MANUAL OF SCALING INSTRUCTIONS

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I. Introduction

This manual summarizes the procedures and instructions for scaling or measuring Crown timber in metric units as approved by the Director of Forestry, Manitoba Agriculture and Resource Development.

The basis for the scaling or measuring instructions in metric units for this manual is the Canadian Standards Association standards entitled *CSA 0302.1-15/0302.2-15 Scaling Roundwood/Measurement of Woodchips, Tree Residues and Byproducts*.

The scaling manual is authorized under The Forest Act and Forest Use and Management Regulation.

II. Principles of Scaling

Scaling is measuring or estimating quantity, expressed as the volume, area, length, mass or number of products obtained from trees after they are felled.

A scaler is a person qualified to scale primary forest products and is usually licensed or appointed by a government agency. No person shall scale Crown timber for the purpose of preparing a monthly timber return or monthly timber report unless he or she holds a valid scaler's licence issued by the Forestry Branch director.

The scaling of Crown forest resources is the measurement of harvested Crown forest resources and the determination of defects that affect their use. There are several methods of scaling which may be approved for use in Manitoba. They are: solid volume of individual logs, stacked volume, mass scaling, sample scaling and piece and linear scaling. Other methods of scaling may be allowed in exceptional circumstances.

Limits of a Scale

Wood, when scaled by the instructions set out in this manual and without modification, is scaled for usable volume only, without regard for grade, product, or market conditions. Furthermore, wood is recognized as difficult material to measure accurately because every tree, log or bolt has a different size and shape. Wood that is transported, re-piled or further processed will often yield a different scale volume.

Scaling is used to determine wood volumes for:

- crown dues
- wage payments
- inventory control
- statistical data
- commercial transactions
- research and development

Scalers must measure Crown forest resources according to the instructions in this manual. They must be able to identify species, recognize defects and make only such deductions as authorized in this manual. Scalers must provide true and accurate information and must not vary from the prescribed methods of measurement.

All sound or merchantable Crown forest resources, regardless of size or species must be measured and recorded. Only deductions defined by this manual will be shown on scale records returned to Agriculture and Resource Development (ARD).

Wood piled for scaling must be sufficiently separated when different dues rates, cutting authorities, scaling procedures and dates are applicable.

The cubic metre (m^3) is the recognized unit of timber measurement in Manitoba. However, a cubic metre of timber does not always yield a consistent volume of manufactured product. This may be due to different machinery, manufacturing processes or skill of operating personnel. Variations are to be expected and the scaler must not alter scaling practices to adjust for them.

III. Training and Licensing Requirements

Courses

Candidates for a scaler's licence must successfully complete a course of study and pass examinations approved by ARD. Courses are held under the direction of the Director of Forestry in various locations in the province.

Types of Licences

Two types of scaling licences are issued by the province of Manitoba. They are the Manitoba Scalers Licence and the Interim Scalers Licence. An application for a scaler's licence must be made in writing to the director on a form approved by or acceptable to the director and must be accompanied by the appropriate fee. A scaler’s licence is subject to any terms and conditions imposed upon it.

1. Manitoba Scalers Licence

A scaler's licence may only be issued for a period of five years to a person who:

- has successfully completed Manitoba’s scaling licence certificate course with an overall mark of **65%** or greater and achieve a minimum of **50%** on both the field and written tests to satisfy the director that he or she is proficient in scaling
- holds a valid scaling licence or permit from another province or territory.

2. Interim Scalers Licence

An Interim scaler's licence may be issued for a period not exceeding one year, generally under the supervision of a licensed scaler and may be limited in product or scope at the discretion of the Director of Forestry. In most cases the individual will be required to successfully complete the Interim Scaling Licence Eligibility Test before being granted an interim licence.

An Interim scaler's licence may be issued to applicants who:

- achieve an overall mark between **50%** and **64%** on the provincial scaling licence certificate course and are recommended for this licence
- are seeking a Manitoba Scaler's licence with acceptable supporting documents and recommendations as to his/her abilities in scaling

Examination

The Director of Forestry determines the standard and method of examination. Scalers will be required to pass field and written tests. The Director of Forestry will determine the fees for the training course and examination fees to be paid by candidates.

Maintenance of a Valid Licence

It is the responsibility of the scaler to renew his/her licence. A scalers licence may be cancelled by the Director of Forestry if a scaler:

- does not attend and/or successfully complete a full or refresher scaling course within a specified time frame as set by ARD
- consistently obtains results which, when compared to check scales, are outside of the allowed limits
- conducts himself/herself in a manner, with regard to scaling, which the Director of Forestry deems unfit

Responsibilities

A scaler engaged to scale Crown Timber must:

- have a current scaling licence
- scale all Crown timber according to the authorized scaling manual
- know the authority under which a timber cutting operation is carried out
- know the conditions of the timber operation, such as tree species, classes and size of timber to be cut and how timber is to be measured and recorded
- report illegal or wasteful practices to the employing agency whenever these practices are found
- understand the particulars of scaling which may be detailed in any agreement between his employer and ARD
- take care of all equipment, forms and stationery
- submit all records and reports accurately and on time

Refusal to Scale

A scaler may refuse to scale wood where:

- the wood is piled in such a configuration that a scale may not be conducted in a satisfactory manner
- in the undertaking of a scale, the scaler, will be placed in an unsafe or hazardous situation
- on request by the scaler, the party requesting the scale is unable to supply acceptable documentation as to the ownership or legality of the wood in question

Where the refusal to scale is unacceptable to the requesting party, the decision of the Director of Forestry, or their appointed representative, as to scaling the wood or not, is final.

IV. Equipment

Approved scaling equipment should meet the specifications as set out in:

- C.S.A. standard entitled *Scaling Roundwood/Measurement of Woodchips, Tree Residues and Byproducts* CSA 0302.1-15/0302.2-15

Equipment used in scaling should be checked for calibration at least once every six months.

There are three official scaling sticks used for measuring Crown forest resources (Figure 1).

1. The **scaling stick marked MC-1** is used for measuring timber in cubic metres. This stick is graduated in even two centimetre classes with the class boundary occurring on the odd centimetre. The MC-1 shows volumes of 2.54 metre timber in **stacked cubic metres** for each diameter class. In addition, this stick shows diameter reductions for defective logs in each diameter class. For example, an 8 cm defect on a 20 cm diameter log reduces the effective diameter of the log by 2cm.

2. The **scaling stick marked MC-2** is used for measuring large diameter timber in cubic metres. It is graduated in even two centimetre classes with the class boundary occurring on the odd centimetre. The MC-2 shows volumes of 2.54 metre timber in **stacked cubic metres** for each diameter class. It also shows diameter reductions for defective logs in each diameter class.

3. The **stacked wood scaling stick** is used for measuring wood in **stacked cubic metres**. This stick is graduated in even two centimetre classes with the class boundary occurring on the odd centimetre. It is 1.5 metres long and extends to a length of 3 metres. The reverse side of the stick is used to measure log lengths in 20 cm classes with the class boundary occurring on the even centimetre (e.g. 1.0 m, 1.2 m). Log lengths are recorded in the odd centimetre class (e.g. 1.1 m, 1.3 m).

Metric tape measures may also be used to determine the length of stacked piles or individual logs lengths. The use of other equipment requires the prior approval of the Director of Forestry.

When marking timber that has been scaled, the colour blue is reserved for Crown purposes. No operator, individual or scaler who is not authorized or employed to measure timber for ARD may use this colour. Other colours are available to use for non Crown purposes.

Red is requested for use in special scaling cases such as check, audit or rescale purposes, or for special studies, but is not restricted to use by ARD.

MC-1 **MC-2** **Stacked Wood Stick**

Figure 1 Scaling sticks

V. Scaling Information

Check Scaling

A check scale is used as a standard for comparing the work of other scalers for the purpose of maintaining a uniform level of performance and providing a control over human error associated with scaling. The check scaler is an appointed scaler who has demonstrated his or her ability, obtained through experience, to consistently scale accurately.

Check scaling:

- ensures that the determination of volume and stumpage values is accurate
- maintains uniform scaling practices throughout the province
- ensures compliance with the scaling manual
- provides opportunities for continuing instruction to scalers on actual operations
- provides opportunities for checking new scalers
- provides opportunities for checking interim licensed scalers

Check scaling must take place at the location where the timber was originally measured, using the same scaling method, with the timber in the same form and manner of aggregation in which the original scale was made.

The allowable maximum relative scaling error is ± 3 per cent of the official check scale.

If a check scale indicates the scaler is outside the allowable margin of error, ARD may request the scaler be removed from scaling duties pending a satisfactory resolution of the situation.

When cubed wood is check scaled, average diameters, lengths and cull and defect volumes will be recorded.

When stacked wood is check scaled, the measurements (height, length and width of stack), volumes of undersize, cull, defect and voids of each stack will be recorded.

Check scale reports must be reviewed and retained by ARD.

Rescale

To settle a dispute between ARD and a company involving the measurement of Crown forest resources, a rescale may be required. The measurement of the disputed Crown forest resources must:

- be conducted by ARD's licensed scalers
- take place at the location where the wood was originally measured
- be measured using the same scaling method as the original scale
- be in the form in which it was originally scaled

Adjustments to volumes, if necessary, will be made on the disputed Crown forest resources. The cost of measuring previously scaled volumes to resolve a dispute may be assessed against the company if the volume of the re-measurement is within ± 3% of the volume initially determined by ARD.

The Director of Forestry is the sole arbiter in disputes concerning Crown forest resources.

ARD will not enter into, nor arbitrate scaling disputes:

- between a company and a union
- between companies
- between companies and contractors
- in any other situation where scaling is not done for ARD purposes

Company Scalers Measuring For Manitoba Agriculture and Resource Development Purposes

The Minister of Agriculture and Resource Development may authorize the measurement of Crown forest resources, for ARD purposes, by approved scalers employed by companies. They will scale and make returns in accordance with the scaling manual.

All Crown forest resources measured by company scalers are subject to ARD check scales. At the request of an authorized ARD official, all scaling records (ex: tally sheets, check scales, summaries, invoices, statements of accounts) of Crown forest resources measured are to be made available for inspection at reasonable times. Copies of all ARD check scales will be made available to the company concerned.

Company scalers, measuring for ARD purposes, must measure and record all merchantable material of any species used for fuelwood, skids, camps, bridges, corduroy or any construction work on forest operations.

Company scalers may assist, with the written approval of ARD, in sampling Crown forest resources to:

- establish mass/volume ratios
- determine cull, defect and undersize factors
- determine product distribution factors
- gather statistical information for ARD purposes

Measuring and recording for the above purposes must be done in accordance with the instructions in the scaling manual.

Principles of Rounding

The following principles of rounding will apply in wood measurement; for example, when rounding to two decimal places:

- If the last digit is less than five, the second digit to the right of the decimal place remains the same. Ex: 3.234 = 3.23
- If the last digit is greater than five, the second digit to the right of the decimal place is raised to the next highest digit. Ex: 3.236 = 3.24
- **If the last digit is five**, preceded by an even number, the second digit to the right of the decimal place remains the same. Ex: 3.245 = 3.24
- **If the last digit is five**, preceded by an odd number, the second digit to the right of the decimal place is raised to the next highest digit. Ex: 3.255 = 3.26
- These principles also apply when rounding to three or more decimal places.

Principles of Rounding Exercise: (answers in appendix 4)
Round the following to two decimal places
8.377 = _______
8.374 = _______
8.375 = _______
8.365 = _______

2.436 = _______
2.479 = _______
2.123 = ______
2.315 = ______

5.225 = ______
5.528 = ______
5.235 = ______
5.155 = ______

VI. Methods of Wood Measurement

All softwoods and hardwoods of any length may be measured by this method. ***Unit of measurement = solid cubic metre = m^3.***

Cubic Method

There are two scaling systems which may be used to obtain the net volume of solid wood in an individual log in m^3:

1. measuring the small end diameter and the length of a log (Cubic Method One, see page 13)
2. measuring both end diameters and the length of a log (Cubic Method Two, see page 13)

Net volume is obtained by subtracting any defect volume from the gross volume to arrive at the net volume of the log, except in the case of sap rot where a net volume may be directly determined.

Diameter Measurement

Diameters are measured inside the bark in 2 centimetre size class intervals, with the class boundary occurring on the odd centimetre, and recorded in even centimetre classes. A scaled log that coincides with the class boundary of two size classes belongs to the lower size class.

	Range	
Diameter Class	**Lower Limit**	**Upper Limit**
D_8	7.1 cm	9 cm
D_{10}	9.1 cm	11 cm
D_{12}	11.1 cm	13 cm
D_{14}	13.1 cm	15 cm
D_{16}	15.1 cm	17 cm

Example: A diameter that falls on the class boundary between 10 and 12 centimetres (cm) must be read as 10 centimetres.

If a log has a regular sawn surface, a fair diameter measurement must be taken without seeking the largest or smallest diameter (Figure2).

Figure 2 Measuring diameters: logs with regular sawn surfaces

Rounding diameters to even classes is required when averaging diameters based on two or more measurements, the average may result in an answer which is not in the class interval being used (e.g. odd numbers). When this occurs, the measurement for recording purposes will be the closest figure which is evenly divisible by four (4).

Logs with irregular sawn surfaces require at least two measurements taken at right angles to each other (through the shortest axis and longest axis of the sawn surface). When the average of two diameter measurements is an odd number, the diameter recorded is the closest even diameter evenly divisible by 4 (Figure 3).

Figure 3 **Measuring diameters: logs with irregular sawn surfaces**

Figure 3 example:
Two log measurements of 28 cm and 34 cm are taken.

$$\left(\frac{28+34}{2}\right)=\frac{62}{2}=31\ cm$$

Since 31 is an odd number, it cannot be recorded. The scaler must record 30 or 32. Since 32 is evenly divisible by 4 and 30 is not, the scaler records a **32 cm** diameter.

Oblong log diameters are measured as described in measuring logs with irregular sawn surfaces (figure 3). Add the diameter measurements together and divide by 2 to obtain the mean. If the mean is an odd number raise or lower the diameter to the closest even centimetre class that is evenly divisible by 4.
Examples:

Measurements	**Average**	**Recorded as**
28 + 24 = 52/2 =	26 – in class interval	**26**
28 + 26 = 54/2 =	27 – not in class interval	**28** (class interval, divisible by 4)
28 + 30 = 58/2 =	29 – not in class interval	**28** (class interval, divisible by 4)
28 + 32 = 60/2 =	30 – in class interval	**30**
30 + 32 = 62/2 =	31 – not in class interval	**32** (class interval, divisible by 4)

Diameter Averaging Exercise: (answers in appendix 4)

Measurements	Average	Recorded as
44+46	________	________
24+28	________	________
34+40	________	________

Length Measurement

The length of a log is the distance along the longitudinal axis between the two end planes perpendicular to this axis and passing through the geometric centre of the log.

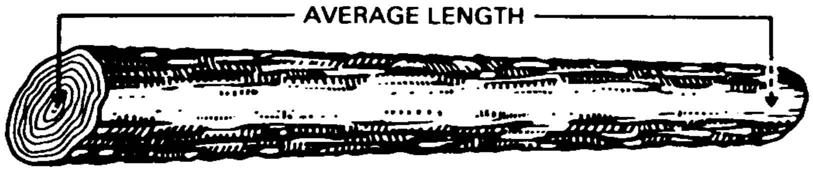

Figure 4 Log length measurement

For the cubic method of wood measurement log lengths are usually measured and recorded in metres and 2 centimetre (.02) classes with the class boundary occurring on the odd centimetre class (Figure 5). Log lengths can also be measured in metres and 20 centimetre (0.2 m) classes with the class boundary occurring on the even centimetre if Table 3 or 4 is to be used for volume determination. Lengths are recorded in the odd centimetre class (Figure 6).

Figure 5 Length class determination in 2 cm class

Figure 5 example: Logs greater than 2.41 m in length, up to and including 2.43 m in length, are recorded as 2.42 m logs.

Figure 6 **Length class determination in 20 cm class**

Figure 6 example: Logs greater than 2.4 m in length, up to and including 2.6 m in length, are recorded as 2.5 m logs.

Cubic Method One: Measuring the Small End Only of a Log

Here, the gross volume of a log is determined by measuring the diameter of the top or small end of the log and the length and using the following taper formula:

$$V = L \times \frac{\pi}{40{,}000} \times \left[d_1 + \left(L \times 0.5\right)\right]^2$$

Where:

V = gross log volume in cubic metres

L = log length in metres

π = 3.14159

d_1 = small or top end log diameter in centimetres

This formula assumes a taper of one cm per metre of length.

Table 4 is used for gross volume determination when measuring the small end of a log. This table is constructed on the above taper formula for a selected range of lengths and top diameters. Log volumes in m^3 are listed by diameter class and 20 cm length classes.

Cubic Method Two: Measuring Both Ends of a Log – Smalian's Formula

The gross volume of a log is determined by using Smalian's formula which states: *The volume of a log is the area of the small end, plus the area of the large end, both divided by two; then multiplied by the log length.* All components must be in the same units. In symbol form Smalian's formula is:

$$V = \frac{A_s + A_l}{2} \times L$$

V = log volume in cubic metres
A_s = area of small end in square metres
A_l = area of large end in square metres

The end area of the small and large end of a log may be calculated by the following formulae:

$A_s = \pi \left(\frac{ds}{2 \times 100}\right)^2$ = area (m^2) of the small end of the log

$A_l = \pi \left(\frac{dl}{2 \times 100}\right)^2$ = area (m^2) of the large end of the log

ds = diameter of small end in centimetres
dl = diameter of large end in centimetres
L = length of log in metres
π = 3.14159

Table 3 may be used for **gross log volume** determination when measuring both ends of a log if the log lengths have been measured in 20 cm classes with the class boundary occurring on the even cm class.

After gross log volume is determined using Smalian's formula or Table 3 allowable defect deductions calculated from **Table 3** are subtracted from the gross log volume to determine **net log volume**.

To determine cube scale volumes Table 2 can be used to find average end area;
Volume m^3 = average end area x length

Table 2 indicates the area of circles in metres squared (m^2) correct to four decimal places for diameters from 4 cm to 128 cm.

An alternate formula for determining the volume of a cylinder is identified below. It can be used for log volumes or defects.

$\frac{D^2 \times 0.7854 \times L}{10{,}000}$ = cubic metres correct to three decimal places

Where: D = average diameter of log or defect in 2 centimetre classes
L = length of log or defect in metres and 2 centimetre classes

Butt Swell

Visible butt swell can be removed by following the normal taper of the log to determine the large end diameter measurement (Figure 7).

Figure 7 Butt Swell

Cubic Method Two Example

Log #	Length	Dia. 1	Area 1	Dia. 2	Area 2	Volume m³ $\frac{Area\ 1 + Area\ 2}{2}$ X length
1	2.52	30	.0707	28	.0616	(.0707 + .0616) /2 X length = .166
2	2.48	18	.0254	20	.0314	(.0254 + .0314) /2 X length = .070
3	2.54	24	.0452	22	.0380	(.0452 + .0380) /2 X length = .106

Cubic Method Two Exercise: (answers in appendix 4)

Log #	Length	Dia. 1	Area 1	Dia. 2	Area 2	Volume m³ $\frac{Area\ 1 + Area\ 2}{2}$ X length
1	2.54	28		30		
2	2.44	20		16		
3	2.56	16		18		

Deductions in Cube Scaling

Allowable defect deductions are subtracted from the gross log volume to determine net log volume. **See the Deduction for Cull, Undersize, Defect and Void section for measurement details.**

Stacked Wood Method

This method of scaling is used to determine stacked roundwood volume of rough or peeled wood piled in an orderly fashion in stacked cubic metres. ***Unit of Measurement = stacked cubic metre = m³ STK.***

A stacked cubic metre is one cubic metre of stacked wood (whole or split, with or without bark) containing wood and airspace with all bolts of similar length piled in an orderly fashion with their longitudinal axis parallel (Figure 8).

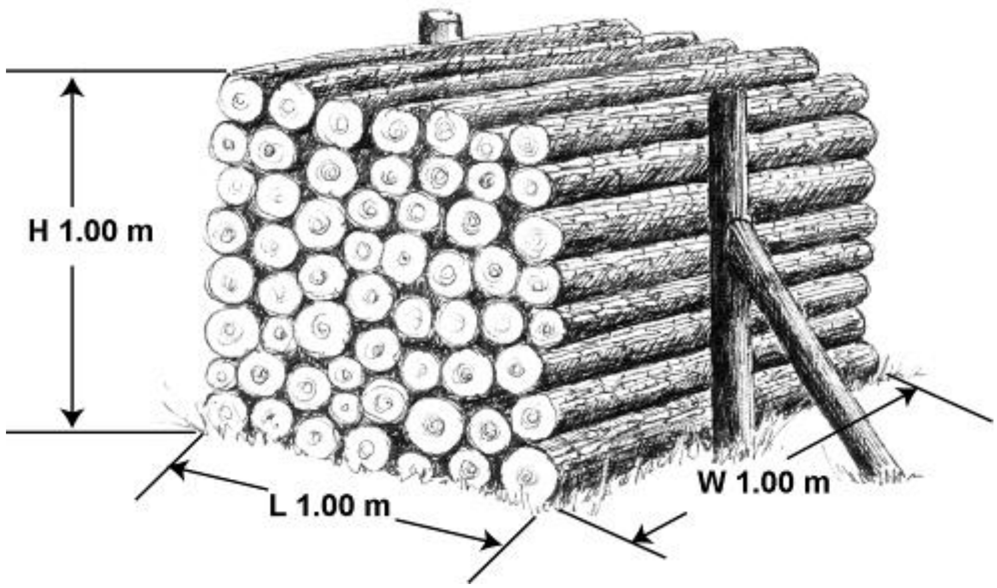

Figure 8 Stacked cubic metre

<u>Measuring Procedure</u>

Heights and lengths are measured on one side of the stack only, by means of an approved stacked wood scaling stick graduated in two centimetre classes and recorded in metres to two decimal places. The scaler must determine if there is an even distribution of tops, butts and defects on both sides of the stack. If there is a predominance of tops, butts or defects showing on one side of the stack, alternate sides must be measured from stack to stack to obtain a fair scale.

