AmericanLifelinesAlliance

A public-private partnership to reduce risk to utility and transportation systems from natural hazards and manmade threats

Flood Resistant Local Road Systems

Appendix B: Allegany County, MD

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This report was written under contract to the American Lifelines Alliance, a public-private partnership between the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). This report was reviewed by a team representing practicing floodplain managers, water resources engineers, civil and structural engineers, and public works managers

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1.1 General Description of the County

Located in Western Maryland in the Appalachian Mountains, Allegany County covers 426 square miles (Figure 1). It stretches about 40 miles east to west, and varies from just five miles to 20 miles in width from north to south.

In 2000, the population of the County and its incorporated municipalities, including the City of Cumberland, was approximately 75,000 people. Like many rural counties in the Rust Belt, Allegany County experienced a net reduction in population between 1980 and 1990, losing 7%. No increase in countywide population was recorded between 1990 and 2000, although increases were experienced in the Cities of Cumberland and Frostburg.

Of the total population, 74,930 live in the unincorporated areas of the County, with more than 50% located within 5 miles of Cumberland or in the Frostburg-Georges Creek-Keyser, WV areas. The majority of the County is sparsely populated, with fewer than 6 persons/square mile. Many people throughout the rural areas travel long distances for employment opportunities in Cumberland and other cities in the region.

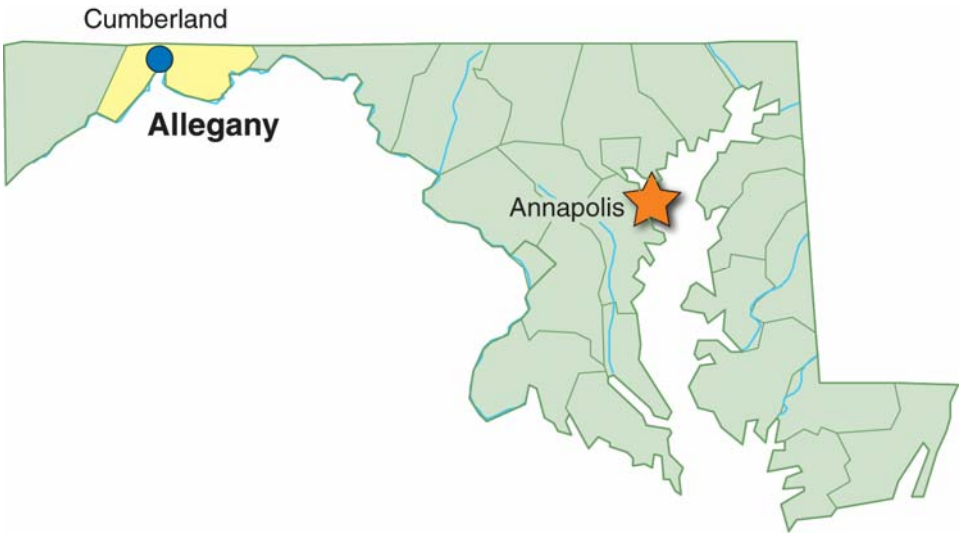


Figure 1. Location Map.

The County's varied topography historically has influenced and constrained development. About 55 percent of its land area is sloped at greater than 25% grade; 25 percent of the area is between 25-8% grade; and only 20% has slopes less than 8% grade. Nearly all urban development has occurred on the flatter lands, which also is where the best agricultural soils, as well as flood-prone areas, are found. Lands steeper than 8% grade have been used for agriculture, mining, forestry, wildlife habitat protection areas, orchards, grazing and some limited development.

1.2 The County's Department of Public Works

The Department of Public Works (DPW) oversees the operation of five major divisions, has a staff of approximately 150 people with an annual operating budget of over $18 million and an ongoing construction budget that ranges from $5 to $15 million.

Allegeny County's Director of Public Works (DPW), a registered professional engineer, started with the County in 1975 as the Assistant County Engineer. He served as the County Engineer between 1980 and 1995, and was appointed the Director in 1995.

The County Engineer, also a registered professional engineer, has worked with the County in several capacities since 1978, serving in the current position since 1995. He is very active in his profession as a member of the County Engineers Association of Maryland, participating on the University of Maryland Technology Transfer Center's Advisory Committee, serving on the National Academy of Science, Transportation Research Board Peer Review for Transportation-Related Papers, and has served on technical committees of the American Association of State Highway and Transportation Officials (AASHTO). His work related to low-volume roads has been presented at several conferences and appeared in a number of publications. He attributes his professional activities and exposure to programs and technology as a significant influence in what he does and design factors he considers.

Two DPW divisions are directly involved with the County's road system:

Engineering Division. With 14 employees (and as-needed contract employees), the Engineering Division's core activities include: preparation of studies, plans and specification for County projects; recommendation, selection, and oversight of outside consultants; handling bidding for, supervision, and inspection all County construction projects; providing technical assistance to other County departments and the County's smaller municipalities; reviewing subdivision plats, development plans, and stormwater management designs; and overseeing solid waste and recycling efforts. The Division's annual budget is $0.86 million, with $0.8 million from the County General Fund and the remainder from reimbursements.

Roads Division. With 71 employees, the Roads Division maintains 550 miles of County roads and 110 bridges and assists other departments with heavy equipment. The Division's annual operating budget is $5.5 million, which is received from State Highway User Funds (gas tax), the County General Fund, the Coal Haul Roads Fund from taxes levied on mined coal, and Capital Projects Funds. The Roads Division is organized into four districts, each with a supervisor and crew. Their job is to regularly inspect roads, bridges and drainage and to report problems. A full time bridge maintenance crew is a part of the Roads Division. Much of its work is driven by the results of the periodic inspections.

Figure 2. Routine Deck Cleaning Maintenance

According to the Allegany County *Comprehensive Plan 2002 Update*, the County's considers that "it is imperative that existing County maintained roads, streets and bridges be maintained and upgraded to satisfy their function." The road, street and bridge maintenance program is updated annually with input from various County agencies and citizens; the budget is approved by the County Commissioners. The Roads Division's program includes the following elements:

1. An ongoing paving and overlay program, listing every road or street and its maintenance/paving needs; those in commercial and residential areas are prioritized higher than those in rural areas serving fewer people.

2. Construction projects for existing County system roads, streets and bridges are prioritized in a 5-year capital program.

3. Safety projects, drainage improvements, and bridge repairs are prioritized in a 5-year capital program; bridges over 20-feet in length are inspected on a regular basis and are programmed for repairs and reconstruction based on the results.

With respect to the Department's responsibilities related to flooding, when predicted or the Department of Emergency Services reports observed rainfall amounts that approach 3-inches in a 12-hour period, DPW personnel are mobilized to monitor bridges and road segments that are known to be prone to flooding. The experienced Roads Division supervisors are very familiar with their districts and know which roads are prone to frequent flooding. The Department recently developed a list of those problem areas in order to document past experience. The County's Department of Emergency Services monitors rainfall throughout the region, including input from local fire departments. Local observations are important because many storms are very local and are not recorded by the National Weather Service.

After a flood, as defined above, the DPW puts together damage assessment teams. As events unfold and it appears that flood damage will result, the Department makes contingency plans and identifies personnel available to participate in assessments. Because DPW roads maintenance crews are occupied in the aftermath, construction inspectors and building inspectors are trained to support damage assessment activities.

At present, the DPW does not rely on the County's Geographic Information System (GIS) capabilities primarily because the transportation elements are not fully developed. Road centerlines are a GIS layer and certain infrastructure (manholes) are being located for inclusion. GIS is not currently used to log citizen complaints or to manage maintenance work.

1.3 The County's Local Road System

Allegany County uses a classification system that is similar to the Maryland State Highway Administration Classification System. Existing roads are grouped according to the function which they perform, not by their present width, surface type or condition. From highest to lowest function, the categories include: principal arterials, major arterials, minor arterials, and connector/collector (or local) streets. The County's roads system contains a relative small number of arterial highways and a large number of connecting and collecting roads and streets. Connectors generally link more remote areas with urban centers; collectors generally are designed to serve residential suburban travel.

The Allegany County DPW maintains over 800 road segments totaling about 550 miles. Approximately 350 miles are asphalt paved (predominantly tar and chip) and located primarily in the eastern part of the County, passing through forests and wildlife management areas. DPW owns and maintains 110 bridges (Table 1), of which 67 meet the federal definition (see Selected Terms).

Structure Type	Number of Structures
Steel Stringer (simply & multiple spans)	83
Truss (simple & multiple spans)	6
Concrete Box/Plank (simple & multiple)	11
Prefabricated Panel (simple & multiple)	2
Concrete T-Beam (multiple span)	1
Steel Pipe (pond or low profile)	6
Reinforced Concrete Pipe (18 cells)	1
Total	110

Table 1. Structures, by Type.

All of the roads maintained by the County are minor collectors, local roads, or low-volume roads. Many County roads have traffic counts as low as 10 vehicles/day, while the average count is on the order of 400-500 vehicles/day.

As evidenced by several factors, such as population and permit records, Allegany County is a low-growth community. No significant increases in traffic counts are anticipated because most new development is concentrated in areas close to the urban centers. Existing roads can safely carry current and projected traffic counts because they are adequate in terms of pavement widths and weight limits for bridges, as evidenced by the County's periodic inspection. However, the Planning Services Division reports that roads in some areas where potential development is projected may not be able to handle the full, expected travel demand. The last planned realignment project was more than 10 years ago and associated with the State's development at Rocky Gap State Park. The County is not currently planning to build any new roads.

Most older roads significantly pre-date the standards set forth in the Subdivision Regulations (which contain standards for privately-developed roads to be taken into the County's system) and the majority also pre-date the State's waterway construction regulatory requirement.

Based on Federal definitions, about 40% of the County's bridges are deficient in some capacity, that is:

1. Structurally deficient for the load expected for the road category, thus requiring posting of weight limits; or
2. Functionally deficient for the road category, which generally is related to the inadequate width of the driving surface or the alignment or grade of the approaches.

1.4 Allegany County Comprehensive Plan 2002 Update

Among several visions set forth in the Allegany County *Comprehensive Plan 2002 Update* is the statement that "Adequate public facilities and infrastructure under the control of the County or a municipal corporation are available or planned in areas where growth is to occur." Growth, consistent with provisions of state laws, is expected to be concentrated in suitable areas, with growth directed to existing population centers while protecting sensitive areas. Specific to Allegany County and supporting the goal of a sound, balanced and diversified economy, is an objective to "provide a transportation network composed of an adequate road system . . . to move people and goods with maximum efficiency between residential areas, employment centers, and other facilities."

The Comprehensive Plan includes a Transportation Element (Section IV) that is intended to serve as a guide for transportation services, including subsections for the Highway Plan, Rail System, Air Travel, Mass Transit, and Trails. The Highway Plan Section is intended to "chart a course for highway and local street development between now and the year 2020." A number of needed improvements both to County and State highways are noted.

County and municipal highway needs are outlined in the Comprehensive Plan, including reconstructions, relocations and extensions. In addition, it is noted that "many County and municipal bridges will need to be updated or replaced in the near future." The Department of Public Works maintains a complete list of proposed bridge projects and bridge status reports. Notably, due to heavy coal truck traffic, nearly all roads in the Georges Creek Coal Basin require extra maintenance and many should be reconstructed.

The Comprehensive Plan notes that road expenditures per capita are significantly higher in the eastern area of the County than in the central and western portions where population is concentrated.

1.5 History of Flooding in Allegany County

Allegany County has experienced a number of flood events in recent decades, although the most significant damages were associated with major floods in the 1930s. Those events prompted the U.S. Army Corps of Engineers to construct large levees that protect much of the City of Cumberland. Flooding has occurred along virtually every waterway, most of which drain small watersheds and, therefore, tend to respond rapidly to rainfall events. Most flooding is "flashy" and associated with locally intense storms. Table 2 lists major disasters declared by FEMA since 1965. FEMA assistance is provided for emergency measures, debris removal, and permanent restoration of damaged public facilities (including roads and bridges).

Date of Declaration	Description of Event	FEMA DR#
6/23/1972	Tropical Storm Agnes	341
9/10/1986	Severe Storm & Flooding	773
2/2/1996	Blizzard of 96 (Severe Snow)	1081
1/30/1996	Severe Storms And Flooding	1094
9/30/1996	Flooding – Hurricane Fran	1139

Table 2. Major Disaster Declarations in Allegany County (as of mid-2004)

The only event in recent decades that affected several watersheds occurred in early 1996. In late January, a blizzard produced heavy snow accumulations. Just days later in early February, a large storm system produced warm rainfall that resulted in rapid melting. Many locally-intense storms occurred during the period from 1995 to 2000.

The localized storm that produced flooding in 2000 did not cause damage levels that qualified for a disaster declaration. Similarly, there other localized events referenced in this report that caused road system damage but are not listed above. The County has not determined the frequency of such localized events. Additional research would be required to extract from historical records and files on individual structures to be able to summarize the nature of these localized floods, the extent and cost of damage, and other impacts on the community.

Historically, more damage has been experienced in the Georges Creek basin where flooding is flashy and high velocities cause scour and undermining of bridge abutments. Extensive coal mining in the basin has contributed to rapid runoff. Until fairly recently, most people used coal to heat their buildings and decades of dumping cinders from coal stoves into the waterways tended to choke flows and exacerbate flooding.

Allegany County has participated in the State's flood management grant program since the mid-1980s, using funds to acquire homes in several locations. Additional federal funds from FEMA (Hazard Mitigation Grant Program) contributed significantly to the County's efforts after the 1996 floods. Managed by the County's Community Services office, the program has acquired approximately 200 homes. The lands are required to be maintained as open space.

The County participated in a cooperative effort with the State Highway Administration that resulted in the County obtaining title to some land from which homes upstream of a State road were removed as part of the joint State/County road improvement project in Westernport. The County used funding from FEMA's Hazard Mitigation Grant Program and the State's program to acquire additional homes.

1.6 Physical Impacts of Flooding on the Road System, Loss of Function, and Emergency Access

No deaths or injuries related to flooded roads or flood-damaged roads have been experienced in Allegany County. Most flooding rises and falls rapidly, which means most roads are not flooded for long periods of time. If a bridge or the road bed is damaged, the road is closed.

Since 1995, Allegany County has had numerous floods that have affected roads and bridges. No catastrophic damage has occurred, that is, no County or State-maintained bridges or culverts were destroyed. Damage to bridges includes exposure and subsidence of footers, wingwall and abutment tilting and/or collapse, washout of large "Belgium-block" type stone from abutments, w-beam traffic barrier alignment damage due to debris accumulation creating a dam effect upstream, surface removal of infilled corrugated metal decking, debris accumulation at beam seats, sloughing of abutment embankments including riprap washouts, removal of wood planking from bridge superstructure and other miscellaneous aesthetic-type issues. Superstructure failures have resulted from undermining scour and settlement of the abutments.

For bridges with a concrete or open-grid deck, the only damage to superstructures has been subsidence due abutment or footer scour. The County has not had to replace any concrete or open-grid deck riding surfaces. It appears for an open-grid deck that the hydrostatic uplift pressure is dissipated through the openings. For a concrete plank superstructure, the weight of the concrete and the method of fixing an end overcomes the hydrostatic issue. Furthermore, the concrete plank-type structures are of a low profile nature, generally 12-18-inches in depth, which allows the water to overtop and appears to lessen the damming effect created upstream by debris accumulation.

Figure 3. Georges Creek in the Town of Westernport (September 1996).

Flood damage to roads and streets has included removal of the riding surface (gravel, tar and chip and hot mix asphalt), embankment sloughing, shoulder washouts,

drainage culvert clogging, w-beam traffic barrier undermining, ditch scouring, ditch surface removal, culvert pipe collapse (especially end sections), road edge raveling and miscellaneous debris clean up.

After the 1996 floods, clean-up and road and bridge repair involved considerable amounts of local funds and state and FEMA funds. The Natural Resource Conservation Service (NRCS) was a highly effective partner, working on streambank restoration at damaged selected sites. NRCS also works with private property owners for debris removal and erosion control.

Flood debris on roads has not caused significant access problems, although physical damage to road surfaces and weight limits due to bridge damage can hinder or limit access. The County's Department of Emergency Services leads and coordinates damage assessments if it appears that an event may prompt a State or federal disaster declaration. The Department of Public Works performs damage assessments on roads and infrastructure. Emergency Services recently used Homeland Security funds to obtain a GPS unit that, with GIS, will be used to manage damage assessments, including damage of roads and bridges.

The County does not routinely remove sediment deposits that build up in stream channels over time, although it is recognized that such deposits may reduce conveyance of floodwaters. Deposition is more prevalent in box culverts, of which the County has only three (Figure 4).

Figure 4. Sediment Buildup in Concrete Box

The only known flood-prone area that has a single access is Locust Grove. Subject to flooding by Wills Creek, this small community is located just outside of the City of Cumberland. Much of the Wills Creek watershed is in Pennsylvania. Allegany Emergency Services is in constant communication with Somerset County, PA, regarding rain conditions in the upper watershed. If the area is predicted to get rain, the County considers evacuating before access becomes restricted. However, even when the Sheriff's Office urges residents to leave, most seem content to stay. This area has been part of the County's floodplain buyout program, so the number of at-risk residents has fallen over time. The U.S. Army Corps of Engineers is looking at improving flood warning in the watershed.

Flooding in the incorporated Town of Westernport, located at the confluence of Georges Creek and the Potomac River, can affect direct access across the creek. However, there are other bridges nearby and emergency response is not affected significantly.

2.0 Environment within which Allegany County Operates

2.1 Overview of Roads Budget

Federal funding for bridge rehabilitation is administered through the State and is conditioned on biennial inspection of bridges that meet the federal definition. Sixty-seven of the County's bridges meet this definition. For many years prior to 2004 the County regularly received about $150,000 in federal "state aid" funding, which is determined by formula. At present, up to 80% of the cost of rehabilitation work can be covered by these funds.

As a matter of practice, due to the bureaucracy associated with federal and state aid funds, Allegany County accesses those funds only for the 55 bridges that are longer than 25-feet. For each bridge rehabilitation or replacement project proposed to use the state aid funds, the County prepares an application with a project scope and budget. From 20-25% of the costs are local share. The County's General Funds are used for work on bridges less than 25-feet in length.

The FY2004 budget identifies the following revenue sources: 49.4% from the State Highway Fund (highway user taxes); 44.5% from the County General Fund; 3.4% from Coal Haul Roads Fund; and 2.7% from the Capital Projects Funds (State Aid). The Pay-As-You-Go Capital Reserve Fund is used only when necessary for capital projects.

The Coal Haul Roads Fund, administered through the State, is revenue generated from a tax on the amount of coal extracted and is paid by the coal companies to the State. The monies Allegany County receives from the Coal Haul Fund must be spent on the maintenance of coal roads with significant use by the industry. The County focuses these funds on roads and bridges in the Georges Creek area, which has the greatest concentration of coal mining activity.

The County also has a standard practice of depositing and banking "leftover" funds (when actual revenues exceed costs) from its entire operating budget into a Reserve Fund which can be allocated and spent in future years. Historically the County has been conservative in estimating revenues and, consequently, there has been a healthy Reserve Fund. However, in the current economic downturn, the State of Maryland has cut the County's portion of the highway user funds and lower revenues in general have eliminated surpluses and contributions to the Reserve Fund. In these times, the Department of Public Works has increased its draw from the Reserve Fund to complete its regular road maintenance program.

The average annual budget for bridge rehabilitation and replacement is $500,000. The County's identified backlog of rehabilitation/replacements is about $10 million. Generally, 4 or 5 bridge rehabilitation projects are underway at any given time.

For individual bridge replacement projects, the Department uses a phased budget approval process. An estimate of the costs associated with preparation of the design, and an estimate of construction costs, is submitted to the County Commissioners for approval. Upon approval, the Department proceeds with design and has permission to advertise for contractors.

The DPW is familiar with the post-disaster, FEMA-funded Hazard Mitigation Grant Program. These funds have not been considered for road projects for two reasons: the County's floodplain acquisition program is active with many houses to be purchased in order to complete the plan,

and the lengthy and delayed application cycle of FEMA's Hazard Mitigation Grant Program is not responsive to immediate need to restore roads to full function following a flood.

2.2 Regulatory Framework

In Maryland, all work within waterways and floodplains is subject to the State's regulatory requirements. Compliance is achieved through a State permit or authorization. Any local road work undertaken with federal funds must be designed to comply with the AASHTO "Green Book" (*A Policy on Geometric Design of Highways and Streets* and *The Standard Specifications for Highway Bridges*) unless the County provides documentation to justify a waiver. The State Highway Administration does not impose separately promulgated regulations or standards on local road system work that does not involve federal funds.

The County Engineer reports that the AASHTO Green Book uses the 25-year storm as a minimum design requirement: bridges must pass the discharge from that frequency event with at least one-foot of headroom between the predicted water surface elevation and the low chord or lowest element of the superstructure.

The State's nontidal wetlands and waterway/floodplain regulations are administered by the Maryland Department of the Environment. State permits or authorizations are required for all activities within the Waters of the State, defined to include waterways and their 1-percent annual chance floodplain based on ultimate development. The requirement does not apply to waterways with drainage areas less than 400 acres (or less than 100 acres in environmentally sensitive natural and recreational trout waters).

State floodplain regulations require that roads, bridges and culverts pass the discharge associated with the 1-percent annual chance flood that is determined by assuming ultimate development of contributing watersheds. If a bridge or culvert opening is not designed to pass the entire discharge, the crossing must be designed to spill over (weir flow) without causing significant damage. In general, hydraulic analyses are not required for rehabilitation on existing crossings. Work that might change flow characteristics must be assessed to evaluate impacts on the floodplain. Changes that might alter velocity and scour characteristics are also analyzed to evaluate stability of the stream bed and banks.

2.3 Guidance and Local Standards

Periodic Inspections. Since the early 1980s, Allegany County's practice has been to perform inspections of bridges that are under 20-feet in length and that do not meet the "federal definition". Inspections are scheduled every five years and are performed using the same inspection forms and practices as those used for the required inspections of longer bridges. Inspection contractors are selected from the State's pre-qualified list.

The County arbitrarily selected the 5-year period, in part due to the costs, which are entirely covered out of local funds. In addition, the criticality of shorter bridges is less than longer spans because the consequences of failure are significantly less. Short-span bridges often carry only one axle at a time when large trucks pass, and should failure occur, the time for replacement or repair is significantly less than for longer structures.

The purpose of the County's inspections is to track conditions in order to identify changes in advance of problems becoming significant. The practice allows better planning, budgeting, and scheduling rehabilitation of the bridges that are in the worst condition.

After the initial round of inspections a huge inventory of needs was identified. The County began to prioritize the work and to undertake activities that could be done using its own fiscal and manpower resources. A spreadsheet is used to record the inspection results, allowing easy comparison and identification of changes in conditions from inspection to inspection. Trends can be identified easily, and decisions made accordingly.

The decision to start regular inspections that are not required was not prompted by an event or incident. When current DPW Director became the Roads Division manager in 1980, he realized that the Department did not have a good understanding of the status of the road system and, therefore, he could not anticipate workload and budget.

The County's increased costs associated with its voluntary inspections were not viewed as an obstacle, nor did local politics influence the decision. More significant factors in favor of the inspections are how they influence the County's liability and insurance costs, as well as their value for preparing work plans, budgets, and to project operation and maintenance costs. The County's insurance carrier considers that these routine inspections improve maintenance and long-term planning for upgrades and replacements, which, in turn, decrease exposure. The carrier checks that the inspections are performed and is notified when repair and replacement work is performed. The Federal Highway Administration, the County's insurance carrier, and other agencies have told the County that it is unusual for a local government to have a voluntary routine inspection program that matches the program for mandated inspections.

Bridges/Culvert. For rehabilitation, replacement or construction of any new bridge, the County follows AASHTO's *The Standard Specifications for Highway Bridges* and the *Policies and Procedures of the Maryland Department of Transportation*, as applicable. All materials, workmanship, equipment and incidentals are in accordance with the Maryland State Highway Administration *Standard Specifications for Construction and Materials*. The County adopted and follows these standards and guidelines in order to insure consistency in design and construction, and adherence to a statewide recognized standard for materials and construction techniques.

The majority of the roads and bridges in Allegany County's local system were developed many years ago, predating any regulation. Most bridges, ditches and cross-drain culverts are now undersized given the upstream development. This means at some locations, water over roads occurs fairly frequently, often without causing damage.

Even for the County's bridges less than 20-feet in length that are not subject to State and Federal highway requirements, the County generally uses the State's design guidelines. When outside consultants are used, this approach saves time and money because the consultants are familiar with those requirements. While some flexibility to modify the guidelines to match the County's needs can be exercised, in general, the County believes that its liability is reduced if established guidelines are followed unless there is clear justification to do otherwise.

The County Engineer routinely performs floodplain analyses when considering designs for work that will alter flow characteristics. Water surface elevations and other flow characteristics are

evaluated for discharges for the 2-, 10-, 25-, 50-, and 100-year floods. Due to the generally high velocity conditions experienced throughout the County, scour analyses are performed to evaluate designs to protect or replace vulnerable bridge abutments. The analyses are performed in accordance with Federal Highway Administration's Circular No. 18, *Evaluating Scour at Bridges*, and Hydraulic Circular No. 20, *Stream Stability at Highway Structures*. Both documents are adopted by the Maryland Department of Transportation, State Highway Administration. The analyses influence the type of foundation selected and the type of scour protection provided. A general estimate is that scour assessments add 15-20 hours of design time and less than 10% of the total cost of construction to achieve the added protection.

For planned upgrades, the County uses discharges associated with current watershed hydrology when evaluating design alternatives. However, hydraulics is only one of several parameters that drives the final design of a structure, especially replacements and rehabilitations.

Pavement/Shoulders/Drainage. The applicable adopted design standards for rehabilitated, replaced or proposed roads or streets are both AASHTO standards: A Policy on Geometric Design of Highways and Streets or Guidelines for Geometric Design of Very Low-Volume Local Roads. The roadway design standards were not formally implemented until the mid-1980s.

For any road rehabilitation, the County's standard is to apply three layers of aggregate (No. 67, No. 7 and No. 8 with intermediate layers of emulsified asphalt binding agent). If a road is being resurfaced only to remove minor surface irregularities and/or for routine pothole patching, then two layers of aggregate are applied (No. 7 and No. 8 with intermediate layers of emulsified asphalt binding agent). On tar and chips roads that exhibit severe pavement rutting and distress, primarily roads with heavy coal or pulp wood truck traffic, the County has also utilized a polymer-based additive in the emulsified asphalt to a minimal extent with positive results. However, the additional cost for this material can be cost prohibitive. The estimated centerline miles of tar and chip roads within the County are 180 miles.

In the mid-1980s the DPW began a long-term program to rehabilitate existing tar and chip roads with asphalt as funds and manpower become available. The priority for this conversion considers snow emergency route, school bus routes, industrial parks, collectors and local roads. The hot mix asphalt road surface is comprised of a surface course (1 ½ - 2 inches), placed over a minimum of 8-inches and base course (2 ½-inches or greater) subbase stone. The centerline miles of hot mix asphalt roads are approximately 70. Since December 1997, roads in new subdivisions must be surfaced with hot mix asphalt.

The County's standards for road, shoulder, and right-of-way widths are listed in Table 3.

	Arterial Major Collectors	**Other Roads**	**Low Volume Roads**
Paved roadway without curbing	24'	20'	18-20'
Paved roadway with curbing	34'	26'	26'
Shoulder width; each side (no curbing)	10'	6'	2-4'
Right-of-Way Width (minimum)	60'	50'	50'

Table 3. Standard Road, Shoulder and Right-of-Widths.

Standard requirements for roadside drainage and culvert sizing is 12-inches minimum diameter for driveway pipes and 15-inches for a cross culvert. These values may be adjusted based on drainage runoff calculations. Similarly, roadside ditches are sized based on hydrologic and hydraulic evaluation, the preferred type of ditch is flat-bottom trapezoidal with 2:1 side slopes, although V-shaped ditches have been installed in areas where the right-of-way widths are narrow due to construction prior to 1985.

2.4 County Standards for New Roads and Bridges

Standards for new roads are contained in the Subdivision Regulations and are based on two scenarios, that is AASHTO standards for roads with more than 400 vehicles per day, and low volume roads with fewer than 400 vehicles per day. If privately-developed roads and bridges meet those standards, they may be accepted into the County system. Roads that impinge on the FEMA-mapped floodplain, or that affect a 50- or 25-foot buffer (as a function of drainage area and intermittency of the streamflow), must also be approved by the County Engineer and comply with the Floodplain Regulations adopted to participate in the National Flood Insurance Program. In addition, bridges and large culverts or pipes are subject to site-specific design criteria established by the County Engineer.

The Subdivision Regulations contain a provision that exceeds the minimum requirements of the National Flood Insurance Program. New planned subdivisions that are proposed to have a flood-prone access must have at least one access that is passable during flood events. Because crossing streams involves obtaining permits from the State and the U.S. Army Corps of Engineers, developers avoid this requirement by purchasing additional land in order to have access that does not impinge on the floodplain or cross streams. Subdivision streets are to be designed to handle drainage for the 10-year rainfall (about 4.5” in 24-hours).

2.5 Post-Flood Experiences and Influences

The County’s post-flood experience with state and federal agencies was mixed after the 1996 floods, the most recent events that were declared as major disasters. The Maryland Department of the Environment, which administers the State’s wetlands and waterways regulatory program, was extremely helpful. State inspectors were paired with County staff for inspections and they were authorized to issue emergency permits, especially for repairs. While normal State permit submissions require formal design drawings, State inspectors approved work other than in-kind work based on sketches rather than formal designed drawings. Of particular importance, the State exercised its authority to approve projects that may have some hydraulic changes, without requiring in-depth studies.

In 1996, FEMA’s Region III inspectors were reasonably well-prepared and easy to work with. However, they looked narrowly at in-kind repairs and restoration only. The County’s experience was that even if effective measures were identified to reduce future flood-related damage, FEMA Region III consistently held that work in excess of in-kind was not eligible. In one case, although FEMA initially insisted that the proposed work was not eligible, the County prevailed by demonstrating significant improvement in hydraulic performance. An abutment was damaged due to significant erosion on the outside of a meander and the County wanted to realign the wingwall to more efficiently convey flood flows.

The County understands that FEMA Region III currently is more willing to work with communities to incorporate mitigation and damage reduction as part of recovery. However, the County has not experienced a disaster since that shift in policy.

A significant problem with FEMA's approach after the 1996 disaster was reliance on the "FEMA cost book." FEMA would not accept the County's cost estimates, even though those costs were based on years of experience. This was particularly frustrating if the County proposed the use of its own forces and existing stockpiled materials. Local union rates were also higher than FEMA's cost book rates.

Also problematic in 1996 was that FEMA typically authorized reimbursement based on an initial estimate of the cost to repair in-kind. If the actual work exceeded the initial cost, the reimbursement was not adjusted, and the County was responsible for paying the entire excess.

FEMA Region III field personnel demonstrated a lack of understanding of the type of roads that are prevalent in Allegany County. Most roads are tar and chip, which can peel up or wash away when overtopped by high velocity water. FEMA approved only costs associated with three layers of tar and chip, without accepting that the County may have added more than three layers to the road bed over the years. Thus, the post-flood repairs do not restore the road to "in-kind" conditions.

The Maryland Emergency Management Agency, responsible for coordinating with FEMA Region III and managing Public Assistance funding, did not influence the technical aspects of the County's recovery work related to roads and bridges. While there were some difficulties associated with administrative matters, those difficulties did not affect the actual projects undertaken.

Flooding since 1996 has affected how the County handles stream bank protection. Rather than using gabions where high velocities are anticipated, a different type of protection, imbricated riprap, has been used in several locations and has proven more effective, especially when combined in in-stream grade controls (Figure 5).

The County has found that in some locations gabion basket retaining structures have a tendency to collapse due to channel scour or stream flow turbulence that scours the downstream end of the gabion structure. When flow manages to scour behind the end of the structure, a "domino" effect occurs whereby the wall begins to fall over or tilt, and subsequently the stream bank is undermine and sloughs off. Because the gabion baskets are interlaced, a collapse of this nature will generally

Figure 5. Installed Imbricated Riprap

involve a major portion, if not all of the structure. Although not flood-related, failure of wire baskets has also occurred where acid mine drainage results in highly acid stream water. Wire ties and the basket wiring lose strength and the baskets bulge, break and/or collapse.

Imbricated riprap is a quarried limestone rock, blasted in the approximate dimensions of 2 x 2 x 3 feet, and pre-drilled for easy installation. When the blocks are placed, steel rods are threaded through the pre-drilled holes for added stability. This form of protection has long been utilized by the Natural Resource Conservation Service, the Soil Conservation District, and the County for streambank restoration and retaining-type wall applications. The hardness of the limestone rock resists abrasion by stream bedload and the size of this material, through trial and error, is acceptable for gravity-type wall design. Use of imbricated riprap takes into consideration natural processes at specific locations by examining velocities and scour and using more naturalized protective measures. It can control channel downcutting to avoid undermining of bridge abutments and footers. Allegany County has ready access to locally quarried rock.

2.6 Emergency Response and Planning

The Allegany County Department of Emergency Services and Communications is responsible for coordinating the County's readiness planning and response, including working with the incorporated municipalities, and local volunteer fire and rescue services. The County does not have formal evacuation plans for flooding, in part due to the flashy nature of flooding. A project that is underway will evaluate evacuation routes and limitations and capture local institutional knowledge.

There are 26 volunteer fire stations in the County, each with about 30 volunteers and 4 fire/EMS vehicles per station. Four additional independent EMS stations are staffed with about 120 members. The County has no professional firefighters, although the City of Cumberland's career firefighters number about 70.

Local volunteer fire and rescue teams know how, through experience, where the most common flooding problems are located and which roads are most likely to flood. Every station is connected to the County Emergency Services for weather reports. When the National Weather Service predicts large storms, the local chiefs are asked to meet with the County to talk about response and reporting. Allegany County is a NWS StormReady community. The U.S. Army Corps of Engineers is considering adding the Wills Creek watershed to the regional automated flood warning network.

Three USGS gages are located in Allegany County: Georges Creek at Westernport; Wills Creek at Locust Grove; and the Potomac River at Wiley Ford. The telephone line for the Westernport gage is paid by the County while data from the other gages is transmitted by satellite. Although USGS had scheduled to shut down the gages in Locust Grove and Westernport, Corps of Engineers has agreed to pay for continued operation and maintenance. The gages improve the quality of information used to issue flood warnings in the area and the data are utilized in the County's flood studies and bridge design work.

