WATER AND MATERIAL BALANCE AT MINE TAILINGS IMPOUNDMENTS - SOFTWARE PROGRAM DEVELOPMENT AND RISK ANALYSIS

by

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ABSTRACT

Tailings impoundments are commonly used in the mining industry for the disposal and storage of mine wastes including tailings, waste rock and process water. The impoundments often require engineered embankment dams to facilitate containment. Failure of impoundment dams can lead to serious effects downstream due to the release of significant amounts of water and solids. Inadequate water management has been recognized as the primary cause of such failures.

Tailings impoundment dam design involves estimating the site water and material balance to design appropriate impoundment structures and material management facilities. The balances are usually conducted using monthly average hydrologic values and output from the balance are the required dam crest elevations during the life of the mine.

The "models" that are employed by industry and their consultants to complete these hydrologic budgets are simple and spreadsheet based, using average hydrologic values to predict required monthly dam crest elevations. The lack of flexibility and transparency in these spreadsheet balances has been identified as a problem by mining engineers.

A Microsoft Windows based software program written in Visual Basic, *Visual Balance*, was developed as part of this study. Visual Balance is a fast, simple method of modelling the water and material balance in a single impoundment tailings disposal system and predicting required dam crest elevations. Visual Balance also includes a risk analysis module which predicts

probable impoundment operation and closure conditions based on a Monte Carlo simulation of expected precipitation and surface runoff values.

Water management problems identified by Visual Balance include insufficient free pond water available for reclaim, inadequate freeboard, uncontrolled release requirements, or tailings solids exposure. Knowledge and anticipation of these challenges could influence tailings impoundment site selection, design, or mine operating conditions. Planning for these conditions in impoundment and facility design could save companies considerable cost and aggravation.

The results of the five Case Studies conducted as part of this study emphasized the predictive capabilities of Visual Balance. Monthly dam crest elevations similar to those previously predicted by spreadsheet based balances were modelled for the five Case Studies by Visual Balance. In the two Case Studies where actual operating conditions were available for comparison, insufficient free pond water availability and excess water leading to low freeboards experienced at each site were successfully predicted by Visual Balance.

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LIST OF SYMBOLS

Symbol	Units	Description
A_c	m^2	catchment area
A_b	m^2	tailings impoundment beach area
A_r	m^2	reservoir surface area
b		term used in the asymptotic expansion expression
C		units conversion constant = $5.12*10^{-4}$
$\bar{d}$	m	average water depth along the direction of wind
d_{sp}	mm	snowpack depth
d_{si}	m	depth to spillway
D_m	days	number of days in month
d_r	mm	runoff depth
$(E_w)_{ps}$	m	elevation of water "post spill"
E_{dc}	m	elevation of dam crest
E_m	mm	monthly evaporation depth
E_r	mm	average monthly evaporation depth from reservoir
E_b	mm	average monthly evaporation depth from beaches
f	km	fetch or distance over which wind acts on the water
$f(x)$		general distribution function
$F(x)$		cumulative distribution function
f_s		fraction of precipitation as snow in a given month
f_m		fraction of snowmelt occurring in a given month
f_{rd}		fraction of catchment area diverted
f_{wrs}		fraction of waste rock submerged in reservoir
f_{wri}		fraction of waste rock sent to reservoir
f_c		fraction of tailings cycloned out of reservoir

Symbol	Units	Description
f_l		
$g_l(x_p)$		functions used in the asymptotic expansion expression
G_s		specific gravity
Δh_u	m	set-up height
I_p	m^3	volume of direct precipitation
I_r	m^3	surface water inflow volume
I_{gw}	m^3	groundwater inflow volume
I_{sw}	m^3	surface water inflow volume
I_{mw}	m^3	minewater inflow volume
I_{gr}	m^3	groundwater recovery or treated water return inflow volume
I_s	m^3	solids inflow volume
I_{tt}	m^3	total tailings solids and voids inflow volume
I_{wrt}	m^3	total waste rock solids and voids inflow volume
l_R	mm	runoff loss in a given month
M	tonnes	total mass
M_w	tonnes	mass of water
M_s	tonnes	mass of solids
n		sample size
O_E	m^3	volume of total evaporative loss
O_{gw}	m^3	groundwater outflow volume
O_v	m^3	total volume of water loss to solids voids
O_{rc}	m^3	mine recycle or reclaim outflow volume
O_{sr}	m^3	spills and release volume (may include release to water treatment facility)
OD_m	days	operating days in month

Symbol	Units	Description
O_{re}	m^3	volume of evaporative loss from reservoir pond
O_{be}	m^3	volume of evaporative loss from beaches
O_{tv}	m^3	volume of water lost to tailings voids
O_{wrv}	m^3	volume of water lost to waste rock voids
O_{sv}	m^3	volume of tailings solids lost to waste rock voids
P_R	mm	randomly generated precipitation
p		random number between 0 and 1
P_m	mm	average monthly precipitation depth
r_i		i-th random number
R_d	mm	average monthly runoff depth
R_{gi}	m^3/hr	groundwater inflow rate
R_{sw}	m^3/hr	slurry water inflow rate
R_{mw}	m^3/hr	minewater inflow rate
s		sample standard deviation
S_r		degree of saturation
ΔS	m^3	change in storage volume
t		Student's t statistic
t_p		number of standard deviations from the mean
u	km/hr	wind speed (km/hr)
V	m^3	total volume
V_r	m^3	volume of runoff
V_s	m^3	volume of solids
V_v	m^3	volume of voids
V_w	m^3	volume of water

Symbol	Units	Description
$(V_t)_{ps}$	m^3	total actual volume of solids and water in the impoundment post spill
V_s	m^3	volume of solids
$(V_w)_{ps}$	m^3	volume of water in impoundment after a spill
w		water content
$\bar{x}$	mm	mean total annual precipitation
x_i		random variate
x_p		randomly generated number of standard deviations from mean
$\bar{y}$		sample mean
z		term in x_p approximation
μ		population mean
e		void ratio
ρ_w	kg/m^3	density of water
$\epsilon(p)$		error term
ρ_d	$tonnes/m^3$	dry density
ρ	$tonnes/m^3$	bulk density
ν		degree of freedom (n-2)

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CHAPTER 1.0 INTRODUCTION

1.1 Background

Tailings impoundments are widely used in the mining industry for the disposal and storage of mine wastes including tailings, waste rock and process water. *Tailings* is the term used for the fine grained residual solids generated at the "tail end" of many process industries, including ore processing. The impoundments designed to store mine waste material and water often require engineered embankment dams to facilitate containment. Embankment dams for these storage facilities are typically constructed using the coarser fraction of the tailings or waste rock from mining, or borrowed earth or rock fill.

Failure of large earth embankment dams can lead to serious effects downstream due to the release of significant amounts of water and solids. Environmental impacts resulting from failures can be particularly significant if hazardous constituents are included in either the water or solids being impounded. For example, process water may contain high suspended solids concentrations, heavy metals, or toxic residual chemicals such as cyanide. As well, mine tailings and waste rock can contain sulphide minerals with the potential for acid rock drainage.

The most significant causal factor of tailings impoundment failure is inadequate water management (UNEP, 1998). Insufficient freeboard, spillway capacity, or diversion capacity can lead to overtopping of the dam by flood discharge. Hydraulic failure in the form of overtopping accounts for nearly 40% of all the earth dam disasters in the world (Murthy, 1991). Deficient water management at tailings impoundments can also lead to excessive seepage, uncontrolled effluent spills, or dam failure, which can impact the downstream environment.

Over the last two decades, the focus on the potential hazard created by mining waste disposal has increased due in part to the public awareness of failures causing death and severe environmental impacts. The need for better design of tailings impoundments was recognized by the International Committee on Large Dams (ICOLD) when they formed the Committee on Mine and Industrial Tailings Dams in 1976. Despite the regulatory emphasis on improved design methods and management, there have been several recorded failures of large tailings embankment dams in the last two decades. These catastrophic events have resulted in loss of life and widespread environmental and property damage.

Recently, the failure of a tailings impoundment at the Boliden A/S Los Frailes mine near Andalucia, Spain in July 1998 resulted in direct contamination of over 2,000 hectares of agricultural and undeveloped parkland. Reports suggest that Boliden will spend up to US $60 million in clean up and compensation costs. The Merriespruit tailings dam failure in South Africa in February 1994 resulted in the loss of seventeen lives, severe destruction of property, and widespread environmental damage. This failure involved the collapse of a thirty-one metre high tailings dam upslope of the suburb of Merriespruit and the release of 600,000 m^3 of tailings that flowed through the town. The mine tailings storage facility collapse near Stava, Italy in July 1985, resulted in 268 lives lost and considerable property damage.

The mining industry has additional reason to seek effective measures to control water and wastes because the lack of sound mine water management is a common cause of permit violations, an impediment to sustainable mine reclamation, and an expensive irritation to mine operators (Sawatsky et. al., 1998).

The need to anticipate and control surface water during the initial impoundment planning and design is critical. Because of failure to properly account for accumulated volumes of precipitation and runoff water, many tailings impoundments, while initially sized to contain the anticipated tailings output, become full to design capacity long before the end of mine production (Vick, 1990). Tailings impoundments filled more rapidly than originally designed for can result in compromised freeboard and the increased potential for overtopping due to an extreme precipitation or flood event.

Tailings impoundment dam design involves estimating the site water and material balance to design appropriate impoundment structures and material management facilities. Water and material balance for these impoundments requires accounting of inflow of water and material in the form of precipitation, snow and glacier melt, effluent water, waste solids and slurries, and the outflow or loss of water via evapotranspiration, runoff, infiltration, process reclaim water, planned releases and water treatment withdrawals. The balances are usually conducted using monthly average hydrologic values. Safety provisions are added for the storage of a design flood volume and wave and safety freeboard. The output from the water and material balance is a dam *staging curve* showing the required dam crest elevations during the life of the mine (Figure 1.1).

At present, the "models" that are employed by industry and their consultants to complete these hydrologic budgets are simple and spreadsheet based. Many of these water balance spreadsheets are not transferable between projects and are regenerated on a project-by-project basis. The spreadsheets also contain "magic numbers": site specific variables set to unique values that can not be seen or understood by the user without detailed review of the spreadsheet set up. Although this is an inefficient use of resources, the large amount of time and associated expense needed to develop a flexible water and material balance application has not been afforded.

1.2 Research Objectives

The objective of this research was to develop a prototype computer software application for water and material balance that could be employed at single reservoir tailings impoundment sites, particularly in the mining industry. The study involved the following components as outlined in a research proposal to the Science Council of British Columbia:

- review available methods for tailings impoundment water and material balance;
- assess the applicability of selected methods using hydrology data typically available from remote British Columbia mine sites;
- develop and test a prototype methodology and computer software program for water and material balance at simple tailings impoundments; and
- assess long term uncertainty and risk associated with current design standards and design practices.

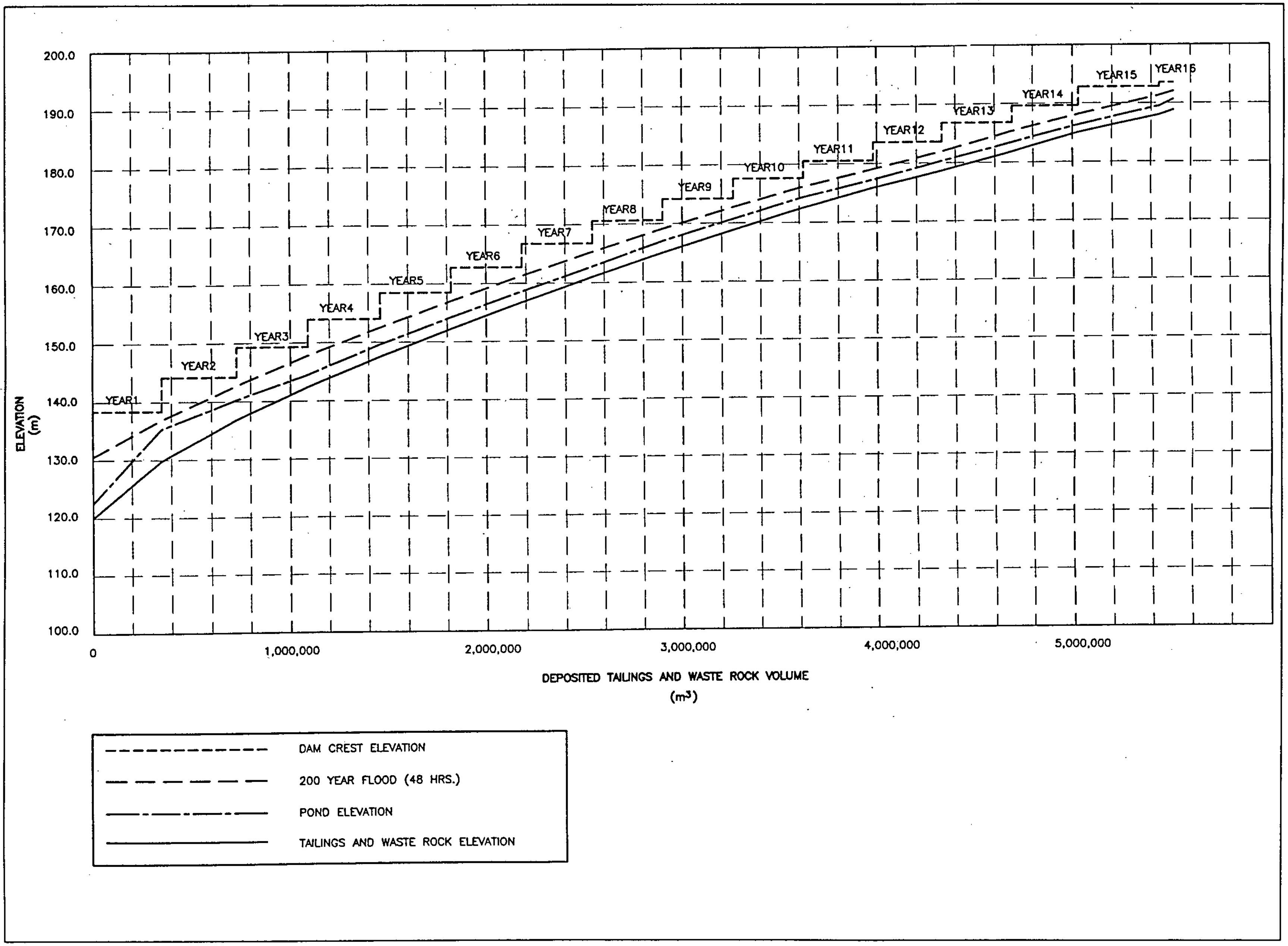


Figure 1.1 Dam Staging Curve

The results of the research will provide the mining industry with a better understanding of available methods for small-scale water and material balance at tailings impoundments and provide a needed tool for improving these balances. Both outcomes can be expected to increase the efficiency of impoundment site assessment, enhance the efficacy of mine operation, and improve associated environmental and human health protection.

1.3 Thesis Outline

Development of a water and material balance model for tailings impoundments combines concepts from a number of different scientific and engineering disciplines. This research has involved integrating common design practices from the following areas:

- tailings disposal methods and impoundment design practices,
- mine waste and mine pollution,
- water balance and hydrology, and
- risk analysis and uncertainty in water resource projects.

A review of technical issues relevant to tailings disposal and impoundment design are covered in Chapter 2.0. Water and material balance computational algorithms and risk analysis concepts are presented in Chapter 3.0. The structure and performance of the water and material balance software program, *Visual Balance*, developed as part of this research is outlined in Chapters 4.0 and 5.0. The statistical approach and methods for conducting risk analysis at tailings impoundments using the program are also detailed. Five recent tailings impoundment water and material balance case studies were analyzed using the program and the results of expected impoundment performance are included in Chapter 6.0. Conclusions regarding applicability of the program and recommendations for further research are included in Chapter 7.0. Computer code for the software program is provided in Appendix C.

CHAPTER 2.0 TAILINGS DISPOSAL AND IMPOUNDMENT DESIGN

The issue of water and waste management in the mining industry is significant. Worldwide, the tonnage of mine waste handled on an annual basis exceeds that of any other industry, including non-mine construction (ICOLD, 1996). Mineral processing wastes can contain hazardous residual chemicals, heavy metals, and may produce additional hazardous reactions after disposal. In the following sections, mine waste characteristics, methods of tailings and waste disposal, impoundment design, and impoundment failure causes and case studies are discussed.

