INDOT Research

TECHNICAL *Summary*

Technology Transfer and Project Implementation Information

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Maintenance Quality Assurance Program

Introduction

Quality Assurance (QA) programs have impacted many industries within the United States. Common results are productivity increases, improved product quality, more efficient use of resources, and greater efficiencies in work processes. The Indiana Department of Transportation has been in the process of implementing QA principles in its various functions.

NCHRP Project 14-12, "Highway Maintenance Quality Assurance," describes a state-of-the art maintenance QA program. This prototype program was developed by utilizing standard principles of QA (Deming and others), statistical analysis techniques and evaluating other DOT organizations that have implemented QA programs.

The DOT organizations that have implemented a Maintenance QA program are Florida, Maryland, Oregon, Washington, and British Columbia. Each one of these is using some type of Level of Service (LOS) program to categorize and standardize for comparison purposes. Florida DOT prepared a report describing its Maintenance Rating Program. To some degree each of these programs are described in the NCHRP report. Some of these programs were used as background information in developing the INDOT program described in this report.

At INDOT, a maintenance QA program had been developed and implemented at the activity level. Every maintenance activity is checked and evaluated by QA guidelines. One area that has been considered as an ideal candidate for QA is at the management level of maintenance operations. This report describes a program that implements QA principles into the managing of field activities.

Findings

Several benefits can result from this program. Some of the typical ones experienced by other state DOTs that have enacted a Maintenance QA program are described next.

One expected result is a uniformly maintained system that is more consistent across the state. This can be accomplished through a standardized system of inspection, evaluation, weighting, and evaluation criteria, inspection procedures, and training program.

This project will provide an understanding of what LOS is important to the traveling public for various system components. For example, pavement smoothness, traffic control devices, or roadside vegetation are represent system components that will be ranked by the users. With this understanding INDOT can include user preferences in ranking the importance of various maintenance activities.

The ability to determine what level of funding is required for an activity to reach or maintain a certain LOS. This will help to generate more realistic budget requirements and allow for improved budget determinations of individual maintenance activities as well as at district and state-wide levels.

This program provides the ability to perform LOS and statistical analysis on maintenance activities and make corresponding adjustments and allocations in resources to achieve a level of quality service across the Districts. By improving the allocation of resources an equitable level of quality among the main activities can be created and a more uniform state-wide facility created.

Implementation

This program is an efficient way to collect information on roadway conditions. The inspection can be performed during the winter months by construction personnel, requiring no additional equipment or resources, and completed in a timely manner (400-450 manhours). Because of the random sample program, the results have a high level of certainty they represent the conditions in the District. The results can be used to develop a baseline of conditions that can be used for comparative purposes in the state and within the District for assessing Maintenance operations.

This program needs INDOT Executive Staff support to make this program a part of the normal work plan for the District Operations. An individual within the Operations Support Division needs to be assigned the task of managing and administering this Maintenance QA program. This individual will be responsible for providing the random sample locations and for analyzing and reporting the results. Implementation assistance will be available by contacting the JTRP office or Bob McCullouch (bgm@ecn.purdue.edu, 765-494-0643).

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16. Abstract

An INDOT maintenance QA program has been developed and implemented at the activity level. Every maintenance activity is checked and evaluated by QA guidelines. One area that has been considered as an ideal candidate for QA is at the management level of maintenance operations. This program uses a random sample population at a certain confidence level to evaluate the maintenance condition of INDOT roads. Five categories are evaluated: pavement, roadside features, shoulder, drainage, and traffic control. A field inspection program utilizes INDOT personnel and resources. A scoring program yields results that provides for category and individual item evaluations. Data collected in this program can be used to evaluate resource utilization and maintenance budgets. Statewide evaluation and District and even sub-district evaluations can be performed.

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Final Report

Maintenance Quality Assurance Program

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Table of Contents

Table of Figures

Introduction

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Work Activities

The below activities were performed on this project and are further described and explained.

1. Prioritize Activities.
2. Perform LOS analysis and inspections.
3. Perform a QA analysis with a statistical foundation.
4. Develop an integrated field and management program.
5. Document implementation costs and required time.

6. Develop a training program and perform state-wide implementation.

This program was tested in the Laporte District during the winter of 2001-2002. Fortunately the winter was a mild one and the field activities were completed very quickly. The test program provided valuable information on the field activities; like what resources will be needed, the time required, and can it be performed in the winter time.

Activity Prioritization

Maintenance operations are involved in many activities, from repairing damaged pavements to sign replacement. These activities are numerous with a small number consuming the majority of the resources. All activities should not be considered in a QA analysis program. One way of ranking or prioritizing is by the amount of money spent on an activity; another is by what the users(traveling public) deem to be important. The latter requires obtaining input from the traveling public. The most effective way is to use a scientific survey either through the mail or by phone solicitation. A public solicitation program that incorporates statistical sampling principles was developed and administered on this project. Survey results and INDOT input will determine the ranking of activities.

Public Survey

This started by meeting with Richard Feinberg, Professor in Consumer Sciences and Retailing at Purdue University. Dr. Feinberg recommended using three focus groups scattered geographically to design the survey form. He also recommended that the survey should use a 100 point distribution among the various activities. Dr. Feinberg has a center that can perform this type of survey. The center is named the "Center for Customer-Driven Quality." The Center can do a random scientific sample of Indiana residents, 370 people, for $15-$20 each. This sample will represent 95% of Indiana residents and takes about 6 weeks to perform. So for performing the survey it would cost between $5500 and $7500. This price is just for executing the survey. There is additional cost for analyzing and doing the focus groups. This cost was prohibitive so another option was explored based on this meeting and the process that was explained by Dr. Feinberg.

This option started with developing the survey through a campus focus group and administering the survey through selected Bureau of Motor Vehicle (BMV) branches and rest stops along the Interstate system. To diminish seasonal biases in the survey results it was decided to perform the survey in the early spring(April and May). Winter activities were still fresh and what needed to be done to maintain the system was ahead.

It was decided to use a focus group of randomly selected employees at Purdue University to help create the public survey. Random phone calls were made and eight individuals were selected for the focus group. On February 25, 2000 the focus group met for a luncheon at the Lafayette ballroom of the Union Building, Purdue University. In attendance where, Bob McCullouch (Purdue), Dave Ward (INDOT), Eke Maclean (INDOT/Purdue), Jan Ogden (Business office Purdue), Mike Grenat (University warehouse), Ragland Marion (Human relations), Mark English (Purchasing), Deborah Mistina (Psycological sciences) and Dan Larson (Purdue Police). The meeting started with a description of the project and a proposed draft survey(Figure 1). The group was asked to structure the questionnaire. A draft survey was distributed for use as a talking document. The discussion recommended the survey be printed on a light concrete gray color paper, tri-folded with Indiana State logo on one side and Purdue on the other. It was also suggested that two different prints of the survey be produced for the BMV and for the Rest Areas. A copy of the Survey used is located in the Appendix.

JTRP Maintenance Quality Assurance Program
Customer Expectation Survey (Example)

The Indiana Department of Transportation and Purdue University is interested in developing a program that applies Quality Management techniques to improve Indiana roadway Maintenance.

Prioritize the below activities in the order from most important too least important. Roadside Maintenance has been grouped into 10 activities. So in your opinion, the one with the highest priority is assigned 1 and the one with the lowest is assigned a 10.

Also for the below, in the Satisfaction column circle the number. 1 means acceptable satisfaction, no improvement is needed, 2 means some improvement is needed, 3 means a great deal of improvement is needed.

Maintenance Activity	**Satisfaction**	**Priority**
How are you satisfied with Patching potholes.	1 2 3	---------
How important is debris removal from pavement (Trash, animals, etc.).	1 2 3	---------
How important are adequate and quality roadside signs. (e. g. Stop, curves, speed limits, destination, mileage, school zone)	1 2 3	---------
Pavement reflectors, painting, striping and markings. (e. g. arrows, centerline, edge lines, no passing, lane dividers)	1 2 3	---------
How are you satisfied with litter removal along Roadway?	1 2 3	---------
How important to you is controlling roadside vegetation (e. g. mowing grass, cutting brush, etc.)	1 2 3	---------
How important are clean rest areas.	1 2 3	---------
How are you satisfied with the Smooth riding surface	1 2 3	---------
How important is removing snow and ice from roadways.	1 2 3	---------
How important is Maintaining bridges, guardrails.	1 2 3	---------

What is your County/State of Residence----------
Do you own/drive a Car, pickup, Suv, Van, Truck, Tractor trailer (circle those that apply)
How many miles do you drive per year (estimate), (less) than 10,000miles, (less) or (more) than 20,000miles, Check one.

Additional comments:

_____
_____
_____
_____

Figure 1 – Initial Survey for Focus Group

The survey was distributed to ten BMV branches scattered geographically around the state. The locations were: Bloomington, Columbus, Fort Wayne, Goshen, Kokomo, Lafayette, Sellersburg, Speedway, Terre Haute, and Valparaiso. The Survey was also placed at two rest stops. One at the I-65 rest stop near Rensselaer and the second was on I-70 near the Illinois state line. Survey

responses collected were 550 from the BMV and forty from the rest stops. The surveys were at the BMV branches for approximately a month and the rest stops for about two weeks. The survey asked to rank in priority of importance the below nine maintenance activities:

1. Repair Potholes
2. Remove Debris
3. Keep Roadside Signs Legible
4. Keep Pavement Markings Visible
5. Control Roadside Vegetation
6. Keep Rest Areas Clean
7. Remove Snow and Ice
8. Maintain Bridges and Guardrails
9. Keep Riding Surface Smooth

The survey results yielded the following priorities.

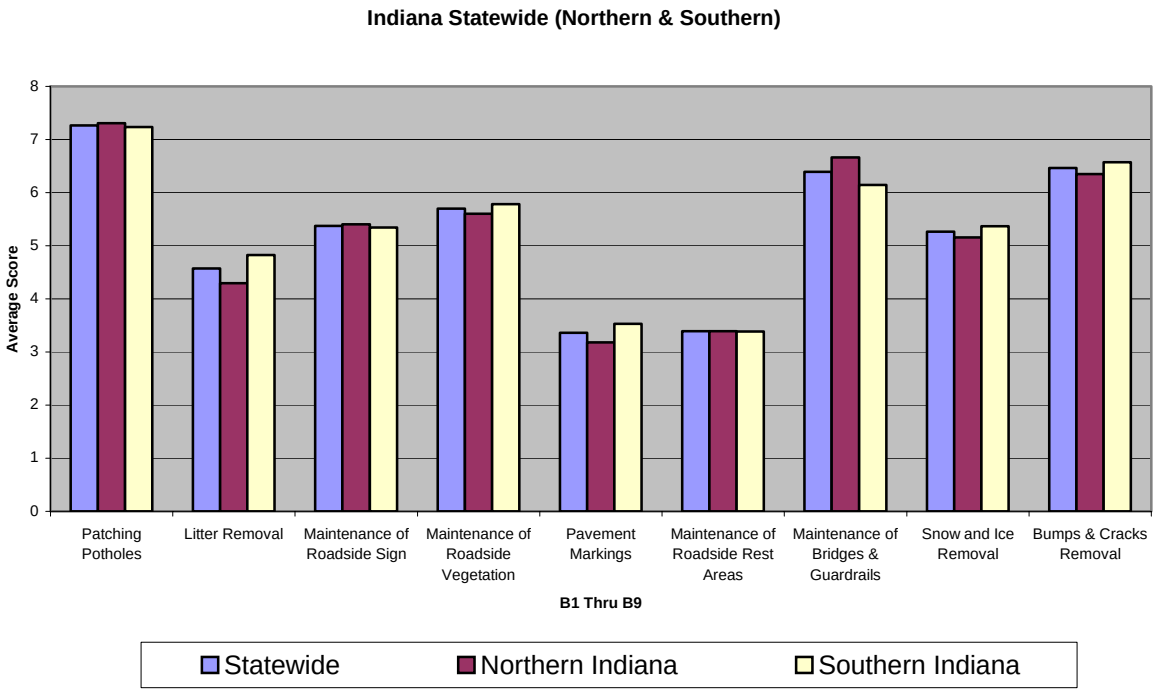
North	South
1. Repair potholes	1. Repair potholes
2. Remove snow and ice	2. Keep riding surface smooth
3. Keep riding surface smooth	3. Remove snow and ice
4. Keep pavement markings visible	4. Keep pavement markings visible
5. Keep roadside signs legible	5. Maintain bridges and guardrails
6. Maintain bridges and guardrails	6. Keep roadside signs legible
7. Remove debris	7. Remove debris
8. Keep rest areas clean	8. Control Roadside vegetation
9. Control roadside vegetation	9. Keep rest areas clean

Regional differences and preferences are reflected in the priorities. Snow and Ice removal has a little higher priority in the north and in the south roadside vegetation and maintaining bridges are higher. These differences reflect some regional preferences but the differences are minor.

