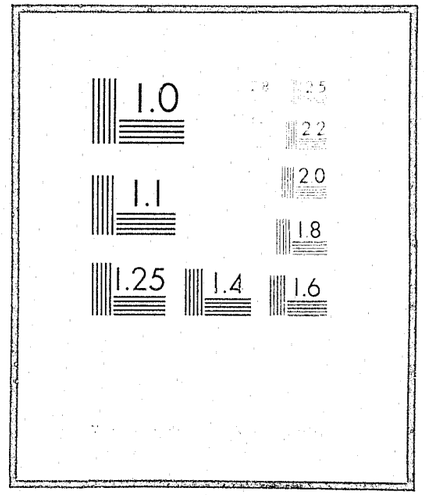

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PATROL OPERATIONS OF BURNABY R.C.M.P. DETACHMENT ANALYSIS AND SIMULATION

SUMMARY REPORT

F.R. LIPSETT, A.F. DALLEY* AND J.G. ARNOLD
*GUEST WORKER FROM R.C.M.P.

ERB - 886
(A COMPLETE REPORT IS GIVEN IN ERB-887)

JULY 1975

RADIO AND ELECTRICAL ENGINEERING DIVISION

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ABSTRACT

Work carried out under the NRC-RCMP Patrol Deployment Project, whose objectives were to optimize patrol operations of the RCMP Detachment, is summarized. The map of Burnaby was divided into 368 small areas called "atoms". Analysis of data on calls for service, obtained during a two-week period and classified according to time, nature and atom, served as the basis for a set of computer simulations in which the number of cars, arrangements of zones, and number of calls for service were varied. Patrol car and response time forecasting tables and suggestions for improving patrol operations are given.

PATROL OPERATIONS OF BURNABY R.C.M.P. DETACHMENT ANALYSIS AND SIMULATION

SUMMARY REPORT

F.R. Lipsett, A.F. Dalley* and J.G. Arnold

Introduction

This report summarizes work carried out under the NRC-RCMP Patrol Deployment Project, whose objectives were to optimize patrol operations of the RCMP Detachment and to seek new research results. The map of Burnaby was divided into 368 small areas called *atoms*, each intended to have roughly the same number of calls for service and to be fairly uniform in land use, type of resident, and so on; data on calls for service were obtained during a two-week period, and each call was classified according to time, nature and atom. Analysis of these data served as the basis for a set of computer simulations in which the number of cars, arrangement of zones, and number of calls for service were varied. The simulation results were used together with the data on calls to prepare patrol car and response time forecasting tables. Suggestions for improving patrol operations were made.

Atom Map and Data on Patrol Operations

The map of Burnaby was divided, with the assistance of experienced police officers, into 368 small areas called *geographical atoms* or simply *atoms.* A section of the basic atom map is shown in Fig. 1. The basic map was digitized and redrawn with a computer-controlled plotter for use in tabulating data and arranging zones. An example is shown in Fig.2, in which the 6-zone arrangement adopted by the Detachment is drawn.

Each call to which a car was dispatched during the experimental period was assigned to the appropriate atom. The data were keypunched and run through a computer program which summarized all types of occurrences, atom by atom. The results were printed out as a table giving a detailed record of the calls. Such a table could be produced periodically for management purposes. The municipality was divided into zones, each of which included several atoms, the number of calls per atom being used as the basis for division into 4, 6 or 8 zones, each with approximately the same workload.

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* Guest Worker from R.C.M.P.

