Texas Water Development Board

Report 357

Characterization of Playa Basins on the High Plains of Texas

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August 2003

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Texas Water Development Board

Published and distributed
by the
Texas Water Development Board
P.O. Box 13231, Capitol Station
Austin, Texas 78711-3231

August 2003
Report 357
(Printed on recycled paper)

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3 Playa basins exhibiting water retention fluctuations ranging from 25 to 75 percent during the period from 1985 through 2000.

1.0 Executive Summary

In House Bill 1, the 77th Texas Legislature directed the Texas Water Development Board (TWDB) to investigate the aquifer recharge characteristics of playa basins on the High Plains of Texas. To fulfill this charge, TWDB collaborated with The University of Texas at Austin Center for Space Research (CSR) to determine how often playa basins held water from 1985 through 2000. Satellite remote sensing and computer-automated classification technology facilitated the rapid inspection of the thousands of playa basins located within the region of investigation. A total of 19,226 playa basins were characterized according to wetness regime based on an analysis of 300 satellite images. The assessment is being used to identify playa basins that hold water most of the time, some of the time, and are dry most of the time. Some of the playa basins that retain water a significant portion of the time may be modified to increase recharge to the Ogallala aquifer. These results verify that satellite image analysis can efficiently assess and monitor water retention in playa basins under a variety of climatic conditions.

In a previous study, TWDB investigated recharge potential through Natural Resources Conservation Service (NRCS) flood retention structures in Running Water Draw in Hale County. In addition, TWDB recommended further recharge studies of playas because of their abundance and significant role in regional recharge on the Southern and Central High Plains of Texas. The current study results identify playas capable of retaining surface water and subsequently recharging the Ogallala aquifer through infiltration.

TWDB and CSR staff accomplished the following tasks during the High Plains Playa Characterization Project:

Analysis of Climatic Data
Historical monthly rainfall data from the TWDB archives were analyzed to establish the general seasonal precipitation pattern in the region. Analysis of climate data ensured that appropriate months were selected for image interpretation and classification. Following the review of monthly data, daily precipitation values were compiled for officially recognized weather stations within the study area in order to refine the selection of suitable satellite imagery.

Satellite Image Acquisition
The best available cloud-free satellite images were reviewed and selected from the data archive of the U.S. Geological Survey (USGS) Earth Resources Observation Systems (EROS) Data Center. Candidate images from 1985 through 2000 were reviewed. A total of 300 scenes were selected, representing a series of 42 to 44 observations for each of the seven Landsat Thematic Mapper (TM) scenes required to cover the entire region of investigation.

Satellite Image Classification and Analysis
Using a map of playa basins for reference and applying automated image classification procedures, the visible, infrared, and thermal responses of the surface within each playa were analyzed to determine the presence or absence of water. Results for each observation date were compiled into a database. An accuracy assessment of the classification results confirmed the reliability of the classification protocol. The assessment indicates a success rate of 89 percent, a rate that surpasses the normally accepted rate for automated classification procedures.

Data Interpretation

A frequency distribution graph displays how often the 19,226 playa basins analyzed for the study held water between 1985 and 2000. Frequency rates ranged from 0 to 100 percent. Most of the playa basins (11,275) were inundated by a minimal extent of water more than 75 percent of the times sampled. A much smaller number (1,049) appeared to have been wet during fewer than 25 percent of the times. About 6,902, or 35.9 percent, of the observed playa basins held water from 25 to 75 percent of the time. For discussion purposes and possible future research, these basins are considered to be candidates for possible recharge enhancement.

2.0 Purpose

The Ogallala aquifer, a vitally important regional water resource, underlies most of the High Plains of Texas. In 2000, the portion of the Ogallala aquifer in Texas was estimated to have provided about 5 million acre-feet of water. By 2050, the annual available groundwater supply may decline by 24 percent (TWDB, 2002, p. 47). Ogallala aquifer water levels declined significantly in the latter half of the 20th century as agricultural irrigation and livestock production expanded in the region. Although new agricultural conservation methods have been introduced, the Panhandle, Llano Estacado, and Region F Regional Water Planning Groups have indicated that the tapping of new groundwater resources would be an important water management strategy for the next 50 years (TWDB, 2002, p. 87, 97, and 115). A reduction of water-intensive agriculture will occur as supplies decline, but the Ogallala aquifer will still be relied upon as a major source of water far into the future (TWDB, 2002).

Playa basins are recognized as important recharge features on the High Plains of Texas (Gustavson and others, 1995, p. 4; TWDB, 2002, p. 84). Some playa basins infiltrate water to the aquifer at a rapid rate and rarely hold surface water for extended periods. Others may be considered to be perennial lakes, despite their reputed ephemeral nature. Some of these surface-water features retain water seasonally, following rain events that temporarily fill the shallow depressions. Many playa basins have been modified in recent times to support agriculture (Fish and others, 2000, p. 2). Although extensive work has been undertaken to delineate the playa basins of Texas through the Playa Lakes Joint Venture of the North American Waterfowl Management Plan, no previous attempt has been made to characterize on a regional scale the water-retention history of these surface-water features.

TWDB and CSR developed a classification procedure to identify areas of open water within playa basins in the Southern and Central High Plains of Texas using satellite remote sensing techniques. The study traced seasonal fluctuations of surface water held in playa basins in order to provide a quantitative assessment of playas potentially suitable for recharging the aquifer. Results verify that satellite image analysis can be used to efficiently assess and monitor water retention in playa basins. The satellite assessment identified playa basins that may serve as wetlands (hold water most of the time), playa basins that actively recharge the aquifer (dry most of the time), and playa basins that may be modified to increase recharge to the aquifer.

3.0 Location And Description

The region of investigation is located in northwest Texas (Figure 3-1). The Great Plains extend throughout the midsection of North America from Texas north to Canada. The High Plains, a subset of this region, are frequently divided into the Northern, Central, and Southern High Plains. In Texas, the Southern High Plains are located south of the Canadian River and the Central High Plains extend from the Canadian River to the Oklahoma border (Wermund, 1996). Most of the High Plains of Texas are underlain by the Ogallala aquifer. The Ogallala aquifer, the largest water-bearing subsurface formation in the United States, extends from Texas to South Dakota. The region of investigation for this study includes all playa basins on the portion of the High Plains of Texas overlaying the Ogallala aquifer.

The Southern and Central High Plains of Texas consist primarily of the High Plains physiographic province. The region features mostly treeless flat plateaus, few perennial streams, relatively low annual precipitation, and high wind velocities (Wermund, 1996). Elevations range from more than 2,000 feet above mean sea level in the southeast above the canyonlands of the Colorado River headwaters to more than 4,000 feet in the northwest corner of the Texas

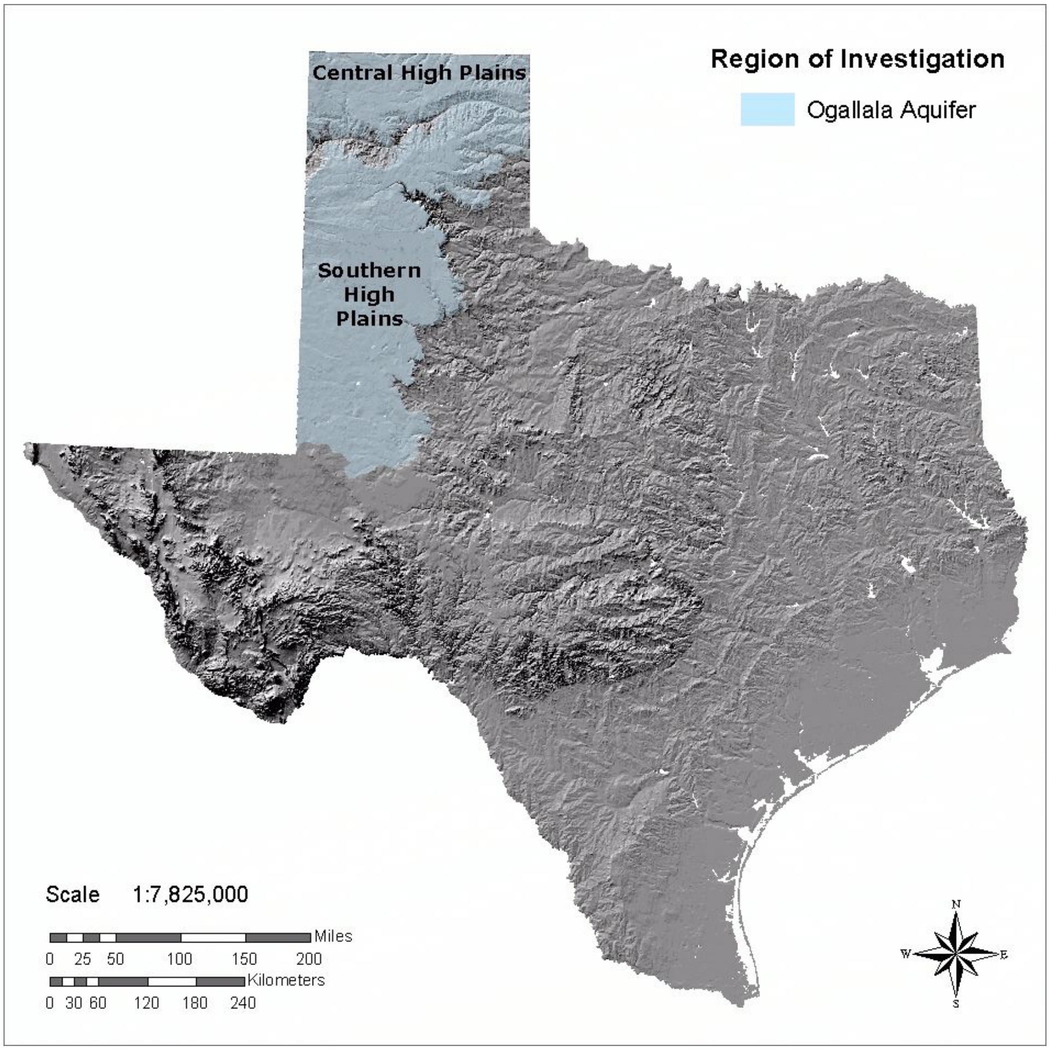


Figure 3-1. The Southern and Central High Plains of Texas underlain by the Ogallala aquifer.

