effective coordination between separate entities was unlikely and would "degrade" plant operations and control systems effectiveness. Perhaps BRSC sought longer O&M contracts, since they contracted with Reclamation on a yearly-renewable basis. Their desire for long-term O&M continuity is understandable, given all the complicated variables possible with operating a desalting plant.[63]

Contractor personnel matters complicated the problem. In the BRSC second quarter 1989 report, they mentioned that employee morale and recruitment had become serious issues since Reclamation announced they would assume all plant O&M functions at the end of FY1990 contract period. "Difficulties in these areas will increase as the contract term becomes shorter," the BRSC report stated with no uncertainty. In addition to more delays with acquiring the plant-critical PMSC system, the report stated other critically serious issues and missteps that could further delay plant production; again, in no uncertain terms: [64]

- Minor (unmentioned) plant retrofit contracts take an unacceptably long time, that the first item identified in 1986 still has not been "accomplished,"

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[61] Burns and Roe Services, *Fourth Quarter FY88 Report*, 1-2.

[62] Ibid., 5

[63] Ibid., 5-6.

[64] Burns and Roe Services, *Second Quarter FY89 Report*, 3-6.

- Schedule of items previously identified stretched well into 1990,
- That the (A-22) sludge pipeline pumps being installed were clean water pumps without the capacity to pump grit and biomass through the pipeline,
- "Slow and erratic" procurement of chemical supplies had a detrimental effect on operations, especially the test train, and
- Much of the equipment installed by Brinderson, and accepted by Reclamation, was not operable due to "piece meal turn over" and the absence of "any real" integrated startup and testing.

Reclamation's threat of terminating BRSC's contract, however, did not materialize. The contract was renewed, again on an annual basis, with the BRSC reports providing the only available written record of preparations as the plant approached its long-awaited operational status.

6. Approaching Operational Status

While the production plant had long periods of downtime in 1991, BRSC took advantage of this downtime to install new traveling water screens and biomass handling equipment at the MODE. Using a temporary intake pump at the MODE, the test train remained in service with only minimal downtime throughout the year. The longest test train outage that year was for switchyard maintenance by WAPA after a car accident broke the intake line, plus a few short outages cause by the chlorine system and filter valves. Test train operations concentrated on evaluation constant pretreatment conditions to stabilize operations and identify the extent of the on-going membrane degradation problems. When the Clean Water System went on line, BRSC used this system to identify the problem. They concluded it was due to the combination of chlorine and one or more suspended particles, and when either of these ingredients were removed, degradation stopped. A "practical" solution, they felt, was to use chloramines for biologic control instead of free chlorine, accomplished by injecting ammonia into the RO feed lines to convert chlorine to chloramines. [65]

Despite an array of ongoing minor repair and modification issues that, according to BRSC, resulted in delays obtaining materials and parts for repair and replacement, the contractor felt confident the plant could go online by December 1991. They expected extensive overtime by employees in the maintenance department to complete all the projects, plus rewiring the recently-procured PMSC system prior to plant startup. However, there were other major projects: installation of the MODE biomass handling equipment, completion of 01 area modifications, and acid system tie-in. But other modifications, such as repair of welds on the aluminum-bronze reject line, were delayed by equipment problems and difficulty in obtaining "sound welds." A couple related items that BRSC proudly proclaimed were the renewal of O&M contracts that checked low employee morale, and an "outstanding" safety record over the previous six years: an average of 4.1 lost work days per year per 100 employees, compared

[65] BRSC, *Fourth Quarter FY91 Report*, 1-2.

to the national average of 8.0 per 100.[66] Much of this was attributable to extensive on-going BRSC (and Reclamation) safety training during plant downtimes.