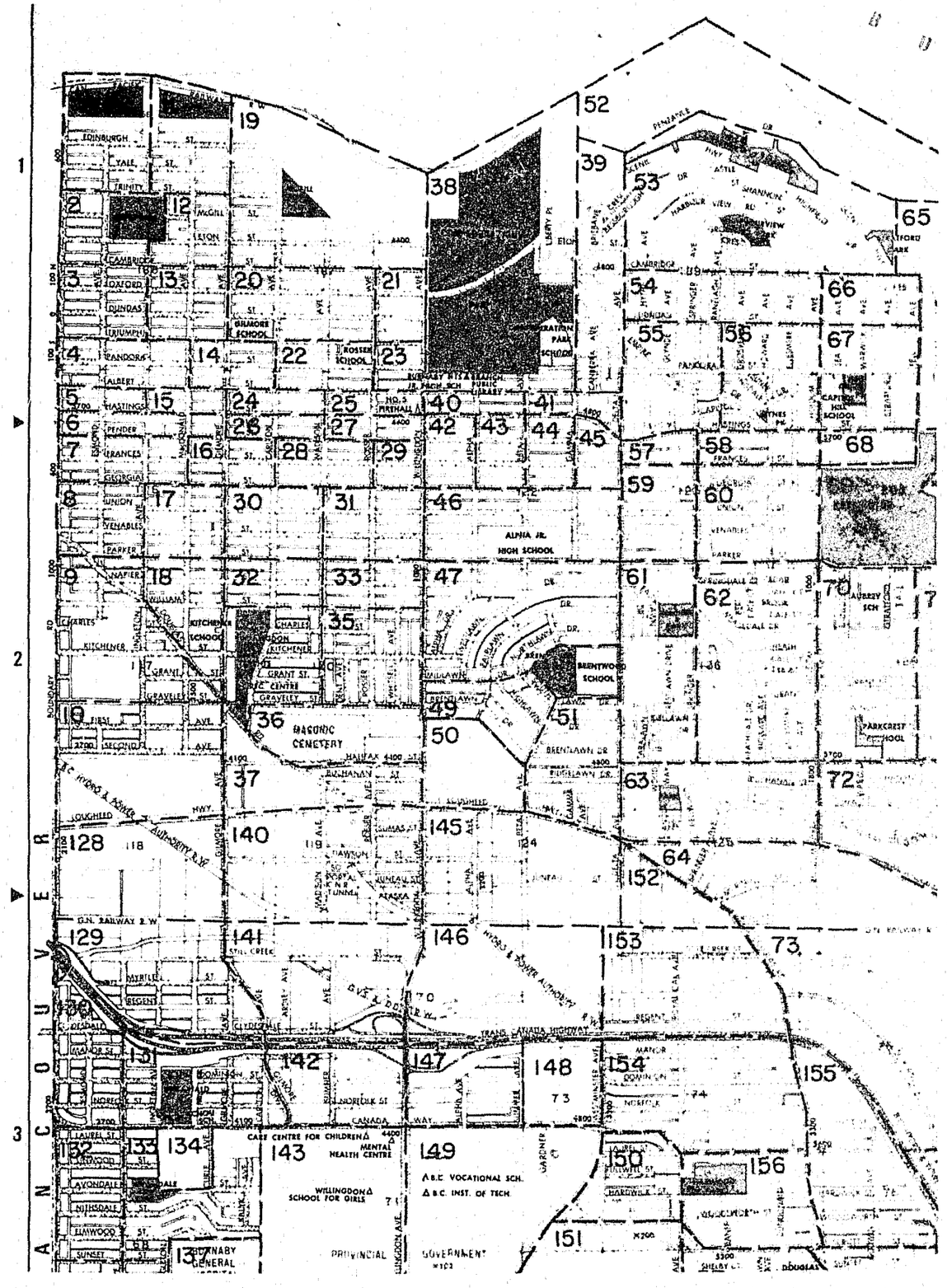
