The Ontario Approach to Maintenance Management

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Research has shown that significant reductions can be made in highway maintenance expenditures. The systems approach is directed toward maximization of this reduction. A total system for planning, organizing, directing and controlling of the maintenance function is presented in this paper. The elements of the system are discussed and a model of the system illustrated.

With increasing labor costs and design complexity, highway maintenance is fast becoming a major expenditure for most highway authorities. In Ontario, the Department of Highways is responsible for year-round maintenance of approximately 10,000 miles of paved and 3,000 miles of unpaved roads. The Department employs a maintenance staff of about 6,000 men in the summer, and the maintenance and operation of a huge fleet of snow-clearing equipment requires a further 3,000 men in winter. All this effort costs approximately $30 million for summer maintenance and $25 million for winter operations. These statistics alone establish highway maintenance as truly big business.

Historically, management of maintenance in Ontario has been done principally through the medium of fiscal control by analysis of reported expenditure. Fiscal accounting, however, is useful only to control expenditures from year to year. In terms of today's management information systems, it offers only a small fraction of the data required by modern managers. In reporting expenditure, a second need, that of accounting to the taxpayer, is also fulfilled. However, no matter how costs are analyzed, reported or combined, the end product provides information only on the amount of money spent. With this type of control, it is only possible to allocate resources on the basis of historic cost and to modify these allocations in accordance with changes in labor rates or material prices. It is not possible to allocate on the basis of need.

Recognizing the limitations of fiscal control and desiring to rationalize the operation of the maintenance function, the Department engaged the firm of Roy Jorgensen and Associates, highway engineering and management consultants, to devise a conceptual management system and later to test and, as it turned out, to implement the recommended system.

THE SYSTEMS APPROACH

A number of approaches to managing highway maintenance functions have been developed by government agencies. One approach appears to offer considerable potential for economic benefit through increased efficiency. This concept—the systems approach—is defined as follows:

> The systems approach to maintenance management anticipates the development of an integrated system of procedures in order to provide an objective basis for the planning, organizing, staffing, directing and controlling of all maintenance activities for which an organization is responsible.

FUNCTIONS OF MANAGEMENT

The systems approach to maintenance management is built around the basic functions of management—planning, organizing, directing, and controlling.

- Planning—the selection, from among alternatives, of courses of future action. This is the function by which management determines what goals are to be accomplished (objectives for the organization) and a timetable for reaching these goals.
- Organizing—the establishment of a grouping of activities and authority relationships in which people know what their tasks are, how their tasks relate to each other, and where authority for decisions needed to accomplish these tasks rests—includes staffing to carry out tasks.
- Directing—the issuance of policies, procedures, instructions, and plans in order that organizations' efforts can be directed toward the accomplishment of established goals.
- Controlling—the measuring and correcting of activities of workers to ensure that these activities are contributing to the achievement of planned goals.

These basic management functions are, in fact, decision-making functions. Decisions can be made subjectively—based on opinion, emotion, and incomplete information—or they can be made objectively—based on facts and complete information. This does not imply that managers (the decision-makers) should necessarily make decisions based only on the facts, but they should have complete information so that their decisions are made with complete knowledge of the facts.

One way to interject a higher degree of objectivity into decision-making in the highway maintenance function is to implement a maintenance management system which provides for:

1. The setting of measurable objectives.
2. The allocation of resources to meet those objectives.
3. Reporting of performance related to the objectives.
4. Management actions to assure the attainment of desired modifications to objectives.

SYSTEM INPUT

The basic input requirements for the highway maintenance system are specific operation definitions, accomplishment units, quality standards, and standard values.

Operation Definitions and Accomplishment Units

Uniform, specific operation definitions are the first requirement of any management system. In highway maintenance work, specific operations, such as spray patching, crack sealing, and machine mowing, need to be defined so that the amount of work accomplished and the resources utilized—man-hours, materials and equipment—can be accurately reported by field personnel. The definitions of operations must be in enough detail to allow the resource requirements to be easily related to the required work and the work performed for planning and controlling purposes.

Once maintenance operations are clearly defined, quantitative units of measure (accomplishment units) must be established for the major operations in order that management can establish how much of a particular operation will be performed and, in turn, how much was actually accomplished (Fig. 1).

Some common accomplishment units for highway maintenance operations are tons of patching, acres of mowing, and miles of ditching.

Operation Number	Description	Accomplishment Unit	Code
	SURFACE		
1001	PATCHING with pre-mixed asphaltic materials (hot mix or cold mix). Potholes, depressions, bumps and pavement edge defects. Materials spread by hand and compacted with hand tools and/or truck wheels.	TONS of Hot Mix or Cold Mix Used	23
1002	PATCHING with pre-mixed asphaltic materials (hot mix or cold mix). Potholes, depressions, bumps and pavement edge defects. Materials spread and compacted with grader and/or roller.	TONS of Hot Mix or Cold Mix Used	23
1003	CRACK SEALING using asphalt kettle or pouring can. Include minor repair of distressed areas of pavement and pavement edge defects when this is done during the main activity.	Number of LANE MILES on which crack sealing carried out	32
1004	SPRAY PATCHING distressed areas of pavement and pavement edge defects. Include minor crack sealing when this is done during the main activity.	GALLONS of Asphalt Used	15
1005	JOINT SEALING on concrete pavement using hot poured bituminous material.	GALLONS of Bituminous Material Used	15
1006	JOINT SEALING on concrete pavement using neoprene jointing material.	LINEAL FEET of Neoprene Used	31
1007	GRADING gravel roads Include picking up stones. N. B. Where one pass is made on one mile of gravel road, the accomplishment is one pass mile. Where two passes are made on one mile of gravel road, the accomplishment is two pass miles. Where three passes are made on one mile of gravel road, the accomplishment is three pass miles.	PASS MILES of grading	32

Figure 1. Section of an activity definition list.

Quality Standards

Quality standards must be established for the major areas of maintenance such as surface, shoulders, and roadside for the various classes of highway. By establishing quality standards, the levels of service to be maintained on these classes of highway are specifically defined.

The essential features of quality standards are that quantitative limits are established whenever possible and common goals, for all similar management units, are established. By setting these quantitative limits, objective decisions, based on measurable factors, can be made by field supervisors who must decide whether or not work should be performed, and if so, how much work. [For a typical example of a quality standard, see Highway Research Record 241, p. 9-15, 1968.]

Standard Values

Standard values are of two types—quantity standards and production standards (Figs. 2 and 3). These values must be related to the types of highway on which operations are performed, since workloads and subsequent maintenance costs vary for different highway types. To obtain information by highway type, it is necessary to classify each

ACTIVITY	ACCOMPLISHMENT UNIT	QUANTITY PER MILE OF ROAD		
		ROAD TYPE A	ROAD TYPE B	ROAD TYPE C
Premix Patching	Tons Mix	10.0	1.5	0.1
Shoulder Grading	Miles Graded	4.5	7.0	10.0
Shoulder Patching	Yds.^{3} Aggregate	5.5	13.0	2.0
Roadside Mowing	Acres	3.0	6.0	10.0

Figure 2. Example of quantity standards.

highway according to its characteristics, such as surface type, surface width and traffic volume.

The quality standards establish the objectives for the maintenance effort. While they describe the objective desired, they do not define the kinds or the amount of maintenance effort required to achieve the objective. It is necessary, therefore, to convert the quality standards to quantity standards, which reflect, when related to different highway types, the amount of maintenance work by specific operation which is required to achieve the quality level desired. For example, the quantity standard for the surface operation hot-mix patching might be established at 5.0 tons per miles per year for a certain type of highway. The quantity standard for the roadside operation machine mowing for a specified highway type might be expressed in terms of mowing frequency, such as three mowings per season.

