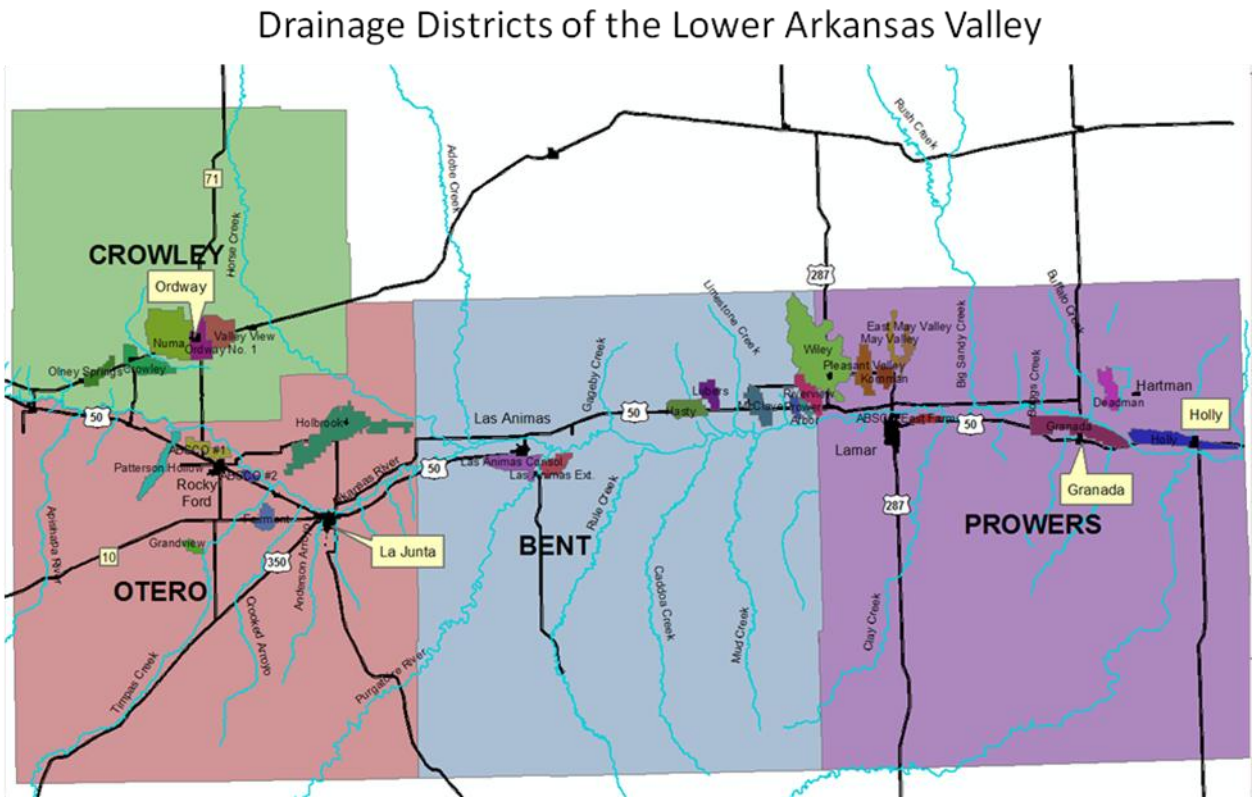

FINAL REPORT

Chapter I

Introduction

The following report summarizes the activities and results of a three year study on the present condition and future use of aging agricultural subsurface and open surface drainage infrastructure in the lower Arkansas Valley, Colorado. The study was funded by the Colorado Water Conservation Board. Direct assistance was provided by several small, one-hundred year old, autonomous drainage districts in the lower Arkansas Valley. Additional assistance was provided by the Lower Arkansas Valley Water Conservancy District, the Colorado Department of Transportation, the City of Lamar and four counties (Prowers, Bent, Otero and Crowley counties). The study was sponsored locally by the Southeast Colorado Resource Conservation and Development (RC&D).[1]

The target area of the study comprised that extensive reach of the lower Arkansas River between Fowler, Colorado and the Colorado-Kansas state line. Again, the unique subsurface and open surface

[1] Additional support was provided by U.S.D.A's Natural Resource Conservation Service (NRCS) field office in Lamer, Colorado, the NRCS Area office in La Junta, Colorado, the Colorado Agricultural Experiment Station, the City of la Junta, the City of Aurora, and a U.S.D.A. Hatch Grant through Colorado State University.

drainage system in this region is nearing 100 years old.[2] The several small autonomous drainage districts located throughout this portion of the valley have the nominal role of maintaining and overseeing this extensive drainage system. The study was prompted by the deteriorating condition of the tile drains and associated manholes, collectors, and open waste-ways of this extensive drainage system. This deterioration can subject many farms to saline high water tables and poor soil hydrologic conductivity or seep, thereby reducing crop productivity. Communities and rural housing subdivisions located in the valley's floor can also be affected by high water tables partly attributed to the poor drainage of surrounding irrigated lands resulting from this drainage infrastructure deterioration.

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Orientation Photos – (1) Looking east across Wiley Drainage District; (2) Aerial photo showing crop marks indicating location of buried tile lines (open collector drain in blue); (3) Crop mark of tile line; (4) Tile line outlet into open collector drain.

The study involved developing and/or updating maps of the valley's drainage system, conducting an assessment of its current condition, and determining the approximate cost of rehabilitating various portions of the drainage system where it appears to be needed. Additional activities included conducting demonstrations of proper tile line cleaning, conducting study tours for local landowners to active and successful drainage district programs in other states, soliciting guest speakers from drainage districts in other states to speak to Arkansas Valley drainage district leaders, exploring options for consolidating many of the valley's drainage districts under a new drainage district authority, and writing additional grants in support of future drainage system rehabilitation.[3] Since the study stressed the need for high levels of stakeholder input, an advisory committee of local landowners, county commissioners, and other

[2] John H. Griffin, Associate Engineer Appraiser and A. R. Owens, Assistant Engineer Appraiser, The Federal Land Bank of Wichita, 1943.

[3] A recent grant was awarded by a Colorado rural development agency for the purpose of obtaining equipment to conduct tile line cleaning demonstrations for local landowners.

regional community leaders was also formed to oversee the study. The results of the study flow from a cohesive effort involving dialogue between those who conducted the study and area residents who contributed to its activities.

Importance of the Study

Drainage is closely linked to the present and future of the valley's agricultural water supply system and crop productivity. Improved drainage was continually emphasized by agricultural landowners as being a necessary future capital improvement activity for agricultural production. Low interest construction loans provided through state agencies for improving drainage district infrastructure in the lower Arkansas Valley are believed to be accessible to landowners. However, in order to determine the level of funding that might be required to improve drainage in the lower Arkansas Valley, it was necessary to perform a thorough inventory of the drainage system. This was the core task of the study, and involved mapping the tile line system, as well as updating information on the location of old maintenance manholes (maintenance entry points), drainage effluent outlets and collector drains, and other important features of this extensive drainage system.

Typical Tile Line Outlet with Effluent Flowing into Open Drain (forefront)

Close View of Outlet

Obstructions in Tile Line Before Cleaning

Exposing a Tile Line Before Installing a Manhole

During the preparation of the study, general agreement was found among many landowners that updated information was needed on the exact underground location and performance of the drainage system. Much of this system is comprised of clay tile lines buried deep in the ground. Its extent and location is additionally relevant because recent research conducted by Colorado State University has

shown that drainage is of major concern to future agricultural production in the lower Arkansas Valley.[4] Poor drainage will likely be improved mainly through a combination of modifications to current irrigation practices and reducing seepage through earthen canals. However, one of the most important and necessary additional modifications in land management will be improvement in the design and performance of this old but still very usable drainage system.

The study worked cooperatively with thirteen active drainage districts and numerous landowners in the lower Arkansas Valley to inventory the drainage system. This included estimating the benefits and costs associated with rehabilitating approximately 84 miles of subsurface tile drain lines and 107 miles of open surface drainage waste-ways. Again, to accomplish this task, an advisory committee of county commissioners, businessmen and other community leaders was formed early in the fieldwork to maximize community participation and to facilitate data collection from landowners and drainage districts.

Landowner Advisory Committee

- Mr. Matt Heimerich, Crowley County Commissioner
- Mr. Harold "Jake" Klein, Otero County Commissioner
- Mr. Robert Hamiltion, Southeast Colorado WCD
- Mr. Lawrence Braze, owner, Guarantee Insurance Agency
- Mr. Jay Winner, Director, Lower Arkansas WCD
- Mr. Del Chase, State Board of Agriculture
- Mr. Lyndon Gill, Bent County Commissioner
- Mr. Leroy Mauch, Prowers County Commissioner
- Mr. Leroy Braze, Landowner
- Mr. Bob England, Landowner
- Dr. Lorenz Sutherland, USDA-NRCS
- Mr. Gordon (Bud) Scranton, Landowner
- Mr. Clay Sniff, Vice-President, Colorado East Bank
- Mr. Bill Grasmick, Landowner

In addition, efforts were made to explore how the organization and conduct of annual operation and maintenance activities of this drainage system might be improved over time. This included sounding out landowner opinions regarding the possibility of a more consolidated approach to the current annual maintenance program. It was the viewpoint of the study early on that a more consolidated approach might lead to better use of more modern drainage technologies and improved economies of scale in financing such maintenance. The opinions of outside consultants from three large drainage districts elsewhere in the West, along with the experience obtained from study tours with landowners, provided some support for the idea of drainage district consolidation.[5]

Local communities were also considered stakeholders in the study, not just agricultural landowners, since proper drainage of irrigated lands can affect municipal approaches to flood control and residential and commercial development in the area. Cities and counties were therefore involved in the various activities of the study. They also assisted the study in conducting demonstrations of tile line cleaning and maintenance for landowners. Several landowners were involved directly, by way of allowing tile lines on their property to be cleaned by the study. This collaboration helped demonstrate the benefits of improved maintenance procedures as well.

[4] Gates, Timothy, K., J. Philip Burkhalter, John W. Labadie, James Valliant, and Israel Broner, Monitoring and Modeling Flow and Salt Transport in a Salinity-Threatened Irrigated Valley. Journal of Irrigation and Drainage Engineering (March/April, 2002).

[5] These included the Tulare Lake Drainage District, Tulare, California; The Grand Junction Drainage District, Grand Junction, Colorado; and the South Columbia Basin Irrigation District and its drainage district component, Pasco, Washington.

In a recent meeting held in La Junta, Colorado, for the purpose of soliciting stakeholder input in ranking the importance of various issues pertaining to the Arkansas Valley's future water supply and water quality, land drainage was identified by both agricultural landowners and local community leaders as one of three top future watershed management concerns.[6] The concern over land drainage is not surprising - and not new - given the 150 year old economic history of irrigation in the valley. Since the beginning of irrigation in the 1860s, landowners have made serious attempts to address drainage, most notably in the 1920s when substantial investments were made to install these deep clay tile lines to drain agricultural lands (Table 1 and 2). This concerted effort continued after World War II well into the 1960s, when it gradually began to decline for a variety of reasons.[7] This general decline in interest and understanding of how the drainage system was designed and maintained in the past has contributed to salinity and waterlogging problems in selected areas of the valley.

Table 1 - Early Investment in Lower Arkansas Valley Drainage (Water District 67) Based on Federal Land Bank Records

Drainage District	Date of Formation	Miles of Tile Drains	Miles of Open Drains	Acreage Assessed	Value of Original Serial Bonds
Granada D.D.	1922	0	11	7812	$90,000
Arbor D.D.	1923	2	0	572	$12,000
Kornman D.D.	1921	3	2	1754	$28,500
Lubers D.D.	1921	0	6.5	2500	$32,000
May Valley D.D.	1914	0	9	2000	$25,000
McClave D.D.	1921	2	3.5	3300	$35,000
Pleasant Valley D.D.	1917	1 (private)	5	3500	$26,000
Riverview D.D.	1921	3	5.5	2650	$50,000
Wiley D.D.	1918	40	10	18100	$140,000
Holly D.D.	1922	0	22	6200	$105,000
Dry Creek D.D.	1920	0	0	0	0
Prosperity D.D.	?	0	Not known	560	$11,000
Deadman	?	0	Not known	2406	$23,000
Vista Del Rio	?	0	Not known	4900	$75,000
Total for Prowers Co.		51	74.5	56,781	$652,500

[6] This meeting was organized and sponsored by the Southeast Colorado Resource Conservation and Development (RC&D) Council for the Lower Arkansas Watershed Improvement Association (October 29, 2007). The purpose of the meeting was to solicit stakeholder input on goals to be addressed by a newly proposed watershed plan for the lower Arkansas River Basin.

[7] Possible reasons for a declining interest in maintaining this drainage infrastructure are discussed later in the report. In short, it probably resulted from a combination of factors, such as changing farm tenure and/or ownership, and/or the replacement of specialty crops by small grains that were perhaps somewhat less susceptible to the effects of poor drainage. Increased production costs with the advent of farm mechanization may have diverted some farm income away from drainage maintenance as well, combined with relatively stagnant growth in farm income in the valley over the years.

Federal Land Bank records obtained by this study from the Farm Credit Service Agency in Wichita, Kansas show a large valley-wide effort to address drainage issues commencing around 1911 – the year of the passage of Colorado's first drainage district legislation. This effort continued through the 1920s. This was a period of favorable farm commodity prices, which helped finance such efforts. Drainage installations were financed through serial bonds issued by financial houses in Denver, for the most part. Landowners then paid annual assessments to local drainage districts to pay off these bonds.

Table 2 - Early Investment in Lower Arkansas Valley Drainage
(Water District 17) Based on Federal Land Bank Records

Drainage District	Date of Formation	Miles of Tile Drains	Miles of Open Drains	Acreage Assessed	Value of Original Serial Bonds
Grand Valley D.D.	1923	0	3	850	$22,000
Fairmount D.D.	1918	22	0	1900	$25,000
Los Animas Consolidated D.D.	1911	6	0	1800	$20,000
Los Animas Extension D.D.	1919	5	0	2351	$30,000
Holbrook D.D.	1924	0	30	9469	$182,000
Crowley D.D.	1923	0	Not known	4243	$75,000
King Center D.D.	?	0	Not known	2863	41,000
Numa D.D.	1922			9616	$175,000
Olney Springs D.D.	1921	Not known	0	2023	$40,000
Ordway D.D.	1922			3929	$70,000
Valley View D.D.	1922	0	Not known	4047	$75,000
Total for Bent,Otero and Crowley Co's		+33	+33	43,091	$755,000
Total Lower Arkansas Valley		+84	+107.5	99,872	$1,407,500

The recent renewed interest and concern regarding land drainage has been prompted by mounting land and water quality problems in the valley. Recent investigations by Colorado State University – and corroborated by federal and state agency monitoring of environmental quality in the valley – have shown an alarming increase in river salinity and selenium, along with increasing areas of saline soils and high groundwater levels.[8] These conditions are particularly notable in the reach of the valley between Pueblo, Colorado and the Colorado-Kansas state line.

Inefficient irrigation can contribute significantly to these mounting environmental problems, but poor drainage may be even more of a significant factor. The local relationship between poor drainage and water quality is not well understood and will continue to be so until controlled studies are made of this relationship. For instance, it is known that salinity and selenium readings are higher in certain reaches of the lower Arkansas River basin, but it is not empirically clear that ineffective agricultural land drainage is related to elevated salinity readings. Meanwhile, it has been clearly shown that inefficient irrigation, most

notably from seepage in earthen irrigation canals, is related to high groundwater levels and saline soils. The missing link in the current understanding of these relationships appears to be the role played by drainage. Nevertheless, early settlers apparently understood some elements of this relationship, given the millions of dollars they spent on tile line installation nearly a century ago.

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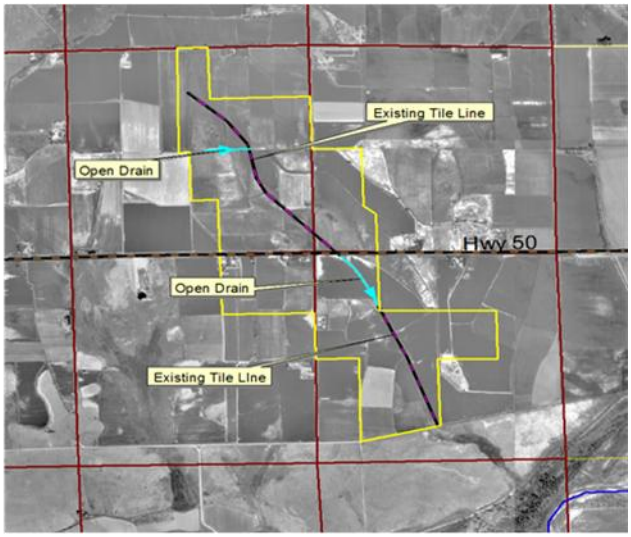

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Miscellaneous Photos – (1) Cleaning out a tile line in the Wiley Drainage District; (2) Map showing the alignment of a damaged drain in the Arbor Drainage District; (3) Typical tile line repair procedure in field.

Other Important Considerations

The study was prompted by the peculiar problem of why these old tile lines have largely become neglected over the years, along with the generally reduced local concern over more aggressive approaches toward land drainage. During interviews, many agricultural landowners expressed interest in these old tile lines but remained vague about their location and characteristics. With a few exceptions– notably the Wiley Drainage District in Prowers County and the Fairmont Drainage District in Otero County (see Map on page 1) - the tile lines have not been routinely rehabilitated and maintained over the years. Consequently, the study has attempted to promote more interest in them by mapping their extent using global positioning (GPS) and geographical information systems (GIS) techniques. As mentioned earlier, additional interest was promoted through numerous informational meetings, study tours, and guest speakers. The good news is that many, if not most, of the valley's tile lines appear to remain very usable. However, they are need of considerable upgrading to be effective. The major problem remains one of mobilizing adequate financing to improve and routinely maintain this extensive system.

There are many other peripheral issues to be addressed as well. These include correctly estimating the potential cost and benefit of such improvements, and equity in the distribution of costs to landowners if one were to initiate a more comprehensive valley-wide drainage system program. Other

issues concern the potential impacts on Colorado-Kansas Compact requirements for both water quantity and quality crossing the state line, individual or shared jurisdictional responsibilities for land drainage, and the most effective organizational means of financing and sustaining such drainage improvements in the future. The study has clarified some of these issues, while others – such as the issue surrounding Colorado-Kansas compact requirements - were not included as an objective of this study.

Modern day technical solutions to drainage are fairly well understood. The science is there, so to speak. However, the mobilization of financial resources and adequate leadership can pose constraints in moving toward an acceptable technical solution. Drainage can be a difficult activity to mobilize resources for. This is due partly to the fact that the benefits of drainage maintenance can be difficult for landowners to gauge, relative to their individual farm operation. Production problems possibly associated with poor drainage are not always self-evident and these problems can build up slowly over the course of many years, sometimes masking their relationship from the landowner. In addition, a group of landowners can share a common drainage problem without clearly being able to determine how maintenance costs can be equitably apportioned between them.