Panhandle. Annual precipitation rates decrease from 22 inches on the east edge of the High Plains to 14 inches in the northwest and southwest corners. In the upper Panhandle, the Canadian Breaks cut through both the High Plains and the underlying Ogallala Formation. The vegetation of the Texas High Plains originally consisted of short prairie grasslands, much of which has been converted to either dryland or irrigated farmland (Opie, 2000). Although the Southern High Plains extend west into the Pecos River drainage basin and south to the Edwards Plateau, the study area is restricted to that part of the region underlain by the Ogallala aquifer.

Playa basins are not evenly distributed throughout the Texas High Plains. In the northeast quadrant of the study area, surface sediments are finer grained, composed of windblown loess, and playa basins are larger in area. Windblown sands dominate the south half of the study area. In the southwest quadrant, sands have covered many playa features. Also, playas in the south are smaller because of rapid infiltration through sandy sediments. Some of the larger playas in the north quadrant, found in rich loess soils, are often modified for agriculture and may hold water less frequently as a consequence. The playas surrounding Palo Duro Canyon along the east-central edge of the Ogallala aquifer may experience rapid infiltration because of structural controls in the subsurface near tributaries. In the south, lower precipitation and higher evapotranspiration rates, coupled with sandy soils and smaller basin areas, may influence water retention.

The region of investigation is further defined by the observation units used to conduct the analysis, the basic observation unit being the surface area covered by a single Landsat TM satellite scene (Figure 3-2). Seven individual Landsat scenes covered the area of interest. Landsat satellites have collected imagery at regular temporal and spatial intervals since the early 1970s. The first TM sensor was launched in 1982, and similar sensors have collected information ever since. The first complete year of record for the Landsat 5 TM sensor, the sensor used to collect imagery used in the current study, was 1985. The Landsat satellite revisits any given north-to-south swath, or path, every 16 days. These paths are numbered from 1 to 233 from east to west. The paths are subdivided into increments, called rows, numbered from 1 to 248 from north to south. The paths that cross the project area are paths 30 and 31. Rows 35 to 37 along path 31 and rows 35 to 38 along path 30 covered the region of investigation. Although same-date observations are commonly available along a single path, cloud cover and other factors sometimes thwarted attempts to assemble a database of consistent, same-date image sequences.

The TM sensor collects images by simultaneously recording the intensity of reflected light in seven separate wavelengths, or bands. Bands can be combined to make color images that are similar to photographs made using color film. Different band combinations accentuate different surface feature conditions. The bands can also be analyzed statistically. Such methods are used to identify similar surface features, such as vegetation or water, and form the basis for the classification undertaken in this study.

An existing playa basin digital database produced by Texas Tech University (TTU) was utilized as the base coverage for this study. Each playa basin contained in the database was digitized from USGS topographic maps into a Geographic Information System (GIS) format and was tagged with a unique identifier (Fish and others, 2000). In the TTU GIS database, Fish and others (2000) delineated 20,557 playas in the High Plains of Texas and identified 65 counties as belonging to this physiographic province. Summary statistics calculated for the report

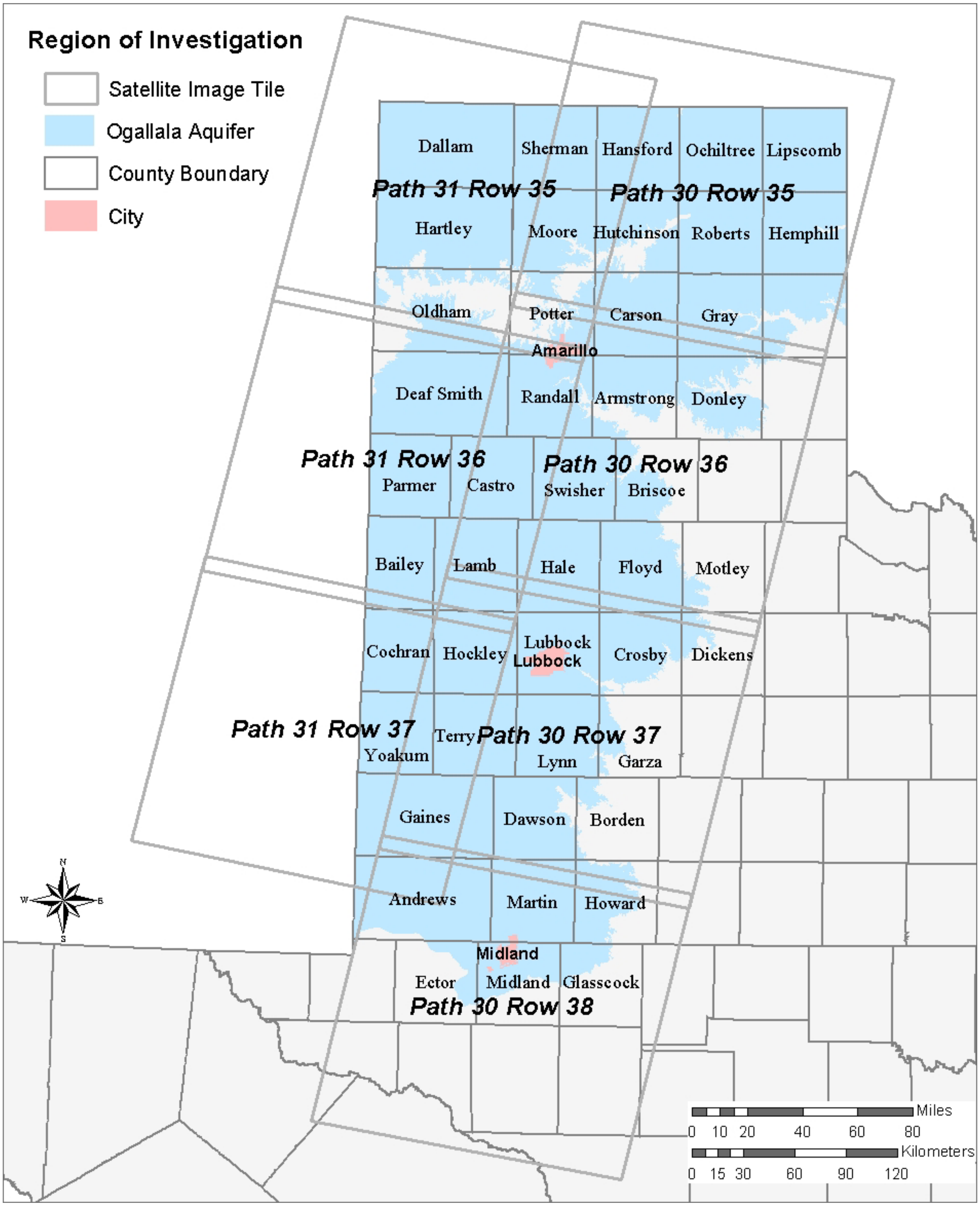


Figure 3-2. Region of investigation showing seven overlapping satellite image tiles used in analysis. Counties that overlay the Ogallala aquifer and contain playa basins are labeled.

accompanying the published database show that the average playa basin measures 18.7 acres, with the two smallest playas measuring 0.30 acres and the largest encompassing 843.4 acres. Playas cover a total area of 385,092 acres within the counties and, on average, constitute 1 percent of an individual county's surface area (Fish and others*,* 2000).

Of the more than 20,000 playa basins cited earlier, 19,226 overlay the Ogallala aquifer as delineated by TWDB. A total of 49 Texas counties overlay at least a small portion of the Ogallala aquifer. Of these, 45 counties contain playa basins and are labeled in figure 3-2. Half of the playa basins are concentrated in 10 counties, and more than one-quarter are distributed within 4 counties (Floyd, Hale, Lamb, and Lubbock). Floyd County contains the most playa basins (1,721), whereas the fewest (8) are found in Hemphill County. The median playa basin count is 297 in Terry County.

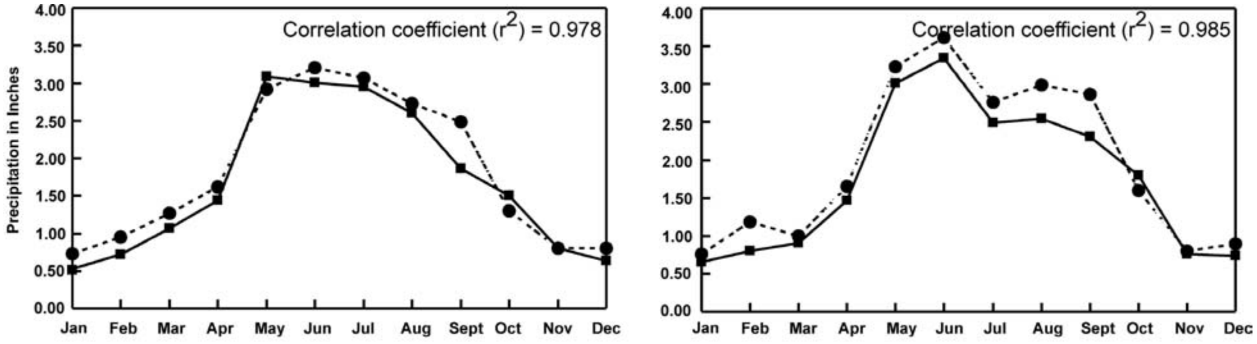
4.0 Methods and Approaches

The following sections describe the methods used conduct the climate and precipitation analysis, selection of satellite images, image processing data interpretation used to complete this project. An example of TM scene analysis is also included.