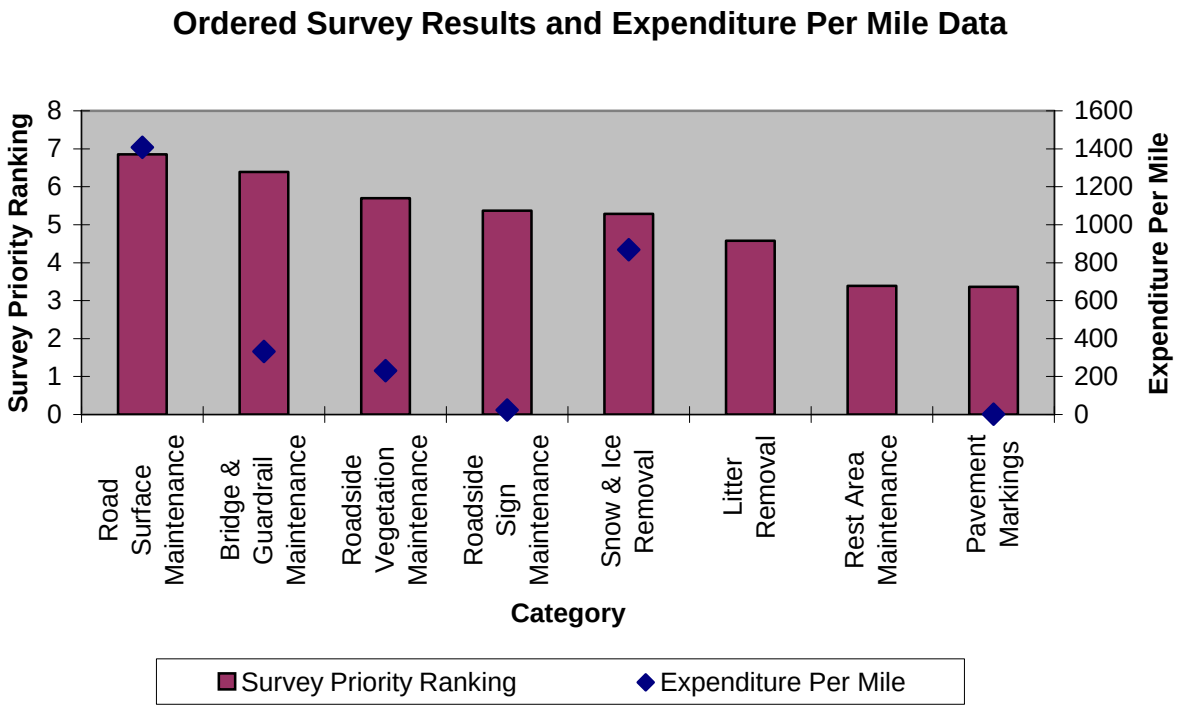
The statewide average rankings are:

1.Repair Potholes
2. Keep Riding Surface Smooth
3. Remove Snow and Ice
4. Keep Pavement Markings Visible
5. Keep Roadside signs legible
6. Maintain Bridges and Guardrails
7. Remove Debris
8. Keep Rest Areas Clean
9. Control Roadside Vegetation

The below chart illustrates the regional and statewide priority scores.



In the above priority ranking one and two are grouped into a category called pavement maintenance. Pavement maintenance does focus on repairing potholes and trying to keep the pavement smooth. Consolidating those two items and then looking at cost in terms of how much money is spent on these categories in terms of $/mile produces the below figure.

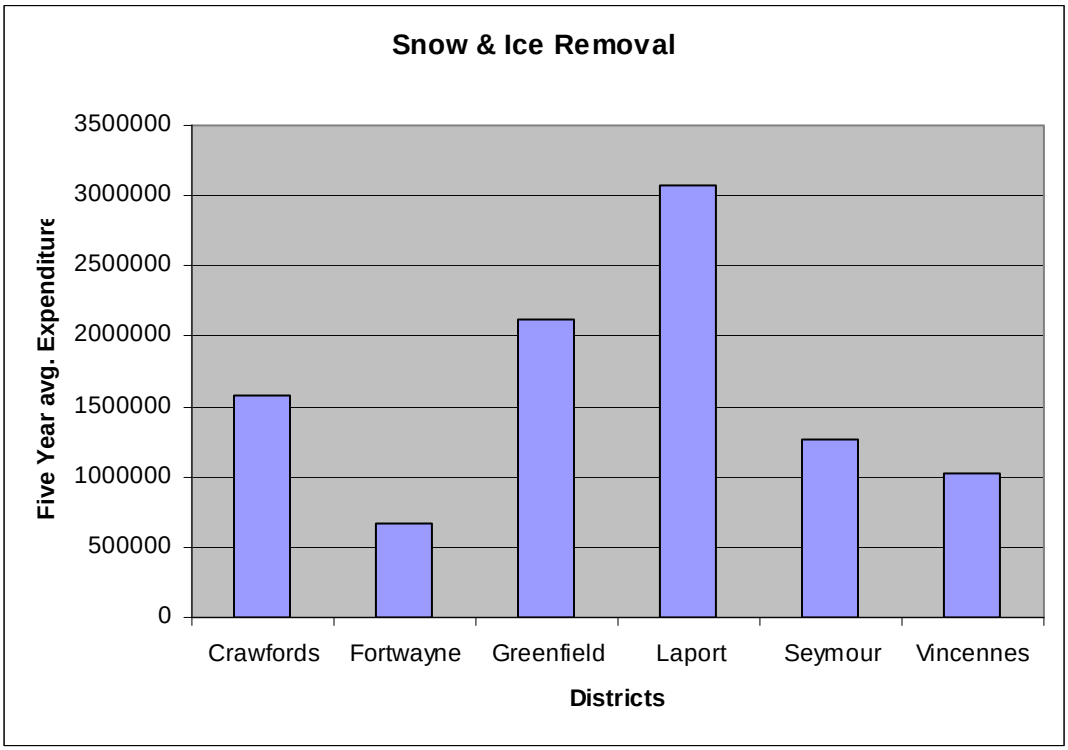


Maintenance Costs

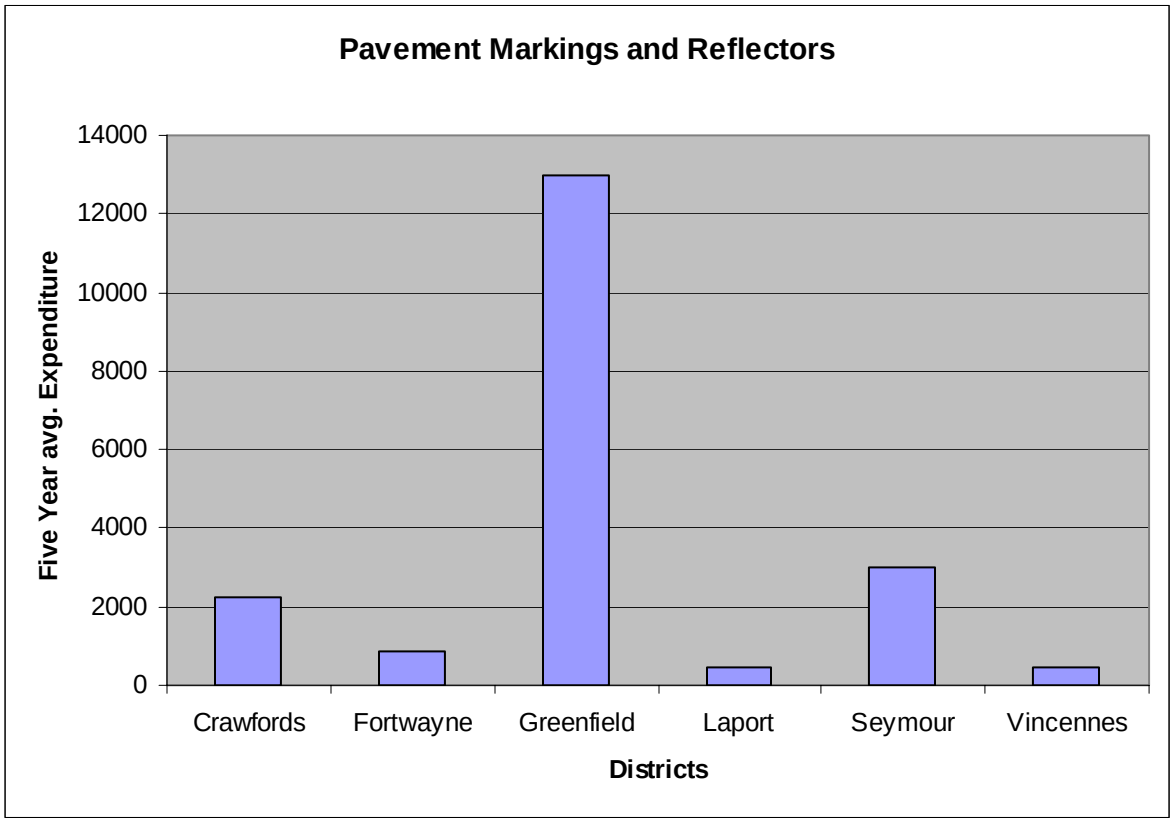
Maintenance costs for various activities were provided by INDOT. Costs were obtained for six years, FY 95 – FY 2000. The below table shows average costs for some of these maintenance categories over this time period.

