

# Water Control and Settlement in Colonial Mexico's First Frontier: The Bordo System of the Eastern Bajío

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## Abstract

The sequence of human adaptation, whereby Spanish culture reacted to and integrated with indigenous cultures and the frontier environment led to the development of new water control systems in colonial Mexico. The *bordo* system, comprised of embanked fields and canals, played a major role in the establishment and movement of settlements northward from the valley of Mexico throughout the colonial period. In the high altitude alluvial valleys north of Mexico City, known as the Bajío, these systems created an agricultural center of major importance to central and northern Mexico. The design, development, and operation of the colonial water control systems in the eastern Bajío, can be reconstructed in part from: (1) survey and mapping of extant colonial water control systems, (2) collection of oral histories from individuals with knowledge of traditional colonial land use practices, and (3) examination of colonial illustrations. Combined with a synthesis of previously published materials, these data provide a diachronic picture of landuse in Mexico's first colonial frontier.

Key words: *Archivo General de la Nación, Bajío, bordo, frontier, oral history, water control.*

## INTRODUCTION

European settlers on the northern frontier of New Spain suddenly and radically changed the environment of the region known as the Bajío (Figure 1). Central to this transformation was the introduction of water control technologies. The development of new agricultural systems that included (canals), *cajas* (water storage boxes), and embanked and flooded fields (*bordos*) established an historical trajectory of land use and water rights that persisted for more than four centuries and had specific and significant impacts on both economy and society in the region. (Chevalier 1963, 64-66; Murphy 1986).

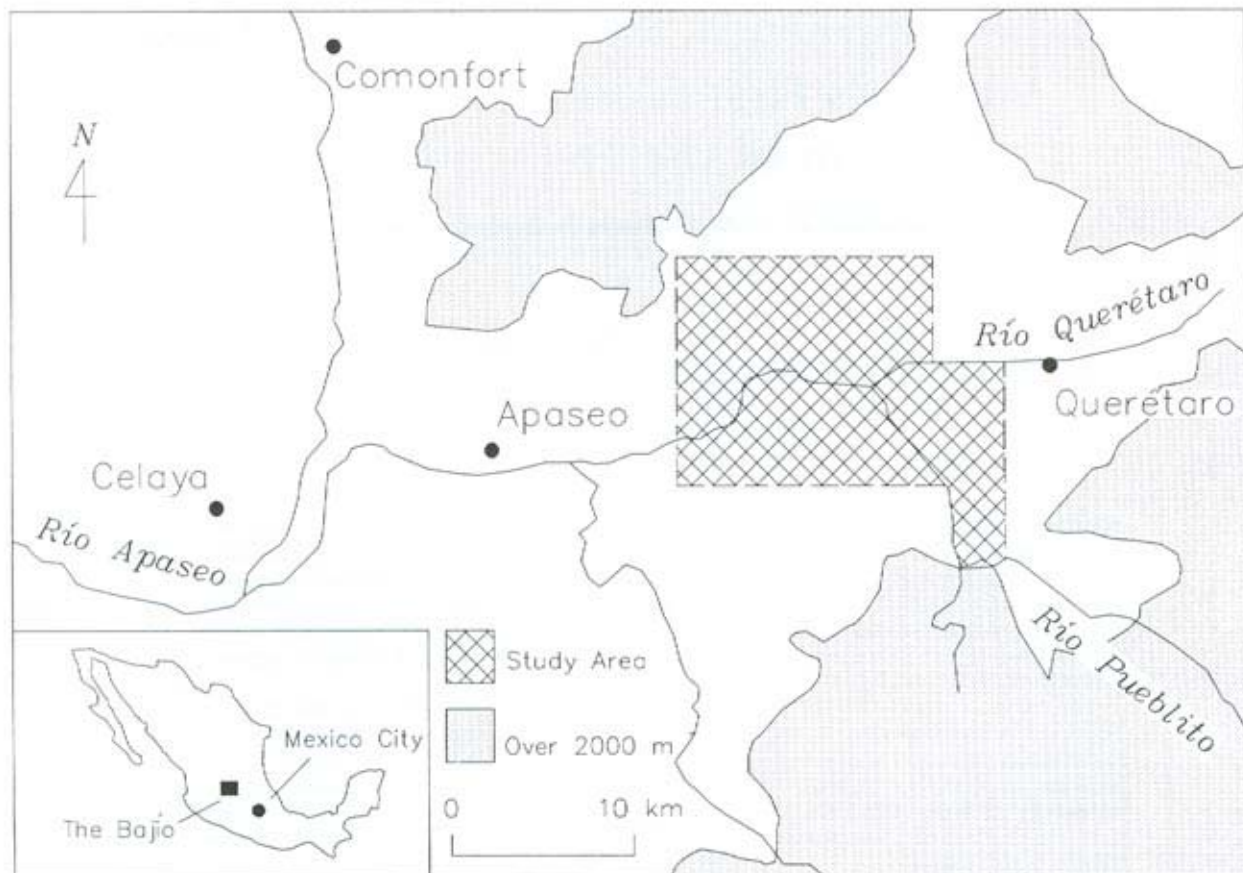


Fig. 1. The eastern Bajío and vicinity. The lowland *bordos* and irrigated fields described in this paper occupy the crosshatched area.

