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MINING WATER FOR THE REVOLUTION: MARTE R. GÓMEZ AND THE BUSINESS OF AGRARIAN REFORM IN "LA LAGUNA," MEXICO, 1920S TO 1960S

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Working Paper # 371 – July 2010

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* I wish to thank participants of the Writers' Workshop at the Center for US-Mexican Studies at UCSD (December 2009) for helpful feedback on a rough draft of this paper. I am also grateful to Ted Beatty for his extensive comments on a second draft as well as two anonymous readers for their critical peer reviews. The views expressed here are mine only and do not represent the official views of the University of Notre Dame, UCSD, UCLA, or any other academic unit. All errors are my own.

ABSTRACT

In this paper I examine the little explored historical relationship between advances in "eco-technical" knowledge of Mexico's scarce and fragile water resources and the state developmental imperatives of agrarian reform from the 1920s to the 1960s. In particular, I focus on how this relationship played out in the Comarca Lagunera of north-central Mexico, which was the emblematic region of Cardenista agrarian reform in the 1930s. Drawing on primary documentation, technical journals, newspapers, and secondary sources, I argue that the key actor in this history, hydraulic engineer-agronomist and Secretary of Agriculture Marte R. Gómez, epitomized the contradictions among advances in scientific understanding of Mexico's hydrology, agricultural development, and business. I further contend that these contradictions were at the heart of Mexican agrarian reform and its long-term ecological as well as social and economic unsustainability.

RESUMEN

En este artículo examino la poco explorada relación entre los avances en el conocimiento "eco-técnico" de los escasos y débiles recursos hídricos de México y los imperativos estatales de desarrollo asociados con la reforma agraria entre los años 1920 hasta los 1960. En particular, me concentro en el modo en que se desarrolló esta relación en la Comarca Lagunera del centro-norte de México, una región emblemática de la reforma agraria cardenista en los años 30. A partir de documentación primaria, revistas técnicas, diarios y fuentes secundarias, sostengo que el actor principal en esta historia, el agrónomo e ingeniero hidráulico y Secretario de Agricultura Marte R. Gómez, personifica las contradicciones entre los avances en el entendimiento científico de la hidrología de México y los negocios y el desarrollo agrícolas. Finalmente, propongo que estas contradicciones se encontraban en el corazón mismo de la reforma agraria y en su falta de sustentabilidad, tanto ecológica a largo plazo, como social y económica.

In the last two decades, Mexican water history, long considered a subfield of agrarian history, has become its own recognized field. This is due in large part to the founding of the Archivo Histórico del Agua (Historical Water Archive) in 1994, which made thousands of documents from federal water agencies available to researchers. As a result, a growing corpus of scholarly literature has emerged focusing on how and why Mexico underwent a technological revolution in water use and management, one that was an integral component of the country's seventy-five year experiment in agrarian reform (1917–1992).[1] In addition to the distribution of half of the country's arable land to some 30,000 *ejidos* (state communal land grants) and small landholders, the Mexican postrevolutionary state constructed hundreds of large dams and vastly increased groundwater-pumping capacity. In line with world trends, from 1910 to 1993 water stored in dam reservoirs in Mexico increased from under one billion cubic meters to 143 billion cubic meters, while groundwater pumping increased from a negligible portion to 37 percent of total water use.[2] Although Mexico is now a primarily urban and industrial country, its agricultural sector still consumes the vast majority (77 percent) of both surface and subsurface water resources.[3]

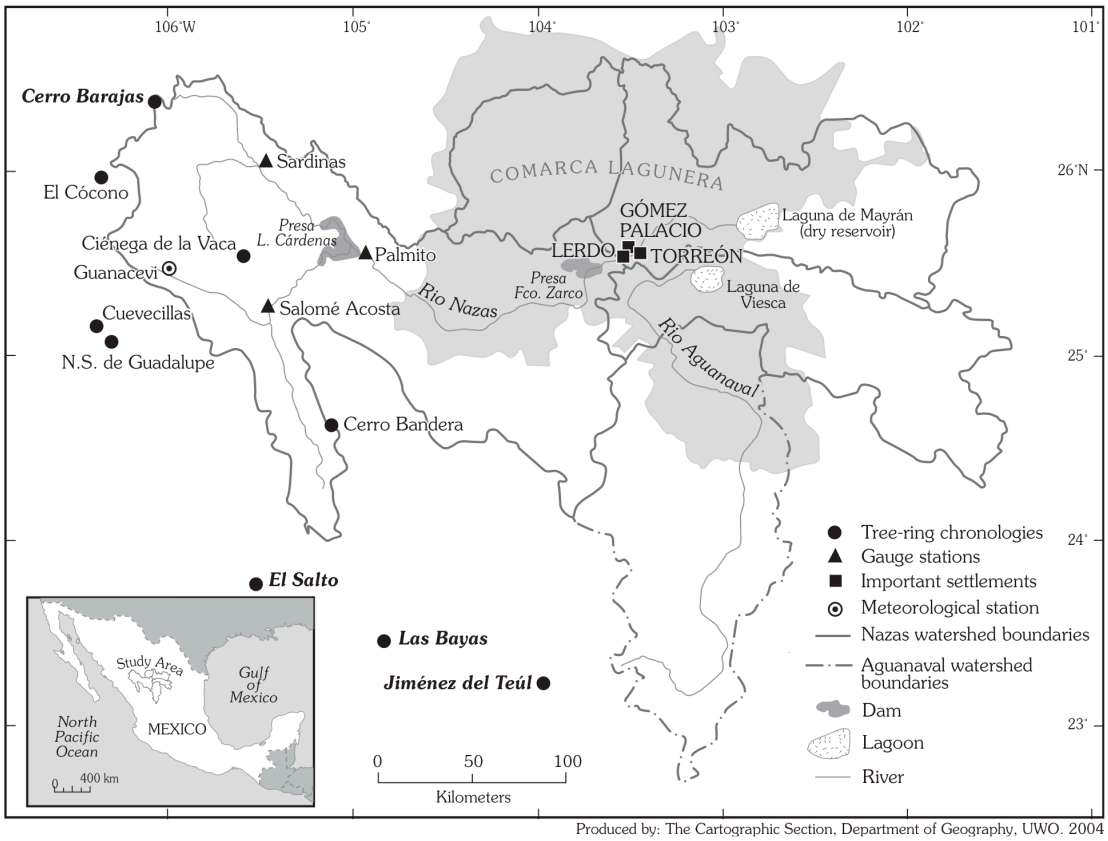
In 1992, when Carlos Salinas de Gortari announced the revision of Article 27 of the 1917 Constitution that effectively terminated agrarian reform by ceasing new land distribution, he proudly referenced this technological revolution in water use and management. He declared that it had put Mexico among the top five countries in irrigated land area and praised the 15,000 *técnicos* (engineers, agronomists, topographers, and land surveyors) employed in different government agencies for their painstaking work on the revision. At the same time, he also highlighted the numerous environmental consequences that poor agricultural practices had wrought for decades: deforestation, soil erosion, contamination of waterways, and the depletion of aquifers, among others.[4] Yet Salinas—reflecting the voluminous scholarship on Mexican agrarian reform, including his own important contribution[5]—seemed to be largely unaware or unconcerned that the application of these very same technologies he praised had in fact facilitated many of the unsustainable agricultural practices he decried.

In this paper, I examine the little explored historical relationship within the above-cited literature between advances in "eco-technical" knowledge of Mexico's scarce and fragile water resources and the developmental imperatives of agrarian reform from the 1920s to the 1960s. By eco-technical knowledge, I mean the process by which hydraulic engineers, agronomists, and geohydrologists acquired their understanding and knowledge of nature's workings through field observation, surveying, experimentation and testing to better exploit nature for developmental purposes.[6] In particular I focus on how this relationship played out in the "Laguna" region of north-central Mexico. The Laguna, short for the Comarca Lagunera of southwestern Coahuila and northeastern Durango, was the emblematic region of Cardenista agrarian reform. There, in the fall of 1936, Lázaro Cárdenas decreed, and for three weeks even personally supervised, the expropriation of 226 cotton and wheat haciendas to create nearly 300 collective *ejidos*—the largest concentration in a single area of the country. The semiarid Laguna was Mexico's preeminent cotton-growing region from the late nineteenth century. The torrential flows of the Nazas and Aguanaval rivers and the aquifers they recharged made the Laguna's soil among the most fertile in the country—provided that farmers could secure sufficient water from the rivers and, from the 1920s, increasingly via groundwater pumping in order to irrigate their lands.

After reviewing the technological revolution in groundwater pumping and the planning and building of a high dam on the Nazas in the 1920s and 1930s and how integral both were to the 1936 Cardenista agrarian reform in the Laguna, I introduce a key actor in this history, Marte R. Gómez. Gómez earned the degree of *ingeniero agrónomo y hidráulico* (hydraulic agronomist engineer) at the National School of Agriculture in 1917. During the Revolution he styled himself a Zapatista after traveling to Morelos and Yucatán to survey land for distribution. He went on after the Revolution to serve in such important posts as Secretary of Agriculture (1928–30), Secretary of the Treasury (1933–34), governor of his home state of Tamaulipas (1937–1940), and again Secretary of Agriculture under Ávila Camacho (1940–1946).[7] During his second term as Secretary of Agriculture, Gómez was instrumental in introducing the "Green Revolution"—as it was later termed in 1968—to Mexico as well as revising

Article 27 of the 1917 Constitution in 1945 to make groundwater subject to federal regulation. Initially sponsored by the Rockefeller Foundation, the Green Revolution was the brainchild of the late Norman Borlaug, a Nobel Prize–winning plant pathologist and geneticist who developed high-yield, disease-resistant corn and wheat varieties in Mexico. Mexico in turn served as the demonstration site for other developing countries in Latin America, South Asia, and Africa where the Green Revolution rapidly spread. The agricultural production techniques needed to grow these varieties required huge amounts of water, chemical fertilizers and pesticides, and fossil fuel powered machinery.[8] In 1946 when his term ended, Gómez left politics and used his many connections to become the president of the Mexican subsidiary of the US-based multinational Worthington Pump and Machinery Corporation. He thereby facilitated the massive exploitation of fragile and limited groundwater sources needed for higher-yielding agriculture.

Drawing on primary documentation from the Archivo Histórico del Agua (AHA), technical journals, newspapers, and secondary sources, I argue in this paper that Gómez epitomized the contradictions between advances in scientific understanding of Mexico's geohydrology, agricultural development, and business during his career both in and out of the government. I shall further contend that these contradictions—indeed, at times conflicts of interest, if not corruption—were at the heart of Mexican agrarian reform. Yet the substantial literature on political *técnicos*, corruption, and the Americanization of the Mexican economy has largely understudied this factor in explaining how and why the reform became ecologically as well as socially, economically, and politically unsustainable by the 1960s.[9] This paper places this contradiction front and center. It was a contradiction inherent, as we shall see, in Article 27 of the 1917 Constitution and in techno-political actors like Gómez who served as intermediaries among the Mexican state, society, and nature.



Modern Laguna Watershed Map. This map displays the major cities of Lerdo, Gómez Palacio, and Torreón, the Nazas and Aguanaval rivers, and the two major storage dams—the Lázaro Cárdenas/El Palmito Dam in the northwest at the origin point of the Nazas and the Francisco Zarco near Lerdo—on the Nazas. The desiccated lagoons of Mayrán and Viesca into which the Nazas and Aguanaval once flowed regularly are also shown. Source: "Hydroclimatic Variability of the Upper Nazas Basin: Water Management Implications for the Irrigated area of the Comarca Lagunera, Mexico," *Dendrochronología* 22 (2005).

