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Capturing the waters: the hydraulic mission in the Lerma–Chapala Basin, Mexico (1876–1976)

Philippus Wester

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Abstract The hydraulic mission of the Mexican federal government, embodied in its hydraulic bureaucracy (hydrocracy), led to the centralization of water development and the creation of water overexploitation in the Lerma–Chapala Basin between 1876 and 1976. In the late nineteenth century, the federal government began asserting its control over water, both to promote commercial agriculture and to arbitrate in water allocation conflicts between large landowners. The centralization of water development accelerated after the Mexican Revolution (1910–1920) and continued until the 1970s. These 50 years witnessed a large increase in the irrigated area in the Lerma–Chapala Basin, intertwined with the formation and expansion of a strong hydrocracy with a keen sense of its hydraulic mission. This led to the creation of water overexploitation in the basin, through the construction of dams and irrigation systems, and modifications to Lake Chapala. This article argues that this was not an unforeseen side effect, but the deliberate intent of the hydrocrats working in the basin.

Keywords Hydraulic mission · Hydraulic bureaucracy · Water resources management · River basin closure · Lerma–Chapala Basin · Mexico

Introduction

Water resources development has led to water overexploitation in many river basins around the world (Molle et al. 2009). This has happened because of the "overbuilding" of water infrastructure in river basins for the extraction of surface and groundwater, to the point that more water is consumed by agriculture, industry, and humans than is renewably available (Molle et al. 2007). This process has been termed as river basin closure, a term coined by Seckler (1996) to characterize river basins where consumptive water use is approaching or equal to the level of annual renewable water. Turton and Ohlsson (1999)

P. Wester (✉)
Irrigation and Water Engineering Group, Center for Water and Climate, Wageningen University, Wageningen, The Netherlands
e-mail: flip.wester@wur.nl

further developed the river basin closure concept by positing that water scarcity per se is not the key issue, but rather whether a society has the adaptive capacity to cope with the challenges water scarcity poses. They argue that two institutional transitions occur as more water is used for human purposes: the first when water abundance turns to water shortage due to withdrawals and the second when water shortage turns to water overexploitation. The first transition entails the construction of significant hydraulic infrastructure by government agencies to capture more water. Based on the study of Worster (1985), Reisner (1993), and Swyngedouw (1999), they refer to this transition to water resources development as the birth of the hydraulic mission, embodied in a central government agency consisting of hydraulic engineers.[1] Whereas water was controlled locally before, its development becomes state led and centralized after the first transition, leading to the growth of hydrocracies bent on "developing" water resources.

Based on Wester (2008), this article defines the hydraulic mission as the strong conviction that every drop of water flowing to the ocean is a waste and that the state should develop hydraulic infrastructure to capture as much water as possible for human uses. The carrier of this mission is the hydrocracy, that, based on a high-modernist worldview (Scott 1998; Allan 2002), sets out to control nature and "conquer the desert" by "developing" water resources for the sake of progress and development. The term mission is used intentionally because of its military and religious connotations and to reflect the conviction that it is the duty of the state to develop water resources. However, the use of the term is not intended as a value judgment, but rather is an attempt to conceptualize an empirically verifiable mindset. Also, the hydraulic mission and the hydrocracy are not monolithic and how strong or contested they are in different time periods and countries is an empirical question.

This article sketches the history of water development and the creation of water overexploitation in the Lerma–Chapala Basin,[2] located in central Mexico (Fig. 1), and links this to the development of a strong federal hydrocracy.[3] The hydraulic mission of the hydrocracy and the bureaucratic-authoritarian state that developed in Mexico after the revolution of 1910–1920 strongly influenced water development in the basin. The hydraulic mission of the hydrocracy was premised on the notion that the federal government should capture as much water as possible for human use through infrastructure development. The hydraulic mission, the centralization of water resources development, and the growth of the federal hydrocracy mutually reinforced each other and formed an important component of state formation in post-revolutionary Mexico. This article brings out how the centralization process and irrigation and river basin development in the Lerma–Chapala Basin led to water overexploitation and the strengthening of state control over water and water users. Through highlighting these processes, this article contributes to the growing body of scholarly work on the links between the hydraulic mission, hydrocracies, and river basin closure (cf. Worster 1985; Reisner 1993; Swyngedouw 1999; Allan 2002; Pisani 2002; O'Neill 2006; Swyngedouw 2007).

[1] However, Reisner (1993) does not use the term hydraulic mission in his book, while Swyngedouw (1999) speaks of the hydraulic engineering mission, but does not define it.

[2] For details on the Lerma–Chapala Basin, see Wester (2008) and Wester et al. (2008).

[3] This article is based on secondary sources, interviews for the SRH era, and primary sources from the Archivo Histórico del Agua (AHA) contained on the DVD *Riego y Gestión del Agua en la Cuenca Lerma-Chapala: Documentos para su Historia, 1896–1985*, complied by Isnardo Santos, Sergio Vargas, and Eric Mollard. An earlier version of this article appeared in Wester (2008).

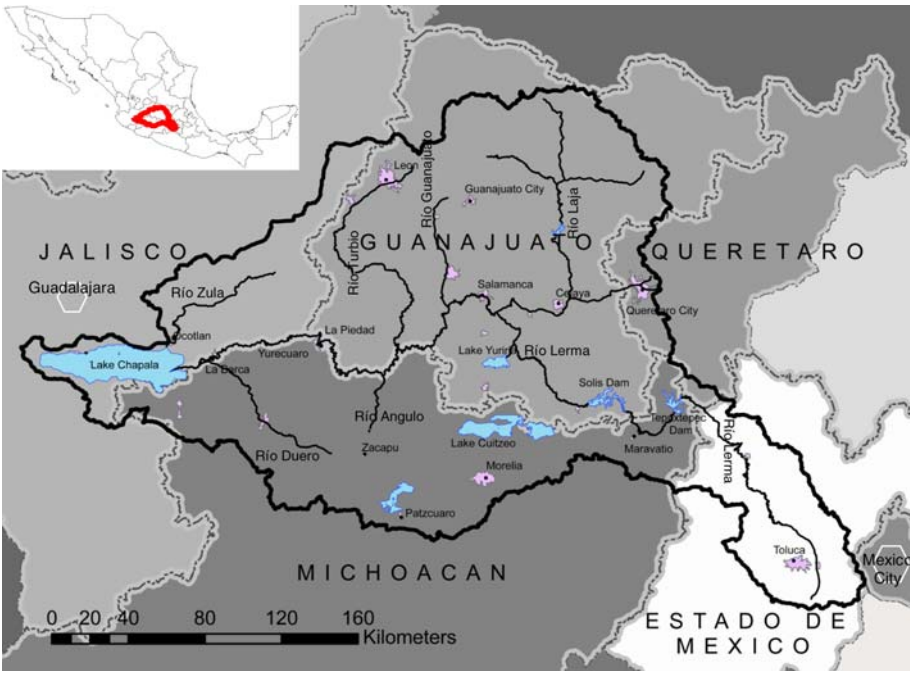

Fig. 1 The Lerma–Chapala Basin

This article identifies three phases in the centralization of water resources development in Mexico and analyzes how these played out in the Lerma–Chapala Basin. The section "Toward federal water control: the birth of the hydraulic mission" sketches the birth of the hydraulic mission in the late nineteenth century, which entailed a gradual and contested move away from local water control toward larger intervention by the federal government. The section "The rise of the hydraulic mission: from oligarchic to revolutionary irrigation" analyzes how the rise of the hydraulic mission during the *Comisión Nacional de Irrigación* (CNI; National Irrigation Commission) era (1926–1946) led to increased federal control over water in the Lerma–Chapala Basin and the expansion of the irrigation frontier. The section "The zenith of the hydraulic mission: SRH and river basin development" discusses how the zenith of the hydraulic mission during the *Secretaría de Recursos Hidráulicos* (SRH; Ministry of Hydraulic Resources) era (1946–1976) led to the creation of water overexploitation in the Lerma–Chapala Basin, even though it was clear that the ecological limits of the basin had already been reached. The article concludes that this was not an unforeseen side effect of the hydraulic mission, but a direct consequence of it.

