Planning, Developing, and Implementing the Iowa Pavement Marking Management System (IPMMS): Phases I and II

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16. Abstract

With an annual pavement marking program of approximately $2 million and another $750 thousand invested in maintenance of durable markings each year, the Iowa DOT is seeking every opportunity to provide all-year markings staying in acceptable condition under all weather conditions. The goal of this study is to analyze existing pavement marking practices and to develop a prototype Pavement Marking Management System (PMMS).

This report documents the first two phases of a three-phase research project. Phase I includes an overview of the Iowa DOT's existing practices and a literature review regarding pavement marking practices in other states. Based on this information, a work plan was developed for Phases II and III of this study.

Phase II organized the key components necessary to develop a prototype PMMS for the Iowa DOT. The two primary components are (1) performance/life cycle curves for pavement marking products, and (2) an application matrix tailored to the pavement marking products and roadway and environmental conditions faced by the Iowa DOT. Both components will continue to be refined and tailored to Iowa materials and conditions as more performance data becomes available.

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EXECUTIVE SUMMARY

The importance of roadway pavement markings needs no reinforcement among the staff at the Iowa Department of Transportation (Iowa DOT). With an annual pavement marking program of approximately $2 million and another $750 thousand invested in maintenance of durable markings each year, the Iowa DOT is seeking every opportunity to improve marking performance and minimize costs. The Iowa DOT Pavement Marking Task Force has recently completed the first two phases of a thorough evaluation of pavement marking materials, installation, and statewide management of performance (daytime visual and nighttime retroreflectivity). This diverse group focused on developing practical tools and methods to improve the DOT pavement marking program. This document summarizes the key findings from Phases I and II of this study.

INTRODUCTION

The importance of roadway pavement markings to motorists and pedestrians needs no reinforcement among the staff at the Iowa Department of Transportation (Iowa DOT). With an annual pavement marking program of approximately $2 million and another $750 thousand invested in maintenance of durable markings each year, the Iowa DOT is seeking every opportunity to provide all-year markings that can maintain an acceptable condition under all weather conditions. The goal of this study is to analyze existing pavement marking practices and to develop a prototype Pavement Marking Management System (PMMS). A practical and integrated PMMS would allow for more accurate development of annual marking needs as well as provide guidance on durable pavement marking applications and overall marking strategies on a statewide basis.

This report serves as documentation of Phase I and Phase II and includes the following information:

- Phase I—Work Plan Development
    - Existing Practices
    - Literature Review
    - Work Plan
- Phase II—Design Component
    - Performance Curves
    - Application Matrix

A future phase, which is not part of this report, is Phase III:

- Phase III—Implementation and Operations Plan

The Iowa DOT has established a project steering committee (Pavement Marking Steering Committee) responsible for guiding this research effort and linking DOT staff and resources. The established work plan represents the committee’s final direction for Phase III and is an effort to maximize the practicality and usefulness of the study findings.

PHASE I—WORK PLAN DEVELOPMENT

The value of a PMMS is derived from its ability to improve existing practices and at the same time encompass new techniques and decision-making opportunities. The ability to determine those new techniques and options comes from a variety of sources, including discussions with staff; materials, standards, and regulations research; and developing an understanding of similar efforts by peer agencies.

This work plan is based upon a review of existing Iowa DOT pavement marking practices, a literature review, and discussions with the project steering committee. The information below documents each of the Phase I findings.

Existing Practices

On March 17–18, 2004, the Iowa DOT staff held a Spring Paint Meeting in Ames, Iowa. Much of the information presented here regarding existing practice was obtained at this meeting or through additional staff and field crew discussions.

Spring Assessment

In Iowa, there is a limited window of time each year to install or maintain pavement markings. The winter and early spring seasons have proven to be the harshest times for exposure to damaging elements such as sand, salt brine, and snow plow blades. To gain an understanding of winter operations, Figure 1 depicts normal levels of seasonal snowfall within Iowa as developed over a thirty-year span (from 1970 through 2000). As shown in Figure 1, average snow accumulations are heaviest in the northeast portion of the state, at 40 inches, with the rest of the state showing around 30 inches of snow. The southern two tiers fall within the 20-inch accumulation category. Figure 2 depicts seasonal snowfall normals statewide for the months of November through April. Figures 1 and 2 were derived from data provided by Harry Hillaker, State Climatologist.

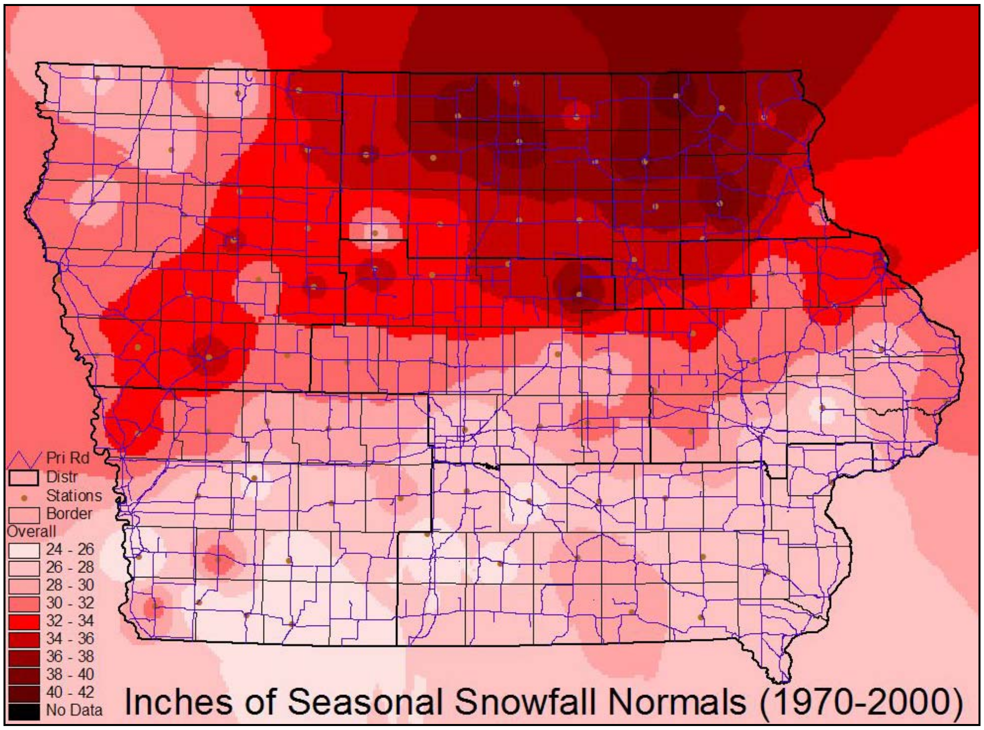

Figure 1. Composite all-year snowfall normals

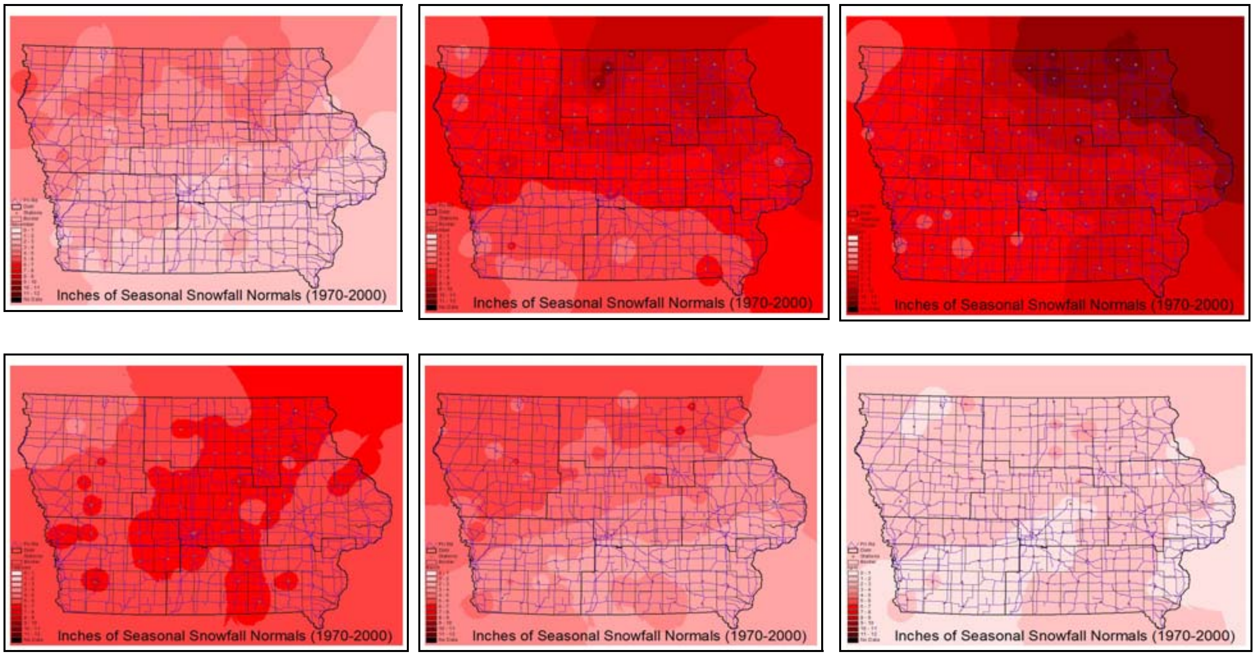

Figure 2. Seasonal snowfall averages statewide, 1970–2000: top row depicts November, December, and January (respectively); bottom row depicts February, March, and April (respectively)

Each of the six Iowa DOT districts provides winter maintenance on a hierarchy of roadways. Figures 3 and 4 depict the average tons of salt and sand (respectively) used across the state during the 2000–2004 time period.

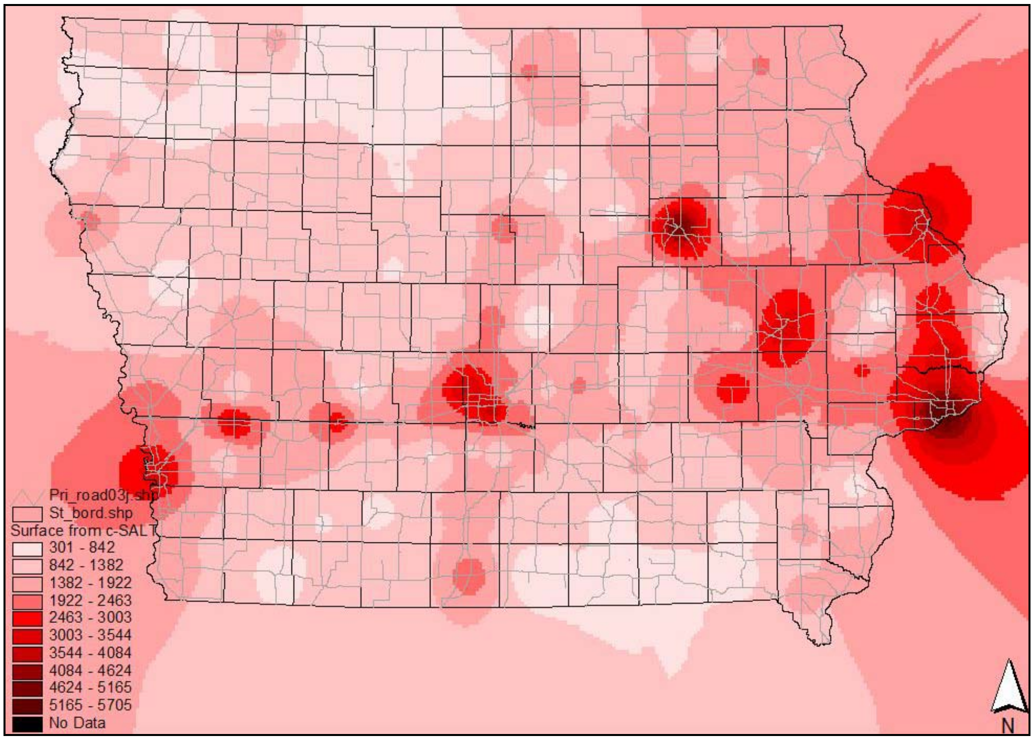

Figure 3. Average salt usage statewide, 2000–2004

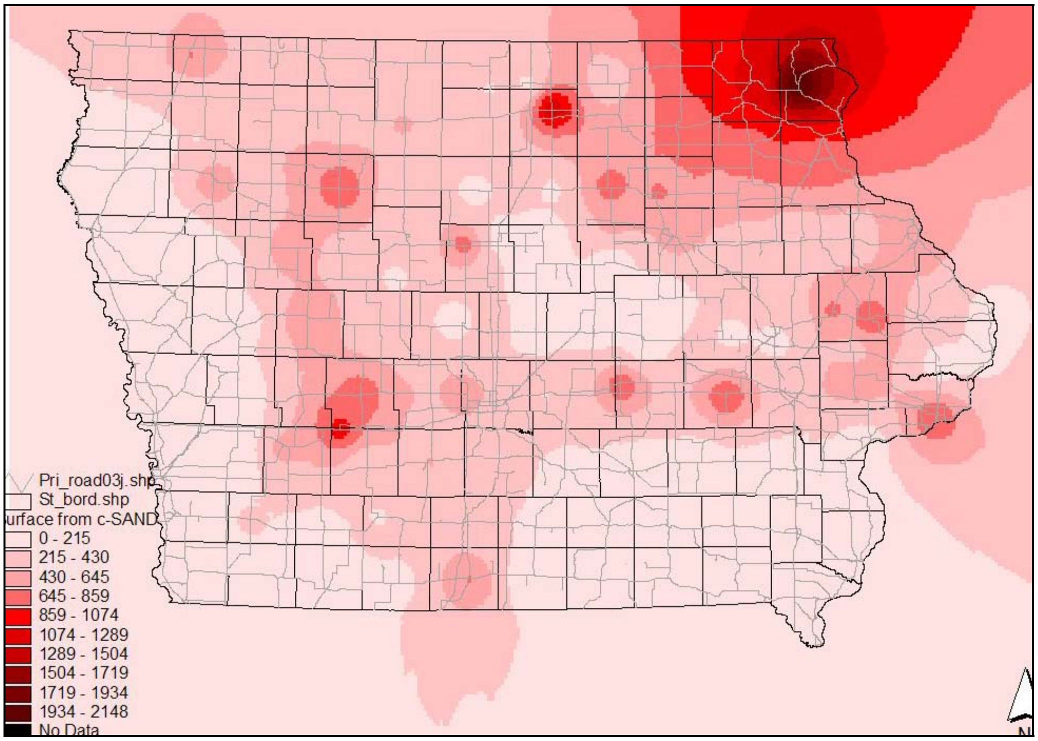

Figure 4. Average sand usage statewide, 2000–2004

The distribution of snow coverage and the resulting winter operations across the state provide perspective on the variation of damaging factors that pavement markings are exposed to in Iowa.

Early in the spring, staff assess pavement marking conditions and prioritize early spring painting locations in an effort to maximize the limited fiscal year funds available. Visual inspection is a component of gauging pavement marking conditions each spring; however, pavement marking retroreflectivity sampling is the primary means of contrasting and prioritizing needs statewide.

Measuring Reflectivity

Two methods are used for reflectivity measurements. For interstate highways and some major four-lane roadways, reflectivity is measured with the Iowa DOT Lazerlux van. All other measurements are completed by individual districts through use of LTL-X handheld machines. A description of both these devices follows.

Lazerlux Van

Iowa DOT began collecting reflectivity measurements with the Lazerlux van in 2002; however, it got a late start in September of the first year, and the following year included a significant amount of staff training and shuffling of personnel. The Lazerlux van is equipped with a 30-meter geometry Lazerlux retroreflectometer that samples markings every second and averages the results based upon one-tenth mile segments. The van is capable of taking readings from either side of the vehicle, and readings are obtained at an average speed of 55 mph. Machine calibration is performed at least once per day and whenever erratic measurements are observed. Calibration blocks are used for this process. In general, use of the Lazerlux van is a centralized process which covers the entire state. The crew consists of a driver and an operator who codes reading data by type of line, marking material, and location. Figure 5 shows a picture of the van in 2004. These machines are currently not being used for validation of contractor-installed markings.

Figure 5. Iowa DOT Lazerlux van

LTL-X Handheld Devices

In spring 2004, the Iowa DOT purchased three additional LTL-X machines for a total of six, one assigned to each district. The LTL-X handheld devices are 30-meter geometry machines that can sample reflexivity measurements or compute averages at a variety of settings. These devices include a Global Positioning System (GPS) coordinate for orientation of each measurement; however, for consistency with the Lazerlux van data, each segment’s route and mileposts are used as location references. These units also have calibration blocks for validation. Although the units can be operated by a single person, traffic control and personal safety require additional staff support while sampling. Figure 6 shows a picture of the device used by the Iowa DOT.

Figure 6. LTL-X handheld device, 2004

Sampling Frequency

For the handheld devices, the Iowa DOT Office of Maintenance has developed a standard protocol for districts to follow regarding how often to take a sample and how many points to read per location. In general, test locations are selected every 4 to 5 miles and readings are taken at the mile-post. For dash lines, the DOT samples 4 consecutive dashes at 3 locations per dash (1 foot in from each end and at the center). For edge lines, 5 equally-spaced readings are obtained over a 160-lineal-foot section.

Field Reflectivity Information

In early spring of 2004, both the Lazerlux van and the six handheld devices collected reflectivity information, as shown in Figures 7 and 8. The information is depicted through use of Geographic Information System (GIS) tools using routes and mileposts as references to grid.

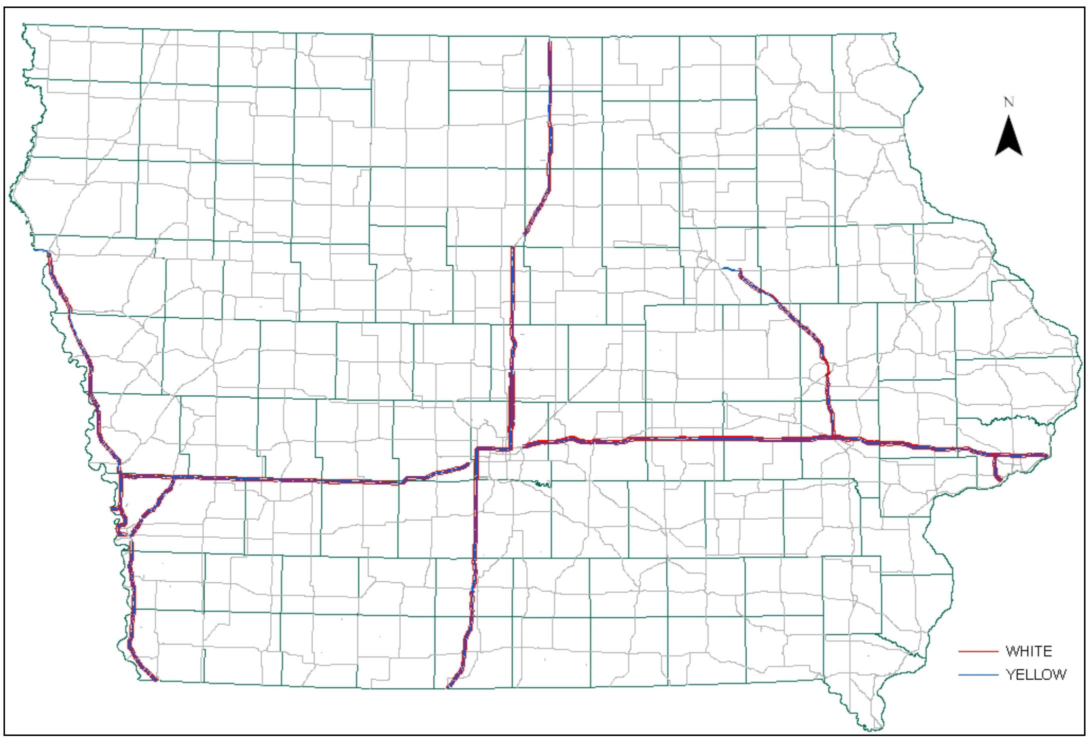

Figure 7. Lazerlux van retroreflective data collection points, spring 2004

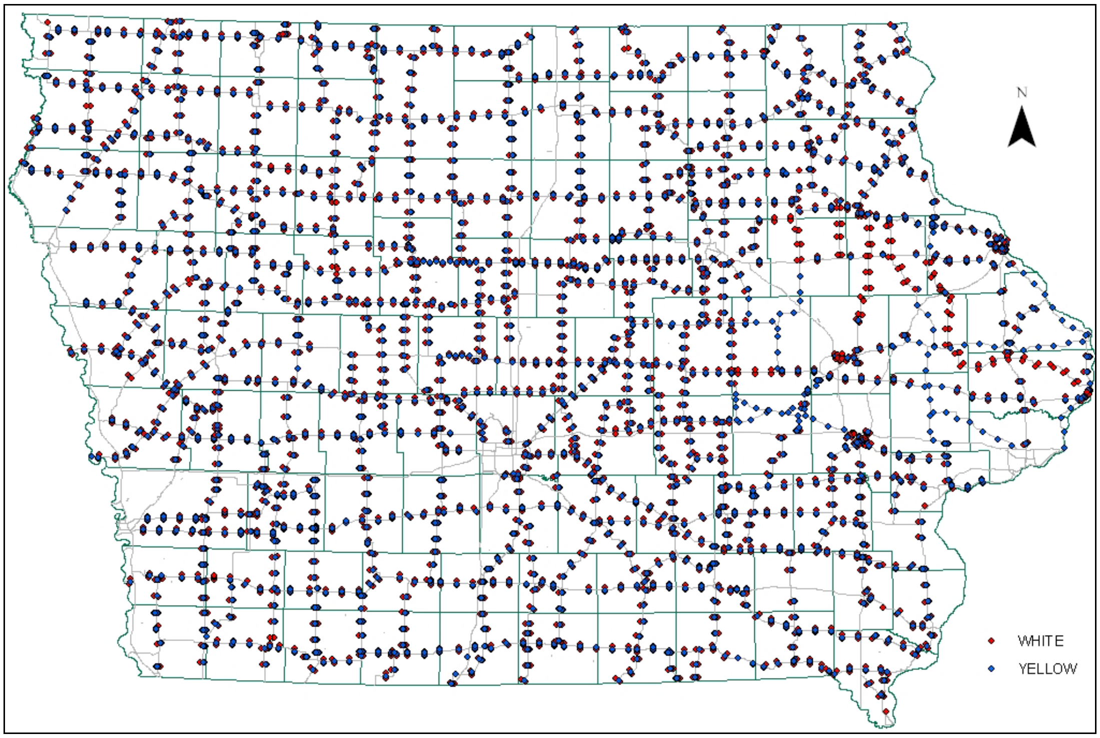

Figure 8. Handheld unit retroreflective data collection points, spring 2004

Database

The Iowa DOT has two separate databases for recording pavement marking information. The databases consist of reflectivity information (both van and handheld data) and paint application information. The van reflectivity information is read directly into the database through a spreadsheet format. Handheld data are retrieved from each machine electronically and then entered into a CITRIX interface, which assists in formatting the data fields. The CITRIX interface also provides the formatting for the daily paint log information, which is entered into a separate database.

