FERIC FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA
INSTITUT CANADIEN DE RECHERCHES EN GÉNIE FORESTIER

TN #
53

Grapple Yarding with a Steel Tower

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FOREWORD

FERIC gratefully acknowledges the assistance and cooperation of the supervisors and the J-78 crew at the Kelsey Bay Division of MacMillan Bloedel Ltd. P. Forrester and P. Tse of FERIC assisted in the data collection and computation. Jim Connor and Dave Vandale, who were associated with development of the system, provided helpful reviews of the draft report.

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SUMMARY

The Kelsey Bay Division of MacMillan Bloedel are experienced grapple tower operators. For a number of years conventional highlead towers have been converted to grapple yarding in order to extend grapple yarding into areas beyond the scope of yarding cranes. Longer line capacity and greater tower height allow the tower to grapple-yard on ground where choker-setting may be unsafe. The J-78 evolved when concern was raised for the short line life experienced with the use of line shorteners (line shorteners were installed to provide the difference in mainline lengths required to operate a grapple).

The J-78 is a modified Madill 009 yarder and 27.4 m tower mounted on an overhauled Kenworth truck. The major modifications included the addition of an extra mainline drum, replacing the double mainline sheave on the tower fairlead with two sheaves 1.5 m apart, development of electro-servo controls to control the yarder and the installation of a hydraulic winch at the base of the tower that can be used for road changes.

Table S-1 summarizes the yarding production during the study.

TABLE S-1. Summary of J-78 Production.

	Yarding Direction	
	Uphill	Downhill
Production:		
Average volume yarded/shift	167 m^3	176 m^3
Average pieces/shift	110	86
Average yarding distance	110 m	140 m
Maximum yarding distance	215 m	335 m
Machine availability	99%	97%
Machine utilization	61%	60%
Average net cycle time	2.37 min	2.75 min
Average delay time	1.60 min	1.94 min
Average total turn time	4.31 min	5.13 min

Production was lower than expected as a result of the significantly high proportion of turn time (37%) taken-up by delays.

Yarding breakage was not significant during the study. Uphill yarding resulted in 0.6% of the yarded logs being broken compared to 0.9% when downhill yarding.

The J-78 performed satisfactorily. The grapple lines did not tangle when the carriage was out long distances (up to 335 m) and line wear had been reduced (operating lines lasted ten months on the J-78 compared to six months on conventional grapple towers).

An operating cost of $172 per hour was calculated for the J-78.

SOMMAIRE

La Division de Kelsey Bay de MacMillan Bloedel possède des opérateurs expérimentés de câbles-grues à chariot autoleveur. Ils ont, depuis plusieurs années déjà, converti les pylônes traditionnels de téléphérage relevé en câbles-grues à chariot autoleveur. Le J-78 a été mis au point lorsqu'on s'est inquiété de la courte durée des câbles, suite à l'utilisation de raccourcisseurs de câbles (ces raccourcisseurs avaient été installés pour permettre d'obtenir les différentes longueurs de câble tracteur principal nécessaires au fonctionnement d'un grappin).

Le J-78 est un engin de débusquage Madill 009 avec une tour de 27.4 m montée sur un camion Kenworth modifié. Les modifications principales comprenaient l'addition d'un tambour supplémentaire pour le câble tracteur principal, le remplacement de la poulie à double câble tracteur sur le guide-câble du pylône par deux poulies situées à 1.5 m l'une de l'autre, la mise au point de commandes servo-électriques pour diriger l'engin de débusquage et l'installation au bas du pylône d'un treuil hydraulique qui peut être utilisé lors des changements de routes.

Le tableau S-1 donne un aperçu de la production du débusquage au cours de l'étude.

La production s'est avérée plus faible que prévue, due à la très grande proportion de délais (37%) par rapport au temps total d'un cycle de production.

Au cours de l'étude, le nombre de grumes brisées lors du débusquage n'était pas significatif, soit 0.6% des billes débusquées vers le haut de la pente, comparativement à 0.9% vers le bas de la pente.

La performance du J-78 s'avéra satisfaisante. Les câbles du grappin ne s'emmêlaient pas lorsque le chariot se déplaçait sur de longues distances (jusqu'à 335 m) et on nota une réduction de l'usure des câbles (les câbles durèrent 10 mois sur le J-78 comparativement à 6 mois sur les câbles-grues traditionnels.

On calcula le coût de fonctionnement du J-78 à $172/heure.

Tableau S-1. Production du J-78.

	Direction du débusquage	
	Vers le haut de la pente	Vers le bas de la pente
Production:		
Volume moyen débusqué/poste de travail	167 m^3	176 m^3
Nombre de grumes/poste de travail	110	86
Distance moyenne de débusquage	110 m	140 m
Distance maximum de débusquage	215 m	335 m
Disponibilité de la machine	99%	97%
Taux d'utilisation de la machine	61%	60%
Temps moyen net par cycle	2.37 min	2.75 min
Temps morts moyens	1.60 min	1.94 min
Temps total moyen/cycle	4.31 min	5.13 min

INTRODUCTION

MacMillan Bloedel's Kelsey Bay Division found major safety benefits in grapple yarding. Rather than having chokermen and rigging slingers working on steep or broken ground, spotters could locate themselves at safe observation spots, clear of potential runaway logs, debris or rocks.

The yarding crane, the most common grapple yarder used in British Columbia, has limited line capacity and its 15 m tower height is insufficient when yarding from landings on steep sidehills. The grapple tower was designed to extend the areas available for grapple yarding, and thus to complement the grapple crane.

A regular 2-drum highlead yarder can be modified for grapple operation by splitting the mainline drum and adding a line shortener for one of the mainlines to run through (to produce the variation in line length needed to operate the grapple). The tower fairlead must also be modified so the second mainline can be accommodated (Sauder, 1981).

The Kelsey Bay Division have found that grapple towers can yard longer roads and rougher terrain than the yarding cranes. One drawback was the line shortener which created high stress in the wire rope and reduced its life considerably. In order to avoid the line shortener, a major modification was proposed--to add an extra drum to a highlead yarder so each mainline could be independently operated. In addition, the tower fairlead was modified, the yarder controls were changed and a drum was added (at the base of the tower) to use for road changes. The new yarder was called the J-78.

Yarding distances to 370 m are possible; however, yarding is usually kept within 210 m. During the past year production has varied between 150 to 250 pieces per shift.

STUDY OBJECTIVES

Four principal objectives for the study were:

(1) to determine the productivity of the J-78 grapple tower,
(2) to examine the delays occurring during yarding to see how the operational delays could be minimized,
(3) to determine if there was a significant variation in uphill or downhill yarding breakage,
(4) to note specific aspects of yarding operation that would be of interest in other operations.

AREA

Table 1 summarizes the setting characteristics and shows the variation in yarding slopes during the study. Figures A and B show the upper and lower portions of the setting and Figure C is a map of the yarded area.

The topography on the lower side was fairly uniform, with the cutting boundary generally located above a drop-off to a creek below. Where the line was beyond the drop-off, trees felled into the timber were yarded using chokers.

The upper side was steeper than the lower side, and had a series of rock bluffs below the cutting line. Haulback tailholds were located above the rock bluffs and most trees had been felled into the yarding area.

Appendix I includes several yarding road deflection lines.

TABLE 1. Description of Area.

	Yarding Direction	
	Uphill	Downhill
Average yarding distance	110 m	140 m
Maximum yarding distance	215 m	335 m
Average yarding slope	15%	47%
Timber types	Hemlock, Balsam	Hemlock, Balsam
Average log size	1.52 m^3	2.05 m^3
Terrain	uniform	some rock outcrops
Deflection	good (uniform slope)	fair (convex slope)
Operator visibility	clear, not obstructed	clear

YARDING SLOPE VARIATION

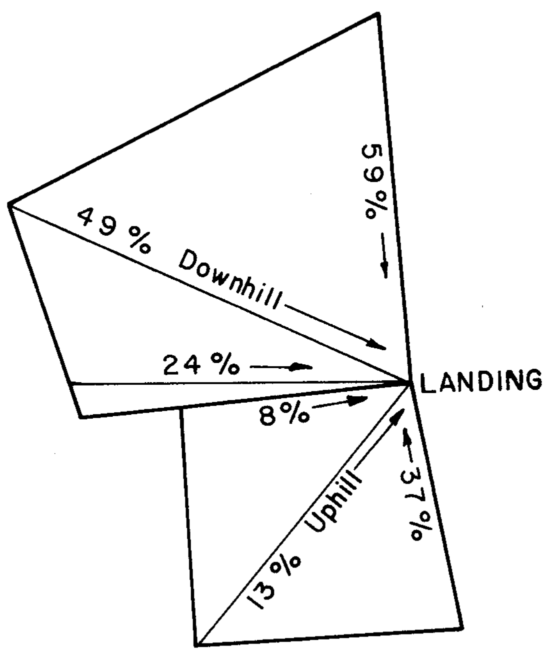


FIGURE A.