2.1 Mine Waste

Waste materials and wastewater from mining activities vary depending on the method of mining and mineral processing. Solid waste materials can include unprocessed waste rock, tailings, and waste surface soil material. The extraction of sulphide bearing rock, which is the predominant type of rock associated with metalliferous mining, can expose large volumes of potentially acid generating rock. Generation of acid from waste rock and tailings can lead to leaching of low pH water from the storage facility, which may also contain elevated heavy metals concentrations.

Water and wastewater sources from mining activities can include milling process water, water contained in a tailings slurry, treatment plant effluent water, and mine site runoff. Specific metals and hazardous chemical concentrations in the milling process water will depend on the metal extraction process employed. For example, cyanide is often a necessary reagent and problematic constituent in process effluents from gold-silver milling. Cyanide is also sometimes used in concentration processes such as lead and tungsten flotation (Vick, 1990). Mine site runoff, although usually a much smaller volume of water than the process sources mentioned, could include contaminants associated with industrial site activities such as hydrocarbons and metals, and nitrate and ammonia residues from blasting practices using ammonium nitrate (Vick, 1990).

Mineral processing wastes may also produce additional hazardous chemical reactions after disposal, which may persist for many years or centuries after mine closure. For example, acid can be generated in mine wastes through the oxidation of iron sulfide minerals (pyrite). The extraction and milling operations of mining expose large volumes of sulphide rock, potentially increasing the rate of acid rock drainage (ARD).

Current methods of ARD reduction include minimization of contact between mine wastes and the primary ARD reaction constituents, water and oxygen. These methods include:

- permanent waste submergence under water in dammed reservoirs, natural lakes, or marine disposal,
- prevention of waste contact with water through encapsulation or drainage, and
- chemical treatment.

Based on the high potential for acid generation in many mine wastes and the difficulties in preventing this outcome, ARD has been described as the largest environmental problem facing the mining industry in the United States (U.S. Forest Service 1993, Ferguson and Erickson 1988, Lapakko 1993). The success of ARD prevention through waste submergence or drainage is heavily dependent on the successful prediction of water management and impoundment water balance. Risk analysis of hydrologic variables may be an effective method of predicting the probability of submergence over the long term.

2.2 Tailings Disposal Methods

Waste from mining operations can be disposed by a number of methods which depend on local geography and hydrology, and on the nature of the waste to be stored. The main by-product of processing rock for the purpose of extracting minerals is a tailings slurry. Generally, the water content of the tailings slurry is high enough to transport the slurry along a channel or it may be pumped through pipelines to a disposal area. The common disposal methods include deposition in:

- storage reservoirs, either in existing pits and depressions or behind engineered embankments;
- underground spaces, such as old mine works,
- the environment, such as discharge to a river, lake, or ocean; and
- dry waste dumps on land.

Tailings storage impoundments bound by engineered tailings dams are the most common form of disposal (ICOLD, 1996) and are the focus of this research and software product development.

2.3 Tailings Impoundment Design

Tailings impoundments typically include the construction of dams and the development of waste reservoirs behind the dams. The dams are commonly constructed of mill tailings, mine waste rock, or "borrow material" such as earth or rock fill.

The challenges of building effective tailings dams are significant when it is understood that, according to the World Register of Mine and Industrial Tailings Dams, tailings dams are amongst the largest dams in the world, with at least eight dams higher than 150 metres and over 130 dams higher than fifty metres. Also, six impoundments have a surface storage area greater than 100 km^2 and a storage volume greater than 50,000,000 m^3 (ICOLD, 1996). However, inadequate design of even small dams can have significant consequences on the downstream inhabitants and environment.

Tailings dams share common structural features and design standards with earth fill embankment dams (Figure 2.1). Tailings dams are earth fill construction dams typically consisting of a core of waste rock or borrow materials (soil or rock) and completed with raises of spigotted, cycloned tailings material (Figure 2.2). However, some notable differences in their use and construction require unique planning and design approaches. For example, in contrast to water conservation or flood-control dams, the major part of the stored volume behind tailings dams is comprised of the solid fraction of tailings (Cassidy and Hui, 1990). Also, tailings dams are designed to be abandoned within a relatively shorter period of time than water retention dams.

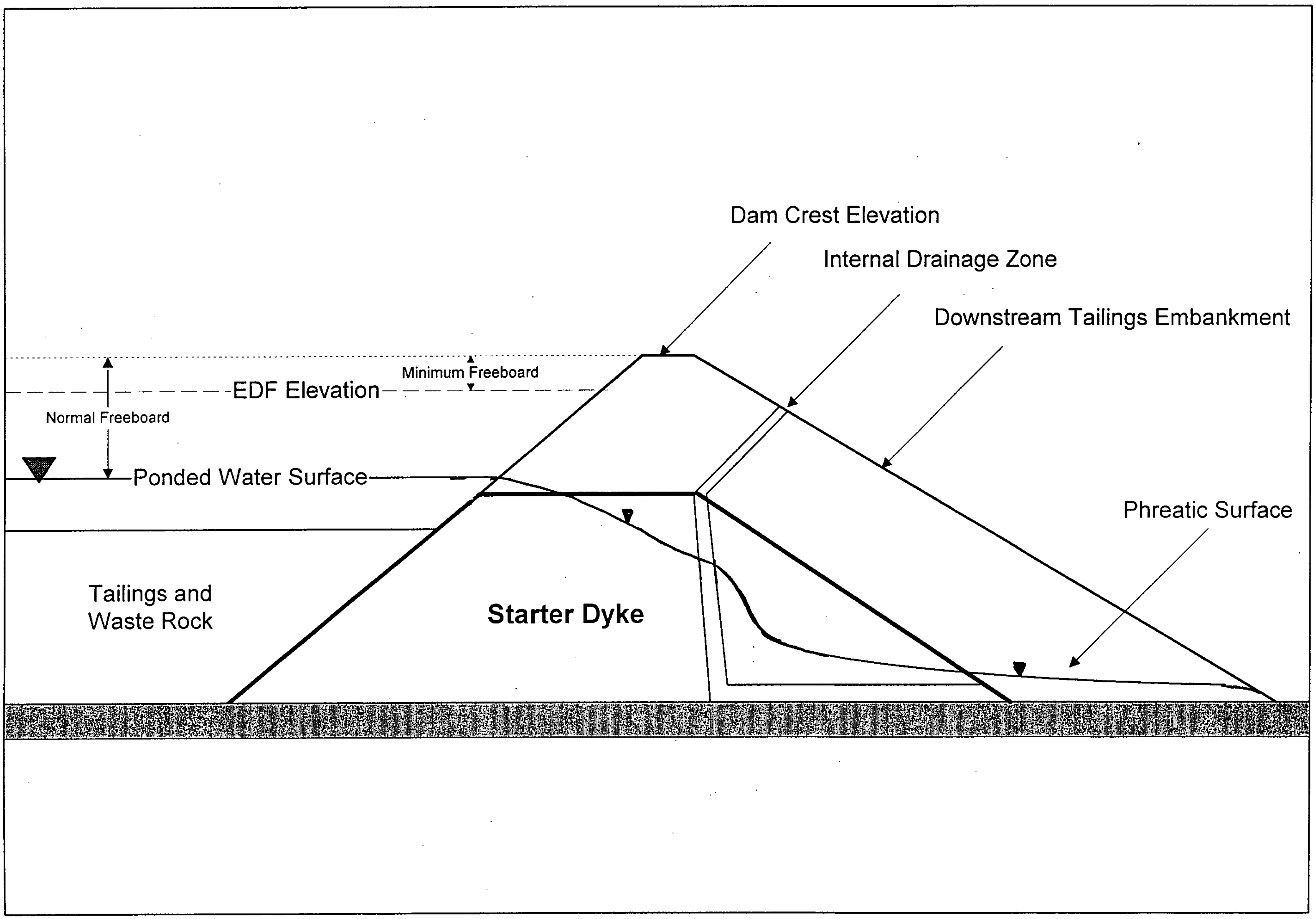
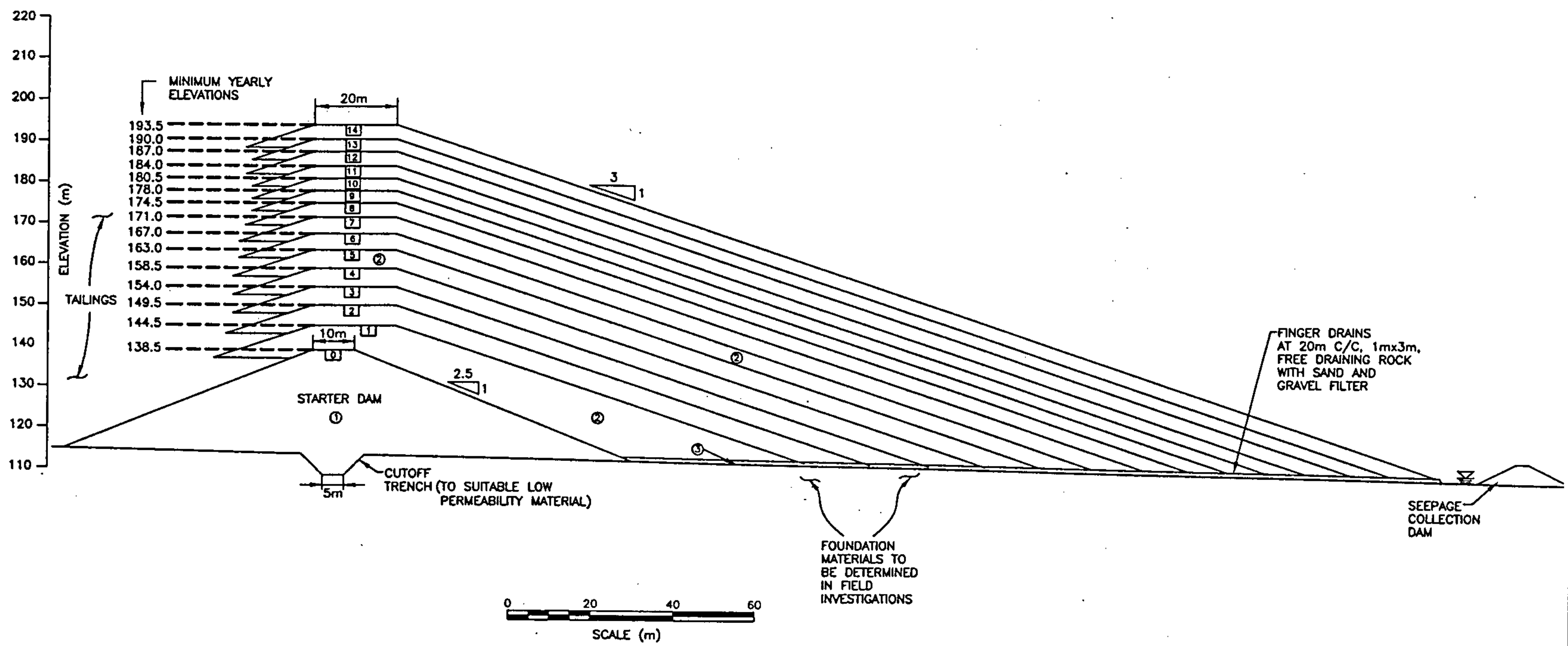


Figure 2.1 Typical Embankment Profile



SUMMARY OF EMBANKMENT ZONES

EMBANKMENT ZONE	DESCRIPTION	MATERIAL TYPE
①	STARTER DAM	COMPACTED TILL
②	MAIN DAM	COMPACTED CYCLONED TAILING SANDS
③	DRAIN	FREE DRAINING ROCK

[14] REQUIRED DAM CREST ELEV. AT END OF YEAR

NOTE: 1. MATERIALS USED IN STARTER DAM MAY BE VARIED SUBJECT TO AVAILABILITY.

2. FILTERS TO BE DESIGNED TO BE COMPATIBLE WITH TAILINGS SAND AND FREE DRAINING ROCK.

Figure 2.2 Tailings Dam Profile Showing Scheduled Lifts

Tailings impoundments need to be designed with both active life and post-closure in mind. Particularly, the dam will be designed for safe abandonment, little or no long-term maintenance, and restoration to a suitable land use and vegetation cover. Dam construction is usually ongoing during mine operation. Tailings dam designs need to be made simple and robust to allow for less than perfect construction control by mine operators.

Tailings impoundments are typically located in a topographic depression where the number and size of impoundment dams can be minimized. Valley sites are often selected, which can result in the need for embankment of the tailings on only the downstream side (Figure 2.3). In some valley locations, both the upstream and downstream sides require embankment. Off-valley sites may require embankment around the full perimeter of the stored waste. Off-valley sites have the disadvantage of a lower storage volume to confining embankment volume, but the amount of natural runoff to be controlled may be significantly reduced. Existing pits, such as former open cast or underground workings, can also be used for tailings impoundment and may need to be supplemented with embankments.

Tailings dam design techniques involve a series of successive lifts or dam raises during operation of the mine (Figure 2.2). In the case of embankments constructed from tailings material, a procedure called hydrocycloning may be used to separate fine material and water from the somewhat larger diameter granular material to be used in dam construction. Dam lifts may occur continuously with the deposition of tailings, annually during optimum dryer construction seasons or on a more infrequent basis as required by the characteristics of the impoundment area.

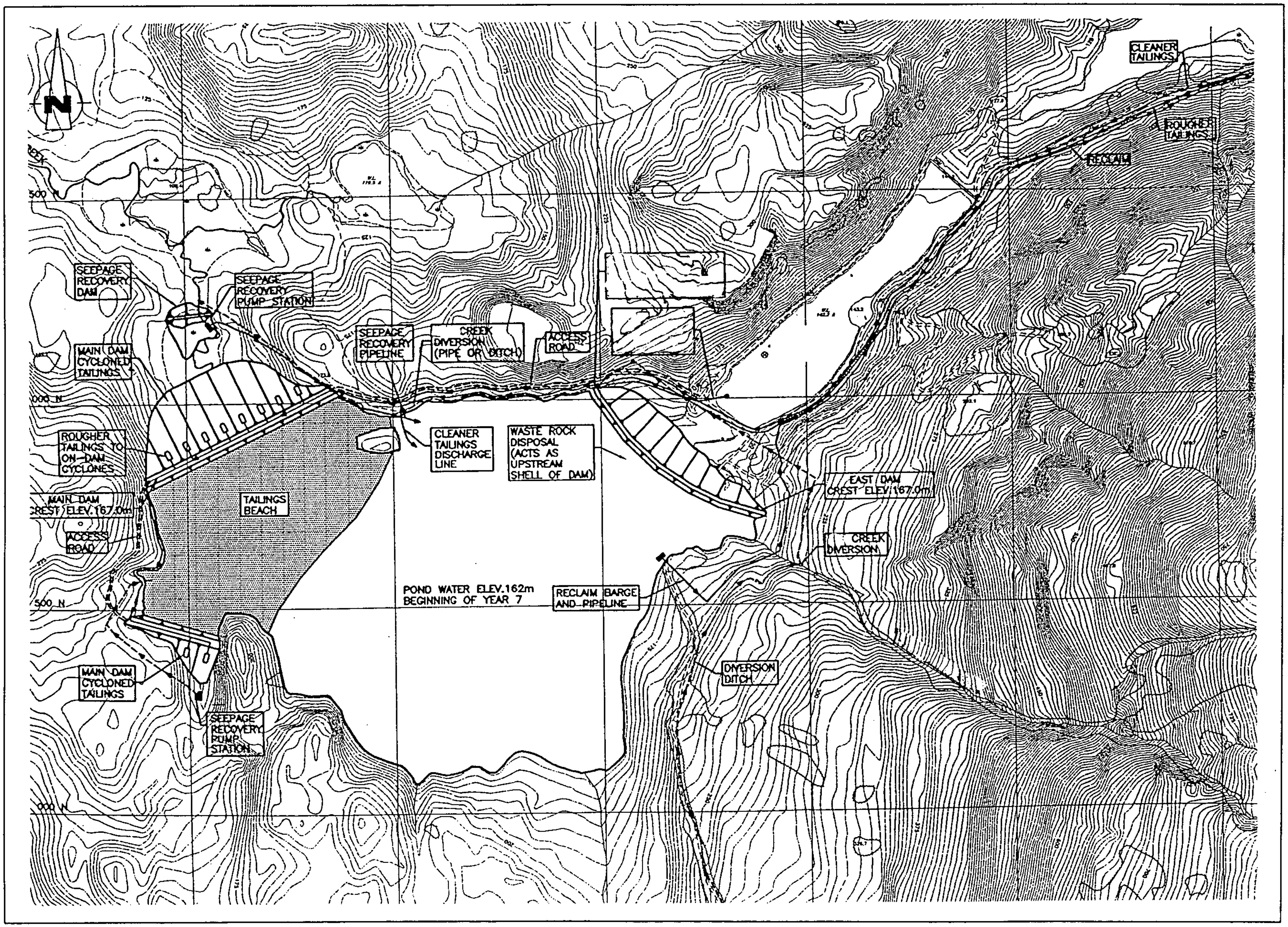


Figure 2.3 Cross-valley Impoundment Allignment and Surface Water Diversions

Water and material balance is commonly calculated on a monthly basis to predict and schedule the dam height requirements. Methods such as the finite difference analysis performed by Consoli (1997) have been developed to estimate the reservoir filling and detailed sedimentation patterns of tailings behind dams. Consoli's numerical analysis successfully predicted the filling of a reservoir with bauxite mine tailings as well as the longitudinal underwater slope profile formed by the solids during the process. However, Consoli's model focuses solely on tailings deposition, whereas both water and other waste material inflows are significant in the overall filling of tailings impoundment reservoirs. Models related to water and material balance are presented in Section 3.3.