6.1. Plant Goes Online—But Here Comes the Flood

On July 31, 1992, all the hard work getting plant and process authorized, planned, designed, tested, constructed, and prepared for operation came to fruition. In just over 18 years after President Nixon signed the Salinity Control Act into law, BRSC loaded the final set of control blocks in the Hydranautics RO section, and YDP became operational with full Section 1, or one-third capacity. By the end of September, including quantities produced the plant's initial standby-level startup three months earlier, the plant successfully produced 7,499,000 liters of desalted water. While there were some equipment malfunctions in pretreatment during this time, BRSC was able to keep the plant online using feedwater from the PP clearwell. Any RO outages were of short duration caused by pH and ammonia problems and tie in of the new dynamic cold storage test unit. Generally, BRSC was very pleased with the Hydranautics and Fluid Systems RO units, which continued to perform better than the manufacturers' predicted performance for standard flux and rejection; continued use of chloramines to control biologic fouling proved as effective.[67]

This brief streak of good fortune, however, was about to grind to a halt, thanks to Mother Nature. Less than a year later, after almost two weeks of intense winter storms, on January 15, 1993 massive flash floods on the Gila River damaged the MODE and shut down the plant. Flood waters from higher elevations north and east of Phoenix and Tucson filled Painted Rock reservoir near Gila Bend with 2.8 million acre-feet of water, creating what one newspaper called the "largest lake in Arizona." Painted Rock Dam's spillways—for the first time since the dam was built 34 years earlier—released records amount of flood water downstream to the Wellton-Mohawk valley and eventually Yuma.[68] The MODE and other conveyances could not handle the volume, and the result was (in addition to millions of dollars in property and other damage) a brand-new, shuttered desalt plant.

While BRSC could continue tests using the Clear Water System, and could start with the cold biocide test program, the production side was closed. With no feed water intake from the MODE, pretreatment and production processes were not possible. And the future looked bleak. Almost 6 months later, BRSC said that while repairs to the MODE were expected by April 1994, they had not yet begun—and that plant operation was not expected in the near future or FY1995 due to no expected operations funding. Therefore, the plan was to place the plant in ready reserve mode, one that could have the plant up and

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[66] Ibid., 8.

[67] Burns and Roe Services, *Fourth Quarter FY92 Report*, 1-2.

[68] "Arizona Braces to Meet Once-in-200-Years Flood, *New York Times*, February 26, 1993, at https://www.nytimes.com/1993/02/26/us/arizona-braces-to-meet-once-in-200-years-flood.html, accessed July 24, 2020. See also 'Floods in Arizona, January 1993 at https://pubs.usgs.gov/of/1993/0054/report.pdf

operating in one year after notification of need, but only if "funding to operate is provided." Measures were taken to protect the expensive membranes in-place with water chilled to 10 degrees Celsius mixed with 0.1 percent glutaraldehyde, with the PSMC automatically circulating the mixture into each of 15 control blocks for 55 minutes then switching to the next block.[69]

6.2. Demonstration and Pilot Runs

While the flood of 1993 passed, YDP operations never fully recovered from its consequences. There were, however, a couple opportunities to update plant and infrastructure technologies and prove to stakeholders that YDP was still viable and relevant: the short 2007 demonstration run and the much longer 2010 to 2011 Pilot Run—the longest continuous operational durations above ready reserve since the 1993 flood halted production.

While similar, both differed in scope. Reclamation executed the demonstration run to acquire current operational data, test equipment already replaced to address known design deficiencies, and conduct research applicable to resolving any remaining design flaws. However successful, since the plant had not operated above ready reserve since 1994 due to budgetary constraints and that high Colorado River flows met Minute 242 requirements, this demonstration period still did not provide sufficient data to evaluate long-term operation. In addition, the demonstration run utilized a different pre-treatment process (polymer in place of lime-softening process) than called for in original plant design; it was also conducted at an insufficient scale and limited time period. Therefore, data from this run was insufficient to provide the level of cost and performance information needed to evaluate long-term operation at a minimum one-third capacity.[70]

Operating for the first time in almost 14 years at one-tenth capacity from March 1 to May 1, 2007, it was a still a success. The demonstration run produced 858 million gallons (2,632 acre-feet) of RO product water with an average TDS concentration of 252 milligrams per liter (mg/L), calculated from daily manual conductivity readings collected by operations. Flow volume delivered to the Colorado River was 1.4 billion gallons (4,349 acre-feet) with an average TDS concentration of 1,157 mg/L, also calculated from daily manual conductivity readings, and included RO product water blended with MODE water. Demonstration run costs for preparation, monitoring, and O&M was $2,070,000.[71]

While minimal and of brief duration, it was successful enough to attract the attention of a few high-level municipal stakeholders who wondered if YDP could operate at a higher production level over an extended period. A couple years later, these project stakeholders stepped forth

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[69] Burns and Roe Services, *Third Quarter FY93 Report*, 1.