Upper Part of Setting.

FIGURE B. Lower Part of Setting.

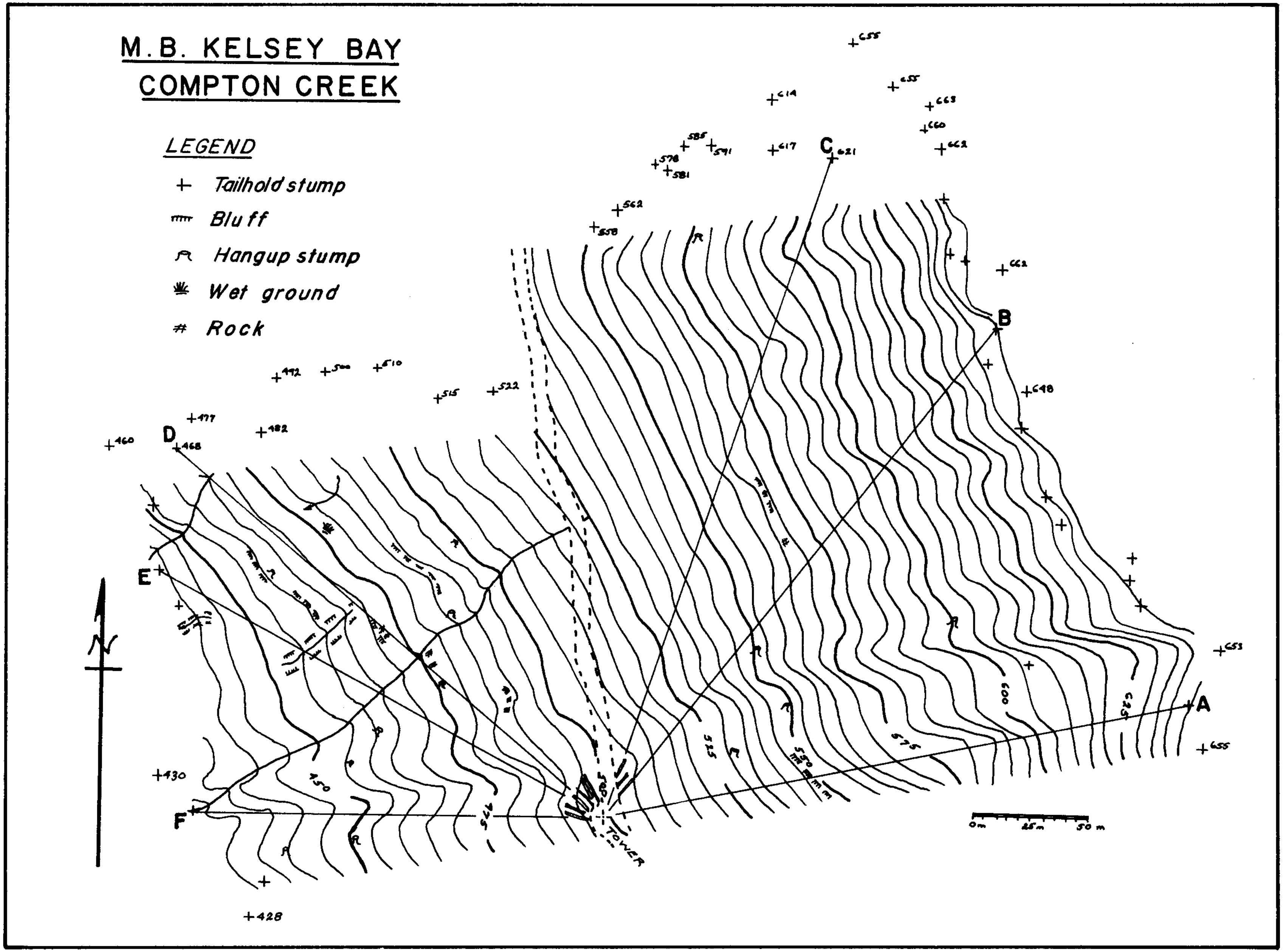


FIGURE C. Map of Yarding Area.

YARDER

The J-78 is a modified Madill 009 tower-yarder mounted on a Kenworth truck chassis (Figure D). Specifications are summarized in Table 2.

FIGURE D. J-78 Grapple Tower Yarder.

TABLE 2. Summary of J-78 Yarder Specifications. (From discussions and manufacturer)

Engine		Detroit 12V71 340 kW
Tower height		27.4 m
Number of guylines		6
Weight (approx.)		66 700 kg
Undercarriage		Kenworth truck chassis
	Line Capacity Dia. Length	Line Pull
Haulback	22 mm 790 m	Bare: 22 450 kg Mid : 15 425 Full: 11 430
Main drums (2)	22 mm 460 m	Bare: 60 780 kg Mid : 41 730 Full: 31 070
Strawline	11 mm 1 130 m	7 000 to 16 000 kg
Guylines	32 mm 130 m	4 080 kg (8 160 kg for 2 raising guylines)
Road change	22 mm 600 m	

The major modifications included:

(1) the addition of a second mainline drum (Figure E). There are three yarding operating drums (two mainline drums and a haulback drum), a strawline drum and six guyline drums. (The conventional Madill 009 has only one mainline and a haulback drum.)

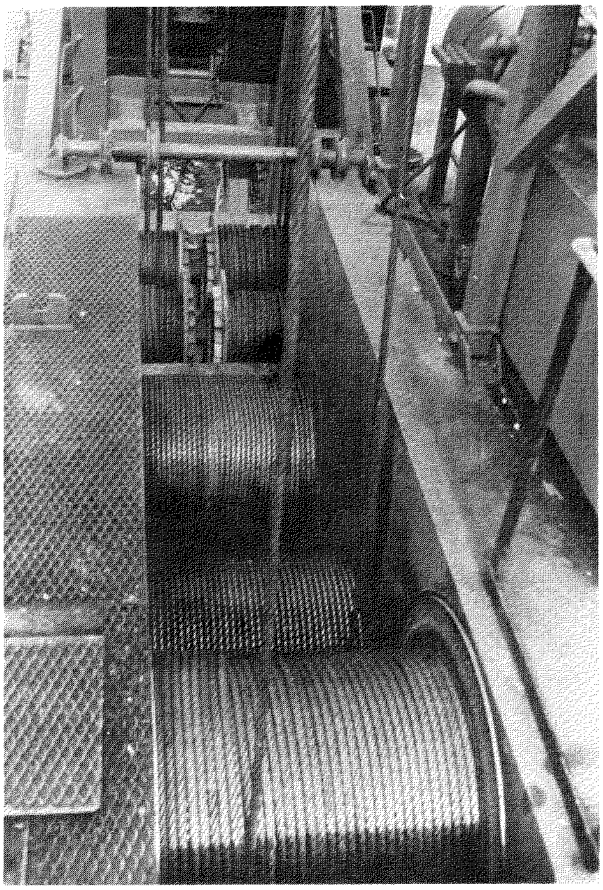


FIGURE E. J-78 Yarding Drums (haulback drum in foreground).

(2) the separation of the two mainlines at the tower fairlead. One of the mainlines uses a new sheave installed 1.5 m below the conventional (see Figure F). This separation reduced line twisting, especially when the grapple was out long distances.

FIGURE F. Tower Fairlead.
(running lines from top: - haulback
- mainline
- guylines
- mainline)

(3) installation of a hydraulically-driven drum at the base of the tower to be used for road changes (Figure G). Its use is explained in the following section on Operating Method, Road Changes.

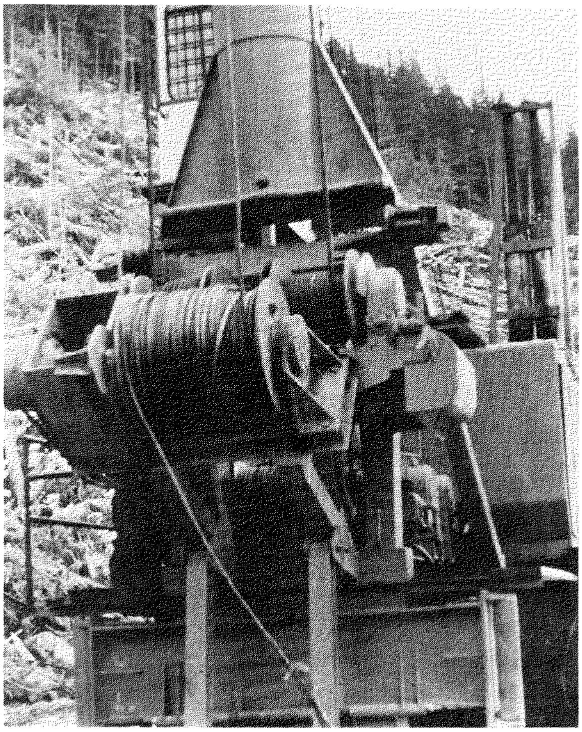


FIGURE G. Road Change Drum.