Length

Length of the stack is measured in metres and two centimetre size classes with the break occurring on the odd centimetre. Lengths are recorded in the even centimetre class. (Ex. Length 10.42 m, 25.64 m)

When a stack drops off in height at one or both ends, measure the length to a point on the slope of the stack where the area of the stack that is now cut off will fill the space required to square the stack (Figure 9).

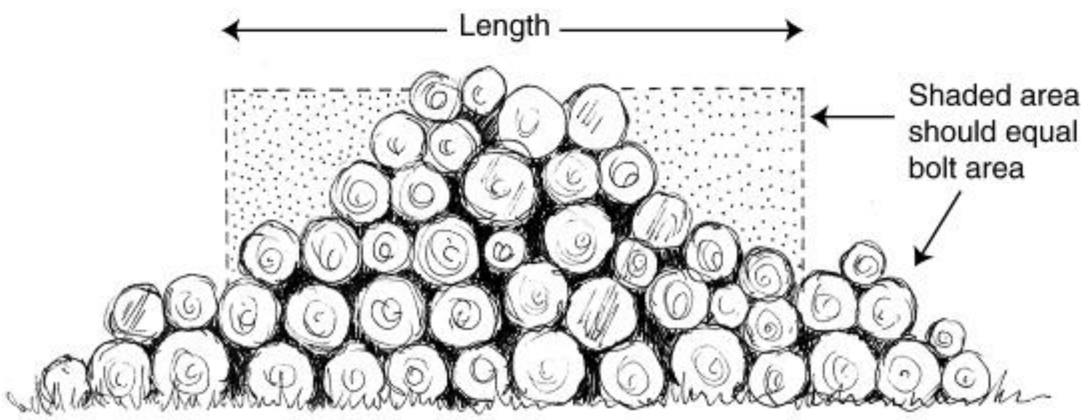

Figure 9 **Measuring length of stack when stack drops off at both ends**

On hillsides, measure the length of the stack parallel with the bottom of the stack (Figure 10).

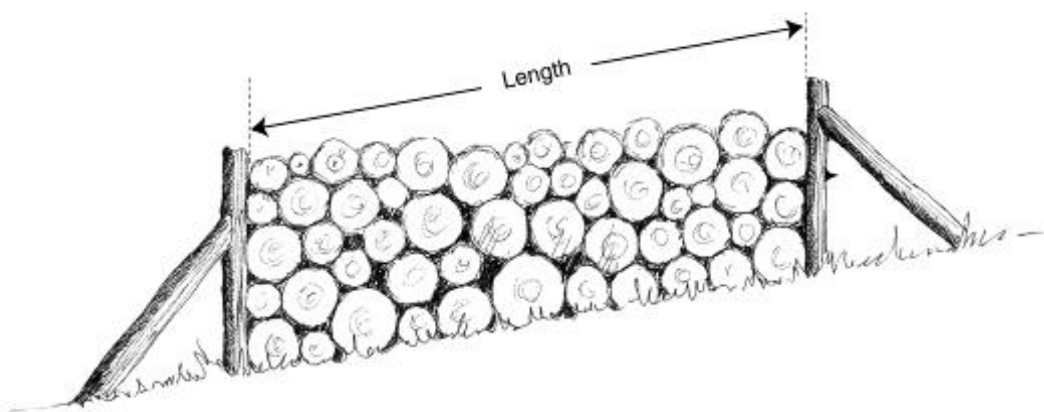

Figure 10 **Measuring length of stack on a slope**

The maximum recordable length of a stack is 30 metres**.** Where exceedingly long stacks are encountered, separate them into sections no longer than 30 metres. Measure and record each section as a separate stack and mark each section of the stack clearly with a line.

Height

Height is measured in metres and two centimetre size classes with the break occurring on the odd centimetre and recorded in even centimetre classes. ***The maximum allowable height of a stack is 5 metres***. Stacks higher than 5 metres may have to be re-piled to permit safe and accurate measurement.

When a number of height measurements are averaged to two decimal places, odd numbers may be recorded for the height measurement**. Rounding of numbers does not apply to averaged stack heights**. The third and subsequent decimal places are disregarded.

Heights are measured at equal intervals along the length of a stack, and averaged to two decimal places to obtain the average height of a stack (Figure 11). When the ends of a pile with sloping ends are theoretically squared off to determine the pile length, the centre part of the pile with a relatively even height is considered the **working stack height**.

Figure 11 illustrates where the working stack height would be located. The first height measurement is to be taken at 0.5m from the beginning of the working height. Intervals between 1.0 – 3.0 m should be used depending on the uniformity of the stack height and overall length of the pile. More height measurements are required on stacks with irregular heights.

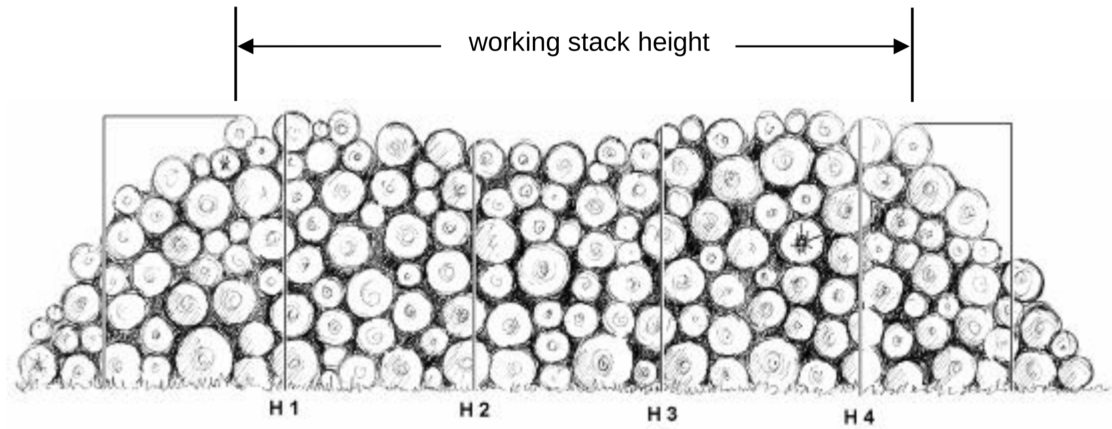

Figure 11 **Measuring height of stack**

Height 1=1.84 m, Height 2=1.78 m, Height 3=1.82 m, Height 4=1.84 m

Figure 11 example: Determining stack height from measurements taken at equal intervals along the length of a stack:

Average height of stack = $\left(\frac{1.84+1.78+1.82+1.84}{4}\right)=\frac{7.28}{4}=1.82\text{ m}$

Record the height as 1.82 m.

The height measurement commences on the lower edge of a bottom bolt or at the exterior tangent of two adjacent bottom bolts and terminates on the upper edge of a top bolt or exterior tangent common to two adjacent top bolts. This method can be used to smooth the pile height when a significantly different height measurement is indicated along each edge of the stacked wood stick. The reading is taken where the line transects the centre of the stacked wood stick. See Figure 12.

Correct Incorrect

Figure 12 Measuring stack height using exterior tangents

Figure 13 example: Determining stack height from measurements taken at equal intervals on a loaded truck. Each tier is considered to be a separate stack and average height measurements must be obtained for each tier.

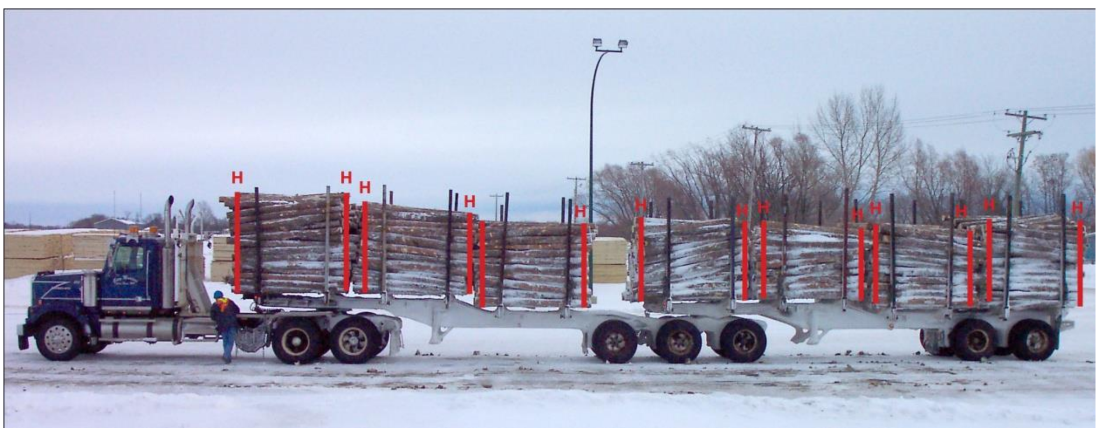

Figure 13 Height measurements taken on a loaded truck

Tier 1 $\frac{1.78+1.84}{2}=\frac{3.62}{2}=1.81$

Tier 2 $\frac{1.84+1.86}{2}=\frac{3.70}{2}=1.85$

Tier 3 $\frac{1.76+1.80}{2}=\frac{3.56}{2}=1.78$

Tier 4 $\frac{1.82+1.84}{2}=\frac{3.66}{2}=1.83$

Tier 5 $\frac{1.78+1.80}{2}=\frac{3.58}{2}=1.79$

Tier 6 $\frac{1.82+1.90}{2}=\frac{3.72}{2}=1.86$

Tier 7 $\frac{1.74+1.78}{2}=\frac{3.52}{2}=1.76$

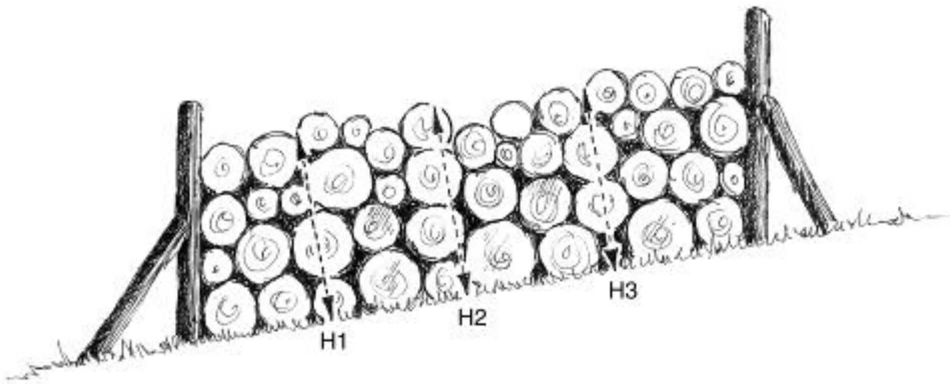

Figure 14 Measuring height of stack piled on a slope

Where wood is stacked on a slope, the height measurements are taken at right angles to the slope (Figure 14).

Width

The width of a stack is the actual length of the logs or bolts measured in metres and two centimetre classes with the break occurring on the odd centimetre and recorded on the even centimetre class. All the wood in one stack must be the same length. As the roundwood is put up in a pile, the stack width will be determined from log or bolt lengths selected on the pile top which are representative of the actual pile width.

When a number of width measurements are averaged to two decimal places, odd numbers may be recorded for the width measurement**. Rounding of numbers does not apply to averaged stack** widths. The third and subsequent decimal places are disregarded. Pile widths more than 2.80 metres cannot be stack scaled unless approved otherwise.

In application, the width of the pile will be calculated as the average of 10 log length measurements in metres and 2 centimetre classes. The calculated average pile width is allowed to be an odd number to the nearest centimetre for the purpose of calculating stack volume.

Example: 10 measurements

2.58	2.46	2.54	2.56	2.44	2.56	2.52	2.54	2.54	2.52

= 25.26/10 The average pile width is 2.52 m

Calculation of Volume

The stacked pile volume before deductions is found by multiplying the pile height times the pile length, times the pile width (Figure 15).

The formula is: $GVS = H \times L \times W$

Where:

GVS = the gross volume of the stack of wood (expressed with a precision of 0.01 m^3 stacked)

H = the pile height in metres and two centimetre classes

L = the pile length in metres and two centimetre classes

W = the pile width (length of bolt) in metres and two centimetre classes

Figure 15 Example: A stack of wood measuring 2.50 m in height, 4.00 m in length and 2.60 m in width has a volume of 2.50 x 4.00 x 2.60 = 26.00 m³ STK

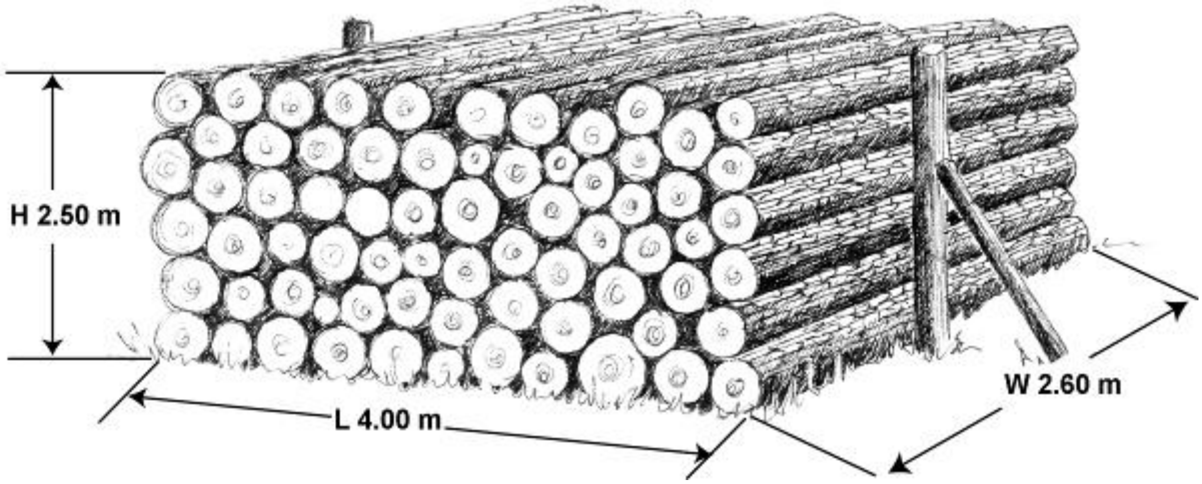

Figure 15 Stacked wood

Deductions for Stack Scaling

Deductions for cull, undersize, defect and void are permitted in stackwood scaling. They are measured with an approved scaling stick (MC-1, MC-2) graduated in two cm classes with the class boundary on the odd centimetre. They are calculated from diameter measurements of culls, undersize, defects and voids visible on the side selected for scaling and are assumed to extend the length of the log or width of the stack. It is assumed that there is an even distribution of defects on both sides of the stack. See the Deduction for Cull, Undersize, Defect and Void section for measurement details.

Identification of Stacks

When a stack has been measured, the scaler must mark the following information on one or more conspicuous bolts (Figure 16):

- stack number
- date
- scaler's initials
- any other information requested by ARD.

Figure 16 **Stack identification**

Conversion Factors for Rough and Peeled Bolts

Tests have determined that, on average, a stacked cubic metre of wood is made up of approximately:

66 %	wood
12 %	bark
22 %	air space
100 %	

Rough Wood Factor

To calculate the volume of stacked cubic metres of rough wood represented by **a single bolt**, undersize, defect, cull or void, the solid cubic metre volume must be multiplied by the rough wood factor 1.51.

The factor is derived as follows:

$$66\% wood = \frac{100\%}{66\%} = 1.51$$

Example: A single 18 cm x 2.5 m bolt has a volume of 0.064 m^3.
To determine the volume the single bolt represents in stacked cubic metres:
$0.064\ m^3 \times 1.51 = 0.097\ m^3$ STK correct to 2 decimal places

Peeled Wood Factor

To calculate the volume of stacked cubic metres of peeled wood represented by **a single bolt**, undersize, defect, cull or void, the solid cubic metre volume must be multiplied by the peeled wood factor 1.28.

This factor is derived as follows:

100%
-22% air
78%

$$\frac{100\%}{78\%} = 1.28$$

Example: A single 18 cm x 2.5 m peeled bolt has a volume of 0.064 m^3. To determine the volume the single bolt represents in stacked cubic metres peeled:

$0.064 m^3 \times 1.28 = 0.08\ m^3$ STK correct to 2 decimal places

Conversion Factors for Stacks

To convert stacked cubic metres to solid cubic metres, multiply the volume in stacked cubic metres (correct to two decimal places) by:

0.664 for rough wood
0.781 for peeled wood

Round all volumes in solid cubic metres correct to two decimal places.

Example: A stack of rough wood has a volume of 36.05 m^3 STK.
To determine the volume in solid m^3:

$$36.05 \times 0.664 = 23.94\ m^3$$

To convert solid cubic metres to stacked cubic metres, divide the volume in solid cubic metres (correct to three decimal places) by:

0.664 for rough wood
0.781 for peeled wood

Round all volumes in stacked cubic metres correct to two decimal places.
Example: A stack of rough wood has a solid wood volume of 358.909 m^3. To determine the volume in stacked m^3:

$358.909 \div 0.664 = 540.52\ m^3$ STK.

Mass Scaling Method

This system of scaling is used to determine the mass of quantities of roundwood, chip fibre and fuelwood in tonnes or kilograms. Units of mass are converted to units of volume by using mass/volume ratios developed for each species.

Manned or unmanned weigh scales are acceptable means of measuring provided they meet ARD standards. The Director of Forestry, in consultation with the appropriate industry representatives, must ensure scale operations meet all regulatory requirements.

Weighing devices, their manufacture, installation and use are regulated by the Weights and Measures Act of Canada. The act states that all weighing devices must be approved and certified prior to use and that any commodity, traded on the basis of weight, must be measured within the prescribed limits of error as defined in the regulations.

The Weights and Measures *Act* specifies those regulations pertaining to:

- the design, configuration and construction of weighing devices
- installation and use
- their performance

The Director of Forestry must approve all exceptions to the minimum facility standards.

All weighing devices will be operated within the standards as specified in the Weights and Measures Act. Scales will be maintained in good operating condition. The deck must be kept clear of ice, snow and other material that may accumulate during the hauling operation. When mass measuring is in progress the scale must be adjusted to read zero mass after each transaction. When mass scaling on a motor vehicle, the empty or tare weight of the vehicle shall be taken as soon as possible after unloading each time a mass is taken of the loaded vehicle.

Unit of Measurement - Kilogram or tonne

Mass Scaling Measuring Procedure

To mass scale Crown forest resources for Crown purposes, the weigh scale facility must conduct measuring procedures in the following manner:

- The weigh scale facility must be approved to measure unscaled Crown forest resources.
- A completed load slip will accompany each load of unscaled Crown forest resources to the weighing location.
- The gross mass (weight of tractor, trailer and load) and the tare mass (weight of the tractor and empty trailer) will be measured and recorded for each load.
- Every tractor and empty trailer must be weighed to determine its tare mass after the delivery of each load.
- If the gross mass includes the weight of the driver, then the tare mass must also include the weight of the driver.
- The tractor and empty trailer must not be cleaned of debris between the gross and tare measurements.
- The tractor must not be refuelled between gross and tare measurements.
- The net mass of the load is determined by subtracting the tare mass of the empty vehicle from the gross mass of the loaded vehicle.
- A mass scale slip/ticket that displays all information required for the identification of the load, will be produced.
- Vehicles used for hauling Crown forest resources to a weigh scale facility must be properly identified and the information recorded on the mass slip/ticket (Ex. truck/trailer licence plate numbers, truck owner/number).
- The weigh scale facility will maintain a record of all mass measured transactions in a manner approved by ARD.
- A schedule will be implemented for the timely submission of mass measure transactions to the Crown.

Note: Where the deck of the weigh scale is not long enough to accommodate the entire length of the tractor and trailer, the driver will place the entire trailer on the scale deck, detach the tractor from the trailer and remove the tractor from the deck prior to both (gross and tare) measurements.

The practice of combining separate (split) axle weights to determine the gross mass or the tare mass is not permitted.

Where the weighing device becomes inoperable, an alternate method of measurement, acceptable to ARD, will be implemented.

Calculation of Volume

On mass measuring operations, for each harvesting authority, the following must be determined annually:

- for all softwoods and hardwoods: factors for undersize, cull and defect deduction and product(s)

Applying Factors to Determine Volume

- Each species has its own mass/volume ratio, derived from sampling program that converts the mass of the load from kilograms to solid cubic metres.
- For single species (pure) loads, calculate the gross volume of the load using the mass/volume ratio for that species.
- The undersize factor is applied to the gross volume for each species prior to applying defect factors.
- The net volume is determined by applying the defect factor to the sum of the gross volume less undersize.
- Volumes are expressed in cubic metres correct to two decimal places.

Example: Determining the gross volume of a single species (pure) load.
A load of jack pine logs is delivered to a mass measuring site:

Gross weight is 62,780 kgs
Tare weight of the tractor and trailer is 20,490 kgs.
For this example the mass/volume ratio for jack pine is 808 kgs per cubic metre of solid wood.