[70] Bureau of Reclamation, *Final Environmental Assessment, Yuma Desalting Plant Pilot Run*, (Yuma: Yuma Area Office, August 2009), 4. Hereafter *Pilot Run EA.*

[71] Burns and Roe Services, *FY2007 Annual Report*, 1-2. This was Burns and Roe Service's final report, as Reclamation terminated their O&M contract so the agency could assume these responsibilities. However, right before the Pilot Run Reclamation signed a 5-year O&M contract with KCorp Technology Services (KTS), Fairbanks, Alaska, effective March 1, 2009.

with an idea that could prove this point—and would provide partial funding to do so. The Central Arizona Water Conservation District, Metropolitan Water District of Southern California, and Southern Nevada Water Authority penned a January 14, 2009 joint letter asking Reclamation to consider a Pilot Run "in order to obtain information regarding the capability and operational readiness of the YDP that can only be understood through actual operation of the YDP." This consortium would partially fund this Pilot Run in exchange for "intentionally created surplus credits (ICS) in accordance with the 2007 Colorado River Interim Guidelines" and even offered to not hold Reclamation to any "long-term commitment with regard to how or even if YDP would operate in the future…"[72]

Reclamation jumped on this opportunity, and fast-tracked a required Environmental Assessment (EA) detailing their proposed actions behind a Pilot Run. This run would operate YDP as designed at a sufficient flow and appropriate duration to gather benchmark performance and cost data that can only be obtained through actual plant operations; determine whether any additional corrective actions to plant design or equipment are necessary for long-term plant operation; and test those changes and corrections (such as the fully-automated distributed control system) that have already been implemented at YDP to maintain ready reserve status. This extended operation would allow Reclamation and the three funding stakeholders to better understand operational reliability, suitability of treatment processes, baseline operating costs, and any possible environmental consequences as a result of extended plant operation.[73]

In the proposed action, Reclamation clarified that, as part of its process design, they felt confident that YDP could run at one-third increments. Therefore, they proposed to operate it at one-third capacity for 365 operating days, for a minimum of 12 and maximum of 18 months, as an indicator of how YDP could likely run on a long term basis. Diverting approximately 7,300 acre-feet of water via the MODE 1 Diversion/Return structure near the Drainage Pump Outlet Channel, the Pilot Run would start at 11 percent capacity, ramp up to 22 percent, then reach the 33 percent maximum threshold for the study duration.[74]

During the study, YDP would treat approximately 104 acre-feet of MODE drainage water daily, for a total of approximately 37,980 acre-feet. This process would yield about 61 acre-feet of product water per day (about 22,400 acre-feet total) with a salinity of around 160 ppm TDS. 700 acre-feet of this water would be retained for internal YDP use, with the remaining 21,700 acre-feet of YDP product water discharged into the Colorado River. This desalinated water, and approximately 7,300 acre-feet of MODE flows to be discharged to the Colorado River, would be included in water deliveries to Mexico; it was considered part of the annual

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[72] Letter from Central Arizona Water Conservation District, Metropolitan Water District of Southern California, and the Southern Nevada Water Authority to Bureau of Reclamation Lower Colorado Regional Director, January 14, 2009, at https://www.usbr.gov/lc/yuma/environmental_docs/ydp/ydp_request_14Jan09.pdf, accessed July 27, 2020.

[73] *Pilot Run EA*, 6.

[74] Ibid, 11, 15.

allotment of water deliveries to Mexico under the 1944 Water Treaty and "appropriate implementing protocol."[75]

Once the new YDP O&M contractor KCorp Technology Services (KTS) came on board in March 2009, planning and preparations began for Pilot Run. At Reclamation's request, and similar to the demonstration run, non-critical labor efforts were realigned; all YDP non-critical and non-operative preventative maintenance was suspended and redirected towards getting the plant ready. In addition to the large amount of mechanical, electrical, and instrumentation work performed for the Pilot Run, another major task was receiving, inspecting, and installing 2,304 Fluid Systems RO membrane elements into 24 control blocks. A total of 1,152 control block pressure vessel end caps were also rebuilt prior to Pilot Run operation. After securing the required State of Arizona pollutant discharge and aquifer protection permits, on May 5, 2010, YDP delivered the first Pilot Run RO water via MODE 2 to the Colorado River.[76]

