DEPARTMENT OF TRANSPORT

OFFICE OF ROAD SAFETY

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A Software Package to Identify and Select Treatments for Hazardous Utility Poles

Author(s)

Performing Organisation (Name and Address)

Sinclair Knight Nairn and Partners,
Suite 207, M.T.I.A. House,
214 Northbourne Avenue,
BRADDON, A.C.T. 2601

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Abstract

This manual describes a suite of computer programs that identify and evaluate treatments for hazardous roadside utility poles. The program PRANK is used to identify the hazardous poles in the set of poles that is input to it. The program POLFIX is used to evaluate feasible treatments to a small group of utility poles. The cost of each treatment is compared against the expected benefits accruing from a decrease in accident frequency and/or severity. Included in this manual are detailed User Instructions and examples of the program use.

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VOLUME I:

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APPENDIX E EXAMPLES OF PROGRAM USE

E.1 An example run of PRANK

This section includes a copy of the prepared data and the output report. The input forms for this run may be found in Section 3. as figures 3.4, 3.5, 3.6, 3.7, 3.8 and 3.9.

```
1OPTNYNYYYNB  USER MANUAL FOR A POLE ACCIDENT REMEDIAL PROGRAM
2OPTN 4.36     .            0.00378 0.2
1MNI     10FOX REPORT 381 PAGES EAST OF PAGE 1.  CASE STUDY NUMBER 1.
2MNI     10  5 5 83  U110U17500450.2  12.4C                          10
1MNI     20FOX REPORT 385 PAGES EAST OF PAGE 1.  CASE STUDY NUMBER 2.
2MNI     20  42            1250064 0.75    N
1MJMI    30FOX REPORT 385 PAGES EAST OF PAGE1.  ABOVE POLE AS MJMI.
2MJMI    30 4 2            1250064 0.75 7.4 Y-2.6 T       12
1MJMJ    40HIGH ST 200M SE OF MAIN AVE UTOPIA CITY.
2MJMJ    40 4 3            1534045 0.16     N-0.5 T5900 Y   Y
1MINI    50SMITH ST 20M WEST OF BROWN ST SUBURBIA.
2MINI    50 6 5                  500.75 6.0     1.0
```

Prepared Input Data

OPTIONS AND PARAMETERS

RELATIVE RISKS BY POLE CATEGORIES

MNI	4.36
MINI	0.33
MJNJ	7.27
MJMI	0.65

OPTIONS

REPORT SORTED BY NUMBER OF ACCIDENTS	T
FULL REPORT	F
UNSORTED REPORT	T
FULL REPORT	T
INCLUDE RECORDED ACCIDENTS	F
SKID TESTER	BPS
CUTOFF NUMBER OF ACCIDENTS	0.20
POLE/SECOND TRIAL PROBABILITY	0.003780
PRINT STANDARD DEVIATIONS	T

UTILITY POLE EXPECTED ACCIDENT RESULTS 24-NOV-80

MNI LOCATION: FOX REPORT 381 PAGES EAST OF PAGE 1. CASE STUDY NUMBER 1. NUMBER 10.
CONSTRUCTION: RIGID BASE STEEL USAGE: LIGHTING EXPECTED ACCIDENTS P/A 0.53768
TOTAL RELATIVE RISK 142.24 DEGREE OF SHIELDING 10 STANDARD DEVIATION = 0.38

SITE VARIABLE	VALUE	RELATIVE RISK
ABSOLUTE MAXIMUM CURVATURE	0.0120	3.11
AADT	17500.	1.24
SKID TEST	45	1.50
LATERAL OFFSET	0.20	1.38
WIDTH	12.4	1.32
DISTANCE FROM CURVE START	110	1.12
POLE ON INSIDE OF CURVE	OUT	1.15
PAVEMENT DEFICIENCIES	CORR	2.00
SUPERELAVATION	BAD	1.20

MNI LOCATION: FOX REPORT 385 PAGES EAST OF PAGE 1. CASE STUDY NUMBER 2. NUMBER 20.
CONSTRUCTION: RIGID BASE TIMBER USAGE: ELECTRICAL CONDUCTOR EXPECTED ACCIDENTS P/A 0.00823
TOTAL RELATIVE RISK 2.18 DEGREE OF SHIELDING 0 STANDARD DEVIATION = 0.00

SITE VARIABLE	VALUE	RELATIVE RISK
ABSOLUTE MAXIMUM CURVATURE	0.0000	0.60
AADT	12500.	1.04
SKID TEST	64	0.70
LATERAL OFFSET	0.75	1.23
WIDTH	UNSP	1.00
DISTANCE FROM CURVE START	UNSP	1.00
POLE ON INSIDE OF CURVE	UNSP	1.00
PAVEMENT DEFICIENCIES	NONE	0.93
SUPERELAVATION	UNSP	1.00

MJMI LOCATION: FOX REPORT 385 PAGES EAST OF PAGE1. ABOVE POLE AS MJMI NUMBER 30
CONSTRUCTION: RIGID BASE TIMBER USAGE: ELECTRICAL CONDUCTOR EXPECTED ACCIDENTS P/A 0.00045
TOTAL RELATIVE RISK 0.12 DEGREE OF SHIELDING 0 STANDARD DEVIATION = 0.00

SITE VARIABLE	VALUE	RELATIVE RISK
AADT	12500.	0.68
SKID TEST	64	0.65
LATERAL OFFSET	0.75	1.42
WIDTH	7.4	0.63
THROUGH ROADWAY DIVIDED	YES	0.58
GRADE 30M UPSTREAM OF INTERSECTION	-2.60	1.03
INTERSECTION TYPE	TEE	0.70
RADIAL DISTANCE FROM INTERSECTION	12.	1.04

UTILITY POLE EXPECTED ACCIDENT RESULTS 24-NOV-80

MJMJ LOCATION: HIGH ST 200M SE OF MAIN AVE UTOPIA CITY. NUMBER 40.

CONSTRUCTION: RIGID BASE TIMBER USAGE: LIGHTING & CONDUCTOR EXPECTED ACCIDENTS P/A 0.01893

TOTAL RELATIVE RISK 5.01 DEGREE OF SHIELDING 0 STANDARD DEVIATION = 0.02

SITE VARIABLE	VALUE	RELATIVE RISK
AADT	15340.	0.92
SKID TEST	45	1.15
LATERAL OFFSET	0.20	1.82
THROUGH ROADWAY DIVIDED	NO	1.00
GRADE 30M UPSTREAM OF INTERSECTION	-0.50	0.86
INTERSECTION TYPE	TTL	1.00
AADT INTERSECTING ROADWAY	5900	0.62
INTERSECTING ROADWAY DIVIDED	YES	1.00
TRAFFIC LIGHTS	YES	

MINI LOCATION: SMITH ST 20M WEST OF BROWN ST SUBURBIA. NUMBER 50.

CONSTRUCTION: RIGID BASE CONCRETE USAGE: LIGHTING EXPECTED ACCIDENTS P/A 0.00158

TOTAL RELATIVE RISK 0.42 DEGREE OF SHIELDING 0 STANDARD DEVIATION = 0.00

SITE VARIABLE	VALUE	RELATIVE RISK
ABSOLUTE MAXIMUM CURVATURE	0.0000	0.60
POLE ON INSIDE OF CURVE	UNSP	1.00
SKID TEST	50	2.94
LATERAL OFFSET	0.75	1.40
WIDTH	6.0	0.50
GRADE 30M UPSTREAM OF POLE	1.00	1.03

UTILITY POLE RISKS SORTED BY EXPECTED ACCIDENTS 24-NOV-80

MNI LOCATION: FOX REPORT 381 PAGES EAST OF PAGE 1. CASE STUDY NUMBER 1. NUMBER 10
CONSTRUCTION: RIGID BASE STEEL USAGE: LIGHTING EXPECTED ACCIDENTS P/A 0.53766
TOTAL RELATIVE RISK 142.24 DEGREE OF SHIELDING 10 STANDARD DEVIATION = 0.38

MJMJ LOCATION: HIGH ST 200M SE OF MAIN AVE UTOPIA CITY NUMBER 40
CONSTRUCTION: RIGID BASE TIMBER USAGE: LIGHTING & CONDUCTOR EXPECTED ACCIDENTS P/A 0.01893
TOTAL RELATIVE RISK 5.01 DEGREE OF SHIELDING 0 STANDARD DEVIATION = 0.02

ACCEPTED RECORDS = 5
ERROR RECORDS = 0
TOTAL RECORDS = 5

E.2 An example run of POLFIX

This section includes a sample batch of input forms, a copy of the prepared data and the output report. Note that usage of the input forms results in a large amount of paper being used. When the user is familiar with the package he may elect to code directly onto coding forms.

```
10PTN USER MANUAL FOR A POLE PLACEMENT REMEDIAL PROGRAM
20PTN                                    10 OBE
1SITE   7          TOWNSVILLE, SMITH ST  1200 EAST OF JONES ST
1DMNI   7 1 5 5      0      2500050 0 7512 5M
1DMNI   7 2  5 5    400 400U2500045 0 7512 5C
1DMNI   7 3  5 5    600U200U2500040 0 7512 5C
1TPRT 1  3  RELOCATE ALL POLES TO A LATERAL OFFSET OF 2 5M
2TPRT          3
1TEFF   7 1                          2 5
1TEFF   7 2                          2 5
1TEFF   7 3                          2.5
1TPRT 2    CONVERT POLES 2 AND 3 TO WRAP AROUND CONSTRUCTION
2TPRT15800     2
1TEFF   7 2  9
1TEFF   7 3  9
1TPRT 2    CONVERT REMAINING POLE TO WRAP AROUND
2TPRT15800     1
1TEFF   7 1  9
```

Prepared Input Data

UTILITY POLE SITE TREATMENT PROGRAM

OPTIONS

1	O	P	T	N
1				

HEADING FOR OUTPUT

USER MANUAL FOR A POLE ACCIDENT REMEDIAL PROGRAM
6 16 26 36 46 56

RELATIVE RISK BY POLE CATEGORIES

2	O	P	T	N
1				

MAJOR ROAD NON INTERSECTION	MINOR ROAD NON INTERSECTION	MAJOR/MAJOR INTERSECTION	MAJOR/MINOR INTERSECTION
6	11	16	21

ACCIDENT FACTOR	INTEREST RATE	SKID TESTER B = BPS S = SCRIM	RANK BY B/C RATIO = B RANK BY NPV = N
26	34	B (38)	B (39)

PRINT POLE DESC. Y or N	PRINT TREATMENT EFFECT DETAILS
40	

UTILITY POLE SITE TREATMENT PROGRAM

SITE DESCRIPTION FORM

1	S	I	T	E
1				

SITE NUMBER: 6 — 7

SITE BUDGET: 12 — 18

SITE DESCRIPTION

19	29	39	49	59	69

UTILITY POLE SITE TREATMENT PROGRAM

POL-5

MAJOR ROAD NON-INTERSECTION POLE DESCRIPTION

1	D	M	N	I
1				

SITE NUMBER	POLE NUMBER	CONSTRUCTION USAGE		MINIMUM RADIUS OF CURVE	POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE	DISTANCE FROM CURVE START
7	1	5.	5	.0		
6	10	12 13	15	17 18	22	23

SUPER-ELEVATION (F or U)	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	PAVEMENT DEFICIENCIES (N,T,D,C)	
	25000	50	.075	12.5	N	
26	27	32	34	39	43	44

		.			
45	50	51	56	57	60

UTILITY POLE SITE TREATMENT PROGRAM

POL-5

MAJOR ROAD NON-INTERSECTION POLE DESCRIPTION

1	D	M	N	I
1				

SITE NUMBER	POLE NUMBER	CONSTRUCTION USAGE		MINIMUM RADIUS OF CURVE	POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE	DISTANCE FROM CURVE START
7	2	5	5	60	U	40
6	10	12 13	15	17 18	22	23

SUPER-ELEVATION (F or U)	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	PAVEMENT DEFICIENCIES (N,T,D,C)	
U	25000	45	.075	12.5	C	
26	27	32	34	39	43	44

		.			
45	50	51	56	57	60

UTILITY POLE SITE TREATMENT PROGRAM

POL-5

MAJOR ROAD NON-INTERSECTION POLE DESCRIPTION

1DMNT

SITE NUMBER	POLE NUMBER		CONSTRUCTION	USAGE		MINIMUM RADIUS OF CURVE	POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE	DISTANCE FROM CURVE START
7	3	■	5	5	■	.60	U	120
6	10	12	13	15	17	18	22	23

SUPER-ELEVATION (F or U)	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	PAVEMENT DEFICIENCIES (N,T,D,C)	
U	25000	40	0.75	12.5	C	
26	27	32	34	39	43	44

45	50	51	56	57	60

UTILITY POLE SITE TREATMENT PROGRAM

POL-3

TREATMENT DESCRIPTION

1TPRT

ALTERNATIVE NUMBER		TREATMENT CODE	
1	■	3	■
6	8	9	11

DESCRIPTION OF TREATMENT

RELOCATE ALL POLES IN CUT TO A LATERAL OF 2.5M

12 22 32 42 52 62

2TPRT

SERVICE LIFE	CAPITAL COST/UNIT	NUMBER OF UNITS	ANNUAL COST
		3	
6	8	15	20

UTILITY POLE SITE TREATMENT PROGRAM POL-4

TREATMENT EFFECT FORM

Only fill in fields that have changed

1	T	E	F	F

1

SITE NUMBER	POLE NUMBER		CONSTRUCTION	USAGE		MINIMUM RADIUS OF CURVE	POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE	DISTANCE FROM CURVE START
7	1	■			■			
6	10	12	13	15	17	18	22	23

SUPER-ELEVATION (F or U)	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	PAVEMENT DEFICIENCIES (N,T,D,C)	ROADWAY 1 DIVIDED
			2.5			
26	27	32	34	39	43	44

GRADE	INTERSECTION TYPE(X or T)	AADT INTERSECTING ROADWAY	INTERSECTION ROADWAY DIVIDED	RADIAL DISTANCE FROM INTERSECTION	INTERSECTION CONTROLLED BY TRAFFIC LIGHTS
45	50	51	56	57	60

UTILITY POLE SITE TREATMENT PROGRAM POL-4

TREATMENT EFFECT FORM

Only fill in fields that have changed

1	T	E	F	F

1

SITE NUMBER	POLE NUMBER		CONSTRUCTION	USAGE		MINIMUM RADIUS OF CURVE	POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE	DISTANCE FROM CURVE START
7	2	■			■			
6	10	12	13	15	17	18	22	23

SUPER-ELEVATION (F or U)	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	PAVEMENT DEFICIENCIES (N,T,D,C)	ROADWAY 1 DIVIDED
			2.5			
26	27	32	34	39	43	44

GRADE	INTERSECTION TYPE(X or T)	AADT INTERSECTING ROADWAY	INTERSECTION ROADWAY DIVIDED	RADIAL DISTANCE FROM INTERSECTION	INTERSECTION CONTROLLED BY TRAFFIC LIGHTS
45	50	51	56	57	60

UTILITY POLE SITE TREATMENT PROGRAM

POL-4

TREATMENT EFFECT FORM

Only fill in fields that have changed

1	T	E	F	F

1

-98-

SITE NUMBER	POLE NUMBER		CONSTRUCTION	USAGE		MINIMUM RADIUS OF CURVE	POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE	DISTANCE FROM CURVE START
7	3	■			■			
6	10	12	13	15	17	18	22	23

SUPER-ELEVATION (F or U)	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	PAVEMENT DEFICIENCIES (N,T,D,C)	ROADWAY 1 DIVIDED
			2.5			
26	27	32	34	39	43	44

GRADE	INTERSECTION TYPE(X or T)	AADT INTERSECTING ROADWAY	INTERSECTION ROADWAY DIVIDED	RADIAL DISTANCE FROM INTERSECTION	INTERSECTION CONTROLLED BY TRAFFIC LIGHTS
45	50	51	56	57	60

UTILITY POLE SITE TREATMENT PROGRAM

POL-3

TREATMENT DESCRIPTION

1	T	P	R	T

1

ALTERNATIVE NUMBER		TREATMENT CODE	
2	■		■
6	8	9	11

DESCRIPTION OF TREATMENT

C	O	M	V	E	R	T		P	O	L	E	S		2		A	M	O		3		F	T		W	A	S		A	S	C	O	U	N	D		C	O	M	S	T	R	U	T	I	O	N							
12							22						32						42						52						62																									

2	T	P	R	T

1

SERVICE LIFE	CAPITAL COST/UNIT	NUMBER OF UNITS	ANNUAL COST
15	800	2	
6	8	15	20

TREATMENT EFFECT FORM

Only fill in fields that have changed

1 T E F F

1

SITE NUMBER 7 (6) | POLE NUMBER 2 (10) | ■ (12) | CONSTRUCTION 9 (13) | USAGE (15) | ■ (17) | MINIMUM RADIUS OF CURVE (18) | POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE (22) | DISTANCE FROM CURVE START (23)

SUPER-ELEVATION (F or U) (26) | AADT (27) | SKID TEST (32) | LATERAL OFFSET (34) | ROAD WIDTH (39) | PAVEMENT DEFICIENCIES (N,T,D,C) (43) | ROADWAY 1 DIVIDED (44)

GRADE (45) | INTERSECTION TYPE(X or T) (50) | AADT INTERSECTING ROADWAY (51) | INTERSECTION ROADWAY DIVIDED (56) | RADIAL DISTANCE FROM INTERSECTION (57) | INTERSECTION CONTROLLED BY TRAFFIC LIGHTS (60)