For example, in the early 16th century when few dams or irrigation canals existed, maize (corn) was grown widely and used primarily for subsistence purposes by Spaniards as well as Indians living in a few small towns or villages (Simpson 1950, 159; Brading 1978, 39). In contrast, by the 18th century, water storage boxes and embanked fields were common and the population was quite large. Spanish, Indians, Blacks, and mixed races resided mainly in large towns or small cities surrounded by large commercial landholdings (Brading 1978, 44-47; Murphy 1986, 5-8). During this period, wheat and other cash crops were shipped to markets in the northern mining centers and to the rapidly expanding Mexico City (Chevalier 1963, 117; Brading 1978, 61). The colonial settlements of the Querétaro/ Apaseo valleys of the eastern Bajío were in the heart of this frontier enterprise.

Measuring changes in past landuse is a difficult task. Previous studies of the Bajío centered on aspects of economic production (Brading 1978), class structure (Wolf and Palerm 1955), and water rights (Murphy 1986), but overlooked the importance of landuse change and water control. Investigations of archival records by Simpson (1950), Brading (1978), and Murphy (1986), have shown that colonial records provide incomplete temporal and spatial information on landuse change. While local and national archives are often extensive in their coverage of landuse during the colonial period, they provide few clues as to how irrigation systems were designed, built, and functioned.

This paper combines a geographical synthesis of existing knowledge on landuse change in the eastern Bajío, with preliminary data on the operation, design, and evolution of embanked fields systems and canals collected during two years of field research.<sup>1</sup> The chronology and patterns of water control suggested by this paper are the result of three methodological approaches: (1) survey and mapping of extant landscape

features, (2) the collection of oral histories from individuals with "in situ" knowledge of colonial water use practices, and (3) examination of colonial illustrations in the Tierras (Lands) volumes of the National Archives of Mexico. This research suggests that the *bordo* systems of embanked and flooded fields were in operation by the middle of the 17th-century in the Querétaro/ Apaseo Valley (Davis and Moguel 1989, 44-50) and continued to operate essentially unchanged through the early 20th-century.

## **RESEARCH GOALS AND METHODOLOGY**

The goal of this research is to address fundamental questions of how Old World information and technology were selected and modified to create new agrarian communities in central Mexico. The study examines the historical development (AD 1531-1910) of water control systems of communities surrounding the colonial cities of Querétaro and Celaya in the Querétaro and lower Laja river valleys respectively, and how diachronically the communities and water control practices interacted to produce specific agronomic systems. This type of reconstruction has been effectively carried out by geographers such as Butzer (1985) and Doolittle (1984).

The research goal includes four specific areas of investigation: (1) extant colonial water systems on the landscape in the Querétaro/ Apaseo and lower Laja river valleys (eastern Bajío), (2) the history and location of colonial communities in the eastern Bajío, (3) archival illustrations of land use in the eastern Bajío and adjacent gateway communities, and (4) traditional land and water-use practices in the 19th and 20th century. Objectives of the research are as follows: (1) produce a series of chronological maps for the region indicating where the water control systems and communities were located, (2) locate and map critical colonial land use features and community types, (3) interview members of hacienda communities with knowledge of local, traditional agricultural practices, (4) map in detail the embanked field systems in the region, and (5) describe and analyze colonial illustrations and their accompanying text from the Tierras (Lands) volumes of the Archivo General de Nación in Mexico City.

During the months of February through September of 1988, colonial water control features (canals, dams, reservoirs, terraces, embanked fields, *norias* (wells), and aqueducts) were mapped, photographed, and drawn in the Querétaro and lower Laja valleys. The boundaries of the 1:50,000 map covering Querétaro and the eastern Bajío (INAH 1986, F-14-C-65) were used to set the limits for survey and mapping (the rectangular area shown in Fig. 1). This area encompasses approximately 967 square kilometers. The identification and location of water control features was accomplished by combining intensive ground survey with black and white aerial photography (1:20,000). Colonial landscape features were placed directly onto an enlarged mosaic of the air photos and then located on largescale topographic maps.