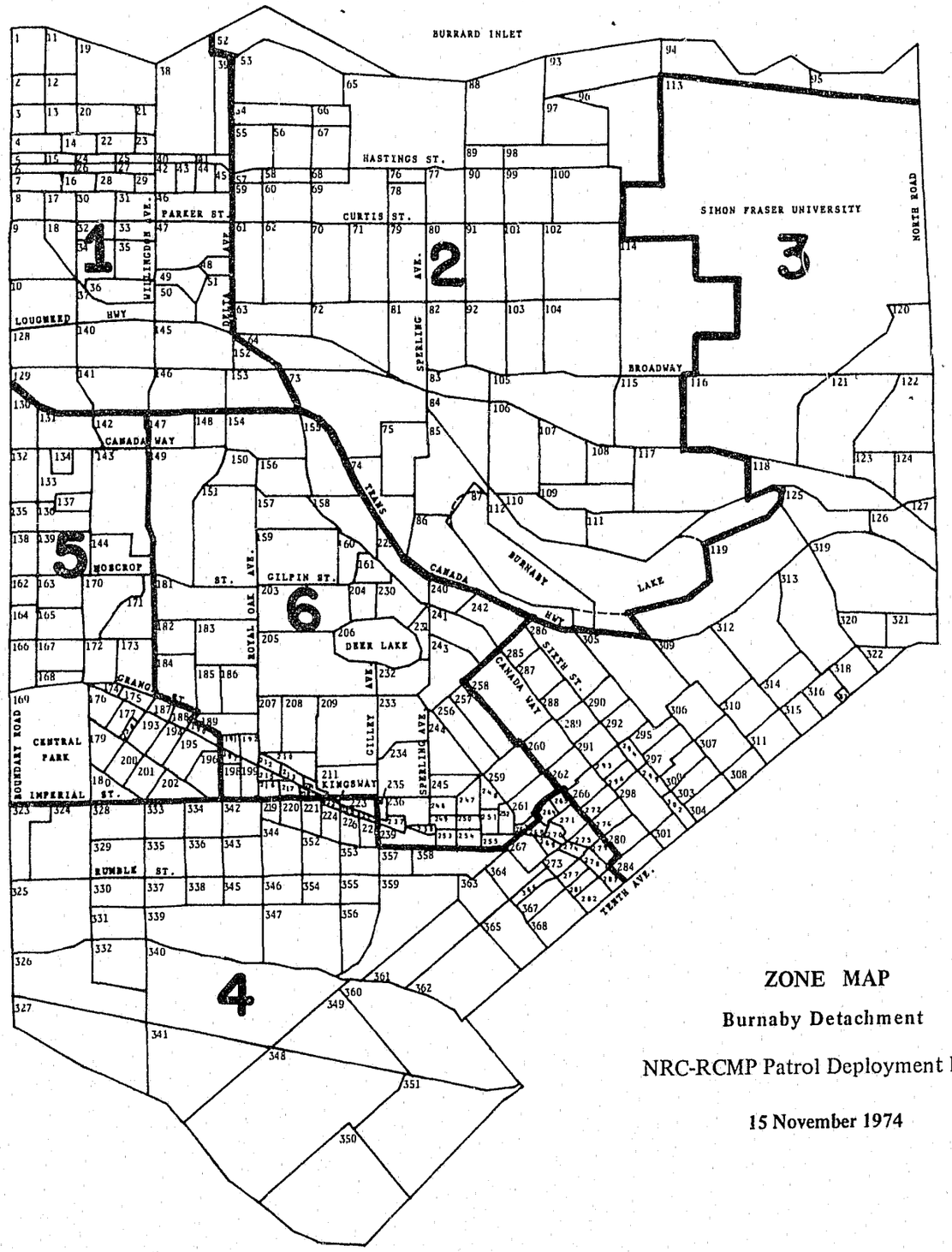


