MINE RECLAMATION

COSTING AND SPREADSHEET

Version 3.5.2

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MINISTRY OF ENERGY AND MINES

Mines and Mineral Resources Division

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ABOUT VERSION 3.5.2

Revisions included in Version 3.5.2 encompass all of those to the text and format in Version 3.5.1 as well as updated administrative and contact information:

- Diane Howe's position has evolved from "Senior Reclamation Specialist" to "Deputy Chief Inspector of Mines – Permitting".

- The name of the "Mining and Minerals Division" has been changed to the "Mines and Mineral Resources Division".

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1.0 INTRODUCTION

Estimating cost of mine reclamation in British Columbia is made more challenging by mountainous terrain and the complexity that exists in the natural environment. Despite this, costing can be made more efficient through definition of common categories of mine activity and reclamation prescription, and through their presentation and analysis on a spreadsheet.

The spreadsheet which is described in these pages facilitates estimation of the cost of reclamation that remains outstanding at that specific point in time that is chosen by the estimator. Often, this is set to coincide with the date of the current annual reclamation report.

The spreadsheet also facilitates estimation of costs that may exist in the future; for example to support an application for mine approval under Part 10.1.2(6) of the *Mines Act - Health, Safety and Reclamation Code.* In determination of the *"... total costs of outstanding reclamation over the planned life of the mine ...",* certain assumptions must be made as to the scope of gross disturbance that will be caused by the mine, and how this will be reduced by ongoing reclamation. Forecasting the pattern of future cost is simplified through estimating outstanding liability at a few critical stages in the life of the mine, as discussed in Part 2. An important aspect here is the determination of maximum cost of outstanding reclamation, and the time when this will occur.

The use of spreadsheets by mining companies in B.C. is now commonplace. An excellent and recent treatment was presented by Highland Valley Copper, (R.W. Graden), at the 1996 Annual B.C. Mine Reclamation Symposium in Kamloops. It is included in the proceedings, and is available from BiTech Publications in Vancouver. Highland Valley Copper's system integrates reclamation costs with overall mining costs, a step which hopefully can be added to future editions of this discussion.

2.0 PATTERN IN COST OF RECLAMATION OVER LIFE OF MINE

Differing and justifiable answers exist for costing questions posed on any given site. These will depend on such things as: whether the objective is to determine cost to the mining company, or to government; or whether work is to be done during life of mine or in premature closure.

These questions are best examined within the context of the pattern of cost that will develop over life of mine - as illustrated by imaginary mine in Figure 1 - a simple case in which all areas of surface disturbance are reclaimed at closure, and no post closure expenses occur.

2.1 Aggregating Outstanding Cost Over Life of Mine

At start of mining, (construction of roads and clearing of plant site, pit and dump areas), the rate of surface disturbance is high. However, the unit cost of reclaiming this type of work is relatively low (usually in the order of $1500 per ha), and it may or may not be true that the backlog of reclamation increases as steeply as shown in the upper curve of the top diagram of Figure 1. This top curve might equally be called 'Aggregate (or Gross) Outstanding Reclamation Cost'.

End of construction and start of production will likely see a change in the rate of disturbance. Further change will occur as the mining plan adapts to new market conditions, technology and geological knowledge. The outstanding cost curve may reach a plateau as closure approaches and stockpiles are drawn down and run through the mill.