From May 1989 to June 1990, 13 interviews with 10 long-term members of colonial haciendas, were recorded on tape. These provided 14 hours of oral history which were recorded, transcribed and translated. Informants were selected vis-a-vis preliminary interviews based on the depth of their knowledge of colonial agricultural practices and irrigation systems. Final interviews were directed toward answering questions on traditional agricultural practices, hacienda life, and the operation, design, and construction of colonial irrigation systems. Oral history interviews were carried out by myself and at least one other member of the local community who aided in translation. These interviews provide data on the operation of *bordo* systems, originally constructed during the colonial period. Cross-checking the information on the operation of such systems with the informants' parents and grandparents, pushed the knowledge of traditional water control practices back to at least the mid-1800s.

Illustrations contained in the Tierras volumes contain a wealth of information on the design and operation of water control systems in the eastern Bajío. Murphy (1986) and Wobeser (1983) used examples from these volumes but failed to provide the kind of complete regional coverage contained in the volumes. At the present time, 89 illustrations and accompanying text are being analyzed and described from the eastern Bajío and the San Juan Del Río and Acámbaro regions.

## **ENVIRONMENT AND SETTLEMENT IN THE EASTERN BAJIO**

The Bajío is a high (1,800-2,100 m) alluvium filled basin consisting of a number of ancient lakebeds with grasslands, marshes, and rolling, cactus-studded hills immediately north of the Valley of Mexico. Within ten years of the collapse of the Aztec capital at Tenochtitlán the region became a major center of frontier settlement for Spanish and Spanish allied Indians seeking agricultural and pastoral lands (Murphy 1986; Brading 1978, 13). The hand-in-hand movement of Spanish and Indians in the settlement, pacification, and development of the Bajío rapidly changed its character. This change was led by the initiation of irrigation practices (Murphy 1986,89) and the formation of livestock ranches (Brading 1978). Wheat, cattle, and sheep production dramatically restructured the use of land and water in these low-lying uplands and gave definition to the word Bajío as this region came to be known in the 18th century.

The flat, narrow, interconnected valleys of the eastern Bajío are old lakebeds formed by the enclosure of drainage patterns by volcanic activity during the early Cretaceous period. Alluvial and lacustrine deposits often exceed 300 meters in thickness (Waitz 1943,123). Perennial springs are common inside and at the entrance to canyons, and on the rolling upland slopes surrounding the valleys. The locations of springs in defensible uplands close to the rich vertisolic soils of the old lakebeds were the favored sites of both colonial and pre-Columbian frontier settlement (Davis and Moguel 1989, 32-34).

The climate is moderately arid with a mean annual precipitation of 650 mm. Eighty-five percent of the annual rainfall occurs in the months of June, July, and August. Northers occasionally bring rain in the winter months. High thermal activity, high winds, and low relative humidity produce a high evapotranspiration rate which leads to water stress in the spring when water tables are lowest and no rainfall is available (Síntesis Geográfica del Estado de Querétaro 1986, 9-28). Dry farming in this type of climate was a risky venture and therefore limited proto-historic and historic settlement to the terraces of perennial water sources.

The hills surrounding the valleys consist of moderately steep topography with mixed cactus and grass vegetation, and thin soils interspersed with pockets of moderately rich soils. Rainfall quickly runs off these slopes frequently creating flash floods and overbank events. The location of springs along the ridges and the shallow depth of ground water made it possible for proto-historic peoples to cultivate maize, and for early colonial settlers to establish secure ranches on which cattle and sheep could easily be penned and provided with sufficient water (Butzer 1989,91-122).

The eastern valleys of the Bajío are located adjacent to the western slope of the Sierra Gorda divide (Sierra Madre Oriental). These slopes are drained westward by the Río Querétaro and Río Pueblito which combine near Apaseo to form the Río Apaseo. The much larger Río Laja drains the northern uplands of the Bajío to join the Río Apaseo near Celaya (Figure 1). It was along the Río Apaseo, near Celaya, that the Spanish *encomendero* Hernán Pérez de Bocanegra, established mid-16th century settlements from his base in Acámbaro (Murphy 1986, 9). Replete with diverse types and scales of irrigation systems by the 17th century and dominated by systems of embanked fields by the end of the 18th century, these valleys were the most densely occupied region of the Bajío during the colonial period.

### **FRONTIER SETTLEMENT IN THE BAJIO**

The Bajío was not only a frontier for Spanish colonial settlement but also the frontier for indigenous populations. It was generally occupied at the time of contact by nomadic or semi-nomadic groups of warlike Indians, called collectively Chichimecas by the Spanish. These Indians were hostile to both Spanish and central Mexican Indians (Wright 1988, 20). Although village and pyramid sites of previous sedentary groups exist in the Bajío, their final abandonment seems to have taken place by A.D. 1100. Archaeological evidence from Preclassic times onward indicates that the Bajío has experienced a number of frontier recessions and advances (Braniff 1974, 40; Brown 1985, 219), in no small part a function of raids on Bajío settlements by peoples from the north.