Local fire and rescue teams report flooding of residential areas and road flooding to County Emergency Services, which in turn can request that the police stop traffic until the DPW can barricade roads to help protect citizens. State and county police also report problems. Road barricades are used rarely due to the rapid rise and fall of flooding and because the County is so

large. No roads in Allegany County have permanent "flood warning" signs and the County has never been requested to post such signs. During storms, heavy equipment operators who are out supporting response are cautioned about going through flooded roads.

The Department of Public Works notifies Emergency Services in advance of major road work and closures. Work sites and schedules are shared with the volunteer fire and rescue service providers so they plan response routes. The County does not designate alternate routes for emergency response because all local providers are familiar with the roads in their service areas. No specific, long-term re-routing of emergency response vehicles has been prompted by road/bridge work because good alternate routes are generally available.

When the results of a bridge inspection prompts a change in weight limitations, the DPW notifies Emergency Services. In turn, Emergency Services notifies the fire and rescue service providers so they can either respond with smaller vehicles or use alternate routes. Many older vehicles and pieces of equipment are heavier than current bridge limitations.

The County Emergency Services communicates with citizens in a variety of ways to issue notices and warnings:

1. A contract for mass telephone calling (reverse 911) is in-place, although not currently configured to target specific areas based on flooding. Because most flooding is so flashy and likely to subside by the time warnings are issued it is doubtful that the system will be used for site-specific warnings.
2. Local observations of rainfall and weather conditions are reported to the Maryland Emergency Management Agency and the local office of the National Weather Service. NWS airs alerts on the NOAA Weather Radio which are picked up by local cable channels and local radio news.
3. The State and NWS can activate the Emergency Alert System on radio and TV. The County expects to be able to make local activations in the near future.

3.0 Overview of Local Decision Process

In the absence of recent damaging floods, the periodic bridge inspections performed by Allegany County generate the most important information that is used to plan for bridge maintenance and upgrades. The data allow the County to project work over a 5-year period. The anticipated work is reviewed and modified annually to account for changing conditions. When damage is sustained that jeopardizes safe travel, prompts severe weight limitations, or closes a road, then restoration of service is given the highest priority.

The inspection results in a "Sufficiency Rating," and is identical to the required inspection of bridges that meet the federal definition (i.e., longer than 20-feet). By tracking the results of inspections and monitoring how conditions change over time, the County can look at several factors when planning work. Systematic evaluations are especially valuable when projecting which structures will require significant and costly work that needs to be incorporated into the capital budget.

The Sufficiency Rating is a 100-point scale that is used to help decide what work to do, and the Federal Highway Administration uses it to determine funding allocations. The Sufficiency Rating does not include an explicit factor related to flooding (i.e., a determination as to the adequacy of hydraulic conveyance is not part of the inspection). However, flow-related effects (even if not caused by a big flood) such as scour, are picked up during the inspection. Generally, if the Sufficiency Rating is less than or equal to 50, replacement is appropriate. If the Sufficiency Rating is between 50 and 80, rehabilitation is appropriate, and if the Rating exceeds 80 the structure is generally acceptable for use.

When replacement is the chosen course of action, whether indicated by the Sufficiency Rating or because of significant flood damage, another set of factors influences decisions related to timing and design selection. Factors described in Section 3.1 below are important considerations in evaluating and selecting designs.

3.1 Factors Considered in Local Decisions

Allegany County does not rely on a formalized and rigid decision process when evaluating options for bridge rehabilitation or replacement. The design evaluations and technical expertise are the responsibility of the Engineering Division under the supervision of the County Engineer. Generally speaking bridge and road design and construction management is the responsibility of County Engineer; the Director's advice is sought when unusual circumstances are encountered.

The Director of Public Works has the ultimate decision authority for public works capital improvement projects, especially if proposed work exceeds initial cost estimates. Only when costs associated with achieving the preferred design are considerably higher is the decision to move forward subject to budget approval by the County Commission. This degree of authority rests with the DPW in part because the County's management and elected officials have high confidence in the decisions made by the Department.

Decision factors related to design of replacement structures and the general order of other factors are considered in prioritizing which bridges to upgrade, including decisions related to the type of structure to use, include:

1. Whether the road has functional deficiencies (e.g., width is inadequate for the traffic usage);
2. Whether the bridge is inadequate for current and projected traffic loads and truck weights;
3. The costs of various options and availability of funds;
4. The duration of construction (significantly influenced by the type of structure selected);
5. Season of construction (especially on critical school bus routes);
6. Whether alternate routes are available; and
7. The flood characteristics at the bridge and the stream alignment.

The County does not use the flood-resistance or inadequate hydraulic capacity of bridges as the dominant factor when selecting bridges for rehabilitation or upgrading. However, the County generally takes the approach that if and when it invests in upgrading a bridge the structure should remain functional even after floods. In the design process, which is iterative, considerable effort is invested in examining hydraulics for the State's permit and addressing other regulatory demands, notably wetlands. Past practice was to match the existing opening when designing a new structure; however, experience has shown the need to evaluate the larger picture to improve hydraulics.

The County does consider the economic impacts if a bridge has to be closed or downgraded to the point that a weight limit affects local businesses and industries. This consideration is qualitative and subjective, based on knowledge of the businesses and industries in the area that use the road.

Many of the County's bridges are constrained by the surrounding topography and alignment of the approaches. This can limit consideration of alternatives during planning and design of upgrades and replacements. Unless the road profile is constrained by limitations on the approaches, it is relatively inexpensive to raise the existing abutments to open up the effective flow area. However, generally it is difficult to increase the width of the opening between abutments because of site limitations and, in part, due to constraints associated with wetlands and waterway regulations.

Emergency issues do influence bridge design and construction for replacements/upgrades, especially if the road is the only access. Although there are a few areas of the County that have only one access road, in those cases speed of construction becomes a more critical factor, which influences structure type. In one case, the fire department positioned a truck and basic fire fighting supplies on the isolated side of a bridge during construction. In some cases, a temporary pedestrian bridge is installed.

With respect to work identified during routine inspections of roads, the Roads Division Chief, Roads Superintendent, District Supervisor, Bridge and Traffic Control Supervisor, Road Foreman and also each Crew Leader all have the authority to make routine operations and maintenance decisions. For example, ditch cleaning, debris/vegetation removal, pothole patching, road regrading and tar and chipping, minor slope regrading, culvert replacement, traffic control device replacement, bridge maintenance and other similar work are routine decisions.

Installation of any new traffic control devices or safety improvements such as traffic barrier installation or intersection widening involve input from the County Engineer or Director of Public Works. If any type of structural modification or improvement of a bridge superstructure, box culvert, or retaining wall is required, then the County Engineer or Director of Public Works is consulted and the ultimate decision is handled at that level.

With respect to upgrading roads, of the many factors that influence which projects are undertaken, population and usage are the most significant, with particular emphasis on school bus routes, emergency services access, and snow emergency routes. Traffic weight loads associated with economic development are important; for example, if an area is designated for industrial development then upgrading the roads for anticipated traffic becomes important. The number of accidents and number of complaints, both influenced by population and traffic counts, are also considered.

The most recent bridge replacement project is Smouse's Mill Road over Evitts Creek. After the 1972 floods the County installed a Bailey bridge (a type of temporary bridge built on-site from pre-engineered, ready-to-assemble components). The bridge had been overtopped frequently by flooding. It was prioritized for replacement because it was structurally deficient (one lane with posted weight limits). Flooding added to the decision to replace rather than rehabilitate the structure, but did not drive the decision. The replacement bridge was widened and raised and the alignment to the stream was improved, although hydraulic modeling shows it will still overtop during the 100-year event. Uplift forces will be somewhat minimized by use of open steel grid decking.

3.2 Considering Flood Risks

The DPW's primary goal is to provide safe roads for the traveling public. Road safety factors include pavement condition, road width, shoulder width, guard rails, blind curves, and bridge weight limits.

When flood damage is severe enough to close a road to traffic, then it becomes a significant priority. In the absence of damage, the County does not routinely determine the frequency of flooding at specific locations and the desire to achieve certain degree of flood resistance (avoid risk or damage) is not a dominant factor for selection of project priorities. However, when a bridge or culvert is replaced, regardless of the reason, improving flood resistance is included in design and cost decisions.

The County Engineer asserted that the DPW has become more aware of issues related to flood resistance, especially the benefits of scour protection. Where the typical approach in the past was simply to key the footers into bedrock, damage experienced in the last 10 years has lead to a more proactive approach. Even where requirements are absent or analyses of scour potential do not indicate a critical need, scour protection is installed.

Sometimes high water marks are recorded, but back calculations are not performed to determine the frequency of actual flood events. If water levels above the predicted 1-percent-annual chance flood (commonly called the "100-year flood" have been experienced, that is a factor considered by the County Engineer when evaluating design alternatives.

3.3 Considering Benefits and Costs

Costs associated with the work the County does to improve flood resistance of roads and bridges, and to provide scour protection are viewed as justified due to broad benefits. A formal cost-benefit analysis is not performed and, within reason, the higher costs do not have to be justified separately to the County Council.

Costs associated with meeting the State's floodplain permit requirements are minimal, in large measure because the analyses are performed by the County Engineer rather than consultants. The County does not consider there to be any significant burden associated with meeting State floodplain and wetland permit requirements, especially with the State's regional authorization mechanisms that cover most of the work undertaken by the County. The regional authorizations require periodic reporting so that the State can monitor long term resource impacts.

3.4 Weighing Alternatives

Rather than have formal guidelines for evaluating alternatives for waterway crossings, the consideration of various design factors and site-specific constraints is iterative and not quantitative; it is based on the experience of the County Engineer and local consultants. That experience also is brought to bear when considering different types of structures and to satisfy the State's regulatory requirements related to flood hazards. In general, with regard to improving flood resistance, the County asserts that it is important to look at the field conditions as a whole, rather than focus narrowly on one design parameter. For example, examining downstream conditions may suggest the potential for higher velocities or incipient bank erosion, which then suggests that deeper footers or more robust scour protection is warranted.

Open grid decking made of weathering steel is a very effective way to minimize damage especially if a bridge is expected to be inundated frequently. Under flood conditions, rising water does not create significant uplift on open deck systems, which can be a problem with solid decking. Open grid decking is easy to install and has low maintenance requirements. Used by the County since the late 1970s, open decking is used on about 50 bridges. The County routinely uses open grid decks for deck replacements for state-aid bridges and bridges less than 20-feet. A 3.5-foot wide pedestrian path is installed on one side. Identified drawbacks are not related to flood resistance: horses will not cross an open grid deck bridge; bicyclists complain of the roughness, and the driving surface can be slippery. Because of this later drawback, the State Highway Administration generally does not endorse open grid decking.

Because minimizing construction time is important on many routes, especially if closures impact school bus routes, the County uses precast concrete planks for some replacement bridges. They are easy to install and widely accepted. Since their initial installation in 1984, concrete planks have been used on nine bridges. Although none of these bridges have yet experienced serious flooding, the County expects good performance. Primarily because the depth of the planks is generally less than other types of superstructure and thus presents less obstruction to flow, allowing water to easily overtop without the same pressures (although hydraulic uplift must be accounted for in design). The shallow planks also tend to shed flood-borne debris better resulting in less obstruction to the flow of water.

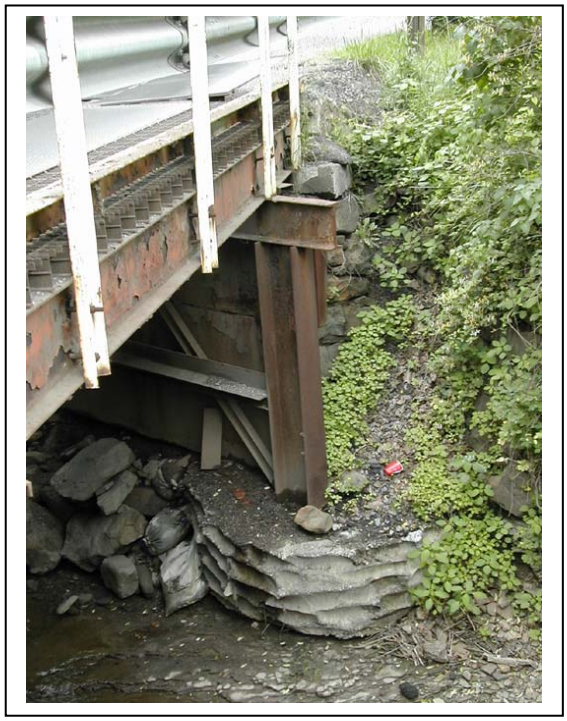
The County has used bottomless metal arch culverts at eight locations (Figure 6). Usually these culverts are appropriate on smaller streams with low-approach and low-profile roads that are designed to overtop during high water conditions. A significant benefit is that they are easy to install using County crews, which reduces total construction costs. Depending on what the hydraulic model shows in terms of erosion and scour, imbricated riprap is used on the upstream and downstream ends rather than traditional headwalls.

Figure 6. Typical Bottomless Culvert

A new approach is proposed for an upgraded crossing on Bartlett Run Road. Currently, both abutments are deteriorating and one has temporary steel shoring due to a recent collapse (Figure7 and Figure 8)

The site is severely restricted and the road is a significant route for coal hauling. The County Engineer is specifying a precast concrete arch structure that will be sinuous in shape in order to avoid stream relocation. The hydraulic capacity of the waterway will be increased because the structure will be slightly wider than the current channel and the smooth walls will more efficiently pass flood discharges. Federal approval of the proposed structure is required because it will be paid for by a combination of federal funds and coal haul funds. The County had to negotiate acceptance through the State Highway Administration and the environmental regulators because it is not a recognized structure type.

The County has a few rural locations where abandoned railroad tank cars (with ends removed) are used as culverts. One installation shifted due to flooding; resetting it was accomplished readily with County personnel and equipment. These structures are unlikely to be used in the future, except perhaps in remote areas where investment of significant funds to design and construct traditional bridges is not prudent. Rural locations may also benefit from another low-cost solution. The County Engineer is aware of research undertaken by the Iowa State University to examine use of used railroad flat car beds as the bridge superstructure. For small spans, only three car beds are required to create a 2-lane bridge. A prime benefit would be speed of installation.



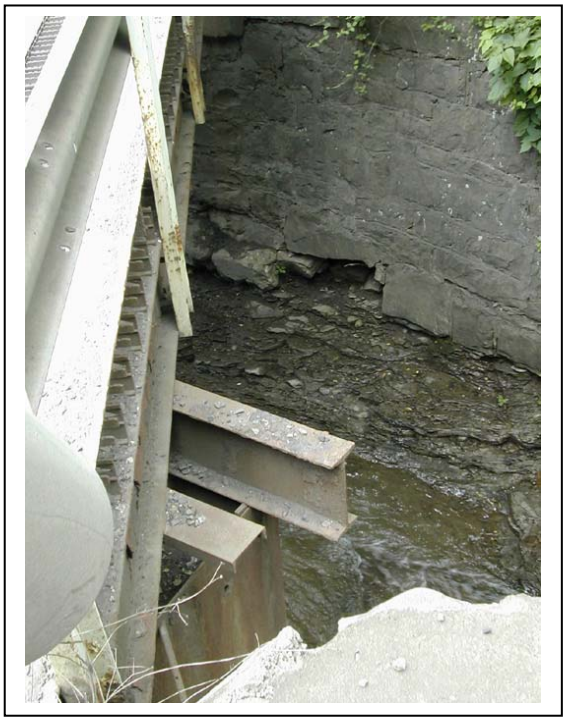


Figure 7 and Figure 8. Deteriorating Abutments

4.0 Site-Specific Examination of Decisions

4.1 Damaged Site: Sugar Maple Road Bridge

Sugar Maple Road Bridge, originally known as Main Street - Dogwood Flat Road is located near the town of Barton in southwest Allegany County. This local road carries about 50 vehicles per day. A construction contractor's facility is located on the upstream side. There is one alternate route that carries traffic through the nearby town, a minor detour that adds just minutes to travel time.

Originally built in 1950 and reconstructed in 1962, the deck was replaced in 1982 with steel stringers and open-grid riding surface. No other work specifically related to reducing flood damage had been done prior to the 2002 flood. The bridge is shorter than 20-feet in length and thus is not required to be inspected by the State. Under the County's inspection program it was inspected in 1993 and 1998. The inspection reports did not identify any significant problems and subsequent routine inspections by the Roads Division revealed only minor bank erosion.

Sugar Maple Road Bridge, with at-grade road approaches, spans an unnamed stream that has been exposed to numerous floods since the late 1980s. It has experienced stream channel scour, embankment sloughing, stream meandering upstream of the bridge, and blockage of the downstream box culvert under MD 36 due to stream bed deposition. The stream carries significant bedload. Deposition is fostered when high velocities transition to the flatter channel just upstream of the MD 36 box culvert. Furthermore, since Sugar Maple Road Bridge is located only 500 feet upstream from the confluence with the primary waterway Georges Creek, the unnamed tributary can not discharge when Georges Creek is high, impeding flow even more.

After the flood of 2002 subsided, the DPW's inspection revealed that the south abutment, originally built of large "Belgium-style" stone blocks, had collapsed and the steel stringer with open-grid decking superstructure had settled several feet. Undermining of the abutment was due to streambed degradation associated with debris blockage and work at the State's bridge. A water line and gas line mounted on the Sugar Maple Road Bridge were not damaged. Other roads and bridges in the area were overtopped but did not sustain structural damage.

Figure 9. Sugar Maple Road New South Abutment (looking downstream)

Consideration of the frequency and nature of previous flooding incidents in the area (1985, 1987, 1993, and 2000) led the Natural Resource Conservation Service, Soil Conservation Service, Maryland State Highway Administration and the County to install imbricated riprap on the stream bank to stabilize slopes and stream channel rock vanes to lessen stream undercutting. The NRCS prepared the

hydraulic analysis and design of the erosion protection between the State's bridge upstream to Sugar Maple Road.

At the time of the flood the design requirements in effect were those associated with the State's waterway construction floodplain permit. The bridge replacement work was eligible under one of the State's regional authorizations, even though the final design modified the hydraulics by raising the bridge deck. The north abutment was replaced and protected with riprap (Figure 10). The original south abutment was incorporated into a new abutment and the superstructure was raised about 18-inches as shown in Figure 11. This additional height was chosen based on site constraints, not because it was required to pass a specific discharge. A FEMA flood map change was not required.

Sugar Maple Road was closed for a total of 6 months. The actual construction period was 70 days. The County posted detour signs and, due to proximity to the State road, the detour plan was approved by the State Highway Administration. The detour added only 5–8 minutes travel time. The economic impact associated with the damage/detour was considered by local officials to be minor due to the low traffic volume.

Sugar Maple Road has not experienced significant flooding since the current bridge was installed. Water flows have exceeded normal, as evidenced by debris lines and discoloration along riprap due to acidity of the water.

Allegany County's Hindsight Assessment: The County Engineer is pleased with both the partnership formed to investigate and design the work, and the resulting project on Sugar Maple Road. He did not identify anything that he would have done differently.

Figure 10. Sugar Maple Road Imbricated Riprap Protected North Abutment (looking upstream)

Figure 11. Sugar Maple Road New South Abutment (looking upstream)

4.2 Undamaged Site: Klondike Road

Located in the middle of the Georges Creek watershed in western Allegany County, the Klondike Road over Georges Creek is a collector street, with approximately 200 vehicles per day. It is an important route for fire and emergency services. Experience indicates that Georges Creek is flashier than the predicted 100-year flood (based on 24-hour rainfall), and the existing bridge has overtopped on numerous occasions since its construction in 1985. Floodwaters topped the bridge – without damage – in 1987, 1988, 1989, 1991, 1995, 1997, 1999, and 2000.

The original bridge was a truss bridge that had significant structural problems and had been closed to traffic for some time before construction of the current concrete, low-profile concrete deck bridge in 1986. The current design and selected structure type were influenced by ease of construction and cost. Hydraulic analyses were prepared by the County Engineer and the design was based on carrying the 100-year flood discharge. A FEMA map change was not required.

Figure 12. Klondike Road.

The gradient of the streambed is fairly flat in this reach. With a total span of 53 feet, the Klondike Road bridge does not alter the natural channel width and flows are not concentrated. The bridge itself presents minimal obstruction to the passage of floodwaters because the approaches are essentially at-grade and perpendicular to the stream, the abutments are keyed into bedrock, and the bridge deck is shallow. No utilities are mounted on the bridge. While some minor debris removal has been required, accumulation of debris and blockage of flows has not been a problem.

Figure 13. Klondike Road Bridge (upstream).

The most recent flood that affected this bridge was in 2000. Water rose over the bridge, but was observed to crest at about 10” below the top of the guardrail. No damage was sustained.

Allegany County’s Hindsight Assessment: The County Engineer is pleased with the performance of this bridge. He credits lack of damage to the relatively lower velocities due to the natural stream gradient and the choice of a wide span which avoids concentrating flows that might create scour.

5.0 Observations

5.1 The County's Observations on Flood-Resistance

The DPW Director and County Engineer were asked to address flood-resistance of the County's road system. They commented on the State's regulatory requirements, their proactive inspection program, and how recent flood events have influenced their operations. In particular, they noted that they did not believe that a separate standard regarding decision-making guidelines for flood resistance would improve their approaches, and could in some ways limit the flexibility they consider an essential part of their current success.

The State's Regulatory Requirement

The County generally finds the State's requirement to pass the discharge of the ultimate development 1-percent annual chance flood (the100-year flood) to be reasonable. The benefits are significant in terms of increasing the flood-resistance of the factors that must be addressed: abutment protection against scour; opening dimensions; and design for safe passage of flood. Although most of the flooding in recent years has affected older bridges and road segments, those that were built in compliance with State requirements have performed well. Some riprap has been shifted, but generally there is no significant scour.

The County's Pro-Active Inspection Program

By inspecting all local bridges (less than 20-feet long) every 5 years, the County believes that it has reduced the overall cost of its roads program and, in the process, improved resistance to flood damage. In virtually all cases, rehabilitation is less expensive and less disruptive than replacement. By monitoring conditions over time, deterioration is identified and can be addressed in its early stages.

The Influence of Floods

In terms of road and bridge designs, experiences gained after recent floods have somewhat altered how the County weighs various factors related to flood resistance. Based on the success of the in-stream grade controls and imbricated riprap, the County Engineer now evaluates stream morphology by investigating further upstream and downstream to see if conditions that might contribute to erosion and scour can be identified and addressed.

The County has found that it is easier in the post-flood period to undertake joint cooperative efforts with other agencies, primarily the State Highway Administration and the Natural Resources Conservation Service. When a project is in the planning state, informal consultations with NRCS help determine if there is a formal role for its involvement. That determination is followed up with a formal request for assistance.

The 1996 flood along Georges Creek, with its many bridges, showed some conditions and flow lines that are not consistent with the FEMA map. FEMA is undertaking a restudy (currently on-hold). The County, with assistance from the Maryland Department of Natural Resources, performed a Watershed Restoration Action Survey (although it was not intended to identify matters specific to bridges and flood-resistance). The Georges Creek Watershed Association, a citizen's organization, is involved in stewardship and cleanup.

Although not related to improving the flood-resistance of the County's local road system, Department personnel reported making significant changes in manpower usage and record keeping when responding to floods that may qualify for federal assistance. The changes were made in order to satisfy FEMA requirements and facilitate reimbursement requests and include:

- Keep work orders for manpower, equipment and materials work orders separate from work orders for other road maintenance activities;
- Rather than use existing work orders with vendors, issue separate purchase orders for materials used for flood recovery, especially gravel and asphalt products;
- Take more photographs depicting the damage from multiple angles;
- Prepare inventory of materials used at a damaged site based on field measurements rather than map-based measurements; and
- Use local contractors to perform repairs versus in-house forces because FEMA's reimbursement of contracted work is more efficient and requires less paperwork than when in-house forces are used.

The County believes that its voluntary periodic inspections, with photographs, provide good documentation of pre-flood conditions in order to counter FEMA's challenges about "what was there," and this, in turn, should make it easier to negotiate incorporation of mitigation measures in the future.

5.2 Case Study Team Observations

The Allegany County Department of Public Works is a very effective organization. Overall, the Department is staffed with very experienced professionals and field personnel who have a depth of knowledge that makes for very efficient operations, including the processes of inspection, planning for rehabilitations and replacements, funding, timing, and actual work.

The case study team made the following observations about significant factors that positively influence the flood-resistance of the County's local road system:

1. The current procedures for the Engineering Division and the Roads Division are stable. The decision making process has been in place for many years, evolving from changes instituted by current staff dating back to 1980.

Key personnel are active in their profession at the state level. They participate in professional reviews for national-level research. They have the knowledge and authority to make excellent decisions based on their depth of experience and lengthy tenure with the County. They are not afraid to approach problems with innovative solutions.

The DPW proactively identifies needs by undertaking – at the County's expense – engineering evaluations of non-federal system bridges every 5 years. This allows them to monitor conditions and plan maintenance and rehabilitation work before problems escalate and threaten users.

In-house design capability is significant, allowing the County to efficiently evaluate the hydraulic effectiveness of alternatives for many projects, without incurring high costs for

consultants. Rather than rely on a rigid process, they rely on their hands-on experience and their knowledge of effective technologies to identify solutions, including measures to increase flood resistance of roads and bridges.

The Engineering Division and the Roads Division staffs are trained and have experience in routine examination of roads and bridges to identify maintenance needs. The in-house staff and equipment are sufficient to undertake much of the work, allowing for responsive and cost-effective operations.

The Public Works budget has been stable for many years, making it relatively easy to plan to address rehabilitation needs and routine maintenance.

The Department willingly enters into partnerships with the State Highway Administration and the Natural Resources Conservation Service to investigate alternatives to address bank erosion and abutment scour.

The County expressed an awareness of the shift in FEMA's policy regarding funding of mitigation measures that has occurred since its last major disaster in 1996. Paired with its in-house ability to identify such measures, the County anticipates incorporating mitigation in its efforts to recovery from future disasters that damage the local road system. With its in-house capabilities and experience, the County has the ability to propose and defend such measures.

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Selected Terms

Source: The following text was extracted from *Overview of the Federal Highway Bridge Replacement and Rehabilitation Program*) and is offered as general context.

Bridge. The definition of "bridge" as provided in Title 23, Code of Federal Regulations (CFR), Section 650.403(a) is: "a structure including supports erected over a depression or an obstruction, such as water, highway or railway, and having a track or passageway for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 feet between undercopings of abutments or spring lines of arches, or extreme ends of openings for multiple boxes; it may also include multiple pipes where the clear distance between openings is less than half of the smaller contiguous opening. [Texas specific note: The definition of a bridge allows for the inclusion of multiple pipe structures, although such structures are not usually included in the inventory and the bridge inspection database, unless "multiple pipes are 60-inches or more in diameter.]

Bridge Replacement and Bridge Rehabilitation. Bridge replacement means total replacement of a deficient-classified bridge with a facility constructed in the same general traffic corridor. The replacement structure should meet the current geometric, construction, and structural standards required for the type and volume of traffic expected on the facility over its design life. Applicable American Association of State Highway and Transportation Officials (AASHTO) design standards should be used.

Bridge rehabilitation refers to project requirements necessary to perform the major work of restoring the structural integrity of a bridge as well as work necessary to correct major safety defects. Related costs are eligible except as noted under the Ineligible Work paragraph [omitted from this summary].

Bridges to be replaced or rehabilitated both on and off the federal-aid highways should, as a minimum, conform to the provisions of Code of Federal Regulations, Title 23, Part 625, Design Standards for Federal-Aid Highways, for the class of highway of which the bridge is a part.

Sufficiency Rating. The sufficiency rating of a bridge is a single numerical representation of the sufficiency of the bridge that ranges from 0 to 100. In calculating the rating, consideration is given to the structural adequacy and safety, serviceability and functional obsolescence, and essentiality of traffic service. The higher the number, the more sufficient the bridge. The sufficiency rating serves as a basis for establishing eligibility for replacement or rehabilitation of deficient-classified bridges on the program. If the bridge is deficient and the rating is less than 50, the bridge is eligible for replacement or rehabilitation. If the bridge is deficient and the rating is between 50 and 80, the bridge is eligible for rehabilitation only unless replacement can be justified by engineering or economic analysis. For ratings higher than 80, the bridge is not eligible for remedy under the federal Highway Bridge Replacement and Rehabilitation Program.

AmericanLifelinesAlliance

A public-private partnership to reduce risk to utility and transportation systems from natural hazards and manmade threats

Flood Resistant Local Road Systems

Appendix C: Allegany County, NY

January 2005

www.americanlifelinesalliance.org

This report was written under contract to the American Lifelines Alliance, a public-private partnership between the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). This report was reviewed by a team representing practicing floodplain managers, water resources engineers, civil and structural engineers, and public works managers

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1.0 Allegany County, New York

Allegany County, NY, encompasses 1,030 square miles in New York's Southern Tier, along the Pennsylvania border (Figure 1). The topography throughout the region is the result of glacial action, with rounded hills and deep, wide valleys. The entire county is underlain by nearly horizontal beds of shale and sandstone rocks, which are buried under glacial drift that is very deep in the valleys, but ranges from less than a foot to 10 or 15 feet deep on the hills and valley sides.

Figure 1. Location map

The County is dominated by the drainage basin of the Genesee River (Figure 2). The river flows diagonally from the southeastern corner towards the northwest. A small area on the east is part of the upper headwaters of waterways that flow to the Susquehanna River and the Chesapeake Bay. The area in the southwest corner of the County flows south to the Allegheny River and on to the Mississippi River. Ground elevations range from 2,548 feet above sea level at Alma Hill in the south, which is largely forested, to 1,137 feet where the Genesee River leaves the County on the north, where the landscape is more open.

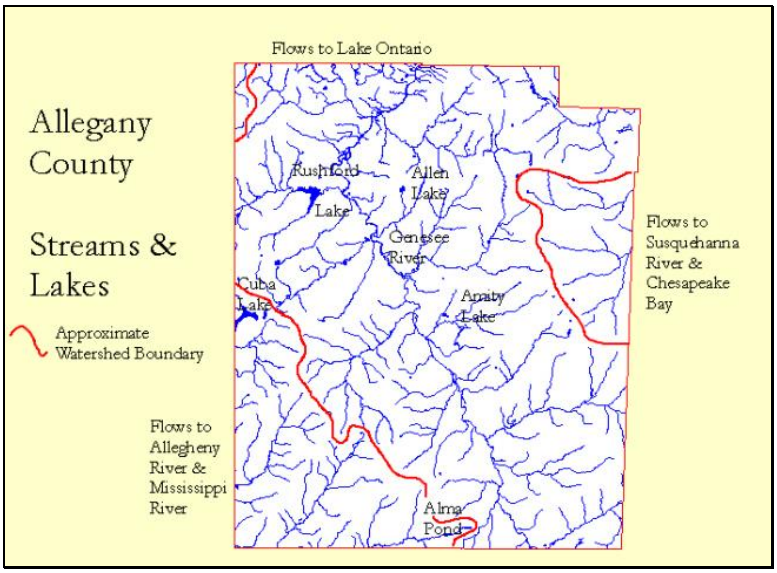

Figure 2. Drainage network

Allegany County has a continental climate characterized by fairly high day temperatures (frequently greater than 90 F.) and cool nights during the comparatively short summer. The winter is long and severe; usually lasting from the middle of November until March. The county has an average annual snowfall of 63.9 inches with the total annual precipitation ranging from 33 inches in the northern part of the county to 40 inches in the more mountainous southern part.

1.1 Government Structure

New York State law provides for four types of municipal general purpose governments: counties, cities, towns, and villages. Originally, the differences between each related to the services provided. Over time, patterns of services have been as much a product of politics as they are part of a strategic plan of governance. The State Constitution allows local jurisdictions to transfer powers to each other.

In the State of New York, local land use authority is vested at the city, village and town levels. Counties do not have land use authority and there are no unincorporated areas. Counties perform a number of countywide functions, such as maintaining and operating a limited network of county-owned roads. Each town and village is responsible for its own roads and bridges, although most are staffed minimally with a full time Highway Superintendent, two to four full time crew members, and some part time and seasonal workers. Counties cooperate with towns and villages on a variety of projects, including roads, often on a cost-reimbursable basis.

Allegany County is composed entirely of 29 towns within which are located 10 villages (Figure 3; there are no unincorporated areas). The Village of Belmont is the county seat; hamlets are unincorporated areas that are named. Geographically, towns are larger than villages, but are separate municipal entities from the villages that may be within their boundaries. Villages generally are where populations are concentrated. The U.S. Census for 2000 indicates a total population of nearly 50,000. Town populations range from under 300 (Birdsall) to about 2,700 (Caneadea). The Village of Wellsville is the largest village with about 5,100 people, while Oil Springs is the smallest with a population of only 11.

The County's Legislature, Treasurer, and Clerk are elected. A County Administrator, appointed by the Legislature, oversees the day-to-day operations. The Director of the Department of Public Works also is appointed by the Legislature.

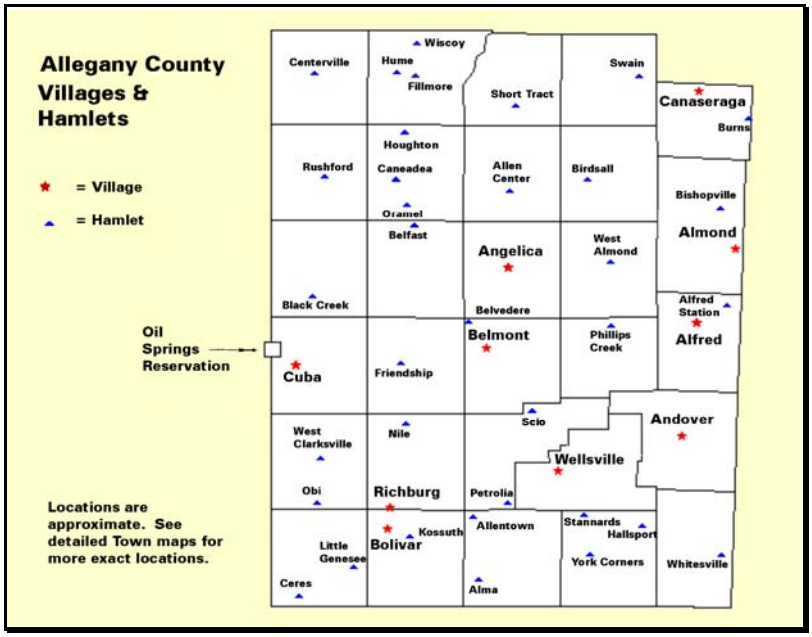

Figure 3. Allegany County, villages & hamlets

1.2 The County's Department of Public Works

The Allegany County, NY, Department of Public Works (DPW) is composed of five sections with a total of 106 positions: Administration (6); Engineering (4); Highway (65); Solid Waste (20) and Buildings & Grounds (11). Staff levels have been reduced since 2001, when a total of 111 positions were funded. An additional 18 summer employees are added, with the majority working in the Highways section.