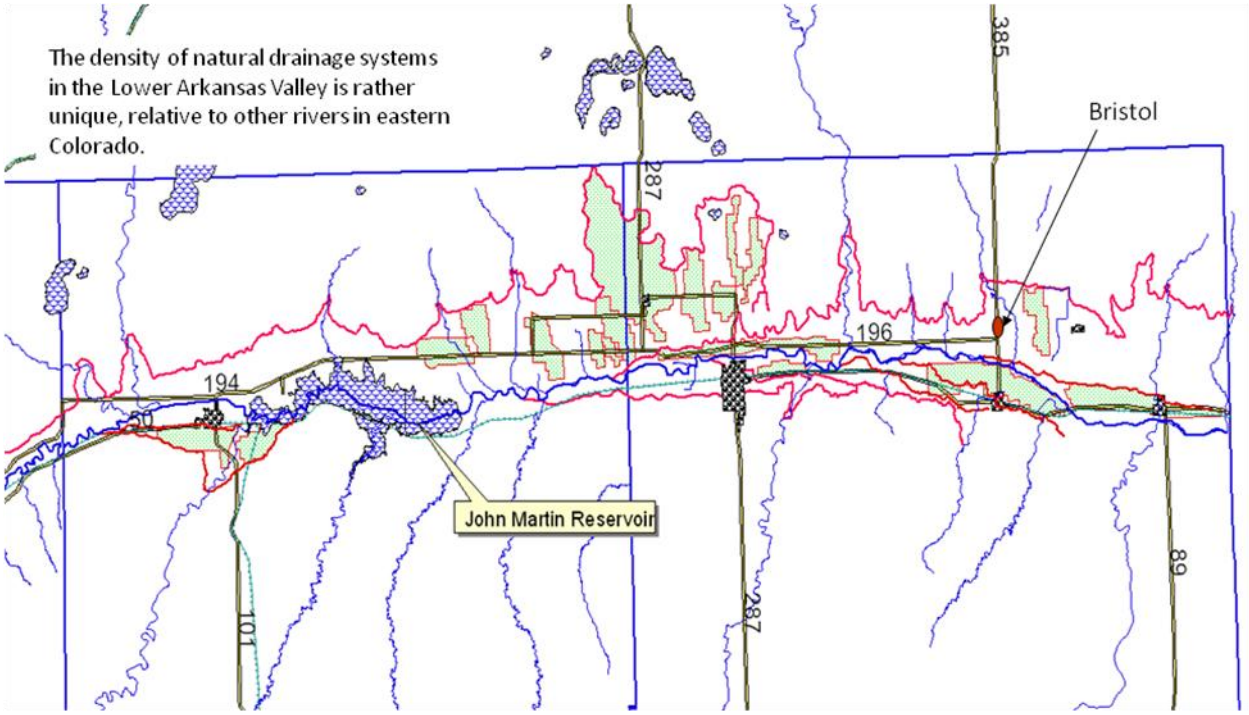
Drainage maintenance equipment – (1) Combo jet-vac rig; (2) Pressure hose on trailer; (3) Mobile camera for drain investigation; (4) Water truck with trailer hose.

In any event, it must be recognized at the outset that improvements in drainage are likely to be costly. It is quite evident that, even with the possibility of an improvement in farm commodity prices in the future, agricultural landowners will likely need the assistance of the entire population of the valley to finance such improvements. Perhaps the good news for agricultural landowners potentially faced with the daunting task of financing such improvements entirely on their own in the future, is that the drainage problems that now exist in the lower Arkansas Valley no longer appear to be solely connected to

agricultural land management practices. Drainage problems appear to result from the activities of all types of land uses; agricultural, residential and commercial.

Organizational and Jurisdictional Concerns

Although the use of existing drainage infrastructure could be a foundation on which to build a more cost-effective technical solution, this is likely to require a substantial organizational effort on the part of community leaders and landowners. The study demonstrated that there are important organizational issues to confront, most notably having to do with the potential need to consolidate many disparate and small scale jurisdictional efforts. This jurisdictional issue is primarily in the form of some thirty small drainage districts scattered throughout the lower Arkansas Valley, of which thirteen are currently active. The combined efforts and benefits of these jurisdictions appear to be seriously hindered by their relatively small individual revenue streams. Furthermore, drainage district land assessments are currently collected largely only for emergencies. This approach toward annual assessments generally does not provide the means of catching up with deferred (accumulated) tile line maintenance over the years.

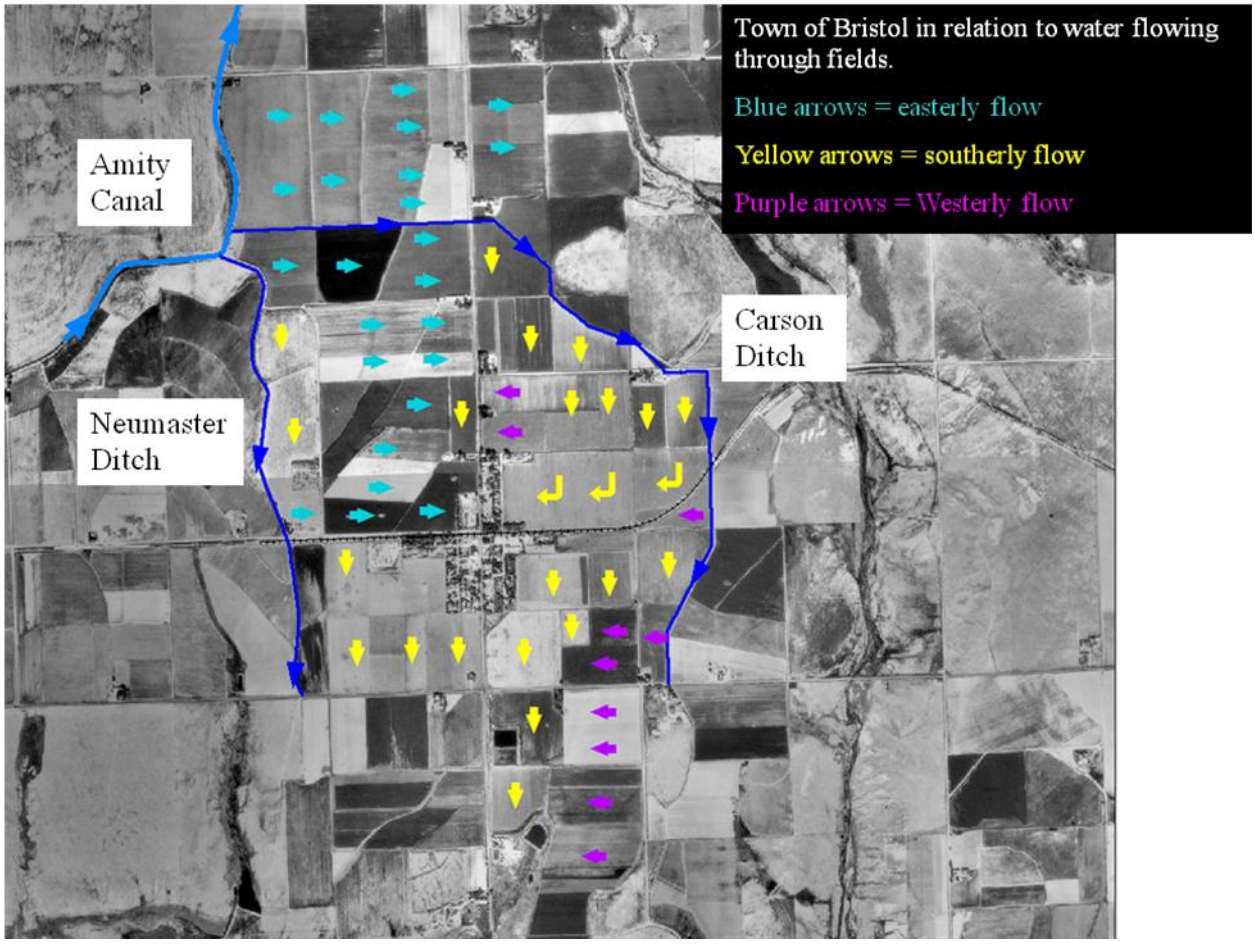


Natural drainage in the Lower Arkansas Valley contributes significantly to flooding in the smaller communities, particularly those located along the bench lands. Bends in the Fort Lyon Canal and Amity Canal (in red on the north side of the Arkansas River) frequently negotiate bench land drainage, the origin of many flood flows for small communities such as Bristol (above).

Two points are clearly evident from available historical records. First, in the early years of addressing drainage, principally between 1911 and the onset of World War II, the financing of this activity fell largely on the shoulders of agricultural landowners. The organizational vehicle, so to speak, was the concept of the special district – or drainage district – following the 1911 Colorado drainage act. The second evident observation from the historical record is that the upkeep and performance of this infrastructure of clay tile lines – often installed as deep as ten to twelve feet in the ground – was greatly

dependent on farm income. Agricultural landowners paid annual assessments to these special districts, the funds of which were collected by the county assessor, then forwarded to district boards for administration (i.e., for payment of bonds, installation, rehabilitation, and annual maintenance).

There appear to be two relevant points for the future. The first is that it does not seem any longer meaningful or fair for agricultural landowners to shoulder the full cost of drainage outside incorporated areas. Secondly, financial sources other than farm income will likely be needed to bring the valley's drainage infrastructure up to the standard it needs to be to address water quality, high groundwater management concerns, and public safety. In short, drainage has gradually become a "community-wide" problem rather than uniquely an "agricultural landowner" problem in the lower basin. Clogged tile lines, damaged lines from residential utility excavation, the dumping of household trash and other debris in open collector drains, residential building on drainage easements, localized flooding in surrounding communities from the convergence of convectional thunderstorms in the summer, surface irrigation flows, and high groundwater have <u>all</u> contributed to drainage becoming a "community-wide" issue in the valley.



A preliminary study conducted in Bristol, Colorado on the north side bench lands of the lower Arkansas Valley – and discussed later in this report – demonstrated the effect that inadequate drainage structures can have on such communities (Appendix C). Small towns in the lower valley are literally surrounded by surface water and high groundwater during the irrigation season. The diagram on the previous page shows the Town of Bristol surrounded by return flows from surface irrigation. When convectional thunderstorms occurring during the irrigation season converge with irrigation return flows,

high groundwater, fully saturated soils, and poor drainage infrastructure, the result can be serious flooding in these small communities. Larger communities have a more substantial tax base to plan and build for proper drainage. More rural residential subdivisions, which are growing in number throughout lower valley, obviously do not. Consequently, it appears that a land assessment program for drainage originally designed nearly 100 years ago primarily for agriculture land management may have become somewhat obsolete, both in its organizational framework and its revenue base, to meet broader community needs.

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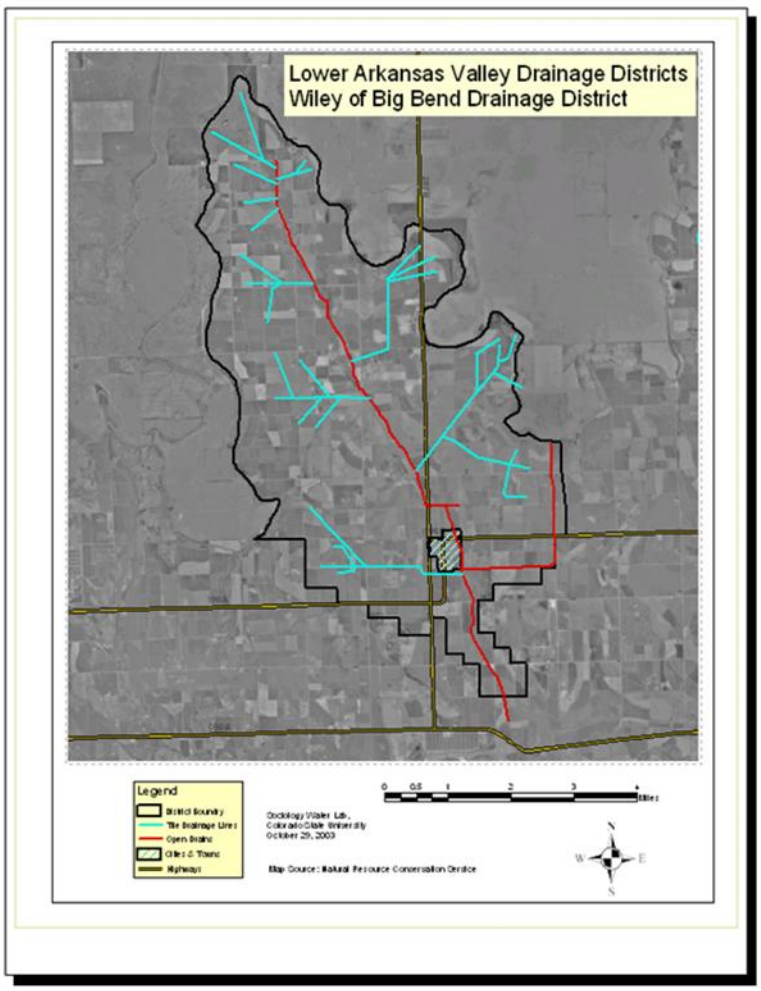
South Columbia Basin Irrigation District (three man drainage crew) – (1) Dan Morasch, Technician (retired); (2) total field crew for 1200 miles of tile lines and 3000 manholes; (3) Cleaning a root ball out of a manhole; (4) Cleaning out a manhole Their maintenance program is discussed later in the report.

Summary

Some of these observations are probably not good news for community officials often struggling with equity in the allocation of drainage costs to town and rural residential subdivision property. Drainage is moving in the direction of being another cost borne by a rural population that continues to struggle with a limited tax base. For elected officials, the prospect of another new tax on property owners to address what almost everyone now recognizes as a growing problem, and one that is largely indifferent to traditional jurisdictional boundaries, may well require sustained consensus building to initiate an expanded revenue stream and different drainage system organizational arrangements.

Yet, there is good news. Investigations reported here, as well as important observations made by outside consultants to the study, such as the South Colombia Basin Irrigation District, Pasco, Washington, suggest that the original drainage infrastructure installed during the early years of the last century is still very usable. These tubular clay lines, many of which were designed with sleeves for inserting one thirty inch section into another to prevent subsidence at the joints, appear to be largely indestructible if not

disturbed by improper excavation. Many lines have been blocked by tree roots or silted up over the years. This is a natural process which is normally remedied only by routine cleaning – an effort which really never occurred in the valley on a consistent basis in the past. A consultant from the South Columbia Basin Irrigation District provided a presentation to the advisory committee of this study on how three men assigned to the drainage maintenance team of his district (images on previous page) routinely repairs and maintains 1200 miles of tile lines and 3000 manholes with an annual materials budget of $13,000! This, of course, excludes salaries and the one time purchase of tile line cleaning and repairing equipment. Nevertheless, such an approach as that found in the South Columbia Basin Irrigation District is potentially very applicable to the lower Arkansas Valley. This approach could make use of both the older drainage infrastructure and newly engineered additions to it, once a full rehabilitation was achieved and proper equipment was purchased to conduct routine maintenance of the tile lines.



The Wiley Drainage District is the largest and most extensive tile line system in the Lower Arkansas Valley.

The main open collector drain is in red.

General location of tile drains are indicated in blue.

The location of the tile drains were initially penciled in during reconnaissance, then verified and plotted with GPS.

This report will attempt to argue that not only is there an organizational solution that is practical and cost effective, but that such a solution is practiced elsewhere in the West with very favorable results. The study has utilized the knowledge of drainage financing and management techniques practiced elsewhere to visualize a potentially successful drainage program for the Arkansas Valley. Representatives from the South Columbia Basin Irrigation District in Washington, the Tulare Lake Drainage District in the Central Valley of California, and Colorado's own Grand Junction Drainage District have visited the valley and made public presentations. They have spoken to community leaders, individual landowners and the study's advisory committee. They have come away convinced that a

program of rehabilitation and maintenance of existing rural drainage infrastructure – along with additional improvements – could easily address the valley's drainage problems. However, it will take informed leadership, a high level of cooperation between counties, cities, and agricultural landowners, and a reliable revenue stream to ensure routine annual maintenance for sustainable management.

In summary, this report will show that: 1) there are many benefits to utilizing existing drainage infrastructure and which can effectively accommodate new additions to it; 2) changes in the organization of drainage in the valley are needed and that there are excellent examples of good organizational design to draw from, and, 3) drainage should no longer be considered as simply an agricultural landowner problem but rather a liability that probably should be shared by all residents of the valley.

Chapter 2

Brief Historical Context

Drainage district acts were passed in 1911 and 1919 by the Colorado legislature authorizing the formation of special districts for drainage.[9] Between 1911 and 1922, there were 25 known drainage districts organized in Water Districts 67 and 17 in the lower Arkansas Valley.[10] Most of these were organized in Bent and Prowers counties, although several were also organized in Otero, Crowley and Pueblo counties (Map 1, page 1 and Table 1 and 2, page 5-6). Frequently, national sugar corporations operating in the valley helped finance these organizational efforts.

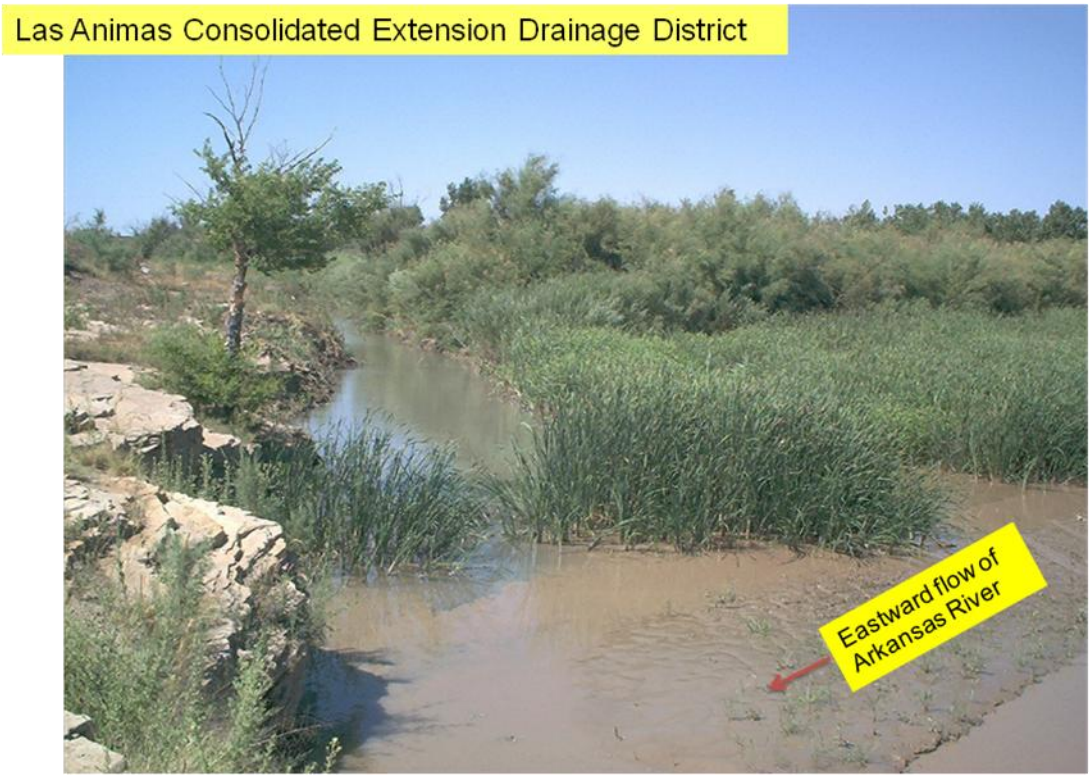
Open collector drains – (1) Los Animas Consolidated (extension) DD (previously a buried tile line); (2) Kornman DD; (3) Pleasant Valley DD; (4) Wiley DD open collector drain where it meets the Amity Canal. These open drains collect effluent from the tile lines.