To say the Pilot Run was a success is an understatement, and is the high point in plant history. It operated continuously for 328 days, from May 3, 2010 to March 26, 2011, and achieved a 100% on-stream factor with zero planned or forced outages. No major equipment problems occurred during the Pilot Run. Additionally, it was completed ahead of schedule and under budget (see Table 1), mostly as a result of pre-run shakedown testing and plant stabilization that proved less challenging than expected; ramp-up to one-third capacity required less time than anticipated. In addition, much of the Pilot Run budget forecasting was done before the economic downturn, so labor and other associated costs were lower. While Reclamation and its stakeholder partners budgeted $23.2 million for the Pilot Run, they spent $15.97 million including preparing, operating, maintaining, then returning the plant to ready reserve status once Pilot Run operations concluded.[77]

And although Reclamation stressed that while water savings was not part of the Pilot Run plan, YDP conserved 30,496 acre-feet of water, which was included in water deliveries to Mexico with the same volume not released from Lake Mead. As Reclamation noted in their post-study report, it was a "noteworthy milestone" in YDP history, for prior to the Pilot Run YDP's longest operational duration was 168 days from when the plant fired up on July 31, 1992, to when the Gila River flood shut down operations on January 15, 1993.[78]

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[75] Ibid.

[76] KCorp Technology Services, *Yuma Desalting Plant, 2010 Annual Report*, (Yuma: KCorp Technology Services,) 1-2.

[77] Bureau of Reclamation, *Yuma Desalting Plant Pilot Run Final Report,* (Yuma: Yuma Area Office, 2012), 1, 37.

[78] Ibid.

Preparing for the Pilot Run	Budget	Actual	Difference
One-time projects	$ 2,605,000	$ 2,477,035	$ 127,965
Reclamation labor	$ 2,751,853	$ 2,011,434	$ 740,419
Reclamation other	$ 0	$ 104,293	($ 104,293)
Contract labor and services[58]	$ 1,144,584	$ 1,048,131	$ 96,453
Materials, supplies, and parts	$ 130,500	$ 102,987	$ 27,513
Total	**$ 6,631,937**	**$ 5,743,880**	**$ 888,057**
Reclamation	*$ 5,356,853*	*$ 4,592,762*	*$ 764,091*
Municipal Utilities	*$ 1,275,084*	*$ 1,151,118*	*$ 123,966*
Conducting the Pilot Run	**Budget**	**Actual**	**Difference**
Reclamation labor	$ 3,411,492	$ 1,502,568	$ 1,908,924
Contract labor and services	$ 2,662,752	$ 2,656,869	$ 5,883
Power	$ 3,304,516	$ 1,396,904	$ 1,907,612
Chemicals	$ 6,415,610	$ 3,645,652	$ 2,769,958
Materials, supplies, and parts	$ 349,200	$ 614,641	($ 265,441)
Contingency	$ 414,500	$ 404,496	$ 10,004
Total	**$ 16,558,070**	**$ 10,221,130**	**$ 6,336,940**
Reclamation	*$ 3,825,992*	*$ 1,907,064*	*$ 1,918,928*
Municipal Utilities	*$ 12,732,078*	*$ 8,314,066*	*$ 4,418,012*
Grand Total	**$ 23,190,007**	**$ 15,965,010**	**$ 7,224,997**
Reclamation	*$ 9,182,845*	*$ 6,499,826*	*$ 2,683,019*
Municipal Utilities	*$ 14,007,162*	*$ 9,465,184*	*$ 4,541,978*

Table 1 – Final Pilot Run Costs[79]

Reclamation also acknowledged that not only did the Pilot Run provide an opportunity to see how new technologies worked and the possibility of incorporating those technologies in plant upgrades, but that certain plant components needed upgrading and/or replacement for future sustained runs. Among the new technologies to consider was installing a new liquid ferric sulfate system to replace handling of (the now more expensive and harder to handle) solid liquid sulfate, a new sodium bisulfate system to neutralize residual chloramines present in residual product water, and modify/modernize MODE 1 Diversion/Return facility.

Additionally, there were design deficiencies flagged during the Pilot Run as in need of resolving before further long-term sustained YDP operations. These included upgrading the chlorine and ammonia systems, replacing the high-pressure reverse osmosis pumps, completing change-out of control blocks valves and actuators, and recoating Solids Contact

[79] Table in Ibid., 88.