2.2 Ongoing Reclamation and Outstanding Cost

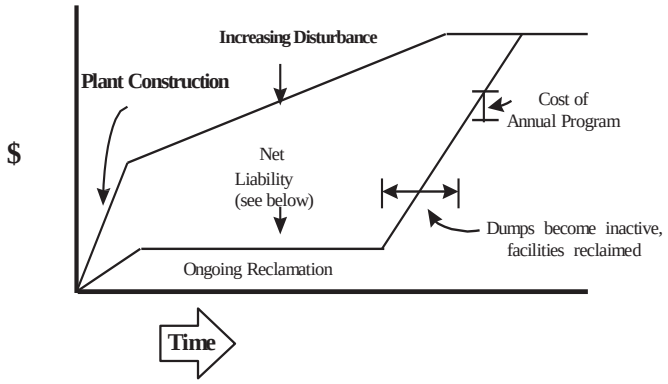
In Figure 1, the lower curve of the upper diagram sums ongoing reclamation expenditures. At startup, an initial surge of reclamation activity is indicated (e.g. seeding of new road shoulders, borrow pits and plant areas). Following this, annual expenditures may stabilize until significant dump or pit areas become inactive and available for reclamation. The liability posed by outstanding reclamation at any point in time is the difference between the upper and lower curves - shown in the middle diagram of Figure 1.

Although it is tempting to equate increasing area disturbance with liability, two exceptions exist: wraparound berms; and valley fills. The former are constructed against lower sections of high dumps, and reduce effective height of dump, and therefore cost of resloping, as this varies exponentially with height. Valley fills may be constructed on rock drains to extend between opposing mountain flanks with similar effect (see Note in Section 3.3). A concern here is that the mine may close prior to completion of the fill.

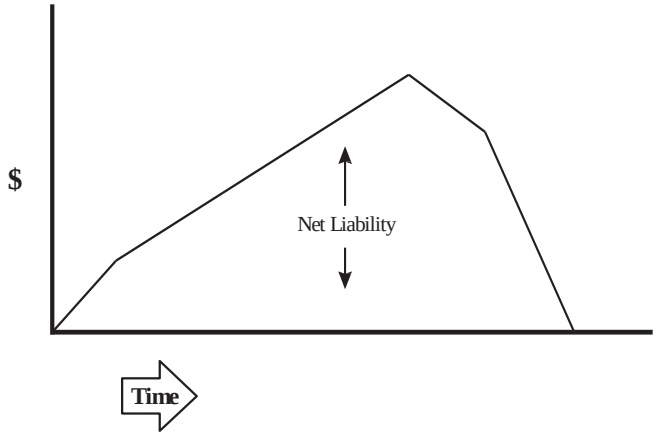
Operations which are able to close out discrete areas of surface work during life of mine hold an advantage over those that cannot, being able both to reduce outstanding cost, and gain in reclamation experience during life of mine. Reclamation done concurrently with mining enjoys several cost advantages:

- equipment - may be switched back and forth between mining and reclamation
- trained personnel
- supervision
- power
- communications
- staff support (accommodation and catering).

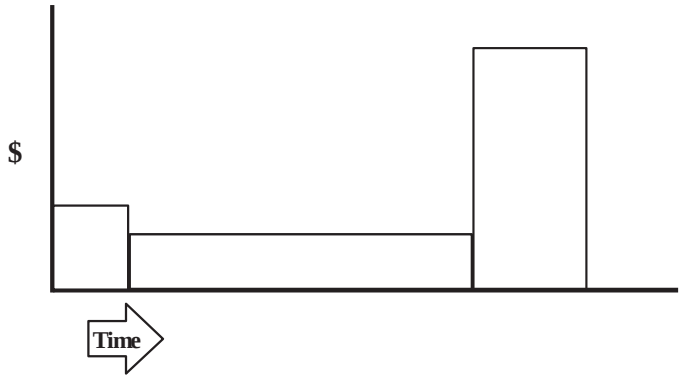
FIGURE 1: RECLAMATION COST RELATIONSHIPS
(ARD Costs Not Included)



COSTS AGGREGATED OVER LIFE OF MINE



**NET LIABILITY (COST OF OUTSTANDING RECLAMATION)
AT ANY POINT IN LIFE OF MINE**



COST OF ANNUAL RECLAMATION PROGRAM

A full discussion of cost of outstanding reclamation would consider a third curve, (not shown), in the top diagram of Figure 1, to represent *'Area Available for Reclamation'.* Development of this data will provide the mine with a statistical measure of reclamation performance through comparison of the area that has become available for reclamation, to that which has actually been reclaimed.

