WOOD HARVESTING
Technical Note TN-201 September 1993

OBSERVATIONS OF TWO SKYLEAD C40 CABLE YARDERS

Patrick D. Forrester

Abstract

During the summer and fall of 1991 the Forest Engineering Research Institute of Canada (FERIC) observed two Skylead C40 cable yarders, working in the North Okanagan area of British Columbia, for the purpose of determining system costs and productivities. The Skylead is one of a number of cable yarders operating in the Interior of British Columbia to be studied by FERIC.

Introduction

During the summer and fall of 1991 the Forest Engineering Research Institute of Canada (FERIC) observed two models of Skylead C40 cable yarders working in the North Okanagan area of British Columbia. These cable yarders are manufactured by Skylead Equipment Corp. of Enderby, British Columbia, and are owned by Critical Site Logging Inc. of Vernon, British Columbia. FERIC observed a Model 16000 working in the summer on a stripcut harvesting block near Vernon, British Columbia for Fletcher Challenge Canada Limited (now Riverside Forest Products Ltd.), and a Model 8000 working in the late fall on a clearcut block near Lumby, British Columbia for Weyerhaeuser Canada Limited.

Steep slopes and the attendant environmental concerns frequently rule out the use of conventional ground-based harvesting systems (e.g. feller-bunchers and skidders). Yarding felled and bunched wood with a grapple system may not be an option when the slopes are too steep or broken for a feller-buncher to operate, or when the ground profile (deflection) requires tailholds to be rigged at heights greater than possible with a mobile backspar (Moshenko 1991).

Where these terrain limitations occur, a skyline cable-yarding system can be an option. This study was initiated to quantify the costs and productivities associated with using a skyline system, and to identify factors that influence these costs and productivities.

Study Method

Shift-level timing data were collected with a Model DSR Servis recorder, and through descriptions of activities and delays noted by the yarding crews. This data included productive (yarding and road change) time, and non-productive (delay) time greater than 10 minutes. The cooperating forest companies provided the net log volumes from their weigh-scale records. A FERIC researcher used a stop watch to gather detailed-timing data intermittently throughout the study. The duration of yarding cycle elements and delays <10 min were recorded by FERIC researchers along with the number of logs or trees yarded per cycle. FERIC also conducted a site-disturbance survey at one study location using the grid point intercept system and random bearings.

Site and System Description

The Skylead yarders were observed working at two locations: one near Vernon and the other near Lumby. At Vernon the slope fell away steeply from the road to a flat area that extended out to a stream. The timber composition included Douglas-fir (85%), occurring mainly on the upper slope; ponderosa pine (8%); lodgepole pine (1%); and Western red cedar (6%), occur-

Keywords: Harvesting, Cable logging, Skyline, Harvesting systems, Productivity, Costs, Skylead C40 cable yarder.

Author: Patrick D. Forrester is a Researcher in the Harvesting Operations Group, Western Division.

FOREST ENGINEERING RESEARCH INSTITUTE OF CANADA
INSTITUT CANADIEN DE RECHERCHES EN GENIE FORESTIER
143 Place Frontenac
Pointe Claire, Québec
Canada H9R 4Z7
(514) 694-1140
2601 East Mall
Vancouver, B.C.
Canada V6T 1W5
(604) 228-1555

PRINTED IN CANADA
 ISSN 0381-7741

ring mostly on the lower slope and flats. Slope distance from the road to the stream averaged 136 m and ranged from 80 to 205 m. Trees were harvested in 20-m wide strips with 40-m wide leave strips to preserve ungulate winter range (Figure 1).

The block at Lumby was originally developed for small tractor harvesting; however, because of the risk of soil erosion resulting from cross-contour skid-trail construction, a cable-harvesting system was used instead. The broken slopes ranged from concave to convex in some locations, with lateral ridges obstructing some yarding lanes. The stand consisted of 55% lodgepole pine, 18% white pine, 12% spruce, 7% subalpine fir, 5% Douglas-fir, and 3% Western red cedar. During FERIC's study, yarding distance averaged 180 m and ranged from 110 to 230 m.