CONTROVERSIAL DAM, UNCONTROVERSIAL PUMPS

When the Mexican Revolution initially triumphed in 1911 under Francisco Madero's leadership, the cotton-rich Laguna and its principal city of Torreón, a central rail hub of northern Mexico created in the 1880s, had long been a model of Porfirian agro-industrial development. Madero was a *Lagunero*, or native of the Laguna region, who hailed from San Pedro de las Colonias near the terminus of the Nazas River where it once drained inland into the Laguna de Mayrán (see map above). In 1907, just as he

was launching his political career, Madero published a small book advocating the building of a large dam on the Nazas in order to better control its torrential flows, reduce damage from unpredictable flooding and drought, and thereby vastly increase agricultural production. Drawing on the studies of federal engineers in the 1890s and his own agronomic training for his proposal, he asked Laguna agriculturalists to place their faith in an untested technology that would revolutionize their use of Nazas water. This proposed revolution, however, met with apathy, indifference and even hostility from most large landowners in the region, as Madero lamented in his study. He was unable to succeed in assuaging their fears of the dam's potentially adverse impact on the river's fertilizing flows, their water rights, and their pocketbooks (assuming as they did that they would foot the bill).[10]

Nevertheless, Porfirio Díaz strongly approved of Madero's proposed project and hired the prestigious British engineering firm Pearson and Son to assess its feasibility. The demise of his regime and the onset of the Revolution indefinitely suspended it, however.[11] Years after the end of the Revolution, in 1926 a coalition of federal engineers, a minority of landowners, the governors of Durango and Coahuila, and the mayors of Torreón and the Laguna's other cities revived the project. In that same year the federal government under President Plutarco Elías Calles's leadership founded the National Irrigation Commission (CNI). The CNI was modeled on the US Bureau of Reclamation to spur irrigation and colonization of unused arid lands. Since American and European technical know-how and technology still dominated the design and construction of most hydraulic engineering projects, the nationalist postrevolutionary state strove to "Mexicanize" them by hiring American engineers to train and tutor their Mexican counterparts.[12]

With the advent of agrarian reform as a constitutionally mandated policy that could be implemented at any time, coupled with *agraristas* (agrarian activists) demanding land expropriations to form *ejidos*, most Laguna landowners—about 90 percent according to one of Torreón's two newspapers[13] —vehemently opposed the dam that the new CNI would plan and build. These landowners regarded the dam as the technological facilitator of a potentially radical agrarian reform. That is, by more equitably distributing river water among more water users, they feared that the

government would abrogate the water rights they had acquired prior to the Revolution. These had allowed some of the largest and most powerful landowners, such as the British-American Tlahualilo Cotton Estate, to consume or waste far more water than they needed. Moreover, many landowners also feared that damming the Nazas would impede the flow of rich fertilizing sediments that they captured and diverted onto their lands through flood irrigation methods.[14]

While the dam engendered much heated controversy and divided Laguna agriculturalists, the introduction of new groundwater pumps powered by internal combustion engines, electricity, or a combination thereof was comparatively uncontroversial. The difference lay in the individual nature of groundwater pumps, the social and environmental costs of which were far less visible and thus less feared. Each landowner could purchase and install a pump-powered well on his or her own property with few legal constraints, the only major obstacle being financial cost. By contrast, building the dam necessarily entailed a major federal role in its planning and construction and would impact the flow of a river essential to all water users. As such, the dam's potential social, economic and environmental costs were far more visible and better understood than the gradual depletion of the underground aquifer.

Landowners therefore enthusiastically welcomed the revolution in groundwater pumping. According to the newspapers, memoirs, journals, private correspondence, and reports they produced, agriculturalists' expectation was that a major expansion of groundwater pumping capacity would reduce their reliance on irregular river flow for their irrigation needs. As such, by increasing flexibility in irrigation, pumping would also reduce exposure of the cotton plant to the devastating pinkworm blight accidentally introduced to the Americas from Egypt in the 1910s. The blight could ruin up to 35 percent of the cotton crop in any given year.[15]

The *Siglo de Torreón* daily's full transcription of a certain Dr. Juan Castillon's presentation to the Rotary Club of Torreón in the summer of 1923 provides an example of the euphoria and pump-as-savior fervor that became pervasive in the region for decades. In his presentation Castillon described the Laguna as sitting on a "subterranean lake the dimensions of which I cannot calculate."[16] He called it a matter of "providence" that the flooding of the Nazas River's torrential flows would

eventually filter down into the aquifer to the depth of 150 meters. The summer river flows helped "maintain this subterranean lake, always supplied with water," thereby enabling "abundant harvests." But this was nothing compared with what agriculturalists could expect if they "knew how to use natural resources." The first well drilled for agricultural use in the Laguna, he noted, was in 1893. The well was still in use in the 1920s but able to water three times as much land area with the addition of a motor-powered pump. Every day more and more wells, he remarked enthusiastically, were being drilled and constructed along with the installation of power plants supplying the energy to run them.

The cost of well drilling was variable, Castillon explained, and depended on subsoil conditions. Water could be tapped at 12, 37, or more meters in depth. Once tapped, however, wells could last indefinitely, since "not a single well has run out of water to the point of becoming unproductive." As of August 1923 when Castillon spoke, 80 wells were pumping out 6,000 liters of water per second from the aquifer, and by the end of the year he anticipated that 20 more would be drilled. "The development of this new industry—that is, pump irrigation here—has increased greatly and there is a veritable fever to drill more wells." He boldly predicted that such wells "will affirm the wealth of the region" by pumping 7,500 liters of water per second. Looking ahead to 1924, he foresaw 100 more wells increasing the total volume to 15,000 liters per second after 300 days of pumping, equivalent to 366,000 cubic meters of water—exceeding the entire volume of the Nazas flow of 293,000 cubic meters in 1910. In economic terms, he concluded, an investment of 12.5 million pesos to finance 500 wells would increase agricultural production by 18 million pesos over what could be earned using river-based irrigation only.[17] Although Castillon's predictions about the increase and economic profitability of groundwater pumping were largely accurate, they would prove to be far too optimistic with regard to its ecological impact on the regional aquifer, as we shall see later.

At the time of Castillo's speech, a number of American and European companies sought to enter this booming market in the groundwater pumps that were revolutionizing the Laguna's—and much of Mexico's—irrigated agriculture. Two that stood out in engineering and newspaper reports and advertisements were the Texas-

based Layne and Bowler Pump Company and the New York–based Worthington Pump and Machinery Corporation. Layne and Bowler, as will be detailed further below, was mentioned in an important federal engineers' investigative report, while Worthington appeared in far more newspaper stories and advertisements. The latter was the namesake of the American engineer-inventor Henry R. Worthington, about which one historian of the vertical turbine pump industry remarked, "Certainly if there was one only proper name that meant pumps, it would be Worthington."[18] Indeed, his invention of the "single direct-acting steam pump" dramatically reduced the manual labor of steam-powered boats in 1840 and launched his career as a wildly successful entrepreneur. For forty years, he improved, expanded, and diversified his inventions and therefore product lines, including to such customers as the US Navy and various US municipal water works. In 1876 at least eighty major Worthington water works pumping engines had been installed in different parts of the US and Canada, with capacities ranging from half a million to fifteen million gallons daily. From 1883 Worthington began to aggressively seek foreign business. Less than a decade later, in 1893, Worthington's markets had expanded outside of the US and Canada and its total estimated pumping capacity then in use was nearly three billion gallons in twenty-four hours. Among these foreign markets was Mexico, where the first sale of record was made in 1886. By 1940 Worthington was present in Europe, Asia, Africa, Oceania, and the Americas—specifically, in nineteen countries of Latin America and the Caribbean. Mexico was one of only two Latin American countries (the other Brazil) with two Worthington offices, one in Mexico City and the other in Monterrey.[19]

In a September 1925 full-page advertisement in the *El Siglo de Torreón*, Worthington showcased two haciendas that had installed their engines and pumps, replete with illustrations and photographs. One included a photograph of the Las Vegas Hacienda station with the caption explaining how three diesel engines connected to an electric generator produced 200 horsepower. The other featured a picture of the Bohemia Hacienda's irrigation canal being filled with water coming out of a discharge tube installed in the wells. This combination of Worthington diesel engines and *coniflo* pumps, the advertisement claimed, was especially designed to serve the irrigation needs of cotton and wheat planting. The results obtained, they further claimed, were

incomparable to any other installation in the Laguna. Moreover, both the diesel motors and the pumps were of extremely simple construction but worked as powerfully and safely as steam engines—the repair and maintenance of which could be entrusted to any competent mechanic without any special knowledge of them.[20]

Worthington's successful expansion into Latin America as the demand for groundwater pumping dramatically increased was driven by the invention of two pumps—the aforementioned Coniflo and the Axiflo—that resolved the challenge of elevating groundwater to the surface. The Axiflo pump was designed for wells with a diameter of 15 to 50 centimeters where water was found at a depth of no more than 60 meters from ground surface. Smaller Axiflo pumps could pump out water from a greater depth. The amount of water obtainable with Axiflo pumps varied from 380 to 22,700 liters per minute. The Coniflo pump was primarily designed to serve wells of 120 meters depth with the capacity to pump out 750 to 13,250 liters per minute. The ingeniousness of Coniflo pumps was their flexible design. In a successful installation in a Cuban sugar mill, an electric motor was mounted on the upper part of the pump's external mechanism in order to power it. But the pump could run from power generated from diesel or gas engines or steam machines through a transmission line when an electric current was unavailable.[21] The instruction manual for these two kinds of Worthington pumps forthrightly admonished, "the deep well pump must not run without an adequate supply of water."[22]

In 1928 Calles dispatched a commission of three prominent engineers to investigate the social and economic conditions of the Laguna in order to make recommendations for the implementation of a potential agrarian reform program. The engineers noted that landowners had connected internal combustion motors to their pumps by installing the former above ground. The discharge tubes for these wells averaged 8 to 10 inches in diameter and enabled the pumps to descend to a depth of 10 to 20 meters. In order to increase the flow of water to wells agriculturalists sunk the longer tubes that penetrated the water table some 60 meters below ground. While Worthington heavily advertised in the *Siglo de Torreón*, according to these engineers Laguna agriculturalists most commonly used the American company Layne and Bowler's system of wells. The system consisted of drilling a hole of about 108

centimeters in diameter and then penetrating various layers of sand in a rotary fashion until the drill reached the water table. Through an intricate technique of placing narrow longer tubes within thicker shorter tubes that could descend further underground a motor wheel could then be installed to pump the water from the aquifer through these tubes. These types of Layne and Bowler pumps could extract 80 to 120 liters of water per second.[23]

The cost of purchasing the pumps, tubes, and motors as well as the installation could be prohibitive for all but the wealthiest haciendas, however. Each unit with a motor varied between 20,000 and 40,000 pesos, but drilling several wells in the same lot and installing a central electric plant could substantially reduce the cost per unit. As competition for well drilling increased among several companies, a well could be purchased for between 8,000 and 10,000 pesos excluding the motor. Motors were of 75 to 80 horsepower for extracting water. Once installed, a well could irrigate up to 100 hectares at a cost of 2,000 pesos. The pumps lasted between eight and ten years, ample time to pay off a loan with interest while productivity greatly increased, provided that the machinery was well maintained. The engineers observed that the most efficient means of using the wells was to drill several of them on the same lot and to combine the water obtained from them with surface water conducted through special canals. If one well could produce 100 liters of water per second to fill a one square kilometer lot of land 22 centimeters high in forty days, five wells producing 500 liters per second could irrigate five lots in thirty days. In contrast to Worthington's advertisements highlighting the flexible power source for their pumps, the engineers noted that the proliferation of such Layne and Bowler wells required using electric rather than motor pumps. To that end, another American company had planned to establish a grand central electric plant with a capacity of 50,000 to 70,000 horsepower to provide a sufficient and economical supply of electricity. The principal obstacle to the power plant, in the minds of Laguna agriculturalists, was the lack of sufficient guarantees owing to the indefinite status of agrarian reform in the region.[24]

Overall, the well option enabled a reduction in the reliance on surface irrigation from fickle river flow that ensured better harvests, more regular annual crop yields and calming of social tensions by stabilizing employment for thousands of rural workers.[25]

While the wells did not turn out to be the panacea that water-hungry agriculturalists had hoped, they did become an important supplementary source of irrigation water for small cotton plants during the scorching summer months. They also increased flexibility for planting times to mitigate losses caused by the aforementioned pinkworm blight. On the Las Vegas hacienda featured in the aforementioned Worthington advertisement, before the installation of wells in 1920, a maximum of 150 hectares could be cultivated; from 1920 to 1924 six wells were drilled augmenting the irrigable land area to nearly 880 hectares.[26] By 1925 pump-powered wells had partially liberated growers from near exclusive reliance on cotton and considerably augmented wheat production during the cotton off-season.