The formation of drainage districts represented a considerable capital investment by growers in the lower valley, attesting to the importance of drainage to agricultural production then and now.

[9] Colorado Revised Statutes.

[10] The study researched archives of the Federal Land Bank at the Farm Credit Service (FCS) office in Wichita, Kansas. Special thanks to Dexter Henderson (deceased), Engineer Appraiser and long-time employee of the Federal Land Bank for assisting our research at FCS. Engineering Report on Water Districts 17 and 67. John H. Griffin, Associate Engineer Appraiser and A. R. Owens, Assistant Engineer Appraiser, The Federal Land Bank of Wichita, 1943.

Combining the infrastructure of the known drainage districts, approximately 84 miles of tile drains and 107 miles of open collector drains were constructed at a cost of $1.4 million dollars between 1911 and 1925. These drainage systems served a minimum of 99,872 acres. The original benefited acreage was estimated by the Federal Land Bank based on the number of acres reported as being assessed by the drainage districts.[11]



This photo shows the main open collector drain of the drainage district entering the Arkansas River. Due to the silting up of the river (and the drain), the drain has lost all elevation relative to the river. The drain thus backs up, further damaging the tile line system in the district; the large majority of which has been dug up because the tile lines no longer function adequately.

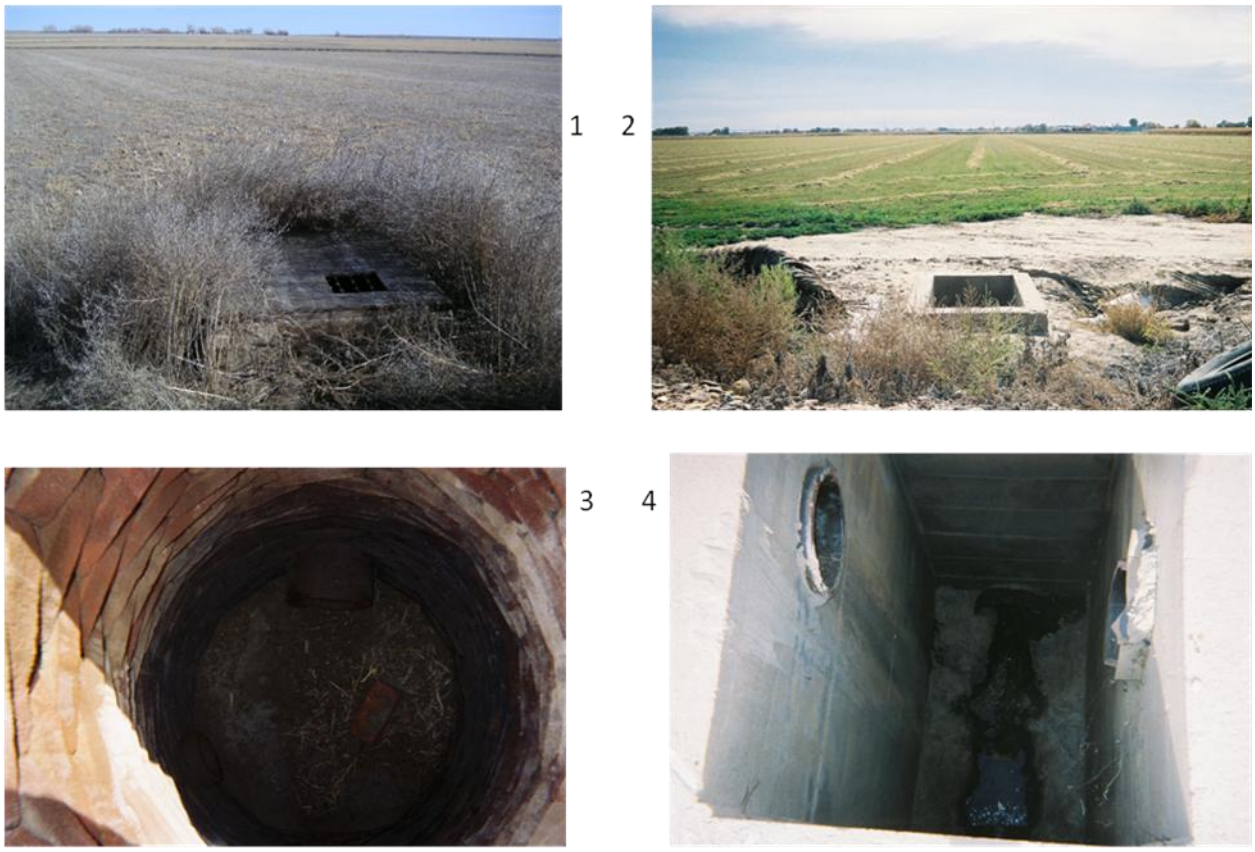
It is not completely understood what inspired such a large drainage district movement in the lower Arkansas Valley at that time. Presumably, 50-60 years of irrigating in the lower Arkansas Valley had demonstrated the need for adequate drainage.[12] In later years, drainage problems of a more or less serious nature were again reported for various points throughout the lower valley. Sub-drainage problems were particularly notable in the area east of Las Animas, Colorado. In 1942, backwater and silting up of the Arkansas River was noted by the Federal Land Bank as causing problems with some of the drainage systems that were installed in the 1920s. This is also the case today, notably evident for one of the study's participating drainage districts near Las Animas, Colorado (above photo).

Elsewhere, some of the tile drains observed during the study probably experienced considerable subsidence, losing proper alignment over the years. This generally led to their being permanently

[11] Federal Land Bank Report, 1943. Unpublished archive, courtesy of Farm Credit Services, Wichita, is available on request.

[12] The previously cited Federal Land Bank study reports that irrigation commenced in the Arkansas Valley in the early 1860s, as it did elsewhere in Colorado.

removed rather than being replaced.[13] In addition, an insufficient number of tile line observation manholes were installed to service the lines. These were often constructed of timber in the past rather than of concrete. Inadequate manholes for the purpose of conducting routine maintenance on the tile lines were - and continue to be - at the core of drainage problems in the lower valley. As will be discussed later, these tile line access manholes are essential to a sound maintenance program.



Manholes – (1) Old wooden manhole; (2) Newer concrete manhole; (3 and 4) Inside manholes.

It is known that many of the drainage districts had problems meeting annual assessments during the Depression of the 1930s. This resulted in considerable deferred maintenance on the drainage system for a number of years, particularly in the smaller drainage districts. The Reconstruction Finance Corporation (RFC) under the Roosevelt Administration provided funds to refinance many of the indebted district serial bonds. However, this refinancing was followed by another probable reduction in farm income due to the scaling down of sugar beet production in the 1970s. This economic slump appears to have led to further deferred or discontinued maintenance of the drainage systems.

In subsequent years, farm income declined further. This tended to lead to some reluctance on the part of growers to increase drainage district assessments to meet an emerging drainage problem for crop production in the lower valley. Meanwhile, those growers who were familiar with the whereabouts of tile drain systems were beginning to pass on. Today, there is a core of octogenarian growers whose

[13] Federal Land Bank Report, 1943. See footnote, page 15.

knowledge of these tile lines is the only real connection to the past and to the true whereabouts of the tile drain system. Obviously, they have been of great assistance to the study's tile line mapping program.[14]

Some old engineering layout sheets of the drainage systems have been obtained from various sources during the study. They were provided by local farmers, and/or found in the archives of local county assessor's offices or in local federal agency offices. However, they are often incomplete and likely do not represent the final installation alignment of existing tile lines. Only the location of principal open collector drains is clearly observable in more current documents, aerial photos, county soil maps, and other relevant data sources that were consulted during the study.

The study confirmed that many of the subsurface drains continue to carry substantial water, even during a recent prolonged drought. This is observable at identifiable outlets along open collector drains, and by observing flows through very dilapidated timber manholes throughout the lower valley. However, over the years, and often due to the transfer of ownership of land, there has been a loss of knowledge of the whereabouts of the tile lines under farm ground, and that once discharged into nearby open surface collector drains. This has often led to tile line outlets being covered up and lines being damaged during land preparation or during the installation of natural gas and other utility pipelines in the valley.

The Holly Drainage District

This drainage district is located near the Kansas state line. The photo is of a branch of the main open drain just west of the Town of Holly, looking south, right on Highway 50. The drain shows substantial flow during a drought. The photo was taken on August 5, 2003.

[14] The research team is especially grateful for the assistance of Mr. Olaf Sharp and Mr. James Colvin for their assistance in mapping the Wiley Drainage District, the largest district in the lower valley.

Although cropping and irrigation practices have changed over the years, the drainage network is still valuable in protecting the crop root zone from overly saturated soils in wet years and to manage a characteristically high water table for the region in normal years. Growers interviewed affirm this fact. Even recent drought years have shown considerable flows in the tile lines (above photo). The predominance of clay loam and loam soils in the lower Arkansas Valley appears to be an important reason for the continued need of tile lines. The natural surface drainage off bench lands and seepage from highline canals negotiating the topography of the valley floor, as mentioned previously, also contribute to drainage problems and the need for proper drainage.

More modern drainage systems, such as those found in the U.S. Bureau of Reclamation's Columbia Basin Project in the State of Washington, were built with observation manholes located at every junction of lines in the tile drain system, and at the location of tile line diameter changes as well.[15] It is believed that the drainage systems in the lower Arkansas Valley were designed with a limited number of observation manholes, making it difficult to track the performance of the valley's drainage system over time. Manholes are also needed for maintenance, and a lack of adequately constructed manholes of a width and depth sufficient to access drains for observation and cleaning do not appear to have been part of the early design of drainage systems in the lower Arkansas Valley, except perhaps for the Fairmont Drainage District in Otero County (to be discussed later in the report).

Today, lack of knowledge of the whereabouts of the drainage structures makes it difficult for the drainage districts to schedule maintenance and plan for long-term rehabilitation. Some of the subsurface drains have "boiled up" in unexpected localities, creating cavernous sinkholes. In other localities, inadequately maintained surface collector drains have silted up to the point where tile line outlets that discharge into these open drains have been blocked (see previous photo of the Las Animas Consolidated Extension Drainage District open drain entering the Arkansas River). This blockage can contribute to seepy ground and even wet basements in rural subdivision homes located over such lines.[16]

Federal Land Bank Records

The best historical information available on drainage problems in the lower Arkansas Valley can be found in engineering appraisal reports compiled by Federal Land Bank employees beginning as early as the 1920s. These appraisers were assigned by the Bank to compile detailed information on the water rights of landowners applying for government assistance during and after the Depression. The records continue to remain some of the most authoritative historical documents on water supply and drainage systems in the West. A sample of these records is provided in Appendix A. It reports on the status of the Fairmont Drainage District as of 1942.

A long time employee of the Bank was responsible for compiling such records for Colorado and Kansas over many years and following many return visits and interviews with mutual water companies and drainage districts in irrigated areas like the Arkansas Valley. It is instructive to hear what this Bank employee has to say about drainage problems and drainage district formation in the lower Arkansas Valley as of the early 1940s. The reference to Colorado water districts utilizes an older state numerical designation for districts. Bracketed text has been added to suggest present locations or conditions:

[15] Personal visit by the P.I. and discussions with Mr. Dan Morasch, Drainage Technician, South Columbia Basin Irrigation District, Pasco, Washington.

[16] The "boiling up" of tile lines is a term referring to when a line gets plugged by tree roots or other debris in the line, leading to a patch of seepy ground that can often be a surprise to a landowner operating a hay swather at night.

"Surface drainage throughout the Arkansas Valley may be generally termed as good. This is particularly true of the bench lands and undulating uplands, all of which have a good slope toward the river from both sides. On the bottom lands, the surface drainage is not as good, but in general these have a sufficient slope to the east and also toward the river, which, with the aid of frequent intersecting watercourses, affords an outlet for surface water and results in only a limited number of small areas where water does not drain off readily."

"Subdrainage, however, has been a major problem in the valley, particularly in the area east of Las Animas, and large sums of money have been spent in an effort to overcome its detrimental effects upon crop production and prevent the further raising of water tables and increase in alkalification."

"In Water District No. 14, or Pueblo County, there is a sufficient depth of gravel or sufficiently pervious subsoil above the underlying shales to produce generally free subdrainage. In this area, the lands are comparatively free from alkali and all artificial [man made] drainage has been confined to a few scattered tracts on the bench lands and a relatively small area of river bottom land."

"On the true terrace lands lying on the south side of the river in Otero County in Water District No. 17, the subdrainage is likewise generally good. Two small drainage districts [probably the Fairmount Drainage District under the Catlin Consolidated Canal Company, and the Grand Valley Drainage District under the High Line Canal Company] have been organized in this area, but natural drainage has generally proven adequate and the principal alkalized or seeped areas consist of narrow strips of land adjacent to natural water courses."

"Drainage difficulties of a more or less serious nature have occurred at various points in almost the entire remaining part of the valley, although there is an area on the north side of the river under the Fort Lyon system [Fort Lyon Canal Company], between La Junta and a point about five miles east of Las Animas, which has been relatively free of drainage troubles – also a large part of the area under the Amity System in Prowers County [the Amity Mutual Irrigation Company]."

"Twenty-five drainage districts have been organized in Water Districts Nos. 17 and 67, embracing approximately 100,000 acres. The drainage facilities were constructed in all but one of these districts. Of this total area, approximately 77,000 acres, or 77% of the gross area in the districts, is under cultivation at the present time. A part of this non-cultivated acreage consists of lands which do not have water rights and is not the result of ineffectiveness of the drainage systems. Several private and partnership systems have been constructed in addition to those organized drainage districts. The American Crystal Sugar Company operates a system under the Rocky Ford Canal and another under the Lamar Canal, both of which serve a considerable area of land. Another partnership system, which serves a fair sized body of land, has been constructed on Limestone Creek, west of McClave."

"The systems have functioned with varying degrees of effectiveness, but aside from three districts, the results have been generally satisfactory. During the dry period of 1931 to 1940, many of the drains ran but very little water, but in the last two years have again began to function. In the dry cycle the ditches were indifferently maintained and many of the laterals were allowed to become rather badly filled by weeds and silt [probably referring to both irrigation ditches and open collector drains]. Better maintenance will be required in the future if the effectiveness of the system is to continue, but it is believed that in most instances this may reasonably be expected as the lands are of good class and sufficient maintenance work will be done for their protection."

"Six of the organized drainage districts paid off bonded indebtedness as per schedule. Financial difficulties have been encountered by the remaining districts, in varying degrees, and defaults have occurred. In six districts, the indebtedness was not refinanced and from 75% to 90% of the outstanding bonds have now been paid. This was accomplished to some extent by landowners buying up bonds at depreciated values and applying them on their drainage assessments. All assessments as provided by law have been levied and the outstanding debt in such districts is a liability on only the lands that are delinquent. Nine districts have been refinanced by the R.F.C. [the Roosevelt Era's Reconstruction Finance Corporation] and all but one of these, the Holbrook Drainage District, are current with bond and interest payments. Several are considerably ahead of schedule."

This rather lengthy quote from the engineer appraisal report submitted to the Federal Land Bank in 1942 is revealing, showing that drainage district formation and management was an integral part of irrigation in the lower Arkansas Valley. Tables 1 and 2 (page 5-6) shows the degree of capitalization entered into by landowners to improve drainage in the area during that era. Nine drainage districts are most noted for having extensive tile line systems. These include Olney Springs (in Crowley County), Fairmount (Otero County), Las Animas Consolidated, Las Animas Consolidated Extension and Arbor (all in Bent County), and McClave, Riverview, Wiley and Kornman (all in Prowers County). The Olney Springs and Fairmount drainage districts appear to have been the most sophisticated systems, with many small tile line laterals leading into main collector drains, and numerous entry points (concrete or brick manholes) for maintenance. However, both of these districts were quite small in size. The most extensive tile line system in the valley was laid on the north side of the Arkansas Valley between Bent County Road 1 and extending past Highway 287 about four miles. These lands were designated in the Wiley Drainage District.

The sample engineer appraiser report for the Fairmount Drainage District is worth glancing at (see Appendix A). Like the other 24 reports, it contains valuable summaries of the district. Unfortunately, little information is given on the alignment (location) of the tile lines. Nor is there information on the maintenance practices of the districts, other than to report if maintenance was being conducted on a routine basis.

District assessments appear to have been based on various prorated formulas adapted to each district. The most common method appears to have been to prorate the assessment of $1.00 per acre of 100 percent of benefitted land. This meant that each acre (or tract) of land in a district would theoretically have a different assessment, depending upon what percentage of the acre was determined by the district to be benefitted by the drainage system. This would have required some kind of assessment ledger for each district; an example of which was unfortunately not made available to the study. These prorated values were then summed for all acreage irrigated by the landowner to determine the assessment owed to the district each year.

In summary, it is clear that the historical information on these districts demonstrates the uncontested nature of their importance to the lower Arkansas Valley. In the past, they were viewed as essential to the maintenance of productive farmland, and ought to be viewed so today. Those localities where the districts are active today are generally the most productive areas of the valley, whereas those areas where the districts have lapsed are generally the least productive. Yet, as mentioned previously, the importance of the districts is now a community-wide concern, rather than simply the concern of agricultural producers. Hopefully, the lower valley as a whole is coming to the recognition of this shared interest and need.

Chapter III

Drainage System Management

The major activity undertaken in the study was to map and inventory this drainage infrastructure, to determine its location and length, and to develop a location finder method that could be used to guide drainage system maintenance and rehabilitation in the future. This raised the need for visiting existing tile line maintenance programs elsewhere in the West that could be used as potential models of drainage system management for the Arkansas Valley.

Arkansas Valley landowners participated in a study tour to the South Columbia Basin Irrigation District (SCBID) in Pasco, Washington. As mentioned earlier, this district was built by the U.S. Bureau of Reclamation as part of its enormous Columbia Basin project. The district maintains approximately 1200 miles of tile lines. It is a good example of a modern, efficient, drainage system maintenance program.

DRAINS WITH ROOT PROBLEMS

Saw | Nozzle | No roots

BLOCK 20

DRAIN	UNIT	MH to MH	Sta to Sta	LENGTH	TYPE ROOT	OWNER	TREES REMOVED	DATES AND TIME OF CL						
								Date	Dist.	Time	Date	Dist	Time	Dat
D20-46	46	Cmp to 2	0+64 to 3+72	308	Cherry			9/11/03	308	0.5				05/25
D20-46		2 to 3	3+72 to 8+20	450	Cherry			9/11/03	450	0.5				
D20-46		3 to 4	8+20 to 13+20	500	Cherry			9/11/03	500	0.4				
D20-46		4 to EOL	13+20 to 28+50	1530	Cherry			9/11/03	660	1.0				
D20-46A	46	2 to EOL	0+00 to 5+50	550	Cherry			9/11/03	510	0.4				05/25
D20-46B	46	0+00 to EOL	0+00 to 15+00	1500	Cherry			9/11/03	920	0.9				
D20-61T		13 to 32	0+00 to 8+93	893	Poplar?			9/10/03	385 20'	1.0				05/25
D20-69	65	5 to 4	17+27 to 14+49	278	Poplar		No	9/10/03	278	0.5				05/25
D20-109	109	6 to 5	32+57 to 27+35	522	Roots			3/3/99	500	0.7				
D20-114P	91	11 to ----	0+00 to 9+30	930	Possible Roots									
D20-131E	129	CMP to 25	0+27 to 8+83	856	Grapes			9/28/01	840	1.5 hr				
D20-131E		25 to EOL	8+83 to 26+00	1717	Grapes				400	6.0 hr				
D20-200	200	CMP to 1+00	0+22 to 1+00	78	Willow Roots		yes	8/13/03	100	1				
D20-200-2A	200	4 to 5		500	Willow Roots									
D20-212-2	46	11 to 12	84+92 to 93+65	873	Apple			4/16/02	837.4	1.3	923/03	840	1.6	05/26
D20-212-2	46	12 to 13	93+65 to 100+28	663	Apple			10/17/2002	633		9/23/03	635	0.7	05/26
D20-212-2	55	13 TO EOL	100+28 TO	633	Apple			10/17/2002	1020					05/26
D20-212-2J	92	20 to 19	33+29 to 23+10	1019	Apple			10/16/02	80					
D20-212-2J	214	20 to EOL	33+29 to 42+00	871	Apple			10/17/02	860					

Entries in the distance column (purple and yellow) represent the number of feet cleaned in a particular drain to date. The number 20 in the column for "Dist.," in the row for drain D20-61T, indicates that 20' of the 385' cleaned was also cleaned with a saw. The entire 1200 mile drain system is thoroughly cleaned every five years, as the program moves through the system on an annual basis.