Activities	Districts					
	Crawfords.	Fortwayne	Greenfield	Laporte	Seymour	Vincennes
Snow & Ice Removal	1577610	670754	2123065	3080138	1267398	1,019,365
Vegetation Mgmt.	433573	575157	299864	352769	492849	435683
Guardrail Maintenance	205211	206703	356434	399128	205682	189382
Bridge Maintenance	369340	191916	652115	192074	299584	463961
Roadside Signs	37232	19875	59529	107027	31774	5284
Pavement Markings & Reflectors	2265	869	12994	466	2996	460
Pavement Items	2212018	2542181	2251543	3001173	3165539	2620684
Total	4837249	4207455	5755544	7132775	5465822	4734819

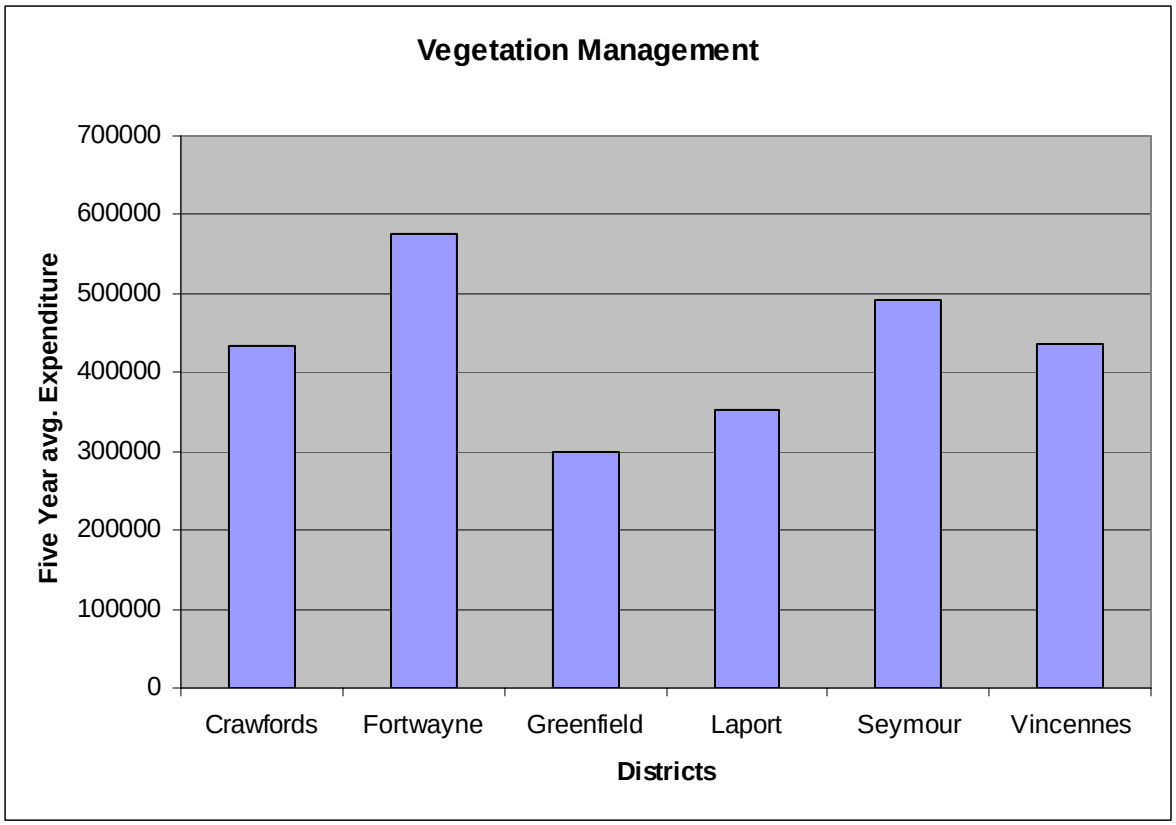
The following figures were generated from the cost data.



The chart shows that the Vincennes District spends more on snow and ice removal than Fort Wayne District. This is not true. In reality, Fort Wayne has higher yearly expenditures but does not include operational activities in the general maintenance cost data.



The chart shows that the Greenfield District out spends the rest of the Districts significantly. A plausible explanation is Greenfield has a district-wide striping program where all roads are re-striped every year.



A reasonable explanation for the disproportionate levels of expenditures is that vegetation management is contracted out in some districts. The higher percentage of outside contracts the higher the cost.

Previous Maintenance QA System

Prior to this research project INDOT did have a Maintenance QA program named Operating Procedure 25. It consisted of guidelines and performance standards for the more common maintenance activities. When an activity was completed the foreman would fill out the paperwork indicating that activity had been completed according to the standard. Success or failure of the program was based on the number of activities completed. Work quality tended to suffer since the emphasis was on number of activities completed.

AASHTO Workshop

The AASHTO Subcommittee on Maintenance sponsored a National workshop titled "Common Maintenance Performance Measures." It was held on June 5-7, 2000 in Scottsdale, Arizona. Attending from Indiana were Terry Bryns and Bob McCullouch. The following information was collected at the meeting.

There are common foundation issues in establishing and measuring maintenance performance. They are: develop a customer focus; be mission driven, performance based, linked to technical analysis, establish and maintain inventory and condition databases, be responsive to technological advances, and sensitive to outside factors.

After determining what elements to measure, related steps are what conditions to measure, what criteria is used as a standard, and what are the appropriate units and lengths to measure?

The goals of measurement are to gauge the customer satisfaction, quantify the assets, and obtain an accurate condition assessment. Items to measure should include functionality, deterioration, safety, quality, aesthetics, and customer satisfaction.

Caltrans Program

The California Department of Transportation (CalTrans) has developed a Level of Service(LOS) evaluation program. It started in 1998 and features a field survey performed in the Fall and the Spring. Their program does evaluate the snow and ice removal activities. Ten percent of the inventory is surveyed at a 95% confidence level. This requires one coordinator per district two months time to administer and evaluate each survey. CalTrans has invested significant resources in this program, and one result is an increase in the annual maintenance budget from the state legislature. The software used in this program is Microsoft Access.

State Programs

This section contains descriptions of Maintenance Quality Assurance programs developed in other states.

Florida

Started their program in 1985. Their surveys and level of service scores were initially used as a baseline of condition assessment and in the following years used to evaluate improvements. The program has resulted in raising the value and quality of their system facilities and also helped to establish uniformity across the state. Other outcomes are an improved balance of work among the maintenance activities and lower unit and total costs. Some of the particulars are there are five categories evaluated; pavement, roadside, traffic services, drainage, and vegetation/aesthetics. Each of these categories is comprised of multiple items and each item has criteria that define a maintenance condition to meet. Their sample segment length is 0.1 mile. Their program has been very successful and was used as a guide to develop the one for Indiana.

Maryland

A pilot program was started in 1992. They have experienced similar results experienced in the Florida program. The information collected has been used to make comparisons among activities and Districts and has provided an opportunity to make and evaluate adjustments.

Colorado

Like most states Colorado uses random sampling and they survey at a 95% confidence level. Their program is similar to the other states. One outcome from the program has been a 15% increase in the maintenance budget.

Utah(UDOT)

UDOT surveys twice a year(Spring and Fall). Twenty-Five random sections are picked and the inspected sections are 0.10 mile long. UDOT places emphasis on training inspectors for the reasons of obtaining consistency and objectivity in the results. UDOT uses this tool to show the relationship between budget and maintenance performance.

Level of Service Rating

After ranking work activities, a Level of Service(LOS) rating system was developed. This consists of establishing a set of condition standards criteria, developing weighting factors,

identifying roadway segments to sample, establishing a statistical based approach for selecting roadway segments to sample, and developing the process to collect, analyze, and report LOS data.

LOS criteria is where each ranked activity will have criteria established that determines if it has passed or failed. These criteria were established by a group of experts knowledgeable in performance standards and service life expectations. Two groups were formed to do this, one at Laporte and the other at the Seymour District office. The Laporte District members were Tom Konieczny, Jim Bevins, and Fred Krismanich. In the Seymour District it was Terry Bryns, Bill Jarvis, Bill Tompkins, Bob Bowen, and Mike Rivers.

Data from the Florida and California programs were provided as a reference for these groups to identify the Maintenance categories. The below table shows the Florida and California categories.

Florida

Flexible Pavement	Shoulders	Drainage	Traffic Control	Roadside
Potholes	Joints	Roadside ditch	Signs	Mowing/Grass
Cracking	potholes	Outfall ditch	pavement markings/symbols	Litter/Debris
Shoving	cracking	Median ditch	striping	Brush control
Rutting	drop off	culverts/pipes	raised pavement markers	Fence
Depressions/Bumps	Edge	catch basins/drop inlets	luminaries	Sidewalks
Raveling/Stripping	drainage	curb/gutter	barrier wall	Landscaping
Edge Raveling	buildup		guardrail	Barrier walls
	distortion		impact attenuators	
Rigid Pavement				
Potholes				
Spalls				
Cracking				
Joints				
Depressions/Bumps				
Voids				

California

Flexible Pavement	Drainage	Traffic Guidance	Roadside
Rideability	Surface Drains	Striping	Roadside vegetation
Cracks	Cross Drains	Pavement Markings	Fences
Alligator Cracking	Ditches	Raised Markers	Tree/Brush Encroachment
Potholes	Slopes	Guide markers	Litter/Debris
Rutting	Ramps	Signs	Graffiti
Coarse Raveling		Guardrail	Landscaping
Bleeding		Barriers	Ramps
Pavement Edge		Attenuators	
Paved Shoulders		Ramps	
Unpaved Shoulders			
Ramps			

Rigid Pavement
Joint Separation
Slab Failure
Cracks
Potholes
Paved Shoulders
Unpaved Shoulders
Ramps

Maintenance activities were grouped into six categories: Pavements(Flexible or Rigid), Shoulders, Drainage, Traffic Control, and Roadside. A category for Snow and Ice removal was made too. These categories and the characteristics that fall within are shown in the below table.

Category	Characteristics
Flexible Pavements	Potholes Cracking Shoving/Rutting Depressions/Bumps Raveling/Stripping Smoothness
Rigid Pavements	Potholes Cracking Joints Depressions/Bumps Spalls Smoothness
Shoulders	Potholes Cracking Drop-off Drainage

Drainage	Ditches Culverts/Pipes Catch basins/Inlets Curbs/gutters Underdrains
Traffic Control	Signs Striping Pavement Markings Raised Pavement Markings Guardrail Attenuators Barrier Walls
Roadside	Mowing Litter/Debris Tree/Brush Landscaping Fence Noxious Weeds
Snow and Ice Removal	Call out Routing Clear Wheel Path Bare Pavement Clean up Critique

The criteria established by Florida is shown below and was used as example criteria for establishing the INDOT criteria.

Florida Criteria

Categories	Distress Characteristics	Condition Standards
Flexible Pavement	Potholes	No defect >0.5 ft² in area and 1.5 in deep. Previous base must not be exposed in any hole.
	Cracking	99% of roadway is free of unsealed Class III cracking.
	Shoving	The shoved area should not exceed a cumulative 25 ft².
	Rutting	Rutting area are not >0.5 in. average depth, with no one measurement exceeding 0.75 in.
	Depressions/Bumps	No Measurement varies more than 0.5 in. within the initial 10-ft increments or plus 0.375 in. for each addition 10-ft increment.
	Raveling/ Stripping	95% of roadway surface is free of stripping or delamination.