With the onset of the Great Depression, Calles in 1930 declared an end to land distribution, but not before he faced the vehement protests of federal agronomists and *agraristas* who pressured him to reverse his decision.[27] In the Laguna agrarian reform managed to stay on the agenda in spite of the constant efforts of large landowners to exempt the region from it. As always, water was the key to any possible change in land tenure. In 1932 the number of wells mushroomed to 365, which CNI geologists began to notice.[28] The leading CNI geologist was the Austrian Paul Waitz, a geochemist by training hired by Porfirio Díaz's Instituto Nacional de Geología shortly before the Revolution. Waitz remained to become one of Mexico's leading figures in the burgeoning field of geohydrology in the 1920s and 1930s.[29] The hydraulic engineer and historian José P. Arreguín Mañón defines geohydrology as "the study of the presence, distribution, movement, quality and rational use of subterranean water." He demarcates 1935 as a turning point in Mexican geohydrology for two reasons. First, Charles V. Theis of the US Geological Survey formulated the first transient solution for groundwater flow toward a well by understanding the vital analogy between groundwater flow and heat transfer. The Theis transient pump test solution then became the standard for geohydrologists globally for well test interpretation. Second, that year also coincided with the first massive development of wells, especially in Mexico City and in other agricultural regions such as the Hermosillo coast in Sonora.[30]

In this context Waitz published numerous studies on Mexico's groundwater resources in the CNI's new quarterly journal *Irrigación en México* that described how

to detect, measure, and extract them. Regarding the Laguna in 1930, he observed that groundwater exploitation with "pumps of a great diameter" had increased to such an extent that "great quantities of water" were being extracted at "very deep levels" from the infiltration of Nazas River flow deposits into the alluvial plain.[31] Underlying his studies was a sense of caution about the potential consequences of profligate exploitation of groundwater from fragile aquifers. Fellow geologist and Waitz student Gonzalo Vivar made this sentiment explicit in a 1934 study on the Laguna:

> It is desirable that in the case of drilling in the plain in search of water under pressure there exist adequate regulations on behalf of all. So far a true anarchy reigns with regard to the exploitation of groundwater: There is no technical direction in the distribution of drillings, or in the extraction of water from each drilling.[32]

At the time Vivar recommended that the Agricultural Chamber of the Laguna, consisting of powerful agriculturalists, regulate drilling. This proved fruitless, as landowners jealously guarded their precious water resources and were loath to cooperate with one another or the federal government for fear that their lands would be expropriated.[33] In the meantime, the *Siglo* continued to run ads for Worthington pumps, one of them by a distributor named Engineer W. S. Hessel. Hessel's slogan was "The Great Pump for the Laguna," symbolized by the Worthington trademark eagle.[34] By October 1, 1936, just five days before Cárdenas decreed the Laguna's historic agrarian reform, Hessel had formed his own company, "Técnica del Norte," with two other partners and had become a Worthington distributor in Torreón.[35]

THE DILEMMA OF PUMPING FOR CARDENISTA AGRARIAN REFORM IN THE LAGUNA

President Lázaro Cárdenas's October 6, 1936, decree for the Laguna was a landmark event in the history of Mexican and Latin American agrarian reform. Pressured by a general strike of over a hundred urban and rural unions the previous summer that brought the regional economy to a standstill, Cárdenas promised a resolution to the problem in exchange for the strike's termination.[36] In less than two months after the decree, he delivered by distributing more than 200,000 hectares (494,000 acres) of

irrigable land to a total of nearly 40,000 heads of families. The hydraulic technologies that Cárdenas perceived as the reforms' technological lynchpins were as important as the social and political events and processes driving this grand social experiment: a monumental dam to be built on the Nazas River and pump-powered wells. Landowners, who had long opposed the construction of the dam, had resigned themselves to it as well as to the expropriation of their lands, which they saw as complementary. After all, in the semiarid Laguna secure water was more important than the quantity of land, since it largely determined the *quality* of the land. Expropriated landowners thus accepted much reduced land areas in exchange for keeping their valuable hydraulic infrastructure, especially wells and pumps.

The correspondence of hydraulic engineers as Cárdenas assigned them the task of synchronizing the *reparto de tierras* (land distribution) with the *reparto de aguas* (water distribution) reveal much concern and even an air of panic. While the dam was heralded as the ultimate solution to the Laguna's water problems, it would not be built for years. In the meantime, there simply were not sufficient water resources to irrigate all of the distributed lands to *ejidos* and small landholders alike. Groundwater access was thus key.

Nevertheless, engineers articulated a conundrum regarding such access. On November 16, 1936, while Cárdenas was still in the Laguna expediting land petitions to *ejidos*, CNI engineers charged with devising new water regulations noted in a memo to him that the excessive drilling of new wells should be impeded, and well drilling regulated in general. Overpumping, they noted, was drawing down the regional aquifer and thereby diminishing the irrigated area to the possible detriment of *ejidos*.[37]

Indeed, over eighteen months after the *reparto de tierras*, the engineer Francisco Allen proffered his opinion on the proliferation of pump-powered wells in a review of the progress of the *reparto de aguas* after attending meetings with the Coahuila Governor Rodriguez Triana and CNI executive Gabino Vázquez in June 1938. He wrote that wells should be merely a supplementary source of water for irrigating wheat and cotton fields—the primary source remaining the Nazas and Aguanaval river flows. He noted "every day [extracting water from wells] becomes more random and costly."[38] As an illustration of its effects, pumping had become so

intense that it had begun to harm the urban dwellers of Lerdo City in the Durango portion of the Laguna. With no potable water services, houses supplied with wells saw them dry up and were left with no domestic water source for several months of the year.[39] Overall, in spite of repeated warnings from engineers throughout the 1930s, well drilling continued unabated as the construction of the Nazas River Dam dragged on into the 1940s. Estimates of the total number of wells by 1938 were between 900 and 1,000, a tenfold increase over 1926, when there were around 100.[40] In spite of this growing concern, the most that the CNI did about unregulated drilling, pumping, and extractions during Cárdenas's term was to undertake preliminary surveys of wells in use and estimate how much water was being withdrawn from the principal aquifer—without reliable knowledge of the precise volume of water it contained. As we will see below, there did not yet exist a regulatory legal framework for controlling groundwater extraction, which had not been explicitly incorporated into the 1917 Constitution, its regulations, and the Agrarian and Civil Codes of 1934.

MARTE R. GÓMEZ AND POST-CARDENISTA AGRARIAN REFORM

By the start of Gómez's tenure as Ávila Camacho's Secretary of Agriculture in 1940, groups to the left and right of Cárdenas had already judged the Laguna *reparto de tierras* to be inadequate or a total failure that should never have been carried out.[41] This was largely on account of the incomplete *reparto de aguas* that had generated much conflict between *ejidos* and small landholders. Each bitterly complained to the government that the other was depriving them of water to grow their crops. Gómez continued to publicly defend the Cardenista *reforma agraria* in the Laguna, however, and looked to the completion of the delayed Nazas Dam as the eventual solution to the problem of water distribution conflicts and insufficient sources. In the meantime, he saw continued limited drilling of new wells as a stopgap measure.

In spite of public proclamations that the dam would make enough water available to irrigate up to 300,000 hectares, Gómez acknowledged in private that at maximum the Laguna's irrigation district would only yield 160,000 hectares, with 100,000 from the dam reservoir and 60,000 from wells. Moreover, in confidential field

notes he took on a trip to the Laguna in 1941, he remarked that the combination of unabated well drilling and the construction of the dam could disrupt the fragile hydrological cycle between river flow and aquifer recharge. In other words, the traditional flood irrigation method known as *aniego* (flood) diverted the nutrient-rich Nazas flow onto croplands in order to retain their moisture for sufficient time until climatic conditions were appropriate for planting cotton and wheat. Since croplands could not absorb all of the water, much of it would evaporate or seep underground.

Engineers, including Gómez, were of two minds about this irrigation method. On one hand, they deemed it to be wasteful, since so much water went unused. On the other hand, the water infiltrating back underground helped recharge the aquifer, thereby ensuring water was available for pumping. A more "rational use of water," as Gómez referred to damming the Nazas in his notes, would "likely diminish" aquifer levels and therefore "limit" the use of its waters. Moreover, the deteriorating quality of well water, as the use of "open wells" had demonstrated, was a "limiting factor" in the use of groundwater. For instance, on occasion groundwater could become so saturated with salt that its use would "not only harm the soil" but become detrimental to the entire regional economy, since so much of the land "would have to be abandoned for good." Lastly, echoing Cardenista engineers before him, he reiterated that groundwater pumping could not be a principal source for irrigation water, but only "supplementary." Therefore he stressed that no irrigation zone should rely exclusively on groundwater.[42]

By 1941, however, as much as a third of the Laguna's irrigated water relied exclusively on groundwater pumping. Gómez thus could only push for the intensification of more studies to determine how much water was being pumped and to classify by zone where irrigation should be used exclusively with surface water and where it should be a combination of the two. The CNI's top engineers—Antonio Coria and the naturalized Mexican Andrew Weiss—estimated in internal correspondence that there were as many as 2,500 wells in the Laguna and although "no study has shown the feasibility of using wells… indicators show it is unfeasible. Some are drawing up salt water," including prominent small property owners, such as Señor don Agustín Zarzosa, owner of the La Granja Ranch near the Noé train station in Gómez Palacio,

Durango. Even with various pumping plants, "his soil is gradually hardening from using salt water from his wells. This is common and can continue until the soil has to be abandoned. This matter of salt water from water pumps is of prime importance to the life of the land in this region."[43]

Pump sellers seized on the opportunity to expand their sales of pump equipment. In 1941, there were at least two dozen ads in the *Siglo de Torreón* for new and used Worthington pumps. There is also indirect, circumstantial evidence that Gómez himself was involved in this pump business while in the government. In September 1945 the organizational umbrella for the Laguna's *ejidos*, the Collective Ejidal Societies, accused Gómez of being an associate of the company "Equipos Mecánicos" and forcing them to buy Worthington products. The company, which sold Worthington pumps and engines in Torreón, vehemently denied the charge in a letter to the newspaper. In doing so, they took the opportunity to advertise their products and their much lower prices.[44] Only five years after leaving office, however, Gómez's private activities made such charges appear to have some grounds. In a letter to Miguel Alemán in June 1950, Gómez called Equipos Mecánicos "our [Worthington de México's] distributors."[45]

THE INAUGURATION OF WORTHINGTON DE MÉXICO

After his stint as Secretary of Agriculture under Camacho, Gómez left politics to concentrate on business in the late 1940s and 1950s, in particular the establishment of the Mexican subsidiary of the New York–based Worthington Pump and Machinery Corporation. On May 15, 1951, his efforts bore fruit: Miguel Alemán and an entourage of cabinet members and prominent Mexican and American business representatives gathered to inaugurate the newly installed Worthington de México factory in Mexico City. In addition to Gómez, its President, the Vice President of its US parent company in New York, Clarence E. Searle, was also present. Both gave eloquent speeches describing the importance of the occasion and what it augured for Mexico. Searle placed it in the larger context of the Cold War, of "free nations of the world" combating "the forces of totalitarianism," making the "interdependence of our two

nations even more significant." In particular, he praised the efforts of the Mexican government to augment food production for self-sufficiency. Searle announced that Worthington would play a vital role in Mexico's agricultural expansion, given that its activities were primarily devoted to the production of turbine pumps for irrigation. This would only be a beginning, however, as he hoped Worthington would expand its operations to include other types of equipment required for industrial uses.[46]

In his speech Gómez framed the inauguration of the factory in nationalist terms. Citing a United Nations economic study on the need for Mexico to produce its own capital goods, from tractors to water pumps, he declared the founding of Worthington de México a "matter of economic independence." He noted that its initial paid up capital of four million pesos was entirely Mexican and would eventually increase to ten million. He did not shy away from announcing the pivotal role that the government played in supplying this all-Mexican capital: making use of the Ley de Fomento de Industria de Transformación (Law to Promote Industry), the Treasury Ministry provided much of the financing and import permits, while the Federal District provided tax exemptions through title 30 of a 1949 decree on the subject. In addition, Nacional Financiera (the national development bank) floated "series B bonds" totaling some 25 percent of Worthington de México's total paid up capital.[47] For his part, Alemán described the process as a "combined effort between Mexican capital and American technical cooperation to satisfy a great need for the country." It was an effort in line with the objectives of Import Substitution Industrialization (ISI) then prevailing in much of Latin America and the developing world.[48]

According to Gómez, Worthington de México was poised to meet those needs for a major expansion in irrigation capacity throughout the country. It would produce 70 to 75 units of "pumps of great power for deep wells" on a monthly basis and also repair such pumps of the world-renowned Worthington line. As we have seen, Worthington had a long history of doing business in Mexico by 1951. In his inaugural speech Gómez noted the favorable reviews its products had received from the Secretary of Agriculture and Livestock via the Agricultural and Ejidal Banks, as well as from the Ministry of Hydraulic Resources, Pemex, and the Federal Electricity Commission. In other words, Worthington de México as a subsidiary of this

multinational corporation could already count on a virtually guaranteed domestic market—and one that Gómez would ensure to keep in Worthington's hands as competitors sought to enter the market.[49] Seemingly anticipating criticisms of such a sheltered industry, Gómez asserted that it was private initiative that had made it possible to bring Worthington to Mexico and import its technical capacity.[50] Speaking directly to the President, Gómez nevertheless conceded, "we recognize that without the tutelary existence of the State, without the sympathy and stimulus that it has provided us, Worthington of Mexico might never have been founded."