The quantitatively expressed standard values, related to specific highway types, provide the bases for determining the workload for each defined operation performed by an organization. For example, if an organization has 100 acres of roadside which must be mowed three times per season to attain the desired quality, the workload for the roadside operation machine mowing would be 300 acres. Or, if there are 100 miles of a highway of a certain type which require hot-mix patching, and it is established that 5 tons of hot-mix material is the quantity of work required annually per mile to attain the desired level of maintenance, then 500 tons of hot-mix patching would be the workload for this operation to be performed on the highway type. To determine quantity standards, it is necessary to conduct intensive analyses of actual performance data and of the quality levels achieved and desired.

ACTIVITY	ACCOMPLISHMENT UNIT	MAN-HOURS PER ACC. UNIT		
		ROAD TYPE A	ROAD TYPE B	ROAD TYPE C
Premix Patching	Tons Mix	5.30	6.70	6.70
Shoulder Grading	Miles Graded	0.45	0.45	0.45
Shoulder Patching	Yds.^{3} Aggregate	0.23	0.23	0.23
Roadside Mowing	Acres	1.33	1.33	1.00

Figure 3. Example of production standards.

Production standards express the resources required to produce a quantity of work. They are normally expressed in man-hours or dollars per unit of work. Ideally, production standards for each operation should be determined on the basis of an analysis of the methods of performing that operation. In this way, the most efficient methods for performing work can be identified, operating personnel can be trained to utilize the prescribed methods, and standard production rates based on these methods can be established. For example, if it is determined that one man using one machine is the best method of performing roadside mowing, and that one acre of roadside should, on the average, be mowed in an hour by a trained operator using the prescribed method and equipment, the standard production rate would be one man-hour per acre.

Once the production standards have been established, the manpower required to perform the workload of each operation can be determined. For example, it was postulated that the workload for the roadside operation 'machine mowing' was 300 acres. Thus, if the mowing production rate is one man-hour per acre, the manpower required to accomplish the planned workload would be 300 man-hours. Expenditures can be forecast in a similar manner. For example, if the cost of mowing an acre of grass was calculated to be 5 dollars (cost of manpower and equipment), the budgeted expenditures for the mowing operation in this case would be 1500 dollars.

Standard values are established on the basis of reported data by highway type. The reported values of a particular highway will vary considerably due to such factors as distance from the work site and length of haul for materials. Specific standard values for planning and controlling each operation on each type of highway is selected on the basis of values that are readily achievable by a majority of the work force and on the basis of available methods studies. Understandably, selection of standard values on the basis of methods studies is the most ideal since inefficiencies and waste are detected during study and improved procedures are developed and disseminated as a result.

DESCRIPTION OF THE SYSTEM

Once the basic input requirements of a system—specific operation definitions, measurable accomplishment units, quality standards, quantity standards, and productivity standards—are established, a highway maintenance management system can be designed around the basic functions of management.

The basic management functions can be more specifically related to a highway maintenance management system.

- Planning—Standard values, related to different highway types, provide a basis for determining the workload in each management unit necessary to achieve the desired level of quality. Budgets prepared on this basis provide sufficient resources to maintain the desired level of service.
- Organizing—Production rates based on methods analysis provide bases for establishing the most effective organization structure and for determining the amounts of manpower, equipment and materials necessary to achieve the planned workload.
- Directing—Planned workloads and allocations of resources provide supervisors with a firm plan to be used as a basis for scheduling the efforts of their work units according to established policies and procedures. Scheduling the performance of maintenance operations throughout the year gives direction to organizational units and enables maximum utilization of manpower, equipment and materials.
- Controlling—In order for management to control mantenance operations, it is necessary to have an information feedback system which provides information on how the

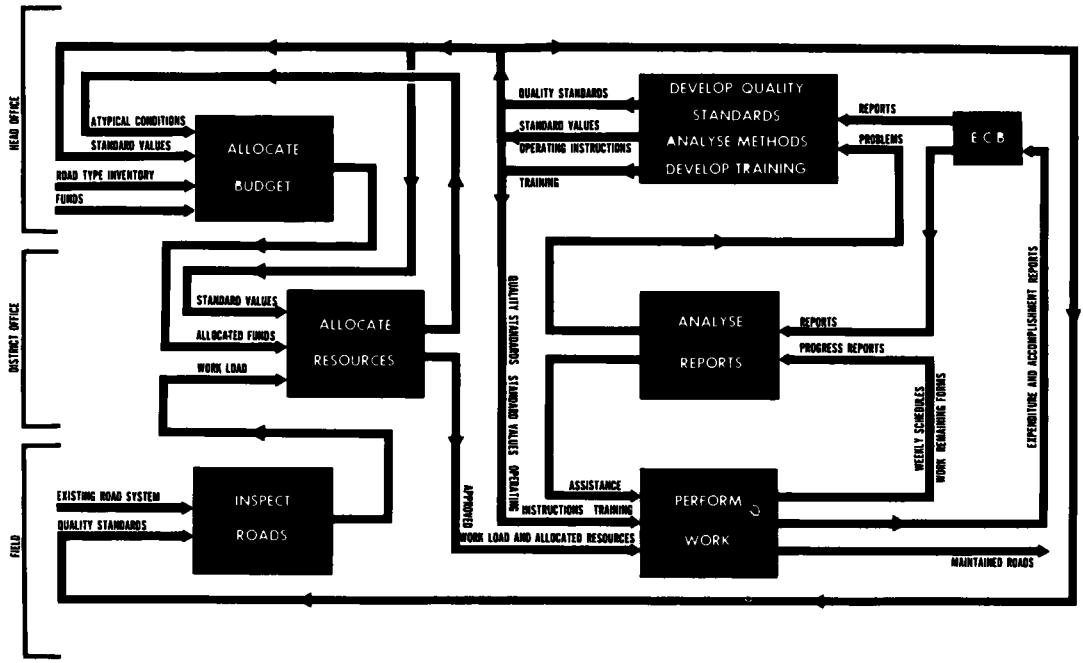

Figure 4. Model of maintenance management system.

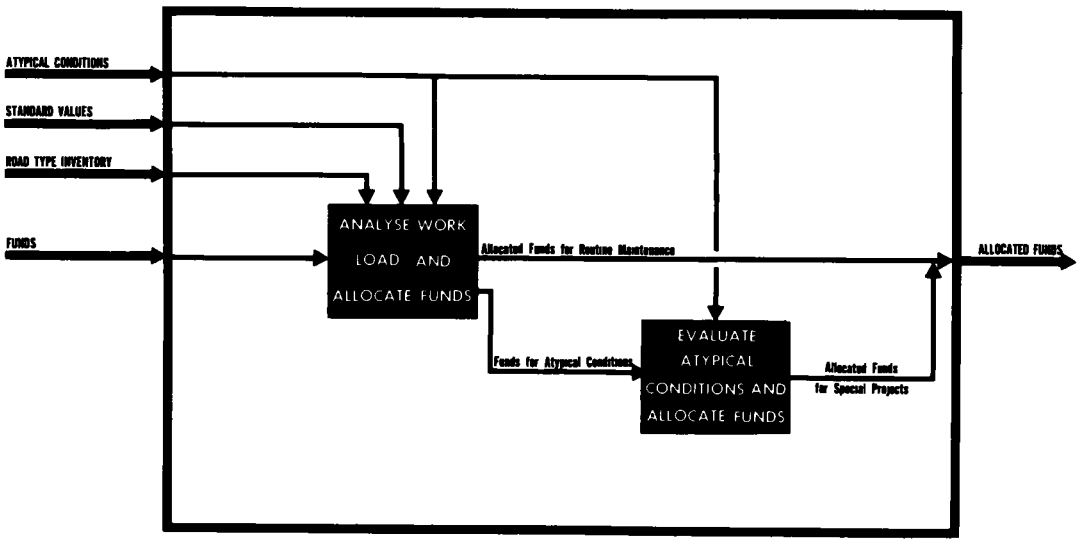

Figure 5. Model of "Allocate Budget—Head Office" function.

organization actually performed each maintenance operation. Information feedback should assure timely reports to management in terms of the man-hours, equipment, hours and material quantities used in performing each activity, and the amount of work accomplished with these resources. In addition, it is necessary for work accomplishment by operation and highway type to be identifiable with the organizational units responsible for performance.