The maintenance of the Washington district's drainage system is conducted by three full-time employees (photo, page 11). The program is guided by a detailed inventory of the system, with a locater identification numerical system for tile lines and manholes that is entered on spreadsheets, and detailed enough to keep track of all aspects of the system's maintenance (above). This includes the actual linear

footage of these lines and their location and direction underground, their dimensions, the location and numbering of manholes used to enter the lines, and a record of all past maintenance conducted on the system. Additional items entered on the maintenance spreadsheet of this model drainage program include typical problems addressed during maintenance, such as silting up of lines, tree root problems, and surface conditions (i.e., type of crop grown in the area, irrigation method, etc.). These spreadsheet entries are routinely used to schedule maintenance on the system.

All lines, manholes and other features of the SCBID system are checked at least once every five years, a time span that is generally considered sufficient to keep the drainage system operating efficiently. Thus, in a five year period, all 1200 miles of drainage line are regularly serviced. This compares to the rather meager 150 miles of tile line in the Arkansas Valley that is only being serviced on an "as needed" basis or as a particular problem arises. Hence, the enormous value of the South Columbia Basin Irrigation District's program as a prototype for the Arkansas Valley.

The geographical scale of the Washington drainage district is certainly comparable to the Arkansas Valley's farm acreage. The district is comprised of about 250,000 acres of farmland, spread across the eastern side of the Columbia River, north of Pasco, Washington. The headquarters of the drainage maintenance program, which consists of several small storage sheds and a yard for parking cleaning equipment, is located in the center of the district and conveniently situated to service the drainage system. The Arkansas Valley, on the other hand, is characterized by many small drainage districts located between Pueblo and Lamar and into Crowley County (where many old lines are located but no longer useful because of greatly reduced irrigation in Crowley County). The obvious point to be made here is that the three employees of the Washington district manage a drainage system the size of which dwarfs that of the lower Arkansas Valley.

In the Washington district, drainage line maintenance is conducted utilizing standard sewer cleaning equipment typically found in large municipalities today. These include a jet cleaning and vacuum combine truck, a water tanker truck used to accompany the jet cleaner anywhere in the district, a mobile camera attached to a cable that is used to enter and travel up drain lines and display and/or videotape problems before cleaning or maintenance begins in the lines, and a variety of water nozzles and other equipment to cut into heavy silt and root problems in the drains and manholes (see photos, page 11). The vacuum is used to clean out manholes and to facilitate other activities when flowing water or heavy silt obstruct cleaning activities. Once purchased, this equipment is not expensive to operate, and can generally be managed by two people. That is the case in the Washington district, where two field staff employees perform most work under the supervision of one experienced drainage technician hired by the district to oversee their entire drainage maintenance program.

In contrast, the Arkansas Valley has thirteen active and numerous inactive districts. Many of the Arkansas Valley drainage district systems are quite small, and the way in which they are currently organized to coordinate and conduct maintenance leaves much to be desired. The active districts are governed by elected boards, none of which have an employee dedicated to maintaining any of these systems. Most work is performed on a voluntary basis, or individual landowners contract to have a problem taken care of by a local sewer cleaning or excavation company when problems arise on their farm land.

This situation suggests that the valley's districts could conceivably be consolidated into one operation to benefit from the economy of scale found in the Washington district. One team of three full time employees with the proper equipment could manage the valley's entire drainage system, including both the old tile lines and the open collector drains located throughout the valley's extent from Pueblo to the Kansas state line. This would minimize the need to contract with private sector firms to occasionally dig up and replace lines when emergencies arise. Some maintenance is being performed regularly on the

valley's drainage system, but most landowners would agree that it is not being conducted in a very systematic way, and most certainly not for routine maintenance. The scheduling and performance of routine maintenance on these drainage systems is what makes the Washington district's program so effective and sustainable over time. Routine maintenance of the system ensures that small problems are addressed before they turn into big problems requiring substantial and expensive excavation and replacement of lines.

One of the interesting observations made during the study tours to the Washington district was the great number of access manholes in the underground drainage system. It is clearly evident that the presence of manholes facilitates routine maintenance, for there would be no other way of entering the drain lines except at the point where they discharge from underground into open collector drains. It is believed that in the early years of tile line installation in the Arkansas Valley, inadequate attention was given to the need for sufficient manholes to enter and maintain the system. In support of this observation, most landowners in the valley who are familiar with these drain lines readily agreed that the lack of manholes made it difficult to maintain them with any degree of regularity. The absence of manholes has often led to the general abandonment of these lines as well. It is very probable that improvement in the performance of the valley's drainage system would require a substantial investment in manhole installation, a possible economic stumbling block in bringing these lines up to a more modern standard of performance. The tile lines themselves appear to be capable of being reconditioned, but only if investment in additional manholes is part of such a program.

In recent years, several landowners in the Arkansas Valley have either contracted to have shallower and smaller plastic drain lines installed by local companies, or have applied to the U.S.D.A.'s Natural Resource Conservation Service's Environmental Quality Incentives Program (EQIP) for federal cost share funds. Such action has usually been prompted by the emergence of sinkholes or localized seepy ground on the farm, and often where an old tile line system has finally given way. Generally, little attention is given to the idea of attempting to locate and repair the old line first, and then assessing whether it might be possible to join new drain lines into the old system. This would not be practical in all instances, but most certainly could be taken into consideration when planning these newer installations. However, it would take a coordinated effort to locate existing lines, assess their current condition, and schedule rehabilitation or maintenance before connecting any new drainage lines to the older system. Such a coordinated effort is likely only feasible if the drainage maintenance programs of several small districts in the Arkansas Valley are combined into a valley-wide effort. This is one of the key recommendations coming out of the study, but admittedly has some detractors. This consolidation issue will be discussed later in the report.

Some landowners have indicated that the periodic hiring of private contractors would normally be sufficient to maintain such a far-flung system, rather than relying on the small staff of a "mega-drainage district." There is some merit to this argument, particularly with regard to keeping district overhead costs to a minimum. However, as with local ditch companies in the area, the use of private contractors can result in the inability to address emergencies promptly and to ensure that work is done to the specifications of the district. Very few ditch companies rely solely on private contractors for the upkeep of their irrigation system. Rather, most of this work is done "in house." The situation with drainage districts may be comparable. It is difficult to see how a sustainable maintenance program could evolve under a regime using only private contractors, particularly a program that could address the needs of so many small districts in the valley, unless a joint effort by several districts was made to develop an annual maintenance schedule that a private contractor could integrate into its normal business activities.

Current Drainage District Activity in the Arkansas Valley

Of the 25 or so drainage districts that were formed in the early years, 13 appear to be active today. By "active," is meant that annual assessments are being collected from landowners, largely adhering to an assessment formula that has been in use since their formation. Presently, as well as in the past, assessments are remitted to the County Assessor, who then disburses the funds at the district's request. County assessors indicate that they do not function in any other capacity for the districts other than to be the depository of these special district funds. Individual boards are elected in each of the active districts, whose responsibility is to decide how the assessments are to be spent. Most of the presently active districts are quite small in acreage extent, having only a couple of landowners as members. Farm consolidation over the years has reduced the number of landowners involved, although apparently not the formula itself for assessments on acreage.

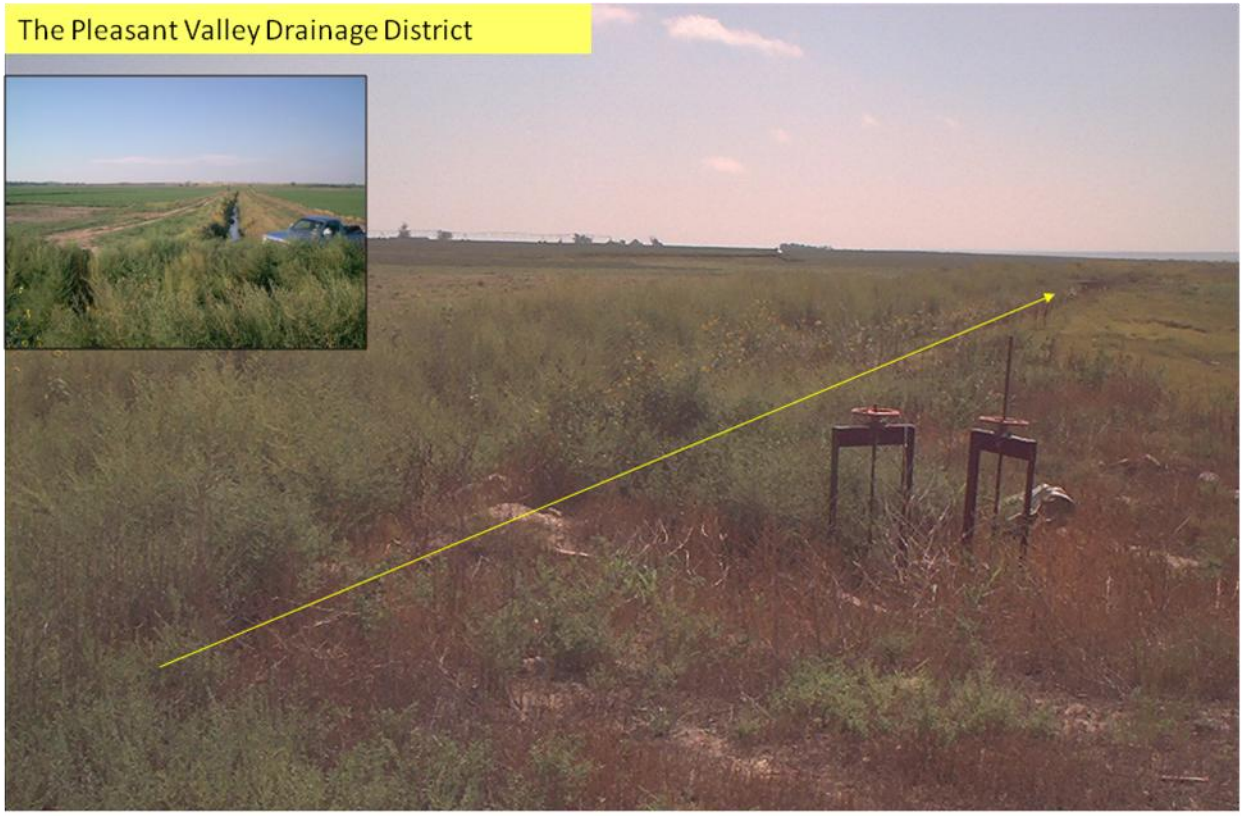
In some instances, district assessments have been increased, while in others they have remained generally unchanged for many years. Decisions leading to the increase in assessments appear to be largely the result of emergency drainage problems that arise in the district, often during a wet cycle in the weather, or after a major rain or snow storm. Again, very few of these districts have an annual maintenance program of any kind. Two notable exceptions are the Fairmont Drainage District in Otero County and the Wiley Drainage District in Prowers County. Both of these districts have substantial drain lines still functioning quite well, and consequently utilize annual assessments for their upkeep. However, in both of these instances, a routine maintenance program is not in evidence, but rather maintenance efforts are simply undertaken to address problems as they arise – usually the result of landowners contacting the board and requesting help in cleaning a plugged line, or more frequently, burying a manhole outlet in a field in order to facilitate cultivation and harvesting.

Frequently, it has been necessary for individual landowners to dig up portions of the old tile line system in order to properly drain a field. Although this can be detrimental to the overall drainage system, it is quite obviously necessary to take such emergency action in the absence of rapidly available organized help. There are often either insufficient funds in the district to hire a contractor experienced in drain line maintenance, or the problem represents an emergency for the landowner – a crop in jeopardy. Added to this is the fact that most landowners do not know the actual alignment of these drain lines, and therefore are unable to address the problem in any systematic way. The result is usually that the landowner must dig up large portions of the tile drain line, or at least to permanently disturb the line's alignment and proper functioning in the process of doing so. Again, the mapping program completed by this study should provide a more systematic way of addressing these problems. Still, the absence of a local drainage technician familiar with these systems and how they function, and a small supporting staff that could be called out to fix a line during an emergency or to conduct routine maintenance, appear to be major stumbling blocks toward a uniform and sustainable drainage maintenance program in the lower valley.

The maintenance of the large open collector drains that have been excavated throughout the valley over the years are currently treated with more consistency. They are visible and easily cleaned, although the earthwork involved can represent a considerable cost to the drainage district. Some of these open drains can be 20 to 30 feet deep and can become clogged with weeds in a matter of a few years (see photos, page 14). They are an integral part of the tile line drain system, since the deeply buried clay tile lines discharge into these open drains. The open drains have to be routinely cleaned of weeds and mud usually every couple of years. Even if the tile lines discharging into these open drains no longer function, the open drains are effective in draining much of the surrounding land. Groundwater seeps through the sides of these deep open drains, which is then conveyed to the river.

A few of the smaller open drains actually have irrigation diversion decrees filed on them, where drain water effluent is brought back onto the land for irrigation. Some of the open drain lines also

discharge into irrigation canals managed by the mutual water companies in the Arkansas Valley. Most drainage district assessments collected in the valley go primarily to cleaning these open drains. Except for the two districts mentioned earlier with an active maintenance program, very little in the way of district assessments go to cleaning, replacing, or adding to the old tile line system.

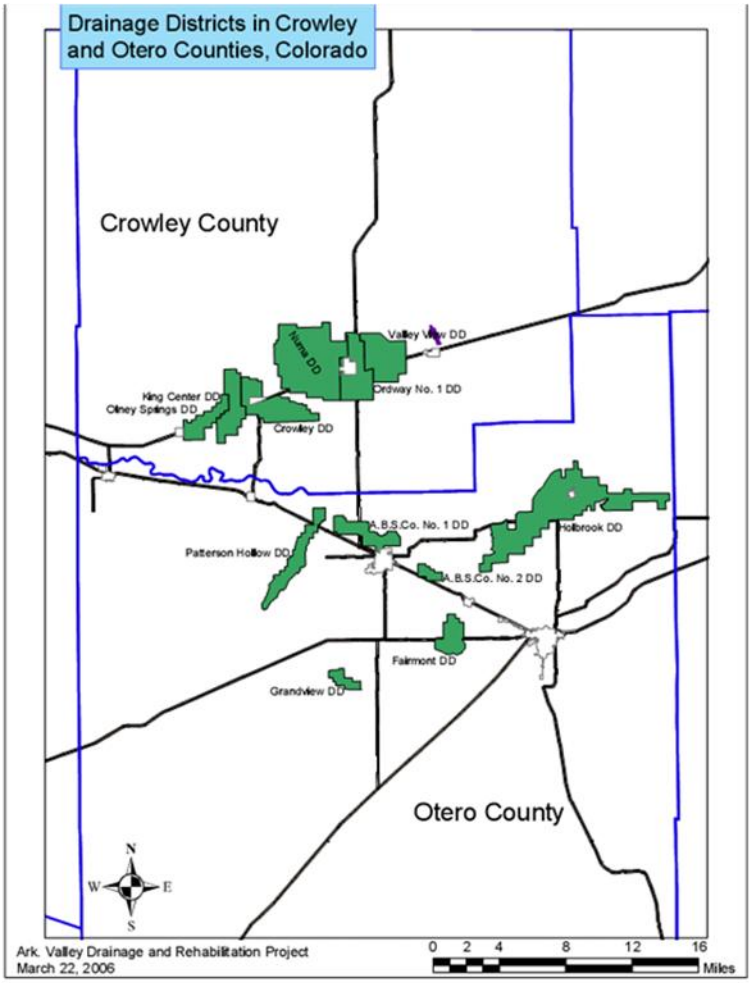


Yellow arrow shows the alignment of the upper reaches of the main collector drain shown in the inset photo. Notice the headgate diversion point on the upper reaches of the drain that takes water into a field for irrigation. Water rights are filed on these diversions.

The Tile Line System

Through the study's mapping program, it was determined that there may be approximately 140 linear miles of tile lines in the lower Arkansas Valley. It is impossible to determine what percentage of this system is actually operating effectively to drain the lands today. In addition, many of these drain lines underlay land that is no longer being cultivated. For instance, in Crowley County, where much of the water supply for irrigation has been sold off the land, there is an extensive system that was at least partly financed by the sugar companies that operated in the county in the early years of the last century. Except in a few isolated localities such as in the Olney Springs Drainage District, this extensive drainage system is generally no longer of any use to landowners.

Another area with extensive tile lines that are no longer functioning in any capacity, except in a few localized areas, is in Bent County where, again, water has been sold off the land. Outside of these two large areas in Crowley and Bent counties, there may be extensive tile lines systems in eastern Pueblo County, in western portions of Otero County, and in eastern portions of Prowers County. These are areas that remain largely unmapped by our study, due primarily to the fact that no one can provide guidance or has sufficient information regarding the possible location of tile lines.



The many drainage districts that were formed in Crowley County attest to the enormous irrigation and drainage infrastructure that was developed for this once highly productive land.

It is estimated that some 60,000 acres of irrigated land once supported this county. Many of the drainage systems were financed by the sugar companies that operated in the lower Arkansas Valley from the early "teens" of the last century through the early 1970s.

19

A valuable method used was to study aerial photos to locate crop marks suggesting the presence of a line in a field. As imperfect as this method might seem, it was often the only means of locating the lines. In such instances, ground verification could then be obtained by an old-timer in the area, or by one of the drainage district board members. In other areas, it was impossible to verify whether a crop mark was a tile line or some other feature, such as a gas pipeline or soil unconformity.

The tile lines are in various dimensions; 15 inch, 12 inch, 10 inch, 8 inch and 6 inch lines being the most common. The 15 inch and 12 inch lines were often installed as main collector lines, or trunk lines, in a field that would serve to carry drainage effluent coming from smaller 6 and 8 inch lateral drains. The larger drains then discharge into deep open collector drains leading back to the river or to one of the major irrigation canals in the valley. It appears that most original field installations simply included one large diameter trunk line to take up water percolating through the soil throughout a more extensive area. Smaller lines (laterals) were installed in areas where the ground was particularly seepy, such as near an existing irrigation canal or in a particularly low spot on farmland that frequently experienced the ponding of water. This could be the result of a perched water table or an underground geological unconformity, such as an old "oxbow" associated with the river's earlier meandering in the valley. The tile lines were set in the ground, often by hand digging, but also by early steam driven trenchers occasionally using ploughs placed on slip forms when excavation had to be conducted in watery areas.

