

HIGHWAY MAINTENANCE MANAGEMENT IN ONTARIO: A PROGRESS REPORT

F. Rendulic and T. A. Hickey, Department of Highways, Ontario

•IN 1965, the Department of Highways, Ontario, undertook a study to determine the feasibility of conducting a comprehensive analysis of its maintenance function. The objective of this analysis was to find ways to optimize maintenance efforts throughout the province.

As a result of the early analysis, department management took positive steps to develop and implement a maintenance management system. The system was founded conceptually on "the systems approach." The systems approach to maintenance management provides for an integrated system of procedures designed to provide an objective basis for planning, organizing, staffing, directing, and controlling maintenance activities.

Figure 1 shows a flow chart of the department's maintenance management system. Figure 2 shows the organizational structure of the department's maintenance operation from the head office to the field. With a few exceptions, the management system is indicative of what is taking place in highway maintenance in Ontario today. Progress to the present time is outlined in the following pages, which include some of the problems encountered and their solutions and the benefits obtained from the system (particularly utilization of the reported data from the field).

FIELD

Planning and Organizing

Field crews, usually consisting of a patrol supervisor and a patrolman or crew foreman, conduct road inspections as a prelude to the development of a summer work plan for the ensuing summer maintenance season. The degree of inspection is usually based on the type of highway, its local problems, and its history. To date, no standard pattern of inspection has emerged. A second inspection is made the following spring to observe unexpected conditions caused by the spring breakup. A list of maintenance needs is then submitted to the district office to form a part of its maintenance work plan.

Directing

All field units utilize a weekly schedule, which is normally prepared on the Thursday or Friday prior to the work week. This schedule is made up by the patrolman or crew foreman, in conjunction with the patrol supervisor. The services supervisor schedules his crews (zone painting, electrical, forestry, etc.) in the same manner and informs the patrol supervisors of his requirements in order to coordinate staff and equipment in the best manner. Results of scheduling are discussed later in this report.

After completion of the work, the results (man-hours worked, equipment, accomplishment, and materials consumed) are reported on special forms for district office use. (Samples of the forms are included with this report.) A work remaining form (Fig. 3) is made out to show how well the patrol is functioning in accordance with its plan. Service crews follow a similar procedure. This reporting system was introduced prior to the implementation of the maintenance management system.

DISTRICT

Planning and Organizing

All districts now prepare a tentative summer maintenance work plan that is compiled from information on the patrol inspection reports, the work remaining form, report 12

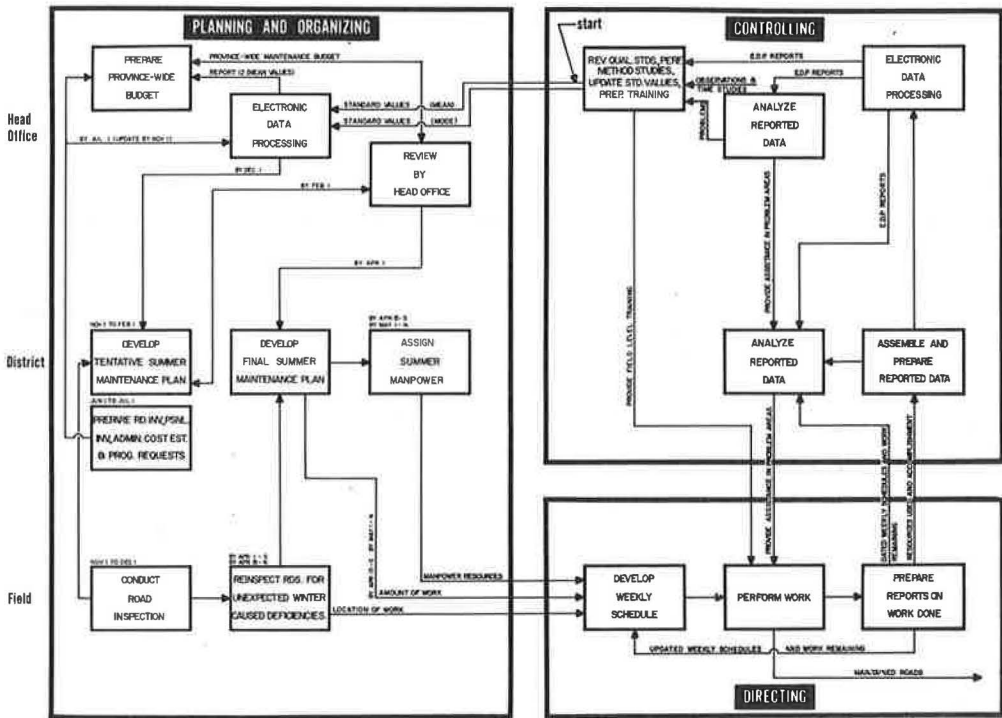


Figure 1. Maintenance management flow chart.

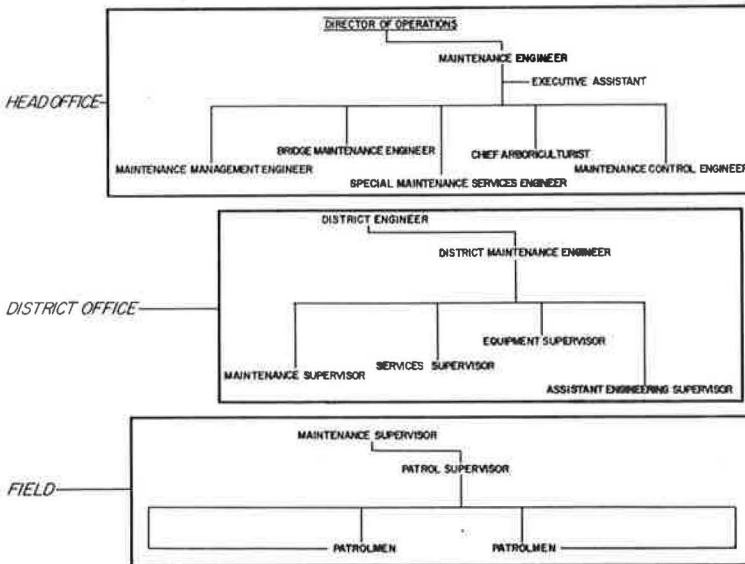


Figure 2. Organization structure, maintenance operation.

OPERATION NO.																			
UNITS																			
PLANNED QUANTITY																			
ACCOMP PERIOD 1																			
BALANCE																			
ACCOMP PERIOD 2																			
BALANCE																			
ACCOMP PERIOD 3																			
BALANCE																			
ACCOMP PERIOD 4																			
BALANCE																			
ACCOMP PERIOD 5																			
BALANCE																			
ACCOMP PERIOD 6																			
BALANCE																			
ACCOMP PERIOD 7																			
BALANCE																			
ACCOMP PERIOD 8																			
BALANCE																			
ACCOMP PERIOD 9																			
BALANCE																			
ACCOMP PERIOD 10																			
BALANCE																			
ACCOMP PERIOD 11																			
BALANCE																			
ACCOMP PERIOD 12																			
BALANCE																			
ACCOMP PERIOD 13																			
BALANCE FORWARD																			

Figure 3. Work remaining form.

and report 8B [Report 12 is the report wherein standard values have been applied to road inventories previously submitted by the district. Report 8B contains all the charges (man-hours, dollars, accomplishment, and so forth) for a maintenance period.] An even distribution is carried out by district patrol personnel to adjust the work load to fit the resources available. After all adjustments have been made, a plan emerges that is sent to head office for processing by electronic computer. All districts prepare these plans, and only minor localized problems exist. The district office prepares a work remaining form from each patrol plan and sends it to the patrol concerned.

Controlling

Some of the reported data (e.g., work remaining forms) are available for immediate analysis by district managers. The bulk of the reported data is forwarded to the electronic computing branch of DHO for processing. Reports are then prepared and submitted to the district for their analysis. Several types of reports will be described later.

District managers are thus able to receive the type of information that formerly was unavailable and the reports point out many abnormalities requiring further examination.

HEAD OFFICE

Planning and Organizing

Head office effort is divided into two channels: systems and methods. The systems section constantly updates standard values that are fundamental in making the planning report (report 12), for preparing a province-wide budget, and in allocating resources to districts. The methods section prepares, devises, and implements quality standards that are also used in preparing the planning report.

