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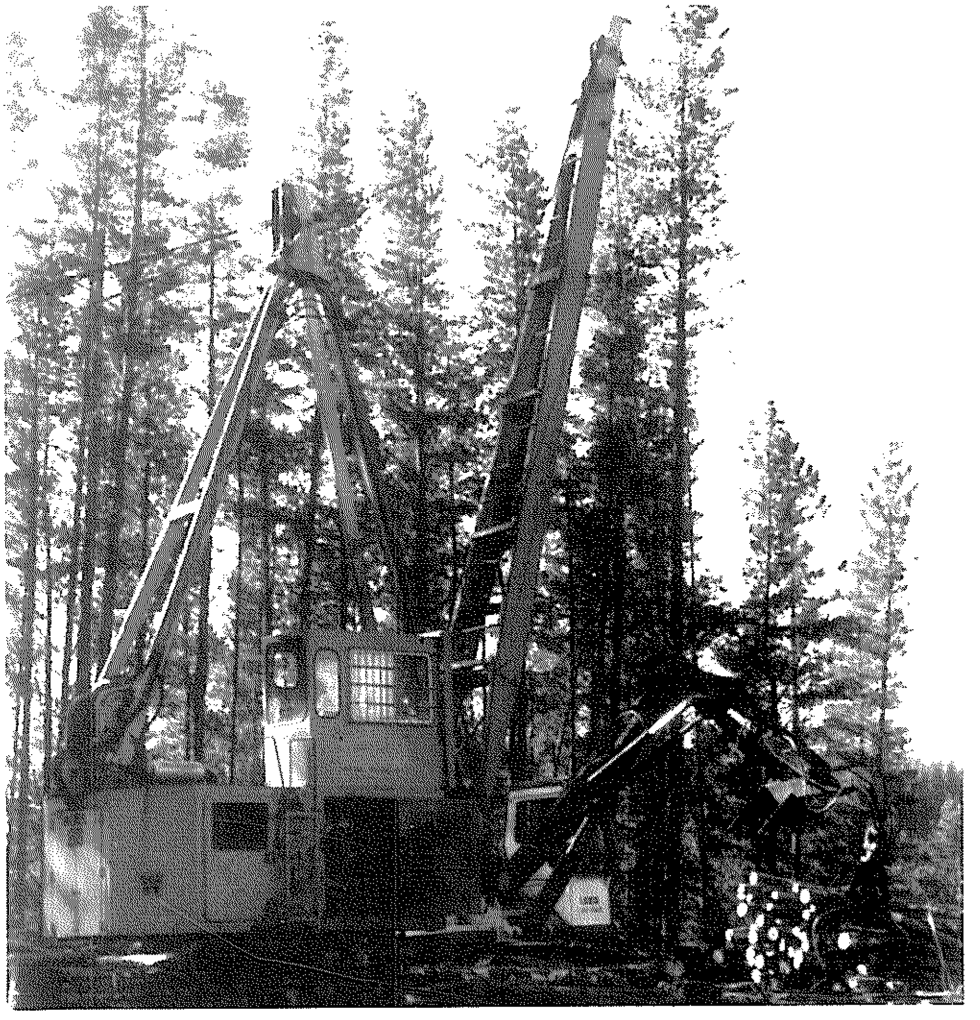
PROJECT REPORT

A STUDY OF LOG LENGTH AND TREE LENGTH EXTRACTION USING A WASHINGTON 88 HAULER

ROB PREBBLE



Project Report

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A STUDY OF LOG LENGTH AND TREE LENGTH EXTRACTION USING A WASHINGTON 88 HAULER

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ABSTRACT

The Washington 88 hauler operating in Kaingaroa Forest, has never performed as well as expected. Shifting it from old crop to transition crop was an ideal time to experiment with alternative systems. A trial was set up with the hauler pulling log length logs to a landing where a knuckleboom loader was used to fleet them. Data was also collected on the conventional system, where the hauler pulled tree length logs to the landing for a rubber tyred front end loader to clear to a processing area.

In the log length operation, the fallers did not fully adopt the technique of processing at the stump because their productivity was low and there was a safety hazard with logs rolling after being cut. Problems were also found with out-of-spec logs which needed re-processing on the landing.

On a PMH (productive machine hour) basis, there was no significant difference between log length and tree length extraction. Landing related delays however reduced productivity by 21% in the log length operation and only 12% in the tree length operation. The main reason for the much higher delay factor in the log length operation was the reprocessing required on the landing.

Two types of log attachment method were studied, one with the strops permanently attached to the drop line and the other using a "pre-stropping" system. Prestropping was up to 15% more productive than attached strops.

Overall the log length operation was 8 to 11% less productive than tree length.

Analysis of the landing operations showed that the knuckleboom loader was reasonably well occupied with 76% of its productive time spent fleeting and loading trucks. A further 11% of its available time however, was spent either waiting for skiddies to finish re-measuring and cutting or waiting for the hauler.

The rubber tyred front end loader operating in the tree length operation spent a similar proportion of its time fleeting, clearing the tower and loading trucks.

The two skiddies had more idle time in the log length operation than they did in the tree length operation.

In this trial too much processing was carried out on the slope. The merchantable tree size was only 1.3 m³ and processing reduced this to 0.5 m³ per log. Although more pieces were hooked on, drag volumes were 20% lower than the tree length extraction it is recommended that for future log length trials, the optimum processed log size be kept close to 1.0 m³.

Indications were that if the log length operation was allowed to continue to enable the crew to become proficient at their respective tasks then it could have been as productive as the tree length operation. The high work content and potential hazards involved with in-bush processing needs to be further investigated.

ACKNOWLEDGEMENTS

LIRA gratefully acknowledges the cooperation of Timberlands, Kaingaroa and Contractor Jim Helmbright during the data collection for this study.

BACKGROUND

Cable logging operations in New Zealand have never consistently achieved the production levels expected of them. The main reasons for this have been identified as; the lack of a suitable range of equipment to optimize productivity (Donovan,1979), a relatively low level of utilization from our haulers despite high availability levels (Murphy, 1978) and our adherence to tree length logging (Galbraith, 1986).

Research into overseas practices with cable machines indicated that mobile swing boom haulers such as the

Washington 88 were achieving high production levels, (Schaffer, 1983; Anon, 1982; Major, 1984). Fundamental changes to the New Zealand way of operating were necessary however, before these machines would perform well here (Spiers, 1983). These changes included:

- Locating the hauler close to the edge of the landing.

- Rigging tail trees for clearance.

- Prestropping.

Predictions were made on the potential of the Washington 88 in New Zealand conditions, based on a study done in the Pacific North West (Hemphill, 1983). Production levels of between 250 and 450 m^3 were predicted in old crop and 200-400 m^3 in new crop. These figures were dependent on sufficient deflection being available, proper training for the crew and two staging or cutting to length in the bush.

Earlier studies in New Zealand had indicated that processing trees into logs in the bush was not a viable option (Murphy, 1977) but this was based on a study of a large two drum hauler using a system with limited lateral slackpulling ability.

Recent studies of smaller, more mobile haulers, with lateral slackpulling ability, have indicated that log length extraction could be as productive as tree length extraction provided that the system and machinery were correctly matched, and that the operation was properly planned. (Simpson, 1986; Kellogg, 1987).

The real differences in operating techniques between cable loggers in the Pacific North West and New Zealand operators, are the practice of cutting trees into log lengths in the bush, prestropping each drag, and the use of large knuckleboom loaders at the landing (pers comms Kellogg). Indications are however, that cutting to log length in the bush is sensitive to tree size and about 1 m^3 is the minimum average processed log size that can be accommodated before drag size is affected (McConchie pers comms).

INTRODUCTION.

The Washington 88 swing boom hauler owned by Timberlands Kaingaroa has never performed as well as expected in old crop. A shift from old crop to transition crop in 1987 was an opportune time to investigate ways of improving efficiency by introducing changes to the logging system. Ground profiles with limited deflection and a small narrow skidsite in the first setting looked to be particularly difficult for conventional tree length logging using a short 15 m high tower.

To address these issues, Timberlands, Kaingaroa put forward a proposal to hire a hydraulic knuckleboom loader and approached LIRA to assist in the design of a suitable logging system. To fully exploit the potential of the knuckleboom loader, a system based on cutting trees to log length specifications in the bush was recommended. It was planned that LIRA would develop the felling method prior to the operation starting up and then instruct the crew in the technique and study the result. Due to unforeseen complications, the log making at the stump was discontinued before being properly evaluated (see page 4).

The objectives of the study were :

1. Compare the productivity of the Washington 88 hauler using two logging systems :

   (i) a log length system with small landing and hydraulic knuckleboom loader

   (ii) a conventional tree length logging system with processing on the landing and rubber tyred front end loader.

2. For both log length and tree length systems, compare the productivity of conventional attached strop and prestrop breaking out methods.

1. Trial Area

The compartment (1098) in Kaingaroa Forest consisted of a 40 ha block of 31 year old P.radiata transition crop, stocked at 626 stems per hectare. Stand details from pre assessment data are shown in Table 1.

Table 1 - Stand Details, Compartment 1098, Kaingaroa Forest

	Live	N.M.D.*	Total.
No of plots	10	10	10
Stocking (SPH).	632	141	773
Mean DBH (cm).	37.3	21.0	34.9
Ave. merch. length (m).	34.9		
Mean merch. volume (m3/stem).	1.3		
Merchantable vol. (m3/ha)	798.8		

* Non merchantable/dead

The predominant lean of the trees was down the true LHS of the gully and up the true RHS, (see fig. 1). This made it difficult to adopt a coordinated approach to the felling because the wood could not be left on the ground for any length of time and cross slope felling into standing trees is not a desirable practice.

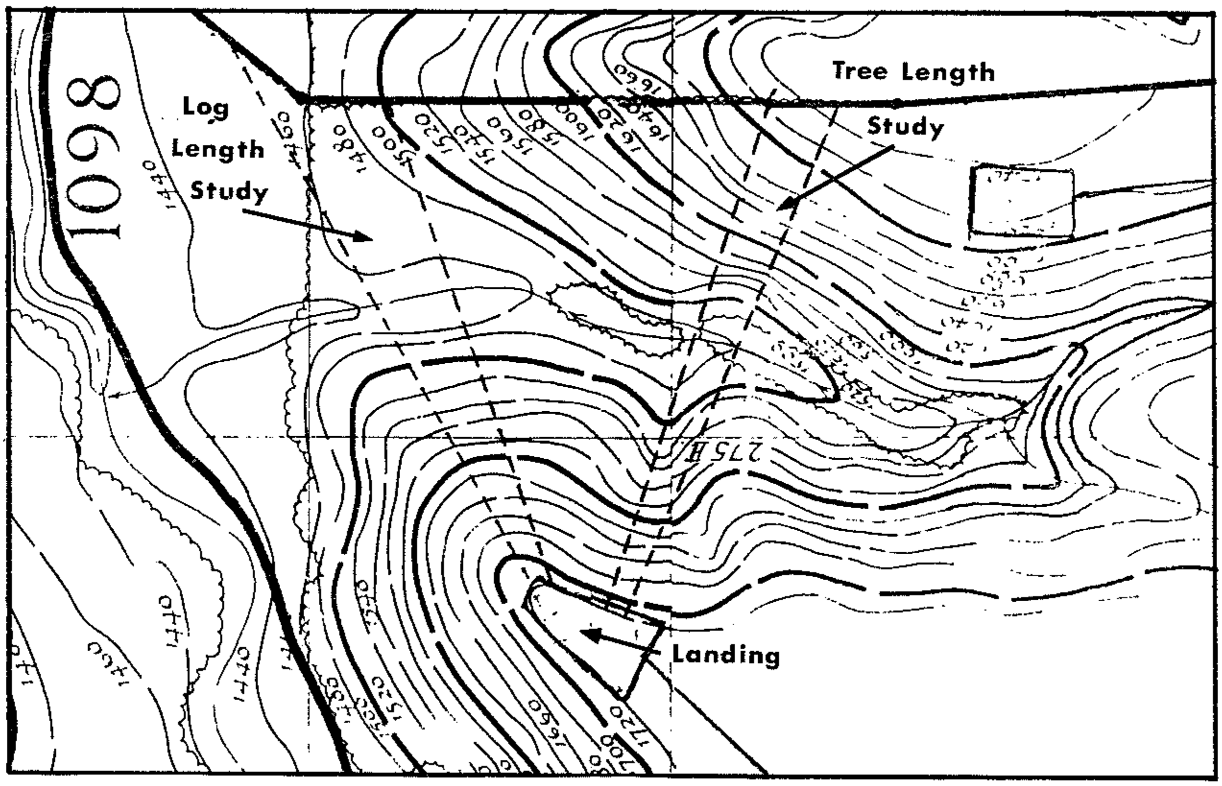

Figure 1 - Contour Map, Compartment 1098 (Scale 1 : 5000)

Slopes in the area ranged from 8% to 53% with mid slope rock outcrops on many of the profiles. The soil type was Otanewainuku steepland soil derived from Rhyolite ash and Rhyolite. A small flowing stream divided the area in two (see fig. 1). Compartment 1102 bounding the RHS of the setting was stocked with young Douglas fir and the flat part of 1098 on top of the ridge (R. foreground, fig. 1) had been previously logged with a skidder.