A simplified illustration of the Ontario Highway Maintenance Management System, designed to provide for the basic management functions, is shown in Figure 4. The main functions in the total system are identified and the inputs and outputs of each defined. The interrelationships between the inputs, outputs and functions of each are also shown.

The main functions in order of performance are:

1. ALLOCATE BUDGET—Head Office
2. ALLOCATE RESOURCES—District Office
3. PERFORM WORK—Field

The supporting functions are:

4. DEVELOP STANDARDS
ANALYZE METHODS
DEVELOP TRAINING } Head Office
5. ELECTRONIC COMPUTING BRANCH (ECB)—Head Office
6. ANALYZE REPORTS—District Office
7. INSPECT ROADS—Field

ALLOCATE BUDGET
(Head Office)

Figure 5 shows a model of the "Allocate Budget—Head Office" function.

Input

Funds—representing total maintenance budget for the province.

Outputs

1. Funds for routine maintenance, allocated by district.
2. Funds for special projects allocated by project.

Process

1. The road type inventory and standard values are used to determine the work load for each district, by patrol, highway and activity, and the funds to be allocated for routine maintenance
2. Atypical conditions reported by districts are evaluated and funds allocated for special projects. Atypical conditions are those to which the standard values do not apply, e.g., on highways in poor state of repair or those which have been recently reconstructed.

ALLOCATE RESOURCES
(District Office)

Figure 6 is an example of a resource allocation summary; Figure 7 shows a model of the "Allocate Resources—District Office" function.

DATE OF REPORT JUNE 3 , | MAINTENANCE MANAGEMENT SYSTEM | DISTRICT 1

PERIOD 3/31/68 TO 12 1/68 | MAINTENANCE RESOURCE REQUIREMENTS

PATROL SUPERVISOR AARAM WRIGHT | REPORT 9

Patrol	High-Way No.	Road Type	Equiv. 2-Lane Miles	Code	Operation Description	Acc/ Equiv. 2-Lane Mile	Acc Unit	Acc Upp Lim	Man-Hours /Accom Unit	Dollars /Accomp Unit	Man-Hours /Equiv. 2-Lane Mile	Man Hours Upper Limit	Dollars Equiv. 2-Lane Mile	Total Accomp.	Total Man-Hours	Total Dollars
1	2	26306	19.2	1001	Mix Patch Manual	0.4	Tons		6.700	28.40				7.7	51	218
1	39	27306	11.3	1001	Mix Patch Manual	0.2	Tons		6.700	28.40				2.3	15	64
1 Opern. Total			30.5	1001	Mix Patch Manual	0.3	Tons		6.600	28.20	2.2		9.25	10.0	66	282
1	2	26306	19.2	1002	Mix Patch Grader	1.0	Tons		0.480	8.83				19.2	9	170
1	2	26306	19.2	1003	Crack Sealing	1.0	Mile		8.000	36.00				19.2	154	691
1	39	27306	11.3	1003	Crack Sealing	0.5	Mile		8.000	36.00				5.6	45	203
1 Opern. Total			30.5	1003	Crack Sealing	0.8	Mile		8.024	36.05	6.5		29.31	24.8	199	894
1	2	26306	19.2	1011	Other surface work						2.0		7.00		38	134
1	39	27306	11.3	1011	Other surface work						1.6		6.00		18	68
1 Opern. Total			30.5	1011	Other surface work						1.8		6.62		56	202
1	2	26306	19.2	2002	Shouldering	3.0	Cu. Yd.		0.320	3.40				57.6	18	196
1	39	27306	11.3	2002	Shouldering	3.0	Cu. Yd.		0.320	3.40				33.9	11	115
1 Opern. Total			30.5	2002	Shouldering	3.0	Cu. Yd.		0.317	3.40	1.0		10.20	91.5	29	311
1	2	26306	19.2	2003	Should. -Grader	10.0	Cu. Yd.		0.230	3.06				192.0	44	588
1	39	27306	11.3	2003	Should. -Grader	10.0	Cu. Yd.		0.230	3.06				113.0	26	346
1 Opern. Total			30.5	2003	Should. -Grader	10.0	Cu. Yd.		0.230	3.06	2.3		30.62	305.0	70	934
1	2	26306	19.2	2004	Dust Laying						0.3		3.00		6	58
1	39	27306	11.3	2004	Dust Laying						0.3		3.00		3	34
1 Opern. Total			30.5	2004	Dust Laying						0.3		3.02		9	92

Figure 6. Example of resource allocation summary—see Appendix A for list of road type codes.

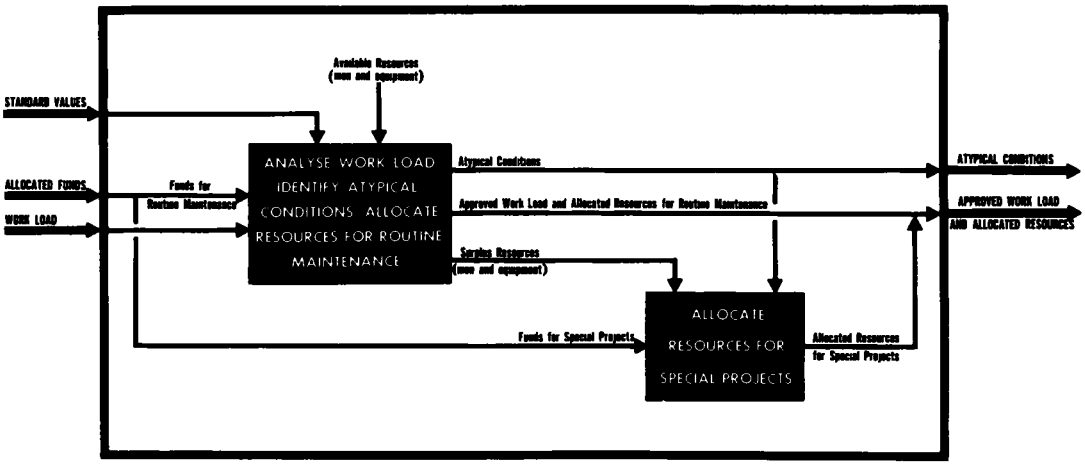

Figure 7. Model of "Allocate Resources—District Office" function.

Inputs

1. (a) Funds allocated by head office for routine maintenance, as determined from road type inventory and standard values.

   (b) Funds allocated by head office for special projects.

2. Work load required to maintain roads to level specified in quality standards, as determined from road inspections.

Outputs

1. Approved work load and allocated resources—men and equipment.
2. Atypical conditions identified in road inspections as being inconsistent with standard values.

Process

1. The work load derived from the road inspection for each patrol is evaluated and adjusted in order that:

   (a) The cost of maintenance work proposed is consistent with the funds allocated to that patrol.

   (b) The number of man-hours required for proposed maintenance work are consistent with those available.