Controlling

The maintenance management section makes extensive use of reported data. This is chiefly in the area of updating standard values for productivity and also to control total

staff requirements and equipment. With respect to analyzing the reported data, the surface has only been scratched so far.

Although it was previously mentioned that the entire system has been fully implemented, in some areas, progress has not met initial expectations. Substantial improvement is being made, however, especially in the following items: introduction and development of cost reporting systems; development of computer reports; and analyzing reported data and in how the data are used.

COST REPORTING SYSTEM

The new maintenance management system necessitated a revised cost reporting system, because the original system was designed to provide fiscal control only. It provided no feedback from head office to the district to ensure proper managerial control. For example, accomplishment was not expressed in terms of measurable units, and it was impossible to assess quantitatively results of expenditures. Furthermore, except for surface and shoulder activities, the specific highway on which work was performed was not reported. Thus it was impossible to relate expenditures to the type of road serviced.

Effective management planning was not possible because plans could not be prepared by specific maintenance operation. Also, management control was limited since actual performance could not be evaluated against planned performance in order to identify areas requiring corrective action.

The new reporting system uses five separate reporting forms for the field units. Three of these were familiar to the maintenance staff although modified, while two were entirely new. The system embodies all maintenance activities, using about 120 activity code numbers and supplying details on employee time, equipment time, material used, and accomplishment for each activity. The reporting system was started in one of the department's districts between 1965 and 1967. This was a development phase and, during the 2 years, changes were made to the system almost daily. By 1967 the system had been stabilized, and head office approval was given to introduce it into three more districts.

Development

The maintenance management section was assigned to produce a field training manual, employing a programmed instruction format, to cover most situations. The development of the training program disclosed a number of unanswered questions about the system, and it was also evident that some activity definitions were inadequate or misleading.

Initial Implementation

Orientation meetings were held in each of the districts involved to familiarize the field supervisors and a selected number of the office staff with the system. The members of field staff were introduced to the training program and instructed on how it should be completed. The results of this effort were mixed; good results were achieved in two districts, and very poor results were achieved in the third. It was later established that less than 50 percent of the field supervisors had actually completed the training in the recommended way. The difference between the districts where good results had been achieved and the districts where results were poor appeared to be related to the attitude of the senior supervisors in the district. Apparently, smooth implementation could only be achieved with a positive attitude and effort on the part of senior supervisors.

The remaining 14 districts were scheduled to enter the system at the rate of two districts per month.

The maintenance management section felt strongly that a good introduction was the real key to success, and to this end a more structured method was developed to introduce other districts into the system. The important points considered were: (a) ensure that everyone was adequately trained; and (b) provide a good feedback system to the field supervisors after implementation of the system.

The main features of the training system were as follows:

1. The patrol supervisors in each district completed the programmed instruction course at a workshop conducted by a member of the training group;
2. The patrol supervisors then conducted similar workshops for their own patrolmen;
3. At the end of the first two-week period following implementation of the cost reporting system, a member of the training group checked all relevant documents submitted, noted errors and omissions, and returned the documents to the appropriate patrolmen for correction and resubmission;
4. At the end of the second two-week period, the documents were checked in similar fashion to ensure that the patrolmen were performing satisfactorily;
5. In cases where performance was considered unsatisfactory a member of the training group endeavored to visit patrolmen concerned; and
6. Thereafter, feedback to patrolmen became the responsibility of the district staff processing the documents prior to submission for data processing.

It is very important that the feedback to the individual supervisor be as positive as possible. The forms returned to the field for correction were annotated with a reinforcing comment. This approach was new to the field staff and the response was excellent. All 14 districts were brought into the system on schedule with very little further trouble.

Follow-Up

A survey was taken in May 1969 to determine the "state of the system." The following information was gathered:

1. The office staff of the various districts reported error rates from the field ranging from 36 to 800 instances. The average was 190.
2. The computer center reported error rates in the documents submitted by the districts, ranging from 5 to 125 instances. The average was 58.

Because the documents were routed through the district office for correction before being submitted to the computer center, this meant that on the average the district office was correcting 70 percent of the errors.

An examination of the methods used to keep the error rate down in each district suggested that the best results were achieved where a close line of communication existed between the office staff who handled the documents and the field staff who produced them. Where a third person, often a supervisor, was involved as a liaison between the office staff and the field staff, results were generally poor. In some districts there was a reluctance to allow the office staff to communicate with the field staff directly. It was therefore necessary to be quite specific about the nature of the communication before supervisors would agree to what they considered to be a by-passing of the normal channels.

Several interesting experiences were uncovered during the survey and are recounted here as a matter of interest. In one district, a comparison was made between two groups of patrolmen, one group considered to be well trained and the other poorly trained. From the error evaluation data shown in Figure 4, it can be seen that the number of errors committed in the first pay period was considerably higher among the poorly trained. Both groups, however, were subjected to intensive feedback at the end of the first pay period and, by the end of the second pay period, were performing equally well.

These results suggest that feedback during implementation was actually more important than the original training. The importance of the feedback is even more forcefully shown in this second example. In another district, the training program was well administered and all the patrolmen were performing satisfactorily by the end of the second pay period. Thereafter, the patrolmen received no feedback from the district office. This had a significant effect on their performance.

The error evaluation chart shows in Figure 5 that the error rate for the district was 153 at the end of the second pay period. With no feedback, the error rate climbed to 1,135 by the end of the fourth pay period.

		TRAINING	ERRORS AFTER 1ST PERIOD	FEEDBACK	ERRORS AFTER 2ND PERIOD
PATROL SUPERVISOR A CONSIDERED TO HAVE DONE A GOOD JOB OF TRAINING.	PATROL MAN 1				4
	2		16		0
	3		5		3
	4		3		6
	5		0		1
TOTAL			28		10
PATROL SUPERVISOR B CONSIDERED TO HAVE DONE AN INADEQUATE JOB OF TRAINING.	PATROL MAN 1		31		2
	2		55		2
	3		56		5
	4		44		0
	5		17		2
TOTAL			203		11

Figure 4. Error evaluation data.

At this stage, a feedback system was introduced that advised patrolmen as to the number of errors made but not the nature. The error rate dropped immediately but not to the original post-training level. This level was not attained until the patrolmen were advised as to the nature of their errors.

At the completion of the survey, a recommendation was made to all districts affording guidance on what should be considered as an acceptable error rate and the steps that should be taken if this was not achieved. The recommendations included steps to improve communications between the district field staff and the district office staff and between the district office and the computing branch. Four months after these recommendations were made, a further survey showed that the error rate had dropped by almost 75 percent and was well within the established guidelines. At this point the reporting system was felt to be fully implemented.

COMPUTER OUTPUT REPORTS

Since the beginning of the maintenance management project in 1965, many computer programs have been written, revised, or discarded in an attempt to provide clear and concise output information in a form suitable for use by field, district, and head office staff for planning, organizing, directing, and controlling maintenance operations.

Basically, the reports have been developed with the intention of providing the information required in the districts. Recently programs have been developed to summarize the district reports. These summaries facilitate comparison and evaluation of district activities by both head office and senior district personnel.

The following is a description of the basic reports as well as several related summary reports. The reports may be divided into three groups:

1. Those providing information required for planning and organizing summer maintenance operations on a district patrol level;
2. Those providing information on operating results for summer maintenance; and
3. Those providing information on operating results for winter maintenance.

Group 1 Reports

Report 5, Summer and Winter Maintenance Resource Expenditure, a typical example of which is shown in Figure 6, was developed to provide head office maintenance management staff with results of operations based on the various road types reported on the district patrol inventories. This report shows: ac-

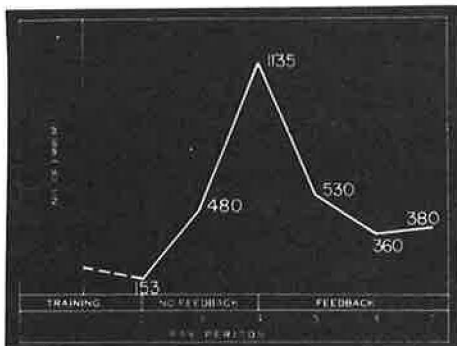


Figure 5. Error evaluation chart.