2.3.1 Design Floods

Tailings impoundment and dam design raises requires consideration of two separate hydrologic conditions: average inflows and extreme floods. Impoundments are usually designed using annual or monthly average hydrologic data combined with the capacity of the dam to hold a so-called Environmental Design Flood (EDF). Additional freeboard above the predicted EDF level is allowed for to account for wave action and to provide a margin of safety (Figure 2.1).

A common method of controlling large floods is through storage rather than periodic controlled releases. Storage avoids the recurring necessity of expensive and sometimes difficult treatment of contaminated water prior to release (Vick, 1990). Tailings impoundments can be designed and operated as "no release" systems that store all flood, precipitation and mine water inflows.

The only allowable loss in through evaporation and minimal seepage through the dam. This method of operation prevents release of contaminants to the environment. However, in some situations topographic constraints or material availability may restrict embankment height and impoundment volume and occasional controlled or scheduled release may be permitted. Also, large annual precipitation rates or high rates of mill water discharge may make storage of flood inflows unfeasible and occasional releases from the impoundment the only option. In addition, although an impoundment may be designed as a "no release" system that is capable of storing large floods, extreme events may be spilled via an emergency spillway.

The Canadian Dam Association (CDA) has developed Dam Safety Guidelines (DSG) for dam design in Canada (Canadian Dam Association, 1999). The guidelines are intended to apply to dams, including tailings dams, if they are at least 2.5 m high and have a minimum of 30,000 m^3 of reservoir capacity. The guidelines also apply to smaller dams where the consequence of failure is classified as "Low" or greater. Such small dams may include dams retaining contaminated fluids.

Previous versions of the DSG included a definition and use of the term "Environmental Design Flood" (EDF) for tailings or industrial dams impounding contaminated water or solids. The impoundment was to be designed to contain an EDF and pass an Inflow Design Flood (IDF). The EDF terminology was dropped in the 1999 version of the DSG and only the volume of the IDF referred to in the guidelines. However, this EDF terminology is quite useful in tailings impoundment design analysis to differentiate between that flood which must be passed without failure of the dam and that flood which must be contained without spilling from the impoundment. The EDF terminolgy is adopted in the Visual Balance program.

The volume of the EDF which the impoundment must contain is often more critical in dam crest elevation determination and impoundment design than the IDF magnitude, which is relevant in the sizing of an emergency spillway. This EDF volume is dependent on the consequence of effluent release which, in turn, is dependent on downstream conditions, release quantity, and effluent quality. For instance, a water release from an impoundment to a downstream sensitive aquatic habitat during a critical ecological period, such as spawning periods, may have severe impacts. If the IDF volume is greater than the EDF volume, dam crest raises are dependent on the EDF and the IDF would determine other design factors, such as spillway capacity and surface water diversion capacity requirements.

Tailings impoundments are usually designed to pass and/or retain a design flood before and after closure. The operating structures associated with the life of the mine may be considered to have a finite life of a few decades. However, some structures will need to be designed or extended to account for the fact that they may be permanent structures. Many regions require essentially the same design flood and seismic criteria during operation as after closure (ICOLD, 1996).

Selection of the design flood typically depends upon the consequences associated with potential failure, such as loss of life, environmental impact and economic loss. Table 2.1 shows the CDA classification system for dams in terms of consequence of failure included in the DSG. This classification is used to determine the appropriate flood and earthquake magnitudes to use in dam design.

Table 2.1
Classification of Dams in Terms of Consequence of Dam Failure (CDA, 1999)

Consequence Category	Potential Incremental Consequences of Failure [a]	
	Life Safety	Socioeconomic Financial & Environmental [b], [c]
Very High	Large Number of Fatalities	Extreme damages
High	Some Fatalities	Large damages
Low	No fatalities anticipated	Moderate damages
Very Low	No fatalities	Minor damage beyond owner's property

(a) Incremental to the impacts which would occur under the same natural conditions (flood, earthquake or other event) but without failure of the dam. The consequence (i.e. loss of life or economic losses) with the higher rating determines which category is assigned to the structure. In the case of tailings dams, consequence categories should be assigned for each stage in the life cycle of the dam.

(b) The criteria which define the Consequence Categories should be established between the owner and regulatory authorities, consistent with societal expectations. Where regulatory authorities do not exist or do not provide guidance, the criteria should be set by the owner to be consistent with societal expectations. The criteria may be based on levels of risk which are acceptable or tolerable to society.

(c) The owner may wish to establish separate corporate financial criteria which reflect their ability to absorb or otherwise manage the direct financial loss to their business and their liability for damage to others.

The CDA DSG state that large dams shall be evaluated for safety and include a spillway structure designed to pass an Inflow Design Flood (IDF). The magnitude of the IDF is based on the potential consequences of dam failure (Table 2.2). For new dams with "very high" or "high" consequences of failure, the CDA states that the maximum design floods at the dam site shall be evaluated by both "statistical analysis and deterministic methods".

Table 2.2
Usual Minimum Criteria for Inflow Design Floods (CDA, 1999)

Consequence Category	Inflow Design Flood (IDF)
Very High	Probable Maximum Flood (PMF) [(a)]
High	Annual Exceedance Probability (AEP) between 1/1000 and the PMF [(b)]
Low	AEP between 1/100 and 1/1000 [(b), (c)]

(a) An appropriate level of conservatism shall be applied to loads from this event, to reduce the risks of dam failure to tolerable values. Thus, the probability of dam failure could be much lower than the probability of extreme event loading.

(b) In the High Consequence category, the IDF is based on the consequences of failure. For example, if one incremental fatality would result from failure, an AEP of 1/1000 could be acceptable, but for consequences approaching those of a Very High Consequence dam, design floods approaching the PMF would be required.

(c) If a Low Consequence structure cannot withstand the minimum criteria, the level of upgrading may be determined by economic risk analysis with consideration of environmental and social impacts.

Failure during an extreme flood event does not necessarily represent poor design. Acceptance of an IDF volume of less than the PMF implies acceptance of a finite possibility of failure. This tolerance of risk is an accepted practice if the consequence of failure are less than the CDA "very high" rating. Moreover, non-failure of such engineered features does not necessarily represent a successful design. Over-design of hydrologic structures is costly and reduces the competitiveness of the company paying for the structure. Therefore, effective methods are required that accurately predict water balance, such that hydrologic engineering features and design account for both safety and economy.

The CDA suggests two methods for the derivation of the IDF. The first method is based on the Probable Maximum Flood (PMF) hydrograph and the second on a flood hydrograph with a specified Annual Exceedance Probability (AEP). After an appropriate IDF peak flow rate and volume are determined for the project, the next task is to review or develop the corresponding hydrograph. This hydrograph is used to assess the freeboard and spillway capacity.

The CDA provides guidelines for the derivation of the PMF which should be the most severe "reasonably possible" combination of rain, snow, snowmelt, and antecedent conditions. Antecedent conditions include impoundment water levels and preceding storms.

It should be noted that recent advances in earth fill dam design and construction have enhanced the possibility of overtopping an earth fill embankment without a resulting breach. Protection methods for the crest and downstream slopes of the dams have increased the feasibility of such a solution in certain situations, particularly where it is not physically or economically feasible to increase the spillway capacity (Murthy, 1991). Nevertheless, the outstanding issue with industrial tailings storage impoundments is that uncontrolled release of effluents may not be desirable or permissible due to potential deleterious downstream impact. In such cases, appropriate water management and embankment design are the remaining options for increased protection of the impoundment.

2.3.2 Design Freeboard

For safety and stability reasons, embankment dams are designed with freeboard. Freeboard is meant to ensure the safety of the dam against overtopping in the event of the EDF, an extreme wave event caused by winds or seismic activity, or a combination of such conditions. Freeboard is the vertical distance between the referenced water surface elevation and the crest of the dam (Figure 2.1). In this study the term *minimum freeboard* is used to describe the distance between the water surface and the dam crest when the water level is at the design flood elevation or EDF (Figure 2.1). Visual Balance computes all freeboards similar to minimum freeboard.

Normal freeboard is defined as the difference in elevation between the crest of the dam and the normal reservoir water level as fixed by design requirements (Figure 2.1). Normal freeboard may be equal to the minimum freeboard in the design of small dams less than 15 metres high where a gated spillway[1] is in place to pass large floods and the surcharge during an IDF is minimal (USBR, 1987). In such a case, the scenario of average water levels combined with extreme wave action, may be the limiting condition for determination of normal freeboard.

The freeboard requirement for tailings dams is often a somewhat subjective estimate made by a knowledgable engineer based on consideration of the following four factors.

- height of wind tide or wind set up,
- height of waves induced by wind shear,
- wave run-up on sloping embankments, and
- additional minimum freeboard for contingencies.

---

[1] In the case of uncontrolled spillways, there is always a surcharge head created during a large flood (USBR, 1987).

Similar to the selection of a design flood frequency, the wind event frequency to be used in the freeboard estimation is typically determined by the dam consequence rating.

Wind exerting a horizontal stress on the free water surface produces a set up effect which raises the water level on the leeward shore and lowers it on the windward side. Wind induced waves and the concept of significant wave height are also a consideration in freeboard selection. Wave run-up is the vertical height a wave will flow up a sloping surface after the wave breaks near or on the embankment. Wave run-up might range from one to three times the wave height for smooth surfaces and approximately one half the wave height for very rough surface such as riprap (Davis, 1969).

Additional freeboard contingencies on the order of 0.3 m to 1.5 m could be provided at dams to account for errors in estimates (Eichert et. al, 1982), although this is not a common practice for tailings dams in British Columbia. This contingency will depend on the quality of the data and data analysis, risk and height of the embankment, and type of embankment construction used. International Standards Code: 10635-1983 "Freeboard Requirements in Embankment Dams," stipulates that freeboard should be determined based on wind set-up and wave run-up. In cases where such information is not available, the code indicates that the normal and minimum freeboard should not be less than 2 metres (Murthy, 1991). It is interesting to note that an observation of design practices for British Columbia tailings impoundments reveals that these dams often operate with a minimum freeboard less than this ISO recommendation. Many tailings dam design practitioners believe the CDA-DSG and associated guidelines to be too conservative for short term tailings impoundment operations. However, long-term closure scenarios must include adequate freeboard provisions.

2.3.3 Surface Water Management

Control of water is essential to the safety of dams constructed using the upstream construction method. The majority of failures of these dams has been due to water causing erosion of the dam face or undesirable pore pressures within the dam (ICOLD, 1996). The design of suitable drainage during construction is required to ensure an effective system. Surface water diversion around the impoundment is one method of reducing water volumes in the reservoir. Diversion efforts may include directing major watercourses around the tailings impoundment (Figure 2.3).

Diversion of natural runoff is often a significant factor in the design and eventual success of a tailings impoundment operation. The diversions may be necessary to maintain design freeboard, to avoid generating contaminated surface runoff, or to reduce the volume of water requiring treatment. As well, in some jurisdictions, runoff diversion is a requirement of impoundment operation (ICOLD, 1996). Failure of the diversion system may lead to overtopping or total failure of the embankment. Water balance at the impoundment site can be used to determine the fraction of surface water requiring diversion and the associated capacity of the diversion systems.

2.3.4 Regulatory Requirements and Guidelines in British Columbia

In Canada, mining activities are regulated primarily by provincial legislation and some federal legislation. In British Columbia, the Mines Act (1989) and the Mine Development Assessment Act (1990) govern mining activities and comprehensive environmental assessment of proposed mine developments. A revision to the Mines Act (1992) included an expanded Health, Safety and Reclamation Code for mines in the province. One of the specifications regarding ARD and secure underwater disposal of tailings or waste rock is that the proponent must show that the water balance ensures that all potentially acid-generating waste will be continuously covered by water and that there will be no significant impacts as a result of wave action, ice, avalanches, flooding, earthquakes, thermal overturn and other natural factors. Effective water balance methods and predictive, risk analysis models are necessary tools for the assurance of underwater disposal and safety.

Water management and environmental performance of tailings impoundments in British Columbia also fall under a variety of related federal and provincial regulations. The federal Metal Mining Liquid Effluent Regulations (1977) include authorized limits for metals and suspended solids in, and the radioactivity and pH of, effluent discharge from all base metal, iron ore, and uranium mines in Canada which commenced operation after February 25, 1977. The federal Fisheries Act prohibits the discharge of substances harmful to fish and their habitat in all Canadian fish bearing water except as authorized by federal regulations (Fisheries Act, 1996).

The provincial Water Act requires proponents to obtain licences to conduct any work involving, among other water related issues, changes in and about a stream. These changes may include modification of a stream by diversion or improvement, or any act or construction within, or has the potential to impact, a stream (BC Water Act, 1996). Activities involved in mine site development and operation, such as controlled water releases and stream diversion works, are governed by these Acts and Regulations.

The Canadian Dam Association (CDA) has developed guidelines for dam design in Canada. However, the CDA has no regulatory capabilities. The guidelines are intended to apply to dams if they are at least 2.5 m high and have at least 30,000 m^3 of reservoir capacity, and also apply to smaller dams where the consequence of failure is classified as "Low" or greater. Such small dams may include dams retaining contaminated fluids. The CDA classification system is included in Section 2.3.1

The Mining Association of Canada has also produced "A Guide to the Management of Tailings Facilities" (1998). This Guide includes:

- a framework of management principles, policies and objectives;
- checklists for implementing the framework through the life of a tailings facility; and
- lists of technical considerations.

The Guide is an extension of The Mining Association of Canada (MAC) Environmental Policy and the MAC Environmental Management Framework specifically applied to tailings management. It is designed to help companies practice due diligence and define the requirements to achieve due diligence by managing their tailings facilities responsibly and safely, and to demonstrate this to regulators and the public. Rather than detailed design guidelines or requirements, this Guide presents a framework to manage tailings facilities in a safe and environmentally responsible manner through the full life cycle of a tailings facility: from site selection and design, through construction and operation, to eventual decommissioning and closure. It is meant to be adapted to specific sites, individual company policies, and local regulatory and community requirements (MAC, 1998).

2.4 Tailings Impoundment Failures and Accidents

Many tailings impoundment failures have received wide public attention due to resulting loss of life or environmental damage. The failures of Aberfan coal waste dump in Wales (1966) and Buffalo Creek coal waste tailings dam in West Virginia, USA (1972) each caused over 100 deaths. These failures were followed by Stava, Italy (1985) which caused over 200 deaths. Numerous more recent accidents and failures concerning water management and tailings dams, including Los Frailes, Spain (1998), El Porco, Bolivia (1996), Omai, Guyana (1995), and Merriespruit, South Africa (1994) have raised public concern about the safety and potential environmental impact of these structures (see Section 2.4.1 for Case Studies). On behalf of UNEP, the Mining Journal Research Services (MJRS) conducted a survey and produced a report entitled Environmental and Safety Incidents Concerning Tailings Dams at Mines (MRJS, 1998). The International Commission on Large Dams (ICOLD) also contributed to the survey. The

MRJS study included the results of a survey for the years 1980-1996. The objectives were to identify:

- common types of environmental and safety impacts,
- the actual frequency of such incidents,
- the environmental and human consequences of such incidents.

The survey collected details from 52 separate incidents in numerous countries between 1980 and 1996. Five incidents involved loss of life, the remainder caused primarily environmental damage and property loss. Most incidents reported were associated with a failure in the dam wall but seepage and discharge of effluent, hazardous dust, damage to habitats, and wildlife poisoning were also recorded.