(4) the development of an electric servo-control system that utilized a joystick-type control to operate the winch (Figure H). The control changes resulted in a quick, smooth winch operation with minimum operator concentration. The basic control function is shown in Figure I.

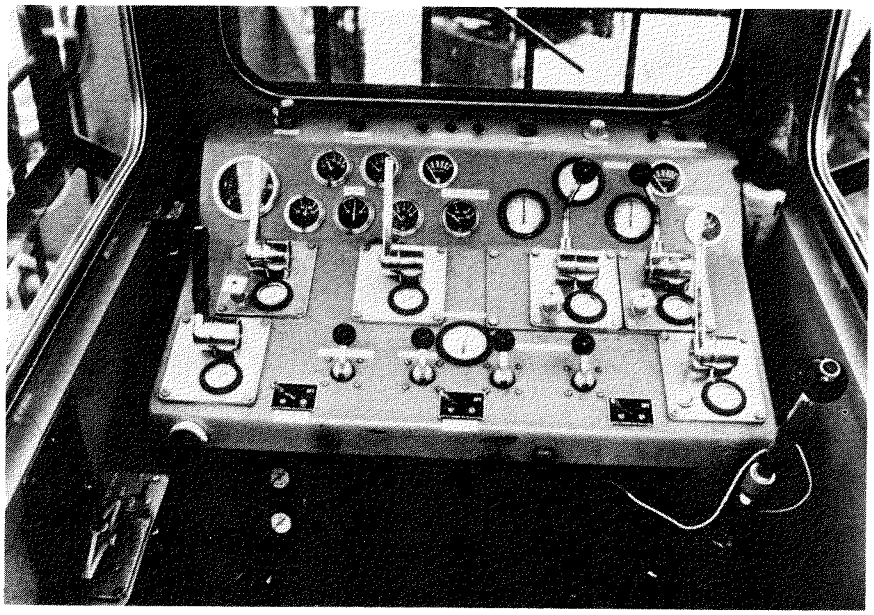


FIGURE H. Controls (winch control lever lower right).

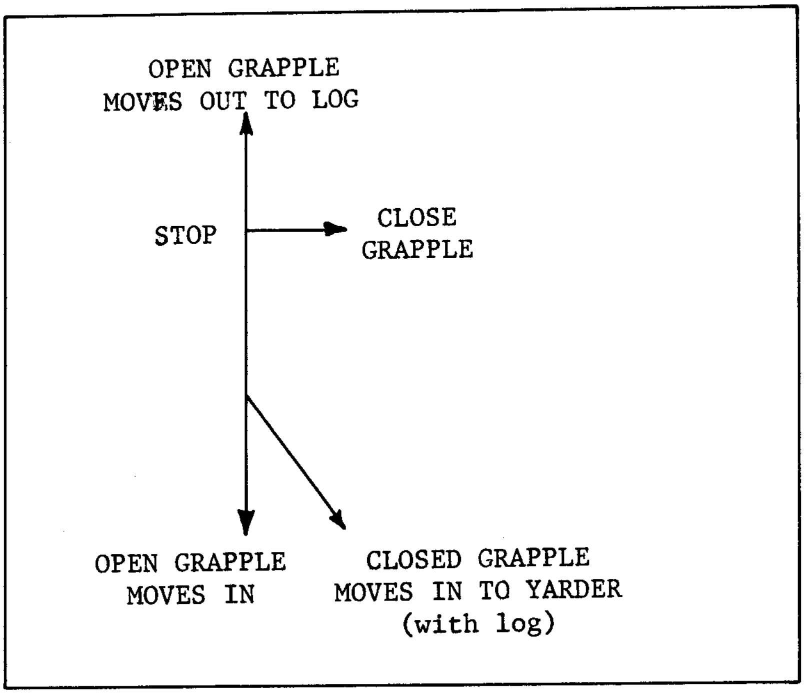


FIGURE I. Winch Control.

(5) the raising of the cab 1.8 m above the normal position to give the operator a better field of vision around the yarder and landing area. Visibility was especially improved during uphill yarding close to the road embankment.

CARRIAGE

The carriage was built by Fauchon Engineering Works in Campbell River (Figure Ja). The mainline sheave was horizontal (Figure Jb), resulting in the two mainlines remaining nearly parallel with each other and reducing line twisting (on carriages where the mainline sheave is vertical, the mainlines, when slackened, wrap around each other). The grapple opening line was attached to one of the mainlines and passed over a small fairlead block.

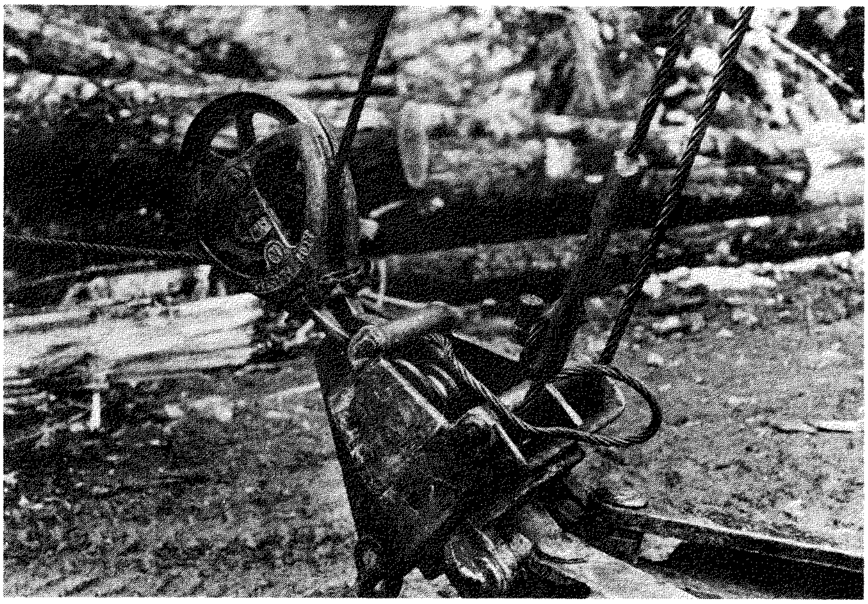
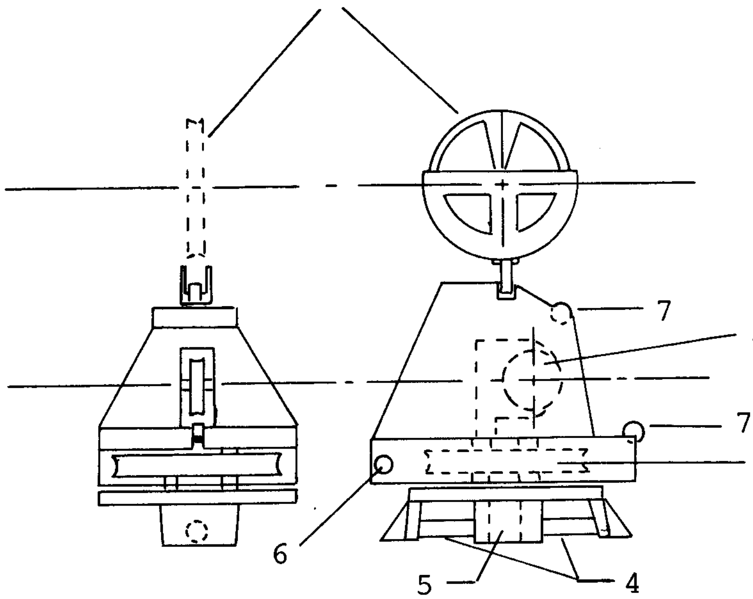


FIGURE Ja. Fauchon Carriage.



KEY

1. Haulback sheave
2. Grapple opening/closing line fairlead
3. Mainline sheave
4. Grapple attachment pins
5. Opening for grapple opening/closing line
6. Haulback shackled to carriage, here
7. Rollers to prevent line wear

FIGURE Jb. Diagram of Fauchon Carriage.

GRAPPLE

The Mar grapple (Figure Ka) used during the study required a grapple opening line. The weight of the jaws closed the grapple when the opening line (Figure Kb) was slackened. The grapple was held open on outhaul to reduce the overall carriage-grapple height. This decreased the chance of the grapple hitting stumps or dragging along the ground.

The Mar grapple's scissor-like action held the logs in place during inhaul. Large logs seldom slipped out, but small logs frequently did.

FIGURE Ka. Mar Grapple Inhauling Log.