Step # 1
Calculate the net weight of the load:

Gross weight	62,780 kgs
Tare weight	- 20,490 kgs
Net weight of load	42,290 kgs

Net weight of load is **42,290 kgs.**

Step # 2
Calculate gross solid cubic metres of jack pine in the load:

$42{,}290\ kgs \div 808\ kg/m^3 = 52.3391 = 52.34\ m^3$ (correct to 2 decimal places)

Gross volume of jack pine is **52.34 m^3**.

Example: Determining the net volume of a single species (pure) load.
To determine the net volume of the load, the undersize and defect, if applicable, must be deducted from the gross volume. Using the gross volume from Example 1, apply an undersize factor of 3.1 per cent and a defect factor of 7.5 per cent to calculate net volume.

Step # 1
Reduce the volume of the load by removing the undersize material:
Gross volume is 52.34 m^3
Undersize factor is 3.1%

Factor to calculate gross volume less undersize $100\% - 3.1\% = 96.9\% \textit{ or } 0.969$

Gross volume less undersize $= 52.34 \times 0.969 = 50.71746 = 50.72\ m^3$ (correct to two decimal places)

Step # 2
Further reduce the volume by removing the <u>defect material</u> to determine the net volume:
Defect factor is 7.5%
Factor to calculate volume less defect $100\% - 7.5\% = 92.5\% \textit{ or } 0.925$

Net volume = $50.72 \times 0.925 = 46.916 = 46.92\ m^3$ (correct to two decimal places)

Therefore the **net volume** of the load is **<u>46.92 m³</u>**.

<u>Identification of Load</u>

Each mass scale slip must show the following information:

- load slip number
- mass scale slip number
- harvesting authority number (forest management licence, timber sale, timber permit, patent land)
- gross mass of loaded vehicle in kilograms
- tare mass of empty vehicle in kilograms
- net mass of load in kilograms
- date
- species
- mass measuring location
- final destination of load
- truck identification (Ex: licence plate numbers, trucker's name)
- scale operator signature
- any other information requested by the Director of Forestry

Sample Scaling Method

Application of Sample Scaling
The principle of sample scaling is that certain characteristics of a large group of similar items can be determined as accurately from a small sample of those items as from measuring the entire group. For example, when sample scaling, only a small proportion of timber piled in a landing is measured. This measured sample is used to determine the total volume of the landing. The emphasis is on the care of measurement and the unbiased selection of the measured sample.

A sample scaling procedure must be applied carefully to ensure that the Crown forest resources measured are representative of all the Crown forest resources harvested. The percentage measured may vary depending on the scaling method used.

The approved scaling percentages are as follows:

- 100 per cent scale — all methods of measurement
- 10 per cent sample scale — approved for fixed length cube scale operations only

Note: The sample scaling percentage for containers (Ex: rail cars, trucks, verifying factors) is stated in the sampling plan and the scaling agreement.

Design of a Sample Survey
- the objective must be clearly stated
- the population will be defined
- the data required to be collected will be specified
- the units to be sampled will be defined
- all measuring (scaling) procedures must be clearly set out
- the desired precision will be specified
- the sampling method will be described in as much detail as necessary
- when there is information lacking on the population in order to determine a sample size, a pre-test will be made
- the organization of the field work will be set down
- the summary and analysis of the data will be detailed

Note: for a complete description of the mathematical procedures commonly used in sample scaling see CSA Standard: Scaling Roundwood 0302.1-15, Section 9

Piece and Linear Scaling Method

Piece and linear scaling is used to describe a quantity of primary forest products resulting in a scale consisting of a piece count or a summation of lengths with a criteria description in metric units. A procedure description of the measurement methods can also be included.

Piece and linear scaling is used for many diverse products and requires the use of descriptive criteria such as species, diameter (cm), length (m) and allowable defects.

Often this scale is converted to a volume or mass description of quantity. However, when determining mass or cubic content is the primary purpose of the scale, piece and/or linear scaling should **not be used**.

Example: To determine the volume of the following material.

100 posts – 16 cm average diameter and 2.5 m in length
1000 lineal metres of rails – 10 cm average diameter and 5 m in length

from Table 3 – a post with 16 cm average diameter and 2.5 m length has a volume of .05 m^3.

volume of posts - 100 x .05 = 5 m^3

from Table 3 – a rail with 10 cm average diameter and 5 m length has a volume of .038 m^3.

number of rails - 1000 lineal metres / 5 metres = 200 rails

volume of rails - 200 x .038 = 7.6 m^3

5.0 m^3 posts
7.6 m^3 rails
12.6 m^3 total volume

Deductions for Cull, Undersize, Defect and Void

Cull
A cull piece is a log, bolt, or tree length having more than 50 per cent of its volume defective. Culls can be determined by comparing the square of the defect diameter with the square of the sawn surface diameter. If the square of the defect diameter is greater than 50 per cent of the square of the sawn surface diameter, the log is a cull. The cull piece is clearly marked by placing an X across the scaled end. The recording of a cull piece is handled either by omitting it from the gross scale record or by assigning a deduction equal to its original volume.

Figure 17 **Cull logs**

Example: A log with a gross diameter of 32 cm has a 26 cm defect on the measured end. The square of the log diameter is 32 x 32 = 1024 cm². The square of the defect diameter is 26 x 26 = 676 cm².

Area: gross diameter 32 cm (Table 1)	= 32 x 32 =	1024 cm^2
Area: defect diameter 26 cm (Table 1)	= 26 x 26 =	-676 cm^2
Sound portion	=	348 cm^2

Since 676 is more than half of 1024, the log is a ***cull***.

Comparing the square of the defect diameter to the square of the log diameter using Table 1 is one method of determining if a log is a cull or not. In most cases it is more efficient than determining the volume of the defect and the volume of the log before making any determination on cull.

Alternatively a cull piece can be determined from the diameter reductions on the MC-1 or MC-2 scaling stick. If the defect is larger than the largest diameter listed under each diameter class the piece is a cull.

Example: A log with a gross diameter of 32 cm has a 26 cm defect on the measured end. On the MC-1 scaling stick the largest defect diameter listed under 32 cm is 22 cm; therefore the log is a cull.

Undersize

Undersize is defined as unmerchantable timber that is smaller than the minimum top diameter utilization standard diameter class. Undersize may only be applied in commercial timber operations and is not for application in personal use or fuelwood operations.

In commercial operations undersize timber would be the portion of:

- softwood timber that has been harvested for use that has a diameter less than 10 centimetres (diameter class)
- hardwood timber that has been harvested for use that has a diameter less than 12 centimetres (diameter class)

If deductions are being made for undersize material, this deduction must be made before any defect deduction is applied. Defect deductions are applied only to merchantable material. There are no deductions for defect in undersize material.

The scaler will not reduce gross diameter of the undersize piece if a defect is encountered. **Any bolt with a diameter less than 6 centimetres is ignored.**

In the stacked method all undersize bolts in the stack will be scaled on the side of the stack being measured and their gross volume recorded in stacked cubic metres. Deductions are made in the same manner as for culls.

Undersize in Fuelwood – There are no deductions for cull, defect or undersize when measuring fuelwood. Only voids are deducted from fuelwood.

Defect

The definition of a defect is naturally missing or charred wood, and rot or advanced decay. Volume deductions are allowed as identified for each scaling system.

All sound or merchantable pieces, regardless of their diameter, length and species, must be scaled and reported to ARD; they cannot be considered rejects or culls.

No allowances for sawmill trim or broomage are permitted outside of the size class interval established in the scaling system.

Defects are measured in the same way as gross diameters**,** in two centimetre size class intervals, with the class boundary occurring on the odd centimetre. Defects are recorded in even centimetre classes.

The volume of a defect is determined using the geometric solid that best represents the shape of the defect. Defect volume determination is normally a product of the average cross-sectional area of the defect times the length affected. Measurements are made in the same units that are used to scale the log.

Enclose the defect in the smallest rectangle possible and obtain the length and width of this rectangle. Add these measurements together and divide by two to obtain the mean. If the mean is an odd number, raise or lower the diameter to the closest even centimetre class that is evenly divisible by four.

When a defect is visible on both ends of a log, measure the defect **on both ends of the log** to obtain the mean defect diameter.

In stack scaling use the defect diameter to calculate the volume of the defect. This can be read directly from the cube scaling stick (for 2.54 m length bolts) marked in hundredths of a stacked cubic metre.

Example: A log contains a defect that measures 10 by 14 cm.

$$\left(\frac{10+14}{2}\right)=\left(\frac{24}{2}\right)=12\ cm$$

The diameter of defect is 12 cm.

Example: A log contains a defect that measures 12 by 18 cm.

$$\left(\frac{12+18}{2}\right)=\left(\frac{30}{2}\right)=15\ cm$$

The diameter of the defect is 15 cm.

Since 15 is an odd number, the scaler must raise this diameter to 16 cm (16 is evenly divisible by four while 14 is not). Therefore, the diameter of the defect is 16 cm.

Note: In the cubic method of measurement:

- **no deduction is made for crook, sweep or seams**
- **no deduction is made for stain or mechanical damage**
- **sound dry wood is not considered a defect**

Full Length Heart Rot (FL)
Heart rot is a very common defect. Full length heart rot is measured as a normal log when the defect shows at both ends.

Figure 18 **Heart rot**

The defect area for heart rot is calculated out as shown below:

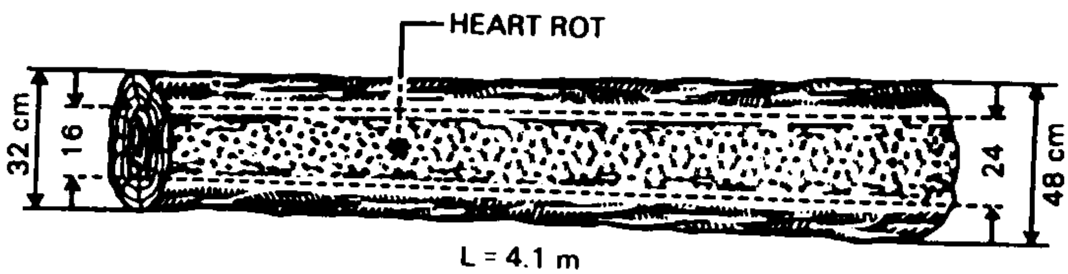

Figure 19 **Full length heart rot (showing at both ends)**

Figure 19 example:
Using true cylinder tables (Table 3)

Log length	=	4.1 m
Gross log diameter (32+48)/2	=	40 cm
Defect diameter (16+24)/2	=	20 cm
Gross log volume (see table 3)	=	0.515 m^3
Defect volume (see table 3)	=	0.129 m^3
Net Log Volume	=	0.386 m^3

Half Length Defect (HL)
When the defect shows only at one end, the volume should be one half the volume of a cylinder. Normally Smalian's formula is used to calculate this defect's volume. Had the defect in the example shown (Figure 19) only occurred in the small end (16 cm diameter) the deduction would have been:

Example:

Log length	=	4.1 m
Gross log diameter (32+48)/2	=	40 cm
Gross log volume (see table 3)	=	0.515 m^3
Defect diameter (small end only)	=	16cm
Half Defect volume (Table 3, 50% of 0.082)	=	0.041 m^3
Net Log Volume	=	0.474 m^3

Butt Length Defect (BL)
This defect is restricted to rot in the end of the log which was originally attached to the stump and seldom extends far into the log. Ordinarily, it reduces in size from the end of the log inward (Figure 20).

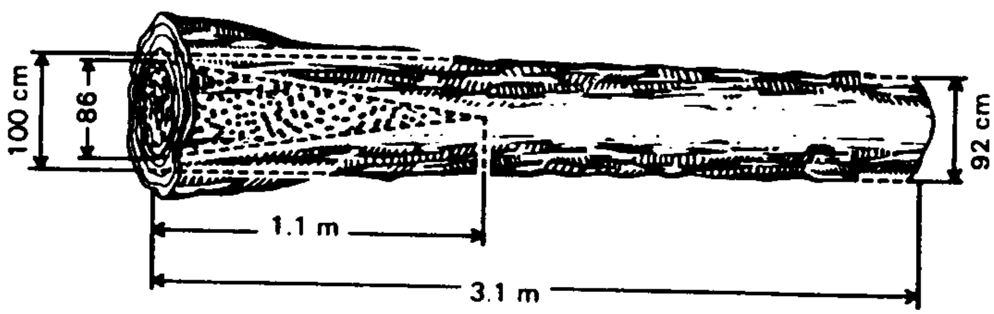

Figure 20 Butt rot

Unless there are indications otherwise, the length of the penetration shall be assumed to be 1.1 m (based on field sampling by ARD staff) and the formula to determine the defective volume is a paraboloid with the following formula:

$$V = \frac{1}{2} \times A \times L$$

Where:
V = volume in cubic metres
A = defect area in square metres
L = defect length in metres (1.1 m)

Note:
- this rot may be easily confused with heart rot

– honeycomb decay or missing wood typically caused by ants in the tree's butt can be classified as butt rot.

Figure 20 example:
Using true cylinder tables (Table 3)

Log length	=	3.1 m
Gross log diameter (100+92=192/2)	=	96 cm
Gross log volume (see table 3)	=	2.244 m³
Defect diameter (at the butt end)	=	86 cm
½ 1.1 m defect volume (see table 3)	=	0.320 m³
Net Log Volume	=	1.924 m³

Butt End Defect Greater Than 75% of Butt End (R1M)
Severe butt rot which affects more than three quarters (75 per cent) of the butt end area shall be handled by reducing the log length by one metre.


Figure 21 **Butt rot**

Figure 21 example:
Log length 5.1 m
Butt diameter = 90 cm Butt area = .6362 cm^2
Butt rot defect = 80 cm Butt rot area = .5027 cm^2
Percentage of butt rot area = .5027/.6362 = 79%
Gross log length is 5.1m
Merchantable log length is 5.1m – 1.0 m = 4.1 m

Punk Rot
This rot may be fully confined to the heart of the log or it may touch the outer surface (Figure 22).

Figure 22 Punk rot

Long Narrow Defects
When the length of a defect is more than twice its width, the scaler must first calculate the area of the defect by multiplying the length by the width. The diameter of the defect is then determined by obtaining the square root of this number and raising or lowering it to the closest perfect square root that is an even number.

Table 1 shows the squares of all even numbers from 4 to 90.

Example: A defect measures 22 by 8 cm. Since the length is more than twice the width, the area of the defect is determined by multiplying 22 x 8 = 176 cm^2 (Figure 23).

Since $\sqrt{176}$ = 13.3 and 13.3 is an odd number, it must be raised or lowered to the closest perfect square root that is an even number, which is 14. Therefore, the diameter of the defect is recorded as 14 cm.

An alternative way of determining the diameter of the defect for the same example would be by referring to the table of squared numbers in Table 1. Note that 176 falls between 144 (12^2) and 196 (14^2). Since 176 is closer to 196, the diameter of the defect is 14 cm.

Figure 23 **Long narrow defect that measures 22 cm x 8 cm**

Heart Check
Over mature timber often shows a heart check, which may extend only part way into the log or may appear on both ends. Heart check must not be confused with sun check or with checks resulting from the normal drying process (Figure 24).

 

Figure 24 **Heart check on the end surface of a log**

Figure 24 example:
heart check 2 cm x 8 cm = 16 cm, √16 = 4 cm diameter
heart check 2 cm x 10 cm = 20 cm, √20 = 4.472 cm diameter
4.472 must be raised or lowered to the closest perfect square root that is an even number = 4 cm diameter

Defects Separated by 14 Centimetres or Less

If a log contains two separate defects that are separated by 14 centimetres or less of sound wood, they must be considered as one defect. The scaler must enclose them in a rectangle to obtain the diameter of the defect (Figure 25).

Figure 25 Two defects separated by 14 cm or less

Example: A log contains two defects that are separated by 12 cm of sound wood. The scaler encloses these defects in a rectangle measuring 16 by 40 cm. Since the length is more than twice the width (long narrow defect), the scaler must calculate the area of the defect, obtain the square root and raise or lower this number to the closest perfect square root that is an even number. Area of defect = 16 x 40 = 640 cm^2.

$= \sqrt{640} = 25.3$

The diameter of the defect is <u>26 *cm.*</u>

Example: A log contains two defects that are separated by 10 cm of sound wood. The rectangle enclosing these defects measures 12 by 20 cm

$$\left(\frac{12+20}{2}\right)=\left(\frac{32}{2}\right)=16\ cm$$

The diameter of the defect is therefore 16 cm.

An alternative way of determining the diameter of the defect for the same example would be by referring to the table of squared numbers in Table 1. Note that 240 (12 x 20 = 240) falls between 196 (14^2) and 256 (16^2). Since 240 is closer to 256, the diameter of the defect is *<u>16 cm</u>*.

Defects Separated by More Than 14 Centimetres

When two defects are separated by more than 14 centimetres of sound wood, the scaler must calculate the area of each defect, add them together, and obtain the square root of this total. This result will then be raised or lowered to the closest perfect square root that is an even number to determine the defect diameter.

Example: A log contains two defects. One measures 10 by 12 cm and the other measures 10 by 14 cm. They are separated by 16 cm of sound wood.

Area of defects $= 10 \times 12 = 120 \text{ cm}^2$

$= 10 \times 14 = \underline{140 \text{ cm}^2}$

260 cm^2

$$= \sqrt{260} = 16.12$$

Therefore, the diameter of the defect is *16 cm*. This can also be determined by referencing Table 1 in the appendices.

Sap Rot Defect

Sap rot is a defect confined to the outer circumference of the log where the heartwood may be unaffected and sound. Diameters must be determined for both the gross and the sound portions of the log. The square of the sound diameter, subtracted from the square of the gross diameter, represents the square of the defect. If the square of the defect is less than the square of the sound diameter, the log is not a cull and the diameter of the sound portion is recorded.

Example: A log has a diameter of 40 cm and a sap rot on the circumference; leaving 32 cm of sound wood (Figure 26).

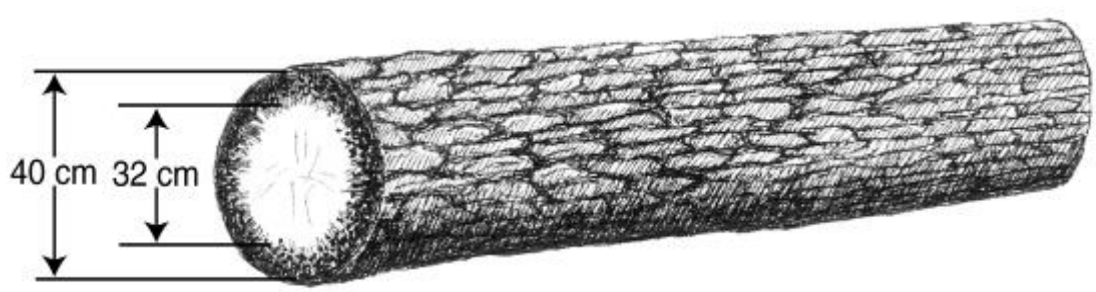

Figure 26 Sap rot

Gross diameter² (40 x 40)	=	1600 cm^2
Minus diameter² of sound wood (32 x 32)	=	$- \underline{1024 \text{ cm}^2}$
Defect	=	576 cm^2

Since the squared diameter of the defect portion is less than the squared diameter of the sound portion, the log is not a cull. The diameter of the sound portion of the log is recorded as 32 cm.

Pipe and Pocket Rot

These rots are varied and their volume is generally calculated by their cross-sectional area times their length.

$$V = A \times L$$

Where: A = defect area in m^2 and is usually a circle or rectangle
L = length of defect in meters.

Included in this class of rots are end checks and splits which warrant a deduction for missing wood.

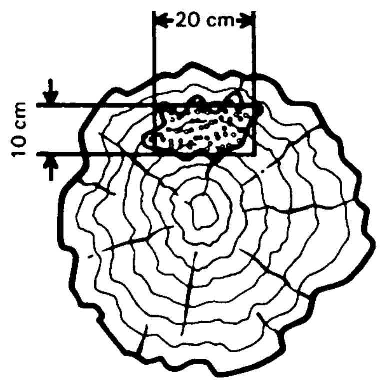

Figure 27 Pipe and pocket rot

Example: (see figure 27)

Area of Pipe Rot: $\frac{L}{100} \times \frac{W}{100} = \frac{20}{100} \times \frac{10}{100} = 0.020 m^2$

Dead Side or Seam Defect or Rot

This class of defect is typified by a split or opening running along some or all of the total log length. Seams that will be eliminated in the manufacturing process are not considered defects.

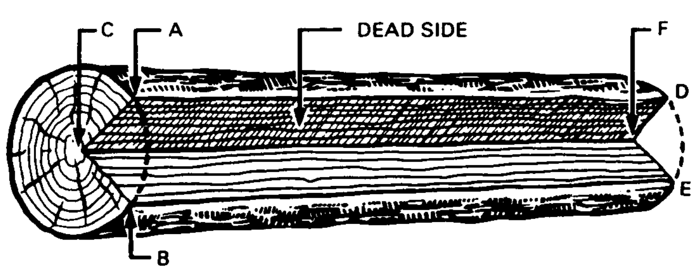

Figure 28 Dead side or seam defect or rot

In cross section it is pie shaped. The formula for its volume is:

$$V = A \times \frac{K}{C} \times L$$

Where:

A = area of end circle in m²

K = arc length of defect in cm (measured from point A to point B)

C = end circle circumference in cm

L = log length in metres

V = volume in cubic metres

An alternate dead side volume calculation is easily found by taking the percentage of the defect sector's angle to 360 ° and applying the result to the gross log volume.

$$VD = VL \times \frac{\text{Sector's angle in degrees}}{360^\circ}$$

Where:

VD = volume of defect in m³

VL = volume of log in m³

This must be further modified if the dead side is not the full log length, or differs considerably at the other end.