The tiles were made of fired clay and generally came in two types. The first and more common tile was a 30 inch tubular section with a sleeve on one end to accommodate the next 30 inch section that was inserted into this sleeve. This is the so-called "bell" tile (see photo #2 below). The second form of tile was similar in every way except for having a flat edge rather than a sleeve. This second type of tile typically shows more subsidence in the tile line when inspected by a mobile camera underground, whereas the sleeves of the bell tiles appear to have been more effective in keeping these lines from subsiding underground at the joints.

1

2

3

4

(1) Rural subdivision encroachment onto open drain; (2) Bell tile joint; (3) Cleaning alfalfa roots out of a tile line; (4) Typical sink hole in middle of field.

Water then percolated through the soil toward the sleeves or joints of these tile lines, where a gap was created by small nipples inside the sleeve that separated each section sufficiently to take up the percolating water. Tile lines with flat edges were simply installed in the ground with a small gap between each 30 inch section to take percolating water; the gap often simply being created by the rough end of the individual tile section itself. The tiles are often stamped with a corporate logo indicating having been manufactured in Pueblo, Colorado at one of the brickworks.

Some of the manholes built for the undoubtedly more costly lines in Crowley County are made of concrete. These are often 12 to 16 feet deep and sufficiently wide enough for a single person to climb down into (see manhole photos, page 16). Some manholes have stair steps made of rebar to descend into them. In other areas, the manholes were made of timber. They are often less deep and have deteriorated or otherwise collapsed over the years.

There are many examples of smaller tile line laterals, 6 to 8 inches in diameter, entering a manhole. The effluent is then being carried on underground toward the open drain by a single 12 or 15

inch line. The manholes were also important for the purpose of removing silt coming from the tile lines. However, frequently the manholes were not large enough to clean the lines with an auger. Cleaning was accomplished primarily by locating where the tile line discharged into an open collector drain and then working an auger on a cable into the line as far as the cable would permit. This appears to be the extent of the maintenance of these lines in the past when the drainage districts were more active. Today, of course, high pressure jet nozzles attached to 1 inch hoses of 500 to a 1000 feet in length can be used to clean drain lines, utilizing an assortment of sand and gravel cutting nozzles, root saws, and other equipment attached to the hoses and worked up the lines. This is standard sewer maintenance equipment for most municipalities today and is what the South Columbia Basin Irrigation District uses in its drainage maintenance program.

Attaching high pressure nozzle to 1" water hose.

Running nozzle and hose into tile line

Working (moving in and out of) tile line

Cleaning roots off nozzle

The Cleaning of Tile Lines

The study was successful in organizing several demonstrations for landowners in the more current methods of tile line maintenance (above). These demonstrations have provided an opportunity to show the usefulness of a routine drainage maintenance program. This in no way suggests that previous efforts at tile line maintenance have been inappropriate. Given the condition of the drainage system and the limited funds available in the past, landowners have simply done the best they could. In addition, several Arkansas Valley contractors have contributed their considerable experience to helping districts and landowners with such efforts.

Nevertheless, several landowners in the valley have plugged lines that they have more or less abandoned over the years, due to an inability to have them serviced in a proper way. The demonstrations

tended to show how cleaning a line and making it serviceable was rather straight-forward if the proper equipment for cleaning was available (below). Some lines do need to be dug up and replaced due to collapsed sections or severe tree root problems. However, in many instances a simple jet cleaning and scoping with a mobile camera can be sufficient to make a line operable, or to at least helpful in identifying the specific problem that is causing the line to function improperly.

Demonstration tile line cleaning on George Reyher farm – (1) Inserting nozzle and hose into tile line; (2) Waiting for the "wart hog" (high pressure nozzle) to pass through the plugged 800 foot long 8" diameter line; (3) Jet nozzle exiting tile line where a new 6' diameter galvanized pipe manhole (above left) is planned; (4) Aerial view of the cleaned tile line on Reyher farm.

The first rule of thumb is generally to clean and scope the plugged tile line before digging. Digging is generally the last resort, and is a decision that may well permanently affect the original alignment of the line. It is quite easy, although often very time-consuming, to dig up and replace a section of a tile line. This has often been the solution in the past, given that landowners have not been privileged with a local service having adequate equipment to clean these lines on a regular basis. Cleaning the line and using a scoping camera on a mobile "tractor" can usually determine the nature of the problem. Most municipal sewer cleaning equipment on the market today consists of a 1000 foot long 1 inch hose with a pressurized nozzle, while the camera is driven by a cable (see photo, page 8). The camera's image is shown on a monitor and can be recorded on videotape. Good quality used equipment of this nature can generally be found for sale in the classified section of sewer trade journals. A sum of $300,000 would appear sufficient to easily outfit a tile line cleaning and maintenance "strike team" organized by a consolidated drainage district operation in the valley.

The second rule of thumb is to commence cleaning a tile line at its discharge point into the open collector drain serving the drainage system. This is what is referred to as the "downstream rule." The cleaning activity moves up the tile line from this starting point as far as the equipment will permit, at

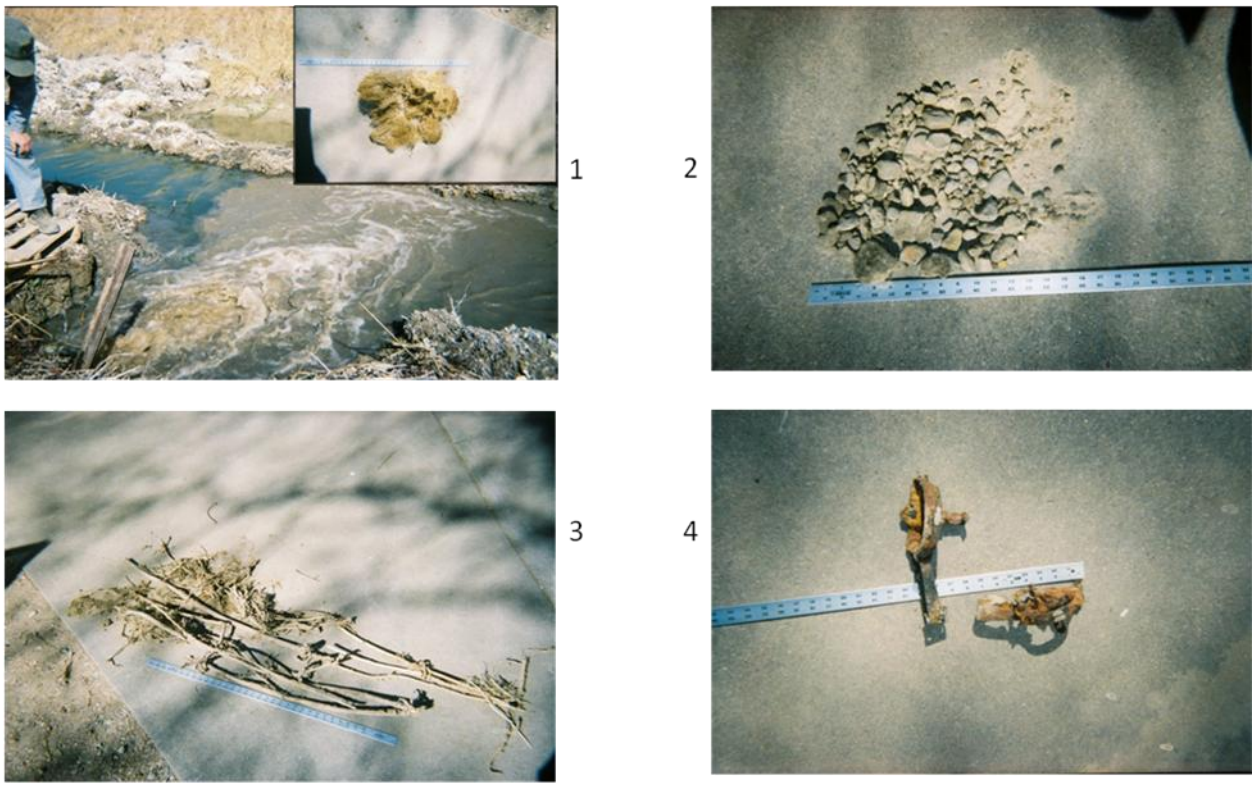
which point the line is then entered into again through a manhole "upstream." As mentioned earlier, one of the major structural problems in the tile line system in the lower Arkansas Valley is an insufficient number of manholes originally built into the system for observation and cleaning. In most modern drainage systems for agriculture, such as those found in the Columbia Basin project in the State of Washington, manholes were built into the system at every 800 feet, as well as at junctions in the tile line system. Unfortunately, the Arkansas Valley's drainage system is not blessed with this type of design. Manholes are usually sparse in number, making it truly difficult to implement the "downstream rule." It appears that an important part of rehabilitating the tile line system in the Arkansas Valley would necessitate the installation of perhaps 100 or more manholes, particularly in those localities where drainage is a noticeable problem. The tile lines cannot be properly serviced otherwise.

The second rule of thumb is to slowly work up a tile line, utilizing a variety of sand and gravel nozzles, interchanging them periodically to address specific problems. There are special nozzles for heavy silt or clay, gravel, and tree root removal (page 27, photo #3). It is an activity that requires a little patience and experience, but again as with the model drainage maintenance program in the Columbia River basin, it can be conducted with generally quite inexpensive equipment and with a very small crew; perhaps no more than two people. A vacuum truck is an ideal complement to the cleaning task, since the vacuum can be used to clean up accumulated water and debris discharging from the tile line, as well as some of the messiness associated with the cleaning activity. A vacuum can also be used to facilitate the cleaning of silt from the tile lines that has accumulated in the manholes over time.

Part of the cleaning involves the utilization of a locator tool attached to the jet hose that can aid in mapping the exact alignment of tile lines as well as identifying the specific location of a problem in the line. It is important to remember that these tile lines are often anywhere from 8 to 12 feet or more in depth in the Arkansas Valley floor. The tile line mapping activity conducted by the study has really only developed a database of the approximate location and alignment of these lines. With the implementation of a full scale maintenance program, and using the study's database, over a few years the true alignment and depth of these lines could be accurately determined. This would facilitate the ability to extend the local "blue stakes" program for locating utility infrastructure to clay lines as well. Improved location of tile lines would also allow landowners to properly assess how the existing drainage system could be improved with additional extensions to, and/or enlargement of, individual lines.

Tile Line Cleaning Demonstrations

Several demonstrations of tile line cleaning were conducted as part of the study. Assistance was provided by the Colorado Department of Transportation, the City of Lamar, and the City of La Junta. They generously provided both equipment and man hours for these demonstrations. The first demonstration was conducted on the property of a landowner near McClave, Colorado who had an old 8" tile line that he was prepared to abandon because it was blocked. It ran through his property and under a large equipment storage shed, making it virtually impossible to dig up and repair the line (photos, page 29). By carefully entering the line at one end, the cleaning activity was able to move nearly 1000 feet up the line and under the storage shed, clearing debris as well as tree roots growing from a tree row on the farm property that ran across the alignment of the tile line. In addition to tree roots, the line appeared to be plugged with clay concretions the size of one inch river pebble aggregate. These clay concretions often form in the lines over the years due to the wet and dry conditions occurring in the lines. These concretions resemble stone gravel in form and texture, but are really clay hardened nearly to the consistency of rock (photos, next page). This particular cleaning demonstration was very successful and much appreciated by the landowner. The landowner gave testimony as to the benefits of the activity at several meetings organized to share this experience.



Common debris in tile lines – (1) Alfalfa roots, whose root system can extend down enough to enter 12' deep tile lines ; (2) Clay concretions (a major culprit); (3) Tree roots, often from windbreaks planted across tile lines); (4) Traps pulled into tile lines by animals.

A second demonstration occurred in conjunction with an effort by Colorado State University to monitor groundwater levels in a landowner's field northwest of Rocky Ford, Colorado. This location had a 10 inch diameter tubular tile line that was installed many years ago to clear seepy ground near an irrigation canal. Being close to the Arkansas River, there were certainly geological conditions, possibly an oxbow of the ancient river bed, contributing to the field's drainage problem as well. In any event, the line was successfully cleaned and two manholes were installed to facilitate the effort. About 1000 feet of line was cleaned. The benefits of the tile line cleaning included increased flow into a deep open collector drain that served the local area (see photos, next page).

A third demonstration involved cleaning a 10 inch tile line near Kornman, Colorado. In this case, the landowner had seepy ground that ought to have been cleared by several tile lines known to exist on the property. However, these smaller lines appeared to have been constrained by blockages in a large trunk tile line at the bottom of the property. The 10 inch trunk line was cleaned in order to see if the lateral lines coming into the trunk line would work more efficiently in draining the property. After a successful demonstration of cleaning the 10 inch line, the landowner requested that the laterals be cleaned as well. The completion of this demonstration was awaiting additional funds at the close of this drainage study.

A fourth demonstration occurred along Bent County Road #1, just north of U.S. Highway 50. This was a 10 inch line that appeared to be a major collector drain for a large area of land, perhaps as much as 1000 acres or more and involving the properties of several landowners. Again, as with the other lines, it was probably installed sometime just prior to - or immediately after - World War II. The line was

cleaned and has shown improved flow. The cleaning of the line has also cleared up a patch of seepy ground that had prevented a local landowner from making full use of his property.

Tile Line Penetration - Installing and then cleaning out a manhole in order to clean an otherwise inaccessible plugged tile line – (1) Carefully excavating tile line to install manhole at bend; (2) Installing manhole, connecting pipe, and use of vacuum to assist installation; (3) Completing installation; (4) vacuuming silt out of manhole after the plugged tile line has been cleaned.

Of course, these various demonstrations of tile line cleaning and repair were not earth shattering. Landowners are aware of the drainage problems in the lower Arkansas Valley and its affect on land management. Given adequate resources in the future, our study demonstrated that utilizing some of the experience of well established drainage district practices in other states could be beneficial. Obviously, those practices are from situations where resources are evidently more robust. However, there is sufficient local expertise to improve drainage in the lower Arkansas Valley. Improvement is simply a question of more resources and perhaps somewhat improved organizational arrangements to complement existing drainage management practices in the valley today.

Some important observations come out of the interaction with landowners in Bent County. They have been extremely cooperative in sharing information on their systems with the study. In the process of doing so, we have learned much about some of the issues that appear to hinder a more aggressive approach to tile line maintenance. A cursory glance at the individual drainage district reports in this study (see Appendix B), particularly the information carefully gathered for each GPS waypoint reading, shows how fragmented is the knowledge that landowners have about the location of tile lines. Obviously, the guesswork involved in mapping the suspected alignment of tile lines was considerable. The field notes taken from landowners during these investigations convey a considerable amount of confusion about the functioning of these tile lines as well. Even local engineering firms in the area appear to have widely

differing views on the continued usefulness of the tile lines and how best to approach improving drainage in the valley.

An example of this problem is the drainage districts in Bent County. This area is believed to have the most extensive system of tile drains in the valley, outside of the Wiley Drainage District in Prowers County and the Fairmont Drainage District in Otero County. However, except for the majority of tile lines in the region of the Town of McClave on the north side of the river, most of the lines in Bent County are functioning poorly today. Various state and federal agency personnel in the valley interviewed during the course of the study have generally discounted the role that the construction of John Martin Reservoir might have played in changing the gradient of the river west of the dam sufficient enough to reduce the efficiency of these tile lines. However, it is the observation of many landowners that changing hydrological conditions resulting from the dam's construction may have affected the drainage of irrigated lands considerably, particularly on the south side of the river just west of Las Animas, Colorado and a little to the east of the Town of Hasty. It may never be known for certain if this is true, and it is probably irrelevant for the future, given that a considerable amount of the water previously used to irrigate lands in this area has been sold. Yet, if water was still available for extensive irrigation in this area of the valley, concerns about drainage would probably be much greater than today.

Any debate over the hypothetical affects of John Martin Reservoir to drainage issues in the valley is not as meaningful as the often conflicting views about the functioning of tile lines and how one might approach improving their maintenance. In discussions with such agencies as the U.S. Bureau of Reclamation, there is general agreement that drainage has become the "orphan" of irrigation hydrology over the years in most areas of the western United States. Drainage in the West, the "second irrigation system" as some hydrologists would say, has lost many of its experienced technicians. The Bureau of Reclamation fully acknowledges that many of its projects lack drainage expertise today, although this was clearly not the case in the past.

What this means is that, in many irrigated areas of the West, including the Arkansas Valley, there is little expertise and experience to draw upon when assessing the performance of drainage systems and building sound maintenance programs. This study was obliged to seek out and obtain information on drainage maintenance programs from the few districts in the western United States that were fortunate enough to have a considerable working knowledge of how these drainage systems function. There appeared to be very little fit between what this outside experience conveyed to our study and what was heard from landowners in the Arkansas Valley.

For example, it was the perception of many landowners that a plugged line should automatically be dug up and replaced or left as an open drain. The whole concept of servicing lines with periodic cleaning is generally absent in the Arkansas Valley. Additional opinions heard during interviews with landowners included the following: 1) tile drains become largely a nuisance and/or ineffective after a few years of operation; 2) large diameter tile lines are more of a problem than smaller diameter lines; 3) tile lines tend to clean themselves, as long as water is flowing in them; 4) what you can't see is what you can likely never fix right; 5) manholes are a nuisance when located in the field. At the very least they should be buried; 6) shallower lines tend to operate more efficiently than deeper lines; 7) old clay tile lines disintegrate over time.

These are only a small sample of local viewpoints that the study came across during fieldwork. However, they are generally inconsistent with perspectives and practices followed by drainage districts in the West blessed with more robust maintenance programs. The approach to drainage in the Arkansas Valley lacks much of the continuity in knowledge and practice that is needed to properly maintain these systems. That is certainly not the fault of landowners in the region, but rather a product of time. Such knowledge has simply been lost, and there are no experienced drainage technicians to be found in the

area. Furthermore, the many small drainage districts in the Arkansas Valley generally cannot produce a revenue stream of sufficient size to organize and conduct proper maintenance of these tile line systems.

One of the more successful demonstrations of tile line cleaning conducted by the study occurred on a farm near the Town of McClave, Colorado. This was the case of an abandoned tile line that was thought by the landowner to be plugged by tree roots. It was! However, using equipment common to the sewer industry, the 8 inch diameter line was cleaned and made serviceable again. No excavation was needed. The demonstration showed that some lines could be unblocked without resorting to excavation, which, in many instances, has left an open ditch representing an inconvenient obstacle for future cultivation of a field. The special equipment needed for this demonstration was more expensive than a single landowner could afford or ever want to invest in. Yet, given sufficient resources, our research has shown that a team of two technicians with such equipment could probably clean the entire tile line system in the Arkansas Valley in a matter of a few years.