The DPW is managed by a Superintendent and two Deputy Superintendents. The Superintendent has been with the County for nearly 30 years. He was appointed to Superintendent in 2000, after serving as a Deputy Superintendent and the Public Works Engineer. One deputy superintendent oversees the Solid Waste Division and a supervisor manages Buildings & Grounds.

This report reflects the County's DPW organization, staff levels, and procedures as of mid-August 2004. Subsequent budget and staff cuts may result in some changes to the processes described herein.

One deputy superintendent is a civil engineer with 8 years experience as a general contractor. He has been with Allegany County for 16 years, including 4 years as the deputy. He oversees the work of two sections:

- Engineering Section, including the Public Works Engineer, a senior engineering technician, and two engineering technicians/inspectors. The Public Works Engineer, a registered professional civil engineer, recently left the County; there are concerns that it will be difficult to attract another engineer with those qualifications.
- Highway Section is led by a General Supervisor who has been with the County for 31 years. The section includes five district Road Maintenance Crews (supervised by District Foreman), the Bridge Maintenance Crew, and the Bridge Construction Crew. Road maintenance includes patching, grading shoulders, clearing brush at intersections, maintaining signage, drainage pipe maintenance, and clearing and dressing ditches. Bridge maintenance functions include washing decks and undersides of superstructures, water-blasting abutments, painting structures, lubricate bearings and tighten fasteners, and restore guide rails and signage.

The Bridge Construction Crew consists of a supervisor and four crewmen. Many rural counties in New York maintain crews that specialize in bridge construction. The history behind this practice is uncertain, but Allegany County believes that a specialized crew is justified because of the volume of work and, in large part, because of cost savings. The Deputy Superintendent reports that work performed with DPW's own forces costs nearly half of what it would cost to contract for similar work. In large part this is because of the differential between the prevailing wage rates in the public and private sectors.

Each of the 29 towns in Allegany County has a Highway Superintendent who is responsible for local roads and bridges. Most towns have only two to four full-time employees working on roads, sometimes augmented by two or three part-time positions. While most town Highway Superintendents have considerable experience, they generally do not have the resources for regular inspection and maintenance. Allegany County has provided design support and

assistance with construction. During emergencies, the ownership of the roads does not delay actions required to safeguard the traveling public, with the County often helping the towns.

The Allegany County Department of Public Works (DPW)'s summary of fiscal year 2003 is, for the most part, representative of the County's responsibilities and workload. The only significant exception was related to the effort to respond to severe flooding and power outages across the County caused by storms between mid-July and mid-August. The level of damage and expenditures related to recovery exceeded the average.

In FY 2003, using County forces, the DPW replaced 3 County bridges and culverts, including one that collapsed due to flooding, and replaced two town bridges. Crews performed post-flood repairs on numerous bridges. The Bridge Maintenance Crew worked on nearly 81 different structures. Engineering and design work began on seven bridges/culverts that were scheduled for construction or rehabilitation in 2004.

Representative of a typical year, work in FY 2003 included contracting for paving of 25 miles with asphalt hot mix and using County forces to apply oil and stone sealant on about 35 miles of road. The Department contracted services for pavement marking (345 miles of centerline and 468 miles of edgeline).

1.3 The County's Local Road System

Villages own the local roads within their boundaries and towns own many of the roads within their boundaries. There is no definitive characterization that explains why certain roads are County roads while others are town roads. County road ownership is rooted in history, rather than determined by definition.

Allegany County, which ranks towards the top of all counties in New York in terms of number of bridges and culverts, is responsible for a network of roads that overlays the town and village roads (Table 1). The Genesee River, with its central location, is crossed by eight County bridges and seven town and/or village bridges. Due to the size and width of the River, these bridge structures are large: the longest is over 600-feet.

	County	Towns/Villages
Miles of road	344	1,324
Number of Bridges*	122	183
Number of Culverts**	286	Unknown
Number of Drainage Culverts***	1,854	Unknown
* Spans greater than 20-feet ** Dimensions from 4-feet to 20-feet (includes bridges less than 20-feet) *** Dimensions from less than 24" to 4-feet		

Table 1. Roads, Bridges and Culverts

Ninety-six miles of the County's 344 miles of road are classified as minor collectors and thus are considered federal-aid roads. The remaining 248 miles of County road are classified as local roads and low-volume roads.

Traffic counts are performed on every County road every two to three years. Many have traffic counts as low as 200-400 vehicles per day; the road with the highest traffic count averages about 4,000 vehicles per day. The average County road carries between 1,500 and 1,800 vehicles per day. All County roads are paved with asphalt. Many town and village roads with very low traffic counts are gravel.

The County's historical records are fairly complete for the larger bridges, although the same cannot be said for most culverts. Of the total inventory of bridges and culverts, 172 are more than 30-years old (and 94 of those are more than 40-years old). It is important to clarify that the date used for the age of a bridge refers to the abutments; many of these older structures have had superstructure replacement or rehabilitation, which may have included raising the superstructure to improve hydraulics.

The American Public Works Association's Projects of the Year recognize outstanding partnerships of the owner, design team and contractor that address challenges. The Alton Sylor Memorial Bridge was recognized in 2004. The project was managed by the County, although the bridge is owned by the Town of Angelica. The glue-laminated timber superstructure replaced a 1930s-era steel girder/truss structure. It is the nation's longest clear span timber arch structure, with a 170-foot main arch and two 50-foot half-arch spans.

Figure 4. Award winning bridge

Of the structures that do not meet the federal definition of a bridge (i.e., structures with spans greater than 20-feet, see Selected Terms), the County reports a total of 286 that have openings that span between 4-feet and 20-feet (Table 2). Drainage culverts less than 4-feet generally carry local drainage rather than flowing streams.

Type of Culvert	Number
Pipe	189
Arch	34
Box	36
Bridge	27
Total	286

Table 2. Type and Number of Culverts (4- to 20-feet)

Towns and villages in Allegany County are not experiencing any significant growth and there is no current or anticipated demand for new County roads.

In an average year, using County forces the DPW rehabilitates or replaces five bridges that are 20-feet or longer and five bridges/culverts that are between 10- and 20-feet long, and installs about 60 to 90 smaller culverts. Given the total inventory (Table 1) and the average number of projects, at the current workload the County is on about a 50-year rotation for replacement or structural rehabilitation of its larger structures. The most important factors that allow this workload are the in-house construction capability and capacity, both the number and skills of the employees and the type of equipment (70 ton crane, pile driver, Under Bridge Unit, hydraulic track excavator, etc.).

1.4 History of Flooding in Allegany County

Allegany County experiences heavy rainfall and flooding on a fairly regular basis. For the 10-year period from 1993 to 2002, the Office of Emergency Services documented 12 floods and flash floods of sufficient size to warrant investigation. No specific area of the County seems to experience flooding more frequently than others, although there are areas where more buildings are exposed than others.

With waterways ranging from headwater streams to the Genesee River, flooding also ranges from flashy to fairly long duration. Most flood events are localized and are caused by small intense storms. These relatively small flood events do not prompt external support, whether from the State or the U.S. Department of Homeland Security (FEMA).

Official records for rainfall associated with the remnants of Tropical Storm Agnes in June 1972 indicate 13.7 inches fell over a 4-day period. Flooding from Tropical Storm Agnes remains the flood of record for the whole county, although isolated areas may have seen worse flooding due to isolated and intense rainfall. Recent events have been localized and more intense, some producing as much as 5 inches in just a few hours (Table 3).

Allegany County is one of only a handful of counties in New York that have received 10 or more presidential disaster declarations since 1965, when the federal government began to keep records on a county-by-county basis. This may, in large measure, be a function of the County's size (one of the largest in the State) and relatively more miles of road and number of structures in the local road systems.

Limited data provided by FEMA for the last four years indicates that Allegany County and its towns and villages collectively received considerably more assistance than other counties received under FEMA's Public Assistance program for losses associated with roads and bridges. The County's spreadsheet for Major Disaster DR#1486 indicates that of about $3.8 million in public assistance allocated to all eligible recipients (federal share, all categories), only $396,000 was attributed to Allegany County. No single town or village received the majority of the balance. In the opinion of the Deputy Superintendent, repair of town roads most likely accounts for the majority of those outlays.

Date of Storm	Rainfall (inches)
March 22-23, 1913	4.93”
July 7-10, 1935	5.86”
July 17-18, 1942	3.83”
November 24-25, 1950	2.24”
March 6-10, 1956	+3.20”
April 24-26, 1961	2.47”
Storms/Flooding Declared as Major Disaster Federal Declarations	
October 1967 (DR#233)	(not reported)
June 1972, Tropical Storm Agnes (DR#338)	13.7” (four day duration)
October 1975 (DR#487)	(not reported)
June 1984 (DR#725)	3-4.5”
January 1996 (DR#1075)	(not reported)
February 1996 (DR#1096)	(not reported)
June 26-July 10, 1998 (DR#1233)	(not reported)
June 16, 2000 (DR#1335)	4-5”
July-August, 2003 (DR1486)	5.24” (four day duration)
May 2004 (DR#1534)	(not reported)

Table 3. Record of Storms & Disaster Declarations (as of mid-2004)

1.5 Physical Impacts of Flooding on the Road System and Loss of Function

The Deputy Superintendent responsible for the Engineering and Roads Sections characterized the general performance of the County’s road system, with respect to flooding. He considers overall performance to be good to very good, although a number of problem areas are apparent. Although a rigorous assessment has not been undertaken, the consensus is that the majority of bridges and culverts that sustain significant flood-related damage are 30 to 40 years old. Prior to the 1960s, the prevailing approach seemed to be doing what was necessary to “get by,” perhaps influenced by economic concerns at the time.

Because of normal winter weather conditions, cyclical temperature differences contributes to separation of pavement layers over time, especially the pavement on bridges. This separation increases the likelihood of damage due to flooding when fast-moving water tops the bridge deck.

The County’s 344 miles of road are paved. Road surfaces do not exhibit flood-related damage every time water is over the road; damage is more likely to occur when velocities are high. Where exposed to flood water flowing across the paved surface, damage is mostly related to failure of the base which leads to floating the pavement. Some undermining of pavement is associated with shoulder damage, especially if the capacity of side drainage ditches is exceeded and undermines the shoulder.

The majority of County road shoulders are rolled and graded gravel. The preferred width of 6-feet is not feasible on some roads because the total width is limited by narrow rights-of-way. While flood-related damage to gravel shoulders can be extensive, shoulders protect the road from damage. Paved shoulders perform best, but are expensive and are not used on low volume roads.

In some locations an edging of cement blocks is added along the asphalt edge of the road to help stabilize the gravel shoulder.

County personnel have observed that damage may, at least in part, be associated with build-up of shoulders due to winter sand and vegetation. The County uses approximately 70 to 90 thousand tons of sand and salt mix in an average winter (about 200 to 260 tons per mile of road). Drainage off of the paved surfaces during typical rainfall, plus movement due to passing vehicles, moves the sand to the shoulders where it tends to build up. When the shoulders block drainage, there is evidence that there is increased drainage parallel to the paved surface rather than across the shoulder to the ditch. This may lead to undermining of the roadbed if the flow volumes and velocities are high enough.

While roadside ditches are not sized for a particular frequency of rainfall-runoff, they generally perform well. However, when very intense storms move through the area, the capacity of road drainage ditches and drainage pipes is exceeded and considerable damage can result. The County reports that a significant portion of FEMA's disaster assistance is expended to restore shoulders and roadside drainage.

About 10-25% of the road and bridge maintenance work is associated with drainage and high water, including debris clearance and shoulder restoration. It is not unusual for shoulder damage to be sustained repeatedly at the same sites, although the degree of damage often is attributed to insufficient time to achieve compaction. When ditch erosion is repetitive, measures to slow flows have been taken, including installation of check dams.

Debris on the road, whether from overhead trees or deposited by floodwaters, is a common but significant consequence of storms. All DPW vehicles carry chain saws in order to take immediate action to clear downed trees and debris from County roads.

The local NYSDOT shop is responsible for maintenance of State highways and roads in the area. The shop does not have construction equipment and does not get involved in heavy post-flood work. State roads generally are elevated and bridge structures are designed for higher discharges, and so State roads do not experience flooding and damage to the same degree as local roads in the area. An exception to this occurred in 2003 with the washout of State Route 275 over Van Campen Creek in the Town of Friendship. This bridge is located just downstream of the County's bridge that washed out during the same event.

2.0 Environment within which Allegany County Operates

2.1 Overview of Roads Budget

The DPW uses a standard approach to develop each year's budget. Given revenue projections, the County's administrator gives each department a budget target for planning purposes. The DPW's operating budget for road and bridge maintenance has been fairly constant. In recent years, the capital budget for work performed by the Bridge Construction Crew has averaged $700,000 per year.

For the capital budget the DPW uses the results of inspections (Sufficiency Ratings and Condition Ratings) to develop a priority list of bridge and culvert projects. Based on experience, costs associated with each of those projects are estimated. The total estimated costs of the projects on the priority list that is submitted for inclusion in the final budget typically exceeds the target amount. This is in large part because, historically, estimates are made before all on-site conditions are fully assessed and alternatives considered. For example, as detailed site-specific work is begun, it may be determined that an abutment can be retained rather than replaced. Thus, work that is on the approved list can be undertaken towards the end of the budget year, even though it was not originally within the approved budget amount.

The DPW's operating budget for FY2004 is $8.1 million (nearly 10% of the County's entire budget). The operating budget includes salaries and expenses for Administration, Buildings & Grounds, Traffic, Engineering, County Roads, Snow Removal, Road Machinery, and Solid Waste. Included in the County Roads budget is $732,860 for ongoing maintenance supplies and materials, including stockpiled materials; nearly half of that amount is allocated for materials the County uses to build its own bridges.

Among revenues specifically related to County Roads are reimbursements from towns (when the County performs work on town roads and bridges), Capital Projects (work on County bridges and culverts), CHIPS ($1.6 million in FY2004, including some rollover from FY2003), and federal and state emergency disaster aid ($54,700 in FY2004).

CHIPS is New York's Consolidated Local Street and Highway Improvement Program. It is intended to assist localities in financing the construction, reconstruction, or improvement of local highways, bridges, highway-railroad crossings, and/or other local facilities. Apportionments are calculated annually according to formulas set forth in statute and are based on local road mileage and a factor associated with use. CHIPS is authorized with two separate and distinct components: Operations & Maintenance which is funded from the State's General Fund; and Capital Fund funded from the sale of Thruway Authority bonds (used only for capital work that has a service life of 10 years or more). In State Fiscal Years 02-03 and 03-04, no funds were provided for Operation & Maintenance, while the Capital Fund was increased.

Most counties pay for paving with local funds and use CHIPS for bridge work. Allegany County, with an above average in-house capacity for bridge construction, uses its entire CHIPS allocation for paving. With reductions in CHIPS and increases in costs, the average mileage that can be paved has fallen in recent years.

County general funds support the DPW's operating and capital budgets. The primary source of general funds is the tax on real property. On occasion, local bonds are used to finance larger projects.

The FY2004 budget does not include any State Aid/Federal Aid funds, referred to as "Pass-Thru" funds. NYSDOT Region 6, which includes Allegany County, receives about $4 million per year in Pass-Thru funds. The six counties in the region cooperate to develop a list of candidate projects (bridges and transportation improvement projects, including eligible projects in the towns and villages). As a group, they recommend priority projects to NYSDOT, which funds those within the allotted budget. Allegany County's candidate projects usually are those that cannot be constructed by the Bridge Construction Crew. The two most recent Pass-Thru funded projects were town bridges; the County managed the design consultant contracts and managed the construction contractors on behalf of the towns on a reimbursable basis.

2.2 State Requirements

The New York State Department of Environmental Conservation (DEC) does not have regulatory authority over activities that occur within floodplains. The agency's influence derives from its role as the State Coordinating Office for the National Flood Insurance Program.

DEC issued a General Permit Renewal to Allegany County DPW in January 2003, extending the authorization until January 2006. The permit is issued pursuant to Environmental Conservation Law, Article 15, Title 5: Protection of Water and Article 24: Freshwater Wetlands, and the State's Water Quality Certification (pursuant to the Clean Water Act).

The General Permit specifically authorizes "construction, reconstruction, maintenance, and repair of bridges and culverts and disturbance to beds and/or banks of all streams, navigable waters and associated Freshwater Wetlands within Allegany County, subject to all terms and conditions stated" in the permit. Special conditions outline the activities that are covered, including:

1. Bridge or culvert replacement in-kind:
    a. With no change in alignment or lowering of the lowest structural member,
    b. No additional fill in the floodway or flood fringe per the Flood Insurance Rate Map, and
    c. No decrease in flow capacity.
2. New or modified (i.e., other than in-kind) bridge or culvert:
    a. Must satisfy FEMA requirement (with delineated floodway no increase in flood levels; without delineated floodway, no more than 1-foot increase in water surface elevation taking into consideration existing and anticipated encroachments); and
    b. Lowest structural member should be 2-feet above the 100-year water surface elevation if possible, otherwise 2-feet above the 50-year ("provided that the 100-year flood can pass through the bridge opening without contacting the bridge's low structural member").

3. Temporary Detour Structures for Traffic Maintenance:
    a. In place less than 10 weeks, must pass the 10-year discharge,
    b. In place less than one construction season, must pass the 25-year discharge, or
    c. Pass the 50-year discharge, and
    d. Prepare an Emergency Action Plan to monitor crossing.
4. New Highway Construction (total length of work is less than 500 feet).
5. Stream Bank Stabilization Activities:
    a. Up to 250 lineal feet of rock rip-rap, sheet piling, or gabion protection adjacent to highways/structures threatened by erosion,
    b. Up to 150 lineal feet of protection using on-site streambed deposits for temporary protection (may not be performed in same section more than once very 2 years),
    c. Channel clearing (including flood debris) of up to 250 cubic yards of gravel/sediment within a 250 lineal foot stream section at bridges to maintain channel or bridge capacity.

The County is required to review and properly identify the status of each project with respect to the State Environmental Quality Review regulations prior to determining whether the General Permit is applicable, specifically related to Water Quality Class. Projects that affect those waters and other projects outside the limits of the General Permit must be individually reviewed by DEC. The County is required to maintain a project log, submit information copies of applications for work under the General Permit, provide an annual summary report of the status of projects undertaken pursuant to the General Permit, and arrange for an annual meeting with DEC.

Certain standards of performance are outlined as special conditions of the General Permit. With respect to flood-resistance, the following are pertinent:

- Channels shall be designed to provide a parabolic shaped bottom, to concentrate flows during low water periods,
- Finished work area to be graded to match the elevation and contours of adjacent undisturbed lands,
- Culverts shall be installed with the inverts “slightly below” streambed elevation,
- Disposal of demolition debris and/or spoil in any regulated 100-year floodplain as identified on FIRMs is prohibited,
- Equipment capable of removing temporary structures (bridges, ramps, cofferdams, etc.) shall be available on-site during construction; in the event of a flood, such structures shall be removed or breached to minimize obstruction to flow.

The General Permit does not authorize removal of sediment and vegetation build-up at County bridges and culverts. For environmental reasons, the DEC is very cautious about in-stream work, controlling both the nature of the work and the time of year that it can be performed. The

DPW must apply for each instance that in-stream work is performed, and it appears that such work is authorized only when it can be shown to be urgent.

The DEC does not prescribe methodologies that must be used by the County to determine the discharges or hydraulics at a given location, but broadly relies on local jurisdictions to use standard engineering methods.

2.3 Guidance and Local Standards

State-Inspected and Funded Bridges. NYSDOT inspects all bridges that are 20-feet long and longer, inspecting about half of the County's 122 qualifying structures each year (as well as the qualifying bridges in the towns and villages). The inspections yield a Condition Rating and Sufficiency Rating which is a compilation of several rating factors. The County receives an annual report compiling the results and individual inspection reports are also provided. The Sufficiency Rating (not its component parts) is used by the County to set priorities when negotiating priorities for the Pass-Thru funds. If the inspection results in a "red flag" for structural concerns about imminent danger, the road must be closed or the weight limit changed until the matter is addressed.

When the State's biennial inspection identifies evidence of significant scour or channel degradation or aggradation, the State has a hydraulic vulnerability assessment prepared. The assessment looks at historic flood characteristics, adequacy of the bridge opening, and overbank flow patterns.

Projects undertaken with Pass Thru funds must be designed by external design consultants to meet specific standards, including hydraulic performance, road width, shoulder width, and drainage ditch dimensions as set forth in the AASHTO "Green Book" (*A Policy on Geometric Design of Highways and Streets* and *The Standard Specifications for Highway Bridges*). The expectation is that bridges will pass the 50-year discharge with 2-feet of freeboard (clearance between water surface and bottom of the superstructure). For scour analyses, the 100-year discharge must be used. Sufficient flexibility exists for the County and the design consultant to select acceptable designs that address multiple objectives.

Periodic Inspection of Bridges and Culverts. For nearly 25 years, it has been the County's standard practice to periodically inspect all culverts and bridges that are not inspected by NYSDOT. Beginning in about 1990, the inspections have been consistently performed using the methodology for small structures outlined in the Federal Highways Administration's *Culvert Inspection Manual: Supplement to the Bridge Inspector's Training Manual*. This manual outlines procedures and documentation to evaluate the major hydraulic and structural components of culverts. The County applies the same method to non-federal bridges (less than 20-feet).

The total current inventory inspected is 2,140 structures that range in size from 24" to just under 20-feet. The 51 structures that range from 10- to 20-feet are inspected every three years. Every five years the remaining 2,089 structures are inspected. This volume of work is largely the responsibility of the engineering technician/inspector who spends more than half of his time in the field, preparing reports, and inputting data. The technician has taken NYSDOT training on culvert inspections, although most of his experience is on-the-job. The County is in the process

of shifting to a road-by-road maintenance program to improve efficiencies for the inspector and the maintenance and construction crews.

The Inspection Report, a one-page form, allows for simple visual assessment of culverts. For culverts that carry waterways, the inspector examines the waterway in the immediate vicinity assigns a 'good' or 'poor' rating for the channel and channel protection, looking for channel scour, embankment erosion, and deposits of debris, sediment, and vegetation. Photographs are taken upstream and downstream of the crossing, especially if poor conditions are identified.

The Inspector examines the inlet and outlet of the structure (barrel, headwall, wingwall) and assigns a numerical rating for condition of each element, settlement, and adequacy of cover (distance from road surface to the top of the opening). The roadway in the vicinity is examined and a numerical rating assigned for the condition of the shoulders, embankment and pavement (and notes whether drainage ditch pipes under driveways need replacing). The inspector also notes the roadway alignment (skew). Three summary General Ratings are assigned, one each for Culvert/Retaining Walls, Roadway, and Roadway Alignment. The inspector's comments are noted and recommended work is described.

Routine Maintenance. The routine road maintenance work performed by the five Road Maintenance Crews is identified by each district's foreman. The foremen determine priorities for the work within their districts (ranging from 64 to 71 miles of road). The foremen also check bridges and culverts and report unusual conditions, including debris at inlets, outlets, and within the County's right-of-way upstream and downstream. Most county roads are driven at least once each week, so maintenance needs are well-defined. In addition to a regular rotation of bridge maintenance, the Bridge Maintenance Crew works on recommendations made in the periodic inspection reports.

Beaver dams regularly create problems and the County has a State permit to trap or kill the animals, and to destroy dams that jeopardize County roads. Dams that impound significant volumes of water have been built upstream of County roads, which the County considers to pose a significant risk. In areas where beavers are active, routine inspection includes looking upstream and downstream of road crossings for evidence of activity.

Daily records of road and bridge maintenance work performed are maintained. The records include what was done, where the work was done (by road number, mile marker, and bridge/culvert number), and the types and quantities of materials used.

Bridges/Culverts – Configurations. Allegany County does not have formalized local requirements applicable to bridges and culverts with less than 20-foot span (i.e., those that do not satisfy the federal definition). For in-house design work the DPW follows NYSDOT guidelines and generic abutment and superstructure drawings, with minor tailoring for site-specific conditions. This approach is taken for consistency and to minimize liability, because the generic drawings were prepared by experienced and qualified authorities. The County is self-insured; consistently applying the same standard to all projects is an effective way to minimize liability in the event of an incident that might be attributed to the physical configuration or condition of the local road system.

Figure 5. Typical small bridge built by County's crew

The type of bridge decking used is a function of several parameters, not the least of which is ease of construction by the County's Bridge Construction Crew (Figure 5). Timber bridges, although limited in span length, are used in many locations because they are easy to install, resist freeze/thaw and deicing agents, use local materials, and are aesthetically pleasing. Precast concrete panels require heavier equipment during construction and can be designed for longer spans. They also offer a shallower profile, which can be important when one of the objectives is to increase the hydraulic opening without significantly changing the grade of the approach roads.

Driven sheetpiling is the preferred treatment for bridge (and some culvert) inlets and outlets. Where the depth of glacial soils preclude keying into bedrock, sheetpiling offers an easy-to-install alternative that can be installed by the Bridge Construction Crew. The standard is to get at least 20 feet of sheetpiling into the ground; at a minimum, the length below-grade is at least twice the length required to be above-grade. Detailed records are retained of the length below-grade and the number of blows required.

In the DPW's experience, sheetpiling offers excellent flood-resistance and protection against scour. Large stone, whether placed or natural, tend to catch in the piling spaces and help resist local scour. Large riprap is placed when scour holes are identified during inspections.

DPW usually keeps a number of recycled railroad tank cars (8- and 10-foot diameter, ends removed) on hand to use when a temporary crossing is needed or an emergency situation arises. On very low volume roads sometimes these installations become more or less permanent, with concrete block endwall treatment. Although they may be more susceptible to flood damage, they are low-cost and easy to replace if damaged before funds are available to install permanent headwalls (Figure 6).

Figure 6. Temporary headwalls at railroad tank culvert

Bridges/Culverts – Hydraulics. The County is required to have hydrologic and hydraulic modeling prepared for bridge projects undertaken with Pass-Thru funding from the Federal

Highway Administration (administered through the NYSDOT). These analyses are prepared as part of the design work that is performed by consultants hired by the County.

Virtually all of the FEMA Flood Insurance Rate Maps for the towns and villages in Allegany County date to 1982. Most waterways have not been studied using detailed methods and the maps show approximate flood zones. The studies that accompany the maps do not contain information that would be useful in evaluating bridge and culvert hydraulics.

For all structures constructed or installed using in-house forces, including drainage pipes that do not carry streams, the DPW handles hydraulic evaluations in-house. Regardless of the area of the drainage basin above the location of interest, the Rational Method is applied to determine discharges for the 25-, 50- and 100-year runoff. This method uses only three variables: drainage area, a runoff coefficient (characterizing land use), and intensity of rainfall. Intensity of rainfall is varied in order to estimate discharges for different frequency events. Another simplified computation is used to determine the square footage of opening required to pass the discharge.

The County's justification for applying simplified methods to determine discharges and openings is based on two factors. First, the methods are easy to apply and yield conservative estimates. The second is related to costs. In the DPW's experience, the biggest cost of a bridge or culvert project is not the materials (i.e., pipe size or girder length), but the time and labor associated with construction. Therefore, it has been determined that it is appropriate to use an easy method that errs on the conservative side, resulting in larger structures than likely would be chosen if more detailed methods were used. While the result may lead to installation of larger structures, the benefits outweigh the costs. At the same time, they are gradually upgrading their inventory of "undersized" structures, with some "margin" allowed for changes in upland land use.

Allegany County's standard practice is to select a structure size that conveys the discharge computed for the 100-year frequency storm event. Site-specific circumstances are then evaluated to determine if there are any constraints that limit the structure size. For example, if a larger pipe or raised superstructure on the same abutments is indicated but the approaches do not readily accommodate the grade change, then options such as a shallower superstructure or widening the opening are examined. There have been instances where one abutment is replaced in order to widen the opening.

Figure 7. Sheetpiling improves inlet conditions

Cost also becomes a factor if a larger structure is called for in order to pass the desired discharge. When considering replacement of circular pipes, if the assessment indicates that a larger pipe size does not provide adequate functioning, then a bridge or box culvert structure is evaluated. Sometimes costs preclude significantly improving hydraulics, although usually some improvement can be provided by improving the headwall (Figure 7).

Allegany County is not experiencing any growth that involves new County roads and bridges. The Department of Planning Services participated in a 2001 State study of the feasibility of alternative routing for an improved access route off of I-86 to the villages of Alfred and Wellsville.

Road Surface/Shoulders. The County's 344 miles of roads are asphalt paved on a graded gravel (or natural hardpan in places). In recent years, only about 25 miles have been repaved each year.

The standard for 2-lane road pavement width is 20-feet at a minimum. The preferred shoulder width is 6 feet, composed of 2-feet asphalt paving and 4-feet of gravel, although narrower shoulders are along roads where the right-of-way is too narrow (many old roads have 49-foot rights-of-way). Due to costs, most shoulders are rolled and graded gravel. When contracted repaving work is done on a road with narrow shoulders, prior to paving the County crews and materials are used to achieve the desired shoulder width.

Stream Bank Protection. The County provides stream bank protection in the immediate vicinity of its road crossings if there is evidence of erosion. At some culvert inlets and outlets the County places concrete block (2'x2'x6') to protect against erosion and scour.

Figure 8. Stone stream bank protection

In a number of locations, large quarried blocks of stone are placed to protect eroding stream banks (Figure 8). When the slope is steep, the blocks are pinned to bedrock and to each other; where slopes allow, the blocks are not pinned. Similar installations have been in place for about 25 years and have proven effective. Scour analyses are not prepared to pick the stone size. The County has a number of road crossings where old laid-up stone walls still provide some stream bank protection. When washed out by floodwaters they are replaced with stone blocks (which are lower cost than FEMA's cost code for replacement of laid-up stone).

The USDA Natural Resource Conservation Service (NRCS) has helped the County by providing bank erosion schematics. In 2003, after flooding collapsed a bridge and exposed a sewer line in the channel bed, NRCS funded grade control and protection of the sewer line.

Annual Bid Prices for Various Road Building Materials. Every year the DPW solicits bids from local providers for standard materials and equipment/operator rates that may be used in building and maintaining local roads. Participating vendors agree to those prices for work by the County and the towns, villages, school districts, and fire districts within the County. In part, the list of prices is maintained to document local prices when negotiating with FEMA to develop project costs for reimbursement.

2.4 Post-Flood Experiences and Influences

Flood damage to the County's ninety-six miles of road that are in the federal-aid system is not eligible for FEMA assistance, but is eligible for 100% reimbursement from the Federal Highway Administration. The Federal Highway Administration has a very strict policy that limits reimbursement to only the costs of in-kind replacement. While a county may elect to upgrade the damaged road or structure, all costs in excess of the cost of in-kind replacement are borne by the county.

If a flood event is declared by the President to be a major disaster, then damage to the County's 248 miles of non-federal-aid roads becomes eligible under FEMA's Public Assistance program. According to FEMA's formula, the federal government provides 75% (and the New York State Emergency Management Office (SEMO) provides 12.5% or half of the local share) of the costs of in-kind replacement. County reports that only in the past two years has it become possible to negotiate with FEMA to approve work that increases flood-resistance, rather than restore in-kind.

Allegany County has extensive experience working with State and FEMA inspectors after flooding events. In addition to maintaining routine inspection reports and records of routine work on the road system, when flooding causes damage the DPW keeps separate records in a format that, in the event a disaster is declared, will facilitate FEMA's inspections and approvals.

Allegany County has been criticized by FEMA inspectors for performing repairs "too quickly," which makes it more difficult for the inspectors to determine the extent of damage. The DPW counters that its primary mission is to provide safe roads and that it cannot wait for what often is weeks before federal inspectors are on-site. In addition, because photographs are taken during routine inspections, as well as after damage, there is sufficient evidence of before and after conditions. The detailed daily records maintained by DPW crews are sufficient evidence of the extent of restoration and repairs, and the County's annual bid prices document costs.

Among the more frustrating aspects of dealing with FEMA inspectors are inconsistencies. Not only do interpretations of what is eligible, required report formats, and required information seem to change from disaster to disaster, but even within a single event there are differences from inspector to inspector. Another complicating factor is that many federal inspectors are unfamiliar with the local environment, the nature of the soils, and construction practices.

FEMA inspectors rely on a standard cost codes to estimate the cost to repair damaged facilities or to replace them in-kind. DPW has objected to the use of those standard costs, which often underestimate actual costs. The County has evidence of valid local costs because it maintains the annual list annual bid prices for various road building materials.

Another post-flood concern raised by the Deputy Superintendent is the turn-around of approvals when a bridge or culvert requires replacement due to damage. Delays are of particular concern when floods occur in the fall, because weather can limit available construction time. In one notable recent instance, County Route 1 over Van Campen Creek was damaged and closed (Figure 9) With an average daily vehicle count of 700 and cold weather fast approaching, the County required the design consultant to complete the design (which removed the center pier to improve hydraulics) and prepare the bid documents in just three weeks. The design package was completed shortly after the event was declared a major disaster (which occurred nearly three weeks after the flood).

FEMA's approval of the project design required took an additional 6 weeks, a factor that contributed to the County's decision to close the road over the winter. Although the approval came in time to complete construction before winter, it was too cold to obtain asphalt to lay the pavement. During construction and for the following winter, the only available detour was provided on private property by installing two 10-foot pipes. The temporary crossing washed out twice before the new bridge was opened the following Spring.

Figure 9. Damaged County Route 1 Bridge over Van Campen Creek.