Church Door or Catface

This defect's volume will normally be a judgement estimate.

Crotch or Forked Top

The crotch or forked top log is determined by measuring an inside bark diameter at the narrowest point below the fork. The diameter is then reduced by one centimetre for every metre of length the narrowest point falls below the top end of the log. This will then yield a small end diameter for recording purposes.

Example: A minimum diameter (inside bark) of 44.0 cm was determined about 2.0 m below the top end of a forked log. The top end diameter is to be recorded as 42 cm (44.0 - 2.0). Table 4 is used to determine the volume of the log.

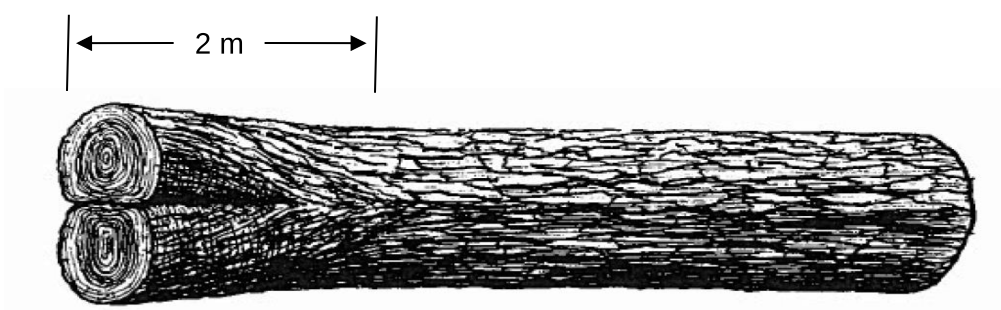

Figure 29 Crotch or Forked Top

Void
Void is a space in the face of a pile which will at least accommodate the average size (diameter) bolt within the pile of wood being scaled. The volume to be deducted will be the product of the number of average bolts required to fill the void times the volume of the average bolt. Voids are not observed along the top or bottom edge of stacked piles.

Example - use of MC-1 scaling stick: if a void in a pile of pulpwood will accommodate 3 average size bolts and their diameter is 12 cm, then the total deduction will be 0.13 m^3 STK (by formulae) or 0.12 m^3 STK by direct reading from the MC-1 scaling stick, for a bolt length of 2.54m (3 x 0.04 m^3 = 0.12m^3 STK).

The volumes by diameter class for cull, defect, void and undersize shown on the MC-1 stick are for wood 2.54 m in length. If the length of wood being measured is different than 2.54 m, the volumes of cull, defect, void and undersize must be calculated by formulae.

Calculating Volume of Cull, Defect or Void by formula:

Vdf = A x L x factor (1.51)

Where:
Vdf = volume of cull, defect, or void expressed with a precision of 0.001 m^3 (stacked)

$$A = \pi\left(\frac{D}{2 \times 100}\right)^2$$

π = 3.14159
D = diameter of cull, defect or void in centimetres
L = length of log in metres when scaling on one side of the pile, and when scaling on both sides, L is ½ the log length
Factor = a factor for expanding the volume to account for bark and air space

The MC-1 and MC-2 scale sticks, contain built-in allowance factors for bark and air space, and can be used to directly measure the stacked cubic metre content of a cull, defect or void, for a 2.54 m bolt length.

Example: Defects in Cube Scaling

Butt length defect – BL

- diameter of defect x 1.1m = volume of defect in m^3
- use Table 3 volume for 1.1 m divided by 2
- must be the large end of the butt log (originally attached to the stump)
- defect must show in butt end only

Half length defect – HL

- diameter x length = volume of defect m^3
- use Table 3 volume divided by 2
- used on logs that are not a butt log
- defect shows on only one end
- assume defect goes ½ length

Full length defect – FL

- average diameter of defect x full length = volume of defect m^3
- use Table 3
- defect shows on both ends
- diameter of defect measured at both ends of log and averaged
- full log length

R1M – reduce log length by 1 m when the defect affects more than 75% of the butt area. This is normally associated with honeycomb caused by ants in the butt end of a tree originally attached to the stump.

Example: Defect Deductions for Cube Scaling

Log length	**Small end diameter**	**Gross Volume m^3 (table 4)**	**Defect**	**Defect Volume m^3**	**Net Volume m^3**
3.7 m	44 cm	0.611	BL 24 cm	.050/2 = .025	0.586
4.9 m	32 cm	0.457	BL 12 cm	.012/2 = .006	0.451
5.1 m	26 cm	0.326	HL 18 cm	.130/2 = .065	0.261

Defect Deductions Exercise: (answers in appendix 4)

Log length	**Small end diameter**	**Gross Volume m^3 (table 4)**	**Defect**	**Defect Volume m^3**	**Net Volume m^3**
3.7 m	34 cm		BL16 cm		
4.9 m	42 cm		BL 12 cm		
5.1 m	36 cm		HL 20 cm		

Example: Net Pile Volume of Stacked Wood

The net pile volume is the gross pile volume minus any allowable deductions for cull, defect, void and undersize. All volumes are recorded in stacked cubic metres.

In figure 30 the stack of 2.54 m rough wood is 7.32 m long and 1.28 m high. In addition to sound wood, it contains the following defects, voids and undersize bolts:

- two 8 cm jack pine undersize bolts
- one 30 cm spruce bolt with a 24 cm defect
- one 26 cm jack pine bolt with a 16 cm defect
- four 12 cm voids

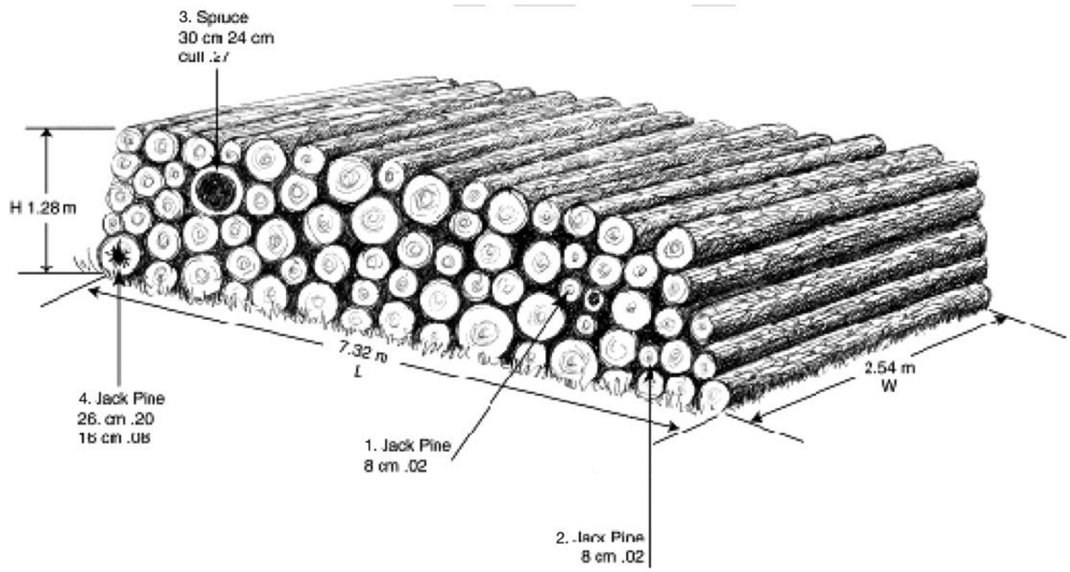

Figure 30 Net pile volume

To determine the net volume of wood in this stack (Figure 30):

Step # 1

Gross Volume of stack is:

$H \times L \times W$ = stacked cubic metres correct to 2 decimal places

$1.28 \times 7.32 \times 2.54 = 23.79898 = 23.80$ m^3 STK

Gross volume of the stack is 23.80 m^{3}STK

Step # 2

Calculate the volume of undersize, cull, defect, and void in the stack:

Undersize Deduction

Two bolts 8 cm diameter = 0.02 m^3 STK as read from MC-1 stick

Undersize volume = $0.02 \times 2 = 0.04$ m^3 STK

Undersize volume of the stack is 0.04 m^3 STK.

Cull Deduction

30 cm in diameter with a 24 cm defect is a cull

30 cm diameter = 0.27 m^3 STK as read from MC-1 stick

Defect volume of this bolt is 0.27 m^3 STK

Defect deduction

26 cm in diameter with a 16 cm defect. This is not a cull.

16 cm diameter = 0.08 m^3 STK as read from MC-1 stick.

Defect volume of this bolt is 0.08 m^3 STK.

Void deduction

12 cm diameter voids = 0.04 m^3 STK as read from MC-1 stick

Deduction volume of voids = $4 \times 0.04 = 0.016$ m^3 STK.

Total deduction volume of the stack is $0.04 + 0.27 + 0.08 + 0.16 = 0.55$ m^3 STK.

Calculate the net volume of the stack:

Gross volume of stack	= 23.80
Less undersize volume	= 0.04
Less cull and defect volume	= 0.35
Less void volume	= 0.16
Net volume of stack	= 23.25 m^3 STK

Solid wood volume of stack (x .664) = 15.44 m^3 solid

VII. Infractions and Wasteful Practices Involving Crown Forest Resources

Infractions

All measurements of Crown forest resources relating to fines or penalties for unauthorized or improper harvesting and unauthorized hauling of Crown forest resources must be conducted by licensed and approved scalers or in a manner approved by ARD, such as an officer's estimate of the gross volume of the timber wasted.

Wasteful Practices

Leaving High Stumps

It is a wasteful practice to leave high stumps. Stump height is the vertical distance between the horizontal plane through the highest point of the stump and the horizontal plane through the highest point of the ground (includes boulders) at its base (Figure 31). A tree must be felled so that its stump height is equal to or less than 30 centimetres.

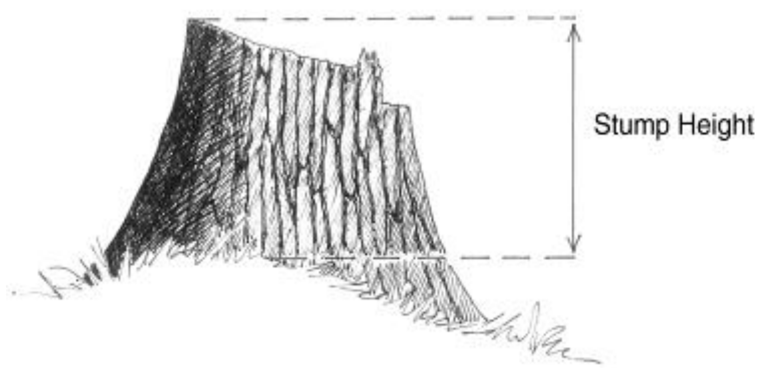

Figure 31 Stump height

Leaving Merchantable Timber of Any Length

It is a wasteful practice to leave merchantable timber of any length in any part of an approval area at the time when a licensee has:

- moved their operation to a different harvest block
- scaled the timber for Crown charges
- not scaled the timber for Crown charges
- abandoned their operating licence
- failed to renew their operating licence

Merchantable timber means:

- any **softwood** log in which more than one half the total content, measured in cubic metres, is sound wood
- in the case of a felled softwood log having a diameter of 10 centimetres (diameter class) or more inside the bark (DIB), at the smaller end (Figure 32)

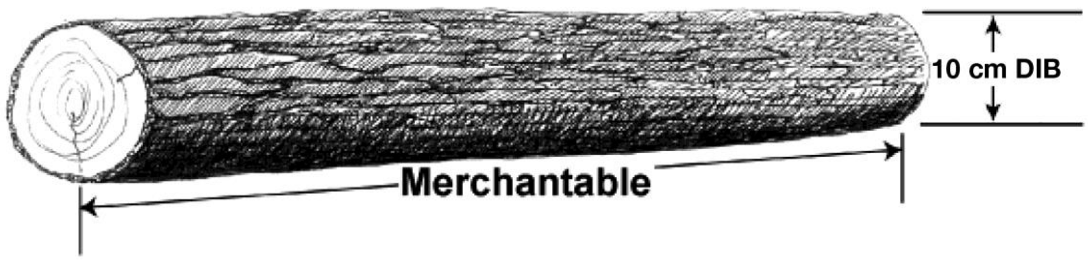

Figure 32 Merchantable softwood timber

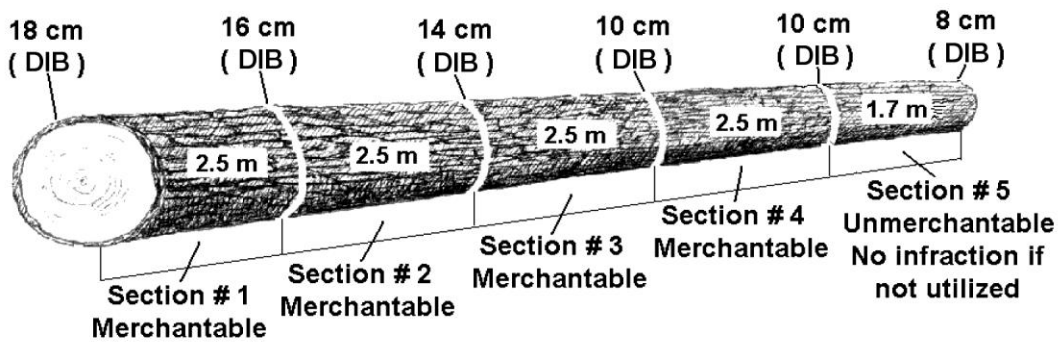

Figure 33 Softwood timber with unmerchantable section

- any **hardwood** log in which more than one half of the total content measured in cubic metres is sound wood
- in the case of felled hardwood timber having a diameter of 12 centimetres (diameter class) or more inside the bark (DIB), at the smaller end (Figure 34)

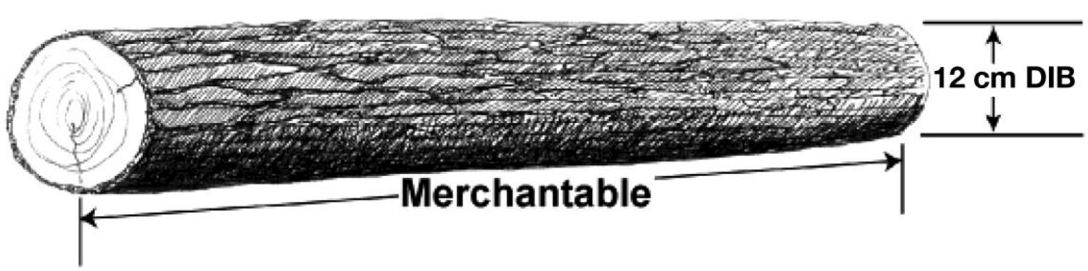

Figure 34 Merchantable hardwood timber

Heavy branching means the lowest part of a tree where the growth of branches is so concentrated that the timber in that section is considered unmerchantable.

The term "merchantable timber of any length" does not apply to **all hardwoods and conifers** beyond the point of heavy branching where a piece less than 2.5 metres remains (Figure 35).

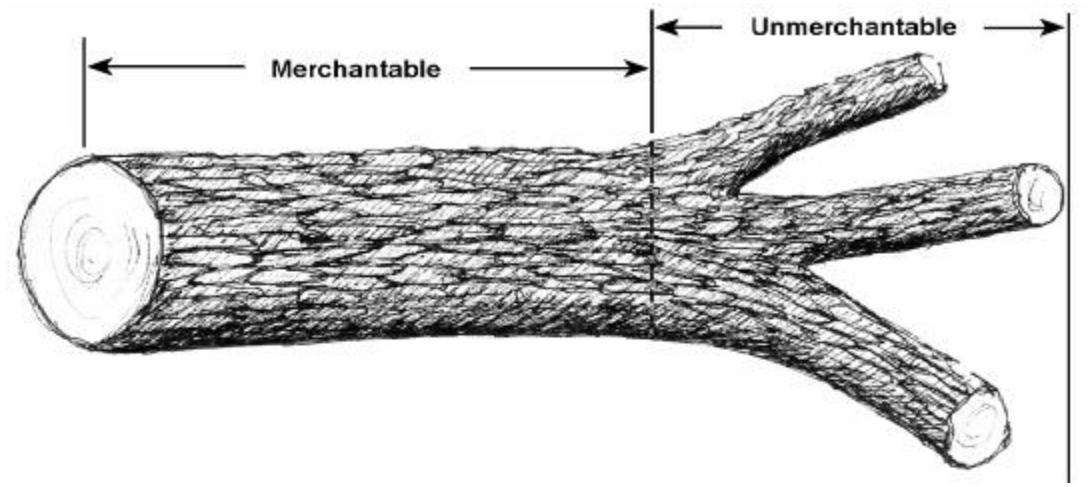

Figure 35 Unmerchantable sections that are less than 2.5 metres in length in an area of heavy branching

The term "merchantable timber of any length" does not apply where a piece less than 2.5 metres in length remains after an unmerchantable section is encountered on the top end of the stem only (Figure 36).

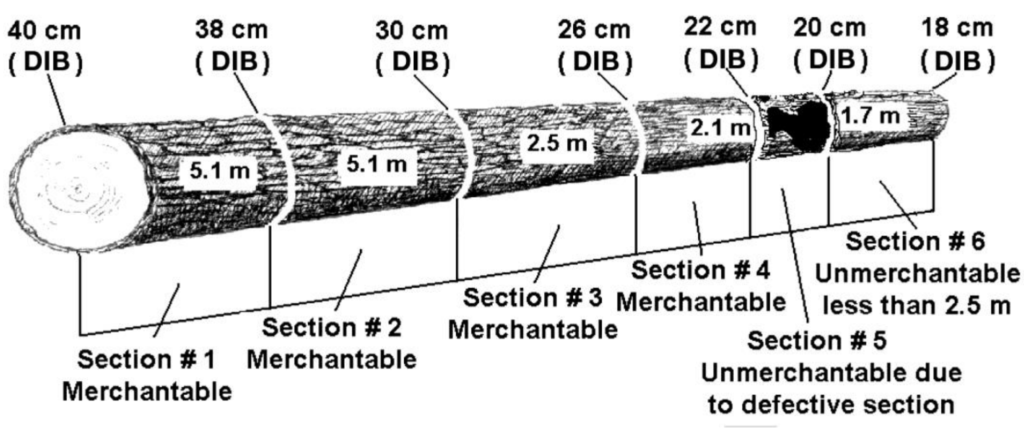

Figure 36 Timber with unmerchantable sections

Not Utilizing Wood Chip Fibre

It is a wasteful practice not to use wood chip fibre.

Wood chip fibre is chip fibre of any species produced by a chip manufacturing facility, whether fixed or mobile.

Figure 37 Un-utilized wood chip fibre.

Assessment of Penalties
Administrative penalties for wasteful practices, as defined by the minimum utilization standards described in this manual:

An administrative penalty for wasteful practices may be assessed even if the timber:
- has been measured, stumpage values collected and no reasonable market opportunity exists
- has been measured and stumpage values have not been collected
- has not been measured

Unauthorized Harvesting
Unauthorized harvesting or possession of unauthorized Crown forest resources occurs in any of the following situations:
- a person harvests resources in a Crown forest without the authority of a licence
- a person fails to comply with the terms of a licence
- a licensee harvests Crown forest resources without a work permit
- a licensee harvests Crown forest resources outside the licence area

Unauthorized Hauling of Crown Forest Resources
Unauthorized hauling is the movement of Crown forest resources from the place of harvesting before measurement, without the written approval of the Director of Forestry.

VIII. Movement and Measurement of Crown Forest Resources

Scaling Plans
Scaling plans are documents communicating the most likely licensed scaler to measure crown wood and the destination of the crown wood. Scaling plans may also be used by ARD to establish an agreement with industry for the measurement and reporting of scaling data for Crown wood not being sent to a weigh scale. (see appendix 5)

Scaling Plans address elements such as:
- parties to the agreement
- name and licence number of licensed scaler
- scaling location
- scaling method
- method and schedule of reporting measurement data
- management of records
- final destination
- estimated volume
- other elements as required

Movement of Unscaled Crown Forest Resources

Unscaled Crown forest resources must not be moved from the place of harvest without authorization of the Director of Forestry.

Unless permitted under an approved scaling plan or by a written authorization from an officer, no Crown timber cut under the authority of a commercial timber cutting right may be removed from the area where it was cut unless it has been scaled by a scaler (Forest Use and Management Regulation).

Load Slip

Load slips are required for the movement of Crown forest resources and to help tracking and auditing. (appendix 6 and appendix 7)

All load slips must:

- be approved by ARD
- be pre-numbered consecutively on all copies
- contain the following minimum information:
  - shipper/seller name and address
  - receiver/purchaser name and address
  - cutting authority
  - signature of timber owner/designate
  - species/product
  - estimated quantity of timber
  - date/time loaded
  - truck/trailer licence numbers
  - truck operator signature
  - transaction number
  - receiver signature
  - date/time received

IX. Sampling for Factors

When the calculation of volumes and determination of stumpage values requires the application of scaling factors, it is critical to both the forest industry and ARD that accurate factors be developed and maintained. To ensure the accuracy of data collected during sampling, only licensed, approved, experienced scalers must be assigned to this work. They should be regularly check scaled. The allowable margin of error is **±3 per cent** of the official check scale.

All sampling for these factors requires a well-designed sampling plan approved by ARD.