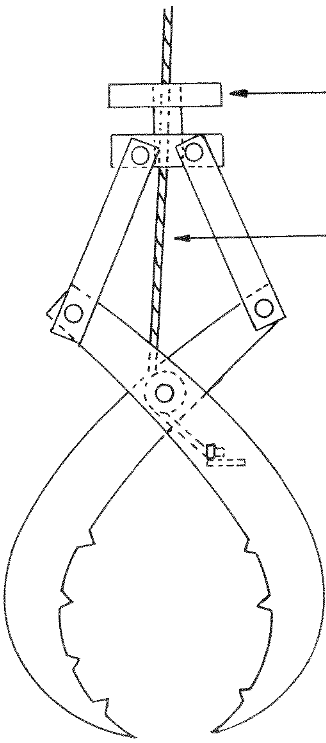


FIGURE Kb. Diagram of Mar Grapple.

GRAPPLE TOWER YARDING

A. Crew

Four men comprised the crew:

(1) yarder operator.
(2) landing man--prepared supplies for road changes, and attached and detached chokers when required.
(3) hooker--supervised general yarding operation, prepared rigging for, and carried out, road changes.
(4) spotter--directed yarder operator in the placing of the grapple on logs out of his field of vision, and assisted the hooker during road changes.

While the tower was being set up, one or two additional crewmen were borrowed from other work sites.

A loader was required to load the log trucks and to clear the decking area of logs. The loader required an operator and a landing bucker.

B. Operating Method

The J-78 grapple tower was rigged up following the same procedures as a highlead tower. Six guylines were set. Initial set-up time was 190 minutes (three guylines pre-rigged and a five-man crew, including operator). The initial haulback placement took 36 minutes. During the study, the yarder was turned around in order to yard the upper portion of the setting. The reset-up time took 169 minutes.

The following general work pattern was followed:

(a) the initial yarding road was located to the highest part of the setting (or portion). This allowed logs that slipped out or were knocked out of the way during yarding to roll into places where they could be grappled during later yarding.

(b) the operator started grappling logs near the landing and progressed to the tailhold, grappling all the logs he could see.

(c) the spotter walked the yarding road and directed the operator (using a portable radio) to obscured logs.

(d) the hooker (with assistance from the spotter) pre-rigged tailhold stumps for the haulback, and changed roads.

Logs that were too small for the grapple, too far to the side or behind the haulback block were choked rather than grappled. Chokers (two could be used at once) were attached to a butt hook on the grapple carriage.

The operator was extremely skilled in the yarder operation and grapple tower technique. He could easily swing the grapple up to 20 m to either side of the yarding road centre line, at yarding distances of 120 m or less, and place the grapple on logs.

When choked logs were brought to a suitable location, the operator would knock the choker loose with the grapple, then complete the inhaul using the grapple. This reduced the chance of the log slipping out of the choker, or hanging-up, and being broken during inhaul.

On the lower side, the yarder could deck most of the logs below the landing. The loader assisted in the decking of the longer logs as they tended to slide down the hill.

During downhill yarding, log truck loading was halted. At times, logs or rocks would be dislodged and run down the sidehill, with the possibility they might enter the landing area. Figure L shows the landing set-up with truck loading in progress during downhill yarding.

C. Road Changes

Two systems were used for road changes:

(1) Tailblocks were rigged on stumps along the backline. The hooker set up for the road changes just prior to the completion of the yarding road, to ensure the new road would remove as many logs as possible while minimizing the need to use chokers on logs to the side. The actual road change was the same as a highlead road change.

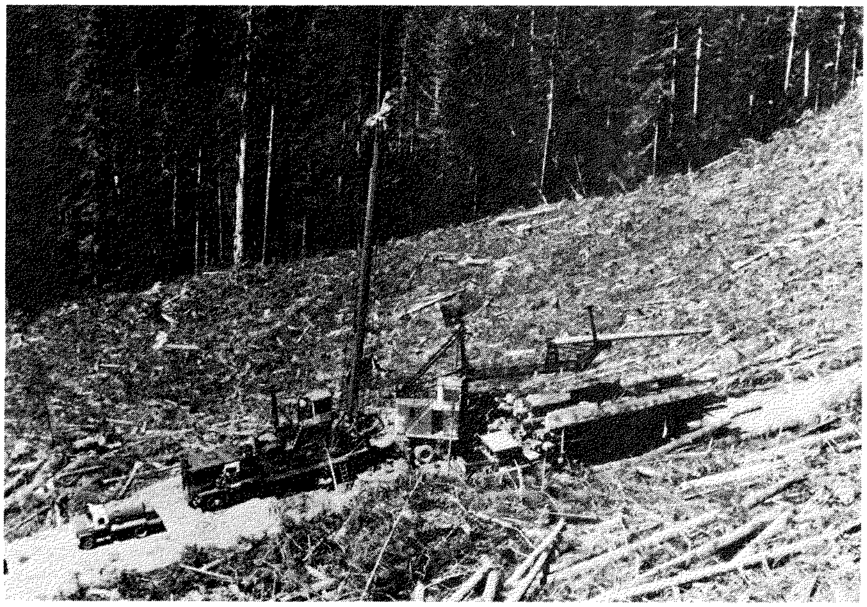


FIGURE L. Landing Set-Up.

(2) The road change drum was utilized to operate a moving tailblock along the backline. Figure M illustrates the technique. During the study, on the lower portion of the setting where the road change line was used, the haulback block on the carriage was removed, so the line configuration resembled a highlead system. Road changes were made by slackening the road change line while tightening the haulback line. The swivel was necessary to prevent twisting of the lines.

Road changes were extremely fast using this method, and the grapple could be easily placed over a log without having to swing the grapple or use a choker. The stumps and blocks of the road change line were well anchored to resist considerable forces exerted when the lines tighten.

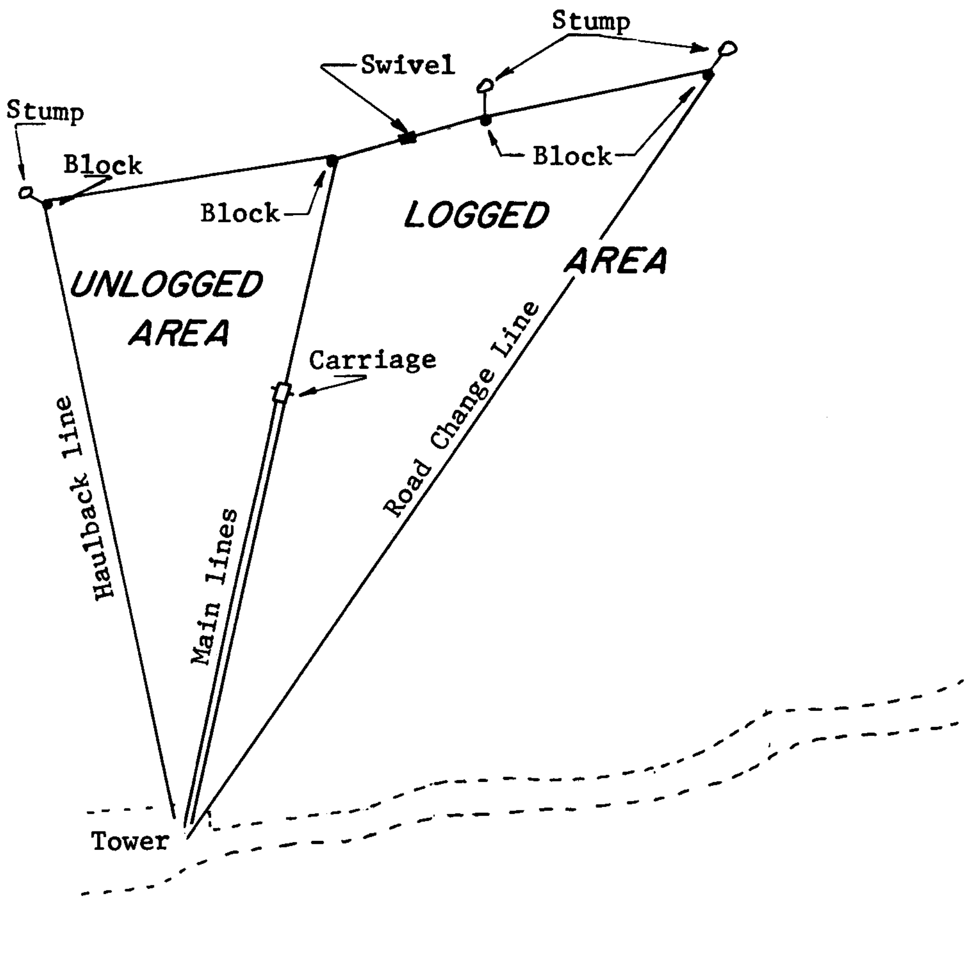


FIGURE M. Road Changes Using Road Change Line and Drum.