The general lack of settled populations and Spanish pressure on populations in and surrounding the Valley of Mexico prompted the movement of settled Indians, such as the Otomí speakers of Jilotepec, Purepechas (Tarascans) from Michoacán, and a few Nahuatl speakers from the Valley of Mexico into the Bajío in the

early 16th century. By the middle of the 16th century the Spanish-allied Otomí speakers, whose settlements surrounded the eastern and southern Chichimec frontier, were well-established in the eastern Bajío (Brading 1978, IS). Often Indian movement was accompanied by Spanish explorers seeking lands for the production of Old World fruits, grains, and livestock, and grants of tribute from settled indigenous populations (Murrphy 1986, 9-118).

In the latter half of the 16th century and continuing through the 18th century the Bajío's change in character was accelerated by the opening of the mines in Zacatecas, Guanajuato, and San Luis Potosí as well as by the increasing population of Mexico City and other communities which sought the wheat and livestock produced in the Bajío. By the end of the 16th century these communities were neither Spanish nor Indian but wholly Mexican. Land accumulation and ownership (*hacienda*) insured the economic growth of this new style of community (Chevalier 1963, 117)

By the end of the 18th century the landscape of the Bajío was blanketed by embanked fields, dams, and canals providing water for crops, animals, and humans. Embanked fields for storage of water and the flooding of fields, expanded in scale and began to encroach on each other and on competing land use practices (Davis and Moguel 1989). As a result, regulation of water became a necessity and concern for all communities in the Bajío, and was especially important in the heavily settled eastern region of the Bajío.

### **EVOLUTION OF THE BORDO SYSTEM**

Early settlers in the eastern Bajío found that livestock, crops, and humans had insufficient water to survive through the dry months that generally occurred from December through April. This forced the construction of small earthen ponds (*jagueyes*) and tanks (*cajas*) for the storage of rainfall that occurred primarily in the months of June, July, and August. The experience of drought years forced the construction of much larger water storage units (*embalsas*) in the form of masonry dams which sealed off and filled up narrow arroyos and valleys. These reservoirs held sufficient water to ameliorate drought years (Davis and Moguel 1989, 46-50).

While maize was the dominant food crop of these early settlers they also experimented with the growing of wheat, the preferred Spanish staple, and with the raising of irrigated crops during the autumn, winter, and early spring. Maize must have proved to be an unacceptable crop for autumn or winter as it is (Murphy 1986, 119) highly sensitive to frosts. However, its drought-resistant qualities made it easy to begin planting in March or April with harvests taking place in December or January. Wheat production proved to be considerably more problematic. Early farmers undoubtedly experimented with growing wheat during the same growing cycle as maize, but the drought sensitivity of the plant precluded it being planted before May. As a result farmers would have experienced a number of difficulties with the planting of wheat in May or June including crop damage by disease and thunderstorm activity during the months of June, July, and August. In addition frequent droughts would have led to loss of the wheat crop during the summer or crop failure in autumn.

By the late 16th century farmers along the flood-plains of perennial water courses such as the Río Laja and Río Apaseo were irrigating wheat during the winter by constructing earthen diversion dams across river courses and diverting water into canals and old river channels for distribution to river terrace farms. The ability of irrigated wheat to withstand frost and produce phenomenal yields quickly made the eastern Bajío a center of production. These systems were extensive along the Río Laja and Río Apaseo/Querétaro by the end of the 16th century. The increasing demands by Mexico City and the northern mines kept wheat prices high during the 17th century (Brading 1978, 174) and allowed a great number of the early farmers to increase their land holdings and to expand water control systems. However, the occurrence of droughts and the reduced water flows due to diversion of waters for irrigation was limiting expansion of wheat fields by the end of the 17th century (Murphy 1986, 23).

The amount of land that early colonial farmers could irrigate and farm effectively on the upland areas surrounding the Bajío was limited by the generally poor quality of its soils and the degree of slope.

However pockets of good soils with little slope were put into production where possible. Expansion into the uplands of the Bajío took place as early as the beginning of the 17th century when farmer/ranchers in upland areas of the eastern Bajío began constructing large masonry dams for water storage (Murphy 1986, 110) making it possible to supply increasing herds of cattle and sheep with water during the winter. Upland settlers also used captured runoff to irrigate small wheat fields in the winter and stockpiled it for release during periods of drought.