SUMMER AND WINTER MAINTENANCE RESOURCE EXPENDITURE											
DATE OF REPORT - MAR 22, 1970				REPORT 5				PAGE 14			
OPERATION 1001 - PATCHING-HAND TOOLS				DISTRICTS 1 TO 9							
				PERIOD STARTING - 69/ 3/28 ENDING - 69/12/5							
ROAD TYPE	MANAGEMENT UNIT	MILES	ACTIV	MAN-HOURS	DOLLARS	ACCOMPLISHMENT	MAN HRS PER MILE	DOLLARS PER MILE	ACCOMP PER MILE	MAN HRS PER ACCOMP	DOLLARS PER ACCOMP
DI	SU	PA									
25306	3	4	1	1001	26	110.00	2.0	0.00	0.00	13.00	55.00
25306	3	4	2	11,30	1001	206	1285.25	59.8	18.23	5.52	32.29
25306	3	4	4	1001	250	1284.55	38.4	0.00	0.00	6.51	33.45
25306	3	5	13	16,20	1001	70	287.80	4.8	4.32	17.76	59.95
25306	3	5	14	10,70	1001	16	52.00	0.0	1.49	-4.85	0.00
25306	DIST. 3 TOTALS		107,20	1001	571	3055.60	85.0	5.32	28.50	0.79	35.94
25306	4	1	5	12,20	1001	66	272.33	4.5	5.40	22.32	60.51
25306	4	1	6	9,20	1001	43	199.92	6.4	4.67	21.73	31.23
25306	4	2	28	4,50	1001	24	116.08	3.2	5.33	25.79	36.27
25306	4	3	14	31,70	1001	258	1404.15	31.6	8.13	44.29	44.43
25306	4	3	16	18,00	1001	148	756.95	25.7	8.22	42.05	29.45
25306	4	3	22	3,90	1001	164	728.97	15.5	42.05	186.91	47.03
25306	DIST. 4 TOTALS		95,90	1001	703	3478.40	86.9	7.33	36.27	0.90	40.02
25306	5	1	14	33,50	1001	16	92.55	3.0	0.47	2.76	30.85
25306	5	1	17	11,20	1001	16	157.61	11.4	1.42	14.07	13.82
25306	5	4	19	17,40	1001	192	990.37	27.5	11.03	56.91	36.01
25306	DIST. 5 TOTALS		71,30	1001	224	1240.53	41.9	3.14	17.39	0.58	29.60
25306	6	1	12	5,40	1001	12	50.92	0.4	2.22	9.42	127.30
25306	6	1	13	12,90	1001	8	26.24	0.0	0.62	2.03	0.00
25306	DIST. 6 TOTALS		24,80	1001	20	77.16	0.4	0.80	3.11	0.01	192.90
25306	7	2	4	40,60	1001	194	915.86	26.1	4.77	22.55	35.09
25306	7	3	5	3,00	1001	65	280.63	3.0	21.66	93.54	93.54
25306	DIST. 7 TOTALS		73,60	1001	259	1196.49	29.1	3.51	16.25	0.39	41.11

Figure 6. Report 5, summer and winter maintenance resource expenditure.

accomplishment quantities; man-hours; dollars expended for each activity per mile of road of a type maintained; productivity (man-hours per accomplishment unit); and unit costs (dollars per accomplishment unit), attained for each activity while working on each road type.

From this report, frequency distributions of production rates (accomplishment per equivalent 2-lane mile; man-hours per accomplishment unit) by road types expected to influence the rate are compiled. For example, a production rate for hand patching pot-holes on a 4-lane divided highway would be expected to be different from that on a 2-lane highway due to differences in crew sizes and equipment requirements.

A mode value (most frequently occurring production rate) is selected from the distribution. As a general rule, the mode production rate from reported data is suitable for planning and allocating resources. However, a production rate based on reported data will reflect all the inefficiencies in performance that may exist at the field level. If sufficient work measurement data are available, extra weight should be given to the data in determining the final production rates, inasmuch as the conditions under which the rate was achieved are known.

Report 12, Maintenance Resource Requirements, a typical example of which is shown in Figure 7, was developed to assist district managers and field staff in the preparation of their summer maintenance work plans and is produced annually. It is generated from information contained in the district road inventories—patrol, highway, road type, and number of equivalent 2-lane miles—and the standard values developed from Report 5—accomplishment per 2-lane mile, man-hours per accomplishment unit, and dollars per accomplishment unit.

The total accomplishment, total man-hours, and total dollars, appearing on the right of the report, are used as input for the planned values shown in Report 1B (Group 2 following) unless modified during the annual road inspection and subsequent balancing of the summer maintenance work load.

Group 2 Reports

Report 1B, Comparison of Actual to Planned Expenditure, was originally developed to provide district managers with the information necessary to control their summer maintenance work plans. Also, as a year end report, it does provide the district man-

DATE OF REPORT SEP. 25, 1969														PAGE 10					
PERIOD 25/04/70 TO 24/10/70														HIDE					
MAINTENANCE MANAGEMENT SYSTEM																			
MAINTENANCE RESOURCE REQUIREMENTS																			
PATROL SUPERVISOR GERRIE AMOS														REPORT 12			DISTRICT 20		
PATROL SUPERVISOR	REPORT	DATE	OPERATION	ACC. UNIT	MANHOURS	DOLLARS	MANHOURS	DOLLARS	TOTAL	TOTAL	TOTAL								
NUMBER	TYPE	MILES	DESCRIPTION	2-LANE MILE	ACC. UNIT	ACC. UNIT	/ EQUIV. 2-LANE MILE	/ EQUIV. 2-LANE MILE	ACCOMPL.	MANHOURS	DOLLARS								
2	72	253 3	13.1	1001	PATCHING-HAND TOOL	.4 TONS				6.800	47.83	5.2	35	249					
2	17	253 6	19.8	1001	PATCHING-HAND TOOL	.4 TONS				6.800	47.83	7.9	54	378					
2 OPER. TOTAL			32.9	1001		.4				6.793	47.86	2.7	19.05	13.1	89	627			
2	72	253 3	13.1	1002	PATCHING-GRADER	1.4 TONS				.720	13.96	18.3	13	255					
2	17	253 6	19.8	1002	PATCHING-GRADER	1.4 TONS				.720	13.96	27.7	20	387					
2 OPER. TOTAL			32.9	1002		1.4				.956	17.08	1.3	23.89	46.0	44	786			
2	17	253 6	19.8	1003	CRACK SEALING	.9 LANE MILES				8.400	64.35	17.8	150	1145					
2	72	253 3	13.1	1003	CRACK SEALING	.9 LANE MILES				8.400	64.35	11.8	99	759					
2 OPER. TOTAL			32.9	1003		.9				8.412	64.32	7.5	57.87	29.6	249	1904			
2	17	253 6	19.8	1004	SPRAY PATCHING	11.5 GALLONS				.240	1.97	227.7	55	449					
2	72	253 3	13.1	1004	SPRAY PATCHING	11.5 GALLONS				.240	1.97	150.7	36	297					
2 OPER. TOTAL			32.9	1004		11.5				.240	1.97	2.7	22.67	378.4	91	746			
2	92	601	111 3	16.1	1007	GRADING	24.0 PASS MILES			.370	5.49	386.4	143	2121					
2	601	111 3	16.1	1008	PATCHING-PT. TR.	16.3 CUBIC YARDS				.480	4.78	262.4	126	1254					

Figure 7. Report 12, maintenance resource requirements.

ager with sufficient information to assess the degree to which the summer maintenance work plans of individual field units, and the district as a whole, have been achieved.

Figure 8 shows a typical page from Report 1B. This report is organized primarily by patrol, then by operation. The data are presented in five primary groups—expenditure, man-hours, accomplishment, unit cost, and rate—each of which is subdivided into three subsidiary groups, actual, planned, and the ratio of actual to planned.

Report 1B, Summary 1, Comparison of Actual to Planned Performance, is a year-end report that supplements Report 1B. It was introduced to provide information whereby head office staff might identify and take action on possible problems in specific districts. It also provides information to district managers whereby they may compare the performance of their districts with that of others.

