Flood Control

Rossville, Kansas

NRES Capstone - 5 May 2006 - Trisha Culbertson - Kevin Unrein - Brad Hus

Acknowledgements

We would like to thank the following people for their contributions. Without thier help, the goals of this report could not have been met.

Robert Wilson

Shelly Buhler

Rhonda Montgomery

Dennis Brinkman

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Purpose:

This purpose of this report was to research and define the specific flooding issues of Rossville, Kansas, and to provide possible solutions and recommendations that could be used to prevent further flooding occurrences.

executive summary

The City of Rossville, Kansas is a small community of 1,014 residents located in northwest Shawnee County. Rossville is situated on Cross Creek, a twisting tributary of the Kansas River that drains nearly 180 square miles of range and cropland north of Rossville. Since its was founded in 1871, the town has been subject to frequent flooding as Cross Creek has repeatedly overflows its banks during periods of high rainfall. Additional contributions to Rossville's flooding issues stem from the hilly topography and shallow soils of the upland areas of the watershed and from agricultural landuses which increase runoff flows into Cross Creek. The most recent flood occurred in October of 2005, causing substantial damage to homes and businesses and spurring the town's interest in exploring flood control options.

Currently, the only source of flood protection for Rossville is a series of 15 small headwater control dams. The southern portion of Rossville receives additional protection from the Union Pacific railroad tracks that bisect the town. However, the protection afforded by either of measures is minimal and additional measures must be taken to mitigate future flooding events. In 1990, the US Army Corps of Engineers proposed several structural projects to alleviate flooding in Rossville. Although these projects are predicted to protect Rossville from the 500-year (or 0.2 % chance) flood event, they would alter both the natural stream channel and floodplain causing adverse ecological effects. In addition, structural projects are very expensive and tend to push flooding problems further downstream.

In addition to the structural measures proposed by the Corps, the environmental, economic, and social impacts of both other localized and watershed-based flood protection measures were examined. Local flood protection measures that were examined include a multipurpose lake and nonstructural flood mitigation measures such as elevating, floodproofing, or relocating flood-prone structures. Runoff reducing strategies to be implemented throughout the watershed include additional watershed dams, proper grazing management, and the reestablishment of grassland, wetland, and riparian buffer systems.

In consideration of the environmental, economic, and social impacts of the flood control methods explored, we recommend that Rossville address flooding issues through a holistic, watershed-based approach. This type of approach offers several advantages over the structural measures proposed by the Corps. First, it will reduce flooding in Rossville by addressing the primary reason for flooding: increased runoff from agricultural landuses throughout the rest of the watershed. Practices such as proper grazing management and the reestablishment of wetlands and riparian buffers along Cross Creek and its tributaries will help reduce flooding downstream at Rossville. Secondly, a watershed-based approach poses relatively little economic burden to the town as Rossville could partner with government agencies such as the Natural Resources and Conservation Service to offer technical assistance and incentive programs to landowners who choose to implement these measures. Finally, water quality issues will be addressed as well since these vegetated systems will filter sediment, nutrients, and agrichemicals from runoff before it reaches Cross Creek.

These watershed-based measures will help reduce the frequency and severity of flooding in Rossville, but will not eliminate it all together. For additional protection, we recommend that Rossville consider implementing nonstructural mitigation strategies within the town. These measures include relocating structures on flood-prone properties to areas that are less likely to flood or altering structures so they are more resistant to flooding. Nonstructural measures are also more economically feasible for Rossville than structural measures and do not pose negative environmental impacts.

Introduction

The small town of Rossville, Kansas is located in Northwest Shawnee County along Highway 24 approximately 15 miles Northwest of Topeka. Figures 1, 2, and 3 to the right locate Shawnee County and the City of Rossville. The town was founded in 1871 at the crossing point of the Oregon and California trails and today has a population of around 1,014 residents. The town covers an area of approximately one-half square mile and sits mostly on the east side of Cross Creek with some of the northern part of town on the west side of Cross Creek. Cross Creek flows through Rossville and empties into the Kansas River about three miles south of town (City of Rossville, 2006)

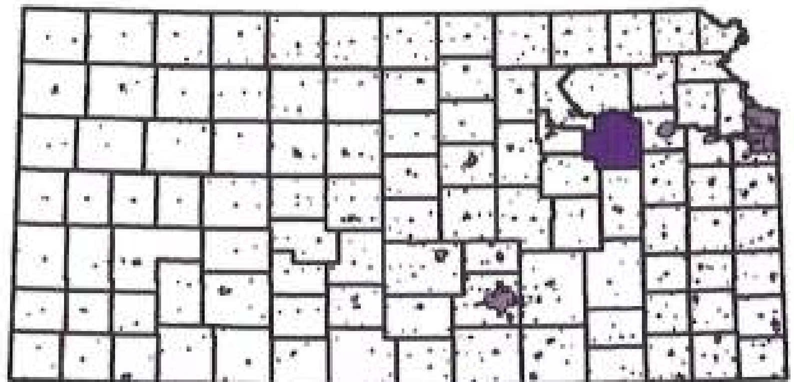

Figure 1: County map of Kansas indicating the location of Shawnee Coutny. Source: Kansas GIS maps.

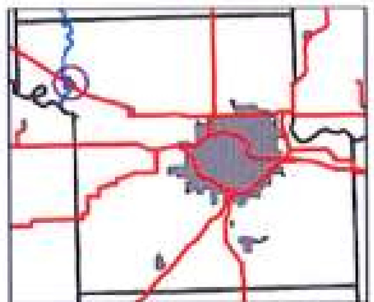

Figure 2: Shawnee County map indication the location of Rossville. Source: Kansas GIS maps.

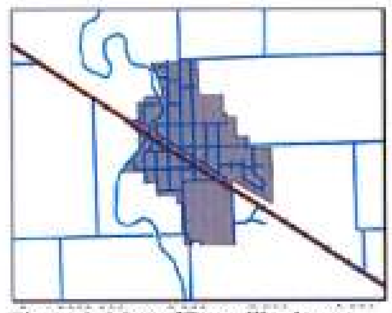

Figure 3: Map of Rossville showing city and county raods, Highway 24, and the Union Pacific Railroad. Source: Kansas GIS maps.

the problem

Rossville is situated along the banks of Cross Creek in the bottom of a valley where there is only about one foot of elevation difference from one side of the town to the other. This flat area of land is called a floodplain. Floodplains are aptly named because they are areas of land commonly flooded during heavy precipitation events. Floodplains are designated with labels like 25 year, 100 year, and 500 year to name a few. The common misconception that these labels imply is that a flood great enough to reach the 500 year floodplain line will happen once every 500 years. However, it actually means that there is only a 1 in 500 chance that a flood of that magnitude will happen in any given year. These floodplain designations can also be given as a percentage. For example, there is a 0.2% (1/500) chance of water reaching the 500 year floodplain in any given year. Similarly, there is a 4.0% (1/25) chance of water reaching the 25 year floodplain in any given year.

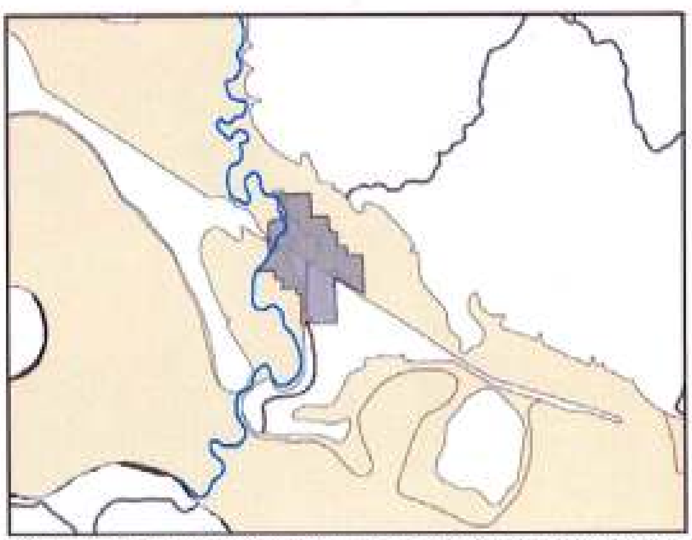

Figure 4: Map locating Rossville within the 500 year floodplain of Cross Creek. Source: Kansas GIS maps.

The entire city of Rossville is located within the floodplain for Cross Creek. Figure 4 on the right depicts Rossville's location within the 500 year Cross Creek floodplain. Because of its proximity to this waterway, the city is subject to frequent inundation by flood waters. The numerous flood events in Rossville's history have caused damage to residential, commercial, and public properties.

Figure 5: Aerial photograph of October 2005 flood event in Rossville. Provided by Shelly Buhler, City of Rossville.

flooding occurrences

Serious floods occurred in June 1951, October 1973, June 1982, and May 1987. Less severe floods occurred in September 1977 and March 1987. The 1982 flood was the largest flood on record for Rossville (Department, 1990). According to the National Weather Service, approximately 250 residences and about 90% of the city sustained damages estimated at $3.8 million in the 1982 flood. The most recent flood occurred in October of 2005. It caused extensive damage and has renewed the cities interest in implementing flood control measures. Figure 5 is a photograph depicting the extent of this event.