2. Hauler Studies.

A detailed continuous time study of the hauler cycles was conducted for 5 days operation in the log length extraction and 2 days operation in the tree length extraction. Parameters recorded during the study were as follows:

- Individual element times for every cycle.
- Whether using attached strops or prestropping.
- The time and causes of production delays.
- Distances for both hauling and slackpulling.
- Log type extracted during log length study.
- Log volumes extracted during tree length study.

Measuring volumes during log length extraction caused too many interruptions to the operation so it was abandoned in favour of a log product type identification of each drag as it arrived on the landings. As the various log types were being loaded onto trucks, a piece count was kept and the net payloads of the trucks divided by the number of pieces in the load gave an average weight per piece for that product. This was then related back to the drag content recorded with each cycle to give an estimation of hauler production.

All drags extracted during the tree length study were scaled as they arrived at the landing.

(i) Log Length Extraction.

The log length study involved partial processing of the trees into log lengths at the stump. Wherever possible, felling was done across slope to facilitate easy delimbing and crosscutting. Trees were cut into log lengths or multiples of log lengths up to a maximum length of 16 m. Log specifications were 12.1 and 8.1 m export grades, pruned random length sawlogs, two grades of unpruned random length short sawlogs and short pulp. Where two or more logs were left uncut in the bush, they were measured and marked for the skiddy to cut.

Initial felling was done by LIRA staff and, when the basic principles were developed, the regular fallers in the crew were given instruction on the technique. Unfortunately the regular fallers were not prepared to fully adopt the practice of cutting to length in the bush and it was stopped prematurely. The reasons for this were:

- The stand was heavily stocked with a wide range of tree sizes which meant that crosscutting had to be done so carefully that productivity was low.
- Insufficient time was allowed to let the fallers get far enough ahead to take the pressure off them and allow them to get fully conversant with the technique.
- No allowance was made to add an extra man in the bush to keep the fallers far enough ahead so that they could concentrate on log quality.
- As a consequence, the quality of log making done in the bush was not up to specification, partly due to a change in the required length during the study, and partly through inaccurate measurement and cutting by the fallers, (including LIRA fallers).
- The Department of Labour inspected the operation and on hearing the fallers' complaints insisted that cross cutting in the bush be discontinued until a safer work technique was developed.

It was intended that only the wood fallen by the crew fallers be considered in the study but when the in-bush processing was abandoned so suddenly, extraction of all the remaining wood processed into log length was studied.

Extraction was done with the Washington rigged as a running skyline with a mechanical slack pulling carriage, (see appendix 1). The machine was located 16m from the edge of the landing area. The strip logged during this study is marked on fig. 1.

Both prestropping and attached strops were used during the study with one and two men breaking out. Two sets of four strops were used, one set being 8 mm chain and the other 16 mm wire rope.

It was necessary to rig tail trees on two of the three skyline roads logged during the study. For the last road, a D85 Komatsu tractor was used as a mobile tailhold.

Ground profiles of two of the skyline roads were measured and run through the computer based skyline payload calculation package, LOGGERPC, (see appendix 2).

The logs were decked in the chute area for the skiddy to make the final cuts and trim any branches remaining on the stem. Originally only one skiddy was envisaged on the landing but changing export specifications and out-of-spec logs meant that most logs had to be re-measured and cut again so two skiddies were used.

The chute area was cleared by the knuckleboom loader which either fleeted the logs into the stacks or loaded out directly onto trucks. Truck loading was done in conjunction with the hauling.

(ii) Tree Length Extraction.

For the study of tree length extraction, the trees were felled across slope and left untrimmed. In most cases, the slovens were cut off after falling. In situations where there was a heavy lean or the terrain was broken, the trees were felled either to their lean, or straight down the slope.

No changes were made to the rigging configuration of the hauler for tree length extraction except that the mobile tailhold was used continuously, and very few occasions of prestropping with one breaker-out were recorded. Both one and two breaker-outs were used with attached strops.

A ground profile of one of the skyline roads was measured and run through LOGGERPC to predict payloads and locate critical points in the profile. The results are shown in appendix 3.

The hauler was located 31 m from the edge of the landing. The strip logged is shown on fig. 1.

Full tree lengths were landed in the chute area and from there, the rubber tyred front end loader pulled them away to a processing area alongside the hauler.

Two skiddies cut the trees into log specifications similar to those used in the log length extraction, except for a long pulp sort that was added.

Once the logs were processed, the loader fleeted them into stacks. Trucks were loaded concurrently with the hauling operation.

3. Landing Studies.

Activity sample data on the loader and two skiddies were collected for five days of log length extraction and two days of tree length extraction. One minute intervals were used during the activity sampling. Parameters recorded were:

- Work elements.
- Non productive activities.
- Interference (from other facets of the operation)
- Idle time.

(i) Log Length Operation.

A Link Belt 4300 loader fitted with a Prentice 610 loading boom (see appendix 4), was used for fleeting and loading out in the log length study. The loader was positioned next to the chute area and picked the logs out of the chute once the skiddies had processed them.

Truck loading was done from the log stacks and occasionally from the chute area. If the skid needed clearing, the loader would have to pick up individual pieces of slash with the grapple or if the concentration was sufficiently heavy the area could be swept with a closed grapple. A plan of the skid layout is shown in fig. 2.

One skiddy would unhook the logs while the other trimmed and crosscut logs in the chute. Between drags the unhooker would also trim and cut logs but the skiddies could only work in the chute area when the ropes were either stationery or unloaded.

The amount of re-measuring and re-cutting was much higher than expected in the log length operation.

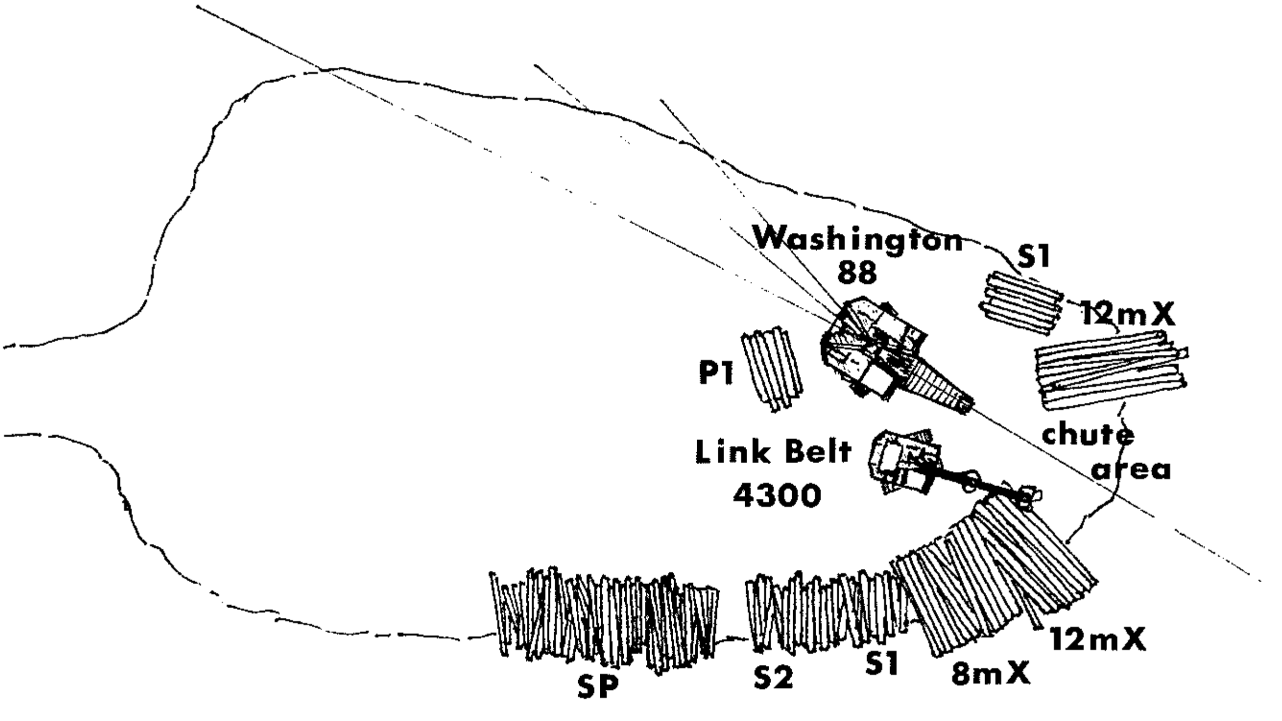

Figure 2 - Plan view of skid layout, log length extraction

(ii) Tree Length Operation.

The link Belt 4300 loader was not considered suitable for the tree length operation so a Fiat Allis 745 rubber tyred front end loader (specifications in appendix 5),was used. It picked the trees out of the chute and swung them into the processing area

Once the logs had been processed, the loader fleeted them into the various log stacks.

Trucks had to be driven between the hauler and the chute to get into position for the loader to load them. A log in the forks of the loader was used to sweep the skid to clear accumulated slash. The skid layout for the tree length operation is shown in fig. 3.

Usually one of the skiddies unhooked the incoming trees from the hauler while the other continued to trim and crosscut the trees in the processing area. Between drags, the skiddy responsible for unhooking would help to measure the logs and assist in the processing of them.

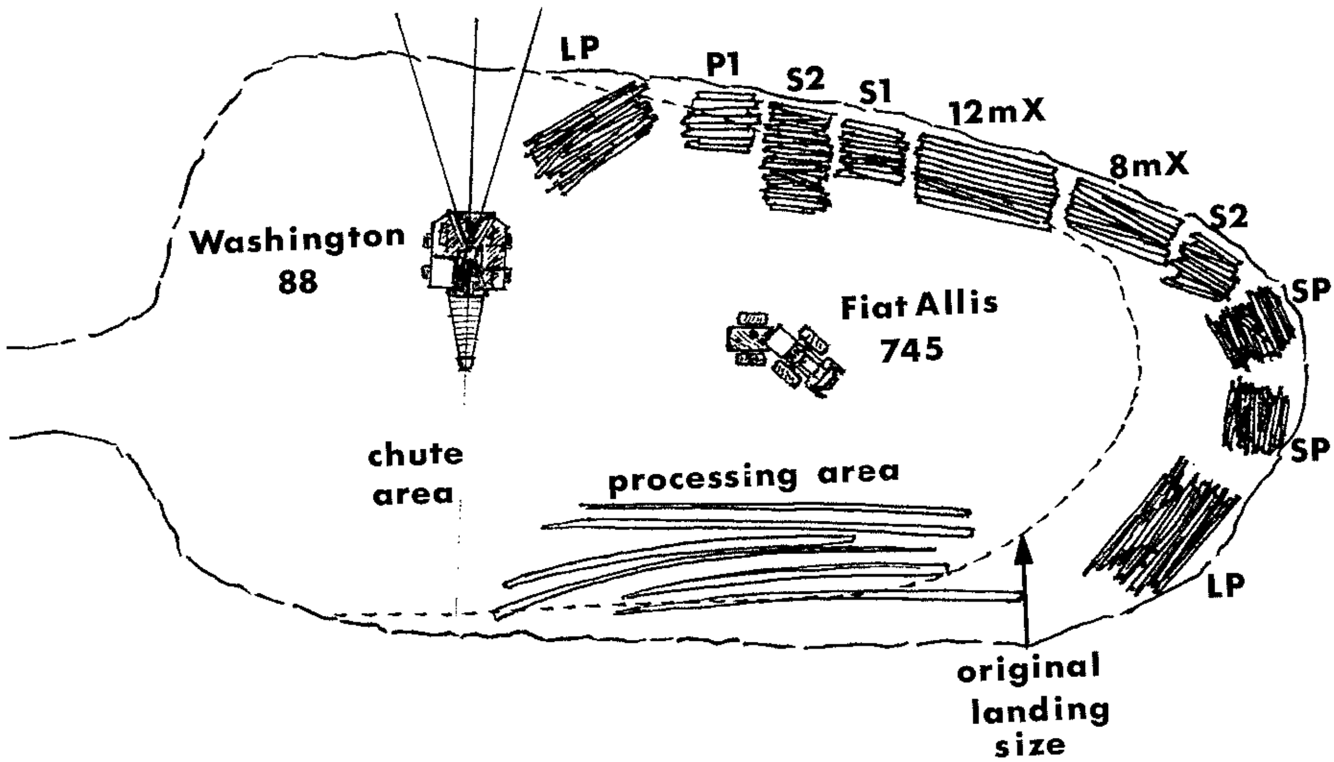

Figure 3 - Plan view of skid layout, tree length extraction

RESULTS.