Figure 9 shows a typical page from Report 1B, Summary 1. The format of this report is very similar to that of Report 1B except that it is organized primarily by operation and district. The data are presented in identical form to that in Report 1B.

Report 8B, Summer Maintenance Resource Expenditure, is organized primarily by operation, then by patrol supervisor's area. The data consist of total charges (man-hours, dollars, and accomplishment) to date. Unit cost and productivity is also shown. Figure 10 is a typical page from Report 8B.

Report 8C, Other Agencies Resource Expenditure, was introduced to overcome a deficiency in the original design of the system, i. e., to provide district managers with detailed information on resources expended on activities other than routine maintenance operations, on a four-week basis.

Until last summer, only activities routinely carried out by maintenance forces were reported by operation. All other activities such as work on contracts, on special projects, and for other agencies were charged to a single operation number, without accomplishment. It became apparent that the resources expended on these activities represented a considerable proportion of the total; therefore, it was desirable that they be reported in a similar manner to the routine maintenance operations.

DATE OF REPORT DEC. 17, 1969															DISTRICT 20				
COMPARISON OF ACTUAL TO PLANNED EXPENDITURE																			
REPORT 1B																			
PATROL SUPERVISOR GERRIE AMOS															PERIOD STARTING 28/03/69			ENDING 07/11/69	
PAT	OPERATION CODE	DESCRIPTION	EXPENDITURE			MAN-HOURS			ACCOMPLISHMENT			UNIT COST			RATE				
			ACTUAL	PLANNED	A/P	ACTUAL	PLANNED	A/P	ACTUAL	PLANNED	A/P	ACTUAL	PLANNED	A/P	ACTUAL	PLANNED	A/P		
1	1001	PATCHING-HAND TOOL	746	1715	.43	144.0	362.0	.39	24.0	54.0	.44	31.08	31.75	.97	6.00	6.70	.89		
1	1003	CRACK SEALING		281						7.0		40.14				8.00			
1	1004	EPRAY PATCHING	1804	284	6.35	315.0	64.0	4.92	1464.0	360.0	4.06	1.23	.78	1.57	.21	.17	1.23		
1	1009	PATCHING ADDED TR.	86			16.0													
1	1090	OTHER	571			163.0													
1	2001	GRADING SHOULDER	1060	1250	.84	149.0	225.0	.66	402.0	500.0	.80	2.63	2.50	1.05	.37	.45	.82		
1	2002	SHOULDERING-PT TR.	988	180	5.48	118.0	16.0	7.37	228.0	50.0	4.56	4.33	3.60	1.20	.51	.32	1.59		
1	2004	DUST LAYING	320	4300	.07	14.0	200.0	.07	86.0	1000.0	.08	3.72	4.30	.86	.16	.20	.80		
1	2005	WASHOUTS	2440	1096	2.22	505.0	264.0	1.91											
1	2006	GRAVEL WINDROW	410	600	.68	126.0	160.0	.78	6040.0	10000.0	.60	.06	.06	1.00	.02	.01	2.00		
1	2990	OTHER	67			13.0													
1	3012	MOWING - 1 OR 2 SW.		78			16.0			31.0		2.51				.51			
1	3014	MOWING - HAND		32			6.0			1600.0		.02				.00			
1	3015	MOWING - WEEDS	412			136.0													
1	3018	WEED SPRAY-TRUCK		180			13.0			4500.0		.04				.00			
1	3026	BRUSH SPRAY		60			3.0			1000.0		.06				.00			
1	3031	LITTER PICK-UP	801	575	1.39	270.0	167.0	1.35	60.0	40.5	1.48	13.35	14.19	.84	3.66	4.00	.91		
1	3033	SWEEPING-MANUAL	189	188	1.00	56.0	50.0	1.12											
1	3041	RD. -PT. STANDARD	949	1744	.54	188.0	320.0	.58											
1	3042	RD. - PT. ABOVE	231			53.0													
1	4101	ROUTINE MAINT.	506	482	1.04	116.0	144.0	.80											

Figure 8. Report 1B, comparison of actual to planned expenditure.

DATE OF REPORT DEC 18, 1969															PAGE 1				
COMPARISON OF ACTUAL TO PLANNED EXPENDITURE																			
REPORT 1B SUMMARY 1																			
OPERATION 1001 PATCHING-HAND TOOL															PERIOD STARTING 69/03/28			ENDING 69/11/07	
ACCOMPLISHMENT UNITS - TONS																			
DISTRICT	ACTUAL	PLANNED	A/P	ACTUAL	PLANNED	A/P	ACTUAL	PLANNED	A/P	ACTUAL	PLANNED	A/P	ACTUAL	PLANNED	A/P	ACTUAL	PLANNED	A/P	
																			1
2	12343	12448	.99	2318.5	2654.0	.87	385.6	392.0	.98	32.00	31.75	1.00	6.01	6.77	.88				
3	10086	12383	.81	2042.0	2492.0	.81	258.0	390.0	.66	39.09	31.75	1.23	7.91	6.38	1.23				
4	36666	31725	1.15	7504.5	8380.0	.89	1251.2	1269.0	.98	29.30	25.00	1.17	5.99	6.60	.90				
5	16097	14451	1.11	3174.0	3168.0	1.00	389.0	455.0	.85	41.38	31.76	1.30	8.15	6.96	1.17				
6	29484	27324	1.07	6382.0	7028.0	.90	266.7	860.5	.30	110.55	31.75	3.48	23.92	8.16	2.93				
7	14208	26832	.52	2832.0	5668.0	.49	453.6	845.0	.53	31.32	31.75	.98	6.24	6.70	.93				
8	55863	41119	1.35	10984.0	8673.0	1.26	1869.7	1295.0	1.44	29.87	31.75	.94	5.87	6.69	.87				
9	37325	25214	1.48	8152.5	5322.0	1.53	714.8	794.0	.90	52.21	31.75	1.64	11.40	6.70	1.70				
10	89887	155766	.57	15700.5	19985.0	.78	3500.5	4906.0	.71	25.67	31.75	.80	4.48	4.07	1.10				
11	50972	46174	1.10	10468.5	10517.0	.99	1470.8	1569.7	.93	34.65	29.41	1.17	7.11	6.70	1.06				
13	71665	84364	.84	14467.0	15144.0	.95	2553.0	2657.0	.96	28.07	31.75	.88	5.66	5.69	.99				
14	59556	105497	.56	10077.5	12313.0	.81	2795.7	3459.0	.80	21.30	30.49	.69	3.60	3.55	1.01				
16	24750	14734	1.67	4453.0	2505.0	1.77	932.8	464.0	2.01	26.53	31.75	.83	4.77	5.39	.88				
17	32141	24988	1.28	6231.5	5276.0	1.18	1012.6	787.0	1.28	31.74	31.75	.99	6.15	6.70	.91				
18	42882	22400	1.91	8936.5	5342.0	1.67	1034.9	800.0	1.29	41.43	28.00	1.47	8.63	6.67	1.29				
19	31957	32927	.97	6137.5	6919.0	.88	867.4	1037.0	.83	36.84	31.75	1.16	7.07	6.67	1.05				
20	57986	51948	1.11	8424.5	7230.0	1.16	2910.2	1645.5	1.76	19.92	31.56	.63	2.89	4.39	.65				
TOTALS	679398	735821	.92	129414.0	129783.0	.99	22806.3	23799.7	.95	29.78	30.91	.96	5.67	5.45	1.04				

Figure 9. Report 1B, Summary 1, comparison of actual to planned expenditure.