Using GIS as a Tool to Interpret Information

The spring 2004 retroreflectivity data were used to depict marking condition information in a visual format using routes and mileposts as references. Some difficulties were discovered when using the route and milepost data due to the GIS background mapping which stops each route at the county border. Additional interpretation issues arise when route segments are concurrent with other routes and milepost references are confused. Through working with DOT staff, a series of 4 plots was used to evaluate early spring marking conditions statewide and on a district level. Figure 9 provides a sample of the GIS plots generated for 2004 reflectivity data. Similar plots were generated for each district at a more detailed scale. The plots in Figure 9 are categorized to show reflectivity information as follows: (1) Yellow Center Line, (2) White Edge Line, (3) White Dashed Center Line, and (4) Yellow Edge Line.

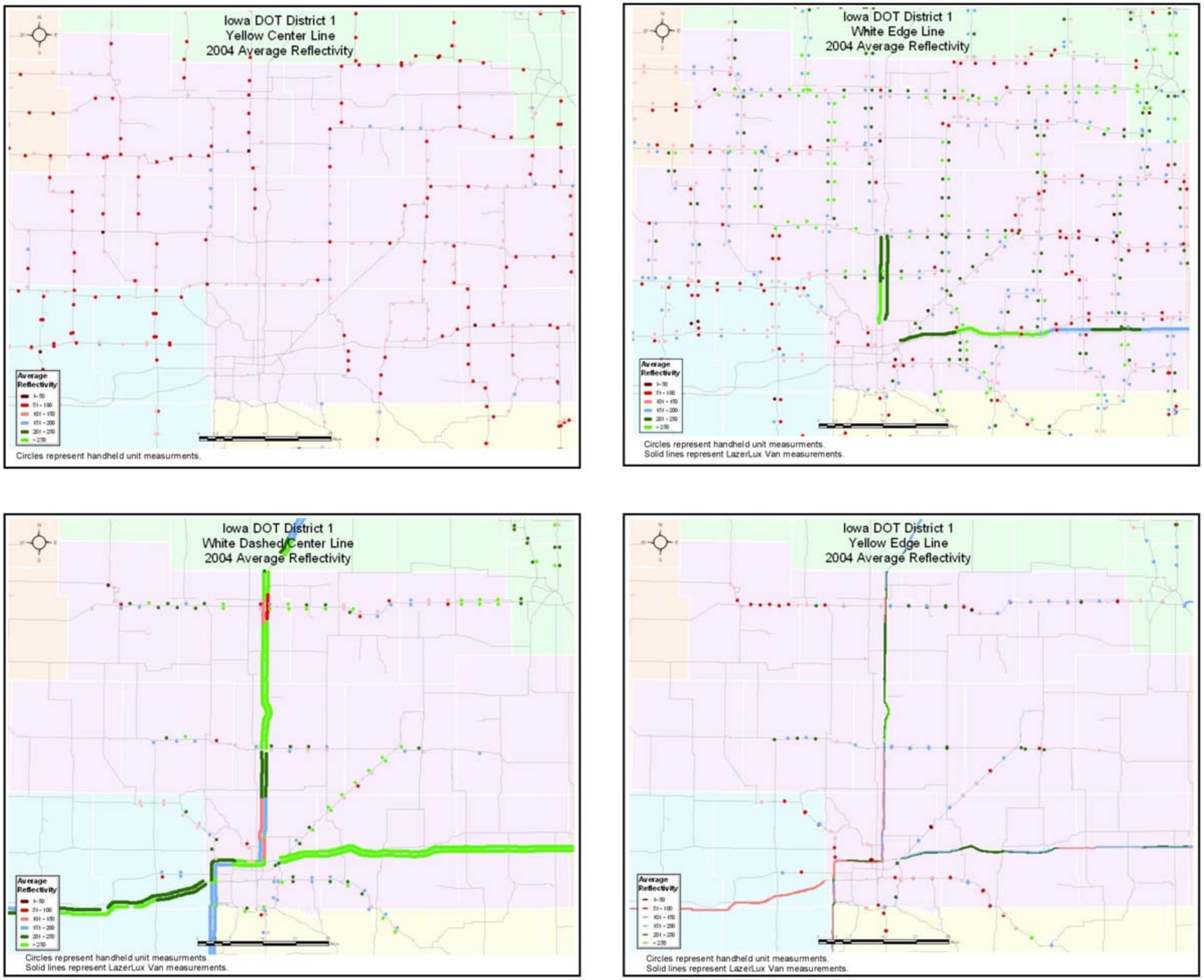

Figure 9. GIS plots for 2004 retroreflectivity data showing four types of lines

Pavement Marking Operations

Current Iowa DOT practice includes installation and maintenance of a variety of pavement marking products. Durable marking materials, such as preformed tapes and epoxy, have recently become standard bid items which can be selected by district staff or consultants for project work. One of the goals of this project was to develop an application matrix which will standardize placement of durable products statewide. One of the issues expressed by maintenance staff is that if the crew painting or obtaining reflectivity measurements is not aware that durable products are in use on a roadway (particularly with the Lazerlux van), these lines may be painted over prematurely or may bias the average reflectivity data.

The locations and types of durable markings placed during new construction are not currently part of a centralized markings database. Based on the available records for durable markings placed as new construction or as part of a statewide durable marking project, the Center for Transportation Research and Education (CTRE) at Iowa State University developed a statewide database which could be depicted in a GIS format. This information is shown for durable markings from 1994 through 2004 on a statewide level (Figure 10) and on a district and arterial level (Figures 11 and 12).

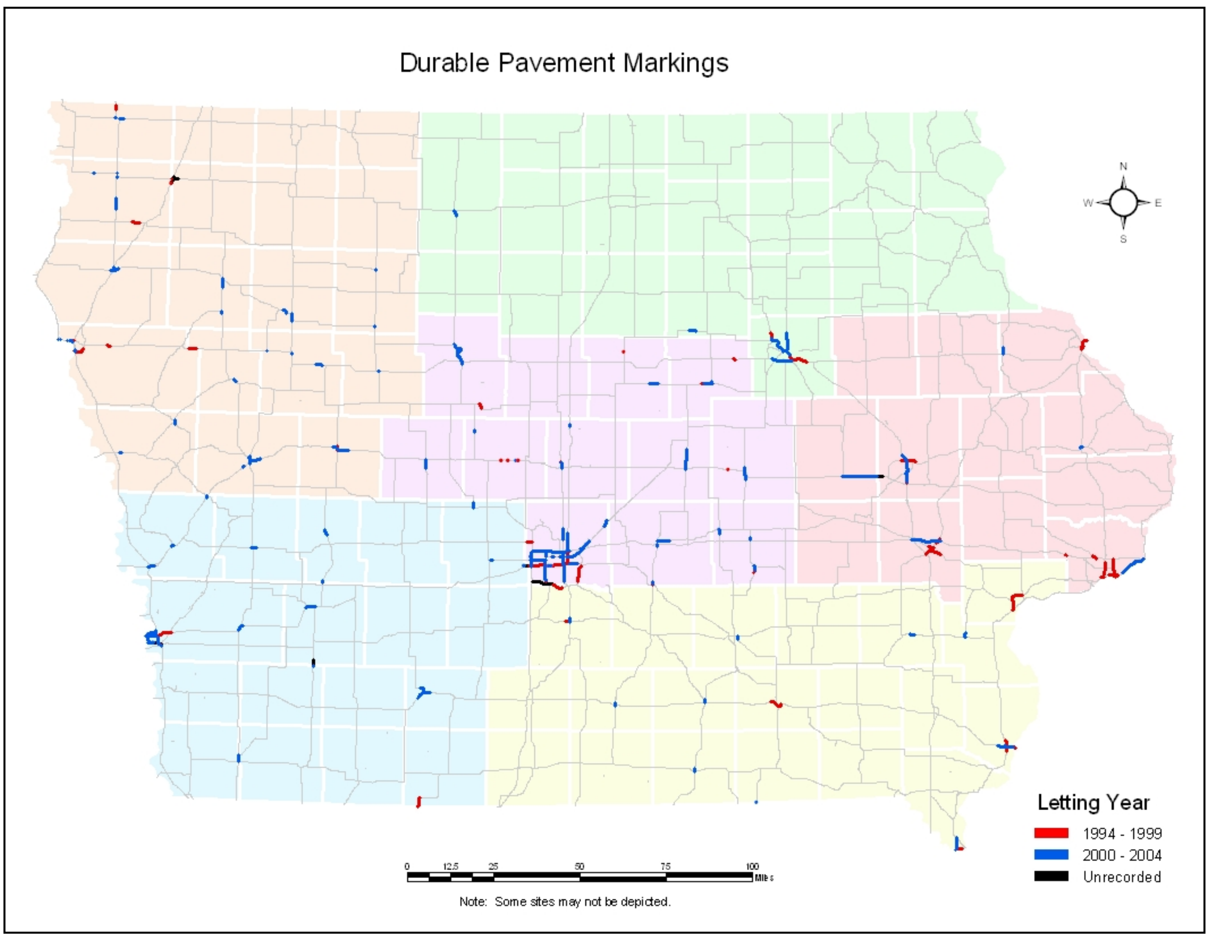

Figure 10. Durable markings statewide by location and letting date

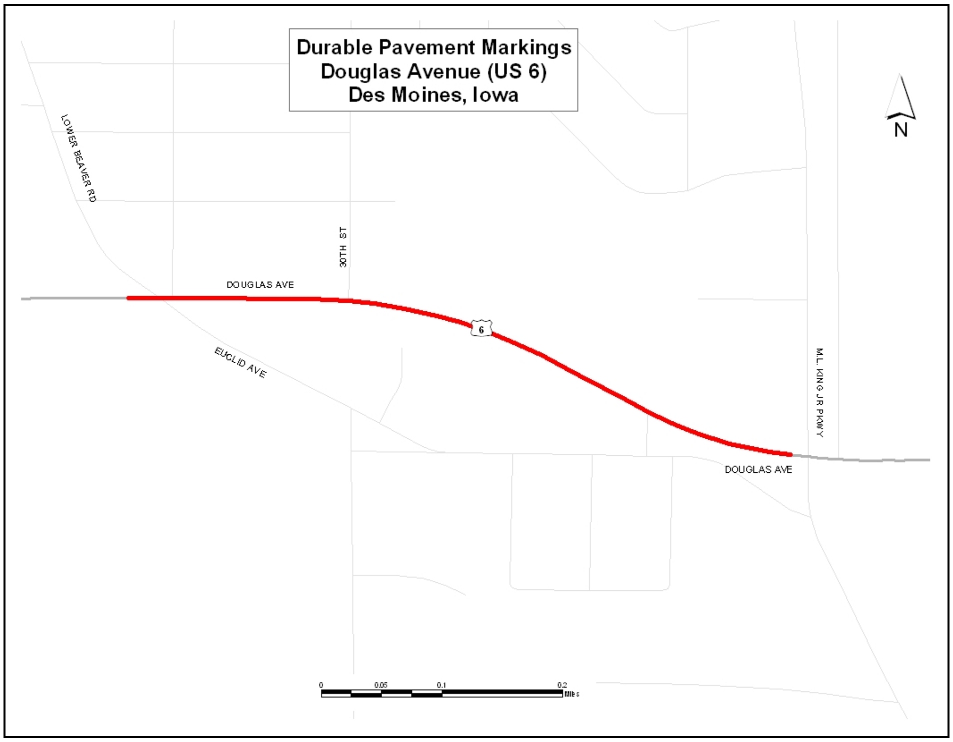

Figure 11. Line map of durable markings arterial level

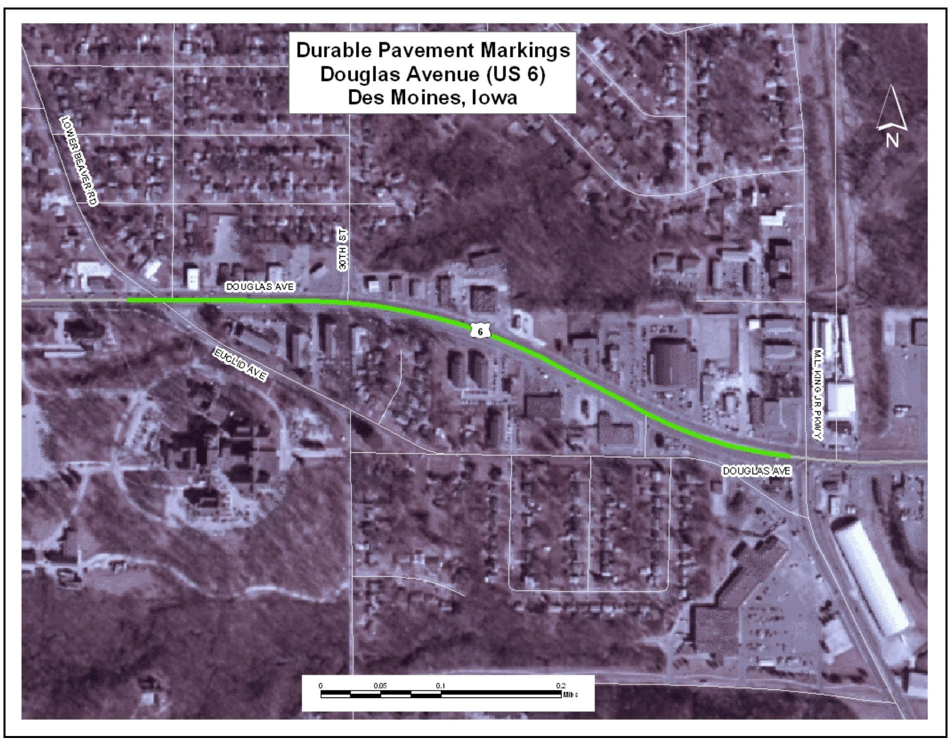

Figure 12. Aerial photo with line map showing durable markings arterial level

Waterborne Pavement Marking Operations

Some contractor painting occurs on new construction and in special circumstances, but the vast majority of pavement markings statewide consist of DOT-applied waterborne paint. Marking operations generally involve materials, equipment, and crews working at the district level. The language of the DOT waterborne paint specification is in the form of a performance specification. The spec language is geared towards contractor-applied new construction work. In comparison, DOT crews tend to use a slightly thinner paint mixture, since they are painting over some lines for the third, fourth, or fifth time.

When the DOT switched to waterborne paint, they realized there would be application issues due to seasonal temperature changes. The compliant volatile organic compounds (VOCs) solvent-based recipe provides a cold-weather alternative. The more expensive solvent-based paint is approved for use in colder weather and between October 8 and 22 of each season. The cold-weather solvent-based paint typically costs around $5.50/gallon, compared to $4.00/gallon for waterborne paint. On average, Iowa DOT crews use 350,000 to 400,000 total gallons annually.

Contractors are free to use any paint as long as it meets the I.M. criteria. Regarding DOT-applied paint, however, an in-house procedure is used for awarding the paint purchasing contract. The process begins with vendors bidding paint in dollars per gallon for a typical three-year period. The three lowest bidders are asked to supply one 250-gallon tote for sampling. The paint is also subjected to field tests which involve the following:

- Time it takes for the DOT to suck the paint out of the tote
- Ease of spraying the paint
- Dry time of the paint (measured by stop watch after the truck passes)
- Initial reflectivity of paints having the same bead type (blind sampling method)
- Retained reflectivity after 3 months

Regarding materials, the DOT has found it extremely beneficial to use the National Transportation Product Evaluation Program (NTPEP), because doing actual tests on binders, beads, and even durables has been found to be extremely time consuming. Following the lab and field tests, all paints are graded based upon a combination of price and performance.

This section provides a summary of materials used for current waterborne and VOC-solvent paint operations.

Binder

Traffic paint for pavement marking is described in Section 2527 of the Standard Specifications as well as Section 4183 for Fast Dry VOC compliant solvent-borne and waterborne paints. This information can be found on the following Web pages:

- Specification: Section 4183. Traffic Paints and Pavement Markings http://www.erl.dot.state.ia.us/Oct_2003/GS/content/4183.htm
- Application: Section 2527.02.B. Pavement Marking http://www.erl.dot.state.ia.us/Oct_2003/GS/content/2527.htm#252702b

Criteria for inspection and acceptance of traffic paints for construction projects, along with a list of approved manufacturers, are found in the Materials I.M. 483.03 document.

Beads

In the past, the Iowa DOT felt as though it was constantly changing its bead specifications. DOT-conducted tests confirm that a bead's coating can make as much as a 150 millicandella difference in retroreflectivity. Previously, the DOT asked the manufacturer for a demonstration application similar to what is done in the NTPEP (http://www.ntpep.org). However, this testing procedure was extremely time consuming and very difficult to control between brands. With regards to DOT beads, there is currently no detailed specification beyond the required AASHTO Type 1 percent rounds and gradation criteria. To improve reflectivity, the rounds allowed under the AASHTO test was increased from 70% to 80%.

Coatings are tested to see if they are present; however, there are some testing limitations concerning the silicon and silane found in dual-coated beads. Silicone is water-repellant, so it does not clump or clog the painting system. It is tested by observing when the beads are submersed in water. Silane requires a more involved test which uses a chemical chloride dye and requires observation of the beads under UV lighting. However, a positive UV light indication does not always indicate a positive silane presence.

With regards to contractor's work, the DOT decided to approve the binder and leave it up to the contractor to select the appropriate bead to meet minimum retroreflectivity levels. In the future, the DOT would like to see more of a performance specification for beads.

Quality Control

Mill thickness and retroreflectivity are the primary controls for painting performance. DOT painting operations are constantly working on improving the process. Last year, District 1 incorporated the use of the LTL-X handheld retroreflective device as part of the daily paint calibration procedure. This technique allows the district to monitor—from the last vehicle in the paint train—the retroreflectivity of the paint operation at about every two miles. If the paint reflectivity is outside the threshold, the paint truck operator will be notified and will make adjustments to the bead rate, the paint rate, and the truck speed, and the operator may stop the operation to change paint nozzles. If the numbers are still out of tolerance, the crew will check the paint beads. This check is relevant because, in one instance, the crew discovered that the beads in use did not have the proper coating compatible with waterborne paint. The DOT has established standard procedures for truck speed, paint rates, and bead rates for the waterborne paint operation.

One issue discussed by crews is that they do not necessarily know when they are approaching or actually painting over durable markings which may be dirty or tarnished. A better record-keeping process would help, particularly when crews are painting in districts other than their own.

Performance Thresholds

DOT staff have established initial marking thresholds of 300 millicandela/meter squared/lux (mcd/m^2/lux) for white and 200 mcd/m^2/lux for yellow lines. Ideally, they would prefer to see the lines above 150 and 100 mcd/m^2/lux (respectively) for two years. No parameters exist at this time for determining the preferable line type (center versus edge). Markings are not washed prior to measurement, although the DOT prefers to measure after some spring rain has washed the pavement.

Durable Pavement Marking Operations

These markings are typically contractor-installed and maintained, with some exceptions. The Standard Specifications outline minimum retroreflectivity values. These numbers are based on the requirements necessary to provide a good line using available products. The DOT has previously compared these thresholds to the thresholds established by other states and noticed has noticed minimal variation (25 mcd/sq.ft./ft.-cdl). There are a number of Iowa DOT-approved durable products with established minimum retroreflectivity values. A partial list is included in Table 1.

Table 1. Durable products approved by the Iowa DOT

Std Spec	I.M.	Product	White*	Yellow*
4183.04	483.04	Durable Paint Pavement Markings	300	200
4183.06 A.	483.06	Pavement Marking Tape (Removable)	550	325
4183.06 B.	483.06	Pavement Marking Tape (Regular)	550	325
4183.06 C.	483.06	Preformed Polymer Marking Material	325	150
4183.06 E.	483.06	Profiled Pavement Marking Tape	700	350
4183.06 F.	483.06	Intersection Marking Tape	150	100

*Specific Luminance in mcd/sq.ft./ft.-cdl.

Tapes represent less than 1% of the entire markings inventory. In 2004, the DOT installed a test section of wet reflective durable markings along I-35 between Ankeny and Des Moines.

Literature Review

Many state DOTs provide paint material specifications on their websites for ease of use among contractors and vendors. This project effort sought to provide a background summary of other states' activities regarding pavement marking practices and management programs. The following items were of particular interest in this study:

- Specific information on a DOT's selection criteria for use of various durable markings
- State marking policies or guidelines
- Required reflectivity thresholds
- Overall materials specifications
- Marking degradation curves

Accordingly, this literature review is divided into two components: a general overview and specific practices of interest.