	Edge Raveling	90% of total roadway edge is free of raveling. No continuous section of edge raveling ≥ 4 in. wide exceeds 25 ft. in length.
Rigid Pavement	Potholes	No defects >0.5 ft² in area and 1.5 in deep. Previous base must not be exposed in any hole.
	Spalls	
	Cracking	90% of roadway slabs have no unsealed cracks wider than 0.125 in.
	Joints	85% of length of transverse and longitudinal joint material appears to function as intended.
	Depressions/ Bumps	No measurement varies more than 0.5 in. within the initial 10-ft increments or plus 0.375 in. for each additional 10-ft increments.
	Roadway Void	90% of slabs exhibit no evidence of pumping.
Shoulders	Joints	75% of the joints appear to function as intended by restricting the intrusion of water and incompressibles.
	Potholes	No defect is greater than 0.5 ft² in area and 1.5 in deep. Previous base is not exposed in any hole.
	Cracking	80% is free of unsealed Class III cracking (asphalt) or unsealed cracks > 0.125 in wide.
	Drop off	Paved: Measurement of each depressed/raised area is made in both directions. No measurement varies more than 1 in within the initial 100-ft increment s or plus 0.375 in. for each additional 100-ft increments. Unpaved: No shoulder drop off exceeds 3 in deep within 1 ft. of the pavement edge for a continuous 25 ft.
	Edge	75% is free of raveling. No continuous section of edge raveling ≥ 4 in. exceeds 50 ft. in length.
	Distortion	No deviation across shoulder width exist > 5 in. below or 2 in. above the design template. No washboard areas exist having a total differential greater than 5 in. from the low spot to the high spot.
Drainage	Roadside ditch	The ditch bottom is ≥ _____ ft below the non-paved outside edge of pavement and/or functions as intended. ▪ Rural limited access: 3 ▪ Rural arterial: 3 ▪ Urban limited access: 2.5 ▪ Urban arterial: 2.5
	Outfall ditch	The ditch bottom is at or within the lower 1/3 of the distance between natural ground and the design flow line.
	Median ditch	The ditch bottom is ≥ 2 ft. below the inside non-paved edge of pavement and/or functions as intended.
	Culverts/pipes	90% (storm drain), 60% (side drain) and 60% (cross drain) of the cross sectional areas are not obstructed.
	Catch basins/drop inlets	90% (curb inlet) and 85% (other inlets) of the opening of each inlet is not obstructed.

	Curb/gutter	Material accumulation is ≤ 0.75 in deep for more than a continuous 1 ft. in the traveled way or shall not exceed 2.25 in. in depth for more than a continuous 1 ft. in any gutter.
Traffic Control	Signs	Warning signs: 95% are functioning as intended. Regular signs: 95% are functioning as intended. Information signs: 85% are functioning as intended.
	Pavement markers/ symbols	Raised markers: 70% of the required markers are functional (reflective). No more than 120 ft of continuous centerline or lane line is without a reflective marker. Symbols: 70% of existing symbols function as intended.
	Pavement stripping	70% of each line functioning as intended.
	Object and Delineator Markers	80% of markers are functioning as intended.
	Luminaries	Sign lighting: 75% of each installation is functioning as intended. Highway lighting: 90% of the installation is functioning as intended.
	Barrier wall	99% of an installation functions as intended.
	Guardrail	Each single run functions as intended.
	Impact attenuators	Each device functions as intended.
Roadside	Mowing/grass	Roadside: no more than 2 % of vegetation exceeds ___ in high. ▪ Rural limited access: 24 ▪ Rural arterial: 18 ▪ Urban limited access: 18 ▪ Urban arterial: 12 Slope: no more than 2% of vegetation exceeds 24 in high.
	Litter/Debris	The volume of litter does not exceed 6 ft^3/acre excluding all roadway pavements.
	Bush control	There is no encroachment of trees, three limbs, or vegetation lower than 14.5 ft. in or over travel way or clear zone, or lower than 10 ft. over sidewalks.
	Fence	No criteria.
	Sidewalks	There is no encroachment of grass and debris ≥ 6 in. onto the curb or sidewalk for more than a continuous 4 ft., or no deviation of soil of more than 4 in. above or 2 in. below the top of curb or sidewalk for more than a continuous 4 ft.
	Landscaping	Vegetation is maintained in a healthy, attractive condition.
	Turf	Turf in the mowing area is 75% free of undesired vegetation.
	Barrier walls	No criteria.

INDOT Criteria

The below table compares the responses from the two teams in Laporte and Seymour.

Categories	Criteria			Weight	VALUE	VALUE
		Laporte District	Seymour District	Laporte		Seymour
Flexible Pavement						
Smoothness	IRI	Minimum as established by CO.	No excessive vibrations or noise when driving over roadway.	1	30	5
Depressions/Bumps		No defects greater than 0.5 inches.	Not to exceed 1/2 inch for 10 ft. length.	2	15	20
Potholes		No defects greater than 0.5 inches.	No defects greater than 0.5 sq.ft in area and 1.5 inches deep.	3	15	30
			Previous base must not be exposed in any hole.			
Shoving/Rutting		No defects greater than 25 sq. ft.	Shoving area not to exceed 25 sq. ft. Rutting not to	4	10	20
			exceed 1/2 inch in depth.			
Cracking		No more than 10% shall not be unsealed.	90% of roadway is free of unsealed cracks.	5	10	15
Raveling/Stripping		No more than 10% shall be defective.	95% of roadway free of stripping or raveling.	6	10	10
Edge Raveling		No more than 10% shall be defective.		7	10	
					100	100
Rigid Pavement						
Smoothness	IRI	Minimum as established by CO.	No excessive vibrations or noise when driving over test area.	1	35	10
Joints		No more than 10% shall not be unsealed.	90% of transverse and longitudinal joint material appears to	2	15	20
			function as intended.			
Depressions/Bumps		No defects greater than 0.5 inches.	Not to exceed 1/2 inch for 10 length.	3	15	15
Potholes		No defects greater than 0.5 inches.	No defects greater than 0.5 sq. ft. in area and 1.5 inches deep.	4	15	30
Spalls		No more than 5% shall be defective.	No defects greater than 0.5 sq. ft. in area and 1.5 inches deep.	5	10	10
Cracking		No more than 10% shall not be unsealed.	90% of roadway slabs have no unsealed cracks.	6	10	15
					100	100
Paved Shoulders						
Mainline Drop off		No defects greater than 1 inch.	No defects greater than 0.5 sq. ft. in area and 1.5 inches deep.	1	20	30
Potholes		No defects greater than 0.5 inches.	Not to exceed 1/2 inch between rigid pavement and shoulder	2	18	20
			surface.			
Distortion		No more than 10% shall not be unsealed.		3	18	
Drainage		No more than 5% shall be defective.	90% of shoulder is free from unsealed cracks.	4	15	25
Shoulder Edge/Buildup		No more than 10% shall be defective.		5	15	
Joints		No more than 25% shall not be unsealed.		6	7	
Cracking		No more than 25% shall not be unsealed.	Concrete Shoulder - alignment consistent with pavement surface.	7	7	10
			Asphalt Shoulder - alignment consistent with pavement surface.			
			Aggregate Shoulder - free of ruts and ridges.			
			Sod Shoulders - free of edge ruts.			

Surface			No water can stand on pavement due to shoulder build-up or			15
			construction.			
					100	100
Drainage						
U-Draws		No more than 10% shall be defective.			16	
Ditches			Ditchlines are clean and there is no evidence of standing water.			35
Roadside Ditch		No more than 10% shall be defective (standing water).			14	
Outfall Ditch		No more than 10% shall be defective.			14	
Median Ditch		No more than 5% shall be defective (standing water).			14	
Culverts/Pipes		75% of all structures shall be open.	90% of the cross-sectional areas are not obstructed.		14	30
			Culverts/Pipes are structurally sound.			
Catch Basins/Drop		No more than 5% shall be defective.	90% of drainage openings are not obstructed.		14	10
Inlets						
Curb/Gutter		No more than 10% shall be defective.	No material accumulation in flow line.		14	10
Subsurface			Outlets are open and suitability marked. Rodent screens			15
(Underdrains)			are in place.			
					100	100
Traffic Control						
Striping		No more than 5% shall be defective.	Lines are distinct, well aligned, and functional.	1	20	25
Signs		No more than 5% shall be defective.	Regulatory - 100% are functioning are intended.	2	15	30
			Warning - 100% are functioning as intended.			
			Information - 90% are functioning as intended.			
Attenuators		No attenuators shall be defective.	Good alignment and functions as intended.	4	15	10
Guardrail		No more than 5% shall be defective.	Good alignment and functions as intended.	5	15	10
Raised pavement		No more than 25% shall be defective.	Fully seated into pavement, reflectors intact and functional.	3	10	15
markers						
Barrier Wall		No more than 5% shall be defective.	Good alignment and functions as intended.	6	10	5
Luminaries		No more than 10% shall be defective.		7	5	
Pavement Markings		No more than 10% shall be defective.	Painted - clearly defined, intact and functional.	8	5	5
			Thermal Plastic - clearly defined, intact and functional.			
Delineators		No more than 10% shall be defective.		9	5	
					100	100
Roadside						
Unpaved Shoulder		No more than 10% defective (> 2" dropoff).		1	50	
Mowing/Grass		No more than 10% shall be taller than specs.	Height of grass is between 6 and 18 inches within designated	2	15	30
			mowing areas.			
Litter/Debris		No more than 3 cu. ft./acre.	No more than 20 pieces of litter in 1/10 mile.	3	10	25
Fence		No more than 5% shall be damaged or missing.		5	10	

Tree/Brush Control		No obstructed signs. No dead trees or limbs	No trees or brush shall be allowed between edge of pavement	4	8	15
		over roadway.	and 8ft. beyond the ditchline. (Exception: Tree plot in urban areas.)			
Landscaping		No illegal weeds.	No plantings in clear zones or in ditchlines. Planting areas are	6	7	10
(Plantings)			mulched and maintained.			
Right-of-Way Fence			Good alignment and functions are intended.			5
Noxious Weed Control			Evidence of control by mowing or herbicide application.			15
					100	100
Snow & Ice Removal (Ours)						
Call Out			90% affirmative response to initial call out.			20
Routing			100% treatment of routes within first 3 hours of storm.			20
Plowing			Plowing is performed as storm conditions and supervisory			15
			decisions warrant.			
Spreading Materials			Materials are applied as storm conditions and supervisory			20
			decisions warrant.			
Clean-Up			Shoulders plowed back and equipment cleaned up within 6 hours			15
			after last measurable precipitation.			
Critique			Supervisors and truck drivers review last storm successes and			10
			failures within 24 hours after last measurable precipitation.			
						100
Snow & Ice Removal (Public)						
Response			Trucks are on their routes within 30 minutes of the start of			20
			measurable precipitation.			
Routing			All roads within the maintenance area have a truck and driver on			10
			the route.			
Clear Wheel Path			A clear wheel path exists on each route within 3 hours from the			10
			beginning of the storm.			
Bare Pavement			All roads have bare pavement within 3 hours from the end of			30
			measurable precipitation.			
Clean Up			Shoulders plowed back and equipment cleaned up within 6 hours			10
			after last measurable precipitation.			
Traffic Delay			Traffic speeds reduced to no less than 1/2 normal speed limit and			20
			there is no road closures.			
						100

The last category Snow and Ice Removal was eliminated from the LOS program for several reasons. One was the lack of uniformity in weather conditions experienced during snow and ice events; the timing of inspections; and the difficulty is establishing criteria to judge by.

The below table contains final results of this phase. It was arrived at through the work of the two groups used in this step. An IRI smoothness value of 145 will be used as the threshold for making the determination if a road segment is smooth or rough. The Research Division provided this number. IRI values for road segments are obtained from Roadway Management. Notice the weight values have been slightly altered.