Sources of Flooding

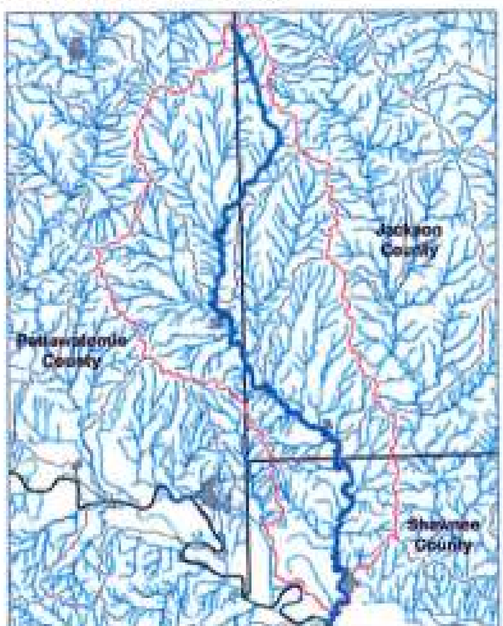

Figure 6: Map locating Cross Creek and its watershed. Source: Kansas GIS map.

cross creek

While there exists a variety of ditches and creeks in and around the City of Rossville, the sole source of flood water comes from Cross Creek. Cross Creek is a long, winding channel that extends across three counties including Shawnee, Jackson, and Pottawatomie. The total length of the creek flow line runs nearly fifty miles with numerous tributaries emptying into this water source. The Cross Creek watershed covers 178 square miles, providing drainage for an excessive area of land. Figure 6 to the left is a map indicating the location of Cross Creek and its watershed.

Cross Creek features a deep, highly eroded channel. The battered banks of the creek expose the network of roots belonging to the trees lining the creek. Various pieces of debris are mangled amongst the roots and embedded into the embankment from the years of flooding. Figures 7, 8, and 9 below are photographs taken of Cross Creek in its current condition.

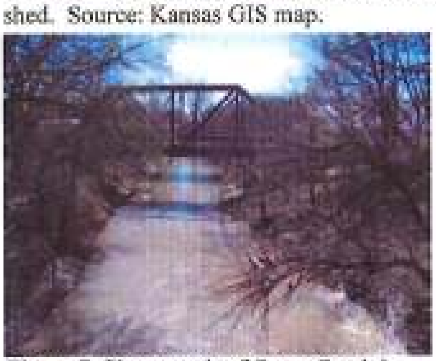

Figure 7: Photograph of Cross Creek in Rossville. Source: Brad Hus.

Figure 8: Photograph of Cross Creek in Delia. Source: Brad Hus.

Figure 9: Photograph of Cross Creek bank erosion. Source: Brad Hus.

Factors of Flooding

soils

The large watershed of Cross Creek includes a variety of soils with a range of properties and characteristics. Figure 10 below outlines the Cross Creek watershed over the soil maps for Shawnee, Jackson, and Pottawatomie counties showing which soil types are within the watershed. Figures A1, A2, and A3 in Appendix A are soil maps for the Shawnee, Jackson, and Pottawatomie counties, respectively. Each map is color coded with a key outlining the various soil types in the county and some of their general characteristics. Also included is a short description of each type of the soil within the Cross Creek watershed. Emphasis was placed on those characteristics most affecting flood issues. All soil information is taken from the Soil Survey books for each county.

The kinds of soils within the Cross Creek watershed are numerous. The two most notable characteristics of the soils within the watershed which most affect the flooding issues include permeability and runoff. Of the 22 soil series listed, all but two of them (Sharpsburg series and Morill series) have either permeability or runoff characteristics that may be contributing to the flood problem.

Permeability refers to the rate at which water makes its way down thru the soil. The slower the permeability of a soil, the longer the water is left on the surface. This increased quantity of water left on the surface increases flood potential. Soil types within the Cross Creek watershed with slow to moderate permeability include Reading, Pawnee, Shelby, Ladysmith, Gymer, Martin, Clime, Tully, Benfield, Wymore, Chase, Wabash, Kennebec, and Zook series.

Runoff refers to the movement of water over land. Rapid runoff means that the water travels to the streams, rivers, creeks, etc at a much faster rate. When this happens, the water resources receiving the flood waters fill up quicker, thus becoming overloaded and causing flood problems. The soils within the Cross Creek watershed described as having moderate to rapid runoff includes Shelby, Ladysmith, Sogn, Clime, Tully, and Benfield series.

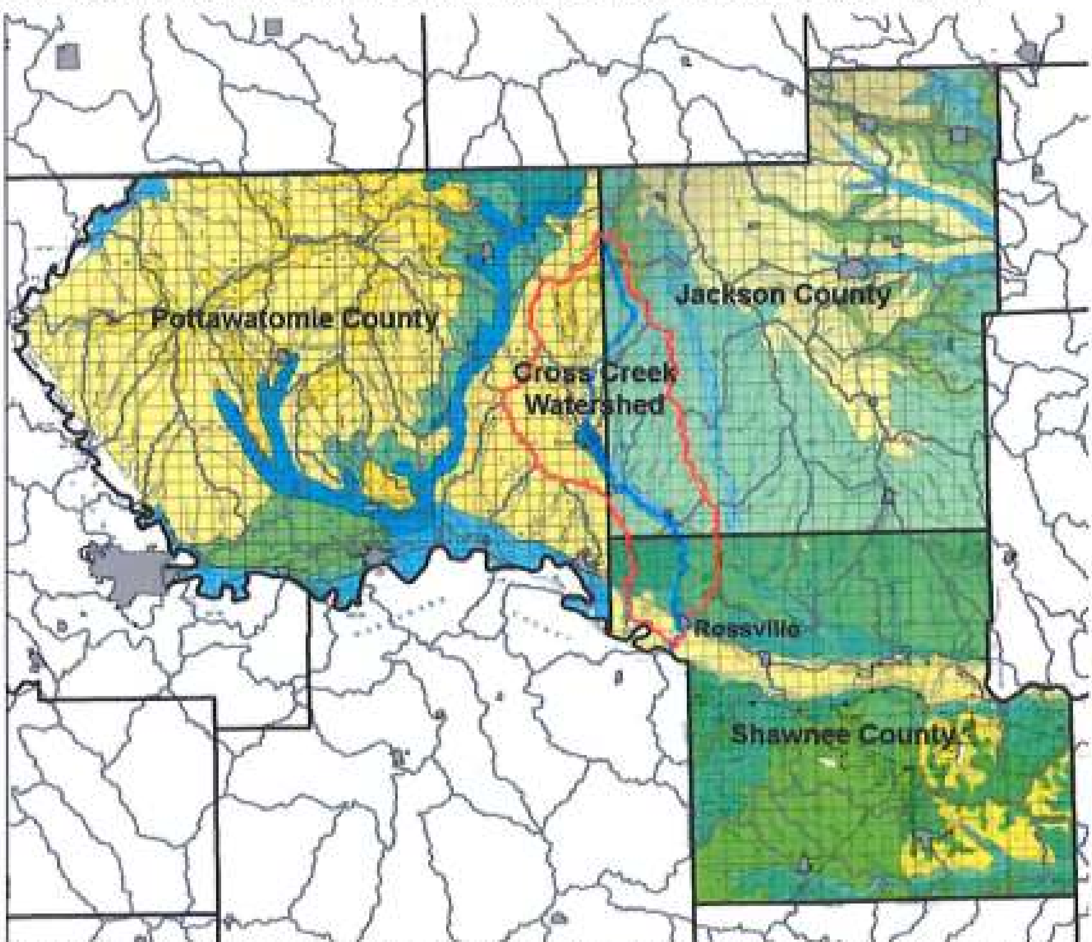

Figure 10: Map locating Cross Creek and its watershed over the county soils maps. Source: Kansas GIS maps and the Shawnee, Jackson, and Pottawatomie Couties Soil Surveys.

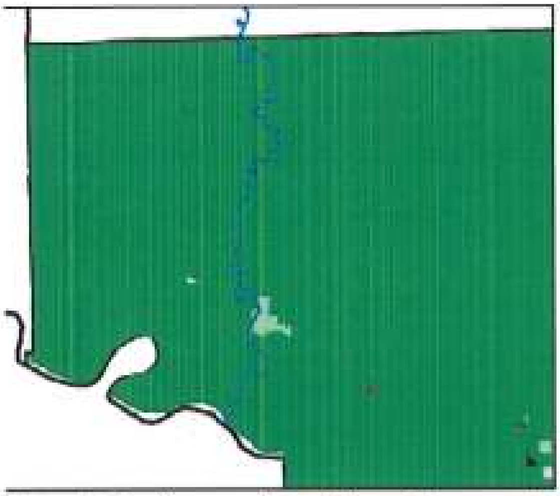

Figure 11: Zoning map of Rossville and the surrounding area. Source: Kansas GIS maps.

land uses

The City of Rossville, Kansas is a rural community surrounded by agricultural lands. Figure 11 to the left is a zoning map from Shawnee County showing the zoning designations for Rossville and the surrounding area. According to Lisa Stum, the zoning for Rossville itself is mostly single family residential (R1) with a little bit of light industrial. The majority of the non-R1 land, however, is designated as C1, central business district (personal interview 4 May 2006). Figure A4 included as an insert in the back of this document is an aerial photo of the areas surrounding Rossville which helps to distinguish between crop land and range land.