4.1 Climate and Precipitation Analysis

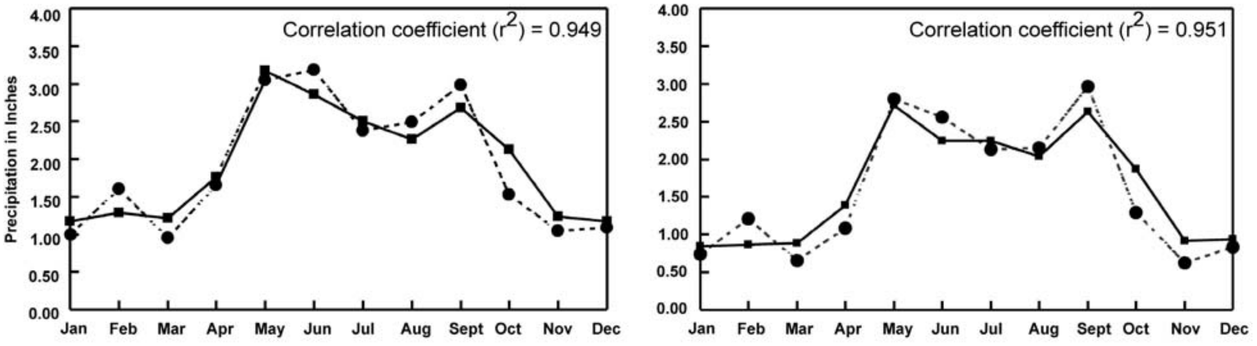
For this investigation, the High Plains of Texas were divided into seven blocks, each block corresponding to a path-row tile where a satellite image was collected. An initial analysis focused on determining whether there had been a significant change from long-term rainfall patterns in the period between 1985 and 1998. The year 1985 represented the first complete year of TM image collection. The TWDB archive of aggregated monthly precipitation records is available for the period of 1940 through 1998. Within each observation unit (path-row tile), the monthly mean precipitation amounts for 1940 through 1998 and for 1985 through 1998 were calculated. Figures 4-1A through figure 4-1G compare monthly mean precipitation within each image tile between 1985 and 1998 (light blue) with the long-term mean monthly precipitation between 1940 and 1998 (dark blue). The correlation coefficients (r^2) for the two time periods are high, ranging from 0.949 to 0.985. The period between 1985 and 1998 is therefore likely to be representative of the longer-term precipitation patterns in the region of investigation.

For 1985 through 1998, seasonal fluctuations were inspected using the same monthly precipitation data in order to identify the wet season, the dry season, and the onset of winter for each year. Under ideal conditions, a satellite image could represent each defined season in every year under analysis. For each block in the High Plains, a review of cloud-free or nearly cloud-free TM scenes was conducted to select images representing the dry and wet seasons, as well as winter onset. For any given block, we anticipated a selection of three images per block for each year.



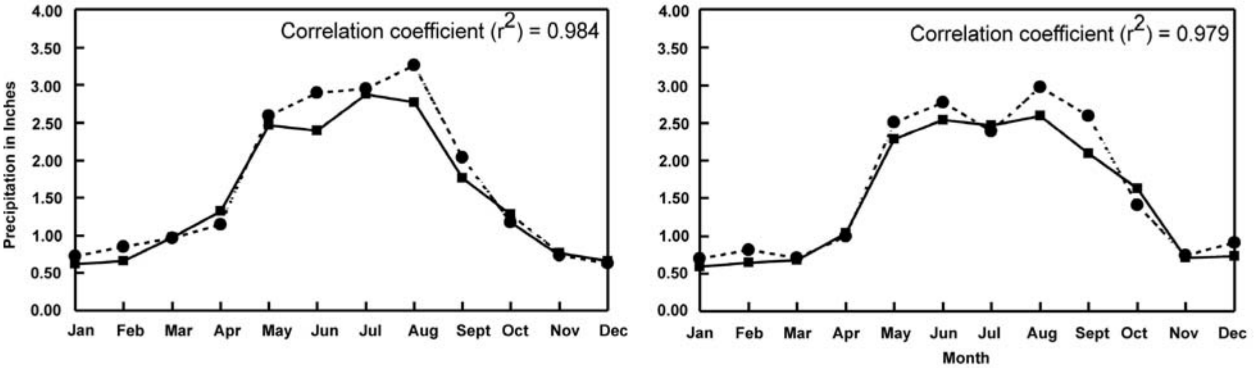
A) Mean monthly precipitation in path 30 row 35 image tile.

B) Mean monthly precipitation in path 30 row 36 image tile.



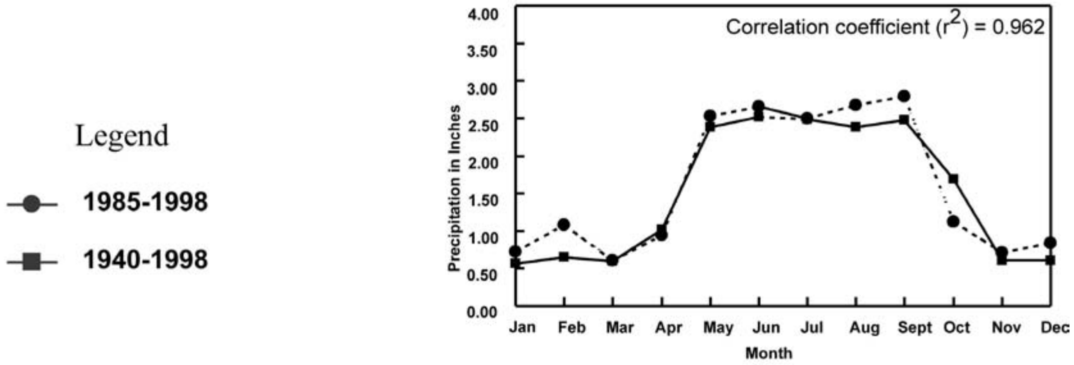
C) Mean monthly precipitation in path 30 row 37 image tile.

D) Mean monthly precipitation in path 30 row 38 image tile.



E) Mean monthly precipitation in path 31 row 35 image tile.

F) Mean monthly precipitation in path 31 row 36 image tile.



G) Mean monthly precipitation in path 31 row 37 image tile.

Figure 4-1. Mean monthly precipitation plots for path/row image tiles.

4.2 Selecting the Satellite Images

The USGS EROS Data Center (EDC) maintains the primary archive of Landsat satellite imagery for the nation and provides an online service for previewing and ordering imagery. The EDC archive was the primary resource used to select imagery for the study. Available TM images were previewed to determine their suitability for the analysis. Some candidate images were unavailable owing to a restructuring of the archive or unsuitable because of inherent data flaws. In addition, cloud cover sometimes obscured long sequences of data collection over the course of several months. Because Landsat passes over any given target area every 16 days, collecting imagery without regard to weather conditions, such cloudy sequences are rather common. Due to gaps in available TM scenes in 1989 and 1990, it was necessary to include imagery collected in 1999 and 2000.

Monthly precipitation amounts do not necessarily indicate whether a particular image reflects wet or dry conditions. Summer rainfall can be sporadic and may be concentrated within a limited time frame. Scene collection could have occurred before or after rain events. An analysis of daily precipitation values was conducted to determine ground conditions immediately before Landsat's regularly scheduled collection. Daily precipitation data collected by 48 primary National Weather Service observation stations were aggregated by image path-row tile. Accumulated daily rainfall for the 2 weeks preceding each image collection date was calculated for candidate imagery, and each candidate image was assigned to one of five categories based on precipitation amounts: Very Dry (less than 0.1 inch of rain), Dry (less than 0.5 inch), Intermediate (less than 1 inch), Wet (less than 2 inches), and Very Wet (more than 2 inches). Percentage of selected TM scenes per precipitation category is displayed in Figure 4-2.

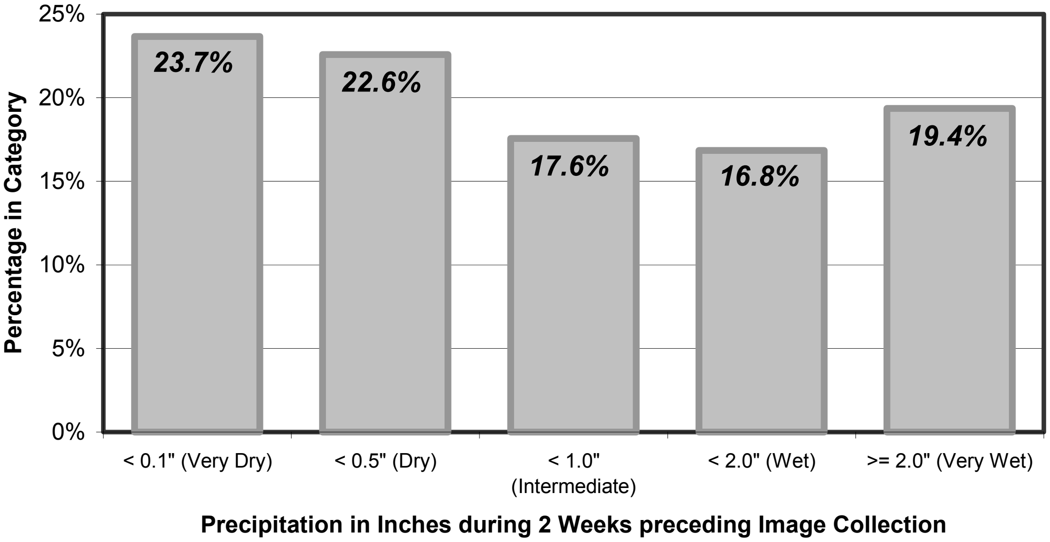


Figure 4-2. Percentage of selected TM images per precipitation category.

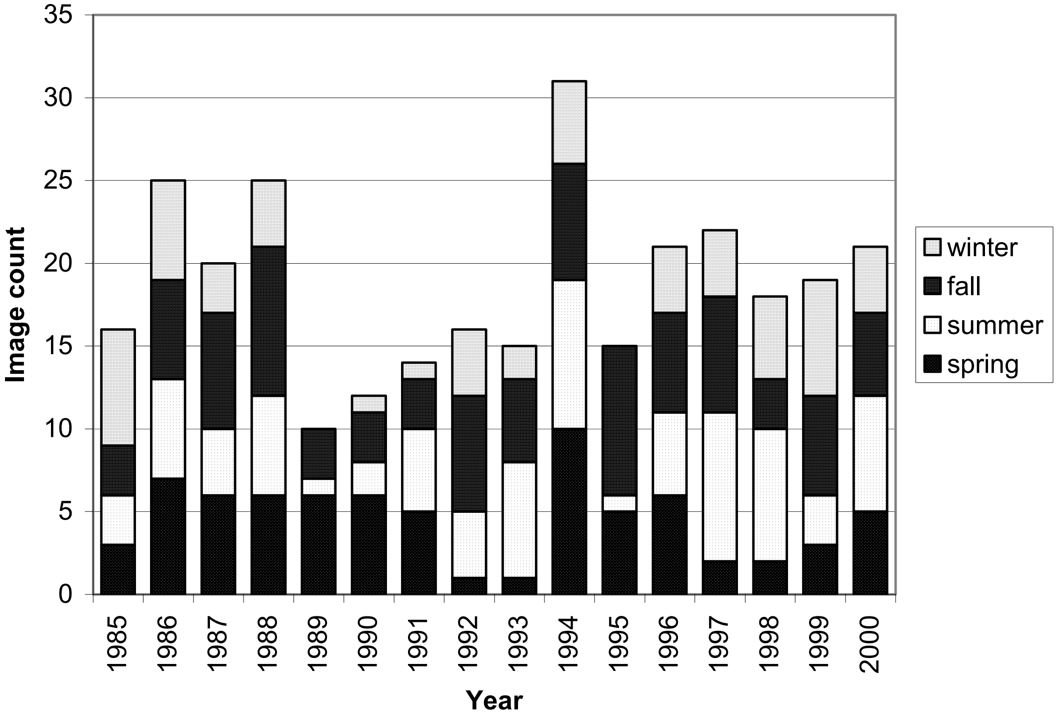


Figure 4-3. Seasonal distribution of selected TM images by year.