Fig. 1.

Part of the basic atom map



ZONE MAP

Burnaby Detachment

NRC-RCMP Patrol Deployment Project

15 November 1974

Fig. 2.

Zone map showing division into six zones on an atom map drawn by a computer-controlled plotter. The printing and overlining were added by hand

Data on patrol operations were obtained during 13–26 March, 1974. Specially prepared forms were filled out by radio dispatchers and radio car officers. Details included the times of receipt, dispatch, arrival, and completion of each call, and the nature and outcome of the call. The calls were found to be divided as follows:

Criminal	47%
Non-criminal	36%
Traffic Accidents	12%
Administrative and Parking	5%
	100%

The number of calls per hour throughout the data-taking period is given in Fig. 3. The number varied from 0 to 21 per hour, and the overall average was 4.3 calls per hour. Saturdays and Sundays had the most calls but large numbers of calls per hour occurred at other times during the week.

The distribution of calls per hour is given Fig. 4, in which the experimental data are shown as a histogram and a theoretical curve (known as a Poisson distribution) is fitted to the data. From the figure it will be seen that 4–5 calls per hour may be expected about 19% of the time, 5–6 may be expected 15% of the time, and so on. More than 12 calls per hour seldom occurred.

Simulations

The simulations attempt to duplicate the operations of police patrols by mathematical operations carried out by a computer. The atom map referred to above is stored in the computer. It is assumed that calls for service arrive at the rate determined during the experimental period. Then radio-equipped patrol cars are dispatched in answer to the calls. They travel at an assumed average speed and take a certain time to deal with the occurrence. Initially, data obtained experimentally are employed for the simulations. Then various factors such as the number of calls per hour, number of cars on duty, or zones are altered. Thus the effect of a change in these factors may be deduced without the expense or difficulty of experiments on the force itself. The purpose of the simulation is to optimize the service by modifying the policing approach. Service may be improved by changing the structure of a zone, number of cars on patrol, and so on.

A set of 324 simulations was carried out. The number of calls for service was varied from 1.875 to 60 per hour, and the number of cars on duty from 4 to 24. Four arrangements of zones and four strategies for answering calls for service were employed. Results from the simulations included response times (time from receipt of a call for service to arrival of a car at the scene), travel time, percentage of time

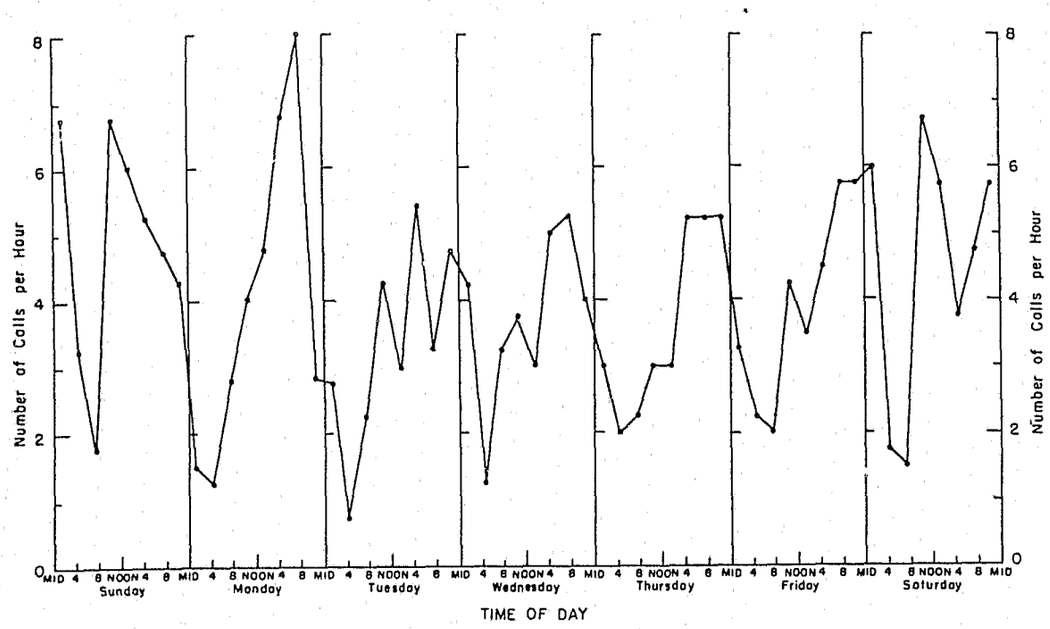


Fig. 3.

Number of calls per hour to which a radio car was dispatched, by time of day for 13 – 26 March 1974. In this diagram the calls have been averaged for three-hour intervals in order to emphasize daily variations.

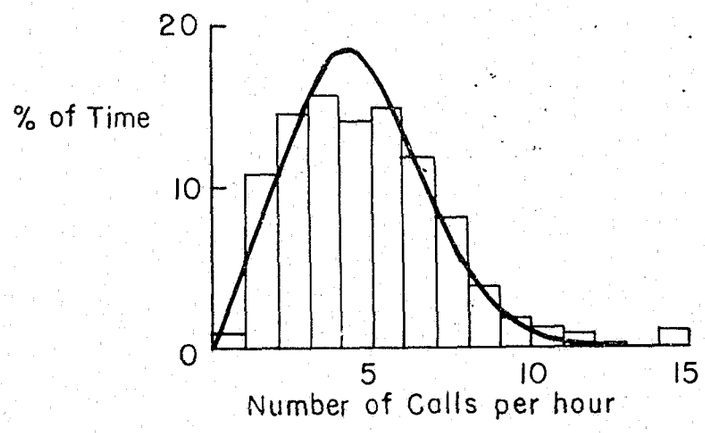


Fig. 4.