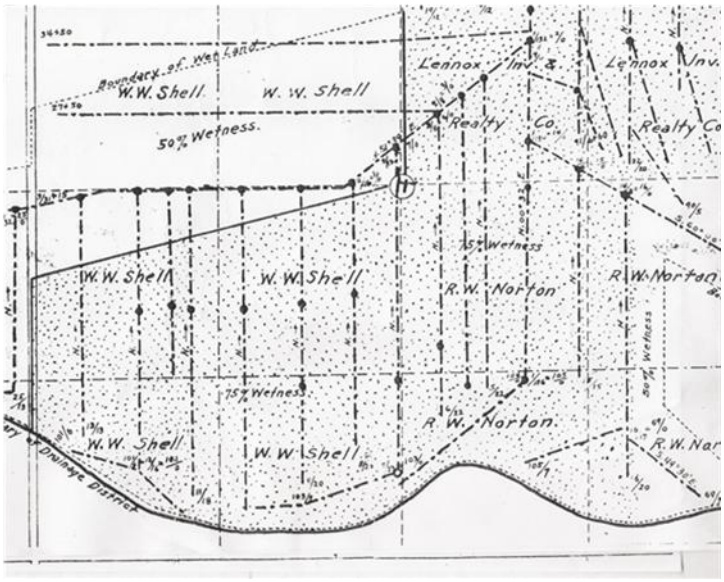
Chapter IV

Inventory of Tile Lines in the Lower Arkansas Valley

One of the principal activities undertaken by the study involved mapping the existing tile line system in the Arkansas Valley. This was a challenge, since there is currently little historical documentation to draw from in determining the location of these lines. As mentioned in the introduction, a few of the U.S.D.A. Natural Resource Conservation Service offices in the region had engineering plats of some of the lines in their archives. However, it was never clear whether these plats represented the actual location of the lines or simply their proposed alignment. Most of the available plats had no information indicating that they represented a "final plat." Furthermore, there are strong reasons to believe that the engineering firms noted on the plats, most of which were once located in Denver but now no longer in existence, possessed these final plats. However, an aggressive search for these plats in regional historical libraries or sugar company archives would have taken the study beyond its resource capabilities. A few districts, as noted in the image below, did have such plats.

In the plat below, the black dots refer to the location of manholes designed to access the drainage system, while the dashed lines show the location of tile lines. It is estimated that the Fairmont DD has upwards of 20 miles of tiles lines of different diameter dimensions. In recent years, many of the manholes in the Fairmont DD have been buried in order to avoid damage during land preparation and harvesting.

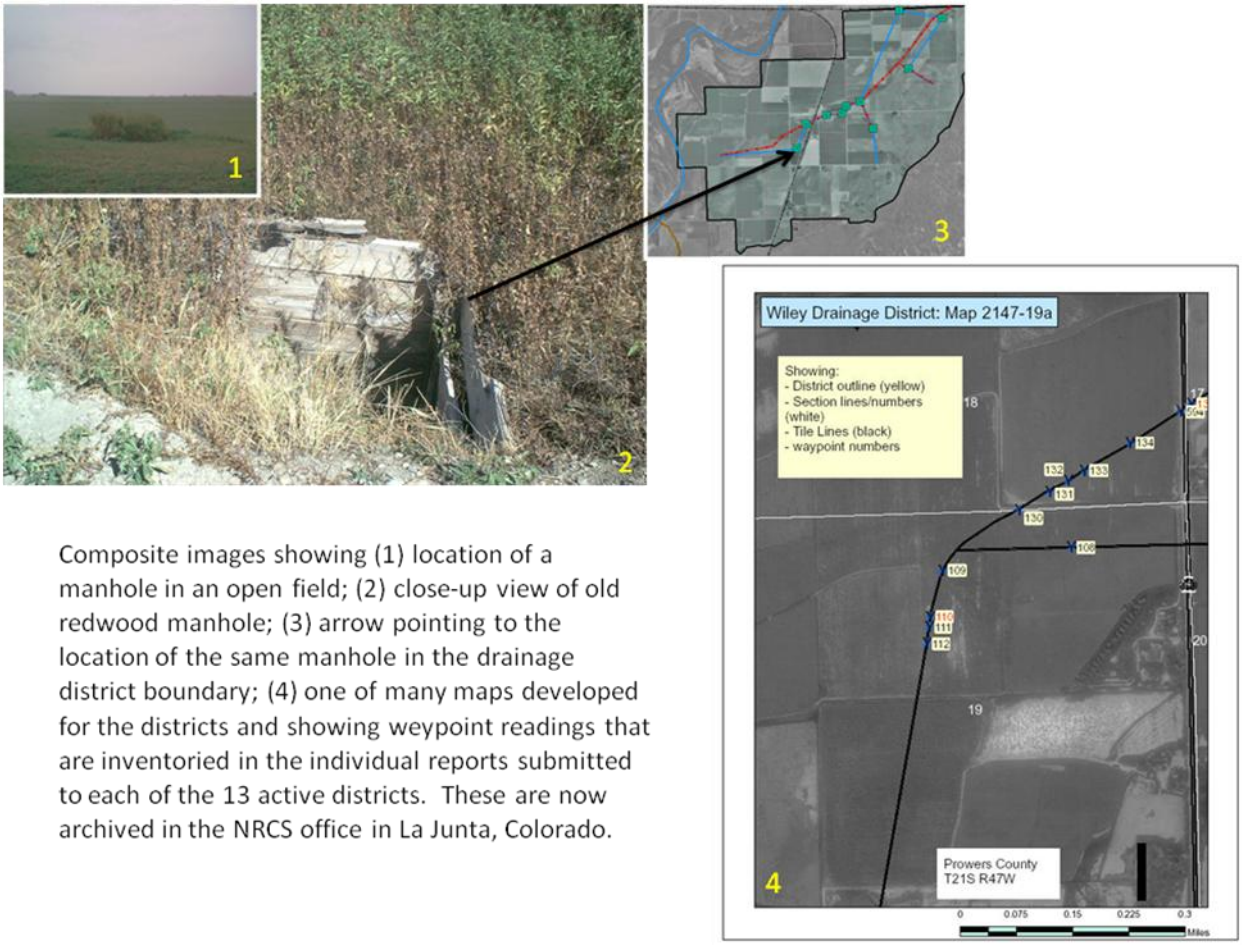
Right - A small section of a typical old drainage plat (rarely available). However, both the Fairmont Drainage District and the Wiley Drainage District had old plats available. These were used to cross-check with the GPS surveying that was conducted by the research team. Although the Fairmont DD plat seems to conform to actual installation, this was not totally clear with the Wiley DD plat. However, the original survey conducted for the Wiley DD installation (not shown), performed around 1920, appeared to be exceptional in its detail regarding such features as soil types and drainage problems in the district.



The Federal Land Bank records obtained from Farm Credit Services in Wichita, Kansas were very informative as to the general description of each drainage district, including the known condition and extent of the tile lines in terms of the estimated number of miles of open drains and clay lines, as well as

other relevant information compiled by the Bank's regional appraisers. However, no maps were available from these sources. As can be seen from these Federal Land Bank engineering appraisal documents in Appendix A on the Wiley and Fairmount drainage districts, the regional appraiser for the Bank did a remarkable job in reporting on the various districts and their conditions. But where were these tile lines?

Our study initially turned to two older landowners who maintained some documentation on their drainage systems. Discussions with these landowners suggested that we could simply walk the fields within their district and, utilizing a standard global positioning system (GPS) instrument, begin to compile waypoint readings of any observable drainage system features on the ground.[17] This included creating GPS weypoints on tile line outlets to open drains, manholes, sinkholes in fields, the presence of broken tiles on the ground, vegetation growth marks suggesting a tile line alignment, the known location of a recent repair to a tile line, and any other observable feature. These waypoint data were then used to build maps. This usually involved drawing lines from one weypoint reading to another, suggesting the alignment of a buried tile line. These inferred alignments were then cross-checked with landowners as to their general accuracy, although most landowners had no real idea of the exact location of these lines.



Composite images showing (1) location of a manhole in an open field; (2) close-up view of old redwood manhole; (3) arrow pointing to the location of the same manhole in the drainage district boundary; (4) one of many maps developed for the districts and showing weypoint readings that are inventoried in the individual reports submitted to each of the 13 active districts. These are now archived in the NRCS office in La Junta, Colorado.

This rather simple process of using local knowledge to develop the maps was simply replicated in other drainage districts throughout the valley. One of the more interesting, but nevertheless sometimes misleading, procedures was to attempt to utilize U.S.D.A. Soil Conservation Service or more recent

[17] Garmin GPSmap76 handheld unit with a backpack differential correction unit to locate the waypoints.

county aerial photos to identify vegetation growth patterns (or crop marks) in cultivated fields (see photos below). These vegetation patterns often could suggest the presence of a tile line. The waypoint readings were overlain on the aerial photos utilizing GIS software to determine if there was a match between vegetation patterns and known features on the ground. Sometimes a match occurred, but not always.

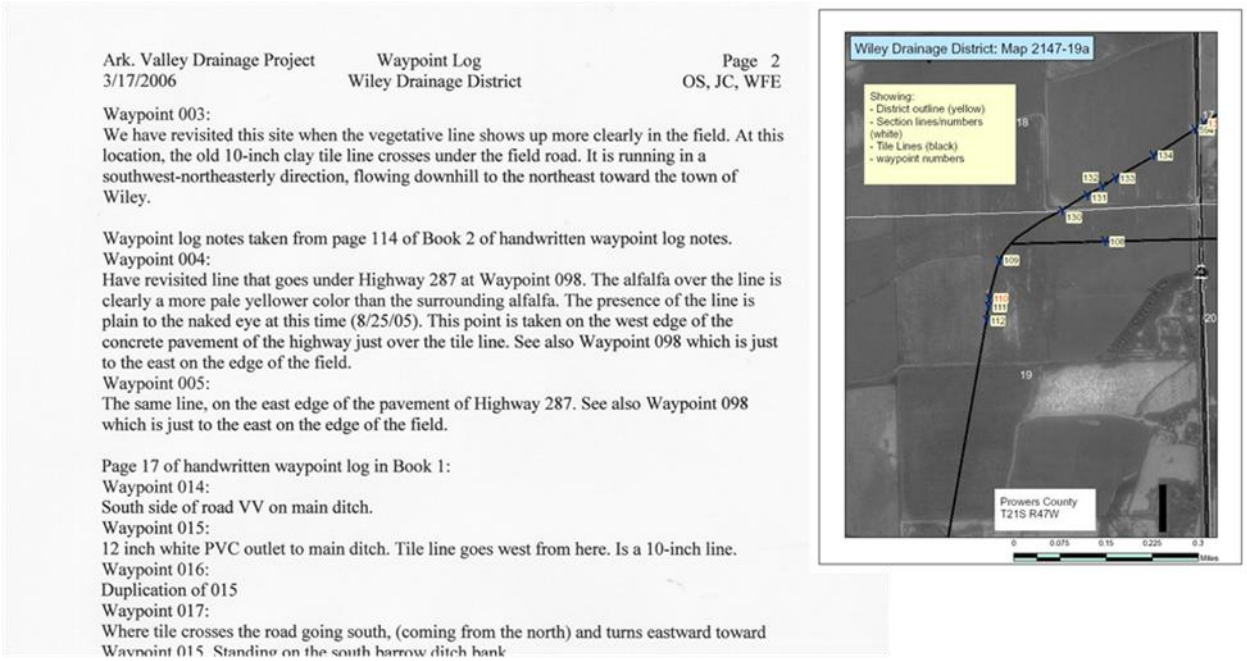
Various images showing the more visual locations of tile lines.

As might be expected, there were many of these very suggestive crop marks that could not be verified on the ground. Clearly they could have been created by a soil disturbance over the years, such as from oil and gas pipeline and utility installations, or simply being the old alignment of a now abandoned irrigation ditch or farm road. The possibility that they were attributable to geology was generally viewed as remote, due to their rather straight alignment and running at odd angles across a field.

The crop marks show up on aerial photos for several reasons, but probably the two most important were due to reversed stratigraphy created by an excavation. This frequently leads to variation in the growth of vegetation along the line of the excavation. Also, the concentration of percolating water underground and around the tile line itself can lead to more vigorous plant growth along the alignment of the line. Nevertheless, further confounding the aerial photo interpretation was the observation that many known tile lines did not show up as crop marks in a field. Needless to say, it was an imperfect method. However, short of attempting to utilize ground penetrating radar or other geophysics methods, which the study could not afford, aerial photo analysis ended up being a quite useful complimentary technique to documenting tile line evidence on the ground.

Given that thirteen drainage districts organized in the lower Arkansas River Basin are still active, an effort was made to focus the mapping effort primarily on those districts. Again, these active districts are known to conduct maintenance on their tile lines at least from time to time, or when necessary due to a major blockage or other problem. It is also believed that these thirteen active districts contain the majority of tile line installed in the valley over the years, although a few of these districts were apparently organized solely for the purpose of maintaining open collector drains. When properly maintained, these open collector drains are still very effective in helping clear the crop root zone from groundwater levels. The location of these open drains is well known by landowners and they are shown on older U.S.D.A. Soil Conservation Service county soil maps as well.

Following the completion of the mapping program, individual reports were compiled for several of the drainage districts (see Appendix B). In addition to a set of maps showing the location of tile lines and other related features in the district, these reports include a detailed description of each waypoint reading. These were documented at the time of the GPS reading, usually with a representative of the drainage district assisting in the effort. The waypoint descriptions convey many unique features and potential problems of the tile line system in each district. They could be very valuable for any future maintenance program that might be undertaken by these districts. Each of the reports also contains a copy of the Federal Land Bank engineering appraisal document pertaining to that district.



Ark. Valley Drainage Project Waypoint Log Page 2
3/17/2006 Wiley Drainage District OS, JC, WFE

Waypoint 003:
We have revisited this site when the vegetative line shows up more clearly in the field. At this location, the old 10-inch clay tile line crosses under the field road. It is running in a southwest-northeasterly direction, flowing downhill to the northeast toward the town of Wiley.

Waypoint log notes taken from page 114 of Book 2 of handwritten waypoint log notes.
Waypoint 004:
Have revisited line that goes under Highway 287 at Waypoint 098. The alfalfa over the line is clearly a more pale yellower color than the surrounding alfalfa. The presence of the line is plain to the naked eye at this time (8/25/05). This point is taken on the west edge of the concrete pavement of the highway just over the tile line. See also Waypoint 098 which is just to the east on the edge of the field.
Waypoint 005:
The same line, on the east edge of the pavement of Highway 287. See also Waypoint 098 which is just to the east on the edge of the field.

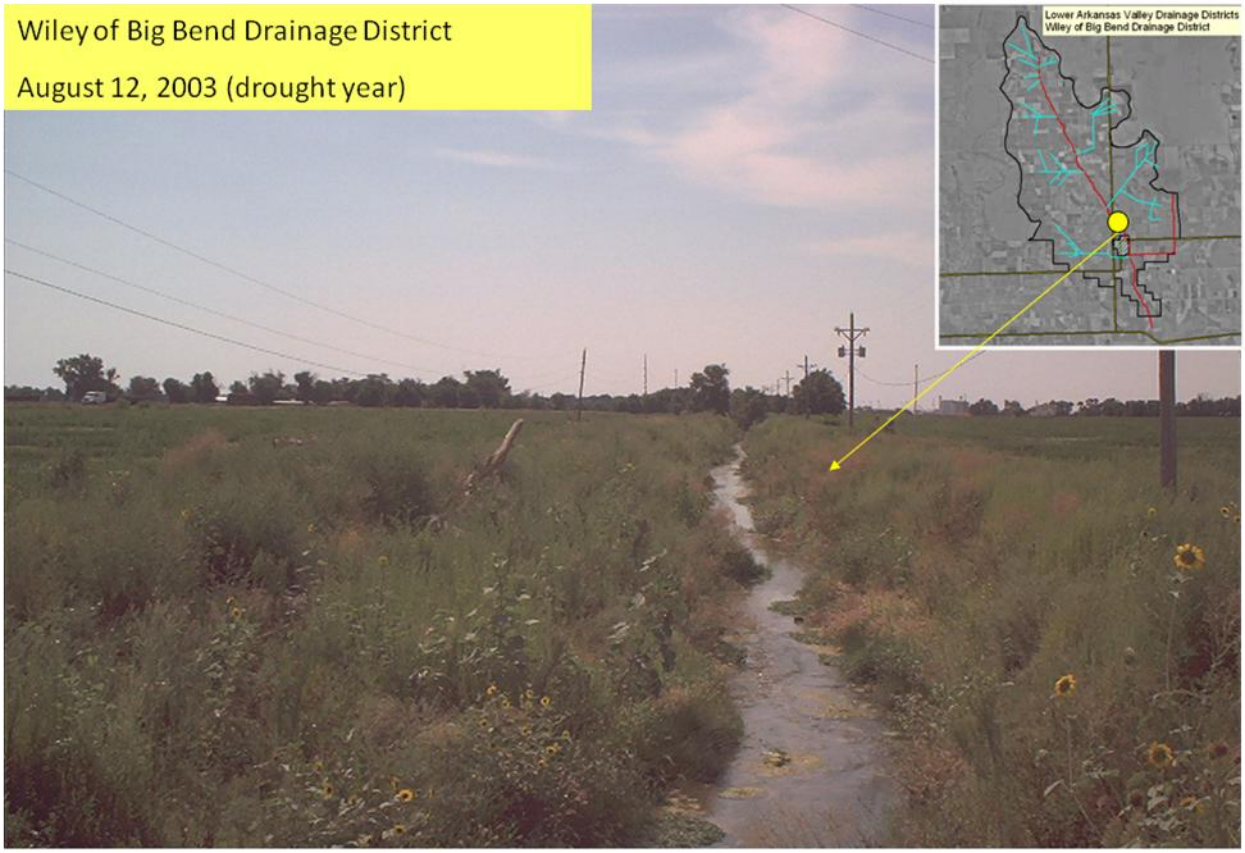
Page 17 of handwritten waypoint log in Book 1:
Waypoint 014:
South side of road VV on main ditch.
Waypoint 015:
12 inch white PVC outlet to main ditch. Tile line goes west from here. Is a 10-inch line.
Waypoint 016:
Duplication of 015
Waypoint 017:
Where tile crosses the road going south, (coming from the north) and turns eastward toward
Waypoint 015. Standing on the south barrow ditch bank

Quite detailed information is available to the 13 active drainage districts as to the location of tile lines and associated problems. These could be observed visually during the research surveying of this drainage infrastructure. Individual reports are available in the appendix.

Prowers County Drainage Districts

The Prowers County drainage districts are very active today, for the most part. There are a few districts around the City of Lamar that have become inactive over the years. However, the bench lands of

the lower Arkansas Valley on the north side of the river between McClave, Colorado, and Hartman, Colorado is a very productive agricultural area. Consequently, there are several districts with extensive tile lines and open drains serving this important area. Again, final reports on each of these districts can be found in Appendix B.