Numerous Mexican and American companies with branches in Mexico seemed to concur with this open endorsement of ISI. National Iron and Steel Works, GE, Electric Industries of Mexico, Remington Rand (makers of office equipment), and Electric Material all filled newspaper pages with their congratulatory messages to Worthington after its inauguration.[51] Mexican workers also came in for much praise from the Worthington Plant Engineer Henry Carney, a New York industrial engineer then residing in Mexico who had planned and directed the construction and installation of the Worthington de México pump manufacturing plant. Carney affirmed, "Mexican technicians and industrial workers now rank among the best in the world."[52] In the following weeks and months editorials were effusive in their praise for the new and most "modern plant" of its kind in the world. Although the plant was then employing only 70 Mexican workers, it was predicted that it would eventually be able to export machinery to other countries in Latin America.[53]

In spite of the generally euphoric coverage of the inauguration of 1951 and the indispensable role that Gómez played in its realization, he was also the target of criticism in some media, to which he replied defensively. At issue in particular was the charge that he benefited from his favorable connections as ex-Agriculture Minister to obtain a contract for well drilling worth an astounding 60 million pesos.[54] He vehemently denied these charges in a letter he wrote to the newspaper, which the latter subsequently published. He replied that "Agriculture has not given me any contract to drill wells: not for 60 pesos, not for 60 million pesos, but what I have received from the President—and without deserving it, since I didn't lend any service to Alemanismo—are personal considerations, moral and economic support for the

organization of the pump factory for which I have dedicated all of my time and energy. From this standpoint, I recognize my indebtedness to President Miguel Alemán; I have said so openly when the occasion has permitted and I don't find it inconvenient to reiterate it in writing."[55]

That the entry of Worthington under the auspices of the heretofore most corrupt Mexican president in the postrevolutionary era was clouded by the likelihood of shady deals and "crony capitalism" is perhaps unsurprising.[56] What went almost entirely uncovered, however, were Mexico's finite water sources, especially in light of one of the worst droughts in the nation's history which had been affecting the most agriculturally productive northern regions since 1948. Indeed, the drought of the 1950s throughout North America including Mexico became known as the "mini-Dust Bowl." It was a repeat on a smaller scale of the devastating Dust Bowl of the 1930s when soil, parched from decades of overgrazing and the plowing up of the prairies of the Great Plains, created huge wind-blown dust storms during a prolonged drought.[57]

Mexico's principal federal water management authority, the Secretaría de Recursos Hidráulicos (SRH) founded as the upgraded successor to the CNI in 1946, had already long noted the increasingly serious deterioration in the state of the country's subterranean water supplies. Thirty years after the 1917 Constitution effectively placed nearly all surface water sources under national stewardship—and at least a decade after engineers started warning of the potentially adverse consequences of unregulated well-drilling and pumping—groundwater was finally incorporated into Article 27 in a 1945 revision under Gómez's term as Agriculture Secretary. As the engineer René Carvajal of the SRH explained in a detailed study of groundwater legislation in 1967, Article 27 did not explicitly include groundwater sources as national property—only indirectly as part of subsoil minerals when these were mined. This was because of the lack of technical knowledge of groundwater sources at the time in Mexico and because of the scant need for intensive use of these sources.[58]

Prior to the 1917 Constitution, the only reference to control of groundwater resources was in civil law from the 1884 Civil Code, subsequently incorporated into the Civil Code of 1932. Numerous articles of the Code granted individuals the right to drill wells or build diversion dams to capture water as they saw fit. However, if water

flowed from one property to another, its use was considered of "public utility" and subject to special regulations. Water users could not harm the interests of their neighbors, but they could use their water if they compensated them for that use. While the civil codes did not expressly regulate groundwater use or restrict it, the principle that the government, as the steward of public waters, could intervene to ensure its availability for all was firmly established.

In that vein, the 1934 Law of Waters of National Property distinguished between private and national waters. It permitted property owners to extract as much water as they needed from their lands so long as these did not include rivers or natural deposits regarded as national property. If national waters were affected, the Secretary in question, in this case Agriculture, could prevent the taking of water or the building of private works that could enable it. In other words, there existed an absolute individual liberty to extract water on private property, so long as this did not affect national waters. The 1945 revision to Article 27, and its subsequent regulations in 1947, changed this by explicitly including groundwater alongside surface water as subject to federal regulation. It thus eliminated the distinction between private and national waters in certain cases. While property owners were free to extract water on their lands, if such activity affected the "public interest" or existing uses, the SRH could regulate the use and extraction of groundwater and establish no-use zones as if private water were national property.

Consequently, the revision established a property owner's obligation to inform the SRH when initiating works to extract groundwater, with the exception of wells for domestic use (as opposed to agricultural use). Most importantly, the 1947 regulations imposed a concrete restriction for the first time that was subject from then on to the knowledge provided by technical studies. If such studies of a zone or region and of the technologies to extract groundwater to its maximum limits determined that doing so was detrimental to the public interest or existing uses, the SRH could propose a prohibition on groundwater extraction to the president.[59]

The 1947 regulation went further by also stipulating penalties for violating the law and authorized the SRH to prevent the installation of works or technologies that could do so, even to the point of demolishing such works. Yet for all of the new

regulations and restrictions on groundwater use, the revision also charged the SRH with fomenting the use of groundwater for the purposes of rapidly increasing agricultural development for a growing population. These two simultaneous stipulations—fomenting and restricting—were clearly at cross-purposes. This became apparent as the SRH declared prohibitions on groundwater use on a yearly basis beginning in 1948 in nearly all of the central and northern areas of the country (see table below):

TABLE 1

PROHIBITIONS ON GROUNDWATER USE

Abasolo, Guanajuato	December 22, 1949
Alvarado, Veracruz	February 3, 1951
Cadereyta, Queretaro	October 3, 1951
Cañada del Marqués, Queretaro	February 13, 1949
Ceballos, Durango	October 28, 1952
Chihuahua, Chihuahua	February 7, 1952
Comarca Lagunera, Durango and Coahuila	April 27, 1949
Costa de Hermosillo, Sonora	July 11, 1951
Costa de Hermosillo, Sonora (Expanded prohibition)	December 11, 1954
Costa de Hermosillo, Sonora	March 14, 1963
Cuenca del Rio Guayalejo, Tamaulipas	February 21, 1955
Distrito de Riego de El Carmen y Villa Ahumada, Chihuahua	January 30, 1957
Distrito de Riego del Rio Colorado, Baja California	December 16, 1955
Distrito de Riego del Rio Mayo, Sonora	February 21, 1956
Distrito de Riego del Rio Mocorito, Sinaloa	December 18, 1956
Distrito de Riego del Rio Yaqui, Sonora	October 14, 1954
Distrito de Riego Laguna de Tecocomulco, Hidalgo	January 26, 1957
Distrito Nacional de Riego of Baja California Sur	July 2, 1954
Distrito Nacional de Riego de Casas Grandes, Chihuahua	July 6, 1954
El Salitre, Michoacán	February 11, 1956
Laguna de los Azufres, Michoacán	February 13, 1956
Laguna de Tachac, Hidalgo	August 19, 1954
León, Guanajuato (Second Zone)	October 25, 1948
León, Guanajuato	October 25, 1948
Monterrey, Nuevo León	July 17, 1951
Monterrey, Nuevo León	December 14, 1956
Monterrey, Nuevo León	December 19, 1956

Monterrey, Nuevo León	June 19, 1958
Ramos Arizpe, Coah. (Expanded prohibition)	March 10, 1951
Region de Jimenez, Chihuahua	July 12, 1951
Región de Tecocomulco, Hidalgo	August 19, 1954
Región Meridional del Teritorio Sur de la Baja California	July 6, 1954
Saltillo, Coahuila	February 7, 1952
San Miguel de Allende, Guanajuato	January 24, 1949
Silao, Irapuato y Salamanca, Guanajuato	June 5, 1957
Tecozautla, Hidalgo	February 11, 1956
Tehuacán, Puebla.	June 28, 1950
Tehuacán, Puebla (Expanded Prohibition)	March 2, 1959
Tequisquiac, Queretaro	October 27, 1950
Tequisquiapán, Queretaro	December 3, 1960
Tijuana Basin, Baja California	November 13, 1956
Valle de Guadiana, Durango	December 19, 1956
Valle de Guaymas, Sonora	December 20, 1956
Valle de Juarez, Chihuahua	March 18, 1952
Valle de México, DF, and Mexico and Hidalgo states	August 19, 1954
Valle Santo Domingo, Baja California Sur	October 8, 1951
Villa Aldama, Chihuahua	December 31, 1953
Zona de Celaya, Guanajuato (Región del Bajio)	October 29, 1952
Zona de Cieneguillas, Sonora	December 19, 1956
Zona de Riego del Rio Fuerte, Sinora	August 25, 1956
Zumpango, Mexico	December 22, 1949

Source: René Carvajal Ramírez, "Aspectos legales del agua subterránea en México," *Ingeniería Hidráulica en México* 23, no. 3 (1967), 255.

As these *vedas*, or prohibitions or moratoriums on groundwater pumping, show, the SRH, at least on paper, tried to exercise its regulatory powers. As the technical studies it undertook indicated alarming levels of depletion and contamination via salinization, the SRH established fifty *vedas* from 1948 to 1963, three of them in the Laguna in

1949, 1952, and 1958.[60] In 1958, the SRH established three kinds of *vedas*: 1) prohibited zones where it is not possible to increase extractions without the danger of dangerously depleting water tables; 2) zones where the capacity of aquifers can only permit extractions for domestic use; 3) zones where the capacity permits limited extractions for domestic, industrial, irrigation, and other uses.[61]

The *vedas* in the Laguna, as elsewhere in Mexico, were rarely enforced. There were two principal reasons for this. One was that the SRH simply did not monitor groundwater withdrawals from individual wells, which was a difficult task as their number increased to over 3,000 by 1958 (see the following table).