Figure 4-3 shows distribution of the 300 TM images that met study criteria by season for every year analyzed for the study. Overall percentages by season were 19.0 percent in winter, 24.7 percent in spring, 26.7 percent in summer, and 29.7 percent in fall. When the year is divided into wet (spring and summer) and dry (fall and winter) periods, then 51.3 percent of thscenes were collected during the wet growing season and 48.7 percent of the scenes depict the dry season.

4.3 Procedures for Image Processing

Once the images were procured from the EDC archive, they were reviewed for data quality. Of the 300 images acquired, 2 were returned because of poor data quality and replaced with alternate scenes. Samples of image data were inspected to confirm spatial accuracy and scene-to-scene registration by overlaying roadbed centerlines collected by the Texas Department of Transportation using global positioning system (GPS) surveys. Both the spectral and spatial quality of the selected images met project requirements. Any cloud cover that could present problems for classification was noted.

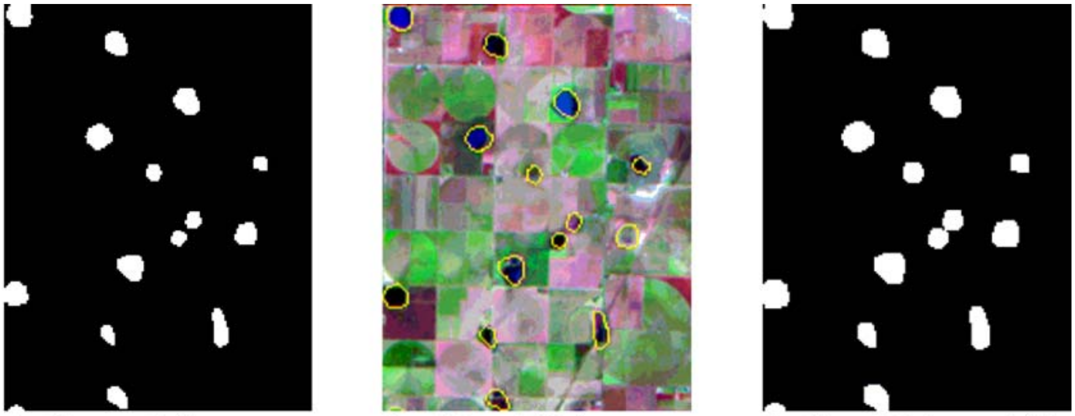
In a standard classification procedure, each picture element, or pixel (the smallest unit of an image—similar to one of the tiny dots used in comic strips), is assigned to a class with other pixels that have similar characteristics. In a high-resolution digital image, individual pixels are not discernable but instead form a picture that the viewer recognizes as a water body, an agricultural field, or a cloud. Each pixel in a TM image has seven associated values, corresponding to the intensity of reflected or emitted light in seven separate wavelengths. Through statistical analysis, pixels that match similar patterns are grouped into a class. Tests using different band combinations as input and varying numbers of classes as output were run to determine what combinations yielded clearly defined water classes. For the final classification procedure, the analysis used all 7 of the visible, infrared, and thermal bands to assign each pixel into one of 15 classes. Of these classes, 6 represented the presence of water.

All 300 TM scenes were analyzed in the same manner. In Figures 4-4A through 4-4G, image details have been enlarged so that individual pixels are discernable. The first step was to create a "mask" (Figure 4-4A) from the digital delineation of the playa basins, seen in Figure 4-4B as yellow lines superimposed on several playas. In the mask file, white areas corresponded to playa locations. All areas in black were masked out, or excluded, from the classification to reduce computation time. Each playa basin in the mask was enlarged by one pixel in circumference to compensate for minor feature displacements and to ensure complete coverage of individual playas (Figure 4-4C). Next, each pixel not suppressed by the mask file was assigned into 1 of 15 classes using standard statistically based classification procedures (Figure 4-4D). Each classed pixel was then color coded according to class assignment. Through visual inspection of the classified results, six classes were determined to designate a high probability of the presence of water and were combined into a single, red-colored class. The remaining nine classes representing "no water" were combined into a second, green-colored class (Figure 4-4E). Through a filtering process, only those clumps of "water" classes containing at least 0.89 acre were retained (Figure 4-4F). Figure 4-4G illustrates the classification results as a yellow outline overlain on the source image. The outlines closely follow the water extent. In a final step, GIS analysis was used to associate classification results with a master GIS database. Figure 4-4H demonstrates the result for the date analyzed. Playas containing water are outlined in yellow, and dry playas are outlined in orange. The difference in shape between mapped playas and classified playas on a particular date is evident.

Following completion of the classification process for all images, the information gathered about each playa during the period of 1985 through 2000 was exported to a database. Database queries were then designed and run for further data analysis, such as acquiring the percentage of the time when a playa contains water during the period under investigation.

4.4 Data Interpretation

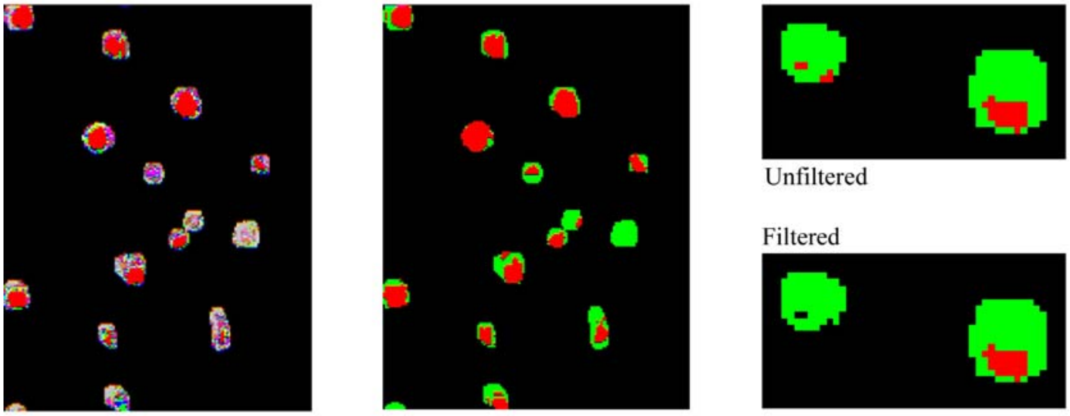
Results from the image classification were compiled in order to calculate the frequency that each playa basin held water between 1985 and 2000. Frequency levels ranged from never to always. According to the automated classification, only a few (80) playa basins never held water during the period of study. A few spurious results may have arisen from incorrect mapping of playa location, and other never-wet results may stem from extensive playa modification for grazing. Slightly more than 3,000, or 15.7 percent, of playa basins held water on each observation date. It is important to remember that a wet playa basin has not necessarily been filled to its maximum extent. According to the study classification rules, a playa was considered to hold water if at least four pixels were classified as "wet." Four pixels cover 0.89 acre. Comparison of yellow outlines in Figures 4-4G and 4-4H shows the difference between standing water as identified on a particular date by the automated classification result and the playa extent as delineated in the TTU GIS database.



A. Playa mask file

B. Color satellite image detail with playas outlined in yellow. Dark blue and black areas indicate water.

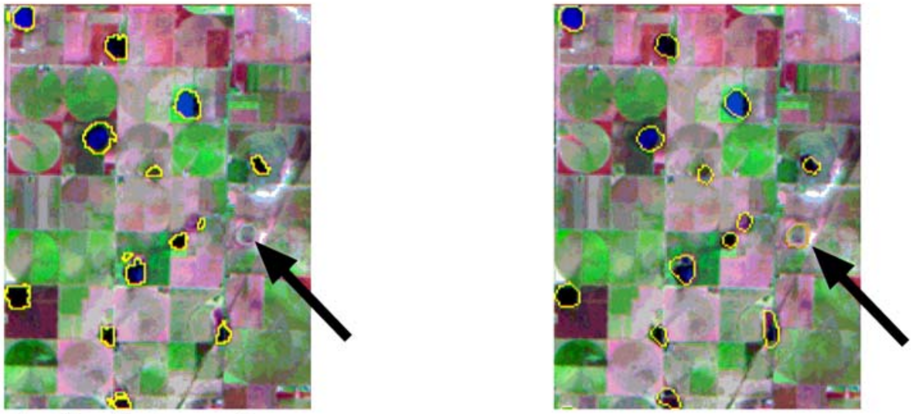
C. Expanded playa mask file.



D. Classification of playa basins into 15 color-coded classes.

E. 15 classes combined into water (red) and no water (green).

F. Filtering eliminates water classes consisting of less than 0.89 acre.



G. Classified areas of open water outlined in yellow. Note lack of yellow outline on playa basin at central right.

H. Final water presence results overlain in yellow and orange outlines. Note orange outline at center right.

Figure 4-4. TM scene analysis.

Table 4-1. Assessment of playa classification accuracy.

	No water	Water	Total
Database results	278	1402	1680
Sampling results	334	1346	1680
Error	118	55	173
Accuracy			89.70

Following the completion of an automated classification, it is customary to conduct an accuracy assessment and to report an overall success rate. Because the volume of satellite remote sensing data tends to be formidably large, assessments are performed on sample areas. To assess the accuracy of classification results for the 19,226 playa basins, stratified random sampling was used to select a test dataset. Then, for each satellite image data block, two image dates from each of the four seasons were randomly chosen for a total of 56 satellite images. Next, for each of the selected images, one percent of the available playa basins within the image extent were randomly selected. Each sample point was inspected visually on the computer monitor by overlaying playa samples on color-composited satellite images. The success or failure of the automated classification was noted for each playa basin, and an accuracy value was calculated for each individual image date.