It should be noted that the survey was unable to give a complete picture of the extent of the problem as it found that few countries collect systematic statistics on tailings dam incident and there is no common format for reporting. Moreover, many countries did not respond to the questionnaire. Some examples of recent impoundment failures, particularly those with water management issues identified as causal factors, are provided in the following section.

2.4.1 Failure Case Studies

In the last decade, a number of tailings dam failures have received widespread public attention due to the loss of life and environmental impact caused by the incidents. The following includes selected examples where water management and hydraulic failure as the likely or suspected cause of the failure.

The Merriespruit, South Africa tailings dam failure in February 1994 resulted in the loss of 17 lives, severe destruction of property, and widespread environmental damage. In the inquest that followed the disaster, the judge called the tailings dam a "time-bomb waiting to explode" (Wagener et. al., 1998). The failure involved the collapse of a 31-metre high tailings dam upslope of the suburb of Merriespruit and the release of 600,000 m^3 of tailings which flowed through the town. The dam failed a few hours after approximately 50 mm of rain fell in 30 minutes during a thunderstorm.

Tailings management, surface water management and dam construction problems have been identified as the main causes of the Merriespruit failure (Wagener et. al, 1998). The proximity of the water table to the northern embankment crest over a number of years, and the rapid deposition rate of tailings in the impoundment, led to a poorly consolidated tailings dam and increased seepage through the embankment. Moreover, only 300 mm of vertical freeboard between the tailings solids and dam crest was maintained in the period preceding the failure. In some places in the impoundment, the freeboard was only 150 mm. It was established that overtopping, as a result of inadequate freeboard, was the primary cause of failure.

The Merriespruit disaster may have been avoided had the mine not been exempt from the Safety of Dams regulation (South African Water Act No. 54, promulgated in 1986), which states the impoundment must maintain capacity for the containment of a 1-in-100 year 24 hour storm event (EDF) and a minimum 0.5 metre freeboard above that EDF.

Boliden's 1998 disaster at their Los Frailes mine in southern Spain is another recent example of a tailings impoundment failure. This failure caused serious environmental damage and public alarm. The tailings solids and contaminated water release was diverted from Donana National Park by quickly built dykes and sent to Guadalquivir River which empties into the Atlantic Ocean. Estimates indicate that over 2,000 hectares of agricultural and undeveloped land were contaminated directly by the spill.

Reports suggest that Boliden will spend up to US$34 to US $60 million in clean up and compensation costs (MacKenzie, 1998 and Anthony, 1999). The new Los Frailes operation, scheduled to reopen in early 1999, will use an abandoned mine pit with a depth of 270 metres for the disposal of tailings (Anthony, 1999). This pit had previously been used for the disposal of waste rock. Some early indications suggest four months of greater than average precipitation preceding the failure may have resulted in the dam breach (Mining Environmental Management, 1998). Three studies have been carried out to investigate the cause of the disaster.

GEOCISA, the company that originally designed and built the tailings impoundment, was retained by Boliden as consultants to advise on the stability of the existing dam and design requirements for extensions to the tailings impoundment. The last investigation was carried out on April 14, 1998 to establish the stability of the structure in the light of very high levels of precipitation that had been experienced over the winter. The company submitted its report five days before the failure happened and, according to Boliden, declared the embankment to be stable.

The mine tailings storage facility collapse near Stava, Italy in July 1985, resulted in 268 lives lost and caused considerable property damage. In this case, it was concluded that the dams were constructed with an unacceptably low factor of safety and circumstantial evidence supports the conclusion that the failure was triggered by a blocked decant pipe located within the tailings (Chandler and Tosatti, 1995).

One of the most devastating tailings disasters in the last century was the Aberfan, Wales disaster in 1966 that resulted in more than 100 lives lost and extensive property damage. The coal tip was located on a steep slope and failed due to a flow slide of oversaturated coal waste. Inadequate water management was the cause of the slide: the coal waste was deposited without underdrainage or attention to precipitation and runoff control (Williamson, 1990).

2.4.2 Failure Causes

The MJRS study conducted on behalf of UNEP indicated that **inadequate water management and hydraulic design were the cause of the majority of the accidents or failures** recorded at mine tailings impoundments. While deficient design and maintenance standards are typically the cause of failures, the trigger of the failure is often a natural event such as heavy rain or an earthquake (ICOLD, 1996). Hydraulic failure in the form of overtopping by flood discharge accounts for nearly 40% of all the earth dam disasters in the world (Murthy, 1991).

Control of the location of the phreatic surface, which is the internal water level within the embankment, is a critical factor in the behaviour and overall stability of an earth filled dam (Figure 2.1). The phreatic level governs the susceptibility of the embankment to seepage-induced failure and the performance of the dam under static and seismic loading conditions (Vick, 1990). The phreatic level should be kept as low as possible and is dependent in part on the material deposition practices, dam construction methods, and water levels maintained in the reservoir. An effective water management plan at a site can assist in the maintenance of a low internal phreatic surface.

The MJRS (1998) report suggests that much progress in dam safety has been made in recent years, but that additional effort is needed by mining companies and the authorities to minimize the risk of incidents. The report advocates widespread adoption of improved design, construction and operational practices for tailings impoundments, and the stipulation of safer practices through legislation.

CHAPTER 3.0 WATER AND MATERIAL BALANCE

A water and material balance is used to predict the monthly and annual progression of solids and water levels in the tailings impoundment throughout a life of the mine. The results of the water and material balance are used to determine critical impoundment design elements, including dam crest elevations, spillway invert elevations and capacity, surface water diversion capacities, and closure scenarios. These water management features perform a significant role in the protection of the hydraulic integrity of tailings dams at impoundment sites. The following sections introduce the concept of water balance, the algorithms used in tailings impoundment water and material balance, models available for conducting impoundment balance, and risk and uncertainty concepts associated with such balances.

3.1 Introduction

The concept of water balance has different meanings for the various specialists involved in water resource problems. On a small scale in the natural sciences, *climatic water balance* is understood to be the balance between the income of water in the form of precipitation and snow melt, and the outflow of water in the form of evaporation and runoff. Methods for estimating water balance have existed in the literature since at least 1944, with the Thornthwaite Climatic Water Balance method (Thornthwaite, 1955). Larger scale water balance may refer to a regional or global scale water budget.

Although climatic water balances are useful for predicting runoff rates or streamflow, additional components must be considered for monitoring industrial waste storage reservoirs. In this thesis, water balance refers to water inflows and outflows to a reservoir, similar to climatic water balance, but will also include anthropogenic sources (slurries and effluent) and reservoir storage concepts.

Water and material balance at industrial waste storage reservoirs requires accounting for waste solids and slurries, as well as inflow of water in the form of precipitation, snow and glacier melt, effluent water. The outflow or loss of water via evaporation, runoff, infiltration, process reclaim water, planned releases and water treatment withdrawals must also be included in the balance.

The volumetric balance for water and solids in an impoundment is commonly conducted on a monthly basis and can be expressed by a modified water balance equation, accounting for solids inflow, as follows in Equation 3.1.

$$I_p + I_r + I_{gw} + I_{sw} + I_{mw} + I_{gr} + I_s - O_E - O_{gw} - O_v - O_{rc} - O_{sr} = \Delta S \qquad (3.1)$$

where,

I_p = direct precipitation (m^3)

I_r = catchment runoff inflow (m^3)

I_{gw} = groundwater inflow (m^3)

I_{sw} = slurry water inflow (m^3)

I_{mw} = mine water inflow (m^3)

I_{gr} = groundwater recovery or treated water return (m^3)

I_s = solids inflow (m^3)

O_E = total evaporation from impoundment pond and beaches (m^3)

O_{gw} = groundwater seepage outflow (m^3)

O_v = loss to solids voids, which may include water and solids loss to voids (m^3)

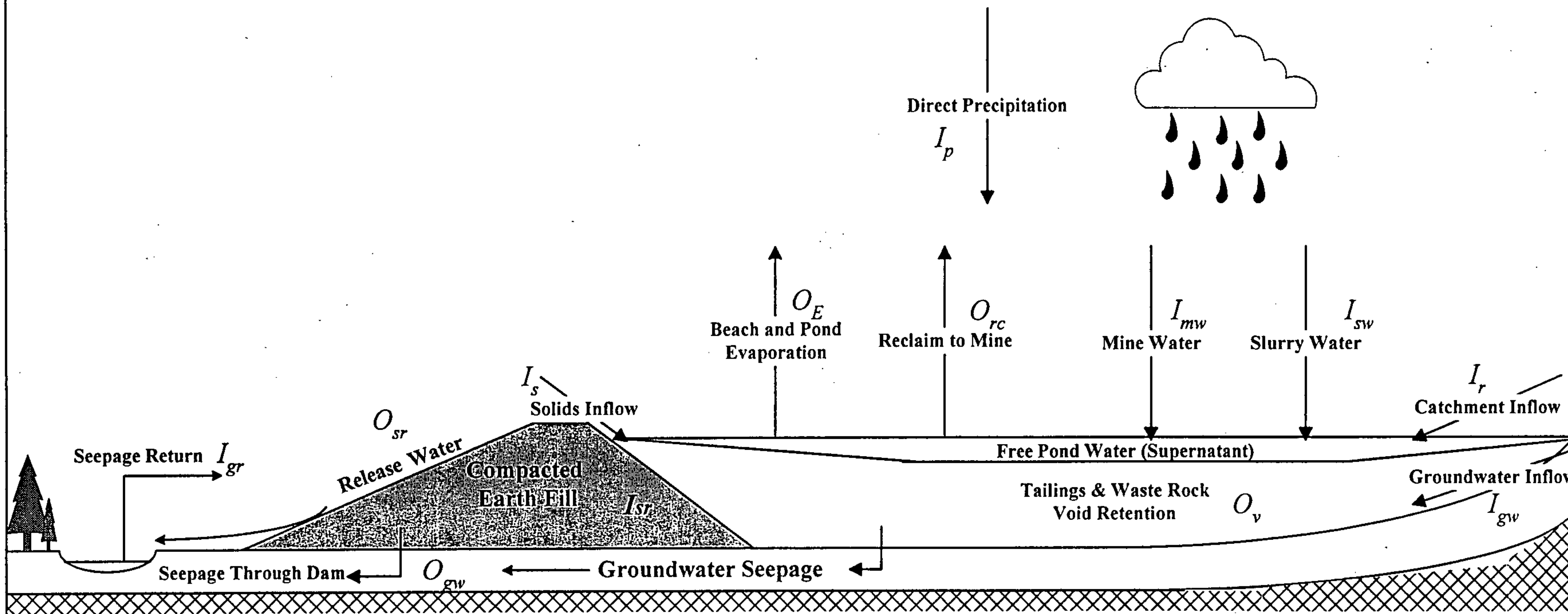
O_{rc} = recycle or reclaim water outflow (m^3)

O_{sr} = spills or release water that may include release to a water treatment facility (m^3)

ΔS = change in storage volume (m^3)

Figure 3.1 shows a schematic representation of water and material inflows and outflows at a mine tailings impoundment.

Because of the potential environmental damage associated with release of untreated water, it is nearly always preferable to operate a tailings impoundment as a closed system, without water releases, O_{sr}. However, confident closure of the water balance equation in practice will be a problem dependent on the inherent errors involved in the parameters of the equation (Ferguson and Znamensky, 1981). The error could be represented by the addition of an error term in the equation to represent the net effect of all errors of the estimate. Alternatively, uncertainty in the equation parameters can be addressed through risk analysis. This second approach has been adopted in the current study (Chapter 5).



Note: Recovery wells or a seepage collection pond may be used to collect contaminated groundwater or release water and pump back to the impoundment.

Figure 3.1 Tailings Impoundment Water and Material Balance Schematic

3.2 Water and Material Balance Calculations

The following sections present the equations used to calculate the inflow and outflow parameters included in the general water and material balance equation (Equation 3.1). A number of these algorithms, particularly the solids inflow volumes and "loss to voids" calculations, are based on parameters and equations routinely used by practitioners of mining engineering in British Columbia. Some of these equations could be simplified and the loss to tailings voids term is essentially redundant. However, since the *Visual Balance* program was intended to be a tool for local mining engineers, these standard equations were used in the program to increase user understanding and comfort. Further explanation of calculation conventions is included in the individual sections describing each inflow and outflow parameter.

Visual Balance data input forms and files are referred to briefly in the sections that follow, however data input and saving procedures within the software program are discussed in detail in Section 4.0.

3.2.1 Water Inflow Calculations

Direct Precipitation, I_p

Direct total precipitation depth values for each month are input by the user into a standard Excel hydrological data input file as averages in units of mm/month. Visual Balance estimates the volume of direct precipitation from the average monthly values using Equation 3.2.

$$I_p = \frac{P_m}{1{,}000} \cdot A_r \cdot 10{,}000 \qquad (3.2)$$

where,

I_p = monthly direct precipitation volume (m^3)

P_m = average monthly precipitation depth (mm)

A_r = impoundment reservoir surface area (beginning of the month reservoir surface area used in program calculations (ha))

Catchment Runoff, I_r

The user inputs, R_d, average monthly runoff depth estimates. The monthly runoff is then calculated using Equation 3.3. The total reservoir catchment area, A_{tc}, is input by the user. The actual catchment area, A_c, contributing the runoff is equal to the total catchment area minus the reservoir surface area. The reservoir surface area is adjusted based on the water level in the impoundment. There is a provision that accounts for the "fraction of runoff diverted", input through the *Reservoir Information* form, which is then factored into the runoff estimation. This results in the contributing catchment area being considered in the calculation of runoff as follows:

$$I_r = \frac{R_d}{1{,}000} \cdot A_c \cdot 10{,}000 \cdot (1 - f_{rd}) \qquad (3.3)$$

where,

I_r = monthly runoff volume inflow (m^3)

R_d = monthly catchment runoff depth (mm)

A_c = total reservoir catchment area (ha).

f_{rd} = fraction of runoff diverted

The risk analysis employs a similar approach to Equation 3.3 for estimating stochastic runoff values. Section 5.3 includes details of the statistical approach used for random runoff volume generation.

Groundwater Seepage, I_{gw}

Groundwater seepage into the reservoir from the catchment area is input by the user as a constant rate through the *Reservoir Information* form. This rate is not changed for the risk analysis and is calculated on a monthly basis using Equation 3.4.

$$I_{gw} = R_{gi} \cdot D_m \cdot 24 \tag{3.4}$$

where,

I_{gw} = monthly groundwater inflow volume (m^3)

R_{gi} = groundwater inflow seepage rate (m^3/hr)

D_m = days in month

Tailings Slurry Water Inflow, I_{sw}

Mine tailings are typically pumped to the impoundment in a slurry. The rate of slurry water inflow, not including solids in the slurry, is input as a constant rate by the user and the volume of slurry water flowing into the tailings impoundment is calculated in the code as follows:

$$I_{sw} = R_{sw} \cdot OD_m \cdot 24 \tag{3.5}$$

where,

I_{sw} = monthly slurry water inflow volume (m^3)

R_{sw} = slurry water inflow rate (m^3/hr)

OD_m = operating days in a given month (days)

Minewater Inflow, I_{nw}

Water inputs from the mine site can include minewater that is collected drainage from pits or underground operations. Monthly volumes of minewater are computed using the constant minewater inflow rate input by the user as follows:

$$I_{mw} = R_{mw} \cdot OD_m \cdot 24 \tag{3.6}$$

where,

I_{mw} = monthly minewater inflow volume (m^3)

R_{mw} = minewater inflow rate (m^3/hr)

Groundwater Recovery or Treated Water Return, I_{gr}

Lastly, water management at some tailings facilities includes groundwater seepage recovery or the return of treated water to the impoundment.. Miscellaneous sources of inflow water have been included in the groundwater recovery term, I_{gr}. A constant rate of return, R_{gr}, is input by the user and I_{gr} is determined as follows:

$$I_{gr} = R_{gr} \cdot D_m \cdot 24 \tag{3.7}$$

where,

I_{gr} = monthly groundwater return inflow volume (m^3)

R_{gr} = groundwater or treated water return inflow rate (m^3/hr)

3.2.2 Solids Inflow Calculations

The inflow volume of total solids and voids to the impoundment can include waste rock, tailings, and solids voids is expressed as:

$$I_s = I_{Tt} + I_{Twr} \tag{3.8}$$

where,

I_{Tt} = total tailings and voids volume (m^3)

I_{Twr} = total waste rock volume, including voids (m^3)

It is necessary to account for the void volume in order to continuously simulate the elevation of the solids. This is especially important where tailings require permanent submergence to minimize acid generation.