UTILITY POLE SITE TREATMENT PROGRAM POL-4

TREATMENT EFFECT FORM

Only fill in fields that have changed

1 T E F F

1

SITE NUMBER 7 (6) | POLE NUMBER 3 (10) | ■ (12) | CONSTRUCTION 9 (13) | USAGE (15) | ■ (17) | MINIMUM RADIUS OF CURVE (18) | POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE (22) | DISTANCE FROM CURVE START (23)

SUPER-ELEVATION (F or U) (26) | AADT (27) | SKID TEST (32) | LATERAL OFFSET (34) | ROAD WIDTH (39) | PAVEMENT DEFICIENCIES (N,T,D,C) (43) | ROADWAY 1 DIVIDED (44)

GRADE (45) | INTERSECTION TYPE(X or T) (50) | AADT INTERSECTING ROADWAY (51) | INTERSECTION ROADWAY DIVIDED (56) | RADIAL DISTANCE FROM INTERSECTION (57) | INTERSECTION CONTROLLED BY TRAFFIC LIGHTS (60)

UTILITY POLE SITE TREATMENT PROGRAM

POL-3

TREATMENT DESCRIPTION

1TPRT (1) ALTERNATIVE NUMBER 2 (6) ■ (8) TREATMENT CODE (9) ■ (11)

DESCRIPTION OF TREATMENT

COMVERT REMAINING POLES TO WOOD POLES (12)

2TPRT (1)

SERVICE LIFE 15 (6) CAPITAL COST/UNIT 800 (8) NUMBER OF UNITS 1 (15) ANNUAL COST (20)

UTILITY POLE SITE TREATMENT PROGRAM

POL-4

TREATMENT EFFECT FORM

Only fill in fields that have changed

1TEFF (1)

SITE NUMBER 7 (6) POLE NUMBER 1 (10) ■ (12) CONSTRUCTION 9 (13) USAGE (15) ■ (17) MINIMUM RADIUS OF CURVE (18) POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE (22) DISTANCE FROM CURVE START (23)

SUPER-ELEVATION (F or U) (26) AADT (27) SKID TEST (32) LATERAL OFFSET (34) ROAD WIDTH (39) PAVEMENT DEFICIENCIES (N,T,D,C) (43) ROADWAY 1 DIVIDED (44)

GRADE (45) INTERSECTION TYPE(X or T) (50) AADT INTERSECTING ROADWAY (51) INTERSECTION ROADWAY DIVIDED (56) RADIAL DISTANCE FROM INTERSECTION (57) INTERSECTION CONTROLLED BY TRAFFIC LIGHTS (60)

UTILITY POLE SITE TREATMENT PROGRAM

PROGRAM PARAMETERS

RELATIVE RISK TO ACCIDENT FACTOR		0.00270
RELATIVE RISK BY POLE CATEGORY:	MNI	4.34
	MTNI	0.33
	MTMI	7.27
	MNMI	0.65
INTEREST RATE		10.00
EVALUATE ALTERNATIVES BY		B/C
SKID TESTER		BPS
PRINT POLE DESCRIPTIONS		Y
PRINT TREATMENT EFFECT DETAILS		Y
PRINT STANDARD DEVIATIONS		Y

SITE: BROWNSVILLE, SMITH ST. 120M EAST OF JONES ST.
SITE NUMBER: 7. SITE BUDGET $ 0

POLE NO.	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELAVATION	TOTAL RR
1	MNI	0.000	25000.	50	0.75	12.5	-1	UNSP	NONE	UNSP	
RR:	4.36	0.60	1.33	1.10	1.27	1.30	1.00	1.00	0.93	1.00	5.69
					++						

CONSTRUCTION: RIGID BASE STEEL USAGE: LIGHTING EXPECTED ACCIDENTS P/A: 0.0215417
ACCIDENT COST FOR THIS POLE TYPE = $ 12495. COST OF EXPECTED ACCIDENTS = $ 269. STANDARD DEVIATION = 0.01

POLE NO.	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELAVATION	TOTAL RR
2	MNI	0.017	25000.	45	0.75	12.5	40	OUT	CORR	BAD	
RR:	4.36	7.40	1.33	1.50	1.23	1.30	1.55	1.15	2.00	1.20	440.30
		++		++	++		++	++	++	++	

CONSTRUCTION: RIGID BASE STEEL USAGE: LIGHTING EXPECTED ACCIDENTS P/A: 1.6665418
ACCIDENT COST FOR THIS POLE TYPE = $ 12495. COST OF EXPECTED ACCIDENTS = $ 20823. STANDARD DEVIATION = 1.04

POLE NO.	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELAVATION	TOTAL RR
3	MNI	0.017	25000.	40	0.75	12.5	120	OUT	CORR	BAD	
RR:	4.36	7.40	1.33	1.89	1.23	1.30	1.05	1.15	2.00	1.20	376.88
		++		++	++			++	++	++	

CONSTRUCTION: RIGID BASE STEEL USAGE: LIGHTING EXPECTED ACCIDENTS P/A: 1.4264911
ACCIDENT COST FOR THIS POLE TYPE = $ 12495. COST OF EXPECTED ACCIDENTS = $ 17824. STANDARD DEVIATION = 1.18

TOTAL NUMBER OF ACCIDENTS EXPECTED PER SITE 3.11 STANDARD DEVIATION = 1.57 TOTAL COST $ 38917.

UTILITY POLE SITE TREATMENT PROGRAM 23-DEC-80

TREATMENT ALTERNATIVE NUMBER 1

TREATMENT PART NUMBER 1 RELOCATE ALL POLES TO A LATERAL OFFSET OF 2.5M

POLE 1 LATERAL OFFSET CHANGED TO 2.50 NEW RELATIVE RISK 0.52
POLE 2 LATERAL OFFSET CHANGED TO 2.50 NEW RELATIVE RISK 0.52
POLE 3 LATERAL OFFSET CHANGED TO 2.50 NEW RELATIVE RISK 0.52
NEW EXPECTED NUMBER OF ACCIDENTS P/A FOR SITE 1.3167 CHANGE = -1.7978
SERVICE LIFE 15 YEARS CAPITAL COST $ 1500. DISCOUNTED BENEFITS $ 93672.
NET PRESENT VALUE $ 92172 BENEFIT/COST RATIO = 62.45 STANDARD DEVIATION = 85.10
** TREATMENT ACCEPTED **

EFFECTS OF ALTERNATIVE NUMBER 1

PARTS INCLUDED:
1
NEW EXPECTED NUMBER OF ACCIDENTS FOR SITE 1.31673 CHANGE = -1.79784
TOTAL CAPITAL COST $ 1500. TOTAL BENEFITS $ 93672.
NET PRESENT VALUE $ 92172. BENEFIT/COST RATIO 62.45 STANDARD DEVIATION = 85.10

TREATMENT ALTERNATIVE NUMBER 2

TREATMENT PART NUMBER 2 CONVERT POLES 2 AND 3 TO WRAP AROUND CONSTRUCTION

POLE 2 CONSTRUCTION CHANGED TO WRAP AROUND NEW ACCIDENT COST = $ 2380.
POLE 3 CONSTRUCTION CHANGED TO WRAP AROUND NEW ACCIDENT COST = $ 2380.
NEW EXPECTED NUMBER OF ACCIDENTS P/A FOR SITE 3.1146 CHANGE = 0.0000
SERVICE LIFE 15 YEARS CAPITAL COST $ 1600 DISCOUNTED BENEFITS $ 130459.
NET PRESENT VALUE $ 128859. BENEFIT/COST RATIO = 81.54 STANDARD DEVIATION = 46.91
** TREATMENT ACCEPTED **

TREATMENT PART NUMBER 3 CONVERT REMAINING POLE TO WRAP AROUND

POLE 1 CONSTRUCTION CHANGED TO WRAP AROUND NEW ACCIDENT COST = $ 2380.

NEW EXPECTED NUMBER OF ACCIDENTS P/Y FOR SITE 3.1146 CHANGE = 0.6000
SERVICE LIFE 15 YEARS CAPITAL COST $ 800 DISCOUNTED BENEFITS $ 909.
NET PRESENT VALUE $ 109. BENEFIT/COST RATIO = 1.14 STANDARD DEVIATION = 66.30
** TREATMENT ACCEPTED **

EFFECTS OF ALTERNATIVE NUMBER 2

PARTS INCLUDED:
2
3

NEW EXPECTED NUMBER OF ACCIDENTS FOR SITE 3.11457 CHANGE = 0.00000
TOTAL CAPITAL COST $ 2400. TOTAL BENEFITS $ 131367.
NET PRESENT VALUE $ 128967 BENEFIT/COST RATIO 54.74 STANDARD DEVIATION = 38.29

RESULTS FOR SITE 7.

ALTERNATIVE NUMBER	EXPECTED ACCIDENTS P/A	CAPITAL COST	TOTAL BENEFITS	NET PRESENT VALUE	BENEFIT/COST RATIO	STANDARD DEVIATION
1	1.3167	$ 1500.	$ 93672.	$ 92172.	62.45	85.10
2	3.1146	$ 2400.	$ 131367.	$ 128967.	54.74	38.29

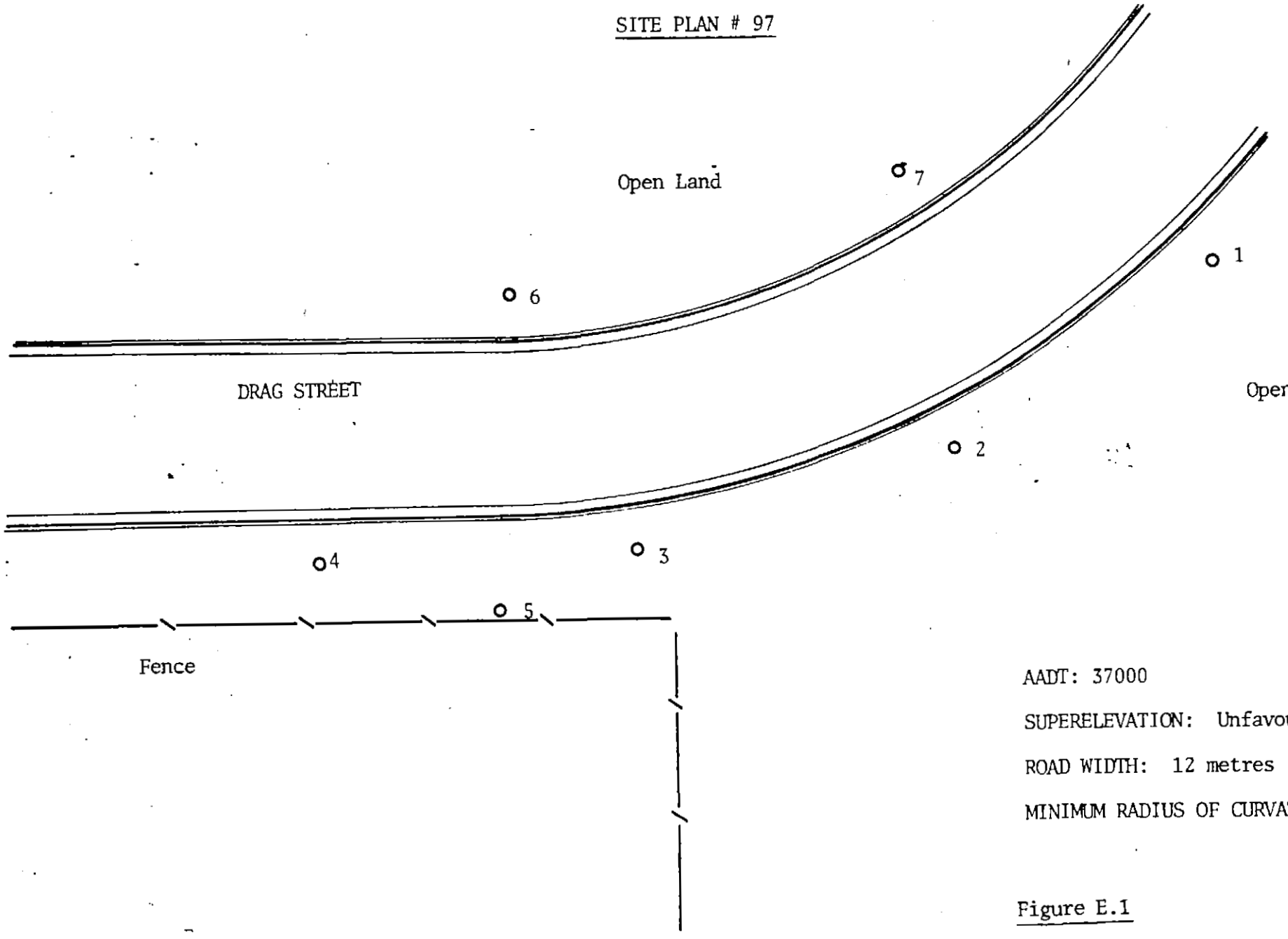
E.3 A further example of POLFIX

This section shows the preferred input data for a treatment site, the site plan and the POLFIX output. Some points to note are:

- Poles on both sides of the road have been included because one of the possible treatments is road re-surfacing.
- Pole number five has been included so that the full benefits or road resurfacing will be shown - i.e. the reduction in the accident risk of the fence is included in the benefits.
- When the poles on the outside of the curve are removed, poles 3 and 4 are changed to 'Fence Equivalent' instead of being totally removed. This is done on the assumption that cars that would have hit poles 3 and 4, will now hit the fence.

```
1OPTN   POLFIX USER MANUAL - A FURTHER POLFIX EXAMPLE
2OPTN                                    V
1SITE  9          HAIRY CORNER ON DRAG STREET - SEE PLAN #97
1DMNI   9 1  4 2  50 U 30U3700040 0 25 12 N
1DMNI   9 2  4 2  50 U 60U3700040 0 25 12 N
1DMNI   9 3  4 2  50 U 90U3700040 0 25 12 C
1DMNI   9 4  4 2  50 U120U3700040 0 25 12 C
1DMNI   9 5  2 6  50 U105U3700040 3.00 12 C
1DMNI   9 6  5 5  50 N 50U3700035 1.0  12 N
1DMNI   9 7  5 5  50 N 90U3700035 1.0  12 N
1TPRT 1    RESURFACE DRAG STREET AT HAIRY CORNER
2TPRT10  3.50  2250
1TEFF   9 1                      60
1TEFF   9 2                      60
1TEFF   9 3                      60
1TEFF   9 4                      60
1TEFF   9 5                      60
1TEFF   9 6                      60
1TEFF   9 7                      60
1TPRT 2    REMOVE ALL POLES ON THE OUTSIDE OF HAIRY CORNER
2TPRT15 5500   4
1TEFF   9 1 3
1TEFF   9 2 3
1TEFF   9 3 2                     4.5
1TEFF   9 4 2                     2.5
1TPRT 3 2  INCREASE THE LATERAL OFFSET OF POLES 3 & 4
2TPRT         2
1TEFF   9 3                       3.0
1TEFF   9 4                       2.5
1TPRT 3 2  INCREASE THE LATERAL OFFSET OF POLES 1 & 2
2TPRT         2
1TEFF   9 1                       3.0
1TEFF   9 2                       3.0
```

SITE PLAN # 97



AADT: 37000

SUPERELEVATION: Unfavourable

ROAD WIDTH: 12 metres

MINIMUM RADIUS OF CURVATURE: 50 metres

Figure E.1

PROGRAM PARAMETERS

RELATIVE RISK TO ACCIDENT FACTOR		0.00376
RELATIVE RISK BY POLE CATEGORY	MNI	4.36
	MINI	0.33
	MJNI	7.27
	MJMI	0.65
INTEREST RATE		10.00
EVALUATE ALTERNATIVES BY		B/C
SKID TESTER		BFS
PRINT POLE DESCRIPTIONS		Y
PRINT TREATMENT EFFECT DETAILS		Y
PRINT STANDARD DEVIATIONS		Y

SITE: HAIRY CORNER ON DRAG STREET - SEE PLAN #97
SITE NUMBER: 9 SITE BUDGET $ 0.