   Where the proposed maintenance work on a patrol is insufficient to utilize the available men and equipment and the excess capacity cannot be reduced by transferring same to adjacent patrols, special projects are set up to improve the existing facilities. Additional funds for these special projects are requested from head office (see Fig. 8).

2. Head office is advised of atypical conditions where excessive resources are required to maintain roads to the level specified in the quality standards or where maintenance requirements are minimal due to recent reconstruction.

Year 1968 — SUMMER MAINTENANCE — District 19

Staff Men (4) Plm (1) Other (—) — REQUIRED MAN-HOURS AND COSTS — Patrol 8

Oper. No.	Unit	Road Insp. Qnty.	Mn-hours/ Accomp. Unit	Total Man-Hours	Dollars per Acc. Unit	Total Dollars	Remarks
1001	Tons	170	6.7	1139	28.40	4828	
1002	Tons		0.48		9.84		
1003	Lane Miles	180	8.0	1440	26.00	6480	
1004	Gal.	2620	.28	734	1 38	3616	
1005	Gal.						
1006	Lineal Ft.						
1007	Pass Miles		.40		3.30		
1008	Cu. Yd		.89		4.20		
1009	Cu. Yd.		.23		3.34		
1010	M. H.		3/mile		3.30		
1011	M. H				4.00		
1201	M. H.				4.00		
2001	Miles	479	.45	216	2.25	1078	
2002	Cu. Yd.	362	.32	116	3.40	1231	
2003	Cu. Yd.	1599	.23	368	3.34	5341	
2004	M. H.		.2/mile		10.00		
2006	Lineal Ft.		.016		05		
2007	M. H.				4 00		
2201	M. H.				4.00		
3011	Acres		1 33		5.45		
3012	Swath Mi.	105	.53	56	2.15	226	
3013	Acres		62		2.50		
3014	Lineal Ft.		.0042		.014		
3015	M. H.	68		68	3.33	226	
3023	M. H.				3.33		
3024	M. H.	40		40	3.33	133	
3031	M. H.	406		406	3.50	1421	
3050	M. H.				4.00		
3990	M. H.				4.00		
4101	M. H.				4.00		
4204	M. H.				4.00		
5011	Lineal Ft.	17850	02	357	11	1964	
5012	Lineal Ft.		.01		.11		
5013	Lineal Ft.		.04		.56		
5014	Lineal Ft.		.04		.37		
5015	Lineal Ft.	2700	.02	54	17	459	
5016	M. H.	8		8	3.33	27	
5030	M. H.	96		96	4.00	384	
5040	M. H.	174		174	4 00	696	
5060	M. H.				4 00		
5990	M. H.				4 00		
5201	M. H.				4.00		
6041	M. H.				9.00		
6042	M. H.				4.00		
6061	# Posts	158	1.33	210	5 30	837	
6062	# Posts	1116	14	156	.50	558	
6063	M. H.				4.50		
6064	M. H.				4 50		
6265	M. H.				4.00		
7017	M. H.				4.00		
7024	M. H.	72		72	4.00	288	
7041	Rolls		1 0		3.00		
7042	Rolls		.5		1 50		
7043	M. H.				4.00		
9000	M. H.		M. H. Reqd. 5710		Total $	27793	
9000	M. H.		M H. Avail 2324		/man)	3460	+ ($865/man-ove.hd)
9000	M. H.		Difference	581		2905	+ ($5 00) (Hrs. Avail.)
9000	M. H.		(±)	= 3386		$ 36158	(Patrolman Cost) Cost

Figure 8. Summary of man-hours and funds required.

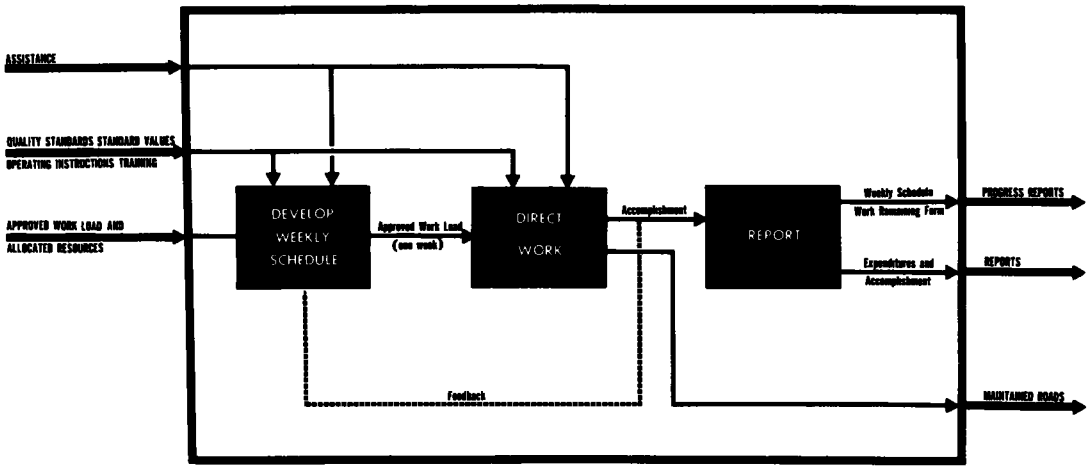

Figure 9. Model of "Perform Work—Field" function.

Effective 5 JUNE to 9 JUNE 1967

DEPARTMENT OF HIGHWAYS, ONTARIO
WEEKLY OPERATIONS SCHEDULE

District 15 Pat Supv 4 Patrol 15

MONDAY

Oper No.	Hwy No.	Equip	Crew Size	Est Accom
½ DAY 3040 4101	-	3 TON	1*	-
½ DAY 6062	88	-	3	78 [illegible] POSTS
½ DAY 6062	88	3 TON	4*	126 [illegible] POSTS

* PATROL MAN

Wet Weather Activity 3961 - 3972

No Assigned to Patrol	+ 4
No Absent	- 0
No Loaned to Other Patrols	- 0
No Transferred from Other Patrols	+ 0
Todays Crew Size	4

TUESDAY

Oper No	Hwy No	Equip.	Crew Size	Est Accom
1003 LOAN TO PAT #6	77	5 TON	1	-
6062	88	3 TON	3*	237 [illegible] POSTS

Wet Weather Activity 3961-3040-3972

No Assigned to Patrol	+ 4
No Absent	- 0
No Loaned to Other Patrols	- 1
No Transferred from Other Patrols	+ 0
Todays Crew Size	3

WEDNESDAY

Oper No	Hwy No	Equip	Crew Size	Est Accom
1003 LOAN TO PAT #6	77	5TON	1	-
6062	88	3TON	2*	192 [illegible] POSTS
8003	-	-	1	-

Wet Weather Activity 3961 - 3972

No Assigned to Patrol	+ 4
No Absent	- 1
No Loaned to Other Patrols	- 1
No Transferred from Other Patrols	+ 0
Todays Crew Size	2

THURSDAY

Oper No	Hwy No	Equip	Crew Size	Est Accom
2002	88	5 TON LOADER	3*	132 [illegible] CU YDS
2002 TRANS FROM PAT #6	88	5 TON	1	-
3012	88	MOWER	1	[illegible] MI

Wet Weather Activity 3961-3040-3972

No Assigned to Patrol	+ 4
No Absent	- 0
No Loaned to Other Patrols	- 0
No Transferred from Other Patrols	+ 1
Todays Crew Size	5

FRIDAY

Oper No	Hwy No	Equip	Crew Size	Est Accom
½ DAY 2002	88	5 TON LOADER	2*	60 CU YDS
3012	88	MOWER	1	[illegible] MI
½ DAY 3040 4101	88	3 TON	1*	-
½ DAY 3014	88	DROPPED ONE AT 3 TON	1	1000 YDS
8003	-	-	1	-

RAINED 3 HOURS IN PM
MEN USED AS FOLLOWS

3961	-	-	2	-
3040	88	3 TON	*	-
3972	-	5 TON	1	-

Wet Weather Activity 3961 - 3972

No Assigned to Patrol	+ 4
No Absent	- 1
No Loaned to Other Patrols	- 0
No Transferred from Other Patrols	+ 0
Todays Crew Size	3

Figure 10. Example of weekly operations schedule.