General Overview

The following information provides a summary of state DOTs' pavement marking activities as surveyed and reported on by other entities. Appropriate references are made where needed.

Selection of the most cost-effective pavement marking system in a given situation depends on three primary factors: retroreflectivity, durability, and cost. Several subordinate factors stem from these main factors, including type of road surface, volume of traffic, orientation with respect to traffic, quality control at the time of installation, winter sanding and snow removal practices, schedule of pavement maintenance activities, and inconvenience experienced by the traveling public during marking installation (Migletz et al. 2001).

In general, conventional paints are used in areas having low traffic volumes and infrequent winter maintenance activities; conversely, products of higher durability are used in areas having more traffic and more instances of sanding and plowing. Mid-durable paints also are being researched that may offer better life cycle costs than either the epoxy or conventional paints. Efforts are also underway to improve the cost-effectiveness of pavement marking programs. This focus includes collecting and storing retroreflectivity data, developing contracts that include warranty specifications, and investigating ways to develop a pavement marking management system (Cuelho, Stephens, and McDonald 2003).

Specific Practices of Interest

A recent document prepared for the Montana Department of Transportation (MDT) provides a summary of pavement marking practices and current efforts in other states (Cuelho, Stephens, and McDonald 2003). The summary is given below.

Pennsylvania

Conventional paints comprise approximately 94% of the pavement markings used in the state of Pennsylvania (McGinnis 2001). The remaining pavement markings include epoxy paints and a small amount of thermoplastics. These products are applied in both rural and urban applications, generally in the longitudinal direction. Of all the states considered in this review, Pennsylvania reported the lowest cost per linear foot (LF) of installed pavement markings, being $0.024 per LF. More recently, Pennsylvania has initiated a study to compare the use of conventional paints with a variety of other marking systems to determine the most appropriate pavement marking based on a life cycle cost analysis.

Kansas

In recent years, the Kansas Department of Transportation (KDOT) has developed a sophisticated methodology to determine the most economical type of pavement marking to be used under various circumstances. From their analysis, a Brightness Benefit Factor (BBF) is determined, which is described as a benefit/cost ratio based on the material's retroreflectivity, durability, and installed cost. The analysis also includes variables such as traffic, expected life of the pavement, and motorists delay. Typical costs of products used by KDOT are provided as well (McGinnis 2001).

Kansas DOT has an integrated preventive maintenance program that tracks all pavement markings by the year applied, expected life of pavement, type of material used, and performance guarantees of the pavement markings. Using this information, a prediction of pavement marking life may be made. In the spring, maintenance crews are sent out to visually inspect specific pavement markings at night for retroreflectivity compliance. Information from the inspections is sent to the engineering department to update the list of roads that require new markings and/or warranty repairs. In addition, the list takes into consideration all planned maintenance activities, so that in selecting the optimal marking material to be used, the service life of the marking can be evaluated relative to the interval until the next pavement maintenance activity (KDOT 1999).

Minnesota

Minnesota, like Pennsylvania, installs approximately 90% of the pavement markings statewide and uses conventional paints for the majority of its striping. Conventional paints, which are generally used in rural areas, make up 90% of the pavement markings throughout the state. Of the remaining 10% percent, approximately 8% are epoxy paints. Conventional paints cost approximately $0.048/LF, while epoxy paints generally cost around $0.19/LF (McGinnis 2001).

In general, traffic levels are considered when choosing an appropriate pavement marking material. Minnesota Department of Transportation (MnDOT) uses durable products on the roadways it maintains in the Twin Cities metropolitan area due to the large volumes of traffic (Montebello and Schroeder 2000). Minnesota also recognizes the need for durable pavement markings due to high wear from snowplow and sanding operations during the winter months, especially in urban areas. MnDOT requests that lane-marking materials be applied offset from the crown of the road to reduce the direct contact with snow removal equipment (Montebello and Schroeder 2000).

The study conducted by Montebello for MnDOT also stated that if a non-conventional marking material is being considered, the condition of the road must first be carefully evaluated to ensure that maintenance or other activities will not shorten the life of the pavement marking and compromise the value of the investment. Since the cost of applying striping materials is directly related to the quantities, traffic control requirements, material costs, and mobilization to and from the job site. an investigation must be conducted into any special mobilization costs for transporting low quantities of specialized materials. The more work is planned and coordinated under a single contract, the greater the efficiency, thereby making projects more cost-effective.

Virginia

Paint, thermoplastics, and waffle tape make up 90% of the pavement markings used by the Virginia Department of Transportation (VDOT). The remainder of the pavement marking materials employed are epoxy paints, polyester paints, and other miscellaneous tapes (Cottrell and Hanson 2001). Since the VDOT recently implemented a pavement preservation management system that includes chip sealing road surfaces on a three-year cycle, it has recently reviewed its pavement marking activities. The overall conclusion of this study was that conventional paints are the most efficient marking material.

Wyoming

The Wyoming Department of Transportation (WYDOT) predominantly uses alkyd or conventional paints for pavement markings (Cuelho, Stephens, and McDonald 2003). WYDOT applies all the conventional paint markings on Wyoming state highways. Epoxy markings are used in areas of high wear, and these markings are installed by outside contractors. Even though the cost of epoxy paint is much higher than of conventional paint, it is required for safety reasons in areas where pavement markings are unable to withstand the wear experienced during the winter season. In addition, it is common for WYDOT to apply paints more than once per year in areas of high wear. In one WYDOT official’s opinion, the main factor reducing the life of pavement marking in the state of Wyoming is winter maintenance, such as sand abrasives and snow plows (Cuelho, Stephens, and McDonald 2003).

North Dakota

The North Dakota Department of Transportation (NDDOT) bases its selection of pavement markings on several criteria, including type and condition of road surface, the anticipated level of traffic, and where on the road the delineation will be used (e.g., center or edge). The materials it considers for use include conventional paint; inlaid, patterned, and preformed plastic; and grooved, patterned, and preformed plastic. A guide has been developed to determine best pavement marking practices in any given situation.

Idaho

Conventional paints comprise approximately 98% of all pavement markings (by mileage) that are used by the Idaho Transportation Department (ITD). The remainder of the pavement markings in Idaho are epoxy paints. ITD maintenance crews install 60% to 80% of the conventional paint markings used in the state. Their installed costs range between $0.035/LF and $0.045/LF. Contractors bid for all of the state's interstate work in large contracts that cover multiple districts, because larger contracts result in lower installation costs. Idaho currently applies paint approximately two times per year in high-wear areas. Idaho is investigating the possibility of using epoxy paints in high-wear areas to reduce costs (Cuelho, Stephens, and McDonald 2003).

Montana

The majority of pavement markings in MDT are conventional products (Cuelho, Stephens, and McDonald 2003). MDT has found that the life expectancy and initial retroreflectivity of alkyd-based paints and waterborne latex paints are generally higher than average. MDT is in the process of developing warranty-based specifications for pavement marking contracts. Performance measures for these warranties will include reflectivity, durability, and color. Contracts with two different warranty periods will be used: a 3-year contract and a 1-year contract. The 3-year contract will give individual contractors the freedom to select a pavement marking product that will meet the specifications set by MDT. The 1-year warrant contract is mainly designed to ensure good workmanship and initially will be used only for epoxy paints (Cuelho, Stephens, and McDonald 2003).

For new pavement projects, contractors generally use conventional paints. After 30 to 45 days, lines are refreshed with a more permanent product (Cuelho, Stephens, and McDonald 2003). MDT uses thermoplastics at high-volume intersections due to the high surface wear from traffic at such locations. MDT is currently developing a Pavement Markings Management System (PMMS) to provide a more thorough life cycle cost analysis for pavement markings throughout the state of Montana. The PMMS will help optimize the use of pavement marking products based on retroreflectivity, durability, and cost. It will establish a strategy for collecting and storing data from a number of sites having a variety of pavement marking products (Cuelho, Stephens, and McDonald 2003).

Pavement marking information is often found combined with sign management discussions. Additional literature providing pavement marking information follows.

NCHRP Synthesis 306—Long Term Pavement Marking Practices

This synthesis examines 61 entities regarding pavement marking practices (Migletz et al. 2001). It documents the current and best practices for managing pavement marking systems, identifies future needs, and it addresses driver needs and methods of communicating information to drivers. It also documents selection criteria (e.g., reflectivity, pavement service life, wet weather performance), materials (e.g., color, durability, cost), specifications, construction practices, inventory management systems, and more.

Missouri

The Missouri Department of Transportation (MoDOT) has developed a PMMS that provides an automated system not only to inventory pavement markings but also to manage them. Tailored for MoDOT conditions, one of the major components of the system is to measure quality and durability (Davidson 2003).

Arizona

The Arizona Department of Transportation is currently developing a management system which will include a database of all signs and pavement markings; a method for tracking lifetime product performance; and procedures and processes for monitoring, maintaining, and replacing these products.

Work Plan

Through reviewing existing Iowa DOT practices and information obtained from other states, a work plan was developed for Phases II and III. Phase II information follows.

PHASE II—DESIGN COMPONENT

Phase II organized the key components necessary to develop a prototype PMMS for the Iowa DOT. This included the following general tasks:

- Performance Curves. Work with DOT staff and industry to obtain performance/life cycle curves for the range of pavement marking products approved for DOT use on roadways. Make future recommendations to customize these curves to Iowa conditions over time and, as deemed necessary, to conditions within individual districts.
- Application Matrix. Based upon research by other state DOTs, work with the Pavement Marking Task Force to develop an application matrix tailored to the pavement marking products and roadway and environmental conditions faced by the Iowa DOT.

The results within this report reflect numerous monthly meetings with the task force and also numerous field meetings and other encounters with Iowa DOT staff, material vendors, paint suppliers, contractors, and knowledgeable staff within the paint marking industry. The recommendations within this report, however, are at the sole discretion of the task force and reflect the interpretation of task force comments and actions by the authors representing CTRE at Iowa State University. This chapter highlights the key findings from Phase II.

Performance Curves

Pavement marking retroreflectivity, along with daytime presence and color, are the primary indicators of the level of marking performance being provided to the public. The length of effective marking life out on the street also becomes a key metric in establishing maintenance cycles and economic impacts as a result of selecting markings by line or roadway type, roadway condition, or location.

Current Activities

In 2004, the Iowa DOT began collecting statewide spring and fall reflectivity information, as well as encouraging longitudinal paint crews to sample and make sure initial reflectivity thresholds were met as part of daily marking operations. These actions have had a significant positive impact on marking quality and the ability to evaluate painting needs and variations system wide. This information also serves as a starting point in the development of Iowa marking performance curves tailored to DOT materials, practices, equipment, measurement, and environmental conditions.

Through the ability to tie marking data with pavement management data, Phase II work also provides a beginning point to match marking performance to pavement type and both roadway and environmental conditions.

Industry Input

Pavement Marking Task Force work also included reaching out to industry to discuss performance/life cycle information for the range of pavement marking products approved for use on DOT roadways. This idea exchange included discussions with 3M, Dennis Parking Lot and Maintenance, Eppoplex, Rohm & Haas, Dow Chemical, Potters, and Swarzco. Due to the proprietary nature of this information, it is not repeated within this report.

Application Matrix

The task force developed a longitudinal pavement marking application matrix based upon drivers' needs, roadway type, pavement service life materials performance, and cost. This initial matrix shown in Table 2 reflects the fact that very little historic information exists today to track material performance over a range of conditions on DOT roadways. However, this information can be collected and used to consider modifications to the application matrix over time. This information is also included in Appendix A along with a summary of each key finding.

Table 2. Longitudinal pavement markings application matrix

LONGITUDINAL PAVEMENT MARKINGS					
Remaining Pavement Surface Life	Primary 2 & 3 - Lane	Primary 4+ - Lane		Interstate	
	RURAL + URBAN ≤ 55 mph	RURAL	URBAN High Traffic	< 50,000 ADT	> 50,000 ADT
	7,811 centerline miles (75% of total)	1,059 centerline miles (10% of total)	556 centerline miles (5% of total)	1,000 centerline miles (9.6% of total)	45 centerline miles (0.4% of total)
≤ 2 yrs	**Waterborne**	**Waterbourne**	**Durable Waterborne**, Waterborne,	**Waterborne**	**Durable Waterborne,** Waterborne
3 - 5 yrs	**Durable Waterborne**, Waterborne	**Durable Waterborne,** Waterborne	**Durable Waterborne,** Waterborne, Epoxy, Polyurea	**Durable Waterborne**	**Durable Waterborne**$^{E\&R}$ Polyurea$^{E\&R}$ Epoxy$^{E\&R}$
5^{+} yrs	**Durable Waterborne**, Waterbourne, Epoxy, Polyurea	**Durable Waterborne**, Waterbourne, Epoxy, Polyurea	***Durable Waterborne**^{E} *Epoxy, *Polyurea, *Tape	**Durable Waterborne**, Epoxy, Polyurea	**Tape**$^{E\&R}$ Durable Waterborne$^{E\&R}$ Epoxy$^{E\&R}$ Polyurea$^{E\&R}$

^{E}Enhancements that could include reflectorized rpm's, wider markings, supplemental strips of wet reflective tape, roadway lighting, larger beads, paint additives, or other forms of enhanced illumination.

^{R}Recessed marking within a groove which is milled into the driving surface.

*Where the characteristics such as heavy volumes, weaving, high speeds, or other conditions exist, markings within this category may be treated similar to urban interstate with over 5 years of life.

CONCLUSIONS

This research provided a significant degree of investigation into existing Iowa DOT pavement marking practices, evaluation of potential new durable waterborne paint and bead combinations, development of a pavement marking application matrix, and short- and long-term recommendations for implementation and operation of a pavement marking management system for the Iowa DOT. The final phases currently underway include the implementation and operations tasks. The work of this task force has already had a significant contribution to DOT pavement marking practices in terms of tracking performance, quality, and management of retroreflectivity on a state-wide basis.

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APPENDIX: KEY FINDINGS FROM PHASES I AND II—IOWA DOT PAVEMENT MARKING MANAGEMENT SYSTEM

APPENDIX

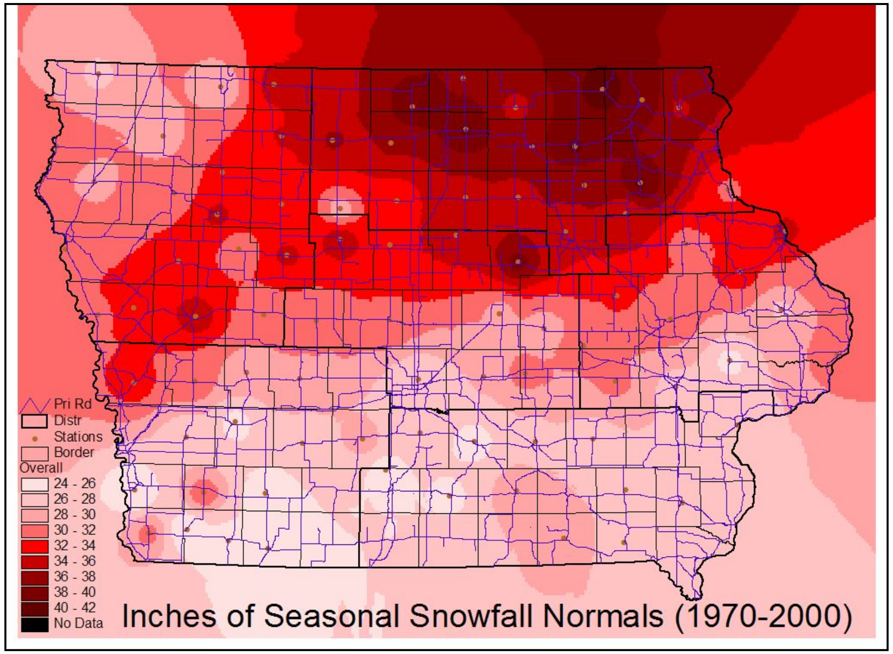
Key Findings from:
Phase 1 and 2 – Iowa DOT Pavement Marking Management System

Iowa Department of Transportation

Issue – Marking Damage

Task Force worked with state climatologist to review 30 year average snowfall by Iowa DOT district as shown. This variability, along with winter maintenance policies, create differences in the frequency individual routes are plowed each year and obviously impact the potential damage to surface applied pavement markings. Existing snow plow and sanding activities are recorded on a person-hour or quantity basis and not by route/milepost.

District staff documented a drop from over 400 mcd to a little over 100 mcd due strictly to maintenance of edge rutting. Task Force also discussed a variety of examples where heavy traffic and/or turning movements have a significant impact on marking performance. Data were also evaluated which confirmed that marking performance was worse on older paved driving surfaces.



Recommendations

Short Term

•Document salt, sand, brine, and plowing operations by route and milepost over the winter season. Evaluate impacts to marking performance and compare these on a district basis. Evaluate winter maintenance practices in contrast to marking performance by district.

•Evaluate potential solutions, such as GPS, to allow for the tracking of winter maintenance activities by route. Such information would allow for quick mapping and could tie directly to a GIS format for looking at pavement marking needs and performance.

•Evaluate edge rut maintenance practices and develop a statewide approach which minimizes damage to edge line markings.

•Incorporate urban vs rural traffic demands and pavement condition into materials selection matrix.

Long Term

•Implement GPS or other tracking techniques for winter maintenance.

•Integrate differences in winter exposure, shoulder edge maintenance, etc. to overall marking application matrix and selection of marking materials, applications, performance, cost, on a district by district basis.

Issue – Measurement

In the spring of 2004, the Iowa DOT purchased 3 more Handheld Delta LTL-X machines for a total of 6 (one per district). Each unit has the ability to record a GPS latitude and longitude with each reading along with the default of entering in the route and milepost. The Iowa DOT has one Lazerlux Van which takes continuous readings on Interstate and major 4-lane highways. The van does not have any GPS equipment thus relying on route and milepost for reference. The van also has a reliance on problematic floppy disks to transfer readings to other computers for analysis or storage. Contractor readings are completed on occasion for verification or dispute resolution. In the Spring of 2004, district crews completed measurements on the entire system and this information was mapped using GIS as shown later in this report. Some districts have a dedicated person to run the LTL-X and others do not. Some crews use this device during their painting season to monitor initial reflectivity.

Recommendations

Short Term

•Implement use of the LTL-X for all DOT crew applied long-line painting operations.

•Require Contractors to provide initial reflectivity readings for all projects.

•Consider additional LTL-X units and training for designated staff to obtain 1-month follow-up readings, other readings within the district, or to monitor Contractor applied markings.

•Consider requiring Contractors to provide 1-month after installation readings or readings at some time period after the excess beads have been removed.

•Incorporate GPS and reflectivity measurement readings into other painting operations such as curb markings, legends, transverse markings etc.

•Evaluate options to incorporate using GPS readings with the Lazerlux Van readings to improve accuracy of route/milepost and to assist in mapping of findings.

•Upgrade the computer equipment in the Lazerlux Van.

•Standardize staffing and schedules for Van measurements along with consideration of how the Van will be used to assist Districts in monitoring Contractor applied markings.

Long Term

•Implement GPS or other tracking techniques with data collection.

•Provide initial and follow-up reflectivity measurements with any DOT crew applied long-line markings and all Contractor applied markings.

Issue – Paint Equipment

The DOT has a variety of on-board quantity tracking devices such as the Bradley device shown here. These units are critical in adjusting paint quality as well as in keeping track of quantities by route and milepost. This information is entered into a database on a weekly basis.

Staff has made considerable efforts to track weather conditions with paint tips, paint rates, mill thicknesses, truck speeds, etc.

Recommendations

Short Term

•Evaluate options to incorporate GPS with these units to eliminate manually entering the data into the DOT database.

•Standardize equipment being used from paint trucks to paint guns, tracking equipment, etc. to eliminate the many variables faced by individual crews.

•Continue to test combinations of truck and material settings based upon ranges of environmental conditions.

•Continue to evaluate zero velocity bead guns to improve operations.

•Evaluate staff demands and provide training and opportunities to work with other crews to maximize performance, production, and safety.

•Continue to evaluate opportunities to apply more durable products using existing equipment and DOT crews.

Long Term

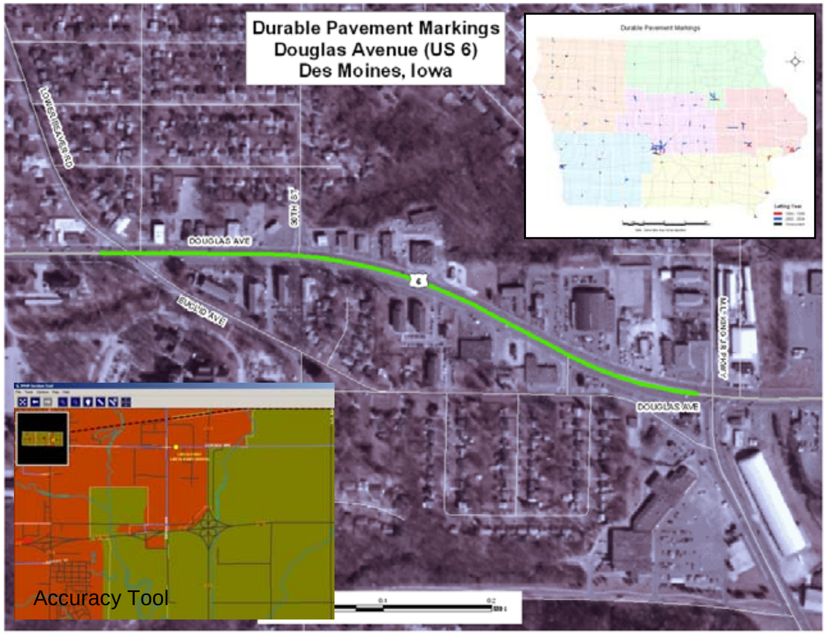
•Implement GPS or other tracking techniques for painting operations.