POLE NO.	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELEVATION	TOTAL RR
1	MNI	0.020	37000.	40	0.25	12.0	30	OUT	NONE	BAD	
RR:	4.36	7.40	1.33	1.09	1.37	1.35	1.55	1.15	0.93	1.20	298.91
		++		++	++	++	++	++		++	

CONSTRUCTION: RIGID BASE TIMBER USAGE: ELECTRICAL CONDUCTOR EXPECTED ACCIDENTS P/A: 1.1313864
ACCIDENT COST FOR THIS POLE TYPE = $ 15589. COST OF EXPECTED ACCIDENTS = $ 17637. STANDARD DEVIATION = 0.52

POLE NO	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELEVATION	TOTAL RR
2	MNI	0.020	37000.	40	0.25	12.0	60	OUT	NONE	BAD	
RR:	4.36	7.40	1.33	1.09	1.37	1.35	1.48	1.15	0.93	1.20	285.09
		++		++	++	++	++	++		++	

CONSTRUCTION: RIGID BASE TIMBER USAGE: ELECTRICAL CONDUCTOR EXPECTED ACCIDENTS P/A: 1.0790751
ACCIDENT COST FOR THIS POLE TYPE = $ 15589. COST OF EXPECTED ACCIDENTS = $ 16822. STANDARD DEVIATION = 0.53

POLE NO.	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELEVATION	TOTAL RR
3	MNI	0.020	37000.	40	0.25	12.0	90	OUT	CORR	BAD	
RR:	4.36	7.40	1.33	1.09	1.37	1.35	1.26	1.15	2.00	1.20	563.94
		++		++	++	++		++	++	++	

CONSTRUCTION: RIGID BASE TIMBER USAGE: ELECTRICAL CONDUCTOR EXPECTED ACCIDENTS P/A: 1.9830983
ACCIDENT COST FOR THIS POLE TYPE = $ 15589. COST OF EXPECTED ACCIDENTS = $ 30915. STANDARD DEVIATION = 1.31

POLE NO	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELEVATION	TOTAL RR
4	MNI	0.020	37000.	40	0.25	12.0	120	OUT	CORR	BAD	
RR:	4.36	7.40	1.33	1.09	1.37	1.35	1.05	1.15	2.00	1.20	435.92
		++		++	++	++		++	++	++	

CONSTRUCTION: RIGID BASE TIMBER USAGE: ELECTRICAL CONDUCTOR EXPECTED ACCIDENTS P/A: 1.6499659
ACCIDENT COST FOR THIS POLE TYPE = $ 15589. COST OF EXPECTED ACCIDENTS = $ 25721. STANDARD DEVIATION = 1.27

POLE NO.	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELEVATION	TOTAL RR
5	MNI	0.020	37000.	40	3.00	12.0	165	OUT	CORR	BAD	
RR:	4.36	7.40	1.33	1.09	0.47	1.35	1.16	1.15	2.00	1.20	164.45
		++		++		++		++	++	++	

CONSTRUCTION: FENCE EQUIVALENT USAGE: NOTHING EXPECTED ACCIDENTS P/A: 0.6224418
ACCIDENT COST FOR THIS POLE TYPE = $ 6378. COST OF EXPECTED ACCIDENTS = $ 3970. STANDARD DEVIATION = 0.49

POLE NO.	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELAVATION	TOTAL RR
6	MNI	0.020	37000	35	1.00	12.0	50	IN	NONE	BAD	
RR:	4.36	7.40 ++	1.33	2.29 ++	1.13	1.35 ++	1.55 ++	0.85	0.93	1.20 ++	220.09

CONSTRUCTION: RIGID BASE STEEL USAGE: LIGHTING EXPECTED ACCIDENTS P/A 0.8330396
ACCIDENT COST FOR THIS POLE TYPE = $ 12495. COST OF EXPECTED ACCIDENTS = $ 10409. STANDARD DEVIATION = 0.45

POLE NO.	POLE TYPE	MAXIMUM CURVATURE	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	DISTANCE FROM CURVE START	INSIDE/ OUTSIDE	PAVEMENT DEFICIENCIES	SUPER-ELAVATION	TOTAL RR
7	MNI	0.020	37000.	35	1.00	12.0	90	IN	NONE	BAD	
RR:	4.36	7.40 ++	1.33	2.29 ++	1.13	1.35 ++	1.27	0.85	0.93	1.20 ++	179.38

CONSTRUCTION: RIGID BASE STEEL USAGE: LIGHTING EXPECTED ACCIDENTS P/A: 0.6769781
ACCIDENT COST FOR THIS POLE TYPE = $ 12495. COST OF EXPECTED ACCIDENTS = $ 8464. STANDARD DEVIATION = 0.43

TOTAL NUMBER OF ACCIDENTS EXPECTED PER SITE 7.98 STANDARD DEVIATION = 2.13 TOTAL COST $113958.

TREATMENT ALTERNATIVE NUMBER 1

TREATMENT PART NUMBER 1 RESURFACE DRAG STREET AT HAIRY CORNER

POLE 1	SKID TEST RESULT	CHANGED TO	60	NEW RELATIVE RISK	0.73
POLE 2	SKID TEST RESULT	CHANGED TO	60	NEW RELATIVE RISK	0.73
POLE 3	SKID TEST RESULT	CHANGED TO	60	NEW RELATIVE RISK	0.73
POLE 4	SKID TEST RESULT	CHANGED TO	60	NEW RELATIVE RISK	0.73
POLE 5	SKID TEST RESULT	CHANGED TO	60	NEW RELATIVE RISK	0.73
POLE 6	SKID TEST RESULT	CHANGED TO	60	NEW RELATIVE RISK	0.73
POLE 7	SKID TEST RESULT	CHANGED TO	60	NEW RELATIVE RISK	0.73

NEW EXPECTED NUMBER OF ACCIDENTS P/A FOR SITE 2.9631 CHANGE = -5.0158
SERVICE LIFE 10 YEARS CAPITAL COST $ 7875. DISCOUNTED BENEFITS $ 298010.
NET PRESENT VALUE $ 290135. BENEFIT/COST RATIO = 37.84 STANDARD DEVIATION = 27.26
** TREATMENT ACCEPTED **

EFFECTS OF ALTERNATIVE NUMBER 1

PARTS INCLUDED:
1

NEW EXPECTED NUMBER OF ACCIDENTS FOR SITE 2.96215 CHANGE = -5.01583
TOTAL CAPITAL COST $ 7875. TOTAL BENEFITS $ 298010.
NET PRESENT VALUE $ 290135. BENEFIT/COST RATIO 37.84 STANDARD DEVIATION = 27.26

TREATMENT ALTERNATIVE NUMBER 2

TREATMENT PART NUMBER 2 REMOVE ALL POLES ON THE OUTSIDE OF HAIRY CORNER

POLE 1	HAS BEEN REMOVED				
POLE 2	HAS BEEN REMOVED				
POLE 3	LATERAL OFFSET	CHANGED TO	4.50	NEW RELATIVE RISK	0.43
POLE 3	CONSTRUCTION CHANGED TO	FENCE EQUIVALENT		NEW ACCIDENT COST = $	6378.
POLE 4	LATERAL OFFSET	CHANGED TO	2.50	NEW RELATIVE RISK	0.52
POLE 4	CONSTRUCTION CHANGED TO	FENCE EQUIVALENT		NEW ACCIDENT COST = $	6378.

NEW EXPECTED NUMBER OF ACCIDENTS P/A FOR SITE 3.3687 CHANGE = -4.6093
SERVICE LIFE 15 YEARS CAPITAL COST $22000. DISCOUNTED BENEFITS $ 347026.
NET PRESENT VALUE $ 325026. BENEFIT/COST RATIO = 15.77 STANDARD DEVIATION = 4.52
** TREATMENT ACCEPTED **

EFFECTS OF ALTERNATIVE NUMBER 2

PARTS INCLUDED:
2
NEW EXPECTED NUMBER OF ACCIDENTS FOR SITE 3.36863 CHANGE = -4.60930
TOTAL CAPITAL COST $22000 TOTAL BENEFITS $ 347026
NET PRESENT VALUE $ 325026 BENEFIT/COST RATIO 15.77 STANDARD DEVIATION = 4.52

TREATMENT ALTERNATIVE NUMBER 3

TREATMENT PART NUMBER 3 INCREASE THE LATERAL OFFSET OF POLES 3 & 4

POLE 3 LATERAL OFFSET CHANGED TO 3.00 NEW RELATIVE RISK 0.47
POLE 4 LATERAL OFFSET CHANGED TO 2.50 NEW RELATIVE RISK 0.52
NEW EXPECTED NUMBER OF ACCIDENTS P/A FOR SITE 5.6515 CHANGE = -2.3265
SERVICE LIFE 15 YEARS CAPITAL COST $ 2000. DISCOUNTED BENEFITS $ 151230
NET PRESENT VALUE $ 149230. BENEFIT/COST RATIO = 75.61 STANDARD DEVIATION = 65.02
** TREATMENT ACCEPTED **

TREATMENT PART NUMBER 4 INCREASE THE LATERAL OFFSET OF POLES 1 & 2

POLE 1 LATERAL OFFSET CHANGED TO 3.00 NEW RELATIVE RISK 0.47
POLE 2 LATERAL OFFSET CHANGED TO 3.00 NEW RELATIVE RISK 0.47
NEW EXPECTED NUMBER OF ACCIDENTS P/A FOR SITE 4.1994 CHANGE = -1.4521
SERVICE LIFE 15 YEARS CAPITAL COST $ 2000. DISCOUNTED BENEFITS $ 94394.
NET PRESENT VALUE $ 92394. BENEFIT/COST RATIO = 47.20 STANDARD DEVIATION = 65.01
** TREATMENT ACCEPTED **

EFFECTS OF ALTERNATIVE NUMBER 3

PARTS INCLUDED:
3
4

NEW EXPECTED NUMBER OF ACCIDENTS FOR SITE 4.1993 CHANGE = -3.7859
TOTAL CAPITAL COST $ 4000. TOTAL BENEFITS $ 245624
NET PRESENT VALUE $ 241624 BENEFIT/COST RATIO 61.41 STANDARD DEVIATION = 45.97

RESULTS FOR SITE 9

ALTERNATIVE NUMBER	EXPECTED ACCIDENTS P/A	CAPITAL COST	TOTAL BENEFITS	NET PRESENT VALUE	BENEFIT/COST RATIO	STANDARD DEVIATION
3	4.1994	$ 4000.	$ 245624.	$ 241624	61.41	45.97
1	2.9621	$ 7875.	$ 298010.	$ 290135	37.84	27.26
2	3.3687	$22000	$ 347026.	$ 325026.	15.77	4.52

****

APPENDIX F ACCIDENT COSTING

Accident costs used in the POLFIX program are based on work done by FOX et al. (1)

Several methods have been proposed for determining the cost of accidents. After a short summary of the most common approaches the costs used in POLFIX will be discussed.

There are two common approaches to assigning accident costs:

a) Ex-poste, and
b) Ex-ante

The ex-poste method is one which reviews the cost elements after the event. The ex-ante approach attempts to assess what society is willing to pay for a given reduction in the probability of an accident. POLFIX uses the ex-poste method.

Accident costs may be classified into two major groups:

a) direct costs, and
b) indirect costs.

Indirect costs include the value of pain and suffering and losses in production by others as a result of the accident.

Direct costs may be further classified as:

a) Use of current resources, and
b) Loss of future production.

Current resources consumed as a result of an accident include property damage repairs, medical and hospital treatment, legal charges, insurance and police costs. Loss of future production occurs in the case of death or permanent disability. This may be modified by subtracting an estimate of future consumption.

Accident Costing Methods Adopted

The approaches adopted in the majority of accident cost studies fall into three main groups.

CRC: Current resource costs only,
TCNC: Total accident costs, including loss of future production net of consumption,
TC: Total accident costs, including loss of future production.

(1) *FOX, J.C, GOOD, M.C., and JOUBERT, P.N. (1979) "Collisions with Utility Poles", Australian Department of Transport, Report CR1.*

The total accident cost (TC) approach was adopted for POLFIX. Cost components included in the total accident cost are:

- o Loss of future production,
- o Loss of services to home, family and community,
- o Medical,
- o Legal and court,
- o Insurance administration,
- o Accident investigation,
- o Losses to others,
- o Vehicle damage,
- o Traffic delay,
- o Pole and utility damage.

The cost of pain and suffering is not included, which makes the estimate of accident costs conservative.

Fox et al estimated accident costs for different injury levels. Since utility pole construction and accident severity are correlated, accident costs can be estimated for different types of pole.

Accident costs are continually changing with inflation. POLFIX attempts to solve this problem by applying the Consumer Price Index to accident cost figures. The initial estimates of cost were in 1977 Australian dollars. POLFIX automatically indexes accident costs to the current year. In order to do this an estimated future inflation rate of 8% per annum is included. This is a conservative estimate. A list of the costs adopted for different pole types may be found in Appendix C.

APPENDIX G TREATMENT COSTING

The cost of implementing remedial treatments will vary according to the SITE being treated. POLFIX has a list of standard treatments and costs. Treatments in the list may be selected by using a numeric treatment code. Details of the standard treatments are listed in Appendix C.3.

If standard treatments do not apply, the user must supply costing information for the treatment, such as:

a) Capital cost per unit of treatment,
b) Service life of the treatment,
c) Number of units included in this treatment, and
d) The annual maintenance cost (if any).

After gaining experience in using the package, the user may wish to update the list of standard treatments in the POLFIX program. The POLAXE Programmer's Guide should be consulted before attempting to change the standard treatments.

APPENDIX H DETAILS OF COST BENEFIT ANALYSIS

Cost benefit analysis is used by the POLFIX program to discriminate between alternative remedial treatments. Discounted present value techniques are used to achieve this goal. The basis of this technique is that a given sum of money is worth more now than at some future year. This is because the money may be invested now and yield returns in future years. To calculate the present value of a future year payment, the payment is multiplied by a present worth (p w) factor. The formula for determining this factor is

$$p\,w_n = 1/(1 + r)^n$$

Where n is the future year

r is the investment interest rate

To obtain the present worth of a steady flow of money, i.e. yearly payments each payment should be multiplied by the present worth factor for that year and the results summed.

POLFIX has adopted the following definitions of costs and benefits:

COSTS - The capital outlay required for the construction of the improvement.

BENEFITS - are defined to be the savings accruing from the reduction in number and/or severity of accidents attributable to the treatment

minus

Annual maintenance costs of the improvement.

One problem in economic analysis of remedial treatments is that alternative treatments may have different service lives. The approach POLFIX adopts is to evaluate all treatments over a period of five years. A five-year period was chosen as the forseeable future. The choice of a relatively small figure ensures that POLFIX is conservative in its predictions.

1. The present value of 5 yearly payments of one dollar is calculated for the specified interest rate.

2. The yearly flow of accident cost saving is calculated as the previous cost of site accidents minus the current cost of site accidents.

3. The yearly flow of accident cost savings are multiplied by the discount factors to give the present worth of 5 years accident savings.

4. The annual flow of maintenance cost is also multiplied by the discount factors.

5. The total present value of benefits is calculated as the present value of accident savings minus the present value of maintenance costs.

6. Since the capital cost is outlaid immediately, no discounting is needed.

7. The Net Present Value of a treatment is the present value of benefits minus the capital cost.

8. The Benefit Cost Ratio is the present value of benefits divided by the capital cost.

APPENDIX I RISK ANALYSIS

I.1 Estimation of Confidence Limits for Risk Factors

This section shows the method of calculating confidence limits for the relative risk factors. A worked example is also presented. For simplicity the MNI model will be considered in the following although the results are general. Three equations are of interest in calculating expected accident rates.

1) $$RF_{MNI} = \prod_i RR_{MNI}^{v_i} \quad (1)$$

i.e. - the risk factor for a pole equals the product of the individual relative risk components.

This calculation of risk factor assumes that the variables have independent effects on the probability of a pole accident.

2) $$TRR = RR^{MNI} \times RF_{MNI}$$

i.e. - the total relative risk for a pole in the MNI group is the product of the risk factor within the data group and the relative risk of that group compared to other data groups.

3) $$\gamma = TRR * \bar{p}T$$

i.e. - the expected number of accidents per annum equals the total relative risk by the mean probability $\bar{p}$ that a pole record trial will result in an accident by the number of trials T in a year.

Confidence limits of 68% are available for the individual relative risk factors. Confidence limits are not available for the relative risk of a data group (RR^{MNI}) or the pole trial probability ($\bar{p}$). These are assumed to be exactly known.

To calculate the standard deviation of the total relative risk only the individual standard deviations of the relative risks of poles within a group (e.g. MNI), will be considered. It will be assumed that the component relative risk values are independent and not related. In addition, a normal distribution of error will be assumed. The assumptions in summary are therefore, that:

- errors of relative risk for poles within a group are normally distributed and independent.
- $\bar{p}$ and RR^{MNI} are known exactly.

Using these assumptions the following formula can be derived:

---

(1) For a full treatment of relative risk calculations see FOX, J.C., GOOD, M.C., and JOUBERT, P.N. (1979) "Collisions with Utility Poles", Australian Department of Transport Report No. CR1. Chapter 4.

4) $V(xyz...) = E(x^2)E(y^2)E(z^2).... - \mu x^2 \mu y^2 \mu z^2$

where $E(x^2) = V(x) + \mu^2 x$

I.2 Example Confidence Limit Calculation

Variable	RR	RR^2	Standard Deviation of RR	Variance of RR
RR^{MNI}	4.36	19.0096	exact	0
KMAX	3.11	9.672	0.57	.33
AADT	1.24	1.538	0.15	.023
ST	1.50	2.25	0.18	0.032
LO	1.38	1.904	0.09	0.008
W	1.32	1.742	0.11	0.012
DC	1.12	1.254	0.59	0.349
PD	2.00	4.0	.6	.36
e	1.20	1.44	exact	0
IOB	1.15	1.323	exact	0

TRR = product of RR's = 142.02
γ = TRR $*\bar{p}T$ = .536

From the above formula

$$\begin{aligned}
Var(TRR) = {} & (19.0096)(9.672 + .33)(1.538 + .023)(2.25 + .032) \\
& (1.904 + 0.008)(1.742 + 0.012)(1.254 + .349) \\
& (4.0 + .36)(1.44)(1.323) \\
& - \\
& (19.0096)(9.672)(1.538)(2.25)(1.904) \\
& (1.742)(1.254)(4.0)(1.44)(1.323) \\
= {} & (19.0096)(10.002)(1.561)(2.282) \\
& (1.912)(1.754)(1.603)(4.36)(1.44)(1.323) \\
& - 20166.15 \\
= {} & 30243.924 - 20166.15 \\
= {} & 10077.77
\end{aligned}$$

Standard deviation = 100.39

Therefore the total relative risk is 142.02 with a standard deviation of 100.38. The 68% confidence limits on this value of TRR are 41.64 to 242.40. The expected number of accidents per annum is .536 with a standard deviation of 0.379. The standard deviation of the expected number of accidents per annum may optionally be included on PRANK and POLFIX reports.

I.3 Estimation of Confidence Limits for Benefit-Cost Ratios

For a site with n = 1,2,3 ... poles the benefit-cost ratio is calculated for the $i \leq n$ poles being treated. The remaining (n-i) poles maintain their untreated accident expectancies and costs, assuming the accident risk of a pole is independent of the pole's proximity to other poles.

The benefit cost(BC) ratio is expressed as

$$BC = \frac{(a_1c_1 - a_2c_2 - M)\ pwf}{t}$$

where a_1 = number of accidents for untreated pole

c_1 = cost of accidents for untreated pole

a_2 = number of accidents for treated pole

c_2 = cost of accidents for treated pole

t = treatment cost

pwf = present worth factor (see Appendix G)

M = Annual maintenance cost

Accident costs c_1 and c_2 vary depending on the pole's construction and hence its accident severity.