TABLE 2:

DISTRIBUTION AND TYPE OF 3,087 WELLS IN LAGUNA: PROHIBITED AND NONPROHIBITED ZONES BETWEEN *EJIDOS* AND SMALL LANDHOLDERS, 1958

	Durango	Coahuila
Prohibited Zone – small landholders	472	618
Prohibited Zone – *ejidos*	310	625
Nonprohibited Zone – small landholders	158	187
Nonprohibited Zone – *ejidos*	552	165
Motor pump-powered wells	402	665
Electric pump-powered wells	1,092	930
State totals	1,492	1,595

Source: *El Siglo de Torreón*[62]

A second reason is that agriculturalists were divided in their reactions to the *vedas*. Some, like the conservation group "Amigos del Suelo" (Friends of the Soil) and the Agricultural Association of Durango, petitioned vigorously for the enforcement of the *vedas*. The association blamed lack of knowledge of the law, economic conditions, and negligence among its members for noncompliance with the *veda*.[63] While the

association's primary concern was economic, Amigos del Suelo articulated an explicitly ecological concern regarding the Laguna's alarming groundwater situation, anticipating the concept of sustainable development made popular worldwide in the 1980s by the Brundtland Report of the United Nations. Founded in 1949 and inspired by the landmark 1946 law on soil and water conservation,[64] in 1957 Amigos del Suelo released to the local press a plea for respect for the government's *vedas*. "It's an elemental principal of our Association to be vigilant that future generations receive the lands, waters, fauna and flora and all the natural resources in a satisfactory state of conservation, without present generations using them exclusively," yet "at present natural resources are being exploited, without regard for the future, to the detriment of present and future generations," they insisted.[65]

Other agricultural associations, including many *ejidos*, petitioned for the temporary or complete lifting of the *vedas*, or that they not be expanded further without more careful studies.[66] The reactions of different groups seemed to depend on their confidence in the SRH's technical studies, the economic impact of drought conditions on them, and their geographical location within the region. Indeed, for some, drilling wells was literally a matter of survival and concerns for conservation were few or nonexistent. As the anthropologist Isabel Kelly of the Institute of Inter-American Affairs, the precursor to the US Agency for International Development (AID), noted in her fieldwork in the Laguna *ejido* of "El Cuije" near Torreón in 1953:

> In the first place, it may be noted that the Cuije *ejidatario* tends to see all agricultural problems exclusively in terms of water shortage. That is to say, he is not conscious of deficiencies on other scores. For this reason, El Cuije deliberately has voted a formidable public indebtedness in order to sink new deep wells, secure in the conviction that these will mean the final solution to all its agricultural problems… At the moment, it should be pointed out that even the water problem itself is not viewed by the *ejidatario* in true perspective. He does not realize that subsurface water is being used at an alarming rate; that every new deep well which is sunk accelerates the consumption of such water and that, if the drought recurs and endures, so that subsurface water is not replenished, the day of reckoning cannot be far removed. Such lack of perspective with respect to local water supply could, in the course of the years, be literally fatal for the whole Laguna. It

> would seem to apply, incidentally, not to the *ejidatario* alone, but perhaps in lesser degree, to the private landholder as well.[67]

Gómez's new Worthington de México was quick to capitalize on the demand for groundwater pumps and motors in the Laguna. Already in October 1948 while he was laying the foundations for its Mexican subsidiary, a Laguna-based Worthington distributor advertised "Mr. Agriculturist: The new high efficiency Worthington pumps have arrived. They can be regulated to extract the amount of water you desire up to a depth of 73 meters. Low prices."[68] Through the 1950s Worthington de México advertised heavily in the *Siglo de Torreón,* either directly or through the newly inaugurated machinery supply store "Equipos Mecánicos de La Laguna." In 1956 Gómez attended the inauguration of the store along with a who's who of government and business elites in agriculture and industry.[69]

It was during the 1950s drought that groundwater pumping reached truly unsustainable levels in the Laguna, according to solemn warnings from engineers' reports to public declarations by the SRH (see appendix B for graph of progressive aquifer depletion). In 1961, just as the region began to recover from the years of drought thanks to increased rainfall and greater agricultural productivity—the latter largely due to the use of hybrid seeds, chemical fertilizers and pesticides as part of the aforementioned "Green Revolution"—Worthington de México intensified its advertising. In one noteworthy instance, it titled an ad "An Inexhaustible Torrent of Water for Sowing your Fields with Worthington Pumps." The ad featured an illustration of an agriculturalist standing beside his motorized pump as it pours a torrent of water like a giant spigot into his field (see advertisement below). The ad continued, "Rain or no rain, farmer friend, your crops are safe with a proper Worthington pump."

Worthington de México advertisement in *El Siglo de Torreón*, June 19, 1961.

This push for the installation of more and improved groundwater pumps coincided with the founding of a dairy industry in the Laguna as part of a local-state-federal effort to diversify the regional economy. Unlike the old white gold of cotton, which faced severe competition from foreign producers, synthetics, and other Mexican areas (Mexicalí, Lower Rio Bravo), there was ever increasing demand for the new white

gold of dairy in Mexico's rapidly growing cities. Like cotton, however, dairy production—from the growing of cattle feed to the daily drinking needs of dairy cows—was highly water-intensive; in fact, it was far more water-intensive than cotton. Today it is estimated that 2,000 gallons of water are required to produce one gallon of milk from dairy cows.[70]

By 1959, however, the Laguna's dairy industry was well on a steady growth path. In 1948 there were 4,000 heads of cattle producing 33,000 liters of milk per day. In 1962 there were 18,000 producing 175,000 liters per day (see Appendix C). This major expansion had its roots in 1949 and 1950, just as Gómez was working to found Worthington de México. In those years the governor of Coahuila worked to secure four million dollars in credit to form a union or cooperative of numerous dairy farms to purchase 10,000 calves. These calves would form the base for a future dairy industry that was to convert the Laguna into the "Wisconsin of Mexico." Equally important was the establishment of a pasteurization plant in Torreón in 1950 to meet new health and hygiene standards for milk production in Mexico.[71] In 1953 the Subsecretary of Livestock and Mexico's representative for the Dutch dairy industry, an engineer, worked to further expand the Laguna's dairy industry by establishing sterilization plants. While small landholders were the most enthusiastic about establishing this agro-industry on a large scale, the *ejidatarios* of the *ejido* Emiliano Zapata of Viesca were also in agreement with the initiative.[72]

There was much tragic irony that such an *ejido* from Viesca, located a little east of Torreón between the Nazas and Aguanaval Rivers, would look to the burgeoning dairy industry as a savior. According to engineers who investigated its underground springs that had been plentiful until the 1940s, from 1947 to 1953 overpumping and the regulation of the Aguanaval River in its upper portion completely extinguished the springs.[73] As one engineer observed after surveying the devastation of Viesca's springs that had prompted the abandonment of several pueblos and rural outmigration towards Mexico's urban areas, "I especially want to emphasize that while small property owners have no limit on what they can exploit from wells to irrigate, using them as they do all year long, the *ejidatario* can only use a well in the summer to cultivate cotton, and with very limited credit."[74] In their desperation for a source of livelihood,

the advent of a dairy industry understandably appeared attractive to *ejidos*, even if it required even more profligate water use.[75]

In 1955 240 cattle were purchased from Canada at one thousand pesos per head for stables in Gómez Palacio, Durango, right across the Nazas riverbed from Torreón. This was heralded as the beginning of the end of cotton monoculture in the Laguna.[76] It was also, however, the beginning of a new *acuifundio*"— or large water monopolizer—that would morph into the "LALA" consortium of dairy producers by the 1970s, while the Laguna's water table continued its relentless decline (see appendix B), two new *vedas* (1965 and 1981) went unenforced, and naturally occurring arsenic began leeching into groundwater as drills penetrated ever more deeply underground (up to 180 meters in the 1970s).

CONCLUSION

In 1965 Worthington de México employed 215 people and had increased its capital threefold to 30 million pesos since its inauguration in 1951.[77] One of the principal reasons for this success, Gómez explained, was the "enthusiastic collaboration of all administrative functionaries, technicians and workers who do not see Worthington de México as a foreign company—one that they only work for to get a salary—but rather as enthusiastically their own."[78] This explanation, however, did not tell the whole story, as we have seen. Political connections, conflicts of interest, and the inherent contradiction between advances in geohydrological knowledge and developmental imperatives were also contributing factors. These all worked together to turn agrarian reform as the overarching postrevolutionary developmental program in the Laguna and throughout Mexico into a veritable business for privileged actors.

Just four years before Gómez boasted of Worthington de México's success, concerned urban residents of Torreón tried to call attention to the extreme hardship *ejidos* were experiencing after years of drought. They noted that fewer *ejidos* had access to groundwater pumps compared with small landholders. In a letter to the *Siglo* unnamed "humanitarian residents" referred to the "drought that has battered the Laguna" and made life in Torreón difficult. But "this is nothing compared with …

[our] poor campesino compatriots, the majority of whose wives are found daily in the streets begging for charity hoping to take back to their children just a little stale piece of bread or clothing with which to cover their humiliated little bodies." In order to help alleviate the lot of pauperized *ejidatarios*, the letter-writers proposed to set up a "Pro-Nativity Committee" exclusively for them made of "altruistic persons" from the community as well as three members from the Ejidal Bank and three *ejidatarios*. Once formed, the committee would ensure that the President, state governors, agriculturalists (presumably referring to small landholders), businessmen, and others equitably distributed the funds raised among all the needy.[79]

The Laguna was only one of many regions to experience the adverse impact of overexploitation of its aquifers as early as the 1930s. Due to the exponential expansion in irrigation, potable water and sewage services, and industrial uses—along with the Worthington-supplied pump and drilling technology that enabled such development—32 of Mexico's 653 aquifers had been overdrawn and contaminated by 1975. These increased to 104 in 2006 and accounted for 60 percent of Mexico's overall groundwater supplies.[80] In 2008 Felipe Calderón termed Mexico's water crisis a matter of "national security."[81]

To say that hindsight is always 20/20 would beg the question of why technopolitical actors like Gómez did not act upon the knowledge and concern that they clearly possessed, even if the concept of "sustainable development" had not yet been formulated and (at least nominally) incorporated into national economic planning. The most compelling answer to the question, as this paper has documented, is a conflict of interest: in a position to regulate groundwater pumping, Gómez had a vested interest in a business and technology that profited from such pumping. Yet there are two caveats to such a seemingly obvious and straightforward explanation. The first is that he also knew that overpumping could undermine the viability of government programs and policies, especially agrarian reform, on which the legitimacy of the one-party state depended. And his pumping business also depended on that continuing legitimacy. Second, Gómez proudly viewed himself as a man of science; as he wrote his son in 1950, "Do not forget, above all, that science is a daily undertaking and those who fail to keep up with its progress, get rusty and fall behind and end up one among

many."[82] Hydraulic science was unquestionably informing him that groundwater pumping was not sustainable at the rate at which it was extracting water from aquifers all over Mexico in the 1940s and 1950s. It is in this sense that José Luis Moreno Vázquez drew the following conclusion in his comprehensive study of the depletion and contamination of the Hermosillo coast aquifer of Sonora:

> Unlike what I had thought when I began this research, the concern for the overexploitation of water exists only in words, not in reality. That is, there is consciousness of aquifer overexploitation and of the negative effects it causes, but no clear strategies or actions are devised to diminish it. The most efficient use of water that there is on a few properties is not for ecological but economic reasons: to increase profitability per cubic meter of water used. The remark often went, "it's still an inexhaustible aquifer," "water is to be used," "with money and technology anything is possible," "if the water runs out we'll go elsewhere and do something else."[83]

Indeed, by the time such knowledge of environmental contamination was incontrovertible and overwhelming in the 1970s, the populist presidencies of Echeverría and Portillo took a strong stand on the global stage that development would come first, environmental protection second—if at all. As Mexico's environmental degradation intensified and began to affect the quality of life of the urban middle and upper classes, however, the de la Madrid and Salinas presidencies passed much progressive environmental legislation in the 1980s and 1990s. Luis Aboites has termed this the transition from the "grand hydraulics" (1920s–1970s) to the "mercantile-environmental" (1980s to the present).[84] With the founding of an Environmental Ministry (SEMARNAT) in 1992, under which the successor to the SRH, the National Water Commission (CNA), was housed, Mexico joined many other developing countries in officially incorporating sustainability into government planning. Unfortunately, the SEMARNAT is among the least powerful and effective of all the ministries, and its budget is comparatively low.[85] Moreover, the kinds of conflicts of interest that existed prior to the official commitment to sustainable developmentalism documented in this paper persist into the present. A case in point is the LALA (short for "La Laguna" dairy group), the origins of which I discussed in this paper.

From the 1970s LALA became the principal agricultural water user of the Laguna by absorbing many private landholders into its consortium of cattle and alfalfa growers. These LALA-affiliated landholders own the most powerful groundwater pumps and are able to drill wells and pump water with abandon despite the passage of far stricter laws and regulations than existed even in the 1940s and 1950s. The CNA does not monitor LALA's groundwater extractions yet strictly rations surface waters released from the Nazas Dam reservoir on which many *ejidos* rely.[86]

In spite of much local protest by *ejidatarios* and concerned citizens against this social and environmental injustice, the first truly democratically elected Mexican president since Francisco Madero in 1911—Vicente Fox of the opposition PAN party in 2000—appointed the CEO of LALA to head the CNA in 2006.[87] The CNA's five-year plan for 2007–2012 publicly released in 2006 entailed the "adequate management and preservation of water, given its importance for social welfare, economic development, and the preservation of the ecological wealth of the country."[88] While more environmentally friendly, the phrasing of the CNA's plan is little changed from that of the revised Article 27 of 1945 or the revision of 1992 that terminated agrarian reform, both of which stipulated two important objectives—development and conservation. These two have yet to be harmonized in Mexico and many areas of the world.