Both study blocks were felled manually by one faller. Trees were felled across the slope where possible, and those with butts >60 cm were bucked. At the Vernon site, the steep slopes at the top of the strips caused a number of stems to slide down the slope to create 'jackpots'; in these cases, hookup and breakout were difficult at times. A severe wind storm in October 1991 blew over a number of trees on the Lumby setting, making falling and yarding difficult during the latter part of the study, and heavy snow during the beginning of November further complicated the situation.

Two models of Skylead C40 yarders were observed. A 1991 Model 16000 yarder worked on the Vernon site (Figure 2) while a 1988 Model 8000 was used near Lumby, both with a 12.2-m tower. The Model 16000 winch had a larger mainline and haulback cable capacity than the Model 8000 (Table 1). Skylead Equipment Corp. mounts the yarder set and tower on a carrier supplied by the purchaser; both machines in this study were mounted on used Timberjack skidders.

Figure 1. Yarding corridor at Vernon.

Yarding at both locations was uphill using a standing skyline, a Maki Mini-Mak I radio-controlled self-clamping carriage, and four chokers. At the Vernon site, the contractor anchored the skyline at the base of a standing tree. However, at Lumby the skyline was run through a block, strapped approximately 18 m up a standing tree to provide additional lift, and then anchored to the base of another standing tree. Two guylines were also attached to the backspar for additional support during lateral yarding (Figure 3).

During the yarding cycle, the operator controlled the yarder and carriage through radio voice communications with the hooktender, and during lateral yarding the hooktender controlled the carriage clamp using a radio transmitter. Gravity pulled the carriage downhill to the desired location, where it was locked onto the skyline on a signal from the hooktender. The mainline drum then free-spooled the butt rigging to the ground

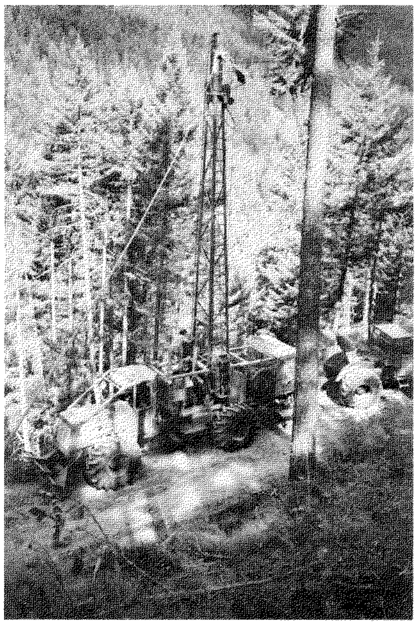

Figure 2. Skylead yarder with Model 16000 winch set, at Vernon.

Table 1. Winch Set Cable: Specifications

Line	Model 8000	Model 16000
Skyline	19 mm - 520 m	19 mm - 520 m
Mainline	12 mm - 300 m 11 mm - 460 m	14 mm - 520 m 12 mm - 670 m
Haulback	12 mm - 300 m 11 mm - 460 m	14 mm - 1097 m 12 mm - 1371 m
Strawline	5 mm - 600 m	5 mm - 1219 m
Guyline	19 mm - 73 m	16 mm - 60 m

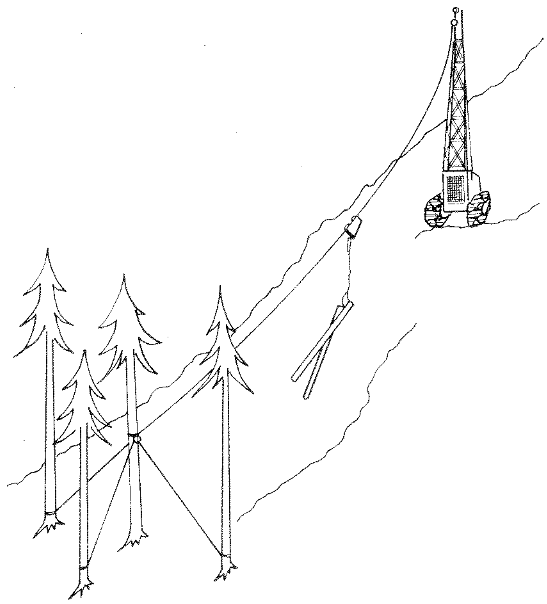

Figure 3. Skyline configuration at Lumby.

