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

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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 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.

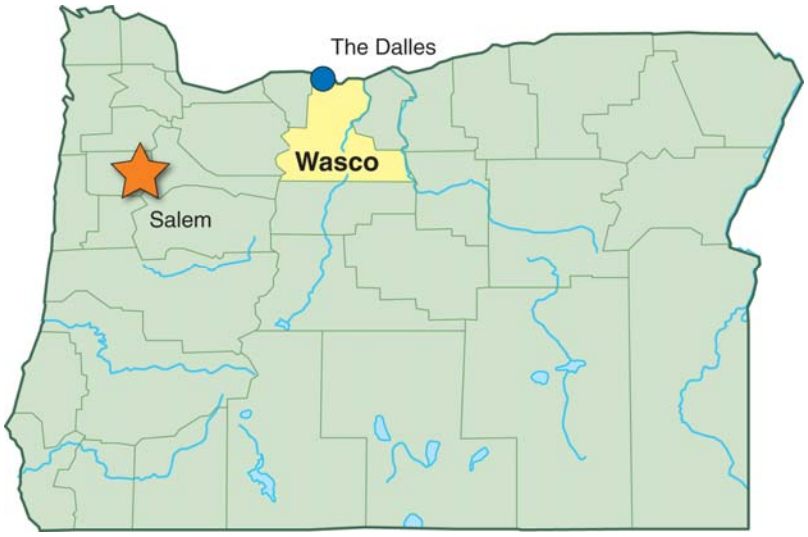

Figure 1. Location map.

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.