A cost plot for an annual reclamation program is shown in the lower diagram of Figure 1. This is the plot of annual costs shown in aggregate in the upper diagram. The annual record of cost is most useful in determining future program budgets.

Developing future budget requirements from cost data requires input from a variety of specialists, and this is sometimes complicated by the many ways in which budgets may be allocated between functions.

2.3 Allocating Costs

Spreadsheets typically document cost of works including equipment (all found), materials and labor. These are sometimes called direct costs.

Part 10.1.2.(6) of the *Health, Safety and Reclamation Code for Mines in British* Columbia also requires estimation of *"... costs of long term monitoring and abatement ...".* This refers particularly to costs of remediating acid drainage.

Overhead costs (generally considered to include administration, management, supervision, and research) are essential to completing works. Total overhead costs for a mine which goes to planned completion will differ from one that does not. In premature closure, reclamation must be done as expeditiously as possible, for delay will increase disturbance of vegetation that may have re-established on the site. The period during which overhead costs may be accumulated is thereby reduced.

When the Province undertakes reclamation work, unit equipment rates set out in the *"Province of British Columbia B.C. Hydro and Power Authority and B.C. Rail Ltd. Equipment Rental Rate Guide"* apply. These tend to be higher than 'in house' costs experienced by mining companies - a reason to maximize ongoing reclamation further to those noted in Section 2.2.

Finally, there is the question of quality of program that can be provided under conditions of default, as opposed to during life of mine. This cannot be addressed in this short presentation, but an argument exists for establishing priority for specific works to be done in a future default situation.

Table 1: CATEGORIES OF MINE ACTIVITY

'AREA DISTURBANCE' CATEGORY

RESLOPING WORKSHEET

- Dump face resloping

MASTER WORKSHEETS

- Dump faces at angle of repose
- Dump tops (the horizontal surface of dump tops, platforms, and benches)
- Pits
- Settling ponds
- Tailings dam(s)
- Tailings beach
- Roads
- Plant Site
- Administration area
- Cleared area

'LUMP SUM ITEMS' CATEGORY

- Mill building
- Administration building
- Mill
- Silos
- Structures
- Power lines
- Pipelines
- Conveyor
- Stockpiles
- Sealing of openings
- ARD capital costs

'POST CLOSURE' CATEGORY

- ARD Operating System
  - Plant
  - Monitoring
  - Other
- Non ARD Operating System
  - Operating
  - Maintenance
  - Monitoring
  - Engineering

3.0 CONCEPT AND USE OF SUMMARY REPORT AND WORKSHEETS

The individual worksheets which together form the workbook are shown schematically in Figure 2, "RECLAMATION COST ESTIMATING WORKBOOK."

In previous versions, the text included an Example Mine to demonstrate use of the spreadsheet, but this is now felt to be redundant.

3.1 The Summary Report

Use of the spreadsheet system begins with entry of project name, reclamation permit number and costing year in the Summary Report.

The Summary Report lists three basic mine activity categories:

- Area Disturbance (all costs which can be estimated on a $/ha basis)
- Lump Sum Items
- Post Closure Costs

Some sub-categories which might be used under the above headings are suggested in Table 1.

A new worksheet is automatically "set up" for each disturbance category as it is entered in the Summary Report. The Summary Report is linked to the other Worksheets, and data entered on the latter automatically appears on the former, where this is common.

3.2 Area Disturbance Category

After determining the various categories of area disturbance that exist at the mine, the user will enter data on these in the appropriate columns of the Summary Report: '*total disturbed'*, '*permanent disturbance'* (pit walls, future permanent access roads, etc.) and '*current reclaimed'* (area reclaimed to date). The program automatically calculates area *'to be reclaimed'.* It is left to the user to decide whether reclamation is complete or not. It was previously required that vegetation be established for a period of one year before completion could be claimed, but this prevented maintenance of a current cost record. Data on unit cost of reclamation prescription can be entered on the worksheets.