Categories	Criteria	Weight	VALUE
Flexible Pavement			
Smoothness	Minimum as established by IRI.	1	25
Rutting	Not to exceed 1/2 inch in depth	2	13
Depressions/Bumps	Not to exceed 1/2 inch for 8-10 ft. length.	3	13
Potholes	No defects greater than 1 sq.ft in area and 1.5 inches deep.	4	13
Shoving/Rutting	Shoving area not to exceed 25 sq. ft.	5	13
Cracking	75% of roadway is free of unsealed cracks.	6	13
Raveling(including edge)	90% of roadway free of raveling.	7	10
			100
Rigid Pavement			
Smoothness	Minimum as established by IRI.	1	25
Joints	75% of transverse and longitudinal joint material appears to keep water out.	2	15
Depressions/Bumps	Not to exceed 1/2 inch for 8-10 ft. length.	3	15
Potholes	No defects greater than 1 sq. ft. in area and 1.5 inches deep.	4	15
Spalls	No defects greater than 1 sq. ft. in area and 1.5 inches deep.	5	15
Cracking	75% of pavement cracks are sealed	6	15
			100
Paved Shoulders			
Mainline Drop off	No drop off greater than 1.5" for a continuous 25 ft.	1	40
Potholes	No defects greater than 1 sq. ft. in area and 1.5 inches deep.	2	20
Misc. Categories	Concrete Shoulder - alignment consistent with pavement surface. Wt. Value = 10 Asphalt Shoulder - alignment consistent with pavement surface. Wt. Value = 10 Joints/Cracks (50% shall be sealed includes transverse and longitudnal cracks) Wt. Value = 10	3	20
Drainage	No water can stand on pavement due to shoulder build-up or construction.	4	20
Roadside			
Unpaved Shoulder	No more than 10% defective (> 2" dropoff).	1	45
Mowing/Grass	Height of grass less than 18 inches within designated mowing area.	2	20
Litter/Debris	No more than 20 pieces of litter 1 sq. ft or larger for 2 lane, 40 for 4 lane.	3	5
Fence	No more than 5% shall be damaged or missing.	5	5
Tree/Brush Control	No obstructed signs. No trees or limbs over roadway lower than 16 ft.	4	5
Noxious Weed Control	Evidence of control by mowing or herbicide application.		20

Drainage			
Ditches	Ditch lines are clean and there is no evidence of standing water.	1	35
Culverts/Pipes	75% of all structures shall be open.	2	30
Catch Basins/Drop Inlets	50% of capacity is available	4	10
Curb/Gutter	90% of curb and gutter areas are free of structural distress	5	10
Subsurface (Underdrains)	90% of outlets are open and suitability marked. Rodent screens are in place.	3	15
			100
Traffic Control			
Striping	Verified by Operations Support Reflectometer testing		
Signs	All signs are functioning are intended. (Shall not lean more than 1" per foot of post)	1	25
Delineators	No more than 10% are defective		5
Attenuators	Good alignment and functions as intended and no attenuators shall be defective.	2	20
Guardrail	No more than 5% shall be defective.	3	20
Raised pavement markers	No more than 10% shall be defective, missing or broken.	4	20
Barrier Wall	100% of barriers do not have missing sections and are properly aligned. 95% of barriers do not have severe cracking	5	5
Pavement Markings	90% of existing markings function as intended	6	5
			100

Field Management Program

The field program is the inspection program. This is comprised of determining what level of certainty to obtain in the results; what segments to inspect, determining what resources are needed; developing the inspection teams; and analyzing the results.

The level of uncertainty on the results was a point of contention within the Study Advisory Committee(SAC). Typically, for Quality Assurance programs, 95% is a level commonly used. This is the level used in manufacturing where conditions can be controlled to a certain degree in producing a product. This is not the case in constructing roads or maintenance during their service life. Weather conditions are the biggest variable, but type and frequency of loads and materials used are others that influence the road condition. So the level of uncertainty should consider this as well. Some of the SAC members wanted the 95% level while others felt that 80% would have been sufficient. The SAC could not come to an agreement on this. The researchers consulted several sources to determine the number of sample sites needed to reach various levels of certainty in the results. Without any preliminary data available on the condition of the system, and after consulting various statistical sampling sources and discussing with the

statisticians at the Division of Research it was decided to use the below relationship to calculate the number of samples.

$$n = \frac{[0.25 \times (b-a)^2 \times z^2 \times N]}{[d^2 \times (N-1) + (0.25 \times z^2 \times (b-a)^2]}$$

n – sample size
N – population size
z – confidence level coefficient
d – probability estimate of population possessing the attribute
b-a – range in probability

The Laporte District volunteered to a field test of the inspection program during the 2001-2002 winter. There are 1624 miles of state maintained roads in this District. The field inspection will use 0.1 mile sections, so the possible number of samples is 1624x10 = 16240. Using a confidence level of 95% the number of random samples to collect in the Laporte District is 305. At 80% the sample size is 132. For the testing the prototype the SAC decided to use the 80% size. At this number the inspection program could be evaluated and the results used to determine the sample size to use for the state-wide program that occurred during the 2002-2003 winter.

Inspection criteria were established to do as many observations from the shoulder as possible, as quickly as possible, and not requiring expensive equipment, but with items that INDOT has in stock. Inspection crew safety was a factor in establishing the inspection criteria. Below shows the equipment and supplies needed for each of the maintenance categories.

.Flexible Pavement (i) Smoothness (ii) Depressions/ Bumps (iii) Potholes (iv) Shoving (v) Cracking (vi) Raveling (including edge)/ Striping (vii) Rutting	Ruler, Straight Edge, Marker, Tape Measure, Calculator
Rigid Pavement (i) Smoothness (ii) Joints (iii) Depressions/ Bumps (iv) Potholes (v) Spalls (vi) Cracking	Tape Measure, Straight Edge, Marker, Ruler
Paved Shoulders (i) Mainline Drop Off (ii) Potholes (iii) Miscellaneous Categories (iv) Drainage	Ruler, Straight Edge, Marker, Tape Measure
Drainage (i) Ditches (ii) Culverts/ Pipes (iii) Catch Basins/ Drop Inlets (iv) Curb/ Gutter (v) Subsurface/ Underdrains	Ruler, Tape Measure
Traffic Control (i) Stripping (ii) Signs (iii) Attenuators (iv) Guardrails (v) Raised Pavement Markers (vi) Barrier Wall (vii) Pavement Markings	Reflectometer Hand Level
Roadside (i) Unpaved Shoulder (ii) Mowing/ Grass (iii) Litter/ Debris (iv) Fence (v) Tree/ Brush Control (vi) Landscaping (Plantings)	Straight Edge, String Line Ruler

Laporte Field Test

During the 2001-2002 winter a field inspection program was performed. The 80% confidence level was used which required 132 random samples. This means that with this sample size, the

results have confidence level of 80% that they reflect the conditions in the Laporte District. Roadway Management at INDOT provided a spreadsheet file of all the mile posts in the District. Using the random generator in Excel, 132 sections were selected.

For the field inspection program to be effective, objectivity and consistency are important. Therefore the inspection team composition and their training are very important. To improve objectivity and minimize bias in the results, the inspection teams were comprised of construction personnel. A couple field tests revealed that a three-person crew was the proper size. Since construction personnel are used, their "slow time" during the year is in the winter. Since the inspections are based on visual inspections the winter months were chosen to do the field inspection. The inspections must be done with no snow cover, that is the only weather limitation.

During this particular winter there was below average snow and above average temperatures in the Laporte District. Due to these factors the inspection program went very well. There were three inspection teams. The average time to perform an inspection was one hour and that included travel time. So the total inspection required approximately 400 man-hours to perform.

The results were evaluated and reported to the District. Because the data included location and road type(State Road, U.S., Interstate) , results have geographic significance. This is essential for comparing sub-districts or unit performance or road conditions by location.

Sample results from this program are shown below.

		25	13	13	13	13	13	10	
		Flexible Pavement							
Sample ID	Date	Smoothness	Rutting	Depressions/Bumps	Potholes	Shoving/Rutting	Cracking	Raveling	Pass Total Percentage
10		1	1	1	1	1	1	1	100.00
1042		1	2	1	1	3	2	3	66.23
1048		1	2	2	1	3	2	3	49.35
1066		1	2	2	1	3	2	3	49.35
1071		1	1	1	1	1	1	3	100.00

•
•

961		1	1	1	1	1	1	1	100.00
969		1	1	1	1	1	1	1	100.00
971		1	1	2	1	1	1	1	87.00
990		1	1	1	1	1	1	1	100.00
Average							1.525	1.049	84.92
High		N/A	N/A	N/A	N/A	N/A	N/A	N/A	100.00
Low		N/A	N/A	N/A	N/A	N/A	N/A	N/A	25.00

The spreadsheet analysis was performed by Purdue University. The above figure shows a small portion of this spreadsheet. The inspection scores are recorded as either 1,2,or 3. One is for pass, or the conditions are satisfied; two means failed, or the conditions are not satisfied; and three means not applicable. For example curb and gutter may not exist so it evaluated as three, not applicable. Smoothness was based on the IRI value. A section is rough if the IRI value is greater than 145. The Research Division provided this threshold number. IRI values were obtained from Roadway Management. If the average score is greater than 1.5 that means more sections failed than passed. The results gave the Operations Engineer in Laporte, Tom Konieczny, management information that can be used to evaluate conditions and possibly performance as well as resources needed.

The category scores are shown below.

Pavement – 84.92
Paved Shoulder – 89.70
Drainage – 74.90
Traffic Control – 82.3
Roadside – 85
Overall – 83.8

This indicates that drainage conditions need to be investigated. Some specific items scores were:

Pavement – Cracking(1.53)
Paved Shoulder – Joints/Cracks(1.47)
Paved Shoulder Drop-Off(1.09)
Litter/Debris(1.06)

These numbers indicate that unsealed cracks is a problem while shoulder drop-off and litter are in good shape. One possible decision is should resources be shifted from the last two to the first two items? When these numbers were revealed, Tom Konieczny thought the district had a problem with unsealed cracks and this verified his assumption.

Management can use these results to evaluate and make decisions about field activities. It is at this time that a LOS analysis be performed. This involves looking at activities and their ratings and making determinations on resource utilization and requirements. When analyzing resource requirements and their availability, an annual workload analysis for each activity can be performed as well as budgetary planning. Other important planning includes evaluating budgetary constraints on LOS and balancing available resources and workloads. One important feature of any QA program is the never-ending process of improving and revisiting the processes in the program.

Training

Training is crucial for implementing this proposed QA program. An Inspection guide was put together that consists of images showing various maintenance conditions. This guide is shown in the Appendix.

Before the winter of 2002-2003 half-day training sessions were held at all the Districts and Toll Road with the exception of the Laporte District. The Laporte District received the training the previous winter. These sessions consisted of explaining the program, describing the Inspection forms; (a form has been developed for both Rigid and Flexible pavements); taking the crews to a couple inspection sites and having them perform an inspection; returning to the District office

and reviewing the teams evaluation; and finally trying to develop a consensus on pass and fail criteria for each item.

State-Wide Inspection, Winter 2002-2003

Using the experience obtained from the Laporte inspection, a state-wide implementation occurred during the 2002-2003 winter. Described above is the training that occurred at each District and Toll Road office. Just as in the Laporte District the crews consisted of construction personnel. They were given the winter months to perform the inspection. This winter had above average snowfall and normal temperatures, which created problems for the inspections. This caused the inspections to run over into March. All the inspections were analyzed at Purdue and the results returned to the Districts for their study. These results are not included in this report. Each Operations Engineer has their results.