The types of sampling carried out in the province are:

- **Mass/Volume**: This sampling is required when Crown forest resources are mass measured to determine a weight to volume ratio. The procedure is detailed in the Mass Scaling Method section. See appendix 9 for a sample tally sheet.

- **Undersize and Defect:** Determination of undersize and defect factors is required where Crown forest resources are mass or tree length scaled for a number of mill facilities in Manitoba. See appendix 10 for a description of the procedures and a sample tally sheet.

- **Chipperwood:** Sampling of chipperwood is required to verify undersize percentages for mill facilities in Manitoba. See appendix 11 for a description of the procedures and a sample tally sheet.

- **Post and Rail:** Sampling is required at mill facilities producing post and rail material. See appendix 12 for a description of the procedures and a sample tally sheet.

X. Information Collection and Management

Data Collectors

Data collectors are portable computerized units used for recording data. They must meet standards that allow for collecting and transferring data to ARD's data management system. Data from the units must be downloaded and backed-up regularly. A hard copy of all data must be available upon request by ARD. Use of data collectors must be approved by ARD.

Tally Sheets, Forms and Records

All Crown forest resources measured must be recorded on forms approved by ARD.

All scale returns must be sent to ARD in a timely manner. The company and ARD will agree on a transfer schedule. Where companies fail to forward scale returns on schedule, ARD may apply interest penalties on the volumes of Crown forest resources not processed.

Electronic Data Transfer

Electronic data transfer is an economical method of transferring scaling returns directly from the company source to ARD's data management system. Scaling data passing through a company electronic transfer system must not be altered prior to transmission to the Crown. Any such data transfer system must be designed with safeguards for protecting the Crown's interests.

The current methods of electronic data transfer make use of:

- on line transfer

- internet transfer

The timber sales manager sets the standards and approves the transfer procedure. The timber harvesting authority will define the schedule for the transfer of scale data (electronic or hard copy) to ARD from the company. Where companies fail to transmit scale returns on schedule, ARD may apply interest penalties on the volumes of Crown forest resources not processed.

Glossary of Terms

Butt Swell – is excessive flair beyond the normal taper of the log on the end of the log originally attached to the stump.

Catface – a defect on the surface of a log resulting from a wound where healing has not re-established the normal cross-section of the log.

Church Door – a defect, caused by a ground fire, resulting in a tapered piece of wood missing from the butt end of a butt log.

Crown Charges – This means all prices, charges, fees, penalties, costs, expenses, interest and fines imposed.

Check Scale – This is a second scale or measurement undertaken by another proficient scaler. It is primarily used for comparing the work of other scalers to maintain a uniform level of performance and control human error associated with scaling.

Heart Rot – rot that is confined to the heartwood of the log. Usually originates in the living tree.

Licensee – A person or company to whom a Licence (Forest Management Licence Agreement, Timber Sale Agreement, or Timber Permit) has been granted.

Operating Year – This is a twelve month period commencing on the 1st day of April in any year and ending on the 31st day of March in the following year.

Pipe Rot – a hole that is produced by decay and runs through the centre of a log.

Pocket Rot – rot localized in small areas and generally forming rounded or lens-shaped cavities. Also known as honeycomb decay.

Primary Forest Products – These are obtained from a forest and consist of commercially valuable raw material. The material is usually roundwood and woodchips.

Primary Wood Products – These are obtained from the stem, limbs or cut tree and have commercial value.

Punk Rot – a soft, weak or spongy condition of the wood caused by decay.

Rescale – This is a second scale of a quantity of wood when parties are not in agreement as to the original or first scale.

Scale Records – These include but are not limited to: scale tallies, delivery ledgers, summaries, statements of the amount of timber measured, purchase records and payment records.

Stumpage Values – In this manual, the term means the Timber dues value, the Forest Renewal Charge, the Forest Protection Charge and any included applicable bid prices.

Timber – In this Manual, timber includes Crown forest resources that are fixed length, tree length and wood chip fibre.

Tree Length – This is a term used to describe a tree after it has been felled, limbed and topped.

Undersize – This is any material below the minimum diameters defined in the utilization standards of this Manual.

Valid Licensed Scale – This is a scale undertaken by the holder of a valid Scalers Licence.

References

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Table 1 Table of Squared Numbers

$4^2 = 16$	$48^2 = 2304$
$6^2 = 36$	$50^2 = 2500$
$8^2 = 64$	$52^2 = 2704$
$10^2 = 100$	$54^2 = 2916$
$12^2 = 144$	$56^2 = 3136$
$14^2 = 196$	$58^2 = 3364$
$16^2 = 256$	$60^2 = 3600$
$18^2 = 324$	$62^2 = 3844$
$20^2 = 400$	$64^2 = 4096$
$22^2 = 484$	$66^2 = 4356$
$24^2 = 576$	$68^2 = 4624$
$26^2 = 676$	$70^2 = 4900$
$28^2 = 784$	$72^2 = 5184$
$30^2 = 900$	$74^2 = 5476$
$32^2 = 1024$	$76^2 = 5776$
$34^2 = 1156$	$78^2 = 6084$
$36^2 = 1296$	$80^2 = 6400$
$38^2 = 1444$	$82^2 = 6724$
$40^2 = 1600$	$84^2 = 7056$
$42^2 = 1764$	$86^2 = 7396$
$44^2 = 1936$	$88^2 = 7744$
$46^2 = 2116$	$90^2 = 8100$

Table 2 Area of a Circle in Square Metres (m^2)

Diameter (cm)	Area (m^2)	Diameter (cm)	Area (m^2)
4.0	0.0013	66.0	0.3421
6.0	0.0028	68.0	0.3632
8.0	0.0050	70.0	0.3848
10.0	0.0079	72.0	0.4072
12.0	0.0113	74.0	0.4301
14.0	0.0154	76.0	0.4536
16.0	0.0201	78.0	0.4778
18.0	0.0254	80.0	0.5027
20.0	0.0314	82.0	0.5281
22.0	0.0380	84.0	0.5542
24.0	0.0452	86.0	0.5809
26.0	0.0531	88.0	0.6082
28.0	0.0616	90.0	0.6362
30.0	0.0707	92.0	0.6648
32.0	0.0804	94.0	0.6940
34.0	0.0908	96.0	0.7238
36.0	0.1018	98.0	0.7543
38.0	0.1134	100.0	0.7854
40.0	0.1257	102.0	0.8171
42.0	0.1385	104.0	0.8495
44.0	0.1521	106.0	0.8825
46.0	0.1662	108.0	0.9161
48.0	0.1810	110.0	0.9503
50.0	0.1963	112.0	0.9852
52.0	0.2124	114.0	1.0207
54.0	0.2290	116.0	1.0568
56.0	0.2463	118.0	1.0936
58.0	0.2642	120.0	1.1310
60.0	0.2827	122.0	1.1690
62 0	0.3019	124.0	1.2076
64.0	0.3217	126.0	1.2469
		128.0	1.2868

Table 3: Log Volume in Cubic Metres of Cylinders

DIAMETER	LENGTH IN METRES																					
cm	**0.9**	**1.1**	**1.3**	**1.5**	**1.7**	**1.9**	**2.1**	**2.3**	**2.5**	**2.7**	**2.9**	**3.1**	**3.3**	**3.5**	**3.7**	**3.9**	**4.1**	**4.3**	**4.5**	**4.7**	**4.9**	**5.1**	**5.3**
4	0.001	0.001	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007
6	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.011	0.012	0.012	0.013	0.013	0.014	0.014	0.015
8	0.005	0.006	0.007	0.008	0.009	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019	0.020	0.021	0.022	0.023	0.024	0.025	0.026	0.027
10	0.007	0.009	0.010	0.012	0.013	0.015	0.016	0.018	0.020	0.021	0.023	0.024	0.026	0.027	0.029	0.031	0.032	0.034	0.035	0.037	0.038	0.040	0.042
12	0.010	0.012	0.015	0.017	0.019	0.021	0.024	0.026	0.028	0.031	0.033	0.035	0.037	0.040	0.042	0.044	0.046	0.049	0.051	0.053	0.055	0.058	0.060
14	0.014	0.017	0.020	0.023	0.026	0.029	0.032	0.035	0.038	0.042	0.045	0.048	0.051	0.054	0.057	0.060	0.063	0.066	0.069	0.072	0.075	0.079	0.082
16	0.018	0.022	0.026	0.030	0.034	0.038	0.042	0.046	0.050	0.054	0.058	0.062	0.066	0.070	0.074	0.078	0.082	0.086	0.090	0.094	0.099	0.103	0.107
18	0.023	0.028	0.033	0.038	0.043	0.048	0.053	0.059	0.064	0.069	0.074	0.079	0.084	0.089	0.094	0.099	0.104	0.109	0.115	0.120	0.125	0.130	0.135
20	0.028	0.035	0.041	0.047	0.053	0.060	0.066	0.072	0.079	0.085	0.091	0.097	0.104	0.110	0.116	0.123	0.129	0.135	0.141	0.148	0.154	0.160	0.167
22	0.034	0.042	0.049	0.057	0.065	0.072	0.080	0.087	0.095	0.103	0.110	0.118	0.125	0.133	0.141	0.148	0.156	0.163	0.171	0.179	0.186	0.194	0.201
24	0.041	0.050	0.059	0.068	0.077	0.086	0.095	0.104	0.113	0.122	0.131	0.140	0.149	0.158	0.167	0.176	0.185	0.195	0.204	0.213	0.222	0.231	0.240
26	0.048	0.058	0.069	0.080	0.090	0.101	0.111	0.122	0.133	0.143	0.154	0.165	0.175	0.186	0.196	0.207	0.218	0.228	0.239	0.250	0.260	0.271	0.281
28	0.055	0.068	0.080	0.092	0.105	0.117	0.129	0.142	0.154	0.166	0.179	0.191	0.203	0.216	0.228	0.240	0.252	0.265	0.277	0.289	0.302	0.314	0.326
30	0.064	0.078	0.092	0.106	0.120	0.134	0.148	0.163	0.177	0.191	0.205	0.219	0.233	0.247	0.262	0.276	0.290	0.304	0.318	0.332	0.346	0.360	0.375
32	0.072	0.088	0.105	0.121	0.137	0.153	0.169	0.185	0.201	0.217	0.233	0.249	0.265	0.281	0.298	0.314	0.330	0.346	0.362	0.378	0.394	0.410	0.426
34	0.082	0.100	0.118	0.136	0.154	0.173	0.191	0.209	0.227	0.245	0.263	0.281	0.300	0.318	0.336	0.354	0.372	0.390	0.409	0.427	0.445	0.463	0.481
36	0.092	0.112	0.132	0.153	0.173	0.193	0.214	0.234	0.254	0.275	0.295	0.316	0.336	0.356	0.377	0.397	0.417	0.438	0.458	0.478	0.499	0.519	0.539
38	0.102	0.125	0.147	0.170	0.193	0.215	0.238	0.261	0.284	0.306	0.329	0.352	0.374	0.397	0.420	0.442	0.465	0.488	0.510	0.533	0.556	0.578	0.601
40	0.113	0.138	0.163	0.188	0.214	0.239	0.264	0.289	0.314	0.339	0.364	0.390	0.415	0.440	0.465	0.490	0.515	0.540	0.565	0.591	0.616	0.641	0.666
42	0.125	0.152	0.180	0.208	0.236	0.263	0.291	0.319	0.346	0.374	0.402	0.429	0.457	0.485	0.513	0.540	0.568	0.596	0.623	0.651	0.679	0.707	0.734
44	0.137	0.167	0.198	0.228	0.258	0.289	0.319	0.350	0.380	0.411	0.441	0.471	0.502	0.532	0.563	0.593	0.623	0.654	0.684	0.715	0.745	0.775	0.806
46	0.150	0.183	0.216	0.249	0.283	0.316	0.349	0.382	0.415	0.449	0.482	0.515	0.548	0.582	0.615	0.648	0.681	0.715	0.748	0.781	0.814	0.848	0.881
48	0.163	0.199	0.235	0.271	0.308	0.344	0.380	0.416	0.452	0.489	0.525	0.561	0.597	0.633	0.670	0.706	0.742	0.778	0.814	0.850	0.887	0.923	0.959
50	0.177	0.216	0.255	0.295	0.334	0.373	0.412	0.452	0.491	0.530	0.569	0.609	0.648	0.687	0.726	0.766	0.805	0.844	0.884	0.923	0.962	1.001	1.041
52	0.191	0.234	0.276	0.319	0.361	0.404	0.446	0.488	0.531	0.573	0.616	0.658	0.701	0.743	0.786	0.828	0.871	0.913	0.956	0.998	1.041	1.083	1.126
54	0.206	0.252	0.298	0.344	0.389	0.435	0.481	0.527	0.573	0.618	0.664	0.710	0.756	0.802	0.847	0.893	0.939	0.985	1.031	1.076	1.122	1.168	1.214
56	0.222	0.271	0.320	0.369	0.419	0.468	0.517	0.566	0.616	0.665	0.714	0.764	0.813	0.862	0.911	0.961	1.010	1.059	1.108	1.158	1.207	1.256	1.305
58	0.238	0.291	0.343	0.396	0.449	0.502	0.555	0.608	0.661	0.713	0.766	0.819	0.872	0.925	0.978	1.030	1.083	1.136	1.189	1.242	1.295	1.347	1.400
60	0.254	0.311	0.368	0.424	0.481	0.537	0.594	0.650	0.707	0.763	0.820	0.877	0.933	0.990	1.046	1.103	1.159	1.216	1.272	1.329	1.385	1.442	1.499
62	0.272	0.332	0.392	0.453	0.513	0.574	0.634	0.694	0.755	0.815	0.876	0.936	0.996	1.057	1.117	1.177	1.238	1.298	1.359	1.419	1.479	1.540	1.600
64	0.290	0.354	0.418	0.483	0.547	0.611	0.676	0.740	0.804	0.869	0.933	0.997	1.062	1.126	1.190	1.255	1.319	1.383	1.448	1.512	1.576	1.641	1.705

Table 3: Log Volume in Cubic Metres of Cylinders

DIAMETER	LENGTH IN METRES																					
cm	**0.9**	**1.1**	**1.3**	**1.5**	**1.7**	**1.9**	**2.1**	**2.3**	**2.5**	**2.7**	**2.9**	**3.1**	**3.3**	**3.5**	**3.7**	**3.9**	**4.1**	**4.3**	**4.5**	**4.7**	**4.9**	**5.1**	**5.3**
66	0.308	0.376	0.445	0.513	0.582	0.650	0.718	0.787	0.855	0.924	0.992	1.061	1.129	1.197	1.266	1.334	1.403	1.471	1.540	1.608	1.676	1.745	1.813
68	0.327	0.399	0.472	0.545	0.617	0.690	0.763	0.835	0.908	0.981	1.053	1.126	1.198	1.271	1.344	1.416	1.489	1.562	1.634	1.707	1.780	1.852	1.925
70	0.346	0.423	0.500	0.577	0.654	0.731	0.808	0.885	0.962	1.039	1.116	1.193	1.270	1.347	1.424	1.501	1.578	1.655	1.732	1.809	1.886	1.963	2.040
72	0.366	0.448	0.529	0.611	0.692	0.774	0.855	0.936	1.018	1.099	1.181	1.262	1.344	1.425	1.506	1.588	1.669	1.751	1.832	1.914	1.995	2.076	2.158
74	0.387	0.473	0.559	0.645	0.731	0.817	0.903	0.989	1.075	1.161	1.247	1.333	1.419	1.505	1.591	1.677	1.763	1.849	1.935	2.021	2.107	2.193	2.279
76	0.408	0.499	0.590	0.680	0.771	0.862	0.953	1.043	1.134	1.225	1.316	1.406	1.497	1.588	1.678	1.769	1.860	1.951	2.041	2.132	2.223	2.314	2.404
78	0.430	0.526	0.621	0.717	0.812	0.908	1.003	1.099	1.195	1.290	1.386	1.481	1.577	1.672	1.768	1.864	1.959	2.055	2.150	2.246	2.341	2.437	2.533
80	0.452	0.553	0.653	0.754	0.855	0.955	1.056	1.156	1.257	1.357	1.458	1.558	1.659	1.759	1.860	1.960	2.061	2.161	2.262	2.362	2.463	2.564	2.664
82	0.475	0.581	0.687	0.792	0.898	1.003	1.109	1.215	1.320	1.426	1.531	1.637	1.743	1.848	1.954	2.060	2.165	2.271	2.376	2.482	2.588	2.693	2.799
84	0.499	0.610	0.720	0.831	0.942	1.053	1.164	1.275	1.385	1.496	1.607	1.718	1.829	1.940	2.050	2.161	2.272	2.383	2.494	2.605	2.715	2.826	2.937
86	0.523	0.639	0.755	0.871	0.987	1.104	1.220	1.336	1.452	1.568	1.685	1.801	1.917	2.033	2.149	2.265	2.382	2.498	2.614	2.730	2.846	2.962	3.079
88	0.547	0.669	0.791	0.912	1.034	1.156	1.277	1.399	1.521	1.642	1.764	1.885	2.007	2.129	2.250	2.372	2.494	2.615	2.737	2.859	2.980	3.102	3.224
90	0.573	0.700	0.827	0.954	1.081	1.209	1.336	1.463	1.590	1.718	1.845	1.972	2.099	2.227	2.354	2.481	2.608	2.736	2.863	2.990	3.117	3.244	3.372
92	0.598	0.731	0.864	0.997	1.130	1.263	1.396	1.529	1.662	1.795	1.928	2.061	2.194	2.327	2.460	2.593	2.726	2.858	2.991	3.124	3.257	3.390	3.523
94	0.625	0.763	0.902	1.041	1.180	1.319	1.457	1.596	1.735	1.874	2.013	2.151	2.290	2.429	2.568	2.707	2.845	2.984	3.123	3.262	3.400	3.539	3.678
96	0.651	0.796	0.941	1.086	1.230	1.375	1.520	1.665	1.810	1.954	2.099	2.244	2.389	2.533	2.678	2.823	2.968	3.112	3.257	3.402	3.547	3.691	3.836
98	0.679	0.830	0.981	1.131	1.282	1.433	1.584	1.735	1.886	2.037	2.187	2.338	2.489	2.640	2.791	2.942	3.093	3.243	3.394	3.545	3.696	3.847	3.998
100	0.707	0.864	1.021	1.178	1.335	1.492	1.649	1.806	1.963	2.121	2.278	2.435	2.592	2.749	2.906	3.063	3.220	3.377	3.534	3.691	3.848	4.006	4.163
102	0.735	0.899	1.062	1.226	1.389	1.553	1.716	1.879	2.043	2.206	2.370	2.533	2.697	2.860	3.023	3.187	3.350	3.514	3.677	3.840	4.004	4.167	4.331
104	0.765	0.934	1.104	1.274	1.444	1.614	1.784	1.954	2.124	2.294	2.464	2.633	2.803	2.973	3.143	3.313	3.483	3.653	3.823	3.993	4.162	4.332	4.502
106	0.794	0.971	1.147	1.324	1.500	1.677	1.853	2.030	2.206	2.383	2.559	2.736	2.912	3.089	3.265	3.442	3.618	3.795	3.971	4.148	4.324	4.501	4.667
108	0.824	1.008	1.191	1.374	1.557	1.741	1.924	2.107	2.290	2.473	2.657	2.840	3.023	3.206	3.390	3.573	3.756	3.939	4.122	4.306	4.489	4.672	4.855
110	0.855	1.045	1.235	1.425	1.616	1.806	1.996	2.186	2.376	2.566	2.756	2.946	3.136	3.326	3.516	3.706	3.896	4.086	4.276	4.467	4.657	4.847	5.037
112	0.887	1.084	1.281	1.478	1.675	1.872	2.069	2.266	2.463	2.660	2.857	3.054	3.251	3.448	3.645	3.842	4.039	4.236	4.433	4.630	4.827	5.025	5.222
114	0.919	1.123	1.327	1.531	1.735	1.939	2.143	2.348	2.552	2.756	2.960	3.164	3.368	3.572	3.777	3.981	4.185	4.389	4.593	4.797	5.001	5.206	5.410