The equations used to estimate the total volume inflow of tailings and waste rock are provided separately below. The properties of the input solids are input through the *Mine Production* form is Visual Balance. The variables used to describe the basic, physical phase components of the solids are as follows[1]:

M_T	=	Total Mass of solids and water (tonnes)
V_T	=	Total volume of solids, water and air filled voids (m^3)
M_S	=	Mass of solids (tonnes)
V_S	=	Volume of solids (m^3)
M_W	=	Mass of water (tonnes)
V_W	=	Volume of water (m^3)
V_V	=	Volume of voids (m^3)

Total Tailings Inflow Volume, I_{tt}

The principal physical input parameters for the tailings solids are as follows:

Tonnes of tailings solids produced per month	=	M_{St}	
Coarse fraction cycloned out	=	f_c, $(0 \le f_c \le 1)$	
Degree of Saturation, S_r	=	V_{Wt} / V_{Vt}	(3.9)
Tailings dry density, ρ_{dt}	=	M_{St} / V_{Tt}	(3.10)
Tailings in situ void ratio, e_t	=	V_{Vt} / V_{St}	(3.11)

The degree of saturation, S_r, can range between the limits of zero for a completely dry soil and one for a fully saturated soil (Craig, 1989). A fully saturated soil is a two-phase composition,

1 Subscripts of "t" and "wr" denote the parameters relating to tailings and waste rock respectively.

consisting of solid soil particles and pore water only. However, the solid waste in a tailings impoundment has the potential to be exposed on beaches, which would imply a three-phase composition of solids soil particles, pore water and pore air (Figure 3.2). The model assumes a level surface of solids deposition. However, if the tailings are expected to be exposed, the degree of saturation can be set to some number less than 1 by the user.

The inflow volume of tailings solids and voids to the reservoir can be expressed as:

$$I_{Tt} = \frac{M_{St}}{\rho_{dt}} \cdot (1 - f_c) \tag{3.12}$$

Total Waste Rock Inflow Volume, I_{wrt}

The input parameters characterizing the waste rock are:

Mass of waste rock solids produced (tonnes)	=	M_{Swr}	
Total mass of waste rock[2] (tonnes)	=	M_{Twr}	
Total volume of waste rock, including voids	=	V_{Twr}	
Bulk Density, ρ_{wr}, (tonnes/m^3)	=	M_{Twr}/ V_{Twr}	(3.13)
Waste rock insitu void ratio, e_{wr}	=	V_{vwr}/V_{Swr}	(3.14)
Fraction of total waste rock generated that is deposited in the impoundment and submerged	=	f_{wri}, $(0 \leq f_{wri} \leq 1)$	

2 Mass of waste rock solids, M_{Swr}, is equal to the total mass of the waste rock, M_{Twr}, if the waste rock is dry. Typically, waste rock is assumed to be dry when deposited in the tailings impoundment.

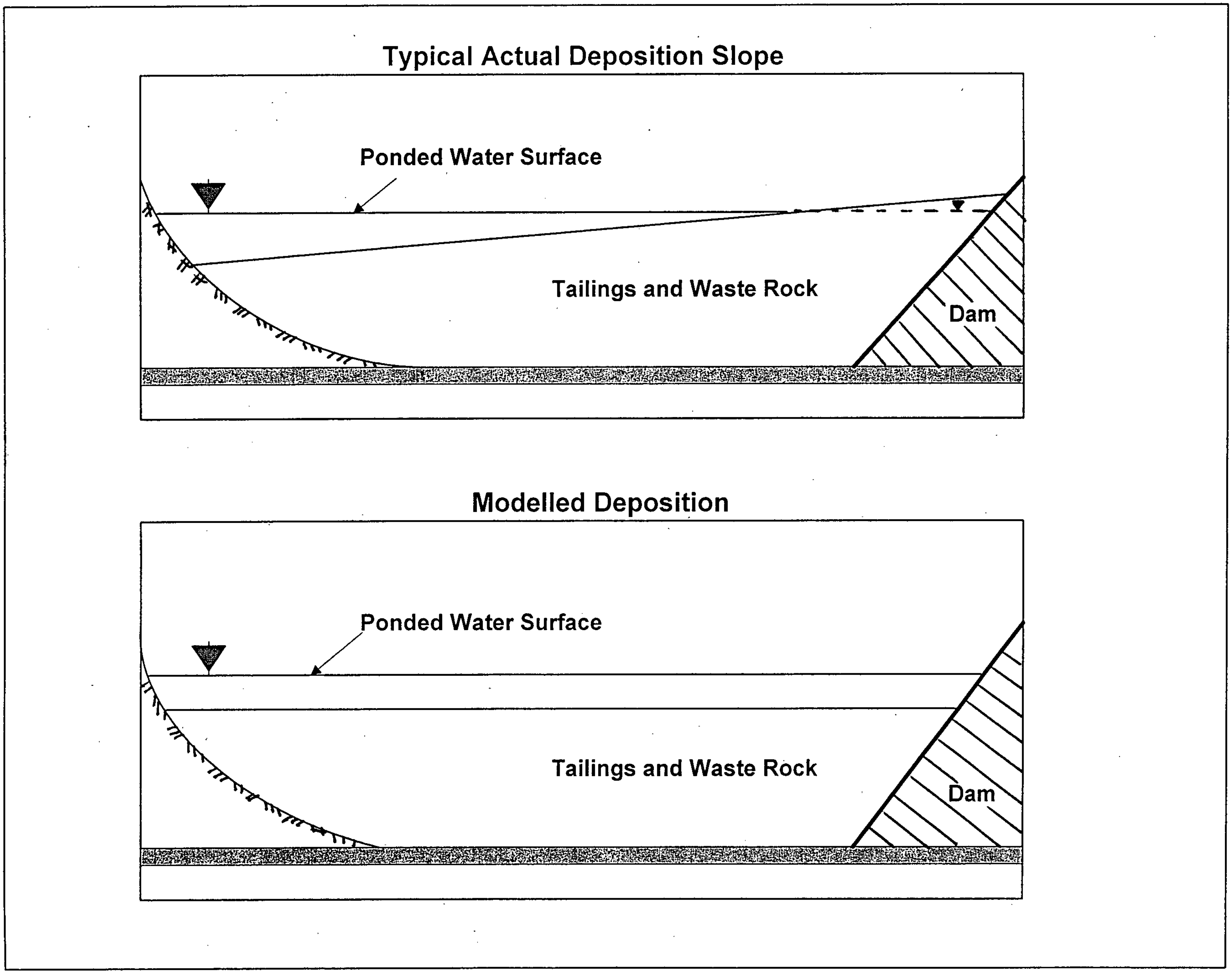


Figure 3.2 - Schematic Representation of Tailings Deposition

The total volume inflow of the waste rock per month, including voids, I_{wrt} is given by:

$$I_{Twr} = \frac{M_{wrt}}{\rho_{wr}} \cdot f_{wri} \qquad (3.15)$$

3.2.3 Water Outflow/Loss Calculations

Water is lost from the tailings impoundment primarily due to evaporative loss from the reservoir and the embankment beaches, and groundwater seepage through the dam. It is common practice in mining engineering in British Columbia to also view water as "lost" to the tailings voids. The volume of water "lost" to solids voids affects only the volume of free pond water, above the elevation of the solids, that is readily available for recycle. However, the total volume of material in the impoundment is not affected by this water "loss" to voids. Moreover, the elevation of the water table in the impoundment is not affected by the volume of water retained in solids voids.

Evaporation, O_E

The monthly average depth of evaporative loss from the impoundment and its beaches is input by the user through the Excel hydrologic data file. The total evaporative loss can be expressed as:

$$O_E = O_{re} + O_{be} \qquad (3.16)$$

where,

O_E = total evaporative loss (m^3)

O_{re} = evaporation from reservoir pond

$$= \frac{E_r}{1{,}000} \cdot A_r \cdot 10{,}000 \qquad (3.17)$$

O_{be} = evaporation from dam beaches

$$= \frac{E_b}{1{,}000} \cdot A_b \qquad (3.18)$$

where,

E_r = monthly depth of evaporation from the pond surface (mm)

A_r = reservoir pond water surface area (beginning of the month A_r used in program calculations (ha)

E_b = monthly depth of evaporation from beaches (mm)

A_b = embankment beach area (m^2)

The reservoir pond water surface area at the beginning of each month is used in Equation 3.17 to calculated the volume of loss due to evaporation for the subsequent month.

Groundwater Seepage Out of Reservoir, O_{gw}

Outflow of water from the impoundment also occurs due to groundwater seepage, mine recycle or reclaim, and controlled spills and releases. Each of these outflows is input by the user as a rate in cubic metres per hour. The balance simply calculates the volume of loss by multiplying the rate by 24 hrs/day and the number of days in the month or operating days in the month as the case may be.

<u>Water "Lost" to Voids, O_v</u>

Water is also considered to be "lost" in the balance to the voids in tailings, waste rock, tailings dams, and any other waste solids that are deposited in the impoundment. The properties of the solids are input through the *Mine Production* form and include degree of saturation, specific gravity, bulk density and void ratio (Section 3.4.2). Total loss to solids voids can be expressed as follows:

$$O_v = O_{tv} + O_{wrv} \qquad (3.19)$$

where,

O_v	=	total volume of water lost to solids voids (m^3)
O_{tv}	=	volume of water loss to tailings voids (m^3)
O_{wrv}	=	loss to waste rock voids (m^3)

Loss to the tailings voids is then calculated using production in tonnes per day (tpd) and a specified number of operating days per month (dpm) as follows:

$$O_{tv} = I_{Tt} \cdot \frac{e_t}{e_t + 1} \cdot S_{rt} \tag{3.20}$$

where,

S_{rt} = in situ degree of saturation, V_{wt}/V_{Vt}

Some fraction of waste rock voids may become filled with tailings in the impoundment. This fraction of voids filled with tailings is input as "fraction of waste rock voids filled with tailings", f_t, input through the *Reservoir Information* form. The loss of water to waste rock voids can be calculated using the total waste rock volume and the void ratio of the waste rock as calculated by the following expression:

$$O_{wrv} = I_{Twr} \cdot \frac{e_{wr}}{1 + e_{wr}} \cdot (1 - f_t) \tag{3.21}$$

where,

O_{wrv} = monthly loss of water to waste rock voids (m^3)

I_{Twr} = inflow volume of waste rock (solids and voids), (m^3/month)

f_t = fraction of waste rock voids filled with tailings solids

e = void ratio

These equations can easily become fraught with errors in spreadsheet applications where the units of production and the phase relationship properties being used are hidden in the spreadsheet. Visual Balance, on the other hand, provides a transparent way of entering solids parameters and estimating the losses with greater confidence.

3.2.4 Solids Loss Calculations

Tailings in Waste Rock Voids, O_{sv}

Generally, solids are not removed from the tailings impoundment once they have been deposited. However, it is customary within local mining engineering to consider a volume of tailings "lost" to the waste rock voids. The pore spaces within the waste rock will likely be filled with a combination of fine solids (tailings) and water. The user is able to specify the fraction of waste rock pores which are occupied by solids. Thus, lowering and more accurately predicting the elevation of tailings solids in the reservoir.

The loss of tailings solids to waste rock voids can be calculated using the total waste rock volume and the void ratio of the waste rock as calculated by the following expression:

$$O_{sv} = I_{Twr} \cdot \frac{e}{1 + e} \cdot f_t \tag{3.22}$$

where,

O_{sv} = monthly loss of tailings to waste rock voids (m^3)

I_{Twr} = inflow volume of waste rock (solids and voids), (m^3/month)

f_t = fraction of waste voids filled with tailings solids

e = void ratio

3.3 Existing Related Water and Material Balance Models

Water and material balance studies during mine feasibility, operation, and closure represent a important component of mine related engineering consulting activities in Vancouver. There are several firms that undertake this type of work. An informal telephone survey, conducted by the author, of six large Vancouver based engineering consulting firms working in the field of tailings impoundment design indicated that detailed spreadsheet "models" were most commonly used to estimate the water and material balance in mine tailings impoundments. These spreadsheets are highly dependent on the applicability of the default equations and parameters embedded in the spreadsheet and on the accuracy of the input data used. Input data can be generated outside the actual impoundment balance using software programs such as QUALHYMO (Rowney and Macrae, 1992) or HEC-5 and HEC-RAS (USACE, 1998) for parameters such as runoff volumes. These hydrologic parameter generating methods are not currently directly incorporated in the *Visual Balance* software program created as part of this research study, but the runoff values generated can be used as input to *Visual Balance*.

On a project specific basis, consultants have created water balance programs and programs to predict water quality at mine tailings impoundments. However, these programs are often written for complicated or special site scenarios. The broad application of these programs to other sites is limited by the specific project operation conditions and practices that are coded into the model.

A number of computer applications have been developed strictly for water balance modelling and runoff modelling. The water balance models typically refer to *climatic water balance*. Climatic water balances are useful for predicting available water for agricultural activities and runoff rate or streamflow estimates. Although these outcomes of climatic water balance are a component of the overall mine tailings impoundment water and material balance, there is no provision in climatic water balance software for storage in a reservoir, alternate anthropogenic sources of water, or volumes of inflow solids. Selected methods of climatic water balance and their applicability to tailings impoundment applications are reviewed in the following section. The concept of climatic water balance was introduced in literature by Thornthwaite in 1944 (Cho, 1986). Other climatic and runoff predicting water balance methods include the Penman-Monteith, Thornthwaite-Mather, and Evapoclimatonomy III (Lettau and Hopkins, 1991). The Thornthwaite climatic water balance is computed using mean monthly air temperatures, mean monthly precipitation, latitude of the site, information on the water holding capacity of the depth of soil for which the balance is to be computed, and information about snow melt pattern. *Water*, a Turbo Pascal Version 3.00 computer program, was developed to perform the Thornthwaite Climatic Water Balance calculations (Cho, 1986). Although this program computes the climatic water balance for a given site, no specific provision is made for the concept of reservoirs, water retention, water reclaim, or solids balance.

Computer programs designed to simulate the precipitation runoff process have existed for decades. The streamflow simulation models and reservoir system analysis models from the US Army Corps of Engineers, Hydrologic Engineering Centre (HEC) have existed since the mid-1970's and is a popular model for runoff estimation and river system analyses (USACE, 1998). The original model was named HEC, and its subsequent versions and developments include HEC-3, HEC-5 and HEC-RAS. SWMM (Huber, 1977), and the USGS Rainfall/Runoff Model for Peak Flow Synthesis (Dawdy, 1972) are two other commonly used streamflow models. HEC models have evolved into MS-Windows based applications that can be used to undertake advanced hydrologic and hydraulic analyses, to predict streamflows, and to model single and multiple reservoir systems. These programs are particularly useful for creating the input hydrologic data for a tailings impoundment water balance. However, the actual accounting and modelling of inflow and outflow in the impoundment must still be performed outside these models.

Another significant hydrologic concern associated with tailings disposal is the amount and quality of infiltration and seepage through the impoundment. Seepage flow from the tailings depend on the moisture retention characteristics and the layering of the tailings. The driving force causing water to move through the impoundment is the vertical hydraulic gradient (Schmidt-Petersen et. al., 1999). Estimation of surface water volume and phreatic surface of the impoundment are critical factors in the simulation of this hydraulic gradient. In addition, in the absence of any knowledge of tailings or dam foundation permeability, an upper bound on the estimate of maximum possible average seepage quantity out of the impoundment can be made from the residual of the impoundment water balance (Vick, 1990).

The Hydrologic Evaluation of Landfill Performance (HELP) Model has been used to estimate infiltration and percolation of water through tailings impoundments for the assessment of metals loading and acid affects on the groundwater system (Davis et. al., 1999 and Patton et. al. 1999). HELP was developed for the US Army Corp of Engineers, Waterways Experimental Station for determining the potential for leachate generation at landfill sites and has been adopted by several government agencies, including US EPA and British Columbia Environment, as an acceptable method of leachate estimation.