Distribution of number of calls per hour as a percentage of time. The histogram shows experimental data to which a theoretical curve has been fitted.

available for preventive patrol and other parameters. The results of the simulations agreed well with the experimental data where comparisons were possible.

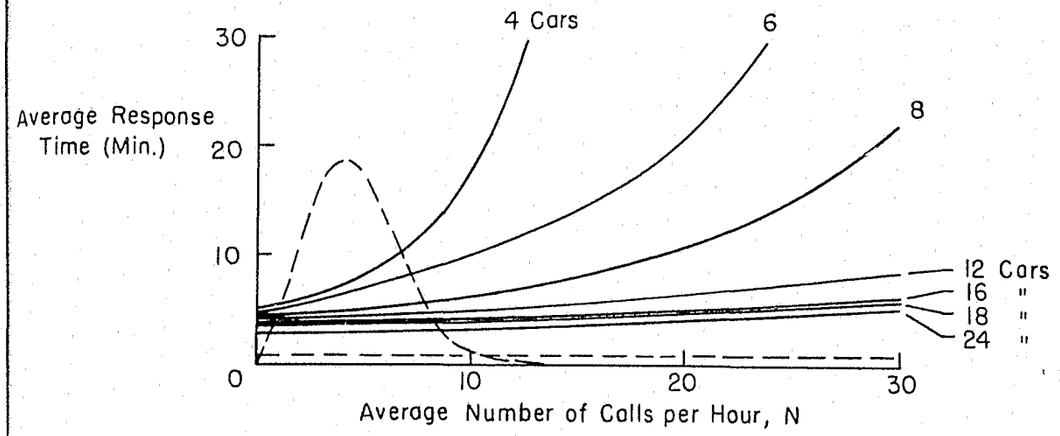


Fig. 5.

Response times deduced from simulations. The distribution of calls per hour from Fig. 4 has been added as a dashed curve. The dispatch delay has been set at 3/4 minute, shown by a dashed straight line.

The response times found from the simulations are shown Fig. 5. It will be seen that if, say, 5 calls per hour are arriving and 4 cars are on patrol, the average response time will be about 8 minutes. If 8 cars are on duty, however, the average response time will be about 5 minutes. Superimposed on the diagram is the distrubution of calls given in Fig. 4.

If a certain number of cars are on patrol and the number of calls per hour becomes unexpectedly large the officers would be unable to handle the calls promptly, with long waiting times resulting. As an extreme example of this, suppose that 4 cars are on patrol and that 20 calls per hour start to arrive. Many of the calls could not be handled and would enter a queue to wait for service. (The most serious calls would be serviced first.) Response times would become increasingly long and the force could be said to be in *saturation*, or no longer able to handle incoming calls. From the simulations it was possible to predict the time at which Burnaby operations would become saturated.

The main results are given Table I, which can be used to estimate the minimum number of cars required for duty with various expected average number of calls.

Table I.

Onset of Saturation

The average number of calls per hour at the onset of saturation, or number above which response times will become unacceptably long

Cars on duty	Calls per hour at onset	Cars on duty	Calls per hour at onset
4	6	9	13
5	7.5	10	14
6	9	11	15
7	10.5	12	16
8	12	14	17.5

Forecasting Tables

The results on response time (Fig. 5) and patrol time have been combined in two forecasting tables. Table II shows the number of patrol cars needed to maintain a certain average response time when a certain average number of calls per hour are being received. Table II may be used as follows. Suppose that during a certain shift (whose calls could be depicted by Fig. 3) 5 calls per hour were expected and a 5 minute response time was desired. From Table II we see that 8 cars would be required to maintain this level of response. Also we see that with 8 cars on duty 84% of the time would be available for preventive patrol or duties other than answering calls. During an 8 hour shift there would be 54 man-hours available for these duties.

Table III gives the same data arranged in a different way. If 8 cars are on duty and 5 calls per hour are arriving we again have a 5 minute response time, 84% preventive patrol time and 54 hours of preventive patrol time. Suppose now that the number of calls suddenly increases to 10 per hour. The average response time would decrease to 6 minutes, preventive patrol time to 67% and hours of preventive patrol to 44. This level of calls would still be below the onset of saturation (12 calls per hour from Table I) so this increase in calls per hour could adequately be handled by 8 cars.