Database results indicate how the automated procedure classified each playa basin, whereas sampling results show the data derived from visual inspection of the imagery collected for those same playa basins (Table 4-1). Within a confidence level of 95 percent, the expectation is that nearly 90 percent of the playa basins were correctly classified. Congalton and Green (1999) specify an overall accuracy level of 85 percent as the cutoff between acceptable and unacceptable results for site-specific classification of remote sensing data, a standard first described by Anderson and others (1976).

As a demonstration of the quality of the data evaluated in this study, a visual tour of some examples of the satellite images analyzed for the project is provided. Examples are taken from an area near the community of Idalou, northeast of Lubbock. All color composites were constructed from the same combination of two infrared bands and one visible band. In the displayed color combination, water features range from black to blue. Black indicates relatively clear water, whereas blue appears where water contains suspended sediment. Growing vegetation is green, and fallow fields display reddish to maroon tones. Each image is characterized by the precipitation regime that preceded image collection, as discussed on page 11 and illustrated in figure 4-2. The images from 1986 were collected following 2 weeks of very dry, wet, intermediate, and very wet conditions, respectively. In 1996, conditions prior to image collection were very dry, very wet, very wet, and dry, respectively.

Overall, 1986 was a wetter year in the Lubbock area than 1996. The monthly precipitation amounts for each year confirm the conditions visible in the image detail series (Figure 4-5 and Figure 4-6). In the dry winter season of January 30, 1986, playa basins did not contain high water

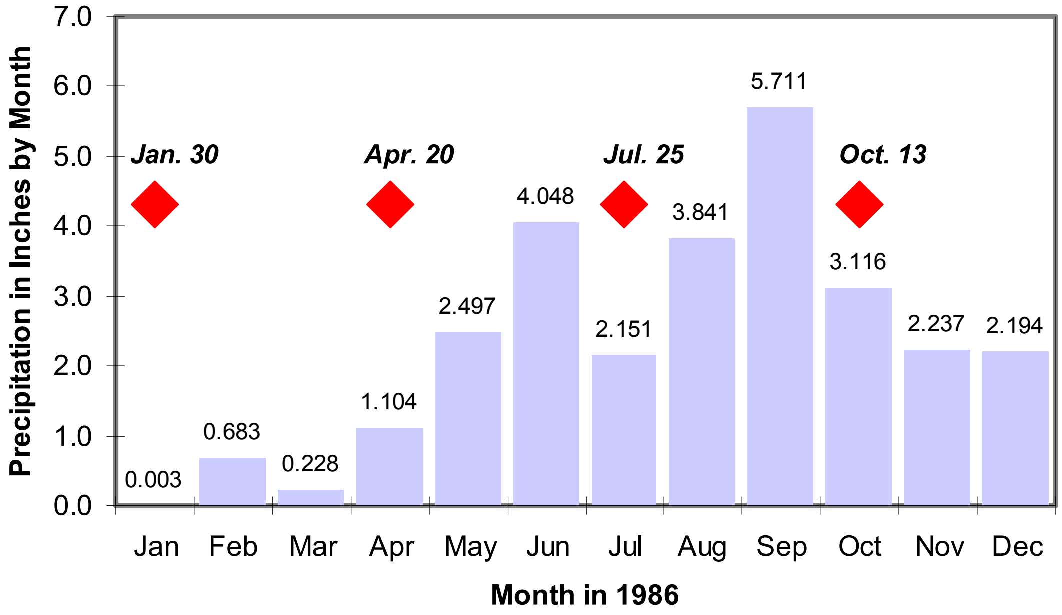


Figure 4-5. TM image acquisition dates (red diamonds) and monthly precipitation (blue columns) in 1986 for Path 30 Row 37.

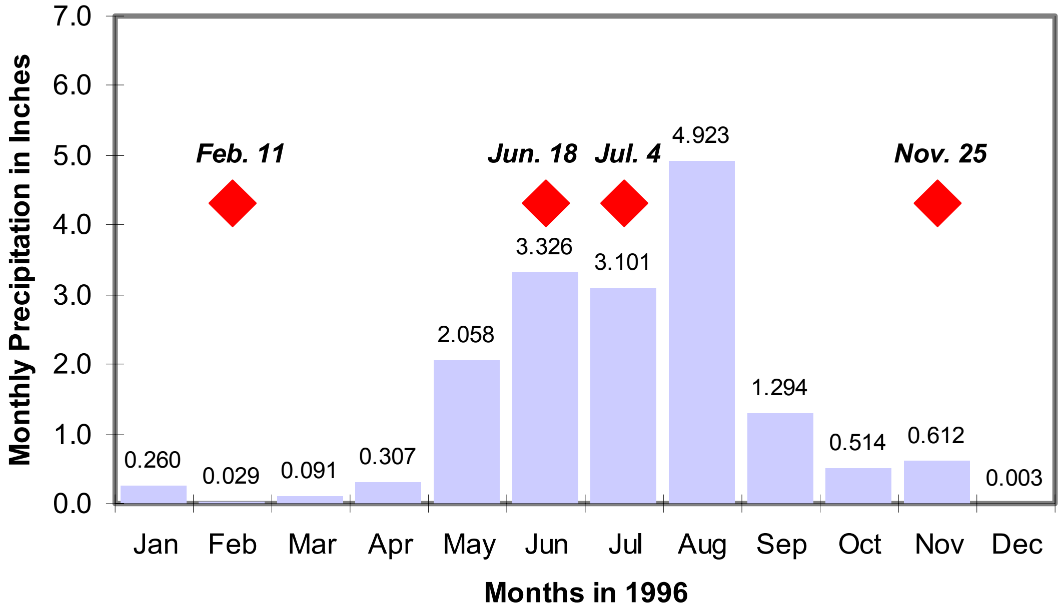
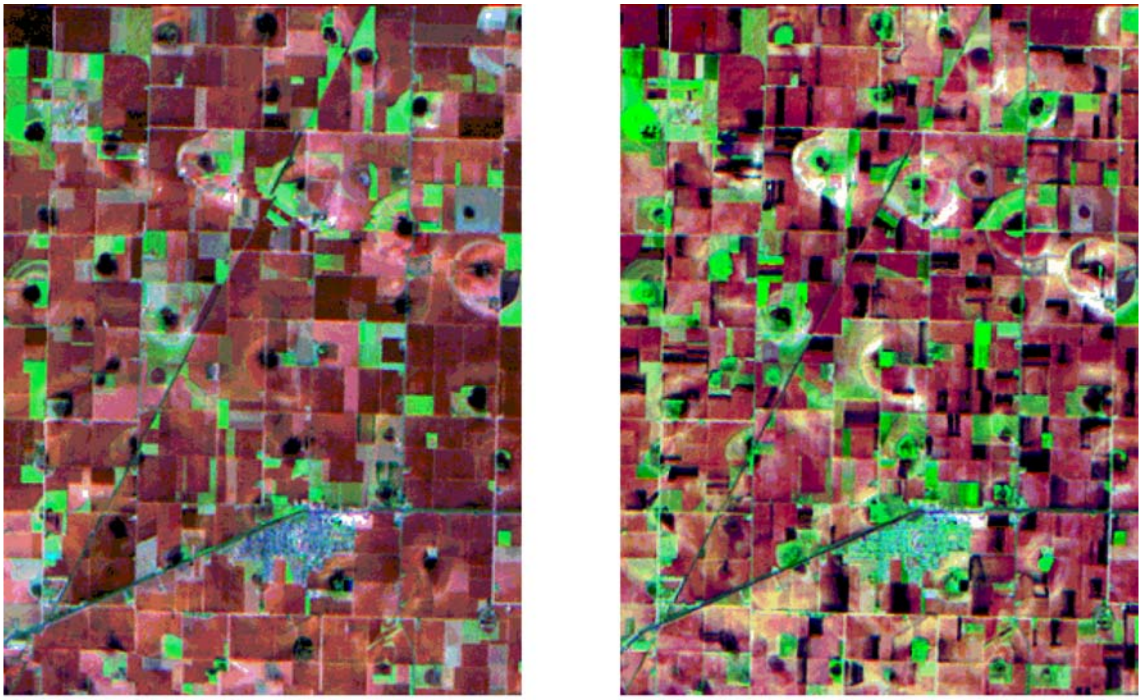
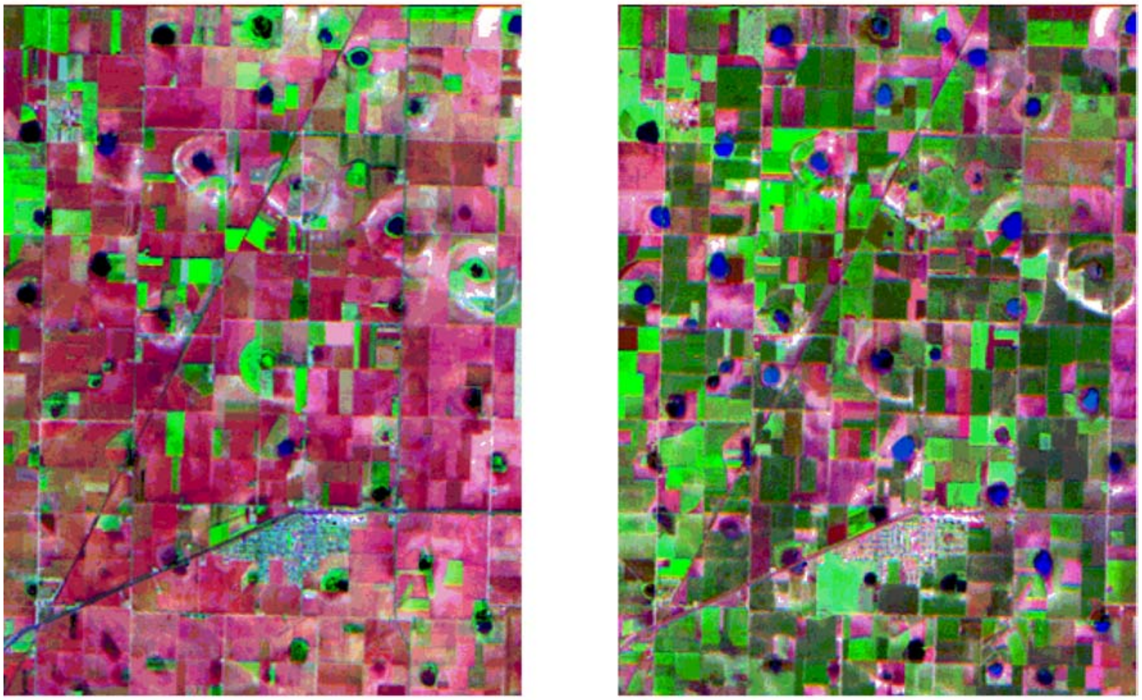


Figure 4-6. TM image acquisition dates (red diamonds) and monthly precipitation (blue columns) in 1996 for Path 30 Row 37.