1. Hauler Studies.

Because two different strop attachment methods were used and the number of breaker-outs changed according to crew complement, the analysis has concentrated on data collected when these two factors were comparable.

(i) <u>Attached Strops</u>.

Delay free cycle times for log length extraction versus tree length extraction using the Washington with attached strops are shown in table 2. There was no significant difference in cycle times between having one or two breaking out for both log and tree length extraction so the results are combined. It was obvious however that the single breaker-out was working much harder when by himself and whether he could sustain the production at the recorded level over a long period is debatable.

Note that haul distances have been standardised to 200 m and element times that were not directly influenced by the system being used, have been standardised to an overall mean for the study. Regresssion equations for outhaul and in haul are shown in appendix 6.

The average volume of the logs in the log length extractions was .50 m^3 and the average volume in the tree length extraction was .85 m^3 (see appendix 6).

Table 2 - Comparison of log length vs tree length extraction with attached strops

Element.	Cycle time, min			
	Log length.		Tree length.	
Raise rigging.	.11		.11	
Outhaul.	.47	(200 m)	.48	(200 m)
Position.	.55		.60	
Lateral out.	.25	(6.6 m)	.31	(10.3 m)
Hook on.	1.63	(4.7pcs)	2.26	(3.7pcs)
Lateral in.	.33		.79	
Inhaul.	.85	(200 m)	1.35	(200 m)
Lower rigging.	.20		.20	
Unhook.	.87	(4.6pcs)	.82	(3.5pcs)
TOTAL.	5.26	(SD = 1.08)	6.92	(SD = 1.44)
Extracted piece size.	.50 m^3		.85 m^3	
Cycle volumes.	2.30 m^3		2.97 m^3	
Production (per PMH).	26.2 m^3		25.8 m^3	

The figures in table 2 are based on delay free cycle times and consider 132 cycles of log length operation and 81 cycles of tree length operation.

The time taken to hook on strops was significantly longer in the tree length operation, i.e. .61 min per piece compared to .35 min per piece when breaking out log length logs, a 43% increase. The main reason for this was that more log ends were available to hook on to in the log length operation.

Log loss during lateral in and inhaul was 1.6% for the log length operation and 5.8% in the tree length operation. The main reason for the higher log loss in the tree length operation was breakage during "lateral in" and "inhaul". This could account for some of the .45 m^3 difference between the scaled log volumes during the study and the pre-assessment data.

The hauler operator had to exercise caution when pulling trees off the top of the rock outcrop to avoid breakage, and excessive loadings on the hauler and ropes as the drag became suspended. The problem would not have been as great with log length logging as the drags would have been easier to break out, breakage would have been much less and there would have been less shock loading on ropes and machine when the drag became suspended.

Inhaul times were 59% longer when pulling tree length while the average volume per cycle was only 29% greater.

Operational delays recorded during the study with attached strops are shown in table 3.

Table 3 - Delays recorded while using attached strops for log and tree length operation

Reason for delay.	Time per cycle, min Log length.		Tree length.	
Strop handling.	.04	(4)	.03	(3)
Hangup during inhaul.	.02	(3)	.05	(7)
Difficulty landing logs.	.04	(7)	.10	(12)
Unhooking logs.	.05	(9)	.09	(5)
Waiting for loader.	.96	(9)	.11	(8)
Wire rope related.	.07	(*)	.07	(*)
Ropeshifts.	.26	(*)	.26	(*)
Other.	.04	(1)	.07	(1)
TOTAL	1.48		.78	

( ) = No. of observations.
(*) = Delay items, not related to the system, that have been standardised as a mean for the study.

Strop handling delays were similar for both operations. These were usually caused by a log or tree resting hard against the ground or the strops getting tangled.

Hangups during inhaul occurred when the drag got caught behind the rock bluff or a stump. There was a higher incidence of this type of delay in tree length logging.

The delays associated with landing logs in the log length operation were caused by short logs swinging ahead of longer logs as they were being landed on the landing. This would require the hauler operator to lift them up again to better align them for unstropping.

Landing trees in the tree length operation was interrupted when there was a stockpile in front of the hauler and the incoming trees got caught up in the heads of the stockpiled trees. Generally there was a higher amount of interference to the landing of the drag in the tree length operation.

Unhooking delays (where the hauler had to raise the rigging to twist the logs to clear the choker bell for unstropping), were longer in the tree length operation, but more frequent in the log length operation.

Delays as long as 48 minutes were recorded while the hauler waited for the loader to clear the chute in the log length operation. The loader in turn was often waiting for the skiddies to catch up with the re-processing of the logs (see loader study). Much less interference happened with the rubber tyred loader in the tree length operation.

All the wire rope delays were associated with splices between the tag line and the toggle hitch.

The average lineshift for both log and tree length operations with attached strops was 40 min.

Total cycle times, with delays included, reduce the overall production of both log length and tree length operations as shown in table 4.

Table 4 - Hauler Production for log and tree length extraction when using attached strops

Element	Cycle time, min. Log Length.	Tree length.
Delay free.	5.26	6.92
Operational delays.	1.48	.78
TOTAL.	6.74	7.70
Cycle volumes.	2.30 m^3	2.97 m^3
Production (per AMH).	20.5 m^3	23.1 m^3

Machine availability for log and tree length operation with attached strops was 97%. A long 24.7 min delay occurred in the tree length operation when the hauler was starving for fuel. Most of the other delays were associated with the MSP carriage and routine maintenance.

(ii) Prestropping.

Delay free cycle times for log and tree length operations with prestropping are shown in table 4. Only cycles with two breaker outs hooking on were considered in this analysis. The crew preferred not to prestrop when one was breaking out in the tree length extraction.

All extraction distances and element times for raising and lowering the rigging have been standardised. Log volumes averaged .50 m^3 per piece in the log length operation and .85 m^3 in the tree length operation.

The figures are derived from 101 cycles of log length operation and 23 cycles of tree length operation. Total cycle times do not include delays.

Table 5 - Comparison of log length versus tree length extraction, prestropping with two breaker-outs

Element.	Cycle time (min). Log length.		Tree length.	
Raise rigging	.11		.11	
Outhaul.	.50	(200 m)	.47	(200 m)
Position.	.53		.71	
Lateral out.	.24	(8.6 m)	.23	(7.8 m)
Hook on.	.91	(4.7pcs)	1.12	(3.7pcs)
Lateral in.	.42		.86	
Inhaul.	.87	(200 m)	1.24	(200 m)
Lower rigging.	.20		.20	
Unhook.	.92	(4.6pcs)	.79	(3.4pcs)
TOTAL.	4.70	(SD = .85)	5.73	(SD = 1.39)
Extracted piece size.	.50 m^3		.85 m^3	
Cycle volumes.	2.30 m^3		2.89 m^3	
Production (per PMH).	29.4 m^3		30.3 m^3	

Hooking on the pre set strops in the log length operation took only .19 min per piece compared to .30 when pulling tree length logs, but on a volume basis, the difference is minimal. There was however, a significant difference between prestropping and attached strops, (see table 6).

Table 6 - The difference in hook on time between attached strops and prestropping

	Hook on time Attached strops.		Prestropping.		Difference.	
	min/piece	min/m3	min/piece	min/m3	/piece	/m3
Log length.	.35	.71	.19	.40	46%	44%
Tree length.	.61	.76	.30	.39	51%	49%

Prestropping was particularly successful with two breaker outs. As soon as the empty strops were disconnected from the tag line, slack would be signaled and one worker would feed the toggle hitch through the rings of the pre-set strops while the other would start to strop up the next drag. By working alternate sides with each drag, minimal interference between the two occurred.

Log loss during "lateral in" and "inhaul" was 1.5% during log length extraction and 7.0% during tree length extraction. The significantly slower "position" and "lateral in" elements in the tree length operation were directly related to the profile being logged.(See earlier comment in "attached strops" Section).

Inhaul times were 43% longer in the tree length extraction with a 26% higher average volume per cycle.

Longer unhooking times occurred in the log length extraction when a stockpile developed in the chute area or when short logs swung ahead of longer logs as they were being landed on the landing. The unhook times in tree length extraction were the same for attached strops as for prestropping, .23 min per piece.

Delays occurring in the prestropping operations are shown in table 7.

Table 7 - Operational delays for log and tree length extraction when prestropping

Reason for delay.	Time per cycle, min Log length.	Tree length.
Strop handling.	.04 (6)	.14 (2)
Hangup during inhaul.	.02 (6)	.03 (2)
Difficulty landing logs.	.04 (7)	.16 (5)
Unhooking logs.	.04 (3)	.00 (0)
Wait for loader.	.80 (9)	.50 (2)
Wire rope related.	.07 (*)	.07 (*)
Ropeshifts.	.26 (*)	.26 (*)
Other.	.00 (0)	.00 (0)
TOTAL.	1.27	1.16

( ) = Number of observations.
(*) = Standardised times not related to the system being used.

The strop handling delays were usually the result of strops getting tangled during "outhaul" or the breaker-outs not getting the strops hooked on before the rigging had been returned for the next cycle. This was particularly evident in the tree length operation.

The time lost due to hangups while inhauling were longer in the tree length extraction. The hauler was unable to keep sufficient tension in the tailrope when suspending some of the tree length drags across the gully and this would cause the carriage to move up the mainrope causing a "belly" in the slackpulling rope. The delays happened when this belly either got caught in the slash or the incoming logs snagged on it.

Problems with the incoming drags getting snagged in the heads of trees stockpiled in the chute area accounted for the "landing the logs" delays in the tree length extraction.

Fewer unhooking delays were recorded in the prestropping study with none occurring in the tree length extraction.

Two long "wait for loader" delays were recorded in the log length prestropping, one of 28 minutes duration and the other taking 42 minutes. By contrast an 11.5 minute delay occurred in the tree length operation. The log length delays were caused by the loader having to wait for the skiddies to re-process logs in the chute, while the tree length delays were associated with the loader pulling trees away from the chute to a processing area.

A splice between the tag line and the mainrope was the cause of an 11 minute wire rope delay in the tree length operation whereas no delays were recorded in the log length operation.

The increase in cycle times as a result of delays, lowered the machine production as shown in table 8.

Mechanical availability of the hauler was 98% in the prestropping study.

Table 8 - Hauler production for log and tree length extraction when prestropping

Element.	Cycle times, min.	
	Log length.	Tree length.
Delay free.	4.70	5.73
Operational delays.	1.27	1.16
TOTAL.	5.97	6.89
Cycle volumes.	2.30 m^3	2.89 m^3
Production (per AMH).	23.1 m^3	25.2 m^3

(iii) <u>Long Term Data Collection</u>

Throughout the log length extraction, (17 days) and through part of the tree length logging, (4 days) the Washington 88 operator was recording production and delay data on a daily basis. Forms were used to record pieces per drag, cycles per day and any delay exceeding 10 minutes. The data is summarised in Appendix 7.

Analysis of this information shows that in the log length operation the hauler had an availability of 92% with a utilization of 70%. By applying the .5 m^3 piece size used in the study to the number of pieces pulled per day, the average production during log length extraction was 126 m^3/day. Load-out figures from the weighbridge confirm this figure with an average 129 m^3/day.

By dividing the PMH into the volume produced during the long term data collection, it can be seen that the hauler produced only 21 m^3 per PMH compared to 26 and 29 m^3 from the study results. This difference can be attributed to delays of less than 10 min not being recorded in the long term data and a possible productivity increase due to the presence of study personnel.

The "waiting for the loader" delay accounted for 15.5 minutes per day throughout the 17 days of log length operation.

Unfortunately the data collection was not kept up in the tree length operation and consequently only 4 days of it could be used. Given the small size of the sample, results can only be considered indicative.