DATE OF REPORT DEC 12, 1969		SUMMER MAINTENANCE RESOURCE EXPENDITURE							PAGE 3036	
		REPORT 8B								
OPERATION 1001 PATCHING-HAND TOOL		DISTRICT 20							PERIOD STARTING 28/03/69	ENDING 07/11/69
	PATROL	TOTAL MAN HOURS	TOTAL DOLLARS	ACCOMPLISHMENT TONS	UNIT COST DOLLARS PER TON	PRODUCTIVITY MAN HOURS PER TON	USAGE TONS PER 2-LANE MILE	EXPENDITURE DOLLARS PER 2-LANE MILE		
SUPERVISOR	CERIE AMOS	1	144	749	24	31.23	6,000	.45	14.16	
		2	33	144	1	96.08	22,000	.03	4.38	
		3	673	4002	157	25.49	4,286	4.13	105.32	
		4	351	1980	65	30.23	5,358	1.96	59.82	
	SUPERVISOR 1 TOTALS		1201	6877	248	27.72	4,862	1.58	43.83 *	
SUPERVISOR	ERIC WICKS	5	221	1237	47	26.32	4,712	1.03	27.07	
		6	30	201	10	20.13	3,000	.30	6.04	
		7	301	1726	64	26.76	4,666	1.16	31.32	
		8	64	340	12	28.35	5,375	.28	7.87	
	SUPERVISOR 2 TOTALS		617	3505	133	26.25	4,621	.75	19.77 *	
SUPERVISOR	ALEX SCRIBBLI	9	121	831	42	19.78	2,892	1.05	20.72	
		10	964	6931	595	11.64	1,618	16.08	187.32	
		11	536	4208	214	19.66	2,504	6.15	120.92	
		12	899	8337	516	16.15	1,743	36.60	591.28	
		13	1121	8917	465	19.17	2,411	21.73	416.68	
	SUPERVISOR 3 TOTALS		3643	29226	1832	15.94	1,987	12.43	198.28 *	
SUPERVISOR	ARNOLD MCLEAN	14	870	5191	174	29.74	4,988	5.88	175.37	
		15	170	934	28	33.37	6,071	1.07	35.79	
		16		"						
		17	21	141	3	47.07	7,000	.05	2.54	
	SUPERVISOR 4 TOTALS		1062	6275	205	30.53	5,165	1.42	43.58 *	
SUPERVISOR	BILL HAMILTON	18	687	4231	158	26.77	4,348	5.39	144.40	
		19	8	39	1	39.06	8,000	.05	1.88	
		20	650	4399	199	22.10	3,268	11.99	265.00	
		21	557	3604	132	27.16	4,197	4.46	121.76	
	SUPERVISOR 5 TOTALS		1903	12275	490	25.01	3,877	5.09	127.60 *	
	OPERATION 1001 TOTALS		8425	58158	2910	19.98	2,694	4.03	80.57 **	

Figure 10. Report 8B, summer maintenance resource expenditure.

Figure 11 shows a typical page from Report 8C. This report is organized primarily by operation, then by contract or project. The data are otherwise presented in the same form as in Report 8B. The information contained in this report is generally self-explanatory although the second column may require clarification.

Activities carried out for other agencies are identified by a fifth digit which precedes the basic operation number. Five basic prefixes used are given in Table 1.

Group 3 Reports

Report 8, Winter Maintenance Resource Expenditure, is primarily organized by patrol, then by operation. Figure 12 shows a typical page from Report 8.

Report 8A, Winter Maintenance Resource Expenditure, is organized primarily by operation and then by patrol. A typical page is shown in Figure 13. The information contained in this report is generally self-explanatory although three of the columns may require clarification.

Consider the first line entry. In the second column, the figure "2" indicates that Patrol 1 operates with a two-shift system. A "1" or a "3" would indicate a single or a three-shift system. In the

TABLE 1
PREFIX CODE USED IN REPORT 8C

Prefix Code	Description
5	Sundry and engineering on capital contracts
6	Sundry and engineering on ordinary contracts
7	Other agencies, municipalities, connecting links, other government departments and agencies, private organizations, etc.
8	Capital day labor
9	Ordinary day labor

DATE OF REPORT - FEB. 21, 1970											PAGE 676	
OTHER AGENCIES RESOURCES EXPENDITURE												
REPORT 8C												
DISTRICT - 11											PERIOD STARTING - 28/03/69	ENDING - 05/12/69
CONTRACT NUMBER	OPERATION NUMBER	DESCRIPTION	REGULAR	MAN-HOURS OVERTIME	TOTAL	EQUIPMENT REGULAR	-HOURS HIRED	TOTAL DOLLAR EXPEND	ACCOMPLISHMENT QUANTITY	UNITS	DOLLARS PER ACCOMP UNIT	
6765	51001	PATCHING-HAND TOOL	64.0		64.0	8.0		269.94	12.0	TONS	22.49	
6765	TOTAL		64.0		64.0	8.0		269.94				
		TOTAL EXPENDITURE MINUS STOCKPILE MATERIAL						225.36				
6997	51001	PATCHING-HAND TOOL	16.0		16.0	4.0		79.12		TONS		
6997	TOTAL		16.0		16.0	4.0		79.12				
		TOTAL EXPENDITURE MINUS STOCKPILE MATERIAL						64.26				
67154	51001	PATCHING-HAND TOOL	24.0		24.0	16.0		298.38	23.5	TONS	12.69	
67154	TOTAL		24.0		24.0	16.0		298.38				
		TOTAL EXPENDITURE MINUS STOCKPILE MATERIAL						123.78				
68123	51001	PATCHING-HAND TOOL	99.0		99.0	16.0		442.40	11.5	TONS	38.46	
68123	TOTAL		99.0		99.0	16.0		442.40				
		TOTAL EXPENDITURE MINUS STOCKPILE MATERIAL						356.95				
68124	51001	PATCHING-HAND TOOL	167.0		167.0	31.0		819.92	30.0	TONS	27.33	
68124	TOTAL		167.0		167.0	31.0		819.92				
		TOTAL EXPENDITURE MINUS STOCKPILE MATERIAL						597.01				
68157	51001	PATCHING-HAND TOOL	296.0	8.0	304.0	79.0	5.0	1491.03	39.0	TONS	38.23	
68157	TOTAL		296.0	8.0	304.0	79.0	5.0	1491.03				
		TOTAL EXPENDITURE MINUS STOCKPILE MATERIAL						1238.41				
68178	51001	PATCHING-HAND TOOL	12.0		12.0	2.0		86.98	4.0	TONS	21.74	

Figure 11. Report 8C, other agencies resources expenditure.

DATE OF REPORT MAY 03, 1970											PAGE 8	
WINTER MAINTENANCE RESOURCE EXPENDITURE												
REPORT 8												
PATROL SUPERVISOR GERRIE AMOS PATROL 8 DISTRICT 20											PERIOD STARTING 20/06/69	ENDING 27/3/70
OPERATION	MAN-HOURS			RATIO OF OVERTIME	EQUIPMENT	HIRED	TOTAL	ACCOMPLISHMENT	RATIO OF			
CODE	DESCRIPTION	REGULAR	OVERTIME	TOTAL	TOTAL HRS	HOURS	DOLLAR EXPENDITURE	QUANTITY	UNIT	DOLLARS OVER ACCOMP. UNIT		
27011	PLOWING TRUCK	383	114	497	.23	260	5059	4443	PASS MILES	1.13		
27012	WINGING BACK TRUCK	144		144		72	1474	872	PASS MILES	1.69		
27013	PLOWING GRADER	107	9	116	.07	123	1038	1110	PASS MILES	1.65		
27014	WINGING BACK GRAD	52		52		52	783	344	PASS MILES	2.27		
27016	SNOW REMOVAL	1103		1103		164	4027					
27018	DRAINAGE	185		185		37	770					
27019	ICE BLADING	63		63		63	970	306	PASS MILES	3.17		
27012	SANDING SPREADER					117	131	2430	441	CU. YD.	5.51	
27022	SANDING PAT TRUCK						13	5	CU. YD.	2.66		
27023	SPOT SANDING	38		38		29	5	346	50	CU. YD.	6.92	
27031	SALTING SPREADER	4		4		78	109	6176	249	TONS	24.77	
27032	SALTING PAT TRUCK	36		36		26	624	21	TONS	29.74		
27033	SPOT SALTING	11		11		13	7	532	19	TONS	28.03	
27050	ROUTINE INSPECTION	647	24	671	.03	655	3355					
27061	STANDBY DAY	485	5	490	.01		1695					
27062	STANDBY NIGHT	378		378			1277					
27070	STANDBY HIRED						1224					
27081	NON-OPERATING TIME						7	45				
WINTER MAINTENANCE TOTALS		3637	152	3789	.04	1691	260	32646				

Figure 12. Report 8, winter maintenance resource expenditure.