Shawnee County has designated Rossville as RR-1: Residential Reserve District. This zoning title is "…intended to provide a transitional area between urbanized development and rural-agricultural areas, and is expected to become urbanized in subsequent planning periods upon the availability and extension of municipal services and facilities" (Shawnee, 2006).

The land surrounding Rossville is designated as RA-1: Rural Agricultural District. The zoning title is described as agricultural activities protected against "encroachment of non-agricultural activities, which are primarily urban in character…" This area also "Permits numerous agricultural associated commercial uses and other rural oriented uses… and single-family dwellings on three (3) acre minimum sites" (Shawnee, 2006).

Because it is located within the Flint Hills, the natural condition of this land is prairie grassland. This natural vegetation features two primary characteristics that affect water and flooding. First, the vegetation grows thick enough to keep the soil from eroding away and reduces the rate of runoff. Second, the plants have an extensive root system which increases the infiltration rate (speed at which water breaks the ground plain) and permeability rate. The root systems of this natural vegetation also acts like a sponge, soaking up the water at incredible rates. An additional advantage to the presence of native vegetation is their ability to filter the water as it passes into the soil.

Some of this land is still used as rangeland for livestock production. According to the Army Corps of Engineers, much of this rangeland is being over grazed (Department, 1990). Overgrazed rangelands lead to a decreased amount of vegetation present on the surface. This will then increase runoff and decrease infiltration and permeability rates, thus contributing to the flood problem.

The majority of the surrounding area is used for cropland. Even though it is possible to grow a variety of crops in this area of the country, they are still not the native species that would naturally occupy this area. For this reason it is safe to say that the natural land uses have been altered.

As the land is transformed from natural prairie grasses to crops, all of the natural water control characteristics are lost. Crops are not designed to soak up the water at high rates, nor are they meant to be planted in dense proportions. Therefore, water can not be drawn into the soil or into the plants as fast, nor will it be slowed down during surface runoff. In addition to losses in infiltration, many cropped systems are designed to promote drainage. This is done to prevent water from ponding in fields for prolonged periods of time, which would reduce crop yields. However, during periods of high rainfall, these drainage practices can aggravate flooding in Rossville by sending large quantities of water quickly downstream to the town.

Many times, urban runoff contributes substantially to flood problems as well. Even though the incorporated areas in and around the Cross Creek watershed are small and sparsely located, controlling runoff from these areas would have some impact on controlling flood waters. Stormwater control measures within the city will have an even greater impact if Rossville begins to expand in the future.

In addition, urban runoff can impact the quality of water resources. As water travels over an urban landscape, it picks up contaminants such as sediment, bacteria, oil, antifreeze, battery acid, heavy metals, etc. These contaminants severely degrade the quality of water within the receiving water bodies. This can cause sickness, disease, or even death amongst a variety of living organisms including humans.

slopes

Much of the Cross Creek watershed is very flat, especially the floodplain surrounding the creek. As mentioned before, this is where the city of Rossville is built and is also the location of most of the croplands. The area surrounding the floodplain, however, is very hilly. Figure A5 included as an insert in the back of this document is a topographic map showing the terrain of the land in and around the Cross Creek watershed.

These land configurations also contribute to the flooding issues. The flat land of the floodplain allows for water to easily spread out and affect a greater area. This water can either come from overflow from the creek, or from water running off the hills surrounding the floodplain. The combination of these water contributions leads to more frequent and severe flood events.

structures

Because Cross Creek runs through the City of Rossville, there are two major transportation structures that cross the waterway. The first is a bridge for Highway 24, and the second is a bridge for the Union Pacific Railroad. These two structures run parallel and are located directly adjacent to one another. Bridges such as these can often times cause obstructions in the waterway, unintentionally damming up the water.

Figure 12: View of Union Pacific Railroad Bridge. Source: Brad Hus.

The Union Pacific Railroad Bridge (Figure 12 to the right) is located north of the Highway 24 bridge and is the structure to which the flooding problem can be attributed. When the water in Cross Creek reaches the level of the bridge, it acts as a dam, reducing water flow and backing it up into the city. For this reason, the northern areas of Rossville flood much more often then the southern areas.

Flooding has been a recurring problem for the City of Rossville since its establishment 135 years ago. The city has sought out alternative solutions to alleviating the chronic flood problem. Several solutions were developed including one from the Soil Conservation Service (now known as the Natural Resources Conservation Service, or NRCS), and five alternatives from the Army Corps of Engineers dating back to 1982 (Department, 1990).

Current Flood Protection Measures

scs dam location map

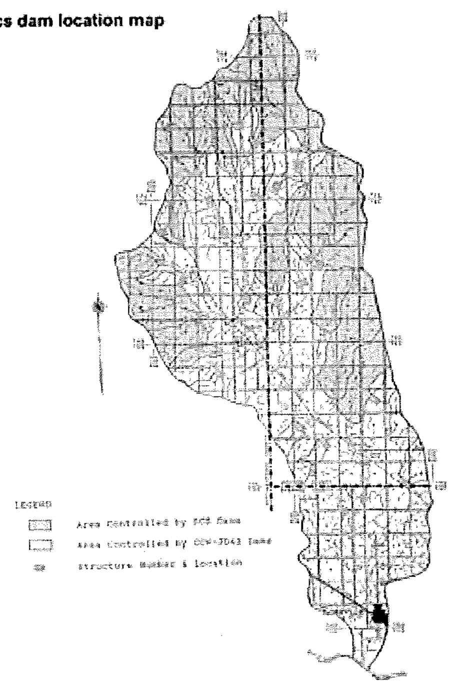

Figure 13: NRCS dam location map. Source: US Army Corp of Engineers.

natural resources conservation service (NRCS)

To date, the NRCS solution has been the only one implemented. This plan called for the construction of "15 small floodwater retarding structures" (Department, pg. 7). These structures were to be located primarily upstream (north) of the town along various tributaries which drain into Cross Creek. The idea of these dams was to reduce the rate at which water flows into Cross Creek, and create small water holding bodies. This would allow more time for the creek to empty into the Kansas River and prevent flooding. Originally, there were nineteen more dams planned, but they were found economically infeasible, and thus were not built (Department, 1990). The locations of the NRCS dams are located in Figure 13 on the left.

A hydrologic analysis was done for the fifteen NRCS structures. It was estimated that the dams would prevent damages in Rossville from 25- to 50-year flood events for areas north of the Union Pacific Railroad Bridge and 50-year flood events for areas south of the bridge. However, nearly all of Rossville north of the bridge and half of the city south of the bridge is located in the 100-year floodplain. This means that there is still a substantial threat of flooding, so further steps must be taken (Department, 1990).

A large upstream flood control dam was also considered. A study was done to determine the feasibility of this solution as well. It was found that the benefits of such a solution did not justify the cost to build it, so the idea was dismissed (Department, 1990).

Proposed Flood Protection Measures

army corps of engineers

The Army Corps of Engineers provided Rossville with a set of five flood control solutions in 1982. Three of the five alternatives were then selected to be looked at in greater detail. An Environmental Impact Statement was also developed to determine the consequences of incorporating any one of the three plans. The efforts of the five alternatives devised by the Army Corps of Engineers were focused directly around the city of Rossville. This means that flooding will not be reduced, just relocated to another area. These solutions may solve the problems for the City of Rossville, but they do not solve the problem itself. To date, none of the plans have been implemented due to the economic limitations of the small, rural town where a smaller population limits the income potential of the city (Department, 1990). The Following is a description of each

army corp of engineers plan 1

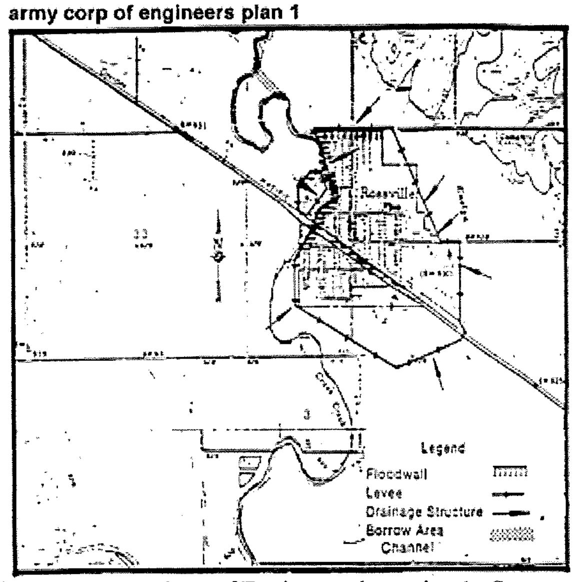

Figure 14: Army Corp of Engineers alternative 1. Source: Army Corp of Engineers.

of the five alternatives devised by the Corps:

Alternative 1: Two Ring Levees and Floodwall Combination.

This plan consists of both a small and a large ring levee. The small levee is located around the northwest corner of the city on the west bank of Cross Creek. The large levee is a combination of a levee around the remaining portions of the city and a floodwall where development occurs near the creek bank. A floodwall was used in this location to minimize the number of residential units that would be relocated because a levee requires a right-of-way. The total length of the ring levee is approximately 19,000 feet with an additional 6,300 feet of floodwall (Department, 1990). This levee system can be seen in Figure 14 above.

The floodwall would be located along the north and west portions of the city and would run "along the south side of the county road adjacent to Ensign Creek ditch and along the left bank of Cross Creek" (Department, pg. 32). The floodwall crosses both Highway 24 and the Union Pacific Railroad, both of which run through the town. Stoplog closures would be required at these intersection points (Department, 1990).