Tables I–III may be used for planning patrol car deployment. Since they are based on the limited amount of data taken 13–26 March 1974, however, they should be used with caution until their predictions are verified.

Suggestions *

1. It is suggested that records of occurrences include the atom number, time, and a number indicating the type of occurrence. If this is done a continuing record of occurrences -- atom by atom and hour by hour -- will be acquired which should be valuable both as record of past occurrences and as an aid in forecasting. Also the number of calls per hour during various times of the day, days of the week, and seasons of the year will become known and facilitate the use of Tables II – III for forecasting patrol operations. The use of a computer as an aid in keeping track of these data should be considered.

2. It is suggested that one of the arrangements of zones worked out by the authors on the basis of equal workloads be adopted. The division into zones should be reviewed from time to time, say every 1 – 2 years, so that changes in the pattern of occurrences can be dealt with.

3. Finally it is suggested that Table I – III be used for determining man power requirements for various shifts. A logical step after forecasting the number of calls per hour is to make appropriate shift schedules. Such schedules were beyond the scope of the work described here, but it is hoped that the results will be useful for this purpose.

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*Some of the suggestions have already been adopted.

Table II

Patrol Car Forecasting Table

R.C.M.P. Burnaby Detachment

Based on data obtained 13 - 26 March 1974

N = number of calls per hour expected to which a radio car will be dispatched.
Av RT = average response time desired, in minutes.
No. C = number of cars required to achieve this Av RT.
% PT = percentage of time each car has for preventive patrol.
Hr PT = number of hours of preventive patrol time the cars will have during an 8 hour shift.

N	Av RT	No. C	% PT	Hr PT	N	Av RT	No. C	% PT	Hr PT
	3	24	98	188		3	24	97	186
	4	13	96	100		4	15	95	114
	5	7	92	52		5	7	88	50
2	6	4	87	28	3	6	6	86	42
	7	4	87	28		7	4	82	26
	8	4	87	28		8	4	82	26
	9	4	87	28		9	4	82	26
	10	4	87	28		10	4	82	26
	3	24	96	184		3	24	95	182
	4	15	93	112		4	16	92	118
	5	7	84	48		5	8	84	54
4	6	6	81	40	5	6	7	84	46
	7	5	78	32		7	6	76	38
	8	4	74	24		8	4	67	22
	9	4	74	24		9	4	67	22
	10	4	74	24		10	4	67	22
	3	24	94	180		3	24	93	178
	4	16	90	116		4	16	89	114
	5	9	82	60		5	11	83	74
6	6	7	77	44	7	6	8	77	50
	7	7	77	44		7	7	73	42
	8	5	67	28		8	6	66	34
	9	4	61	20		9	5	61	26
	10	4	61	20		10	4	54	18
	3	>24				3	>24		
	4	17	88			4	18	88	126
	5	12	82	80		5	12	80	78
8	6	8	74	48	9	6	8	71	46
	7	7	69	28		7	7	65	38
	8	6	61	32		8	7	65	38
	9	6	61	32		9	6	57	30
	10	5	56	24		10	6	57	30
	4	18	87	124		4	18	84	120
	6	9	67	52		6	10	68	56
	8	7	61	36		8	8	61	40
	10	6	52	28		10	7	53	32
10	12	5	45	20	12	12	6	42	24
	14	5	45	20		14	5	34	16
	16	5	45	20		16	5	34	16
	18	4	35	12		18	5	34	16
	20	4	35	12		20	5	34	16
	4	19	82	124		4	20	81	128
	6	11	66	60		6	12	64	64
	8	8	54	36		8	9	53	40
	10	7	46	28		10	8	48	32
14	12	6	33	20	16	12	7	38	24
	14	6	33	20		14	6	23	16
	16	6	33	20		16	6	23	16
	18	5	23	12		18	6	23	16
	20	5	23	12		20	5	12	8

Table III.