where the rigging crew manually pulled the slack required to set the chokers. For the inhaul, the mainline was winched in to bring the turn under the carriage where the hooktender radioed the yarder operator to stop pulling. When lateral yarding stopped, the hooktender released the carriage clamp and notified the yarder operator to continue inhaul. After the turn was decked and unhooked at roadside, it was ground skidded to a central landing for processing and piling.

Changing corridors (Vernon) or roads (Lumby) required the skyline to be lowered, released from the tailhold, and respooled. The carriage was slung and locked on the yarder, the three guylines were released and respooled, and the tower was lowered into a cradle and also locked down. This process was reversed for setup. The landing bucker and skidder operator assisted the yarding crew in pulling the skyline out to the back end. At Lumby, a backspar had to be selected, prepared, and guyed back before the skyline could be raised. When sound guyline stumps were not available the yarder guylines were attached to the blade on a well-anchored tractor (Figure 4).

When the decking slope below the yarder was so steep that yarded stems slid back down the hill, the 'log brake' was installed (Figure 5). This device, secured on the slope by chains attached to stumps, held the yarded wood in place until it could be skidded.

Figure 4. Caterpillar D6 anchor for Skylead yarder, at Lumby.

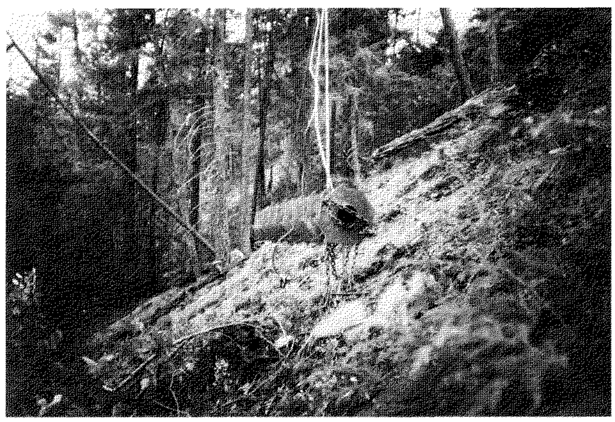

Figure 5. Log brake being set up, at Vernon.

Shift-Level Study

During the nine days of the shift-level study at Vernon, no production days were lost. Of 50 days at Lumby, seven were nonproductive: two shifts were snowed out, winch repairs caused the loss of three shifts, one shift was lost to repair the skyline, and another because the radios malfunctioned.

The Skylead working at Vernon yarded a net volume of 1275 m^3 over nine days for an average daily production of 141.7 m^3 or 17.0 m^3/SMH (Table 2). The Lumby operation yarded a net volume of 6803 m^3 over 43 days for an average daily production of 158.2 m^3 or 19.5 m^3/SMH. The differences in productivity can be attributed to the larger average volume per stem at Lumby and the 7% more time devoted to road changes at Vernon. This higher average volume per stem at Lumby, in conjunction with longer yarding roads, also helped to increase productivity. Observed road changes at Vernon averaged 1.06 h at an average frequency of 2/day. At

Table 2. Shift-Level Study: Summary

Elements	Vernon Time (h)	Vernon %	Lumby Time (h)	Lumby %
Productive machine hours (PMH)				
Yarding	44.07	59	215.82	62
Road changes	19.10	25	63.47	18
Subtotal	63.17	84	279.29	80
Mechanical delays (MDH)				
Repairs	1.66	2	10.43	3
Service	2.75	4	5.37	2
Subtotal	4.41	6	15.80	5
Nonmechanical delays (NMD)				
Operational	7.11	10	50.52	14
Organizational	0.34	≤1	3.82	1
Subtotal	7.45	10	54.34	15
Total, all delays	11.86	16	70.14	20
Scheduled machine hours (SMH)	75.03	100	349.43	100