A. January 30, 1986 (less than 0.1 inch precipitation -very dry winter scene).

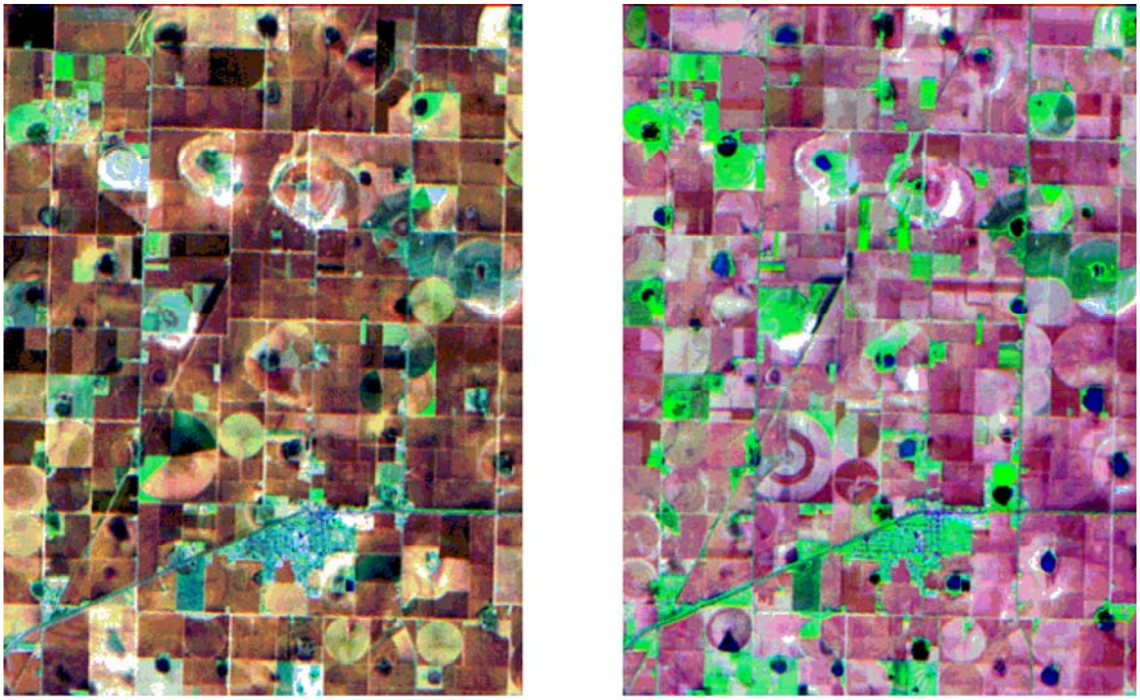
B. April 20, 1986 (between 1.0 and 2.0 inches precipitation – wet spring scene).



C. July 25, 1986 (between 0.5 and 1.0 inches precipitation – intermediate summer scene).

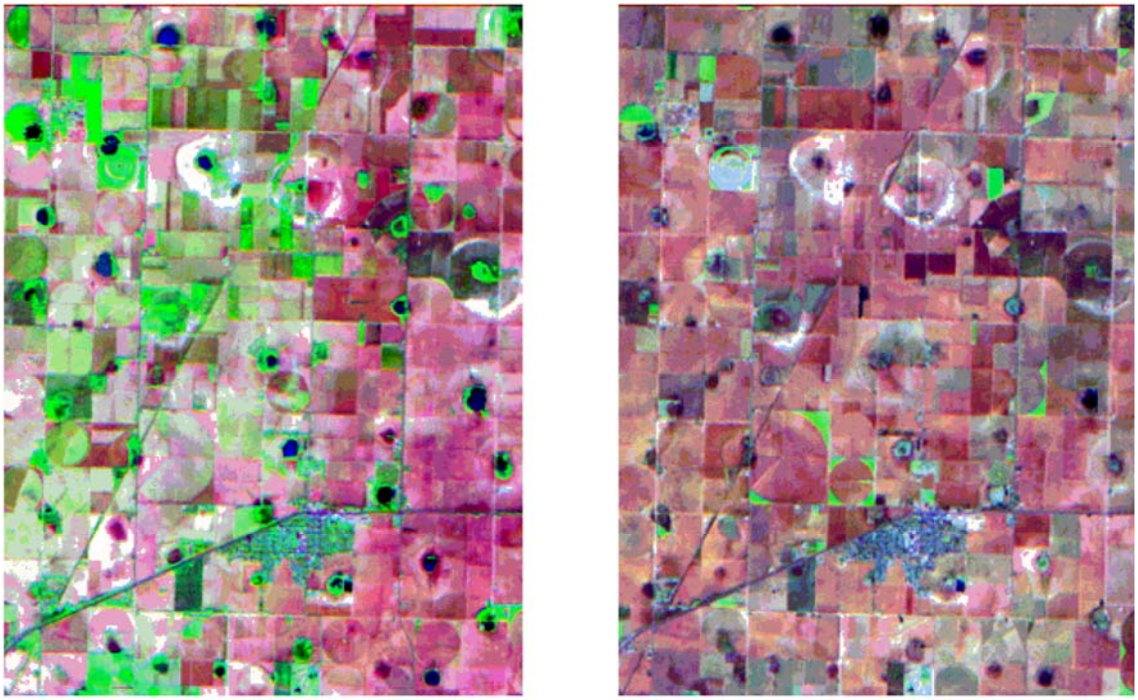
D. October 13, 1986 (more than 2.0 inches precipitation – very wet autumn scene).

Figure 4-7. TM images taken during 1986.



A. February 11, 1996 (less than 0.1 inch precipitation - very dry winter scene).

B. June 18, 1996 (more than 2.0 inches precipitation – very wet spring scene).



C. July 4, 1996 (more than 2.0 inches precipitation – very wet summer scene.

D. November 25, 1996 (between 0.1 and 0.5 inch precipitation – dry autumn scene).

Figure 4-8. TM images taken during 1996.

levels (Figure 4-7A). Although April was relatively wet, water levels did not change dramatically (Figure 4-7B). By July, more playa basins held water, although green rims indicate that there remained the capacity to collect more (Figure 4-7C). However, by October in the same year, most playas appear to be filled to the brim, the bright blue colors indicating the presence of sediment-laden runoff into the basins from recent showers (Figure 4-7D).

In 1996, conditions were much drier overall. The February 11, 1996, image was very dry with little nascent vegetation and little indication of wetness within playa basins (Figure 4-8A). In both June and July of the same year, blue and black pools of water and greener fields indicate the effect of seasonal showers (Figure 4-8B and Figure 4-8C). By November, the early onset of the dry season can be deduced by the faded colors of the image (Figure 4-8D). The playas held very little water by this date.

5.0 Results and Conclusions

Results of the study are presented in three ways: (1) frequency graphs illustrating the proportion of playa basins that were found to hold water during the observation period; (2) maps illustrating the spatial distribution of the characterized playa basins as a function of the amount of time they were found to hold water; and (3) scatter plots of playa basin size relative to water-retention frequency in the study.

Playa basins in the Southern and Central High Plains of Texas vary significantly in terms of how often they retain water. The frequency distribution of water-holding playas is shown in Figure 5-1. In general, this figure indicates that a greater proportion of the playa basins were found to hold water a substantial portion of the time. Far fewer were mostly dry during the observation period for this study.

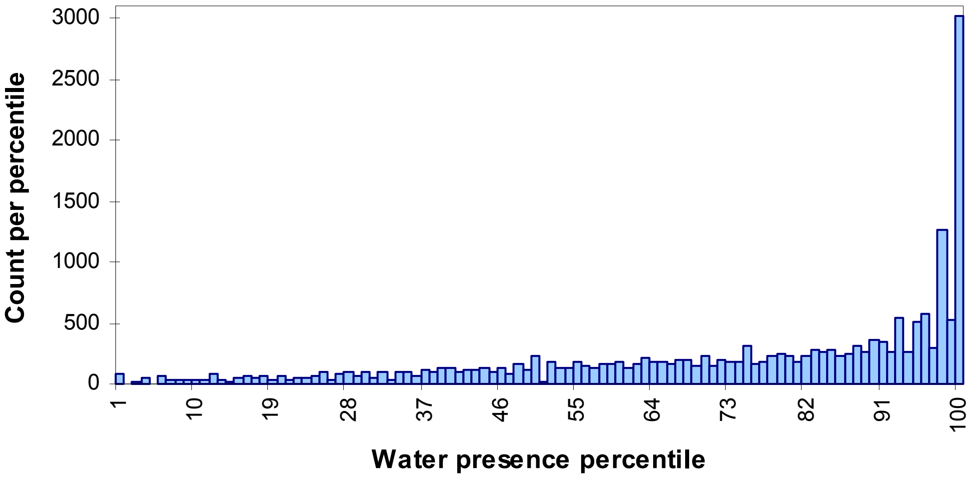


Figure 5-1. Frequency distribution showing wetness of 19,226 playa basins located within the region of investigation.

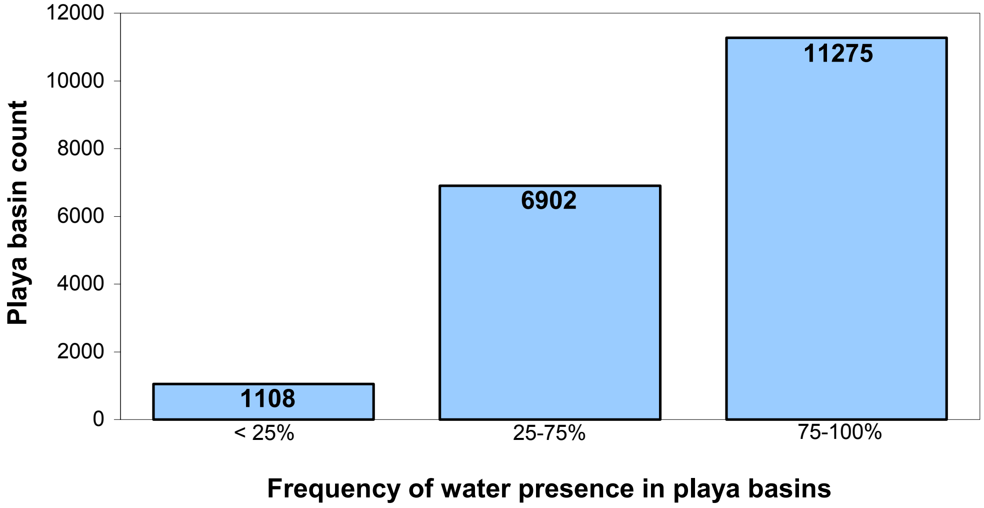


Figure 5-2. General characterization of water presence in playa basins.