Response Time Forecasting Table

R.C.M.P. Burnaby Detachment

Based on data obtained 13 26 March 1974

No. C = number of radio patrol cars on duty
N = number of dispatched calls per hour
Av RT = average response time to be expected with this No. C and N
% PT = percentage of time each car has for preventive patrol
Hr PT = number of hours of preventive patrol time the cars will have during an 8 hour shift.

No. C	N	Av RT	% PT	Hr PT	No. C	N	Av RT	% PT	Hr PT	No. C	N	Av RT	% PT	Hr PT
	2	7	87	28		2	6	89	36		2	5	90	44
	3	7	82	26		3	6	83	34		3	6	86	42
	4	8	74	24		4	7	78	32		4	6	81	40
	5	8	67	22		5	7	72	30		5	7	76	38
	6	9	61	20		6	8	67	28		6	7	71	36
4	7	10	54	18		7	9	61	26		7	8	66	34
	8	12	48	16	5	8	10	56	24	6	8	8	61	32
	9	15	41	14		9	12	50	22		9	9	57	30
	10	18	35	12		10	12	45	20		10	10	52	28
	12	27	22	8		12	14	34	16		12	12	42	14
	14	>30				14	18	23	12		14	12	33	20
	16	>30				16	20	12	8		16	14	23	16
	2	5	92	52		2	4	93	60		2	4	94	68
	3	5	88	50		3	4	90	58		3	4	91	66
	4	5	84	48		4	5	87	56		4	5	88	64
	5	6	84	46		5	5	84	54		5	5	85	62
	6	6	77	44		6	5	80	52		6	5	82	60
	7	7	73	42	8	7	6	77	50	9	7	5	79	58
7	8	7	69	40		8	6	74	48		8	6	77	56
	9	7	65	38		9	6	71	46		9	6	74	54
	10	8	61	36		10	6	67	44		10	6	67	52
	12	10	53	32		12	8	61	40		12	7	65	48
	14	10	46	28		14	8	54	36		14	8	59	44
	16	12	38	24		16	10	48	32		16	8	53	40
	2	4	95	76		2	4	95	84		2	4	95	92
	3	4	92	74		3	4	93	82		3	4	93	90
	4	5	89	72		4	4	90	80		4	4	91	88
	5	5	87	70		5	5	88	78		5	5	89	86
	6	5	84	68		6	5	85	76		6	5	87	84
10	7	5	81	66	11	7	5	83	74	12	7	5	84	82
	8	5	79	64		8	5	81	72		8	5	82	80
	9	5	76	62		9	5	78	70		9	5	80	78
	10	6	73	60		10	5	76	68		10	5	78	76
	12	6	68	56		12	6	71	64		12	5	73	72
	14	7	63	52		14	6	66	60		14	6	69	68
	16	7	57	48		16	7	61	56		16	6	64	64
	2	4	96	108		2	4	97	124		2	4	97	140
	3	4	94	106		3	4	95	122		3	4	96	138
	4	4	92	104		4	4	94	120		4	4	95	136
	5	4	91	102		5	4	92	118		5	4	93	134
	6	4	89	100		6	4	90	116		6	4	92	132
14	7	4	87	98	16	7	4	89	114	18	7	4	91	130
	8	5	85	96		8	4	87	112		8	4	89	128
	9	5	83	94		9	4	86	110		9	4	88	126
	10	5	81	92		10	4	84	108		10	4	87	124
	12	5	78	88		12	4	81	104		12	4	84	120
	14	5	74	84		14	5	78	100		14	4	81	116
	16	6	70	80		16	5	74	96		16	4	79	112
	2	3	98	156		2	3	98	172		2	3	98	188
	3	3	96	154		3	3	97	170		3	3	97	186
	4	3	95	152		4	3	96	168		4	3	96	184
	5	3	94	150		5	3	95	166		5	3	95	182
	6	3	93	148		6	3	93	164		6	3	94	180
20	7	4	91	146	22	7	3	92	162	24	7	3	93	178
	8	4	90	144		8	3	91	160		8	3	92	176
	9	4	89	142		9	3	90	158		9	3	91	174
	10	4	88	140		10	4	89	156		10	3	90	172
	12	4	85	136		12	4	87	152		12	3	88	168
	14	4	83	132		14	4	85	148		14	3	86	164
	16	4	81	128		16	4	82	144		16	4	84	160

END