Simplifying:

$$BC = (a_1c_1 - a_2c_2 - m)K = (a_1c_1 - a_2c_2)K - mK$$

where $K = \frac{pwf}{t}$

and mK is regarded as a constant for the purpose of calculating the variance.

The variance of the variable $(a_1c_1 - a_2c_2)$ can be simply calculated if it is assumed that a_1c_1 and a_2c_2 are independent. Furthermore, since variances are known for a_1 and a_2 it is assumed that c_1 and c_2 can be regarded as constants for each a_1 and a_2.

Therefore from standard formulae:

$$Var(BC) = (c_1^2\ Var(a_1) + c_2^2\ Var(a_2))K^2$$

where $Var(a_1)$ = variance of total relative risk as calculated in the previous section.

For n poles in a site, i of which are treated in some way, the benefit cost calculation for the site is as follows:

6) $$BC \{\sum_{j=1}^{i} a_{jo}c_{jo} - \sum a_{jm}c_{jm}\}*K - \sum_{j=1}^{i} M_1K_1$$

7) $$Var\ (BC) = K^2\{\sum_{j=1}^{i} (c_j^2{}_o\ Var(a_{jo}) + c_j^2{}_m Var(a_{jm}))\}$$

where o (original) denotes accidents and costs prior to treatment,

and m (modified) denotes accidents and costs after treatment.

The standard deviation of Benefit Cost is calculated by and listed in the output of POLFIX.

I.4 Example Calculation of Benefit Cost Variance

Consider a site with three poles; one pole is moved laterally, one pole converted to wrap-around construction and one pole is untouched.

Description	Pole 1	Pole 2	Pole 3
Accidents P/A	4.6	1.4	1.4
Variance	5.9	.5	.5
Cost per accident	$20,000	$10,000	$10,000
Total accident cost	$92,000	$14,000	$14,000
Treatment	increase lateral offset	wrap-around	none
Treatment cost	$ 5,000	$ 4,000	-
New number of accidents P/A	1.6	1.4	1.4
Variance	.4	.5	.5
New cost per accident	$20,000	$ 5,000	$10,000
Annual maintenance cost	$ 0	$ 0	$ 0
Present worth factor for 5 years @ 10%	4.17	4.17	4.17

The benefit cost is then:

$$BC = ((4.6*20,000)+(1.4*10,000)-(1.6*20,000)-(1.4*5,000))*(4.17/9000$$

$$= 106000 - 39000*(4.17/9000)$$

$$= 31.04$$

$$Var(BC) = (4.17/9000)^2\{(20000^2*5.9)+(10000^2 x\ 0.5)+(20000^2*\ 0.4) +(5000^2*\ 0.5)\}$$

$$= 554.41$$

The standard deviation is then 23.46.

Therefore, one standard deviation (or 68%) confidence limits for the benefit cost are 31 ± 23.

APPENDIX J RELATIVE RISK PLOTS

The following relative risk plots are included:

Major Road Non-Intersection (MNI) Model

Variable	Figure or Table
Absolute maximum curvature	F/J.4
Annual average daily traffic	F/J.5
British pendulum skid test result	F/J.5
Lateral offset of the pole	F/J.7
Distance between curbs (undivided roads)	F/J.8
Distance from curve start	F/J.9
Pavement deficiencies	T/J.3
Superelevation of the curve	T/J.4
Pole on inside or outside of bend	T/J.5

Minor Road Non-Intersection (MINI) Model

Variable	Figure or Table
Absolute maximum curvature	F/J.10
Grade at 30m upstream of pole	F/J.11
British pendulum skid test result	F/J.12
Lateral offset of pole	F/J.13
Road Width	F/J.14
Pole on inside or outside of bend	F/J.6

Intersection of Major Roads (MJMJ) Model

Variable	Figure or Table
Intersection type	T/J.8
Annual average daily traffic roadway 1	F/J.15
British pendulum skid test, roadway 1	F/J.16
Lateral offset of the pole	F/J.17
Annual average daily traffic, intersecting roadway 1	F/J.18
Roadway 1 divided/undivided	T/J.7
Intersecting roadway divided/undivided	T/J.7
Grade 30m upstream of intersection on roadway 1	F/J.19

Intersection of Major and Minor Roads (MJMI) Model

Variable	Figure or Table
Intersection type	T/J.10
Annual average daily traffic roadway 1	F/J.20
British pendulum skid test result roadway 1	F/J.21
Lateral offset of pole	F/J.22
Distance between curbs, intersecting roadway	F/J.23
Roadway 1 divided/undivided	T/J.9
Grade 30m upstream of the intersection on roadway 1	F/J.24
Radial distance of pole from centre of intersection	F/J.25

Figure J.1 - deleted

Figure J.2 - deleted

Figure J.3 - deleted

Table J.1 - deleted

Table J.2 - deleted

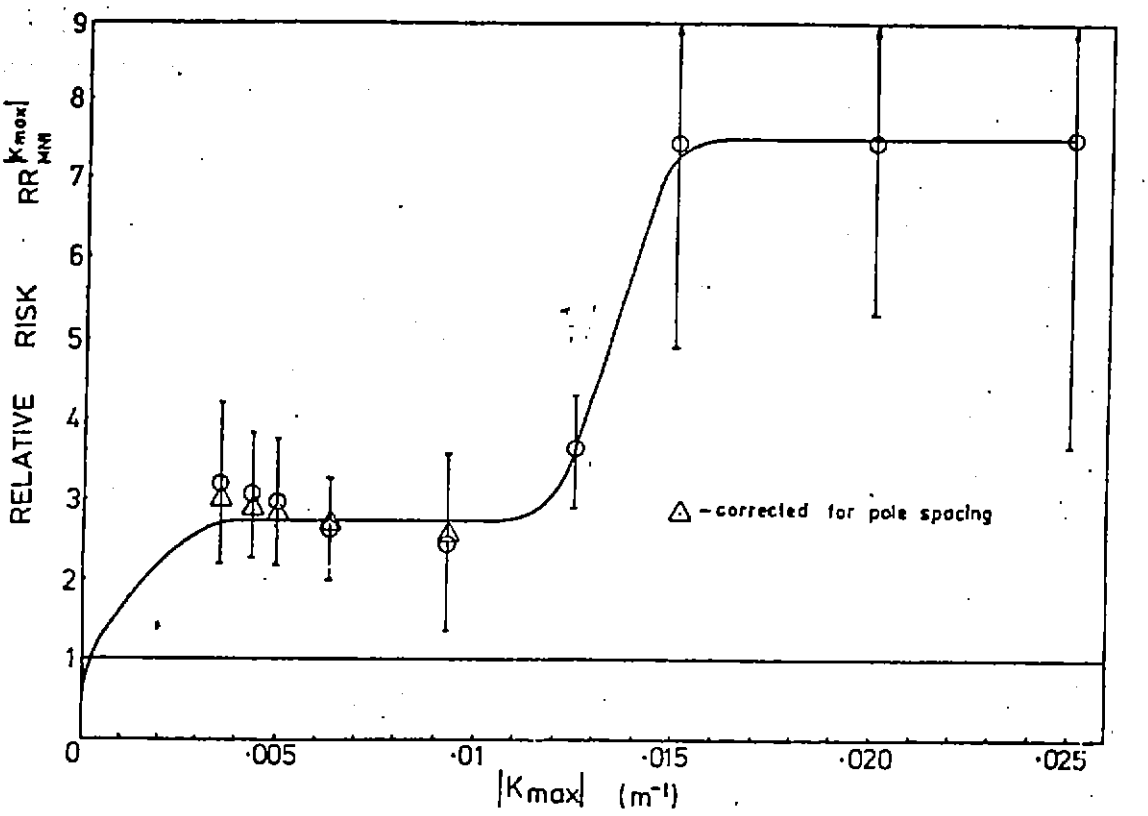


Figure J.4 Relative risk versus absolute maximum curvature upstream of the pole - MNI data group

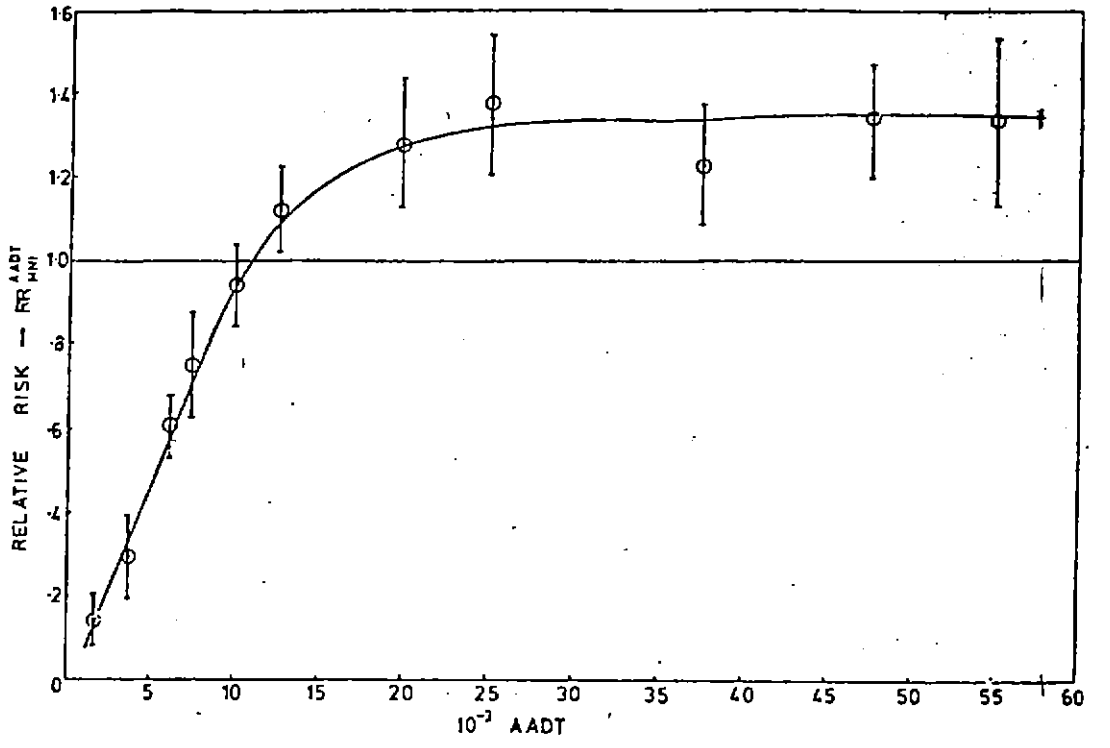


Figure J.5 Relative risk versus AADT - MNI data group

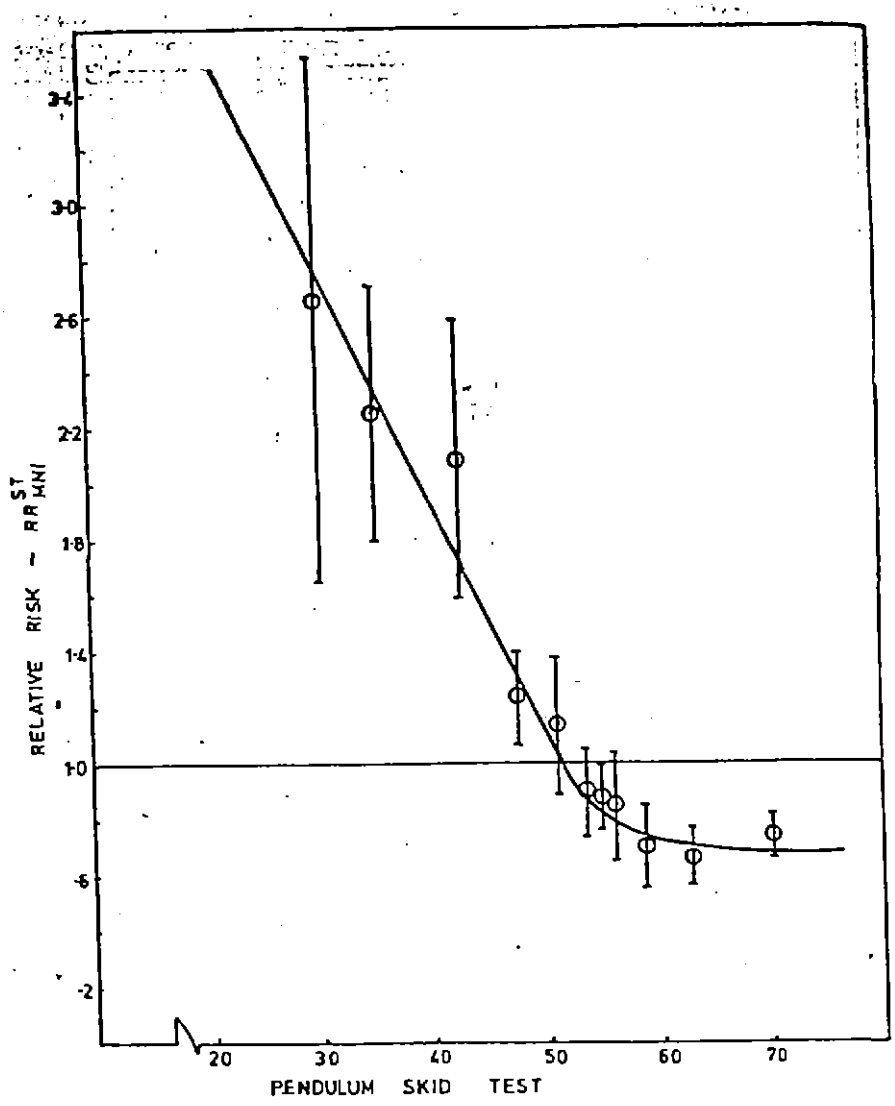


Figure J.6 Relative risk versus British pendulum skid test - MNI data group

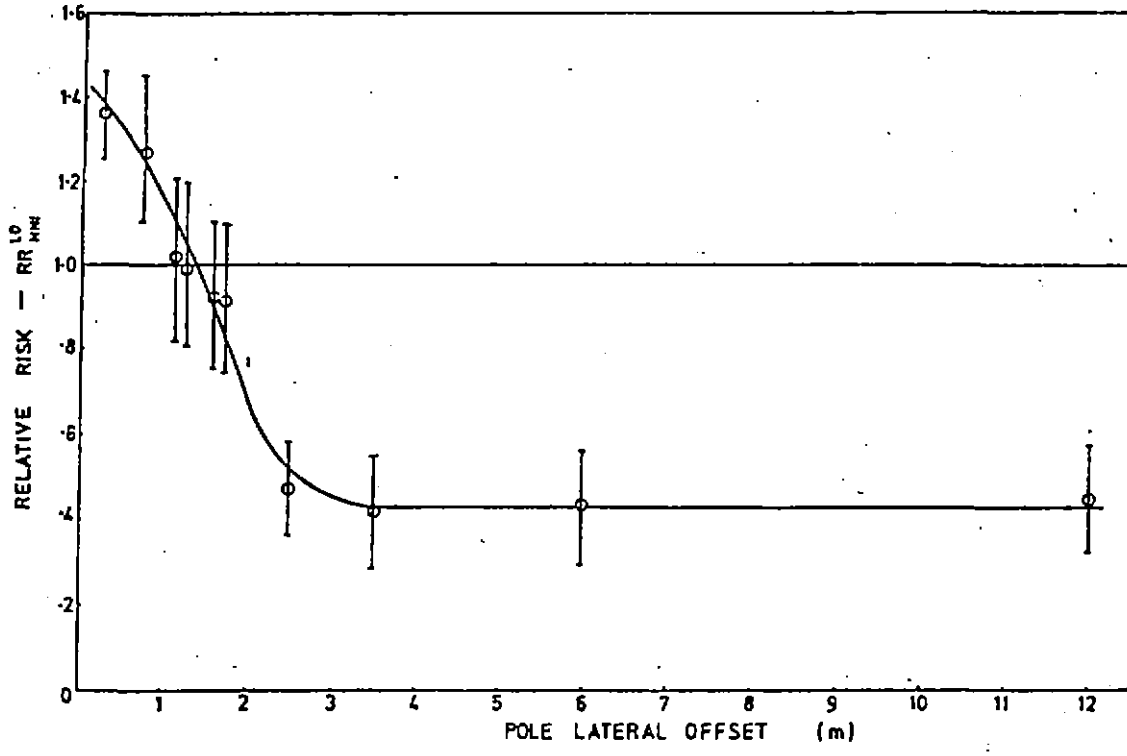


Figure J.7. Relative risk versus pole lateral offset - MNI data group

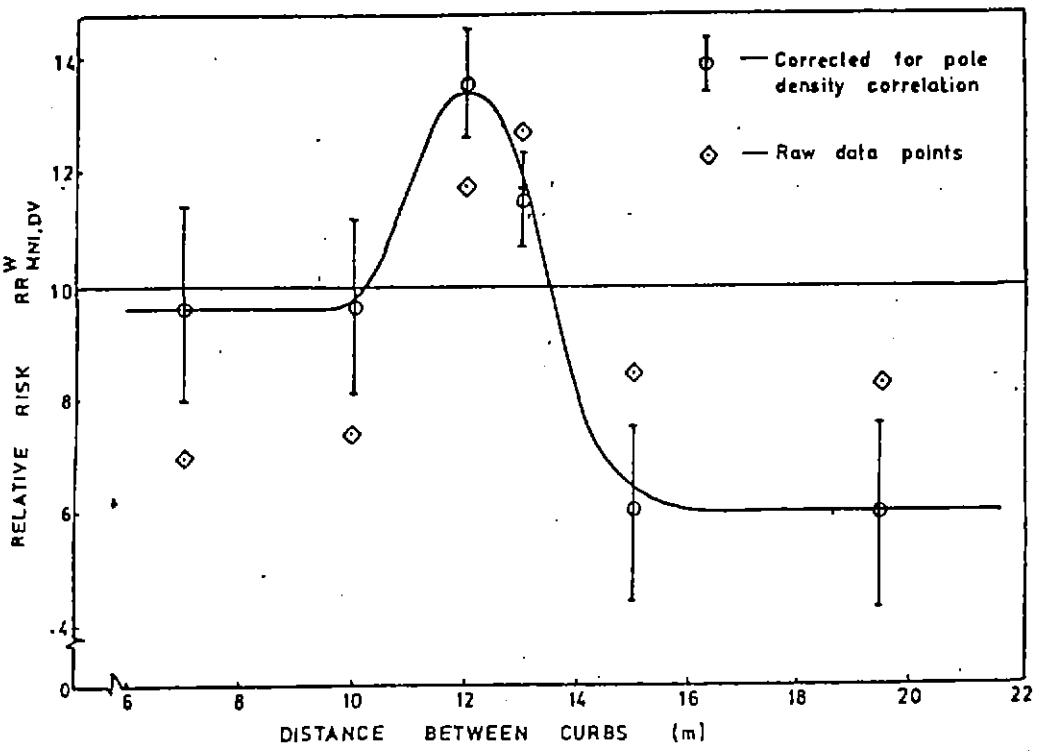


Figure J.8. Relative risk versus distance between curbs (road width) for undivided roads - MNI data group