The analysis shows the scores for each item in the categories, location data, and an overall grade score for each of the samples.

Before the random inspection sites were chosen the sample size was revisited. Consultations with Purdue University Statistics Department and the Division of Research were made. Based on these conversations and using the data from the Laporte sample collected the previous winter, the sample size was calculated using the below equation.

$$N = \frac{(Py)(Pn)}{(\text{Standard error})^2}$$

Py = Probability of yes or pass = 75% (From drainage section, worst case)

Pn = Probability of no or fail = 25%

Obtained from Laporte data collected in the winter 2001-2002.

$$\text{Standard error} = \frac{\%\ \text{of uncertainity}}{\text{Coefficient}}$$

Coefficient values:

80% confidence level = 1.28

90% confidence level = 1.645

95% confidence level = 1.96

It was decided to go with a 90% confidence level, therefore the number of samples required (N) is $N = \frac{(0.75)(0.25)}{(0.1/1.645)^2} = 50$

It was decided that 50 samples are required from each road category in each district :

Interstate

State Road

U.S. Highway

This requires each district to collect 150 samples, and the Toll Road to collect 50, since all its roads are one category.

A random sample list was developed and given to each District and Toll Road for inspecting.

Conclusions

Several benefits can result from this program. Some of the typical ones experienced by other state DOTs that have enacted a Maintenance QA program are described next.

One expected result is a uniformly maintained system that is more consistent across the state. This can be accomplished through a standardized system of inspection, evaluation, weighting, and evaluation criteria, inspection procedures, and training program.

This project will provide an understanding of what LOS is important to the traveling public for various system components. For example, pavement smoothness, traffic control devices, or roadside vegetation represent system components that will be ranked by the users. With this understanding INDOT can include user preferences in ranking the importance of various maintenance activities.

The ability to determine what level of funding is required for an activity to reach or maintain a certain LOS can be obtained through this program. This will help to generate more realistic

budget requirements and allow for improved budget determinations of individual maintenance activities at district and state-wide levels.

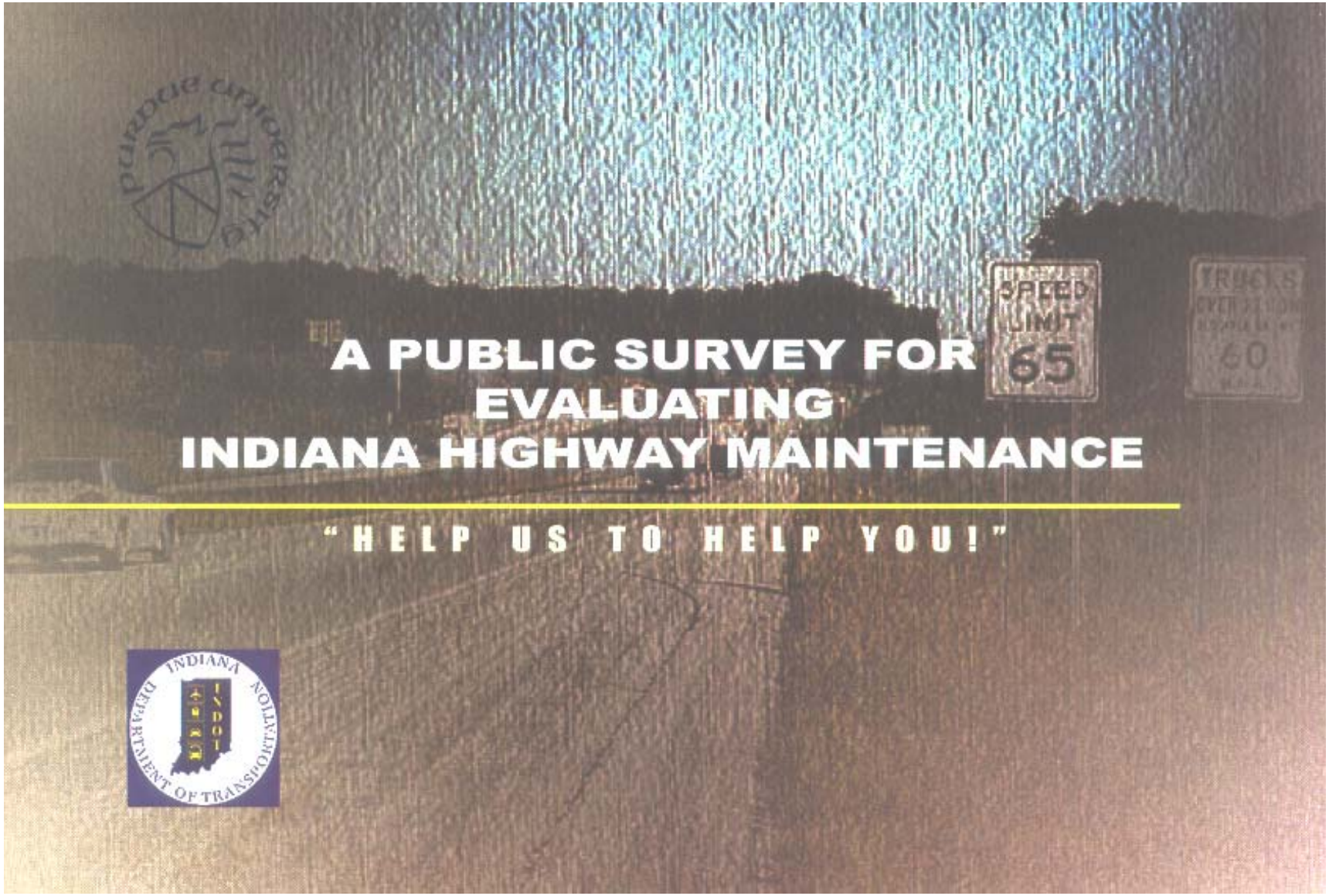
Another benefit is the ability to perform LOS and statistical analysis on maintenance activities and make corresponding adjustments and allocations in resources to achieve a level of quality service across the Districts. By improving the allocation of resources an equitable level of quality among the main activities can be created and a more uniform state-wide facility created.

Implementation

This program is an efficient way to collect information on roadway conditions. The inspection can be performed during the winter months by construction personnel, requiring no additional equipment or resources, and completed in a timely manner (400-450 manhours). Because of the random sample program, the results have a high level of certainty that they represent the conditions in the District. The results can be used to develop a baseline of conditions that can be used for comparative purposes in the state and within the District for assessing Maintenance operations.

This program needs INDOT Executive Staff support to make this program a part of the normal work plan for the District Operations. An individual within Operations Support needs to be assigned the task of managing and administering this Maintenance QA program. This individual will be responsible for providing the random sample locations and for analyzing and reporting the results. Implementation assistance will be available from Purdue University by contacting the JTRP office or Dr. Bob McCullouch(bgm@ecn.purdue.edu, 765-494-0643).

Appendix


A PUBLIC SURVEY FOR
EVALUATING
INDIANA HIGHWAY MAINTENANCE
"HELP US TO HELP YOU!"
SPEED LIMIT
65
TRUCKS
60
INDIANA DEPARTMENT OF TRANSPORTATION

"Evaluating the Interstate and State Highway System"

Indicate your level of satisfaction for each of the below maintenance activities.

	No Improvement Needed	Some Improvement Needed	Significant Improvement Needed
Patching potholes	☐	☐	☐
Litter removal from pavement and roadsides	☐	☐	☐
Maintenance of roadside signs (stop, speed limit, curves, informational, etc.)	☐	☐	☐
Roadside vegetation maintenance (mowing grass, cutting brush, etc.)	☐	☐	☐
Pavement markings (lane striping, arrows, reflectors)	☐	☐	☐
Maintenance of roadside rest areas	☐	☐	☐
Maintenance of bridges and guardrails	☐	☐	☐
Snow and ice removal	☐	☐	☐
Removing bumps, filling joints and cracks	☐	☐	☐

Rank the below activities in order of importance from 1 to 9, with 1 being most important.

- Repair Potholes _____
- Remove Debris _____
- Keep Roadside Signs Legible _____
- Keep Pavement Markings Visible _____
- Control Roadside Vegetation _____
- Keep Rest Areas Clean _____
- Remove Snow and Ice _____
- Maintain Bridges and Guardrails _____
- Keep Riding Surface Smooth _____

Do you live in Indiana ?

☐ Yes ☐ No

What vehicle do you primarily drive? (Check One)

☐ Car ☐ SUV

☐ Van ☐ Truck ☐ Tractor Trailer

How many miles do you drive in Indiana per year? (Check one)

☐ Less than 10,000 miles,
☐ More than 10,000 miles.

Additional Comments

_____

_____

_____

_____

This survey is performed by
The Joint Transportation Research Program in the
School Of Civil Engineering, Purdue University,
West Lafayette, IN

Winter 2001-2002 Laporte Random Sample Locations

Random samples: 132, Confidence Level 80%

Laporte District

ID	County Name	County	Road	Name	Direction	Section	From MP	To MP
274	Carroll	8	SR	25	S	274	65	66
1594	Carroll	8	US	421	S	1594	145.27	146.27
219	Casper	9	SR	25	N	219	66	67
221	Casper	9	SR	25	N	221	68	69
223	Casper	9	SR	25	N	223	70	71
232	Casper	9	SR	25	N	232	79	80
282	Casper	9	SR	25	S	282	73	74
283	Casper	9	SR	25	S	283	74	75
287	Casper	9	SR	25	S	287	78	79
293	Casper	9	SR	25	S	293	84	85.09
733	Casper	9	US	24	E	733	53	54
736	Casper	9	US	24	E	736	56	57
738	Casper	9	US	24	E	738	58	59
744	Casper	9	US	24	E	744	64	65
811	Casper	9	US	24	W	811	55	56
824	Casper	9	US	24	W	824	68	69
1095	Casper	9	US	35	N	1095	118.08	119.08
1112	Casper	9	US	35	N	1112	135.08	136.08
1121	Casper	9	US	35	N	1121	144.08	145.08
1184	Casper	9	US	35	S	1184	120.08	121.08
245	Fulton	25	SR	25	N	245	92.09	93.09
297	Fulton	25	SR	25	S	297	88.09	89.09
309	Fulton	25	SR	25	S	309	103.089	104.089
1042	Fulton	25	US	31	S	1042	199	200
1048	Fulton	25	US	31	S	1048	205	206
3	Jasper	37	I	65	N	3	204.62	205.54
8	Jasper	37	I	65	N	8	209.51	210.51
10	Jasper	37	I	65	N	10	211.51	212.51
71	Jasper	37	I	65	S	71	215.45	216.45
84	Jasper	37	I	65	S	84	228.44	229.37
85	Jasper	37	I	65	S	85	229.37	230.37
362	Jasper	37	SR	49	S	362	1	2
375	Jasper	37	SR	49	S	375	14	15
770	Jasper	37	US	24	W	770	14	15
777	Jasper	37	US	24	W	777	21	22
1401	Jasper	37	US	231	N	1401	240	241
1470	Jasper	37	US	231	S	1470	247	248
1471	Jasper	37	US	231	S	1471	248	249
1484	Jasper	37	US	231	S	1484	261	262