Figure 2: RECLAMATION COST ESTIMATING WORKBOOK

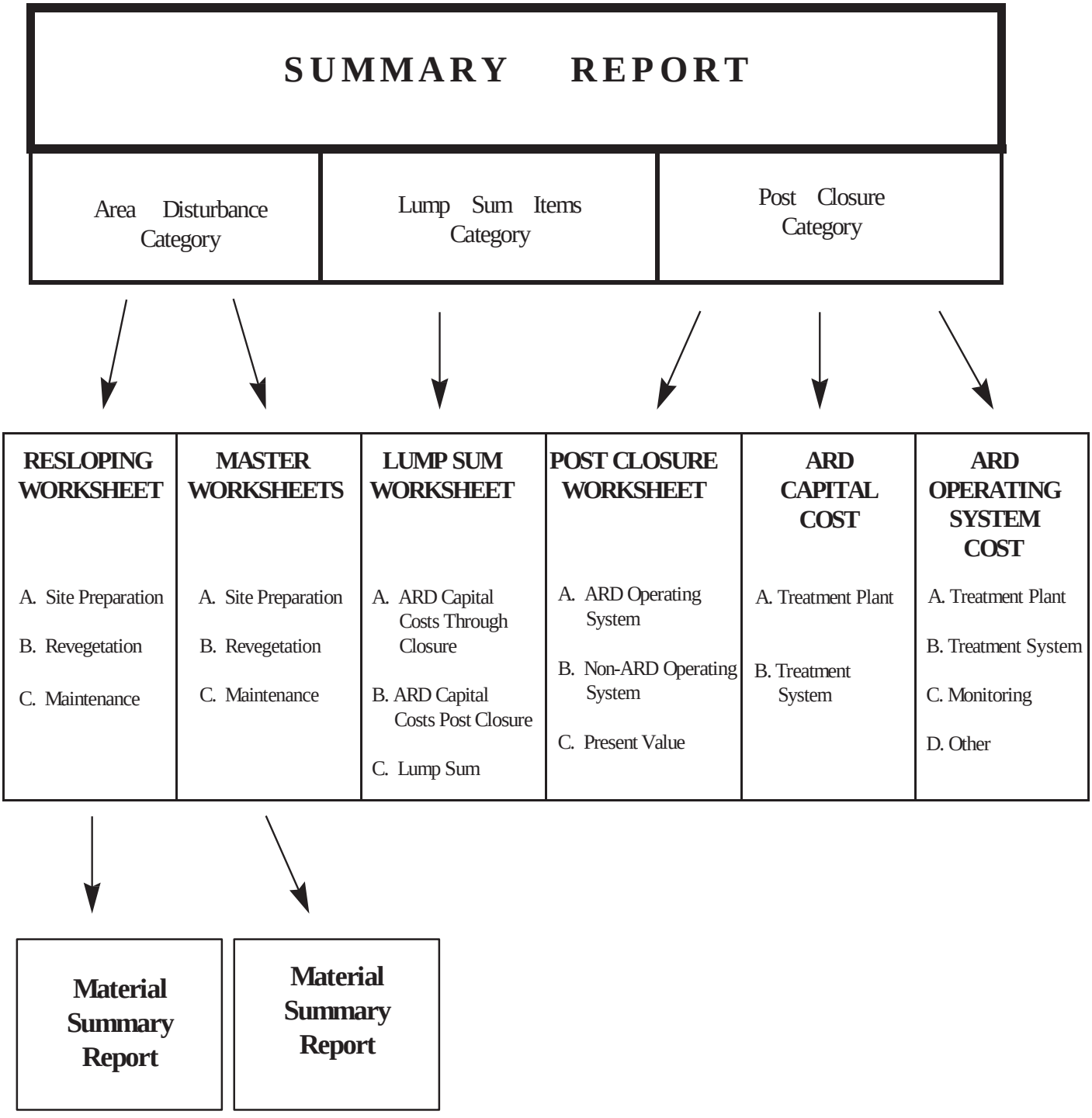
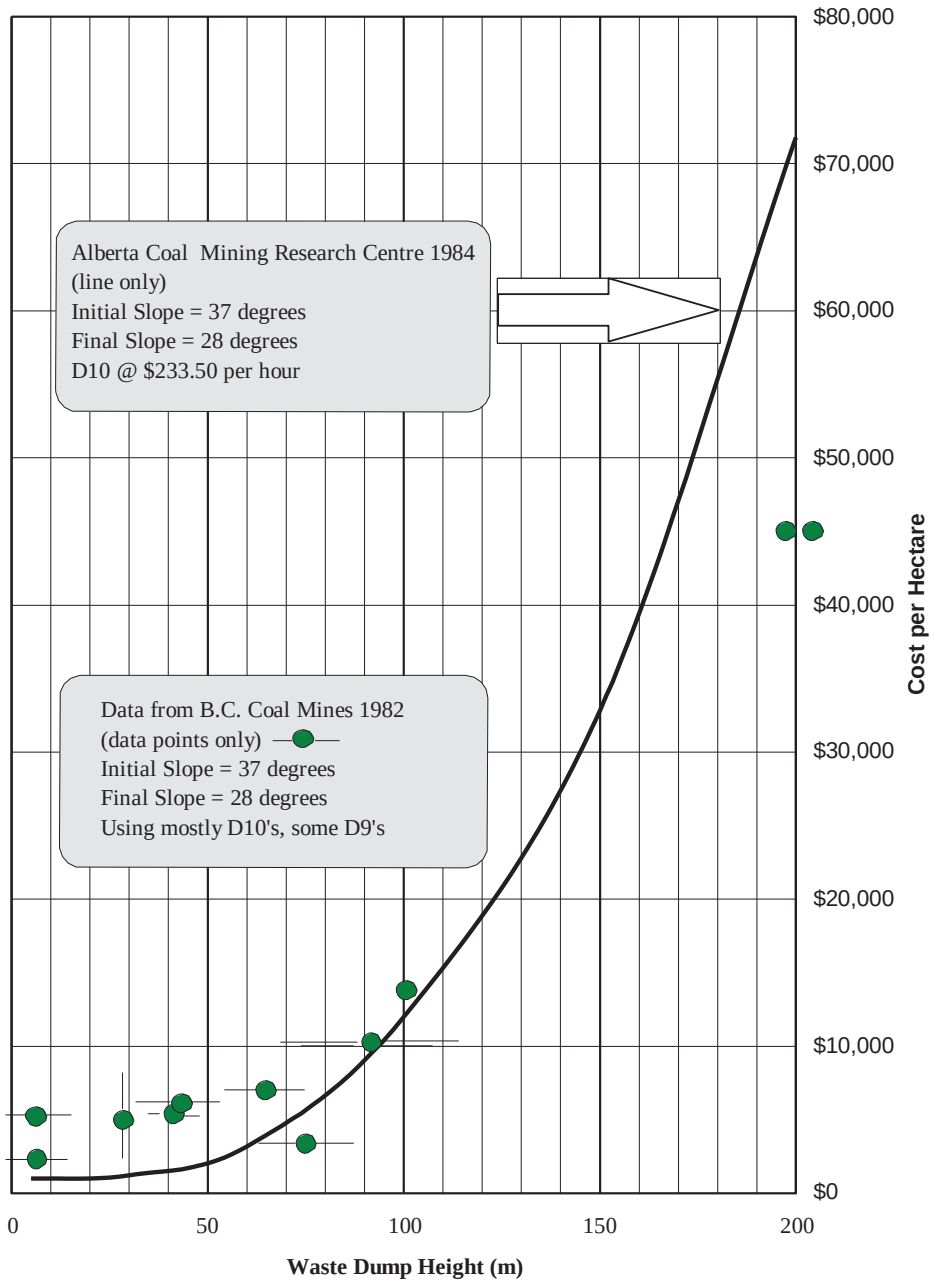