The HELP model is a quasi-two-dimensional hydrologic model of water movement across, into, through and out of landfills. The results are reported by the program as Average Annual Leachate Generation (percentage of annual precipitation). Although using the HELP model to undertake seepage analysis at tailings impoundments may have some limited application, HELP does not model the staging of a waste landfill or assist with impoundment sizing and design scheduling. HELP does not model landfill progression nor operation but could be used to supplement a tailings impoundment volume balance by modelling the potential seepage rate from the impoundment. However, there are computer programs specifically and more suitably designed to model groundwater seepage through an earth fill dam which would be more appropriate to employ for such a modelling task such as SEEP/W (Geo-Slope International Ltd., 1994). HELP has been reported to produce unrealistic model results when balancing the water at impoundment systems (Patton, 1999).

One of the distinct requirements of a waste impoundment balance model is an ability to model water balance throughout the operational life of the impoundment. The monthly and annual progression of solids and water levels in the impoundment and the resultant required dam crest elevations are critical outputs of the water balance. The models examined as part of this research did not include these critical elements nor did not incorporate robust features to enable broad application.

3.4 Risk Analysis and Uncertainty

The concept of employing risk analysis methods at tailings impoundments has become more common in the last decade (Kautsky, 1999, and Niccoli and Finley, 1999), particularly with the increased public and regulatory interest in the potential impacts from impoundments. *Risk* in engineering design is defined qualitatively as probability of occurrence multiplied by the consequence associated with that occurrence. The term *uncertainty* is associated with an absence of information, particularly data regarding prior probabilities or the likelihood of future outcomes (Kautsky, 1999).

Risk is associated with water management facilities at tailings impoundment facilities due, in part, to the uncertainty in hydrologic parameters used for planning and design. Risk assessment has been employed in tailings impoundment projects to assess site options, compare closure scenarios, and estimate appropriate design floods.

Uncertainty related to water resource issues has been defined and classified in a number of different ways. Plate and Duckstein (1987) distinguished between hydrologic and hydraulic uncertainty, and this work has particular usefulness to tailings impoundment application. The distinction between hydrologic and hydraulic uncertainty has been made as follows. Uncertainty in hydrologic variables can arise from data uncertainties or measurement error, sample uncertainties due to a low number of data, and model uncertainty. Hydraulic uncertainties in the process of transformation of hydrologic data include parameter uncertainties in hydraulic equations such as Manning's n, model uncertainty due to the use of empirical equations, and scaling laws used in physical models (Kundzewicz, 1990). In general, the operational influence and losses through hydraulic workings at a tailings impoundment are negligible or zero. Some hydraulic uncertainty may occur due to parameters in hydraulic equations or model uncertainty. However, the uncertainty associated with water management issues at tailings impoundments is associated primarily with hydrologic variables themselves.

The hydrologic water balance in a tailings impoundment is heavily influenced by the volumes of direct precipitation and runoff. In arid climates, evaporation can also be a volumetrically significant hydrologic variable. Tailings impoundments are commonly designed using some average annual hydrologic variable scenario. However, the error limits of hydrologic variable estimation can be large, particularly if generated from small data sets. Climatic factors in the water balance may undergo extreme departures from average conditions, both seasonally and from year to year (Vick, 1990).

Due to the uncertainty in the hydrologic parameters, water balance procedures using averages may only provide a crude estimate of the expected water accumulation in the impoundment. This uncertainty results in increased risk to the environment and human health if necessary safety factors are not employed.

Methods for risk analysis of impoundment balances conducted using spreadsheets are limited to models provided within the spreadsheet packages or statistical models developed on a project specific basis. Statistical methods included with current spreadsheet packages such as Microsoft Excel do not include distribution functions that are suited to analyzing hydrologic data, and are particularly unsuited for use with data from small sample sets. To address this need for effective risk analysis methods in water balance, a risk analysis approach based on sound statistical principles was developed and incorporated into the Visual Balance software program to assess the effects of uncertainty in hydrologic variables associated with water and material balance.

CHAPTER 4.0 VISUAL BALANCE - PROGRAM DEVELOPMENT

In this chapter, the approach used to develop the *Visual Balance* water and material balance program is outlined. The program structure is summarized in Section 4.2 and program data requirements and equations used for water and material balance are explained in Section 4.3. Detailed computer code for the program is included in Appendix C.

4.1 Program Language

Due to the predominant use of IBM® compatible personal computers within the natural science and engineering community, computer software for such applications is typically developed for Microsoft® (MS) Windows™ and MS-DOS platforms. One of the principal goals of the software development conducted as part of this research was to increase ease of use, speed, and user comfort when conducting water and material balance assessments. Given current available technology, such a program would best be developed as a Windows based application. The graphical user interface of the Windows platform increases the ease of use and transparency of the application. The optimization of the speed of the program language is discussed below.

The two most widely used programming languages for MS-Windows based applications are Visual C++ and Visual Basic (MSDN, 1999). There are other languages in the MS-Visual Studio including Visual FoxPro, and Visual Java Plus. The benefits of using Visual Basic language versus Visual C++ language were assessed and Visual Basic was selected as the language of choice for this particular application. A professionally developed Visual Basic application runs as fast or faster than its counterpart written in Visual C++ (Franklin, 1998). Moreover, the Basic language is easier to use and understand than the less English-like C++.

Visual Basic has evolved from QuickBASIC which, in turn, had evolved out of the BASIC language. QuickBASIC included features such as programming without line numbers which set it apart from the traditional BASIC language.

The Visual Basic programming system enables the creation of applications which fully exploit the Microsoft® Windows™ graphical user interface (GUI). Data can be input through forms created by the software program, or through linked software such as MS-Access databases, MS-Excel spreadsheets, and MS-Word text documents. This flexibility in data sources makes Visual Basic a good candidate for programs that are likely to involve moderate to large amounts of data management.

4.2 Program Structure

The first step in the development of Visual Balance was to clearly identify the problem which the software was intended to solve. For tailings impoundment volume balance applications, a model is required to account for inflows and outflows of water and solids, and provide elevation of water and materials and require dam crest elevations based on the characteristics of the reservoir. Because the water balance simulations are usually run over the operational life of an impoundment, calculations are usually performed on a monthly basis. The software could be used to assess the likelihood of spills or exposed tailings, and to assess dry and wet year water levels and their effects on impoundment performance. A module to assess water quality could also be included[1].

The software must handle input data from Excel files and the graphical user interface, and provide output in the form of monthly water, solids, EDF and dam crest elevations.

Visual Balance is constructed with three model levels. Figure 4.1 shows a flow chart of the three program levels and are as follows:

- **Main Menu**
  - Access to project type and directory selection forms
- **Data Editing Menu**
  - Access to data editing forms and files
- **Output Menu**
  - Run Visual Balance Procedures
  - View Input Data Summaries via Excel
  - View Output via Excel

---

1 A good outline of the use of data from water balances for computing the balance of natural substances and pollutants in water bodies is given by Ferguson and Znamensky (1981).

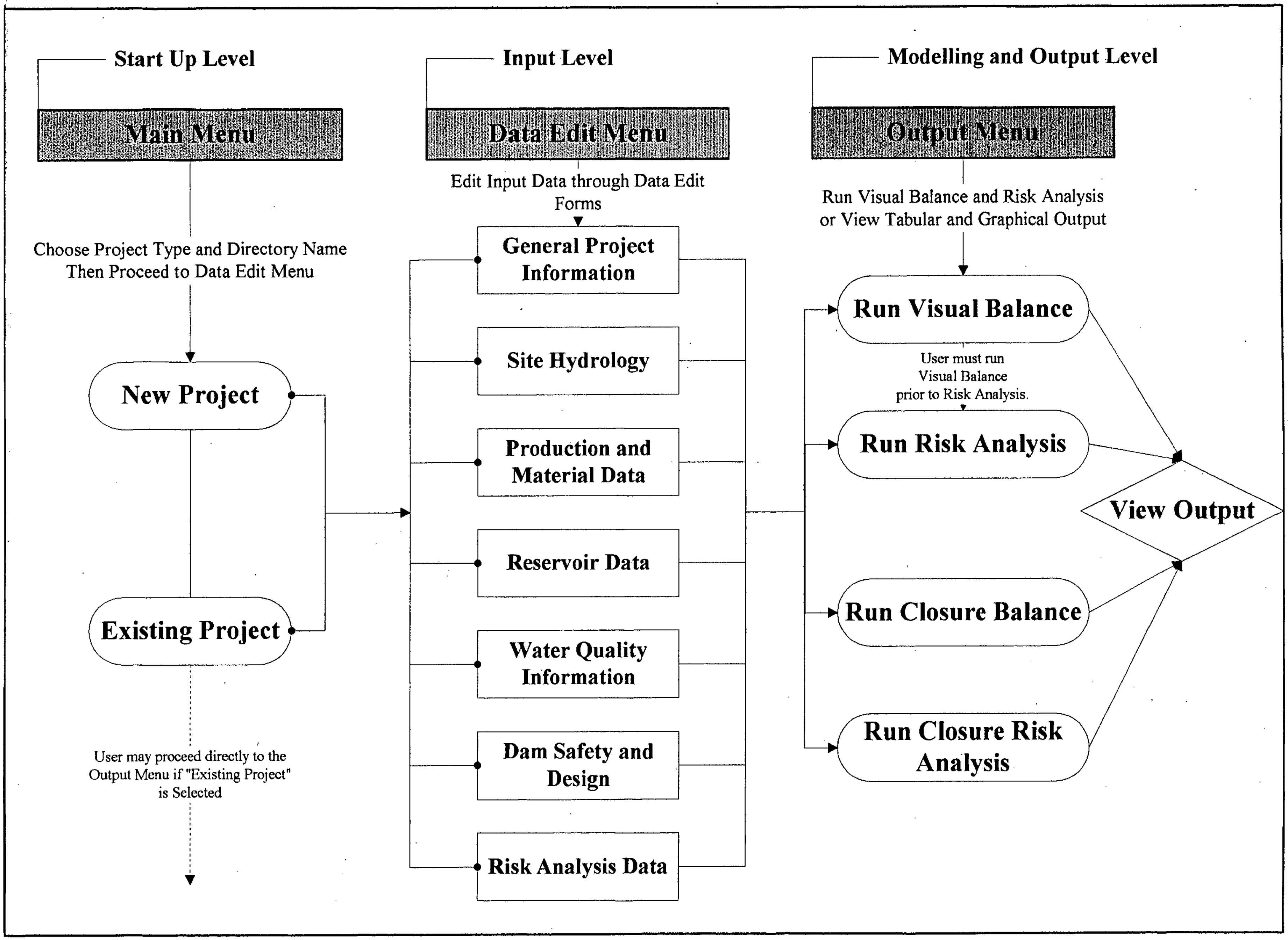


Figure 4.1 Design Levels of the Visual Balance Model

Visual Balance needed to be designed to accept user input data, manage that input data, run a water and material balance for the reservoir over the entire life of the mine, and provide output data in the form of relevant elevations and volumes. The code structure of Visual Balance has four major components:

- User Data Input Forms accessed through the Data Edit Menu,
- Visual Balance Water and Material Balance Procedure,
- Visual Balance Risk Analysis Procedure,
- Average Visual Balance Closure Procedure,
- Visual Balance Closure Risk Analysis, and
- Data Output File Creation accessed through the Output Menu.

The water and material balance portion of the program involves the following general steps:

1. Read user input data such as start up month and year, and initial water and material volumes and elevations to begin balance.
2. Calculate the total inflow of solids and water on a monthly basis.
3. Calculate the total loss of water, including water lost to solid voids on a monthly basis.
4. Sum up the total additional (positive or negative) volume and calculate the new total elevation of solids and water in the impoundment.
5. Add the EDF volume to the end-of-month total volume of solids and water, and calculate the elevation of the EDF.
6. Add the minimum freeboard to EDF elevation to get the design dam crest elevation for

the end of the month. The addition of this EDF volume assumes the solids elevation is level.

The monthly generated balance output data are saved in array type variables and include:

- end of month solids volume, solids and voids volume, and solids elevation,
- end of month water volume, free water volume, free water depth and water elevation,
- end of month EDF elevation, and
- design dam crest elevations accounting for minimum freeboard.

In general, the program simply sums up the inflows and outflows and calculates dam crest elevation requirements. However, two restrictions in dam elevation and operation are coded into the average balance portion of the program, so that dam crest elevations and water consumption are not completely unlimited.

Firstly, the program allows the user to restrict the monthly dam crest elevation lifts. Emergency spill will occur instead of exceeding this dam lift restriction. A large number for *Maximum Dam Lift* can be input to avoid simulating an emergency spill during dam elevation design determination.

Secondly, to ensure that water consumption is not unlimited during dam embankment elevation determination, the reclaim rate to the mine will be set to zero if the free pond water depth is less than some user specified depth required for reclaim. The program checks to see that at the end of the previous month, there was enough pond water for reclaim, or else the reclaim is shut off for the forthcoming month. To avoid Visual Balance setting reclaim to zero during dam elevation design determination, a very low value of "free pond water required" or a negative value, can be input by the user. However, this low level input is not recommended as the typical methods for water reclaim (barge and pump) are not conducive to a low free pond water level.

After a Visual Balance run, the most recently generated values in the arrays of "end-of-month" variables are persistent in the program until the program is exited. These end-of-month values generated using average monthly conditions need to be accessed by the Risk Analysis Procedure. Therefore, Visual Balance requires that a water and material balance run be performed prior to a risk analysis run, for any new set of input data. The monthly design dam crests and solids volumes are set by the "average" balance run, and only the critical, random hydrologic inputs are varied (See Section IV re: Risk Analysis) during the risk analysis. The risk analysis then conducts the following general steps:

1. Each year in the *operation series* [2], a random annual precipitation value is generated using the mean annual precipitation and the standard deviation of the precipitation distribution (for Statistical Methods, see Section 4.5).
2. A random monthly precipitation value is calculated using the temporal distribution of precipitation provided by the user.
3. New direct precipitation values are calculated using the pond area.

[2] The term *operation series* is used to describe one "mine life" series. For example, if the life of the mine spans 12 complete years, then the operation series will include 144 months.

4. Random runoff values are estimated using the random monthly precipitation, temporal distribution, monthly depth loss, percent snow and percent snowmelt. Snow is assumed to accumulate over the period specified by the user, and runoff according to the fractional distribution input by the user. Contrary to the water balance where runoff depths for each month are input directly by the user, this method must back calculate the runoff depths.

5. A new end of month total volume is calculated based on the random direct precipitation and runoff values. Monthly evaporation volumes are also adjusted to account for change in pond area: the pond area at the beginning of each month is used to calculate the volume of evaporation in the subsequent month of the balance.

6. The dam elevations each month are fixed according to the Visual Balance water and material balance run. This approach may seem rigid, but some "yard stick" was needed to assess the potential performance of the impoundment. The risk generated end-of-month water elevation and potential EDF elevation is compared to the design dam crest elevation. Four parameters of interest are summed up during the risk simulation as follows:

   - Tailings Exposed (solids elevation greater than actual water elevation)
   - Low Pond Level (not enough free pond water for reclaim)
   - Low Freeboard (EDF elevation would be within some "risk" freeboard value specified by the user.
   - Spill Required (EDF elevation exceeds the dam crest elevation. No freeboard remaining. Spill required to create some freeboard).

7. The number of *operation series* to be run in a risk simulation is specified by the user, but can not exceed 1,000. The results would then provide the user summary statistical information such as "What is the average number of months of spill required in Year 4 of operation?" or "What is the probability that the tailings will be exposed in Year 10 of operation?"

The program then provides data output options for the user, including viewing and printing the critical input data for a given balance run, and resulting elevations and volumes of solids, free water, and dam crests.

4.2.1 Detailed Design and Coding

The overall design of the procedures and what they were required to do was written in English, drawn in flow charts, and then the Program Design Language (English) was used to create code. Figure 4.1 shows a flow chart of the program structure. The code for Visual Balance is provided in Appendix C.

The Visual Basic coding standards recommend by Microsoft were used in the program wherever possible. The *tag* naming conventions for variable types was also followed which provides variables with a *tag* and a *base name*. The tags are always in lower case so that the reader's eye goes past them to the first upper case letter where the actual base variable name begins. The variables were given names that indicate what they represented (e.g. the rate of seepage outflow was called sngSeepOutRate).

Visual Basic Objects such as Forms, CheckBoxes, Command Buttons, Labels and OLE Objects also have tag conventions of frm, chk, cmd, lbl and ole, respectively. Examples of tags and base names for variables used in the program are presented in Table 4.1.