1489	Jasper	37	US	231	S	1489	266	267
198	La Porte	46	I	94	W	198	37.84	38.84
201	La Porte	46	I	94	W	201	40.83	41.83
202	La Porte	46	I	94	W	202	41.83	42.83
460	La Porte	46	US	6	E	460	46	47
469	La Porte	46	US	6	E	469	55	56
523	La Porte	46	US	6	W	523	40	41
599	La Porte	46	US	20	E	599	44	45
601	La Porte	46	US	20	E	601	46	47
611	La Porte	46	US	20	E	611	56	56.609
653	La Porte	46	US	20	W	653	40	41
868	La Porte	46	US	30	E	868	36	37
874	La Porte	46	US	30	E	874	42	43
1248	La Porte	46	US	35	S	1248	184.08	185.08
1249	La Porte	46	US	35	S	1249	191.08	192.08
1641	La Porte	46	US	421	S	1641	205.27	206.27
1652	La Porte	46	US	421	S	1652	216.27	217.27
1652	La Porte	46	US	421	S	1652	216.27	217.27
1653	La Porte	46	US	421	S	1653	217.27	218.27
39	Lake County	45	I	65	N	39	241.35	242.35
54	Lake County	45	I	65	N	54	256.31	257.31
55	Lake County	45	I	65	N	55	257.31	258.33
56	Lake County	45	I	65	N	56	258.33	259.32
93	Lake County	45	I	65	S	93	237.38	238.37
139	Lake County	45	I	80	W	139	5.98	6.98
432	Lake County	45	US	6	E	432	18	19
573	Lake County	45	US	20	E	573	18	19
633	Lake County	45	US	20	W	633	20	21
847	Lake County	45	US	30	E	847	15	16
1296	Lake County	45	US	41	N	1296	242	243
1297	Lake County	45	US	41	N	1297	243	244
1308	Lake County	45	US	41	N	1308	254	255
1309	Lake County	45	US	41	N	1309	255	256
1312	Lake County	45	US	41	N	1312	258	259
1372	Lake County	45	US	41	S	1372	253	254
1375	Lake County	45	US	41	S	1375	256	257
1381	Lake County	45	US	41	S	1381	262	263
1389	Lake County	45	US	41	S	1389	271	272
1449	Lake County	45	US	231	N	1449	288	289
316	Marshall	50	SR	25	S	316	110.089	111.089
476	Marshall	50	US	6	E	476	62	63
477	Marshall	50	US	6	E	477	63	64
483	Marshall	50	US	6	E	483	69	70
486	Marshall	50	US	6	E	486	72	73
893	Marshall	50	US	30	E	893	61	62
969	Marshall	50	US	30	W	969	57	58
971	Marshall	50	US	30	W	971	59	60
990	Marshall	50	US	30	W	990	78	79

1066	Marshall	50	US	31	S	1066	223	224
1071	Marshall	50	US	31	S	1071	228	229
1073	Marshall	50	US	31	S	1073	230	231
831	Miami	52	US	24	W	831	75	75.6
689	Newton	56	US	24	E	689	9	10
693	Newton	56	US	24	E	693	13	14
1278	Newton	56	US	41	N	1278	224	225
1346	Newton	56	US	41	S	1346	227	228
162	Porter	64	I	94	E	162	29.88	30.88
179	Porter	64	I	94	W	179	17.93	18.91
184	Porter	64	I	94	W	184	23.89	24.89
190	Porter	64	I	94	W	190	29.88	30.88
333	Porter	64	SR	49	N	333	16	17
350	Porter	64	SR	49	N	350	33	34
355	Porter	64	SR	49	N	355	38	39
359	Porter	64	SR	49	N	359	42	43
394	Porter	64	SR	49	S	394	33	34
437	Porter	64	US	6	E	437	23	24
438	Porter	64	US	6	E	438	24	25
439	Porter	64	US	6	E	439	25	26
514	Porter	64	US	6	W	514	31	32
586	Porter	64	US	20	E	586	31	32
591	Porter	64	US	20	E	591	36	37
1440	Porter	64	US	231	N	1440	279	280
1214	Pulaski	66	US	35	S	1214	150.08	151.08
1216	Pulaski	66	US	35	S	1216	152.08	153.08
1550	Pulaski	66	US	421	N	1550	188.27	189.27
1622	Pulaski	66	US	421	S	1622	186.27	187.27
475	Saint Joseph	71	US	6	E	475	61	62
1086	Saint Joseph	71	US	31	S	1086	243	244
878	Starke	75	US	30	E	878	46	47
958	Starke	75	US	30	W	958	46	47
961	Starke	75	US	30	W	961	49	50
1157	Starke	75	US	35	N	1157	180.08	181.08
1236	Starke	75	US	35	S	1236	172.08	173.08
1242	Starke	75	US	35	S	1242	178.08	179.08
1560	Starke	75	US	421	N	1560	198.27	199.27
709	White	91	US	24	E	709	29	30
719	White	91	US	24	E	719	39	40
724	White	91	US	24	E	724	44	45
728	White	91	US	24	E	728	48	49
793	White	91	US	24	W	793	37	38
796	White	91	US	24	W	796	40	41
801	White	91	US	24	W	801	45	46
805	White	91	US	24	W	805	49	50

DATE, 2001

OPERATIONS SUPPORT
MEMORANDUM 01-XX
SIGN

MEMORANDUM:

TO: District Operations Engineers
District Traffic Engineers

FROM: James M. Poturalski, Chief
Operations Support Division

SUBJECT: Sign Quality Assurance (QA) Program

The following procedures will be utilized as a method to insure that INDOT signs are properly installed on State controlled roads in Indiana.

1. QA (conducted by Operations Support Personnel):

a. One road will be selected at random in each subdistrict once per year and a mile marker or reference marker will then be selected at random. Beginning at the mile marker or reference marker selected at random and in a direction also selected at random, every other sign will then be selected for evaluation until a total of ten have been checked.

b. Evaluations should be conducted on panel signs on one road in each district each year. Emphasis should be placed on interstate roads. The road will be selected at random and a mile marker or reference marker will then be selected at random. Beginning at the mile marker or reference marker selected at random and in a direction also selected at random, every other sign will then be selected for evaluation until a total of five have been checked.

c. Signs on roads that are currently under construction or scheduled for construction within three years will not be evaluated.

2. Evaluation procedures:

a. The categories listed below will be checked and noted as 1 or 0 (representing yes or no) for sheet and panel signs.

b. All categories will be treated equally.
The percentage of categories checked 1(yes) verse the total number of categories graded will be calculated and that will be the score for that sign structure QA.
Any sign structure with a serious deficiency will receive a score of 0%.

c. Category of "Sign meeting standards" will not be included in overall grade until 1/1/2003.

d. At the beginning of an evaluation day three sheet sign posts will be selected at random and the depth checked. This will be part of sheet sign category two.

3. Categories:

Sheet Signs

1. Correct height (primary sign, not plaque)
2. Correct application of post

3. Sign angle
4. Date sticker, or other method, visible and sign ≤ 10 years old
5. Bolts and washers correct
6. Sign visible to motorist
7. Correct size for conditions
8. Sign plumb
9. Serious deficiency
10. Sign meets standards

Panel Signs

1. Keeper plate installed
2. Base bolts
3. Bolts staked on base plate
4. Base height above ground
5. I beam plumb
6. Sign angle
7. Correct height
8. Proper mounting
9. Serious deficiency
10. Sign meets standards

4. Definitions:

Correct height:

Sheet Signs - Correct height will be according to the applicable standard sheet (MT9E) for the year the sign was installed

- If a speed advisory plaque is present, then height to bottom of plaque shall be 6 ft to 6 ft 6 inches for four lane roads and 4 ft to 4 ft 6 inches for two lane roads

- In an urban curbed area, bottom of sign shall be 7 ft to 7 ft 6 inches above ground

Panel signs - If ground mounted, minimum height of 7' above roadway and at least 5' above above ground level

Correct application of post - at least minimum size of post for sign structure

Date sticker, or other method, visible on sign and sign < ten years old – district must provide guide if date not on sticker

Bolts and washers correct - Nylon washer against sign face and metal washer between nylon washer and bolt head

- Lock nut or nut and lock washer

Sign visible to motorist - judgement of evaluator

Correct size for condition - at least minimum size requirements for roadway (according to MUTCD)

Sign plumb – ≤ 5 degrees off of plumb

Keeper plate – must be installed

Base bolts – no bolts shall be able to be loosened by hand or be loose

Bolts staked on base plate – all bolts must be staked

Base height above ground – shall be a maximum of 4 in above ground

I beam plumb - ≤ 5 degrees of off plumb

Sign angle – a judgement call by the evaluator, sign should be angled towards the motorist

Proper mounting – sign shall be mounted 1 inch above fuse/hinge plate, this will be judged by the evaluator as the sign is viewed from the ground

Serious deficiency – Items to be considered, but not limited to, are for;

Sheet signs: back to back channel posts unprotected by a guardrail, sign face blocked by brush, sign defaced and difficult to read, sign structure damaged by vehicle or vandalism, post(s) with no sign or button on it and a district is unable to prove that this location is a post(s) only, incorrect channel post splices, and sign > 12 years old or no known age available.

Panel signs: sign on ground, signs or I-beams have been damaged, more than two bolts missing on footer bases, sign mounted across fuse/hinge plate, any part of keeper plate below ground, base height > 4 inches above ground, and sign > 16 years old or no known age available.

.

Sign meets current standard – correct application of standards, policies and accepted practices.

5. Appendixes A and B:
   Will be utilized to collect field data.

JMP/gcb

Cc: Mike Bowman Field Engineers(6) Lori Land Mark Burton Jeff Parker
Sami Mohamed Gary Mroczka Dennis Belter Jim Sturdevant

INDOT Maintenance QA Inspection Form for Flexible Pavements

Route		Mile Post	
County		Inspector	
Sample ID		Date	
Time Required			

Flexible Pavement

P F N/A

Rutting
Not to exceed ½ inch in depth. ☐ ☐ ☐

Visually determine if rutting exists. In these areas use a 8'-10' straight edge. The maintenance condition is not met if the rut depth exceeds ½" for a 50 ft. length.

Depressions/Bumps
Not to exceed ½ in for 8-10 ft. length. ☐ ☐ ☐

Visually determine depression/bump locations. Place the straight edge along the roadway across these areas and measure. If a measurement exceeds ½ inch, the desired maintenance condition is not met.

Potholes
No defects greater than 1 sq. ft. in area and 1.5 inches deep. ☐ ☐ ☐

Visually locate potholes that appear to exceed the dimension requirements. Measure to determine if the criteria is exceeded. If both depth and area are greater than the criteria, the maintenance condition is not met.

Shoving/Rutting
Shoving area not to exceed 25 sq. ft. ☐ ☐ ☐

This characteristic is caused by the acceleration or deceleration of vehicular traffic.

Route _____ Mile Post _____

Cracking
75% of roadway is free of unsealed cracks. ☐ ☐ ☐

Visually estimate crack lengths and determine the length of crack sealed. If more than 25% are unsealed then maintenance condition is not met.

Raveling (including edge)
90% of roadway free of raveling. ☐ ☐ ☐

Roadway edge raveling should not be evaluated when paved shoulders, any type curb, curb and gutter, or any permanent construction is installed that will protect the pavement edge. Measurements are made from the actual edge of pavement. Determine total lengths that have raveled. If the total length of raveling exceeds 50 feet then the maintenance criteria is not met.