Reactor #1. Other work items already known included purchasing more new RO membranes (YDP needed 2,000 for one-third, and 10,000 for full capacity operation) replacing 11,000 linear feet of aluminum-bronze piping with more modern 316 stainless steel and fiberglass pipe common in RO plants, and upgrading the railroad spur—built specifically for the plant but never used—for hazmat and other large-scale chemical and equipment deliveries. Other items that needed attention were a leaking A-22 pipeline (blamed on aging and possible seismic damage), and 65 miles of the MODE/Bypass Drain needing spot repairs.[80] The table below lists one-time expenditure estimates for sustained YDP operations: [81]

One time project	Capacity of Operations			Amortization period
	One third	Two thirds	Full	
Pilot Run Outcome				
Liquid ferric sulfate system	920,000			20
Sodium bisulfite system	250,000			20
MODE 1 diversion facility	1,000,000			45
Design Deficiencies				
Chlorine system	2,000,000			30
Reverse osmosis pumps	2,000,000	2,000,000	2,000,000	20
Ammonia system	1,650,000			20
Control block valves/actuators	590,000	590,000		20
Solids contact reactor		420,000		15
Reverse osmosis membranes	4,000,000	4,000,000	4,000,000	5
High pressure piping*	7,000,000	6,000,000	5,000,000	40
Railroad spur		5,000,000		50
Other repairs				
Media filter effluent piping	700,000			15
Media filter valves	680,000			20
Grit handling	340,000			20
Plant instrumentation	850,000	850,000	850,000	10
DCS strategies	200,000	100,000	50,000	10
Routine start-up activities	900,000	700,000	500,000	10
Totals	23,080,000	19,660,000	12,400,000	

*Assumes 3 separate projects
All values are exclusive of Reclamation labor

Table 2 – One-time Expenditures Estimates for Sustained YDP Operations

[80] Ibid., 96-97. As of 2020, YAO is investigating the construction of a new A-22 pipeline.

[81] Table in Ibid., 100.

7. Epilogue: Perpetual Ready Reserve, Future Status?

Despite the Pilot Run's success, YDP would never again see another long-term operational stretch at any capacity above ready reserve, nor were many of the proposed post-Pilot Run project improvements undertaken, all mostly due to lack of a perceived need for plant services and budgetary constraints. And if there is any quantifiable indicator of consistency in YDP's roller coaster history, it is this glaring fact: as of July 31, 2020—the 38th anniversary of initial startup plant production—it has operated above ready reserve only 586 out of (approximately) 13,870 days—a startling 4.22 percent. Clearly this was not in Reclamation's scheme when the Salinity Control Act was conceived and authorized five decades ago to comply with IBWC Minute 242.

Because of this and other business-centric reasons, during the week of February 2, 2020, YAO management, regional and YAO engineering experts, and economics, history, and asset management subject matter experts from the Denver Office met in Yuma for an intensive Value Planning (VP) study to determine, analyze, and compare viable options for YDP's future. Using creative thinking and idea-generating techniques similar to those used in corporate and academic think-tanks, and based on pre-determined (baseline) business case options, after careful development and comparative analyses the VP team came up with seven alternatives, four of which were accepted in a post-study accountability report.[82]

Under direction from the Lower Colorado Basin Regional Director, these four accepted VP alternatives moved forward to the current "Special Study" analysis:

- **Alternative 2, Operate Plant:** Operate YDP as designed to benefit the system and sponsoring stakeholders.
- **Alternative 4, Abandon Plant:** Abandon, decommission, and demolish YDP and the Pilot System 1 facility.
- **Alternative 6, Transfer Plant Ownership:** If it were clear that Reclamation's mission no longer includes YDP operation, sell the plant (transferred ownership). This was the study's highest-ranking alternative.
- **Alternative 7, Seek Public Private Partnership (P3):** Enter into a P3 with an interested party, to where Reclamation would pay a private partner to run and maintain the plant.