Toward federal water control: the birth of the hydraulic mission

Irrigation development on a large scale in the Lerma–Chapala Basin started with the arrival of the Spaniards and the resulting colonization of the basin. The discovery of silver mines in Guanajuato in the 1550s led to the rapid settlement of the Middle Lerma Basin and the development of irrigated agriculture for wheat cultivation, mostly through private initiative and by monasteries (Murphy 1986). The increasing demand for cereals by cities led to the

expansion of irrigation in the seventeenth and eighteenth centuries based on run-of-the-river irrigation schemes and the ingenious use of flood waters, through the construction of *cajas de agua* (literally water boxes, a system of interlinked and embanked fields of 5–200 ha each filled in succession with flood water and direct runoff), primarily from tributaries of the Río Lerma (Sánchez 2005). By the end of the colonial period, the basin's water resources were already intensively used, and by 1900, the run-of-the-river irrigation potential of the tributaries of the Río Lerma had been largely developed, covering around 60,000 ha (SRH 1953).

Toward the federalization of water allocation and development

The hydraulic mission started to gather force in Mexico toward the end of the nineteenth century, when the federal government began asserting its control over water both to promote commercial agriculture and to arbitrate in water allocation conflicts between *hacendados* (large landowners) (Kroeber 1983; Aboites 1998; Sánchez 2005). Before then, irrigation and drinking water had largely been local affairs, although land and water rights were originally based on royal grants during the colonial period. The first 75 years of the nineteenth century were a period of turmoil and political unrest, with few new irrigation works in the basin. This changed in the last quarter of the nineteenth century, with attempts by *hacendados* to turn marshes and lakes into private property for land reclamation purposes.

The Porfirio Díaz regime (1876–1911), known as the Porfiriato, strongly supported private capital and foreign investment and developed laws that led to extreme forms of land concentration. During the Porfiriato, the federal government established control over the country and focused on the development of mining and railroad construction (Hamilton 1982). The widespread dispossession of *campesinos* and *indígenas* of their communal lands by *hacendados* and foreign companies was encouraged by the federal government through its *baldio* (vacant land) and colonization legislation, under which nearly one-fifth of Mexico's territory was granted to surveying companies between 1883 and 1892 (Hamilton 1982). The extreme concentration of land ownership was a potent ingredient of the revolution that was to follow (Hamilton 1982).

During the Porfiriato, the federal government started to play an active role in water development and the concessioning of water rights. In an excellent historical study, Aboites (1998) analyzes the increasing influence of the federal government in water affairs, through the centralization of political and legal powers and faculties relating to water from 1888 to 1946. Before 1888, communities and municipalities administered water rights, and water was controlled locally. This started to change in 1888, when Congress passed the *Ley General de Vías de Comunicación* (General Law on Communication Routes) that placed lakes and navigable rivers as well as boundary rivers under federal jurisdiction. The law did not establish water as national property, but it did authorize the federal government to regulate the public and private use of navigable and inter-state rivers and specified that water concessions could only be issued by the federal government (Aboites 1998).

The 1888 law met with criticism from large landowners and industrialists, as it was vaguely worded and existing water rights had to be confirmed by the federal government. The federal government, however, wanted to establish federal jurisdiction over all of Mexico's water, but could not, as the liberal 1857 Constitution defined water as private property. A decisive step in the federalization of water management was the amendment of Article 72 of the Constitution in 1908, which placed rivers in the public domain. Based on this amendment, it was concluded that water as private property no longer existed and that

access to water was only possible through concessions issued by the federal government. Thus, in a period of 20 years, in legal terms, water in Mexico passed from being a local affair to falling in the public domain administered by the federal government (Aboites 1998; Sánchez 1999). The birth of the hydraulic mission during the Porfiriato entailed that the federal government gradually increased its control over water and supported private capital (the oligarchy) in developing water resources, as brought out below for the Lerma–Chapala Basin.

Land reclamation projects in the Lerma–Chapala Basin

Water development in the Lerma–Chapala Basin during the Porfiriato consisted of land reclamation, hydropower projects, and some irrigation development. These projects were undertaken by large landowners, sometimes in conjunction with foreign capital, but with an increasingly active involvement of the federal government in the funding and approval of these initiatives. The drainage of the Chapala and Zacapu marshes, stand out as examples of the land reclamation efforts (Wester 2008). The expansion of run-of-the-river irrigation works on tributaries of the Río Lerma also received attention, but the main incursion of the federal government in this area consisted of the formulation of river regulations.

The drainage of the Zacapu marsh (Ciénega de Zacapu), located in Michoacán near the headwaters of the Río Angulo, is exemplary of how land reclamation projects were undertaken during the Porfiriato. As in other land reclamation projects, there was an important link between foreign capital, the federal bureaucracy, and large *hacendados*. The Zacapu marsh covered an area of around 150 km^2, was up to 8 m in depth, and was surrounded by several haciendas and farming communities (Guzmán-Ávila 2002). Eduardo Noriega, a large *hacendado* and friend of Porfirio Díaz, obtained a concession from the federal government in 1900 to drain the marsh. As the Río Angulo was not navigable and did not form a boundary between two states and thus legally did not fall under federal jurisdiction, other *hacendados* challenged this concession, but to no avail. On the reclaimed land of 12,000 ha, Noriega developed an irrigation system that started functioning in 1907, with a large loan from the federal government (Guzmán-Ávila 2002).

Another land reclamation project that was executed before 1910 and that was to have a lasting impact on the basin and Lake Chapala was the draining of the Ciénega de Chapala (Lake Chapala marsh). This land reclamation project was linked to the development of hydropower plants fed by Lake Chapala and set the stage for the first Lake Chapala crisis from 1945 to 1958. Until the late nineteenth century, Lake Chapala remained in its natural state, but this changed dramatically during the Porfiriato, as described below.

In 1894, the El Salto (The Fall) hydropower plant was constructed on the Río Santiago near Juanacatlán, some 60 km downstream of Lake Chapala (see Fig. 2), to provide Guadalajara with electricity. This plant received its water from Lake Chapala, which flowed into the Río Santiago near the city of Ocotlán if the lake level was above cota 95.00.[4] The sill at the mouth of the Río Santiago stopped the flow of water if the lake dropped below this level, while the form of the outlet to the Río Santiago restricted the amount of water leaving the lake. According to Robles-Gil (1896), during the rainy season,

[4] The depth of Lake Chapala is measured with a locally defined benchmark, called the *cota*. This benchmark was established around 1897 by Luis P. Ballesteros, with cota 100 defined as the bottom of the keystone of the sixth arch of the bridge over the Río Santiago in Ocotlán (unfortunately destroyed in 1965). The elevation of this point was later determined to be 1,526.80 m.a.s.l. (de Paula Sandoval 1981, p. 16).