By the mid-1600s the wheat farmers in the river valleys of the eastern Bajío began expanding their original holdings into medium-sized haciendas and a few great estates. However, land expansion during this period was not followed by grants of water, as had been the case in the 16th century when water was diverted directly from rivers to the fields. Yet, the production of wheat increased and more and more fields were put into production. The explanation for this phenomenon lies in the existence of water storage units or *cajas* and the existence of *bordos* near Celaya by 1632. The diversion of water into storage tanks did not require grants of water and, therefore, made it easy to open up new lands to irrigation that previously suffered either from insufficient water or the lack of available water grants (Murphy 1986, 22-23).

During the 18th century, the use of water storage systems (*cajas*) spread rapidly across the flat lands of the eastern Bajío, while gradual expansion in the rolling uplands continued. The flatland *cajas*, which apparently evolved out of the upland *jagueyes*, further evolved on the plains of the Bajío to become systems of interconnected and interrelated embanked and flooded fields that became known as *bordos*.

### **BORDO IRRIGATION IN THE EASTERN BAJIO**

By the end of the 18th century the interconnected valleys of the Rio Querétaro, Rio Pueblito, and the Rio Apaseo were covered with embanked fields used for water storage and flood-water farming (Figures. 2 and 3). It is clear from the oral histories that embanked and flooded fields served two purposes. The first was water storage for canal irrigation. Rainfall and runoff captured by *bordos* during the summer and early winter months was released to non-embanked fields in the winter and spring. Water not used during spring planting was released to fields during the summer if rainfall amounts were insufficient to sustain maize crops. Secondly, *bordos* functioned as flooded fields, primarily in the dry winter months, but also any time that water was available for crops farmed inside the *bordos*.