PERFORM WORK
(Field)

Figure 9 shows a model of the "Perform Work—Field" function.

Inputs

1. (a) Routine maintenance work load approved by district office.
   (b) Non-routine maintenance work load approved by head office as special projects.
2. Resources—men, material and equipment.

Outputs

1. Roads maintained, where practicable, to level specified in quality standards.
2. Detailed reports of labor, equipment, material used and work accomplished.
3. Progress reports of work accomplished.

Process

1. A weekly operations schedule is developed for each patrol. The work to be performed is selected from the approved work load shown on the work remaining form. Men and equipment are allocated, and accomplishment estimated, using information contained in the typical crew size tables (see Appendix B).
2. Work is performed in accordance with the weekly operations schedule (Fig. 10), except when inclement weather or emergency situations intervene.
3. Labor and equipment time sheets, material used reports and accomplishment reports are submitted biweekly for data processing by the electronic computing branch.
4. The work remaining form (Fig. 11) is up-dated and the weekly operations schedule altered to reflect the work accomplished on the patrol during the previous week. These documents form the bases of weekly progress reports submitted to the district office, where analysis of the patrol's performance indicates areas where assistance is required.

DEVELOP STANDARDS, ANALYZE METHODS, DEVELOP TRAINING
(Head Office)

Figure 12 shows a model of the "Develop Standards, Analyze Methods, Develop Training—Head Office" function.

Inputs

1. (a) Historical data from previous years' operations.
   (b) Current data.
   (c) Observed data obtained from study of field operations.
2. Problems referred by districts.

Outputs

1. Quality standards, used by:
   (a) Field units, to determine the total work load during the road inspection.
   (b) Field units, as reference during maintenance operations.

DEPARTMENT OF HIGHWAYS, ONTARIO

15 Dist 4 Pat Sup 15 Pat

Date Inspected APRIL 26, 1967

WORK REMAINING FORM

Hwy No 88

Oper. No	Unit	Road Insp Qty.	Actual Accomplishment For Week/Accomplishment Remaining														
			MAY 5	MAY 12	MAY 19	MAY 26	JUNE 2	JUNE 9	JUNE 16	JUNE 23	JUNE 30	JULY 7	JULY 14	JULY 21	JULY 28	AUG 4	AUG 11
1001	Tons	40	22 / 18	8 / 10	- / 10	- / 10	2 / 8	- / 8									
1002	Tons	-	- / -	- / -	- / -	- / -	- / -	- / -									
1003	Lane Miles	36	- / 36	- / 36	38 / -2	- / -2	- / -2	- / -2									
1004	Gal	230	- / 230	- / 230	- / 230	120 / 110	90 / 20	- / 20									
1005	Gal	-	- / -	- / -	- / -	- / -	- / -	- / -									
			/	/	/	/	/	/									
2001	Miles	64	- / 64	32 / 32	- / 32	- / 32	- / 32	- / 32									
2002	Cu Yd	200	- / 200	- / 200	- / 200	- / 200	- / 200	192 / 8									
2003	Cu Yd	901	- / 901	- / 901	- / 901	- / 901	- / 901	- / 901									
2004	Bags	240	- / 240	- / 240	- / 240	- / 240	100 / 140	- / 140									
2006	Feet	52,30	- / 5230	1400 / 3830	- / 5830	- / 5830	- / 5830	- / 5830									
			/	/	/	/	/	/									
3011	Acres	103	- / 103	- / 103	- / 103	- / 103	- / 103	- / 103									
3012	Swath Miles	352	- / 352	- / 352	- / 352	- / 322	- / 352	30 / 322									
3013	Acres	-	- / -	- / -	- / -	- / -	- / -	- / -									
3014	Man-Hours	42	- / 42	- / 42	- / 42	8 / 34	- / 34	- / 34									
			/	/	/	/	/	/									

Figure 11. Example of work remaining form.

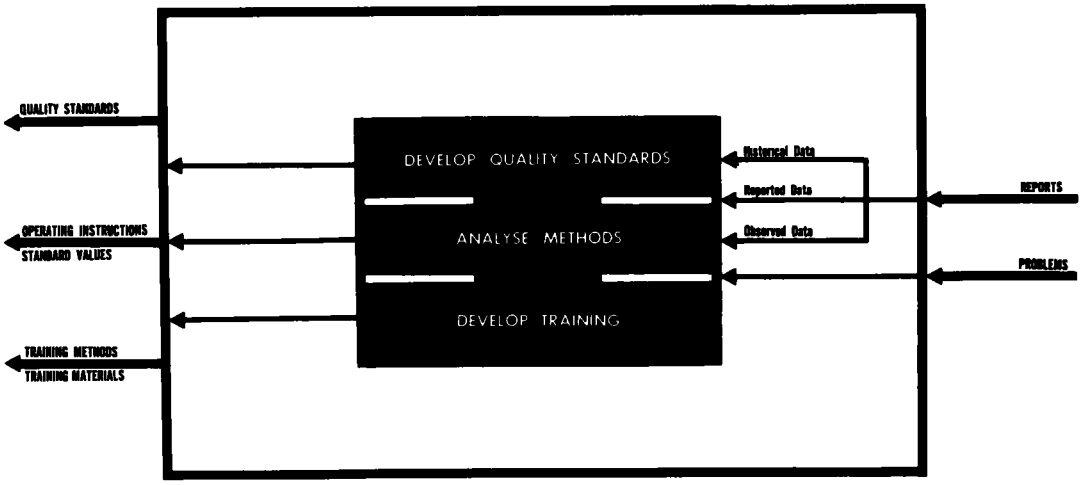

Figure 12. Model of "Develop Standards, Analyze Methods, Develop Training–Head Office" function.

2. Standard values, used by:
   (a) Head office, to allocate funds to districts.
   (b) District office, to allocate resources to field units and to evaluate performance of same.
   (c) Field units, to prepare weekly operations schedules and to evaluate own performance.
3. Operating instructions, used by field units in the conduct of specific maintenance operations.
4. Training materials and methods, used by the district office to train field units in methods and procedures.

Process

1. Quality standards are developed and modified, using historical and current data, to quantitatively specify the level of service to which the various facilities are to be maintained on each type of highway.
2. Standard values are developed and modified using data extracted from reports of expenditure and accomplishment submitted by field units and processed by ECB.
3. Operating instructions are developed using data obtained from field studies to define the procedures to be followed by field units in conducting specific maintenance operations.
4. Training programs and training aids are developed:
   (a) As solutions to problems referred by the district office.
   (b) To meet training needs usually associated with the implementation of new methods and procedures.

ELECTRONIC COMPUTING BRANCH
(Head Office)

Input

Labor and equipment time sheets, material used and accomplishment reports.