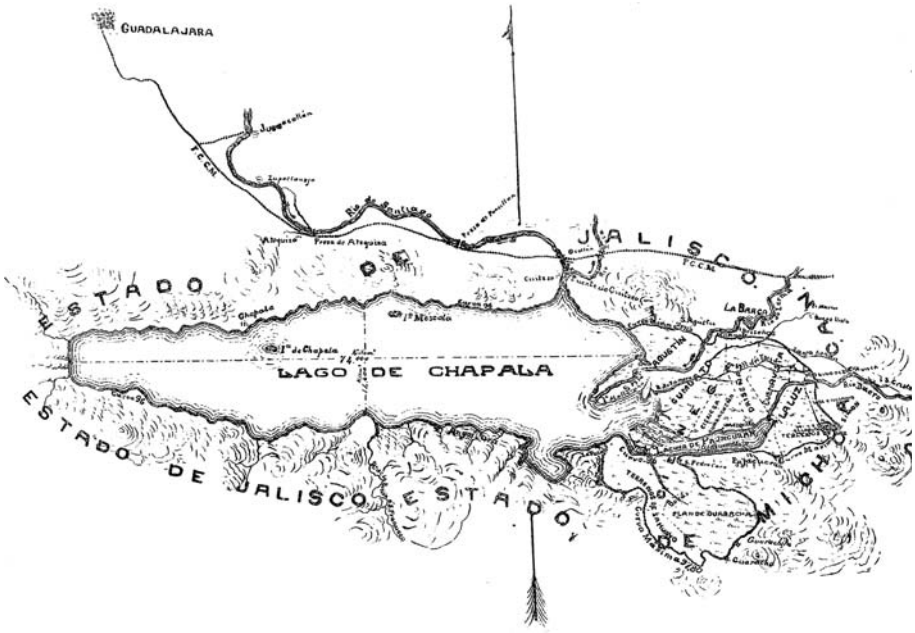

Fig. 2 Original state of Lake Chapala and the courses of the Ríos Lerma and Duero. *Source*: Quevedo y Zubieta (1906)

the waters of the Río Zula, which joins the Río Santiago just below Lake Chapala, would flow in two directions at its confluence, both upstream toward the lake and downstream along the Río Santiago. This effectively blocked the outflow from the lake during the rainy season and combined with the inflows to the lake could head up the water in the lake by some 2–3 m.[5] In one of the first studies on Lake Chapala, Miguel Quevedo y Zubieta mentions that the highest level reached by the lake was around cota 98.50 and that, on average, the lake reached cota 97.13 in the rainy season, and would then fall to an average of cota 95.82 in the dry season, based on measured lake levels from 1896 to 1904 (Quevedo y Zubieta 1906, p. 18).

The studies by Robles-Gil (1896, 1897) and Quevedo y Zubieta (1906) describe Lake Chapala before it was altered. Figure 2 presents the original condition of the lake, showing the large extent of the Ciénega de Chapala at the eastern end of the lake. As the average elevation of the Ciénega was cota 96.20, a large part of it would flood each year, depending on river inflows and lake levels. When the Ciénega was flooded, Lake Chapala would reach a length of 100 km, a surface area of 1,600 km^2, and would store around 9,400 hm^3 (de Paula Sandoval 1994, p. 26). There are reports that in 1897 the lake nearly completely dried up, dropping to around cota 90.50 (de Paula Sandoval 1981, p. 15). However, Quevedo y Zubieta (1906, p. 18) states that between 1896 and 1904, the lowest measured lake level was cota 95.20, and the average low level during the dry season was cota 95.82, thus casting strong doubt on this undocumented claim by de Paula Sandoval.

[5] AHA, Aprovechamientos Superficiales (AS), *Memoria descriptiva del proyecto de las compuertas que el Sr. D. José M. Bermejillo, establecerá en el Puente de Ocotlán*, by Alberto Robles-Gil (1896), Box 4613, File 61389, pp. 94–126.

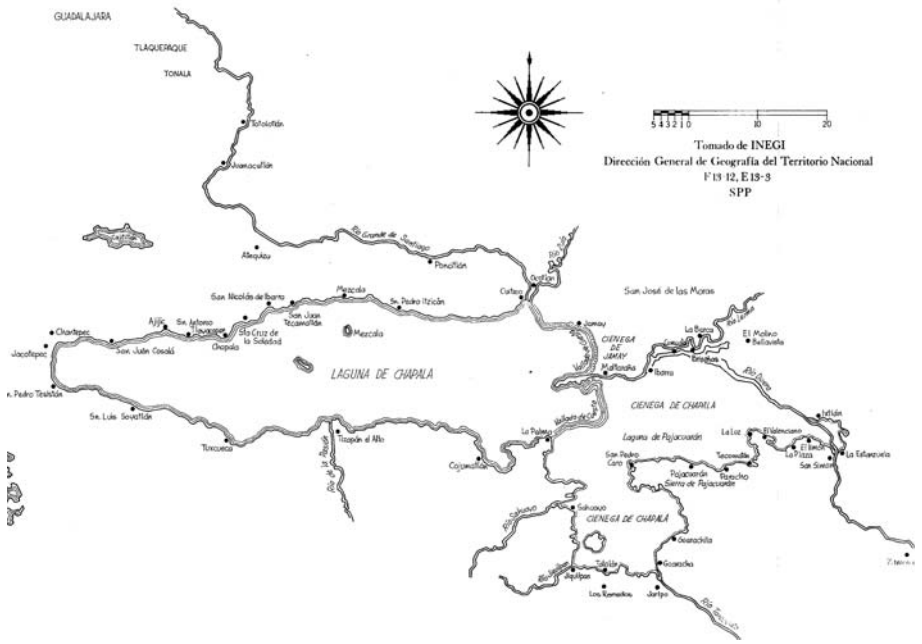

Fig. 3 Map of Lake Chapala and the Ciénega de Chapala after embankment. *Source*: Boehm (1994)

During the dry season when the lake dropped below cota 96.00, the little water that flowed into the Río Santiago was held up at the Poncitlán rapids. This motivated José Bermejillo, a *hacendado* with irrigated land near Poncitlán, to obtain a concession from the *Secretaría de Fomento* in March 1896 to construct a barrage on the Río Santiago. He hired Alberto Robles-Gil to conduct studies to determine the best location to install a gated barrage on the Río Santiago, both to regulate the volumes stored in Lake Chapala and to ensure a continuous flow in the Río Santiago.[6] Robles-Gil recommended constructing a barrage across the rapids of Poncitlán, located some 23 km downstream of Lake Chapala. This barrage was completed in 1903, making it possible to keep the level of Lake Chapala at cota 97.80, to be gradually lowered in the dry season for irrigation and the El Salto hydropower plant. In February 1905, the *Secretaría de Fomento* published a ministerial declaration in the Diario Oficial stating that cota 97.80 was the lake's ordinary high water level and that all the lands covered by water at this level where under federal jurisdiction (Quevedo y Zubieta 1906).

The construction of the Poncitlán barrage entailed that the Ciénega de Chapala remained flooded longer. This led to complaints from *hacendados* with land in the Ciénega (Quevedo y Zubieta 1906) and motivated one of them, Manuel Cuesta-Gallardo, to develop plans to embank and drain the Ciénega de Chapala, both to increase his agricultural lands and the amount of water stored in Lake Chapala for hydropower generation, as he was a partner in the El Salto hydropower company (Boehm 1994). He hired Luis P. Ballesteros to

[6] Archivo Histórico del Agua, AS, *Memoria descriptiva del proyecto de las compuertas que el Sr. D. José M. Bermejillo, establecerá en el Puente de Ocotlán* by Robles-Gil (1896), Box 4613, File 61389, pp. 94–126, and AHA, AS, *Memoria descriptiva de las obras hidráulicas de los rapidos de Poncitlán* by Robles-Gil (1897), Box 4619, File 61484, pp. 65–69.

develop a plan for the reclamation and subsequent irrigation of the Ciénega, and in 1903, he obtained a concession from the federal government to do so (Boehm 1994). In 1905, work started on constructing embankments with a length of 95 km to separate the Ciénega from Lake Chapala, which was completed in 1910 (see Fig. 3). An area of 500 km^2 (50,000 ha) was cut off from the lake, reducing the storage capacity of the lake by some 1,500 hm^3 and leading to its current operating storage capacity of 7,900 hm^3 at cota 97.80 (Boehm 1994).