STUDY METHOD

Detailed timing of the yarding cycle was carried out. The following elements were noted:

(1) outhaul--the time required for the grapple to clear the decking area and arrive at the log.

(2) hook-up--the time required to grapple, or choke a log.

(3) inhaul--the time required to bring the log to the deck area.

(4) deck--the time required to position the log at the deck.

(5) unhook--the time required to release the grapple or unhook the chokers.

(6) delay--any interruption to the yarding cycle.

(7) road change--the time required to change yarding roads (from the time the last log was unhooked to when the first outhaul of the new road began).

Visual scaling of most turns, with continuous check scales to ensure accuracy, was used to determine the yarded piece sizes.

STUDY RESULTS

1. DETAILED TIMING

Table 3 summarizes the detailed timing study and presents the data by various yarding distances.

There were 1,428 turns yarded uphill and 1,638 turns yarded downhill. The maximum uphill yarding distance was 215 m and averaged 110 m. The maximum downhill yarding distance was 335 m, with an average of 140 m.

Uphill yarding net cycle time was faster than downhill yarding, for distances less than 120 m. When yarding distances

TABLE 3. Summary of Detailed Timing.

	Yarding Distance	No. of Turns	Avg. No. Logs per Turn	Time (minutes) Outhaul	Hookup	Inhaul	Deck	Hook	Net Cycle	Road Change	Total Prod. Time	Total Delay	Total Turn Time
UPHILL YARDING	0 to 30 m	46	1	.30	.48	.17	.32	.01	1.28	1.26	2.55	2.57	5.11
	30 to 60 m	161	1	.32	.52	.26	.20	.00	1.30	.31	1.61	1.42	3.02
	60 to 90 m	261	1	.38	.58	.42	.22	.00	1.61	.12	1.73	1.59	3.32
	90 to 120 m	345	1	.52	.77	.59	.25	.01	2.14	.10	2.25	.94	3.19
	120 to 150 m	312	1	.63	.96	.80	.28	.02	2.70	.39	3.09	1.86	4.95
	150 to 180 m	162	1	.86	1.61	1.08	.33	.12	4.00	.68	4.68	2.22	6.90
	180 to 215 m	65	1	.98	1.81	1.16	.37	.15	4.47	.86	5.33	2.11	7.44
	AVG. 110 m	1,428	1	.55	.89	.64	.26	.03	2.37	.34	2.72	1.60	4.31
DOWNHILL YARDING	0 to 30 m	62	1	.17	4.61	.15	.28	.00	5.21	.00	5.21	1.31	6.52
	30 to 60 m	174	1	.25	2.36	.21	.27	.00	3.10	.05	3.15	1.24	4.39
	60 to 90 m	173	1	.34	1.07	.35	.27	.00	2.03	.00	2.03	1.66	3.69
	90 to 120 m	247	1	.47	1.17	.54	.28	.00	2.47	.10	2.57	2.35	4.92
	120 to 150 m	248	1	.63	.79	.73	.32	.01	2.49	.00	2.49	1.96	4.45
	150 to 180 m	247	1	.78	1.17	.90	.31	.02	3.17	.30	3.47	2.79	6.26
	180 to 215 m	176	1	.93	.93	1.10	.51	.02	3.49	.84	4.33	2.43	6.76
	215 to 245 m	112	1	1.07	1.07	1.29	.37	.00	3.81	1.69	5.50	3.40	8.90
	245 to 275 m	86	1	1.30	1.34	1.40	.32	.04	4.39	3.00	7.38	3.35	10.73
	275 to 305 m	30	1	1.25	1.17	1.35	.27	.03	4.07	1.63	5.70	1.35	7.05
	305 to 335 m	13	1	1.37	1.07	1.45	.32	.05	4.26	4.49	8.74	2.71	11.46
	AVG. 140 m	1,638	1	.66	1.34	.74	.32	.01	3.07	.51	3.59	2.24	5.83
COMBINED - UPHILL AND DOWNHILL YARDING	AVG. 125 m	3,066	1	.61	1.13	.69	.30	.02	2.75	.44	3.18	1.94	5.13

exceeded 120 m, downhill yarding time per turn was faster. Operator visibility was excellent for the first 100 m of uphill yarding and little assistance was needed from the spotter. While downhill yarding, the operator had restricted vision (due to brush and gullies along the sidehill slope) and relied on the spotter to direct the grapple more often. As the sidehill became steeper, the operator could see the logs himself.

Downhill yarding outhaul times became noticeably longer past 250 m. Poor deflection near the tailblock required the haulback line to be kept tensioned (mainline brakes applied) in order for the grapple to clear obstructions and the ground. This resulted in the yarder brakes becoming overheated and delays while they cooled.

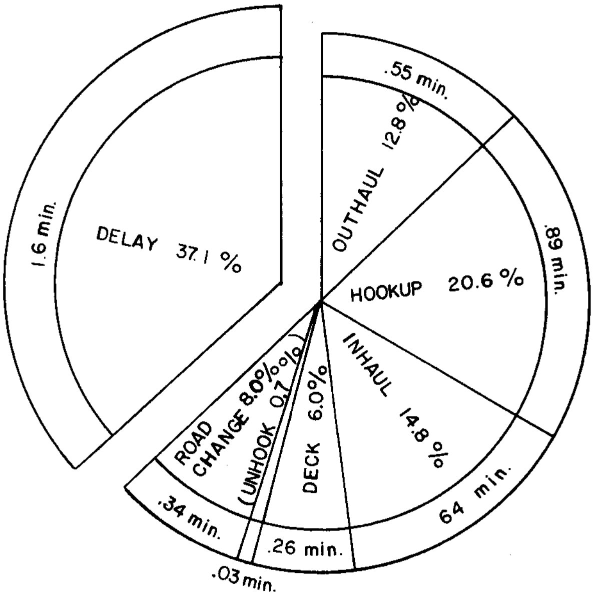
A possible explanation for the shorter element times recorded during downhill yarding in the 275 to 305 m zone is that the logs were in a better location for grappling (better local deflection, logs were aligned perpendicular to the yarding road, and the logs were visible to the operator). Logs above this interval tended to lie parallel to the yarding roads to prevent their hanging-up in standing timber when felled. Logs lying below 275 m tended to slide down the rock bluffs and were poorly located for grappling.

Figure N shows the distribution of timing elements for uphill and downhill yarding and for both combined. Although the average turn time was 1.5 minutes longer for downhill yarding, the percentage distributions were similar to those for uphill yarding.

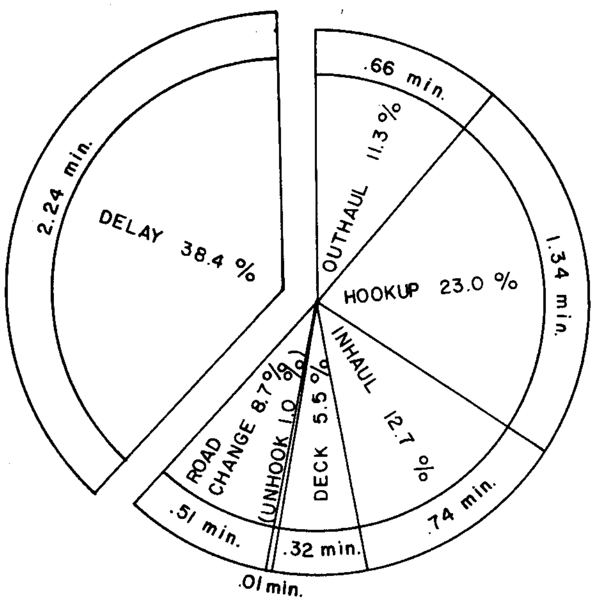
A regression analysis was undertaken to determine if yarding distance could be related to any of the cycle element times. Turn volume was not considered a significant factor as the grapple could only pick-up one log at a time, regardless of the size. Figure O summarizes the regressions determined to have significant correlation coefficients.

One logical explanation for the lower correlations (R^2 values) for uphill yarding was the inclusion of road change time in the outhaul yarding element. The road change line was used during uphill yarding and road changes made by side-blocking the carriage during outhaul were not separated out of the cycle time.