Stated in a different way, a total of only 1,049 playa basins (5.5 percent) were found to hold water less than 25 percent of the time. 6,902 playa basins (35.9 percent) held water between 25 and 75 percent of the time. Finally, a total of 11,275 playa basins (58.6 percent) were found to be at least partially wet more than 75 percent of the time (Figure 5-2). The locations of the playa basins falling within the three above categories are shown using red outlines on Figures 5-3 to 5-5, respectively.

Plate 1 highlights frequently dry playa basins, namely, those containing water less than 25 percent of the observation times. These playa basins appear to be more highly concentrated along the eastern margin of the study area. Lack of water retention for some of these playas may be related to structural controls in the Palo Duro Canyon area. In the northern portion of the study area, playa modification for agricultural purposes may contribute to a reduction in water retention.

Plate 2 displays the locations of those playa basins that were found to hold water between 25 and 75 percent of the observation times. While playa basins included in this category can be found throughout the entire study area, they appear to be more highly concentrated along the eastern edge of the Ogallala aquifer, as well as along the northeast and west-central portions of the study area.

Plate 3 presents the locations of playa basins that were found to hold water during more than 75 percent of the observation times. This category includes over half of all identified playas. These playas are primarily located in the central portion of the study area.

Figures 5-3 through 5-5 feature scatter plots of the area covered by playas as a function of their observed water-retention frequency. These figures indicate that water retention frequency increases as playa basin size increases. Most of the driest playa basins are less than 20 acres in size (Figure 5-3). Playa basins that held water between 25 and 75 percent of the times observed rarely exceed 100 acres in size (Figure 5-4). The wettest playa basins generally cover less than 200 acres, although the acreage of playa basins that were observed to always hold water ranges in size from 1.2 to 843.4 acres.

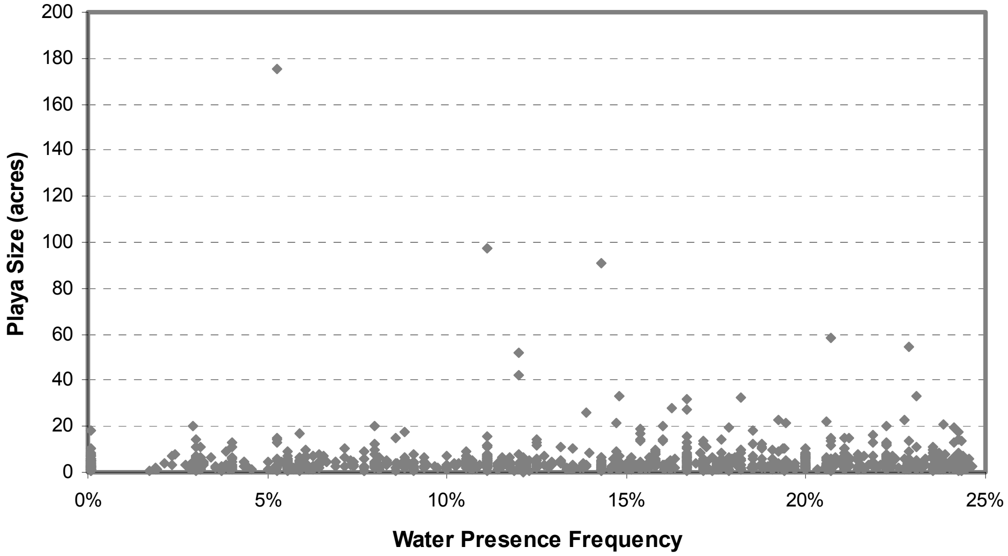


Figure 5-3. Playa acreage in relation to water-retention frequency of less than 25 percent.

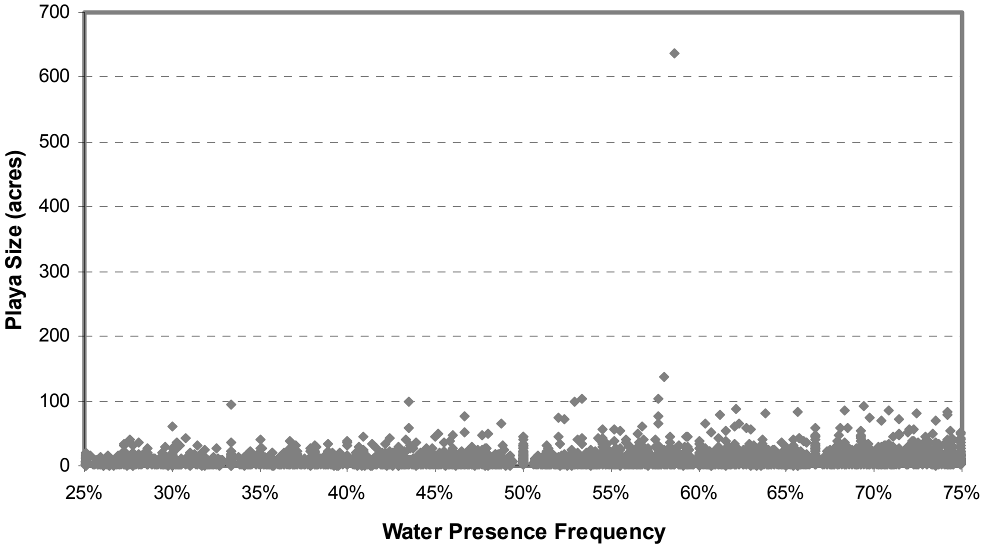


Figure 5-4. Playa acreage in relation to water-retention frequency of between 25 and 75 percent.

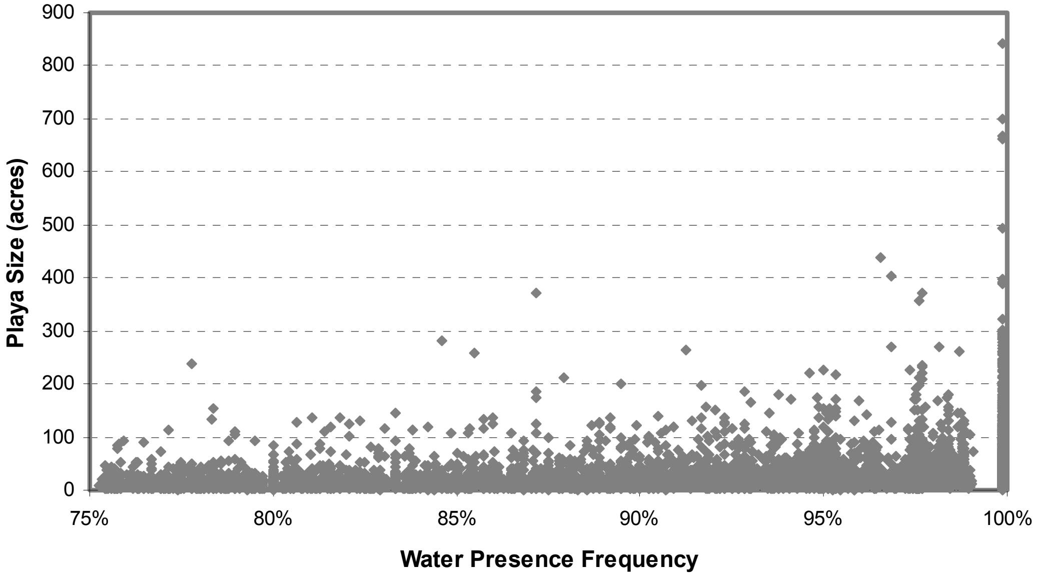


Figure 5-5. Playa acreage in relation to water-retention frequency of more than 75 percent.

Table 5-1. Playa basin size in relation to wetness frequency.

	Playa acreage less than 25%	**Playa acreage between 25 - 75%**	**Playa acreage greater than 75%**
Playa Count	1049	6902	11,275
Median size (acres)	3.4	5.8	17.8
Mean size (acres)	5.1	8.3	26.4
Standard deviation (acres)	8.3	11.6	32.6
Percent less than mean size	71.2 %	69.5%	67.8%
Count less than 20 acres	1,025	6,439	6,236
Percent less than 20 acres	97.7%	93.3%	55.3%

Table 5-1 presents statistics describing median and mean playa basin size in relation to wetness regime. In general, the numbers indicate that as playa basin size increases, water retention also increases in frequency. Figures 5-6 through 5-8 are scatterplots representing the relationship between playa basin size and water retention frequency. However, these figures show only points representing playa basins of less than 50 acres in size. Figure 5-7 serves as an indicator of the typical surface area that would be considered for modification in selected playas.

In a companion map publication, Howard and others (2003) show playa basins presented at a larger map scale, with frequency rates between 25 and 75 percent color coded by deciles. At the scale presented, relative basin size becomes apparent as a controlling factor of water retention. The largest playa basins tend to hold water with the greatest frequency. Clusters of smaller playas with similar frequency rates are dispersed throughout the study area.