What the County views as one of its assets – its ability to move quickly, both for design and the construction of high priority work – has contributed to difficult negotiations with FEMA. The project described above was eligible under DR#1486. The damage occurred on August 9, with the formal disaster declaration issued on August 29, 2003, shortly before the design work was completed. The County reports that FEMA's insistence that work performed in advance of approvals is not reimbursable is unrealistic in when a high priority road is closed to traffic. Although FEMA ultimately reimbursed the County for the design work, it involved considerable effort to come to resolution.

Another aspect of this project was contentious, but the issue is a long-standing concern of the County's. Because installation of the temporary crossing and detour was performed by County forces during regular hours, FEMA would not approve reimbursement. Allegany County understands, but disagrees with, the limitation on reimbursement of regular time labor. Had a contractor been retained to perform the same work the total cost would have been significantly higher. In a sense, the County feels penalized because of its capacity and capabilities.

With regard to FEMA's limitations on eligible work, even in the work following DR #1486 in August 2003 FEMA inspectors insisted that only "in-kind' work was reimbursable. At one specific site, FEMA asserted that the County acted too quickly when it replaced a damaged culvert with a larger pipe to improve hydraulic efficiency. After considerable negotiation, FEMA concurred that the larger pipe constituted mitigation that will reduce future damage and approved the increased cost of the increased costs.

With regard to FEMA approvals and reimbursements for damage to pavement, shoulders and drainage ditches and pipes, the County indicates that reimbursements are strictly limited to in-kind replacement, even if it is asserted that thicker paving would be more resistant. Even though the County often has performed the work prior to inspection (necessary to provide safe roads), FEMA's inspectors generally accept the DPW's documentation.

The Deputy Superintendent shared his observations regarding FEMA's high obligations for public assistance in Category C (road and bridge) in Allegany County. In some towns, the

majority of town roads are gravel. While paved roads perform better under flood and heavy rainfall runoff, experience in the area indicates that gravel roads are cheaper to repair. It is unclear whether available records of road damage that has qualified for FEMA reimbursement would indicate a pattern of repetitive damage.

2.5 Emergency Response and Planning

The Allegany County Emergency Services is responsible for coordinating the County's readiness planning and response, including working with the towns, villages, and local volunteer fire services. Emergency Services' procedures manual contains formal checklists and call-down lists when flooding and severe weather occur. The County does not have formal evacuation plans for flooding.

Towns and villages are responsible for fire and emergency services. The 25 departments are all voluntary and none are staffed on a 24-hour basis. County Dispatch coordinates town resources, while the Village of Wellsville's forces generally have adequate capacity to handle demand. All towns, villages and volunteer services follow protocol and contact County Dispatch if flooding is observed. Citizens routinely report flooding or downed trees.

When DPW plans a project that involves closing a road and posting a detour, notice is provided to County Dispatch, Emergency Services' fire coordinator, and local newspapers.

Weather reports are obtained from the National Weather Service office in Buffalo. Five local residents are weather observers and report regularly to the NWS. Severe weather alerts are released to the State Emergency Management Office and State Police. Local officials in the affected areas are contacted by the State.

When weather alerts are received during regular work hours, Emergency Services notifies DPW by radio; the DPW Superintendent and Deputy Superintendents are notified by phone when alerts occur after hours. Flooded roads are reported by DPW staff and the public. During daylight hours DPW personnel drive the road network to check on flooded roads and to respond to citizen reports; after dark, DPW only closes roads because it is dangerous to undertake other activities.

The five district foremen, who each have been with the County from 10 to 30 years, are familiar with areas prone to flooding. When flooding is predicted they and their crews regularly check problem areas. For rapid deployment, traffic cones and barricades are stored in the main highway shop and in the five district shops. The DPW Superintendent has the formal authority to close roads. District foremen make on-site decisions based on an assessment of conditions. Closed roads are then reported to County Dispatch.

No County roads are dead ends and most flood-prone roads have reasonable detour options, even if not officially posted. Because of the nature of the entire road network that is a combination of State, County, town and village roads, only some town roads serve locations that become isolated due to flooding. Only one incident in recent years involved a rescue from a flooded vehicle.

Although rare, in part due to limited access, DPW has used its own equipment to clear accumulating debris as floodwaters rose to reduce the likelihood of damage to a bridge.

When an event occurs that might qualify for a federal disaster declaration, whether in Allegany County or other counties in the area, DPW's staff prepares early estimates of damage. If the towns have experienced flooding they usually request assistance from the County to prepare their preliminary damage estimates. Depending on the magnitude of the event, SEMO personnel, accompanied by FEMA staff, may conduct additional assessments to check local estimates.

3.0 Overview of Local Decision Process

Allegany County characterizes its responsibilities in two statements:

1. Our job is to keep our roads safe, and
2. It's better to be proactive than reactive.

The highest priority work is to repair or replace crossings that sustain structural damage, such as when flooding undermines piers and abutments. Priorities also are driven by NYSDOT's inspections of bridges longer than 20-feet, if needed to address a safety concern or if a bridge has to be posted with weight limits. The results of the County's inspections (Sufficiency Ratings and Condition Ratings) are used to prioritize remaining work. The number of capital projects and bridge rehabilitation projects undertaken in a given year is a function of the budgets, which in turn are in part driven by the DPW's list of priority projects.

The fact that a given crossing may be subject to flooding and not have the preferred hydraulic capacity does not, by itself, automatically create a priority situation. However, the County's objective to improve flood resistance combines with other factors to help determine priority projects.

A formal methodology is not used to guide decisions related to selection of specific bridge types and dimensions (for replacements). The decision process is not linear and one decision does not flow directly from another. The process is iterative and fluid to be able to account for consideration of many factors simultaneously. The process is, in large measure, based on experience and the types of sizes of structures that can be built by the County's Bridge Construction Crew. For example, configurations that are within the capacity of the crew will be examined thoroughly before a determination is made that a different or larger types of structure is appropriate. Every step in the process is not documented for each project. Simplified computations are used to look at adequacy and capacity of alternative structure sizes to carry flood discharges, but there is no specific frequency flood event that is mandated to force decisions.

Pavement decisions are more straightforward because there are fewer variables. The most significant factor is the availability of CHIPS funding. In recent years, as the County shifts to a road-by-road maintenance program to improve efficiencies, the selection of roads for repaving is strongly influenced by length of time since the last repaving. At recent CHIPS funding levels, the County is on about a 15-year repaving cycle. Citizen complaints and inspection reports set priorities for where patching work is performed.

3.1 Factors Considered in Local Decisions

When determining which bridge projects to undertake, the factors considered in the general order of importance include:

1. Structures on roads where pavement replacement is already planned are high priority because doing the work prior to paving is more efficient in terms of labor and equipment use;

2. Results of State and County inspections and identified deficiencies, especially if weight limits are indicated;
3. Frequency of flooding (access limitations) or flood damage;
4. Equitable distribution of funding by legislative district;
5. Available funding in the budget categories for materials and capital projects; and
6. Traffic volume and population density (when there are competing demands).

Decisions related to design and costs are made by the Public Works Engineer and the Deputy Superintendent and factors considered include:

1. Whether desired objectives can be achieved with a structure that can be constructed by the County's Bridge Construction Crew with the County's equipment;
2. The extent to which hydraulics can be improved, even if doing so increases costs somewhat;
3. Presence of a center pier and whether it can be removed as part of a replacement project (especially if the resultant longer span structure can be built by the County's crew);
4. Soundness of existing abutments and whether the superstructure can be raised without construction of new abutments; and
5. Whether installing sheetpiling at inlets improves flow efficiency and limits scour.

The district foremen of the five road maintenance crews generally determine the priority of their work. Work on shoulders is determined by two primary factors: whether repair of flood damage is required, and when road paving is scheduled. Work on drainage ditches and pipes is determined by three primary factors: whether repair of flood damage is required, inspection reports, and when road paving is scheduled.

3.2 Flood Resistance and Risk

The DPW's primary goal is to provide safe roads for the traveling public. The concept of acceptable risk is incorporated in how the Department executes that goal without using the term. Risk, as associated with the safety of the traveling public, is distinct from measures undertaken to reduce future flood impacts. Because of the number of flood-prone crossings and the frequency that many are flooded, any measures that can reduce the severity and/or frequency are considered to contribute to acceptable flood resistance – even if that level of performance does not address the 100-year flood discharge.

The Deputy Superintendent identified several factors that contribute to a flood-resistant local road system:

- Regular maintenance of bridges and roads,
- Clean ditches to facilitate drainage,
- Solid shoulders to minimize erosion or failure of the road base,
- Removal of stream debris at culverts and bridges,

- Improving hydraulics to the extent practicable when a bridge or culvert is replaced, and
- Allowing overbank flows through relief culverts under the road approaches or over low spots.

3.3 Considering Benefits and Costs

When making decisions about its local road system, the DPW does not apply a formalized computation of benefits and costs as part of evaluating alternatives. The standard practices and approaches considered are, in large measure, based on long-term experience, not only experience with what works, but what works well given constraints of a modest budget.

The above-average capacity of the DPW's in-house Bridge Construction Crew and County-owned heavy equipment has bearing on costs, and thus is a significant component of design decisions and other decisions made by the Department's management and the Public Works Engineer. County labor and equipment costs are considerably lower than contractor costs.

Regardless of actual traffic loads, the County elects to design its bridges that are less than 20-feet for the same loads that NYSDOT requires for federal-aid system bridges, while also accounting for future extra dead load due to two overlays of asphalt surface. For County roads, this load is higher than necessary given the current inventory of fire trucks, heavy industry trucks, milk trucks, and logging trucks. This practice provides a measure of safety and lengthens the useful life of structures in the event truck loads increase in the future. The incremental costs are not determined on a case-by-case basis and the increased cost is not a determining factor.

With regard to paving, the County has determined that it is too costly to tack between pavement layers. Although doing so would reduce separation associated with freeze-thaw cycles, the additional cost is viewed as too high compared to the cost to repair separations that do occur. Given that flood-related pavement failure appears to be directly related to shoulder erosion and base failure, this decision is not based on or influenced by flood-resistance, and there is no evidence that applying tack would reduce flood-related damage.

4.0 Site-Specific Examination of Decisions

4.1 County Route #19 over Spring Mills Creek

Located in Allegany County's extreme southeast corner, County Route #19 is a low volume road that carries fewer than 250 vehicles a day. The bridge over Spring Mills Creek is just west of the intersection with County Route #19A. The original bridge had flooded many times. The primary objective examined during consideration of alternatives was improvement of safety by realigning the road and nearby intersection. The alternative selected was an entirely new bridge, built just downstream of the old bridge. The work was completed in 2003.

As shown in Figure 10, the old abutments were left in place immediately upstream of the new bridge. There was no evidence of scour, suggesting their effectiveness as erosion protection. Leaving the abutments shortened the period of construction, minimized in-stream disturbances, and will help align flows into the new bridge.

Figure 10. New County Route 19 bridge over Spring Mills Creek

Following the County's standard practice, the replacement bridge opening was selected to improve conveyance of flood flows. The new bridge is the same width as the old bridge and approximately 2 feet higher (for a total of about five feet above normal water surface). This configuration was selected after an in-house determination of the discharge for the 100-year flood (using methods described in Section 2.3).

Despite the conservative design discharge, the bridge was overtopped by approximately 2-feet of water due to a very intense local storm in 2003. Post-flood inspections indicated no structural damage and a re-verification of the discharge used for design confirmed its validity.

Allegany County's Hindsight Assessment. The new bridge performed well under flood conditions which were considerably more severe than the 100-year flood discharge determined by the DPW. The project met the Department's objectives and the Deputy Superintendent did not identify any aspect of the project that should have been done differently.

4.2 York's Corner: County Route #29 over the Genesee River

County Route #29 over the Genesee River in the area known as York's Corner was replaced in 2002. Subsequent flooding in August 2003 and Spring of 2004 demonstrated the effectiveness of the project, which was intended to improve access during most flood events and to reduce flood damage to the road bed and shoulders. The road carries a fairly low vehicle count, but

includes logging trucks that are an important economic factor in this part of the County. The old bridge was posted with a weight limit of 20 tons.

Figure 11. Ice jamming at the old York's Corner bridge

The old bridge was subject to nearly annual flooding, including ice-jamming in the winter (Figure 11). With low approach roads and the bottom of the 80-foot clear span girders barely 3 feet above normal water level, access was severely restricted during high water. The road was closed frequently, not only when water covered the road, but also when water levels approached the bottom of the superstructure, even if the road was not affected. Because the road surface was so low, frequent flooding had caused pavement and shoulder damage but did not result in scour or structural damage. The nearest bridge over the Genesee River that was accessible when the old York's Corner crossing was closed is State Route #19, just a few miles away, but the configuration of gravel town roads did not provide easy access to that bridge, especially by heavy logging trucks.

In another part of the County, nearly 30 miles north, County Route #4 spanned an abandoned railroad right-of-way. Built with four 140-foot long steel plate girders, this bridge was among the inventory inspected by NYSDOT every two years. The girders were sound and investigations indicated that the County road could readily be regraded with cut and fill after removal of the bridge. The County elected to recycle the valuable girders as part of the York's Corner bridge replacement project.

Despite a history of frequent flooding, the York's Corner bridge replacement project was not prompted by a specific instance of structural damage and FEMA funds were not involved. The project was paid entirely with local funds. The Public Works Engineer determined the span of the bridge, given the length of the recycled girders, and prepared the abutment design to provide the desired hydraulic opening (discussed below). A consultant designed the concrete deck in order to achieve the widest road possible. Construction was undertaken with both County forces and a subcontractor, given the equipment needed to remove, transport, and install girders of this size.

Table 4 compares the old bridge and the new bridge. The whole project was paid by the County and cost $756,000 ($136,000 for new abutments; $340,000 for superstructure (demolition, transport, installation); and $280,000 for approaches, guide rails, drainage, and paving). Benefits of the project include: reduced bridge inventory and maintenance requirements; savings by recycling; improved safety and accessibility during minor flood flows; and improved drainage.

Old Bridge	Characteristic	New Bridge
Thru girder	Type	Steel plate girders
80-feet	Waterway span	135-feet
20-feet	Road width	29-feet
±2-feet	Freeboard*	±7-feet
*distance from bottom of the superstructure to normal water level		

Table 4. York's Corner: old and new bridges

Because of the classification of the river and the fact that the project was not an in-kind replacement, the NY Department of Environmental Conservation was involved in decisions related to both the stream environment and floodplain impacts. The replacement bridge raised the driving surface approximately 6 feet, necessitating considerable floodplain fill. To avoid obstructing flow by the raised approaches, pipe culverts were installed on either side of the bridge to handle overbank flow. Although the approach roads remain subject to flooding, the expected frequency of inundation is considerably reduced.

Figure 12. New York's Corner bridge

To improve hydraulic performance, new abutments were constructed both higher and set back from the old abutments, which were left in place both for scour protection and to concentrate low flows for fish passage (Figure 12). The recycled girders are considerably shallower than the old superstructure. The end result is that the bottom of the replacement superstructure is approximately seven feet above the normal water surface. The County estimates that this bridge will pass the discharges associated with the 80-year flood, an acceptable level of performance for clear water flooding. More elevation was desirable to minimize ice jamming, but was not allowed due to the State's concerns about the damming effects of more floodplain fill for the approaches.

Allegany County's Hindsight Assessment. The Deputy Superintendent stated that the major objective of the project – reduction in frequency of flooding – was achieved, albeit not to the full extent preferred by the County due to limitations imposed by the NYS Department of Environmental Conservation. Approximately 10 months after construction was completed the Genesee River rose out of its banks. Although the discharge was not among the highest experienced at this location, it proved that the new bridge and approach road configuration achieved the intended objectives. Water rose to within 5-feet of the bottom of the superstructure of the new bridge and overbank flows were conveyed through the relief culverts without topping the approaches.

5.0 Observations

5.1 The County's Observations on Flood-Resistance

Allegany County has created and is implementing a long-term plan that specifically addresses local problems. The DPW officials do not believe that the same design standards used in urban areas should apply to roads with low and very low traffic counts, especially if there are few if any very heavy vehicles.

A major goal of the DPW is to achieve a good level of overall flood-resistance. However, due to the fact that there are about 170 bridges and large culverts that are more than 30 years old, at a rate of approximately 10 projects per year, achieving the goal will take time. To ensure that new structures perform adequately, for more than 20 years the County has deliberately factored improved hydraulics into its decisions for bridge and culvert replacements. All improved crossings built since this policy was instituted have performed well under flood conditions, which reinforces assumed benefits associated with the somewhat higher costs. The incremental costs to provide this level of improvement is characterized as relatively small because the majority of costs associated with construction of new bridges are labor costs. In most instances, labor costs are relatively insensitive to some changes in configuration, such as a longer span between abutments.

In Allegany County, approximately 60-70% of FEMA's public assistance Category C (roads and bridges) funding is used for ditch and shoulder work. A rigorous analysis has not been done, but experience in Allegany County indicates that it is not cost effective to change how ditches and shoulders are handled in order to protect against low probability events. Although a crossing is occasionally significantly damaged to a degree that requires replacement (usually because of unknown conditions due to lack of documentation on bridges older than 30 years old), most of the remaining 30-40% of FEMA's funds cover work associated with scour at bridge abutments and around culvert inlets.

The Deputy Superintendent asserted that the DPW would not change how it makes decisions and the type of restorative work that is performed if post-flood reimbursements were not provided by FEMA. However, the net effect would be an overall deterioration of the County's local road system because more of the County's funds would be spent on flood recovery, rather than on continual maintenance and scheduled upgrades. As it stands, the County is gradually improving the entire road systems, including pavement, shoulders, and bridges and culverts.

High Capability Bridge Construction and Maintenance Crews. The Deputy Superintendent repeatedly credited the DPW's ability to sustain its Bridge Construction Crew and heavy equipment as a significant factor that contributes to the high functionality of the local road system. Although other counties have some construction capacity, most do not have the same capability to build larger structures. Because County labor and equipment costs are considerably lower than contractor costs, the DPW can accomplish more bridge/culvert work than other jurisdictions with comparable capital budgets.

The importance of regular maintenance, especially when indicated by the periodic inspection reports, was also emphasized by the Deputy Superintendent. Having well-staffed Bridge Maintenance Crew that has ready access to the necessary vehicles, equipment, and stockpiled materials contributes to the overall performance of the County's road system.

The County's Inspection Program. The DPW elects to inspect all structures that are not inspected by NYSDOT as part of an overall philosophy that it is better to be proactive than to be reactive. Performed by an engineering technician/inspector, the inspections formally identify maintenance needs. Having a steady workload for the well-equipped and skilled Bridge Construction Crew and Bridge Maintenance Crew is an important part of the DPW's performance because it is more efficient and cost-effective to maintain that capacity than simply to react to demand, for example driven by flood damage.

For the most part the stream crossings that sustain flood damage, especially washout around culvert end treatments and bridge abutments, are those for which inspections indicated some maintenance needs, but which had not yet risen to a priority level, given constraints of funding and workload .

The State's General Permit. The majority of bridge and culvert work undertaken by the County falls under the conditions of the general permit issued by the NYS Department of Environmental Conservation. For other than in-kind work, improvement of hydraulic performance is behind a requirement related to flood resistance: the lowest structural member is supposed to be 2-feet above the 100-year water surface elevation if possible, or 2-feet above the 50-year water surface "provided that the 100-year flood can pass through the bridge opening without contacting the bridge's low structural member." DEC does not mandate how flood discharges and water surface elevations are determined; it specifies that generally acceptable practices be employed.

Allegany County has internalized the flood-resistance objectives set forth in the General Permit in that it uses what it considers to be conservative approaches when determining flood discharges and sizing bridge openings.

There have been instances where the County perceives that the State's environmental concerns limit effective stream channel maintenance by limiting the scope of work that can be performed under the General Permit. This occurs in the vicinity of road crossings where sediment and vegetation build up to the extent that flows are restricted. Although Individual Permits can be obtained, the process is overly complex for what the County asserts should be considered routine maintenance.

Influence of Floods. The Deputy Superintendent responsible for engineering and roads does not believe that flood damage to County roads can be attributed to lack of maintenance, given the County's extensive program for inspection and maintenance. In contrast, the towns and villages lack the same resources (staff, equipment, and budget) to perform the same degree of maintenance and do not routinely undertake work of the same magnitude, which does contribute to the greater degree of damage and higher costs for recovery.

Flooding occurs nearly every year in some part of the County. However, because the County performs routine inspections of bridges and culverts, it knows its problems and priorities and does not wait for damage to force prioritizations. A steady flow of funding leads to a higher performing local road system than does reliance on post-disaster funding.

After recent declared disaster the County is aware that it is possible to negotiate with FEMA to incorporate identified flood-resistant measures into work that is eligible for reimbursement. The

matter of documenting pre-flood conditions remains a concern despite the numerous photographs that the DPW keeps as part of its routine inspections.

Flooding adversely affects the County's routine maintenance and planned rehabilitation and replacement activities by, in effect, reducing the budget for those activities. If the County is not reimbursed by FEMA, then the year's budget for routine and planned work is depleted. If the County is reimbursed by FEMA, only 75% of the cost of certain work that is deemed eligible is restored to the budget. If a large project is eligible for reimbursement, a capital account is set up, and the County must pay for 12.5% of eligible costs (SEMO pays 12.5%) and all costs determined to be ineligible.

Post-Disaster Recovery. Work done in the post-flood recovery period is a significant component of improving the local road system's resistance to future flooding. The Deputy Superintendent, who has been with the County through five declared disasters, shared some observations about FEMA's processes and involvement:

- The County would find it helpful if changes in FEMA's processes could be communicated on a regular basis rather than only in the recovery period. This is especially important if there is a change in record keeping requirements. It is too late to learn about such changes at the Applicants' Briefing.
- Because of the County's ability to move quickly to perform emergency work – including design and construction of replacement structures – it has had some difficult negotiations with FEMA inspectors regarding eligible work that was performed prior to authorization. The County would welcome FEMA's advice on how to facilitate such instances in the future.
- Clearer guidance is needed regarding what constitutes mitigation as part of FEMA's Public Assistance and what documentation is required to justify such measures, especially if incorporating mitigation is part of the DPW's standard practices.
- Valid and documented local costs, which the County maintains by annual updates of bid prices for various road building materials and equipment, should be accepted for the purpose of FEMA reimbursements.

5.2 Case Study Team Observations

The Allegany County Department of Public Works demonstrates a number of effective ways to work within imposed constraints, notably budget limitations. Staffed by management and field personnel with many years of experience in the County, the Department has developed efficient processes for inspection, design, and construction.

The case study team made the following observations about significant factors that positively influence the flood-resistance of the County's local road system:

1. The Deputy Superintendent and Public Works Engineer are willing to look at a variety of solutions based on their experience that no single approach yields the desired results in every instance.

2. Use of methods to determine flood discharges and desired bridge openings that, in the County's opinion are conservative, appear to be justified given the good performance of bridges and culverts that were sized using these methods.

3. A major component of the DPW's overall goal to provide safe roads is to improve flood-resistance. Every bridge and culvert project is looked at with an eye towards doing something to increase hydraulic conveyance and to provide long-lasting scour protection for abutments and endwalls, usually by installing sheetpiling.

4. Maintaining the skilled Bridge Construction Crew and Bridge Maintenance Crew and providing high capacity equipment increases the County's ability to continually improve its local road system despite a modest budget.

5. The DPW's decision to use CHIPS funding only for paving instead of structures appears counter-intuitive on the surface. However, the decision is justified by County's lack of equipment to undertake large paving jobs combined with the desire to fully utilize the capacity of the Bridge Construction Crew (which costs less than if comparable work was contracted) on projects funded with County funds.

References

American Association of State Highway and Transportation Officials. *A Policy on Geometric Design of Highways and Streets.* 4th edition; 2001. [Referred to as the "Green Book"]

Hydraulic Design of Highway Culverts. FHWA-IP-85-15). Sept 1985 [we use for headwall, slope of pipe.

Federal Highway Administration. *Culvert Inspection Manual: Supplement to the Bridge Inspector's Training Manual* (Report No. FHWA-IP-86-2). U.S. Department of Transportation. July 1986

Selected Terms

Terminology & State Law (excerpts); Source: "NYS highway laws" online

§ 230. Definitions. As used in this article the following terms shall have the following meanings:

1. "Bridge" means a structure including supports erected over a depression or an obstruction such as water, highway, or railway, having a track or passageway for carrying traffic or other moving loads and having an opening measured along the center of the track or roadway of more than twenty feet between under croppings of abutments or spring lines or arches, or extreme ends of openings for multiple boxes and may include multiple pipes where the clear distance between openings is less than half of the smaller contiguous opening. The term bridge, as defined in this section, shall also include the approaches.

2. "Culvert" means a structure whether of single or multiple span construction within an interior width of twenty feet or less when measurement is made horizontally along the center line of roadway from face to face of abutments or sidewalls immediately below the copings or fillets; or, if there are no copings or fillets at points six inches below the bridge seats or immediately under the top slab in the case of frame structures. In the case of arches, the span shall be measured from spring line to spring line. All measurements shall include the widths of intervening piers or division walls as well as the width of copings or fillets. The term culvert, as defined in this section, shall also include the approaches.

3. "Publicly-owned, operated or maintained" means a bridge that is owned, operated or maintained by any department, board, bureau, commission or agency of the state or its political subdivisions, public benefit corporation or by any public authority including the port authority of New York and New Jersey.

§ 232. Uniform code of bridge inspection [selected portions excerpted]

2. Periodic inspections. Any bridge publicly-owned, operated or maintained shall be inspected at least once every two years in accordance with the provisions of the code and shall be further inspected and/or evaluated at such other times as may be required therein. The code shall also set forth requirements for the interim inspections or evaluations and the scope of such inspections or evaluations where the structural integrity of a bridge is or has been threatened by a storm, flood, natural phenomenon, accident or manmade occurrence; where a bridge has known deficiencies; and where a bridge is posted for weight limits less than that which is legal on the highway leading to or from the bridge.

§ 234. Public authority, public benefit corporation, commission, county, town, city or village bridges.

1. a. All public authorities, public benefit corporations, commissions, county superintendents of highways, town superintendents of highways, and legislative bodies of cities and villages shall cause an inspection to be made of each bridge under their respective jurisdictions. Such inspection shall be made on a frequency and shall be conducted under standards prescribed by the commissioner pursuant to rules and regulations adopted in accordance with this article.

b. The cost of the inspection of any bridge owned by a public authority or a public benefit corporation shall be the responsibility of such public authority or public benefit corporation.

AmericanLifelinesAlliance

A public-private partnership to reduce risk to utility and transportation systems from natural hazards and manmade threats

Flood Resistant Local Road Systems

Appendix D: Calhoun County, IL

January 2005

www.americanlifelinesalliance.org

This report was written under contract to the American Lifelines Alliance, a public-private partnership between the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). This report was reviewed by a team representing practicing floodplain managers, water resources engineers, civil and structural engineers, and public works manager

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1.0 Calhoun County, Illinois

Calhoun County is located in western Illinois, about 80 miles southwest of Springfield (Figure 1). It is a narrow peninsula, approximately 37 miles from north to south and between 3 ½ to 17 miles in width from east to west, bounded by the Mississippi and the Illinois rivers, whose confluence is situated at the southeastern tip of the County. Access to the County is limited. There is only one bridge linking Calhoun County to Illinois to the east near the County seat, Hardin. Ferries near the Village of Kampsville to the north and near the southern end of the County compensate for the lack of bridges. There are no bridges crossing the Mississippi River to Missouri; all traffic is by ferry. The only roads in and out of the County are at the northern end crossing into Pike County.[1]

Figure 1. Location Map.

According to the Illinois State Geological Survey, the total land area is 281 square miles and the average percent slope is 3.55%. There are two dams located on the Mississippi River adjacent to the County, Clarksville Lock & Dam Number 24 near its northern end and Winfield Lock & Dam Number 25 near its southern end. Approximately 30 river miles down stream below the confluence of the Mississippi and Illinois rivers is the Melvin Price Locks & Dam Number 26. The latter dam is situated upstream, just north, of the confluence of the Mississippi and the Missouri rivers.

Calhoun County was one of a few areas in Illinois not to be glaciated during the Illinoian stage of Pleistocene glaciation. As a consequence, Calhoun County is not as flat as surrounding areas. It consists of generally rugged terrain with river bluffs, limestone cliffs, and ravines, as well as extensive wetlands adjoining its bordering rivers near their confluence. Its highest peak is about 400 feet above its lowest level. The river system landscape is a spider web-like network of numerous drainage pathways, both underground and on the surface, that converge into creeks and small streams, which become progressively larger as the water moves on downstream, eventually reaching either the Mississippi or Illinois rivers. Because of the narrow width of the County and small drainage areas (most under 1 square mile), the longest streams measure just a few miles in length and others are considerably shorter.

In 2000, the total population of Calhoun County was 5,069, roughly 5% less than 1990. About 1,000 of those residents live in the five incorporated villages, of which Hardin is the largest. Most of the County's inhabitants live in rural settings and make their living through farming. A large percentage of the residents, possibly over half, have lived in the County their entire lives.

[1] The two main roads between Calhoun and Pike Counties are not susceptible to flooding damage near their common border.

There is very little new construction in Calhoun County. Currently, there is one small housing development that will take many years to complete. A subdivision of ultimately 50 or so homes is being constructed above the 100-year floodplain atop low cliffs overlooking the Mississippi River near a ferry landing that links to Missouri above the city of St. Charles. The houses are upscale, more expensive than average homes, but less expensive than equivalent homes on the opposite Missouri side of the river, and thus attractive to retirees and workers from the St. Louis metropolitan region.

1.1 The County Unit Road District

The Calhoun County Unit Road District (URD) has a staff of 13 full-time and 2 part-time personnel headed by the County Engineer, who is the only Professional Engineer on staff. The County Engineer, who was hired in this position 11 years ago, was born and raised in the County and was trained in mechanical and materials engineering. Prior to this job, he spent over 20 years in the power industry. A Field Supervisor, a 25-year employee of the URD and a lifetime resident who has an encyclopedic grasp of every road, is the County Engineer's "right hand man."

The road system is divided into three sections, roughly splitting the County into thirds from north to south. A foreman heads each section and has general responsibility for inspection and maintenance. However, irrespective of title, each URD employee is considered a "utility player" and can perform all the basic tasks required of URD employees. Because there are so few employees, everyone can be and is assigned work throughout the County, depending on need. About half the time, the road crews work on routine jobs that include patching, ditch maintenance, mowing grasses along the shoulders in the summer, and snow removal in the winter. For the other half of the time, the County Engineer creates a schedule for each day's work, which usually includes grading and paving, and any large or unusual job that requires most, if not all of the staff. Interactions between the County Engineer and staff are informal; reports to superiors are made verbally, in person or by two-way radio.

When he took his job, the County Engineer reported that most of the roads were gravel, many existing bridges and box culverts were old and in poor condition, and there were many low-water crossings, locally referred to as "creek crossings." He came on board less than two months before the 1993 Mississippi River flood (the flood of record) that caused significant damage in the region. After seeing the damage and believing that repairs alone would not provide long-term flood solutions, he set goals to replace all gravel roads in the hills with oil and chip paved surfaces, to build new structures in place of creek crossings, and to replace all old bridges and box culverts. In the process of replacing gravel roads with paved surfaces, he also planned on putting in larger diameter culverts and drainage pipes to increase flows under the roads, thereby reducing back up, overflows and shoulder scour.[2]

[2] The budget surplus at the time and how the County Engineer was able to secure funding for these efforts are discussed in several sections below, including Sections 1.2, 1.3, 1.5, and 2.1.

1.2 The County's Local Road System

Calhoun County uses a classification system defined in the Roads and Bridges section of the Illinois Highway Code (Table 1). There are two designated "State Highways," four designated "County Highways," and approximately 125 designated "Township Roads." The State and County highways are the main arteries and have Average Daily Traffic (ADT) counts between 750 and 3,500 vehicles according to the 1998 Traffic Map prepared by the Illinois Department of Transportation (IDOT), the most recent map that URD has received. For the most part, they are north-south roads paralleling the bordering rivers and linking residents to the County's five villages, bridges and ferry crossings on the east and west or to Pike County to the north. They are also part of the Great Rivers Scenic Byway where the Mississippi, Missouri and Illinois rivers meet. The Township Roads are rural low-volume roads with ADT counts generally less than 25, except for a few that intersect the State or County highways near the villages, bridges and ferry crossings that are minor connectors with ADT counts of nearly 500 vehicles. Most of the Township Roads are east-west roads, short, hilly and winding that link farms and rural residents to the State and County roads.

Classification	Road Miles
County Roads (Federal Aid System)	36.38
Federally Assisted Township Roads	10.51
Township Roads (TR)	250.50

Table 1. Road Mileage, by Classification

The State Highways, as well as the bridges and box culverts on them, are maintained by the State. Four County Highways and two Township Roads are designated as Federal aid system roads (FAS); they are physically maintained by the URD, but supported by an allocation of Surface Transportation Repair funds that require a local cost share. The two FAS township roads are included in the Township Road system and bring additional revenue to the URD because important sources of State funding for local roads are based on Township Road mileage. All the remaining Township Roads that do not receive federal aid are owned by the County and maintained by the URD. In addition to County roads, the URD is reimbursed by the villages to maintain all the oil and chip village roads except in the small village of Batchtown. All the villages either have small road crews for routine maintenance of their streets or contract for services.

As stated above, in 1993 most of the Township Roads were gravel. Almost immediately following the 1993 flood, the County Engineer began the process of converting gravel roads to oil and chip for the explicit purpose of improving flood resistance and reducing maintenance costs. At the time, an existing surplus in the Unit Road District – Motor Fuel Tax Fund was tapped to convert 20 to 30 miles per year for several years until the surplus ran out. The average cost to convert a mile of road was about $20,000. Section 2.1 includes additional detail on the budget and sources of funds.

In 1993, despite having old and inefficient equipment, the URD attempted to complete the paving work with its own staff and equipment. Later in the decade, the County Engineer determined that it would be more economical to purchase more efficient oil distributors and

additional graders. As of the last year, the County Engineer stated that all the significant roads in the hills maintained by the County had been converted from gravel to oil and chip. The only gravel roads that remain are either very lightly used roads in the hills or in low areas or bottoms not subject to heavy rain damage. Now that the significant roads in the hills have been paved, the lower priority gravel roads are next in line to be paved. Using Motor Fuel Tax (MFT) funds received each year, the current conversion rate is 2 to 3 miles each year. Currently, as shown in Table 2, over 80% of all Township Roads are now paved using oil and chip.