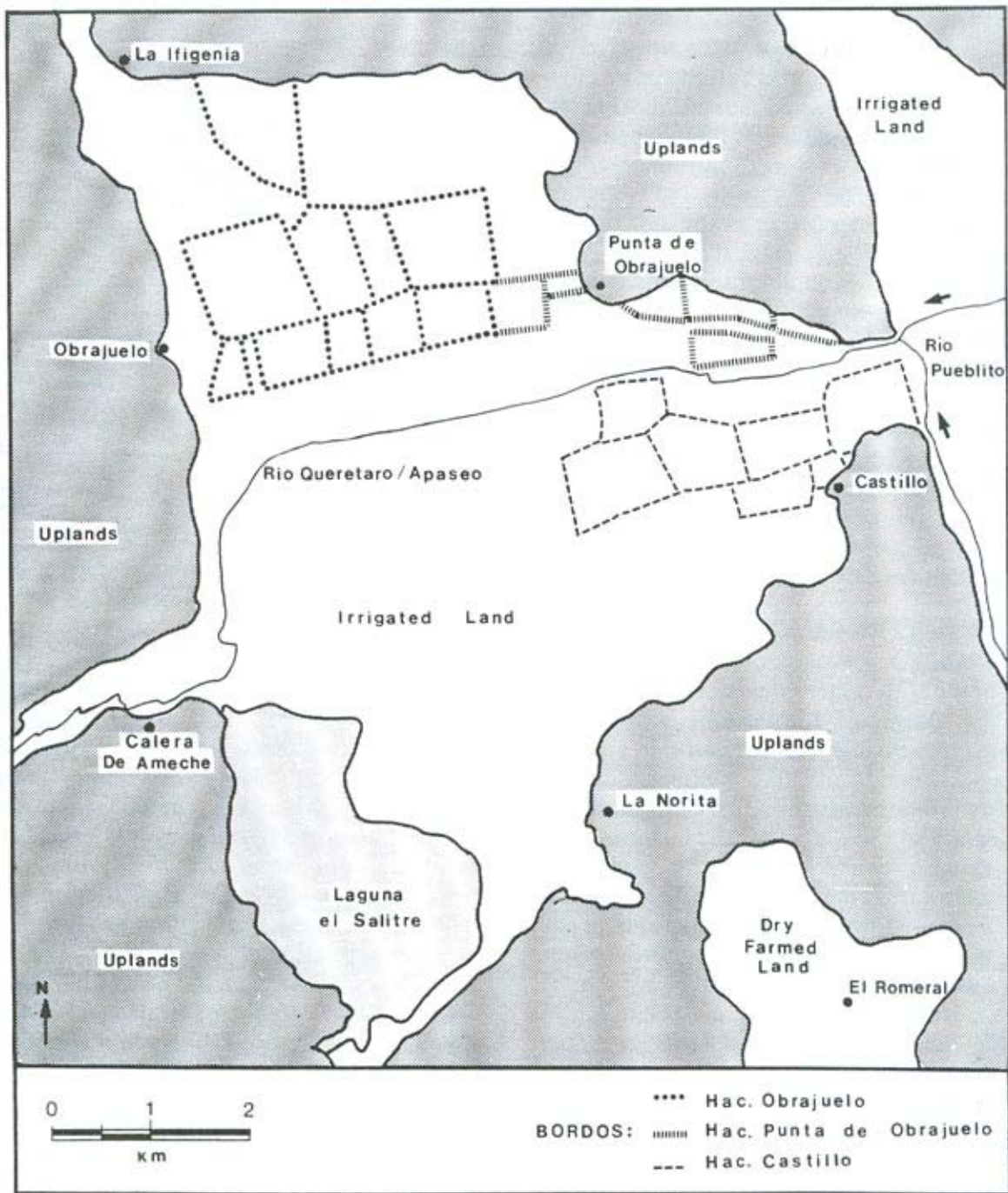


Fig. 2. The embanked fields and irrigated lands of haciendas Castillo, Obrajuelo, and Punta de Obrajuelo.

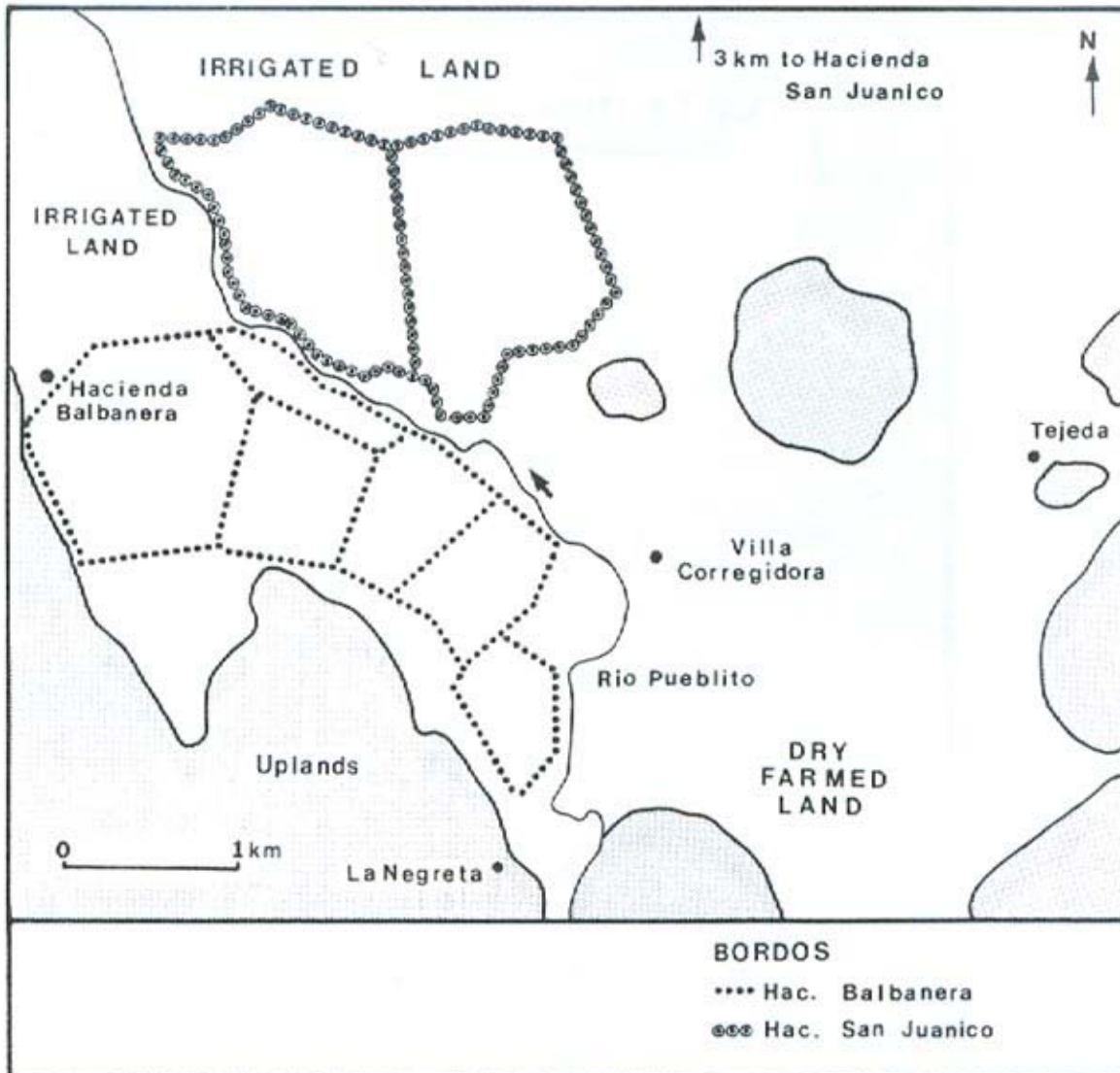


Fig. 3. The embanked fields and irrigated lands of haciendas Balbanera and San Juanico.