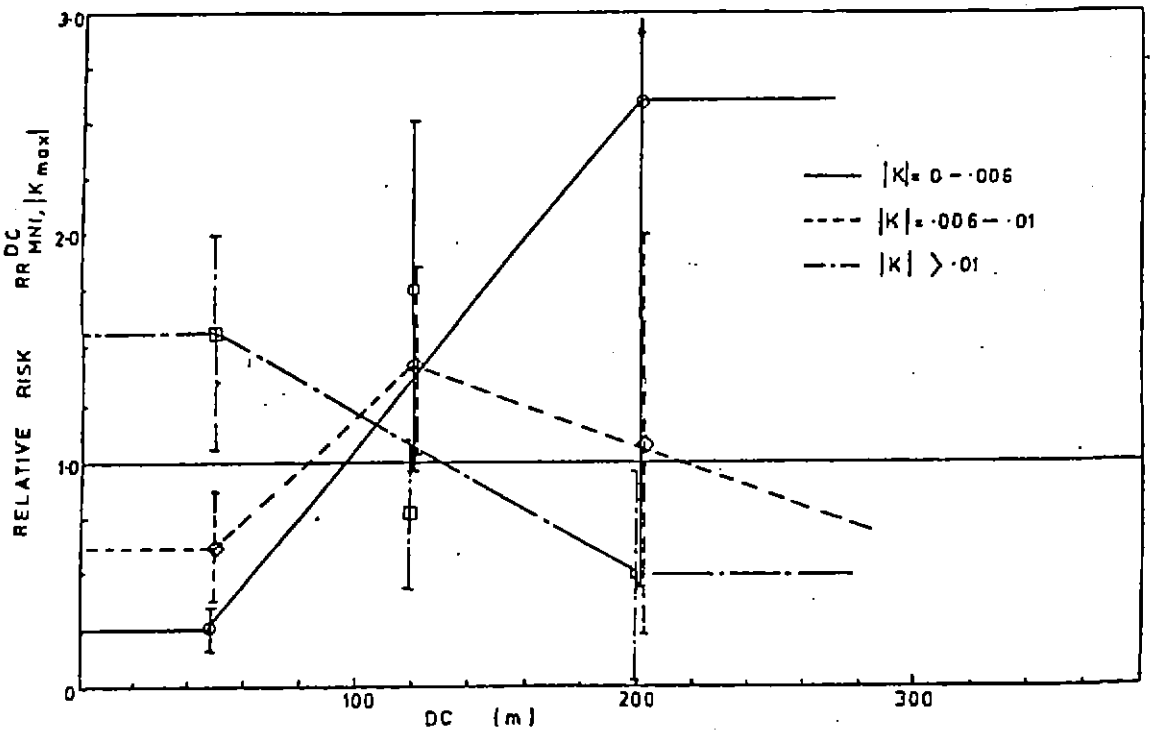


Figure J.9. Relative risk versus distance from curve start controlling for absolute maximum curvature - MNI data group

TABLE J.3

RELATIVE RISK ASSOCIATES WITH PAVEMENT DEFICIENCIES -- MNI DATA GROUP

Pavement deficiency	Relative Risk	Standard Deviation
None	0.93	0.04
Tram tracks	0.99	0.17
Dip/Crest	1.89	0.60
Corrugations, holes	2.00	0.60

TABLE J.4.

RELATIVE RISK FOR SUPERELEVATION GIVEN CURVATURE (RR_k^e) - MNI DATA GROUP

Curvature	Calculated RR_k^e Superelevation		Selected RR_k^e Superelevation	
	-	+	-	+
Left	0.93	1.23	0.9	1.2
Right	1.22	0.78	1.2	0.9

TABLE J.5

RELATIVE RISKS ASSOCIATED WITH POLES ON THE INSIDE AND OUTSIDE OF CURVES -- MNI DATA GROUP

Location of Pole	Relative Risk
Inside	0.85
Outside	1.15

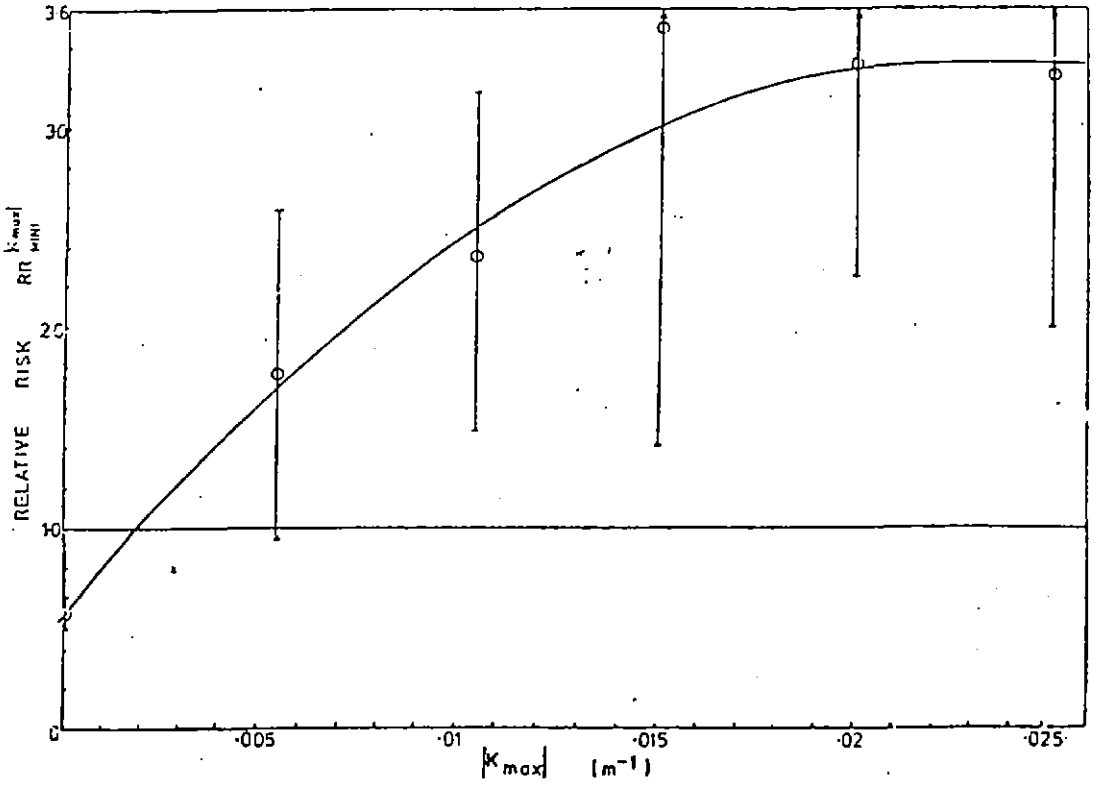


Figure J.10. Relative risk versus absolute maximum curvature upstream of the pole - MINI data group

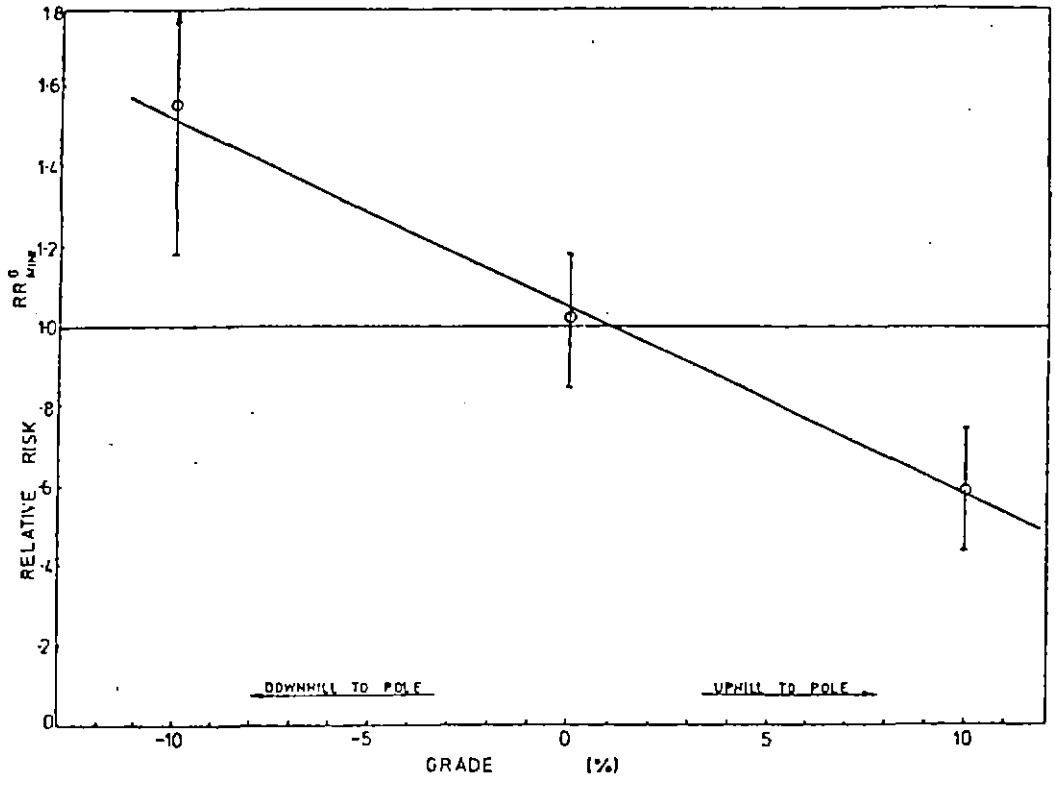


Figure J.11. Relative risk versus grade 30m upstream of the pole - MINI data group