Figure 3: COST OF RESLOPING A WASTE DUMP



3.3 Resloping Worksheet

A special **Resloping Worksheet** was developed for the more complex estimating procedure required for resloping of waste dump faces.

Cost increases exponentially with dump height, and also varies with such things as foundation slope, bulldozer size, type of blade and skill of operator. The cost per hectare for resloping various heights of dump given in Figure 3 "Cost of Resloping a Waste Dump Face" have been drawn, over the years, from several company sources. Although this data reflects past costs and should be used with care, it is felt to be the most accurate depiction of the relationship that exists at the lower end of the cost curve. Resloping dumps less than 10 meters in height is considered 'recontouring', to differentiate this from higher dump work where height has major effect.

The 1984 publication *"Estimating Dozer Production for Waste Dump Resloping"* by the Alberta Coal Mining Research Centre, and *"A Practical Guide to Resloping of Waste Rock Dumps"* by Golder Associates, Vancouver, also provide good guidance.

Specific dump heights shown in Column E have not been locked, so that they may be edited to reflect specific site requirements.

3.4 Master Worksheets

Standard or "Master" worksheets serve for all types of area disturbance except resloping. Each sub-category of area disturbance has its own **Master Worksheet**. Only one Master Worksheet is included in Appendix 1. The same principles that guide the Resloping Worksheet apply to the Master Worksheet.

3.5 Material Summary Report

This is located at the bottom of each worksheet, and provides:

- a tabulated summary of costs for materials only;
- the total cost for materials for each item.

Although it is electronically linked to worksheet Sections B and C, totals developed here are not added directly to the **Summary Report**. To illustrate, entering data in the worksheet column headed *'area'* and *'application rate'* in the row headed *'seed'* in the worksheet, automatically updates *'No. of kg'* on both worksheet and material summary report. Then, entering data on *'unit cost'* in the material summary completes the *'subtotal'* for this item on the material summary. If this is followed by entry of estimated cost per ha. for application under *'Applic. cost'* column in part B, the program automatically calculates both cost of the prescription per ha (materials plus application) and the subtotal for the area.

If the user includes additional materials in Sections B or C, these items and the associated unit costs should be added to the material summary report in the appropriate spaces provided. Formulas have been included in Sections B and C corresponding to the selections of "**optional-material 1 ... optional-material 4, and optional-material 1 ... optional main.material 1 ... optional main.material 2."**

The user should be careful to match any additional entries in the worksheet with the material summary report.

3.6 Lump Sum Items

Costs entered in the **Lump Sum Items Worksheet** are defined as those not related directly to an area of disturbance. The user will first enter sub-categories appropriate to the particular mine site. The sub-category *'Hauling surfacing material'* is included here because the total depends largely on volume and haul distance, not area of surface that is covered. Salvage value will not be deducted from the cost of decommissioning facilities, even if this value exceeds decommissioning costs, because the government may not be first in line in the list of creditors to claim the assets in case of default. Also, Version 3.5.1 includes capital cost of ARD treatment in Part A of this worksheet.

3.7 Post Closure Worksheet

The **Post Closure Worksheet** lists those costs which constitute a stream of expenses extending more than five years beyond closure. Although both to closure and post-closure operating costs for ARD treatment are included in this worksheet, capital costs are included in the Lump Sum Items worksheet in order not to conflict with costing of present value. Non-ARD operational and monitoring costs are added to obtain the annual total, upon which present value is calculated. Entering this in the Post Closure Worksheet automatically updates the Summary Report.

When determining costs related to ARD, it is useful to bear in mind that these will in all likelihood differ significantly from those of the operating period, when the surface was being actively disturbed. Also, the company's method of cost accounting in the post mining period may differ from that used when mining was active.

3.8 ARD Capital Cost Worksheet

The **ARD Capital Cost** lists those costs which are incurred to neutralise the effects of ARD. Items pertaining to the costs of developing a treatment plant and system, including the cost of equipment and direct and indirect costs, are tabulated on this worksheet. ARD treatment plant and system costs are added to obtain the total capital cost. Completing this worksheet automatically updates the Lump Sum Items Worksheet.