Table 3: Log Volume in Cubic Metres of Cylinders

DIAMETER	LENGTH IN METRES																				
cm	**5.5**	**5.7**	**5.9**	**6.1**	**6.3**	**6.5**	**6.7**	**6.9**	**7.1**	**7.3**	**7.5**	**7.7**	**7.9**	**8.1**	**8.3**	**8.5**	**8.7**	**8.9**	**9.1**	**9.3**	**9.5**	**9.7**
4	0.007	0.007	0.007	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.010	0.010	0.010	0.010	0.011	0.011	0.011	0.011	0.012	0.012	0.012
6	0.016	0.016	0.017	0.017	0.018	0.018	0.018	0.020	0.020	0.021	0.021	0.022	0.022	0.023	0.023	0.024	0.025	0.025	0.026	0.026	0.027	0.027
8	0.028	0.029	0.030	0.031	0.032	0.033	0.034	0.035	0.036	0.037	0.038	0.039	0.040	0.041	0.042	0.043	0.044	0.045	0.046	0.047	0.048	0.049
10	0.043	0.045	0.046	0.048	0.049	0.051	0.053	0.054	0.056	0.057	0.059	0.060	0.062	0.064	0.065	0.067	0.068	0.070	0.071	0.073	0.075	0.076
12	0.062	0.064	0.067	0.069	0.071	0.074	0.076	0.078	0.080	0.083	0.085	0.087	0.089	0.092	0.094	0.096	0.098	0.101	0.103	0.105	0.107	0.110
14	0.085	0.088	0.091	0.094	0.097	0.100	0.103	0.106	0.109	0.112	0.115	0.119	0.122	0.125	0.128	0.131	0.134	0.137	0.140	0.143	0.146	0.149
16	0.111	0.115	0.119	0.123	0.127	0.131	0.135	0.139	0.143	0.147	0.151	0.155	0.159	0.163	0.167	0.171	0.175	0.179	0.183	0.187	0.191	0.195
18	0.140	0.145	0.150	0.155	0.160	0.165	0.170	0.176	0.181	0.186	0.191	0.196	0.201	0.206	0.211	0.216	0.221	0.226	0.232	0.237	0.242	0.247
20	0.173	0.179	0.185	0.192	0.198	0.204	0.210	0.217	0.223	0.229	0.236	0.242	0.248	0.254	0.261	0.267	0.273	0.280	0.286	0.292	0.298	0.305
22	0.209	0.217	0.224	0.232	0.239	0.247	0.255	0.262	0.270	0.277	0.385	0.293	0.300	0.308	0.316	0.323	0.331	0.338	0.346	0.354	0.361	0.369
24	0.249	0.258	0.267	0.276	0.285	0.294	0.303	0.312	0.321	0.330	0.339	0.348	0.357	0.366	0.375	0.385	0.394	0.403	0.412	0.421	0.430	0.439
26	0.292	0.303	0.313	0.324	0.334	0.345	0.356	0.366	0.377	0.388	0.398	0.409	0.419	0.430	0.441	0.451	0.462	0.473	0.483	0.494	0.504	0.515
28	0.339	0.351	0.363	0.376	0.388	0.400	0.413	0.425	0.437	0.449	0.462	0.474	0.486	0.499	0.511	0.523	0.536	0.548	0.560	0.573	0.585	0.597
30	0.389	0.403	0.417	0.431	0.445	0.459	0.474	0.488	0.502	0.516	0.530	0.544	0.558	0.573	0.587	0.601	0.615	0.629	0.643	0.657	0.672	0.686
32	0.442	0.458	0.475	0.491	0.507	0.523	0.539	0.555	0.571	0.587	0.603	0.619	0.635	0.651	0.668	0.684	0.700	0.716	0.732	0.748	0.764	0.780
34	0.499	0.518	0.536	0.554	0.572	0.590	0.608	0.626	0.645	0.663	0.681	0.699	0.717	0.735	0.754	0.772	0.790	0.808	0.826	0.844	0.863	0.881
36	0.560	0.580	0.601	0.621	0.641	0.662	0.682	0.702	0.723	0.743	0.763	0.784	0.804	0.824	0.845	0.865	0.886	0.906	0.926	0.947	0.967	0.987
38	0.624	0.646	0.669	0.692	0.714	0.737	0.760	0.783	0.805	0.828	0.851	0.873	0.896	0.919	0.941	0.964	0.987	1.009	1.032	1.055	1.077	1.100
40	0.691	0.716	0.741	0.767	0.792	0.817	0.842	0.867	0.892	0.917	0.942	0.968	0.993	1.018	1.043	1.068	1.093	1.118	1.144	1.169	1.194	1.219
42	0.762	0.790	0.817	0.845	0.873	0.901	0.928	0.956	0.984	1.011	1.039	1.067	1.094	1.122	1.150	1.178	1.205	1.233	1.261	1.288	1.316	1.344
44	0.836	0.867	0.897	0.928	0.958	0.988	1.019	1.049	1.080	1.110	1.140	1.171	1.201	1.232	1.262	1.292	1.323	1.353	1.384	1.414	1.445	1.475
46	0.914	0.947	0.981	1.014	1.047	1.080	1.113	1.147	1.180	1.213	1.246	1.280	1.313	1.346	1.379	1.413	1.446	1.479	1.512	1.546	1.579	1.612
48	0.995	1.031	1.068	1.104	1.140	1.176	1.212	1.249	1.285	1.321	1.357	1.393	1.430	1.466	1.502	1.538	1.574	1.611	1.647	1.683	1.719	1.755
50	1.080	1.119	1.158	1.198	1.237	1.276	1.316	1.355	1.394	1.433	1.473	1.512	1.551	1.590	1.630	1.669	1.708	1.748	1.787	1.826	1.865	1.905
52	1.168	1.211	1.253	1.295	1.338	1.380	1.423	1.465	1.508	1.550	1.593	1.635	1.678	1.720	1.763	1.805	1.848	1.890	1.933	1.975	2.018	2.060
54	1.260	1.305	1.351	1.397	1.443	1.489	1.534	1.580	1.626	1.672	1.718	1.763	1.809	1.855	1.901	1.947	1.992	2.038	2.084	2.130	2.176	2.222
56	1.355	1.404	1.453	1.502	1.552	1.601	1.650	1.699	1.749	1.798	1.847	1.897	1.946	1.995	2.044	2.094	2.143	2.192	2.241	2.291	2.340	2.389
58	1.453	1.506	1.559	1.612	1.665	1.717	1.770	1.823	1.876	1.929	1.982	2.034	2.087	2.140	2.193	2.246	2.299	2.351	2.404	2.457	2.510	2.563
60	1.555	1.612	1.668	1.725	1.781	1.838	1.894	1.951	2.007	2.064	2.121	2.177	2.234	2.290	2.347	2.403	2.460	2.516	2.573	2.630	2.686	2.743
62	1.660	1.721	1.781	1.842	1.902	1.962	2.023	2.083	2.144	2.204	2.264	2.325	2.385	2.445	2.506	2.566	2.627	2.687	2.747	2.808	2.868	2.928
64	1.769	1.834	1.898	1.962	2.027	2.091	2.155	2.220	2.284	2.348	2.413	2.477	2.541	2.606	2.670	2.734	2.799	2.863	2.927	2.992	3.056	3.120

Table 3: Log Volume in Cubic Metres of Cylinders

DIAMETER	LENGTH IN METRES																					
cm	**5.5**	**5.7**	**5.9**	**6.1**	**6.3**	**6.5**	**6.7**	**6.9**	**7.1**	**7.3**	**7.5**	**7.7**	**7.9**	**8.1**	**8.3**	**8.5**	**8.7**	**8.9**	**9.1**	**9.3**	**9.5**	**9.7**
66	1.882	1.950	2.019	2.087	2.155	2.224	2.292	2.361	2.429	2.497	2.566	2.634	2.703	2.771	2.840	2.908	2.976	3.045	3.113	3.182	3.250	3.319
68	1.997	2.070	2.143	2.215	2.288	2.361	2.433	2.506	2.578	2.651	2.724	2.796	2.869	2.942	3.014	3.087	3.160	3.232	3.305	3.377	3.450	3.523
70	2.117	2.194	2.271	2.348	2.425	2.501	2.578	2.655	2.732	2.809	2.886	2.963	3.040	3.117	3.194	3.271	3.348	3.425	3.502	3.579	3.656	3.733
72	2.239	2.321	2.402	2.484	2.565	2.646	2.728	2.809	2.891	2.972	3.054	3.135	3.216	3.298	3.379	3.461	3.542	3.624	3.705	3.786	3.868	3.949
74	2.365	2.451	2.537	2.624	2.710	2.796	2.882	2.968	3.054	3.140	3.226	3.312	3.398	3.484	3.570	3.656	3.742	3.828	3.914	4.000	4.086	4.172
76	2.495	2.586	2.677	2.767	2.858	2.949	3.039	3.130	3.221	3.312	3.402	3.493	3.584	3.675	3.765	3.856	3.947	4.037	4.128	4.219	4.310	4.400
78	2.628	2.724	2.819	2.915	3.010	3.106	3.201	3.297	3.393	3.488	3.584	3.679	3.775	3.870	3.966	4.062	4.157	4.253	4.348	4.444	4.539	4.635
80	2.765	2.865	2.966	3.066	3.167	3.267	3.368	3.468	3.569	3.669	3.770	3.870	3.971	4.071	4.172	4.273	4.373	4.474	4.574	4.675	4.775	4.876
82	2.905	3.010	3.116	3.221	3.327	3.433	3.538	3.644	3.750	3.855	3.961	4.066	4.172	4.278	4.383	4.489	4.594	4.700	4.806	4.911	5.017	5.123
84	3.048	3.159	3.270	3.380	3.491	3.602	3.713	3.824	3.935	4.045	4.156	4.267	4.378	4.489	4.600	4.710	4.821	4.932	5.043	5.154	5.265	5.376
86	3.195	3.311	3.427	3.543	3.660	3.776	3.892	4.008	4.124	4.240	4.357	4.473	4.589	4.705	4.821	4.937	5.054	5.170	5.286	5.402	5.518	5.635
88	3.345	3.467	3.588	3.710	3.832	3.953	4.075	4.197	4.318	4.440	4.562	4.683	4.805	4.927	5.048	5.170	5.291	5.413	5.535	5.656	5.778	5.900
90	3.499	3.626	3.753	3.881	4.008	4.135	4.262	4.390	4.517	4.644	4.771	4.899	5.026	5.153	5.280	5.407	5.535	5.662	5.789	5.916	6.044	6.171
92	3.656	3.789	3.922	4.055	4.188	4.321	4.454	4.587	4.720	4.853	4.986	5.119	5.252	5.385	5.518	5.650	5.783	5.916	6.049	6.182	6.315	6.448
94	3.817	3.956	4.094	4.233	4.327	4.511	4.650	4.788	4.927	5.066	5.205	5.344	5.482	5.621	5.760	5.899	6.038	6.176	6.315	6.454	6.593	6.732
96	3.981	4.126	4.271	4.415	4.560	4.705	4.850	4.944	5.139	5.284	5.429	5.573	5.718	5.863	6.008	6.152	6.297	6.442	6.587	6.732	6.876	7.021
98	4.149	4.299	4.450	4.601	4.752	4.903	5.054	5.205	5.355	5.506	5.657	5.808	5.959	6.110	6.261	6.412	6.562	6.713	6.864	7.015	7.166	7.317
100	4.320	4.477	4.634	4.791	4.948	5.105	5.262	5.419	5.576	5.733	5.890	6.048	6.205	6.362	6.519	6.676	6.833	6.990	7.147	7.304	7.461	7.618
102	4.494	4.658	4.821	4.984	5.148	5.311	5.475	5.638	5.802	5.965	6.128	6.292	6.455	6.619	6.782	6.946	7.109	7.272	7.436	7.599	7.763	7.926
104	4.672	4.842	5.012	5.182	5.352	5.522	5.692	5.861	6.031	6.201	6.371	6.541	6.711	6.881	7.051	7.221	7.391	7.560	7.730	7.900	8.070	8.240
106	4.854	5.030	5.207	5.383	5.560	5.736	5.913	6.089	6.266	6.442	6.619	6.795	6.972	7.148	7.325	7.501	7.678	7.854	8.030	8.207	8.383	8.560
108	5.038	5.222	5.405	5.588	5.771	5.955	6.138	6.321	6.504	6.687	6.871	7.054	7.237	7.420	7.604	7.787	7.970	8.153	8.336	8.520	8.703	8.886
110	5.227	5.417	5.607	5.797	5.987	6.177	6.367	6.557	6.747	6.937	7.127	7.318	7.508	7.698	7.888	8.078	8.268	8.458	8.648	8.838	9.028	9.218
112	5.419	5.616	5.813	6.010	6.207	6.404	6.601	6.798	6.995	7.192	7.389	7.586	7.783	7.980	8.177	8.374	8.571	8.768	8.965	9.162	9.359	9.556
114	5.614	5.818	6.022	6.226	6.430	6.635	6.839	7.043	7.247	7.451	7.655	7.859	8.064	8.268	8.472	8.676	8.880	9.084	9.288	9.493	9.697	9.901

Table 4: Log Volume in Cubic Metres of Tapering Cylinders

DIAMETER (small end)	LENGTH IN METRES																						
cm	**0.9**	**1.1**	**1.3**	**1.5**	**1.7**	**1.9**	**2.1**	**2.3**	**2.5**	**2.7**	**2.9**	**3.1**	**3.3**	**3.5**	**3.7**	**3.9**	**4.1**	**4.3**	**4.5**	**4.7**	**4.9**	**5.1**	**5.3**
4	0.001	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.007	0.008	0.009	0.010	0.011	0.012	0.013	0.014	0.015	0.016	0.017	0.018
6	0.003	0.004	0.005	0.005	0.006	0.007	0.008	0.009	0.010	0.011	0.013	0.014	0.015	0.017	0.018	0.019	0.021	0.022	0.024	0.026	0.027	0.029	0.031
8	0.005	0.006	0.008	0.009	0.010	0.012	0.014	0.015	0.017	0.019	0.020	0.022	0.024	0.026	0.028	0.030	0.033	0.035	0.037	0.040	0.042	0.045	0.047
10	0.008	0.010	0.012	0.014	0.016	0.018	0.020	0.022	0.025	0.027	0.030	0.032	0.035	0.038	0.041	0.044	0.047	0.050	0.053	0.056	0.060	0.063	0.067
12	0.011	0.014	0.016	0.019	0.022	0.025	0.028	0.031	0.034	0.038	0.041	0.045	0.048	0.052	0.056	0.060	0.064	0.068	0.072	0.076	0.080	0.085	0.089
14	0.015	0.018	0.022	0.026	0.029	0.033	0.037	0.041	0.046	0.050	0.054	0.059	0.063	0.068	0.073	0.078	0.083	0.088	0.093	0.099	0.104	0.110	0.115
16	0.019	0.024	0.028	0.033	0.038	0.043	0.048	0.053	0.058	0.064	0.069	0.075	0.081	0.087	0.093	0.099	0.105	0.111	0.118	0.124	0.131	0.138	0.145
18	0.024	0.030	0.036	0.041	0.047	0.054	0.060	0.066	0.073	0.079	0.086	0.093	0.100	0.107	0.115	0.122	0.129	0.137	0.145	0.153	0.161	0.169	0.178
20	0.030	0.036	0.044	0.051	0.058	0.065	0.073	0.081	0.089	0.097	0.105	0.113	0.121	0.130	0.139	0.148	0.157	0.166	0.175	0.184	0.194	0.204	0.214
22	0.036	0.044	0.052	0.061	0.070	0.079	0.088	0.097	0.106	0.116	0.125	0.135	0.145	0.155	0.165	0.176	0.186	0.197	0.208	0.219	0.230	0.241	0.253
24	0.042	0.052	0.062	0.072	0.082	0.093	0.103	0.114	0.125	0.136	0.148	0.159	0.171	0.182	0.194	0.206	0.219	0.231	0.244	0.256	0.269	0.282	0.296
26	0.049	0.061	0.073	0.084	0.096	0.108	0.121	0.133	0.146	0.159	0.172	0.185	0.198	0.212	0.225	0.239	0.253	0.268	0.282	0.297	0.311	0.326	0.342
28	0.057	0.070	0.084	0.097	0.111	0.125	0.139	0.153	0.168	0.183	0.198	0.213	0.228	0.243	0.259	0.275	0.291	0.307	0.323	0.340	0.357	0.374	0.391
30	0.066	0.081	0.096	0.111	0.127	0.143	0.159	0.175	0.192	0.208	0.225	0.242	0.260	0.277	0.295	0.313	0.331	0.349	0.368	0.386	0.405	0.424	0.444
32	0.074	0.092	0.109	0.126	0.144	0.162	0.180	0.199	0.217	0.236	0.255	0.274	0.293	0.313	0.333	0.353	0.373	0.394	0.415	0.436	0.457	0.478	0.500
34	0.084	0.103	0.123	0.142	0.162	0.182	0.203	0.223	0.244	0.265	0.286	0.308	0.329	0.351	0.373	0.396	0.418	0.441	0.464	0.488	0.511	0.535	0.559
36	0.094	0.115	0.137	0.159	0.181	0.204	0.226	0.249	0.272	0.296	0.319	0.343	0.367	0.392	0.416	0.441	0.466	0.492	0.517	0.543	0.569	0.595	0.622
38	0.105	0.128	0.153	0.177	0.202	0.226	0.252	0.277	0.302	0.328	0.354	0.381	0.407	0.434	0.461	0.489	0.517	0.544	0.573	0.601	0.630	0.659	0.688
40	0.116	0.142	0.169	0.196	0.223	0.250	0.278	0.306	0.334	0.363	0.391	0.420	0.450	0.479	0.509	0.539	0.569	0.600	0.631	0.662	0.693	0.725	0.757
42	0.127	0.156	0.186	0.215	0.245	0.275	0.306	0.336	0.367	0.399	0.430	0.462	0.494	0.526	0.559	0.592	0.625	0.658	0.692	0.726	0.760	0.795	0.830
44	0.140	0.171	0.204	0.236	0.269	0.302	0.335	0.368	0.402	0.436	0.470	0.505	0.540	0.575	0.611	0.647	0.683	0.719	0.756	0.793	0.830	0.868	0.906
46	0.153	0.187	0.222	0.257	0.293	0.329	0.365	0.402	0.438	0.475	0.513	0.550	0.588	0.627	0.665	0.704	0.743	0.783	0.823	0.863	0.903	0.944	0.985
48	0.166	0.204	0.242	0.280	0.319	0.358	0.397	0.436	0.476	0.516	0.557	0.598	0.639	0.680	0.722	0.764	0.807	0.849	0.892	0.936	0.980	1.024	1.068
50	0.180	0.221	0.262	0.303	0.345	0.387	0.430	0.473	0.516	0.559	0.603	0.647	0.691	0.736	0.781	0.827	0.872	0.918	0.965	1.012	1.059	1.106	1.154
52	0.194	0.239	0.283	0.328	0.373	0.418	0.464	0.510	0.557	0.604	0.651	0.698	0.746	0.794	0.843	0.892	0.941	0.990	1.040	1.090	1.141	1.192	1.243
54	0.210	0.257	0.305	0.353	0.402	0.451	0.500	0.549	0.599	0.650	0.700	0.751	0.803	0.854	0.906	0.959	1.012	1.065	1.118	1.172	1.226	1.281	1.336
56	0.225	0.276	0.328	0.379	0.432	0.484	0.537	0.590	0.644	0.697	0.752	0.806	0.861	0.917	0.973	1.029	1.085	1.142	1.199	1.257	1.315	1.373	1.432
58	0.241	0.296	0.351	0.407	0.462	0.519	0.575	0.632	0.689	0.747	0.805	0.863	0.922	0.981	1.041	1.101	1.161	1.222	1.283	1.344	1.406	1.469	1.531
60	0.258	0.317	0.376	0.435	0.494	0.554	0.615	0.675	0.737	0.798	0.860	0.922	0.985	1.048	1.112	1.176	1.240	1.304	1.370	1.435	1.501	1.567	1.634
62	0.276	0.338	0.401	0.464	0.527	0.591	0.656	0.720	0.786	0.851	0.917	0.983	1.050	1.117	1.185	1.253	1.321	1.390	1.459	1.529	1.599	1.669	1.740
64	0.294	0.360	0.427	0.494	0.562	0.630	0.698	0.767	0.836	0.906	0.976	1.046	1.117	1.188	1.260	1.332	1.405	1.478	1.551	1.625	1.699	1.774	1.849
66	0.312	0.383	0.454	0.525	0.597	0.669	0.741	0.815	0.888	0.962	1.036	1.111	1.186	1.262	1.338	1.414	1.491	1.569	1.646	1.725	1.803	1.882	1.962
68	0.331	0.406	0.481	0.557	0.633	0.709	0.786	0.864	0.942	1.020	1.099	1.178	1.257	1.337	1.418	1.499	1.580	1.662	1.744	1.827	1.910	1.994	2.078
70	0.351	0.430	0.510	0.590	0.670	0.751	0.833	0.914	0.997	1.080	1.163	1.246	1.331	1.415	1.500	1.586	1.672	1.758	1.845	1.932	2.020	2.108	2.197
72	0.371	0.455	0.539	0.624	0.709	0.794	0.880	0.967	1.054	1.141	1.229	1.317	1.406	1.495	1.585	1.675	1.766	1.857	1.948	2.041	2.133	2.226	2.320
74	0.392	0.480	0.569	0.658	0.748	0.838	0.929	1.020	1.112	1.204	1.297	1.390	1.483	1.577	1.672	1.767	1.862	1.958	2.055	2.152	2.249	2.347	2.446
76	0.413	0.506	0.600	0.694	0.789	0.884	0.979	1.075	1.172	1.269	1.366	1.464	1.563	1.662	1.761	1.861	1.962	2.063	2.164	2.266	2.368	2.471	2.575
78	0.435	0.533	0.632	0.731	0.830	0.930	1.031	1.132	1.233	1.335	1.438	1.541	1.644	1.748	1.853	1.958	2.063	2.170	2.276	2.383	2.491	2.599	2.708
80	0.457	0.561	0.664	0.768	0.873	0.978	1.083	1.190	1.296	1.403	1.511	1.619	1.728	1.837	1.947	2.057	2.168	2.279	2.391	2.503	2.616	2.730	2.843
82	0.481	0.589	0.697	0.807	0.916	1.027	1.138	1.249	1.361	1.473	1.586	1.700	1.814	1.928	2.043	2.159	2.275	2.391	2.509	2.626	2.745	2.863	2.983
84	0.504	0.618	0.732	0.846	0.961	1.077	1.193	1.310	1.427	1.545	1.663	1.782	1.901	2.021	2.142	2.263	2.384	2.507	2.629	2.752	2.876	3.000	3.125