DATE OF REPORT MAY 04, 1970													PAGE 716
WINTER MAINTENANCE RESOURCE EXPENDITURE													
REPORT B A													
OPERATION 27011 PLOWING TRUCK					DISTRICT 13			STARTING 20/06/69 ENDING 27/03/70					
PAT	SHIFT SYSTEM	STAFF	MAN HOURS REG.	HOURS OVERTIME	MAN HOURS TOTAL	OVERTIME OVER TOTAL	EQUIPMENT HOURS	HIRED EQUIPMENT HOURS	TOTAL DOLLARS	ACCOMPLISHMNT PASS MILES	UNIT COST DOLLARS PER PASS MILE	FREQUENCY PASS MILES PER LANE MILE	EXPENDITURE DOLLARS PER 2-LANE MILE
SUPERVISOR R. E. PENTON													
1	2	14	1486	520	2006	.25	1120		17766	18584	.95	146.3	279.78
3	2	17	1171	537	1708	.31	855		15435	12998	1.18	73.0	173.43
7	2	11	904	554	1458	.37	848		12783	14541	.87	184.5	324.44
SUPERVSR 1 TOTALS			3561	1611	5172	.31	2823		45984	46123	.99	120.2	239.62 *
SUPERVISOR J. A. LEPAGE													
5	2	9	635	416	1051	.39	576		9437	9214	1.02	94.0	192.59
6	2	14	845	623	1468	.42	829		14154	15511	.91	117.7	214.78
14	2	13	860	579	1419	.40	711		12999	11788	1.10	86.7	191.16
15	2	6	201	55	256	.21	174		2049	2818	.72	47.1	68.53
SUPERVSR 2 TOTALS			2521	1673	4194	.39	2290		38639	39331	.98	92.4	161.57 *
SUPERVISOR R. KRIEC													
8	2	6	271	75	346	.21	280		3114	3921	.79	59.1	93.80
9	2	10	464	313	777	.40	504		7509	8852	.84	98.6	167.24
11	2	14	650	557	1207	.46	858		11924	17560	.67	134.9	183.16
12	1	22	770	443	1213	.36	731		10687	12058	.88	176.3	312.49
16	2	13	1227	732	1959	.37	1002		18377	20770	.88	182.2	322.40
18	2	6	262	83	345	.24	261		2933	4273	.68	65.5	89.97
SUPERVSR 3 TOTALS			3644	2203	5847	.37	3636		54544	67434	.80	126.3	204.28 *
27011 TOTALS			9740	5487	15227	.36	8749	4	139252	157898	.88	117.5	207.31 **

Figure 13. Report 8A, winter maintenance resource expenditure.

seventh column the ratio ".25" indicates that 25 percent of the operation in question was carried out during overtime. In the twelfth column, the figure "146.3" signifies that the number of pass miles per lane-mile plowed was the equivalent to covering the complete patrol 146 times during the winter season.

Report 8A, Summary 1—Winter Maintenance Resource Expenditure, is a year-end report that supplements Report 8A and was developed for the same reason as the Summary to Report 1B. It provides information whereby head office staff may identify and take action on possible problems in specific districts. It also provides information to district managers whereby they may compare the performance of their districts with that of others.

Figure 14 shows a typical page from Report 8A, Summary 1. The format of this report is very similar to that of Report 8A.

Reports 1B, 8B, and 8C for summer maintenance and Reports 8 and 8A for winter maintenance were developed originally as monthly reports to assist the districts in controlling both the work and expenditure within the districts. There is, however, a considerable delay in receiving the information. In most cases, the individual operations are completed by the time the reports are received. It is too late to take any remedial action. (However, the data are used in the planning of operations for the next summer maintenance season.)

Starting in the fall, these reports will therefore be issued at the completion of either summer or winter maintenance only. Two basic reports organized by operation are being prepared, one for summer and one for winter maintenance. These reports will be issued monthly during their respective seasons, and should provide the districts with the required information currently presented in the summer reports 8B and 1B, and winter reports 8 and 8A.

DATE OF REPORT MAY 06, 1970												PAGE 1
WINTER MAINTENANCE RESOURCE EXPENDITURE												
SUMMARY 1 TO REPORT 8A												
OPERATION 27011 PLOWING TRUCK						PERIOD STARTING 69/06/20 ENDING 70/03/27						
DIST	SHIFT STAFF	MAN-HOURS		MAN HOURS	OVERTIME	EQUIPMENT	HIRE	TOTAL	ACCOMPLISHMENT	UNIT COST	FREQUENCY	EXPENDI-
		REGULAR	OVERTIME	TOTAL	OVER	HOURS	EQUIPMENT	DOLLARS	PASS MILES	DOLLARS	PASS	TURE
					TOTAL		HOURS			PER	MILES	DOLLARS
										PASS MILE	PER	2-
											MILE	TANF
												MILE
1	148	9687	4644	14331	.32	8407		126045	139020	.90	95.1	172.38
2	218	11786	6541	20327	.32	11079		185870	169992	1.09	117.2	256.37
3	247	23910	5655	29565	.19	13724		270395	248052	1.09	177.0	385.81
4	400	12283	5592	17875	.31	9822		160370	142219	1.12	75.8	171.08
5	319	30051	4224	34275	.12	16874		337707	271127	1.24	706.4	514.09
6	492	18811	10169	28980	.35	13100		239378	163317	1.46	83.0	243.39
7	258	12810	5267	18077	.29	8856		164297	163138	1.00	114.9	231.44
8	286	15802	12532	28334	.44	13550		248990	223346	1.11	119.4	266.12
9	274	19117	5128	24245	.21	11743		207074	214112	.96	127.2	245.96
10	127	9683	3777	13460	.28	6786		120253	109543	1.09	81.9	179.76
11	177	13881	6593	20474	.32	10717	373	197776	173046	1.14	126.5	289.13
13	155	9726	5487	15213	.36	8749		139167	152888	.91	113.8	207.19
14	138	11998	3402	15400	.22	7289		133875	113729	1.17	65.5	154.15
16	107	5321	2771	12092	.22	6412		106790	135528	.78	113.2	178.39
17	158	14233	7758	21991	.35	12202		195071	190672	1.02	121.3	248.27
18	163	14289	6040	20329	.29	11630		180058	200008	.90	123.1	221.61
19	168	16980	5633	22613	.24	12946		210278	253292	.83	109.6	181.95
20	123	6619	894	7513	.11	3784		68688	65104	1.05	33.1	69.85
TOTAL	3958	262987	102107	365094	.27	187670	373	3292082	3128133	1.05	108.2	227.81

Figure 14. Report 8A, Summary 1, maintenance resource expenditure.

Analyzing Reports in the Field

The patrol supervisors and the patrolmen use the reports in the following manner:

1. To compare individual patrol achievement with that of adjacent patrols. This enables field management staff to review unit costs, efficiency, and productivity;
2. To analyze differences in achievement, comparing methods of work and effect of various crew sizes and equipment complements; and
3. To review and compare work remaining records, thus maintaining a control of the quantity of work performed on individual operations.

Analyzing reports encourages the patrol supervisors to meet with their patrolmen and review ways and means of improving methods of work. There has been a generally increased interest in efficiency among the field staff as a result of receiving this information on cost awareness.

Analyzing Reports in the District

The district management is using the reports in the following manner:

1. To compare achievements of individual patrols and patrol supervisors' areas;
2. To ensure that the field staff are adhering to planned work load and to review where there are discrepancies;
3. To observe low-costing and expensive operations and to review operations in the field to ensure that patrols are adhering to quality standards;
4. To compare efficiency and productivity with similar districts within the province;
5. To control and compare service-crew operations such as zone painting and forestry; and

6. To plan work load, staff, equipment, and financial requirements for the following season.

Analyzing Reports at Head Office

The head office maintenance staff is using the reports in the following manner:

1. To compare efficiency and management of the different districts;
2. To determine standard values for each operation and related monetary requirements;
3. To use standard values and road code types in determining staff and equipment requirements for individual patrols, areas, and districts;
4. To assess reconstruction requirements in light of current maintenance expenditures for individual roads;
5. To review and compare different methods, staff, and equipment complements for particular operations and thus recommend the most suitable methods and complements;
6. To compare costs by day labor with costs of contracting various operations; and
7. To review service-crew operations and determine staff and equipment requirements.

With reference to some of these uses, the following is a more detailed description, including some of the results experienced.