	Vernon	Lumby
Utilization (PMH/SMH) (%)	84	80
Machine availability [(SMH-MDH)/SMH] (%)	94	95
Volume produced (m^3)	1275	6803
Average stem size (from cruise) (m^3)	0.50	0.82
Shifts with production (no.)	9	43
Productivity		
m^3/PMH	20.2	24.4
m^3/SMH	17.0	19.5
m^3/shift	141.7	158.2
Skylead yarder and carriage ($/h) [a, b]	140.77	135.98
Skylead yarder and carriage ($/$m^3$)	8.28	6.97
Faller ($/$m^3$)	1.75	1.56
Skidder and operator ($/$m^3$) [a]	3.95	3.44
Mobile guyline ($/$m^3$) [a]	0.56	0.48
Total system cost ($/$m^3$) [c]	14.54	12.45

[a] See standard FERIC cost analysis in Appendix I.
[b] Includes hooktender, yarding engineer, chokerman, and buckerman.
[c] FERIC costs and productivities do not include those costs incurred by the company and contractor for planning, nor costs related to lost productivity of one day or more. Production costs exclude loading and hauling.

Lumby, where backspars had to be rigged and tied back, the average road change took 1.59 h at a frequency of 0.93/day.

During the study at Vernon, the Skylead 16000 utilization was 84%, with its mechanical availability at 94%; the cost of wood felled, yarded, skidded, processed, and piled was $14.54/m^3. At Lumby, utilization was 80%, mechanical availability was 95%, and production cost was $12.45/m^3.

Delays >10 min/occurrence are summarized in Table 3. Crew breaks, representing 55% and 60% of this time for Vernon and Lumby respectively, usually occurred after moving and setting up the yarder. The yarder at Lumby required a relatively low amount of service time, probably because the foreman did not report all out-of-shift (i.e. weekend) maintenance.

Detailed-Timing Study

The results of the detailed-timing study are summarized in Table 4. Both of the observed machines yarded about 31 stems/PMH and incurred similar amounts of delay time. The average time/turn at Lumby was 0.77 min longer than at Vernon because of the longer average yarding distance and the longer road change time (Table 5).

Table 3. Shift-Level Delays: Summary

Description	Vernon Occurrences	Vernon Time (h)	Vernon % [a]	Lumby Occurrences	Lumby Time (h)	Lumby % [a]
Mechanical delays						
Yarder repairs	-	-	-	1	2.00	3
Carriage repairs	3	1.33	11	3	2.08	3
Rigging repairs	1	0.33	3	6	6.35	9
Service yarder	4	1.83	15	4	2.87	4
Service skidder	2	0.92	8	2	2.50	4
Subtotal	10	4.41	37	16	15.80	23
Nonmechanical delays						
Operational						
Personal	15	6.51	55	76	41.80	60
Visitors	-	-	-	1	5.00	7
Miscellaneous	-	-	-	5	3.72	5
Auxiliary equipment	3	0.60	5	-	-	-
Organizational						
Wait for other phase	1	0.17	1	2	1.23	2
Miscellaneous	1	0.17	1	6	2.59	4
Subtotal	20	7.45	63	90	54.34	77
Total all delays	30	11.86	100	106	70.14	100

[a] Differences due to rounding.