Of the five alternatives, alternative 1 is the only solution that does not have a major relocation of the Cross Creek channel. A short cutoff of about 800 feet is suggested, but this cutoff would be used for the collection of soil to be used for levee fill material (Department, 1990).

While the flowline of Cross Creek is not relocated, this plan does suggest other changes to the channel within the incorporated area of Rossville. These changes include clearing of the existing channel between the floodwall and the levee. This would improve the hydraulic flow conditions for approximately 4,000 feet of Cross Creek (Department, 1990).

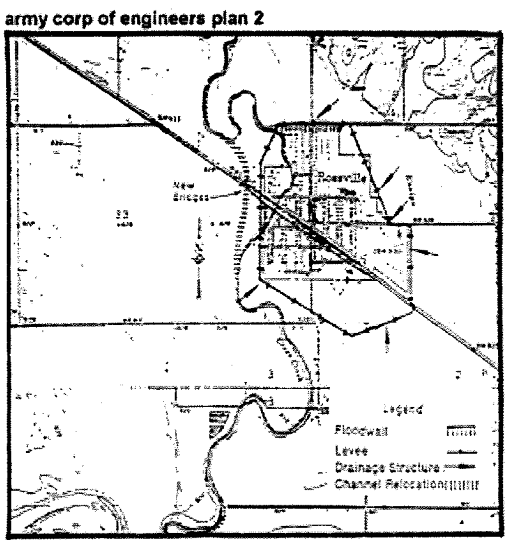

Figure 15: Army Corp of Engineers alternative 2.
Source: Army Corp of Engineers.

Other changes required in this plan include the relocation of the municipal water works, six mobile homes, and twenty five private residences. This plan would provide protection from a 500-year flood event and protect about fifty acres of undeveloped land. As of 1989, the cost of this project is approximately $7,980,000 (Department, 1990).

Alternative 2: Channel Relocation with Ring Levee and Floodwall

For this alternative, a ring levee similar to the one in the first alternative will be constructed around the entire town except for the length along the north end of the town which will be a floodwall. There will be a total of 20,600 feet of levee and 1,600 feet of floodwall. Much of the earth required to build the levee will come from the excavation of 3,800 feet of new creek channel. This plan can be seen in Figure 15 to the left. (Department, 1990).

The new channel in this plan will reduce the flow of water in the meander that runs through the town. Flow of water through this channel will not be completely eliminated as the Ensign Creek drainage ditch would then be directed to flow through the old meander loop and eventually connect to the new channel. The new Cross Creek channel would run from north to south approximately one-forth mile west of the town. New bridges would need to be constructed for both highway 24 and the Union Pacific Railroad (Department, 1990).

This solution would provide protection against a 500-year flooding event and would protect approximately eighty six acres of undeveloped land. The total cost of this plan, as of 1989, was $9,330,000 (Department, 1990).

Alternative 3: Channel Relocation Only

The plans for this alternative include only the relocation of the Cross Creek channel. The relocation of the channel would follow the same path as the proposed channel in alternative 2, and can be seen in Figure 16 to the left. It is also intended to reduce flow in the meander that runs through the city. The Ensign Creek drainage ditch would continue to flow through the old channel in this solution as well (Department, 1990).

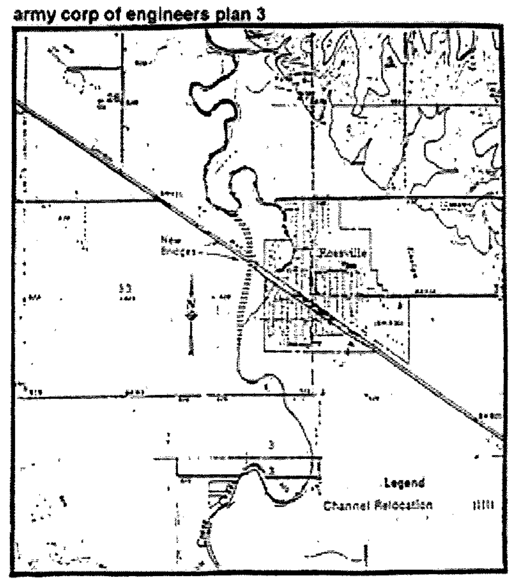

Figure 16: Army Corp of Engineers alternative 3. Source: Army Corp of Engineers.

This new channel is 3,800 feet long and runs north to south about one-fourth mile to west of the town. New bridges will be required for Highway 24 and the Union Pacific Railroad. The earth excavated to construct the new channel will be either relocated into the cut off meander loop or hauled to a disposal site several miles away (Department, 1990).

Although this plan offers some measure of flood protection, it does not protect as well as the plans including levees. The level of protection for this plan is only for a 50-year flood event. Parts of Rossville would still flood from overbank flooding of the channel upstream. With this plan, new developments on currently undeveloped land would need to be placed on fill to help raise them out of the flood zone. The 1989 cost for this project was $6,300,000 (Department, 1990).

Alternative 4: Channel with Floodwall and Trail Levee

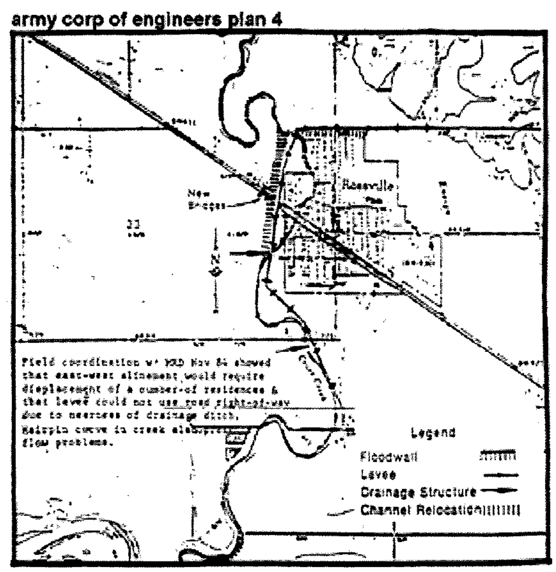

Figure 17: Army Corp of Engineers alternative 4. Source: Army Corp of Engineers.

This plan (Figure 17 to the right) calls for the construction of a new Cross Creek channel as well, measuring approximately 4,100 feet. The down stream connection occurs at the same point as the channel alignment in alternative 2, but the upstream connection is different. This upstream connection occurs near the mouth of the Ensign Creek drainage ditch at the northwest corner of the town (Department, 1990).

Unlike in the previous alternatives, the levee for this solution will be a trail levee, not a ring levee. The trail levee will be about 10,100 feet long and located along the country road across the north edge of town. The levee would begin at Cemetery Hill and extend to the west to the cutoff of the existing channel. It would then turn south and follow the path of the new creek channel and eventually taper off downstream, south of the town (Department, 1990).

The length of channel adjacent to the county road would not follow the road right-of-way exactly. The Ensign Creek drainage ditch is directly flanking the north edge of the road, and the residential houses on the south side of the road are close enough that fifteen residences would have to be removed for a levee to be constructed.

Therefore about 1,600 feet of floodwall will be used in this location, thus reducing the residential displacement of only ten units (Department, 1990).

The Ensign Creek drainage ditch would remain outside of the levee and drain directly into the new Cross Creek channel. The creek meander loop just to the northwest of the town in this design is kept, and it is at this location that the Ensign Creek ditch connects to Cross Creek. For this reason, water flow in the old channel on the protected side of the levee would be completely eliminated except for intermittent storm runoff and flow from several small springs remaining in the channel. The soil excavated to construct the new channel would need to be relocated to an off-site location (Department, 1990).

Protection from a 500-year flood event would be provided to Rossville with alternative 4 as well. This plan would also protect about 452 acres of undeveloped land at an estimated 1989 cost of $8,620,000 (Department, 1990).

army corp of engineers plan 5

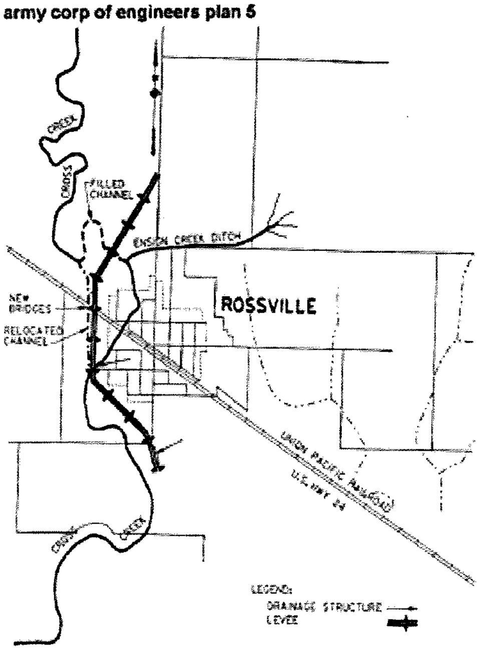

Figure 18: Army Corp of Engineers alternative 5. Source: Army Corp of Engineers.

Alternative 5: Channel with Trail Levee

The channel relocation for alternative 5 (Figure 18 on the left) follows the same path as in alternative 2. It cuts off the creek meander that currently flows through the town. A portion of this meander outside of the levee protected area would be used for the disposal of the wet sand material taken from the excavation of the new channel. This channel connection is also located north of the confluence of the Ensign Creek drainage ditch. This ditch would still empty into the old Cross Creek channel on the protected side of the levee. The channel remaining within the town provides enough capacity for controlling stormwater runoff, and would satisfy the ponding area requirement for interior drainage (Department, 1990).