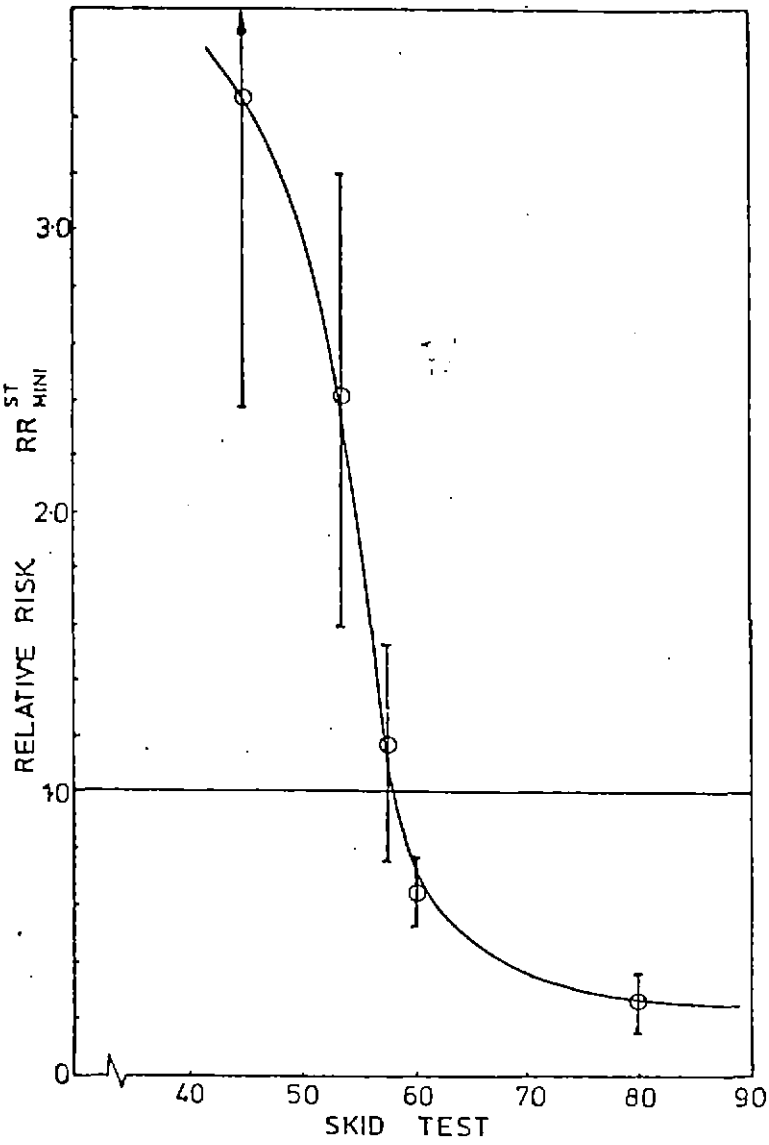


Figure J.12. Relative risk versus skid test - MINI data group

TABLE J.6

RELATIVE RISK VERSUS LOCATION OF POLE ON A CURVE -- MINI DATA GROUP

Position of Pole	RR	SD
Inside of curve	1.25	0.40
Outside of curve	0.70	0.25

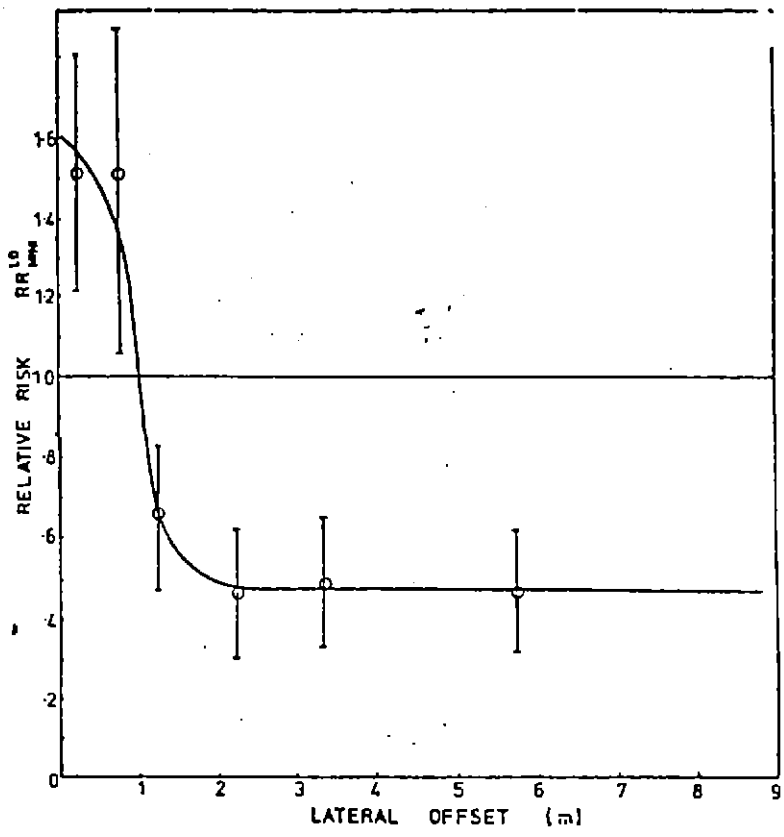


Figure J.13. Relative risk versus pole lateral offset - MINI data group

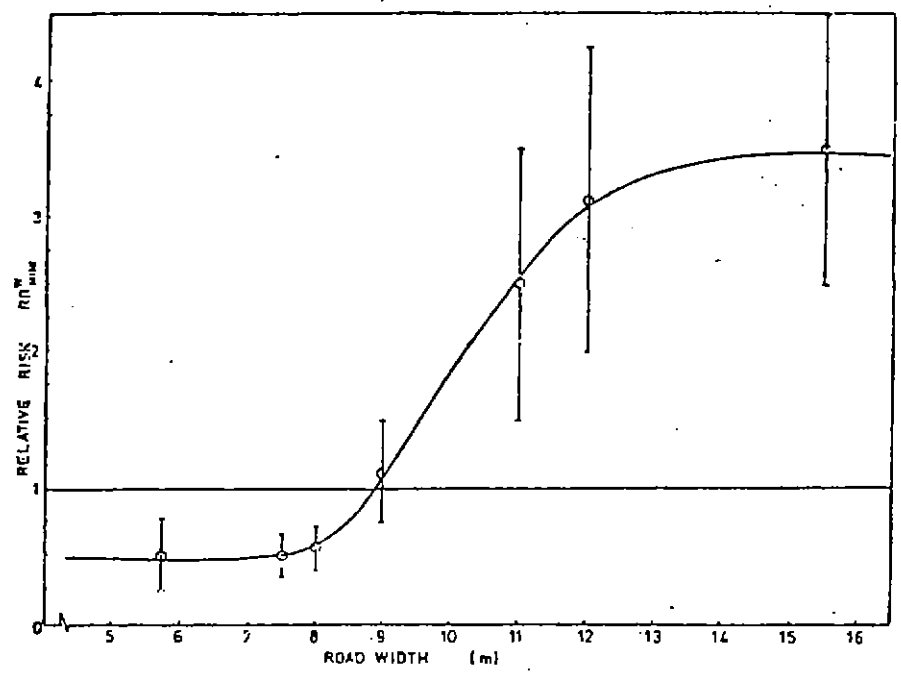


Figure J.14. Relative risk versus road width - MINI data group

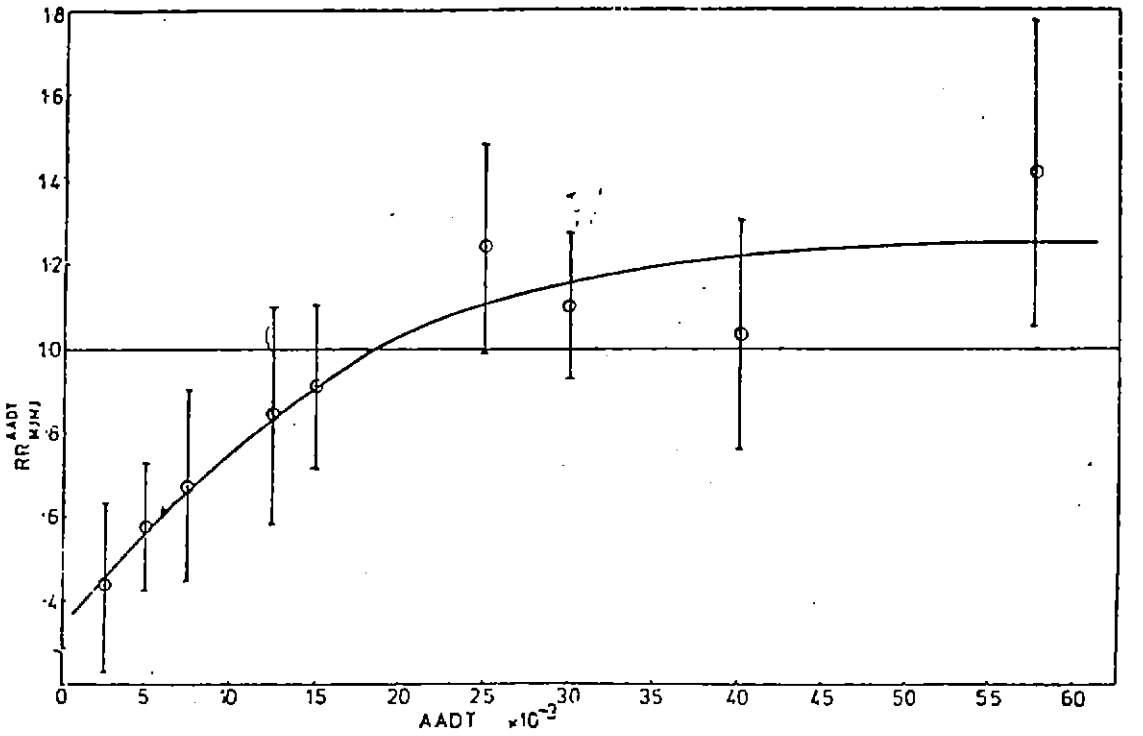


Figure J.15. Relative risk versus AADT on roadway 1 - MJMJ data group

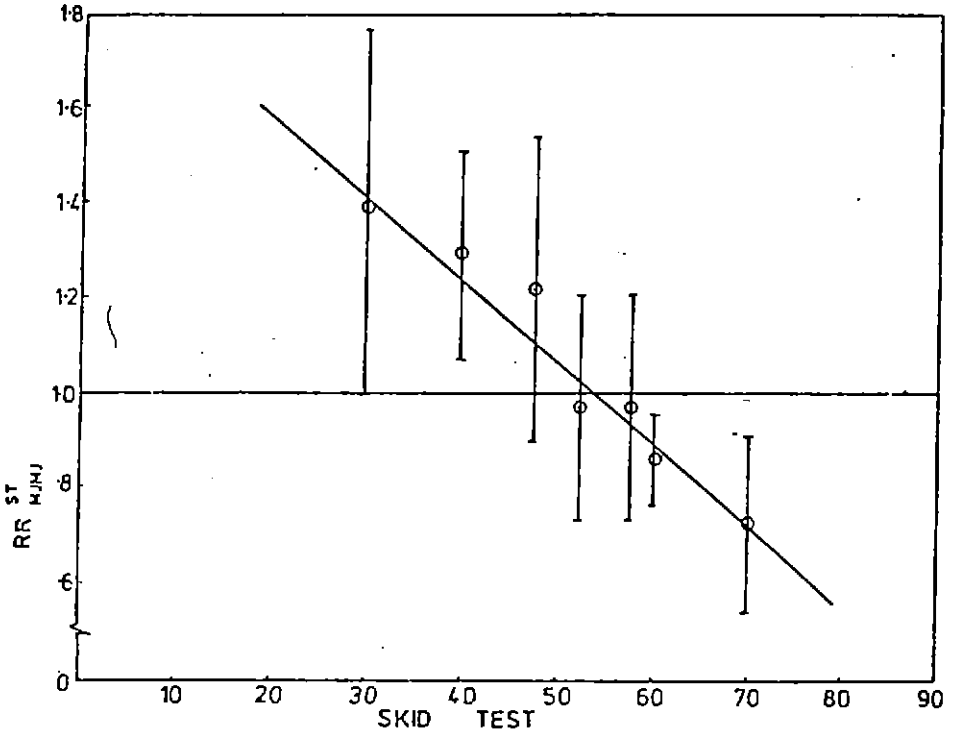


Figure J.16. Relative risk versus skid test on roadway 1 - MJMJ (intersection) data group

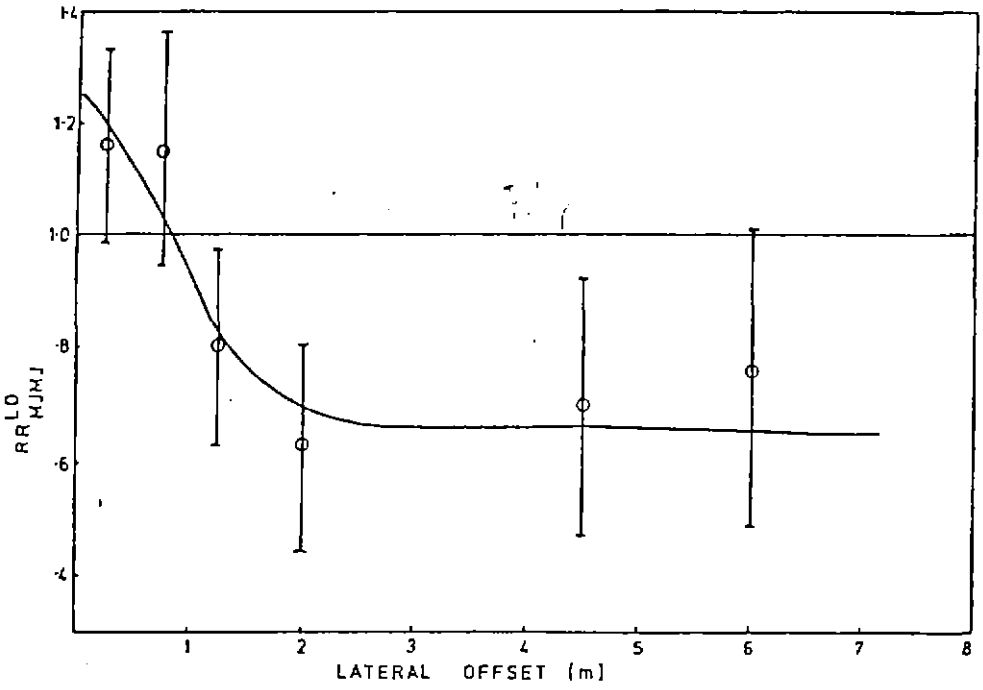


Figure J.17 Relative risk versus pole lateral offset - MJMJ data group

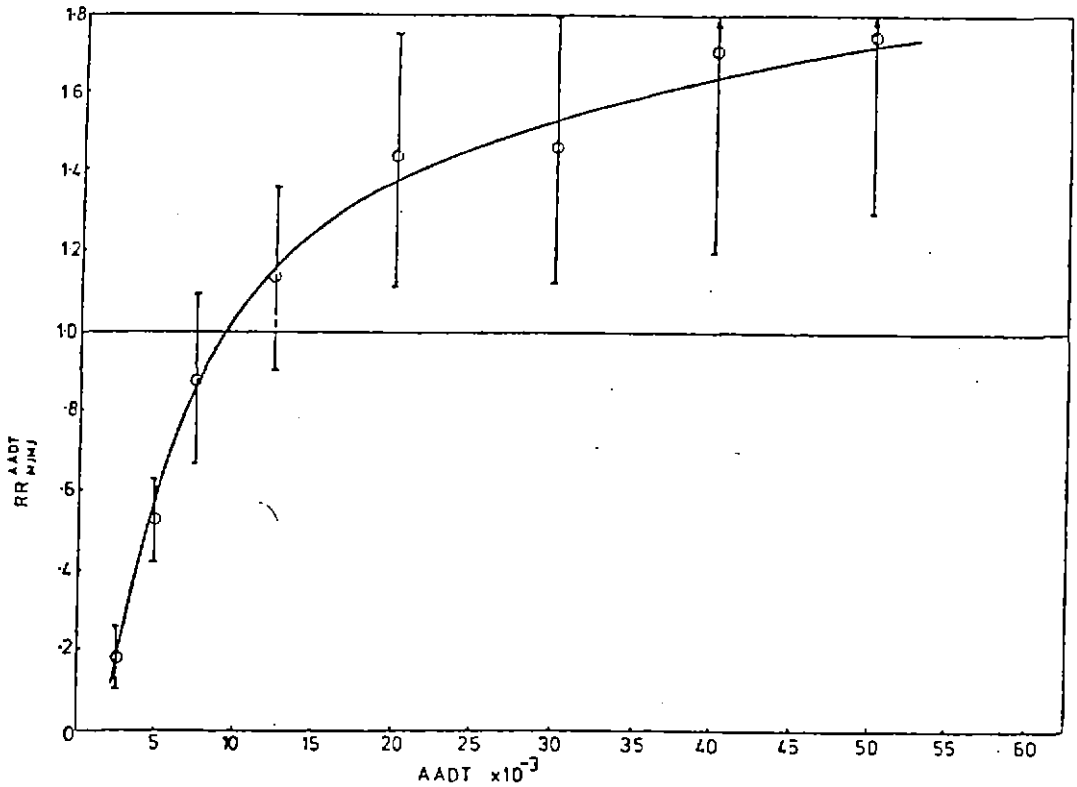


Figure J.18. Relative risk versus AADT on the intersecting roadway - MJMJ data group

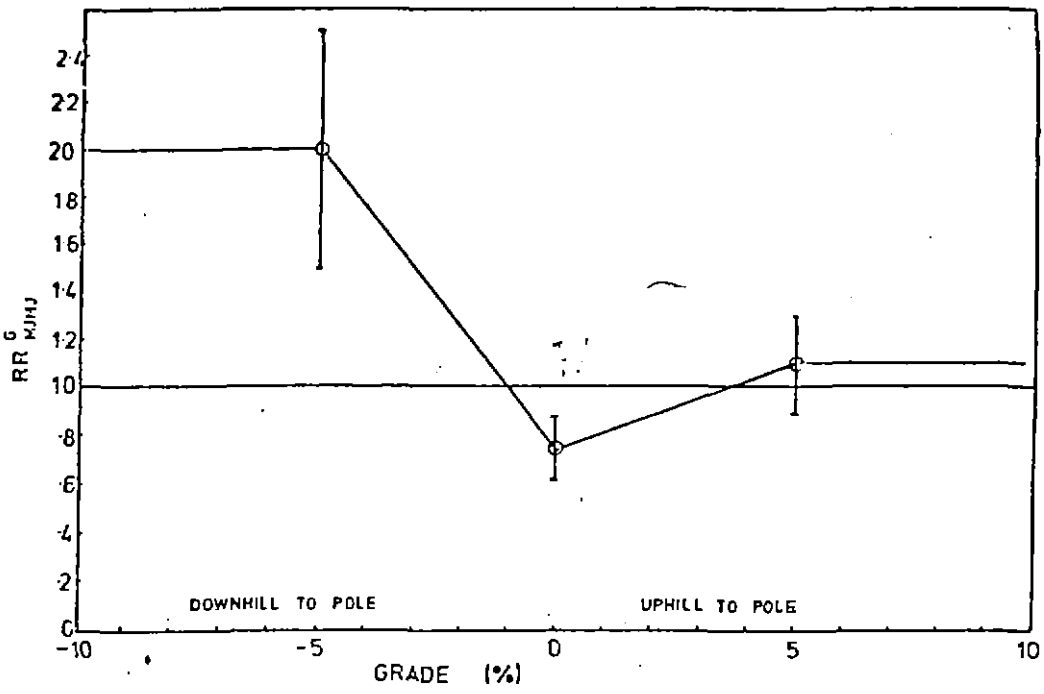


Figure J.19. Relative risk versus grade of roadway 1, 30m before the intersection - MJMJ data group

TABLE J.7

CHOSEN VALUES OF RELATIVE RISK AGAINST BOTH INTERSECTING ROADWAYS DIVIDED/UNDIVIDED CONTROLLING FOR THE PRESENCE OF TRAFFIC LIGHTS -- MJMJ

Roadway Divided/Undivided	Relative Risk	
	Traffic Lights	Other
Divided	1.00	0.11
Undivided	1.00	1.80

TABLE J.8

RELATIVE RISKS FOR CROSS AND TEE INTERSECTIONS, CONTROLLING FOR PRESENCE OF TRAFFIC LIGHTS -- MJMJ

Intersection Type	Type of control	
	Traffic lights	No traffic lights
	RR	RR
Cross	1.0	1.9
Tee	1.0	0.7

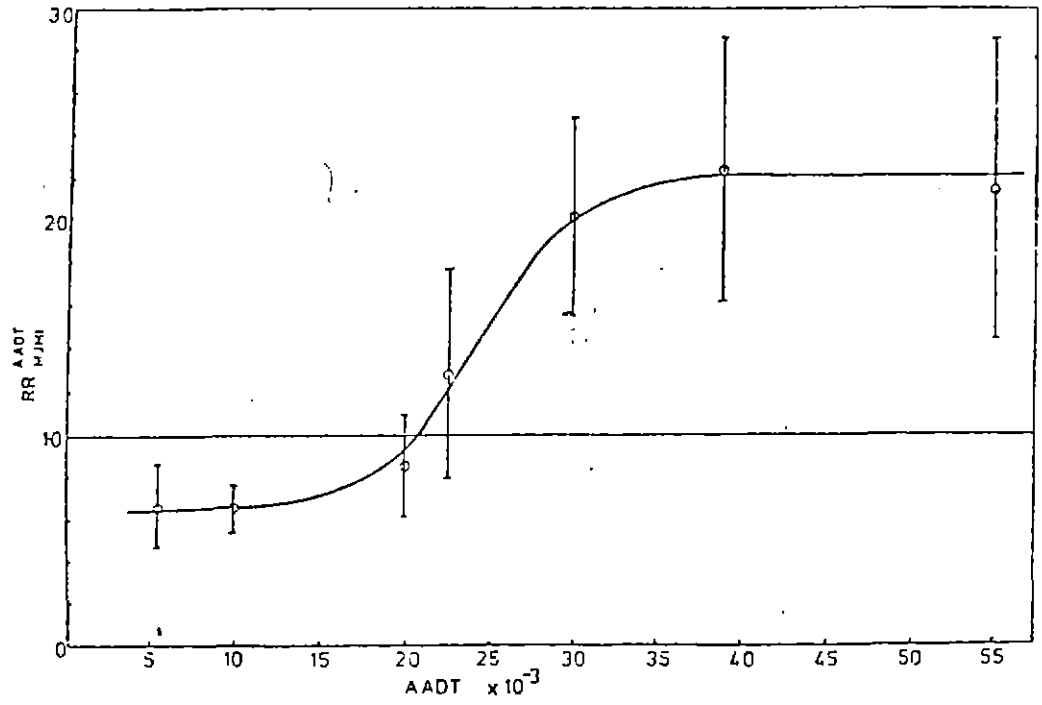


Figure J.20. Relative risk versus AADT on the major road - MJMI data group

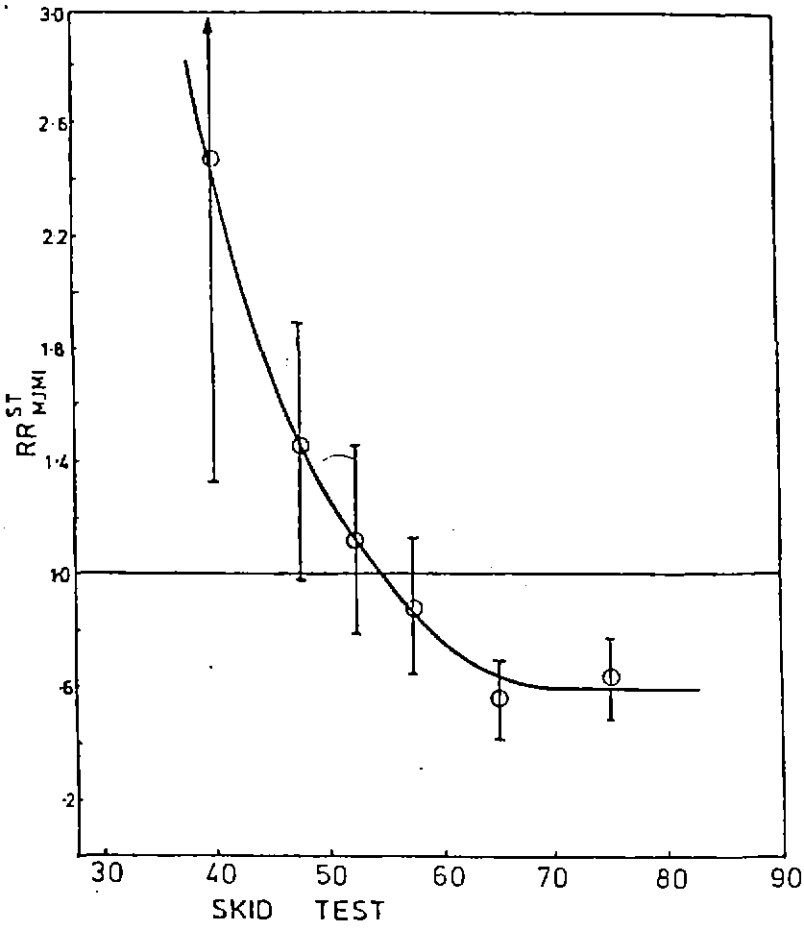


Figure J.21. Relative risk versus British pendulum skid test on the major road - MJMI data group