•Develop working relationships with manufacturers (paint, beads, truck equipment) to maximize the performance of both DOT crew and Contractor applied markings.

Issue – Durable Markings

The DOT has a number of road miles of durable markings which are typically installed as part of a construction contract. The tracking of this information is less than ideal with the occasional issue of maintenance crews painting over these markings. The task force worked at developing an overall durable marking database and in incorporating this information into a graphical GIS format. An example of this is shown here. The Task Force developed alternative techniques to enter the durable marking data through the same technique used for pavement management called a section tool. Such a tool allows for pointing and clicking on the limits of the durable marking. A demonstration of this was developed specific for pavement markings.

The initial cost and cost of maintaining durable markings places a significant burden on maintenance budgets as this impact has been documented by earlier Task Force actions. The pavement marking application matrix which appears later within this report is an attempt to provide guidelines on how markings will be maintained on a long term basis.



Recommendations

Short Term

•Finalize durable marking database and eliminate records which have faulty route/milepost information or are missing location information.

•Develop section tool for districts to use to report and track installation and performance of durable markings.

•Track initial and interim reflectivity and performance of durables which are Contractor applied.

•Continue to evaluate opportunities for DOT crews to apply durable paint products.

Long Term

•Manage durable markings either put down by DOT or by Contractor through a focus on long term performance and consistency of pavement markings on DOT maintained roadways.

•Minimize disconnect between Construction practices versus how these markings will be maintained long term.

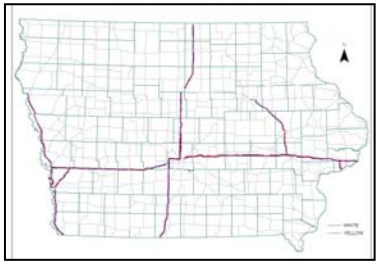
•Evaluate methods, materials, and specifications.

•Evaluate strategies for continued maintenance on the highest categories of roads.

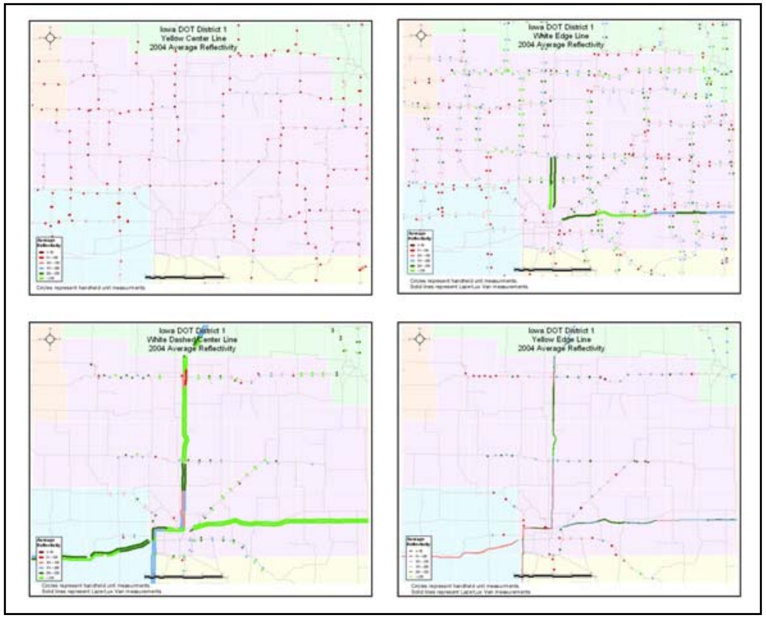
Issue – Analysis Tools

Gathering of paint and reflectivity information on a statewide basis quickly produces a great deal of data. The Task Force placed a high priority on finding ways to present and interpret the field information collected. The most effective tools for this was through the use of GIS which graphically representing the information directly on a roadway segment basis. Following the spring 2004 assessment, the Lazerlux Van and Handheld data were graphically represented in a number of ways as shown on this page.

Handheld LTL-X Spring 2004



Lazerlux Van Spring 2004



Example District 1 reflectivity by type of line Spring 2004

Recommendations

Short Term

•Continue to explore opportunities to use GIS in interpreting both paint and reflectivity data

•Work with district staff to understand format and level of detail desired to be able to interpret and use the paint and marking information data.

•Explore opportunities to streamline the mapping of this data and elimination of errors.

Long Term

•Along with implementing GPS, use GIS to support district paint and marking decision making.

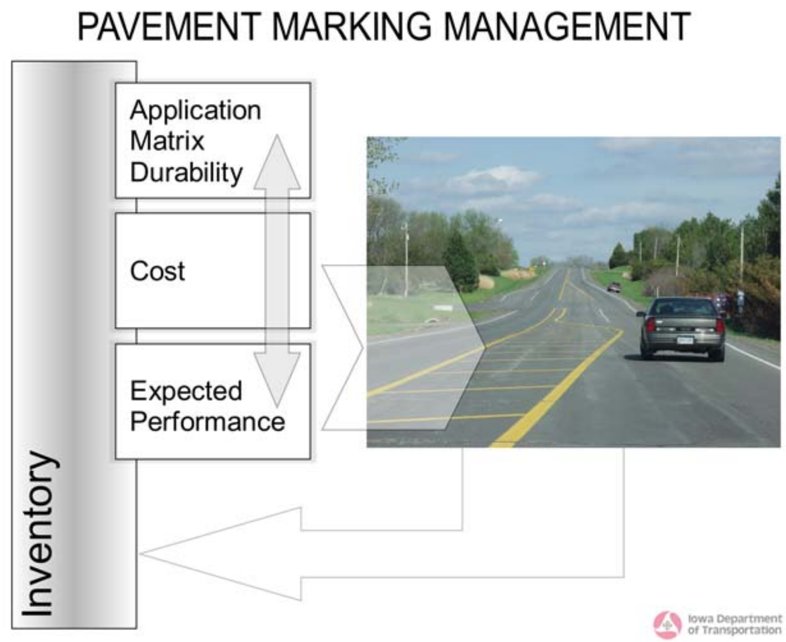
•Evaluate where GIS capabilities would reside and staffing/training/hardware/software needs for such this critical component of a pavement marking management system.

Issue – Database

The Task Force spent time outlining the components of a potential pavement marking management system as shown to the right. Such a system is only as good as the information it is based upon. Accordingly, a focus was placed on existing and future inventory information consisting of (pavement marking, pavement condition, and operations). The first of these two will be discussed next. The operations database does not exist and would represent factors such as the difficulty for crews to place markings in certain areas, heavy weaving or turning areas, areas requiring significant traffic control or night-time operations. The pavement condition data already exists from the DOT pavement management system and it was shown how this can be merged with marking data.

Collecting data strictly on a route and mile post basis creates a number of problems in interpreting the information given concurrent routes and GIS issues at county borders. This effort identified alternative tools to locate segments for paint or reflectivity readings along with the tracking of durable markings.

The Task Force examined pavement marking data input and developed a common listing of data input items as shown at the bottom of this page.



Recommendations

Short Term

•Work with IT to evaluate opportunities for one input screen with simplified data.

•Explore how GPS could simplify storing and mapping marking, reflectivity, and new durable installation information.

•Implement a section tool to simplify locating durable markings along with supplementing any other markings that are desired to be part of the DOT database such as legends, symbols, curb and transverse markings, etc.

•Eliminate the need for paint crews to re-type data into database.

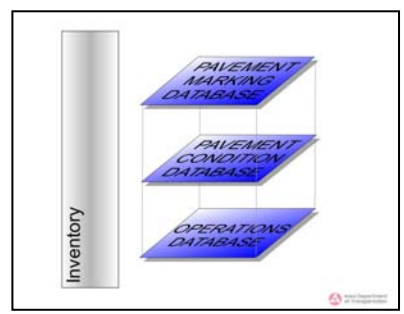
Long Term

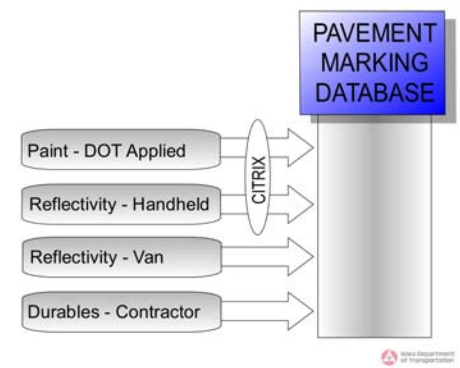
•Implement GPS or other tracking techniques for database.

•Simply input form and ability to query data using GIS tools.

•Integrate with other DOT database and referencing systems.

•Develop operations database specific to markings.





ALL DATA			
LOCATION	DATE	ACTION 1	ACTION 2
Route	Date	Contractor	Reflectivity
Begin Milepost		Type of Line	Standard Deviation
End Milepost		Type of Material	File Name
District		Amount of Paint	
Project_no		Paint Rate	
Location		Bead Rate	
Direction		Work Type 1	

Issue – Field Tests

The Task Force spent considerable effort in beginning a 3-year test along Hwy 5 and 65 within the Des Moines metro (which is the only known test of it's size and quality nationwide) to evaluate two types of durable waterborne paints and glass beads. Since the materials were put down using DOT crews, this demonstration has already provided valuable knowledge regarding how to install these new products. The reflectivity results to date have shown very good results with expectations that these materials will support 3 seasons of service life.

The task force is also evaluating how to groove pavement as part of initial construction to accommodate recessing of the pavement markings.

Recommendations

Short Term

•Document findings from the Hwy 65/5 demonstration and continue to monitor over the 3-year period.

•Track winter maintenance activities along both Hwy 65 and 5 for the 3-year period.

•Continue to rely on NTPEP test deck as the primary determinant of evaluating new products for use on Iowa DOT roadways.

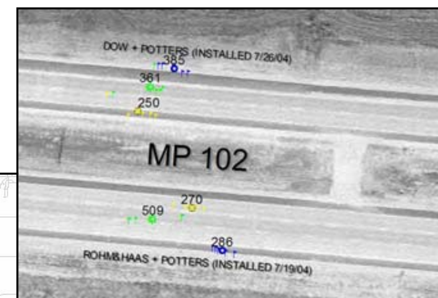
•Continue to evaluate grooving practices such as its benefits or the cost and effectiveness of creating a groove as part of the initial paving.

Long Term

•Implement additional test sections statewide.

•Work with industry to monitor and evaluate results and to evaluate other materials, methods, and applications.

•Work with vendors to demonstrate/evaluate other products if they fit within the Iowa DOT Application Matrix and needs.



Issue – Specification

DOT staff have established initial marking thresholds of 300 millicandela/square foot per foot candle (hereinafter "mcd") for white and 200 for yellow lines. Ideally they would prefer to see the lines above 150/100 for two or three years. No parameters exist for favoring the type of line (center versus edge) at this time. Markings are not washed prior to measurement, however, the DOT prefers to measure after some spring rain has washed the pavement. .

DOT specifications are geared toward Contractor installations. The Standard Specifications outlines minimum durable retroreflectivity values. These numbers are based upon providing a good line using available products. The DOT has previously compared these thresholds to other states and notices little variation (25 mcd. There are a number of approved durable products as well as a variation in retroreflectivity required values. A partial list is shown here.

Std Spec	I.M.	Product	White*	Yellow*
4183.04	483.04	Durable Paint Pavement Markings	300	200
4183.06 A.	483.06	Pavement Marking Tape (Removable)	550	325
4183.06 B.	483.06	Pavement Marking Tape (Regular)	550	325
4183.06 C.	483.06	Preformed Polymer Marking Material	325	150
4183.06 E.	483.06	Profiled Pavement Marking Tape	700	350
4183.06 F.	483.06	Intersection Marking Tape	150	100

* *Specific Luminance in mcd/sq.ft./ft-cdl.*

Recommendations

Short Term

•Include requirements for the measurement and reporting of reflectivity by Contractors both initially and at some designated period after the excess beads have been blown away.

•Review specifications to include durable waterbourne materials and beads.

•Reference the Task Force developed Application Matrix to begin the process of matching initial installation with long-term maintenance.

•Incorporate the Application Matrix into the DOT design manual and other documents.

Long Term

•Consider the benefits of a program where the DOT measures all new markings installed by Contractors for quality assurance purposes.

•Work with industry to maintain effectiveness of specifications and to modify requirements over time.

Issue – Application Matrix

The Task Force developed a materials application matrix based upon meeting drivers needs, consideration of roadway type, pavement service life, the performance of materials, and cost. This initial matrix reflects the fact that very little information is available to track material performance over a range of conditions on DOT roadways. However, this information can be collected and used to consider modifications to the application matrix developed.

Remaining Pavement Surface Life

= 2 yrs

3 - 5 yrs

5^+ yrs

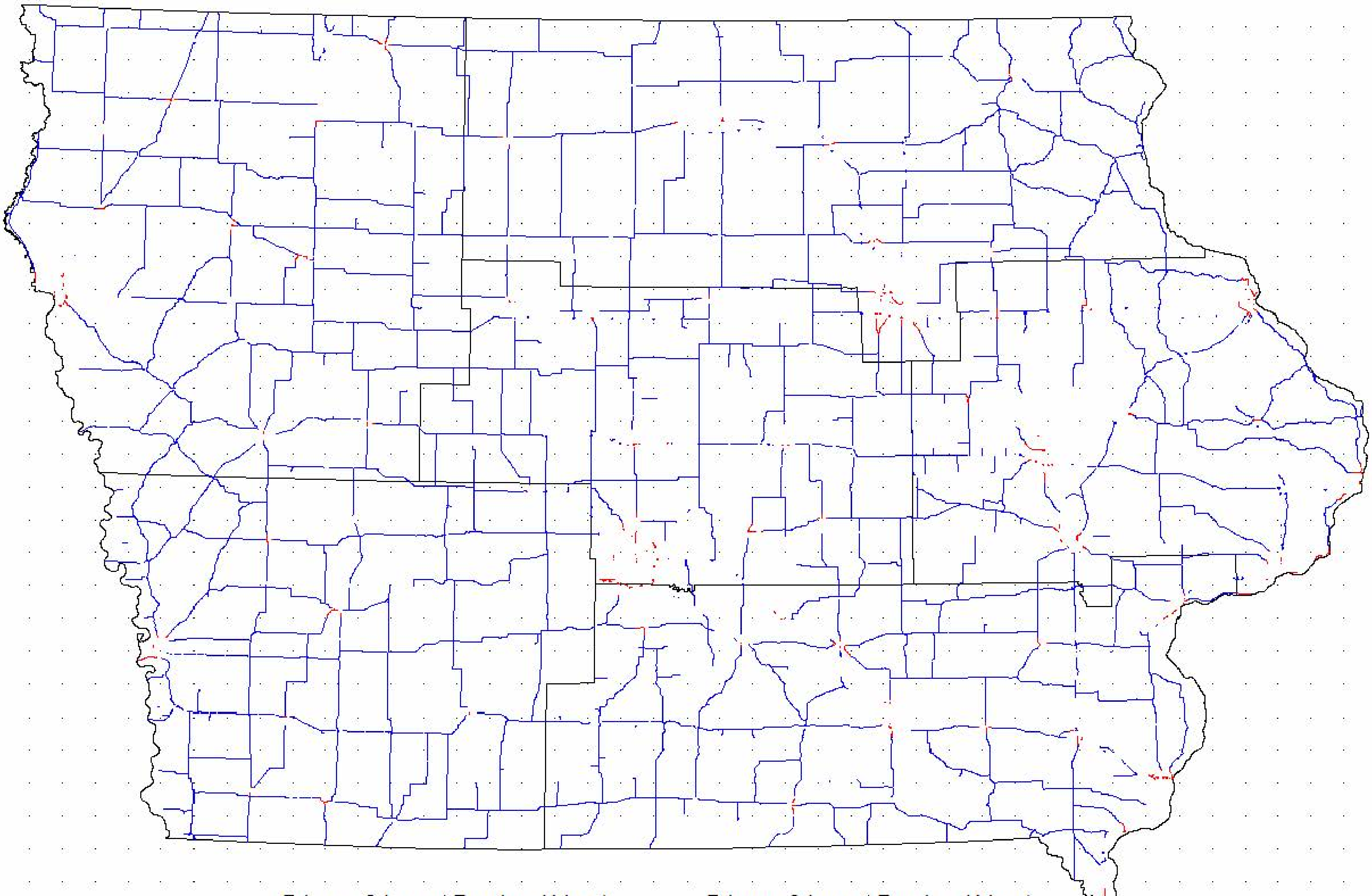
Roadway Characteristics

LONGITUDINAL PAVEMENT MARKINGS

Remaining Pavement Surface Life	Primary 2-Lane ≤ 55 mph	Primary 4-Lane RURAL	Primary 4-Lane URBAN High Traffic	Interstate RURAL ≤ 35,000 ADT	Interstate URBAN > 35,000 ADT
≤ 2 yrs	**Waterbourne**	**Waterbourne**	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea	**Waterbourne**	**Durable Waterbourne**, Epoxy, Polyurea, Tape
3 - 5 yrs	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea	**Durable Waterbourne**	Waterbourne, **Durable Waterbourne** RRPM Epoxy, Polyurea, Tape	**Durable Waterbourne**	**Durable VB** RRPM-Grooved Polyurea RRPM-Grooved Tape RRPM-Grooved
5^+ yrs	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea, Tape	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea	**Durable Waterbourne** RRPM Epoxy, Polyurea, Tape	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea, Tape	Durable WB RRPM-Grooved PolyureaRRPM+Grooved TapeRRMP+Grooved

		Centerline Miles			
		RURAL		URBAN	
Primary 2 Lane	72%	7,251	96%	290	4%
Primary 3 Lane	3%	230	85%	40	15%
Primary 4+ Lane	15%	1,059	66%	556	34%
Interstate	10%	787	75%	258	25%
Totals	100%	9,327	89%	1,144	11%

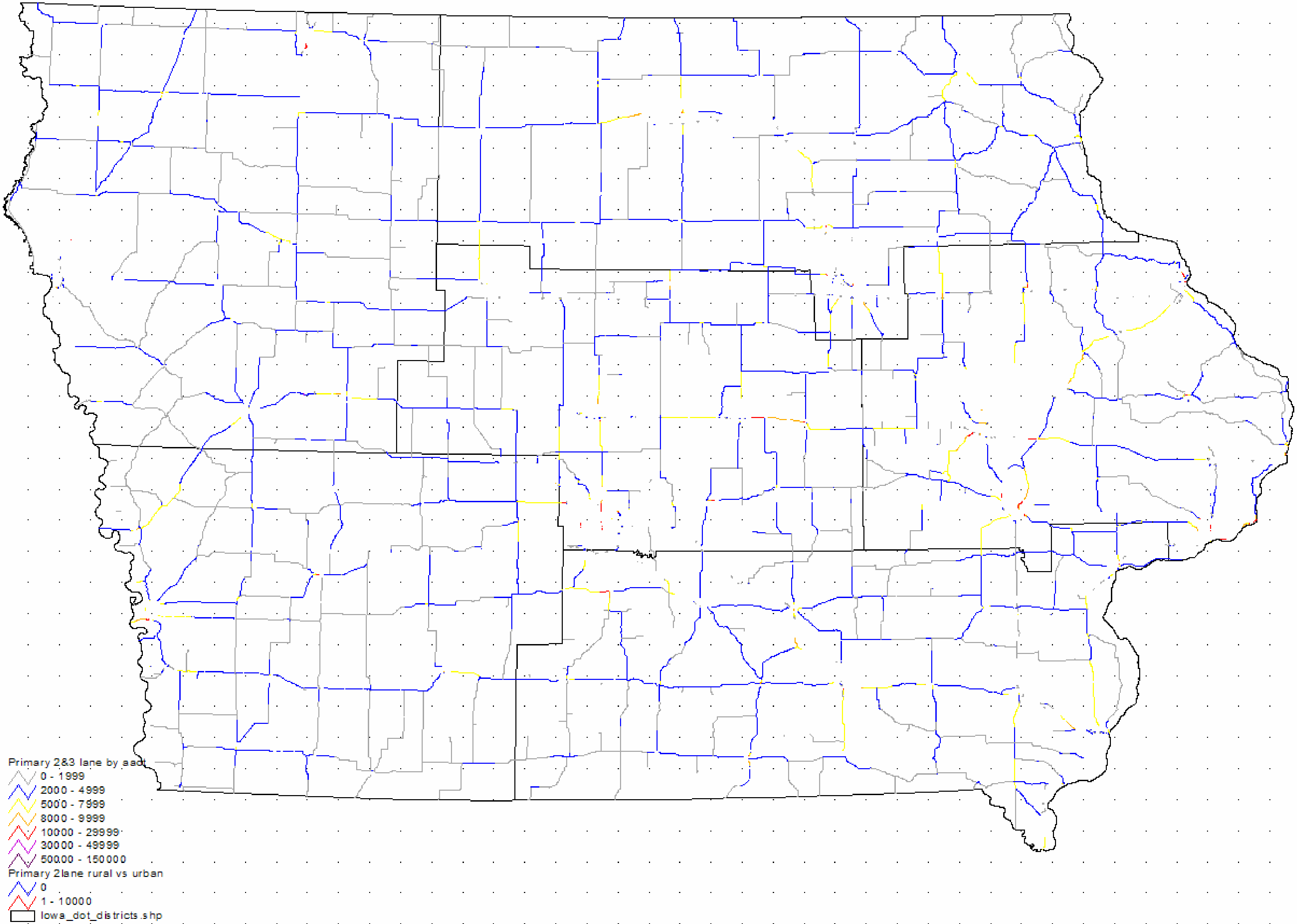
Primary 2 & 3 Lane Roadways (Rural vs Urban)