The federal government granted the 50,000 ha that was embanked and drained to Cuesta-Gallardo. This led to heated debates, as both indigenous communities and *hacendados* already owned land in the Ciénega, and they strongly disagreed with the maximum shoreline of Lake Chapala that the Secretaría de Fomento had set at cota 97.80 (Quevedo y Zubieta 1906). This was to no avail, however, and with the support of the federal government, Cuesta-Gallardo succeeded in obtaining all the property rights to the drained land. However, he did not enjoy these rights for long, as after the revolution, the majority of the lands in the Ciénega were divided and constituted as *ejidos* (land reform communities), and the CNI turned the Ciénega de Chapala into an irrigation district (Vargas-González 1993). Nonetheless, the damage to the lake had been done, with the loss of the extra storage buffer in the Ciénega.

Besides the land reclamation projects, the federal government became actively involved in drawing up river regulations in the 1890s. Kroeber (1983) and Aboites (1998) provide a detailed account of how the Waters Directorate of the *Secretaría de Fomento* rapidly increased the number of river regulations it drew up and how this led to increased federal control over water. In the Lerma–Chapala Basin, the Río Laja, a tributary of the Río Lerma largely flowing through Guanajuato, provides an example of this process (Sánchez 1999). In 1895, *hacendados* with colonial water rights to the Río Laja requested the federal government to settle a water allocation dispute. The federal government quickly established a commission to study the dispute, and in May 1897 decided that a detailed study of the river was necessary to regulate all the water rights on the river. In 1901, the federal government enlarged the mandate of the study commission, to confirm and formalize all existing water rights and to verify if any new water rights could be awarded. This increasing incursion of the federal government was characteristic for all the rivers studied by the Waters Directorate, in its attempt to bring rivers under federal control (cf. Kroeber 1983; Aboites 1998). Interestingly, the Río Laja was not a river falling under federal jurisdiction, but this did not withhold the federal government from proposing a detailed river regulation in 1906, which included the establishment of a permanent federal commission to inspect water withdrawals from the river. Although this was resisted by the haciendas drawing water from the Río Laja, gradually the river was brought under federal control (Sánchez 1999).

The above has reviewed how the federal government started to increase its control over water during the Porfiriato. Through changes in the legal framework, the federal jurisdiction over rivers and lakes was expanded, and the federal government became more involved in confirming existing water rights and the formulation of river regulations. More importantly, large *hacendados* were granted concessions to drain lakes and to construct irrigation and hydropower works, which frequently entailed the dispossession of not only previous water right holders, primarily *campesinos* and *indiginas,* but also other *hacendados*. This oligarchic form of water resources development entailed that the federal government itself did not construct water works, but rather supported a clique of *hacendados* and foreign companies with loans and water concession to do so. However, local autonomy and control over water remained strong during the Porfiriato, and the incursion

of the federal government was selective (Aboites 1998; Sánchez 2005). This changed after the revolution of 1910–1920, with a much stronger centralization of water resources development and federal control over water from the 1930s onward.

The rise of the hydraulic mission: from oligarchic to revolutionary irrigation

This section reviews the rise of the hydraulic mission, and the efforts undertaken by the CNI to develop irrigation districts in the Lerma–Chapala Basin between 1926 and 1946. The Mexican Revolution of 1910–1920 set the stage for the rise of the hydraulic mission, which accelerated with the creation of the CNI in 1926. This hydrocracy set out to develop "revolutionary" irrigation systems, as opposed to the promotion of "oligarchic" irrigation under the Porfiriato (Aboites 1988). The revolutionary aspect initially consisted of the federal government constructing irrigation systems to break up *haciendas* and colonize them with yeoman farmers, working and owning a medium-sized irrigated farm (20–100 ha). With the land reforms of the 1930s, the attention shifted to supporting land reform communities, the *ejidos*, with irrigation works. However, both these forms of "revolutionary" irrigation had in common that the federal government led this social transformation process, and that it led to the growth of a powerful federal hydrocracy, with a keen sense of its hydraulic mission.

Recovering from the revolution

The widespread concentration of landholdings and the impoverishment of large segments of the population were to lead to the Mexican Revolution of 1910–1920. What started as a middle class movement headed by Francisco Madero against the reelection of Porfirio Díaz in 1910, with Díaz going into exile in May 1911 and Madero being elected president in October 1911, rapidly degenerated into a civil war, with Madero being assassinated in February 1913 (Cockcroft 1983). It also led to the rise of the "Constitutionalists," a group of army generals headed by Venustiano Carranza, Alvaro Obregón, and Plutarco Elías Calles from the northern states of Coahuila and Sonora, whose goal was to restore constitutional order. By April 1916, the Constitutionalists had secured control over Mexico City, and Carranza declared himself president and called for a convention to draw up a new constitution. This convention met in late 1916 in Querétaro, leading to the signing of a new constitution on January 31, 1917.

The trend toward stronger federal control over water initiated under Porfirio Diaz's regime was consolidated in Article 27 of the 1917 Constitution. The 1917 Constitution was modeled on the liberal Constitution of 1857, but also partly incorporated the economic and social reforms fought for by the revolutionary armies, especially regarding land ownership and worker rights. It also centralized power in the federal government and gave the president extensive powers. Article 27 defined natural resources, including oil, land, and water, as the inalienable property of the nation and established the *ejido* (common property) form of land tenure for the redistribution of the *haciendas* to the landless, with a combination of community (*ejido*) and private (*ejidatorio*) usufruct. Article 27 also established that the only way to gain access to the nation's water was through a concession granted by the federal government. However, Article 27 also included a provision that the federal government could recognize existing private property rights and could transfer the control over land and water to private parties, thus constituting private property.

Based on Article 27, the centralization of water management began in earnest in the 1920s, when President Calles launched a program for the construction of large-scale irrigation systems (termed irrigation districts in Mexico). This program found its legal expression in the Irrigation Law issued in January 1926, which also created the CNI, the first government agency solely devoted to the design and construction of irrigation districts and their management (Orive-Alba 1960). While under the Porfiriato the federal government did not play a direct role in water resources development, this changed with the creation of the CNI, whose interventions strongly increased federal control over water. As shown by Aboites (1988, 1998), water resources development by the federal government played an important role in the formation and consolidation of the post-revolutionary state.

The construction of irrigation systems was a crucial component of Calles' agrarian policy. In Calles' vision, the agrarian question was to be solved by breaking up the *latifundios* through the construction of irrigation systems and colonizing them with a prosperous group of middle-class farmers. Aboites (1988) has termed this "revolutionary irrigation," as Calles focused on using irrigation to achieve the revolutionary promise of "land and liberty," instead of extensive land reforms. Article 2 of the 1926 irrigation law stated that existing irrigation systems fell under federal jurisdiction, while Article 5 stated that the federal government was to receive a portion of both old and new lands benefited with federal irrigation works (cf. Greenberg 1970). Based on these clauses, the CNI could subdivide *haciendas* where it constructed irrigation systems, thus reducing their size, while handing out the thus obtained land to independent farmers. The CNI was thus instrumental in creating this new class of farmers through the selection of the beneficiaries for the settlement of the newly constructed irrigation districts. In Calles' vision, the *ejidos* were a transitional form of land tenure and in the long-term agriculture would only prosper if it was based on private property. Thus, despite the stated intention of Article 27 of making the peasantry the target of land distribution, Calles' agricultural and irrigation policies contributed to the creation of a new class of middle-sized commercial producers in the northern regions (Aboites 1998).

The CNI was formed as a semi-autonomous agency within the federal *Secretaría de Agricultura y Fomento* (SAyF; Ministry of Agriculture and Development). The Waters Directorate within SAyF also continued to exist and focused on developing river regulations and water concessions as it had during the Porfiriato. The CNI focused on the design and construction of irrigation systems, but as there was hardly any hydraulic expertise in Mexico, several U.S. companies with Mexican subsidiaries were hired to construct dams and other large works. In the early 1940s, the American interests in these subsidiaries were bought out, and the CNI began awarding construction contracts to Mexican companies (Greenberg 1970, p. 18). The CNI also contracted four high-level engineers from the U.S. Bureau of Reclamation, paying them triple their U.S. salaries. While advisors to the CNI, these men took most of the technical decisions in the CNI and trained a new generation of Mexican hydraulic engineers (Greenberg 1970, p. 16). The CNI rapidly established itself as competent hydrocracy and set to work developing irrigation districts, with 11 under construction by 1935. Although exact data on the area irrigated in Mexico before the creation of the CNI are not available, Orive-Alba (1960) estimates it to have been some 800,000 ha. In 20 years time, the CNI doubled this figure through the construction of another 816,200 ha of large-scale irrigation systems and 21,343 ha of small-scale systems (SRH 1975).