Hauler availability in the tree length operation was 96% and utilization 76%, but the utilization figure would be expected to drop over a longer term. By applying the average piece size recorded in the study, to the number of pieces pulled per day, daily production was calculated to be 153 m^3. Weighbridge figures from 4 August to 30 September 1987 indicate a daily production level of 166 m^3. A certain amount of re-structuring of the crew and refining of the operation occurred during September and that could account for the higher weighbridge figure.

Conclusions drawn from the tree length data should be viewed with some caution for the reasons stated previously.

2. LANDING STUDIES.

(i) Knuckleboom Loader

A total of 2090 observations were taken of the knuckleboom loader working in the log length operation. Fig. 4 shows the breakdown of work elements observed. The "other" element includes discussions with the supervisor and crew boss, repositioning the machine, i.e. from one side of the ropes to the other, and machine maintenance.

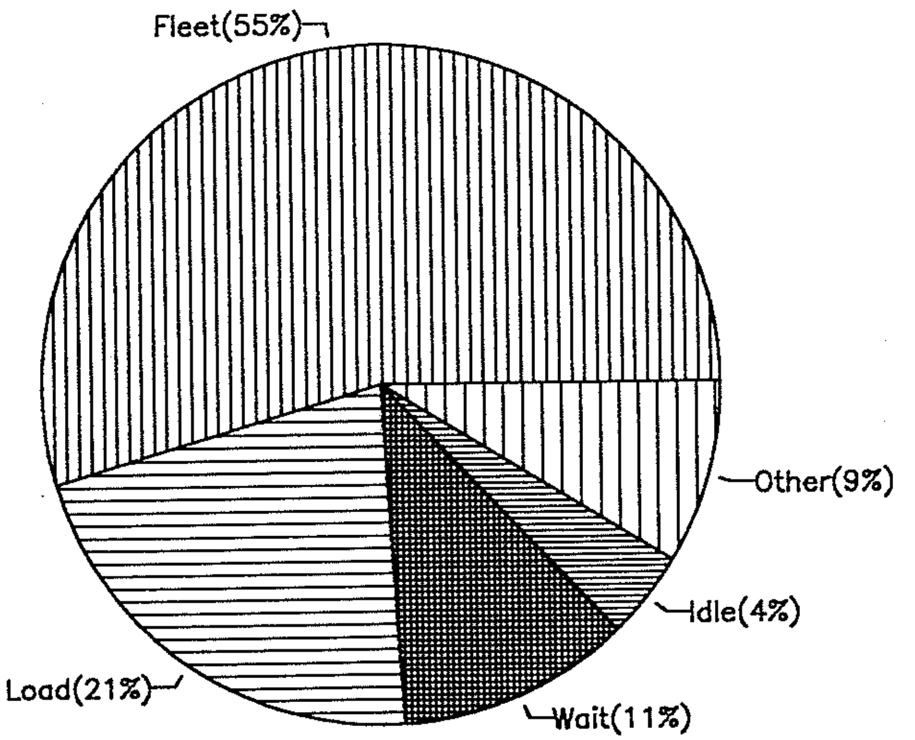

Figure 4 - Time distribution of the knuckleboom loader in log length logging

The operator had limited experience in using a knuckleboom loader and spent longer on some elements of the job than would be expected with a more experienced operator.

Fleeting occupied a major portion of the observed time at 55%. The operator found the grapple clumsy to use when handling small diameter logs or when trying to pick logs out of a pile. Inefficiencies in the method of sorting under the hauler tower i.e. only handling one piece at a time and not sorting before fleeting, meant that the hauler had to stop pulling on occasions while the loader cleared the logs from the chute area.

Truck loading did not pose any problems for the operator although the scheduling of the trucks was not consistent and bottlenecks occurred when stockpiles built up too high or an influx of trucks snowed him under. This resulted in an accumulation of logs in the chute area which the skiddies could not do anything with until the loader had finished loading and was able to lower the pile to a safe working level. The operator did very little loading directly out of the chute.

A high 11% of the loader's time was lost through interference, i.e. waiting for the skiddies to finish re-measuring and cutting the logs under the tower. This re-measuring and cutting would not have been necessary if the problems with the bush processing had been solved.

Only 4% of the loader's time was spent idle. With improved bush processing and a more experienced operator, there would be spare capacity for it to handle an increase in production.

(ii) Rubber Tyred Front End Loader

The rubber tyred front end loader was observed at one minute intervals on 724 occasions while working in the tree length operation. A summary of the work elements are shown in fig 5. The "other" element included machine maintenance and talking to supervisor and crew boss.

The same operator that worked the knuckleboom loader operated the rubber

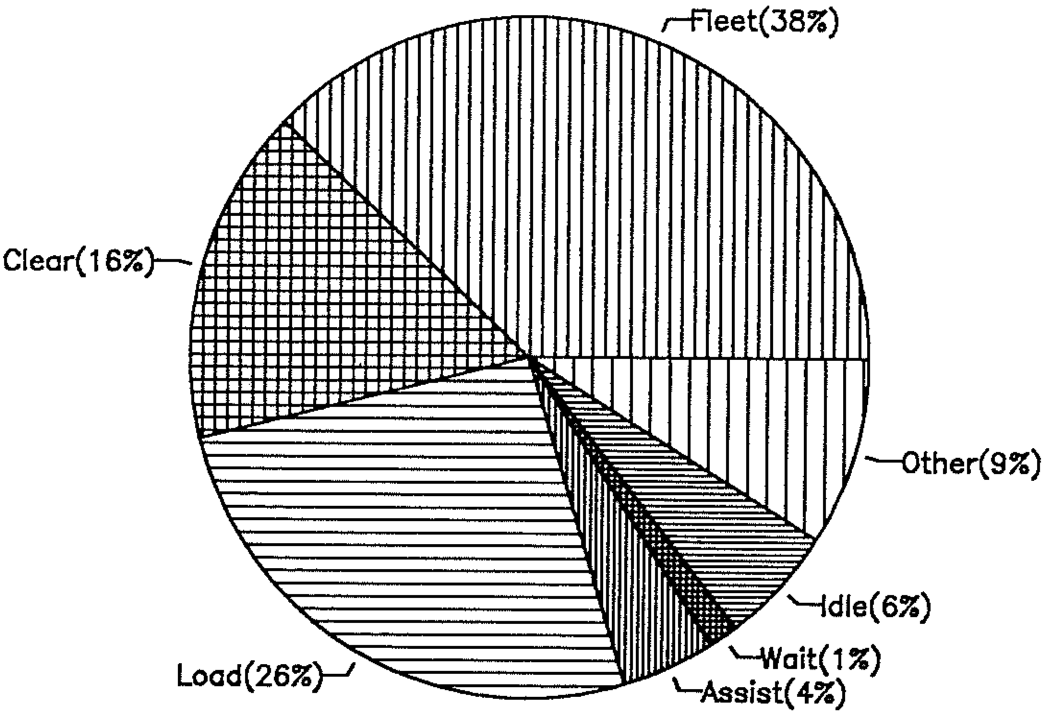

Figure 5 - Time distribution of the rubber-tyred front-end loader in tree length logging

tyred front end loader. He was more experienced with this type of machine.

The condition of the landing deteriorated during the period of study and later on, required total reformation to enable logging to continue. The cost of this and its ramifications are discussed in the summary.

Fleeting occupied only 38% percent of the rubber tyred loader's time compared to 55% with the knuckleboom loader. This could be interpreted as an indication of the skill of the operator on each machine.

Combine that 38% however with the 16% of productive time required for the loader to clear the trees from under the tower, and the ratio of time spent clearing the tower and fleeting logs becomes much the same.

The higher 26% of time spent loading trucks was an indication of the overall increase in production with the tree length extraction. Some loading was done directly from the processing area but most of it was done from the stacks.

A significantly lower proportion of time was spent waiting for work in the tree length operation but there was a slightly higher idle time (6% compared to 4%). Four percent of the productive time was also taken up with assisting the skiddies when their saws were stuck. This element did not appear in the log length operation.

(iii) Skidwork.

In both log length and tree length operations, two skiddies were used. Skiddy 1 was the crew boss and skiddy 2 an employee. A total of 2,081 observations of skiddy 1 and 1,330 observations of skiddy 2 were recorded during the log length study, and 724 observations were made of both skiddies in the tree length operation. The amount of time spent on each aspect of skidwork is shown in table 9.

Table 9 - Percentage of time skiddies spent on each element

Element.	Skiddy 1. Log length	Skiddy 1. Tree length	Skiddy 2. Log length	Skiddy 2. Tree length
Measure.	12	13	10	18
Buck.	7	16	4	12
Trim.	13	9	9	6
Unhook.	10	4	3	2
Check stacks.	1	2	22	5
Walk.	10	10	13	16
Interference.	11	3	6	3
Maintenance.	2	12	2	10
Idle.	22	13	27	9
Other.	12	17	4	18
	100%	100%	100%	100%

It can be seen from table 9, that measure and buck took a lower proportion of time in the log length logging than it did in the tree length logging, i.e. 19% vs 29% for skiddy 1 and 14% vs 30% for skiddy 2. Obviously the measure and buck element would have reduced in the log length operation as the fellers became more skilled at processing in the bush.

Trimming and unhooking by contrast were higher in the log length, by 10% with skiddy 1, and 4% with skiddy 2. More branches were being knocked off the logs during lateral in and inhaul in the tree length operation. The trimming in the log length operation involved cutting branches that had been missed and retrimming stubs flush with the stem.

Checking stacks appeared to be an unnecessary task which occupied a minimal amount of skiddy 1's time, but a considerable proportion of skiddy 2's time, particularly in the log length extraction (22%).

There was a higher interference factor with skiddy 1 in the log length extraction and this is most likely due to the greater proportion of unhooking that he was doing. Saw maintenance is another area where there was a significant difference between the two operations. i.e. 2% vs 12% for skiddy 1 and 2% vs 10% for skiddy 2. This is a direct result of the increase in chainsaw work in the tree length operation.

While the amount of idle time could be interpreted as a reflection of the volume of wood being produced, there is a significantly higher proportion of idle time for both skiddies in the log length logging ie. 22% vs 13% for skiddy 1 and 27% vs 9% for skiddy 2.

Skiddy 2 appeared to be under utilized in the log length operation with only 47% of his time being spent on actual skidwork functions, ie. measure, buck, trim, unhook.

SUMMARY.

Hauler production per PMH when using attached strops was as high in the log length logging as it was in the tree length logging. Production delays associated with landing activities however, reduced the log length productivity to 2.6 m^3 per AMH below the tree length operation.

Similar trends were apparent in the prestropping where an initial difference of .9 m^3 per PMH for log vs tree length extraction, was increased to 2.1 m^3 in favour of the tree length operation.

Prestropping on a PMH basis was 11% more productive than using attached strops in log length logging and 15% more productive in the tree length logging.

Long term data collected by the hauler operator substantiated the conclusions drawn from the study data.

Analysis of the landing activities showed that the knuckleboom loader had the potential to keep up if it did not have to wait for the skiddies to re-process the logs in the log length operation. A more experienced loader operator with improved landing layout, the ability to sort and load from the chute, and a better grapple on the machine, would have further enhanced the loader's ability to keep up. Control over truck arrival times would have also helped the operator balance his work between servicing the hauler and loading trucks.

Apart from adding another machine to secondary pull from the hauler to the landing, there appeared to be fewer opportunities to improve the efficiency of the rubber tyred front end loader in the tree length operation. The operator could have done more sorting before stacking as well as loading directly from the processing area to improve productivity but truck scheduling was again a problem in the tree length operation.

After the study period in the tree length operation, the condition of the landing deteriorated to a state where the loader could not operate. Over 24 hours of bulldozer work at $150/hr, plus other associated costs of $ 2,000 (a total of $5,600) were necessary to allow the operation to continue. This cost would not have been incurred with the knuckleboom loader.

If the log length processing in the bush had been to an acceptable standard, there is little doubt that one skiddy could have handled the skidwork. With an average of 36% between the two skiddies spent either idle or doing unnecessary tasks both men were under utilized. Improving the quality of the in-bush processing would have also reduced the amount of measuring, and bucking necessary at the landing.

There was a definite increase in skiddy saw maintenance in the tree length operation and much less idle time for both men.

Overall the log length logging was 8 to 11% less productive than tree length logging. If the problems with out of spec logs could have been eliminated, then production for the two different types of operation would have been similar.

RECOMMENDATIONS.

From the results of this study a number of recommendations can be made to guide future trials of this nature.

1) Further trials of log processing at the stump on steep slopes need to be done. These would have to consider faller production, his workload, and the safety of his task.