APPENDICES

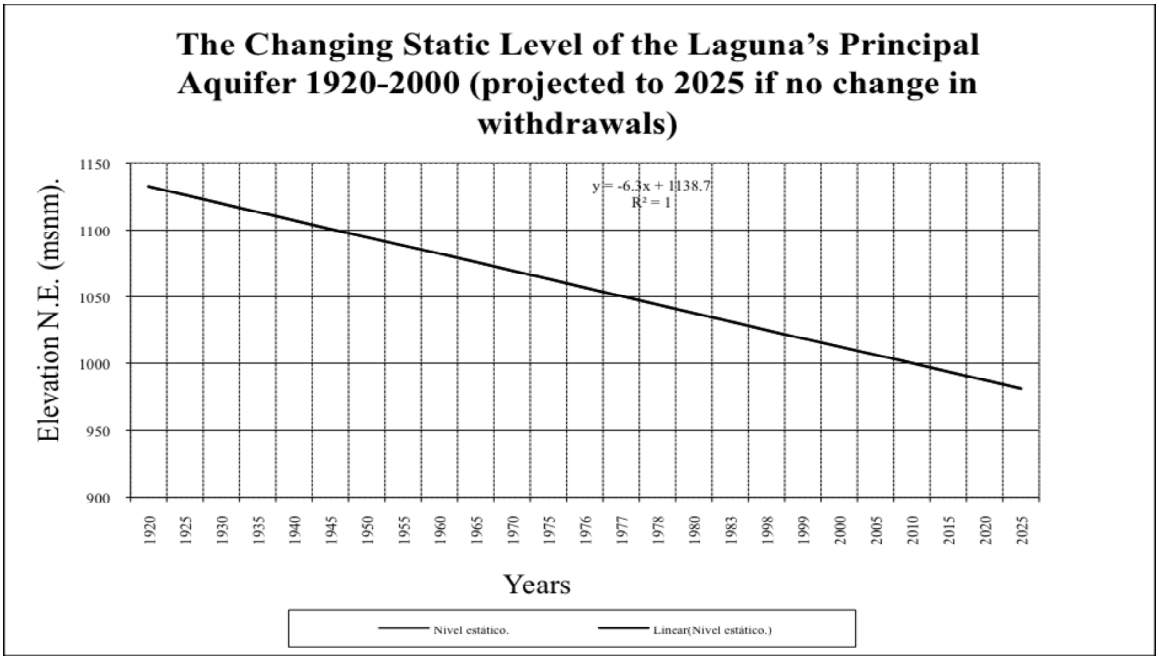
APPENDIX A

ESTIMATE OF WELLS DRILLED AND IN USE IN LAGUNA 1920–1980

Year	Wells Drilled	Wells in Use
1920	12	12
1926	114	114
1932	365	365
1938	996	996
1944	1546	1546
1950	2014	2014
1956	2704	2704
1962	2947	2748
1968	3035	2554
1974	3088	2367
1980	3334	2467

Source: Rolando Victor García and Susana Sanz, *Deterioro ambiental y pobreza en la abundancia productiva: El caso de la Comarca Lagunera* (Mexico: El Centro, La Federación, El Instituto, 1987), 74.

APPENDIX B



Source: Carlos Cháirez Araiza, "El impacto de la regulación de los ríos en la recarga a los acuíferos: El caso del acuífero principal de la Comarca de la Laguna," PhD thesis, Montecillo, Texcoco, Edo de México: Colegio de Postgraduados; Institución de Enseñanza e Investgación en Ciencias Agrícolas; Instituto de Socioeconomía, Estadistica e informática programa en estudios del desarrollo rural, 2005, 214.

APPENDIX C

MILK, CATTLE, AND COTTON PRODUCTION IN LAGUNA 1948–2004

Year	Liters of Milk per Day	Cattle Heads	Area of Cotton in Hectares
1948	33,000	4,000	80,100
1962	175,000	18,000	90,443
1967	220,000	35,000	84,217
1970	450,000	45,000	81,084
1977	1,087,671	90,000	72,236
1980	1,150,684	73,421	65,886
1988	1,290,410	109,000	66,490
1990	1,475,674	200,584	52,281
2000	4,461,281	415,596	8,284
2004	4,850,000	470,000	15,860

Source: Elías García, "El Manejo del Agua en la Laguna, México," Instituto de Desarrollo del Campo, http://www.bancomundial.org/cuartoforo/text/D-CASO-RecursosNaturales.pdf.

ENDNOTES

[1] Beginning with the foundational works of Clifton Kroeber and Luis Aboites in the 1980s, which examined water policies during the late nineteenth and early twentieth centuries respectively, Mexican water history has expanded beyond rural history to examine the changing social uses of water (domestic, agricultural, urban, and industrial), the legal and political aspects of water management and rights at various levels of government (local, state, and federal), and the social and ecological impacts of deploying hydraulic technologies (especially large dams, canals, and groundwater pumps). For a sampling, see Clifton B. Kroeber, *Man, Land, and Water: Mexico's Farmlands Irrigation Policies, 1885–1911* (Berkeley: University of California Press, 1983); Luis Aboites, *La irrigación revolucionaria: Historia del sistema nacional de riego del Río Conchos, Chihuahua, 1927–1938* (México, D.F.: Secretaría de Educación Pública, CIESAS, 1988), Aboites, *El agua de la nación: Una historia política de México (1888–1946)* (México, D.F.: Centro de Investigaciones y Estudios Superiores en Antropología Social, 1998); Aboites and Valeria Estrada Tena, *Del agua municipal al agua nacional: Materiales para una historia de los municipios en México 1901–1945* (Mexico City: CIESAS, AHA, CNA, ECM, 2004); Aboites, *La decadencia del agua de la nación* (México, D.F.: El Colegio de México, 2009); Alejandro Tortolero, *Tierra, agua y bosques: Historia y medio ambiente en el México central* (Ciudad de México and Guadalajara, Jalisco, Mexico: Universidad de Guadalajara, 1996); Tortolero, *El agua y su historia: México y sus desafíos hacia el siglo XXI*, Umbrales de México: Cultura y sociedad (México, D.F.: Siglo Veintiuno Editores, 2000); Antonio Escobar Ohmstede, Martín Sánchez, and Ana María Graciela Gutiérrez Rivas, *Agua y tierra en México, siglos XIX y XX*, 2 vols. (Zamora, Mich: El Colegio de Michoacán, El Colegio de San Luis, 2008).

[2] Aboites, *La decadencia del agua de la nación*, 25; Comisión Nacional del Agua (CNA), "Situación de los recursos hídricos," www.cna.gob.mx (accessed May 25, 2010).

[3] CNA, "Usos del agua," www.cna.gob.mx (accessed May 25, 2010).

[4] Carlos Salinas de Gortari, *México: Un paso difícil a la modernidad*, 1st ed. (Barcelona: Plaza & Janés Editores, 2000), 676–92.

[5] Salinas, *Political Participation, Public Investment, and Support for the System: A Comparative Study of Rural Communities in Mexico* (La Jolla, CA: Center for US-Mexican Studies, University of California San Diego, 1982). For a few of the major works in the enormous literature on agrarian reform, see George McCutchen McBride, *The Land Systems of Mexico* (New York: American Geographical Society, 1923); Frank Tannenbaum, *Peace by Revolution: Mexico after 1910* (New York: Columbia University Press, 1966); Jesús Silva Herzog, *El agrarismo mexicano*

y la reforma agraria: Exposición y crítica (Mexico: Fondo de Cultura Económica, 1964); Arturo Warman, *"We Come to Object": The Peasants of Morelos and the National State* (Baltimore: Johns Hopkins University Press, 1980); Antonio García de León, Enrique Semo, and Julio Moguel, *Historia de la cuestión agraria mexicana*, 8 vols. (Mexico: Siglo Veintiuno Editores: Centro de Estudios Históricos del Agrarismo en México, 1988).

[6] I thank Ted Beatty for suggesting this term to me. The works of James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998), Paul R. Josephson, *Industrialized Nature: Brute Force Technology and the Transformation of the Natural World* (Washington, DC: Island Press, 2002), Donald Worster, *Rivers of Empire: Water, Aridity, and the Growth of the American West* (New York: Pantheon Books, 1985), and Bruno Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Cambridge, MA: Harvard University Press, 1987), have profoundly influenced my thinking on this issue.

[7] Michael Ervin, "Marte R. Gómez of Tamaulipas: Governing Agrarian Revolution," in Jürgen Buchenau and William H. Beezley, eds., *State Governors of the Mexican Revolution, 1910–1952* (Lanham, MD: Rowman and Littlefield Publishers, Inc., 2009), 123–24; James Wallace Wilkie, Edna Monzón de Wilkie, and Ramón Beteta, *México visto en el siglo XX, entrevistas de historia oral* (Mexico: Instituto Mexicano de Investigaciones Económicas, 1969), 73–139.

[8] There is a large literature on the Green Revolution, but few works on Mexico examine its environmental consequences. See Stephen Lewontin, "The Green Revolution and the Politics of Agricultural Development" (PhD thesis, University of Chicago, 1983); Cynthia Hewitt de Alcántara, *Modernizing Mexican Agriculture: Socioeconomic Implications of Technological Change, 1940–1970* (Geneva: United Nations Research Institute for Social Development, 1976); Laura González Martínez, *Respuesta Campesina a la Revolución Verde en el Bajío* (México, D.F.: Universidad Iberoamericana, 1992); Marcos Cueto, *Missionaries of Science: The Rockefeller Foundation and Latin America*, Philanthropic Studies (Bloomington: Indiana University Press, 1994); Joseph Cotter, *Troubled Harvest: Agronomy and Revolution in Mexico, 1880–2002* (Westport, CT: Praeger, 2003). For one of the few works that examines the public health consequences of Green Revolution–spurred pesticide use in Mexico, see Angus Lindsay Wright, *The Death of Ramón González: The Modern Agricultural Dilemma* (Austin: University of Texas Press, 2005).

[9] The following works discuss corruption, technocrats, and the Americanization of the Mexican economy but say little to nothing about eco-technical knowledge or environmental change in

general: Stephen R. Niblo, *War, Diplomacy, and Development: The United States and Mexico, 1938–1954* (Wilmington, DE: Scholarly Resources, 1995); Niblo, *Mexico in the 1940s: Modernity, Politics, and Corruption* (Wilmington, DE: SR Books, 1999); Susan M. Gauss, "Made in Mexico: The Rise of Mexican Industrialism, 1938–1952" (PhD thesis, State University of Stony Brook, 2002), and "The Politics of Economic Nationalism in Postrevolutionary Mexico," *History Compass* 4, no. 3 (2006). For works on the "failure" of Cardenista agrarian reform in Yucatán and Michoacán from social anthropological and political historical perspectives with little mention of technical actors and natural resource management, see John Gledhill, *Casi Nada: A Study of Agrarian Reform in the Homeland of Cardenismo* (Austin: University of Texas Press, 1991), and Ben Fallaw, *Cárdenas Compromised: The Failure of Reform in Postrevolutionary Yucatán* (Durham, NC: Duke University Press, 2001).

[10] Francisco I. Madero, *Estudio sobre la conveniencia de la construcción de una presa* (San Pedro, Coahuila, Mexico: Impreso en los Talleres de Tipografia Benito Juarez, 1907), 41–53.

[11] Kroeber, *Man, Land, and Water*, 70–73, 216.

[12] Aboites, *La irrigación*, 1–53, and *El agua*, 112–13.

[13] *La Opinión* (Torreón), March 10, 1926.

[14] On the Tlahualilo Company see Martín Díaz y Díaz, "El litigio del Tlahualilo: Presagio de un derecho de propiedad sin arrogancia," *Revista de Investigaciones Jurídicas* 14, no. 14 (1990); Clifton B. Kroeber, "La Cuestión del Nazas hasta 1913," *Historia Mexicana* 79 (January–March 1971); William K. Meyers, "Politics, Vested Rights, and Economic Growth in Porfirian Mexico: The Company Tlahualilo in the Comarca Lagunera, 1885–1911," *The Hispanic American Historical Review* 57, no. 3 (August 1977); Guadalupe Villa Guerrero, "Una mina de oro blanco: La compañía agrícola del Tlahualilo," in Mario Cerruti, ed., *Durango (1840–1915): Banca, transportes, tierra e industria*, *historia económica del Norte de México (siglos XIX y XX)* (Monterrey, Nuevo Léon: Universidad Autónoma de Nueva León, 1995).