An important outcome of the irrigation development efforts under Calles was that subsequent administrations continued to support large irrigation works. From the 1930s onward, the content of irrigation policy was subject to the vicissitudes in the relationship

between the state and the peasantry. This revolved around the long-standing tension between policies targeting private capital as a means of increasing agricultural production and those directed at the *ejido* sector to retain political support in rural areas (cf. Fox 1992; Stanford 1993). In the mid-1930s, President Cárdenas (1934–1940) dealt with this challenge by proceeding to make true the revolutionary promise of giving the "land to the tiller," especially in regions where large landowners were amongst his political opponents. In 1930, *ejidos* only controlled 15% of the land in irrigation districts, but by 1940, this had increased to 60% (Wionczek 1982, p. 370). Although the beneficiaries of the revolutionary irrigation policy were different, what remained the same was that the federal government led this social transformation process. By constructing irrigation systems it built the state at the same time (Aboites 1998). The management of the irrigation districts also became increasingly centralized from the 1930s onward, although the various water laws promulgated between 1926 and 1947 contained provisions for the creation of water boards to manage irrigation districts (Rap et al. 2004). However, the CNI frequently took control of the irrigation districts, as detailed below for the Lerma–Chapala Basin.

The Comisión Nacional de Irrigación in the Lerma–Chapala Basin

The following provides a preliminary sketch of the history of irrigation and water resources development in the basin during the CNI era, primarily based on archive material, without going into the relationships between land reform, agrarian change, and irrigation development. Attention is mainly paid to the creation of the Alto Río Lerma irrigation district (ARLID) in the Middle Lerma region, which was to become the largest irrigation district in the basin, and brief mention is made of developments in the Lower Lerma region. This brings out how the CNI increased its control over water in the basin and set in motion the creation of water overexploitation in the basin.

Heavy rainfall in 1926 led to extensive flooding in the Lerma–Chapala Basin, including all of the Ciénega de Chapala. The CNI immediately focused its attention on the Lerma–Chapala Basin and formed two commissions, led by Pedro Dosal and Luis Ballesteros, to develop plans for the development of irrigation districts and hydropower plants in the basin. In their combined proposal published in 1927, they recommended the construction of the Corrales dam on the Río Lerma on the border between the Middle and Lower Lerma region, to complement the Tepuxtepec dam then under construction on the border of the Upper and Middle Lerma (Cuevas-Bulnes 1941, p. 21). The Corrales dam, with a planned storage capacity of between 750 and 1,500 hm^3, would serve to irrigate the lands of the Lower Lerma region, including the Ciénega de Chapala, and to generate hydropower using the 150 m drop of the Zoró falls on the Río Lerma. They also recommended the construction of a new dam downstream of Tepuxtepec, to store more water for irrigation. It was estimated that 261,000 ha could be irrigated in the basin with surface water if these two new dams were built. Figure 4 presents the area currently irrigated in the basin, and the main irrigation schemes and dams discussed in this article.

A report by a CNI engineer on the possibilities of irrigation development in Guanajuato clearly brings out the hydraulic mission mindset of the CNI in its early days:

> It being the mission of this institution [the CNI] to utilize all the waters in irrigation works or for producing energy, it has focused its attention on the Río Lerma precisely in the stretch that crosses and delimits the state of Guanajuato (…) It can be said of this dam [Tepuxtepec] that it is the first of the works that the [CNI] is studying to

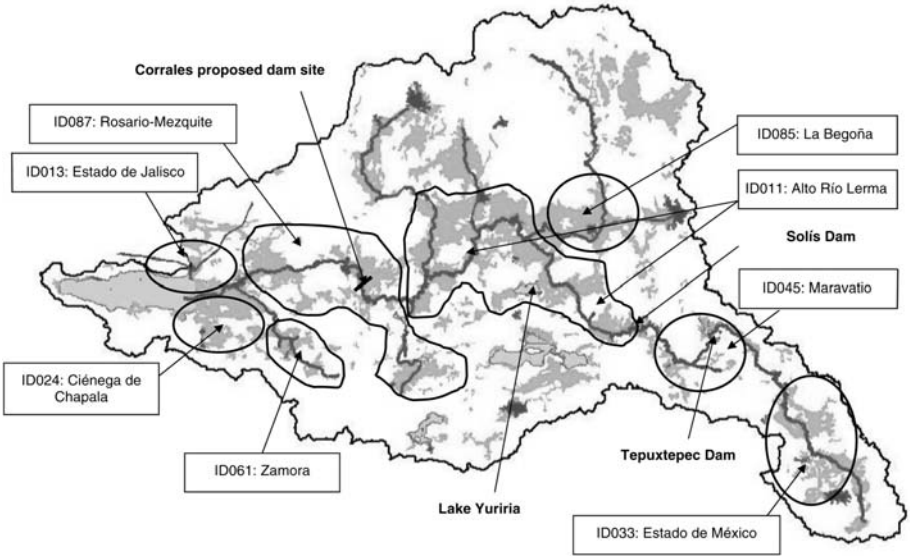

Fig. 4 Main dams and irrigation districts in the Lerma–Chapala Basin

> achieve the most efficient and complete utilization of the waters of the Río Lerma. (Quiros-Martinez 1931, p. 451)[7]

When the CNI presented its master plan, the construction of the Tepuxtepec dam had just started. In October 1926, a contract was signed between SAyF and the Light and Power Company of Southwest Mexico, granting it an annual water concession of 750 hm^3 for hydropower generation and permission to construct the dam. The dam was completed in 1936, with a storage capacity of 370 hm^3 (Santos-Salcedo 1937, p. 157). Between 1970 and 1973, SRH elevated the dam's crest, increasing its storage capacity to 585 hm^3 (Garcia-Huerta 2000, p. 103).

After the construction of the Tepuxtepec dam, the amount of water flowing in the Río Lerma increased during the winter season. This led to an increase in the irrigated area from 36,000 ha in 1927 to 46,575 ha in 1937 in the area that was to become the Alto Río Lerma irrigation district (Santos-Salcedo 1937, p. 160). This increase occurred mainly because the CNI had started rehabilitating the old run-of-the-river canals and constructing new ones on the Río Lerma below the dam. In 1933, the CNI formed the National Irrigation System Number 11 (Alto Río Lerma) to fully develop the lands that could be irrigated with water from the Tepuxtepec dam.

However, this created conflicts with water users on already existing canals, which resisted the intrusion of the CNI. During the 1920s, the Waters Directorate of SAyF had drawn up water distribution regulations for the run-of-the-river canals along the Río

[7] "Siendo la misión de ésta [CNI] aprovechar todas las aguas en obras de riego o producir energía, ha fijado su atención en el río Lerma precisamente en el tramo que cruza y limita el Estado de Guanajuato (…) Esta presa [de Tepuxtepec] se puede decir que es la obra inicial de las que está estudiando la [CNI] para el más eficiente y completo aprovechamiento de las aguas del río Lerma."

Lerma, including the canals of Acámbaro,[8] Valle de Santiago and Jaral de Progreso.[9] For these canals, *Juntas de Aguas* (Water Boards) were established based on the 1926 irrigation law. In November 1933, an agreement was signed between the CNI and the Waters Directorate, in which control over all the irrigated areas from the Tepuxtepec dam to the city of Salamanca were passed to the CNI, to fall under the newly created Alto Río Lerma irrigation district.[10] Through this agreement, the CNI increased its control over an irrigated area that until then had been managed locally for nearly 400 years.