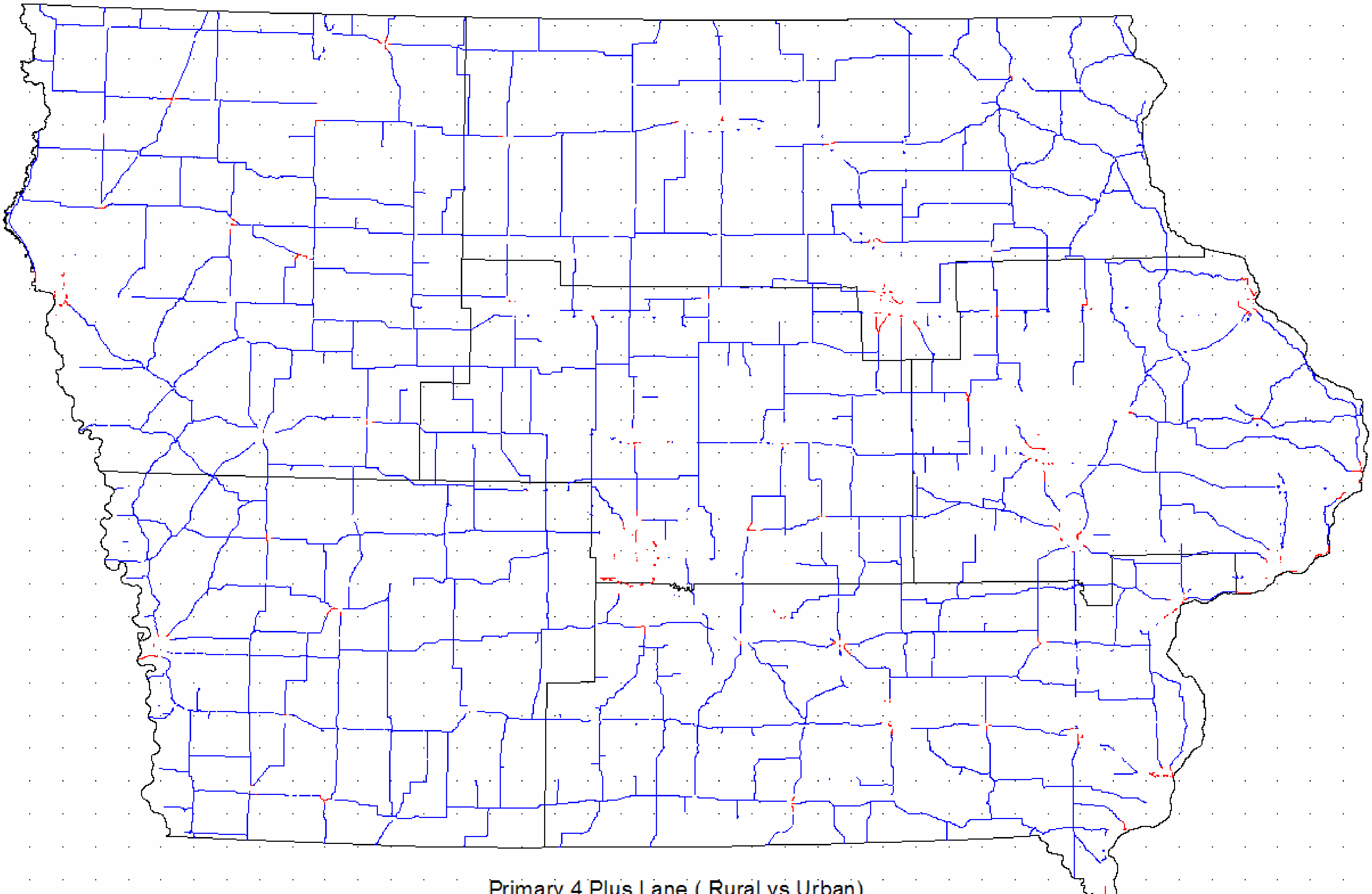
Primary 2-Lane (Rural vs Urban)
Rural in Blue = 7,251 centerline miles
Urban in Red = 290 centerline miles

Primary 3-Lane (Rural vs Urban)
Rural in Blue = 230 centerline miles
Urban in Red = 40 centerline miles

Primary 2&3-Lane (By AADT)

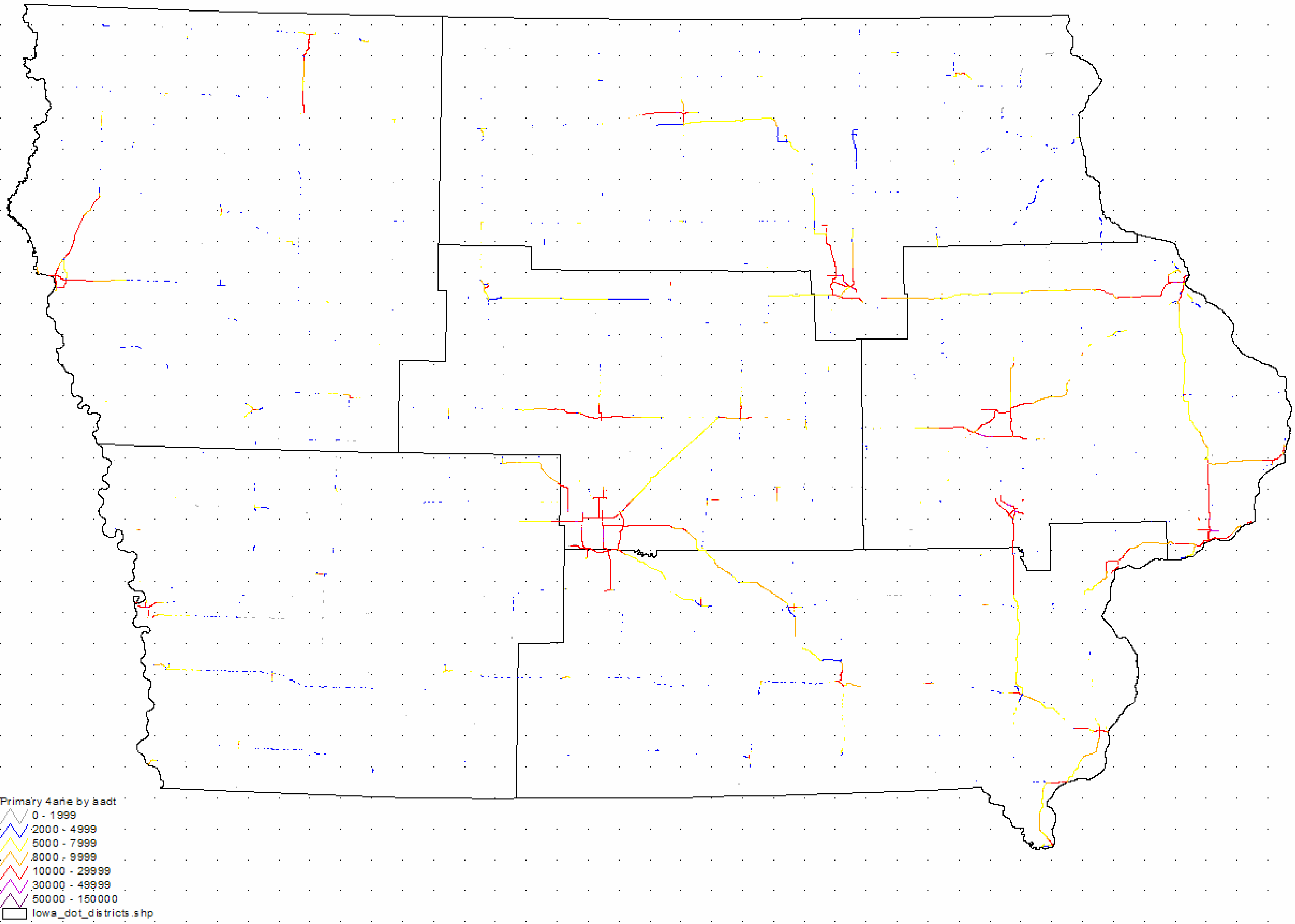


Primary 4 Plus Lane Roadways (Rural vs Urban)

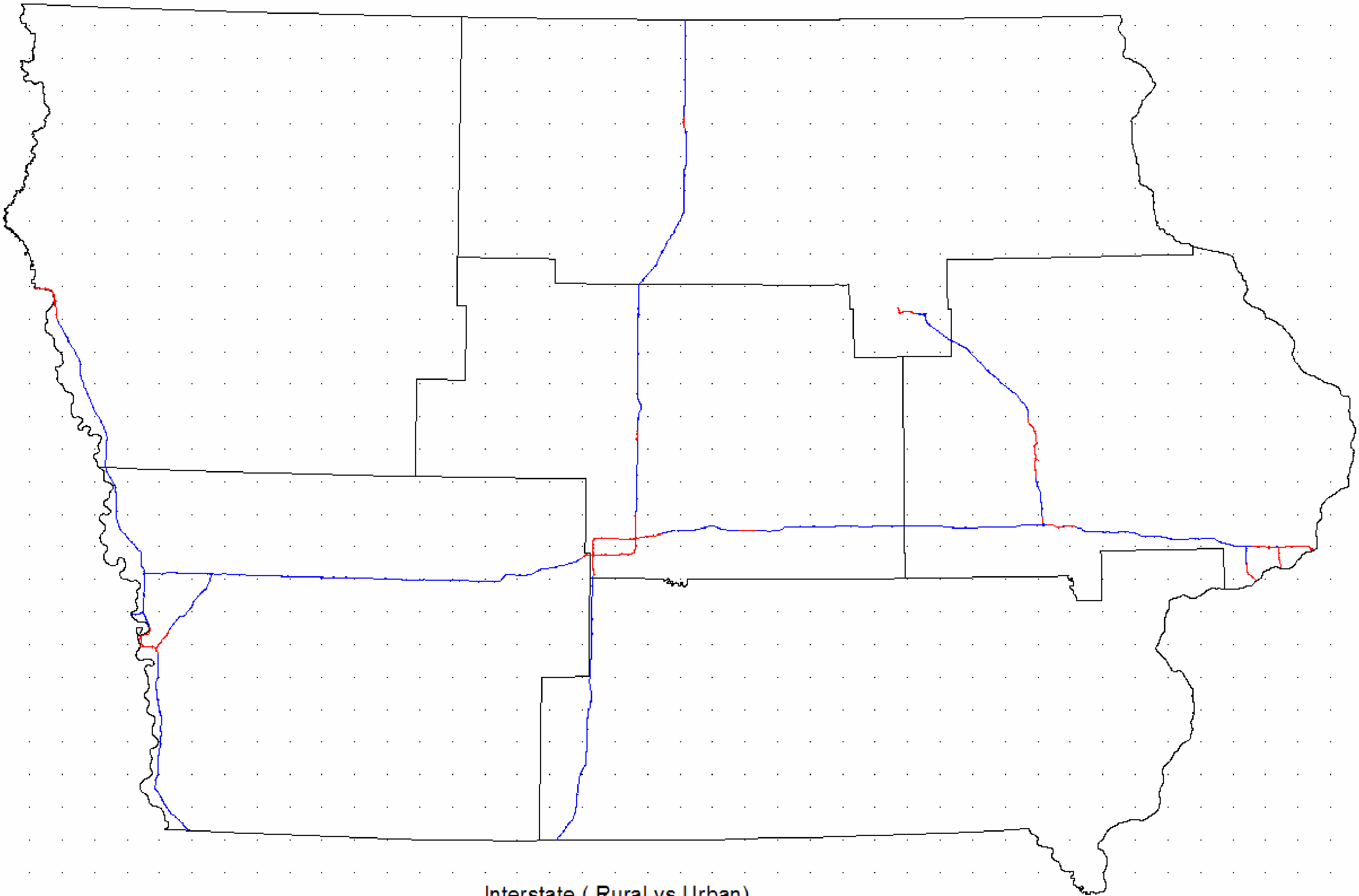


Primary 4 Plus Lane (Rural vs Urban)
Rural in Blue = 1,059 centerline miles
Urban in Red = 556 centerline miles

Primary 4-Lane (By AADT)

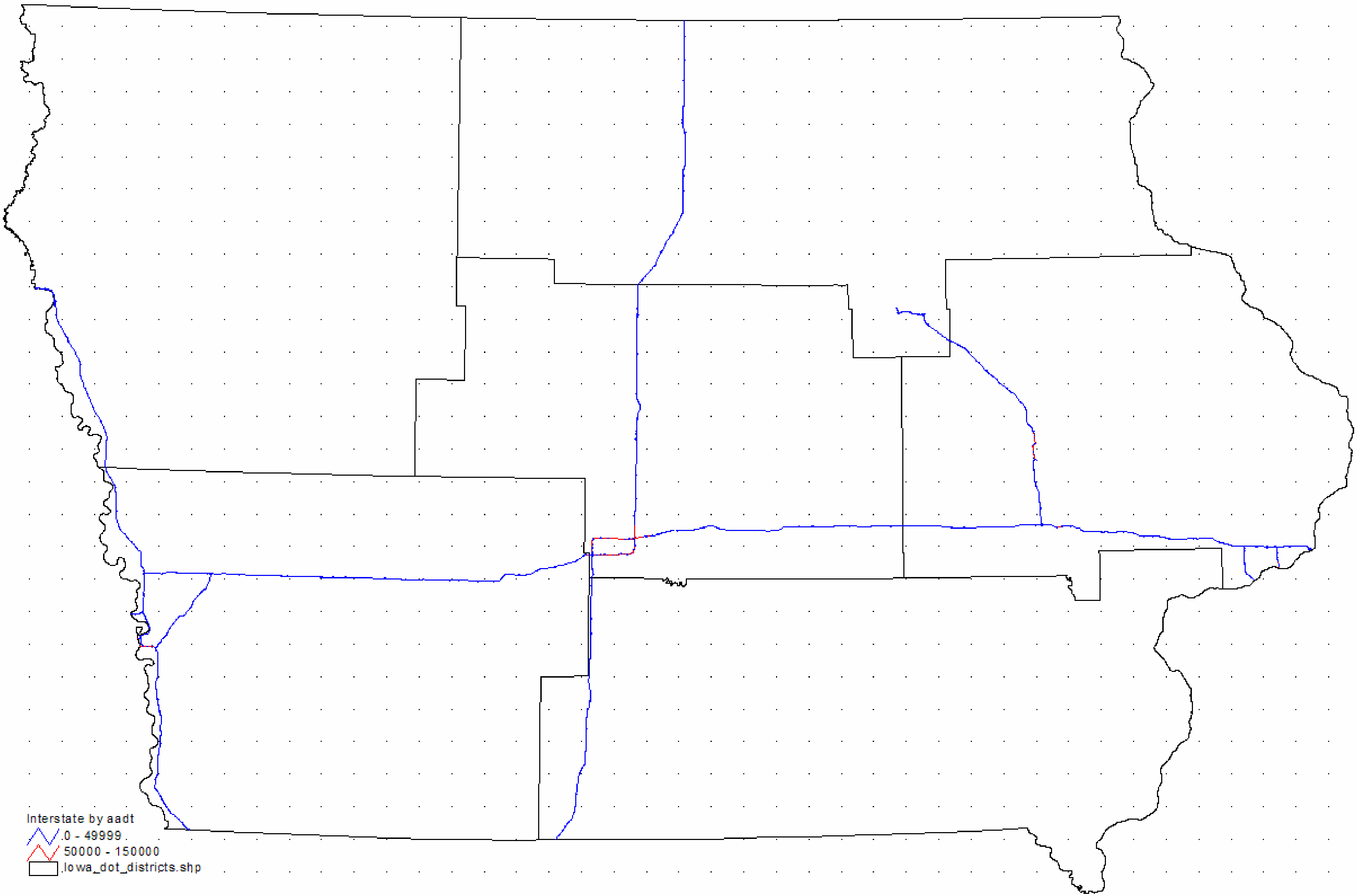


Interstate Roadways (Rural vs Urban)



Interstate (Rural vs Urban)
Rural in Blue = 787 centerline miles
Urban in Red = 258 centerline miles

Interstate (By AADT)



Issue – Application Matrix

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Recommendations

Short Term

•Adopt Application Matrix and as following years performance information is obtained refine the content of the selection criteria.

Long Term

•Consider all relevant factors which influence performance of pavement markings and incorporate into the Application Matrix.

•Work with industry to evaluate the effectiveness and cost impacts of the matrix and identify future enhancements, improvements, and evaluations for new methods and materials.

Remaining Pavement Surface Life
= 2 yrs
3 - 5 yrs
5^+ yrs

LONGITUDINAL PAVEMENT MARKINGS

ROADWAY CHARACTERISTICS

LONGITUDINAL PAVEMENT MARKINGS

Remaining Pavement Surface Life	Primary 2-Lane	Primary 4-Lane		Interstate	
	≤ 55 mph	RURAL	URBAN High Traffic	RURAL ≤ 35,000 ADT	URBAN > 35,000 ADT
≤ 2 yrs	**Waterbourne**	**Waterbourne**	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea	**Waterbourne**	**Durable Waterbourne**, Epoxy, Polyurea, Tape
3 - 5 yrs	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea	**Durable Waterbourne**	Waterbourne, **Durable Waterbourne**^{RRPM} Epoxy, Polyurea, Tape	**Durable Waterbourne**	**Durable WB**$^{RRPM\text{-}Grooved}$ Polyurea$^{RRPM\text{-}Grooved}$ Tape$^{RRPM\text{-}Grooved}$
5^+ yrs	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea, Tape	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea	**Durable Waterbourne**^{RRPM} Epoxy, Polyurea, Tape	Waterbourne, **Durable Waterbourne**, Epoxy, Polyurea, Tape	Durable WB$^{RRPM\text{-}Grooved}$ PolyureaRRPM+Grooved TapeRRMP+Grooved

LONGITUDINAL PAVEMENT MARKINGS

Remaining Pavement Surface Life	Primary 2 & 3 - Lane	Primary 4+ - Lane		Interstate	
	RURAL + URBAN ≤ 55 mph	RURAL	URBAN High Traffic	< 50,000 ADT	> 50,000 ADT
	7,811 centerline miles (75% of total)	1,059 centerline miles (10% of total)	556 centerline miles (5% of total)	1,000 centerline miles (9.6% of total)	45 centerline miles (0.4% of total)
≤ 2 yrs	**Waterborne**	**Waterbourne**	**Durable Waterborne**, Waterborne,	**Waterborne**	**Durable Waterborne,** Waterborne
3 - 5 yrs	**Durable Waterborne**, Waterborne	**Durable Waterborne,** Waterborne	**Durable Waterborne,** Waterborne, Epoxy, Polyurea	**Durable Waterborne**	**Durable Waterborne**[E&R] Polyurea[E&R] Epoxy[E&R]
5^{+} yrs	**Durable Waterborne**, Waterbourne, Epoxy, Polyurea	**Durable Waterborne**, Waterbourne, Epoxy, Polyurea	*****Durable Waterborne**[E] *Epoxy, *Polyurea, *Tape	**Durable Waterborne**, Epoxy, Polyurea	**Tape**[E&R] Durable Waterborne[E&R] Epoxy[E&R] Polyurea[E&R]

"E"=Enhancements could include reflectorized rpm’s, wider markings, supplemental strips of wet reflective tape, roadway lighting, larger beads, paint additives, or other forms of enhanced illumination.