A 9,500 foot trail levee would be constructed in this plan as well. This levee would commence at Peanaz Hill along the county road north of town. The levee alignment would extend southwest until it reached the new Cross Creek channel, at which point it would turn due south and parallel the new channel, approximately one-fourth mile west of town. New bridges would be required for both Highway 24 and the Union Pacific Railroad where they intersect with the levee. The levee would continue to roughly follow the creek alignment and eventually taper off south of the town (Department, 1990).

Alternative 5 provides Rossville with protection from a 500-year flood event. It also protects 536 acres of undeveloped land and has a 1989 estimated cost of approximately $7,150,000 (Department, 1990).

Table 13. COMPARISON OF STRUCTURAL PLAN COSTS AND BENEFITS

Plan	Total Cost	Annual Cost	Annual Benefits	BCR	Net Benefits
Plan 1	$7,980,000	$715,000	$190,000	0.27	negative
Plan 2	$9,330,000	$835,000	$328,000	0.39	negative
Plan 3	$6,300,000	$563,000	$176,000	0.31	negative
Plan 4	$8,620,000	$771,000	$682,000	0.88	negative
Plan 5	$7,150,000	$682,000	$771,000	1.13	$89,000

Table 1: Cost comparison table for economic benefits of all 5 alternatives proposed by the Army Corp of Engineers. Source: Army Corp of Engineers.

Figure 19: Aerial photograph of October 2005 flood showing original location of Ensign Creek. Source: Shelly Buhler, City of Rossville.

Figure 20: Aerial photograph of October 2005 flood showing original location of Ensign Creek. Source: Shelly Buhler, City of Rossville.

The Army Corps of Engineers also developed a table comparing the structural plan costs and benefits of each project. The total cost of the project, the annual cost (for operation and maintenance), and the annual benefits were all considered for this comparison. Table 1 above shows this comparison study. Note that plan 5 is the only alternative showing a positive net benefit (Department, 1990).

All of the alternatives describe their relationship with Ensign Creek drainage ditch. However, this drainage structure no longer exists. It has since been filled in and is currently farmed on. The old channel is barely visible in the landscape. Figures 19 and 20 above are aerial views of the field where Ensign Creek used to be located. A man made ditch exists along a country road located north of the city. This helps to control some of the storm water issues, but is obviously not enough.

environmental impact

Of the five alternatives developed, plans two, four, and five were selected for further study. The environmental impact of these solutions was scrutinized in order to determine how they would affect both aquatic and terrestrial systems. These affects were included in and Environmental Impact Statement made by the Corps (Department, 1990).

Aquatic Resources:

All three of the selected alternatives involve relocating the existing Cross Creek channel. The new channel alignments reduce both the length and meandering of the stream, resulting in a straight, featureless alignment. These changes cause a reduction of the aquatic habitat, and have a variety of impacts. Alternatives two and five both result in 0.5 miles of new channel, replacing 1.4 miles of existing creek bed. Alternative four replaces only 0.6 miles of the natural channel (Department, 1990).

The primary impact of constructing a new channel alignment is the initial lack of a riparian zone and vegetation. These riparian zones reduce streambank erosion, and filter out sediments and pollutants from runoff, thus improving water quality. Vegetation on the streambank shades the water during the warmer months, and produces litter drop to provide the detrital base for various aquatic organism (Department, 1990).

The straight alignment of the channel also decreases the aquatic habitat diversity. This decrease in habitat diversity would "decrease the food sources, and resting, escape, spawning, and rearing cover for some fish and other aquatic organisms" (Department, pg. F-17). Downstream effects of this realignment include "increase in sediments transported by the stream and decrease in water quality" (Department, pg. F-17). Other impacts may include erosion problems where Cross Creek meets the Kansas River. The straight alignment of the creek will increase the velocity of water flow, and can then increase the amount of erosion that occurs and this confluence.

Terrestrial Resources:

The loss of riparian vegetation is also the major concern for the impacts the alternatives would have on the terrestrial resources. This is because riparian woodlands provide habitat for a variety of wildlife. The physical and biological features of which make these riparian woodlands so important includes "the predominance of a woody plant community; the presence of surface water for abundant soil moisture; extensive edge; heterogeneous habitat; diverse structural features; and its distribution in long corridors that provide routes for movement between habitats" (Department, F-17).

Approximately four acres of riparian zone would be removed for any of the three alternatives to take place. Furthermore, 12.6 acres of riparian zone would no longer receive water flow, as the channel will be filled with leftover borrow material if alternatives two or five were implemented. Finally, the implementation of any of the three alternatives would result in about 10 acres of riparian land receiving reduced amounts of water flow. The only water would come from intermittent flows and some springs within the channel. This means that both the diversity and quality of the riparian vegetation would suffer. A shift from water tolerant species to drought tolerant species would take place. The reproduction of some of the riparian vegetation would also be adversely affected from reduced flows (Department, 1990).

Fortunately, the removal of these riparian zones does not have any effect on either endangered or threatened species. The listed endangered species in the Rossville, Kansas vicinity include the Peregrine falcon and the Bald eagle (although it is not listed as endangered any longer). The species proposed to be listed as endangered include the Interior least tern and the Piping plover. It was determined that the construction of any of the Corps solutions would not adversely affect any of these species (Department, 1990).

Recommendations for Flood Protection Measures - local

The flood protection measures proposed by the Corps address flooding on a local level, focusing efforts in the areas immediately surrounding the City of Rossville. Below is an example of a similar type of project undertaken by the Corps in another small community. Also included are descriptions of other localized flood control measures that Rossville should consider.

halstead, kansas case study

The City of Halstead, Kansas is an example of a town close to the size of Rossville that was in a similar flooding situation. To address these flood issues, Halstead adopted a levee system proposed by the Army Corps of Engineers. This solution is very similar to the alternatives proposed by the Corps for the City of Rossville. The following provides a description of the flood control project in Halstead and serves as a case study for Rossville to examine when exploring possible solutions.

Halstead is at the junction of the Little Arkansas River and Black Kettle Creek in Harvey County Kansas. Frequent flooding occurred due to the flat topography and the location of the town at the Black Kettle Creek and Little Arkansas River junction. Like Rossville, the town of Halstead was located within the flood plain. No flood control structures or any other measures were in place within the drainage basin prior to 1991 when construction of a levee system was started.

In 1991 the levee was constructed to the North, Northwest, South and East of Halstead as these were the areas in close proximity to the River and Creek. The levees were designed to handle three additional feet of flood waters over the projected and historic flood levels. Each side of town also had a flood gate built so that in times of flooding the gate could be closed to hold the water out of the town. Nine drain structures were also installed to allow water inside the town to escape and not flood from within the levee itself. The levee system in Halstead consisted of earthen dikes and the two flood gates on each side of town. The levees themselves are an average of 13 feet high and are 21,460 feet long.

In addition to the construction of the levee structures, the channels for the creek were cleaned of debris, widened, straightened, and also made deeper in places. This, along with the levee system was designed to lessen the extent of future flooding even after having built the levee system. Trees and other vegetation were also planted to control erosion of the stream and reduce the speed and sediment load of the channels that can contribute to flooding problems. Existing bridge structures were also analyzed to determine what role they played in flooding. Low bridges or ones with too many or poorly located pilings could trap debris and essentially create a dam causing flood waters to build up only to later release rapidly (Halstead Flood Plain Information 1974). Work was done to bridges and guidelines for future bridges and structures were set to plan for the future. Since the levee system was constructed the town of Halstead has been protected from flooding (1991 US Army Corps of Engineers). Figure A6 on page vi in Appendix A is a satellite image of Halstead showing the levee system. Figure A7 on page vii in Appendix A is a topographic map of Halstead.

reduction of urban runoff

Urban runoff is another major issue often contributing to flooding. In an urban setting, the amount of impervious surfaces increases. Impervious surfaces are surfaces that water cannot penetrate, so when more impervious surfaces are added, more runoff is created. While the problem is more substantial in larger cities, the small amount produced by Rossville may be contributing to the problem, even a little. Controlling stormwater within the city is another step that can be taken to resolving the issue.

Controlling stormwater within Rossville should go beyond digging more ditches. Other, newer methods include bio-retention cells, rain barrels (Figure 21 below), rain gardens (Figure 22 below), and stormwater collection amenities like cisterns and bio-swales (Figure 23 below). The bio-retention cells, bio-swales, and rain gardens are all designed to collect water and let it infiltrate into the ground. These facilities are planted with native vegetation to increase this infiltration rate. The rain barrels and cisterns are designed to collect and hold the rain and hold it. This rain can then be used later for such things as irrigation

These stormwater control facilities can be implemented at a couple of different levels. First, the city can consider at putting them in public spaces, especially those areas most affected by flood events. Furthermore, homeowners can consider the possibility of putting them on their own property. The facilities can then be

Figure 21: Rain barrel illustration. Source: www.ci.minneapolis.mn.us/.