Staff Requirements

The computer output report 12 provides the total man-hour requirements of a patrol, including both routine work and overheads such as vacation and sick leave. This total-hours figure is compared with the actual total man-hours available. The difference gives the number of man-hours surplus or deficient within the work unit and is easily translated into numbers of men by dividing the difference by the total hours available per man. This method of calculation of work-unit staffing may be used to calculate the provincial staff requirements.

A second method is used to recalculate a specific district or portion of a district that has been reorganized. This method involves a calculation of the man-hours required per mile of each road type on the patrol(s) multiplied by the miles of road, to which is added the usual overheads. This total man-hours is divided by the number of hours available for work per man, giving the number of men required on the patrol.

Both of these methods are based on the latest mode values, which are determined from data in other reports. As a result of this system of calculating staff requirements there has been a substantial reduction in the department's field maintenance forces with little impact on the level of service provided to the motoring public. The reduction has taken place largely by means of attrition together with transfers of personnel where feasible.

Winter Shift Systems

Prior to the study, the department had seven types of shift systems. The use of specific shift systems was based almost entirely on an evaluation of need by the individual districts. The study reduced the number of shift systems to three basic types. The actual manpower and equipment complements used criteria such as snowplow speed, the rate of snow fall in inches per hour, and the maximum allowable accumulation on the road, which was an expression of the traffic volume with the following formula being derived: number of plows equals lane miles of road divided by plow speed (mph), multiplied by maximum allowable accumulation (in.) divided by snowfall rate (in./hr).

The equipment complement for each patrol was calculated by computer and adjusted where necessary to take into account a number of parameters, such as very severe snow-belt areas and very high traffic volumes. The cost savings are difficult to assess due to the variations in winter severity, although the winter maintenance staff was reduced by about 20 percent. Approximate savings in wages are given in Table 2.

The winter maintenance output reports referred to elsewhere in this paper are being further refined but currently provide management with useful data on the unit cost of

the major winter maintenance activities—snowplowing, sanding, salting, and routine inspection. Ratios of regular man-hours expended compared to overtime will point out where more economies may be realized. Analysis of these data is really just beginning and, with a computer-oriented system, the ways in which data can be manipulated are unlimited. It is expected that the information system will provide the data necessary to refine further winter maintenance practices and continue to provide the level of service currently existent.

Patrol and District Boundaries

In determining the recommended patrol staff, the total was usually selected by rounding the required staff to the nearest whole number. Due to the rounding process, the recommended staff usually increased slightly over the required total. This surplus was reviewed together with such aspects as two crews working out of the same yard and future changes in the highway system, with the result that patrol mileages and even district boundaries were adjusted to approach more closely the actual staff complement required. The adjustment in patrol and district boundaries has decreased the number of patrols by about 12 percent while total mileage increased by approximately 5 percent during the same time span.

Equipment Complements

A further use of the information reporting system is in the calculation of optimum equipment complements. Historically, the patrol boundaries have received the same for both winter and summer operations. With the use of calibrated, geared-to-the-road spreaders and standard rates of application of chemicals and abrasives, it has been determined that considerable economies can accrue in the total fleet complement. It is apparent that a summer patrol boundary is not necessarily the optimum turnaround point for a sand spreader, nor are patrol years necessarily the optimum location for stockpiles of abrasives. These adjustments are continuing to take place, with new computer programs being written, which will calculate the optimum spreader complement or the optimum stockpile location or both.

The information-reporting system has indicated other areas where the equipment complement can be determined more objectively. An example is the number of graders used for the maintenance of gravel surfaces. Standard values have been produced by which the number of grader operators have been allocated. Comparisons of actual to planned performance provide management with an objective basis for control of the operation.

It has not been possible to quantify precisely the economic benefit to the department from implementation of the maintenance management system, but an order of magnitude can be established. A reduction in the winter maintenance staff by 10 percent with a similar reduction in the summer staff is in part due to the information system as is the reallocation of equipment for more effective use. As the information system is further refined, it is expected that many additional efficiencies will be introduced.

Problems Encountered

During the implementation of the system, the department became aware of various problems and some modifications were required. The following sections will explain some of the problems and the solutions that have been introduced or proposed.

Field Information—The field documents originally had to be completed in duplicate to satisfy fiscal requirements, as well as the maintenance system.

The documents were then forwarded to the electronic computing branch at head office for keypunching. This created a large backlog of keypunching in head office, as well

TABLE 2

LABOR SAVINGS TO THE DEPARTMENT THROUGH
REDUCTION OF WINTER STAFFING LEVELS

Year	Staff Reduction	Avg Hours in Winter Season	Avg Hourly Rate (\$)	Savings to Dept. (\$)
1967-68	470	862	2.38	964,230
1968-69	914	802	2.80	2,200,030
1969-70	986	862	3.00	2,549,800
Total				5,720,060

as extra work for the field and district staff. By introducing equipment in the district offices to keypunch cards to the bookkeeping machines, this problem in the head office and the duplication of documents was eliminated.

Each line entry from the documents still had to be keypunched separately resulting in a heavy work load for the district keypunch operators and payroll section. For this reason, new documents were devised and introduced in a trial area. The trial area is presently being expanded to include three districts. The documents appear to have substantially reduced the work and time requirements in the district office as well as making it more convenient for the field staff to complete the documents, which are:

1. Attendance and Pay Document—This form verifies attendance and hours worked or time off and reason. The form is so simple that all employees can fill it in thereby lessening the patrolman's paperwork. Because no distribution is shown, the fiscal processing by the payroll section can proceed uninterrupted. An example is shown in Figure 15.

2. Checksheet—This is a working form on which the total hours available for work can be checked against the hours distributed (Fig. 16).

3. Posting Document—This document made out by operation by highway, shows total man-hours, equipment hours, material used, accomplishment, and hired equipment. Because all information can be totalled for the period, keypunch entries are reduced by approximately 80 percent (Fig. 17).

These three forms replace six forms that are currently being completed in the non-test areas and substantially reduce the posting and keypunching in the district offices. The time reported on these forms is broken down by operation and day or shift.

Computer Reports—As mentioned previously there is a considerable delay in the reports being forwarded to the districts (approximately 6 weeks after the end of a pay period). Some modifications in existing programs and the new posting documents should reduce this period to 4 or 5 weeks.

Since the reports have this time delay, the use of the work remaining form is the principal means of controlling the maintenance operations. The new documents will also assist in providing the current status and necessary control.

Scheduling—The department has had varying degrees of success in scheduling. Scheduling has always been done in one form or another, so when it was decided to write up a schedule the week before, a number of deficiencies came to light. The main complaint was that a written schedule required constant changing as a result of weather, equipment breakdown, sickness, and emergencies. These constant changes proved to be the exception rather than the rule and the main solution to scheduling is through training and follow-up. Patrols that have little or no scheduling problems have discovered the merits of scheduling in efficiency and lower cost. Revisions to the form are being considered and it is anticipated that, with continuing effort, all districts will find continuing advantage in increasing the efficiency of the organization.

In order to minimize a scheduling change, all the maintenance groups in a district must schedule their work (i. e., the field mechanics working out of a district garage, the service crews, sign-shop crews, etc.). The district management should also maintain a control of emergency-type interruptions.

Road Inspections—Originally the patrol supervisor and patrolman performed a detailed inspection of each road in the fall, noting all operations that would be required the following summer. This procedure occupied considerable time. The detail also proved to be unrealistic and impractical. The procedure has been changed so that only unusual or particular requirements are reviewed at the site. The routine operation requirements are determined from the previous summer's work, the mode values, and the field supervisor's knowledge of road conditions.