UPHILL YARDING
Avg. 4.31 min./turn
Avg. Yarding Distance = 110m



DOWNHILL YARDING
Avg. 5.83 min./turn
Avg. Yarding Distance = 140m



BOTH UPHILL AND DOWNHILL YARDING
Avg. 5.13 min./turn
Avg. Yarding Distance = 125m

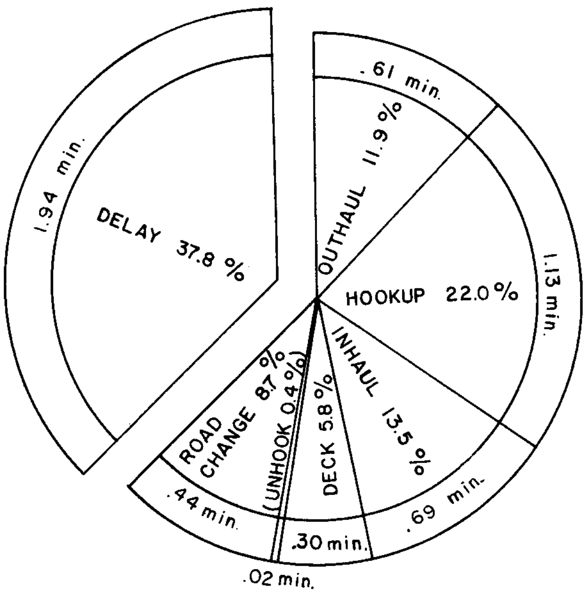
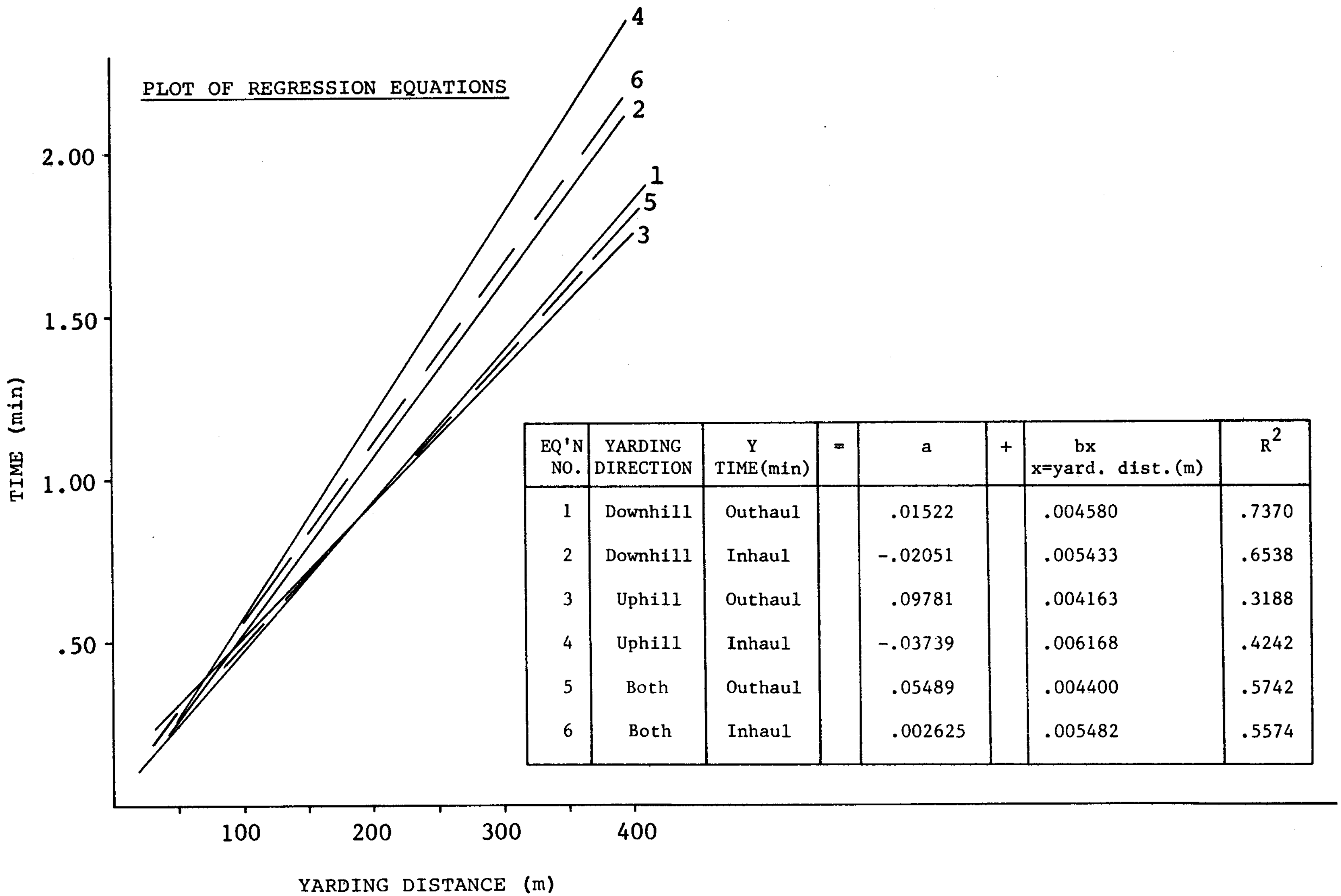


FIGURE N. Distribution of Yarding Elements.



EQ'N NO.	YARDING DIRECTION	Y TIME(min)	=	a	+	bx x=yard. dist.(m)	R^2
1	Downhill	Outhaul		.01522		.004580	.7370
2	Downhill	Inhaul		-.02051		.005433	.6538
3	Uphill	Outhaul		.09781		.004163	.3188
4	Uphill	Inhaul		-.03739		.006168	.4242
5	Both	Outhaul		.05489		.004400	.5742
6	Both	Inhaul		.002625		.005482	.5574

FIGURE O. Summary of Regression Analysis.

2. Delays

Table 4 outlines the types of delays that averaged over twenty minutes per occurrence, and summarizes the delays by categories.

The following specific grapple yarding delays were noted:

(a) checking for logs--the spotter delayed yarding to look for logs 28 times during uphill yarding and 50 times during downhill yarding. The average delay to yarding was 1.80 minutes.

(b) hook-up delays--refer to Table 5.

A complete breakdown of delays is available from FERIC on request.

In general, when uphill yarding distances were less than 90 m, 50% of the total turn time was delay, and for yarding distances greater than 90 m, 30% of the total turn time was delay. During all downhill yarding, approximately 40% of the total turn time was delay.

Fifty-seven percent of the uphill yarding delays and 44 percent of the downhill yarding delays were associated with a variety of operational delays averaging less than 2 minutes per occurrence . During uphill yarding, the following operational delays occurred frequently, and with short durations: loader in the way of incoming turn--151 minutes (54 occurrences), hookup delays--280 minutes (235 occurrences), and retrieving logs that slid out of deck--107 minutes (119 occurrences). Downhill yarding operational delays that occurred frequently included: bucking at landing--117 minutes (20 occurrences), turn lost during inhaul--115 minutes (35 occurrences), hookup delays--593 minutes (418 occurrences), and replacing grapple opening lines--110 minutes (9 occurrences).

Very little time was lost due to yarder mechanical delays. Machine availability was found to be 98% during the study. The haulback line and mainline replacement delays were the first in ten months of operation.

TABLE 4. Summary of Delays.

		No. of Occur.	Time (minutes) Average Time per Delay	Total Delay Time	% of Total Delay
UPHILL YARDING	Repairs to System				
	- grapple broke and was replaced	1	61	61	
	- others	2	4	9	
	Total Repairs	3	23	70	3%
	Service to System				
	- various delays	31	8	235	11%
	Operational Lost Time				
	- moving guylines	2	40	20	
	- preparing to pull out road change line	7	140	20	
	- splicing haulback eye at grapple	2	87	44	
	- splice stranded mainline	1	40	40	
	- change mainline	1	160	160	
	- others	640	2	1,210	
	Total Operational Delays	653	2	1,494	70%
	Personnel Delays				
	- morning/noon/end of shift delays	2	33	66	
	- others	55	5	266	
	Total Personnel Delays	57	6	332	16%
	TOTAL DELAYS	744	3	2,130	100%
DOWNHILL YARDING	Repairs to System				
	- weld grapple	1	102	102	
	- replace complete grapple	1	29	29	
	- wait for mechanics	1	24	24	
	- others	9	10	89	
	Total Repairs	12	20	244	7%
	Service to System				
	- upend haulback	1	83	83	
	- others	44	7	287	
	Total Service	45	8	370	11%
	Operational Lost Time				
	- change haulback	1	72	72	
	- haulback stranded--splice	1	110	110	
	- replace grapple opening line	1	53	53	
	- wait for logging truck to load	33	20	675	
	- change grapple on haulback	1	32	32	
	- untwisting grapple	1	21	21	
	- emptying fire truck of water	1	27	27	
	- others	791	2	1,559	
	Total Operational Delays	830	3	2,549	72%
	Personnel Delays				
	- various delays	75	5	348	10%
	TOTAL DELAYS	962	4	3,511	100%

TABLE 5. Summary of Hookup Delays.