Figure 22: Rain garden. Source: http://ohiowatersheds.osu.edu/

Figure 23: Series of bio-swales in Topeka, Kansas. Source: Brad Hus.

designed to act as aesthetic amenities, adding both beauty and value to a home or to the city. Amenities such as these should especially be incorporated into any new development that happens in or around Rossville. This solution should not be relied upon as the only method of controlling stormwater. Rather, it should be something that is done in addition to other control measures.

lake

Another option is to use elements with water holding capacity, not just water retarding capacity. The addition of a large lake would decrease the amount of water flowing directly into Cross Creek. In contrast to the dams placed in the headwaters of the watershed, the lake could be placed near the City of Rossville, affording the city even greater flood protection.

The lake option could be one that is completely detached from Cross Creek, or it could be a reservoir created by damming up the waterway. Both options come with some major ecological setbacks. Creating a lake changes the micro-ecosystem from terrestrial to aquatic, and damming up the creek will have significant changes on its natural system and processes as well. The Corps has already examined the feasibility of a large reservoir like this along Cross Creek and found that it was not economically viable (Department, 1990). However, the feasibility of a small, multipurpose lake could be investigated. The city would need to consider economic and ecological factors in addition to the challenge of acquiring lands that have traditionally been used for agriculture.

nonstructural measures

In addition to the large-scale, structural projects proposed by the Corps, nonstructural measures to control localized flooding also exist. Unlike structural projects, which modify the stream and flood plain systems in response to flooding, nonstructural measures aim to adjust human activities to reduce flood damages (NAI, 2003). Since nonstructural flood control practices do not alter the natural fluvial systems, the environmental impact associated with these measures is relatively insignificant. According to Rhonda Montgomery, the National Flood Insurance Program coordinator for the State of Kansas, nonstructural flood control approaches cost much less than structural measures (personal interview, 19 April 2006). For these reasons, Rossville should consider nonstructural approaches to flood control.

Several different nonstructural approaches have been implemented in communities throughout the country to successfully abate flooding. Nonstructural practices range from physically moving buildings from flood-prone areas to altering buildings so that they can be left in place but be more resistant to flooding. (NAI, 2003). The most common nonstructural practices are explained in greater detail in the following sections.

The surest way to protect structures from flooding is to move them out of the flood plain. Two common practices have been developed to do this: relocation and acquisition. In relocation, buildings are simply lifted from their foundation and transported to higher, less flood-prone ground. Since the majority of Rossville lies in the flood plain, finding relocation areas within the city limits that are safe from flooding may be difficult. However, since the town rarely floods south of the railroad tracks, relocation to this area may be an option. Acquisition measures can also be implemented to move buildings out of flood-prone areas. The primary difference between acquisition and relocation is that the cost to clear (either by relocation or demolition) structures from flood-prone property is borne by the city or other government agency rather than the property owner. The property is then usually converted to a public use, such as a park or open space, providing benefits to both the community and the environment.

Often, acquiring or relocating properties can be a sensitive subject since many homeowners have sentimental ties to their property. If removing structures from flood-prone areas is not an option, the structures can be

Fig. 24: House being elevated out of flooding reaches. Photo by Brad Hus.

Fig. 25: Low flood wall for private residence. Source: NAI, 2003

altered to protect them from future flood events. Houses can be elevated above the flood level to keep floodwater below areas of the house that are more prone to damage. One homeowner in Rossville is already working to elevate their home, as shown in Figure 24. Barriers can also be constructed to keep surface floodwaters from reaching a building. These barriers can be built from a range of materials and can even be incorporated as an aesthetic part of the home's landscaping, as was the low floodwall pictured in Figure 25. Another alternative for onsite flood protection is floodproofing. Floodproofing practices include coating the exterior of buildings with waterproofing compounds to prevent floodwaters from entering. This type of nonstructural measure is usually only feasible for areas with shallow flooding (2 feet or less). Buildings can also be floodproofed so that floodwaters are allowed in with minimal damage to the building and its contents. This can be done by elevating valuable items (such as hot water hearers) or rebuilding the flood-able portion of the home with materials that are not subject to water damage, such as concrete. This is the most common type of floodproofing used to protect preexisting homes (NAI, 2003).

Recommendations for Flood Protection Measures - watershed

While flood protection measures at a local level help to alleviate the problem within the city, they do not address the source of the problem. The Cross Creek watershed drains an extensive area of land, so addressing the flooding issues more holistically through a watershed wide approach will help alleviate the flood problem altogether, not just shifting the problem elsewhere.

additional dams

Dams are a method commonly used for the control and mitigation of stormwater. As mentioned previously, the Natural Resources Conservation Service (NRCS) has already implemented a series of small dams throughout Shawnee County within the Cross Creek watershed. However, flooding is still an issue for Rossville and the surrounding area. Additional dams such as these may assist in alleviating the problem by slowing the rate at which the water empties into Cross Creek, but they will not solve the problem. Dams do not reduce the amount of water that flows into the system; they just regulate water flow times. If additional dams are considered, they should not be the only method used. They should be used in conjunction with other solutions.

Hydraulic analysis conducted by the Corps found that the 15 dams currently in place provide hydraulic control of 38% of the watershed. According to Shawnee County District Conservationist Dennis Brinkman, once a watershed is 40% controlled, it is difficult to fund additional dams because the economic return from such structures rapidly declines after this point (personal interview, 30 March 2006). Studies have also shown that dams have dramatic impacts on river systems by altering flows and blocking the passage of aquatic organisms (FEMA, 2002).

wetlands along cross creek

Often times, as stormwater quantity issues are mitigated, stormwater quality issues can also be controlled. Runoff from agricultural land is usually tainted with chemicals from such things as fertilizers and pesticides. One water control option is to incorporate a series wetlands along Cross Creek. Considerable research has been conducted to demonstrate the impacts that wetlands have on both runoff quantity and quality (Mitsch, 2004; FEMA, 2002). Incorporating wetlands increases the water holding capacity of Cross Creek, and also helps to clean and filter the water as well. Vegetation planted in these wetlands is meant to do three things: help slow the rate at which the water flows, increase the infiltration capacity of the wetlands, and clean and purify the water that flows into the system.

Figure 26: Diagram of concept of incorporating wetlands along Cross Creek. Source: Brad Hus.

Figure 27: Photograph of wetlands incorporated along Soldier Creek in Topeka. Source: Brad Hus.

The wetlands will occur as a sequence of ponding areas along the waterway and will have a special mixture of wetland vegetation planted around them. A ring of prairie grasses will then be used around the wetland vegetation mix. Figure 26 above roughly diagrams this wetland solution. The City of Topeka, Kansas has already begun practices such as these along Soldier Creek. Figure 27 to the left is a photograph of these wetlands.

proper grazing management

As previously mentioned, the natural condition of this area is prairie grassland. This kind of land use is ideal for allowing water to permeate and infiltrate into the earth. A small amount of this rangeland is still maintained and used for raising livestock, but according to the Army Corps of Engineers 1990 report, it is being mismanaged. Overgrazing of rangeland reduces the amount of vegetation cover. Less vegetation leads to less water being soaked into the earth or taken up by the plants. The reduced plant cover also means that water runs across the Earth's surface easier, draining into the rivers quicker and in larger quantities. Over stocked ranges also leads to the compaction of the soils, further reducing infiltration and increasing runoff.

Improving the methods used for rangeland management could greatly reduce the impact that this land has on the flooding problem. For instance, using the proper, calculated stocking rate greatly improves the efficiency to which the rangeland is utilized. Furthermore, using a variety of livestock (such as cattle and sheep) allows for better grazing habits. These two animal breeds feed differently and on various parts of the plants. When they graze together, they take full advantage of the vegetation, so nothing is wasted or misused.

Using proper management and livestock mitigation practices improves both the amount and quality of the vegetation on the surface. The water can then remain where it lands instead of running off into the stream where it will then be carried away, causing flood problems elsewhere.

agricultural land use changes

The role that cropland plays in the contribution to flooding, and the role that rangeland plays in controlling flood water have already been identified. Therefore, another solution to controlling the chronic flood problem is to change the cropland back to rangeland. This plan would be extremely difficult to implement as it would require the cooperation of many of the land owners, many of whom have been farming the land for generations. In order to work, this plan would have to be done on a large scale, extending beyond to borders of Shawnee County.

Going from cropland to rangeland does not necessarily mean a complete change in lifestyle. Many people think that rangeland is only good for raising livestock. However, the prairie grasses could be grown and then hayed and sold for profit. Because the grasses are native, the only maintenance they require is burning once a year.

Planting natural vegetation on a massive scale can also be done along Cross Creek as a buffer between agricultural land and the waterway as well. According to Carol Blacksome, extension assistant for Kansas State University, buffer strips consisting of native rangeland vegetation would help slow, filter, and infiltrate the water into the ground before it reaches the creek. This solution could be implemented at a large scale, and would affect a large number of land owners, but only utilizing a minimal amount of land from each land owner. A study should be conducted to determine the extent to which the vegetation would need to be planted.

Solutions such as this are not uncommon. Charlotte-Meklenburg Storm Water Services in Charlotte, North Carolina conducted a floodwater modeling study to examine the impacts of buffers on reducing flood levels. They found that the buffers decreased flood heights by 0.5 feet. On the other hand, model results indicated that filling in the floodplain could raise the flood level by almost 2.5 feet (ASFPM, 2004).