2) A risk analysis of both conventional and cutting to length operations is recommended.

3) Any plans to research log making at the stump should seek the approval of the Department of Labour before starting up.

4) Fallers need to be given a reasonable amount of time to adapt to the new technique before being put under production pressures.

5) Allowance has to be made to have at least one extra man at the falling face.

6) The average piece size hauled should be close to 1.0 m^3 to fully utilize the capacity of haulers in the Washington 88's class.

7) Log length logs need to be cut to approximately the same length to minimise problems with landing them at the landing. This would entail marking of sorts or multiples of sorts and cutting to a length that falls within a specified range.

8) The extraction system should be kept consistent to avoid complicating the analysis, e.g. Use two breaker-outs all the time and opt for either prestropping or attached strops, not a combination of the two.

9) Further work is needed on the use of knuckleboom loaders on hauler landings, and close scrutiny of landing layout and work methods will be necessary.

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APPENDICES.

Appendix 1. Specifications of the Washington 88 hauler and the Young YCC13 carriage.

Appendix 2. LOGGERPC analysis of hauler payloads over ground profiles in the log length study.

Appendix 3. LOGGERPC analysis of hauler payloads over ground profiles in the tree length study.

Appendix 4. Specifications of the Linkbelt 4300 loader.

Appendix 5. Specifications of the Fiat Allis loader.

Appendix 6. Regression Equations for Outhaul and Inhaul times, and Cycle Volume Calculations.

Appendix 7. Summaries of daily production and delay data collected by the hauler operator.

Specifications of the Washington 88 Hauler and the Young YCC Carriage. 13

MODEL 88 MOBILE SWING YARDER

POWER PLANT
The power plant is a Detroit Diesel Model 8V71, 304 HP at 2100 RPM. It is equipped with a Twin Disc TD-44-1131 transmission, with four speeds forward and four speeds reverse, and a Twin Disc 8FLW 1452 single stage torque converter. The hydraulic pump for the guylines and swing is located on the converter PTO.

INTERMEDIATE SHAFT
The intermediate drive shaft assembly, which includes the strawdrum unit, is driven by a chain drive from the power plant. The main drum pinion, clutch, two haulback drum pinions, jaw clutch for selecting inhaul/outhaul gear ratio, and down drive sprocket are also mounted on the intermediate shaft.

DRUMS
The rear main, haulback, and strawline drums are equipped with air actuated clutches and air/hydraulic brakes with spring set parking brakes. The front main is equipped with an air/hydraulic actuated clutch and a spring set parking brake. The front main can be rotated in the opposite direction from the rear main to pull slack for a dropline carriage or to operate a grapple. The haulback drum is interlocked to the main drum by means of clutches and two gears, one for inhaul and one for outhaul.

THE HAULBACK DRUM assembly consists of the drum, bearings, service brakes, parking brakes, two bull gears, and a water-cooled clutch. The larger bull gear is engaged for the inhaul cycle and the smaller gear for outhaul. The interlock system is designed to minimize horsepower loss at high line tensions. The caliper type service brakes are mounted on the bearing housings for positive alignment and maximum stability.

REAR MAIN DRUM assembly consists of the drum, bearings, service brakes, parking brake, bull gear, reversing clutch, and drive sprockets. The bull gear drives the front main drum; the sprocket is engaged to drive the front main in the opposite direction for operating a drop line carriage or a grapple. The caliper type service brakes are mounted on the bearing housings for positive alignment and maximum stability.

FRONT MAIN DRUM assembly consists of drum, bearings, parking brake, bull gear with clutch, and a driven sprocket. The rear main drum bull gear normally drives the front drum; the sprocket is driven to operate the drop line carriage or grapple.

STRAWDRUM is mounted on the intermediate drive shaft assembly on ball bearings. It is equipped with a clutch and a caliper type disc brake.

Two **GUY DRUMS** are standard, each powered in either dir tion by independent hydraulic motor and chain drive. Guy drums are held in place by spring set, air released dogs. The guy lines are singlepart, walking type for ease of yarding along a road. The guy lines are used to raise and lower the boom and A frame.

SWING ASSEMBLY
The swing unit assembly is powered by a vane type hydraulic motor, with gears and pinions housed in a fabricated steel case.

CRAWLER CARRIER
The carrier incorporates M32 drive components, suspension, and trucks mounted in a fabricated steel frame. Drive is from the intermediate shaft through two bevel gear boxes to the carrier transmission. Track pads can be supplied with grousers or rubber pads. Travel speed is approximately six MPH; gradability up to 25%.

BOOM AND "A" FRAME
The boom and "A" frame are raised and lowered by the guylines and are controlled from the operator's cab. They f over the end of the machinery platform and rest on the carrier-mounted boom support for one piece moves. The "A" frame, which includes the guyline drums and lead sheaves, is designed to minimize guyline loading. The boom incorporates three large diameter, wide throat sheaves and two sets of side rolls.

OPERATOR'S CAB AND CONTROLS
The operator's cab is located for maximum view of operating drums and landing. It is completely guarded and equipped with heater, defroster, windshield wiper, horn, and side opening windows. Clutch, brake, swing, and transmission controls are positioned to give the operator control of the rigging at all times. A single lever controls the haulback tension.

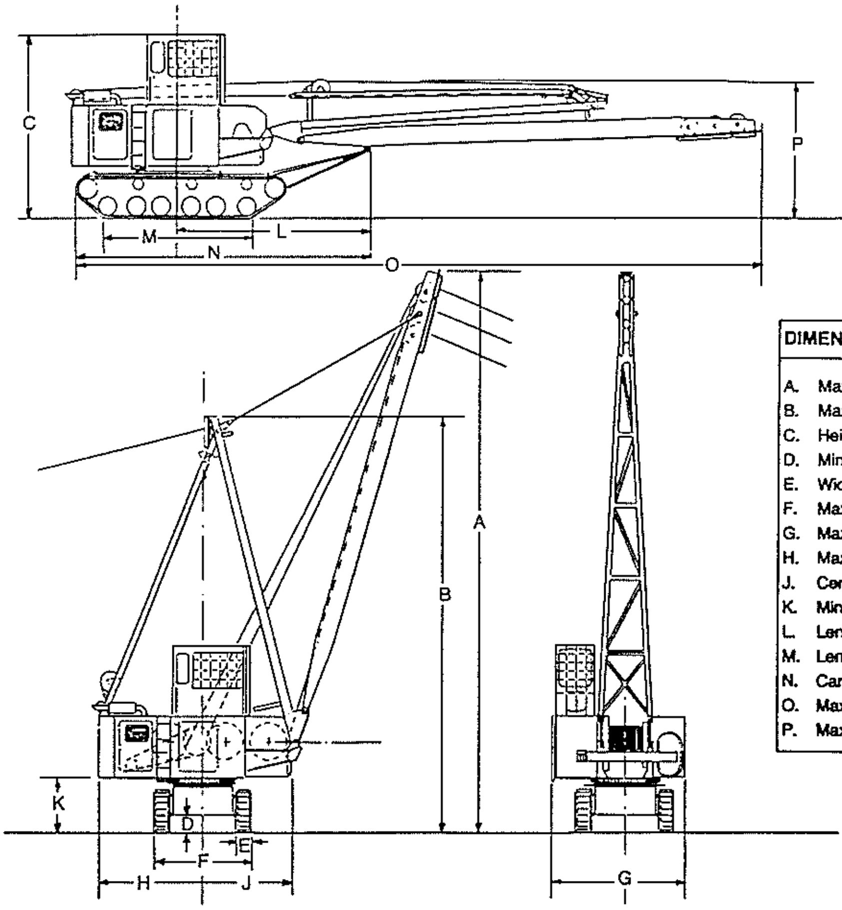
LINE SPEEDS AND PULLS (85% EFFICIENCY)

DRUMS	REAR MAIN	FRONT MAIN	HAULBACK	STRAW	GUYLINE
Maximum Line Pull (lb)					
Full	45,000	23,300	17,000	3,600	6,380
Empty	51,000	26,100	20,000	13,000	9,850
Maximum Line Speed (FPM)					
Full	2,650	2,650	3,160	5,950 (3rd gr)	140
Empty	2,360	2,360	2,700	1,650	90

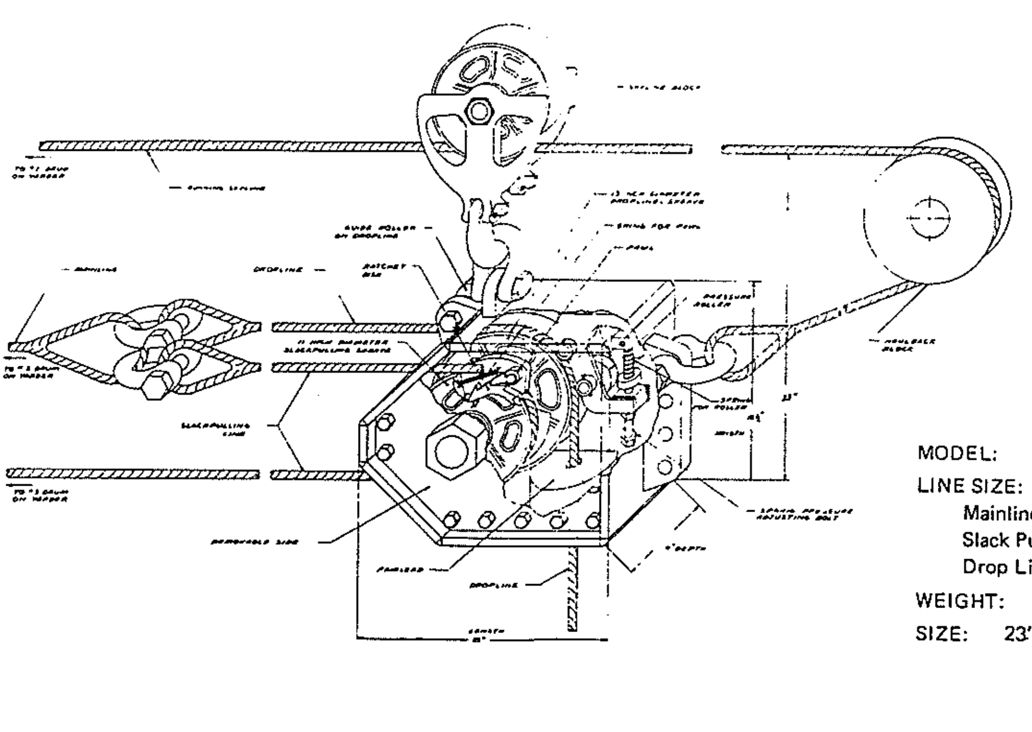
RUNNING SKYLINE CABLE

DRUMS	REAR MAIN	FRONT MAIN	HAULBACK	STRAW	GUYLINE
Line Capacity (Ft-Dia)	1750'-¾"	1750'-¾"	3500'-¾"	4450'-⅜"	(2) 100'

COMPONENT WEIGHTS	
Boom	3460 LBS.
A frame	4220 LBS.
Machinery Platform	38,500 LBS.
Crawler	32,000 LBS.
Fuel and Lines	10,090 LBS.
TOTAL	88,270 LBS.



DIMENSIONS		
A.	Maximum height over top of Boom	48'-0"
B.	Maximum height over top of "A" frame	35'-7"
C.	Height to top of cab	16'-2½"
D.	Minimum ground clearance	1'-6"
E.	Width of crawler tread	1'-4½"
F.	Maximum track width	8'-3½"
G.	Maximum machine width	11'-5"
H.	Maximum swing radius (tail swing)	9'-6"
J.	Center of rotation to front of machinery deck	8'-0"
K.	Minimum swing clearance	4'-6½"
L.	Length from center of rotation to end of boom support	16'-5½'
M.	Length of bearing area	12'-3"
N.	Carrier length including boom support	25'-3½"
O.	Maximum length with boom lowered	58'-7"
P.	Maximum height overall (with cab removed)	12'-0"



SPECIFICATIONS

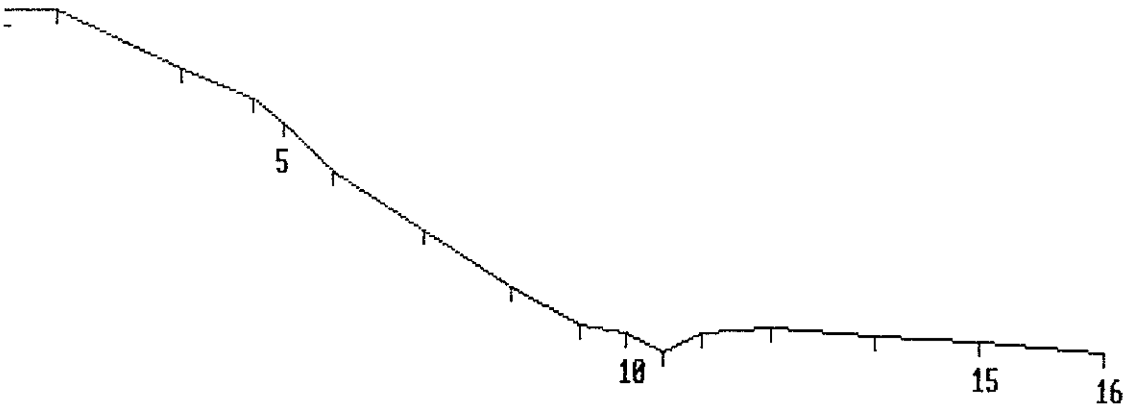
MODEL:	YCC-12	YCC-13
LINE SIZE:		
Mainline	5/8	3/4
Slack Pulling Line	5/8	3/4
Drop Line	5/8	3/4
WEIGHT:	500	525

SIZE: 23" Long – 9" Deep – 18½" High

APPENDIX 2.