	Uphill Yarding		Downhill Yarding		Average per occur. (min)
	No. of occur.	Total time (min)	No. of occur.	Total time (min)	
Grapple slipped off log	12	10	5	4	0.8
Moving to another log	23	18	2	1	0.8
Lost log - new pick-up	110	128	221	342	1.4
Log grabbed was cull - new pick-up	116	137	168	172	1.0
Grapple tangled	9	15	29	79	2.5

3. Log Size

The uphill yarded portion of the setting had a piece size of 1.52 m^3, whereas the downhill yarded portion averaged 2.05 m^3 (standard deviation of 2.27 and 2.28 respectively). Species were hemlock and balsam, with some cedar. The top portion appeared to have more logs in the 2.50 m^3 to 6.50 m^3 classes than the lower portion of the setting. The average for all logs yarded was 1.83 m^3 (standard deviation 2.29 m^3).

4. Production

Grapple turns averaged one log per turn. When two chokers were used, an average of 1.3 logs per turn were yarded. The yarder volume production is directly related to piece size because the turn time for any given yarding distance is the same for a big log as a small log.

Table 6 outlines the overall production, utilization and machine availability during the study. Production was lower than expected, as a result of the significantly high proportion of turn time, 37%, taken-up by delays.

TABLE 6. Summary of J-78 Production.

	Uphill Yarding		Downhill Yarding		Total Study	
		% of Total Time		% of Total Time		% of Total Time
Productive Time (min)						
Yarding	3,207	54%	4,817	52%	8,024	53%
Yarding road changes	464	8	807	8	1,271	8
Delays (min)						
Mechanical	70	1	244	3	314	2
Yarder set-ups	190	3	169	2	359	2
Other delays	2,060	34	3,267	35	5,327	35
TOTAL SCHEDULED TIME (min)	5,991	100%	9,304	100%	15,295	100%
Number of shifts observed	13		19		32	
Average time per shift (hrs)	7.7		8.2		8.0	
Number of logs yarded	1,428		1,638		3,066	
Number of logs yarded/shift	110		86		96	
Average volume per log (m^3)	1.52		2.05		1.83	
Average volume per shift (m^3)	167		176		176	
Number of turns yarded	1,352		1,568		2,920	
Average number of turns per shift	104		83		91	
Machine availability	99%		97%		98%	
Machine utilization	61%		60%		61%	

5. Yarding Breakage

During the study, less than 1% of the yarded logs were broken. Downhill yarding breakage averaged 0.9% of the logs compared to 0.6% for uphill yarding.

The majority of logs were broken on breakout, and only the top pieces were usually left behind.

6. Yarding Cost

The hourly cost of owning and operating the J-78 was estimated at $172 (see Table 7). Figure P, derived from this hourly rate, illustrates how yarding cost varies in relation to average piece size and turns per hour. For example, during the study the yarder averaged 11.4 turns per hour with pieces 1.83 m^3, resulting in an estimated yarding cost of $8.00/$m^3$.

TABLE 7. Estimate of Hourly Owning and Operating Cost.[1]

Equipment Cost[2]	$260,500
Salvage value 10%	
Depreciation period 12 years, 1600 h/yr	
Annual interest 15% of AAI	
Insurance, tax etc. 5%	
Owning cost	$ 31.34/h
Repair and Maintenance[3]	13.43
Fuel and lube	26.50
Lines[4]	15.00
Rigging[5]	2.08
Crew wages[6]	46.90
Fringe benefits, travel time, etc.	20.81
	$156.06
Supervision and overhead (10%)	15.61
Owning and Operating Cost per hour (rounded)	$172.00

Notes:

[1]From: Mifflin, R.W. and H.H. Lysons. 1978. Skyline yarding cost estimating guide. USDA For. Serv. Res. Note PNW-325.

[2]Yarder mounted on fully-depreciated logging truck.

[3]At 110% of depreciation cost.

[4]$20,000 for 1333 hours.

[5]$10,000 for 4800 hours.

[6]Operator, hooker, spotter, landing man.

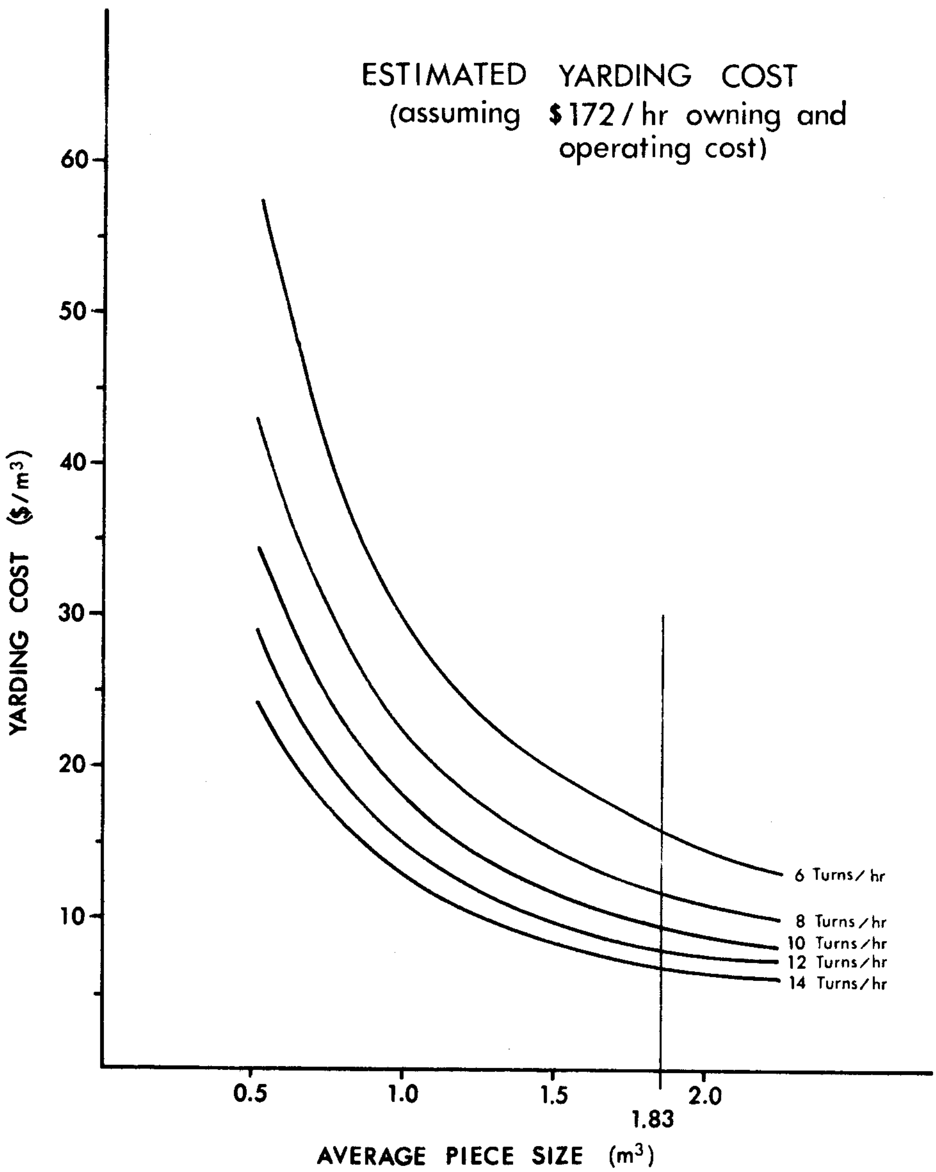


FIGURE P. Estimated Yarding Cost.

CONCLUSIONS

The modifications made to the yarder worked well. The mainline did not tangle when the grapple was out long distances, and line wear had been reduced (mainlines lasted six months on line shortener grapple towers compared to ten months for the J-78). The controls were very responsive and the operator found the yarder uncomplicated to operate. Machine availability averaged 98%.

The J-78 is a slower operating yarder than the Madill 044 yarding crane. FERIC Technical Note No. TN-36 "An Evaluation of Grapple Yarding in Coastal B.C." (Sauder, 1980) indicates that Madill 044 total turn times for similar yarding distances were nearly one-third less than the J-78 (however, yarding crane grapple yarding is usually restricted to yarding distances less than 150 m).

Piece size is very important when determining the yarding cost of grappled wood, as only one piece is yarded at a time. When the yarding distances increased beyond 150 m production decreased to less than 10 turns per hour, and yarding costs increased to \$10 to \$14 per m^3.

Most of the delays that occurred were infrequent and part of the normal working cycles. An improved landing would have reduced decking delays and the number of logs that slid out of the deck. Grapple opening lines were replaced more often during the downhill yarding portion. Replacement of the running lines during other times would have been difficult as the full crew was needed.

The use of a "power-closing" type grapple may reduce the number of logs that slipped out of the grapple during inhaul (especially when downhill yarding). A grapple with a better clamping ability than the one observed would reduce the chance of small logs slipping out.

Yarding breakage did not appear significant.