Implementing a solution such as this could be done with the aid of the Conservation Reserve Program (CRP). This program "encourages environmental enhancement" and "encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filterstrips, or riparian buffers." With this program, the farmers enter in to a contract for a specified term in which they receive an annual rental payment. The cost sharing that is provided to establish these practices also provides up front incentives for taking advantage of the opportunities offered by the program (Natural, 2006).

Community Integration

While the environmental impacts of any flood mitigation strategy should be critically examined, the City of Rossville must also consider the social and economic impact of potential flood control projects. The following sections will examine both of these aspects of flood control approaches, and how flood control measures could enhance growth and the quality of life of Rossville's citizens.

localized flood control measures

Because these measures fortify the immediate Rossville vicinity against flooding, localized flood control measures have the greatest potential to reduce flooding in the town. As a result, these measures offer Rossville more opportunities to grow with less risk of flood events. Some of the larger-scale, structural measures have the potential to be tied into future community development projects. A levee system could be integrated into a recreational trail system for the town, such as has been done in the City of Manhattan, located approximately 45 miles to the west. A trail system could also be incorporated using nonstructural relocation or acquisition measures. For example, by acquiring the few properties that line the west bank of Cross Creek, this area could be reserved as open space or a park. A trail could be built through this area, utilizing the pedestrian bridge that currently spans Cross Creek to link the area to the community. A multi-purpose lake, strategically placed to control flooding in Rossville, could also offer the community fishing, wildlife viewing, camping, and other recreational activities.

While such large scale local flood control measures may provide amenities to Rossville citizens, the town should take into consideration impacts on the quality of life of its immediate agricultural neighbors. A trail levee system, as presented by the Corps of Engineers, would require realigning the Cross Creek channel to divert its flow to the western edge of the city. Historical channel realignment projects have proven to move the flooding problem further downstream. In the case of Rossville, the burden of diverted Cross Creek flows would fall upon producers farming the area between Rossville and the Kansas River. Acquiring land for a multi-purpose lake raises similar concerns, this time for agricultural neighbors upstream of the town. Most nonstructural measures, on the other hand, only affect property owners in the town and would have minimal impact on agricultural neighbors. One of the goals of environmental land use planning is to involve multiple stakeholders in the decision making process. As a result, impacts on the agricultural community must be considered as well.

Another aspect to take into consideration when assessing potential flood control measures is the economic impact their implementation will have on the city. Because Rossville is a small community with limited financial resources, the city should explore partnerships with federal, state, and local entities to fund a flood protection program. For large-scale structural projects, such as those undertaken by the Corps of Engineers, several funding sources exist. At the Federal level, the US Army Corps of Engineers will provide some assistance for small flood control projects as authorized by Section 205 of the 1948 Flood Control Act (US Army Corps, 1990). According to this Act, Federal expenditures cannot exceed $5 million on a single Section 205 project. This project money would only be available to Rossville should the City choose to pursue one of the projects presented by the Corps. For major structural endeavors, such as the channel realignment and trail levee construction proposed in the initial Corps study, the City would still be left with an immense bill to pay (nearly $2.5 million according to the 1989 Corps report).

In the initial flood control study conducted by the Corps of Engineers, the Corps' recommended plan involved replacing the bridge that currently spans Cross Creek along Highway 24. At the time of the report, the Kansas Department of Transportation (KDOT) agreed to assist the city in this effort by fully funding the design, construction, and maintenance of this new bridge with State highway monies. Should Rossville choose to adopt a structural means of flood control which requires replacing the bridge, KDOT could be reconsidered as a potential funding source.

Even with federal and state aid, structural approaches with the greatest flood control benefits remain expensive. Nonstructural measures, such as relocating or elevating homes, should be considered as a more economically feasible means of providing flood protection. Although project costs may be borne by individual homeowners, grants may be available through FEMA since Rossville participates in FEMA's National Flood Insurance Program. FEMA administers two programs to assist in the acquisition, relocation, elevation, or floodproofing of flood-prone buildings: the Hazard Mitigation Grant Program and the Flood Mitigation Assistance Program (FEMA, 2002). Regardless of whether Rossville chooses a structural or nonstructural approach to address flooding issues, the City needs to assess whether the cost will be offset by the economic benefits gained by flood protection.

watershed-based flood control approaches

Although large-scale, localized flood control measures have the greatest potential to control flooding in Rossville, these projects tend to be ecologically invasive and remain expensive. For this reason, non-structural flood control measures should be considered as well. Although non-structural measures can be applied in the area immediate to Rossville, these methods are most effective when applied as part of a comprehensive watershed management plan. A more holistic watershed approach will encourage cooperation between the City of Rossville and private landowners throughout the Cross Creek Drainage district, and has the potential to increase the quality of life for both parties. A watershed-based approach seeks to treat the cause of the problem rather than the problem itself by decreasing runoff throughout the Cross Creek watershed. Since excess runoff is part of the cause of Rossville's flooding woes, decreasing runoff will potentially decrease the frequency of downstream flooding in Rossville. In addition to decreasing runoff, many of these approaches improve runoff quality, thus protecting Cross Creek from impairments caused by contaminants in runoff.

While watershed-based solutions lie for the most part outside the city's limits, they can still contribute to the quality of life of Rossville's citizens. One method of flood control is to reestablish riparian buffers and wetlands along Cross Creek. This could create additional outdoor recreational opportunities for Rossville's citizens. A trail system could be created throughout the riparian corridor. Other community amenities could include an educational open space area established on rangeland near the city. These areas could include nature trails and be used as a means of communicating the importance of proper range management practices. Native prairie grasses and their role in reducing runoff through infiltration could be highlighted as well.

Whether reestablishing riparian buffers and wetlands or managing properly grazed prairie, it should be noted that close cooperation between Rossville and private landowners will be required. Unlike localized flood control measures, which can be initiated solely by the city, a watershed-based approach will require the initiative of landowners throughout the Cross Creek watershed. Such coordination will present challenges, but several public services are in place to aid those who are willing to participate. The USDA Natural Resources Conservation Service is one of the most visible of these service organizations. The NRCS was formed to provide conservation and land-use planning services to landowners. All of their programs are voluntary, and most are eligible for cost-share incentives to help facilitate their implementation. Programs include the Wetland Reserve Program for the reestablishment of wetlands in the Cross Creek drainage area, Conservation Buffer Program, which will fund buffers up to 120 feet wide in riparian areas, and the Conservation Reserve Program, which pays landowners to convert erodible cropland to native prairie grasses. These programs would serve to make conservation measures, such as riparian buffers and wetlands, more affordable for producers while helping to reduce water quality and quantity problems downstream in Rossville. Rossville could be a more active participant in this process by offering additional funds to landowners who are willing to adopt conservation measures on their land. This would give the community a greater sense of ownership in the project. Such supplements to NRCS incentives have been offered by several Kansas communities. According to Kansas Wildlife and Parks biologist Bob Culbertson, both the City of Wichita and communities within the Hillsdale Watershed have partnered with the NRCS to offer additional benefits to landowners with some measure of success (personal interview, 3 May 2006).

increased community involvement

Both local and watershed-based flood control approaches offer the City of Rossville the opportunity to increase community involvement in the environmental planning process, of which flood mitigation is a major part. Rossville has already taken the first step in this direction; the City recently organized a citizen-based organization called the Pride Program to develop guidelines for community growth that will enhance both the community and the environment. The flooding issue in Rossville is at the forefront of this group's agenda as flooding is a major factor in determining future growth in the community. According to a flood control study conducted by the Corp of Engineers in 1989, the town's growth has slowed since the flood of 1982 (US Army, 1990). Indeed, the town's population, which grew steadily from 1950 to 1980, has declined slightly from 1,045 in 1980 to 1,014 in 2000 (Rossville Kansas, 2006). Members of the Pride Program would like to address flooding issues in Rossville as more than a matter of controlling water quantity. According to Shelly Buhler, Rossville's mayor and co-chair of the Pride Program, the committee has a strong desire to consider the environmental aspects of flood control approaches (personal communication, 10 February 2006). Members of the Pride Program have begun attending workshops to learn how to integrate environmental planning with decision making and land use planning. The town is also preparing to create a Comprehensive Land Use Plan. This process will be most successful if it solicits inputs from the entire community. By strategically directing future growth away from riparian areas along Cross Creek and in the more flood-sensitive portion of town north of the railroad tracks, Rossville can avoid creating additional flooding concerns.

Summary/ Choosing a Solution

This study has examined the causes and sources of flooding within the City of Rossville, Kansas and has produced potential solutions to alleviate these flooding issues. The social, economic, and environmental impacts of these solutions have also been identified along with methods for implementation.

The key to resolving flooding issues is not just to divert it elsewhere, which has been the common method of control for years. This kind of solution does not solve the problem, it merely moves it elsewhere. Rerouting the river and building a levee would help prevent flooding within the City of Rossville, but adverse affects outside the protection zone and downstream will still exist. Instead, holistic solutions that look beyond just Rossville are necessary.

A better solution to controlling stormwater is to prevent horizontal movement of water and keep it where it lands. The less water that is emptied into a river, creek, stream, or other water body, the less opportunity there is for the occurrence of a flood event. This is why solutions such as increasing permeation and infiltration of the land have been so heavily addressed. This type of solution cannot be kept local; it must be done on a larger, more holistic scale.