Road Surface Type	Miles
Gravel	43.15
Oil and Chip	217.86

Table 2. Township Road Surfaces.

The URD is not constructing any new roads. However, the County will take ownership of roads built by developers who build new subdivisions. As of mid-2004, the contractor for the only subdivision being developed, following State guidelines, has constructed a half-mile of roads (of a projected total one-mile). When the entire project is completed the roads will be turned over to the County for maintenance.

1.3 The County's Local Bridges and Box Culverts

The Unit Road District is responsible for the maintenance of County and township bridges and box culverts, all of which are owned by the County. There are nine County bridges and seven large box culverts between ten and twenty feet in length that are monitored by the URD. There are also 41 township bridges and 5 identified box culverts. In addition, the County has taken responsibility for inspection of four village bridges.

The bridges and large box culverts are typically located over streams that do not often flood. They are in low-lying areas along the bordering rivers away from the hills and not highly prone to flash flooding or backwater. Two of the bridges were replaced in 1991 and 1994 through the federal bridge replacement program. None of the bridges or box culverts has been severely damaged from recent floods.

The township bridges are typically located near the confluence of two major streams near the downstream end of small drainage basins where one of the streams needs to be crossed to provide access to the upper watershed. They are often just inland of the State or County roads, and because of location, are subject to both flash flooding and backwater from the Mississippi or Illinois rivers.

Between 1978 and 2000, twenty-five township bridges were either replaced because of flood damage or planned replacement or are now scheduled for replacement (details on work completed after the floods in 2001 and 2002 were not available). During that same period, five new bridges were built to replace creek crossings. When the queue of bridges scheduled for replacement is exhausted, only 11 of the township bridges built before 1978 will remain. All but one of these older bridges was built between 1900 and 1937. The URD's policy is not to

rehabilitate old bridges, so it is just a matter of time before these are replaced. Reasons for this policy include (1) federal funds are only provided for bridge replacement, and (2) old bridges generally were constructed with wooden abutments that have deteriorated and the County Engineer wants them replaced with reinforced concrete structures.

Like the township bridges, the village bridges are located in high potential flood areas near the confluence of two streams at the downstream end of a drainage basin. All four of the bridges have been built or replaced since 1977.

As noted above, the URD keeps track of 5 large box culverts along township roads. Most were built early in the century and none have been severely damaged from flooding. It is estimated that there are also several small box culverts per township road mile or over 1,000 in all, which are not regularly monitored. Most are less than four feet in length, permitting water to drain from farmland to the main streams along preexisting small creeks or man-made drainage diversions. Whenever any are damaged and need repair or replacement, they are considered as part of road repair and usually replaced with larger diameter pipes or recycled railroad tank cars.

Many of the old creek crossings now have permanent bridges. The twenty or so low-water crossings that remain are in extremely remote hill locations and are very lightly traveled. The URD's long-term objective is to build bridges for these locations in order to provide year-round access to remote areas and to maintain the integrity of the creeks. A number of these bridges are currently in the planning stage. To maintain serviceability of these crossings during the Fall and Winter when creek levels rise, the URD implements emergency measures for each crossing in the following fashion: (1) a length of culvert pipe and a pile of large gravel are stored nearby; (2) in the Fall, the pipe is laid in the creek and a crossing road is formed with the gravel; and (3) following the Spring rain, when the creek falls to lower levels, the gravel and pipe are removed and placed to the side, restoring the low level creek crossing.

1.4 History of Flooding in Calhoun County

There are three types of flood scenarios that affect Calhoun County. First, the County may flood whenever there are large flows from the upper Mississippi River Basin, normally occurring after the combination of winter snowmelt and excessive spring rain. When the Mississippi rises to near flood levels, the U.S. Army Corps of Engineers may close Locks & Dam Number 26 downstream of the County to limit the flow past St. Louis. When that occurs, the County Engineer believes the water level rise behind the Locks & Dam increases the threat of flooding.

The second type of flooding is associated with the County's topography and location where cool, dry northern and warm, moist, unstable southern weather systems often collide. The region is subject to potential heavy rains at all times of the year. Whenever a downpour of 3 inches or more falls in an hour in one or more drainage basins, the runoff in the affected areas may cause flash flooding. Typically, because storms are isolated and move through quickly, an entire flood event will usually take place within a 12-hour period. On rare occasions, rainfall may persist, and the duration of flooding will exceed 12 hours.

The most serious damage occurs in a third scenario when both of the previously mentioned flood scenarios occur concurrently. When that happens, the pools in the Mississippi and Illinois rivers will rise to a height that saturates the low areas and backs up streams preventing runoff from reaching the rivers. The result is a combination of upper watershed flash flooding, lower watershed flooding due to a combination of excessive stream flow and river backwater, and flooding all along the major rivers. Potentially, the most severely affected structures will be the village and township road bridges.

As displayed in Table 3, Calhoun County has been part of declared disasters 15 times between 1969 and 2002, and the events have occurred in all seasons. Most of these events were associated with sudden downpours. The County Engineer reported that flooding of this nature occurs every year, often more than once. He also noted that one time in 1994, there were landslides in the upper watershed caused by a combination of heavy rainfall and previously saturated soils.

Date of Declaration	Description	FEMA DR#
06/06/1969	Flooding	262
08/30/1969	Heavy rains & flooding	276
04/27/1973	Severe storms & flooding	373
06/13/1974	Severe storms & flooding	438
04/30/1979	Severe storms & flooding	583
12/13/1982	Severe storms, tornadoes & flooding	674
06/06/1983	Severe storms, tornadoes & flooding	684
03/29/1985	Severe storms & flooding	735
10/14/1986	Severe storms & flooding	776
08/02/1990	Severe storms, tornadoes & flooding	871
07/15/1993	Severe storms & flooding	997
05/12/1994	Severe storms and flooding	1025
06/16/1995	Severe storms and flooding	1053
06/07/2001	Flooding	1368
06/06/2002	Severe storms, tornadoes and flooding	1416

Table 3. Major Disaster Declarations (as of mid-2004).

Not all floods, however, have been part of Presidentially declared disasters. The dollar amount of damage resulting from a downpour in Calhoun County is normally not sufficient to meet the minimum threshold needed for a disaster to be declared; other counties in the State must also suffer damages before the Governor requests a disaster declaration. The second most frequent cause of flooding occurs when the upper Mississippi River floods and there are coincidental downpours, which has occurred in 1973 and 1993. In the County Engineer's opinion, flooding is exacerbated when water is held back at Locks & Dam Number 26.

In addition to being affected by the dams on the Mississippi River, Calhoun County also is affected by the La Grange Lock & Dam about 60 miles upstream on the Illinois River. The level of the Illinois River is regulated as it passes the County, and as a consequence of dam management, no recent floods have resulted from Illinois River flows.

1.5 Impacts of Flooding on the Road System

The County Engineer and Field Supervisor both commented that since 1993, when the County Engineer was appointed, the general performance of the County road system has improved considerably, from poor to very good. Eleven years ago, the road system consisted of mostly paved roads in the low flat bottom areas and mostly gravel roads in the hills. During rains, the gravel roads and shoulders would scour dramatically, and stream banks adjacent to the roads would erode, often cutting into the roads. Many times, bridges at the downstream end of drainage basins would be severely damaged, requiring replacement.

Following the 1993 floods, the County received over $500,000 from FEMA for road and bridge repair and replacement and $5,000,000 from the National Resource Conservation Service (NRCS) for bank stabilization as part of its Emergency Watershed Protection Program. The local NRCS agent, who oversaw the bank stabilization program in Calhoun County, noted that the federal government paid 100% of the costs because Calhoun County was identified as a poor, needy county. Approximately 50 to 75 sites were stabilized with gabion baskets and grouted riprap and some with additional instream installations called barbs and riffles to direct stream channels away from the roadside stream bank. NRCS financed, managed, and oversaw all stream bank stabilization work.

By way of comparison, following the 2002 floods, the URD received approximately $400,000 from FEMA and $436,000 from NRCS and the URD paid the full local share of 25% required by FEMA and NRCS. However, between the 1993 and 2002 events the URD had increased its manpower and equipment capacities to do all repair and replacement work with its own resources. Because the URD performed all the work, it was able to begin recovery work immediately. A significant financial consequence was that the total cost of the work was much less than that if the work was performed by outside contractors. In fact, all that was needed administratively was as an accounting transfer of the local share from a general URD fund account to another account that reimbursed the URD for costs related to labor, equipment rental, and materials that were approved by the federal agencies. Because out-of-pocket costs (mostly materials) were less than the 75% paid by the federal agencies, there was a positive net inflow of funds into the URD.

2.0 Environment within which Calhoun County Operates

2.1 Overview of Roads Budget

The annual budget of the URD is part of a complicated County budget system whose main revenues come from dedicated federal, State, and County funding sources.[3] As an independent entity, the URD budget is not set solely by the County Council, although the Council approves it, and thus is not directly subject to the political process. The County keeps track of its receipts and disbursements in a series of independent funds that may receive revenues and to which expenses may be charged. Funds may run surpluses or deficits, and interfund transfers are often used to cover deficits.

The annual budget over the past 5 years has grown from approximately $1 million to $1.8 million, with most of the increase due to federal disaster-related payments resulting from Presidentially declared disasters in 2001 and 2002. There is no capital budget; capital expenditures are itemized in the annual budget. By way of comparison, the annual budget for the rest of the County has remained relatively stable at $1 million. Neither the URD nor the County has any long-term debt.

Before the fiscal year, the URD estimates the amount of revenues that will be forthcoming from dedicated sources. As a rough rule of thumb, the total is approximately 3% larger than the previous year. There are eight basic funds that may receive local and State revenues and to which expenses can be charged, and estimates for each must be provided. Table 4 lists the funds and their primary sources of revenue.

Budget Funds	Funding Sources
Highway Department – General Fund	Local Property Taxes
County Road and Bridge – General Fund	Local Property Taxes
County Motor Fuel Tax (MFT)	State MFT Program; State "County Needy Program"
Federal Aid Matching Fund	Local Property Taxes
Township Bridge – General Fund	State Bridge Rehabilitation Program
County Highway Rock and Gravel	(Currently Inactive)
Unit Road District – Bridge Fund	Local Property Taxes
Unit Road District – Motor Fuel Tax Fund	State MFT Program; State "County Needy Program"

Table 4. County Budget Funds and Funding Sources.

The funds provided to URD come from sources that use formulas to determine amounts. Four funds are based on a portion of local property taxes. The County Motor Fuel Tax (MFT) comes from two sources: (1) MFT funds based on the number of vehicle registrations in the County; and (2) County Needy Program funds based on a complicated formula that includes township mileage and the County tax base (total assessed value). In 2004, Township Bridge – General

[3] There is no published annual budget. Information in this section is based on two documents produced by the County's outside auditor, the *Calhoun County, Illinois Report and Financial Statements August 31, 2003* and the *Calhoun County, Illinois Budget and Appropriations Ordinance Fiscal Year ended August 31, 2004.*

Fund revenue was calculated as $209.45 per township mile and Unit Road District – Motor Fuel Tax Fund revenue was $1,375.84 per township mile. Formulas in State funding programs are adjusted annually depending on total receipts and political choices.

In addition to these eight independent funds, there is a comprehensive account, the "Unit Road District – General Fund," which comes closest to what the actual budget might be.[4] It includes all the funds listed in Table 4 that receive money from the State of Illinois and all discretionary income from local and federal sources related to roads and bridges. Sources of local revenues include reimbursements from villages for work provided and payments from private citizens for oil and chip paving of private roads.

Federal sources include Bridge Repair Program (BRP) funds from federal gas taxes and Surface Transportation Repair (STR) funds that reimburse the URD for costs expended on FAS roads. In the aftermath of Presidentially declared disasters, the URD has also received federal disaster-related funds from FEMA, the Department of Agriculture's Natural Resource Conservation Service (NRCS) and Farmers Home Administration (FmHA). The receipt of these funds is initially posted in the County Disaster Fund. In the past five years, the amount received annually has been less than $300,000 on one occasion, and revenues have ranged from $62,000 in 2001 to $778,000 in 2003. When spending is budgeted, the funds are transferred to other accounts, most (including all the funds from FEMA and the NRCS) are transferred to the Unit Road District General Fund and the remainder (from FmHA) into the County Highway Fund.

In the latest fiscal year ending August 30, 2004, the Unit Road District – General Fund included a total of $1,828,230 in revenues from all sources. Of that, 63% came from annual County, State, and federal sources and 16% came from disaster related sources. The single largest traditional source of funding is from the State's Motor Fuel Tax disbursements (28%). The Unit Road District – Motor Fuel Tax Fund contributed 20%, the Township Bridge – General Fund 3%, and the County Motor Fuel Tax Fund 5%. While it is possible to identify fund sources, disbursements are aggregated by labor, materials, equipment, etc., not by contracts or individual projects. Thus, it is not possible to determine differences between activities that are covered by normal budgeted funds and work that is reimbursed from federal disaster programs.

After revenues have been estimated, costs are estimated to balance the account, a requirement of the budgetary process. The FY 2004 Unit Road District – General Fund covers costs for Labor and Expenses ($470,000), Materials ($500,000) and Capital Outlay – Equipment ($250,000). Except for labor expenses, the estimates are generally not indicative of actual expenses. Severe weather events which occur frequently may change the demand for certain activities during the year, forcing adjustments in spending. In addition, the County Engineer has discretion to adjust spending as he sees fit. Actual expenses have differed from original estimates by about 25% in previous years. When flood damage is minimal, actual revenues will typically exceed actual costs, providing a surplus to this account. Currently, several funds have surpluses which are invested to provide additional revenues.

[4] This account tracks most of the URD revenues and expenses from the eight funds listed in Table 1-3 plus additional revenues and expenses from other funds. However, it may understate the actual budget by 10% because entries in other road-related funds are not included. Because the auditor's reports contain no explanations of differences in accounts and no details of interfund transfers, no attempt has been made to create an actual budget.

Replacements for the old bridges and box culverts, as well as new bridges replacing creek crossings, are paid for using funds from three sources: (1) federal bridge funds to replace structures whose Sufficiency Ratings are below 50 or construct new bridges; (2) FEMA Public Assistance funds for box culverts damaged during floods; and (3) earmarked State funds to replace Township Bridges with Sufficiency Ratings below 50. Funds from these sources are not commingled. After sufficient funds are received from any of the three sources to pay for a new or replacement bridge, bridge design and construction will take place. Currently, the URD can replace about one bridge every two years using Bridge Replacement Program funds.

Township Bridge replacement is funded by the State Bridge Rehabilitation Program, which now provides about $55,000 per year from the State Motor Fuel Tax fund. In the past, one bridge could be replaced every two years. However, the construction and material costs have gone up in recent years such that the sum of receipts from two consecutive years is not quite enough to pay for a new bridge whose cost is currently estimated to be $120,000. The County Engineer forecasts that over time the gap between annual funds received and bridge costs will grow, slowing bridge replacement using this funding source.

It was stated previously that the County Engineer is determined to replace gravel roads with oil and chip. One reason is to reduce damages from flooding and another is to reduce maintenance costs. According to figures provided by the County Engineer, the current annual cost of maintaining one mile of gravel road is $4,360 and the annual cost of applying normal oil and chipping is $1,000 using County-owned equipment (see Table 5). A direct result of the switch to oil and chip is that all the roads maintained by URD can be resurfaced every three years. When the majority of roads were gravel, the URD could only maintain the main roads and those damaged in disasters.

Road Surfacing Method	Materials and Labor Used	Cost/Mile
Gravel	Blading Gravel (Uniform 1-inch)	$ 500 $3,850 Total: $4,365
Oil and Chip	Oil and Chip	$1,000

Table 5. Road Surfacing Cost per Mile

2.2 Regulatory Framework

The Calhoun County Unit Road District contracts out the design of all bridges to consulting engineers who also are tasked with performing hydraulic assessments and securing all necessary permits. Because Calhoun County is rural with small drainage basins, it qualifies to use the fast-track permit approval process under "Statewide Permit No. 2 – Rural Bridges Over Streams Draining 10 to 25 Square Miles." Application for the permit is submitted jointly to the Illinois Department of Natural Resources, Office of Water Resources (DNR/OWR), the U. S. Army Corps of Engineers, and the Illinois Environmental Protection Agency. Because there are Native American archaeological sites throughout Calhoun County, the application is also submitted to the Illinois Historic Preservation Agency.

Securing approval of individual projects under Statewide Permit No. 2 is a streamlined process that was introduced to reduce unnecessary delays in the approval of bridges that have little likelihood of causing significant flood damage due to changes in the floodplain, including the impacts of backwater flooding. The permit applies to both new and replacement structures. In order for a project to be approved under Statewide Permit No. 2, two certifications are needed. First, an Illinois registered professional engineer must certify that the bridge has been designed using standard hydrologic and hydraulic engineering methods and that it complies with the terms and conditions of the Permit and applicable rules of the DNR/OWR. Second, a second Illinois registered professional engineer must review the design and find the hydrologic and hydraulic design of the bridge to be in compliance with the terms and conditions of the Permit and applicable rules. If the applicant chooses to proceed through the normal review process, as URD has consistently done, the second certification can be skipped and the DNR/OWR staff reviews the bridge design.

In order to be authorized by this permit, bridge and culvert structures must meet the following special conditions:

1. In the case of a replacement bridge or culvert structure which the appropriate Department of Transportation, Division of Highways' District Engineer certifies as not having been the cause of demonstrable flood damage and which would not involve any appreciable raising of the roadway, the proposed replacement structure must provide at least the same amount of effective waterway opening as the existing structure.
2. A new bridge or replacement bridge which would involve raising the roadway must be:
   (a) Designed such that it will not result in an increase in water surface profile elevation in excess of 1.0 foot over the unencroached condition for any frequency flow up to and including the 100-year frequency flood;
   (b) Designed such that it will not result in an increase in water surface profile elevation in excess of 0.5 ft over the unencroached condition at a point 1,000 feet upstream of the proposed structure (as determined by the horizontal projection of the maximum created head and the slope of the hydraulic grade line) for any frequency flood up to and including the 100-year frequency flood.
3. The proposed bridge or culvert structure, whether new or replacement, must not involve the straightening, enlargement or relocation of the existing channel of the river or stream. Removal of debris from the river or stream is not considered straightening, enlargement or relocation.

According to the Local Roads Manual published by the Illinois Department of Transportation (IDOT), bridges with Average Daily Traffic counts of less than 250 must be constructed to pass the 15-year frequency flood discharge.

2.3 Guidance and Local Standards

Inspection of Bridges. Since the late 1980's, trained Calhoun County URD staff members have inspected all County, village and township bridges twenty-feet and over every two years. Prior to then, inspection was conducted by IDOT. The inspections yield a Condition Rating and Sufficiency Rating that is a compilation of several rating factors. The Sufficiency Rating is used by the URD to identify bridges needing replacement. Depending on structural concerns for imminent danger, priorities for replacement are established. Because the budget surplus of the early 1990s has been depleted, there is a queue for replacement and current sources of funds are insufficient to replace all bridges. Thus, years may pass before replacement of the bridges of lowest concern takes place. In spite of that, no roads or bridges have been closed as a result of inspections. Inspection reports are kept in the main office files. They have not been computerized and no analysis of changes of bridge condition over time has been made.

Figure 2. The Silver Creek Bridge recycled superstructure.

If inspected bridges are evaluated as needing rehabilitation, the URD monitors the bridges but does not initiate any program addressed at improving bridge conditions. It will, however, apply "band-aids" to stabilize a bridge if needed until sufficient funds become available for replacement. The County Engineer stated that his decision not to rehabilitate is based on financial concerns. He does not believe that federal funds are available for rehabilitation.

The County Engineer also noted that one of the URD's goals is to replace all old bridges that currently have wood abutments that should be replaced by reinforced concrete structures. Therefore, the URD waits until a bridge has a Sufficiency Rating that prompts replacement before initiating a remedy. Figure 2 and Figure 3 show the Silver Creek Bridge. With a Sufficiency Rating less than 50, this structure has been in the queue for replacement since 1999.

Figure 3. The Silver Creek Bridge deteriorated wood abutments

Inspection of Box Culverts. The URD does not perform formal inspections of box culverts. These structures are all relatively small and regularly examined when staff drive by or work in the vicinity, or when citizens call about potential problems after floods.

Routine Maintenance. Three road foremen are responsible for all routine maintenance in their assigned sections. Road crews are small, generally the foreman and two additional workers. Their main functions are patching, ditch maintenance, and mowing grasses along the shoulders in the summer and snow removal in the winter. Their work is self-directed.

Part of routine maintenance is resurfacing the oil and chip roads. Approximately one-third of the roads are resurfaced every year during the warm months. When this work is undertaken, the County Engineer orders the materials and the entire staff reports to the location selected by the County Engineer to complete its task.

The County Engineer also schedules a few days each year to pave private gravel roads or repave private paved roads. The owners of such roads are charged for the work and materials, and the revenue is placed in the Unit Road District General Fund. As a direct consequence of this practice, private roads are improved and less damage results from heavy rains. An important consideration is that the URD's post-flood clean-up is reduced because gravel from paved private roads is not washed onto intersecting County or Township Roads, thereby reducing post-flood clean up.

Daily records of road and bridge maintenance work performed are maintained. The records include locations of the work by road number, time sheets of workers (showing regular and overtime hours), the types and quantities of materials used, and equipment used. Record keeping is extremely important to the URD because reimbursements from FEMA for work following floods require precise information.

Bridges/Culverts – Configurations. Since 1993, new bridges constructed by the URD's crew have all been of the same structural configuration: prestressed concrete deck beams on reinforced concrete piling abutments. The URD also uses a standard structural configuration for box culverts to simplify construction. Pipe culverts may be corrugated metal pipe or recycled steel railroad tank cars with concrete grouted riprap as wing walls. All designs were chosen for ease of construction by the URD staff and low construction cost, but also factors such low maintenance cost and flood resistance have been factored in the decision to use these standard configurations. The choice to use standard structural configurations was influenced also by the fact that most crossings are about the same length and sited in locations with similar geographic characteristics.

Stream Bank Protection and Stabilization. The URD provides stream bank protection in the immediate vicinity of its road crossings and stream bank stabilization along all the roads in its network. Most bridge and culvert inlets and outlets are protected by grouted riprap.

Over the years, there have been many forms of stream bank stabilization along side roads including old car bodies filled with rock that were used in the late 1960's and early 1970's. Since 1993, following floods, URD has been granted millions of dollars from the NRCS Emergency Watershed Protection Program to stabilize stream banks. Because of the frequency of floods, this NRCS program has become the primary source of funds for stream bank stabilization. Stream banks are generally stabilized using a combination of gabion baskets, and instream barbs and riffles.

2.4 Post-Flood Experiences and Influences

Calhoun County has extensive experience working with State and federal officials after flood events. There are four groups of officials that the County normally interacts with: FEMA, the NRCS, and representatives from IDOT and the Illinois Emergency Management Agency. No matter how many Presidential declarations there have been, the County has found that each experience is unique and has responded accordingly in a "resourceful" manner, maximizing its opportunities for securing post-disaster grants. The County is also prepared to pay the required local share of federal grants. For many years, the County has set aside approximately $25,000 annually in its Federal Aid Matching Fund from property taxes to pay for local shares. If additional funds have been needed, the County Council has voted to provide them.

Working with FEMA has been a learning experience for the URD. URD has found that opinions provided by inspectors change from disaster to disaster and it must be resourceful to maximize its cost recovery. For example, after declared disasters in 1993, 1994, and 1995, URD disputed how reimbursements for equipment rental were calculated and filed an appeal to the inspectors decision (the appeal was denied). The URD realizes it is dependent on FEMA inspectors and how they evaluate road, ditch, and stream bank losses; therefore, it has developed excellent record keeping procedures to support its reimbursement requests. In general, the County has also found that inspectors who have done a lot of FEMA work have established positions on issues and do not negotiate, while inspectors who are new to the work are more open to alternatives if convincing justifications are given. Having applied for and received funding for many public assistance projects after many declared disasters, the URD considers itself quite capable of dealing with FEMA and in recent years has not had negative experiences.

Because the URD uses its own staff to do post-disaster repairs and replacements, it begins immediately after flooding subsides and often files Public Assistance applications after the work is complete. Generally, FEMA has no trouble with this approach and the URD is fully reimbursed for eligible labor, equipment rental, and material costs. Some of its public assistance grants have included hazard mitigation elements, such as the using recycled steel railroad tank cars to replace damaged box culverts (see Section 4.1 below).

Working with NRCS is different from FEMA in one critical way. Since 1993, when the County received its first Emergency Watershed Protection Program grants, it has interacted with the same NRCS official and developed a long-term relationship. Its experience has been very positive.

The greatest challenge following floods has been working with officials from the Illinois Department of Transportation and the Illinois Emergency Management Agency. Although no specific examples were provided, the County Engineer characterized that the Illinois Emergency Management Agency has sometimes not approved URD's requests for Public Assistance, thus preventing the receipt of grants for what it believed were eligible projects.

2.5 Emergency Response and Planning

Calhoun County has an Emergency Services and Disaster Agency whose one employee is part-time and lives in Calhoun County, but works a full-time job outside the county. The agency budget has averaged about $4,200 per year for the past five years. According to the County Engineer, there is no emergency plan that addresses flooding because, in addition to the low density of development, conditions generally do not warrant evacuation. In the case of Mississippi River floods, there is typically a two to three month window between the measurement of snow in the upper watershed and rising water in Calhoun County. The floods affect well-known and predictable locations. Most buildings that are damaged by flood are privately owned cabins on land leased from the U.S. Army Corps of Engineers and in low-lying neighborhoods in the incorporated villages. Following the 1993 floods, FEMA and the State of Illinois provided mitigation funding for the acquisition of nearly 150 flood-prone properties.

When heavy rains affect the smaller watersheds, flash floods last a short time and have not been a serious threat to residents. Outside of the villages, there are virtually no houses or high occupancy buildings next to streams that flood. If roads or bridges are damaged, there are usually one or more alternative routes in and out of all the hollows. There are, however, a few roads that dead end and have no alternative routes. When these roads are damaged or blocked, URD does make them top priority for assistance. In most cases, the water subsides quickly and all roads become passable after debris is removed. This outcome has become the norm since the gravel roads were replaced by paved roads.

URD road crews are intimately familiar with roads in their areas and will drive by the areas most prone to flooding for evaluation. On their way, they will remove heavy debris or push it to the sides of the roads for later removal. Local farmers may also remove road impediments with their tractors. If URD's road crews need assistance, they radio damage reports and ask the Chief Engineer or Field Supervisor for additional equipment or personnel. If roads cannot be readily opened, they will put up barricades that are kept in the back of their trucks. In most hollows, there are only a few farm families that regularly use local roads and some private roads can be used to avoid or go around closed County roads.

3.0 Overview of Local Decision Process

The Calhoun County Chief Engineer characterizes URD as "resourceful," indicating that he and his staff have the ability to respond quickly to changing circumstances and to make the best of all situations. Having a highly capable staff, a large inventory of equipment and a history of successful grant writing has given the URD options that were not available ten years ago.

Currently priorities depend on whether the County has recently suffered extensive flood damage and if external funding is available to repair or replace damaged roads and bridges. In the aftermath of flooding, the URD can quickly marshal its forces to repair roads, replace and enlarge culverts, and apply short-term repairs to bridges and culverts until they can be replaced. The County Engineer makes decisions regarding what gets done first, which is usually determined by emergency need, importance of the road or bridge, and if there is an external source of funding that can be tapped. The technical goal is to put in "things that won't cause us trouble again," most often such things have been implemented successfully in similar circumstances before.

When not responding to floods, a key decision factor in URD's work to upgrade its roads and bridges is to reduce potential flood damages. The County Engineer shifts budget funds into replacement projects or reserves existing funds as surpluses until sufficient amounts have been accumulated to fully pay for capital projects. One consequence of the new roads and bridges is that it takes less time and cost to maintain them. Eventually, the URD believes it will be able to complete its normal maintenance and all unexpected post-flood repairs each year because damages will decrease and repairs will take relatively less time.

3.1 Factors Considered in Local Decisions

For the previous ten years, Calhoun County has been successful in paving all its significant hill roads, replacing the majority of its old bridges, and stabilizing its most erosion-vulnerable stream banks. It is now left with relatively low priority projects. The most critical factor in deciding what to do is the nature of damage caused by rains and floods. Routine maintenance and long-term upgrades are postponed when staff and funds are diverted to respond to flood damage.

Acceptable risk is not overtly part of the URD decision process. However, implementing the goals of upgrading roads, bridges, culverts and stream banks to reduce potential damage from recurring floods have reduced flood risks considerably. According to the County Engineer, the URD has improved dramatically the flood-resistance of the local road system.

When making decisions about its local road system, the URD does not apply a formalized computation of benefits and costs as part of evaluating alternative uses of its revenues. The standard practices and approaches are, in large measure, based on complying with State regulations such as those in Statewide Permit No. 2 and on long-term experience, not only experience with what works, but with what works well given constraints of a modest budget.

The benefits most often cited by the County Engineer concerning roads and bridges were increased ability to withstand floods and not having repetitively flooded roads and bridges.

The capacity of the URD's in-house staff and equipment has a bearing on costs, and thus is a significant component of design, construction, and maintenance decisions. The URD's labor and equipment costs are considerably lower than contractor costs.

4.0 Site Specific Examination of Decisions

4.1 Township Road 28: Hoot Owl Hollow Road Culvert

Hoot Owl Hollow Road is located in the northwest region of Calhoun County. Hoot Owl Hollow Road is a winding, hilly road that connects two other Township Roads. Its full length is about 1.88 miles, of which 1.33 is gravel and 0.55 is oil and chip. Average daily traffic count is less than 25.

During the 2002 floods, heavy rains caused overland flooding, surface aggregate loss on the gravel section of the roadway 1.33 miles long and 12' wide, and washed out one 15" culvert and an 8' x 8' x 36' concrete box culvert with wing walls. Even though this road had been washed out and the box culvert had been damaged several previous times and there was a history of flooding in the area, the site was not mapped in FEMA's floodplain. Damage repair to the entire road was considered as a single road repair project.

The original box culvert was constructed before 1940. According to the County Engineer, there were no design requirements applicable at the time of construction and he was not aware of any factors that may have been included in the original design decision process.

The box culvert was one of many that are not routinely inspected. Hoot Owl Hollow Road was visually checked when the road was repaved and after any flooding in the drainage basin. Flooding typically scoured the gravel section of the road and caused minor scour around the box culvert. Past repairs were minor. At the time of the 2002 flood, there were no flood risk-reduction measures in place.

During the 2002 floods, water overtopped the box culvert and washed out the roadbed on both sides. The abutment pilings and then one side of the decking collapsed and both wing walls were severely scoured. The extent of damage led to the decision to replace the box culvert.

The damaged box culvert was one of the old culverts that the County Engineer planned to replace with a recycled steel railroad tank car. In this case, the new culvert is 8' in diameter with grouted riprap at both ends to protect against erosion in case of future overtopping (Figure 4 and Figure 5). It met the State requirement that a replacement culvert must provide at least the same amount of effective waterway opening as the pre-existing structure.

Figure 4. New culvert on Hoot Owl Hollow Road –downstream.

Figure 5. New culvert on Hoot Owl Hollow Road – interior.

Note in Figure 6 that there is no bridge railing. Throughout the County, there are many narrow roads and bridges. On many of the bridges, railings are not present because they may restrict the passage of farm equipment or cause damage to passing farm equipment.

When the decision was made to utilize the tank car as the culvert, it was based on two criteria: cost and ease and speed of installation. The Public Assistance Project Worksheet Report filed with FEMA indicates that the change from a concrete box culvert to a circular tank car was justified as hazard mitigation. If a similar box culvert were constructed, it would have cost over $5,000 more than the tank car. Thus, the same benefits would be gained at a lower cost, and there was a higher benefit to cost ratio associated with the change. In terms of repair time, the removal of the old box culvert and the installation of the tank car culvert took six days.

The replacement decision was straightforward and without complications. The only residents affected were four or five families that live on the road who had a relatively long detour. Before construction ended, there were unmanned barricades on both ends of the site.

Figure 6. Hoot Owl Hollow Road.

The URD's Hindsight Assessment: Since the road repairs and culvert replacements were completed, there have been two heavy rains that caused flooding in the vicinity. The new culvert performed well in both instances that, in the opinion of the County Engineer, would likely have caused damage to the old structure. The project met the URD's objective of "putting something in that won't cause us to work on it again." The County Engineer said he would do nothing differently.

4.2 Township Road 19B: Belleview Hollow Road Bridge

Belleview Hollow Road is located in the northwest region of Calhoun County. The road is completely paved and had an average daily traffic count of 230 when engineering plans were drawn up for its replacement in 1994. The bridge is located at the downstream end of a small drainage basin of 0.36 square miles.

The original Belleview Hollow Road Bridge was constructed in about 1930. It was built as a single span steel stringer, concrete deck bridge with closed concrete abutments and wing walls. Because of repair requirements, the superstructure was changed in 1981 from a single span to two spans with a wooden pier at the center of the overall span. The structure was 41' – 6" long, 19' – 6" wide and posted for a 19 ton load limit. In 1994, the bridge had a sufficiency rating of 22.3. Biannual inspections noted increasing deterioration of steel stringers and wooden pier and scour of both abutments had been detected. The consulting engineers who evaluated the bridge recommended replacing it to safely service traffic in the future.

Figure 7. New Belleview Hollow Road Bridge

Although engineering plans were drawn up in 1994, construction by URD's crew started in October 1998 and took seven months. Funding came from Federal Bridge Repair funds and the total cost was about $102,000. The bridge has a superstructure of precast, prestressed concrete deck beams and closed concrete abutments with sheetpiling inlet and outlet protection (Figure 7 and Figure 8). Changes from the old structure were that the surface width was widened slightly and the shoulder to shoulder width was increased from 22' to 24' thereby permitting the safe use of bridge rails (Figure 9).

The new bridge provides the same hydraulic capacity as the old bridge. In accordance with the State regulatory requirements and the Local Roads Manual requirement for bridges with ADT less than 250, the capacity to handle the 15-year flood discharge was verified; it was also determined that the bridge passes the 100-year flood discharge with approximately three feet of freeboard between the water surface elevation and the underside of the superstructure, much more than the minimum one-foot called for in the Illinois floodplain regulations. To address the issue of scour, driven sheetpiling wingwalls were installed. The URD relied fully on the consultant for all design work and did not request any features that varied from the standard configuration that has been used for other bridge replacement projects.