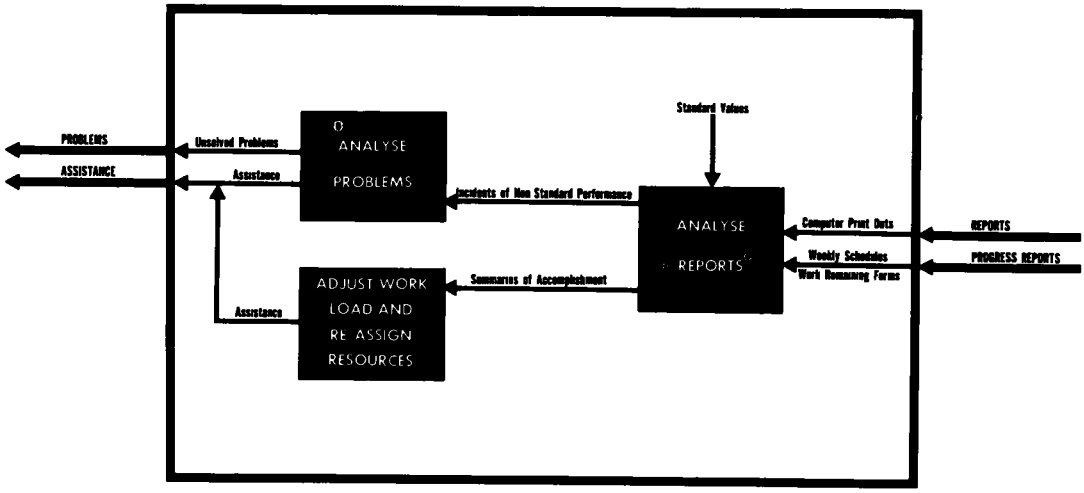

Figure 13. Model of "Analyze Reports—District Office" function.

DATE OF REPORT July 16 1968. DISTRICT NO. 7

COMPARISON FOR EACH ACTIVITY OF PLANNED DOLLAR AND MAN HOUR EXPENDITURES, ACCOMPLISHMENT QUANTITY, UNIT COST, AND PRODUCTIVITY
REPORT 1 (B)

PATROL SUPERVISOR R. MACLEAN TEN WEEK ACCOUNT PERIOD ENDING JUNE 7 1968

Patrol	Code	Operation Description	Expenditure Dollars	A/P	Man Hours Hours	A/P	Accomplishment Quantity	A/P	Unit Cost Dollars	A/P	Rate Hours	A/P	
6	1001	Mix Patch Manual	325		80.0		8.0		40.63		10.00		ACTUAL
			494	0.66	116.0	0.69	17.3	0.46	28.55	1.42	6.70	1.49	PLANNED
6	1002	Mix Patch Machines											ACTUAL
			54		3.0		6.1		8.25		0.49		PLANNED
6	1003	Spray Patch Cracks	935		240.0		16 0		58.44		15.00		ACTUAL
			1254	0.74	279.0	0.86	34.8	0.46	36.03	1.62	8.02	1.87	PLANNED
6	1004	Spray Patch Areas	1326		338.0		544.3		2.44		0.62		ACTUAL
													PLANNED
6	1011	Other Work											ACTUAL
			168		37.0								PLANNED
6	1000	Surface	2586		658.0								ACTUAL
		Operation Group Total	1970	1.31	435.0	1.51							PLANNED
6	2001	Grading	863		151.0		341.0		2.53		0.44		ACTUAL
													PLANNED
6	2002	Shouldering											ACTUAL
			47		4.0		13.8		3.40		0.29		PLANNED
6	2003	Shouldering Grader											ACTUAL
			603		46.0		197.0		3.06		0.23		PLANNED
6	2004	Dust Laying	380		36.0								ACTUAL
			74	5.13	7.0	5.14							PLANNED
6	2005	Washouts	80		24.0								ACTUAL
			627	.13	173.0	0.14							PLANNED
6	2006	Gravel Windrow	364		134.0		12808.0		0.03		0.01		ACTUAL
			216	1.68	69.0	1.94	4332.0	2.96	0.05	0.57	0.01	0.66	PLANNED
6	2007	Other Work	44		8.0								ACTUAL
			69	0.64	17.0	0.47							PLANNED
6	2000	Shoulders	1731		353.0								ACTUAL
		Operation Group Total	1636	1.06	316.0	1.12							PLANNED

Figure 14. Example of a monthly report from ECB.

Outputs

1. Reports to head office containing data from which standard values are developed and modified.
2. Reports to district office itemizing expenditures and productivity for each field unit.

ANALYZE REPORTS
(District Office)

Figure 13 shows a model of the "Analyze Reports—District Office" function.

Inputs

1. Weekly progress reports from field units—weekly operations schedules and updated work remaining forms.
2. Monthly reports from the ECB, itemizing expenditures and productivity for each field unit (Fig. 14).

Outputs

1. Assistance to field units.
2. Unsolved problems referred to head office.

Process

1. The weekly progress reports submitted by field units and the monthly reports from the ECB are analyzed to ascertain if work is being carried out as planned and if production rates are consistent with the standard values:

Date Inspected APRIL 17, 1967 — DEPARTMENT OF HIGHWAYS, ONTARIO — Sheet 1 of 16
Starting Point GLEWFIELD CITY LIMITS — ROAD INSPECTION — Dist 15 Pat Sup 4 Pat 15
Miles to End 29.4 MILES — Road Type 2-LANE
HIGHWAY NO 15 SOUTH SIDE

	Miles from Start	Oper No	Qnty	Accomp Rate	Miles from Start	Oper No	Qnty	Accomp Rate	Miles from Start	Oper No	Qnty	Accomp Rate	Miles from Start	Oper No	Qnty	Accomp Rate	
1	0 1	1004	2 GAL	—	1 1	6062	38 POSTS	—	2 3	2002	36 YDS	—	3 0	1005	4 GAL	—	1
2	0 2	2002	18 YDS	—	1 1	6061	5 POSTS	2.5 MAN HRS	2.3→2.5	7000	80 YDS	—	3 3	6062	20 POSTS	—	2
3	0 2	6062	43 POSTS	—	1 1	5011	120 FT	2 HRS	2 4	2002	4 YDS	—	3 5	5011	100 FT	2 HRS	3
4	0 2	6061	3 POSTS	3 MAN-HRS	1 5	2002	24 YDS	—	2 4	6062	40 POSTS	—	3 5	6061	3 POSTS	1.5 MAN-HRS	4
5	0 7	2004	10 BAGS	—	16→39	3011	15 ACRES	—	2 6	1001	3 TONS	—	3 6	2002	24 YDS	—	5
6	0 8	6062	27 POSTS	—	1 7	2002	100 YDS	—	2 8	1004	3 GAL	—	3 7	1001	.5 TON	—	6
7					1 9	5060	7 CATCH BASINS	7 MAN HRS	2 8	6062	12 POSTS & BARRELS	—	3 7	6062	23 POSTS	—	7
8					1 9	5016	300 FT	4 MAN HRS	2 9	4101	8 TABLES	1 MAN-HR Mod - VAC - GAL	3 9	6064	100 FT	—	8
9									2 9	2002	4 YDS	—					9
10																	10
11																	11
12																	12
13																	13

Figure 15. Example of road inspection form.

(a) Incidents of substandard performance are investigated. Assistance is given, where necessary, to rectify the situation.

(b) Incidents of consistent above-standard performance are referred to head office for study.

2. Performance problems which cannot be solved at the district level are referred to head office.

INSPECT ROADS
(Field)

Input

Existing road system.

Output

Total work load necessary to maintain roads to level specified in quality standards.

Process

Prior to the start of the summer maintenance season each field unit conducts a detailed road inspection in which all work necessary to maintain the road to the level specified in the quality standard is recorded, by activity, on road inspection forms (Fig. 15).