According to Shelly Buhler, mayor of Rossville, the city only floods when a rain event occurs to the north. This makes sense as the majority of Cross Creek is located north of the city. For this reason, the scope of the solution should extend not only outside of Rossville, but outside of Shawnee County as well. The watershed for Cross Creek is large enough that there are a variety of opportunities presented. Involvement of land owners from both Pottawatomie and Jackson Counties is essential for producing a holistic solution to the problem.

None of the solutions presented above are meant to be localized or used exclusively. Implementing multiple flood control methods at a larger scale is the best way of solving the problem. We recommend that a combination of additional rangeland with prairie grasses and the inclusion of a series of wetlands along Cross Creek would be the most economical and beneficial solution. The addition of prairie grasses should be done both as a buffer along the length of Cross Creek and in the form of land use conversion from cropland to prairie land with as many willing land owners as possible.

While the holistic watershed approach will reduce the frequency and severity of flooding in Rossville, it will not eliminate it completely since Rossville is located in the natural floodplain of Cross Creek. To provide additional protection, Rossville should consider nonstructural flood mitigation projects such as relocation, acquisition, elevating structures and floodproofing. These projects can be integrated into the community to protect against flooding while posing few, if any, adverse affects to either Rossville's agricultural neighbors or the environment.

Appendix A

Shawnee County Soils:

Reading-Wabash Association:

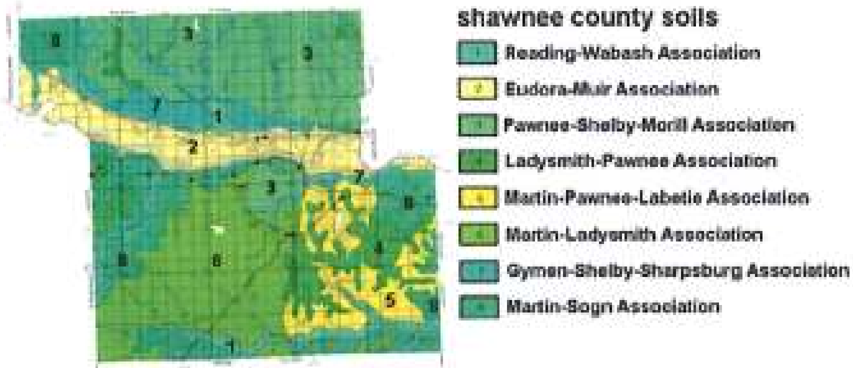

Figure A1: General soil map for Shawnee County. Source: Shawnee Coutny Soil Survey.

Reading Series: These soils are found in level areas along streams and creeks and are great soils for cultivation. These soils are listed as having a slow permeability rate, which would suggest an increased flooding potential. However, the soil is described as having a high water release rate and is seldom flooded.

Wabash Series: These soils are found in flat areas along streams and creeks. Because of this, these soils are occasionally flooded, either from the streams or water running in from surrounding uplands. The soils are moderately well drained to somewhat poorly drained. They dry slowly, allowing the water to stay on the surface for a longer period of time.

Pawnee-Shelby-Morill Association:

Pawnee Series: These soils are also found in uplands and range from gently sloping areas to strongly sloping areas. They have a high moisture capacity and slow permeability.

Shelby Series: These soils are found on gently sloping to strongly sloping areas of the uplands. They have moderately slow permeability and runoff is medium in areas of gentle slopes and rapid in strongly sloping areas. This runoff potential increases the probability of flooding in the lowlands.

Morill Series: These soils are found on gently sloping to strongly sloping areas on uplands. They are also well drained, and take in large amounts of water for use by plants.

Ladysmith-Pawnee Association:

Ladysmith Series: These soils are found in uplands, but are nearly level to gently sloping. They are described as having slow to very slow permeability, with medium runoff potential on gentle slopes.

Pawnee Series: These soils are also found in uplands and range from gently sloping areas to strongly sloping areas. They have a high moisture capacity and slow permeability.

Gymer-Shelby-Sharpsburg Association:

Gymer Series: These are sloping soils in uplands and have high available moisture capacity and slow permeability.

Shelby Series: These soils are found on gently sloping to strongly sloping areas of the uplands. They have moderately slow permeability and runoff is medium in areas of gentle slopes and rapid in strongly sloping areas. This runoff potential increases the probability of flooding in the lowlands.

Sharpsburg Series: These soils are located on gently sloping to slopin areas on uplands and are deep and well drained.

Martin-Sogn Association:

Martin Series: These soils are found on gently to strongly sloping areas in uplands and have high moisture capacity and slow permeability.

Sogn Series: These soils are found on gently to strongly sloping areas in uplands and runoff is rapid in these soils.

Pottawatomie County Soils:

Clime-Tully-Benfield Association:

Clime Series: These soils are located on upland breaks and side slopes. They are well drained and generally steep. Permeability is slow and runoff is rapid.

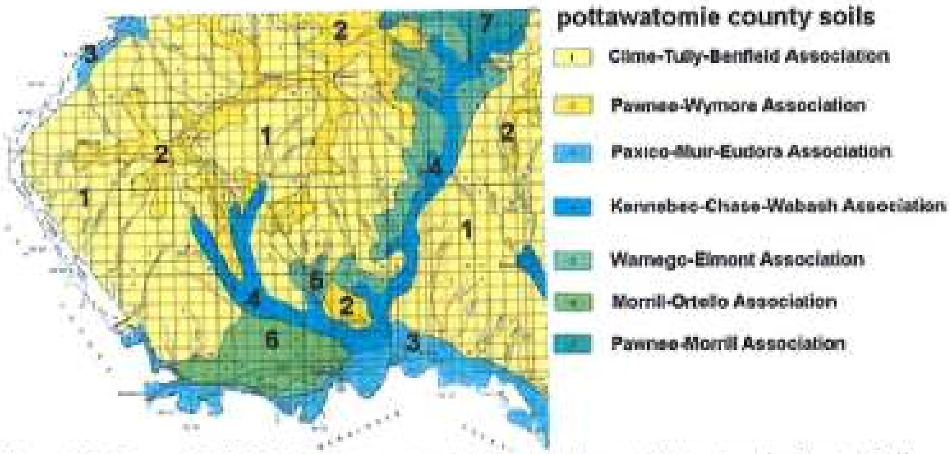

Figure A2: General Soil Map for Pottawatomie County. Source: Pottawatomie County Soil Survey.

Tully Series: These soils are located on moderately sloping, concave foot slopes. They are will drained with slow permeability and medium runoff.

Benfield Series: These soils are located on narrow ridge tops on moderate slopes. These soils are well drained, so permeability is slow and runoff is medium.

Pawnee-Wymore Association:

Pawnee Series: These soils are located on gently sloping to moderately sloping uplands and are well drained with slow permeability.

Wymore Series: These soils are located on gently sloping to moderately sloping uplands and are moderately well drained with slow permeability.

Kennebec-Chase-Wabash Association:

Kennebec Series: These soils are located on gently sloping lowlands and floodplains. They are moderately well drained and have moderate permeability.

Chase Series: These soils are located on gently sloping stream terraces. They are somewhat poorly drained with slow permeability.

Wabash Series: These soils are located on gently sloping floodplains. They are very poorly drained with very slow permeability.

Jackson County Soils:

Kennebec-Zook-Wabash Association:

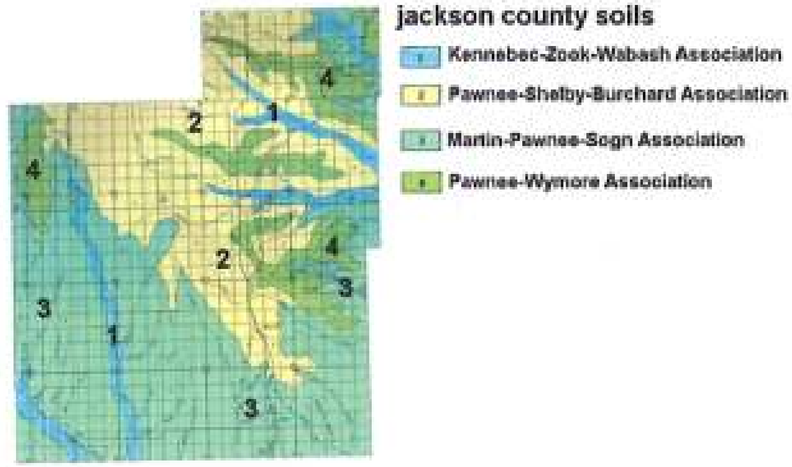

Figure A3: General Soil Map of Jackson County. Source: Jackson County Soil Survey.

Kennebec Series: These soils are located on gently sloping lowlands and floodplains. They are moderately well drained and have moderate permeability.

Zook Series: These soils are found on gently sloping areas in floodplains. They are poorly drained and slowly permeable.

Wabash Series: These soils are located on gently sloping floodplains. They are very poorly drained with very slow permeability.

Martin-Pawnee-Sogn:

Martin Series: These soils are found on gently to strongly sloping areas in uplands and have high available moisture capacity and slow permeability.

Pawnee Series: These soils are located on gently sloping to moderately sloping uplands and are well drained with slow permeability.

Sogn Series: These soils are found on gently to strongly sloping areas in uplands and runoff is rapid on these soils.

Pawnee-Waymore:

Pawnee Series: These soils are located on gently sloping to moderately sloping uplands and are well drained with slow permeability.

Wymore Series: These soils are located on gently sloping to moderately sloping uplands and are moderately well drained with slow permeability.

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