The URD's Hindsight Assessment: Since construction was completed, there have been several heavy rains and high stream flows that might have resulted in damage to the old bridge. However, there no appreciable damage was sustained. The new bridge has performed as expected. The URD is quite satisfied with the standard approach to sizing bridge openings and the standard designs for the superstructure and abutments that are used for all bridge replacements. The County Engineer credits the design for improved flood resistance.

Figure 8. Metal sheetpling at Belleview Hollow Road Bridge.

Figure 9. New Belleview Hollow Road Bridge – widened road and shoulders.

5.0 Observations

5.1 The County's Observations on Flood-Resistance

Since 1993, following the hiring of the County Engineer and the flood of record, the Calhoun County Unit Road District has set in motion a coordinated set of decisions that aimed specifically at reducing flood damage to the local road system. In just eleven years, the URD has replaced the most flood-prone roads, bridges and culverts and is now working on replacing less vulnerable roads, bridges, and culverts. The County Engineer pointed out that there are several important factors that make the overall program a success, including:

- On-the-job training of a dedicated and capable staff;
- An inventory of equipment capable of performing all maintenance and construction jobs;
- An initial surplus of Motor Fuel Tax funds to transform gravel roads to oil and chip paved roads;
- Sufficient funds to replace old deteriorating bridges;
- Sufficient funds to construct bridges to replace low-water creek crossings;
- Post-flood disaster assistance grants to replace undersized and deteriorating box culverts;
- Proven standard structural designs and construction specifications are used for bridges and box culverts, optimizing work by URD forces;
- Post-flood federal NRCS grants to stabilize stream banks; and
- URD's resourceful management.

5.2 Case Study Team Observations

The Calhoun County Unit Road District demonstrates that a systematic program focused on flood-resistance can be successful. Key factors include a good manager with a vision, a dedicated staff, and an ability to use the local budget and post-flood federal grant processes to further established goals.

The case study team made the following observations about significant factors that positively influence the flood-resistance of the County's local road system:

1. Floods annually cause road damage. Their ubiquity places them at the forefront of attention, which has caused the Unit Road District to make the reduction of future flood damage its primary objective. All URD work has flood-resistance components.
2. The URD has used many approaches, such as paving roads with oil and chip, replacing box culverts with recycled steel railroad tank cars, and using a common design for construction of new and replacement structures, to maximize learning curve advantages such as minimizing time of work and associated costs to complete successive jobs.

3. The URD has become expert in maximizing returns from post-flood federal grant programs, including obtaining approvals to incorporate mitigation into several Public Assistance grants to go beyond in-kind replacement.

4. By using its staff and equipment, rather than contracting, to complete work identified in post-flood federal grants, the URD has a net inflow of federal funds into its budget. This allows for an accumulation of surplus funds from other sources that can be used to improve roads, bridges, and culverts.

AmericanLifelinesAlliance

A public-private partnership to reduce risk to utility and transportation systems from natural hazards and manmade threats

Flood Resistant Local Road Systems

Appendix E: Uvalde County, TX

January 2005

www.americanlifelinesalliance.org

This report was written under contract to the American Lifelines Alliance, a public-private partnership between the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). This report was reviewed by a team representing practicing floodplain managers, water resources engineers, civil and structural engineers, and public works manager

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1.0 Uvalde County, Texas

Uvalde County, named for Spaniard Juan de Ugalde, is in Southwest Texas about 150 miles southwest of Austin (Figure 1). The cities of Uvalde and Sabinal are the only incorporated municipalities.

Southwest Texas has a subtropical climate where summer temperatures average 92°F and winter temperature range from 60°F to lows of 29°F. Average annual rainfall is 25.7 inches, usually experienced from early spring to late fall. The heaviest and most widespread rainfalls are associated with tropical low pressure systems that occur during hurricane season. However, torrential local storms are common, often of short duration and affecting only one tributary to a river.

With the Edwards Plateau extending across the northern half of the County and much of the remaining landscape described as low rolling hills with deep canyons, only about 15% of the land area is considered to be flat to gently rolling. Ground elevations range from over 2,300 to about 940 feet above mean sea level. Soils throughout the County are caliche (fractured limestone), with a thin layer of sandy loam over underlying gravel and limestone rock. In the northern part of the County (above US Highway 90) shallow soils and steep terrain result in high runoff potential.

Figure 1. Location Map.

Uvalde County is located in the upper portion of the Nueces River, a major river basin in Texas (see Figure 2). The watersheds of the Frio, Dry Frio, Sabinal and Nueces Rivers drain from counties to the north. Along with some of their larger tributaries, these rivers have daily flow, but many smaller tributaries are dry except during heavy rainfall-runoff events.

With a total area of 1,588 square miles, Uvalde County is sparsely populated. According to the 2000 Census, Uvalde County's total population is 25,926, of which fewer than 10,000 live in the unincorporated County. Tourism and recreation swell the number of people to as much as ten times the permanent population during peak season between Memorial Day and Labor Day.

The County's economy is primarily tourism and recreation, rural agricultural farms and pasturelands, and some small industries. Seasonal tourism – drawn by the rivers and hunting

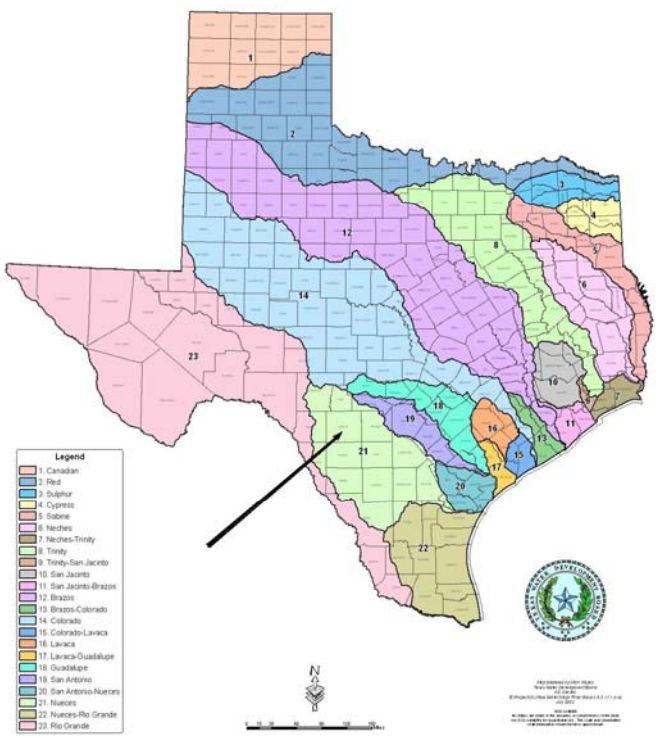

Figure 2. Major River Basins in Texas (arrow points to Uvalde County in the upper Nueces River Basin).

opportunities – is a growing part of the economy. Approximately 85% of the unimproved land is dedicated to hunting preserves, recreational uses, and pastureland. Traffic on roads throughout the County is significantly increased during peak tourist season, especially on roads accessing river recreation along the Frio, Dry Frio, Sabinal and Nueces Rivers.

The Texas Constitution spells out the structure of County governments, thereby making counties functional agents of the State. Counties, unlike cities, are limited to those areas of responsibility specifically spelled out in laws passed by the Texas Legislature. At the heart of Texas county government is the Commissioners Court, composed of a County judge and four precinct commissioners. Precinct boundaries are drawn based on population. The Commissioners Court conducts the general business of the County and oversees financial matters. Elective offices include the county attorney, county clerk, district clerk, county treasurer, sheriff, tax assessor-collector, justice of the peace, and constable.

1.1 The County Road Department

The mission of the Uvalde County Road Department is to serve the public by maintaining and improving the local road system. The Road Department consists of the Road Administrator, an Assistant Administrator, the Office Manager, and 13 crew members. The Department does not employ any engineers, in part due to budget constraints, but also because Texas State law does not require counties with fewer than 50,000 residents to have a registered professional engineer on staff. The cities of Uvalde and Sabinal are responsible for roads within their corporate limits. Although there may be some equipment borrowing between the jurisdictions, the County does not do reimbursable work for the cities.

The Road Administrator position is appointed by the Commissioners Court to oversee and manage the Roads Department. The Road Administrator is responsible for identifying and prioritizing the work of the Department, for preparing and managing the budget, estimating the cost of work, representing the Department before the Commissioners Court, and interfacing with

the public. The current Administrator has been with the County for 13 years, before which he was involved in construction related jobs for the Federal government. He credits his construction experience with a practical approach to "getting the job done, given what we have."

The Assistant Administrator is responsible for the day to day management of the crews and schedules the work. He has been with the County for nearly 10 years.

The 13 crew members are organized based on the type of work underway at any given time and all members work countywide, rather than assignment by precinct. During their regular work, crews observe all components of the road system, including signage, ditches, drainage culverts, debris at crossings, and erosion and scour at crossings. Observed problems and maintenance needs are reported to the Assistant Administrator. Other than training necessary to operate heavy equipment, crew members learn through on-the-job training.

Detailed daily records of maintenance work performed are maintained. Information recorded include the road number, river crossing number, the work performed, crew members involved, materials and quantities used, and equipment used. This level of detail is required for various purposes, including documentation of use of certain State funds and, after floods, to facilitate reimbursement if State or federal aid funds become available. Work that is eligible for federal aid from the Federal Emergency Management Agency (FEMA) is documented on "project worksheets" that are kept in County files.

The Road Department regularly constructs all of the types of waterway crossings used in the County, including concrete slab crossings, box culverts, and caliche crossings (described in Section 1.2)

The County owns and maintains an extensive inventory of vehicles and equipment, including dump trucks, water trucks, rubber tire loaders, tracked loader, a dozer, graders, a chip spreader, rollers, and an asphalt paver. Stockpiled materials include culvert pipe in various lengths and diameters (from 12" to 48"), pavement patching material (cold mix), pre-coated rock used with asphalt, surplus base milled from State highways, and crushed base materials.

1.2 The County Local Road System

Uvalde County is bisected by two major U.S. highways, US 90 and US 83 intersect in the City of Uvalde. Only two Texas State Highways, TX 55 and TX 127, are found in Uvalde County.

The Uvalde County road system consists of a 143 separately numbered roads, many of which extend off of the U.S. highways and State highways. Most County roads are short, dead end roads and some serve as few as three property owners. The typical road width is 22-feet of treated surface, although some unpaved roads are narrower, and most shoulders are grassed.

Figure 3. Typical unpaved very low volume road.

Uvalde County has a total of 315 miles of roads in its system (Table 1), of which about 111.5 miles are paved. Unpaved roads account for 203 miles, of which many miles carry very low traffic volumes (Figure 3). Precinct 3 is the largest of the four precincts, covering roughly the eastern third of the County. It is very sparsely populated, yet contains 63% of all County roads. Compared to the other precincts, Precinct 3 has relatively fewer miles of paved roads. Paving is cold mix asphalt or chip and seal. Only about 15 miles of paved roads are seal coated each year. New paved miles are added only when the Commissioners Court allocates specific funding for that purpose. Unpaved roads are surfaced with graded and rolled State-approved crushed limestone (locally called caliche).

Precinct	**1**	**2**	**3**	**4**
Numbered roads	12	7	26	98
Paved miles	11.7	18.8	56.6	24.4
Unpaved miles	3.6	8.8	142.3	48.9
Total miles	15.3	27.6	198.9	73.3

Table 1. Roads, by Precinct.

The current County road system includes the roads that were maintained as of 1981. The County does not plan any new roads, nor are any major upgrades or realignment projects anticipated. Some subdivision development is occurring in the County, although subdivision roads have not been accepted into the road system since the mid-1980s.

Table 2 summarizes the waterway crossings on County Roads. There are no bridges that are configured with abutments and superstructures. Most of the rivers and tributaries, with channel widths ranging about 20 feet to upwards of 100 feet, have very low flow or are dry much of the year. The types of waterway crossings used by the County are easy to construct using County forces and equipment. One benefit of this is that it allows rapid response after flood-related damage, which occurs somewhere in the County several times each year. The three types of crossings, described below, include concrete slab crossings, box culvert crossings, and caliche crossings.

Length of Structure Across Waterway (bank-to-bank)	# of Structures
20 feet or less	3 box culverts 1 slab crossing
21-30 feet	2 box culverts 10 slab crossings
31-50 feet	2 box culverts 5 slab crossings
51-80 feet	10 slab crossings
200-300 feet	1 slab crossing w/pipes 2 slab crossings w/o pipes 6 caliche crossing
Totals	**7 box culverts** **19 slab crossings** **6 caliche crossings**

Table 2. Concrete Slab and Box Culvert Crossings on County Roads.

Concrete slab crossings. The County's 18 concrete slab crossings are keyed into bedrock and made of poured in place concrete. In nine locations, especially where there is very little traffic and the riverbeds are dry much of the time, the slab is a true low water crossing that is at the same grade as the bottom of the channel (Figure 4). In nine other locations where traffic counts are higher and it is important to provide some access even during relatively moderate flows, the slab crossings are raised with multiple corrugated metal pipes to carry flow (Figure 5). These structures are low profile and intended to overtop during high water events. The Road Department has constructed eight slab crossings since 1992.

Figure 4. Typical concrete slab low water crossing (without pipes).

Figure 5. Typical concrete slab crossing (with pipes).

Single or multiple cell box culverts. These crossings are low profile structures that are intended carry relatively moderate rises in flows without interrupting traffic, yet will overtop by high water (Figure 6). Because they are installed where they can be keyed into bedrock, significant scour is not problematic, although minor scour occurs where the structure ties into the approach road. Three box culvert crossings have been built by the County since 1992. There is no documentation regarding design decisions on the other four.

Figure 6. Box culvert built by Uvalde County.

Caliche crossings. Caliche crossings are used at six locations: five on the Nueces River and one on Bear Creek (Figure 7). These crossings provide access and serviceability for moderate traffic volumes and where other types of crossings are not feasible because the lack of foundation/bedrock precludes construction of concrete slab crossings or box culverts. For example, investigations at County Road 414 over the Nueces River revealed nearly 40-foot thick gravel deposits over bedrock. The crossings are composed of multiple corrugated metal pipes laid in the streambed, typically to one side of the main channel, with local gravel deposits pushed over the pipes. The driving surface is created by spreading crushed limestone gravel (caliche) that is then graded and rolled. By their very nature, caliche crossings are prone to washout, but also are easy to restore.

Figure 7. Caliche crossing for County Road 414 over the Nueces River.

1.3 Nature and History of Flooding in Uvalde County

Flooding occurs somewhere in Uvalde County every year. In the past decade, only three of the numerous small and large floods have qualified as Presidential Disaster Declarations. Table 3 lists the more significant events since 1997, but does not list every event that caused damage to the local road system.

Date	FEMA DR#	Event
July 1997	1179	Severe storms & flooding
August 1998	1239	Tropical Storm Charley
November 2001	-	Severe storms & flooding
June 2002	-	Severe storms & flooding
September 2002	-	Tropical Storm Faye
July 2003	1479	Hurricane Claudette
July 2004	-	Severe storms & flooding

Table 3. Recent Significant Storms and Disaster Declarations.

Heavy rainfalls typically create flash flood conditions, especially in the hilly terrain in the northern part of the County. Some of the larger watersheds tend to experience rapid on-set of high water, often exceeding 20-30 feet deep. After the peak passes, it can take more than a week for flows to fall to less than 4-8 feet deep, prolonging access problems and delaying recovery.

Erosion occurs during high water events, especially in the hillier parts of the County where soils are unconsolidated and gravely. Huge quantities of bed load are moved during high water, with sizes ranging to small boulders. Dislodged gravel and rock are washed down the rivers and smaller tributaries, often blocking road crossings with tons of deposited material.

1.4 Impacts of Flooding on the Road System

Every year high water that affects the local road system occurs somewhere in Uvalde County. When flooding is reported, the Road Administrator and crews inspect affected areas. For the most part, effects are localized and repairs are handled within the routine work of the Road Department. The Flood Fund (see Section 2.1) has been adequate to cover such localized impacts in most years. Large storm systems that affect multiple watersheds occur infrequently, but the resulting damage can quickly exceed the County's budget.

Typical flood damage due to smaller event includes washing out caliche crossings, washing out approaches to other types of crossings, erosion of side drainage ditches, and damage to road surfaces (paved and unpaved). Due to the nature of caliche crossings it usually takes the County's crew about four days after water recedes to complete resetting the pipes, bulldozing gravel over the pipes, and laying the limestone grave driving surface (costing approximately $4,500). If the pipes are lost or damaged and if replacements are not in stock, ordering new pipe extends the period of recovery (and increases costs to $8,500 or more).

In the hillier northern part of the County more damage is associated with runoff of heavy rainfall that exceeds the drainage ditch capacity, rather than damage due to rivers overflowing their banks.

Removal of debris at bridges and crossings is always required after any high water event. Relatively small floods can lodge debris at low crossings that are designed to overtop during more severe flooding. County crews regularly check for debris deposits after high water has been reported.

More severe damage to the local road system can result from larger storms that produce heavier or more prolonged rainfall. In particular, ditch damage can be so extensive as to undermine paved roads and wash away unpaved roads. The Road Administrator observed that while paved surfaces may be more resistant to overtopping by floodwaters than are unpaved roads, it is easier and faster to repair damage to unpaved roads. Figure 8 shows a typical dip in an unpaved road and shows the drainage flow path.

The Nueces River is particularly subject to local flooding that closes County roads and damages the six caliche crossings. State Highway TX 55 parallels the River for much of its length and numerous County roads extend off of the highway. In one 12 month period in the early 1990s, the Road Department rebuilt all six caliche crossings thirteen times. None of the events warranted State or federal disaster assistance. Sometimes high flows open a short breach in the crossing, while other times the entire crossing is washed out and the culvert pipes are dislodged or damaged.

Figure 8. Typical dip in unpaved road, showing washout path (from left to right).

If the four of the County's box culvert crossings that are inspected by the Texas Department of Transportation (TXDOT) are damaged, the County share is limited to 20% of the repair costs, with the remainder covered by the State (and federal assistance if the event is declared a major disaster). Since 1992, none of these crossings has sustained significant damage.

Shifting river channels have caused significant problems in recent floods. At the location shown in Figure 9, the actively eroding 15-foot high riverbank is steep and unstable on the outside of the meander bend. Major erosion that affected the road occurred in an event that prompted a federal disaster declaration in 1997. Stabilization of the erosion was not feasible and the roadbed was shifted to its current location. Federal disaster assistance was provided to help purchase the

Figure 9. High bank erosion threatens relocated unpaved road (to right).

new right-of-way. During high water in 2002, this same area eroded again, taking another 20-25 feet and now the top of bank is now within about 25 feet of the road.

2.0 Environment within which Uvalde County Operates

2.1 Overview of Road Department Budget

The Texas Constitution spells out the structure of County governments, thereby making counties functional agents of the State. Counties, unlike cities, are limited in their actions to areas of responsibility specifically spelled out in laws passed by the Texas Legislature.

At the heart of Texas county government is the Commissioners Court, composed of a county judge and four precinct commissioners. Although this body conducts the general business of the county and oversees financial matters, the Texas Constitution established a strong system of checks and balances by creating other elected offices in each county, including the county attorney, county and district clerk, county treasurer, sheriff, tax assessor-collector, justice of the peace, and constable.

The Uvalde County Commissioners Court prepares and approves the County's annual budget, including the annual budget for the Road Department which averages about $980,000 per year. The work performed in any given year is determined based on the budget, unless a high priority need is identified. If significant new paving or a large river crossing is required, the Road Administrator develops cost estimates and requests additional general funds.

Prior to 1992, the County established the Road and Bridge Fund into which appropriated general funds and fee income are deposited. In the current budget, $515,000 is for operations (including $175,000 for materials), and over $387,000 is in accounts for insurance expenditures, environmental expenditures, and payroll for the other employees.

The Road and Bridge Fund is funded in large part by income generated by a $10.50 fee assessed on every vehicle registered in the County. Also deposited into the Road and Bridge Fund is a percent of fines assessed by the County on certain violations and a percent of certain special permit fees. At the end of the fiscal year, unspent Road and Bridge Funds are returned to the general fund.

Due to the prevalence of flood damage the County routinely appropriates approximately $55,000 in general funds specifically for the Flood Fund. The amount is determined as a percent (0.0668%) of property tax revenue. The Flood Fund mechanism predates the current Road Administrator. The funds are used for materials and supplies required for repair of flood damage. The Flood Fund is the only County account that can accumulate from year to year, allowing unspent amounts to build reserve for years when more severe flood damage occurs.

The Lateral Road Fund contains funds provided by the Texas Department of Transportation for do work on County roads that intersect State Highways. The amount is determined based on the number of roads, yielding approximately $23,000 for Uvalde County each year. These funds may be use for any purpose on eligible roads. The County uses its share primarily for materials and supplies. Detailed records are maintained to document use of the funds.

The Road Administrator is authorized to spend up to $25,000 on individual purchases of equipment and vehicles, or for individual projects, without explicit approval by the Commissioners' Court. In order to purchase more expensive equipment or to undertake larger capital projects, the Road Administrator must prepare cost estimates and seek approval from the Court.

2.2 Nationwide Permit #3 for Maintenance

The State of Texas has not issued its own general permit in order to conform with the requirements of the Clean Water Act. Therefore, activities that impact wetlands and waterways are subject to the authorizations administered by the U.S. Army Corps of Engineers. Specific to local road systems, work that involves repair, rehabilitation or replacement of serviceable structures is authorized by the U.S. Army Corps of Engineer's Nationwide Permit #3. It specifically "authorizes the repair, rehabilitation, or replacement of those structures or fills destroyed or damaged by storms, floods, fire or other discrete events, provided the repair, rehabilitation, or replacement is commenced, or is under contract to commence, within two years of the date of their destruction or damage." The permit does not authorize work that would cause "more than minimal changes to the flow characteristics of the stream, or increase flooding." The Texas Commission on Environmental Quality has certified Nationwide Permit #3 for use in Texas, with certain added conditions.

The Uvalde County Road Department performs routine maintenance work under Nationwide Permit #3, including work that requires entering riverbeds such as repairing scour, replacing old crossings with concrete slab or box culvert crossings, and restoring washed out caliche crossings. Only gravel deposited in the vicinity of crossings can be disturbed, which always provides adequate quantities of material ranging from pea size to small boulders. The permit does not require reporting routine activities that are performed in compliance with its terms and conditions.

2.3 Guidance and Local Standards

State Specifications. The State of Texas imposes no rules, regulations or standards on the design of local roads, bridges and culverts. The Lateral Road Funds, provided by TXDOT and used only on county roads that intersect State Highways, are not accompanied by specific design requirements.

TXDOT makes available a manual that includes standards and specifications for typical designs for low volume roads. In 1996, the Uvalde County Road Administrator consulted with the TXDOT's San Antonio District about a multi-cell box structure. The district provided a generic structural design that allows the user to select the number of cells and well as the height and width of the box cells. The Road Department has used this generic design three times since 1992.

Periodic Inspections: The Road Administrator drives every mile of County road twice each year to examine conditions and identify maintenance needs. Detailed records of specific sites are not maintained. All crew members report observed problems encountered during scheduled work, although performing routine inspections is not part of their responsibilities. The public regularly reports problems, including water damage and rough gravel surfaces.

Every two years the Texas Department of Transportation inspects the four box culvert crossings in Uvalde County that have combined openings that are longer than 20 feet. Copies of the inspection reports are provided to the Road Administrator. Although the reports may include recommendations for work, the County decides the priority of the actual work. Certain corrections, if identified by TXDOT, must be undertaken in order to keep the crossings eligible for State inspection. TXDOT provides no continuous funding specifically to support work on these bridges, although if they are damaged by flooding that is declared a State or federal disaster, then the County is responsible for only 20% of the cost of repairs with the remainder covered by TXDOT (and federal assistance, if the event is declared a major disaster).

Routine Maintenance: Based on the problems identified during periodic inspections, the Road Administrator identifies, categorizes, and establishes priorities for work. Factors that influence priorities include severity of problems, number of citizen complaints, awareness of traffic volumes, and a desire to equitably distribute funds between the four politically delineated precincts based on total road mileage. The Assistant Administrator manages the day-to-day work based on the work plan for routine maintenance and the established priorities. While in the field, crews take care of additional routine needs that are observed. If their observations indicate more work or work of a significantly different nature that requires different equipment or materials, the needs are reported to the Assistant Administrator.

Selection of Waterway Crossing Configuration: The FEMA Flood Insurance Rate Maps for Uvalde County date to 1987. All waterways are shown with approximate flood zones except for a small portion of Cook's Slough just outside of the City of Uvalde that was improved by a joint project with the City in order to reduce flooding. The report that accompanies the FEMA maps does not contain information that would be useful in evaluating bridge and culvert hydraulics.

For each of the three types of crossings used in the County, configuration is driven largely by site-specific considerations:

- For the three box culverts constructed since 1992, the County hired an engineer to survey the stream and determine the discharges of the "normal flood" (likely to occur at least once or twice each year) and the 100-year flood. The objective is to provide serviceability; therefore, the number and size of box culverts are selected to handle flows that result in 5-8 feet of water without topping the driving surface. As part of selecting the configuration of the boxes the engineer looks at the potential backwater impact of floodplain fill which is required to raise the approach roads to match the top of the box culvert structure. While it is common for floods to peak has much as 20-30 feet above the channel, high water usually falls rapidly. However, it can take several more days before flows fall below 5-8 feet, making true low water crossings unacceptable in some locations where access is important due to the number of residents and tourist interests served.

- The eight concrete slab crossings built since 1992 are all true low water crossings with the driving surface at the same grade as the channel bottom (without pipes). When concrete slab crossings with pipes are built, the number of size of the pipes will be selected in the same manner described for box culverts.

- The configuration of caliche crossings is determined more by the grade of the existing approach roads and experience based on what the Road Administrator considers to be frequent but small increases in normal flows. By their very nature they are not intended to resist flood damage, but are expected to overtop and breach. The County does take steps to protect the culvert pipe used to convey low flows from damage that might occur due to high flows so that the crossing can be restored quickly without having to purchase replacement pipe. Protection is achieved by positioning the pipes on the side of the channel where lower velocities are expected, such as on the inside of a meander bend, making it less likely that the pipes will be transported downstream and damaged.

2.4 Post-Flood Experiences and Influences

Most of the County's flood-related road system damage can be repaired relatively quickly because caliche crossings and unpaved roads are most susceptible. The County photographs damaged areas and keeps records of restoration and repair work performed so that, if an event is determined to qualify for State or federal assistance, the documentation will be acceptable. This is especially important because State and federal inspectors usually arrive weeks after an event. The Road Administrator observed that many federal inspectors seem to be retired from jobs that provide reasonable experience, and most do not challenge the County's records of repairs because they are able recognize new work in the field.

FEMA uses regionalized costs to prepare estimates for reimbursement requests. During recovery after the 2003 disaster, Uvalde County found that those costs were acceptable to cover the County's costs, but were considerably under commercial rates, especially for rental equipment. Because the Road Department has a good inventory of vehicles and equipment, it has to rent additional resources only rarely.

The Road Administrator reported that, for the most part, the County has good working relationships with State and federal inspectors after flood events prompt consideration of financial assistance. TXDOT's San Antonio District, which may offer help after extreme events, occasionally makes available surplus materials such as recycled road base materials. Despite the generally good experiences, a few notable exceptions in recent years stand out and are described below.

Often the County's cost to repair individual sites falls below FEMA's threshold minimum of $1,000 per damaged area. Inspectors have not allowed the County to combine nearby sites into a single project, even if those sites are on the same road.

Flooding in early July 2004 prompted 20-foot rises on the Frio and Neueces Rivers, causing about $330,000 in damage to County roads and crossings. State inspectors were deployed to evaluate the damage and determine eligibility for reimbursement. The event did not qualify for federal aid. At one location where the County had restored the roadbed but not the paving, the State inspector refused aid, asserting lack of evidence of the pre-damage road conditions. The County had photographic documentation of the area and records of the quantities of materials and nature of the work performed. The speed with which repairs were accomplished put the

County at a disadvantage. However, because more than 50 families were isolated and due to the anticipated influx of visitors for the July 4th weekend, work could not have been postponed.

As described in Section 1.4, the flood in 1997 that prompted federal disaster assistance eroded a streambank to such an extent that it damaged County Road 405. It was readily apparent that stabilizing the bank would be a very expensive undertaking, especially to protect a road that has a very low traffic count. FEMA's contribution helped obtain the right-of-way for relocating the road. FEMA suggested contacting the U.S. Army Corps of Engineers for assistance to explore other options. After visiting the site, the Corps' response indicated that pre-damage assistance might have been made available, but post-disaster assistance could not be provided. A similar response was given by the USDA Natural Resources Conservation Service.

The Road Administrator reported that in disasters declared in 1997 and 1998, FEMA only authorized in-kind work, which also was emphasized in the initial meetings after the disaster declared in 2003. However, during recovery after the latter event, some federal inspectors talked about improving flood resistance, although others were not inclined to bring it up. A more significant negative factor was experienced when measures to reduce future damage were identified for County Road 350 over a tributary to the Frio River. The first federal inspector on-site was not authorized to approve additional work. FEMA deployed a different team of inspectors specifically to examine and rule on the mitigation proposal. In that instance, FEMA approved additional costs to replace a small pipe culvert with a box culvert which has performed well in subsequent events (Figure 8 in Section 1.2).

It is notable that the Road Administrator, while indicating the difficulty of negotiating with FEMA to approve work other than in-kind, acknowledged that he did not propose mitigation measures at other sites because more flood-resistant – and cost effective – solutions are not apparent, especially where caliche crossings are used because bed rock is inaccessible.

2.5 Emergency Response and Planning

The County Judge is designated as the County's Emergency Management Coordinator and is responsible for administration of emergency management functions in Uvalde County. In addition, he administers the County's floodplain management ordinance. The volunteer Emergency Management Director is a professor at the Southwest Texas Junior College main campus located the City of Uvalde. Various County departments are represented on the County's emergency management committee.

Emergency management is coordinated at the county level for the County and cities of Uvalde and Sabinal. Day-to-day operations are supported with funding from the County and the cities; State and federal funds become available only after events are declared as State emergencies or major disasters. Certain funds to support emergency exercises are available upon application to the Texas Emergency Management Agency.

The Emergency Management Plan for Uvalde County outlines procedures for warning and evacuation. Signals from NOAA weather radios can be received in about 90% of the County, and about 80% of the County is in the broadcast area of the local radio station (KVOU AM/FM). One local cable company has transmission capabilities.

The Uvalde Police Communications Center receives reports of actual or potential emergencies from State and federal agencies, local officials, news media, and the general public. Communications from the federal level are transmitted on the National Warning System; the Texas Warning System is a state level extension of the federal system. The County also receives NOAA weather radio signals and direct telephone communication from the National Weather Service's regional weather office in New Braunfels, TX, and the Texas Emergency Management Agency. Valuable information is provided by upstream counties that notify the County Sheriff's office when flooding occurs.

After verification, warning information is disseminated according to the established Emergency Notification Matrix to specific local officials and departments. Official warnings are provided to local media and the Communications Center contacts a list of vulnerable campgrounds to alert owners to the potential for dangerous conditions.

The Road Department sends crews to deploy barricades in areas known to flood. Barricades are stored in outlying areas so that crew members can access them without returning to the main shop outside of the City of Uvalde.

In recent years, only one death has been attributed to flooded roads in Uvalde County. In 2002, a man who successfully drove out of a flooded crossing elected to reenter the area and was swept away.

Although many river crossings carry dead end County roads over waterways, few instances of prolonged isolation have occurred. The Fire Department, Sheriff's Office and the Police Department all may participate in evacuating residents stranded by washed out river crossings and the Road Department's equipment is adequate for emergency access after peak flows pass. After floods in 1998 and 2002, a helicopter was required to carry food and medicine to stranded residents after flooding washed out the County Road 408 the Nueces River. This river often rises and falls more than once during a single event, delaying repairs. In much of the County it is more common for flooding to quickly recede to levels that, although above normal flow rates, allow access. Usually the Road Department is able to initiate repairs within a few days after passage of the flood flow.

Emergency vehicle access is limited in most locations if road crossings wash out because due to the nature of the County road network with many dead ends. Where detours using County roads are available they generally are long. It is not uncommon for residents to drive cross-country, with landowner permission, when a County road is closed due to flooding or during construction. Depending on the type of crossing and the degree of flood damage, roads may be reopened quickly. Low water crossings typically can be repaired and back in service within a week. If construction takes longer, evacuated residents typically do not return to their isolated homes unless an informal cross-country route is available.

3.0 Overview of Local Decision Processes

3.1 Factors Considered in Local Decisions

The Road Administrator makes all decisions that affect the size and type of waterway crossings, with the advice of a consulting engineer when box culverts are proposed. In terms of factoring flood resistance into local decisions, actual flood experience identifies the problem areas, some of which have flooded multiple times in the past decade. The Road Department does not use FEMA's Flood Insurance Rate Maps because only approximate flood zones are shown.

The Road Administrator also decides where repaving work is performed, where and when unpaved road is paved, and where drainage pipes are installed to handle local drainage. While the severity of pavement condition and citizen complaints are significant factors in determining paving priorities, so is a desire to equitably distribute limited paving funds between the four politically delineated precincts based on total road mileage.

The difference in flood resistance and types of damage sustained by paved roads versus unpaved roads has been observed and is considered. However, while paved surfaces are more resistant to damage caused by overtopping by floodwaters at waterways, paved roads are significantly more expensive to repair when damage is caused by side ditch erosion or overtopping by local drainage. A more important factor is that, other than at waterway crossings, specific lengths of ditches and road rarely are damaged repetitively. Therefore, resistance to runoff damage is insufficient justification to pave more miles of road.

Due to the frequency of damage to County waterway crossings, the Road Administrator has considered alternatives that might reduce future damage. Ideally, every crossing should have some type of structure that provides safe travel even during minor rises in stream flow. However, rises of more than 5 to 8 feet are quite common, and the County does not have sufficient budget to install larger structures in every location.