Table 4: Log Volume in Cubic Metres of Tapering Cylinders

DIAMETER (small end)	LENGTH IN METRES																					
cm	**0.9**	**1.1**	**1.3**	**1.5**	**1.7**	**1.9**	**2.1**	**2.3**	**2.5**	**2.7**	**2.9**	**3.1**	**3.3**	**3.5**	**3.7**	**3.9**	**4.1**	**4.3**	**4.5**	**4.7**	**4.9**	**5.1**	**5.3**
86	0.528	0.647	0.767	0.887	1.007	1.128	1.250	1.372	1.495	1.618	1.742	1.866	1.991	2.117	2.243	2.369	2.497	2.624	2.753	2.881	3.011	3.141	3.271
88	0.553	0.677	0.802	0.928	1.054	1.181	1.308	1.436	1.564	1.693	1.822	1.952	2.083	2.214	2.346	2.478	2.611	2.745	2.879	3.013	3.148	3.284	3.421
90	0.578	0.708	0.839	0.970	1.102	1.234	1.367	1.501	1.635	1.770	1.905	2.041	2.177	2.314	2.452	2.590	2.728	2.868	3.008	3.148	3.289	3.431	3.573
92	0.604	0.740	0.876	1.013	1.151	1.289	1.428	1.567	1.707	1.848	1.989	2.131	2.273	2.416	2.560	2.704	2.848	2.994	3.140	3.286	3.433	3.581	3.729
94	0.631	0.772	0.915	1.058	1.201	1.345	1.490	1.635	1.781	1.928	2.075	2.223	2.371	2.520	2.670	2.820	2.971	3.122	3.274	3.427	3.580	3.734	3.888
96	0.658	0.805	0.954	1.103	1.252	1.403	1.553	1.705	1.857	2.010	2.163	2.317	2.471	2.627	2.782	2.939	3.096	3.253	3.412	3.571	3.730	3.890	4.051
98	0.685	0.839	0.994	1.149	1.305	1.461	1.618	1.776	1.934	2.093	2.253	2.413	2.574	2.735	2.897	3.060	3.223	3.387	3.552	3.717	3.883	4.050	4.217
100	0.713	0.873	1.034	1.196	1.358	1.521	1.684	1.848	2.013	2.178	2.344	2.511	2.678	2.846	3.014	3.184	3.354	3.524	3.695	3.867	4.039	4.212	4.386
102	0.742	0.909	1.076	1.244	1.412	1.582	1.751	1.922	2.093	2.265	2.438	2.611	2.784	2.959	3.134	3.310	3.486	3.663	3.841	4.019	4.199	4.378	4.559
104	0.771	0.944	1.118	1.293	1.468	1.644	1.820	1.997	2.175	2.354	2.533	2.712	2.893	3.074	3.256	3.438	3.622	3.805	3.990	4.175	4.361	4.547	4.735
106	0.801	0.981	1.161	1.343	1.524	1.707	1.890	2.074	2.259	2.444	2.630	2.816	3.004	3.191	3.380	3.569	3.759	3.950	4.142	4.334	4.526	4.720	4.914
108	0.831	1.018	1.205	1.393	1.582	1.771	1.961	2.152	2.344	2.536	2.728	2.922	3.116	3.311	3.507	3.703	3.900	4.098	4.296	4.495	4.695	4.895	5.096
110	0.862	1.056	1.250	1.445	1.641	1.837	2.034	2.232	2.430	2.629	2.829	3.030	3.231	3.433	3.635	3.839	4.043	4.248	4.453	4.659	4.866	5.074	5.282
112	0.894	1.094	1.296	1.498	1.700	1.904	2.108	2.313	2.518	2.725	2.932	3.139	3.348	3.557	3.767	3.977	4.189	4.401	4.613	4.827	5.041	5.256	5.472
114	0.926	1.134	1.342	1.551	1.761	1.972	2.183	2.395	2.608	2.822	3.036	3.251	3.467	3.683	3.900	4.118	4.337	4.556	4.776	4.997	5.219	5.441	5.664

Table 4: Log Volume in Cubic Metres of Tapering Cylinders

DIAMETER (small end)	LENGTH IN METRES																				
cm	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7
4	0.020	0.021	0.022	0.024	0.025	0.027	0.028	0.030	0.032	0.034	0.035	0.037	0.039	0.041	0.043	0.045	0.048	0.050	0.052	0.055	0.057	0.060
6	0.033	0.035	0.037	0.039	0.041	0.044	0.046	0.048	0.051	0.053	0.056	0.059	0.061	0.064	0.067	0.070	0.073	0.076	0.080	0.083	0.086	0.090
8	0.050	0.053	0.056	0.058	0.062	0.065	0.068	0.071	0.074	0.078	0.081	0.085	0.089	0.092	0.096	0.100	0.104	0.108	0.113	0.117	0.121	0.126
10	0.070	0.074	0.078	0.082	0.086	0.090	0.094	0.098	0.102	0.107	0.111	0.116	0.121	0.126	0.131	0.136	0.141	0.146	0.151	0.157	0.162	0.168
12	0.094	0.090	0.104	0.109	0.114	0.119	0.124	0.129	0.135	0.140	0.146	0.152	0.158	0.164	0.170	0.176	0.183	0.189	0.196	0.202	0.209	0.216
14	0.121	0.127	0.133	0.139	0.146	0.152	0.158	0.165	0.172	0.179	0.186	0.193	0.200	0.207	0.215	0.222	0.230	0.238	0.246	0.254	0.262	0.271
16	0.152	0.159	0.166	0.174	0.181	0.189	0.197	0.205	0.213	0.221	0.230	0.238	0.247	0.256	0.265	0.274	0.283	0.292	0.302	0.311	0.321	0.331
18	0.186	0.195	0.203	0.212	0.221	0.231	0.240	0.249	0.259	0.269	0.279	0.289	0.299	0.309	0.320	0.330	0.341	0.352	0.363	0.375	0.386	0.398
20	0.224	0.234	0.244	0.255	0.265	0.276	0.287	0.298	0.309	0.321	0.332	0.344	0.356	0.368	0.380	0.393	0.405	0.418	0.431	0.444	0.457	0.470
22	0.265	0.276	0.288	0.301	0.313	0.325	0.338	0.351	0.364	0.377	0.391	0.404	0.418	0.432	0.446	0.460	0.474	0.489	0.504	0.519	0.534	0.549
24	0.309	0.323	0.337	0.351	0.365	0.379	0.394	0.408	0.423	0.438	0.454	0.469	0.485	0.501	0.517	0.533	0.549	0.566	0.583	0.600	0.617	0.634
26	0.357	0.373	0.388	0.404	0.420	0.437	0.453	0.470	0.487	0.504	0.521	0.539	0.557	0.574	0.593	0.611	0.629	0.648	0.667	0.686	0.706	0.725
28	0.408	0.426	0.444	0.462	0.480	0.499	0.517	0.536	0.555	0.574	0.594	0.613	0.633	0.653	0.674	0.694	0.715	0.736	0.757	0.779	0.800	0.822
30	0.463	0.483	0.503	0.523	0.544	0.564	0.585	0.606	0.628	0.649	0.671	0.693	0.715	0.738	0.760	0.783	0.806	0.830	0.853	0.877	0.901	0.925
32	0.522	0.544	0.566	0.589	0.611	0.634	0.658	0.681	0.705	0.729	0.753	0.777	0.802	0.827	0.852	0.877	0.903	0.929	0.955	0.981	1.008	1.035
34	0.583	0.608	0.633	0.658	0.683	0.708	0.734	0.760	0.786	0.813	0.839	0.866	0.894	0.921	0.949	0.977	1.005	1.033	1.062	1.091	1.120	1.150
36	0.649	0.676	0.703	0.731	0.758	0.786	0.815	0.843	0.872	0.901	0.931	0.960	0.990	1.020	1.051	1.082	1.112	1.144	1.175	1.207	1.239	1.271
38	0.717	0.747	0.777	0.807	0.838	0.869	0.900	0.931	0.963	0.995	1.027	1.059	1.090	1.125	1.158	1.192	1.226	1.260	1.294	1.329	1.364	1.399
40	0.789	0.822	0.855	0.888	0.921	0.955	0.989	1.023	1.058	1.092	1.127	1.163	1.198	1.234	1.271	1.307	1.344	1.381	1.418	1.456	1.494	1.532
42	0.865	0.901	0.936	0.972	1.009	1.045	1.082	1.119	1.157	1.195	1.233	1.271	1.310	1.349	1.388	1.428	1.468	1.508	1.549	1.590	1.631	1.672
44	0.944	0.983	1.021	1.061	1.100	1.140	1.180	1.220	1.261	1.302	1.343	1.385	1.427	1.469	1.511	1.554	1.597	1.641	1.685	1.729	1.773	1.818
46	1.027	1.068	1.110	1.153	1.195	1.238	1.282	1.325	1.369	1.413	1.458	1.503	1.548	1.594	1.639	1.686	1.732	1.779	1.826	1.874	1.922	1.970
48	1.113	1.158	1.203	1.249	1.295	1.341	1.388	1.435	1.482	1.530	1.578	1.626	1.675	1.724	1.773	1.823	1.873	1.923	1.974	2.025	2.076	2.128
50	1.202	1.250	1.299	1.348	1.398	1.448	1.498	1.548	1.599	1.650	1.702	1.754	1.806	1.859	1.911	1.965	2.018	2.072	2.127	2.181	2.237	2.292
52	1.295	1.347	1.399	1.452	1.505	1.558	1.612	1.666	1.721	1.776	1.831	1.886	1.942	1.999	2.055	2.112	2.170	2.227	2.286	2.344	2.403	2.462
54	1.391	1.447	1.503	1.559	1.616	1.673	1.731	1.789	1.847	1.906	1.965	2.024	2.084	2.144	2.204	2.265	2.326	2.388	2.450	2.513	2.575	2.638
56	1.491	1.550	1.610	1.671	1.731	1.792	1.854	1.915	1.977	2.040	2.103	2.166	2.230	2.294	2.359	2.423	2.489	2.554	2.620	2.687	2.754	2.821
58	1.594	1.658	1.721	1.786	1.850	1.915	1.981	2.046	2.113	2.179	2.246	2.313	2.381	2.449	2.518	2.587	2.656	2.726	2.796	2.867	2.938	3.009
60	1.701	1.768	1.836	1.905	1.973	2.042	2.112	2.182	2.252	2.323	2.394	2.465	2.537	2.610	2.683	2.756	2.829	2.904	2.978	3.053	3.128	3.204
62	1.811	1.883	1.955	2.027	2.100	2.174	2.247	2.321	2.396	2.471	2.546	2.622	2.699	2.775	2.853	2.930	3.008	3.087	3.165	3.245	3.324	3.405
64	1.925	2.001	2.077	2.154	2.231	2.309	2.387	2.465	2.544	2.624	2.704	2.784	2.865	2.946	3.028	3.110	3.192	3.275	3.358	3.442	3.527	3.611
66	2.042	2.122	2.203	2.284	2.366	2.448	2.531	2.614	2.697	2.781	2.866	2.951	3.036	3.122	3.208	3.295	3.382	3.469	3.557	3.646	3.735	3.824
68	2.162	2.247	2.333	2.419	2.505	2.592	2.679	2.767	2.855	2.943	3.032	3.122	3.212	3.302	3.393	3.485	3.577	3.669	3.762	3.855	3.949	4.043
70	2.286	2.376	2.466	2.557	2.648	2.739	2.831	2.924	3.017	3.110	3.204	3.298	3.393	3.488	3.584	3.680	3.777	3.874	3.972	4.070	4.169	4.268
72	2.414	2.508	2.603	2.698	2.794	2.891	2.988	3.085	3.183	3.281	3.380	3.479	3.579	3.679	3.780	3.881	3.983	4.085	4.188	4.291	4.395	4.499
74	2.545	2.644	2.744	2.844	2.945	3.046	3.148	3.251	3.354	3.457	3.561	3.665	3.770	3.875	3.981	4.088	4.195	4.302	4.410	4.518	4.627	4.737
76	2.679	2.783	2.888	2.994	3.100	3.206	3.313	3.421	3.529	3.637	3.746	3.856	3.966	4.077	4.188	4.299	4.411	4.524	4.637	4.751	4.865	4.980
78	2.817	2.926	3.037	3.147	3.258	3.370	3.482	3.595	3.708	3.822	3.937	4.052	4.167	4.283	4.399	4.516	4.634	4.752	4.870	4.990	5.109	5.229
80	2.958	3.073	3.188	3.304	3.421	3.538	3.656	3.774	3.893	4.012	4.132	4.252	4.373	4.494	4.616	4.739	4.862	4.985	5.109	5.234	5.359	5.485
82	3.103	3.233	3.344	3.466	3.588	3.710	3.833	3.957	4.081	4.206	4.331	4.457	4.584	4.711	4.838	4.966	5.095	5.224	5.454	5.484	5.615	5.746
84	3.251	3.377	3.503	3.630	3.758	3.886	4.015	4.144	4.274	4.405	4.536	4.667	4.799	4.932	5.065	5.199	5.334	5.469	5.604	5.740	5.877	6.014

Table 4: Log Volume in Cubic Metres of Tapering Cylinders

DIAMETER (small end) cm	LENGTH IN METRES 5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5	8.7	8.9	9.1	9.3	9.5	9.7
86	3.402	3.534	3.666	3.799	3.933	4.066	4.201	4.336	4.472	4.608	4.745	4.882	5.020	5.159	5.298	5.438	5.578	5.719	5.860	6.002	6.145	6.288
88	3.558	3.695	3.833	3.972	4.111	4.251	4.391	4.532	4.674	4.816	4.959	5.102	5.246	5.390	5.536	5.681	5.828	5.974	6.122	6.270	6.419	6.568
90	3.716	3.859	4.004	4.148	4.293	4.439	4.586	4.733	4.800	5.028	5.177	5.327	5.477	5.627	5.778	5.930	6.083	6.236	6.389	6.544	6.698	6.854
92	3.878	4.028	4.178	4.328	4.480	4.632	4.784	4.937	5.091	5.245	5.400	5.556	5.712	5.869	6.027	6.185	6.343	6.503	6.662	6.823	6.984	7.146
94	4.043	4.199	4.355	4.512	4.670	4.828	4.987	5.146	5.306	5.467	5.628	5.790	5.953	6.116	6.280	6.444	6.609	6.775	6.941	7.108	7.276	7.444
96	4.212	4.374	4.537	4.700	4.864	5.029	5.194	5.360	5.526	5.693	5.861	6.029	6.198	6.368	6.538	6.709	6.881	7.053	7.226	7.399	7.574	7.748
98	4.385	4.553	4.722	4.892	5.062	5.234	5.405	5.578	5.751	5.924	6.098	6.273	6.449	6.625	6.802	6.980	7.158	7.337	7.516	7.696	7.877	8.059
100	4.561	4.736	4.911	5.088	5.265	5.442	5.621	5.800	5.979	6.160	6.341	6.522	6.704	6.887	7.071	7.255	7.440	7.626	7.812	7.999	8.187	8.375
102	4.740	4.922	5.104	5.287	5.471	5.655	5.840	6.026	6.212	6.400	6.587	6.776	6.965	7.155	7.345	7.536	7.728	7.921	8.114	8.303	8.503	8.698
104	4.923	5.111	5.300	5.490	5.681	5.872	6.064	6.257	6.450	6.644	6.839	7.034	7.230	7.427	7.625	7.823	8.022	8.221	8.422	8.622	8.824	9.026
106	5.109	5.304	5.500	5.697	5.895	6.093	6.292	6.492	6.692	6.893	7.095	7.298	7.501	7.705	7.909	8.115	8.321	8.527	8.735	8.943	9.152	9.361
108	5.298	5.501	5.704	5.908	6.113	6.318	6.524	6.731	6.939	7.147	7.356	7.566	7.776	7.987	8.199	8.412	8.625	8.839	9.054	9.269	9.485	9.702
110	5.491	5.701	5.912	6.123	6.335	6.548	6.761	6.975	7.190	7.405	7.622	7.839	8.056	8.275	8.494	8.714	8.935	9.156	9.378	9.601	9.825	10.049
112	5.688	5.905	6.123	6.342	6.561	6.781	7.002	7.223	7.445	7.668	7.892	8.117	8.342	8.568	8.794	9.022	9.250	9.479	9.709	9.939	10.170	10.402
114	5.888	6.113	6.338	6.564	6.791	7.018	7.247	7.476	7.705	7.936	8.167	8.399	8.632	8.866	9.100	9.335	9.571	9.807	10.045	10.283	10.522	10.761

Table 5 Factors for Metric Conversion

Stacked Wood Conversion

One cubic metre (m^3)	= one cubic metre of solid wood
One stacked cubic metre [m^3 (stacked)]	= a properly piled stack of wood 1 m x 1 m x 1 m
1 m^3	= 1.51 m^3 (stacked)
1 m^3	= 1.28 m^3 (stacked) peeled
1 m^3 (stacked)	= 0.664 m^3
1 m^3 (stacked) peeled	= 0.781 m^3

One stacked cubic metre is approximately:
66% Wood
12% Bark
22% Airspace

APPENDICES

Appendix 1

Log Identification

Definitions

Bark – The outer portion is dry, hard, and forms many patterns. The inner portion is soft, and usually lighter in colour.

Wood – It consists of heartwood and sapwood. The sapwood surrounds the heartwood and is usually lighter in colour.

Rays – A pattern that shows on the end of some logs. It appears as fine lines that look like the spokes of a wheel.

Annual Ring – The end of a log shows concentric rings. Each ring represents the annual growth of spring and summer wood. The spring wood is the inner portion of the annual ring. The summer wood is the outer portion and is a darker colour.

Ring Porous – These are open grained woods. They have large openings or pores in the spring wood, easily detected by the eye.

Diffuse Porous – These are close grained woods. The pores are too small to be seen easily.

Hardwoods

Hardwoods that have diffuse porous wood with rays that are not visible include birch, basswood, aspen and poplar.

Birch – Heartwood, usually regular in outline and light to reddish brown with milky circles.
Yellow birch has yellowish bark in thin layers of curly or flat flakes.
White birch has creamy white bark in thin paper-like layers.

Basswood – This wood is very soft. The outer bark has flat-topped ridges on large logs, and is smooth on small logs. The inner bark is fibrous and usually separated from the wood. The line between wood and bark is scalloped. The heartwood is not easily recognized, and may be slightly stained and diseased.

Trembling Aspen – This wood is moderately light, soft, and relatively low in strength. The outer bark is smooth with a waxy appearance and pale green to almost white. With age, it becomes grey, breaking up into hard, flat topped ridges that are separated by shallow fissures.
The interior bark does not separate from the wood.
The heartwood is hard to determine and may be slightly stained and diseased.

Balsam Poplar – This wood is light, soft and low in strength. The heartwood is greyish brown and the sapwood is nearly white. The bark of young trees is smooth, greenish-brown,. It turns dark greyish and becomes furrowed in flat topped rough ridges separated by irregular V-shaped crevices.

Hardwoods that have ring porous wood with rays that are not visible include black ash and white elm.

Black Ash – This wood has a soft thin layer of grey, scaly or slightly ridged outer bark, with a thick layer of inner bark. The heartwood is brownish, and the sapwood is a narrow layer of greyish white. The annual ring is a wide layer of open-grained wood and a narrow layer of close grained wood. The wood is dull in appearance.

White Elm – This wood has outer bark with firm rounded ridges, the cross section of which shows dark brown and light layers. The heartwood is easily determined with a thick layer of sapwood. The annual ring shows a narrow layer of open-grained wood consisting of one line of large openings. The wood is close grained and shows white wavy lines.

Softwoods

Softwoods that have gum in the wood and easily determined heartwood include pine and larch.

Jack Pine – This wood has small beads of gum in the heartwood and sapwood. The bark is scaly and brownish under the scales. The heartwood is a brownish colour and there is a trough-like depression above and below knots.

Larch (Tamarack) – This wood has small beads of gum in the heartwood and sapwood. The bark is reddish brown and purple under the scales. The annual rings are very distinct and the heartwood is dark in colour, so there is a distinct contrast between the sapwood and heartwood.

Softwoods that have gum in the wood but heartwood is hard to determine include spruce.

Spruce – This wood has small beads of gum in the sapwood **only. The** gum dries up, leaving a rough sandpaper-like surface. White spruce is silvery pink under the scales. Black spruce is olive green under the scales

Softwoods that have gum in the bark include balsam and cedar.

Balsam Fir – This wood has liquid-like gum contained in blisters in young, smooth bark. In the older, ridged bark, the gum is crystallized. The heartwood is hard to determine.

Cedar – This wood has amber-coloured beads of gum that appear in the inner bark. The outer bark is broken up into narrow, fibrous ridges and the heartwood is easily determined and often defective.