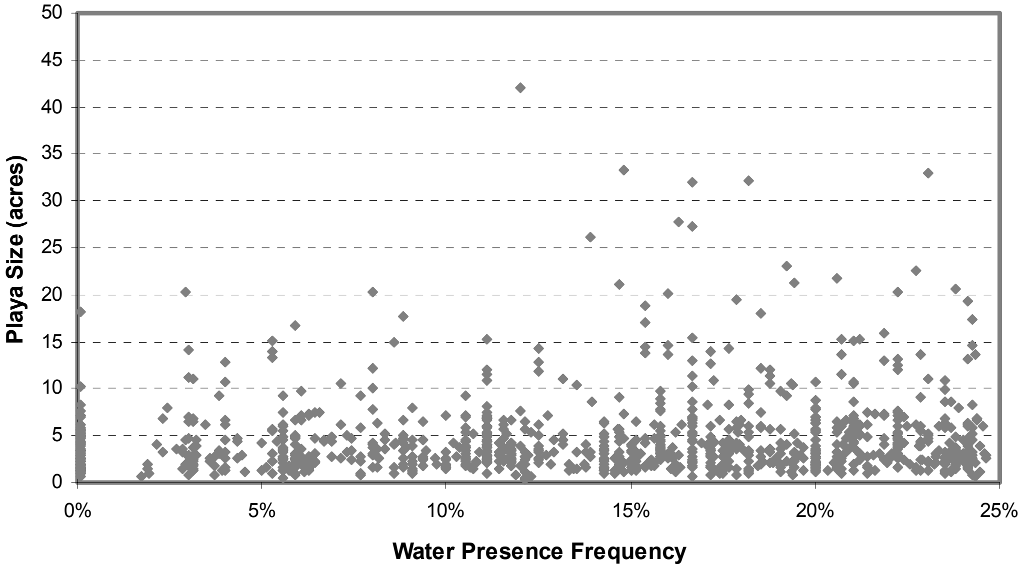


Figure 5-6. Playas of less than 50 acres in relation to water-retention frequency of less than 25 percent.

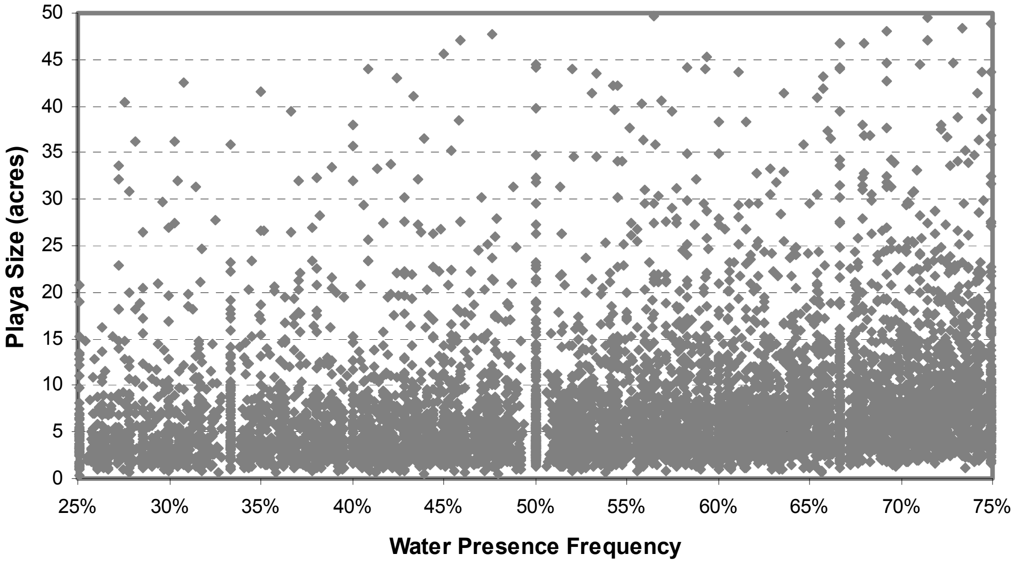


Figure 5-7. Playas of less than 50 acres in relation to water- retention frequency of between 25 and 75 percent.

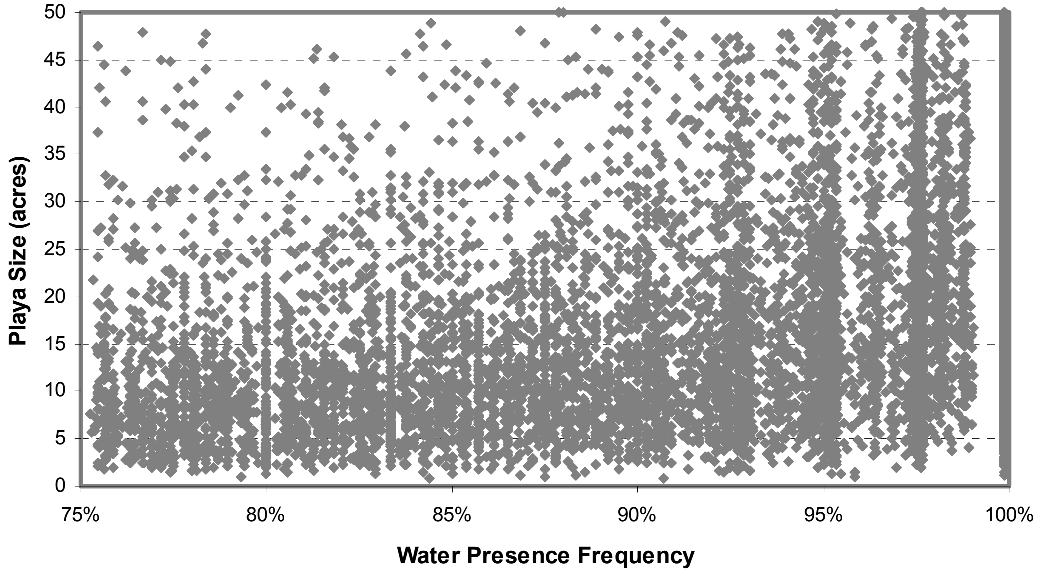


Figure 5-8. Playas of less than 50 acres in relation to water- retention frequency of more than 75 percent.

Table 5-2. Playa basin composition in relation to wetness frequency.

	Playa acreage less than 25%	**Playa acreage between 25 - 75%**	**Playa acreage greater than 75%**
Randall Clay	928	6,299	10,383
Ness Clay	92	328	305
Lipan Clay	11	163	325
Lipan/Roscoe Complex	1	70	255
Lubbock and Randall soils	17	42	7
Percent Randall Clay	88.5%	91.3%	92.1%

Table 5-2 presents the relationship between playa basin composition and water presence frequency. The playa basins delineating in the TTU GIS database consist of features located on Randall clays.

The investigation results indicate that the largest proportion of playas (58.6 percent, or 11,275 playas) were found to hold water more than 75 percent of the times observed during this study. Some of the playas in this category are used routinely to collect runoff from irrigation, and therefore assist with irrigation water management. It is reasonable to conclude that the hydraulic conductivity of the soils underlying the playas in this category is low enough to effectively pond surface water most of the time. Comparatively speaking, among the playas studied, those falling within this category would also require the most significant modification to effectively increase recharge rates into the underlying Ogallala aquifer. In addition, playas in this category would also have the highest probability of being affected by wetlands designations. For these reasons, it is recommended that playas within this category not be considered as potential candidates for future modification.

The investigation concluded that only 5.5 percent (1,049) of the playas do not hold water a substantial portion of the time. These playas are assumed to already be permeable enough to be effective mechanisms for aquifer recharge in their natural state and are therefore not believed to be good candidates for modification. The playa basins identified as holding water between 25 and 75 percent of the time are considered to be an appropriate category for initial selection of potential candidates for playa modification. Advantages to this category include an ability to hold water a substantial portion of the time while probably not being so impermeable that extreme modification measures would be required. The large number of playas in this category (6,902) should allow for thoughtful selection of specific playas as candidates for modification, considering issues such as securing access to playas and permission to modify their surfaces, covering a representative geographic area and underlying geologic substrates, and selecting strategic playa locations within different groundwater conservation districts to be able to generate additional information for as many districts as possible.

6.0 Recommendations

Results from Phase I and Phase II of the High Plains SCS structure and Playa investigations encourage continued effort to determine possible ways to enhance recharge to the Ogallala aquifer through the playas. Phase III should consist of the following:

- ☐ locate between 10 to 30 playas with optimal characteristics for enhancing recharge based on the results of Phase II;
- ☐ develop a network of groundwater wells for quarterly monitoring during the field effort;
- ☐ establish and monitor test sites within the playas where surficial deposits are mechanically modified in various ways;
- ☐ collect and analyze the resulting vadose zone recharge rates and groundwater levels; and
- ☐ determine which modification methods are most appropriate for enhancing recharge.

TWDB should conduct the field effort with assistance from local groundwater districts and other state agencies. The study should entail at least four to six years of monitoring to establish any trends in groundwater flux. In conjunction with the field effort, TWDB should conduct a literature search for similar projects. The TWDB should develop a final report detailing the effort and results for public distribution.

In addition to Phase III efforts, several possible research topics could be pursued with the existing data collected during Phase II. Some of the topics could include:

- ☐ looking for indicators for regional drought severity,

- changing the definition of the minimum surface area for classifying playa basins to evaluate the resulting distribution,
- detecting trends related to the playa basin physical characteristics,
- relating basin depth to volumetric estimates of basin water retention over time, and
- reconfiguring basin classifications to indicate seasonal fluctuations of water volume changes in response to climate or land use.

7.0 Acknowledgements

We wish to thank the following individuals and organizations for their support, insights and contributions during the playa characterization project. Bill Mullican, Harald Petrini, and Robert Mace of the Texas Water Development Board offered guidance, feedback, and editorial advice at different stages of the project. Lana Dieterich of the Bureau of Economic Geology, The University of Texas at Austin, carefully edited draft versions of the report.

The Playa Lakes Joint Venture provided the groundwork for this project. Without their previous work and the Playa Lakes Digital Database for the Texas portion of the Playa Lakes Joint Venture Region mapped by Texas Tech University, our work would not have been possible. Stacey Shankle, GIS Analyst at Ducks Unlimited, Inc., supported our efforts with his willingness to share imagery and information. Dr. J. Ronald Eyton, Professor of Geography at Southwest Texas State University, graciously offered feedback on our strategy for scene selection based on precipitation regime. Cindy Loeffler and other staff members from the Texas Department of Parks and Wildlife met with us to discuss common goals and resources.

We owe a debt of gratitude to the US Geological Survey and to the people who directly assisted us, all employees of SAIC, a contractor in service to the USGS/EROS Data Center, Sioux Falls, SD. Julia Deis of Data and Application Support was our primary contact for Landsat imagery acquisition. She cheerfully ensured that the ordering process was smooth and stress-free. The crew of the Digital Lab, Lori Yunag, Linda Hansen, and Janet Halverson, worked overtime during their busy summer season. Without their timely and able processing of 300 Landsat images, the playa characterization project would not have been possible.

The Synergy program, funded by NASA and managed by Raytheon under the Earth Observing System Data and Information System program, provided some of the financial support for staff working at the Center for Space Research during the course of the project.

We offer special thanks to Edward Angle of the Texas Water Development Board. His persistence, dedication, and attention to detail have transformed the project report into a final product that we can all take pride in.

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