3.9 ARD Operating System Cost

Costs entered into the worksheet titled **ARD Operating System Cost** include those costs to operate the ARD Treatment Plant, the Treatment System, along with monitoring and other associated costs. The totals of these costs are automatically tabulated and linked to the **Post Closure Worksheet**.

4.0 SOME SPECIFICS ON THE PROGRAM

The following sections will provide the user with basic instructions in use of the computer program. These are also to be found in the workbook format and the worksheets and summary report contained within the workbook. This application requires that the user have some basic understanding of the Excel program. For detailed instructions regarding specific Excel functions and options, the user is referred to the Excel manual.

4.1 Document Protection

Certain cells on the worksheet and summary report have been protected so that the contents and formulae may not be changed. The protected cells are "locked," and the user will not be able to alter or format these cells. Cells requiring data input are not protected and the user will be able to enter data pertaining to areas requiring reclamation activities. On each spreadsheet, the cells available for data entry by the user are indicated by colour (gray shading - Excel version 4.0, yellow shading - Excel version 5.0) to provide the user with a "road map" to data entry on the spreadsheets.

Because the document is protected, certain menu options will not be available to the user of the spreadsheet; menu options that are no longer available will appear in gray tones on the menu. Should additional changes/edits be required to the spreadsheets, a password is necessary to edit protected cells. Because changes could potentially affect formulae and document links, the requested revisions should be directed to the ministry staff member responsible for the password and spreadsheet revisions.

4.2 Spreadsheet Features

Several special Excel features have been utilized in the spreadsheets to enhance the "user-friendliness" of the application. These features include: notes in cells, document protection, headers and footers, and document links. The following discussion will provide an overview of each of these features as they pertain to the worksheets and summary report.

4.2.1 Notes in Cells

To facilitate data entry and user understanding of the spreadsheet format, explanatory notes have been attached to many of the cells in the worksheet and summary report. These notes provide information to the user regarding data entry instructions, or

explanatory information for a single cell or range of cells. As these notes should be sufficient to provide the user with instructions while using the spreadsheets, individual cell instructions will not be repeated in detail here. The cells containing notes are indicated on the screen by a red dot in the upper right corner of the cell. Until the user is familiar with data entry in the spreadsheet forms, it is suggested that the user display the cell notes on the screen while using the worksheets. Instructions for displaying cell notes and opening multiple windows are provided below.

4.2.2 Viewing Notes

To view the notes in a cell or worksheet using Excel Version 4.0 choose **Workspace** from the **Options** menu and toggle the **Info Window** option on (it will display an X when it is on). This will open an information window. Next, select the **Window** menu, choose **Arrange**, select **Horizontal**, and click **OK** or press **Enter**. This will display the Info Window tiled (horizontally) with the worksheet. Now activate the worksheet (click within the worksheet) and you will be able to move from cell to cell within the worksheet and view any notes attached to marked cells. The size of each of the windows may be adjusted by the user. To resize a window, move the mouse pointer to the border of the window until the pointer changes to a double arrow. Click the left mouse button, and drag the border to a new position to make the window either larger or smaller. For additional information, refer to the appropriate section of your Excel manual discussing re-sizing and moving windows.

To view notes in a cell or worksheet using Excel Version 5.0 choose **Options** from the **Tools** menu, pick the **View** file card, and toggle the **Info Window** option on (it will display an X when it is on). Next, select the **Window** menu, choose **Arrange**, select **Horizontal**, and click **OK** or press **Enter**. This will display the Info-Window tiled (horizontally) with the worksheet. **Excel 5.0** also allows you to use toolbar keys to access the Info-Window. To display the Info-Window toolbar keys, choose **Toolbars** from the **View** menu. Next, pick **Customize** and pick the **Auditing** menu. Find the **Show Info Window** tool (the letter "i" within a blue circle) and click and drag it up to the toolbar at the top of the screen. Release it at the desired location within the pre-set toolbar. Again, select the **Window** menu, choose **Arrange**, select **Horizontal**, and click **OK** or press **Enter**. This will display the Info-Window tiled (horizontally) with the worksheet.