Table 4. Detailed Timing: Summary

Element	Vernon Time (min)	Vernon %	Lumby Time (min)	Lumby %
Productive time	1716.36	59	3397.47	63
Road-change time	851.00	30	1621.00	30
Sumtime	21.94	1	4.81	<1
Delays <10 min each	296.32	10	402.44	7
Total	2885.62	100	5425.72	100
Total study time (PMH)	48.09		90.43	
Total stems yarded (no.)	1504		2858	
Total estimated volume yarded (m^3)	1167		1825	
Average stem volume (m^3/stem)	0.78		0.64	
Total stems/PMH (no.)	31.3		31.6	
Volume production (m^3/PMH)	24.3		20.2	

Table 5. Breakdown of Timing Elements for All Yarding Cycles

Activity	Vernon[a] Time/cycle (min)	Vernon[a] %	Lumby[b] Time/cycle (min)	Lumby[b] % [c]
Outhaul	0.25	5	0.33	6
Hookup	1.14	24	1.36	25
Inhaul	0.64	14	0.95	17
Deck	0.19	4	0.18	3
Unhook	0.60	13	0.60 [d]	11 [d]
Road change	1.38	30	1.63	30
Delay	0.48	10	0.40	7
Total	4.68	100	5.45	100

[a] Average yarding distance of 108 m.
[b] Average yarding distance of 82 m.
[c] Differences due to rounding.
[d] Excluding week #3 when deck and unhook were combined.

The summary of delays (Table 6) shows a large percentage of nonmechanical delay time is 'wait for skidder to clear'. Generally, these delays occurred between hookup and inhaul, or before decking, these being the only skidding windows available when the mainline was tight (i.e. out of the way of the stems being skidded). These delays, while unavoidable, are more a source of frustration to the rigging crew than an impediment to production. The relatively low production, and lack of landing area for the yarders, could not justify the cost of a loader-type machine to swing the wood clear.

The blowdown in the wake of the October wind storm at Lumby caused some problems in the yarding phase as is reflected in the delay summary. 'Buck in bush', 'hungup', and 'saw on/off rigging' are the delay categories that illustrate the problems. These delays usually occurred with the larger windfallen trees that the faller could not cut from the root mass during normal falling activities. These unbucked roots had to be removed before yarding, so the yarding crews were required to take extra time for bucking after the adjacent logs were removed.

Site Disturbance Survey: Vernon

A site-disturbance survey was not done on the Lumby cutblock because the site was burned before a survey could be conducted.

Although the Pre-Harvest Silviculture Plan (PHSP) for the Vernon block classified the soil compaction hazard as low, the overall soil sensitivity rating for the block was rated high because there was a high displacement hazard, a high mass wasting hazard, and a moderate surface erosion hazard. The maximum soil disturbance allowed is 5% of 5 cm mineral soil disturbance. As Table 7 illustrates, no mineral soil disturbance occurred at 5 cm and only 3% at <5 cm. This percentage is based on observations in the 20-m-wide harvested strips *only*, and does not include the approved haul road at the top of the block. The slash loading was light and discontinuous in the harvested strips. FERIC observed no falling or yarding disturbance in the 40-m-wide leave strips.

Discussion

Directly comparing costs and productivities of different cable systems is difficult because of the many advantages and constraints inherent to each system. However, to illustrate the relative competitiveness of small skyline systems, a simple comparison to grapple yarding feller-bunched stems is provided based on data from a previous FERIC study (Moshenko 1991). Moshenko reported that a Washington 108 grapple yarder with a mobile backspar guyline tailhold, working near Kelowna in the Interior of British Columbia, produced 40 m^3/h when yarding bunched logs on 20% slopes.