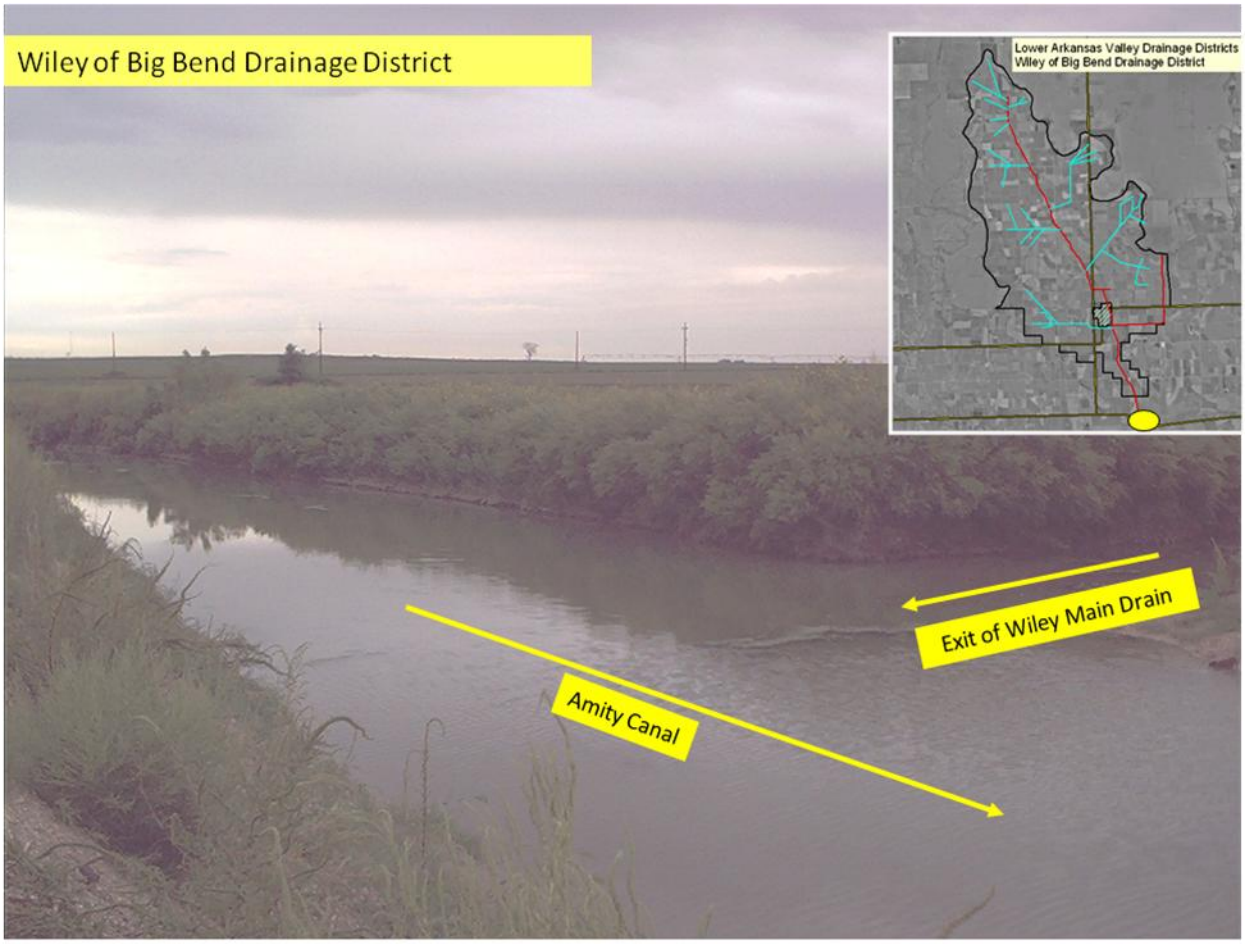


Looking due south down the main collector drain before it crosses Highway 287 (Town of Wiley in distance).

The Wiley Drainage District is the largest district in the lower Arkansas Valley. It was organized in1918. It has an estimated forty miles of tile lines serving an area of about 18,000 acres. Thanks to the help of several landowners, it is believed that the mapping activity has adequately captured the extent of the tile lines in this district and with a considerable degree of accuracy. An old and fairly detailed engineering plat of the tile line system possessed by the district helped the mapping effort considerably. However, the primary source of information on the location of the lines was provided by two of the landowners in the district who currently oversee the district's maintenance program. Aerial photos of the district lands were extremely useful as a cross-check. Many linear crop marks turned out to be the result of tile lines in the ground.

The Wiley Drainage District is characterized by a main open collector drain running north-south through the center of the district (see map image, page 12). This important drain begins just north of the Fort Lyon Canal and continues southward on the west side of State Highway 287 until it reaches the Town of Wiley. At this point it crosses under the highway and continues southward on the east side of the highway, where it eventually discharges into the Amity Mutual Irrigation Company's main canal (see image on next page; also image #4, page 14). As can be seen by the map of the district, all of the main tile lines throughout the district discharge into this open drain. Thus, the drainage effluent from the

irrigated lands of this district does not enter the Arkansas River, but rather continues down the Amity Canal to be reused by irrigators east of the City of Lamar.



Confluence of the Wiley of Big Bend main open drain and the Amity Canal. The headgate of the Amity Canal is just a few hundred yards to the left, on the other side of Highway 50.

In assessing the rehabilitation needs of this district, it is essential that the main open collector drain is kept deep enough throughout its length to take the drainage effluent originating from tile lines on both the east and west side of the district. Although the open drain is routinely cleaned, it has gradually lost depth over the years as it courses south, leading to a few of the tile lines being nearly submerged at their point of entry into the open drain. These are usually 10 inch to 12 inch trunk lines serving to drain extensive acreage in the district, and it is believed that they often have lateral drains coming into them from many different directions.

The district has kept up with repairs to tile lines as blockages and/or sinkholes have occurred over the years. However, the study's assessment is that many of these trunk lines need to be jet cleaned. This jet cleaning would necessitate a considerable deepening of the main open collector drain running through the center of the district, not only to perform this cleaning but also to allow the tile trunk lines to discharge more freely at their outlet. Additional manholes would likely need to be installed to fully rehabilitate this extensive and important drainage system. A glance at the map of the Wiley Drainage District (inset in photo above) shows the great number of tile lines converging on the open collector drain.

The study was not designed to assess what increase in productivity could result from further improvements to this drainage system. All that can be noted here is that there are significant portions of the district that appear to be having some problems with productivity, and very possibly related to poor drainage. Simply because seepy ground is not present in an area does not imply that the crop root zone is not affected by poor drainage. The cleaning of one tile line approximately midway down the open drain produced roots in the line that were probably from a hay crop. Deep rooted crops, such as alfalfa, can be greatly affected by poor drainage, and in turn can clog these drains.

This is a highly productive agricultural area that receives irrigation water from the Fort Lyon Canal. The study feels that it is very important that the Wiley Drainage District be accorded high priority in any major drainage rehabilitation effort undertaken in the Arkansas Valley in the future. At stake are approximately 18,000 acres of very good quality irrigated land.

Most of the other active Prowers County drainage districts were originally organized and responsible for maintaining deep open collector drains. As mentioned earlier, these open drains are very important in clearing seepy acreage along the bench lands of the lower valley, particularly along the north side of the river. Some of these open drains are 20 to 30 feet deep and usually must be re-excavated every few years to remove silt and weeds in order to restore them to their original depth and prism. Since many of the tile lines appear themselves to run at depths of ten to twelve feet, the open drains must be excavated sufficiently deep enough to allow the drainage water from the tile lines to discharge unobstructed from their outlets into these open drains. If an open drain becomes silted up and choked with weeds over the years, the tile lines get backed up, and this leads to seepy acreage appearing along the course of the tile line as it runs back into the countryside. If there are smaller diameter tile line laterals leading into the main tile trunk line, these become backed up as well, leading to a malfunctioning of the whole underground drainage system. This scenario has happened in the valley several times, leading to a good portion of the tile line system in a particular drainage district being dug up by the landowner in frustration. Routine maintenance in the Wiley Drainage District has largely prevented this scenario from occurring.

Just east of the Wiley Drainage District is the Pleasant Valley Drainage District. This is a typical small drainage district in the valley, comprising approximately 3,400 acres. It is estimated that about 450 acres are either moderately or severely affected by poor drainage. This district maintains a large open collector drain of about 5 miles in length that runs north-south through its center (see photo, page 25). A small amount of drainage effluent from this district is reapplied on irrigated lands within the district, while the remainder flows into the Amity Canal. There are several localities in the lower Arkansas Valley where effluent return flow decrees such as these have apparently been filed on over the years. However, the available water from these filings on drainage is generally incidental to the landowner's total irrigation needs.

There are a few tile lines present in the Pleasant Valley Drainage District, but they are the responsibility of individual landowners, not of the district itself. As with many of the open drains in these districts, the Pleasant Valley drain has problems in its lower reaches as elevation, and thus the flow rate in the drain, is reduced. Open drains where the channel depth has been properly maintained tend to have fewer problems with the buildup of sediment as well as weed growth. This is why it appears important that the open drains are routinely dredged; and often the deeper the dredging, the better. Unfortunately, as the Arkansas River itself has silted up over the years, the differential in elevation of the open drains to the river has created additional seepy ground in the lower portions of several districts (photo, page 15). Short of pumping water out of these areas, there appears to be little chance of reclaiming such acreage for crop production.

The Kornman Drainage District is another active district in Prowers County, just east of the Pleasant Valley Drainage District. It was organized in 1921. The district serves approximately 1,700 acres, of which about 260 acres are moderately affected by poor drainage. There are approximately three miles of tile lines in the district. The Kornman open collector drain runs through the town of the same name, and then continues southward to discharge into the Amity Canal.

The Kornman Drainage District

Like several drainage district main collectors in the area, the main drain of the Kornman Drainage District passes through town (Kornman). New subdivisions are being built in town, but the rights-of-way of the drainage systems are frequently not being respected. This prevents proper maintenance. This situation is known to be a problem in the Wiley of Big Bend Drainage District and the Holly Drainage District, as well as in the Kornman Drainage District Town flooding has occurred in all three drainage systems in the past.

Here we encounter another unique problem with drainage in the valley. This has to do with the encroachment of housing subdivisions onto drainage easements. There is generally no bylaw or rule of thumb pertaining to drainage easements in these districts. Subdivision encroachment does not happen frequently, but when it does, it can cause problems for maintenance. Channel dredging activities are hindered by back yard fences and other obstructions. In addition, due to the fact that these open drains can carry storm flows and irrigation return flows as well as drainage effluent, there is the possibility that damage from flooding can occur to homes located near these drains. Flooding can result from household and landscaping debris being inadvertently thrown into these drainage channels as well. In the future, it will be important that drainage easements are honored, much in the same way that irrigation canal easements should be honored, to ensure that routine maintenance can be conducted on these facilities.

As with the two other Prowers County drainage districts mentioned above, the Kornman Drainage District could be improved with additional tile lines, as well as through the cleaning and/or replacement of older lines. A demonstration of jet cleaning of one of the tile lines in the district, conducted for the study by the City of Lamar, showed some of the benefits of cleaning existing lines. Additional manholes may need to be installed to continue the cleaning process up the line.

A proper assessment of rehabilitation needs ideally involves this cleaning step, followed by mobile camera inspection of the tile line. Unfortunately, most of the assessments made in this study on the need for rehabilitation have not benefited from this approach due to the lack of proper equipment to carry out inspection. In addition, considerable time would be needed to perform this inspection task throughout the entire lower valley. Hence, the study has relied on discussions with landowners as to the probable cause of localized drainage problems. In the case of the Kornman Drainage District, it became clear after cleaning approximately 400 feet of a main tile trunk line that the blockage problem was probably in a tile lateral coming into the main trunk line.

Two drainage districts with mainly large open collector drains, but with a considerable number of tile lines installed by individual landowners over the years, are the Granada Drainage District and the Holly Drainage District. These districts are located in the more eastern portions of the county. They were established in the early 1920s, primarily for the purpose of intercepting both surface and subsurface drainage from agricultural lands, and as a mean of protecting surrounding communities from flooding due to storm events as well as from irrigation. This stretch of the Arkansas River Valley is quite flat, having lost much of the undulating land characteristic of the western portion of Prowers County. Consequently, it is likely that, in the early years, the area was not considered to be very accommodating to deep tile lines, there being no real gradient to maintain discharge in such lines. These open collector drains are probably the deepest and widest in the valley.

The combined acreage served by these two drainage districts is approximately 14,000 acres. The two districts together comprise about 33 miles of open drains. Although they have served the area well, they are somewhat of an inconvenience to landowners and are relatively expensive to maintain, compared to tile lines. Their extensive mileage and deep profile divides up the landscape considerably, and they need to be dredged frequently and weeds need to be regularly burnt away to make them useful conduits of drainage. Effluent from these drains returns directly to the river, rather than being picked up by irrigation canals as with the open drains in the western part of the county.

Mention of these two drainage districts leads to revisiting the point that was raised in an earlier section of the report concerning the degree to which drainage has become more of a communitywide issue than simply an agricultural land management issue. Flooding is a persistent problem in the Arkansas Valley because communities in the valley tend to be situated between irrigated lands of slightly higher elevation than the river itself. The combination of water from irrigation return flows, drainage effluent, the occasional overtopping of irrigation canals, and major storm events, can converge on these communities in a dramatic way (see image, page 10). An example is the community of Bristol mentioned earlier in the report, which has experienced repeated flooding over the years due to a combination of these factors along with insufficient upkeep of drainage ditches within the community (photos, next page; see also Appendix C).

Particularly in the case of large open collector drains that act as potential conduits for flood waters, it would seem reasonable that the valley's drainage infrastructure – at least in this area - could be viewed as a "collective good" for all residents in the area, rather than just the responsibility and problem of agricultural landowners. In fact, this is the approach actually taken by the Holly Drainage District which recently moved to a general assessment on all lands within the district, not just the agricultural lands. This has worked well and has provided the district with enough annual revenue to properly maintain the many miles of open drains in the district.

The cost of maintaining both open collector drains and tile lines in the valley is generally conceded by many people to be ultimately too expensive for agricultural landowners to support alone. Perhaps an argument could be made that tile lines are more conceivably a "private good" that landowners

should finance themselves, although the rehabilitation that is needed in the valley to bring this portion of the drainage infrastructure up to standard probably exceeds the financial capabilities of agricultural producers. The open drains appear to be another matter. They are very much a "public good," meaning that everyone living in the valley can be said to ultimately benefit from their proper care. Furthermore, there is a strong argument to be made for the perspective that the tile system would be greatly

Bristol, Colorado – (1) View (north) of Bristol from Highway 50; (2) Bird's eye view of Bristol on irrigated bench lands; (3) Previous flooding in Bristol destroyed downtown; (4) Silted up drainage system in Bristol.

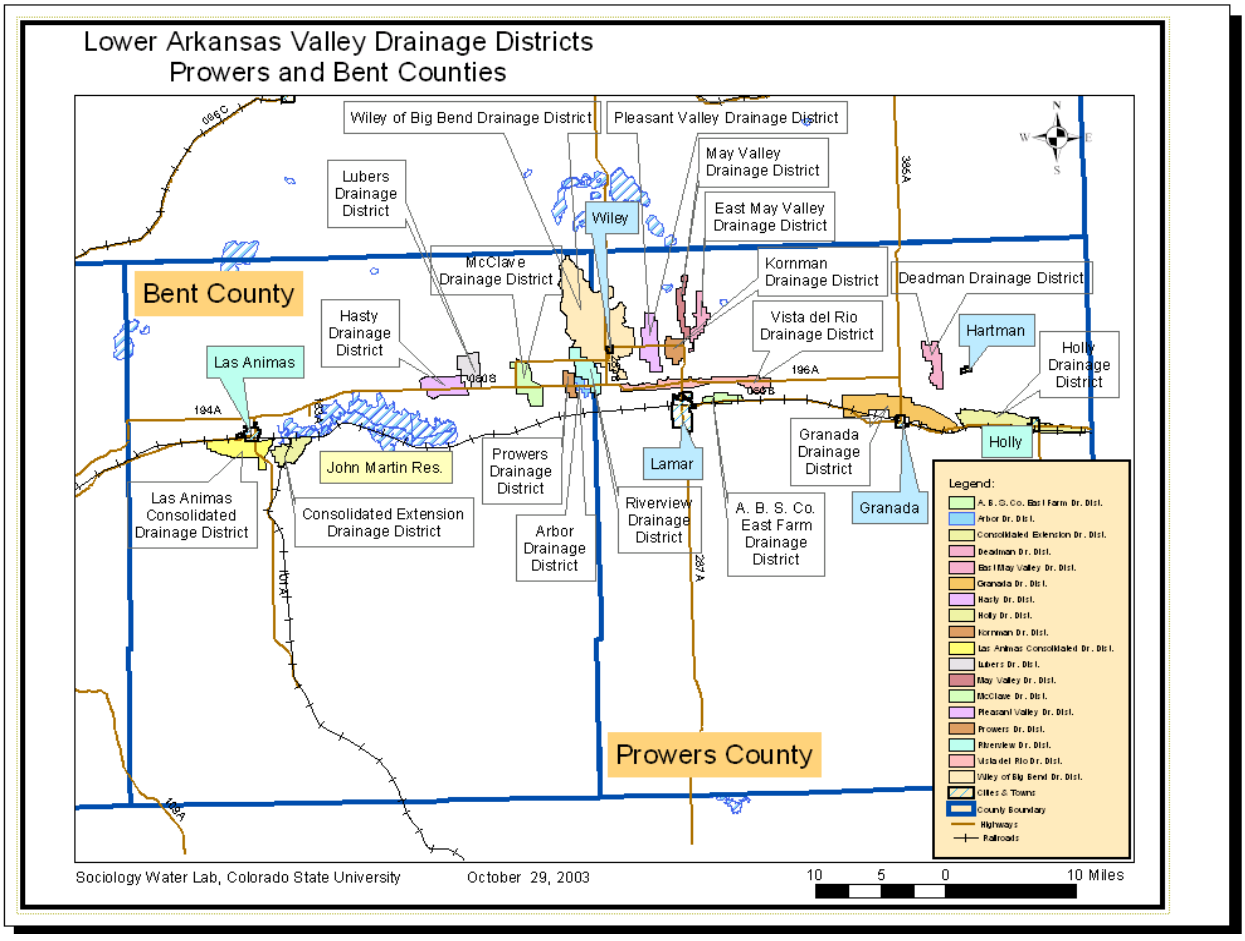
improved with the proper maintenance of these open drains, thereby increasing productivity of the land, and thus the economic multiplier effect that this improved productivity would have on the valley's economy in the long run. Recent investigations by Colorado State University seem to bare out the fact that poor drainage and increased soil salinity is a major constraint on crop production and farm income for many of the lands in the lower Arkansas Valley, not to mention the rural communities in the area.

In summing up the drainage situation in Prowers County, particularly for the agricultural lands, it is quite apparent that every effort has been made to maintain the drainage infrastructure sufficiently relative to the income being generated from the land today. It would be fruitless and unfair to compare the condition of this nearly 100 year old drainage system with drainage systems in the Central Valley of California, or in the U.S. Bureau of Reclamation's Columbia River Basin projects that were constructed largely after World War II. Both of these areas are blessed with very high productivity and a wide variety of cropping systems due to more favorable climate, a better water supply, and much newer drainage infrastructure. Nevertheless, it is also quite apparent that a greatly improved drainage infrastructure in Prowers County and other portions of the lower Arkansas Valley could dramatically improve crop production, regional income, and the protection of small communities in the area. However, increased

financing of drainage will need to be considered. It would appear that some way must be found to view the proper drainage of irrigated lands more as a "public good," rather than purely a "private good" for which the agricultural landowner is solely responsible. Until this perspective of a "public good" becomes more central to the approach taken toward drainage, it will be difficult for the region to improve drainage, salinity problems, and the agricultural base of the economy.

Bent County Drainage Districts

The active drainage districts in Bent County include five on the north side and two on the south side of the Arkansas River, both above and below John Martin Reservoir. The north side districts include the Riverview and Arbor drainage districts located just west of the Bent County line with Prowers County, the McClave drainage district slightly to the west of these first two districts, and the Lubbers and Hasty drainage districts near the town of Hasty, Colorado. The two districts on the south side of the river, and located just west of Las Animas, Colorado are the Las Animas Consolidated and the Las Animas Consolidated Extension drainage districts; both taking their name after the mutual irrigation companies that provide irrigation water to the lands within these districts. Final reports on each of these districts can be found in Appendix B.