LOGGERPC Analysis of Hauler Payloads over Ground Profiles in Log Length Study.

GROUND PROFILE OF 1ST SKYLINE ROAD.



PAYLOAD ANALYSIS FOR LOG LENGTH EXTRACTION.
(Distances in metres, weights in kilograms & tonnes).

----------------------(RUNNING SKYLINE LOAD ANALYSIS)----------------------

PROFILE: a:LOGWA .PRO YARDER: a:WASH88 .YRD

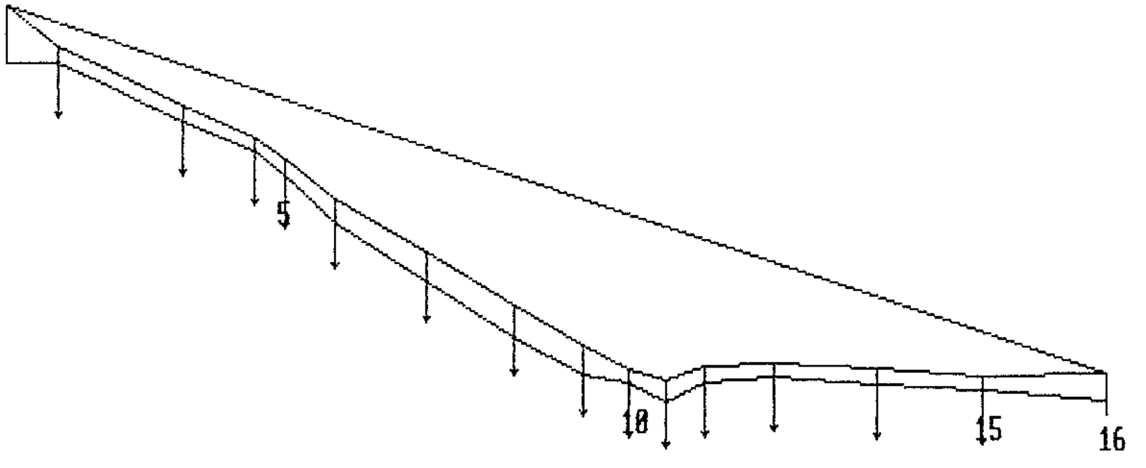
HEADSPAR HT = 15 TAILSPAR HT = 7
LANDING CUT(-)/FILL(+) = 0 YARDING TOWARDS YARDER
CARRIAGE CLEARANCE = 4 LOG DRAG COMPUTED
LOG LENGTH = 16 CHOKER LENGTH = 2

RIGGING LENGTH REQUIREMENTS	REQUIRED	AVAILABLE
MAINLINE	353	533
HAULBACK	794	1357

TERRAIN POINT	PAYLOAD	LIMITING LINE	REQUIRED LINE	CARRIAGE CLEARANCE	LOG CLEARANCE	TYPE SUSPENSION
2	5638	MAINLINE	MAINLINE	4.0	2.6	PARTIAL
3	3459	MAINLINE	MAINLINE	4.0	2.6	PARTIAL
4	2584	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
5	2885	MAINLINE	MAINLINE	4.0	2.8	PARTIAL
6	3822	MAINLINE	MAINLINE	6.3	4.9	PARTIAL
7	4206	MAINLINE	MAINLINE	7.4	5.9	PARTIAL
8	4848	MAINLINE	MAINLINE	8.4	6.8	PARTIAL
9	6334	MAINLINE	MAINLINE	7.4	5.8	PARTIAL
10	5974	MAINLINE	MAINLINE	4.0	2.6	PARTIAL
11	10256	MAINLINE	MAINLINE	5.8	3.7	PARTIAL
12	7640	MAINLINE	MAINLINE	4.0	2.2	PARTIAL
13	6260	MAINLINE	MAINLINE	4.0	2.3	PARTIAL
14	5685	MAINLINE	MAINLINE	4.0	2.3	PARTIAL
15	5617	MAINLINE	MAINLINE	4.0	2.3	PARTIAL

---------------------------(* = Critical pt)---------------------------

SAME PROFILE SHOWING LOADPATH.



PAYLOAD ANALYSIS FOR TREE LENGTH EXTRACTION.

---------------------(RUNNING SKYLINE LOAD ANALYSIS)---------------------

PROFILE: a:LOGWA .PRO   YARDER: a:WASH88 .YRD

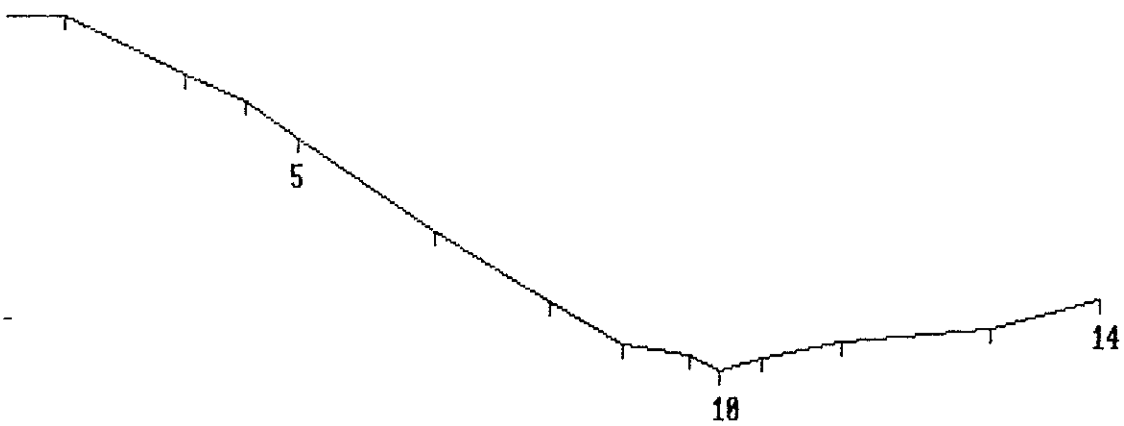
HEADSPAR HT = 15   TAILSPAR HT = 7
LANDING CUT(-)/FILL(+) = 0   YARDING TOWARDS YARDER
CARRIAGE CLEARANCE = 4   LOG DRAG COMPUTED
LOG LENGTH = 32   CHOKER LENGTH = 2

RIGGING LENGTH REQUIREMENTS	REQUIRED	AVAILABLE
MAINLINE	353	533
HAULBACK	794	1357

TERRAIN POINT	PAYLOAD	LIMITING LINE	REQUIRED LINE	CARRIAGE CLEARANCE	LOG CLEARANCE	TYPE SUSPENSION
2	5815	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
3	3591	MAINLINE	MAINLINE	4.0	2.6	PARTIAL
4	2651	MAINLINE	MAINLINE	4.0	2.8	PARTIAL
5	2935	MAINLINE	MAINLINE	4.0	2.8	PARTIAL
6	3980	MAINLINE	MAINLINE	6.3	5.0	PARTIAL
7	4377	MAINLINE	MAINLINE	7.4	6.0	PARTIAL
8	5058	MAINLINE	MAINLINE	8.4	6.9	PARTIAL
9	6658	MAINLINE	MAINLINE	7.4	5.8	PARTIAL
10	6052	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
11	10427	MAINLINE	MAINLINE	5.8	3.7	PARTIAL
12	7826	MAINLINE	MAINLINE	4.0	2.2	PARTIAL
13	6427	MAINLINE	MAINLINE	4.0	2.3	PARTIAL
14	5839	MAINLINE	MAINLINE	4.0	2.3	PARTIAL
15	5761	MAINLINE	MAINLINE	4.0	2.3	PARTIAL

----------------------------(* = Critical pt)----------------------------

GROUND PROFILE OF 2ND SKYLINE ROAD.



PAYLOAD ANALYSIS FOR LOG LENGTH EXTRACTION.
(Distances in metres, weights in kilograms & tonnes).

----------------------< RUNNING SKYLINE LOAD ANALYSIS >---------------------

PROFILE: a:LOGWA2 .PRO YARDER: a:WASH88 .YRD

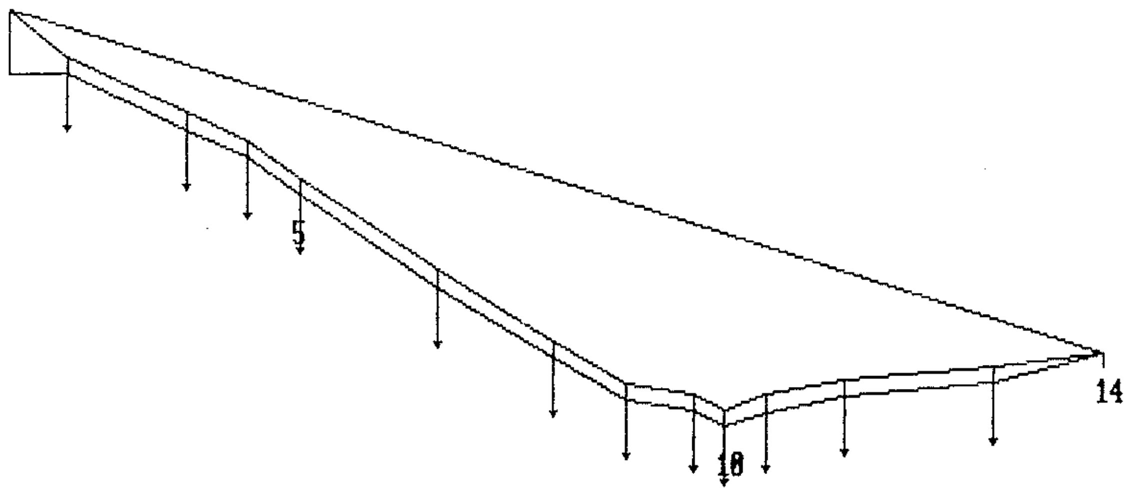
HEADSPAR HT = 15 TAILSPAR HT = 0
LANDING CUT(-)/FILL(+) = 0 YARDING TOWARDS YARDER
CARRIAGE CLEARANCE = 4 LOG DRAG COMPUTED
LOG LENGTH = 16 CHOKER LENGTH = 2

RIGGING LENGTH REQUIREMENTS	REQUIRED	AVAILABLE
MAINLINE	323	533
HAULBACK	678	1357

TERRAIN POINT	PAYLOAD	LIMITING LINE	REQUIRED LINE	CARRIAGE CLEARANCE	LOG CLEARANCE	TYPE SUSPENSION
2	5823	MAINLINE	MAINLINE	4.0	2.6	PARTIAL
3	3968	MAINLINE	MAINLINE	4.0	2.6	PARTIAL
4	3439	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
5	3998	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
6	5137	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
7	5949	MAINLINE	MAINLINE	4.0	2.6	PARTIAL
8	8183	MAINLINE	MAINLINE	4.0	2.4	PARTIAL
9	6762	MAINLINE	MAINLINE	4.0	2.6	PARTIAL
10	12151	MAINLINE	MAINLINE	4.0	1.9	PARTIAL
11	10179	MAINLINE	MAINLINE	4.0	2.0	PARTIAL
12	8503	MAINLINE	MAINLINE	4.0	2.1	PARTIAL
13	8698	MAINLINE	MAINLINE	4.0	2.0	PARTIAL

----------------------------< * = Critical pt >----------------------------

SAME PROFILE SHOWING LOADPATH.