The VP study (included within this Special Study report as Appendix A1) was based on four business case "baseline" options with YDP's minimal operational history and high annual

[82] Yuma Area Office (YAO) Manager to Lower Colorado Basin Regional Director, "Accountability Report on the Value Planning Study for the Yuma Desalting Plant (YDP) Alternatives Study," May 1, 2020, file in YAO Central Files. Hereafter *YDP VP Study Accountability Memo.* See also Bureau of Reclamation, *Yuma Desalting Plant Alternatives Value Planning Study,* (Yuma: Yuma Area Office, 2020). Hereafter *2020 YDP VP Study.*

operating costs as a contextual framework for analysis. While all four business options became alternatives, one was rejected in the final VP report: a "Status Quo/No Action" proposal to examine lower cost options to maintain YDP in ready reserve status, which included exploring plans for replacing Wellton-Mohawk drainage waters being bypassed around Morelos Dam.[83]

A major disadvantage of this option were the perceived high O&M costs with low benefits: approximately $8 million (M) in annual contract and internal costs with no benefits to Reclamation and project stakeholders, to basically extend the plant's track record of (approximately) 13,284 days in non-production status. While there were advantages, among them YDP's excellent feedback for the demo and Pilot runs that proved its readiness when needed, and in maintaining YDP's functional value as a "tool" for meeting ecological challenges and population growth, it was obvious to leadership that tacking on additional ready reserve time to the 36 *years* already on the plant's clock was not feasible.[84]

Eight million annually to maintain an asset to address possible future conditions is an enormous price to pay for a budget-thirsty, high capacity desalting plant with a near-nil operating record and a cloudy future. This leads back to an old saying, "how did we get here, and where are we going?" While this narrative attempted to provide snapshot insights into the major events that shaped YDP history, a history that culminated in the recent VP study, the picture remains incomplete. If anything, there are more questions to ask, ones that revolve around major decisions.

Other CRBSCP Title I and even Title II (saline reduction measures north of Imperial Dam) programs may have contributed to this lack of YDP need. It is known that before dirt was turned on the plant site in the early 1980s that Title I Wellton-Mohawk Irrigation and Drainage District irrigation efficiencies and land reduction measures were reducing the saline content of drainage waters flowing west; the reduction of plant production capabilities from around 100 Mgal/D to 73 Mgal/D during its design phase was one indicator of this success.

But to what extent did, the separate, but related Title II's successful implementation of upper river basin saline reduction projects affect leadership's perceived need for YDP? Did Title II success affect pre- and post-Pilot Run plant budgetary considerations? One issue with post-Pilot Run YDP history was the lack of budgetary support, which is a mystery given the Pilot Run's well-documented success. Seems logical: if there are successful programs elsewhere reducing saline levels, why spend more money on a plant that has only operated as designed a mere 4.22 percent of its near four-decade-year-long post-construction life?

Then there is the unpredictable factor that caused YDP to shut down in January 1993: Mother Nature. It is known that unusually wet and normal winters in the upper and lower basins in the plant's post-construction era resulted in less water being released out of Lake Powell and Lake Mead, with more flowing to Mexico to meet treaty requirements, thus reducing a need for desalting the (already reduced) WMIDD flows. Of the various factors, this is the most obvious. Still, there were dry winters and reduced flows, and yet YDP did not operate. How did the vagaries of climate shape this picture?

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[83] *YDP VP Study Accountability Memo.*

[84] See *2020 YDP VP Study,* Alternative 1, 11-12. Not surprisingly, this alternative finished in last place.

At this time no concrete conclusions can be proffered. To answer these and other related questions is beyond the pinpoint focus of this brief, plant-centric narrative. Further research is needed into both titles and their *individual* levels of salinity reduction success as directly related to plant operations—one could fashion an entire history with this approach—then how and to what extent *both* titles and climate worked together to reduce the basin salinity of Colorado River water sent to Mexico. Perhaps that kind of history needs to be researched and written first to demonstrate the broader, interrelated contexts behind both titles, the Colorado River, climate, binational history and diplomatic relations, and Yuma Desalting Plant.

As mentioned earlier, due to travel restrictions and archival research facility closures, currently there is no way to perform deeper research into project correspondence to discover, analyze, and incorporate crucial decision-making documents that can provide conclusive answers. Yet all history builds upon foundations. A principal goal of this “very short” history was to provide a narrative foundation that will help guide future analyses on history’s role in understanding the multi-dimensional complexities of expensive (and controversial) government asset capital investments. The complex interrelations of far-reaching river basin programs, along with the implementation of alternative and untested technologies, all worked together to try and address and meet agency, domestic and binational stakeholder, and taxpayer expectations.

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