Although it is not recommended to use the J-78 grapple yarder for long distance grapple yarding, there are times when the terrain is so steep or rugged that chokermen would be put in dangerous situations or would require excessive time to set turns. In these situations, the J-78 can yard the wood with minimal danger to a woods crew.

During uphill and downhill yarding, frequent occurrences of a variety of short operational delays considerably reduced the number of pieces yarded per shift. Production was directly affected by the high proportion of turn time taken-up with delays.

The J-78 has potential for use in a gravity yarding mode, or, with the addition of a suitable carriage, a lateral yarding system. Both configurations would enable several logs to be yarded with each turn.

REFERENCES

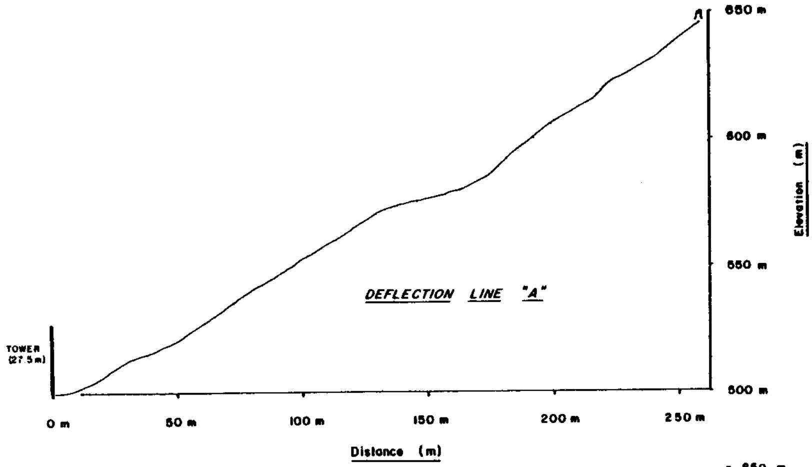
1. Mifflin, R.W. 1980. Computer Assisted Yarding Cost Analysis. Pacific Northwest Forest and Range Experiment Station, General Technical Report PNW-108.

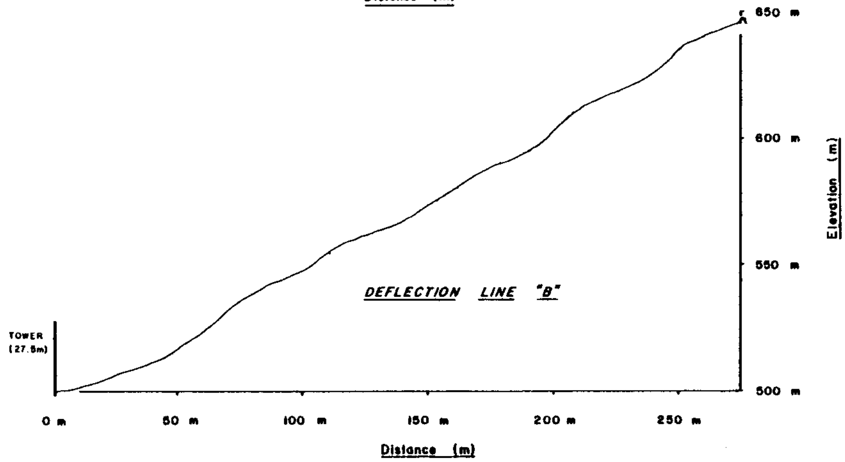
2. Sauder, E.A. 1981. Grapple Yarding Today and in the Future. Paper presented to the 5th Northwest Skyline Logging Symposium, Seattle, Wa.

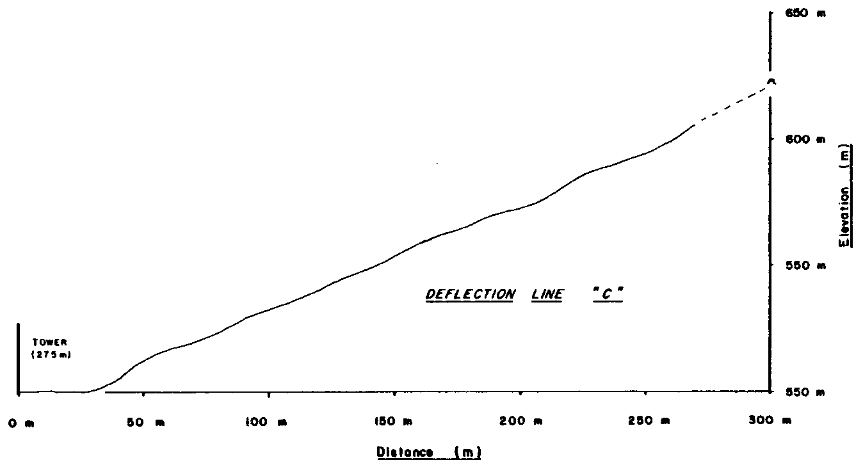
3. Sauder, E.A. 1980. An Evaluation of Grapple Crane Yarding in Coastal B.C. FERIC Technical Note No. TN-36.

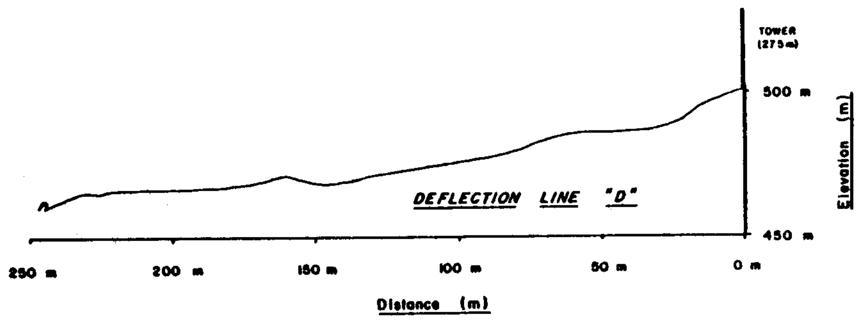
APPENDIX I

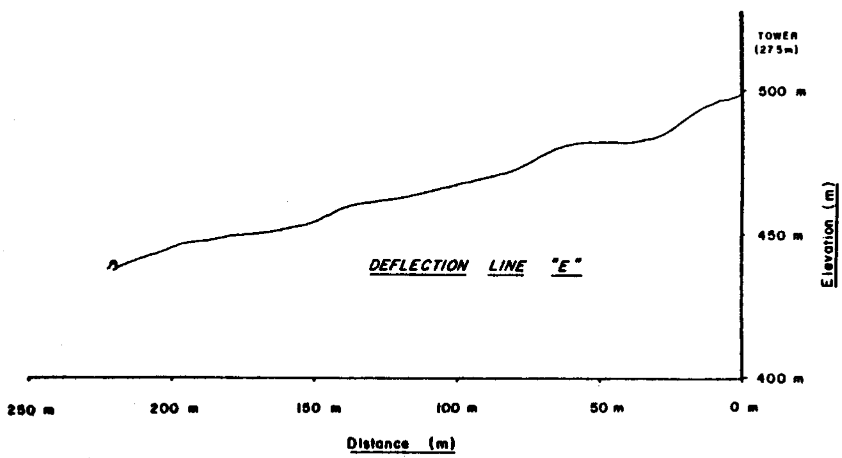
Deflection Lines For Study Area

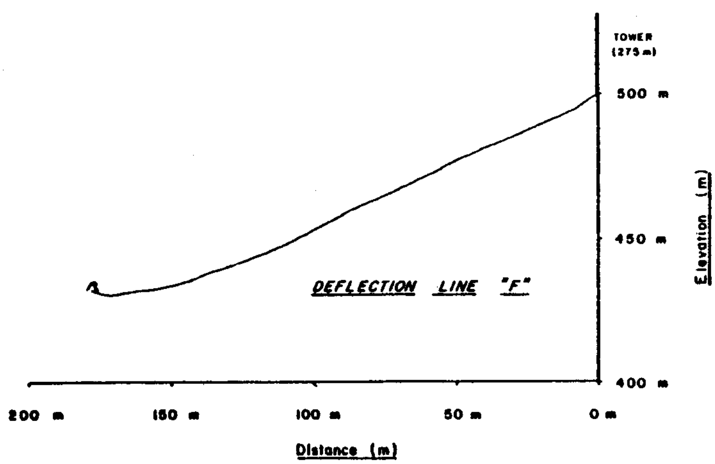







TOWER (275m)
500 m
450 m
Elevation (m)
DEFLECTION LINE "D"
250 m
200 m
150 m
100 m
50 m
0 m
Distance (m)


TOWER (275m)
500 m
450 m
400 m
Elevation (m)
DEFLECTION LINE "E"
250 m
200 m
150 m
100 m
50 m
0 m
Distance (m)


TOWER (275m)
500 m
450 m
400 m
Elevation (m)
DEFLECTION LINE "F"
200 m
150 m
100 m
50 m
0 m
Distance (m)