"R"=Recessed marking within a groove which is milled into the driving surface

"*” =Where the characteristics such as heavy volumes, weaving, high speeds, or other conditions exist markings within this category may be treated similar to Interstate Urban with > 5 years life

ASSESSMENT

Pavement Marking Assessment

(Long Line Markings)
2004

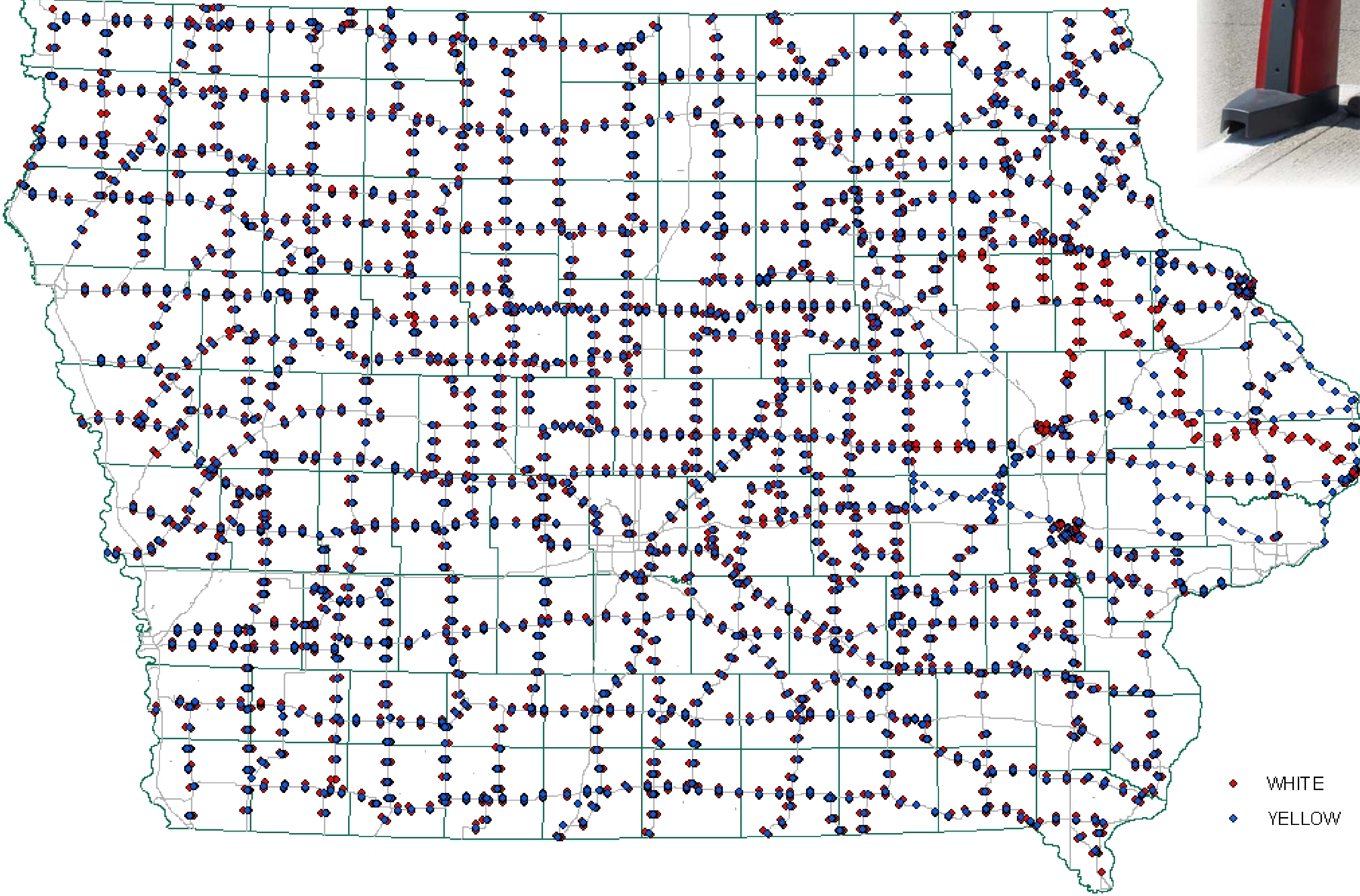
Iowa Department of Transportation

LaserLux Van

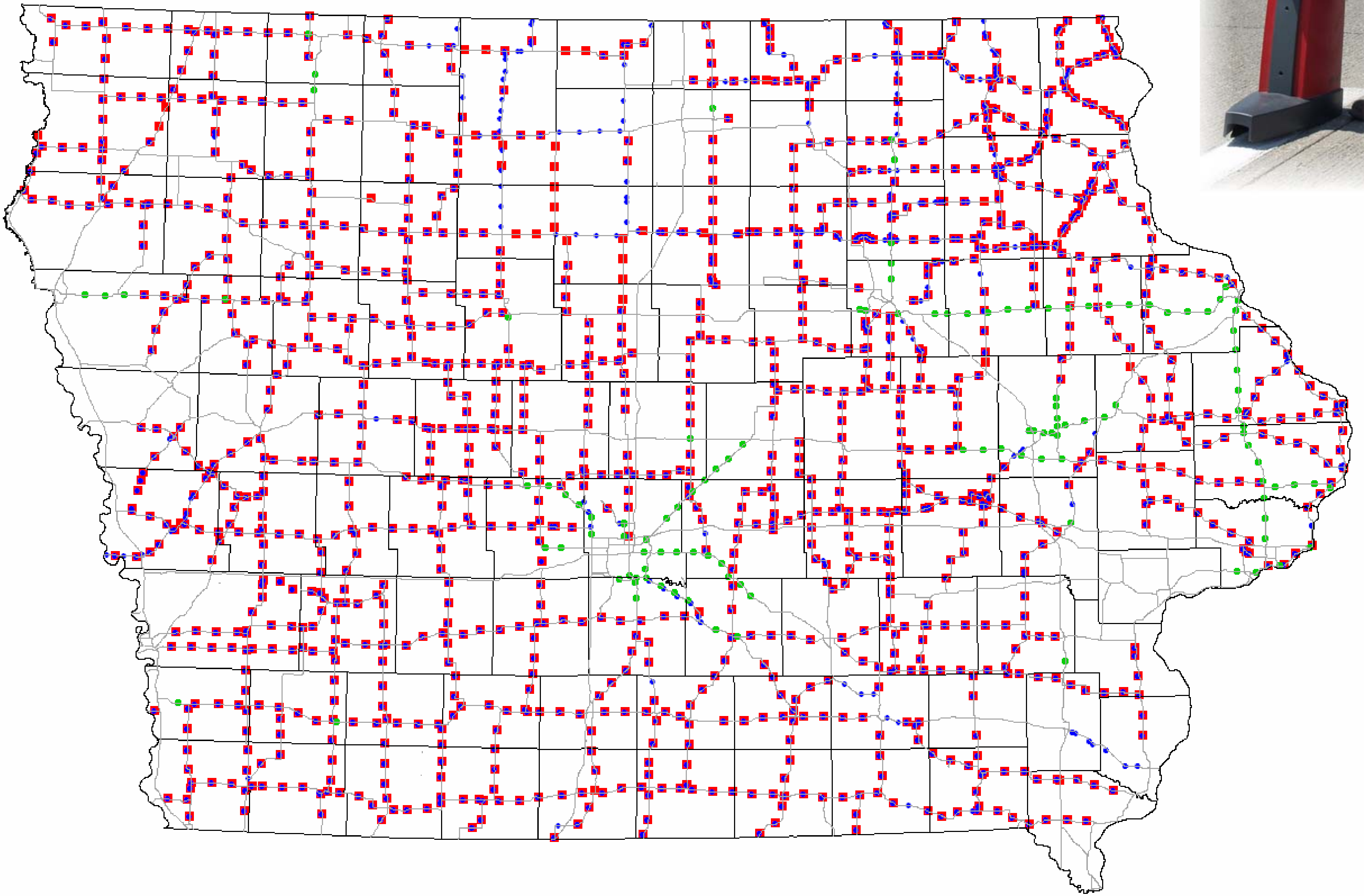
Handheld LTL-X

PAVEMENT MARKING REFLECTIVITY MEASURMENTS 2004

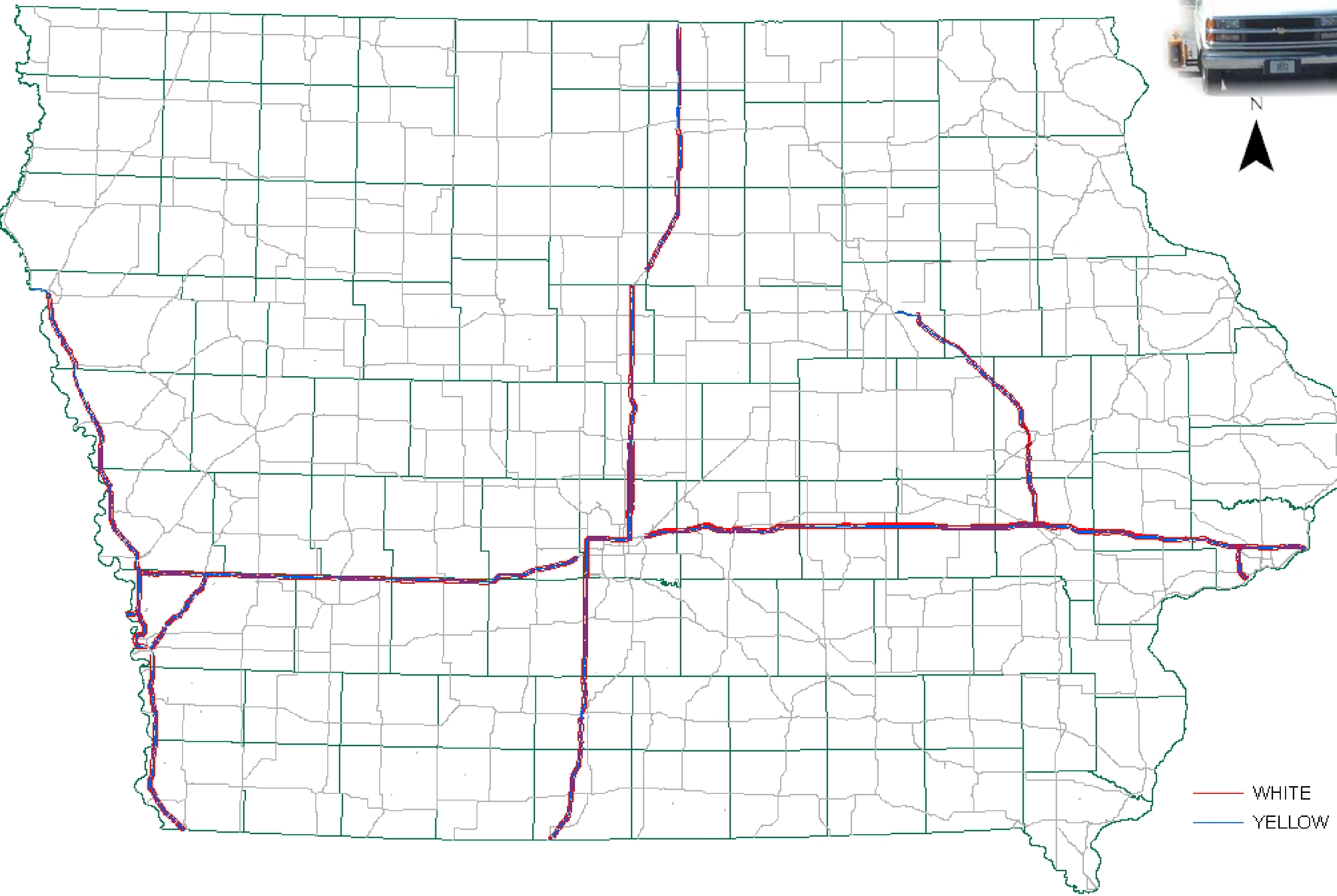
SPRING 2004 – <u>Handheld</u> Measurement Locations



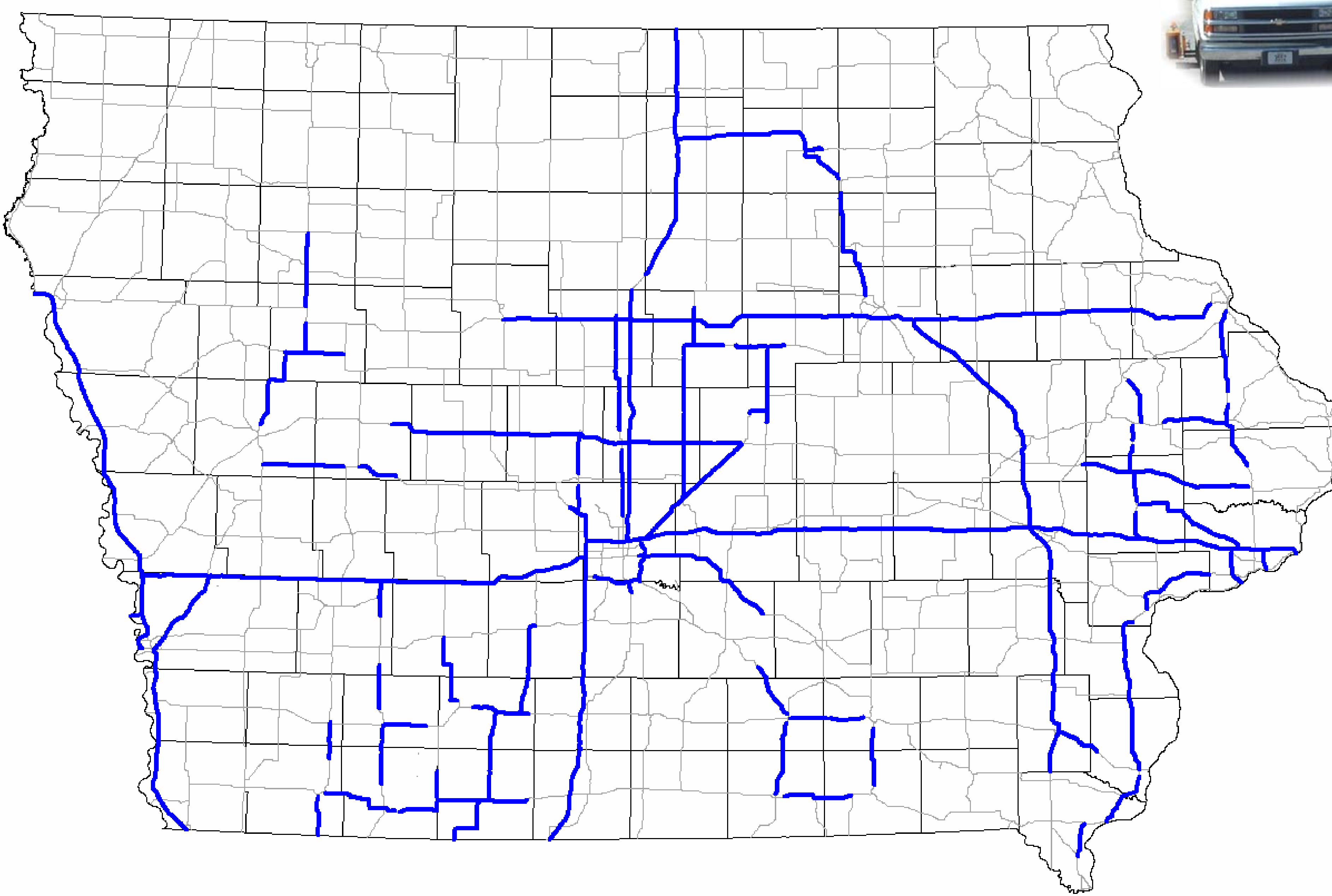
FALL 2004 – <u>Handheld</u> Measurement Locations



SPRING 2004 – Van Measurement Locations

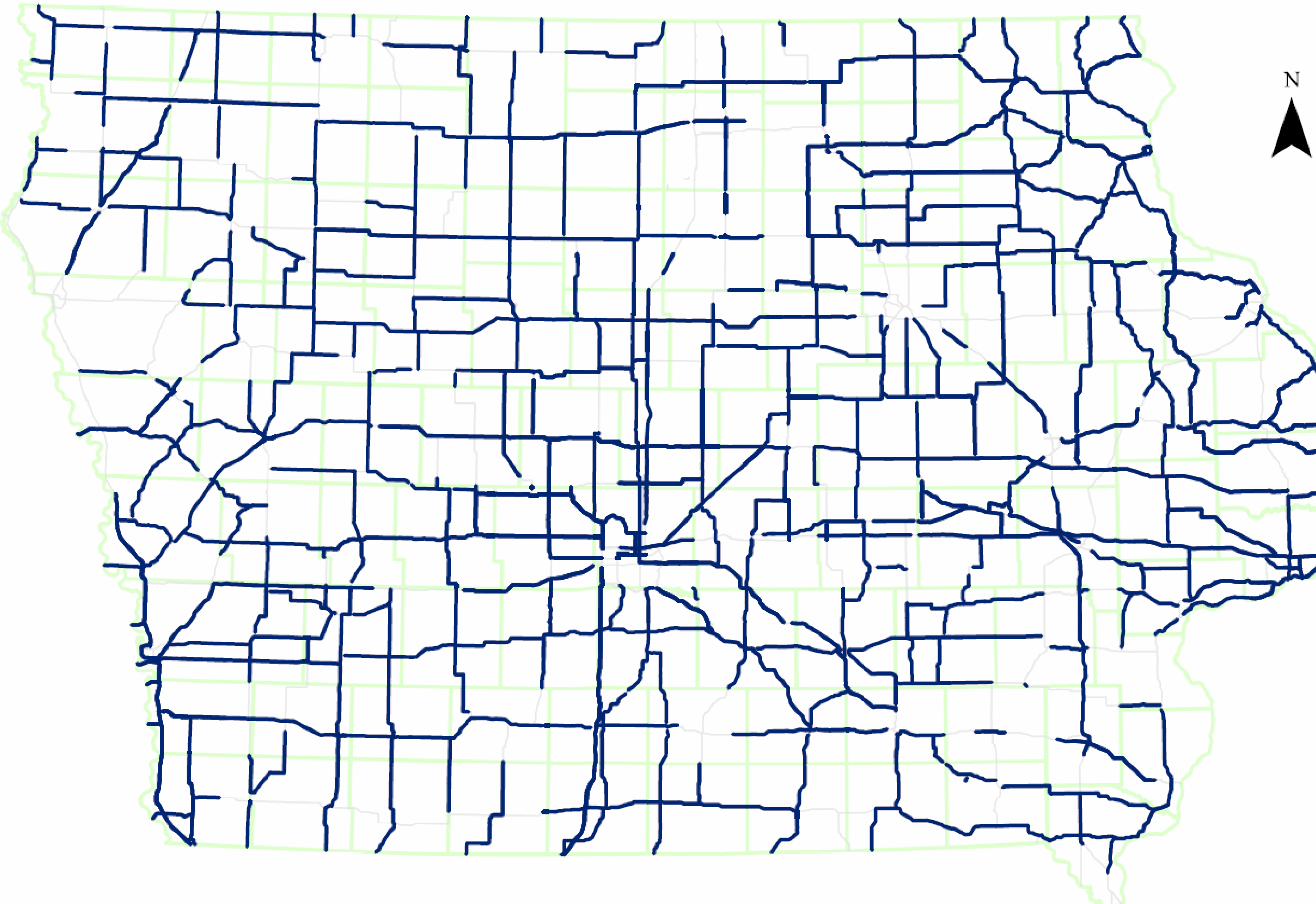


FALL 2004 – Van Measurement Locations




LONG LINE
PAINTING COMPLETED
2004

2004 - Locations where new paint was applied

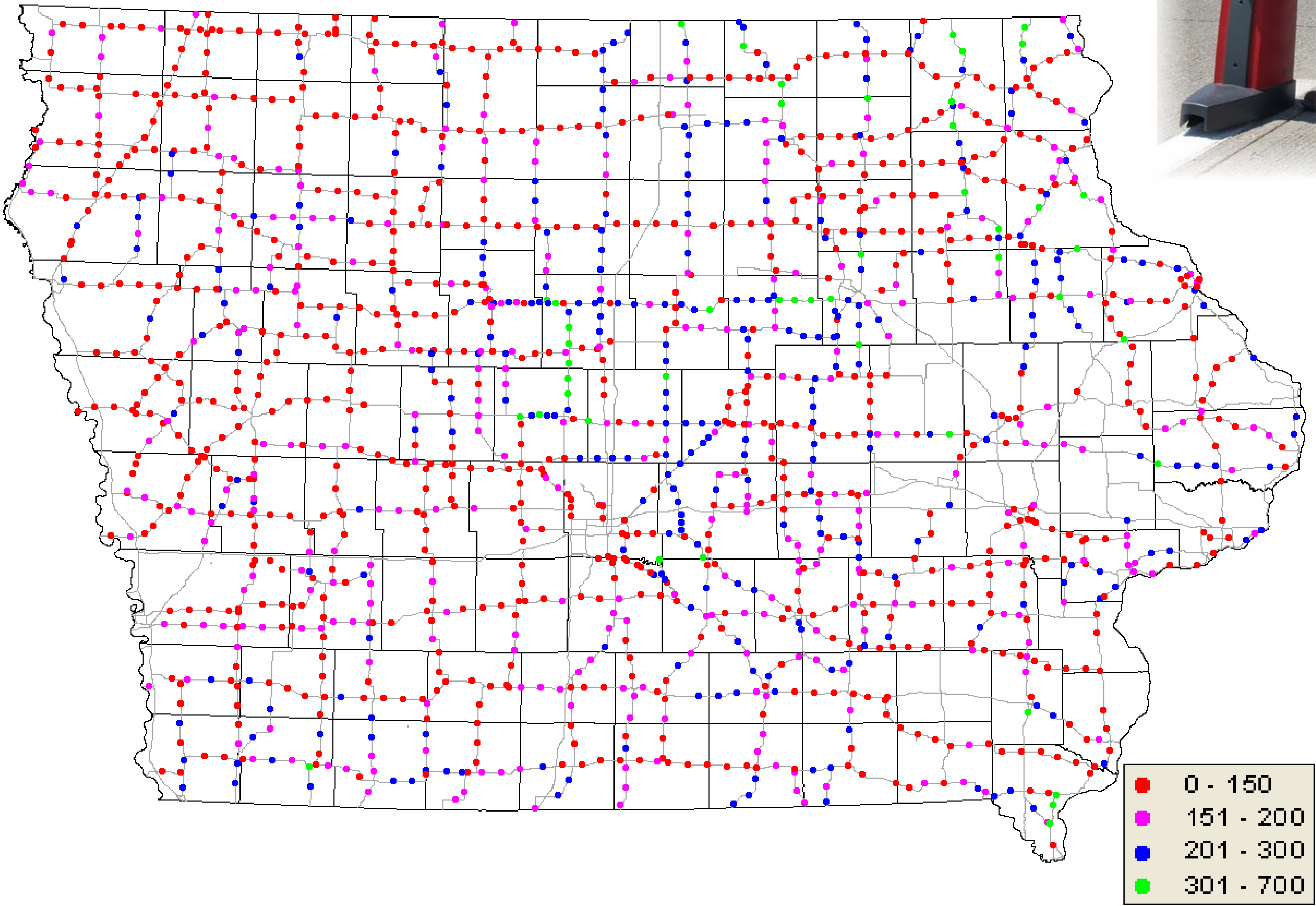


All Line Types

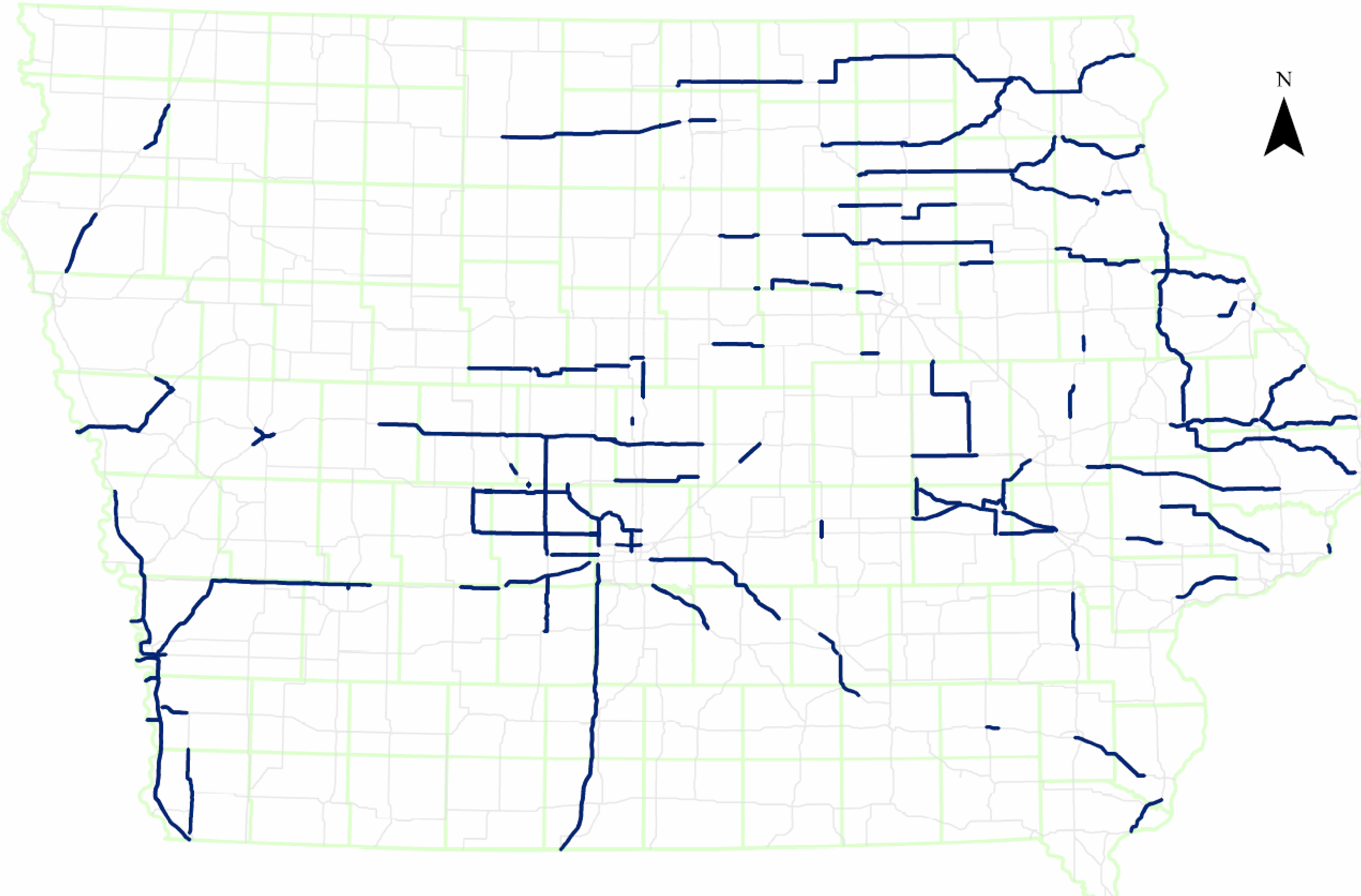
PAVEMENT MARKING ASSESSMENT BY TYPE OF LINE