Table 6. Delay Summary: Detailed Timing

Description	Vernon Occurrence (no.)	Vernon Time (min)	Vernon %	Lumby Occurrence (no.)	Lumby Time (min)	Lumby % [a]
Mechanical delays						
Respool and untangle lines	19	12.66	4	24	18.77	5
Radio malfunction	2	8.26	3	4	3.60	1
Winch	0	0	0	2	8.17	2
Rigging repairs	1	2.85	1	4	15.85	4
Carriage malfunction	6	20.71	7	2	2.52	1
Subtotal	28	44.48	15	36	48.91	12
Nonmechanical delays						
Wait for skidder to clear	214	192.69	65	201	167.44	42
Unknown landing delay	16	12.24	4	22	22.97	6
Rehook	0	0	0	5	3.42	1
Hungup	9	5.75	2	18	23.14	6
Buck in bush	3	10.63	4	5	29.68	7
Buck at landing	5	6.64	2	10	25.62	6
Discussion	1	1.03	<1	9	15.02	4
Saw on/off rigging	0	0	0	13	33.26	8
Yard sliders	2	5.21	2	3	7.14	2
Drop guylines for truck	0	0	0	3	5.90	1
Miscellaneous	9	17.65	6	19	19.94	5
Subtotal	259	251.84	85	308	353.53	88
Total delays	287	296.32	100	344	402.44	100

[a] Differences due to rounding.

Table 7. Results of Disturbance Survey: Vernon

	Disturbance depth		
	0 cm (%)	<5 cm (%)	5 cm (%)
Harvested strips			
Undisturbed organic	86	-	-
Disturbed organic	-	10	<1
Disturbed mineral	-	3	0

This wood was delimbed and topped by a mechanical processor for a total system cost of $10.28/m^3. If the grapple yarder had been working under conditions similar to those of the two Skylead machines (i.e. >40% slope), mechanical feller-bunching would not have been an option and some increase in production costs would be expected. Moshenko estimated an additional cost of $2.76/m^3 to reflect both incremental hand-falling costs and reduced turn payloads for the grapple yarder. This additional cost would raise the production cost (excluding loading and hauling) to $13.04/m^3. In comparison, the small skyline yarders produced 17.0 m^3/h at Vernon and 19.5 m^3/h at Lumby for respective production costs of $14.54/m^3 and $12.45/m^3.

Capital cost is another consideration in the application of yarding systems. For example, the grapple yarder system consisted of a Timberjack 2520 feller-buncher, a Washington 108 swing yarder, a Caterpillar D8 mobile backspar (used), a Dresser TD20 mobile guyline tailhold (used), and a Denis D3000 stroke delimber, having an estimated total capital investment of $1.6 million. By comparison, the system studied at Vernon—consisting of a Skylead Model 16000 yarder, a Maki Mini-Mak I carriage, a Timberjack 450C line skidder, and a used Caterpillar D6 crawler-tractor—had a capital investment of $391 000. Because of the higher overall machine costs resulting from capital investment, the grapple system must achieve much higher productivities to compete with the smaller skyline system. This is done by minimizing nonproductive time through the use of a mobile backspar, and maximizing turn volume through bunching. When terrain conditions prevent the use of bunchers and mobile backspars (i.e. on slopes >40%) small skyline systems can become an economical option.

Conclusions and Recommendations

The Skylead C40 yarders observed by FERIC near Vernon and Lumby in 1991 efficiently and economically harvested areas unsuited to either ground-based systems or larger grapple-yarder systems. The feasibility of using a small skyline yarder like the Skylead is growing because more harvesting is now occurring on steep slopes, and policies regarding visual impacts are dictating the use of smaller clearcuts and partial cuts.

It is recommended that future studies on this equipment be directed towards their use for partial cutting (commercial thinning, etc.) and downhill yarding.

References

Moshenko, Darcy W. 1991. *Grapple Yarding in the Interior of British Columbia.* Vancouver: FERIC. Technical Note TN-176. 10 pp.

Acknowledgements

The author is grateful for the cooperation and assistance provided by the crews of Critical Site Logging Inc., Gerry Wellburn of Fletcher Challenge Canada Limited (Armstrong Division) (now Riverside Forest Products Ltd.), and Albie Thomson of Weyerhaeuser Canada Limited (Lumby Division). Thanks also to Craig Evans of FERIC for field assistance and data analysis, and to Kathi Hagan, Chris van Beusekom, Karen Somerville, and Tony Sauder of FERIC for their assistance in the preparation of this report.