The tile lines in Bent County have lost much of their integrity due to changes in county land use over the years. There are large sections of the county with high water table conditions, presumably due to the construction of John Martin Reservoir. There has also been a considerable amount of irrigation water

sold off the land. This has resulted in the drying up of productive acreage, limiting the use of, and interest in, the county's tile line infrastructure in some localities within the county. Exceptions to this observation are the rather extensive tile line systems generally located around the Town of McClave. These lines are included within so-called unconsolidated drainage units or partnerships of private landowners. They have been installed at the expense of individual landowners, rather than through an organized drainage district governed by a board of directors and having annual assessments.

Tile lines in these unconsolidated drainage systems are generally well maintained and remain of considerable importance to local landowners. They have been expanded gradually over the years, although it appears that most of the lines are newer, having been installed shortly after World War II. They are often quite deep. There are several localities where they are accessible through manholes, although as with other areas of the valley, there are generally an insufficient number of these access points to conduct proper maintenance. Local landowners in these unconsolidated areas usually have a fairly good idea of where their lines are located and occasionally have been able to provide maps of these lines to our study. In a couple of instances, these maps have apparently been developed over the years by employees of the old Soil Conservation Service (SCS). In years past, the SCS had drainage technicians in some of the agency's area field offices, although this is generally not the case today with its successor agency – the Natural Resources Conservation Service.

There is a considerable amount of tile line rehabilitation needed in Bent County, the benefits of which would likely be of considerable value to landowners. In particular, the Riverview and Arbor drainage districts are in need of substantial improvements. Although these drainage districts are relatively small, the land is still very productive. Several landowners who kindly participated in the study appear very favorable to any future efforts directed at improving the drainage of their lands. There are significant opportunities to make use of existing tile lines, if additional new lines were installed. The per-acre costs are likely to be quite expensive, and this fact has limited the interest in individual landowners financing such rehabilitation on their own. It would seemingly take a reconstituted drainage district effort to make such improvements affordable to landowners. Despite this, it appears that many of the tile lines simply need to be cleaned and the depth of open collector drains increased to provide sufficient drop at the tile line outlets to ensure unobstructed discharge of the lines.

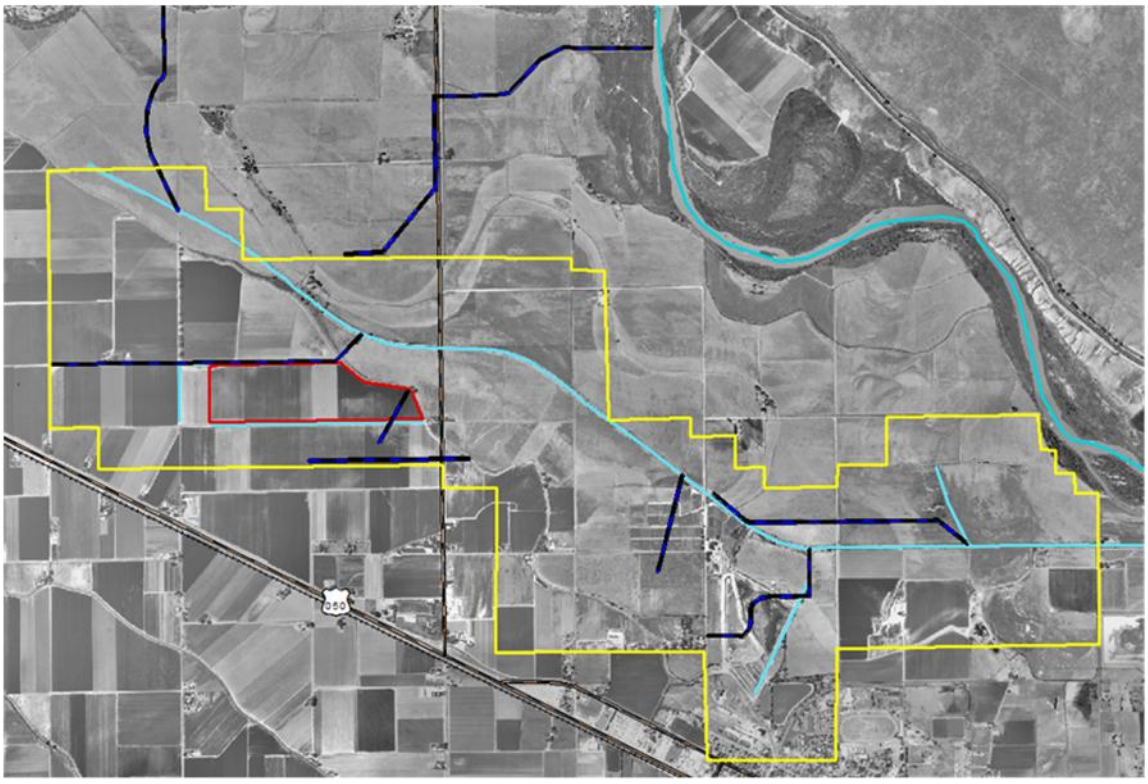
As with the other district reports, the waypoint readings and the information associated with the drainage districts in Bent County could be of great value to future rehabilitation efforts. If one simply scans through one of the district maps compiled using these waypoint readings, and follows the waypoint descriptions, it is easy to see how a rehabilitation program could be guided by this information. Landowners have already contributed a considerable amount of their personal time in providing information on the condition of their systems at various localities. These maps and weypoint descriptions provide documentation on where problems are located and what needs to be done to improve the system.

Otero County Drainage Districts

Historically, cropping patterns tended to be quite different in Otero County. This area of the Arkansas Valley was very favorable to the production of fruits and vegetables from almost the beginning of the last century. In addition, the refining of sugar from sugar beets was carried out by three major sugar companies. This was combined with several canning companies in the county to create a very active and profitable food processing industry beginning in the 1920s and carrying through the late 1960s. One district, from its beginning, was largely co-terminus with the service area of a local mutual irrigation company. This is the Fairmont Drainage District. Most of its tile line system is within the Catlin Canal Company service area. It is an extensive system with some 20 plus miles of tile line with many manholes (see images, page 35). This drainage system was clearly designed along more modern lines, as

evidenced by its many small lateral lines feeding into large trunk lines conveying drainage water back to the river, via Timpas Creek.

Other Otero County drainage districts include the Grand Valley Drainage District, the Holbrook Drainage District, the Patterson Hollow Drainage District, and two districts formed by the American Beet Sugar Company (ABSCO); ABSCO District #1 and ABSCO District #2. The two sugar beet company districts are no longer active, while the Patterson Hollow district is largely relegated to a private endeavor.



Although no longer functioning as an organized drainage district, the American Beet Sugar Company Drainage District #2 (outlined in yellow) appears to have a considerable number of tile lines (indicated in blue but not finally confirmed at the end of the project). Some of these are known by local landowners, but there is no organized maintenance program for these drain lines. The area outlined in red represents a salinity research study field for another Colorado State University project. 34

The Grand Valley Drainage District was organized in 1923 and is not known to have tile lines, but rather had a deep open drain traversing through the middle of the district. As with most open drains, the effectiveness of the drainage system over the years has been contingent upon maintaining the open drain to its recommended depth. Maintenance on this open drain has not always created the most optimal conditions for draining the lands it was designed to serve on the south side of the river. The district comprises about 800 acres and is irrigated from the High Line Canal Company.

The Holbrook Drainage District was organized in 1924 and originally served about 9000 assessed acres of land on the north side of the Arkansas River, due north of La Junta, Colorado. Land in the district is irrigated by the Holbrook Irrigation District, one of the few such districts in Colorado. The drainage district is characterized by being in a partially closed basin, with drainage water emptying into Cheraw Lake (mainly) and Horse Creek. Although the district has no tile lines, its open drain system has been important in keeping the land productive over the years. As with most open drain systems, routine

maintenance is needed, particularly in keeping weeds down and in ensuring that the open drain remains deep enough to be effective.

Returning to the Fairmont Drainage District, it is an actively managed tile line system today. It was organized in 1917 and originally served about 900 acres (assessed), although today its service area is estimated at 1,971 acres. This is almost entirely a tile line system laid at depths of 3 to 5 feet, with some lines at 8 foot depths. The tile is usually 6 inches in diameter, but with some larger diameter trunk lines. There are about 24 miles of tile lines. The district was also designed with numerous brick manholes for maintenance purposes. The present number of manholes is not known exactly, but is probably in the range of 70 to 90 such entry points. This design is more in keeping with a more modern tile lines system, and indicating that such a design layout was not unknown at the time of construction (see old plat of the district, page 35).

It's not known why landowners in this area opted for such an extensive tile line system for so few acres, and at a cost of about $47,000 in 1918. It is probable that the vegetable/produce crop production in this area, which included such crops as sugar beets, melons, onions, tomatoes, and vine crops in the early years, was a contributing factor. It was a vibrant production area with sugar factories, canning plants, grain elevators, onion storage sheds, seed houses, and packing sheds. With the reintroduction of small grain and hay (alfalfa) production in the area, efforts are now being made to bury manholes in order to facilitate the preparation, cultivation, and harvesting of these crops. Although the burying of manholes can affect the long term maintenance needs of the system, at least with the introduction of global positioning (GPS) technology, the location of these entry points into the tile line system can be archived for future maintenance needs whenever they are capped and buried.

Crowley County Drainage Districts

The Federal Land Bank engineering appraisal of drainage districts in Crowley County reports only one district with tile lines (see map, page 26). This is the Olney Springs Drainage District. Although a relatively small district of a little over 2000 acres, it has an extensive tile line system with numerous manholes. This system was installed in the early 1920s. As with many drainage districts in the Arkansas Valley, maintenance during the water short years of the 1930s tended to be lax. Needless to say, a series of water short years almost immediately following the installation of tile lines in the lower Arkansas Valley undoubtedly contributed to some disinclination to regularly maintain these systems and to continue financing them. A lengthy period of ten to fifteen years without regular maintenance would have resulted in some permanent deterioration of these lines. The Federal Land Bank also reported that the debt burden associated with the formation of these districts may have contributed to the disinclination to finance annual maintenance during the 1930s.

Due to the fact that much of the irrigation water rights in Crowley County have been sold to Colorado Front Range cities, it is unclear whether this drainage system will remain in use. There is a large area in Crowley County around Olney Springs, Ordway, and Sugar City that was under irrigation in the past. Most of some 50,000 acres was served by the Twin Lakes Reservoir and Canal Company which operates the Colorado Canal. The service area of this mutual irrigation company overlaps several drainage districts besides the Olney Springs Drainage District. These include the King Center Drainage District, the Crowley Drainage District, the Numa Drainage District, the Ordway Drainage District and the Valley View Drainage District. Overall, the area has a history of generally good surface drainage but with slow subsurface drainage except on sandy soils.

The Federal Land Bank reported that, as of 1972, it was unlikely that agricultural land owners in this area would continue to qualify for federal loans or other U.S.D.A. programs. At that time, a land company was in the process of purchasing a good portion of the transmountain diversion rights and the

Arkansas River diversion rights of the these mutual irrigation companies; about one-half of the area's water supply coming from each of these sources. Water rights purchased by the land company were then being sold to the Front Range cities. Only a small amount of acreage in the area is being irrigated today. It is likely that the withdrawal of the sugar companies from the lower Arkansas Valley contributed significantly to the willingness of landowners to sell their water rights to the land company.[18]

It is doubtful if water would ever be brought back onto this land, which places in question the need to maintain the drainage infrastructure in this area. The sugar companies installed additional tile lines around Sugar City. Some of these lines continue to be used by local landowners, although there is no drainage district currently overseeing these lines. However, discussions with local landowners around Sugar City indicate an interest in servicing some of these lines. Some maintenance work could be done in the area to address seepage problems. The sugar companies routinely installed manholes, and many of these are still in relatively good condition today.

A survey was conducted on the Numa Drainage District and the Crowley Drainage District at the request of landowners. These districts have numerous open drains, although they have no tile lines, except perhaps those that may have been installed by individual landowners over the years.

The situation in Crowley County does raise the question of the value of continuing with efforts to improve and maintain the tile line and open drainage system in the lower Arkansas Valley. The value of making capital improvements to the valley's drainage infrastructure appears contingent upon the availability of future water supply for irrigation. Water rights in the lower valley continue to be sold with plans to divert them to Front Range cities, leaving large acreage without future water rights. Even current discussions in planning roundtables tend to suggest only financial or alternative development mitigation for the selling of these water rights, not necessarily in securing alternate water supplies for the valley's future.

Efforts by local special districts in the lower valley to purchase water whenever it is placed on the market are laudable and provide an opportunity to reduce the "futures forgone" associated with such resource losses. However, cities on the Front Range will always have more capability to outbid local districts for water in these open markets. Until water rights are permanently secured for the valley, it will be difficult for agricultural landowners to qualify for agricultural subsidies and funding for technological improvements to their production systems, and needless to say, improvements to their drainage infrastructure.

[18] A certain degree of humor is often expressed by landowners in the area regarding the name of this land company, the Crowley County Land and Development Company. Today, as a result of the actions of this company, not much land is being irrigated and not much development is being experienced in the county either. With two excellent storage facilities under the mutual irrigation company, and a relatively good history of water supply, the area could have continued to develop into a major agricultural production area in the state. It was a diverse area, with about 20 percent in alfalfa, 25 percent in corn, 8 percent in sugar beets, 12 percent in beans, 15 percent in small grains, and 20 percent in pasture and other crops (circa 1970).

Chapter V

Drainage District Consolidation

This final chapter attempts to set out a plan for drainage rehabilitation that can address the future needs of the valley's agricultural production system. In doing so, several issues need to be clarified. These have been alluded to in previous chapters, and can be summarized here. They include a manageable rehabilitation and maintenance plan for drainage, improvements in organizational capacity to address drainage problems, a means of financing drainage into the future, and the benefits that might be achieved with improved drainage. They also include the recognition that drainage problems in the lower Arkansas Valley have now evolved into a community-wide issue, rather than simply one pertaining to agricultural landowners and their farm land drainage needs.

No efforts were attempted during the study to initiate discussion about the future organization of drainage in the lower Arkansas Valley, other than to raise the need to consider alternatives in the future during workshops and through scheduled guest speakers. Both the Tulare Lake Drainage District and the Grand Junction Drainage District, along with a representative from the South Columbia Basin Irrigation District, visited the Arkansas Valley and made presentations at several study-sponsored meetings on their individual drainage programs. What came out of these discussions was the recognition that the way in which drainage had originally been organized in the valley was perhaps good for its era, but no longer a feasible strategy for today's needs. It is not surprising either that the U.S. Bureau of Reclamation, as part of its water infrastructure development in the West over the past five or six decades, has seen no reason to follow such an organizational strategy as is currently found in the valley. Most modern irrigation districts in need of drainage infrastructure, and most do, have moved to an integrated program where the two irrigation systems (surface and drainage) are combined into one organizational framework. However, the big question is what that organizational framework should ideally look like.

The historical impetus for the valley's current organizational framework comes largely from the mutual irrigation company tradition in the West. Prior to Reclamation's involvement in water development in the 17 western states, most irrigation systems were organized by local grass-roots entities; some being joint stock companies while others were small tax districts. Both of these forms of organization were charted (or legalized) under state statutes; the variations in these statutes being notably quite minor from one western state to another. It was, therefore, logical for the early drainage district movement to adopt this organizational framework for drainage as well. The philosophy adopted by landowners toward local problems was local initiatives leading to desirable local solutions, and preferably ones where sufficient oversight could be assured by local leadership. Communities like Lamar, Las Animas, La Junta, and Rocky Ford grew up with this idea of local autonomy in their decision-making, given that central government was relatively weak, or at least lacked the regulatory reach back then that it has today. Yet, in the early days of irrigation, these irrigation and drainage problems were largely local problems, not the regional or valley-wide problems that exist today with selenium and sedimentation. At first glance, this would seemingly call forth greater central government reach to address them, in the absence of local initiatives.

There is nevertheless a desire in the valley to hold onto older traditions because they are familiar, and they have worked well in the past. The mutual irrigation company tradition addressed equity issues well. The ability to respond to local problems surrounding water delivery and use, to sanction landowners who failed to abide by the articles of incorporation and bylaws, and the ability of such entities to finance

local improvements, were all part of the philosophy drawn upon to address drainage problems in the past. However, unlike the many issues surrounding reliable and equitable water deliveries to landowners, the drainage problem has been lost sight of, at least in the degree to which it is viewed as an organizational problem rather than specifically an individual landowner problem. It would appear that this older organizational tradition has played out its usefulness with regard to drainage, and new organizational arrangements must be devised.

So, what is there to draw upon from this experience? There are really not many other choices for such a "collective good" problem as drainage. By this, economists usually refer to commodities or services where regulatory or market-based organizational frameworks are often not as effective in controlling the "free rider;" in the case of drainage, the inability to specify ownership of the "negative externalities" (flooding, salinity) created by water use. If the problem is regional, then the organizational framework would seemingly have to be regional as well. All three of the outside districts called in to give presentations on this issue conveyed the clear message that all water use directly or inadvertently contributes to the drainage problem, and therefore there is a need to "socialize" the costs of drainage; requiring all valley residents to contribute to drainage maintenance. However, as with the locally familiar mutual company tradition, this socialization of cost can be tempered by prorating the cost to the amount of water used or the amount of land irrigated, rather than as a simple flat tax on all landowners and city residents. Although never perfect, such proration of costs ensures a significant degree of equity to maintain support of the organization, its leadership, and its drainage maintenance program. Yet, this strategy does not appear totally adequate, and that is because the problem of drainage has become a problem for all members of the community; residential as well as agricultural and industrial. Somehow, a way must be found to expand the idea and philosophy underlying the mutual irrigation company tradition to a broader regional concern.

The best option appears to be a regional tax district that would integrate many small efforts into one larger effort that would incorporate the needs of agricultural, industrial and residential water use in the valley, while at the same time adhering to the organizational framework of a traditional mutual irrigation company. This is similar to a watershed approach, and perhaps even an eco-systemic approach, to addressing point source and non-point source pollution of water. The only difference here is that the emphasis is being placed on a regional infrastructure to clear the land of standing water and high water tables. To an important degree, both concerns are closely connected and would seemingly be better addressed through the "economies of scale" that can come from a special district devoted to drainage problems created by irrigated agriculture and residential-industrial use of water. Again, one is not alluding to a large organization of dozens of employees, but rather a small team of two or three people with adequate equipment and a maintenance plan – such as the one discussed earlier – working throughout the year to service the drainage system.

Before that strategy is made useful, the agricultural drainage system will have to be improved considerably. This calls forth a rather large and expensive effort throughout the lower valley. However, the study has shown that the older drainage system can be made use of in a very effective way, until such time that the communities in the valley can afford a larger drainage infrastructure renovation. This might be assisted through a coordinated cost-sharing effort, combining the efforts of agricultural landowners and local community residents. A local effort using local leadership, participation of a diverse set of stakeholders in the valley, building trust through sustained community participation, and a free exchange of information on the problem and its causes, could go a long way in discovering the trick of how to move the mutual irrigation company tradition to a larger scale effort. In some respects, the current Super Ditch concept being explored in the valley for water marketing purposes is an example of an effort to move the mutual irrigation company tradition to a larger regional scale.

The study has more or less concluded that the drainage problem in the lower Arkansas Valley is largely an organizational issue. Through the collaboration with the South Columbia Basin Irrigation District and others, it has provided many examples of approaches that can be taken in developing a full scale maintenance program. It has also shown how the currently technology for drainage has advanced to the point that a small crew of employees could service a large area with minimal expense to agricultural and residential landowners. Drainage problems need focused attention. They need constant attention, and they need a reliable and qualified permanent staff to meet that challenge.