In most locations field conditions limit low cost options, for example, when the depth to bedrock makes it impractical to install foundations to anchor box culverts and concrete slab crossings. However, even if a feasible alternative is identified, for some locations the increased cost may not be justified given very low traffic counts.

3.2 Flood Resistance and Risk

The Road Administrator asserted that the concept of "flood resistant" means something different in Southwest Texas than what may be considered in other parts of the country. Due to the nearly annual occurrence of deep water, combined with the very low traffic counts, it often is impractical and not cost effective to build traditional bridges, box culvert structures, or concrete slab crossings. With respect to public safety, the Road Department's objective is to provide passable roads during both frequent moderate rises in river flow and after high peaks passed. In Uvalde County, achieving flood resistance and reduced risk is a balancing act, where the desire to keep roads open during and after high water is balanced with what is feasible and can be done within the County's budget. Budget limitations exert the most influence, followed by feasibility

of a solution – and both factors are strongly influenced by whether the solution can be constructed by the Road Department's crew.

4.0 Site-Specific Examination of Decisions

4.1 County Road 414 over the Nueces River

A caliche crossing (with seven 48-inch pipes and two 60-inch pipes) carries County Road 414 across the Nueces River (Figure 7 in Section 1.2). It is a dead end road that serves about 20 year-round families and numerous seasonal rental homes. The crossing is located at immediately downstream of a sharp meander bend where the river channel is approximately 400 feet wide. Observed flood flow velocities appear to be high in the effective flow area.

At this location it is normal for flows to top the crossing at least once each year, and each time the crossing is damaged or washed out completely. The most recent high water rose to 12 feet over the road. Repairing this crossing usually is the highest priority due to the number of people that may be stranded during summer months. Depending on the extent of damage at other locations and the availability of the County's crews, rebuilding the caliche crossing takes from two to seven days. The cost to restore the crossing ranges from $4,500 to $8,500, depending largely on whether the culvert pipes can be reused.

As part of the decision process, the County explored the feasibility of a permanent structure for this site by drilling to determine the depth to bedrock. With about 40 feet of unconsolidated gravels, it is not feasible or cost effective to construct a concrete slab bridge or box culvert crossing which would require anchoring to bedrock.

After laying aside a permanent structure as infeasible, the County's next priority was to increase the likelihood that the pipes will not be moved off-site or damaged during high flows. In this way, both the effort and time to repair – and the cost of repairs – are reduced. Rather than place the pipes in the most obvious location where normal flow occurs, at the outside of the meander bend, the Road Administrator decided to install the pipes where flood velocities are lower, thus exposing them to less damage. In order to carry daily low flows the river bed is shaped to direct low flow towards the pipes.

County's Hindsight Assessment: The Road Administrator, while frustrated with the frequency that this crossing washes out, recognizes that a more flood-resistant alternative is not cost effective given the physical constraints and the low traffic count. Experience indicates that careful placement of the pipes does reduce the time and cost of repairs, which reduces the burden on County crews and the budget.

4.2 County Road 348 over the Frio River

County Road 348 crosses the Frio River twice. The upstream crossing is provided by a concrete slab with six small diameter pipes. Until it was replaced in 1999, the crossing downstream also was a concrete slab, low water crossing. The Frio River floods frequently, sometimes more than once a year. Although the flood peak may rise more than 20-feet above the channel and fall rapidly, high water about 5-feet deep usually lasts for several days, stranding nearly 650 people during one event.

Figure 10. Typical box culvert built by Uvalde County, County Road 348 over the Frio River.

The number and size of the box culverts were selected based on an evaluation of flood discharges prepared by a consulting engineer. Although the County's standard procedure is to select dimension to carry "normal" floods, in this instance the Road Administrator selected a larger a configuration to carry twice that volume in order to improve flood resistance and accessibility. This decision was based on having sufficient funds for the larger structure and was not constrained by the in-house capacity for construction since it was going to be built by a contractor.

The crossing consists of four boxes each measuring 9-feet wide and 5-feet high (Figure 10). The structural design was based on the generic structural design provided by the San Antonio District Office of TXDOT. The upstream and downstream concrete faces of the crossing on both sides of the boxes are shaped to facilitate overtopping as flood flows rise.

Figure 11. Scour at transition of approach road and crossing.

The crossing is keyed into bedrock, which is visible in the channel, resulting in a very stable structure. The low profile, while allowing continued traffic during moderate flows, is low enough that it tops frequently and presents little obstruction to higher flows. For flows that top the crossing, debris is not

usually a problem. Some erosion has occurred at each end during higher volume flows, requiring relatively minor effort to repair (Figure 11). The road repairs often extend the concrete driving surface to transition from the unpaved road further landward of the channel, with an eye towards reducing the frequency that the approaches wash out. Removal of gravel deposits from the effective flow area has qualified for federal disaster assistance in the past.

The box culvert crossing has performed well under numerous high water events, including the most significant event in recent years that saw the Frio River peak at about 36 feet high. The most recent flood that topped the crossing occurred in June 2004, when water rose about 12 feet above the channel bed (approximately 8 feet above the road surface). The road was barricaded until the water receded to the point that flow was contained in the box culverts and the crossing had been examined by the Road Department. The inspection revealed no structural damage. The County's clean-up involved removing downed trees, accumulated debris, and gravel deposits that had built up in the effective flow area.

County's Hindsight Assessment: The Road Administrator attributes three factors to the flood resistance of this crossing: it is solidly keyed into bedrock, the standard construction plans call for significant steel reinforcing, and it is low enough that it becomes submerged quickly and debris is washed over it.

5.0 Observations

5.1 The County's Observations on Flood-Resistance

The Road Administrator observed that Uvalde County's local road system is in good condition, especially when compared to other rural counties in the area. He attributed Uvalde County's success to the following factors:

- The work ethic of the experienced Department employees;
- The Department's overall objective to improve the roads to better serve the public;
- The Commissioners Court's recognition of the need to continue annual contributions to the Flood Fund and to allow unused funds to accrue;
- The steady funding source created by assessing a fee on vehicles registered in Uvalde County;
- Changes made in the past decade to improve the Department's capacity to perform more work (i.e., vehicles and equipment); and
- Concerted effort in the past decade to improve the roads, including drainage elements, through regular inspection and maintenance.

Specifically with respect to flood resistance, the Road Administrator shared the following observations:

- The concept of "flood resistant" means something different than what it might mean elsewhere. In Southwest Texas, due to the frequency of deep water combined with the very low traffic counts, it often is impractical and not cost effective to build traditional bridge or box culvert structures.
- Flood resistance is a balancing act, where the desire to keep roads open during and after high water (which generally calls for permanent larger culverts) is balanced with what is feasible within any year's budget (which in part depends on recent flood experience and the system-wide need for road maintenance), what is feasible due to site constraints, and what can be constructed by the County's crew.
- Unpaved roads would benefit from installing cross drainage pipes or concrete slabs in low spots where intense rainfall-runoff causes damage (Figure 9 in Section 1.4). FEMA has declined to view such measures as cost-effective mitigation.

The Road Administrator and the County Judge shared observations regarding dealing with the State and FEMA in the aftermath of declared disasters:

- While FEMA's inspectors are familiar with construction practices, often they are unfamiliar with the types of conditions encountered in Southwest Texas.
- By limiting disaster assistance reimbursements to costs to restore damage to minimum standards, FEMA is perpetuating future damages.

- The State's reluctance to reimburse for work that the County performs immediately after damage in order to restore access on the County's many dead end roads is of concern, especially since the County documents with post-flood photographs and keeps records of the work performed.
- FEMA and the Texas Emergency Management Agency should be more proactive in advising counties when policies and paperwork requirements change, rather than wait until they are deployed for the next disaster. This is especially important because the County has to move quickly to restore roads to service prior to federal and State inspections.
- The County has never obtained reimbursement from FEMA for replacement pavement that is damaged due to flooding, although reimbursements are made for washed out fill and base materials. There are two factors that seem to influence this situation: (1) the rationale provided by State and/or federal inspectors is that they cannot estimate the wear and tear of the damaged paved surface and therefore are unable to determine what constitutes "in-kind" replacement; and (2) sometimes the cost of repair of an individual site is too low to qualify for FEMA's minimum $1,000 limit.

5.2 Case Study Team Observations

The Uvalde County Road Department demonstrates that a rural county with limited resources can, with careful consideration and attention, reduce some of the flood damage sustained by its road system. However, given the nature of the environment, the very low density of development, and the depth and frequency of flooding, some degree of flood damage is part of its day-to-day reality.

The case study team made the following observations about significant factors that positively influence the flood-resistance of the County's local road system:

1. The Road Administrator's construction experience, not just public works experience, enhances his ability to examine the causes of damage and to evaluate practical solutions.
2. Uvalde County considers flooding to be a regular occurrence and, through the establishment of a dedicated fund, assures that the Road Department has some resources to perform repairs quickly to restore serviceability.
3. The Road Administrator balances several factors when evaluating alternatives for waterway crossings that resist damage and provide reasonable serviceability and access during frequent small rises in water and for the longer-duration flows that occur after passage of large flood flows. The factors considered include: what is feasible for the physical conditions of the site (waterway width, depth to bedrock, "normal flow" volume); what can be constructed by County crews; and what the budget can bear.
4. Reducing the impacts of flooding does not necessarily mean eliminating damage or building more robustly. Where frequent high water occurs and site constraints and budget do not allow other types of crossings, low-cost and easy to rebuild caliche crossings effectively reduce the impacts of flooding.

AmericanLifelinesAlliance

A public-private partnership to reduce risk to utility and transportation systems from natural hazards and manmade threats

Flood Resistant Local Road Systems

Appendix F: Wasco County, OR

January 2005

www.americanlifelinesalliance.org

This report was written under contract to the American Lifelines Alliance, a public-private partnership between the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). This report was reviewed by a team representing practicing floodplain managers, water resources engineers, civil and structural engineers, and public works manager

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1.0 Wasco County, Oregon

Wasco County is located in north-central Oregon, approximately 80 miles east of the city of Portland (Figure 1). It is a large county with an area of 2,396 square miles. The topography of the land is varied, with roughly 15% considered to be flat, 50 % is rolling hills, and 35% is mountainous. The County is bordered by the Columbia River to the north, the Deschutes River to the east, the Warm Springs Indian Reservation on the south, and Mt. Hood National Forest on the west.

Several short, relatively wide watershed basins with headwaters in the foothills of Mt. Hood and the Cascade range run parallel to one another and drain in a north-east direction into the Columbia River. In general, they are characterized by a long single channel with few side streams.

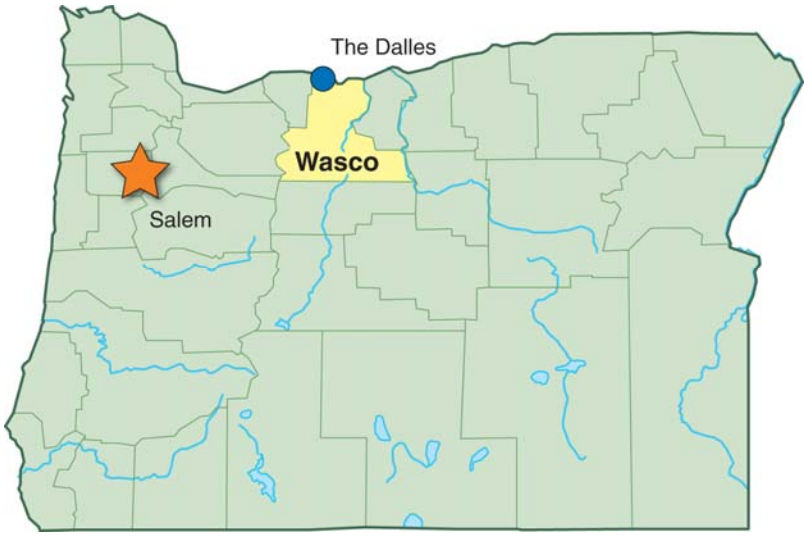

Figure 1. Location map.

Two streams, Mill Creek and Fifteenmile Creek, have special characteristics. The last 850 feet of Mill Creek flows through a tunnel beneath the county seat, the City of The Dalles. Fifteenmile Creek is the only stream in Wasco County that remains a habitat for wild, not hatchery-spawned, anadromous fish – salmon and steelhead. In 1996, it was designated as a *geographical priority area* for federal funding from the Environmental Quality Incentives Program of the Natural Resources Conservation Service, U.S. Department of Agriculture.

Because the Cascade Mountain range to the west blocks Pacific moisture, Wasco County's annual precipitation is just 14.9 inches. This average is somewhat deceiving, however, since the headwaters of major county streams receive well above twice that amount. Most precipitation occurs in the winter, although heavy rains often occur during summer thunderstorms. It is also not uncommon for many areas in the lower watersheds to have recurring drought conditions.

Wasco County is one of three contiguous counties in Oregon, including Multnomah and Hood River, that are part of the Columbia River Gorge National Scenic Area. All lands that can be seen from the Columbia River are included. This so-called "viewshed" may extend inland from the River from one-fourth of a mile to approximately two miles.

In 2000, the population of Wasco County was 23,791, an increase of 9.72% since 1990. Over half of the residents (12,156) resided in The Dalles, which is situated along the Columbia River. The Dalles is one of six incorporated cities; the others are Antelope, Dufur, Maupin, Mosier, and Shaniko. Dufur, the second largest city, had a population of 588. Most of the county is sparsely population farmland or forest. The County Planner estimated that only 3% of the county is populous.

There were once spectacular waterfalls, Celilo Falls, on the Columbia River near The Dalles. However, in 1957, The Dalles Dam was constructed to facilitate river traffic past the waterfall and some of the most treacherous and dangerous rapids in the area and to provide hydroelectric power for the region.

The Office of the County Court governs Wasco County. It consists of an elected full-time County Judge and two elected half-time County Commissioners. The County Court is an administrative body, not judicial. Other elected county officials are the District Attorney, the County Assessor, the County Clerk, the Sheriff, the County Surveyor, and the County Treasurer.

1.1 The County Department of Public Works

The mission of the Wasco County Department of Public Works (DPW) is "We pledge to make Wasco County's roads safe for the traveling public, to the best of our abilities and within our means."

The DPW is headed by the Public Works Director, who also currently is the elected County Surveyor and a registered professional land surveyor (a legal requirement for the elected position). He grew up in the county, began working for the department in 1976 during his college years, and after graduation signed on full time. He worked his way up through the organization, culminating with his appointment as Director in 1992. He was elected County Surveyor in 2003 for a four-year term, and in that capacity he reviews all subdivisions and plats and maintains the library of recorded land surveys.

The DPW is organized into four divisions with a total of 39 full-time equivalent positions (currently constrained by budget to 36 positions):

1. The Road Division, with 29 positions, is headed by a Road Superintendent and several subordinate supervisors who manage road crews.
2. The Engineering and Survey Division is composed of a Project Manager, a Surveyor, and an Engineering Technician.
3. The Weed Division is headed by a Weed Superintendent.
4. The GIS Division is composed of the GIS Coordinator and an analyst.

The Director noted that for the past two decades the staffing of the Road Division has been just enough to fight snow and ice and perform routine road maintenance the rest of the year.

There are two engineering graduates in DPW, and both are registered professional land surveyors. There are no professional engineers, and none are required by Oregon law. The Engineering and Survey Division's Project Manager has responsibility for flood response, and the Engineering Technician conducts inspections of all non-National Bridge Inventory structures.

The Road Division is in charge of road maintenance, including maintenance of pavements, bridges, culverts, ditches, rock shoulders, guardrails, traffic signs and road striping. The road network is divided into five districts. During winter storms, the district crews perform snow and ice removal, and during flood or fire conditions the focus is repair of damaged roads. The main office, yard, and maintenance shop are located in The Dalles. Four satellite facilities (and permanently assigned personnel) are located in Antelope, Dufur, Mosier, and Wamic.

1.2 The County's Local Road System

There are five federal and two state highways that run through Wasco County and all of the populous areas of the county are located on or near these seven roads. The most prominent is the east-west U.S. I-84, which roughly traces the path of the original Oregon Trail along the Columbia River. U.S. Highway 30, now called the Historic Columbia Gorge Highway, is a frontage road that runs parallel to I-84 from Mosier to The Dalles. The main north-west road is U.S. 197 that runs south from the Washington border at The Dalles where it intersects I-84 to just north of the southern county boundary where it intersects U.S. 97, which in turn continues south through the state to the California border. A portion of U.S. 26 traverses the Warm Springs Indian Reservation. The two state highways, 216 and 218, provide east-west routes in the central and southern parts of the county and connect rural parts of the state to U.S. 197.

The remaining roads in the county are county roads, local access roads, city streets, or private roads. *County roads* are defined as "those roads accepted into the County Road System by a vote of the County Court for county maintenance." *Local access roads* are defined as public roads that are not county, state, or federal roads; they have been dedicated to the public but not accepted by the County Court for maintenance. *City streets* are generally maintained by the incorporated cities (the DPW maintains some by agreement). *Private roads* are maintained by their owners.

Although it has not been done in more than 10 years, property owners can request that local access roads be accepted into the County Road System through formal application to the Local Improvement District (LID) program. This allows people to have their roads improved to County standards and then accepted into the county system for continual maintenance. In most cases, improvement implies one or more of the following: paving gravel roads, widening roads, and improving drainage. Owners of the land abutting the proposed improvements are assessed to pay all costs, including $5,000 in administrative fees if the project costs more than $50,000.

Currently there are 697 miles of county roads, 300 of which are paved. For the most part, the roads are fairly long, running either parallel to primary streams, along the ridges, or linking neighboring watersheds. There are some dead end roads in sparsely populated areas.

Wasco County is experiencing little new development, and none that has required the construction of new county roads. Most construction projects involve just a few houses. Virtually all of the development is occurring in the vicinity of either The Dalles or Mosier where the road network is generally adequate. New roads are not being planned.

Generally, roads are paved using hot asphalt and concrete. In the past, some roads were paved using bituminous or cold asphalt. Oil and chip are used to maintain paved roads. Most paving and maintenance are done using in-house labor and equipment. However, DPW and the road department of The Dalles often trade equipment, thereby sharing lesser-used, more expensive equipment. For example, DPW borrows a paver from the city whenever paving jobs are scheduled.

Every three years, all County Road segments are rated to determine priorities for future improvement (briefly described in Section 3.1 and in detail in the Addendum). The priority rating program was established in 1973 and is now known as the "Transportation Improvement Program." The result of the process is a list of road segments recommended for significant repaving, heavy maintenance, or full reconstruction in the next six years. Pavement ratings are scheduled depending on the road classification, from every year to every three years. A formal Pavement Management Program has been used since 1997 and identifies needs and helps schedule relatively small road maintenance projects.

For the past few years, the county has joined with neighboring Sherman County to conduct joint inspections. According to the DPW Director, the cooperative venture has improved DPW's rating skills and reduced the time it would take to do the inspections independently.

DPW replaces between 500 and 1000 feet of side drainage and underdrain culverts in a year. Based on previous inspections conducted using the Transportation Improvement Program and the Pavement Management Program, which identified consistent damage resulting from small 12" culverts, all 12" culverts are replaced with at least 18" culverts, the county's current minimum standard. The average project involves between 40 and 60 feet of pipe, and work at 8 to 12 sites is completed in a year.

Of the slightly less than 400 miles of gravel road, all are bladed at least once each year. The most traveled roads may be bladed several times in the summer. During blading, crew members identify problems that may be addressed in routine maintenance. A gravel road is considered for paving when its average daily traffic count reaches 100. Because conversion to paved road involves meeting all standards it is very expensive. To justify the cost, such a project must score very high on the priority road list, although political influences may become important. Twice a year, members of the County Court travel the

road system for first-hand knowledge of conditions and to view roads that citizens have called for paving.

1.3 Local Bridges and Box Culverts

There are 67 National Bridge Inventory (NBI) bridges (twenty-feet or longer) and 57 non-NBI bridges (less than twenty-feet) in the county. In the latter category, only 20 or so non-NBI bridges are considered substantial. There are many smaller drainage culverts averaging 18 inches that carry local runoff, estimated at well over 1,000, throughout the county. However, there is no inventory and they are not regularly inspected.

Most of the NBI bridges span the primary waterway channels. In the more developed watersheds, multiple bridges have been constructed to open access routes to homes and farms. The non-NBI bridges typically span side or intermittent streams and serve multiple purposes, including cattle passes. Figure 2 and Figure 3 illustrate the inlet and outlet of a typical short span bridge (timber superstructure on masonry abutments) over an intermittent stream.

Figure 2. Inlet of Typical Short Span Bridge

Figure 3. Outlet of Typical Short Span Bridge

In the past ten years, DPW has replaced or rehabilitated 10 bridges with financial assistance from the federal Highway Bridge Replacement and Rehabilitation program. Currently there are seven bridges, some load limited, which have been identified for either rehabilitation or replacement. The next scheduled bridge rehabilitation for two bridges using these funds will take place in 2006.

Three Wasco County bridges were selected this year for rehabilitation under the Oregon Transportation Investment Act of 2003, Local Bridge Program. The single eligibility criterion was importance to freight movement; final selections were driven by sufficiency rating. According to the DPW Director, in recent years the most pressing problem affecting the condition of Wasco County bridges is directly related to freight. Trucks are

now bigger, longer, and heavier than assumed in the original design specifications. Engineering designs for the new bridges will accommodate the increased weight demands.

1.4 History of Flooding in Wasco County

Wasco County's flooding occurs in two seasons, each with distinct characteristics. First, in winter months, there are "rain on snow" events. A warm Chinook wind, often called "the pineapple express," accompanied by rain melts accumulated snow on frozen ground near the headwaters of one or more watersheds. The result is extended flooding for several days. Second, summer thunderstorms may occasionally drop 2 inches or more of rain in 20 minutes, causing flash flooding in one or a few adjacent watersheds. Neither type of event is predictable as to location; however, they tend to occur in what are commonly termed the "mile" creeks, e.g., Fivemile Creek, Eightmile Creek, and Fifteenmile Creek, that have their headwaters on the eastern slope of Mt. Hood.

While some level of flooding occurs with regularity somewhere in the county, significant flood events have been declared major disasters four times since 1964, most recently in 1995 and 1996 (Table 1). Three of the floods occurred in the winter and one in the summer. The flood of record, nicknamed "The Christmas Flood," took place just before Christmas in 1964. In terms of damage, the January, 1974 flood was the worst, destroying nine bridges.

Date	FEMA DR#	Event
December 1964	184	Heavy rains & flooding
January 1974	413	Severe storms, snowmelt & flooding
August 1995	1061	Summer Flash Flooding
February 1996	1099	High winds, severe storms, flooding

Table 1. Major Disaster Declarations.

The 1996 flood was typical of winter floods. The U. S. Department of Agriculture, Natural Resources Conservation Service (NRCS), District Conservationist, who assists Wasco and Hood River Soil and Water Conservation Districts, described the flood as follows:

> On February 7 and 8, 1996, the mid-Columbia area experienced a rapid warming with stations in Wasco County recording 2-2.5 inches of precipitation. At the time, the soil and the creeks were frozen. As the rain began to fall the snow "sealed over" with a hard crust in some areas with no place for water to infiltrate. Streams in drainages with forested elevations up to 3,500 feet began to swell. Initially, ice jams clogged culverts and bridges and reduced stream capacity. The frozen soil and "sealed over" snow reduced infiltration, increasing runoff and erosion of the saturated upper soil layers. These conditions led to widespread flooding, landslides, erosion, and debris flows. Most of the costly damage

> in Hood River and Wasco Counties and the Warm Springs Reservation were confined to flood plains and middle elevation drainages.[1]

Mill Creek was one of the streams that flooded in February 1996. Heavy debris flows and log jams at the mouth of the Mill Creek tunnel inlet coupled with reduced discharge caused by backwater from the Columbia River flooded the downtown business area of The Dalles. Further upstream, in Wasco County, several roads and bridges were damaged.

1.5 Impacts of Flooding on the Road System

Typical winter floods in the mountainous upper watersheds are associated with debris flows that consist of ice, top soil, rocks, and vegetation including small trees that may have grown in the stream bed during droughts and low flows. The debris plugs up culverts and bridge openings, resulting in the overtopping of roadways. Bridges may be washed away or severely damaged. Generally, the roadway approaches (pavements and subgrade) up to twenty or so feet from the ends of the bridge and ditches are scoured away. Landslides alongside roads also occur, blocking drainage which adds to the scour and making road segments impassable.

In the 1996 event, the bridges and culverts in the upper watersheds took the brunt of the force and many were severely damaged. Less but still significant damage to roads and bridges occurred downstream.

County roads (pavements, shoulders, and adjoining ditches) in the mountainous and rolling hill areas that run parallel to streams experience some damage when waters rise outside of channels. Sediment runoff from farmland is a major consequence of rainfall-runoff in the hilly and mountainous parts of the County, clogging ditches and drainage culverts and covering roads. In the mountains, more significant damage is caused by landslides.

To date, no one in Wasco County is known to have been killed or injured by floods, and no one has been stranded for more than a day.

[1] "The Great Flood of '96" by Dusty Eddy, Internal NRCS document, n.d.

2.0 Environment within which Wasco County Operates

2.1 Overview of Public Works Budget

The annual budget is prepared by DPW and approved by the County Court. The Road Division is supported by dedicated funds allocated solely for the development, operation, and maintenance of the Wasco County road system. There are two primary sources of funding:

1. The Oregon State Motor Vehicle Fund whose sources are gas taxes, truck weight/mile taxes, and vehicle registration fees, and
2. Federal Forest Receipts, which were traditionally a percentage of receipts from the sale of timber, are now based on historic levels of timber harvested from federal lands in the Mt. Hood Forest (not actual receipts). These funds are authorizeduntil the end of federal fiscal year 2006.

In the 2003-2004 budget, the Motor Vehicle Fund provided $1,185,000 and Federal Forest Receipts provided $1,817,000. The total road fund was just over $3 million. For the past ten years, funding from these sources has remained relatively constant, varying annually in a range from $3 to $3.3 million. Taking inflation into account, the DPW Director estimated that road fund revenues in 2002-03 were 28% less than in 1992-93.

Significant sources of revenues are not received at the beginning of the County's fiscal year. Federal Forest Receipts, for examples, are received after the end of the federal fiscal year, usually December. During the summer period before the funds are received, the majority of road maintenance occurs and significant expenditures and monetary obligations are incurred. So, to stay solvent and pay bills, the Road Division begins each fiscal year with a cash balance of around $2.5 million.

DPW allocates approximately $50,000 annually for the maintenance of non-NBI bridges, of which about 10% need attention at any one time. Maintenance jobs typically take 3 to 4 weeks to complete. If superstructures are replaced, the county uses concrete slabs that are either cast in its own facility (which has the capacity to cast slabs up to 18 feet in length) or purchased from a prestressed slab manufacturer. The DPW crews also replace bridge abutments if indicated by the inspection. During maintenance work, DPW attempts to keep one lane open at all times, although, there are times when bridges may be closed for a few hours. Emergency or temporary detours have not been required because total replacement of short span crossings have not been required since 1974 when flooding destroyed many bridges.

While the revenues have remained relatively constant without adjusting for inflation, many costs have dramatically increased, causing less work to be scheduled and accomplished. Due to the rising cost of crude oil and the closing of rock pits in the Columbia Gorge National Scenic area, the resulting increased cost of materials (aggregate, asphalt, and fuel) has been profound.

The DPW uses a cost accounting system that has been mandated by the State of Oregon to track maintenance, equipment, and construction costs (especially dedicated road funds) and to make budget projections. Called IRIS (Integrated Road Information System), it is installed and maintained on-line by the Association of Oregon Counties. All labor costs, material costs, and equipment costs are charged, by specific county road, through employee time cards which are completed as the work is done. All overhead costs are loaded into labor and equipment billing rates.

2.2 Regulatory Framework

Bridge and road construction and rehabilitation in Wasco County are variously subject to regulations or requirements of the Oregon Department of Transportation (ODOT), the Oregon Division of State Lands (DSL), Oregon Department of Fish and Wildlife (ODFW), and the U.S. Army Corps of Engineers (USACE). In addition they are subject to the Wasco County Land Use and Development Ordinance and the Columbia Gorge National Scenic Area Land Use and Development Ordinance.

The ODOT Hydraulics Manual specifies that NBI bridges be constructed to pass the 100-year flood and recommends that there be one foot of freeboard between the 100-year flood elevation and the underside of the superstructure. Where bridges are also subject to debris flows, they must be sized to meet the more restrictive of the 100-year flood or be able to pass the 25-year flood with three feet of freeboard.

The National Scenic Area Land Use and Development Ordinance and the Wasco County Land Use and Development Ordinance both require that bridges be constructed to pass the 100-year flood discharge.

Oregon's Removal-Fill Law requires those who plan to remove material in waters of the state to obtain a permit from the Department of State Lands. Permits are required for any project with the intent to remove or fill 50 cubic yards or material in waters of the state. Permits are also required for the removal or fill of any material, regardless of the number of cubic yards, in a stream designated as essential salmon habitat or from the bed and banks of scenic waterways. Material removed or filled includes riprap, rock, gravel, sand, silt, clay, and organics. In case any project also requires a permit from the U.S. Army Corps of Engineers, a Joint Permit Application Form is always completed and copies sent to both the USACE and DSL.

DSL approves projects which have a minimum effect on water resources and adjacent properties. It recommends that projects contain mitigation elements that enhance fish habitat and restore wetlands. The Oregon Fish and Wildlife Department also reviews projects to ensure that native fish are not negatively impacted.

Exemptions. The Wasco County Land Use and Development Ordinance exempts most maintenance and rehabilitation of roads and other elements of the road system from the

provisions of the ordinance, including the necessity to secure local permits. Section 4.040 states that:

> Nothing in this Ordinance shall be deemed to apply to the construction, reconstruction, or alteration by a government agency of road or highway systems, or to the use of materials within rights-of-way. In addition, maintenance, rehabilitation, repair and minor betterment activities, not considered to have land use impacts, by a governmental agency on public property or facilities, shall also be exempt from the provisions of this Ordinance. Public works projects or land uses, authorized or approved by the County Court and determined by the Director to be consistent with the long-term objectives of the Comprehensive Plan, shall be exempt from the current provisions of the Ordinance.

DSL exempts three types of projects that affect DPW from having to get Removal-Fill permits. First, it exempts the maintenance or reconstruction of existing serviceable structures (such as dikes, dams, levees, groins, riprap, tidegates, drainage ditches, irrigation ditches, and tile drain systems) on an in-kind, in-place basis. Second, it exempts maintenance, including emergency reconstruction of recently damaged parts, of currently serviceable road or transportation structures (such as groins and riprap protecting roads, causeways and bridge abutments). Third, it exempts the maintenance, repair, removal and replacement of culverts. As to the latter exemption, DSL encourages the use of bridges rather than culverts to maintain stream bottom integrity.

2.3 Guidance and Local Standards

Inspection of Bridges. Bridges in the NBI (longer than 20 feet) are inspected biennially (in even numbered years) by engineering consultants under contract to the Oregon Department of Transportation. Copies of reports are provided to the DPW.

Non-NBI bridges (less than 20 feet) are also inspected biennially, in odd numbered years, by the Engineering Technician in the Engineering and Survey Division who has been trained to conduct inspections. The inspection standards and procedures are equivalent to those used for NBI structures. The DPW considers the procedures adequate to identify flood-related conditions.

A staff member in the Road Division is a bridge maintenance specialist. If the Engineering Technician doing bridge inspection sees a problem such as scour, he may ask the specialist to determine if DPW can do in-house maintenance or if the problem is sufficiently severe to warrant tasking a consultant to conduct an engineering evaluation.

Road Inspections and Standards. The DPW applies an internally-developed rating system when conducting road inspections (see Section 1.2 and Addendum). The system is based in part on *A Policy on Geometric Design of Highways and Streets* published by the American Association of State Highway and Transportation Officials (AASHTO). Existing road dimensions and conditions are compared to the standards (as a function of

width) to identify deficiencies in dimensions and geometry. With respect to drainage capacity, for the most part adequacy is based on the field judgment of the inspector; computations of rainfall-runoff and drainage system dimensions may performed on a case-by-case basis. The County's objective is to bring existing roads up to standard when possible and within budget.

Transportation System Plan. The State of Oregon mandates all counties with populations over 25,000 to maintain a Transportation System Plan as an element of their comprehensive plans. A Transportation System Plan is a 20-year projection of need and is intended to provide the basis for making prudent investments in all modes of transportation and related land use decisions. With fewer than 25,000 residents, Wasco County and its incorporated municipalities are not required to prepare a plan and have not done so.

Bridges/Culverts – Configurations. As a condition of the federal funding, all work related to NBI bridges is conducted by outside contractors, from design to construction. When the NBI Sufficiency Rating indicates the need for more than routine maintenance, the DPW hires a consulting engineer to further evaluate the structure and recommend either rehabilitation or replacement. Designs are required to address state regulations described above, including flood resistant elements (conveyance with freeboard and scour analyses for abutment protection). Because of the nature of the substrate and stream channels, which move regularly, analyses are used to position the bridge over the area expected to carry the dominant discharges. Riprap emplacements to protect streambanks from erosion are placed as far from channels as possible to minimize disruptions to fish habitat.

The last time a non-NBI crossing was replaced was after the floods in 1996. If a replacement structure was deemed necessary today, a consultant would be hired to evaluate the hydraulic and structural requirements. In 1996 a bridge with wooden abutments and superstructure was replaced with a reinforced concrete box culvert. DPW prefers box culverts because smaller ones can be built with in-house crew members, have lower construction costs, and are easier to maintain.

2.4 Post Flood Experiences and Influences

The current staff in the Wasco County DPW has had experience working with state and federal officials following flood events. Three major floods occurred in the mid-1990s, resulting in two Presidentially-declared disaster declarations, all affecting the ecologically sensitive Fifteenmile Creek and Mill Creek.

Post-flood activities, including a successful Hazard Mitigation Grant Program (HMGP) award (described below), required coordinated efforts of Wasco County, the Wasco County Soil & Water Conservation District (SWCD), the City of Dufor, the City of The Dalles, Oregon Department of Fish & Wildlife, the Oregon Department of State Lands, the Oregon Department of Highways, the Oregon Office of Emergency Management

(OEM), the USDA NRCS, the USDA Forest Service, the U.S. Army Corps of Engineers, and the Federal Emergency Management Agency (FEMA).