4.2.3 Opening Additional Windows

At times it may be useful to open additional windows to view several worksheets simultaneously. To open a new window, select the **Window** menu, and choose **New Window** and a new window will appear. Select the **Window** menu again, choose **Arrange**, and select **Tiled, Vertical** or **Horizontal** (play with these options to achieve your preference). Once you have opened additional windows, you can click the mouse on the window you wish to activate, and page between worksheets using the icons at the bottom right of the window to display the worksheet of choice.

4.2.4 Formulae and Named Ranges

Formulae have been used extensively in the worksheets and summary report to generate unit cost ($/ha) and total costs of reclamation activities. The cells containing formulae may not be changed without a password to disable the document protection. In order to simplify the formulae and enhance the user's understanding of the formulae, named ranges have been used for all formulae. Named ranges are an option that permits the user to assign a recognizable name to a single cell or range of cells. As an example, Column D of the worksheet, titled "Area (ha)" contains only information pertaining to areas requiring reclamation activities, and this column has been named "Area." These named ranges are then incorporated into the formulae rather than specific cell addresses. A list of named ranges and corresponding cell addresses is provided below the Material Summary Report on each worksheet.

4.2.5 Headers and Footers

Headers and footers have been specified for the worksheets and summary report in the workbook. These may be changed by the user if desired. The header prints the filename in the upper left of the page, the title of the worksheet in the upper center of the page, and the date and time in the upper right of the page. The footer prints the page number at the bottom center of the page.

4.2.6 Linking Documents

Specific cells of the summary report are linked to each worksheet in the workbook. These cells include the project name, reclamation permit number, disturbance category, and area to be reclaimed. As this information is entered on the summary report it is automatically directed to individual worksheets in the workbook. In a similar manner,

cells reporting the total cost of site preparation, revegetation and maintenance on each worksheet are linked to the summary report. As the reclamation requirements for a specific disturbance category are defined, the summary report is automatically updated with the costs.

In order to allow the user greater flexibility and minimize memory requirements, cells and cell ranges within the worksheets have not been linked (i.e. **Master1** is not linked to **Master2**). The user may find that linking some of the cells could be useful. As an example, one could link the cells containing aerial broadcast seed and fertilizer application rates. This would allow the user to change the application rates on one worksheet and simultaneously update the application rates reported on all linked worksheets.

Establishing document links is very easily accomplished using the **Copy** and **Paste Link** commands on the **Edit** menu. A password would be required to disable the document protection prior to establishing the document links. For further information regarding linked documents, refer to the appropriate section of the Excel manual.

4.3 Using the Workbook

To apply the workbook spreadsheet for your own application, you will want to open the Excel workbook (**RC993.5.xls**) and then save it under a new name. This will preserve the original Excel file as the template workbook, and allow you to create an identical copy of the workbook for data entry. You may wish to save your new workbook under the mine name. Note however, that the workbook name may not exceed eight characters in length.

4.3.1 Saving a Spreadsheet Under a New Name

To save each spreadsheet under a new name within the workbook, scroll to the **Master1** spreadsheet. Select **File**, **Save As**, and notice the dialogue box **Bound Save As** will appear. Click the mouse on the space under **Bound Sheet Name** and enter the new name. Remember that because the spreadsheet is bound, you are able to select names up to 30 characters in length. After you have typed in your new file name, click on **OK**, or press **Enter**. As each worksheet presents data for a specific disturbance category, it may be useful to assign spreadsheet names that correspond to the disturbance category (i.e. Master1 becomes **dumptop.xls,** Master2 becomes **millarea.xls,** Master3 becomes **roads.xls, tailings.xls,** etc.). Renaming the worksheets will not affect any of the links between the worksheets.

4.3.2 Saving and Exiting the Workbook

To save the workbook, select **File**, **Save Workbook**; Excel will save each of the files in the workbook. To exit the workbook, select **File**, **Close Workbook**.