PAYLOAD ANALYSIS FOR TREE LENGTH EXTRACTION.

----------------------(RUNNING SKYLINE LOAD ANALYSIS)----------------------

PROFILE: a:LOGWA2 .PRO   YARDER: a:WASH88 .YRD

HEADSPAR HT = 15   TAILSPAR HT = 0
LANDING CUT(-)/FILL(+) = 0   YARDING TOWARDS YARDER
CARRIAGE CLEARANCE = 4   LOG DRAG COMPUTED
LOG LENGTH = 32   CHOKER LENGTH = 2

RIGGING LENGTH REQUIREMENTS	REQUIRED	AVAILABLE
MAINLINE	323	533
HAULBACK	678	1357

TERRAIN POINT	PAYLOAD	LIMITING LINE	REQUIRED LINE	CARRIAGE CLEARANCE	LOG CLEARANCE	TYPE SUSPENSION
2	5991	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
3	4100	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
4	3525	MAINLINE	MAINLINE	4.0	2.8	PARTIAL
5	4088	MAINLINE	MAINLINE	4.0	2.8	PARTIAL
6	5223	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
7	6013	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
8	8332	MAINLINE	MAINLINE	4.0	2.4	PARTIAL
9	6807	MAINLINE	MAINLINE	4.0	2.7	PARTIAL
10	12312	MAINLINE	MAINLINE	4.0	1.9	PARTIAL
11	10360	MAINLINE	MAINLINE	4.0	2.0	PARTIAL
12	8676	MAINLINE	MAINLINE	4.0	2.2	PARTIAL
13	8845	MAINLINE	MAINLINE	4.0	2.0	PARTIAL

-----------------------------(* = Critical pt)-----------------------------

Specifications of the Linkbelt 4300 Loader.

SUMITOMO Link-Belt

LS-4300EJ

Hydraulic Excavator

Bucket Capacity : 1.0 ~ 1.6 m^3
Engine Output : 192 PS @ 1,800 rpm
Gross Weight : 30,100 kg ~ 30,700 kg

Crawler Mounting —

Lower Frame — All-welded, precision machined inner turntable bearing race, with integral internal swing (ring) gear, bolted to frame.

Tracks — Tractor-type rails; 47 shoes per crawler side frame. Standard — 600 mm wide, three bar grouser shoes. Optional — 800 mm wide, three bar grouser shoes.

Track Rollers — 7 bottom rollers per side frame; heat treated, mounted on phosphor bronze bushings, sealed for lifetime lubrication.

Track Carrier Rollers — 2 rollers on each side frame; heat treated, mounted on phosphor bronze bushing, sealed for lifetime lubrication.

Track Drive Mechanism — Hydrostatic drive, hydraulic motor output shaft coupled to gear reduction unit and track drive sprocket — one complete unit mounted at inside of drive end of each side frame.

Travel Motors — Two directional, fixed displacement, compact type axial piston hydraulic motors. Each motor equipped with port relief valve to prevent overpressurizing motors on downhill grade. Counter rotation of tracks provided.

Track Drive Sprockets — Heat treated; bolted to outside case, coupled to input shaft thru planetary gears of gear reduction unit, sealed for lifetime lubrication.

Track Idler Wheels — One per side frame; mounted on phosphor-bronze bushings, sealed for lifetime lubrication. Hydraulic cushioned shock absorber assembly at idler end of each side frame.

Track Adjustment — Idler wheel axles adjustment and track tension is maintained by hydraulic compensating cylinder operated by S.O.M. system pressure. One per side frame.

Travel Speed — Zero to 3.1 km/hr.

Steer/Digging Brakes — Wet-disc type brakes; integral with track drive gear reduction units. Brakes spring applied, hydraulically released.

Gradeability — 70% (35 degrees)

Upper Revolving Superstructure —

Frame — All-welded, precision machined.

Turntable Bearing — Ball bearing type; outer race bolted to frame.

Engine — **Nissan PD6T04** diesel; water-cooled 4-cycle, 6-cylinder, 125 mm bore, 140 mm stroke, 10.308 cc displacement; max. rated output **192 PS @1,800 rpm.**

Fuel Tank — Capacity 440 liters; equipped with fuel sight level and filler pipe cap.

Counterweight — One-piece design bolted in position; 5,500 kg.

Main Pumps — Double, variable displacement, axial piston pump and double gear pump; direct driven by engine. Double Variable displacement axial piston pump equipped with horsepower summation control (cross-sensing mechanism) with a combined oil flow. (274 liters/min. x 2). Constant horsepower pump delivers oil under pressure to hydraulic system control valves.

Hydraulic Oil Sump Tank — All-welded, 200 liters capacity; pressurized at 0.8 to 1.5 kgf/cm^2 to prevent pump cavitation.

Filtration System — Mounted within oil sump tank. 10 micron filter with disposable element to filter all return oil from control valves. Filter has a 1.0 kgf/cm^2 bypass valve to permit bypassing oil in the event filter should become inoperative. A 150 mesh strainer is mounted in the main pump suction line.

Oil Cooler — Mounted in front of engine radiator. Flow from two control valve circuits is routed through the cooler for maximum cooling of oil. A 0.5 kgf/cm^2 bypass check valve is installed in oil cooler circuit to bypass oil for cold weather operation.

Power System Relief Valves — Each control valve has a system relief valve in its circuit; relief valve set at 280 kgf/cm^2 to divert oil back to sump tank in the event that this pressure is exceeded.

Electrical System — Includes two 12-volt, 150 ampere hour batteries; cab interior lights, and two automotive type headlights at front of machine.

Operator's Cab — Full-vision, cushion rubber mounted, well-ventilated and compartment operator's cab with safety glass in all windows: front slide-up window, rear fixed window, hinged door with sliding tinted window and R.H. side sliding tinted window. Heater, cooler or air condition and ratio are available as optional extra.

Instrument Panel — Located at right hand side of operator's cab. Panel includes engine hour meter, temperature gauge, fuel oil gauge and warning lamps for battery charge, engine oil pressure, engine overheat, radiator water level, air cleaner, engine warming-up, glow lamp, battery water level and remaining fuel.

Control System — Consists primarily of two universal type main levers and two centre levers. Arm and swing circuits controlled by L.H. main lever. Right-hand main lever controls bucket and boom motions; center two levers control travel/steer. High-speed boomhoist is integral with R.H. main control lever. Each spool function on the control valves has port relief valve — each set at 320 kgf/cm^2. Boom lowering port relief set at 250 kgf/cm^2.

Main Power Directional Control Valves — 4-spool and 4-spool valve. In one valve, the first spool controls the travel motor; the second spool controls the high-speed boomhoist; the third spool controls the swing motor, and the fourth spool controls the arm cylinder. In the other valve, the first spool for the boom, the second spool controls the bucket, the third spool controls the travel and the fourth spool controls for other control as space.

Upper Machinery Cab — Hinged doors for machinery access; fitted with wire mesh for ventilation. Air horn warning device.

Swing System — Utilizes a portion of the output of one main pump section and one gear pump, in conjunction with the spool in the control valve, to provide pressure flow to the swing motor.

Swing Motor — Hydraulic motor; protected from over-running by a counter-balance valve in the circuit plus a cross-port relief valve set at 210 kgf/cm^2.

Swing Speed Reducer — Mounted on output shaft of hydraulic motor.

Swing Brake — Braking accomplished through with cross over relief system.

Swing Pinion — Mounted on output shaft of swing speed reducer; meshes with internal swing (ring) gear inside turntable bearing.

Swing Lock — Hand controlled drop pin is inserted in locking tube integral with lower frame.

Swing Speed — Zero to 8.4 rpm.

Attachment —

Boom — All-welded, box type construction; gooseneck design; mounted in boomfoot lugs in hardened steel bushing; 6,500 mm in length. The boom fits centralized greasing device for lublication points of attachment.

Arm — All-welded mounts to boom in hardened steel bushings. Choice of three arm lengths — **2.69m, 3.40m** and **4.06m** long.

Buckets — Bucket mounting lugs and articulating linkage equipped hardened steel bushings.

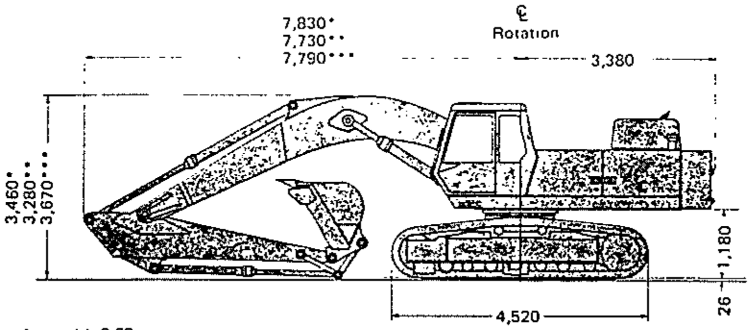
Cylinders — Double-acting hydraulic; hardened steel bushings installed in cylinder tube and rod tang ends.

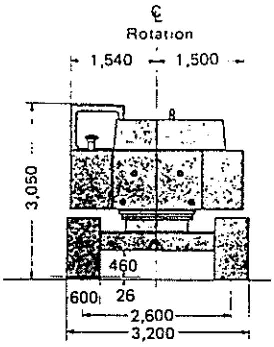
Weight and Ground Pressure —
30,100 kg, w/600 mm 3-bar grouser shoes: 0.64 kgf/cm^2
30,700 kg, w/800 mm 3-bar grouser shoes: 0.49 kgf/cm^2

Digging Force —
16,200 kgf by bucket cylinder at 2.69m arm
14,100 kgf by arm cylinder at 2.69m arm

Traction Force —
22,300 kgf

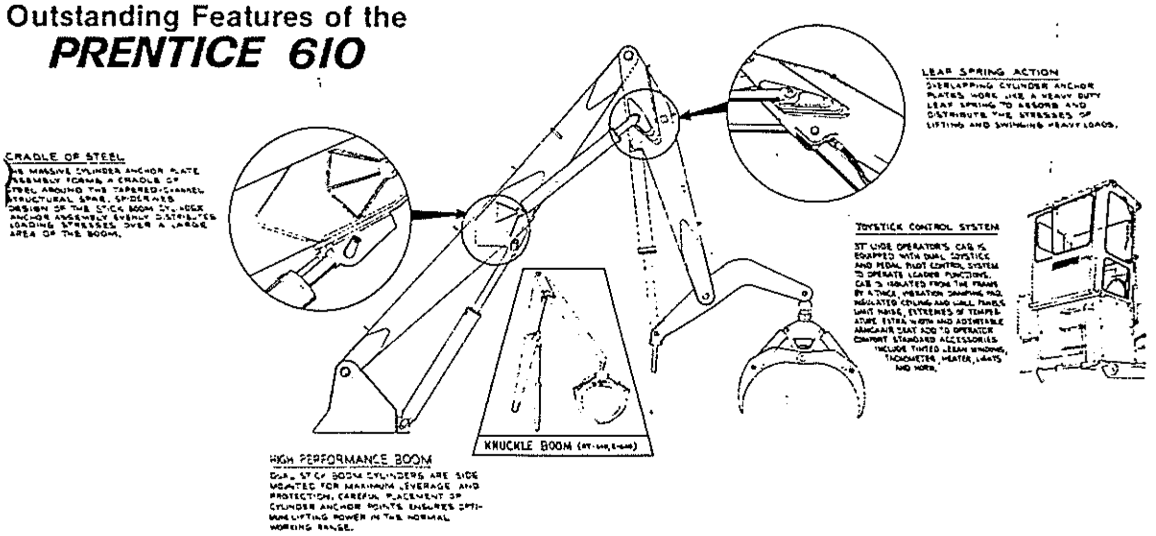
Dimensions for Transporting (in mm)

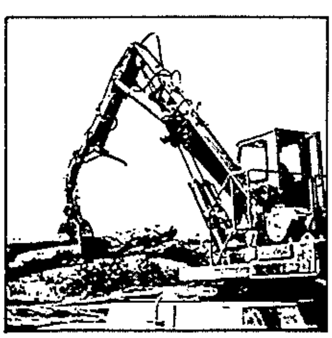


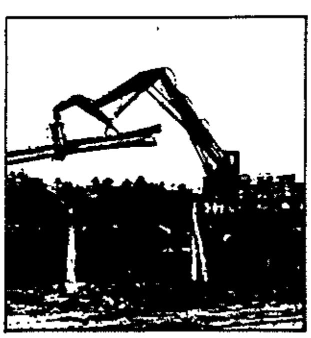


* : with 2.69m arm
** : with 3.40m arm
*** : with 4.06m arm

Outstanding Features of the
PRENTICE 610







MAIN BOOM LIFT CAPACITY

Average foot-pound rating: 483,516

Deduct weight of grapple — System pressure 2350 psi

Radius (ft)	8	10	15	20	25
Capacity (lbs)	60,850	49,020	33,470	24,960	19,820

Radius (ft)	30	32
Capacity (lbs)	16,090	13,380

Available as: 610-T Truck Mount; 610-C Crawler/Carrier Mount; RT610 Self-Propelled; E-610-SM Stationary Mount

Specifications of the Fiat Allis 745 Loader.