WHITE EDGE
LINE

Spring'04 – white edge line handheld reflectivity

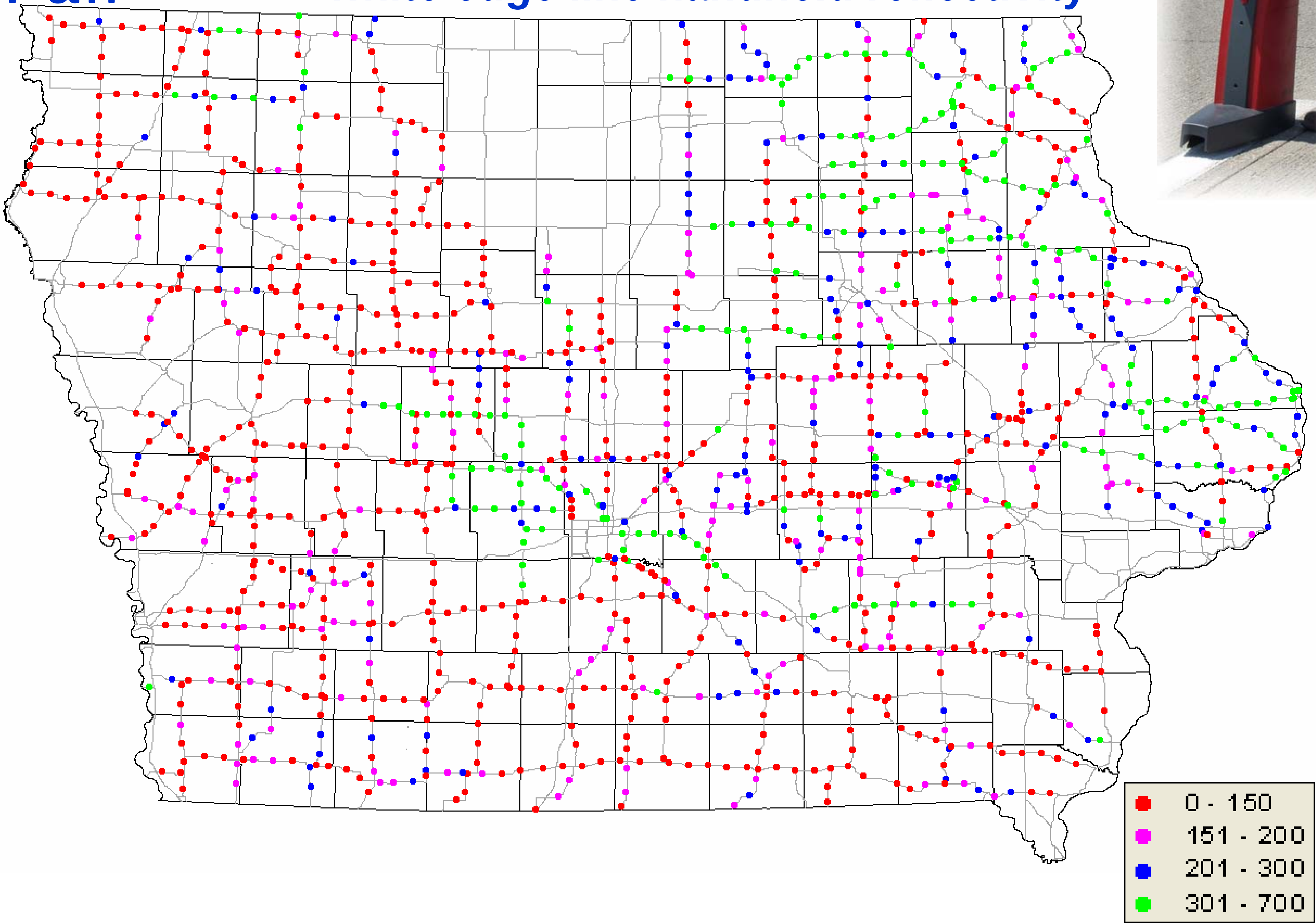


2004 - Locations where new paint was applied



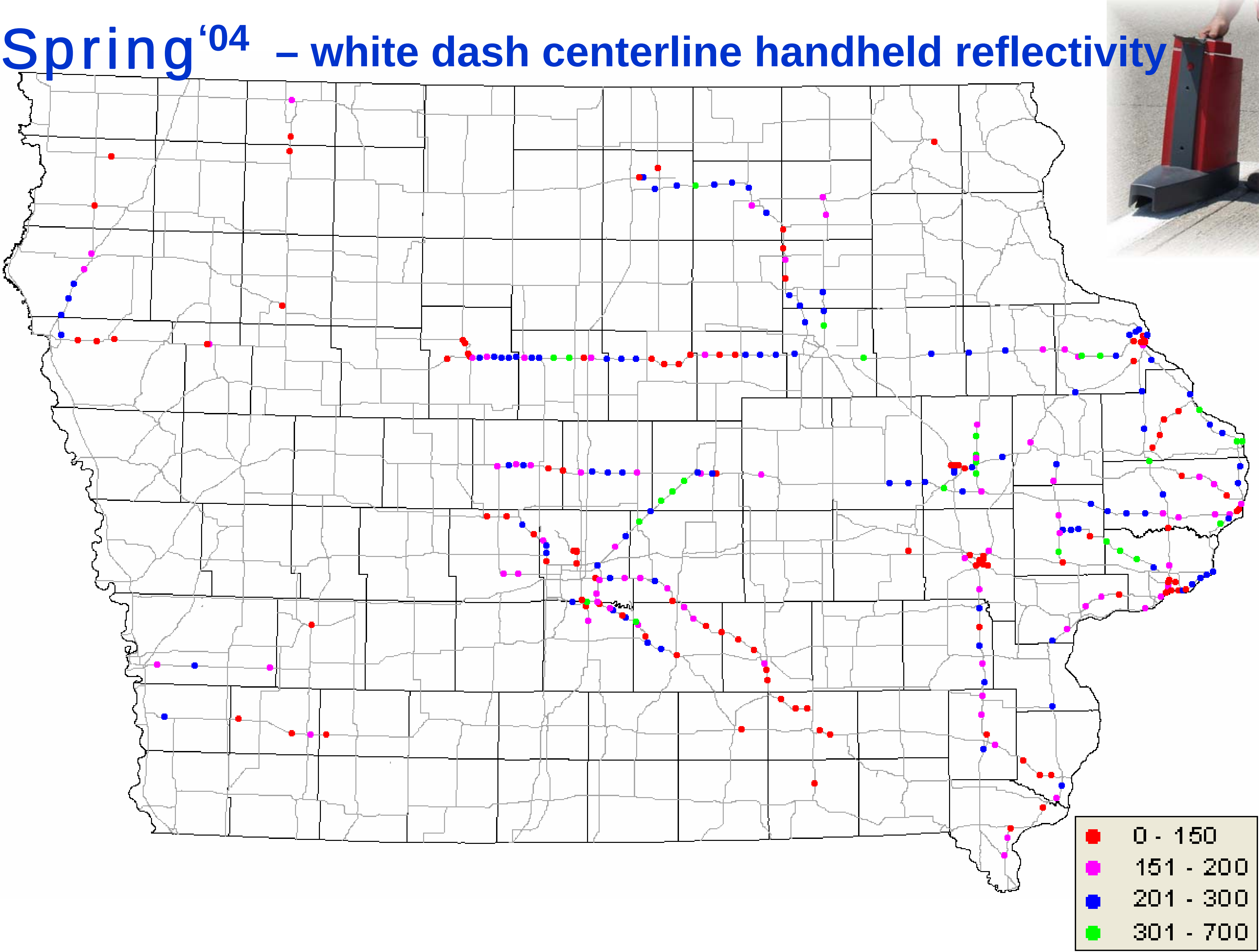
White Edge Line

Fall '04 – white edge line handheld reflectivity

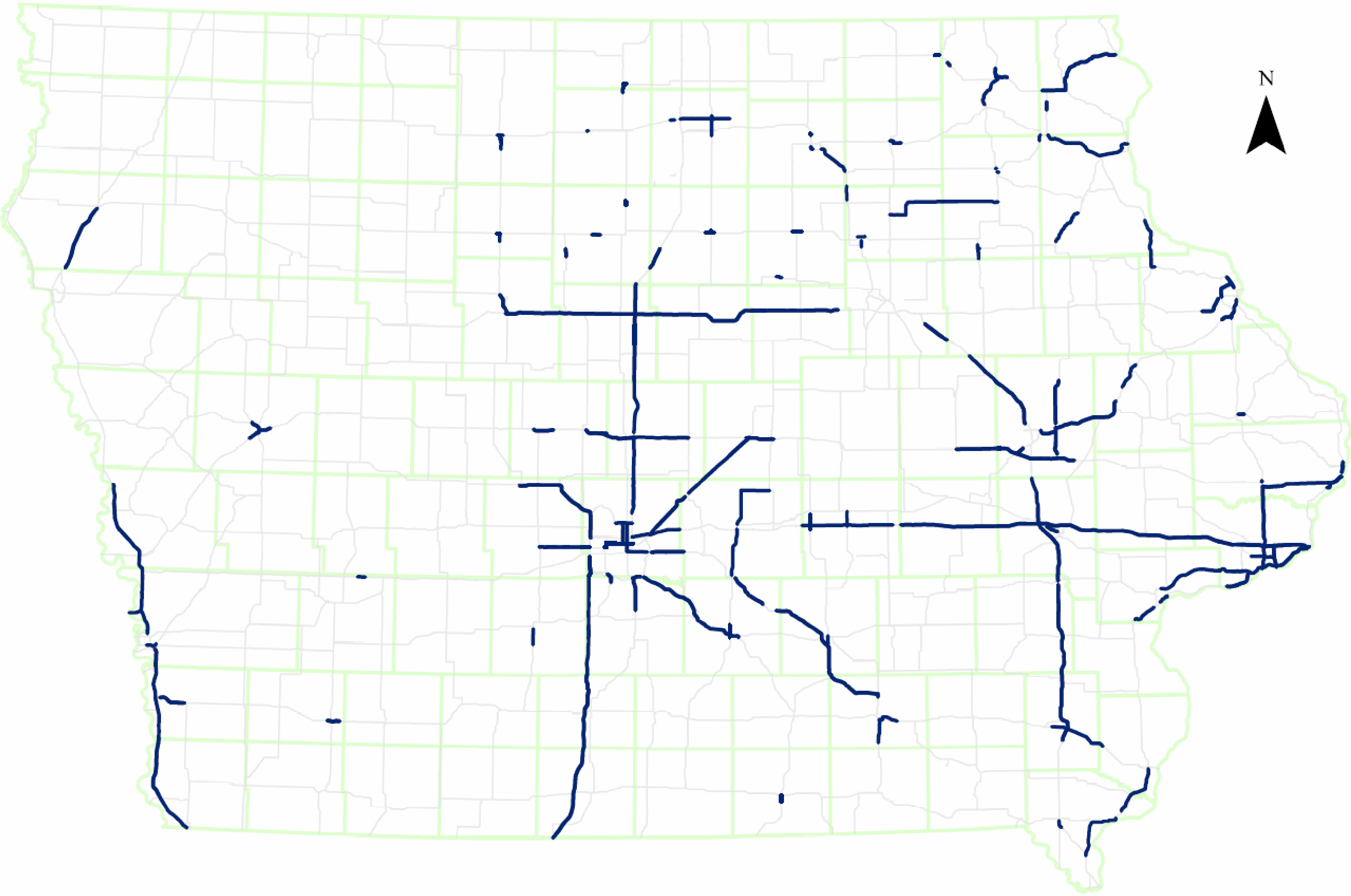



WHITE SKIP
(DASHED)
CENTERLINE

Spring'04 – white dash centerline handheld reflectivity

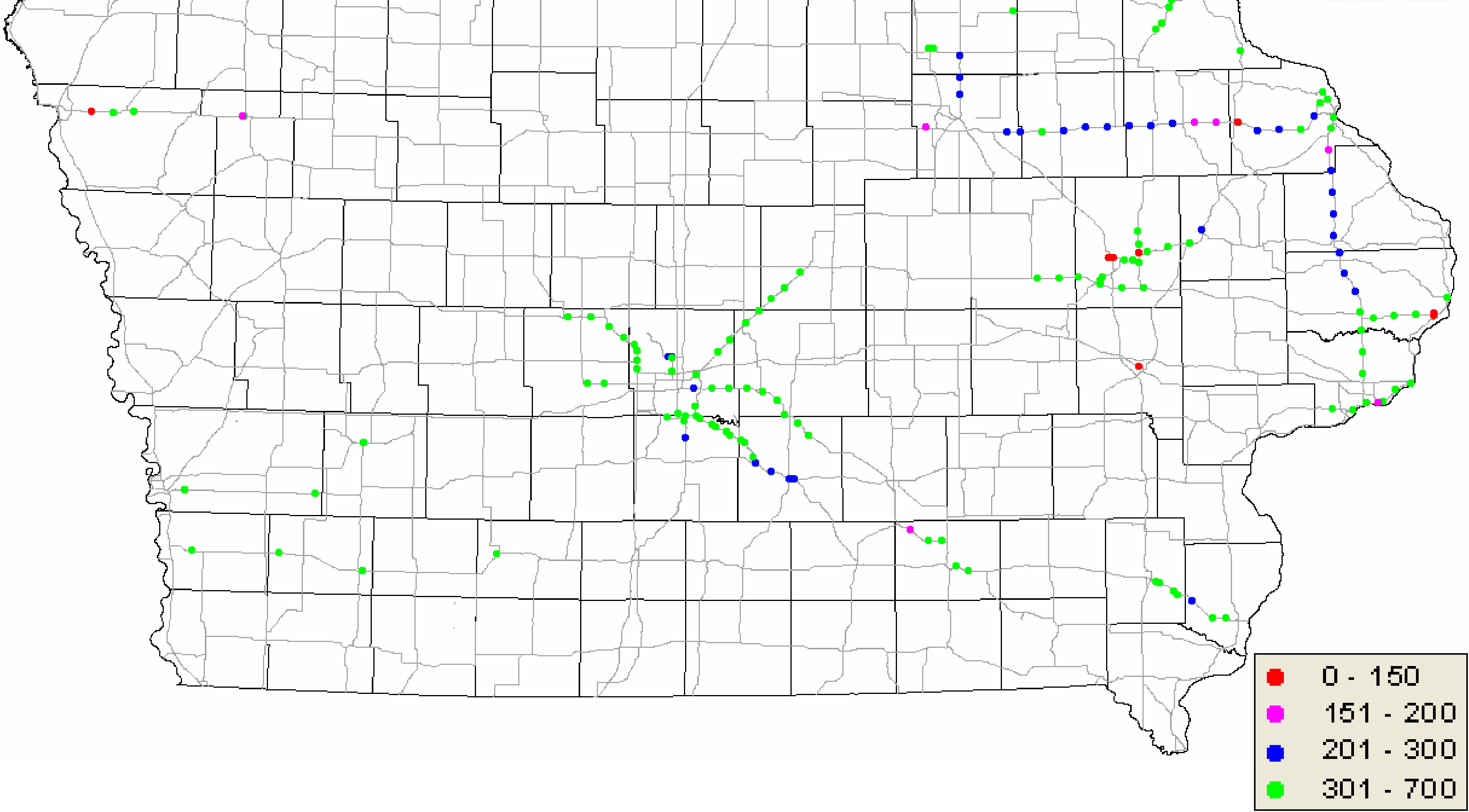


2004 - Locations where new paint was applied



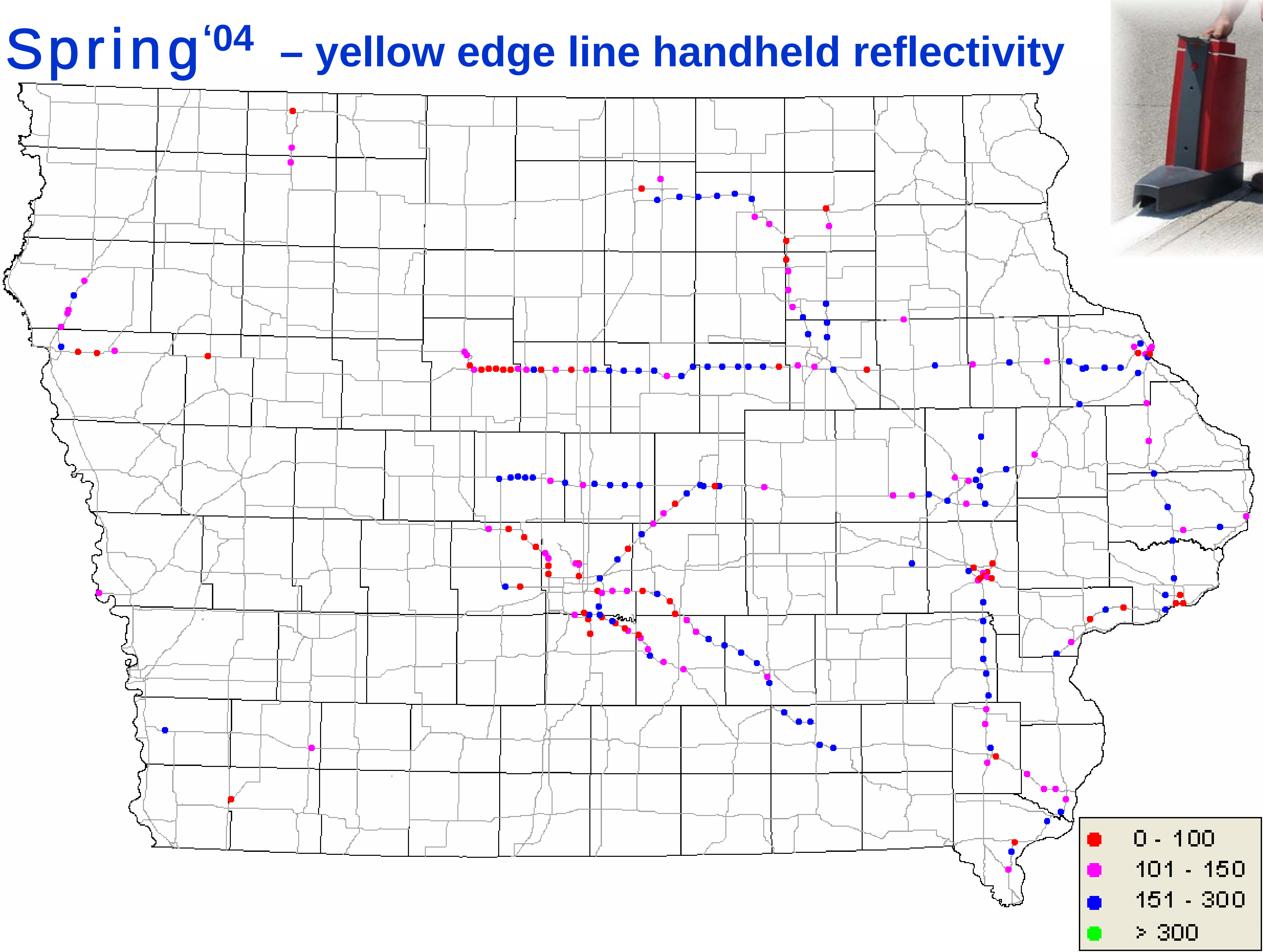
White Dashed Centerline

Fall'04 – white dash centerline handheld reflectivity

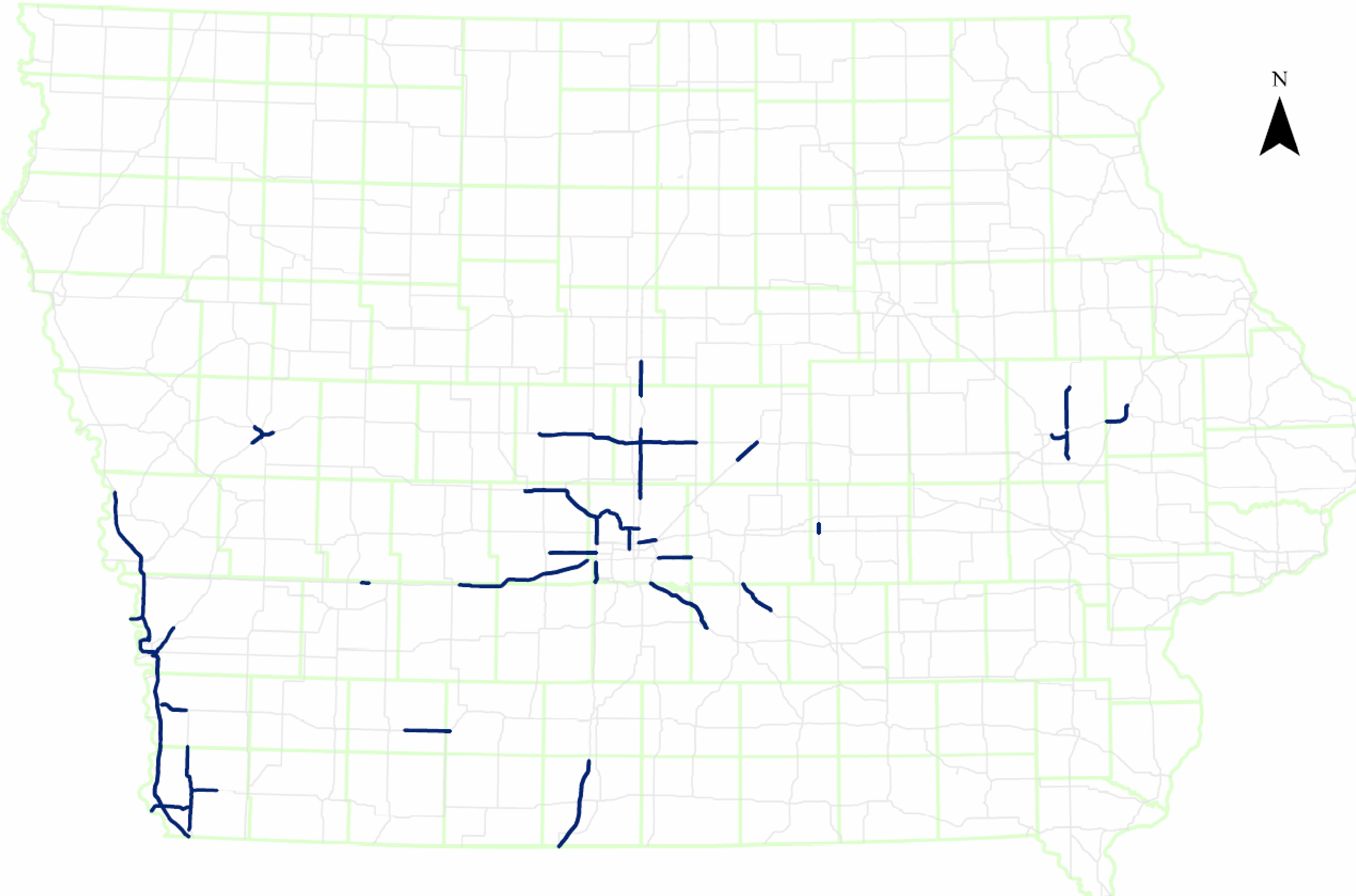



YELLOW EDGE
LINE

Spring '04 – yellow edge line handheld reflectivity

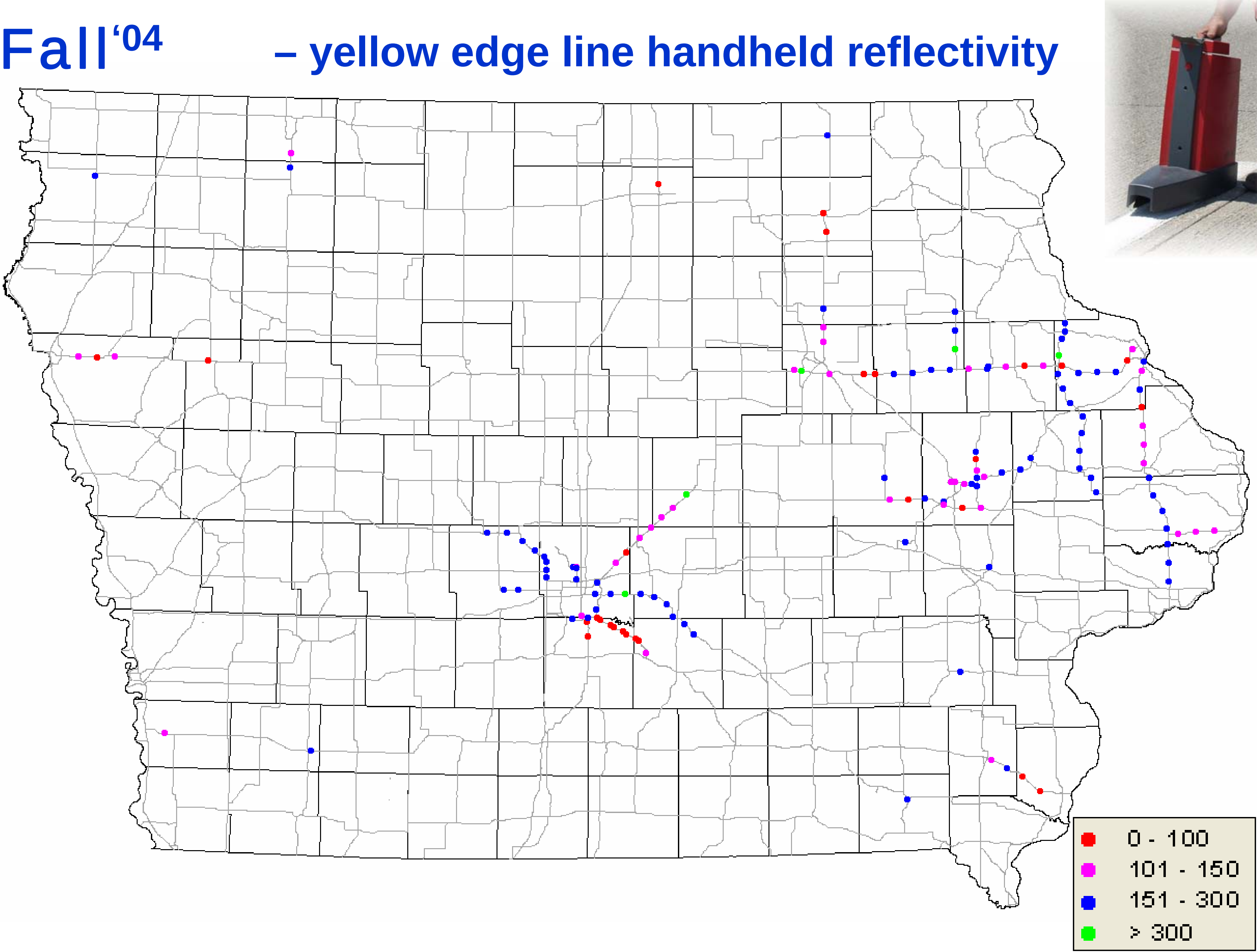


2004 - Locations where new paint was applied



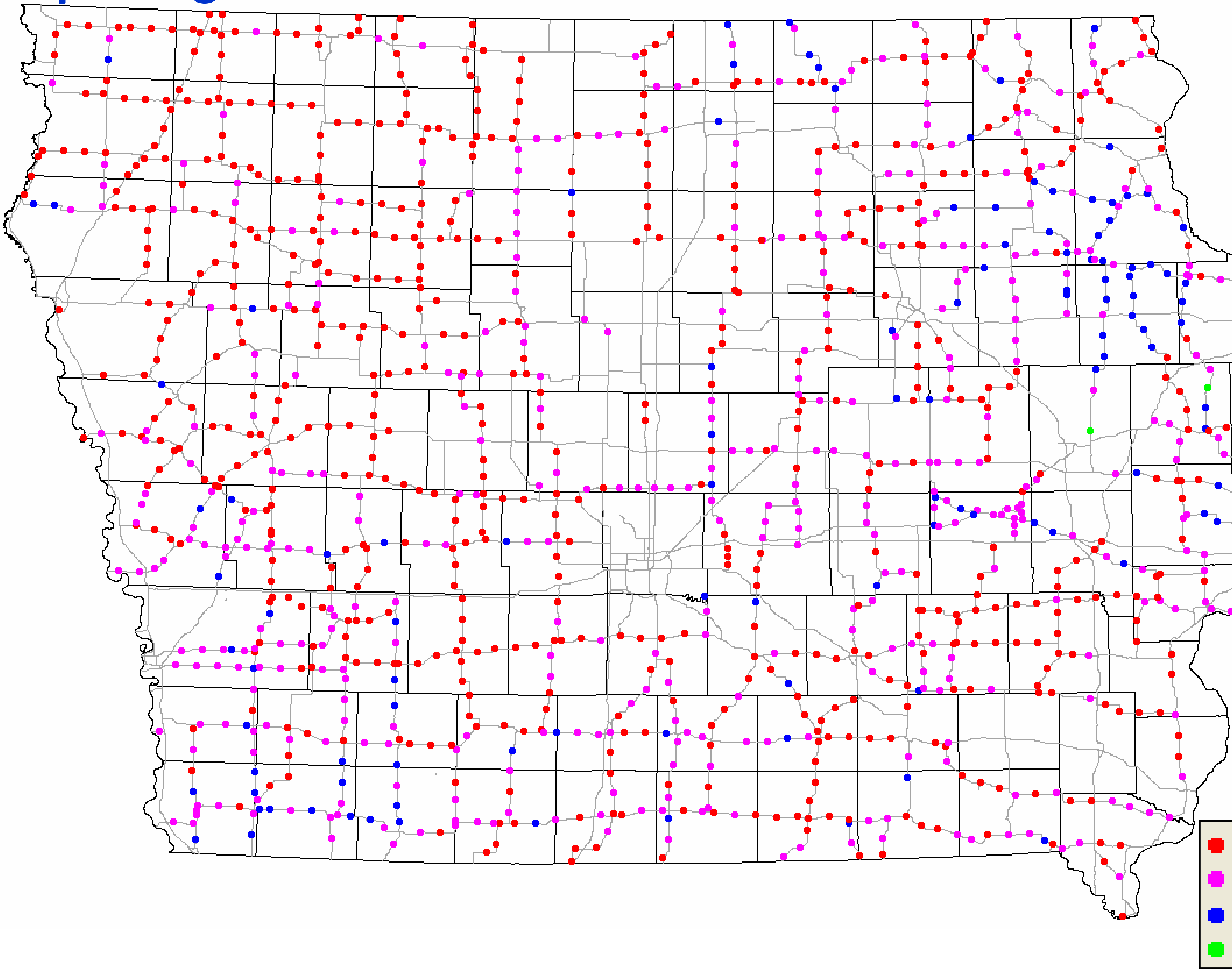
Yellow Edge Line

Fall '04 – yellow edge line handheld reflectivity

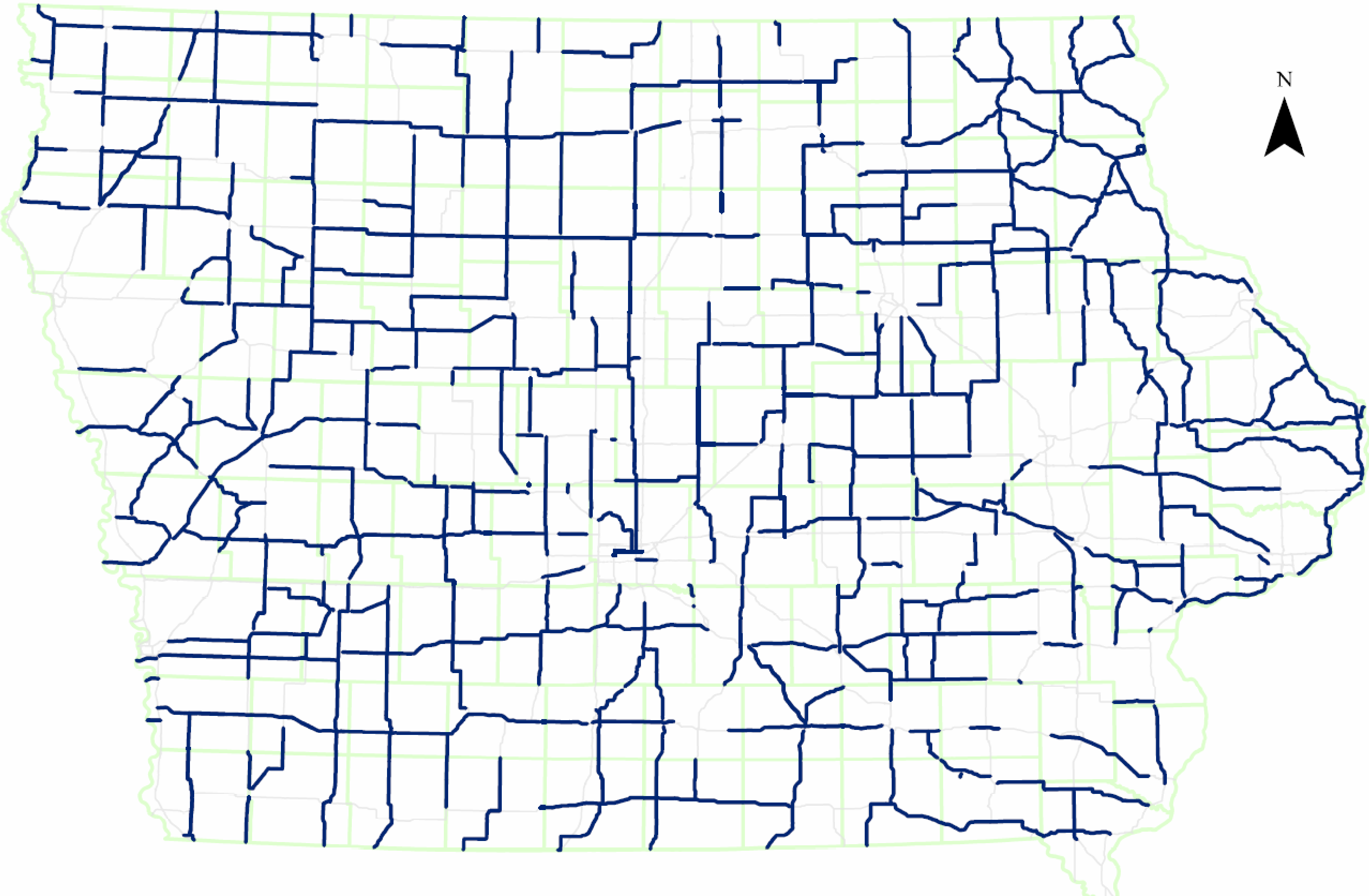



VOLVO
SAIA
5425
GMC
RIDESHARE
INFORMATION
288-RIDE
YELLOW
CENTERLINE

Spring'04 – yellow centerline handheld reflectivity

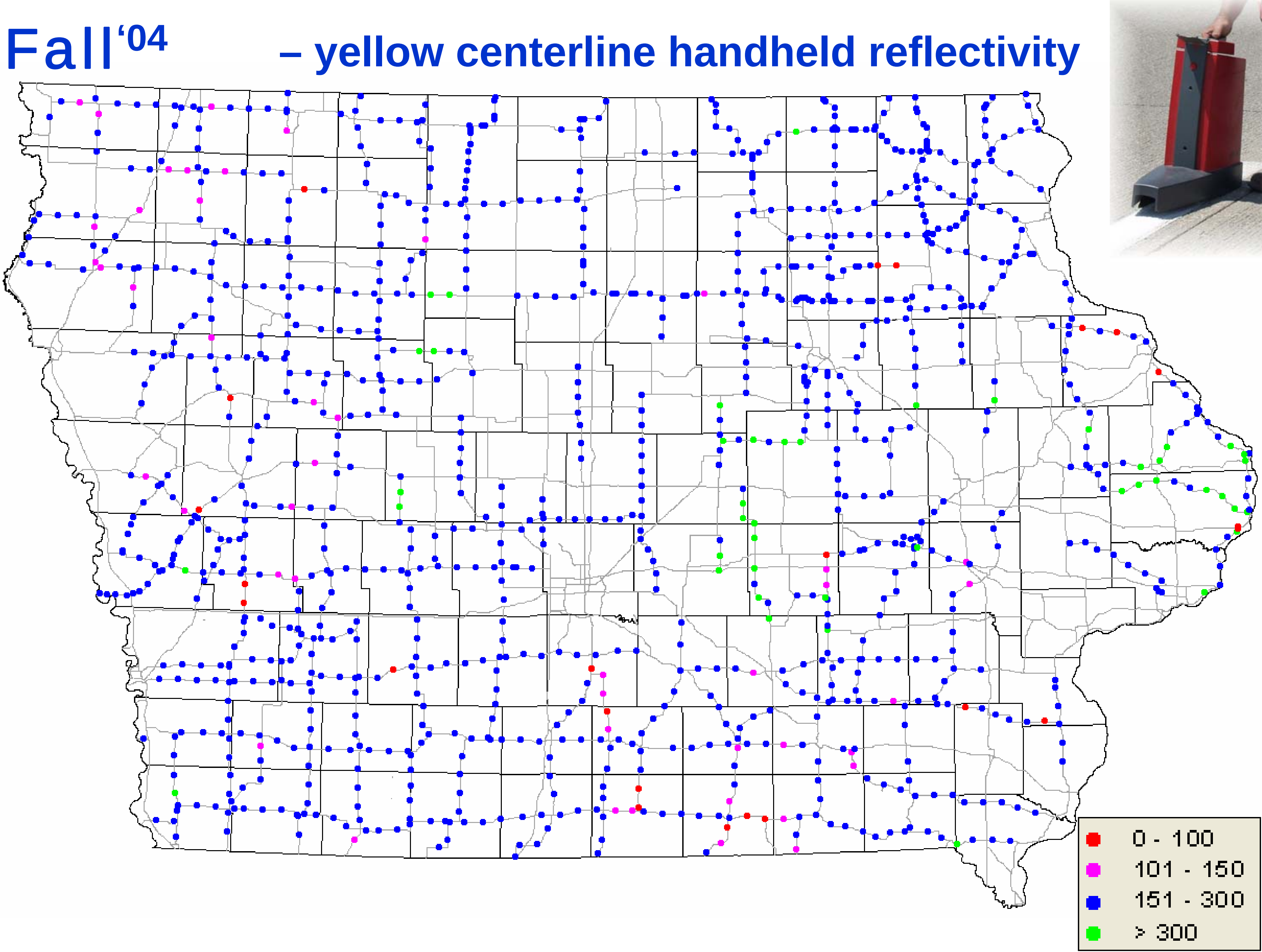


2004 - Locations where new paint was applied



Yellow Centerline

Fall'04 – yellow centerline handheld reflectivity



Overall Comparison - handheld reflectivity

Line Type			Spring 2004	Fall 2004
	WHITE EDGE LINE	Average	154	183
		Max	389	640
		Min	0	0
		# of readings	1898	1661
	WHITE SKIP LINE	Average	193	334
		Max	431	744
		Min	9	19
		# of readings	746	434
	YELLOW EDGE LINE	Average	146	175
		Max	265	428
		Min	17	35
		# of readings	625	369
	YELLOW CENTER LINE	Average	116	241
		Max	349	356
		Min	11	1
		# of readings	1351	1374

Task Force Recommendations:

1. Continue further development of the pavement marking program.

2. Continue to develop techniques for improving the performance of all pavement markings on DOT roadways.