The increasing intrusion of the CNI led to protests from the existing *Juntas de Aguas*. In November 1936, the Acámbaro *Junta de Aguas* wrote a letter to the SAyF minister protesting against the actions of the manager of ID011, José Santos-Salcedo.[11] Their protest was to cost them dearly. In February 1938, the CNI reacted by suspending all the *Juntas de Aguas* and taking over their responsibilities.[12] It was not until the irrigation management transfer program in the 1990s that these *Juntas de Aguas* were reestablished, this time as water user associations. Until then, the hydrocracy controlled the irrigation district, as made abundantly clear in the Regulations of the Alto Río Lerma irrigation district published in March 1939 in the Diario Oficial:

> The Irrigation District will have absolute control over all the existing and to be constructed hydraulic works in its jurisdiction, to utilize in any manner the waters of the Río Lerma, taking charge of the management of the gates [and] the surveillance of the rivers and canals, whether these are federal or private property (…) The control and distribution of the waters of the Río Lerma will be the exclusive charge of the District.[13]

While establishing its control over the run-of-the-river canals, the CNI also started work on the construction of the Solís dam, some 10 km upstream of Acámbaro in Guanajuato. The purpose of this dam was to improve flood control and store the water released from the Tepuxtepec dam (for hydropower generation) for irrigation. After a series of studies, construction of the Solís dam, with a capacity of 800 hm^3, started in 1939 and was completed in 1949. The CNI also built several large new canals to expand the area under irrigation in ID011, especially the Bajo de Salamanca canal that brought 17,000 ha under irrigation. By 1946, the irrigated area in ID011 had increased to 75,860 ha, more than double the area irrigated in 1927 of 36,000 ha when the CNI started to bring the area under

[8] AHA, AS, *Proyecto de Reglamento para la Distribución de las Aguas que se Derivan del río Lerma, Destinados al Riego de Terrenos en la Hacienda de San Cristóbal, Acámbaro, Gto. y para los Canales de Desagüe de los mismos Terrenos de 13 de noviembre de 1925*, Box 1143, File 16004, pp. 159–165.

[9] AHA, AS, *Reglamento para la Distribución de las Aguas del Río Lerma y sus Brazos Llamados "El Arroyo" o "Río Lerma" y "El Arroyito" o "Río de la Zanja", en el Tramo Comprendido entre la Presa de "Lomo de Toro" y el Rancho "La Puerta del Valle", en los Distritos de Jaral del Progreso y Valle de Santiago del Estado de Guanajuato. 30 de julio de 1926*, Box 2488, File 34920, pp. 2–16.

[10] AHA, AS, *Acuerdo a la Comisión Nacional de Irrigación y a la Dirección de Aguas, Tierras y Colonización de 25 de noviembre de 1933*, Box 2279, File 33469, p. 70.

[11] AHA, AS, Box 2406, File 34110, pp. 54–56.

[12] AHA, AS, *Acuerdo del Secretario de Agricultura y Fomento de 25 de febrero de 1938*, Box 2279, File 33469, pp. 264–265.

[13] "El Distrito de Riego tendrá absoluto control sobre todas las obras hidráulicas existentes o que se construyan dentro de su jurisdicción, para aprovechar en qualquier forma las aguas del río Lerma, encargándose del manejo de compuertas, vigilancia en ríos y canales, ya sean estos últimos propiedad federal o particular (…) el control y distribución de las aguas del río Lerma, estará a cargo exclusivo de aquél." in AHA, AS, *Reglamento General para el Distrito de Riego "Alto Río Lerma", Diario Oficial viernes 17 de marzo de 1939*, Box 397, File 7689, pp. 362–363.

its control.[14] By 1940, the CNI had also developed plans for the further expansion of irrigation in the state of Guanajuato, including the construction of the Alto de Salamanca canal (later renamed the Coria canal) to bring 25,000 ha under irrigation and the Begoña dam in the Río Laja to irrigate some 18,000 ha.[15] Due to the first Lake Chapala crisis (see next section), these works were delayed but were completed by the end of the 1970s.

A similar process occurred in the Lower Lerma region, where the CNI took over the control of the Ciénega de Chapala through the construction of irrigation and drainage works under the leadership of Ballesteros. Vargas-González (1993) provides a detailed account of how these developments interrelated with the redistribution of land in the area and how this led to increased federal control over the area. Ballesteros joined the CNI in 1926 as chief engineer of the Lower Lerma region and vigorously promoted the construction of the Corrales dam to increase the irrigated area in the Lower Lerma.[16] After his death in 1932, he was replaced by Elías González-Chávez, who was to play a crucial role in the development of the basin until the end of the 1960s.

In the end, the Corrales dam was not built, initially due to financial constraints and later because it became clear that the proposed dam site was situated on a geological fault. Nonetheless, the water master plan presented by Ballesteros in 1927 was to guide developments in the basin until the late 1970s and most of the works he and his CNI colleagues proposed in the 1930s were eventually constructed. This has led Pérez-Peña (2004, p. 57) to speak of the "Ballesteros school" in the development of the Lerma–Chapala Basin, whose objective was the full utilization of the basin's waters. The leader of the third generation of this school, engineer Francisco de Paula Sandoval eloquently summarized the mindset of the Ballesteros school in an interview with Pérez-Peña in 1999: "The civil engineer has to see to it that all the rivers do not reach the ocean. What does this mean? well to utilize and take advantage of all the water (…) The federal government has to satisfy the demands of the people and to increase production it is necessary to cultivate more [land]" (Pérez-Peña 2004, p. 227).[17]

The above has outlined how the CNI increased its role in water development in the Lerma–Chapala Basin, by taking over the control of irrigation systems that had previously been managed locally, through both legal means and through the construction of hydraulic infrastructure. This was most apparent in the Middle Lerma region, where through the creation and expansion of the Alto Río Lerma irrigation district the CNI incorporated the existing, dispersed run-of-the-river irrigation systems in the Bajío and replaced them with a centrally controlled grid of irrigation canals fed by the Solís dam. Especially, the dissolution of the *Juntas de Aguas* in ID011 was a harbinger of the highly centralized water control that was to develop after the 1940s. The land reform program partly helped the CNI in establishing its control, but a stronger drive was its hydraulic mission to make good the promises of the revolution by developing "revolutionary irrigation." This mission was to

[14] AHA, Consultivo Técnico (CT), *Distrito de Riego del Alto Lerma, Mich. Y Gto.*, Box 211, File 1839, pp. 203–214.

[15] AHA, CT, *Proyectos de Riego en el Estado de Guanajuato mediante Obras de Grande Irrigación*, Box 211, File 1839, pp. 132–133.

[16] AHA, CT, *Observaciones y rectificaciones al estudio que sobre aguas disponibles en el río Lerma en "Los Corrales", se presentó el 21 de agusto de 1930* by Luis P. Ballesteros, Box 238, File 1966, pp. 343–352.

[17] "El ing. civil tiene que encargarse de que todos los ríos no lleguen al mar. [¿que quería decir? pues aprovechar toda el agua] (…) El gobierno federal tiene que satisfacer las necesidades de la gente y para aumentar la producción necesita sembrar más."

reach its zenith between 1946 and 1976, with the creation of the SRH and the continued expansion of the irrigation frontier in the Lerma–Chapala Basin.