Waters were moved from bordo to bordo depending on the season, amount of water available and crop demand. Fields inside the embankments were flooded and then planted requiring no further application of water. Alexander von Humboldt (1973, 81) noted in 1803 that these systems were most similar in design and function to the flood water fields of early Egypt.

Mapping of extant colonial bordos in the eastern Bajío shows that these are systematically interdigitating, earth embanked fields that were filled with water from perennial streams and rivers and/or ephemeral drainages. Individual bordos are typically square to rectangular in shape and range from 250 to 1,000 m on a side. In the Querétaro/ Apaseo River valley (Figures 2 and 3), individual systems consist of from 2 to 5 bordos and maintain a relatively standard size from 1 to 4 square kilometers (Figure 2). Hacienda San Juanico has the largest single embanked field. The two large contiguous bordos of hacienda San Juanico,

each approximately two square kilometers in size, are shown in Figure 3. The similar systems of the haciendas Castillo, Obrajuelo, Punta de Obrajuelo, and Balbanerea are illustrated in Figures 2 and 3 respectively. With the exception of San Juanico, these systems are located contiguous to topographic rises that form natural embankments. Besides the areas under embankment, the *bordo* systems also included an average of one square kilometer of non-embanked fields which were irrigated by canals from the *bordos* (Davis and Moguel 1989, 46-47). Details of the Castillo *bordo* system are shown in Figure 4.

### BORDO SYSTEM OPERATION

The embanked fields collected, stored, and regulated excess summer and winter water to be stored and/or diverted to non-embanked winter wheat fields and summer maize fields based on water availability and crop requirements. *Presas* (dams) on river courses and across valleys controlled and regulated the flow into the *bordos* by means of *lomas* (water catchment gates) while *acequias* (canals) directed it through or around embanked fields (Figure 4). In addition, some embanked fields were flooded in April or May to produce an early crop of maize or in August and September for an autumn crop of wheat (Murphy 1986, 119).