3. Require that all long-line markings include initial and subsequent reflectivity readings.

4. Support and expand retroreflectivity measurements through dedicated staff and additional equipment. Incorporate reflectivity readings into daily painting practices statewide.

Task Force Recommendations:

5. Work with IT to implement prototype tools developed for simplifying data collection, storage, query, and automation in mapping and analysis.

6. Evaluate options for incorporating GPS with data to improve accuracy and reduce staff time needed to manually re-enter data into the inventory database.

7. Continue to build pavement marking performance curves through use of NTPEP test data, demonstrations and performance measurement. Update the application matrix from these findings.

Task Force Recommendations:

8. Work with industry to refine methods, equipment, materials, and analysis tools for entire pavement marking program.

9. Continue to research other key factors which contribute to pavement marking performance such as pavement surface condition and the calculated service life remaining of the pavement.

10. Continue to evaluate new methods such as grooving of pavements or recessing pavement marking as part of new construction.

Task Force Recommendations:

11. Improve specifications to require performance and reflectivity readings. Focus on matching DOT and contractor activities with long term marking maintenance practices using the application matrix.

12. Require contractors to measure and report reflectivity readings on all pavement markings. Consider implementation of performance based incentives/disincentives.

Next Steps:

- **2005 Spring Assessment**
- **Operations and Implementation Plan**
- **Hwy 5/65 Evaluation (3 yr test goes through 2006)**