Table 4.1
Variable Naming Standards for Visual Basic

Variable Type	Tag	Example	Description
Boolean	bln	blnRiskRun	Represents whether a risk analysis has been run for this input data. Certain menu options will be disabled if the user has not run a risk analysis.
Single	sng	sngSeepOutRate	All non-integer variables in the Visual Balance program are "singles", which use less memory than "doubles".
Object	obj	objHydroFile	Excel workbook object containing hydrological data.
String	str	strSiteName	Strings of text (such as the site name)
Long Integer	lng	lngSimSpillMonths	Number of months requiring spill in a given simulation.
Excel Worksheet	wks	wksRiskData	Excel worksheet created to hold risk data inputs.

4.3 Program Data Input

Visual Basic uses a system of "forms" to create Windows environment programs. The user inputs data through seven active data input forms that are accessed through the Visual Balance *Data Edit Menu.* The forms created for the Visual Balance program are displayed in Appendix B. An example of a typical data input form in Visual Balance is shown in Figure 4.2. The Visual Balance data input forms are entitled:

- General Project Information
- Production and Material Information
- Site Hydrologic Data
- Reservoir Information
- Water Quality Information
- Dam Design and Safety Information
- Risk Analysis Data

The water quality information is not currently "balanced" by the program, but is included so that a water quality procedure can be added in the future as required.

4.3.1 General Project Data

The *General Project Information* form is used to input the following data:

- Project Name,

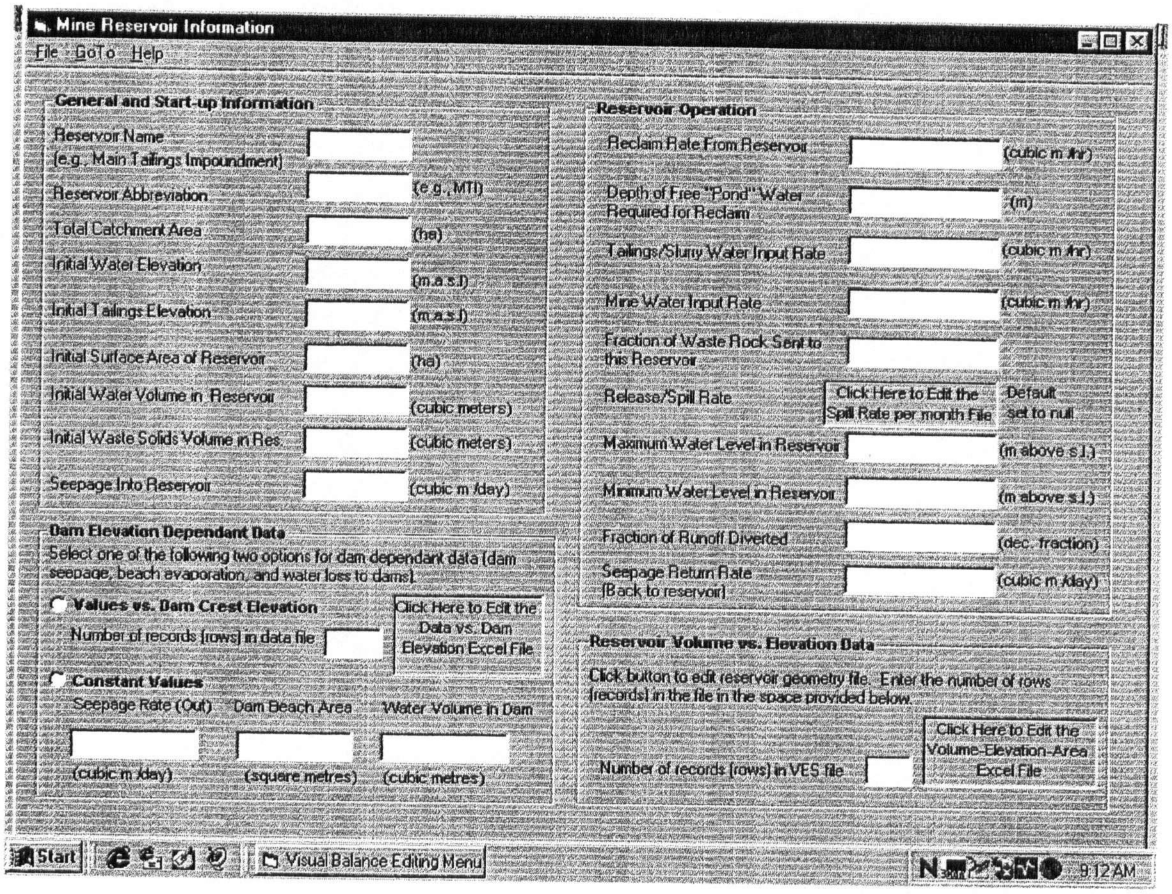


Figure 4.2
Sample Visual Balance Data Input Form - *Reservoir Information Form*

- Project Description,
- Starter Dam Elevation, and
- Number of Reservoirs in the System.

A text file (mine.txt) is created by Visual Balance to save this general information about the project. The variable "number of reservoirs in the system" is not actually used in code, but is intended as a reference for the user to recall whether a system was a single or multiple reservoir system.

4.3.2 Mine Production and Material Data

Data regarding mine production operations and mined material (tailings and waste rock) physical parameters are input on the Form named *Mine Production and Material Data*. Some of the critical parameters input through this form include:

- Month of Production Start Up and Closure
- Start Up Year and Year of Closure
- Production Information

  Total tonnes Mined Per Day

  Tonnes Concentrate Per Day

  Tonnes Waste Rock

  Tonnes Tailings Per Day

- Waste Rock Information[3]

    Bulk Density

    Void Ratio

- Tailings Information

    In situ Degree of Saturation

    Coarse Fraction Cycloned Out

    Dry Density

    Void Ratio

Rather than simply applying an efficiency factor to the entire production year, some flexibility was provided within the user input options for productivity and efficiency by specifying the number of "operating days per month" on an annual basis.

4.3.3 Hydrological Data Inputs

Hydrologic variables are input through the *Site Hydrology* form and its linked standard Excel files. The two primary hydrologic data inputs for the water and material balance are average monthly direct precipitation depths and average monthly runoff depths. Evaporation, and seepage into, or out of, the reservoir are typically proportionally minor components of the water

[3] The equations used to define solids parameters such as *degree of saturation*, are included in Chapter 3.

balance. Direct total precipitation values (snow and rain) are input by the user into a standard Excel hydrological data input file as averages (units: mm/month).

The monthly runoff values are also input by the user in the standard Excel hydrological data file. These runoff values could be estimated from streamflow data from local gauging stations, or from estimation methods such as the rationale formula using average monthly precipitation values, a rational coefficient, and the area of the catchment. This runoff depth should include snowmelt, direct runoff and baseflow. The user inputs average monthly runoff estimates (units: mm/month). There is also a provision that accounts for the "fraction of runoff diverted" as input through the *Reservoir Information* form.

Evaporation depths per month are also input by the user directly into the Excel data input file. Seepage rates into the reservoir and seepage return rates back to the reservoir, as might be found from a treatment pond, are input by the user through the *Reservoir Information* form. Seepage out of the reservoir can be input by the user either as a constant value through the *Reservoir Information* form or a variable dependent on water level and dam crest elevation through the *Dam Dependant Data* standard Excel data input file.

4.3.4 Reservoir Characteristics

The *Reservoir Information* form allows the user to input information about the reservoir and its operation directly into the form.

Reservoir and operational information input through this page includes:

- Reservoir Name
- Reservoir Catchment Area
- Start Up Water and Solids Elevation, Water and Solids Volume, and Reservoir Surface Area
- Seepage Rate In (m^3/day)
- Seepage Rate Out (m^3/day) - either a constant rate or varied depending on dam crest elevation.
- Operation Data
- Reclaim Rate (m^3/hr)
- Pond Depth Required for Reclaim (m)
- Slurry Input Rate (m^3/hr)
- Mine Water Input Rate (m^3/hr)
- Fraction of Waste Rock to Reservoir
- Fraction Runoff Diverted
- Seepage Return Rate (m^3/day)

The *Reservoir Information* form also includes three Microsoft OLE (Object Linked Embedded) links to Excel spreadsheet files, namely:

- Reservoir Volume and Surface Area versus Elevation file (Volume.xls),
- Dam Elevation dependent data (DamInfo.xls), and
- Planned release rates (SpillVolumes.xls).

4.3.5 Dam Safety and Design Information

A *Dam Safety Information* form was created to record design freeboard and maximum monthly dam elevation lifts. The data input requirements on form page include:

- freeboard, period 1
- freeboard, period 2
- maximum monthly dam lift height
- vertical distance between spillway invert and dam crest (used in risk analysis)
- number of years over which to evaluate abandonment scenario (maximum 100 years)

The user is given the option of varying the minimum freeboard during the life of the mine, which may be useful when, during start up years, the potential for damage and the consequence of such damage may not warrant high freeboards. A discussion of minimum freeboard requirements is included in Section 2.3.3.

The "maximum monthly dam elevation lift" input is used in the Visual Balance determination of dam crests elevations. If the monthly solids, water and EDF elevation require the dam crest to be increased beyond this maximum lift, a controlled spill will occur. If the user prefers to ensure that no spill will occur during the water and material balance, the maximum dam crest lift can be set at a high value.

The spillway invert elevation is determined during the risk analysis based on the vertical distance between the design dam crest elevation and the invert provided by the user. Although it is difficult, and rarely done in practice, the spillway invert elevation changes on a monthly basis in the risk analysis portion of the program. Since the risk analysis is intended for impoundment operation assessment rather than detailed design, this spillway invert condition does not diminish the usefulness of the risk analysis results.

4.3.6 Risk Analysis Information

The risk analysis procedure of the software program requires a number of specific data inputs in order to operate. A *Risk Analysis Information* form was created for user input data as follows:

- average annual precipitation (units: mm),
- standard deviation of average annual precipitation,
- number of years of record,
- critical risk freeboard,
- vertical distance between spillway invert and dam crest, and
- number of operation series to generate in the simulation (100 or 1,000).

The risk analysis procedure also requires the following specific hydrological data, which are input through an Excel spreadsheet entitled HydroData.xls:

- average temporal distribution of precipitation,

- fraction of monthly precipitation as snow, and
- fraction of snowpack running off per month.

Lastly, the risk analysis requires the following information input through the *Site Hydrology* form:

- first and last month of snow melt accumulation (defining the snowpack accumulation period).

When running a Closure Scenario risk analysis, the following additional variables are required by Visual Balance, which are also input through the *Risk Analysis Information* form:

- number of years in a *closure series* (maximum 100), and
- number of closure series to be run in simulation (maximum 1,000).

The number of years in the *closure series* is similar to the number of years in an *operation series*, but is generally much longer. Although the persistence of an abandoned tailings impoundment may continue for hundreds of years, the impoundment typically reaches some state of equilibrium after a short number of years. The results of the Closure Scenario risk analysis will be provided on an annual basis for each year in the *closure series*, so that the development of this equilibrium can be observed.

4.3.7 Visual Balance Data Files

There are a number of Excel spreadsheet data files and text files that Visual Balance "reads" data from when running the water balance or risk analysis. The three standardized Excel files that are required for running the balance are shown in Table 4.2. Examples of the Excel data files are included in Appendix C.

Table 4.2
Required Standardized Excel Data Input Files

File Name	Editing Access Through...	Includes Data Re:
HydroData.xls	Site Hydrologic Data Form	Monthly hydrologic data in depths (mm) or fractions: precipitation, temporal distribution, fraction as snow, fraction of snowmelt, runoff, pond evaporation, and beach evaporation.
Volume.xls	Reservoir Information Form	Reservoir geometry: volume and surface area vs. elevation.
OperatingDays.xls	Production and Material Information Form	Number of operating days in a given month (similar to efficiency, but input on a monthly basis).
SpillVolumes.xls	Reservoir Information Form	Monthly varying spill volumes: allows for controlled discharge on a monthly basis as may be required by permits etcetera.

The optional Excel spreadsheet files that can be used to customize data input to a more flexible operation scenario, rather than entering constant values for such parameters as the tailings beach surface area and the volume of water retained within the dam structure, are shown in Table 4.3.

Table 4.3
Optional Standardized Excel Data Input Files

File Name	Editing Access Through...	Includes Data Re:
Production.xls	Production and Material Information form	Annually varying deposition rates: tailings and waste rock deposition rates to the tailings impoundment (tonnes per day).
DamInfo.xls	Reservoir Information form	Additional parameters dependent on dam crest elevations: volume of water lost to dam, beach area, and the rate of seepage out of the impoundment.

The text files created by the program, which save constant values and text data input by users directly into the forms, are as follows in Table 4.4.

Table 4.4
Required Input Text Files (Created by Visual Balance)

File Name	Editing Access Through...	Includes Data Re:
mine.txt	General Project Data	General project information.
extremes.txt	Site Hydrologic Data	Seasonally varied environmental design flood (EDF) is entered and saved through this form.
reservoir.txt	Reservoir Information	Physical and operational reservoir information.
production.txt	Production and Material Information	Form for entering constant, rather than annually varied, production data and solid material data.
Safety.txt	Dam Safety Information	Freeboard and maximum dam lift information.
RiskData.txt	Risk Analysis Data	Statistical and risk data required by risk analysis.

4.4 Program Calculations

Visual Balance uses the equations presented in Section 2.4.1 to compute the tailings impoundment water and solids inflows and outflows on a monthly basis. There are four calculation procedures that are accessed through the output menu in Visual Balance. These procedures are as follows:

1. Average Visual Balance Run
2. Visual Balance Risk Analysis
3. Visual Balance Average Closure Balance
4. Visual Balance Closure Risk Analysis

Procedures 1 is run using average input values for the duration of mine life. For instance, if mine life is expected to be 12 years, Visual Balance will compute 144 months of output elevation data. Procedure 2 , the risk analysis, will simulate 100 or 1,000 12 year *operation series* and calculate probabilities of emergency spill, low freeboard, low pond water levels, or exposed tailings in any year of the operation series.

Procedures 3 and 4 assess the performance of the impoundment after closure of the mine and abandonment of the impoundment. In Procedure 3, the final solids, spillway invert and dam crest elevation are set by Procedure 1, therefore an Average Visual Balance must be run prior to conducting Closure Balance. The Closure Balance accounts for hydrologic inflows and outflows from the reservoir, and allows for spill to take place if the water level in the impoundment exceeds the spillway invert elevation. The user specifies the duration over which to run the Closure Balance, for a maximum of 50 years. Typically, the impoundment reaches a state of equilibrium within a few years. Closure Balance recognizes low freeboard and exposed tailings conditions.

The Closure Risk Analysis calculations included in Procedure 4 are performed similar to the Risk Analysis in Procedure 2, except that the dam crest elevation is fixed and only hydrologic parameters are varied. The Closure Balance records output values, average spill volumes and annual probabilities similar to those included in Procedure 2.

Each of the four computation procedures within Visual Balance use unique variables to describe beginning- and end-of-month solids and water volumes to ensure that procedure specific variables are not persistent between procedure calls.

4.5 Program Output

The program provides data output options for the user, including viewing and printing the critical input data for a given balance run. The program also outputs elevations and volumes of solids, free water, and dam crests. The data output viewing options include viewing and printing:

- Critical input data for a given balance or risk analysis run,
- Average Visual Balance solids, free water, design flood and dam crest elevation, and

solids volumes (tabular, extended tabular, or graphical), and

- Risk Analysis outcomes (table).
- Average Closure Balance (table)
- Closure Risk Analysis (table)

4.6 Debugging and Testing

During the debugging stage of the program development, design-time, compilation, and obvious errors were solved through adding error handlers, increasing program robustness and flexibility, and recoding program modules accordingly.

The errors which still may occur while running Visual Balance can be subdivided into the following four categories:

1. Data Restriction Errors
2. Standardized File Errors
3. Code and Mathematical Errors
4. Fatal Errors

A number of "errors" potentially occur when running Visual Balance that are the result of restrictions imposed by user input variables or files. For example, the user creates a reservoir geometry Excel spreadsheet containing Volume and Surface Area versus Elevation data. This spreadsheet will have a given number of rows and reservoir geometry data up to a given elevation. If the water, EDF or dam crest elevation passed to the "Calculate Volume" module exceeds the maximum elevation in the spreadsheet, an error will occur.

Visual Balance requires standardized text and Excel files in order to run a water and material balance. In particular, Visual Balance requires that *Names*[4] are *Defined* in the Excel spreadsheets that refer to a specific subset of rows and columns (table) from which to retrieve data. If these tables are not properly defined in the Excel spreadsheet, the Visual Basic MS Jet Engine will not be able to retrieve data and the program will discontinue.