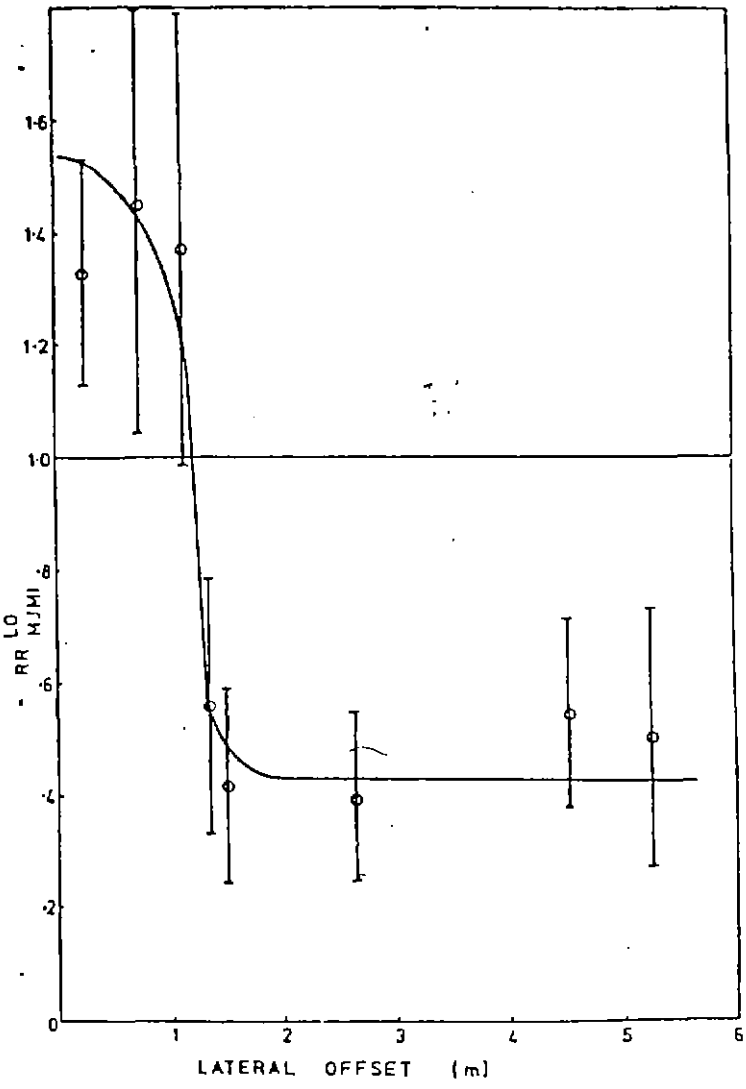


Figure J.22. Relative risk versus pole lateral offset - MJMI data group

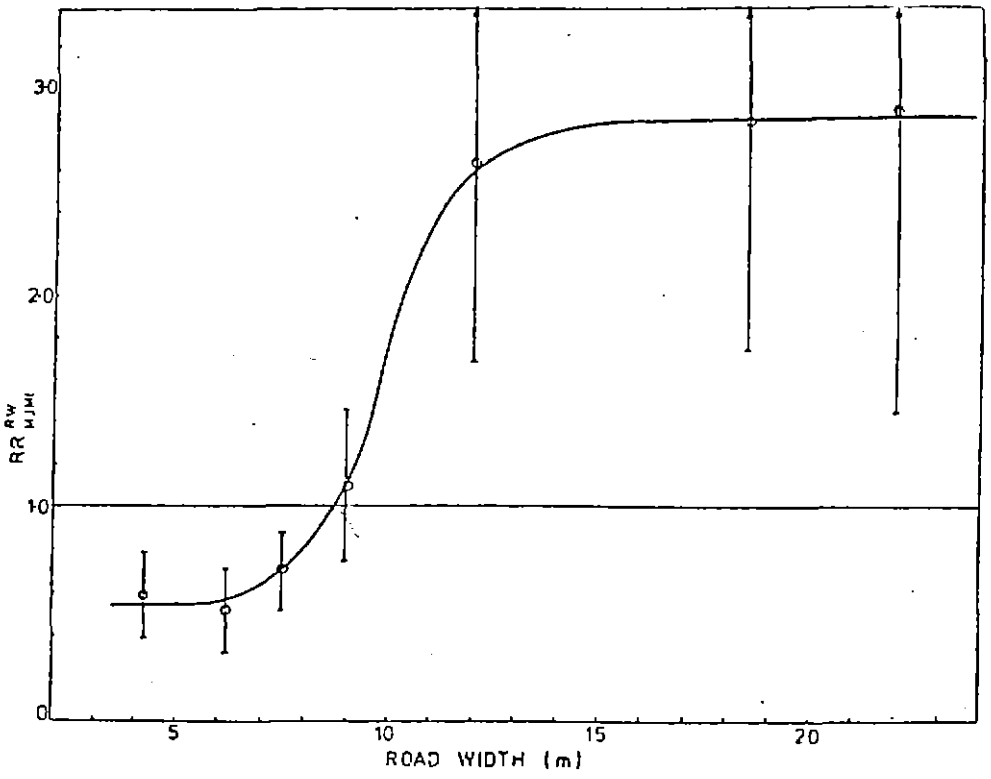


Figure J.23. Relative risk versus width of intersecting minor roadway - MJMI data group

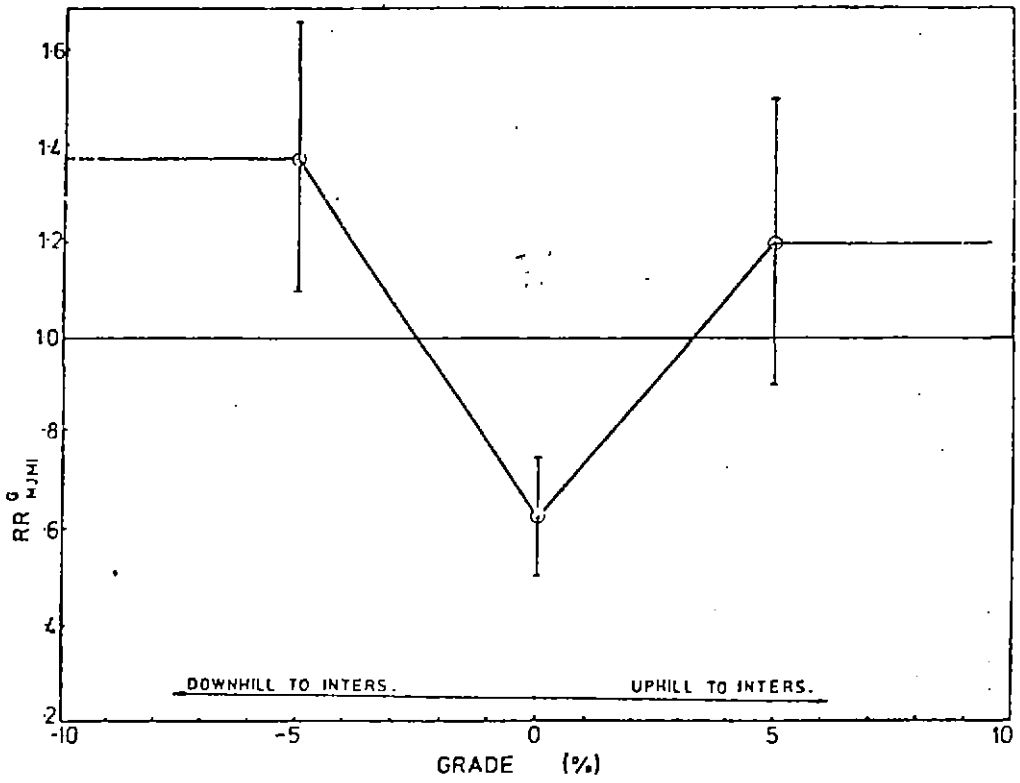


Figure J. 24. Relative risk versus grade of the major road 30m before the intersection - MJMI data group

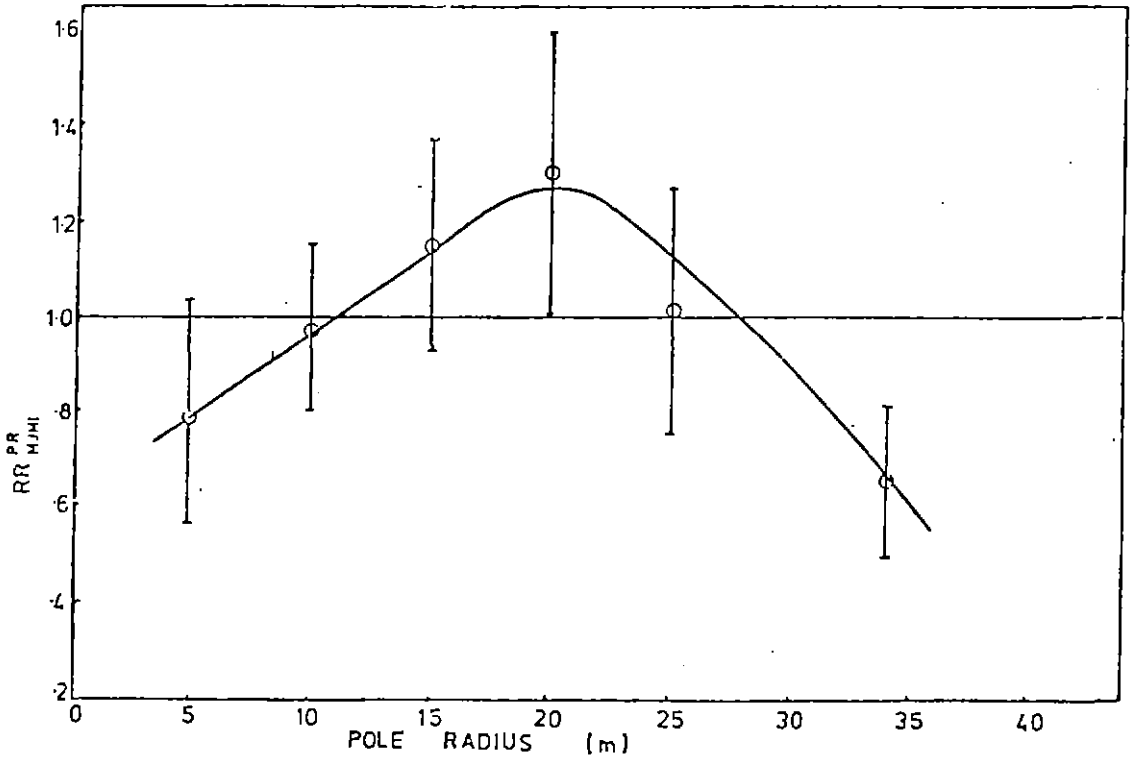


Figure J.25. Relative risk versus radial distance of the pole from the centre of the intersection - MJMI data group

TABLE J.9 .

RELATIVE RISK FOR ROADWAY 1 DIVIDED/UNDIVIDED -- MJMI DATA GROUP

Roadway Divided/Undivided	RR	SD
Divided	0.58	0.21
Undivided	1.43	0.30

TABLE J.10

RELATIVE RISK BY INTERSECTION TYPE (+ OR T) MJMI DATA GROUP

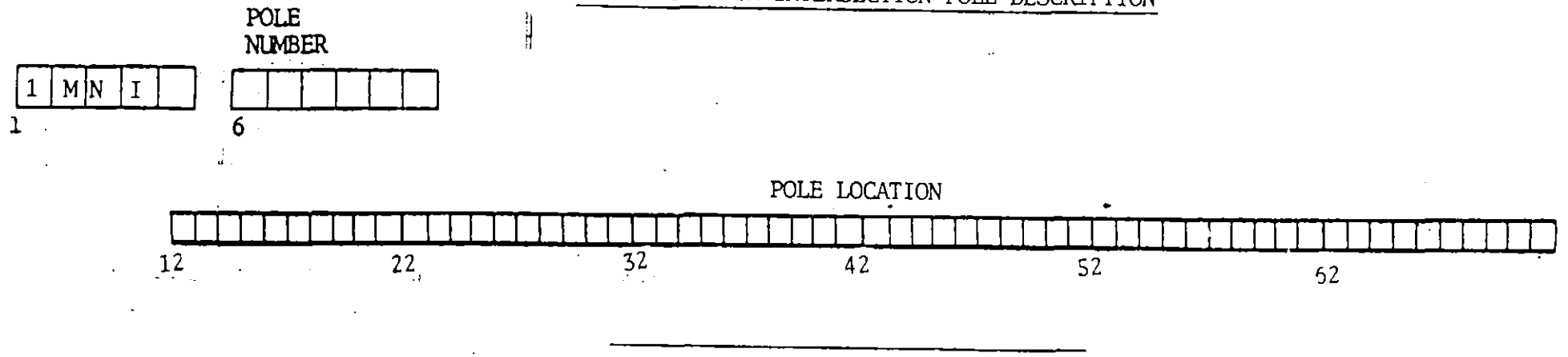
Intersection Type	RR	SD
+	2.50	0.53
T	0.70	0.13

APPENDIX K SAMPLE POLE INPUT FORMS

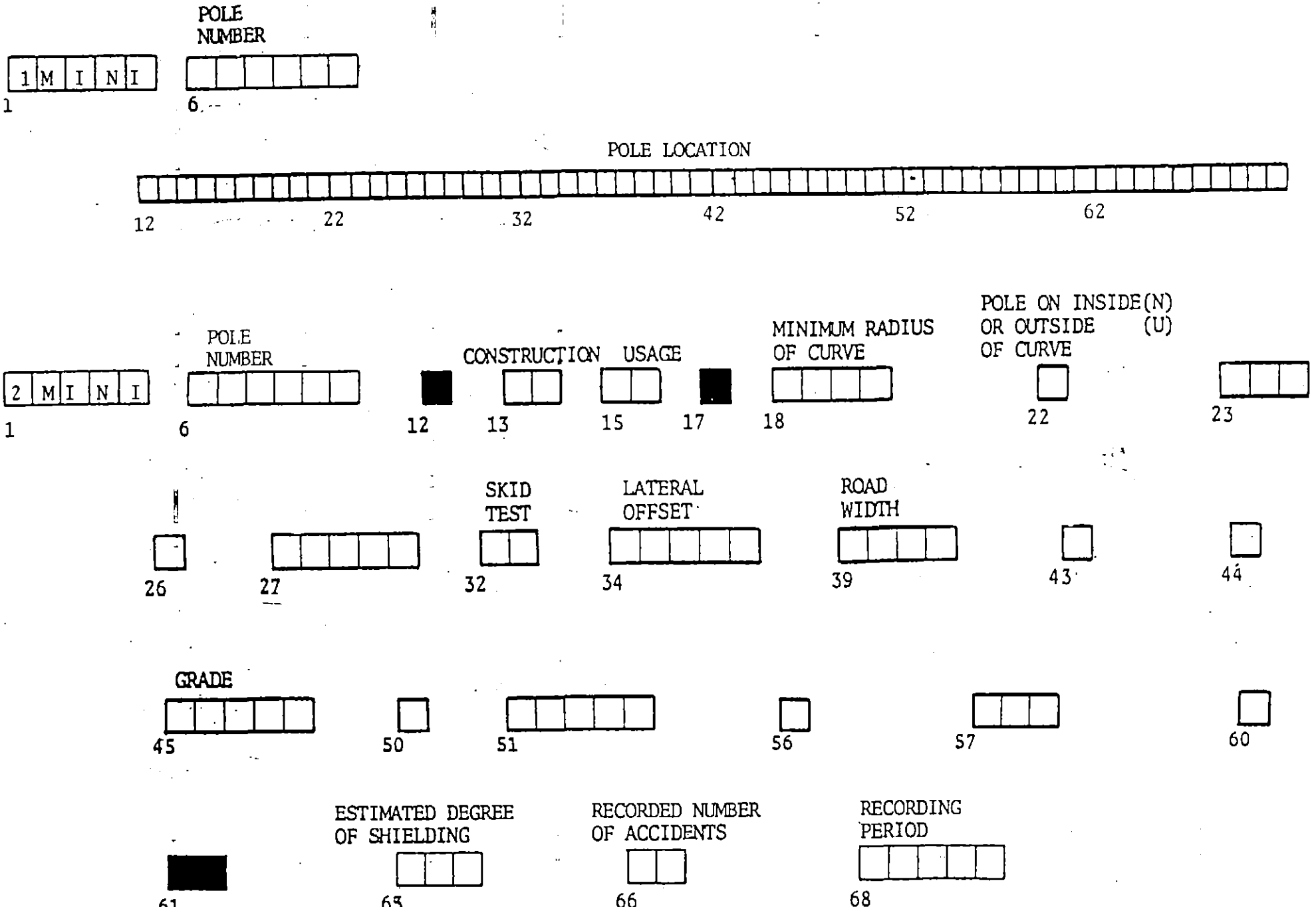
A copy of each pole input form is included for the user to copy.