The zenith of the hydraulic mission: SRH and river basin development

During the 1940s, the concept of river basins as a unit of development started to gain force in Mexico, based on the Tennessee Valley Authority (TVA) model and the flooding of around half a million hectares in the Papaloapan Basin in 1944. Based on a study of this disaster, the CNI suggested that the problems of this region needed to be tackled in a unified manner, through the construction of dams on the principal tributaries and embankments along the length of the main trunk of the river (Poleman 1964). During the election campaign of Miguel Alemán in 1946, the CNI successfully lobbied the presidential candidate to initiate projects for regional development in various Mexican river basins and to form an overarching ministry of water resources. Directly after Alemán became president this happened, with the creation of the SRH in December 1946 to replace the CNI. This was a pioneering move in many respects and was the first time water resources was elevated to the level of a ministry in the Western Hemisphere. The objective of the SRH was the comprehensive development of water resources and the concentration of the government's efforts in this field in a single organization.

Along with the concentration of water resources development in the SRH, river basin commissions were created by presidential decrees between 1947 and 1950 for several of Mexico's key basins, such as the Papaloapan, Tepalcatepec, Fuerte, and Grijalva (Barkin and King 1970). These commissions were to pursue comprehensive river basin development, based on the TVA model, with the SRH minister as their president. The emphasis on comprehensive river basin development was to characterize the zenith of the hydraulic mission. From 1946 to 1976, the SRH vastly expanded its activities and mandate, with the river basin commissions serving to bypass state governments and other federal agencies. In the Lerma–Chapala Basin, the hydraulic mission of the SRH led to the creation of water overexploitation, although it was clear that the basin had already reached its limits of water availability during the first Lake Chapala crisis from 1945 to 1958. The following sketches the developments in the basin during the SRH era, focusing on the Lerma–Chapala–Santiago study commission and the first Lake Chapala crisis.

The Lerma–Chapala–Santiago study commission

In 1950, the SRH formed the Lerma–Chapala–Santiago Basin study commission. This was strongly related to the first Lake Chapala crisis. In April 1947, the lake dropped below cota 95.15, at which point water no longer flows to the Río Santiago, for the first time since 1916. Hence, the three hydropower plants on the Río Santiago that depended on Lake Chapala had to frequently stop operating. As these plants, owned by the *Nueva Compañía Eléctrica Chapala* (New Electricity Company of Chapala),[18] were the only source of electricity for Guadalajara, this led to strong demands from industrialists and the inhabitants of Guadalajara that the lake should be kept full by restricting irrigation in the basin. According to Alba (1988, p. 164), by 1950, the federal government was under intense

[18] This private company was formed after the Revolution based on Cuesta-Gallardo's company, with a U.S. citizen holding most of the shares (de Paula Sandoval 1981). In 1941, the *Comisión Federal de Electricidad* (CFE; Federal Electricity Commission) became the major shareholder of the company.

pressure from interest groups and the basin states to solve the Lake Chapala crisis. In Guadalajara, a media campaign had started against the SRH, blaming the problems of the Lake on the inter-basin water transfers to Mexico City and the completion of the Solís Dam in 1949 (Estrada 1994, p. 11, unpublished document).

This led Orive-Alba, the SRH minister, to form a commission consisting of respected engineers from the basin to study the problems of the basin and to provide a political space where the states could vent their differences and arrive at agreements (Santos 2006, p. 32). In its founding charter of November 28, 1950, the commission was defined as a SRH study commission consisting of representatives from the Federal District and the states of Mexico, Guanajuato, Michoacán, Jalisco, and Nayarit.[19] The SRH representative and chairman of the commission was Antonio Rodríguez-Langoné, SRH director of water development,[20], while Elías González-Chávez, SRH chief engineer of the Bajo Lerma irrigation district, and Andrés García-Quintero, SRH director of hydrology, were designated as technical advisors to the commission.[21] A very young Francisco de Paula Sandoval was appointed as the Jalisco representative. In addition, two of the state representatives (Serrano for Guanajuato and Becerril-Colín for Mexico) had been executive directors of the CNI. This commission of senior hydrocrats, all linked to the SRH, set themselves the task:

> (…) to achieve a complete regularization of the existing water use systems [in the basin] and a better planning of those that can be realized in the future; arrive at a full understanding of the available water resources and their potential; and effectuate a more equitable water distribution in the basin through an adequate and combined operation [of existing infrastructure]. (Vallejo-Ivens 1963, p. 5)[22]

The focus of the study commission was the river basin as a unit for planning the comprehensive development of water resources. Its aim was to fully utilize the basin's water, working over the heads of the states in the basin. The commission immediately set to work and made its first recommendations in September 1951. In the same month, the Mexican president charged González-Chávez with water allocation at the basin level and the operation of the hydraulic infrastructure (Estrada 1994, unpublished document). In a report published in December 1953, the commission sets forth its recommendations for solving the lack of hydropower and for fully utilizing the basin's water (SRH 1953). The commission proposed the construction of a large hydropower dam on the Río Santiago downstream of the confluence of several of its tributaries, to replace the plants that depended on Lake Chapala. It also strongly recommended the construction of the Corrales dam on the Río Lerma, originally proposed by Ballesteros in 1927, with a storage capacity of 500 hm^3, and the construction of the La Begoña dam on the Río Laja with a capacity of

[19] The states of Querétaro, Aguascalientes, Zacatecas, and Durango were not included in the commission, although parts of these states fall in the Lerma–Chapala–Santiago Basin. See AHA, AS, *Acta constitutiva de la Comisión Lerma-Chapala-Santiago*, Box 3085, File 42611, pp. 2–4.

[20] This was the only river basin commission in Mexico whose chairman was not the SRH minister. Estrada (1994, p. 12, unpublished document) suggests that Orive-Alba intentionally distanced himself from the commission so he would no longer be the target of media attacks.

[21] AHA, AS, *Acta constitutiva de la Comisión Lerma-Chapala-Santiago*, Box 3085, File 42611, pp. 2–4.

[22] "(…) lograr una completa reglamentación de los aprovechamientos hidráulicas existentes y una mejor planeación de los que en el futuro se pudieran realizar; para llegar a un conocimiento pleno de las posibilidades y recursos disponibles, y para poder realizar mediante una operación de conjunto adecuada una más equitativa distribución de las aguas."

180 hm^3. Its other proposals consisted of plans to drain lakes throughout the basin to "suppress unnecessary evaporation." Thus, the commission recommended constructing a 20-km long and 6-m high embankment in Lake Chapala to reclaim 25,000 ha for agriculture. It also recommended draining Lake Cuitzeo by constructing a canal connecting it to the Río Lerma, thus reclaiming 45,000 ha for agriculture, and draining Lake Yuriria, to reclaim 7,000 ha (SRH 1953, p. 41). Besides these dam and land reclamation projects, the commission recommended executing more studies that would make it possible to:

> Propose the best solution for the basic hydrological problems in the Basin, including: (…) The rational utilization of the available surface water (…) to allocate the largest possible volume of water to irrigation, (…) increasing to 300,000 ha those 116,000 ha that currently receive irrigation. (SRH 1953, p. 42)[23]

Although the execution of its plans would have a devastating effect on Lake Chapala, there was no disagreement in the commission on the desirability of these plans. The hydraulic mission was clearly in high gear. However, a contentious issue that the commission had to deal with was the sinking of deep tubewells near the headwaters of the Río Lerma to supply drinking water to Mexico City. In the 1940s, work had started on canalizing the mountain streams feeding the Río Lerma and transferring this water to Mexico City through a tunnel. This inter-basin transfer went into operation in 1949, but in addition, it was proposed to sink deep tubewells near the Lagunas de Lerma to augment the supply to Mexico City. The representative of the state of Mexico in the study commission strongly opposed this project (Santos 2006, p. 33). Guanajuato's representative also opposed the inter-basin transfer, arguing it would have negative consequences for agriculture in Guanajuato. However, the government of the Federal District persevered and succeeded in increasing the number of groundwater wells surrounding the Lerma wetlands. In the early 1950s, some 4 m^3/s (126 hm^3/year) were transferred to Mexico City, increasing to 10 m^3/s (315 hm^3/year) by the 1970s (Alba 1988, p. 163). These transfers affected the hydrologic cycle of the basin by sucking dry the Río Lerma at its headwaters. After the inter-basin transfer started, the Lagunas and wetlands quickly fell dry, to only partly fill during the rainy season. Another, even more contentious, issue the study commission had to deal with was the sharp drop in the water levels in Lake Chapala. It had largely been created in 1950 to deal with this crisis, but as the following shows, in many ways its actions made the crisis worse.