QUALITY STANDARDS

A quality standards panel which had been set up prior to the last report (1968) continued to draft, approve, and issue standards of maintenance for highway surfaces, shoulders, and various other elements of right-of-way. There has been some question

PAY PERIOD				DAY	MONTH	YEAR	TO	DAY	MONTH	YEAR	CLASSIFICATION	GIVEN NAME				INIT.	SURNAME				VEHICLES OPERATED									
BOX/HSE/APRT. NO.				STREET/H.R. NO.				RESIDENCE	MAILING ADDRESS				CITY AND PROVINCE				I hereby certify that the below overtime was authorized by me				THIS PERIOD									
BASE SECT. NO.				EMPLOYEE'S SIGNATURE												APPROVED BY					EMPLOYEE'S SUPERVISOR				SUPERVISOR'S IMMEDIATE SUPERIOR				TYPE NO. TYPE NO. TYPE NO. TYPE NO.	
SECT. NO. IF OTHER THAN BASE	DESCRIPTION OF WORK	EXPENDITURE ACCTS. CODES	DATE	DAYS	S	S	M	T	W	T	F	S	S	M	T	W	T	F	TOTAL HOURS	NORMAL HOURS RATE	AMOUNT	OVERTIME PAID OR ACCRUED HOURS CREDITED	RATE	AMOUNT	REASON FOR OVERTIME PLEASE SHOW DATES					
			N O	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/												
			N O	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/												
			N O	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/												
			N O	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/												
			N O	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/												
			N O	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/												
			N O	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/												
			N O	/	/	/	/	/	/	/	/	/	/	/	/	/	/	/												
TOTAL NORMAL TIME WORKED																														
NON-WORKING TIME		HOURS																												
		INSERT TIME OFF CODE																												
SHIFT SUSPENSE WORKED OR TAKEN																														
CIRCLE HOURS WORKED																														
BALANCE																														
NEW EMPLOYEE	OVERTIME ENTER TIME WORKED	FROM																												
TERMINATED		TO																												
REHired																														
FB-5A-129 69-5218 EMPLOYEE TIME SHEET				HOURS CREDITED																										
												TOTAL OVERTIME WORKED																		
												CREDITED																		
												OFFICE USE ONLY				TIME OFF SUMMARY														
																CODES	DAYS/HRs WITH PAY	DAYS/HRs W/OUT PAY	DATES											
																STAT. OR SPEC. HOLS.	1	/	/											
																ILLNESS	3	/	/											
																VACATION	4	/	/											
																LEAVE OF ABSENCE	5	/	/											
																TIME OFF FOR O/TIME	3	/	/											
																W C B	W	/	/											
																MISC. EXPLAIN	4	/	/											

Figure 15. Employee time sheet.

MAINTENANCE EMPLOYEES DAILY CHECK SHEET													
PATROL _____		Day _____					Date _____		Shift _____				
VERIFICATION OF OPERATIONS PERFORMED EMPLOYEES SIGNATURE	TIME		HWY.	WORK PERFORMED OPERATION NO.	HOURS	DEPARTMENT VEHICLE NO.	HOURS	ACCOMPLISHMENT	TYPE OF MATERIAL	QUANTITY OF MATERIAL	BALANCE		
	IN	OUT									HWY.	OPERATION	HOURS
1													
2													
3													
4													
5													
6													
7													
8													
ENSURE Your LOANED IN AND OUT TIME IS REPORTED						TOTALS MUST AGREE							

Figure 16. Daily check sheet.

DEPARTMENT OF HIGHWAYS, ONTARIO
BI-WEEKLY PERIOD MAINTENANCE POSTING DOCUMENT

SHIFT NO. _____
PATROL / CREW NO. _____
CONTRACT, PROJ. E. F. NO. NO. _____

PERIOD ENDS DATE: DAY MONTH YEAR DIST. WORK DONE ON PAT. HWY. NO. OPERATION NO.

DATE	S	S	M	T	W	T	F	S	S	M	T	W	T	F	TOTAL HR. WORKED	DISTRIB. O.Y. HOURS	STD. LABOUR RATE	OVERTIME	TOTAL LABOUR DOLLARS				
NORMAL																							
OVERTIME																							
ACCOMPLISHMENT														EST. ACCON.									
UNITS	QUANTITY													EST. CODE		TOTAL ESTON.							
MATERIALS														TOTAL STOCKPILE AND PREP. DOLL.									
MATERIAL TYPE	QUANTITY													MTL. CODE		UNIT COST		TOTAL PAYROL AND PURCHASE DOLL.					
D.H.O. EQUIPMENT														TOTAL STOCKPILE AND PREP. DOLL.									
EQUIPMENT NO.	EQUIPMENT HOURS													REMARKS		CLASS CODE		TOTAL DHD. EQUIP. HR.		RENTAL RATE		TOTAL DHD. EQUIP. \$	
HIRED EQUIPMENT														TOTAL STOCKPILE AND PREP. DOLL.									
CLASS CODE	EQUIPMENT HOURS													REMARKS		CLASS CODE		TOT. HIRED EQUIP. HR.		STD. EQUIP. RATE		TOT. HIRED EQUIP. \$	

FOR MAINTENANCE MANAGEMENT USE

TOT. LABOUR DOLLARS	TOT. MTL. DOLLARS	TOT. D.H.O. EQUIP. DOLLARS	TOT. HIRED EQUIP. DOLLARS	TOTAL DOLLARS	EST. ACCON.	DOLLARS PER RECOM. UNIT	TOTAL MAN-HOURS	TOT. ACCON.	MAN-HOURS PER ACCON.
---------------------	-------------------	----------------------------	---------------------------	---------------	-------------	-------------------------	-----------------	-------------	----------------------

Figure 17. Bi-weekly period maintenance posting document.

as to degree of standard by various field personnel and these standards are currently undergoing revision. New standards are also being drafted for discussion by the panel.

OPERATING INSTRUCTIONS

In order to assist in establishing standard values for planning, methods of operations are being observed and evaluated. A number of operating instructions are being tested in various parts of the province. These instructions were the result of interviews with district personnel, studies and methods performed by other agencies, and various surveys. It is hoped that at the end of the current summer maintenance season, these instructions will again be reviewed and assessed with the view to standardization of method.

URBAN FREEWAY OPERATIONS

The usual methods of calculating efficient crew and equipment complements, explained before, were found to be unacceptable for urban freeways (Toronto area has approximately 250 equivalent 2-lane miles of freeway, six or more lanes divided or undivided).

The head office maintenance management staff is currently undertaking a study of patrol functions in the freeway area to detail the total involvement of maintenance work, methods and standards, etc. This study is in the initial stages at present and may not yield concrete results for another maintenance season.

CONCLUDING REMARKS

Fifteen months have passed since the Ontario maintenance management system was fully implemented in all districts of the province. Although substantial progress has been made in fulfilling most of the objectives of the system, the major progress has been achieved in the new reporting system and the benefits derived from the information reported. This has resulted in an updating of standard values related to productivity and quantities of work which are essential for planning purposes. Field crews are now proficient in the use of the reporting forms; errors continue to arise, but their frequency has now declined to the point where those made can be tolerated.

Several reports, including those prepared by electronic data processing, are being distributed to district managers in order that they can monitor performance in their own district. District personnel, however, continue to express concern regarding the volume of reports and the lack of time to study them. This area will receive attention in the future to ensure that reports are received in time to take effective action. It is inevitable, however, that feedback will be delayed because field crews report biweekly and processing at head office and the electronic computing branch requires further time. New reporting documents are being tested, however, that have the facility of providing district managers with more rapid feedback.

A staff reduction program, resulting from information obtained from the reporting system and other elements of the maintenance management system, has been under way since 1968. A reduction of 10 percent has so far been possible due to information brought to light by the new reporting methods.

Certain voids and gaps in the system flow have yet to be resolved. One example is the fact that the maintenance budget is not yet prepared from the reported data. This is not possible at the present time because the personnel reporting through the system represent only 65 percent of the total maintenance expenditure. The remaining 35 percent is incurred by electrical and sign-shop crews, unabsorbed garage overhead, and major maintenance projects such as hot mix patching, gravel, liquid calcium chloride, surface treating, and mulch paving. It is intended to incorporate these items into the planning process of the system in the near future.

In the meanwhile improved methods of training and communication are being implemented and further refinements will undoubtedly take place as maintenance personnel become more conversant with the principal aims of the program. Overall response to the demands of the system is generally well received and it is anticipated that gradually

all the participants in the province's maintenance management system will eventually contribute more, as interest increases and new standards of maintenance are achieved.

ACKNOWLEDGMENTS

Grateful acknowledgment is extended to J. M. Childs, former maintenance management engineer; members of the management research office, A. P. Cunliffe, A. Gibson, and T. Hewlett; and the staff of the maintenance section, particularly S. Cohen and A. Anderson for their invaluable contribution and assistance in the preparation of this paper.