745H-B SPECIFICATIONS

ENGINE

Make ... Allis-Chalmers
Model ... 11000 turbo-charged diesel
Maximum horsepower ... 240
Flywheel horsepower* ... 202
Governed rpm ... 2200
Maximum torque
  ft.-lbs. @ rpm ... 575 ft.-lbs. @ 1600 rpm
  kg-m @ rpm ... 79.5 kgm @ 1600 rpm
Bore & stroke ... 4.44" x 5.56" (112 x 141 mm)
Number of cylinders ... 6
Displacement ... 516 cu.in. (8,46 lit)

*Net flywheel horsepower available at the flywheel of the vehicle engine under SAE J816b standard conditions of 85°F (29°C) and 29.38" (746 mm) hg. after deductions have been made for Fan, Alternator, Compressor, Lube Oil Pump, Water Pump, Air Cleaner, and Fuel Pump. This vehicle may be operated up to 8,000 ft. (2438 m) altitude without derating the engine.

TORQUE CONVERTER

Type ... Twin-turbine
Torque multiplication ... 4.62 to 1

TRANSMISSION

Type ... Power shift planetary

Forward speeds	mph	km/hr
1	2.4	3,8
2	5.3	8,5
3	9.2	14,8
4	20.0	32,1
Reverse speeds		
1	3.4	5,4
2	7.3	11,7

SOF-SHIFT transmission permits full power directional shift changes in low ranges for fast cycle time. Shift from 1st to 2nd and 3rd to 4th is automatic.

AXLES

Planetary reduction at wheel end. Axle shafts removable independent of wheel and planetary. Torque proportioning differentials. Axle housing pin-connected to loader frame.
Rear axle oscillation ... 22°
Inches vertical travel ... 16" (406 mm)

BRAKE SYSTEMS

Service—air over hydraulic, dual system.
Emergency—dash mounted lever actuates service brakes.
Parking—mechanically actuated drum brake on drive line.

TIRES

Type ... Tubeless
Loader (L2 traction or L3 rock) ... 23.5 x 25 (16 P.R.)

ELECTRICAL SYSTEM

Voltage ... 24V
Standard alternator ... 30 amp
Battery amp/hour rating ... 180
System protected by circuit breakers.

LOADER HYDRAULIC SYSTEM

Type ... Closed with pressure & vacuum relief
Cylinders ... Double acting
  Lift (2) ... 6.5" x 35.75" (165 x 908 mm)
  Dump (2) ... 6.0" x 39.5" (152 x 1003 mm)
Pump ... Gear type tandem-mounted
  Capacity @ governed rpm ... 95.0 gpm (359,6 lit/min)
Control valve ... Two spool
  Relief valve pressure ... 1825 psi (130 kg/cm²)
Lift time ... 6.5 sec.
Lower time ... 4.5 sec.
Dump time ... 2.6 sec.

STEERING SYSTEM

Type ... Demand
Cylinders ... Two double acting
Bore & stroke ... 3.5" x 20.75" (89 x 527 mm)
Pump ... Gear type
  Capacity @ governed rpm ... 36.0 gpm (136,3 lit/min)
With demand valve interconnection to loader hydraulic system.

FILTRATION SYSTEMS

ENGINE
  Lube oil ... Full flow 25 micron
  Fuel ... Full flow 5 micron
  Air cleaner ... Dry type w/safety element
  Coolant ... Filter conditioner
TRANSMISSION-TORQUE CONVERTER
  Lube oil ... Full flow 25 micron
HYDRAULIC
  Oil ... Full flow 25 micron
  Full flow magnetic
  Full flow wire mesh
  Pressure-vacuum relief ... 40 micron element

CAPACITIES

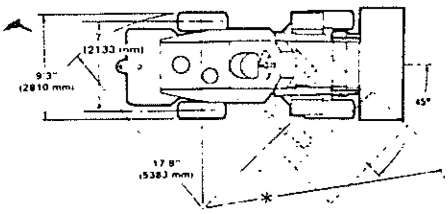
ENGINE
  Lube oil ... 7.5 U.S. gal. (28,4 lit)
  Coolant ... 13.25 U.S. gal. (50,2 lit)
  Fuel tank ... 85.0 U.S. gal. (321,8 lit)
TRANSMISSION ... 9.25 U.S. gal. (35,0 lit)
HYDRAULIC ... 57.0 U.S. gal. (215,8 lit)
AXLES ... 20.0 U.S. gal. (75,7 lit)

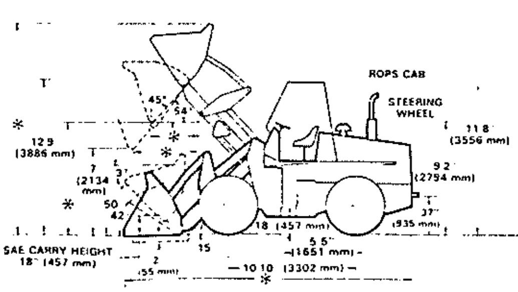
STANDARD EQUIPMENT

● Air cleaner with safety element ● Air filter service indicator ● Air compressor ● Air horn ● Anti-freeze ● Brake moisture ejector ● Bucket level indicator ● Drawbar ● Pusher fan ● Fenders ● Torque proportioning differentials ● Hydraulic oil cooler ● Headlights ● Rear floodlights ● Dash light ● Rear stop and tail lights ● Muffler ● ROPS mounting brackets ● Six-way adjustable bucket seat ● Transmission disconnect ● Gauges: air pressure, low air pressure warning light and buzzer, ammeter, converter oil temperature, engine oil pressure, engine water temperature, fuel level dipstick, hour meter, hydraulic oil level sight gauge, transmission oil pressure ● Water filter.

DIMENSIONS

745H-B





(*) REFER TO PERFORMANCE DATA CHART BELOW

PERFORMANCE DATA

Regression Equations for Outhaul and Inhaul times, and Cycle Volume Calculations

The following regression Equations were used for standardising Outhaul and in-haul times.

Type of Extraction.	Outhaul
Log Length Attached Stops	Y = .2675 + .0010035 (dist)
Tree Length Attached Strops	Y = .23383 + .0012432 (dist)
Log Length Pre-strop	Y = .282 + .0010826 (dist)
Tree Length Pre-strop	Y = .070552 + .0020062 (dist)
	In-haul
Log Length Attached Strops	Y = .30488 + .0027229 (dist)
Tree Length Attached Strops	Y = .93354 + .0020710 (dist)
Log Length Pre-strop	Y = .417 + .0022822 (dist)
Tree Length Pre-strop	Y = .58529 + .0032974 (dist)

Log volumes in the log length operation were calculated by dividing the number of logs in a truckload of a particular product type, into the weight calculated volume of that load across the weighbridge.

Product type	Total Volume	Number of Pieces	Volume/Piece
12 m Export	127.42 m^3	131	.973 m^3
8 m Export	168.31 m^3	282	.597 m^3
P1 Sawlogs	130.85 m^3	168	.779 m^3
S1 Sawlogs	44.25 m^3	58	.763 m^3
S2 Sawlogs	322.02 m^3	1083	.297 m^3
Pulp	91.59 m^3	480	.191 m^3

Hauler cycle volumes were estimated by noting the product type of each log in a drag and multiplying the numbers of each product type by their respective volumes. eg.

A drag consists of :	Volume is :
1 x 12 m Export	.973
1 x P1 Sawlog	.779
2 x S2 Sawlog	.594
Total 4 logs	2.346 m^3

Mean cycle volumes for all log and tree length extraction was as follows :

Extraction type	Cycle Volume	S.D.	N.	Minimum	Maximum
Log length	2.302 m^3	.74	233	.86 m^3	4.79 m^3
Tree Length	2.947 m^3	.99	104	.36 m^3	5.06 m^3

APPENDIX 7.

Summaries of Daily Production and Delay Data Collected by the Hauler Operator.

SUMMARY SHEET

OPERATION : WASHINGTON 88 SYSTEM : LOG LENGTH LOCATION : KAINGAROA

				OPERATIONAL DELAYS								MECHANICAL DELAYS							
DATE (1987)	CYCLES	PIECES	TOTAL TIME	PERSONAL	SET GUYS	RIGGING	ROPE-SHIFTS	SPLICING	WAIT LOADER	OTHER	SUB-TOTAL	START UP	REFUEL	SERVICE	BREAK DOWN	SHUT DOWN	SUB-TOTAL	AVAIL. TIME	PRODUCT TIME
7/7	50	188	540	50	18	14				210	292					11	11	529	237
8/7	70	264	482	47							47	17	7	28	20	12	84	398	351
9/7	58	141	540	60				25		47	132	15			20	16	51	489	357
10/7	63	210	480	47			66	45			158	15					15	465	307
13/7	46	218	540	60				15	40	3	118	25	7		59	15	106	434	316
14/7	35	141	540	60					69	27	156	15			90		105	435	279
15/7	52	169	540	60				30		30	120	15	5			15	35	505	385
16/7	48	241	540	60			37		30		127	15			9	15	39	501	374
17/7	52	189	500	30							30	15					15	485	455
20/7	76	325	540	58	12		24				94	20	8			12	40	500	406
21/7	76	336	540	60				14	56		130	15					15	525	395
22/7	71	316	540	59	20		41		5		125	15	10			10	35	505	380
23/7	59	300	540	60					62	43	165	15				10	25	515	350
27/7	65	315	565	60			35	45	1		141	30					30	535	394
28/7	69	331	500	35							35	25				10	35	465	430
29/7	65	329	540	60							60	30				15	45	495	435
30/7	54	254	540	60			30				90	30					30	510	420
TOTAL	1009	4267	9007	926	50	14	233	174	263	360	2020	312	37	28	198	141	716	8291	6271
MINS/DAY	59.4	251	529.8	54.5	2.9	0.8	13.7	10 2	15.5	21.2	118.8	18.4	2.2	1.6	11.6	8.3	42 1	487.7	368.9
		x.5m³ =	2133.5	or =	125.5m³/day														

LONG TERM DATA COLLECTION - TOTAL PRODUCTION (from Weighbridge figures) = 2,188.03 m^3 = 128.7 m^3/day

PRODUCTION PER PMH = 20.93 m^3 or PRODUCTION PER AMH = 15.83 m^3

AVAILABILITY = 92%

UTILISATION = 70%

SUMMARY SHEET

OPERATION : WASHINGTON 88 SYSTEM : TREE LENGTH LOCATION : KAINGAROA

				OPERATIONAL DELAYS								MECHANICAL DELAYS							
DATE (1987)	CYCLES	PIECES	TOTAL TIME	PERSONAL	SET GUYS	RIGGING	ROPE-SHIFTS	SPLICING	WAIT LOADER	OTHER	SUB-TOTAL	START UP	REFUEL	SERVICE	BREAK DOWN	SHUT DOWN	SUB-TOTAL	AVAIL. TIME	PRODUCT TIME
4/8	50	203	540	60				30			90						-	540	450
5/8	58	252	540	30							30	20	10				30	510	480
6/8	45	153	540	60			105				165	30					30	510	345
3/8	46	226	540	60	18		53		15	30	176	30					30	510	364
5/10	60	195																	
6/10	51	171																	
7/10	51	141								DATA	INCOMPLETE								
8/10	54	128																	
9/10	56	152																	
TOTAL	471	1621	2160	210	18		158	30	15	30	461	80	10				90	2070	1639
MIN/DAY	52.33	180	540	52.5	4.5		39 5	7.5	3.8	7.5	115.3	20	2.5				22.5	517.5	409.8
			x.85 =	1377.9	or =	153.1m³/day													

LONG TERM DATA COLLECTION - TOTAL PRODUCTION (from Weighbridge figures) = 6,797.34 m^3 = 165.79 m^3/day
PRODUCTION PER PMH (based on 3/8/87 to 6/8/87) = 25.95 m^3 or
PRODUCTION PER AMH = 20.55 m^3

AVAILABILITY = 96%

UTILISATION = 76%