[15] See Mikael Wolfe, "Water and Revolution: The Politics, Ecology and Technology of Agrarian Reform in 'La Laguna,' Mexico," PhD thesis, University of Chicago, 2009, Chapter 4.

[16] Unless otherwise noted, all translations are the author's.

[17] "El agua de bombeo," *El Siglo de Torreón*, August 2, 1923.

[18] Everett Lundy, "History of the Vertical Turbine Pump Industry," http://www.lvlpump.com/PDFs%20and%20Docs/Turbine%20Pump%20History.pdf.

[19] Worthington Pump and Machinery Corporation, *100 years, 1840–1940, Worthington* (Harrison, NJ: 1940), 8, 14, 71, 75. Worthington was also a major supplier to the US oil companies in

Mexico, to which the Mexican national oil company Pemex turned for supplies as well after the 1938 nationalization of foreign oil companies. Worthington reluctantly refused on account of the boycott imposed by the US oil industry on Mexico in retaliation for the nationalization. As a newspaper report explained, "Recently a Mexican purchasing agent asked the Worthington Pump Company to sell $40,000 worth of spare parts for oil refining machinery, offering to pay cash. Worthington refused, explained it did $900,000 annual business with Standard and Sinclair (whose properties have been seized by Mexico) that these companies might boycott Worthington if it sold to the Mexican government. So Mexico bought from Germany." "The Washington Merry-Go-Round," *Spokane Daily Chronicle*, January 17, 1939.

[20] Advertisement, *El Siglo de Torreón*, Sept 8, 1925, p. 12.

[21] "Desarrollo de los sistemas de riego," *El Siglo de Torreón*, August 2, 1929.

[22] "Instruction Book and List of Parts for Axiflo and Coniflo Deep Well Pumps," Worthington Pump and Machinery Corporation, Bulletin D-312, August 1925, 19.

[23] Enrique Nájera, Manuel López Portillo, and Estanislao Pena, *Informe general de la Comisión de Estudios de la Comarca Lagunera, designada por el Secretario de Agricultura y Fomento* (Cámara Agrícola Nacional de la Comarca Lagunera, 1930), 195–96.

[24] Ibid., 197.

[25] María Vargas-Lobsinger, *La Comarca Lagunera: De la Revolución a la expropiación de las haciendas, 1910–1940* (Mexico: Universidad Nacional Autónoma de México, 1999), 73; Nájera, Portillo, and Pena, *Informe general*, 194–95.

[26] Vargas-Lobsinger, *La Comarca*, 73.

[27] Michael Ervin, "The 1930 Agrarian Census in Mexico: Agronomists, Middle Politics, and the Negotiation of Data Collection," *Hispanic American Historical Review* 87, no. 3 (August 2007).

[28] Rolando Victor García and Susana Sanz, *Deterioro ambiental y pobreza en la abundancia productiva:El caso de la Comarca Lagunera* (Mexico: El Centro, La Federación, El Instituto, 1987), 74.

[29] A.R.V. Arellano, "Memorial to Paul Waitz (1876–1961)," *Geological Society of America Bulletin* 74, (July 1963).

[30] José P. Arreguín Mañón, *Aportes a la historia de la geohidrología en México, 1890–1995*, Bibliotéca del agua (México, D.F.: CIESAS, Asociación Geohidrológica Mexicana, 1998), 21, 25. See also José Luis Moreno Vázquez, *Por abajo del agua: Sobreexplotación y agotamiento del acuífero de la Costa de Hermosillo, 1945–2005* (Hermosillo, Sonora, Mexico: Colegio de Sonora, 2006).

[31] Paul Waitz, "Algunos datos sobre el agua subterránea y su aprovechamiento," *Irrigación en México* 1, no. 1 (1930).

[32] Gonzalo Vivar, "Recursos de agua de la hacienda de Hornos, municipio de Viesca, estado de Coahuila," *Irrigación en México* 8, no. 4 (1934).

[33] For details of this story see Mikael Wolfe, "Conflicto por un cambio de régimen de aguas en La Laguna: La 'construcción social' de la primera gran presa en el río Nazas, 1900–1936," *Buenaval Journal of the Universidad Iberoamericana-Laguna* 6 (2006).

[34] "La Gran Bomba para La Laguna," *El Siglo de Torreón*, October 23, 1934, Classifieds section. There were also ads on Sept 27th and October 5th of that year.

[35] He was also a distributor of other company products including Bombas Compresoras, Nartillos, Medidores de Agua, A.D. Cook, Inc., Bombas Verticales, Koerting Motores, and Siemens-Mexico, but apparently not Layne and Bowler.

[36] For in-depth examinations of this episode, see Barry Carr, "The Mexican Communist Party and Agrarian Mobilization in the Laguna, 1920–1940: A Worker-Peasant Alliance?" *Hispanic American Historical Review* 67, no. 3 (1987), and Vargas-Lobsinger, *La Comarca*, among others.

[37] AHA, AS, Box 347, File 7226, p. 16. November 16, 1936. This recommendation was incorporated into the December 15, 1936 presidential decree ordering the CNI to study and propose a regulation for well water usage and its legal basis. It would take years to happen and for federal laws to be passed to that effect in the late 1940s, about which more below.

[38] AHA, AS, Box 347, File 7226, p. 213. June 14, 1938.

[39] AHA, AS, Box 347, File 7226, p. 202. Sept 9, 1938.

[40] Wolfe, "Water and Revolution," Chapters 5 and 7. There are an estimated 3,000 wells today pumping water from the aquifers, with few if any measures on water consumption. See appendix A for historical statistics.

[41] The most articulate critique on the left was from Liga de Agrónomos Socialistas, *El colectivismo agrario en México, La Comarca Lagunera* (Mexico: Industrial Gráfica, 1940), and on the right from Manuel Gómez Morín, interviewed in Wilkie, Monzón de Wilkie, and Beteta, *México visto en el siglo XX,* 75–139.

[42] AHA, AS, Box 3067, File 42425, p. 38. Informe de La Laguna, April 12, 1941.

[43] AHA, CT, Box 136, File 1121, p. 397. Informe de Distrito de Riego, Laguna, April 12, 1941.

[44] "Importante aclaración a los ejidatarios," *El Siglo de Torreón*, July 7, 1945, p. 9.

[45] Archivo Marte R. Gómez, 1950 H-M, Gómez to Alemán, June 3, 1950.

[46] *Novedades*, May 15th, 1951.

[47] In a private letter to Alemán, Gómez thanked the President for Nacional Financiera's purchase of one million pesos worth of preferential stock in exchange for three million common stock "in our possession." AMRG, 1950 H-M, Marte R. Gómez to Miguel Alemán, January 13, 1950.

[48] See Sarah L. Babb, *Managing Mexico: Economists from Nationalism to Neoliberalism* (Princeton, NJ / Oxford: Princeton University Press, 2004), Chapter 4, for an overview of ISI, and Gauss, "The Politics of Economic Nationalism in Postrevolutionary Mexico."

[49] Gómez wrote to Alemán that he was seriously worried about the attitude that various foreign factories, especially Fairbank-Morse, were taking by offering up to 15 million pesos in credit to different Mexican agricultural credit banks to purchase just the kind of pumps he planned to manufacture. He appealed to Alemán, as well as to the ministries and banks in question, not to accept such offers until he could make Worthington's case, namely, that it would help spur Mexican industrialization and be able to manufacture the same goods at better prices. AMRG, 1950 H-M, Gómez to Alemán, January 13, 1950 and June 3, 1950. See also Niblo, *Mexico in the 1940s: Modernity, Politics, and Corruption*, 190, for evidence that Gómez sought to keep competitors out two years later in 1952.

[50] Cotter, *Troubled Harvest*, 242, also notes that Gómez became the "presta-nombre," or name-lender, for Worthington in Mexico in order to circumvent laws requiring 51% Mexican ownership of companies.

[51] *Novedades*, May 16th, 1951.

[52] *The News*, May 16, 1951.

[53] *Jornadas Nacionales*, undated, in AMRG.

[54] *Zócalo*, October 9, 1950. There were also articles accusing him of being an "Henriquista," or a supporter of Miguel Henriquez Guzman, a Cardenista who would break with the PRI to run an independent campaign against it in 1952.

[55] AMRG, 1950 H-M.

[56] For an exploration of Alemán's corruption, see Niblo, *Mexico in the 1940s*. This is not to argue that his predecessors Obregón and Calles were not equally corrupt, just that the scale and scope of corruption reached new heights under Alemán.

[57] Donald Worster, *Dust Bowl: The Southern Plains in the 1930s* (New York: Oxford University Press, 2004).

[58] René Carvajal Ramírez, "Aspectos legales del agua subterránea en México," *Ingeniería Hidráulica en México* 23, no. 3 (1967), 253–55. The following paragraphs all draw from this source.

[59] Ibid., 253–55.

[60] From 1948 to 2007, there were a total of 145 according to the CNA. CNA, *Atlas del Agua en México*, http://www.cna.gob.mx/ (accessed March 1, 2010) 2009, 80.

[61] Ibid.

[62] "Las Norias en Operación en esta Comarca," *El Siglo de Torreón*, August 4, 1958. See also Appendix A for historical statistics from 1920 to 1980.

[63] *El Siglo de Torreón*, "Se previenen infracciones a la veda," May 16, 1951, and "Deben Respetar la Zona de Veda, Piden Agricultores," July 27, 1957.

[64] See Lane Simonian, *Defending the Land of the Jaguar: A History of Conservation in Mexico* (Austin: University of Texas Press, 1995), Chapter 6, for details of the law and of national conservation groups such as "Amigos de la Tierra" (Friends of the Earth), which tried to get the government to enforce it to little avail.

[65] "Los Amigos del Suelo Contestan a Robles S.," *El Siglo de Torreón*, January 17, 1957.

[66] *El Siglo de Torreón*, "Daño por Veda en Ceballos: Los Agricultores no creen que se Justifique esa Drástica Medida," January 16, 1953, and "Pide la 40–55 que no Amplíen la Veda para Norias," June 18, 1955.

[67] Isabel Truesdell Kelly, *Notes on the Culture of the Laguna Zone: Population and Sustenance* (Mexico: Institute of Inter-American Affairs, 1954), 10–11.

[68] Advertisement, *El Siglo de Torreón,* October 11, 1948.

[69] "Prominentes Asistentes," *El Siglo de Torreón*, September 15, 1956, page 2.

[70] Fred Pierce, "Earth: The Parched Planet," *The New Scientist*, February 25, 2006. http://www.newscientist.com/article/mg18925401.500 (accessed March 29, 2010). There is no precise measurement for how much water is required to raise a head of cattle, as it is variable according to climatological conditions, genus of cattle, state of technology, and so on. In 1919 two Iowa agricultural extension agents concluded in a study of several dairy cows that they needed a total of 550 pounds of freshwater to produce 100 pounds of milk during the summer months. See "Water Requirements for Milk Production," A. C. McLandish and W. G. Gaessler, http://jds.fass.org/cgi/reprint/2/1/4.pdf (accessed March 29, 2010). In 1959, the *Siglo de Torreón* carried a story indicating that dairy cows in the United States required 151 liters a day each just for drinking. "Requieren Agua Abundante Las Vacas Lecheras," *El Siglo de Torreón*, July 26, 1959.

[71] "Un Proyecto de Granjas Lecheras en esta Región: Crédito de 4 millones de dolares para establecerlas," *El Siglo de Torreón*, September 1, 1949.

[72] "El Fomento de la Industria Lechera," *El Siglo de Torreón,* April 11, 1953.

[73] Carlos Cháirez Araiza, "El impacto de la regulación de los ríos en la recarga a los acuíferos: El caso del acuífero principal de la Comarca de la Laguna" (PhD thesis, Colegio de Postgraduados, 2005), 94.

[74] AHA, AS, Box 136, File 1121, p. 594. November 19, 1968.

[75] I have no information as of now whether these *ejidatarios* hoped for employment on dairy farms in other areas of the Laguna or whether they would be subcontracted out to raise cattle. It would likely be the former as there was no longer water to pump in Viesca, at least not in the immediate area in question.