Appendix 2

Principal Commercial Species: Identification and Symbols

Species	Scientific Name	Symbol	Description
White Spruce	Picea glauca	WS	Salmon pink inner bark
Black Spruce	Picea mariana	BS	Olive coloured inner bark
Balsam Fir	Abies balsamea	BF	Smooth distinctive bark, pitch pockets, odour
Jack Pine	Pinus banksiana	JP	More distinctive growth rings than spruce
Tamarack (Eastern Larch)	Larix laricina	TL	Chocolate hued heartwood, bright purple inner bark
Cedar (Eastern White Cedar)	Thuja occidentalis	EC	Thin, shredded bark with narrow elongated fibrous strips, reddish to pale brown heartwood
Trembling Aspen	Populus tremuloides	TA	On cut face, fuzzy (White Poplar) texture of wood surface, tends to have many stains or decay pockets
Balsam Poplar (Black Poplar)	Populus balsamifera	BA	Tendency to ring shake, dark coloured heartwood and deeply cut bark
Birch (White Birch)	Betula papyrifera	WB	White sapwood, brown heart and wood much harder than the other species

Appendix 3

Summary of Formulae

Smalian's formula
In symbol form Smalian's formula is:

$$V = \frac{A_s + A_l}{2} \times L$$

Where:

$A_s = \pi \left(\frac{ds}{2 \times 100} \right)^2$ = area of the small end of the log

$A_l = \pi \left(\frac{dl}{2 \times 100} \right)^2$ = area of the large end of the log

V = log volume in cubic metres
A = area of log end in square metres
ds = diameter of small end in centimetres
dl = diameter of large end in centimetres
L = length of log in metres
π = 3.14159

Volume in cubic metres of timber or defects

$\frac{D^2 \times 0.7854 \times L}{10{,}000}$ = cubic metres correct to three decimal places

Where: D = diameter of log or defect in 2 centimetre classes
L = length of log or defect in metres and 2 centimetre classes

---

Volume in stacked cubic metres rough for individual logs or defects

$\frac{D^2 \times 0.7854 \times L}{10{,}000}$ = metres cubed correct to 3 decimals x 1.51= stacked cubic metres correct to two decimal places

Where : D = diameter of log or defect in 2 centimetre classes
L = length of log (or width of pile) or defect in metres and 2 centimetre classes

---

Volume in stacked cubic metres peeled for individual logs or defects

$\frac{D^2 \times 0.7854 \times L}{10{,}000}$ = metres cubed correct to 3 decimals x 1.28 = stacked cubic metres correct to two decimal places

Where: D = diameter of log or defect in 2 centimetre classes
L = length of log (or width of pile) centimetre or defect in metres and 2 centimetre classes

---

Volume in stacked cubic metres

$H \times L \times W$ = stacked cubic metres correct to two decimal places

Where: H = height of stack in metres and 2 centimetre classes
L = length of stack in metres (2 decimal places)
W = width of stack (length of bolt) in metres and 2 centimetre classes

---

Appendix 4 Answers to Exercises

Principles of Rounding Exercise – from page 8

8.377 = 8.38
8.374 = 8.37
8.375 = 8.38
8.365 = 8.36

2.436 = 2.44
2.479 = 2.48
2.123 = 2.12
2.315 = 2.32

5.225 = 5.22
5.528 = 5.53
5.235 = 5.24
5.155 = 5.16

Diameter Averaging Exercise – from page 12

Measurements	Average	Recorded as
44 + 46	45	44
24 + 28	26	26
34 + 40	37	36

Cubic Method Two Exercise – from page 15

Log #	Length	Dia. 1	Area 1	Dia. 2	Area 2	Volume m^3 $\frac{Area\ 1 + Area\ 2}{2}$ X length
1	2.54	28	.0616	30	.0707	(.0616 + .0707) /2 X 2.54 = .168
2	2.44	20	.0314	16	.0201	(.0314 + .0201) /2 X 2.44 = .063
3	2.56	16	.0201	18	.0254	(.0201 + .0254) /2 X 2.56 = .058

Defect Deductions Exercise – from page 43

Log length	Small end diameter	Gross Volume m^3 (table 4)	Defect	Defect Volume m^3	Net Volume m^3
3.7 m	34 cm	.373	BL 16 cm	.022/2 = .011	.362
4.9 m	42 cm	.760	BL 12 cm	.012/2 = .006	.754
5.1 m	36 cm	.595	HL 20 cm	.160/2 = .080	.515

Appendix 5 Manitoba Agriculture and Resource Development Scaling Plan

SCALING PLAN
April 1, 20___ – March 31, 20___

Manitoba
Agriculture and Resource Development

Original	☐
Amendment	☐
Replace Original	☐

Name of Cutting Right Holder:

Address: E-Mail:

THIS SCALING PLAN IS FOR TIMBER CUT UNDER THE FOLLOWING AUTHORITY:

Timber Sale # or Timber Permit Quota #:

The timber will be delivered to the locations identified below and scaled using the methods indicated below:

Source/ Location (Cut block #, indicate if On-Hand Wood)	Final Destination (Mill/facility name & town, rail siding, approved stockpile etc.)	Commodity/ Product (eg. Kraft, Newsprint, OSB, SWL, HWL, Biomass, Fuelwood, Post & Rails)	Estimated Volume (m^3)	Species (enter appropriate species or species combination- see abbreviations in instructions)	Scaling Method (use codes see below)	Scaling Location (use codes, see below)	Licenced Scaler Licence # (Not required for weigh scale operations)
		Total	0		1 – Mass a) Roundwood b) Chips 2 – Stack 3 – Solid 4 – Piece/linear	1 – Millgate 2 – In bush 3 – Stockpile 4 – Other	
		To update Volume Total right click and select "Update field"					

SCALING PLAN CONDITIONS: All provisions and requirements of the *Forest Act* and *Regulation* as well as the current *Scaling Manual* must be adhered to.

I, ______________________________, DECLARE THAT THE ABOVE INFORMATION IS CORRECT AND AGREE TO THE CONDITIONS THIS APPROVAL SETS OUT. IF AT ANY TIME THERE IS A CHANGE REQUIRED TO THE ABOVE INFORMATION, I WILL SEND AN AMENDMENT /REPLACEMENT SCALING PLAN TO THE REGIONAL FORESTRY OFFICE

______________________________ ____________________
Cutting Right Holder or Designate Signature Date

____________________ ______________________________ ____________________
Forestry Office Forestry Signature Date

Copy Distribution: ORIGINAL – Sale or Permit Holder
2nd COPY – Region/District
3rd COPY – Winnipeg Forestry Branch
4th COPY – Final Destination

2019-12-11

Appendix 6 Manitoba Agriculture and Resource Development Crown Land Load Slip

Manitoba
Agriculture and Resource Development

CROWN TIMBER LOAD SLIP
Forest Products
Shipping and Receiving Report

50 6331 01

FAILURE TO PROPERLY COMPLETE THIS FORM MAY RESULT IN PROSECUTION

Seller / Shipper	Receiver / Purchaser
1. NAME:	2. NAME:
ADDRESS:	ADDRESS:

3. AUTHORITY This timber was cut under the authority of:

(a) Timber Sale/Permit/Licence No.________ Quota No.________ Operating Permit No.________

(b) Cut Block No.________ Contract No.________

4. Certified Correct:________________ Date:________
Signature of Timber Cutting Right Holder

TRUCKER / CARRIER DATA

5. SPECIES Spruce, Pine, Birch, Poplar, etc.	PRODUCT Tree Length, 16', 8', Chips, etc.	6. ESTIMATED QUANTITY m³, tonnes, kgs, pieces, etc.
a)		
b)		
c)		

7. Loading Point: ________ ☐ Bush ☐ Stockpile ☐ Mill **8. Delivery Location:** ________ ☐ Stockpile ☐ Mill

9. Date Loaded: ________ **Time Loaded:** ________ ☐ am ☐ pm

10. Truck # / Licence #: ________ **Trailer Licence #:** ________

This will certify that the load of timber covered by this Load Slip contains by measurement, or best estimate.

11. Certified Correct: ________________ Date: ________
Signature of Truck Operator

RECEIVER DATA ***EDT Mills*** *- Retain WHITE copy of Load Slip and submit to Forestry Branch monthly.*
All other destinations *- Seller/operator must retain WHITE copy to submit with Timber Return.*

12. SPECIES/PRODUCT Spruce, Pine, Birch, Poplar Etc. Sawlogs, Lumber, Pulp, Posts, Fuelwood, Chips, Etc.	13. QUANTITY RECEIVED m³ or m³ stacked, Pieces, Kgs, Tonnes, Etc.

14. Transaction #: ________ *This will certify that the forest products have been received*

15. Certified Correct: ________________ Date: ________ Time: ________ ☐ am ☐ pm
Signature of Receiver or Transaction #

All Load Slip Books must be returned to issuing office once completed or upon Officer's request
WHITE - Forestry Branch GREEN - Purchaser PINK - Seller/Operator YELLOW - Retain in Book

Appendix 7 Manitoba Agriculture and Resource Development Private Land Load Slip

Manitoba
Agriculture and Resource Development

PRIVATE LAND/TIMBER LOADSLIP

15 2001 01

FAILURE TO PROPERLY COMPLETE THIS FORM MAY RESULT IN PROSECUTION

Seller / Shipper	Receiver / Purchaser
1. NAME:	**2. NAME:**
ADDRESS:	**ADDRESS:**

3. AUTHORITY This timber was cut/purchased under the authority of:

(a) Timber Dealers Licence No. __________

(b) Wood Processing Facility Licence No. __________

(c) Private Land Owned by: __________

1/4 Sec.____ Twp.____ Rge.____ W/EPM

4. Certified Correct: __________ Date __________
Signature of Timber Owner or Designate

TRUCKER / CARRIER DATA

5. **SPECIES/PRODUCT** *Spruce, Pine, Birch, Poplar, Etc. Sawlogs, Lumber, Pulp, Posts, Fuelwood, Chips, Etc.*	**6.** **ESTIMATED QUANTITY** *m3 or m3 stacked, Pieces, Kgs, Tonnes, Etc.*

7. Loading Point: __________ ☐ Bush ☐ Stockpile ☐ Mill **8. Delivery Location:** __________ ☐ Stockpile ☐ Mill

9. Date Loaded: __________ **Time Loaded:** __________ ☐ am ☐ pm

10. Truck # / Licence #: __________ **Trailer Licence #:** __________

This will certify that the load of timber covered by this Load Slip contains by measurement, or best estimate.

11. Certified Correct: __________ Date __________
Signature of Truck Operator

RECEIVER DATA

Timber Dealers must retain WHITE copy of Load Slip to submit to Forestry Branch with Monthly Reports

12. **SPECIES/PRODUCT** *Spruce, Pine, Birch, Poplar, Etc. Sawlogs, Lumber, Pulp, Posts, Fuelwood, Chips, Etc.*	**13.** **QUANTITY RECEIVED** *m3 or m3 stacked, Pieces, Kgs, Tonnes, Etc.*

14. Transaction # __________ *This will certify that the forest products have been received*

15. Certified Correct: __________ Date ______ Time: ______ ☐ am ☐ pm
Signature of Receiver or Transaction #

All Load Slip Books must be returned to issuing office once completed or upon Officer's request
WHITE - Forestry Branch GREEN - Purchaser PINK - Seller/Dealer YELLOW - Retain in book

Manitoba
Agriculture and Resource Development

APPLICATION FOR SCALER'S LICENCE IN MANITOBA

Name: ____

Address: ____

City/Town:____________________________ Postal Code:______________

Phone: ____________________ e-mail: ______________________________

Have you ever held or applied for a scaler's licence in the Province of Manitoba? YES NO
If yes, please state details ____
____

Have you ever taken a Manitoba Scaling course? YES NO
If yes, what year? ____________

Please state any previous scaling experience you may have ____________________
____
____
____

OUT OF PROVINCE SCALER'S:

Do you presently hold a valid scaler's licence from another Province? YES NO

Issuing Province ______________Year Issued __________ Expiry Date ____________

☐ Licence confirmed in good standing ________________
ARD Official

FOR DEPARTMENT USE ONLY

Date Received __________________________ Date Approved ______________

Signing Authority ____

Appendix 9 Mass/Volume Sampling Tally Sheet

MASS CONVERSION SAMPLING Type: TL or Cut to Length

	Species	End "A" Diameter (2 cm class)	End "B" Diameter (2 cm class)	Total Length (m, to 2cm class)		Species	End "A" Diameter (2 cm class)	End "B" Diameter (2 cm class)	Total Length (m, to 2cm class)
1					1				
2					2				
3					3				
4					4				
5					5				
6					6				
7					7				
8					8				
9					9				
0					0				
1					1				
2					2				
3					3				
4					4				
5					5				
6					6				
7					7				
8					8				
9					9				
0					0				
1					1				
2					2				
3					3				
4					4				
5					5				
6					6				
7					7				
8					8				
9					9				
0					0				

Date: Location: Scalers:

Sample Weight: Comments: Page:_____ of _____

Appendix 10 Undersize and Defect Sampling Procedures

Provincial Roundwood
Undersize & Defect
Measurement Procedures

Equipment

Tally sheets/clipboard/pencils
Blue Lumber crayon
Scaling Stick (MC-1 or MC-2)
2 x 1 metre rectangle
Tape measure

Objective

To sample roundwood and verify undersize and defect percentages that are in place for a number of Mill Facilities (ex Tolko & LP) in Manitoba. To meet objectives identified in Regional Scaling Work Plans.

Procedure

Slashed roundwood in a mill yard, stockpile site or in-block can be sampled for undersize and defect, as per the Regional Scaling Work Plan. Sampling is optimized with two people participating, a tally person and a measurement person. One person must have a valid Manitoba Scalers' Licence.

The Scalers' are presented with a row of slashed roundwood, the Scalers start at one end of the pile and work their way towards the opposite end. Log lengths are generally 2.5 or 5.1 metres.

The 2 x 1 metre rectangle is placed on the roundwood pile; diameters are measured and tallied, followed by defect measurements.

1. For small diameter timber, measure logs that are completely within the rectangle. Any logs that have the rectangle over any portion of the log are not tallied.
2. For large diameter timber (>25 cm), measure logs that are within the rectangle and measure logs that the rectangle overlaps.

*Diameters are taken to the 2cm (even) class.

Twenty-five repetitions are suggested as a sample field day for two people. The rectangle is moved across the face of the log pile, so as to capture distinct samples (no overlap).

*Ensure timber was harvested in Manitoba.

Health & Safety

Notify the mill/loader operator that you are entering the site. Care must be taken that the rectangle is hung securely to the log pile, that the rectangle does not fall off the pile and injure the Scalers. Care must also be taken in being observant to operators and equipment that may be active in the mill/stockpile or cut block site. Hard hat and high visibility clothing is required. Additional PPE may be required by the mill site. Ensure proper footing while scaling and do not crawl up piles of stacked timber.

UNDERSIZE AND DEFECT FACTOR SAMPLING

Number			Defect	Cull		Number		Defect	Cull
6					6				
8					8				
10					10				
12					12				
14					14				
16					16				
18					18				
20					20				
22					22				
24					24				
26					26				
28					28				
30					30				
32					32				
34					34				
36					36				
38					38				
40					40				
42					42				
44					44				
46					46				
48					48				
50					50				
Tally of Samples					Tally of Samples				

Column 1
Number of Samples:
Log Length:
Species:

Date:____________________
Location:_________________
Scaler(s):_________________
Comments:________________

Column 2
Number of Samples:
Log Length:
Species:
Page _____of _____

Appendix 11 Chipperwood Sampling Procedures

Provincial
Chipperwood
Measurement Procedures

Equipment

Metric logger's tape	Tally sheets/clipboard/pencil
2 metric carpenter tape measures	Blue lumber crayon
2 calipers (9.1 cm and 5.0 cm)	MC-1 scaling stick

Objective

To sample chipperwood and verify undersize percentages for a number of mill facilities (ex Tolko & SPL) in Manitoba. To meet sampling objectives for total chipperwood measurements and distribution throughout FMU's, within cut blocks and throughout operating seasons as established in Regional Scaling Work Plans.

Procedure

In areas with active operations, Operators maybe asked to spread a sample of a pile (tree length, tops, or cut to length) on the ground for ease of measurement. When operations are inactive, at time of measurements, the ends of piles are measured. The entire tree or piece of a tree must be accessible in order to obtain accurate measurements.

Sampling is most efficient with three people; one person must have a valid Manitoba Scalers Licence.

Large end, top diameters and lengths are recorded to the 2cm class (Ex. 20cm, 6cm, 2.52m etc.). All measured pieces are marked with a lumber crayon on the large end.

The person recording measurements determines the diameter at the large end of the tree, log, or piece. This person also sets the end of the logger's tape at the large end, while another person determines where the 9.1cm diameter exists. The 9.1cm caliper is moved from the base of the tree towards the top of the tree or piece until it falls into place. With the caliper in place, the length from the large end to the caliper is measured.

The 5.1cm caliper is moved from the 9.1cm diameter towards the top of the tree or piece until it falls into place. The length from the 9.1cm caliper to the 5.1cm diameter is recorded. If the top diameter of the tree or piece is between 5.1 and 9.1cm, the top diameter is measured and the length from the 9.1cm diameter to the top is recorded.

When a tree or piece is forked, measurements are taken from the large end to the 5.1cm or top of the dominant fork. The remaining fork or forks are then measured as a separate piece or pieces from where the forking begins to the 5.1cm or top.

Data is entered into an Excel spreadsheet which uses Smalian's formula to calculate merchantable (>9.1cm) and non-merchantable (<9.1 cm) volumes. The non-merchantable factor is calculated by dividing the total non-merchantable volume by the total volume of chipperwood measured. Species is recorded for the sample as Spruce/Pine/Mix.

Health & Safety
Notify the mill/operators if working in the area. Care must be taken in working beside or on a log pile. Care must also be taken in being observant to operators and equipment that may be active in the cut block site. Hard hat and high visibility clothing is required. Additional PPE maybe required by mill/operators. Ensure proper footing while scaling and do not crawl up piles of timber.

CHIPPERWOOD SAMPLING Type: TL or Length_______

	Large End Diameter (cm)	Large End Length (Butt to 9 cm)	Top Diameter (cm)	Total Length (m)		Large End Diameter (cm)	Large End Length (Butt to 9 cm)	Top Diameter (cm)	Total Length (m)
1					31				
2					32				
3					33				
4					34				
5					35				
6					36				
7					37				
8					38				
9					39				
10					40				
11					41				
12					42				
13					43				
14					44				
15					45				
16					46				
17					47				
18					48				
19					49				
20					50				
21					51				
22					52				
23					53				
24					54				
25					55				
26					56				
27					57				
28					58				
29					59				

Date: Location: Scalers:

Comments: Page: _____ of _____

Appendix 12 Post and Rail Sampling Procedures

Provincial
Post and Rail
Measurement Procedures

Equipment

Metric Logger's Tape
2 D-tapes or Measuring Tapes
3 Calipers (13.1 cm, 9.1 cm, & 5.1cm)
Tally sheets/clipboard/pencil
Blue lumber crayon

Objective

To sample post and rail logs, sampled by government scalers, to verify factors and undersize percentages for a number of mill facilities in Manitoba.

Procedures

Sampling is most efficient with three people; one person must have a valid Manitoba Scalers Licence. One person records as the other two measure the logs.

Call the mill ahead of time and ask for operators to spread samples of logs in the yard onto the ground. Logs may be tree length, or cut to a specific length. Make sure to identify the length on the tally sheet.

Diameters are rounded to the nearest centimetre (inside bark) and exact lengths are recorded. (ex. 5.00m, 5.23m, etc). All measured pieces are marked with a lumber crayon on the large end.

The two people measuring the logs will each have an end of the loggers tape and will place the logging tape on top of the log, running the length of the log. The person at the butt end of the log will use a D-tape or measuring tape to measure the diameter of the butt. This measurement will be recorded in the first column of the tally sheet (Large End Diameter).

Using the 13.1cm caliper, determine where the log reaches 13.1cm in diameter, then measure the length from the **butt** of the log to where the 13.1cm caliper lands. Record that length in the second column (Large End Length).

Continue down the log with the 9.1cm caliper and determine where the log reaches a diameter of 9.1cm. Again, measure the length from the **butt** end to the 9.1cm caliper. Record that length in the third column (Middle Length).

The "Top Diameter" is the end of merchantable wood and will be 5.1cm or larger. To measure the "Top Diameter", use the 5cm caliper **OR** measure the diameter of the top end, using a D-tape or measuring tape, and record the **diameter** in the fourth column (Top Diameter).

When a tree or piece is forked, measurements are taken from the large end to the 5.1cm or top of the dominant fork. The remaining fork or forks are then measured as a separate piece or pieces from where the forking begins to the 5.1cm or top.

The last column is the Total Length and is the **length** of the log from the **butt** end to the "**top diameter**".

If your" Large End Diameter" is 13.1cm or less; there will be no "Large End Length" (butt to 13cm), leave that column blank and begin sampling the "Middle Length".

If your "Top Diameter" is between 9.1 and 13.1cm; there will be no "Middle Length" (13.1 to 9.1cm length), leave that column blank, record the "Top Diameter" and record the "Total Length" from the butt to the end of the log.

Examples:

Large End Diameter (cm)	Large End Length (Butt to 13cm)	Middle Length (13cm to 9cm)	Top Diameter (cm)	Total Length (m)
17	1.43	4.72	5	9.61
12		9.95	5	8.55
19	4.70		10	7.23

Health & Safety

Notify the mill/operators when working in the area. Care must also be taken in being observant to operators and equipment that may be active in mill site. Hard hat and high visibility clothing is required. Mills may require additional PPE to be worn.

POST AND RAIL SAMPLING Type: TL or Length_______

Large End Diameter (cm)	Large End Length (Butt to 13 cm)	Middle Length (13 cm to 9 cm)	Top Diameter (cm)	Total Length (m)	Large End Diameter (cm)	Large End Length (Butt to 13 cm)	Middle Length (13 cm to 9 cm)	Top Diameter (cm)	Total Length (m)
1					31				
2					32				
3					33				
4					34				
5					35				
6					36				
7					37				
8					38				
9					39				
10					40				
11					41				
12					42				
13					43				
14					44				
15					45				
16					46				
17					47				
18					48				
19					49				
20					50				
21					51				
22					52				
23					53				
24					54				
25					55				
26					56				
27					57				
28					58				
29					59				
30					60				

Date: Location: Scalers:

Comments: Page: _____ of _____