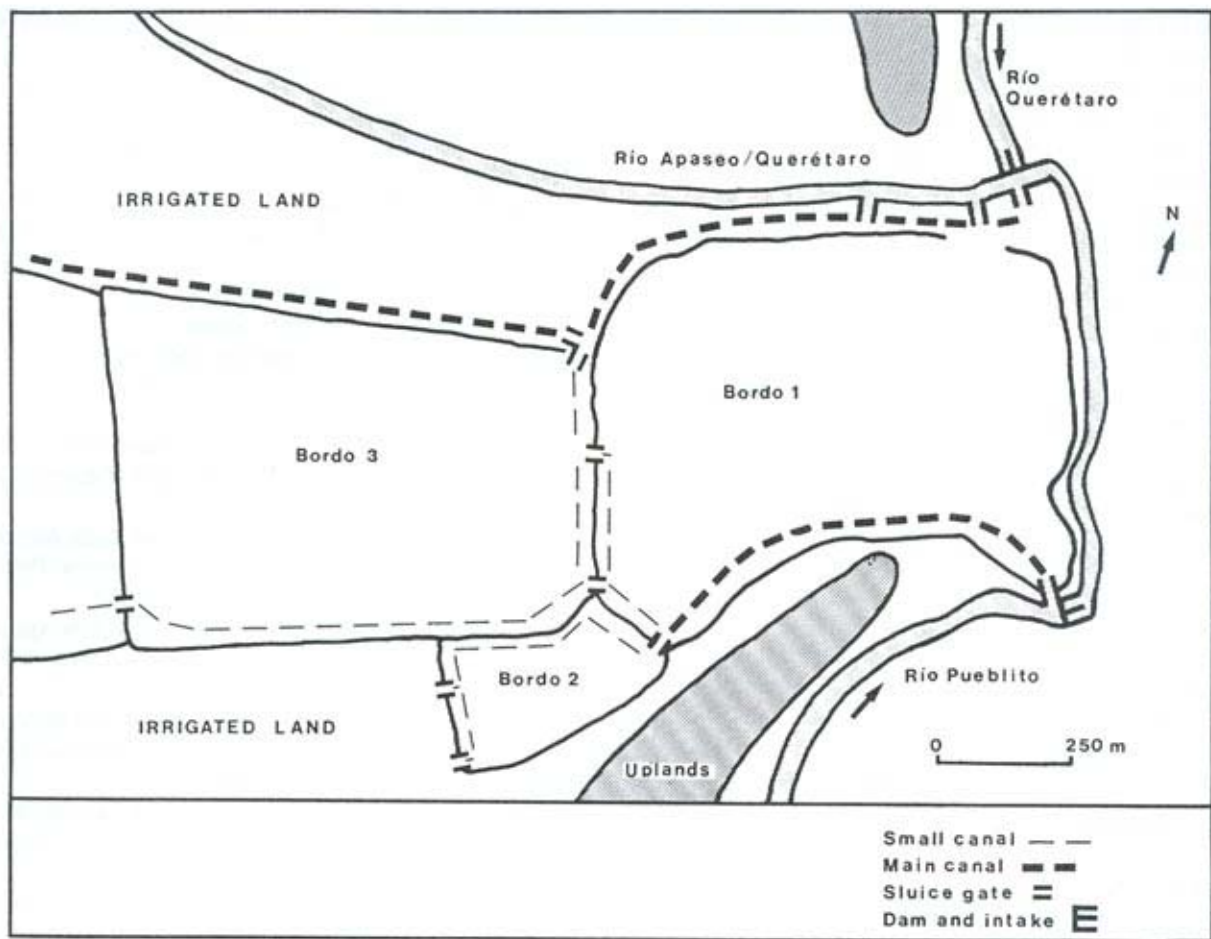


Fig. 4. Intake, dam, sluice gates, and canals of the hacienda Castillo *bordo* system.

In late November or December, when the non-banked fields had completely dried from summer rains, stored water was released from *bordos* to flood these fields. After the *bordo* was emptied, winter crops were often planted inside the *bordos* which required no further water. After the last hard frost sometime in late January, the non-embanked fields were flooded again and wheat seed sown in these fields and within the *bordos*. During the dry months of October and November, late maturing maize fields were flooded by *bordos* and

then harvested in November or December. A third flooding took place in March or April and provided sufficient water for the rest of the wheat season. The wheat was then harvested in May or June before the onslaught of damaging wind and water.

The movement of waters in the *bordo* systems was quite complex. Sets of small sluice gates (*compuertas*) controlled the flow of water to acequias within the embanked fields. Large sluice gates and water boxes controlled the storage and movement of water from one *bordo* to another and interrelated systems of small and large acequias (Figure 4). After leaving the embanked fields the water was then distributed via small irrigation canals to non-embanked fields.

## CONCLUSION

Changes in colonial water use in the eastern Bajío reflect a restricted set of options that colonists had to choose from when determining how they were to survive and prosper. New and distinct patterns of land and water rights created by the application of different water use techniques, contributed to the rapid expansion of the frontier through improved production and better utilization of water.

The development of *bordo* systems set the historical trajectory for land use patterns, water rights, and agricultural systems in the eastern Bajío. Whether they were built by indigenous peoples, *creoles*, *mestizos* or *gachupines* is unknown and begs to be resolved. A major problem is to determine which components of the *bordo* system were indigenously conceived and which were introduced from Spain.

The key is where and how people in the Bajío learned to design, build, and operate the complex systems. Authors such as Brading (1978), Glick (1970), and Meyer (1984) suggest that the irrigation systems are generally of Spanish design brought from Spain by a wide range of people including missionaries and architects. However, such systems have no counterpart on the Iberian Peninsula. Missions, churches, and communities founded by the Spanish, which had water control systems, were done so with Indian populations, Indian labor, and Indian skills. Often the water control systems were maintained by and served Indians (Murphy 1986, 89; Super 1983, 37). Doolittle (1990, 155) suggests that pre-Columbian hydraulic technology may have been involved in the creation of new colonial water control techniques. The extent to which Spanish and/or Indian knowledge and the experimentation of early colonial settlers contributed to the development of *bordo* systems can be answered by a thorough diachronic analysis of the critical factors of design, location, and operation.

## NOTE

1. The research reported here forms part of the unpublished results of the author's doctoral dissertation, "A Legacy of Water Control: Post Classic and Colonial Settlement in the Apaseo/Querétaro Valley of Mexico" Department of Geography, University of Texas at Austin.

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## Resumen

La secuencia de adaptación humana mediante la cual la cultura española reaccionó y se integró con las culturas indígenas y el medio ambiente de esta región fronteriza, produjo el desarrollo de un nuevo sistema para la utilización de los recursos hídricos en el México colonial. El sistema de *bordos*, integrado por represas y canales, es de suma importancia en el proceso de asentamiento humano y movimiento de población hacia el norte desde el Valle de México, durante el transcurso de la época colonial. En el valle aluvial, conocido como el Bajío, estos sistemas crearon el centro agrícola de mayor importancia en la parte central y norte de México. El diseño, desarrollo, y funcionamiento de estos sistemas puede ser reconstruido utilizando los siguientes métodos: (1) delimitamiento, agrimensura, y cartografía de los sistemas existentes, (2) recopilación de historias orales proveniente de individuos familiarizados con las tradiciones y el cultivo de maíz.