The first Lake Chapala crisis (1945–1958)

From 1945 onward, a period of lower than average rainfall,[24] combined with extractions from Lake Chapala for hydropower generation (520 hm^3/year), resulted in the first Lake Chapala crisis (the second occurring in the 1990s, see Wester et al. 2008). The response of the federal government to this crisis was strongly influenced by the hydraulic mission mindset of the time and primarily consisted of efforts to secure the water supply of the hydropower plants operated by the Eléctrica Chapala company on the Río Santiago. The

[23] "Proponer la mejor solución de los problemas hidrológicos básicos dentro de la Cuenca General que son: (…) Utilización racional de las aguas superficiales disponibles (…) para destinar al riego el mayor volumen de agua que sea posible, (…) aumentándose a 300,000 hectáreas las 116,000 que ahora lo reciben."

[24] Average rainfall from 1935 to 1944 was 683 mm in the Lerma–Chapala Basin, while from 1945 to 1958 it was 626 mm (de Paula Sandoval 1994).

hydrocracy blamed the desiccation of the lake on the drought and the high levels of evaporation from the lake (de Paula Sandoval 1981). However, the extractions from the lake by the Eléctrica Chapala company of some 520 hm^3 a year, combined with 215 hm^3 for irrigation, contributed strongly to the decline of the lake. Without these abstractions, the lake would not have fallen below cota 96.00 throughout the 1945–1958 period (de Paula Sandoval 1994). The efforts of the SRH and the Lerma–Chapala–Santiago study commission focused on ensuring these abstractions, by a succession of hydraulic interventions in the lake.

A civil protest movement developed in Guadalajara during the first Lake Chapala crisis that went against the hydraulic mission of the SRH. Pérez-Peña (2004) provides a detailed account of the origin and activities of the *Comité de Defensa del Lago Chapala* (Committee for the Defense of Lake Chapala). This committee initially consisted of four people and was formed to protest the December 18, 1953 presidential decree that authorized the Lerma–Chapala–Santiago commission to reduce the size of the lake by 18,000 ha. In January 1954, the committee sent an open letter to the president requesting the withdrawal of his decree. Throughout 1954, a range of academics, intellectuals, and influential politicians, including José Guadalupe Zuno, an ex-governor of Jalisco, joined the committee and pressured the Jalisco governor to stop the desiccation of the lake. Due to the pressure of the committee, the implementation of the presidential decree was stopped (and finally revoked in 1983). With the recovery of the lake in 1955, the activity of the committee lessened, and by 1958, it had faded away (Pérez-Peña 2004).

Although the Lerma–Chapala–Santiago commission failed to construct a new embankment in Lake Chapala, it did sow the seeds for the second Lake Chapala crisis, by making the decision to use Lake Chapala for Guadalajara's water supply. In 1953, at the height of the first Lake Chapala crisis, the Lerma–Chapala–Santiago commission started work on developing the Atequiza-Las Pintas aqueduct to withdraw water from Lake Chapala for Guadalajara. The aqueduct's starting point was the Ocotlán pumping station, which pumped water from Lake Chapala into the Santiago River, from where it flowed 40 km to the Atequiza canal. At the end of the Atequiza canal, water was pumped up 22 m to the newly dug Las Pintas canal (25 km long), that brought the water to the city's main water supply system. The initial capacity of this work was 1 m^3/s, but this was later increased to 9 m^3/s. It entered into operation in 1956, when the lake had nearly completely dried up (de Paula Sandoval 1981, p. 48).

In 1955, the drought peaked and in July 1955, the lake dropped to its lowest recorded level, namely cota 90.8 (954 hm^3). The pumping station in Ocotlán had to stop operating frequently, and electricity supply to Guadalajara became very erratic. However, very good rains in the autumn brought relief and the lake recovered sufficiently for electricity production to restart. By 1958, the lake had again dropped dangerously low, but another autumn of very good rainfall caused it to recover by nearly 5 m, and the lake remained relatively full until 1979. The heavy rains of 1958 caused extensive flooding in the basin and very nearly led to the failure of the Solís dam. The spillway of the dam was seriously damaged and piping at the downstream base of the dam raised serious concerns. As a result, between 1958 and 1982, Solís dam was not filled to its full storage level but kept around 500 hm^3. The water in excess of this storage was passed on to Lake Chapala until 1982, when the reconstruction of Solís dam was completed.

Although the first Lake Chapala crisis had demonstrated that the basin had already reached its limits concerning water availability, the construction of new dams and the expansion of the irrigation frontier throughout the basin continued unabated during the 1960s and 1970s. Many of the works planned by the commission in 1953 were

constructed by the SRH, and groundwater irrigation became increasingly important. The dam storage capacity in the basin more than doubled from 1,817 hm^3 in 1959 to 3,840 hm^3 in 1979, the largest increase in the history of the basin (de Paula Sandoval 1994), while the irrigated area grew from 390,000 ha in 1960 to 640,000 ha in 1980 (Estrada 1994, unpublished document). The details of these developments will not be recounted here, but they clearly bring out that the hydrocracy took little heed of the warning of the first Lake Chapala crisis, but rather took it as an affirmation of its hydraulic mission to fully develop the water resources of the basin. Having served its purpose, the Lerma–Chapala–Santiago commission was disbanded in November 1970, after González-Chávez had retired in 1968.

Conclusions

The hydraulic mission of the Mexican hydrocracy was to achieve the fullest utilization of water for the greatness of Mexico. The large investments by the post-revolutionary governments in water resources development led to the emergence and expansion of a highly competent hydrocracy, with good data processing capabilities and dedicated staff. In the Lerma–Chapala Basin, its hydraulic mission led to the creation of water overexploitation through the construction of dams, irrigation systems, and modifications to Lake Chapala. This was not an unforeseen side effect, but as this article has shown the deliberate intent of the hydrocrats working in the basin. Every drop of water evaporating from Lake Chapala or flowing to the ocean was seen as a "loss" that needed to be captured for human uses.

Two points of relevance to the Lerma–Chapala Basin brought out by this article are that Lake Chapala did not fall dry in the 1890s and that the first Lake Chapala crisis would not have occurred if no abstractions from the lake for hydropower generation had taken place. Both these points are important, as throughout the years hydrocrats have suggested that the cyclical declines in Lake Chapala were due to years of drought. While years of less rainfall obviously lead to less inflow to the lake, the historical record shows that the lake did not fall dry in the 1890s, while the abstraction of 750 $hm^3\ a^{-1}$ from the lake during the 1940s and 1950s clearly caused the first Lake Chapala crisis. Blaming river basin closure on a drought is a convenient strategy to hide the responsibility of the hydrocracy in the creation of water overexploitation and to continue with the hydraulic mission, thus creating even larger problems in the future.

The processes leading to the "overbuilding" of river basins have been analyzed in detail by Molle (2006, 2008), and are confirmed by this article. As in many other countries (cf. Ertsen 2007; Molle 2006; Reisner 1993; Worster 1985), a highly centralized form of water resources development emerged and grew in Mexico, based on the hydraulic mission and a high-modernist worldview. What was characteristic for Mexico was the importance of "revolutionary" irrigation for post-revolutionary state formation and the very strong position its hydrocracy developed in the federal government. The material presented in this article is insufficient to argue that the hydraulic mission and centralization necessarily go together, but it does show that centralization occurred and that the increased federal control over water and the hydraulic mission of the hydrocracy led to the creation of water overexploitation in the Lerma–Chapala Basin.

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