SUMMARY

The system is dynamic because work quantity standards, production rates and methods of performing work come under continuous scrutiny and are revised and reshaped according to changing conditions. Planning is thus based on current information, thereby allowing maximum utilization of all resources and the achievement of desired level of maintenance service at the lowest practical cost.

Establishment of a highway maintenance management system gives purpose and direction to the highway maintenance function. Without such a system, field managers lack guidance as to what to do, how much and when. With the establishment of a system, they have guides and a reporting mechanism that enables them to know how they are doing.

A highway maintenance management system provides highway management with a basis for setting a maintenance program on level-of-service criteria—quality standards. It gives assurance that the program objective will be uniform throughout the highway department and provides a reporting system that will measure performance. Highway management is able to evaluate organization performance in relation to the objectives by comparing actual production rates and work accomplishment to standard production rates and planned workloads for each operation, and to take appropriate remedial action. In addition, actual expenditures can be compared to planned or budgeted expenditures. Poor performance may indicate such things as the use of improper methods, a need for training, improper scheduling, improper allocation of resources, and poor supervision.

Finally, the highway maintenance management system permits the maintenance function to support highway maintenance budget requirements in terms of measurable and definable work programs.

Appendix A

LIST OF ROAD TYPE CODES

CODE	HIGHWAY TYPE
1	2 Lane (less than 22 ft. width)
2	2 Lane (22 ft. width or greater)
3	3 Lane
4	4 Lane undivided
5	4 Lane divided
6	6 Lane undivided
7	6 Lane divided
8	Other 6 Lanes
9	Other

CODE	SURFACE TYPE
1	Gravel
2	Primed Gravel
3	Surface Treated Primed Gravel
4	Mulch
5	Hot Mix
6	Hot Mix on Concrete
7	Concrete

CODE	SHOULDER TYPE
1	No Shoulder
2	Up to 4 ft. Shoulder - Gravel
3	Over 4 ft. - Gravel
4	Paved Shoulder
5	Other (Curb and Gutter, etc.)

CODE	MOWABLE WIDTH OF RIGHT-OF-WAY
1	None
2	0 to 50 ft
3	51 to 100 ft.
4	101 to 150 ft.
5	151 to 200 ft.
6	201 to 250 ft.
7	Over 250 ft.

CODE	A. A. D. T.
1	1 - 100
2	101 - 250
3	251 - 500
4	501 - 1, 000
5	1, 001 - 2, 500
6	2, 501 - 5, 000
7	5, 001 - 10, 000
8	10, 001 - 25, 000
9	25, 001 - 50, 000
0	More than 50, 000

Appendix B

TYPICAL CREW SIZE TABLES

The following 7 pages contain typical crew size tables.

TYPICAL CREW SIZES, EQUIPMENT AND APPROXIMATE ACCOMPLISHMENT PER DAY

OPERATION	1001 2 LANE ROADS	1001 3 LANE ROADS & ABOVE	1002	1003	
DESCRIPTION	PATCHING with PREMIX using hand tools and/ or truck wheels	PATCHING with PREMIX using hand tools and/ or truck wheels	PATCHING with PREMIX using Grader and/or Roller	CRACK SEALING using asphalt kettle or pouring can	
CREW SIZE Add or delete Flagmen according to manual of "Instructions for Traffic Control at Highway Work Areas". TOTAL	1 - Driver 2 - Shovellers 1 - Flagman 4	2 - Drivers 2 - Shoveller - Rakers 4	1-Grader Oper. 1-Roller Oper 1-Shoveller-Raker 2-Flagmen 1-4 Drivers (refer Table 1) 6-9	Kettle: 1-Spray Bar Op. 2-Sand Spreader 2-Drivers 2-Flagmen 7	Pouring Can: 1-Driver 1-Pourer 2-Sand Spreaders 2-Flagmen 6
EQUIPMENT	3T or 5T Dump	2-5T Dumps (1 truck for traffic control)	1-4 5T truck (refer Table 1) 1-Grader 1-Roller (double roll, width 4')	1-Asphalt Kettle 1-3T (or $\frac{1}{2}$T) to tow kettle 1-5T (or 3T) to carry sand	1-3T Dump (or 5T) to carry emulsion and sand
ACCOMPLISHMENT UNIT	Tons	Tons	Tons 1/	Lane Miles	
NOTES			1/ If less trucks assigned than in Table 1, accomplishment will be less.		

TABLE 1
TRUCK COMPLEMENTS FOR 1002

Ave. Distance of Patch Areas from Premix Plant	No of 5 Ton & 3 Ton 4/ Trucks to Fully Utilize Grader & Roller
4 Miles	1 - 5T
8	1 - 5T, 1 - 3T
12	1 - 5T, 1 - 3T
16	2 - 5T, 1 - 3T
20	2 - 5T, 1 - 3T
24	3 - 5T
28	3 - 5T, 1 - 3T
32	4 - 5T
36	4 - 5T, 1 - 3T
40	4 - 5T, 1 - 3T

Basis;

Roller capacity per day	= 100 Tons
Time available for work per day	= 6 0 Hours
Hauling capacity of 5 Ton Truck	= 9 0 Tons
Hauling capacity of 3 Ton Truck	= 6. 0 Tons
Truck time to dump load & load at plant (or stockpile)	= 17. 0 Min.
Truck travelling speeds (ave full and empty)	= 35 0 mph

4/ If 3 Ton trucks not suitable or unavailable, use 5 Ton trucks

TYPICAL CREW SIZES, EQUIPMENT AND
APPROXIMATF ACCOMPLISHMENTS PER DAY (continued)

OPERATION	1004	1007	1008	1009		1010
DESCRIPTION	SPRAY PATCHING	GRADING - Gravel Roads - include picking up stones	BUILD-UP patching with gravel, grader and patrol truck only	BUILD-UP WITH GRAVEL - Additional DHO (and/or Hired) Trucks		DUST LAYING - Calcium Chloride on gravel roads
CREW SIZE Add or delete Flagmen according to manual of "Instructions for Traffic Control at Highway Work Areas".	1-Spray Bar Oper. 2-Sand Spreaders 2-Drivers 2-Flagmen	1-Grader Operator	1-Driver 1-Shoveller-Raker 1-Flagman	4-Drivers 1-Loader Operator 1-Grader Operator 2-Flagmen	6-Drivers 1-Loader Operator 1-Grader Operator 2-Flagmen	1-Driver 2-Spreaders 1-Flagman
TOTAL	7	1	3	8	10	4
EQUIPMENT	1-Asphalt Kettle 1-3T (or $\frac{1}{2}$T) to tow kettle 1-5T (or 3T) to carry sand 1/	1 - Grader, approx. 100 h. p.	1-3T Dump (or 5T) 1-Loader (as required)	4-5T Dumps 1-Grader (100 h. p.) 1-Loader (approx. 1. 0 cu. yd.)	6-5T Dumps 1-Grader (100 h. p.) 1-Loader (approx. 1. 0 cu. yd.)	1-3T Dump (or 5T)
ACCOMPLISH-MENT UNIT	Gallons	Pass Miles	Cubic Yards	Cubic Yards	Cubic Yards	
NOTES	1/ For heavy patching, add extra driver and 5T Dump					

TYPICAL CREW SIZES, EQUIPMENT AND
APPROXIMATE ACCOMPLISHMENTS PER DAY (continued)