Paved Shoulders

Mainline Drop off
No drop off greater than 1.5" for a continuous 25 ft. ☐ ☐ ☐

Potholes
No defects greater than 1 sq. ft. in area and 1.5 inches deep. ☐ ☐ ☐

Visually locate potholes that appear to exceed the dimension requirements. Measure to determine if the criteria is exceeded. If both depth and area are greater than the criteria, the maintenance condition is not met.

Miscellaneous Categories
- Concrete shoulder (slope is reasonably consistent with pavement surface). ☐ ☐ ☐
- Asphalt shoulder (slope is reasonably consistent with pavement surface). ☐ ☐ ☐
- Joints/Cracks (50% shall be sealed Includes both transverse and longitudinal joints/cracks). ☐ ☐ ☐

As needed to determine criteria described above.

Drainage
No water can stand on pavement due to shoulder build-up or construction. ☐ ☐ ☐

Route _____ Mile Post _____

Roadside

P F N/A

Unpaved Shoulder

No more than 10% defective (>2" dropoff). ☐ ☐ ☐

When measuring unpaved shoulders, measure the shoulder drop off and make sure it does not exceed 2 inches in depth. The minimum length is 25 ft. If there are more than 2 sections (2 lane), 4 sections (4 lane) the maintenance condition is not met.

Mowing/Grass

Height of grass less than 18 inches within designated mowing area. ☐ ☐ ☐

Ten measurements should be taken in the 0.1 mile segment. No measurement shall exceed 18 inches. (Wildflower areas are not included as mowing areas.)

Litter/Debris

No more than 20 pieces of litter 1 sq. ft. or larger for 2 lane road. (40 – 4 lane road). ☐ ☐ ☐

The areas to be evaluated will normally be the mowing limits and all paved shoulders.

Fence

No more than 5% shall be damaged or missing. ☐ ☐ ☐

The fence shall be full height and functioning as designed. No gaps are allowed in the fence (except for roadways and navigable waterways).

Tree/Brush Control

No obstructed signs. No trees or limbs over roadway lower than 16 ft. ☐ ☐ ☐

The roadway shall be from encroachment of tree limbs approximately 16 feet vertically. The right-of-way shall be free of hazardous, leaning or dead trees capable of falling onto roadway. No sign will be obstructed by limbs or brush.

Noxious Weed Control

Evidence of control by mowing or herbicide application. ☐ ☐ ☐

Segment shall be inspected for the noxious weeds Johnson grass and Canadian Thistle. Presence of noxious weeds does not meet the desired maintenance condition.

Route _____ Mile Post _____

Drainage

P F N/A

Ditches

Ditch lines are clean and there is no evidence of standing water. ☐ ☐ ☐

A roadside ditch must have a front slope and at least a 6 in back slope to be considered a ditch. Ditches should be free of standing water, not contain scoured or washed areas, and do not contain clogging or obstructing vegetation.

Culverts/Pipes

All structures shall be 75% open.. ☐ ☐ ☐

Visually observe to determine if pipe is obstructed and if it is not functioning as designed. Visually determine if the obstruction is more than 25% of the culvert or pipe original cross-sectional area.

Catch Basins/Drop Inlets

50% of the capacity is available. ☐ ☐ ☐

This characteristic includes all inlets and enclosed junction boxes. No more than 50% of the storage capacity is filled with sediment . Grates must be correct size and in place to meet maintenance conditions. In place is defined as properly seated in design cradle and cannot be unseated by normal pedestrian or vehicular traffic.

Curb/Gutter

90% of curb and gutter areas are free of structural distress. ☐ ☐ ☐

Structural distress areas determined by visual inspection.

Subsurface (Underdrains)

90% of outlets are open and suitability marked. Rodent screens are in place. ☐ ☐ ☐

Visually determine if flow is occurring at the outlet. Also observe rodent screen to determine if screen is clogged.

Route _____ Mile Post _____

Traffic Control

P F N/A

Signs (All signs functioning as intended) ☐ ☐ ☐

All signs shall not lean more than 1 in per ft of post length

Delineators (No more than 10% defective) ☐ ☐ ☐

Attenuators
Good alignment and functions as intended and no attenuators shall be defective. ☐ ☐ ☐

Upon evaluating attenuators, there are several facts one should know. Vehicle impact attenuators are of various configurations and are designed for different roadway conditions. They are generally constructed of modules or cells containing different types of energy absorption materials. Attenuators are intended to provide a motor vehicle with a cushioned impact area prior to solid obstructions such as parapet walls, bridge columns, sign structures and signal poles. Any obvious malfunction such as water or sand containers that are split, compression of the device or misalignment, causes this characteristic not to meet the desired maintenance condition. When an undesired condition is discovered, the responsible maintenance area should be promptly notified.

Guardrails
No more than 5% shall be defective. ☐ ☐ ☐

All posts, offset blocks, panels and connection hardware shall be in place. Proper height is 2'-3" to the top of the rail from the riding surface. Any section that is 3 in above or 1 in. below for a continuous 25 ft does not meet the desired maintenance condition. (A previous minor collision may not prevent a guardrail system from functioning as designed and would not cause failure.)

Raised Pavement Markers
No more than 10% shall be defective, missing or broken. ☐ ☐ ☐

Castings shall be firmly set in existing pavement. Reflectors shall be in place and clean.

Barrier Wall
100% of barriers do not have missing sections and are properly aligned. 95% of barriers do not have severe cracking. ☐ ☐ ☐

Pavement Markings
90% of existing markings function as intended. For example: turning arrows, stop bars, etc. Does not include lane lines. ☐ ☐ ☐

Comments:

INDOT Maintenance QA Inspection Form for Rigid Pavements

Route		Mile Post	
County		Inspector	
Sample ID		Date	
Time Required			

Rigid Pavement

P F N/A

Joints
75% of transverse and longitudinal joint material appears to keep water out. ☐ ☐ ☐

Walk segment length and visually determine if 75% of the total joint length has material or sealant that keeps water out.

Depressions/Bumps
Not to exceed ½ in for 8-10 ft. length. ☐ ☐ ☐

Visually determine depression/bump locations. Place the straight edge along the roadway across these areas and measure. If a measurement exceeds ½ inch, the desired maintenance condition is not met.

Potholes
No defects greater than 1 sq. ft. in area and 1.5 inches deep. ☐ ☐ ☐

Visually locate potholes that appear to exceed the dimension requirements. Measure to determine if the criteria is exceeded. If both depth and area are greater than the criteria, the maintenance condition is not met.

Spalls
No defects greater than 1 sq. ft. in area and 1.5 inches deep. ☐ ☐ ☐

Check for spalling along pavement edge and at joints. Maintenance condition is not met if the criteria is exceeded.

Cracking
75% of pavement cracks are sealed. ☐ ☐ ☐

Visually estimate crack lengths and determine the length of crack sealed. If more than 25% are unsealed then maintenance condition is not met.

Route _____ Mile Post _____

Roadside

P F N/A

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No more than 10% defective (>2" dropoff). ☐ ☐ ☐

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P F N/A

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Comments:

Inspection Examples

INDOT Maintenance QA Program

Concrete Pavement joints

Good Joint - Notice how the joint material fills the gap and seals it.

Bad Joint – The joint material has receded and there are gaps and spaces at the joint.

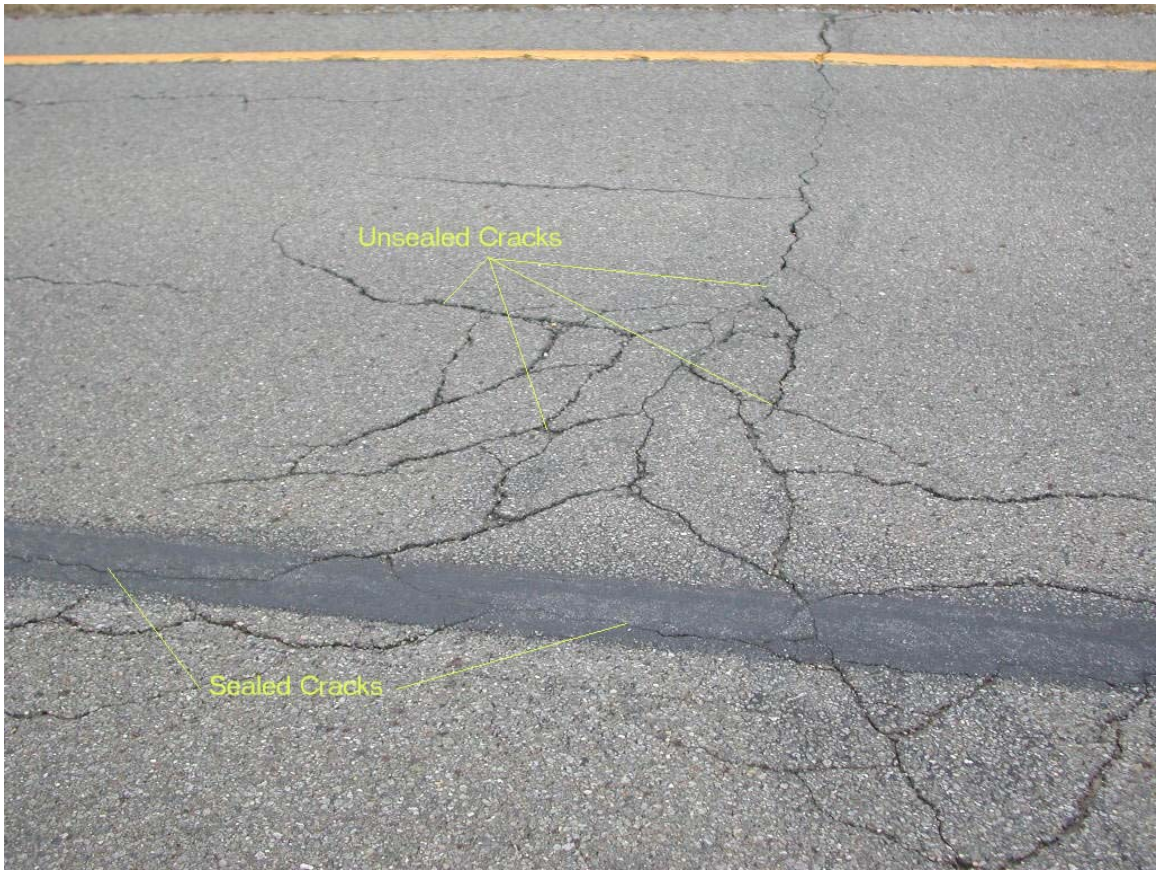
Concrete Spall

Spalls occur at joints and along edges.

Cracks

Unsealed Crack in Concrete Pavement – Notice exposed aggregate and opening in surface.

Sealed Crack in Concrete Pavement – Joint material seals the crack**.**



Asphalt Pavement – Sealed and unsealed cracks.

Asphalt Pavement Rutting

Asphalt Shoving

Asphalt Pavement Edge Raveling

Shoving – Usually occurs at intersection where acceleration and de-acceleration occurs. Causes ripples or washboard type effects in the pavement surface.

Paved Shoulders Drop Off

Unpaved Shoulder Drop Off

Partially Closed Pipe

Catch Basin Partially Obstructed

Curb with Structural Distress

Broken Raised Pavement Marker

Lens has been crushed and reflectivity lost.

Noxious Weeds

Johnson Grass

Thistle