After the disaster declaration in 1995, Wasco County believed it had a very positive experience with FEMA. The DPW Director attributed this to having had experienced FEMA personnel assigned to work with the county. The experience following the declaration in 1996 went less well, partially due to inexperienced FEMA inspectors. The Director noted that, despite differences in FEMA personnel, there was one constant. Both times the actual cost to bring gravel roads back to their pre-flood condition was more than allowed by FEMA or the State Highway Department. Both agencies disallowed full payment for the amount of aggregate used to repair gravel roads, apparently believing that less material was there prior to flooding.

As pointed out below in the discussion of the response to the July 1995 Fifteenmile Creek flood, the DPW has been actively engaged with local, state and federal agencies, ultimately developing a "systems approach" to address the main causes of damage from flash floods, runoff and undersized stream and drainage culverts.

Fifteenmile Creek – A Systems Approach. In July 1995, a summer thunderstorm and resulting flash flood in the Fifteenmile Creek watershed caused severe damage to roads, culverts, and bridges, estimated at $5.3 million. In the private sector, losses included crop damage and soil erosion. The Fifteenmile Creek streambed and a large segment of its fish habitat were also damaged.

After receiving technical engineering assistance from the state to assess road and bridge damage, county road crews and local contractors were able to temporarily repair roads sufficient to allow farm-to-market traffic for the wheat industry. Following these initial efforts, with FEMA and OEM support, four Public Assistance grants were approved for road reconstruction. The projects were completed by private contractors and included subgrade replacement, installation of riprap, installation of replacement culverts, and paving. After the major road repair work was completed, the work crews began to reconstruct ditches and small sections of washouts along county roads.

In addition to repairing damaged infrastructure, DPW also wanted to mitigate future losses from flash floods. There was a history of plans for Fifteenmile Creek that started in 1987, when the Oregon Department of Fish & Wildlife, USDA Forest Service, Confederated Tribes of the Warm Springs Indian Reservation, Wasco County SWCD, Bonneville Power Administration (BPA), and private landowners created the Fifteenmile Creek Implementation Plan. The main impetus for planning had been to improve wild winter steelhead production.

Under the leadership of the Wasco County SWCD[2], an interagency planning group of six agencies including the DPW representing the County Court, the Oregon Department of Fish & Wildlife, USDA Forest Service, City of Dufur, and NRCS was formed to write

[2] SWCD had successfully initiated an interagency watershed project for Buck Hollow in 1990. Its success encouraged SWCD to lead this watershed project.

the Fifteenmile Creek Hazard Mitigation Plan. The plan was completed in October 1995 and subsequently approved by OEM and FEMA. Each agency developed a list of site-specific and long-term hazard mitigation projects that meet three objectives:

1. Reduce the impact of runoff and erosion on infrastructure (e.g., roadways, bridges, culverts, stormwater systems);
2. Reduce erosion on and from agricultural lands; and
3. Reduce the negative consequences of runoff and erosion on wildlife and fish habitat.

The Wasco County SWCD applied to FEMA for a HMGP grant in April 1996 to implement the recommendations of the Plan. The total cost estimate was $312,750 of which $202,047 would come from FEMA. Funds and in-kind services from the six agencies were committed for the non-federal share.

The HMGP application explains the approach behind the Hazard Mitigation Plan. It states,

> "The preferred alternative is to use a *systems approach* in implementing recommendations of the approved Wasco County Hazard Mitigation Plan. The intent of using a systems approach is twofold. First, areas treated will be looked at in terms of *complete treatment for the sub-basin* or drainage area involved by appropriate integration of complementary treatment practices. Second, an effort will be made to ensure use of as many different recommended practices as possible with broadest possible involvement of agencies and private landowners. This is expected to set the stage for a *cooperative, long-term, comprehensive watershed treatment project*. Further, completed elements, in addition to reducing likelihood of future damage, will have high value for educational use as practical demonstration projects."

Eight distinct elements were proposed (and subsequently completed), including:

1. Stream bank stabilization of Lower Fifteenmile Creek.
2. Stabilize Shotgun Hollow drainage.
3. Reforestation of 20 acres of critical riparian area on upper Fifteenmile Creek and 35 acres on upper Fivemile Creek.
4. Stabilize Emerson Loop sub-basin.
5. Reduce road damage in Long Hollow.
6. Reduce road damage to Fargher Road.
7. Reduce damage to City of Dufur infrastructure.
8. Reduce sediment delivery to Fifteenmile Creek from Douglas Hollow.

To illustrate the systems approach taken by the partnership, stabilizing Shotgun Hollow drainage (#2 above) involves the following work elements:

> "Install series of 5 flood water retarding structures in ephemeral reaches of Shotgun Hollow. Install a round, galvanized 6-ft. culvert on Adkisson Road. Complete culvert and road bed work at two sites on Steuber Road. Install best management practices (BMP) on adjacent farm land. Applicable BMPs in this area will be gradient or level terraces, sediment basins, and potentially sod waterways, buffer strips, or conversion of some fields to divided slope systems. This project will reduce runoff and erosion from farm land, reduce likelihood of culvert capacity being exceeded with accompanying damage to roadways, reduce energy of concentrated flows in Shotgun Hollow and reduce bed and suspended sediment load potential from those flows."

The HMGP application does not contain a formal benefit-to-cost analysis. However, the application's authors estimated annual savings if the project were completed. FEMA estimated that the 1995 flash flood was a 12- to 15-year frequency event and total was estimated at $10.1 million ($2 million from infrastructure damage and $8.1 million from damage to agricultural lands, streams, and fish habitat). A very simplified approach was taken to approximate the annual damage as $750,000. The application also indicated that the project would reduce or eliminate annual maintenance expenditures totaling about $77,000: the City of Dufur spends about $3,000 pear year on removal of siltation attributed to runoff and erosion, and the DPW's annual costs for removal of silt deposited on roads in the Lower Fifteenmile Creek Watershed averaged about $74,000 (data from 1988-1990). Thus, it was estimated that annual savings would be $827,000. Considering only the one-time investment of project construction costs ($312,750), the project yields benefits that far outweigh the costs.

2.5 Emergency Response and Planning

The Wasco County Emergency Manager reported that there is no formal emergency plan for disasters such as floods. The main concern of the local fire departments is forest fire, and fire stations have been located to maximize fire suppression response.

The Emergency Manager provided four opinions that support having no formal emergency plan for flood:

1. Schools are not located in floodplains;
2. Most areas have multiple access roads and citizens can bypass flooded areas;
3. The county is so large that evacuation routes cannot be identified; however, "lifeline routes" are identified; and
4. Significant floods affecting large areas are not common.

3.0 Overview of Local Decision Processes

The Wasco County DPW uses formal decision tools to identify and set priorities for major road repair (including drainage work) and routine pavement maintenance work (see Addendum). When a project is identified, the scope of work is determined by comparing roads to standards that it has adopted. The Transportation Improvement Program is an internally developed program, and the Pavement Management Program (see Section 1.2) was created by the Association of Oregon Counties based on a similar program originally developed in Oakland, California.

The biennial inspection of all bridges (NBI and non-NBI) results in Sufficiency Ratings which is the basis of decisions regarding which projects are priorities. Bridges that receive Sufficiency Ratings that identify them as needing either rehabilitation or replacement are ranked according to their condition and how important the bridge is (similar to how roads are prioritized for reconstruction, see Addendum).

All NBI bridges in the state compete for an annual allotment of federal funds. Thus, given budgetary constraints, the DPW cannot undertake work on NBI bridges unless its proposed projects are awarded funds through the state program. County funds are expended on non-NBI bridges.

3.1 The Transportation Improvement Program

As stated earlier, Wasco County has used a road priority program, now called the Transportation Improvement Program, since 1973 to aid the DPW in programming construction jobs for the improvement of the county road system (see Addendum). Each county road receives a rating review every three years, the last being in 2003.

The rating process attempts to evaluate two basic qualities of all roadway segments:

- Condition Rating – How does the road compare with standards?
- Service Rating – How important is the road?

Practical Considerations. DPW notes that there are many considerations in project selection that cannot be reduced to a formula. Sole utilization of the priority determination in program formulation would lead to ineffective programs without the practical considerations of forecasts, civic and political policies, and economic benefits. The priority rating should be the governing factor in priority programming but, to be responsible, DPW must exercise judgment and take experience into account, weighing all variables to select the projects to be undertaken at successive time intervals.

Table 2 lists some of the practical considerations that DPW describes as influencing decisions to move roadway segments up or down on the priority list. The order of the list does not imply a rigid ranking of importance; the degree of influence of each of these considerations varies according to site-specific conditions, budget constraints, and other factors.

1. Funding available.	13. Construction season length vs. time to complete project.
2. Scheduling of projects to minimize total inconvenience to traffic during construction.	14. Small vs. large projects vs. stage construction.
3. Desired continuity of improvements along a particular route.	15. Lead time for negotiations and hearings – other agencies, utilities, land development.
4. Balance between types of work – grading, surfacing, and structures.	16. Preparation of plans.
5. Geographic distribution of work – may involve small projects for district crew when not engaged in maintenance.	17. Right of way acquisitions.
6. Adequacy of contractor – supply vs. competition.	18. Industrial or other land use development.
7. Adequacy of labor and material supply.	19. Adequacy of County engineering staff.
8. Projects for which numerical priority analysis is not practical, including • Further stage construction on projects already initiated. • Entirely new facilities.	20. Desires of public officials.
9. Accident record and safety.	21. Demands of private citizens.
10. Emergency (disaster) needs.	22. Requirements of law.
11. Temporary vs. permanent improvements.	23. Environmental impact.
12. Maintenance costs.	24. Projects that may be constructed during adverse weather conditions.

Table 2. Considerations that Influence Prioritization of Projects.

Recent Recommendations. The last two priority lists were issued in 2000 and 2003. In 2000, 18 road segments with an average of 1 mile each were recommended for improvements. Between 2000 and 2003, construction projects for 12 of the roads were completed. In 2003, the six uncompleted projects from 2000 remained on the list along with 11 additional road segments. The 2003 list does not include the length of each road segment but it does identify projects according road classification. Four major collectors, 10 minor collectors, and 3 local access roads were included. One of the projects was labeled as needing work for a storm sewer and one for drainage.

One unexpected result arose after the priority rating system went into effect. Once a road was rebuilt to county standards, its traffic volume increased, thereby raising its priority rating in subsequent investigations. A practice to review roads with high condition ratings (90+) was initiated to avoid including them in the list of recommended road projects solely due to increased traffic.

In the last decade, insufficient funds have been available to undertake the identified work, especially projects that involve major reconstruction. Therefore, the majority of road projects have consisted of safety-related upgrades, heavy maintenance projects on small sections of road, and repairs.

3.2 Changes in Local Decision Processes Since 1996

Wasco County DPW learned a number of lessons regarding flood loss reduction since the floods in 1996 and associated with implementation of the Fifteenmile Creek Hazard Mitigation Plan. These lessons have been incorporated into its decision processes.

- Drainage problems are viewed on a watershed basis rather than site by site. The same waterway may be crossed by two or more roads or multiple times by a single road. If a drainage problem is identified during road inspection of one crossing, then all crossings are inspected to determine the cause of the problem. In some instances, the primary cause may not be a road problem but may be associated with runoff that can be addressed by changing farming practices. Or, if the identified drainage problem turns out to be an undersized structure that creates a bottleneck, a solution may involve diverting water at an upstream location or making changes to what appeared at first to be a problem-free road. In the past, DPW would have considered only changes at the initially-identified problem site.

- The DPW increased its minimum standard drainage pipe size from 12-inches to 18-inches.

- The DPW continues to work with the Wasco County SWCD on fish habitat improvement projects.[3] A current project, funded by the Bonneville Power Administration, involves removal of an 8-foot long culvert on Eightmile Creek because it has been identified as a fish barrier. It will be replaced with either a bridge or an arched plate culvert with an open bottom. In addition to addressing the minimum flood-resistant requirements of state regulations, the design will take into consideration additional measures because an upstream farmhouse flooded in 1997 by backwater after the crossing was plugged by debris.

[3] In 1994, The Northwest Power and Conservation Council added the Fifteenmile Creek Subbasin to its Columbia River Basin Fish and Wildlife Program. Since 1995, the Bonneville Power Administration has awarded Wasco County over $3.3 million for fish habitat improvement.

4.0 Site Specific Examination of Decisions

4.1 Wilson Road – Bridge 65C65

Wilson Road is a winding mountainous gravel surfaced road classified as a Rural Local Road. The County standard design section for this classification is a 24-foot wide traveling surface with 2-foot shoulders for a total width of 28 feet. The average daily traffic at this site was estimated at 35.

Bridge 65C65 spans West Fork Mosier Creek in a steep narrow canyon. It is not mapped as a regulatory floodplain. According to the August 1996 engineering report[4], the bridge that existed prior to the February 1996 flood was constructed in 1955. Prior to 1970, it was a 32-foot single span log bridge with a wood plank deck; in 1970 vertical concrete walls and wingwalls were constructed to help protect the wood sill abutments and to help support the log and timber superstructure. The concrete walls were supported on shallow-depth concrete spread footings with the bottoms of the footings at approximately the elevation of the streambed. The bridge was listed in the National Bridge Inventory System as having a main span of 13 feet and two approach spans. Apparently the distance between the two concrete walls was 13 feet. The bridge had a roadway width of 17.8 feet and an overall deck width of 18.8 feet. The 1992 bridge inspection report noted that the design load of the bridge was AASHTO H-15.

The February 1996 flash flood exceeded the capacity of the bridge opening. Flood water overtopped the concrete wall and wingwalls and washed out the east abutment. The spread footings supporting the concrete walls and wingwalls were undermined by scour, and various sections of the walls and wingwalls settled, tilted, or fell over. The east end of the bridge dropped 2 feet or more, and the road approach to the east end was washed out for about 15 feet.

According to the engineer's hydraulic report, the bridge failure probably occurred because of a combination of scour under the abutments and the dynamic forces of water flowing in and around the structure. The last bridge inspection prior to the flood identified 1.5 feet of scour under one side of the upstream abutment and additional scour damage at a downstream corner of the structure. The inspector also noted that the "waterway opening questionable during times of high flow."

After its failure, the DPW removed the damaged structure bridge and installed a temporary 8-foot diameter culvert pipe. The culvert pipe was backfilled and the road was repaired to allow the passage of traffic. The hydraulic capacity of the culvert was significantly less than the original structure, and the DPW wanted a replacement constructed prior to December to prevent a potential washout due to winter flows. In addition, the temporary crossing was considered to be structurally inadequate for large truck traffic loads.

[4] Anderson-Perry & Associates, Inc., *Engineering Report for West Fork Mosier Creek, Wilson Road, Bridge No. 65C65, Wasco County, Oregon*, La Grande, Oregon, August 1966.

Alternative Replacement Bridge Designs. The engineering consultant developed three alternative designs, all capable of passing the 25-year design flood with a minimum of three feet of clearance for debris and ice and of passing the 100-year flood without overtopping the roadway. Each design also contained mitigation elements, primarily to meet to the building codes and road standards, including the roadway width on the structure of a nominal 28 feet.

Design Standards: Design standards referenced for the replacement structure included:

- Wasco County Road Design Standards
- Oregon Department of Transportation – "Bridge Design Manual"
- Oregon Department of Transportation – "Roadway Design Manual"
- AASHTO – "Geometric Design of Highways and Streets"
- Design Live Load of Box Culverts and Bridges – AASHTO HS25

Alternative A – Concrete Box Culvert: The features of this alternative are:

- Recommended size of the box culvert – 9-foot rise by 16-foot span
- The box culvert will need to be skewed 37 degrees from a 90-degree crossing of the road in order to match the alignment of the stream
- Recommended length of the box culvert – 64 feet with a slope of 2.0 percent
- Concrete aprons to be constructed at the inlet and outlet ends of the box culvert. Cutoff walls should be constructed on the ends of both aprons
- Class 2000 riprap to be placed along the stream banks and across the stream bottom at the inlet and outlet ends to protect the box culvert from streambed scour and bank erosion
- Special attention should be given to the road grade over the top of the culvert
- Estimated Total Project Costs - $198,000

Alternative B – New Bridge with Concrete Spread Footing Foundation: The features of this alternative are:

- Vertical abutments with spread footings. Abutments will be skewed 37 degrees. The bridge site is located immediately downstream of a relatively sharp bend in the stream channel, and vertical concrete abutments will provide better control of the water through the bridge opening. To provide protection of the footings from undermining by stream scour, the footings will be constructed 8 feet below the stream bottom. Class 2000 riprap will be placed over the footing on the stream side for additional protection of the footings from scour.
- The superstructure will consist of seven 24-foot single span precast prestressed voided concrete slabs. The recommended overall deck width is 28 feet.
- Recommended type of bridge rail – thrie beam side-mounted rail. With this type of bridge rail, the roadway width on the bridge will be 27 feet, 6 inches.
- Estimated Total Project Costs - $267,000

Alternative C – New Bridge with Steel Pile Foundation: The features of this alternative are:

- Bridge opening will be a spill-through type. The new bridge will be constructed with a steel pile foundation with concrete pile cap-type abutments. Abutments will be skewed 37 degrees.
- Bridge and slopes constructed on a 1.5H:1V slope, and protected with a 3-foot layer of Class 2000 riprap.
- The superstructure will consist of seven 24-foot single span precast prestressed voided concrete slabs. The recommended overall deck width is 28 feet.
- Recommended type of bridge rail – thrie beam side-mounted rail. With this type of bridge rail, the roadway width on the bridge will be 27 feet, 6 inches.
- Estimated Total Project Costs - $254,000

Final Replacement Selection: Alternative A was the least-cost design that also met all of the primary hydraulic design requirements. It was the alternative recommended by the engineering consultant and was selected by the DPW for construction. (See Figure 4 and Figure 5.)

Figure 4. Inlet of Box Culvert, with Fish Passage Channel

Figure 5. Bridge 65C65, Wilson Road over West Fork Mosier Creek

Fish Habitat Considerations: The Oregon Department of Fish & Wildlife imposes constraints on the allowable period for in-stream work so that disturbances occur during low flows, generally July 1 through October 31. The agency also reviews proposals for fish passage. For the Box Culvert 65C65, it requested that the bottom of the box culvert have a V-shaped channel (8 inches deep and 8 feet top width) to maximize flow depths during low flows.

Other Considerations: During the 3-month construction period Wilson Road was closed at the project site. This resulted in a detour of approximately 5 miles; temporary signage was erected to direct the traffic around the detour. At the project site, barricades and concrete barriers were installed to warn and protect the public. A temporary footbridge with handrails was erected to serve the three

isolated families.

The DPW's Hindsight Assessment: Since the new bridge was erected, there have been no flood events to test the new design. The DPW Director said that the process to design the new crossing is comprehensive, the new box culvert meets the flood standards, and he has no basis for questioning the design decisions.

4.2 Wilson Road – Bridge 65C74

Bridge 65C74 over West Fork Mosier Creek is about a half-mile east and downstream of Bridge 65C65 on Wilson Road. At this location Wilson Road is a 24-foot gravel road with two feet of shoulder on each side and an average daily traffic count of about 35. It is located about a hundred yards from the confluence with Mosier Creek; unlike the site of Bridge 65C65, the terrain is relatively flat.

Bridge 65C74 was constructed in 1950. With a clear span of 25-feet, the superstructure of the bridge is described as "timber open girder" with a timber deck. It has concrete abutments and the deck has an asphalt concrete overlay. It has a design load of AASHTO H-15. Although the bridge is relatively old and does not meet today's flood resistant and other design standards, past bridge inspection reports consistently concluded that it is in very good condition. Its current sufficiency rating is 85.80. (See Figure 6 and Figure 7.)

In the February 1996 flood that collapsed Bridge 65C65, Bridge 65C74 was overtopped, the guard rails torn up, and the waterway opening was filled with debris. The flood caused some wingwall damage and minor scour. Although this location has flooded before, this was the first time that the bridge had sustained even minor structural damage.

Following the February 1996 flood, the bridge was repaired, including the armoring of the wingwalls and the placement of riprap both up and downstream to limit scouring.

Figure 6. Upstream of Bridge 65C74 (timber superstructure, concrete abutments, vegetative growth in stream)

The DPW's Hindsight Assessment: In the DPW Director's opinion, the reason Bridge 65C74 suffered so little damage was because the bridge is positioned such that the main flood flows approach the opening directly, rather than from an angle, thus reducing the potential for scour. This reinforces the importance of the current requirements to analyze channel migration when positioning replacement bridges. It is also possible that Bridge 65C65 absorbed the brunt of the flood water and collected a great deal of the debris, lessening the force that hit this bridge. Since 1996, there have been no flood events at this location and the bridge remains in very good condition and served its purpose. However, its design load is less than needed to handle current freight traffic. This inadequacy will be addressed with the bridge is scheduled for replacement.

Figure 7. Wilson Road (constant width over bridge).

5.0 Observations

5.1 The County's Observations on Flood-Resistance

Since 1973, with the introduction of the Transportation Improvement Program, Wasco County has systematically been improving its entire road system, a consequence of the comprehensive program is an overall improvement in flood-resistance. The DPW director identified several factors that have made Wasco County more flood-resistant:

- Complying with state requirements generally results in increasing the hydraulic opening size of replacement bridges and culverts
- Farming practices evolving from plowed lands to no till, keeping silt out of streams and ditches
- Using riprap and planting native trees and shrubs along stream banks for erosion control
- Continuing partnership programs, such as the Fifteenmile Creek initiative, in association with the Wasco County Soil & Water Conservation District
- Proactive inspections of bridges and roads to identify and respond to potential problems before they become critical
- Adopting a watershed approach to evaluate drainage problems and determine the best solutions

5.2 Case Study Team Observations

The Wasco County Department of Public Works manages its local road system based on a structured "systems approach" that permits it to find multiple causes and solutions for flooding in a watershed. Since 1996, it has addressed root causes rather than focusing on how to prevent continued damage to specific local roads and bridges. It works with other agencies such as the Soil & Water Conservation District to change farming practices in order to reduce runoff and erosion, two of the main causes of flood damage to roads and drainage components.

Even though the DPW has operated with reduced revenues for the past ten years, its formal bridge and road inspection programs have allowed it to isolate the major problems and proactively resolve them prior to flooding. Of the eight variables in The Transportation Improvement Program, drainage has been one of the two most important, with a factor weight of 20 percent.

The Pavement Management Program introduced in 1997 is structured to monitor long-term changes through annual inspection of all road surfaces, and schedule maintenance

projects to address the most significant needs. Roads are not allowed to deteriorate to critical conditions, thereby reducing the probability of damage in the event of floods or runoff that exceeds the drainage system capacity.

The last flood that caused significant damage to the local road system occurred in 1997. Since then the DPW has been able to upgrade its bridges, culverts, and roads without having to divert resources to respond to disaster damage.

The county actively partners with others to complete its tasks and achieve multiple objectives, including The City of Dalles and the Oregon Department of Transportation (ODOT) (sharing equipment keeps costs down), Sherman County (sharing road inspection duties is efficient use of staff resources), and the Soil & Water Conservation District (multiple elements to reduce flood hazards and damage).

DPW is open to new ideas and is not bound by tradition – it adapts new engineering knowledge into its practices.

Addendum: Wasco's Transportation Improvement Program

The following is based largely on an internal DPW document, *Priority Rating Program for Road Improvement*, originally written in 1973 and amended several times thereafter. The DPW indicated that it is, for the most part, compatible with AASHTO's *A Policy on Geometric Design of Highways and Streets*.

Condition Rating. The Condition Rating is the result of a physical inspection completed by DPW staff based on a comparison of different road components with DPW road standards. Every road in the county road system is categorized and comparisons are made to the appropriate standard.

The Condition Rating is based on eight weighted factors listed in Table A1 and described below. The weights assigned total 100. A road rated perfect in each of the eight factors would have a condition rating of 100. Any deficiencies will decrease the rating.

Condition Rating	
Pavement Width	10
Shoulder to Shoulder Width	10
Alignment	10
Grade	10
Maintenance Cost per Mile	10
Surface Riding Condition	10
Structural Adequacy	20
Drainage Adequacy	20
Maximum Possible Condition Rating	100

Table A1. Condition Rating

Rating Determinations:

Pavement Width: Field measurements are made at different points along the road segment. The average existing width is compared to the standard width and differences determine the rating score.

Difference in Width (Standard – Existing) (feet)	0	1	2	3	4	5	6 or more
Points	10	9	8	7	5	2	0

Pavement width is identified as critical if a road supposed to be 24 feet wide is under 20 feet and a road supposed to be 22 feet wide is under 19 feet.

Shoulder to Shoulder Width: Field measurements are made at several places along the road segment and averaged. The average is then compared to tables based on standards for 8 classifications of roads with average daily traffic counts ranging from under 25 to 6,000 and with corresponding widths ranging from 18 to 44 feet.

For the narrowest roads, even slight deviations from the standards yield low numerical ratings. For the widest roads, slight deviations do not have the same negative impact on numerical ratings.

Shoulder width is identified as critical if rated 5 or less. For all eight road classifications, a numerical rating of 5 is given when the width of the existing road is about 20% less than the standard.

Alignment: The alignment rating is made from either strip maps or the combination of air photos and a template to measure the curvature of the road. The following formula, originally taken from the AASHTO Road Manual, is used to determine the rating. (Note: the lower case letters should be subscripts.)

$$Ra = 10 - (De - Ds) / 2L$$

Where: Ra = Alignment Rating
De = Existing Degree of Curvature
Ds = Maximum Degree of Curvature According To Standards
L = Length of Section in Miles

This formula has been empirically tested for the past 14 years, and DPW believes it has worked satisfactorily.

Grade: The grade is determined by a rater in the field using a grade measuring device. The rater estimates the percent of the road exceeding the grade standard and assigns a numerical value from the following table:

% Over Standard	5	4	3	2	1	0
Rating	0	2	4	6	8	10

The grade is identified as critical if 3% or more of the section exceeds standards.

Maintenance Cost per Mile: Maintenance cost per mile is a relative rating based upon a three-year average cost for maintaining the section of the road. An extremely expensive road rates 0, a road requiring little or no maintenance rates a 9 or 10. If rated 1 or less, this factor is rated critical.

Riding Surface Quality: Riding Surface Quality is a relative rating involving only the judgment of the rater using the following guidelines relating to driving ease, comfort, and safety:

- Deficiencies on paved surfaces include excessive or uneven crown, washboarding, raveling, and bumpiness due to cracking, scaling or unsmooth pitching.
- Deficiencies on gravel or stone surfaces do *not* include situations that can be readily corrected by maintenance blading, but do include loose surface due to poorly graded aggregate or permanent roughness due to insufficient depth or poor gradation of surfacing aggregate, or to weak subgrade.
- Deficiencies on unsurfaced roads are those qualities of roughness or irregularity that are inherent in the character of the soil, and that cannot be eliminated by maintenance blading.

Effects of surface riding quality deficiencies, in order or seriousness, include:

- Noise
- Vibration
- Sway or jounce
- Excessive steering effort
- Reduced speed

Four riding quality evaluation ratings have been developed to assist the rater:

- Good: Provides fully adequate standard of service. Possible to maintain a desirable operating speed with no annoyance or discomfort.[5]
- Fair: Possible to maintain desirable operating speed, but with a noticeable amount of annoyance to the driver due to sway, vibration, or steering effort but no feeling of either hazard or serious unkindness to the vehicle.
- Poor: Attempting to maintain the desirable operating speed will result in either or both of the following situations: 1) a "tug of war" with too steep or uneven crown, or 2) a feeling the vehicle's undercarriage is getting a severe workout.
- Very Poor: Surface irregularities so severe that a driver will tend to reduce speed considerably, possibly even charting an irregular course. Or, as an another condition a crown so steep as to be hazardous of passage under icy conditions.

In instances where the surface riding condition quality varies considerably over the section of the road being rated, the rating shall be based on the worst condition that prevails over as much as 20 percent of the road.

Structural Adequacy: Structural adequacy[6] is a relative rating involving only the judgement of the rater using past history of the road (not bridges), knowledge of construction designs, and utilizing the following guidelines:

[5] DPW defines a "desirable operating speed" as usually 85 to 90 percent of the design speed.

[6] The DPW does not equate riding quality to structural strength. A paved road may have poor riding quality due to roughness of previous patchings, yet be structurally adequate. A gravel or unsurfaced road may have poor riding quality due to inadequate blading, yet be capable of carrying the imposed traffic. Conversely, a surface may ride smoothly, but on close examination show surface cracking or unevenness in cross section indicating structural weakness and impending failure.

Surface and Base: Relates to load supporting ability and resistance to deformation or rupture of the surfacing and the base course material. For paved surfaces, distress signs are cracking, rutting, washboarding, heaving, shoving, and potholing. For gravel or unsurfaced roads, distress signs are heaving, rutting, and potholing.

Structural condition is rated in accordance with the following definitions:

- Good: No distress pattern on entire portion of road being rated.
- Adequate: Sections of road showing the visible distress patterns listed above represent less than 5 percent of the length of the entire portion of road being tested.
- Fair: Sections of road showing the visible distress patterns listed above represent 5 to 20 percent of the length of the entire portion of road being tested. Necessary maintenance effort may be above average, but not necessarily uneconomic from point of view of weighting maintenance cost against cost of reconstruction.
- Poor: Sections of road showing the distress patterns listed above represent more than 20 percent of the length of the entire portion of road being tested. Necessary maintenance is extensive. Warrants reconstruction now.
- Very Poor: Extreme distress, as evidenced by severe heaving, rutting or breakup of surface indicates that structural integrity has been destroyed. No amount of maintenance can restore to an acceptable basis. Warrants reconstruction on an urgent basis.

A structural strength rated poor or very poor constitutes a critical deficiency.

Drainage Adequacy: Drainage adequacy is a relative rating involving only the judgement of the rater. Adequacy[7] of drainage components (not bridges) is based on the following:

- Height of grade line.
- Design of cross section (crown, slopes and ditches).
- Capacity of cross drains (culverts) sufficient to maintain a well drained surface on a stable subgrade.
- If in snow country, a cross section that allows freedom from severe drifting.

Drainage adequacy is rated in accordance with the following definitions:

- Good: Fully adequate drainage and cross section design. No problem.
- Adequate: Height of grade line, design of cross section, or culvert capacity somewhat below standard that would apply if rebuilt.
- Fair: Some added maintenance effort required due to drainage or snow removal problems, but not serious enough to warrant reconstruction for that reason alone.

[7] DPW warns not to rate as deficient a poor drainage condition that can be remedied by proper maintenance; i.e., proper shaping of roadway cross section and/or cleaning of ditches and cross drains.

- Poor: Considerable excess maintenance effort required in order to provide adequate traffic service, due to drainage or snow removal problem. Warrants improvement now.
- Very Poor: Very difficult or at times impossible to provide adequate traffic service. Can be due to severe surface breakup or to flooding or snow drifting that may make road impassible at times. Warrants improvement on an urgent basis.

Other Deficiencies: Although not included in the condition rating, DPW asks its raters to be aware of special conditions not apt to be routinely encountered. Typical examples are locations having landslide problems or abnormal accident hazards.

Total Condition Rating: The total condition rating is determined by adding the individual ratings of all eight factors. The total in turn is used in combination with the service rating to produce a priority rating for each roadway section.

Service Rating. The Service Rating is the evaluation of the importance of a road in relation to other roads of the same classification. Assuming two roads of the same classification have the same degree of physical inadequacy, the one having the greater service rating would warrant earlier improvement.

According to DPW, one of the simplest and most reliable indicators of a road's importance to a community is the amount and type of traffic using it. Traffic counts are used as the primary factor in the service rating and is modified by a number of other pertinent factors: traffic count, school bus route, mail route, economic impact, recreation, service, and community (described below).

Traffic Count: Service Rating begins with the Average Daily Traffic (ADT) for the road segment. All other factors are arbitrarily converted into equivalent traffic volume and added to the ADT. The final Service Rating is the sum of all these evaluations.

Rating Determinations:

School Bus Route: A regular school bus route on the segment being rated is assigned an equivalent of 75 cars a day.

Mail Route: A mail route is assigned an equivalent of 50 cars a day.

Economy: The County Court assists DPW by supplying direct input into the service ratings by independently evaluating this and the following three other categories, recreation, service, community. The Court in their evaluations uses public input, calls, and comments.

Economy is a land use rating. Five economic uses are rated on a scale from zero to ten as it affects, or is affected, by the road. The uses are: Agricultural crops; Orchards; Stock; Logging; Industrial.

The average rating for these uses is multiplied by a factor of 4 to determine an equivalent traffic volume (average rating is 10, equivalent ADT is 40).

Recreation: The recreation rating is an attempt to measure the importance of the common recreation activities in the county. Seven recreation activities are rated on a scale from zero to ten as it affects, or is affected, by the road. The activities are: Hunting; Lake access; Stream access; Scenic drive; Camp site access; Park access; Resort area.

The average rating for these activities is multiplied by a factor of 1 to determine an equivalent traffic volume (average rating is 10, equivalent ADT is 10).

Service: Service is an attempt to measure important uses of a road other than for school bus or mail routes and is measured separately. Five uses are rated on a scale from zero to ten as it affects, or is affected, by the road. The uses are: Commercial bus; Commercial haul; Market haul – logs – farms; Commuter; Inter-community connection.

The average rating for these uses is multiplied by a factor of 1.5 to determine an equivalent traffic volume (average rating is 10, equivalent ADT is 15).

Community: The last of this series of judgment ratings is called community and is an attempt to rate the importance of the road in relation to such public service destinations as schools, grange halls, fire stations, churches, or post offices. Six uses are rated on a scale from zero to ten as it affects, or is affected, by road. The uses are: Church; Grange or lodge; School; Fire station; Post office; Shopping center.

The average rating for these uses is multiplied by a factor of 1.5 to determine an equivalent traffic volume (average rating is 10, equivalent ADT is 15).

Total Service Rating: The total service rating is determined by adding traffic volume equivalents of the six rating variables to the actual ADT of the road segment. It can be seen that the service rating has only a negligible effect on relatively high traffic volume roads while it can have a substantial effect on low volume roads.

Priority Rating. The Priority Rating for a road segment is calculated using the following formula:

PR = 8.48 (SR**1.25) Log (100/CR)

Where: PR = Priority Rating
SR = Service Rating
CR = Condition Rating

The formula was designed so that PR = 0 when SR = 0 or CR = 100.