[76] "Adquisición de 240 Vacas Lecheras: Fin al Monocultivo del Algodón en Región Lagunera de Durango," *El Siglo de Torreón,* December 8, 1955.

[77] For comparison, Worthington's headquarters in New Jersey employed over 1,000 people. But though the Mexican factories were small with few employees, their efficiency made for mass production capability.

[78] January 29, 1965; untitled newspaper, AMRG.

[79] "Lo que el público reclama: Forman El Comité Pro-Navidad de Ejidatarios," *El Siglo de Torreón*, December 14, 1961.

[80] http://www.imta.mx/index.php?option=com_content&view=article&id=181:agua-subterranea&catid=52:enciclopedia-del-agua&Itemid=80. See also Aboites, *La decadencia del agua de la nación*; and *La Jornada*, *Agua* (2005).

[81] http://www.presidencia.gob.mx/prensa/ultimasnoticias/?contenido=34446 (accessed February 27, 2010).

[82] AMRG, 1951 F-1, Marte R. Gómez to son Rodolfo, October 17, 1951.

[83] Moreno Vázquez, *Por abajo del agua*, 22.

[84] Aboites, *La decadencia del agua de la nación*, 12–13.

[85] Ibid., 105.

[86] Jornada, *Agua*, 244.

[87] http://fox.presidencia.gob.mx/gabinete/?contenido=15031 (accessed March 1, 2010).

[88] "Plan Nacional Hídrico," http://www.cna.gob.mx/ (accessed March 1, 2010).

SOURCES AND BIBLIOGRAPHY

Archivo Marte R. Gómez (AMRG)

Archivo Histórico del Agua (AHA)

Fondo Aprovechamientos Superficiales (AS)

Fondo Consultivo Técnico (CT)

Comisión Nacional del Agua [National Water Commission] (CNA)

Ingeniería hidráulica en México

Irrigación en México

El Siglo de Torreón

Aboites, Luis. *El agua de la nación: Una historia política de México (1888–1946)*. México, D.F.: Centro de Investigaciones y Estudios Superiores en Antropología Social, 1998.

———. *La decadencia del agua de la nación*. México, D.F.: El Colegio de México, 2009.

———. *La irrigación revolucionaria: Historia del sistema nacional de riego del Río Conchos, Chihuahua, 1927–1938*. México, D.F.: Secretaría de Educación Pública, CIESAS, 1988.

Aboites, Luis, and Valeria Estrada Tena. *Del agua municipal al agua nacional: Materiales para una historia de los municipios en México 1901–1945*. Mexico City: CIESAS, AHA, CNA, ECM, 2004.

Arellano, A.R.V. "Memorial to Paul Waitz (1876–1961)." *Geological Society of America Bulletin* 74 (July 1963): 107–12.

Arreguín Mañón, José P. *Aportes a la historia de la geohidrología en México, 1890–1995*. Biblioteca del agua. Mexico, D.F.: CIESAS, Asociación Geohidrológica Mexicana, 1998.

Babb, Sarah L. *Managing Mexico: Economists from Nationalism to Neoliberalism*. Princeton Paperbacks. Princeton, NJ / Oxford: Princeton University Press, 2004.

Carr, Barry. "The Mexican Communist Party and Agrarian Mobilization in the Laguna, 1920–1940: A Worker-Peasant Alliance?" *Hispanic American Historical Review* 67, no. 3 (1987): 371–404.

Carvajal Ramírez, René. "Aspectos legales del agua subterránea en México." *Ingeniería Hidráulica en México* 23, no. 3 (1967): 249–58.

Cháirez Araiza, Carlos "El impacto de la regulación de los ríos en la recarga a los acuíferos: El caso del acuífero principal de la Comarca de la Laguna." PhD thesis, Montecillo, Texcoco, Edo de México: Colegio de Postgraduados; Institución de Enseñanza e Investgación en Ciencias Agrícolas; Instituto de Socioeconomía, Estadistica e informática programa en estudios del desarrollo rural, 2005.

Cotter, Joseph. *Troubled Harvest: Agronomy and Revolution in Mexico, 1880–2002*. Westport, CT: Praeger, 2003.

Cueto, Marcos. *Missionaries of Science: The Rockefeller Foundation and Latin America*. Philanthropic Studies. Bloomington: Indiana University Press, 1994.

Díaz y Díaz, Martín. "El litigio del Tlahualilo: Presagio de un derecho de propiedad sin arrogancia." *Revista de Investigaciones Jurídicas* 14, no. 14 (1990): 129–94.

Ervin, Michael. "Marte R. Gómez of Tamaulipas: Governing Agrarian Revolution." In Jürgen Buchenau and William H. Beezley, eds., *State Governors of the Mexican Revolution, 1910–1952*, 123–38. Lanham, MD: Rowman and Littlefield Publishers, Inc., 2009.

———. "The 1930 Agrarian Census in Mexico: Agronomists, Middle Politics, and the Negotiation of Data Collection." *Hispanic American Historical Review* 87, no. 3 (August 2007): 537–70.

Escobar Ohmstede, Antonio, Martín Sánchez, and Ana María Graciela Gutiérrez Rivas. *Agua y tierra en México, siglos XIX y XX*. 2 vols. Zamora, Mich, El Colegio de Michoacán / El Colegio de San Luis, 2008.

Fallaw, Ben. *Cárdenas Compromised: The Failure of Reform in Postrevolutionary Yucatán*. Durham, NC: Duke University Press, 2001.

García, Rolando Victor, and Susana Sanz. *Deterioro ambiental y pobreza en la abundancia productiva: El caso de la Comarca Lagunera*. Mexico: El Centro, La Federación, El Instituto, 1987.

García de León, Antonio, Enrique Semo, and Julio Moguel. *Historia de la cuestión agraria mexicana*. 8 vols. Mexico: Siglo Veintiuno Editores, Centro de Estudios Históricos del Agrarismo en México, 1988.

Gauss, Susan M. "Made in Mexico: The Rise of Mexican Industrialism, 1938–1952." PhD thesis, State University of Stony Brook, 2002.

———. "The Politics of Economic Nationalism in Postrevolutionary Mexico." *History Compass* 4, no. 3 (2006).

Gledhill, John. *Casi Nada: A Study of Agrarian Reform in the Homeland of Cardenismo*. Austin: University of Texas Press, 1991.

González Martínez, Laura. *Respuesta Campesina a la Revolución Verde en el Bajío*. México, D.F.: Universidad Iberoamericana, 1992.

Hewitt de Alcántara, Cynthia. *Modernizing Mexican Agriculture: Socioeconomic Implications of Technological Change, 1940–1970*. Geneva: United Nations Research Institute for Social Development, 1976.

Josephson, Paul R. *Industrialized Nature: Brute Force Technology and the Transformation of the Natural World*. Washington, DC: Island Press, 2002.

Kelly, Isabel Truesdell. *Notes on the Culture of the Laguna Zone: Population and Sustenance*. Mexico: Institute of Inter-American Affairs, 1954.

Kroeber, Clifton B. "La Cuestión del Nazas hasta 1913." *Historia Mexicana* 79 (January–March 1971): 428–56.

———. *Man, Land, and Water: Mexico's Farmlands Irrigation Policies, 1885–1911*. Berkeley: University of California Press, 1983.

Latour, Bruno. *Science in Action: How to Follow Scientists and Engineers through Society*. Cambridge, MA: Harvard University Press, 1987.

Lewontin, Stephen. "The Green Revolution and the Politics of Agricultural Development." PhD thesis, University of Chicago, 1983.

Liga de Agrónomos Socialistas. *El colectivismo agrario en México, La Comarca Lagunera*. Mexico: Industrial Gráfica, 1940.

Madero, Francisco I. *Estudio sobre la conveniencia de la construcción de una presa*. San Pedro, Coahuila, Mexico, 1907.

McBride, George McCutchen. *The Land Systems of Mexico*. New York: American Geographical Society, 1923.

Meyers, William K. "Politics, Vested Rights, and Economic Growth in Porfirian Mexico: The Company Tlahualilo in the Comarca Lagunera, 1885–1911." *The Hispanic American Historical Review* 57, no. 3 (August 1977).

Moreno Vázquez, José Luis. *Por abajo del agua: Sobreexplotación y agotamiento del acuífero de la Costa de Hermosillo, 1945–2005*. Hermosillo, Sonora, Mexico: Colegio de Sonora, 2006.

Nájera, Enrique, Manuel López Portillo, and Estanislao Pena. *Informe general de la Comisión de Estudios de la Comarca Lagunera, designada por el secretario de Agricultura y Fomento*. Cámara Agrícola Nacional de la Comarca Lagunera, 1930.

Niblo, Stephen R. *Mexico in the 1940s: Modernity, Politics, and Corruption*. Wilmington, DE: SR Books, 1999.

———. *War, Diplomacy, and Development: The United States and Mexico, 1938–1954*. Wilmington, DE: Scholarly Resources, 1995.

Salinas de Gortari, Carlos. *México: Un paso difícil a la modernidad*. 1st ed. Barcelona: Plaza & Janés Editores, 2000.

———. *Political Participation, Public Investment, and Support for the System: A Comparative Study of Rural Communities in Mexico*. La Jolla, CA: Center for US-Mexican Studies, University of California San Diego, 1982.

Scott, James C. *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed*. New Haven: Yale University Press, 1998.

Silva Herzog, Jesús. *El agrarismo mexicano y la reforma agraria; Exposición y crítica*. Mexico: Fondo de Cultura Económica, 1964.

Simonian, Lane. *Defending the Land of the Jaguar: A History of Conservation in Mexico*. Austin: University of Texas Press, 1995.

Tannenbaum, Frank. *Peace by Revolution: Mexico after 1910*. New York: Columbia University Press, 1966.

Tortolero, Alejandro. *El agua y su historia: México y sus desafíos hacia el siglo XXI*. Umbrales de México: Cultura y sociedad. México, D.F.: Siglo Veintiuno Editores, 2000.

———. *Tierra, agua y bosques: Historia y medio ambiente en el México central*. Ciudad de México and Guadalajara, Jalisco, Mexico: Universidad de Guadalajara, 1996.

Vargas-Lobsinger, María. *La Comarca Lagunera: De la Revolución a la expropiación de las haciendas, 1910–1940*. Mexico: Universidad Nacional Autónoma de México, 1999.

Villa Guerrero, Guadalupe. “Una mina de oro blanco: La compañía agrícola del Tlahualilo.” In Mario Cerruti, ed., *Durango (1840–1915): Banca, transportes, tierra e industria, historia económica del Norte de México (siglos XIX y XX)*. Monterrey, Nuevo Léon: Universidad Autónoma de Nueva León, 1995.

Vivar, Gonzalo. “Recursos de agua de la hacienda de Hornos, municipio de Viesca, estado de Coahuila.” *Irrigación en México* 8, no. 4 (1934).

Waitz, Paul. “Algunos datos sobre el agua subterránea y su aprovechamiento.” *Irrigación en México* 1, no. 1 (1930).

Warman, Arturo. *“We Come to Object”: The Peasants of Morelos and the National State*. Baltimore: Johns Hopkins University Press, 1980.

Wilkie, James Wallace, Edna Monzón de Wilkie, and Ramón Beteta. *México visto en el siglo XX, entrevistas de historia oral*. Mexico: Instituto Mexicano de Investigaciones Económicas, 1969.

Wolfe, Mikael. “Conflicto por un cambio de régimen de aguas en La Laguna: La ‘construcción social’ de la primera gran presa en el río Nazas, 1900–1936.” *Buenaval Journal of the Universidad Iberoamericana-Laguna* 6 (2006).

———. “Water and Revolution: The Politics, Ecology and Technology of Agrarian Reform in ‘La Laguna,’ Mexico.” PhD thesis, University of Chicago, 2009.

Worster, Donald. *Dust Bowl: The Southern Plains in the 1930s*. New York: Oxford University Press, 2004.

———. *Rivers of Empire: Water, Aridity, and the Growth of the American West*. New York: Pantheon Books, 1985.

Worthington Pump and Machinery Corporation. “Instruction Book and List of Parts for Axiflo and Coniflo Deep Well Pumps,” Bulletin D-312. August 1925.

———. *100 years, 1840–1940, Worthington*. Harrison, New Jersey, 1940.

Wright, Angus Lindsay. *The Death of Ramón González: The Modern Agricultural Dilemma*. Austin: University of Texas Press, 2005.