OPERATION	2001	2002		2003		2004	2005	2006	
DESCRIPTION	GRADING - Routine grading of gravel shoulders	SHOULDERING with GRAVEL - No Grader		SHOULDERING with GRAVEL - Grader Included		DUST LAYING Calcium Chloride on shoulders	WASHOUTS	GRAVEL WINDROW between Guide Rail Posts	
CREW SIZE Add or delete Flagmen according to manual of "Instructions for Traffic Control at Hwy. Work Areas" TOT.	1 - Grader Op 1	1-Driver 1-Flagman - Sweeper 2	2-Drivers 1-Flagman - Sweeper 3	4-Drivers 1-Loader Op 1-Grader Op 1-Flagman 1-Sweeper 8	6-Drivers 1-Loader Op. 1-Grader Op. 1-Flagman 1-Sweeper 10	1-Driver 2-Spreaders 3	1-Driver (assist Shoveller) 1-Shoveller 2-Raker-Flagmen 4	1-Driver (assists) 2-Shoveller-Rakers 3	1-Driver (assists) 3-Shoveller-Rakers 4
EQUIPMENT	1-Grader (50-75 hp) with berm leveller	1-5T Dump 1-Loader as required	2-5T Dumps 1-Loader as required	4-5T Dumps 1-Loader (approx. 1.0 cu. yd.)	6-5T Dumps 1-Loader (approx. 1.0 cu. yd.)	1-3T Dump (or 5T)	1-3T Dump (or 5T) 1-Loader as required	1 - Patrol Truck	
ACCOMPLISHMENT UNIT	Shoulder Miles Graded	Cubic Yards	Cubic Yards	Cubic Yards	Cubic Yards	-	-	Lineal Feet	Lineal Feet

TYPICAL CREW SIZES, EQUIPMENT AND
APPROXIMATE ACCOMPLISHMENTS PER DAY (continued)

OPERATION	3011	3012	3013	3014			3031		3041	3042
DESCRIPTION	MOWING with tractor - MORE THAN 2 SWATHS	MOWING with tractor - 1 or 2 SWATHS ONLY (adjacent to shoulder)	MOWING with tractor - MEDIANS ONLY	MOWING with hand mower or scythe around guide rail.			ROUTINE MAINTENANCE		ROUTINE INSPEC-TION	NON-ROUTINE INSPECTION
							Ave. roadside width 1/ less than 50'	Ave roadside width 1/ greater than 50'		
CREW SIZE TOTAL	1-Mower Oper. 1	1-Mower Oper 1	1-Mower Oper 1	2 Men with Scythes 2	3 Men with Scythes 3	4 Men with Scythes 4	1-Driver 2-Pickup Men 3	1-Driver 3-Pickup Men 4	1-Driver (Patrol-man) 1	1-Driver (Patrol-man) 1-Labourer 2
EQUIPMENT	1-Tractor Mower with 5' Sickle or Rotary	1-Tractor Mower with 5' Sickle or Rotary	1-Tractor Mower with 5' Sickle Bar or Rotary	1- Patrol Truck (or 3T) Scythes			1 - Patrol Truck Garbage Pails		1-Patrol Truck (or 3T)	1-Patrol Truck 1-Power Mower (or Tractor Mower when required)
ACCOMPLISH-MENT UNIT	Acres	Swath Miles	Acres	Lineal Feet	Lineal Feet	Lineal Feet	-	-	-	-

TYPICAL CREW SIZES, EQUIPMENT AND
APPROXIMATE ACCOMPLISHMENTS PER DAY (continued)

OPERATION	5011	5012	5013	5014	5015	5040	5060	6042
DESCRIPTION	DITCHES - GRADALL, Waste Material hauled away	DITCHES - GRADALL, No hauling of waste	DITCHES - LOADER-BACK-HOE, waste hauled away	DITCHES - LOADER-BACK-HOE, no hauling of waste	DITCHES - GRADER only	MAINTENANCE and repair of culverts and catchbasins, etc attached to culverts	MAINTENANCE and repair of storm sewer systems	REPAIRING and straightening signs
CREW SIZE Add or delete Flagmen according to manual of "Instructions for Traffic Control at Highway Work Areas" TOTAL	1-Gradall Driver /Flagman 1-Gradall Oper. 2-Truck Drivers 4	1-Gradall Driver /Flagman 1-Gradall Oper. 2	2-Truck Drivers 1-Loader-Backhoe Operator 1-Grader Oper. (if required) 1-Flagman 5	1-Loader-Back-hoe Operator 1	1-Grader Oper 1	1-Driver (assist) 2-Labourers 3	1-Driver (assist) 1-Labourer 2	1-Driver (assist) 1-Labourer 2
EQUIPMENT	1-Gradall 2-5T Dumps	1-Gradall	2-5T Dumps 1-Loader-Backhoe (1.0 cu yd.) 1-Grader (100 hp) (if required)	1-Loader-Backhoe (1.0 cu. yd.)	1-Grader (100 h.p.)	1-Patrol Truck (or 3T)	1-Patrol Truck (or 3T)	1-Patrol Truck (or 3T)
ACCOMPLISHMENT UNIT	Feet	Feet	Feet	Feet	Feet	-	-	-

TYPICAL CREW SIZES, EQUIPMENT AND
APPROXIMATE ACCOMPLISHMENTS PER DAY (continued)

OPERATION	6061	6062				6063	6064
DESCRIPTION	CABLE GUIDE RAIL - Straighten and/or Replace Posts	CABLE GUIDE RAIL - Clean and Paint Guide Rail Posts				CABLE GUIDE RAIL - OTHER - -Replacing or tightening cable -reflectorized strips	STEEL BEAM GUIDE RAIL - All Work
CREW SIZE Add or delete Flagmen according to manual of "Instructions for Traffic Control at Highway Work Areas"	1-Driver 2-Labourers	1-Scrape & Paint 1-Paint	1-Scrape Only 1-Scrape & Paint 1-Paint only	1-Scrape Only 1-Scrape & Paint 2-Paint only	2-Scrape Only 3-Paint Only	1-Driver 2-Labourers	1-Driver 4-Labourers
TOTAL	3	2	3	4	5	3	5
EQUIPMENT	1 - Patrol Truck	1 - Patrol Truck				1-Patrol Truck	1-Patrol Truck (or 3T)
ACCOMPLISHMENT UNIT	Posts	Posts	Posts	Posts	Posts	-	-

TYPICAL CREW SIZES, EQUIPMENT AND
APPROXIMATE ACCOMPLISHMENTS PER DAY (continued)

OPERATION	7017	7041			7042		
DESCRIPTION	ERECTION AND REMOVAL OF SNOW PLOW MARKERS	SNOW FENCE ERECTION			SNOW FENCE REMOVAL		
CREW SIZE	Erection: 1-Driver (assist) 3-Erectors 4 Removal: 1-Driver (assist) 2-Removers 3	2-Drive posts 2-Unravel & position rolls, set up fence & attach wire clips	2-Drive posts 1-Unravel & position rolls 2-Set up fence & attach wire clips	2-Drive posts 1-Unravel & position rolls 3-Set up fence & attach wire clips	2-Unclip wire from posts & joints 1-Pull out posts 1-Assist in pulling out posts, rolling fence, roll to R O W fence Rolls & posts stacked at ROW fence	2-Unclip wire from posts & joints 2-Pull out steel posts, assist in removing wire, rolling up fence 1-Roll up fence & roll to ROW fence Rolls & posts stacked at ROW fence	3-Unclip wire from posts & joints 2-Pull out steel posts & assist in rolling up fence 1-Roll up fence & roll to ROW fence Rolls & posts stacked at ROW fence
TOTAL	3	4	5	6	4	5	6
EQUIPMENT	1-Patrol Truck (or 3T)	1- Patrol Truck			1-Patrol Truck		
ACCOMPLISHMENT UNIT		Rolls	Rolls	Rolls	Rolls	Rolls	Rolls