UTILITY POLE RANKING PROGRAM

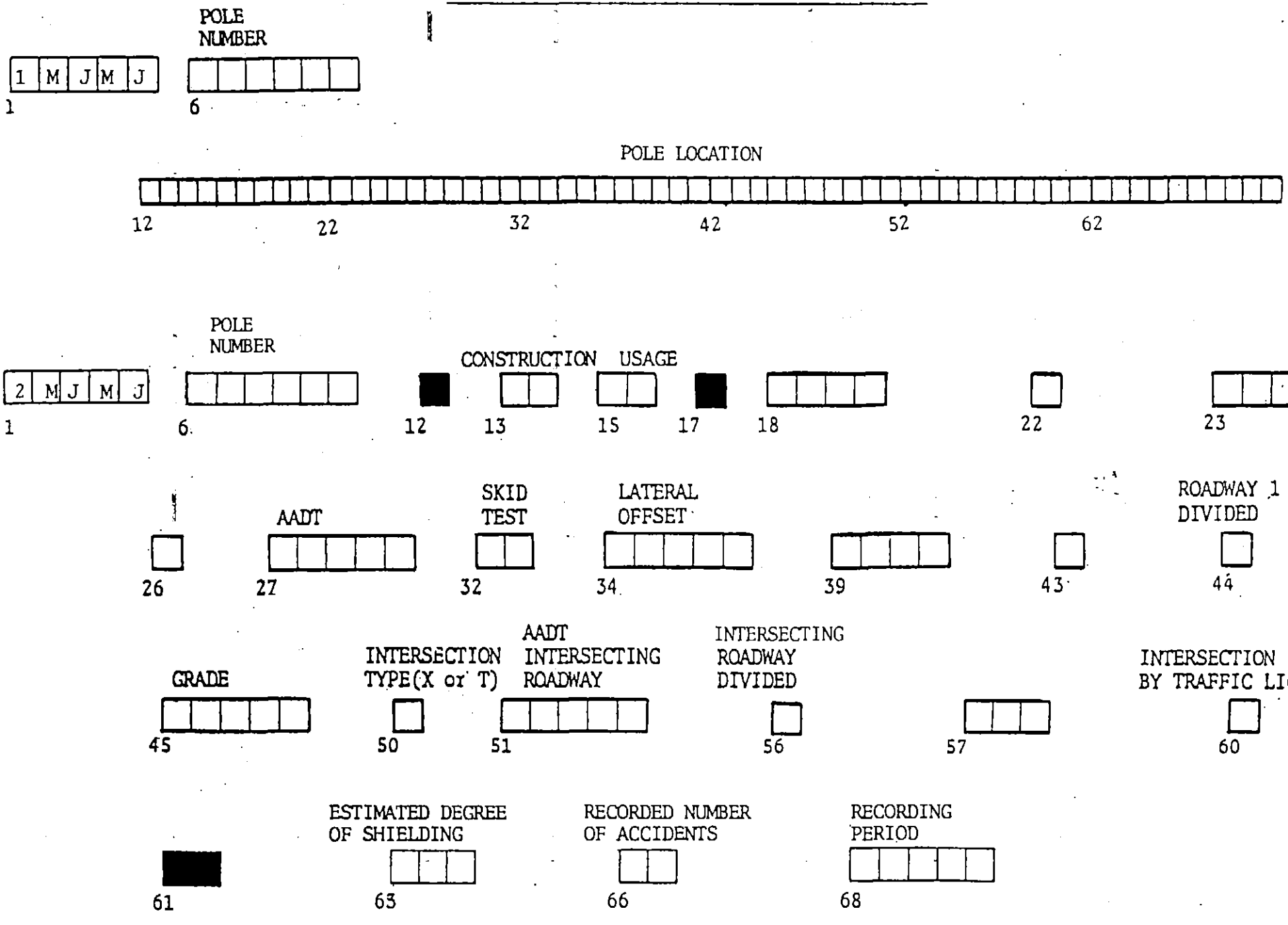
MAJOR ROAD NON-INTERSECTION POLE DESCRIPTION



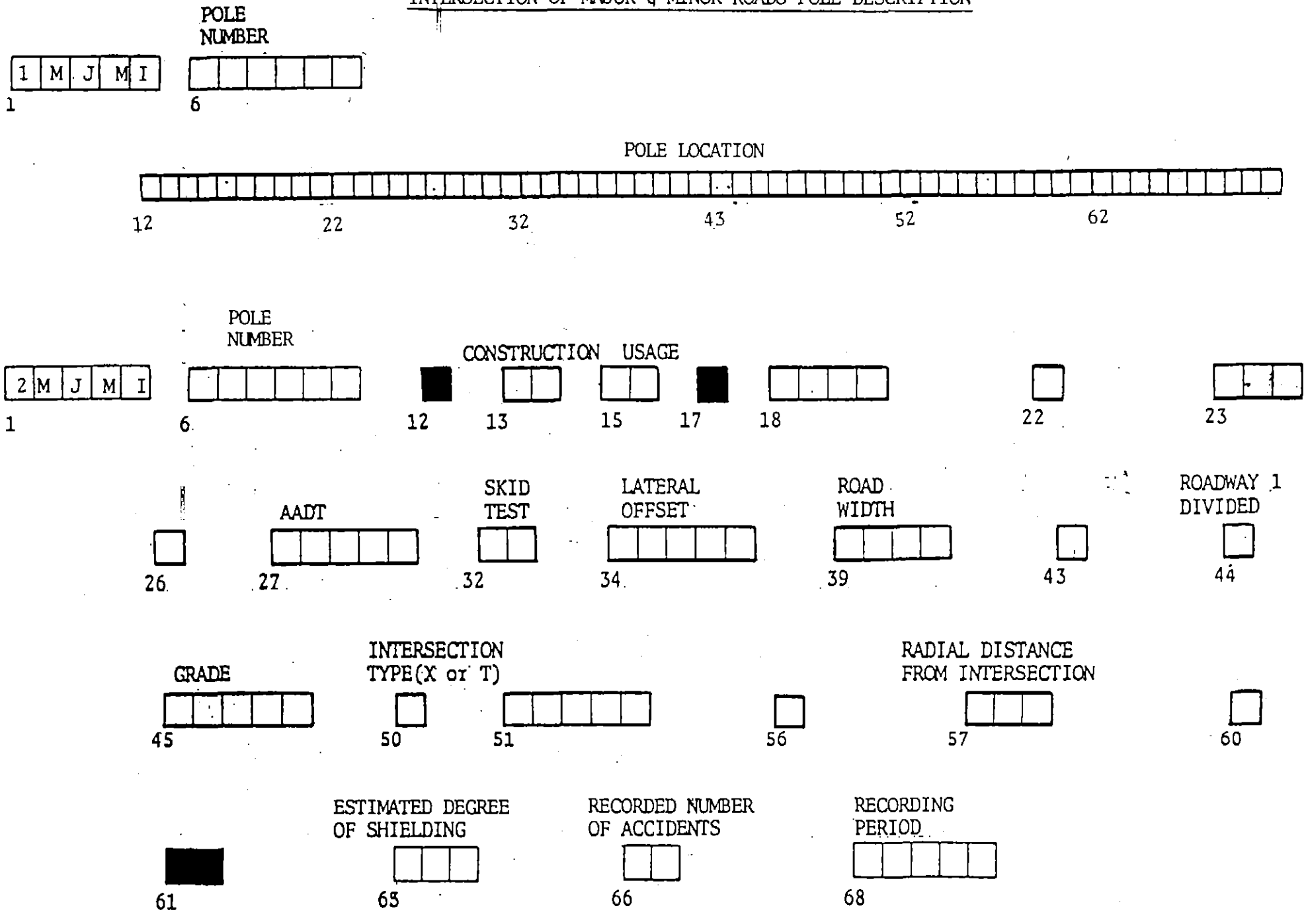
MINOR ROAD NON-INTERSECTION POLE DESCRIPTION



INTERSECTION OF MAJOR ROADS POLE DESCRIPTION



INTERSECTION OF MAJOR & MINOR ROADS POLE DESCRIPTION



OPTIONS AND PARAMETERS

1	O	P	T	N

1

PRINT REPORT SORTED BY EXPECTED NUMBER OF ACCIDENTS (Y or N) — 6

FULL SORTED REPORT (Y or N) — 7

UNSORTED REPORT (Y or N) — 8

FULL UNSORTED REPORT (Y or N) — 9

READ RECORDED ACCIDENTS (Y or N) — 10

SKID TESTER B = BRITISH PORTABLE S = SCRIM — 11

PRINT STANDARD DEVIATIONS (Y or N) — 12

13

HEADING FOR OUTPUT

14 24 34 44 54 64

RELATIVE RISK BY POLE CATEGORIES

2	O	P	T	N

1

MAJOR ROAD NON INTERSECTION — 6

MINOR ROAD NON INTERSECTION — 11

MAJOR/MAJOR INTERSECTION — 16

MAJOR/MINOR INTERSECTION — 21

ACCIDENT FACTOR — 26

CUTOFF NUMBER OF ACCIDENTS — 34

OPTIONS

1 | 1 | O | P | T | N |

HEADING FOR OUTPUT

6	16	26	36	46	56

RELATIVE RISK BY POLE CATEGORIES

1 | 2 | O | P | T | N |

MAJOR ROAD NON INTERSECTION [ ] 6

MINOR ROAD NON INTERSECTION [ ] 11

MAJOR/MAJOR INTERSECTION [ ] 16

MAJOR/MINOR INTERSECTION [ ] 21

ACCIDENT FACTOR [ ] 26

INTEREST RATE [ ] 34

SKID TESTER
B = BPS
S = SCRIM
[ ] 38

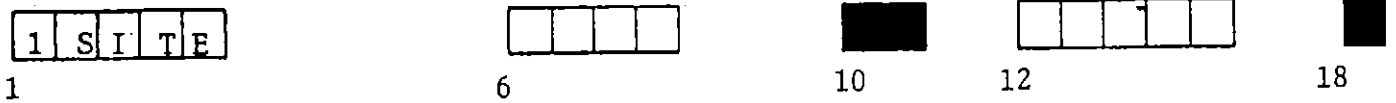
RANK BY B/C RATIO = B
RANK BY NPV = N
[ ] 39

PRINT POLE DESC. Y or N [ ] 40

PRINT TREATMENT EFFECT DETAILS [ ] 41

PRINT STANDARD DEVIATIONS (Y or N) [ ] 42

SITE DESCRIPTION FORM



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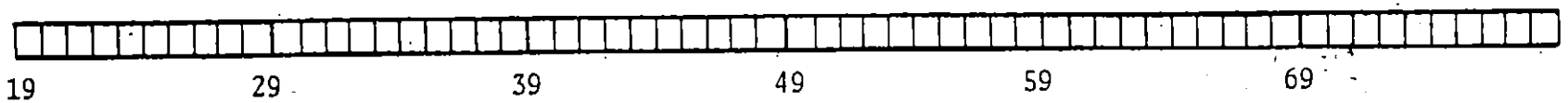
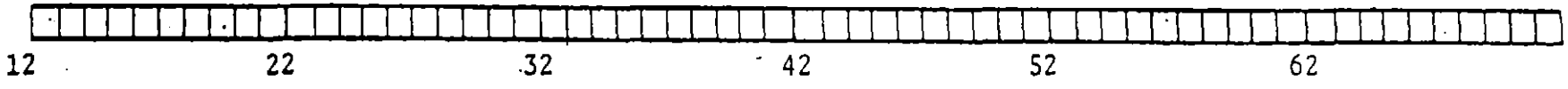
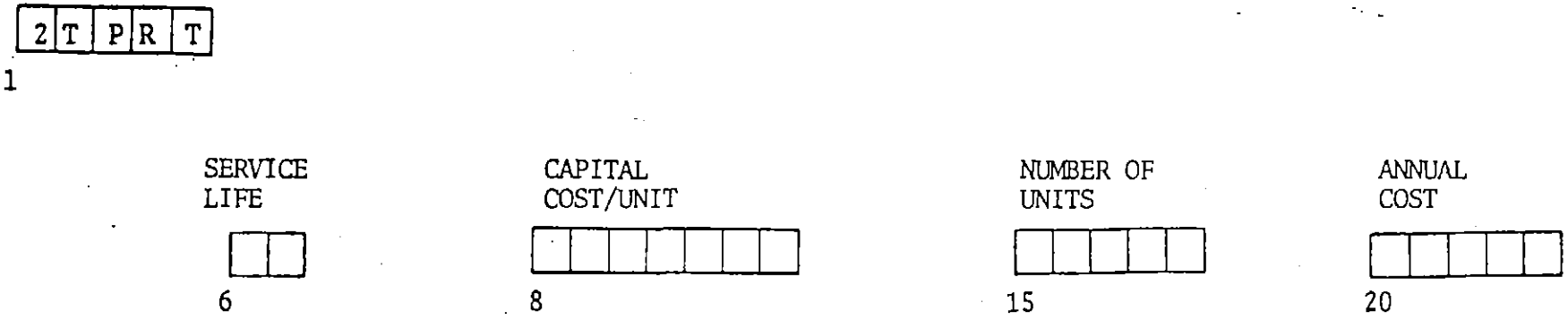


TREATMENT DESCRIPTION

DESCRIPTION OF TREATMENT





UTILITY POLE SITE TREATMENT PROGRAM

TREATMENT EFFECT FORM

Only fill in fields that have changed

1	T	E	F	F

1

SITE NUMBER (6)

POLE NUMBER (10)

(12)

CONSTRUCTION (13)

USAGE (15)

(17)

MINIMUM RADIUS OF CURVE (18)

POLE ON INSIDE(N) OR OUTSIDE (U) OF CURVE (22)

DISTANCE FROM CURVE START (23)

SUPER-ELEVATION (F or U) (26)

AADT (27)

SKID TEST (32)

LATERAL OFFSET (34)

ROAD WIDTH (39)

PAVEMENT DEFICIENCIES (N,T,D,C) (43)

ROADWAY 1 DIVIDED (44)

GRADE (45)

INTERSECTION TYPE(X or T) (50)

AADT INTERSECTING ROADWAY (51)

INTERSECTING ROADWAY DIVIDED (56)

RADIAL DISTANCE FROM INTERSECTION (57)

INTERSECTION CONTROLLED BY TRAFFIC LIGHTS (60)

MAJOR ROAD NON-INTERSECTION POLE DESCRIPTION

1	D	M	N	I

1

SITE NUMBER	POLE NUMBER		CONSTRUCTION USAGE			MINIMUM RADIUS OF CURVE	POLE ON INSIDE (N) OR OUTSIDE (U) OF CURVE	DISTANCE FROM CURVE START
6	10	12	13	15	17	18	22	23

SUPER-ELEVATION (F or U)	AADT	SKID TEST	LATERAL OFFSET	ROAD WIDTH	PAVEMENT DEFICIENCIES (N,T,D,C)	
26	27	32	34	39	43	44

45	50	51	56	57		60

UTILITY POLE SITE TREATMENT PROGRAM

DESCRIPTION OF POLE AT INTERSECTION OF MAJOR ROADS

1	D	M	J	J

1

SITE NUMBER (6)

POLE NUMBER (10)

(12)

CONSTRUCTION (13)

USAGE (15)

(17)

(18)

(22)

(23)

(26)

AADT (27)

SKID TEST (32)

LATERAL OFFSET (34)

(39)

(43)

ROADWAY 1 DIVIDED (44)

GRADE (45)

INTERSECTION TYPE (X or T) (50)

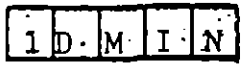
AADT INTERSECTING ROADWAY (51)

INTERSECTING ROADWAY DIVIDED (56)

(57)

INTERSECTION CONTROLLED BY TRAFFIC LIGHTS (60)

MINOR ROAD NON INTERSECTION POLE DESCRIPTION



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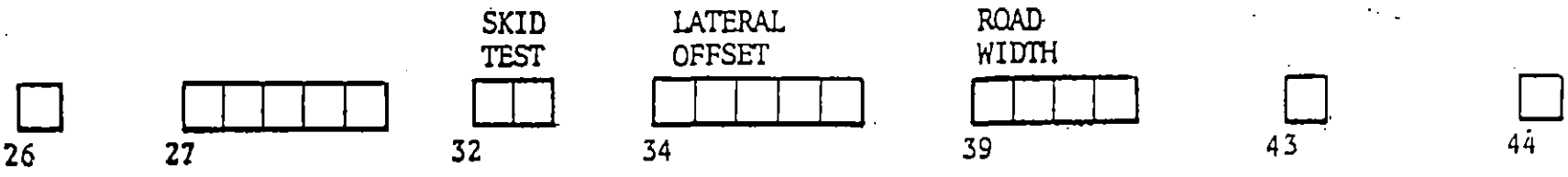

DESCRIPTION OF POLE AT INTERSECTION OF MAJOR & MINOR ROADS

1

SITE NUMBER 6

POLE NUMBER 10

12

CONSTRUCTION 13

USAGE 15

17

18

22

23

26

AADT 27

SKID TEST 32

LATERAL OFFSET 34

ROAD WIDTH 39

43

ROADWAY 1 DIVIDED 44

GRADE 45

INTERSECTION TYPE(X or T) 50

51

56

RADIAL DISTANCE FROM INTERSECTION 57

60