Disclaimer

Appendix I

Costing Summary: Yarders, Skidders, Carriage, and Crawler-Tractor

	Skylead Model 8000 yarder & skidder	Maki Mini-Mak I carriage	Skylead Model 16000 yarder & skidder	Timberjack 450C line skidder	Caterpillar D6 used crawler-tractor
OWNERSHIP COSTS					
Purchase price					
C40 yarder $	124 979		152 979		
Used skidder $	15 000		15 000		
Total base price (P) $	139 979	17 450	167 979	151 866	38 500
Lines $	8 000		10 050		
Rigging and radios $	5 250		5 250		
Total purchase price (Pt) $	153 229	17 450	183 279	151 866	38 500
Expected life (Y) yr	10	5	10	5	6
Expected life (H) h	16 000	8 000	16 000	10 000	9 600
Scheduled hours per year (h) h	1 600	1 600	1 600	2 000	1 600
Salvage value as % of P (s) %	20	20	20	30	20
Interest rate (Int) %	12.0	12.0	12.0	12.0	12.0
Insurance rate (Ins) %	2.0	2.0	2.0	2.0	2.0
Salvage value (S)=((s•P)/100) $	27 996	3 490	33 596	45 560	7 700
Average investment (AVI)=((Pt+S)/2) $	90 612	10 470	108 437	98 713	23 100
Loss in resale value = ((Pt-S)/H) $/h	7.83	1.75	9.36	10.63	3.21
Interest = ((Int•AVI)/h) $/h	6.80	0.79	8.13	5.92	1.73
Insurance = ((Ins•AVI)/h) $/h	1.13	0.13	1.36	0.99	0.29
Total ownership costs (OW) $/h	15.76	2.67	18.85	17.54	5.23
OPERATING AND REPAIR COSTS					
Wire rope (wc) $	8 000		10 050		
Wire rope life (wh) h	1 600		1 600		
Rigging and radio (rc) $	5 250		5 250		
Rigging and radio life (rh) h	2 400		2 400		
Fuel consumption (F) L/h	3.8		3.8	20.5	2
Fuel (fc) $/L	0.45		0.45	0.45	0.45
Lube and oil as % of fuel (fp) %	10		10	10	10
Annual tire consumption (t) no.				2	
Tire replacement (tc) $				2 500	
Annual operating supplies (Oc) $				4 560	1 500
Annual repair and maintenance[a] (Rp) $	13 998	3 490	16 798	30 373	6 417
Wages $/h					
Operator	20.76		20.76	18.79	
Hooktender	19.34		19.34		
Chokerman	17.76		17.76		
Buckerman	20.02		20.02		
Total wages (W) $/h	77.88		77.88	18.79	
Wage benefit loading (WBL) %	35		35	35	
Wire rope (wc/wh) $/h	5.00		6.28		
Rigging and radio (rc/rh) $/h	2.19		2.19		
Fuel (F•fc) $/h	1.71		1.71	9.23	0.90
Lube and oil ((fp/100)•(F•fc)) $/h	0.17		0.17	0.92	0.09
Tire (t•tc)/h $/h				2.50	
Operating supplies (Oc/h) $/h				2.28	0.94
Repair and maintenance (Rp/h) $/h	8.75	2.18	10.50	15.19	4.01
Wages and benefits (W•(1+WBL/100)) $/h	105.14		105.14	25.37	
Total operating costs (OP) $/h	122.96	2.18	125.99	55.49	5.94
TOTAL OWNERSHIP AND OPERATING COSTS					
(OW+OP)[b] $/h	138.72	4.85	144.84	73.03	11.17
Excluding interest[b] $/h	131.92	4.06	136.71	67.11	9.44

[a] Annual repair and maintenance costs were estimated by dividing the purchase price for the individual equipment (P) by their expected life (y).
[b] These costs are based on FERIC's standard costing methodology for determining machine ownership and operating costs. These costs do not include supervision, profit and overhead, nor costs related to lost productivity of one day or more; costs are not the actual costs of the contractor or company studied.