Standardized, Read-Only protected files are provided with the Visual Balance software package for these Excel data files that must be readable with the MS Jet Engine.

Five case studies were run through the program to test the software. Additional robustness features, such as data input flexibility, and debugging were conducted during this stage of the research.

The maintenance of a software program involves reacting to user feedback and continuous testing. This step will be post research work to maintain the program for AGRA and other users.

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4 "Name" and "Define" are terminology used in MS Excel to specify a table of data.

CHAPTER 5.0 RISK ANALYSIS

Currently in British Columbia, tailings impoundment design is based only on "average" precipitation and runoff values, together with an extreme event runoff volume, such as a PMF. In this thesis, a risk analysis procedure has been developed that allows the performance and design of a tailings impoundment to be assessed under a stochastically generated wet and dry sequence. A unique and useful feature of the risk analysis approach is that it requires limited precipitation data, which is often all that is available for remote impoundment sites.

5.1 Critical Risk Parameters

Variables in the water and material balance were qualitatively assessed for their potential to impact the overall conclusions of the impoundment balance. Aside from embankment design and construction methods, the hydrologic variables of precipitation and runoff were deemed to have the greatest potential to increase long-term risk associated with a tailings impoundments. Moreover, hydrologic variables were considered to have the highest associated degree of uncertainty. Although volumes of tailings, slurry water, and mine reclaim water are typically the largest estimated volumes in the balance, these variables are associated with relatively low uncertainty since they are controlled by mine operation activities.

The sensitivity of a water and material balance to particular parameters varies widely depending on general climatic conditions, length of the balance period, season of the year, physiographic factors, and nature and degree of consumptive uses and controls. For example, in temperate and coastal regions such as British Columbia, the second largest variables, by volume, in the balance are direct precipitation and surface water runoff. However, in arid climates, water volume lost due to evaporation may exceed the volume of hydrologic inflow. The risk analysis included in Visual Balance simulates random series of precipitation and runoff. However, a risk analysis involving alternate water balance components could be adopted into the software program depending on local conditions.

The level of risk associated with a tailings impoundment is dependent on the associated consequence of failure (hazard) and probability of failure. The concept of uncertainty is incorporated into risk analysis as part of the probability of failure. The more uncertainty associated with failure actuation, the more uncertain the actual risk associated with a given project.

5.2 Risk Analysis Approach

The following additional hydrologic parameters are input by the user for use in the risk analysis:

- Average annual precipitation (mm)
- Standard Deviation of average annual precipitation (mm)

- Average temporal distribution of precipitation[1]
- Fraction of monthly precipitation as snowmelt
- Fraction of snowpack running off per month
- First and last month of snow melt accumulation (defining the snowpack accumulation period)
- Number of years of record
- Critical Freeboard (m)
- Spillway invert elevation below dam crest (m)
- Number of operation series to generate in the simulation (100 to 1,000)

The steps which Visual Balance conducts to complete the risk analysis are as follows:

Step 1. Conduct a Monte Carlo simulation, generating random annual precipitation values using statistics (Section 5.3).

Step 2. Estimate random monthly precipitation values using the defined temporal distribution.

Step 3. Estimate stochastic runoff values using the following equation taking into account the fraction of precipitation that is accumulated in the snowpack, the fraction of snowpack that runs off in a given month, and the runoff loss (units: mm). The runoff loss is similar to a runoff coefficient, accounting for infiltration and evaporation losses in the catchment area.

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[1] The average temporal distribution of precipitation, fraction of monthly precipitation as snowmelt and fraction of snowmelt running off in a given month are input through the standard Excel hydrological data input sheet (Appendix B).

Random runoff values are estimated using the random monthly precipitation, temporal distribution, monthly depth loss, percent snow and percent snowmelt. Snow is assumed to accumulate over the period specified by the user and runoff according to the fractional distribution input by the user. In contrast to the Visual Balance average value balance, where runoff depths for each month are input directly by the user, this method must back-calculate the runoff depths as shown in Equation 5.1.

$$d_r = P_r \cdot (1 - f_s) - l_r + (d_{sp} \cdot f_m) \tag{5.1}$$

where,

d_r	=	Runoff Depth (mm)
P_r	=	randomly generated precipitation (mm)
f_s	=	fraction of precipitation as snow in a given month
l_R	=	runoff loss in a given month (mm)
d_{sp}	=	snowpack depth (mm)
f_m	=	Fraction of snowmelt occurring in a given month

The user inputs a fixed *runoff loss depth* per month, l_R, that is subtracted from the randomly generated runoff depth. The groundwater seepage rate into the reservoir remains constant. Although in practice it is likely that precipitation volumes in excess of average volumes would increase the groundwater seepage rate due to an increase in runoff loss depth, the increased precipitation volume is likely going to reach the reservoir. By using a constant runoff loss depth, Visual Balance assumes that all excess precipitation, greater than average precipitation volumes in the catchment area, reaches the reservoir. This may be a conservative estimate.

The snowpack depth is updated on a monthly basis within the program. The user specifies the month in which snowpack begins accumulation, and the month in which snowpack accumulation ends and depletion begins. The snowpack is updated using Equation 5.2.

$$(d_{sp})_{cm} = (d_{sp})_{pm} + (P_r \cdot f_s) \tag{5.2}$$

where,

$(d_{sp})_{cm}$ = current month

$(d_{sp})_{pm}$ = previous month

The runoff volume is then calculated as shown in Equation 5.3.

$$V_r = d_r \cdot A_c \cdot (1 - f_{rd}) \tag{5.3}$$

where,

V_r = volume of runoff (m^3)

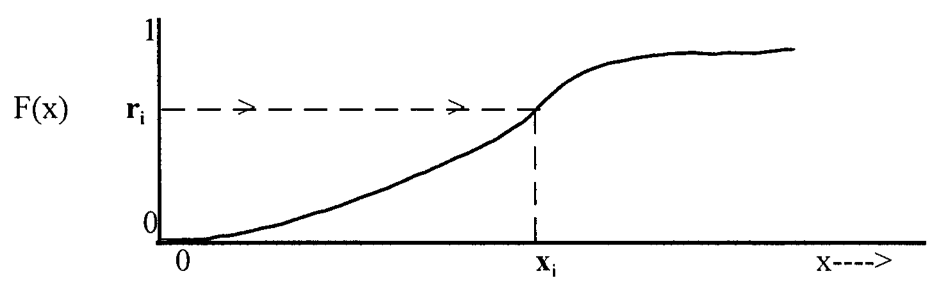
A_c = catchment area (m^2)

f_{rd} = fraction of catchment area diverted

5.3 Statistical Theory

Typically, historical data represented by real sequences of past data are insufficient for a long simulation run and, in general, are not as flexible as a sampled sequence (Davies et. al., 1972). Monte Carlo uncertainty analysis techniques are used for probabilistic prediction, which can be a component of risk analysis for stochastic variables. The hydrologic variability of the mean annual precipitation is considered to be stochastic, meaning the values are random and can take on an infinite number of values within a specified range.

Monte Carlo simulation involves the representation of the actual data by a probability distribution from which a sequence can be sampled randomly. A method of obtaining a random variate x_i from the general distribution $f(x)$ is required. If the cumulative distribution function F(x) is known, a random number, r_i, is generated between 0 and 1, and the value x_i for which $F(x_i) = r_i$ can be found by inverting the cumulative distribution function (CDF). The approach is illustrated in Figure 5.1.



Where x_i represents the random variate (for example annual precipitation corresponding to a randomly generated r_i.

Figure 5.1 - Random Variate Generation Using the Cumulative Distribution Function.

Annual precipitation data are usually observed to exhibit a normal distribution (Ferguson and Znamensky, 1981). However, the sample size in remote areas is typically limited, which in turn limits the applicability of a normal distribution. The normal distribution assumes an infinite sample size. A more suitable and robust distribution is required for the risk analysis of data from small sample sizes.

In 1908, William Sealy Gosset published a paper under the pseudonym "Student" in which he observed that if random samples of size less than 30 are taken from a normal distribution and the samples used to estimate the variance, then the statistic represented by t is not normally distributed.

$$t = \frac{\bar{y} - \mu}{s/\sqrt{n}} \qquad (5.4)$$

where,

$\bar{y}$ = sample point estimate of the mean

μ = population mean

s = sample standard deviation

n = sample size

The sample distributions Gosset studied are called Student's t-distributions where t is equal to the statistic in Equation 5.4. The shape of the t-distribution is less peaked than the normal distribution, with a greater proportion of the values situation at the tails of the distribution. The *t*-distribution approaches the shape of the normal distribution for sample sizes greater than 30. Therefore, the *t*-distribution adequately represents both small and large sample sets from normally distributed populations. The Student's *t*-distribution can also be used to estimate probabilities when the population distribution is not normal, as long as the distribution is at least symmetrical, unimodal, and with a variance that is not inordinately large. In such cases, the *t*-distribution is a good estimate of the actual sampling distribution (Dowdy and Wearden, 1983).

The *t*-distribution was thus used to represent the mean annual precipitation data. Once the sample size, mean, and standard deviation are estimated, the *t*-distribution can be used to generate a set of random mean annual precipitation data from the sample distribution. Random numbers generated by computers are typically generated from a uniform distribution between 0 and 1. Visual Basic includes a function call *Rnd()* that will automatically generate random numbers less than 1 but greater than or equal to zero.

For any given initial *seed* in a computerized random number generator, the same number sequence is generated because each successive call to the *Rnd* function uses the previous number as a seed for the next number in the sequence. The randomize statement is used in the Visual Balance code to initialize the random-number generator with a seed based on the system timer. The uniform random number generated, p, can be converted to a normally distributed random variate, x_p, using the following equations (Abramowitz and Stegun, 1966, p.933).

Rational Approximations for x_p where $Q(x_p) = p$

$0 < p \leq 0.5$

$$x_p = z - \frac{a_0 + a_1 z}{1 + b_1 z + b_2 z^2} + \varepsilon(p) \tag{5.5}$$

$$z = \sqrt{\ln \frac{1}{p^3}} \tag{5.6}$$

where,

p	=	random number[2] between 0 and 1
$\lvert\varepsilon(p)\rvert$	=	error term $< 3 \times 10^{-3}$
x_p	=	number of standard deviations from sample mean
a_0	=	2.30753
a_1	=	0.27061
b_0	=	0.99229
b_1	=	0.04481

In Equation 5.5, the variable x_p represents a random, normally distributed variate. The corresponding t-statistic for the Student t-distribution can then be generated using an asymtotic expansion for the inverse function and is a function of degrees of freedom, ν (Abramowitz and Stegen, 1966, p.949).

2 It should be noted that the above set of equations is valid when the variable p is less than 0.5. When the computer generates random value $p > 0.5$, p is set to $1-p$ and $x_p = -x_p$.

$$t_p \sim x_p + \frac{g_1(x_p)}{\nu} + \frac{g_2(x_p)}{\nu^2} + \frac{g_3(x_p)}{\nu^3} + \frac{g_4(x_p)}{\nu^4} \qquad (5.7)$$

where,

ν = degrees of freedom = $n - 2$

n = sample size (# of years of record)

$$g_1(x_p) = \frac{1}{4}(x_p^3 + x_p) \qquad (5.8)$$

$$g_2(x_p) = \frac{1}{96}(5x_p^5 + 16x_p^3 + 3x_p) \qquad (5.9)$$

$$g_3(x_p) = \frac{1}{384}(3x_p^7 + 19x_p^5 + 17x_p^3 - 15x_p) \qquad (5.10)$$

$$g_4(x_p) = \frac{1}{92{,}160}(79x_p^9 + 776x_p^7 + 1482x_p^5 - 1920x_p^3 - 945x_p) \qquad (5.11)$$

The randomly generated mean annual precipitation values (x_i) are generated from the random t-statistics as follows in Equation 5.12.

$$x_i = \bar{x} + t_p \times s \qquad (5.12)$$

where,

x_i = randomly generated annual precipitation (mm)

$\bar{x}$ = mean annual precipitation (mm)

t_p = random t-statistic previously defined in Equation 5.6, equal to the number of standard deviations corresponding to random number p.

s = standard deviation of annual precipitation (mm)

Depending on the number of "series per simulation" selected by the user, 100 or 1,000 random annual precipitation values are generated using Equations 5.1 through 5.12. The steps for generating the random operation series are as follows:

Step 1. The average-case total production series is run using Visual Balance based on the mean annual precipitation. From this average-case, the design dam heights are saved in the program code.

Step 2. A water and materials balance is re-run using random annual precipitation values in each year. A different random annual precipitation value was used for each year of the operation series. That is, if the total production duration was 15 years and the number of series requested to be run in the simulation was 100, 1500 randomly generated precipitation values would be used in Step 2 (i.e., 100 15-year sequences).

Step 3. Risk analysis output operation assessment counters are generated.

5.4 Risk Analysis Module Performance

The risk analysis module code includes counters to keep track of the following reservoir performance parameters:

- the number of months reclaim was required to be shut off,
- the number of months the tailings were exposed,
- the number of months with "low freeboard", and
- the number of months requiring spill.

The user specifies a depth of water required in the pond in order for reclaim to occur, which is entered through the *Reservoir Information* form. If the depth of free water elevation at the beginning of the month is less than the depth required for reclaim, then reclaim will be shut off for the subsequent month in the series. The depth of free water is equal to the actual free water elevation minus the actual solids elevation. Although shutting off reclaim for a whole month may be a somewhat unrealistic action, the risk analysis operates on a monthly basis, therefore, the critical counters are summed up on a monthly basis. These records of how often reclaim is required to be shut off could be significant to the feasibility of a mine operation if sources of additional fresh make up water for processing are remote and potentially expensive.

Monthly solids elevations in the balance are set by the average balance run and the risk generated water elevations are calculated by Visual Balance using the randomly generated hydrologic inflows. At the end of the month, if the elevation of the solids in the pond is greater than the elevation of the new free water surface, then the risk module records a month with "tailings exposed". A counter variable *sglMonthsDryTail* is increased by 1 in the case of tailings exposure at the end of any given month. Such an occurrence could be significant in situations where tailings are potentially acid generating and are meant to be permanently submerged.

As part of the risk analysis data input, the user specifies a critical risk freeboard value that may be equal to or less than the design minimum freeboard. The program checks to see if the actual freeboard in a given month of the random operation series is less than the risk freeboard. The "Actual Freeboard" in the risk analysis is defined as the dam crest elevation (fixed from average run of water balance) minus the EDF elevation. Months with freeboard lower than the specified risk freeboard could be an indicator of an impoundment that is going to operate quite full. Such an operating scenario may indicate that greater dam raises are required, which could lead to the need for additional saddle dams at increased elevations, or that there is additional water available for fresh water make up, or that increased surface water diversion is needed.

It is recommended that the user select a risk freeboard somewhat less than the minimum design freeboard or erroneously negative results are likely to come from the risk analysis. This is a consequence of having fixed dam crest elevations in each month based on the results of the "average value" Visual Balance run. Since it is not unreasonable that some fluctuation will occur in the randomly generated water elevation and subsequent EDF elevation, the risk freeboard should be selected with care. In some jurisdictions, a minimum 0.5 metre freeboard maintained at all times above the EDF is recommended (Williamson, 1990). This may be a suitable risk freeboard in cases where the minimum design freeboard is greater than one metre, providing the user with representative, but not overly conservative, risk analysis results.

If the Actual Freeboard is less than the risk freeboard, then the program recognizes the month as a Low Freeboard Month. If the Actual Freeboard is less than the risk freeboard and is less than zero, indicating that an EDF event would overtop the dam, then a month with spill required is recognized by the risk module.

The volume of the emergency spill in the risk analysis is dependent on the vertical distance between the dam crest and the spillway invert provided by the user. Essentially, spill occurs until the actual water elevation is equal to that of the dam crest minus the vertical distance to the spillway invert. The spillway invert elevation is set within the program on a monthly basis dependent on the dam crest elevation. It should be noted that spillway inverts are not typically adjusted on a monthly basis during actual impoundment construction and operation. The new water elevation at the end of the month is recalculated as:

$$(E_w)_{ps} = E_{dc} - d_{si} \tag{5.13}$$

where,

$(E_w)_{ps}$ = elevation of water "post spill"

E_{dc} = elevation of dam crest

d_{si} = depth to spillway invert from dam crest elevation

The new "total" volume in the reservoir is calculated based on the post-spill water volume and the solids volume as follows in Equation 5.14. The EDF elevation is then adjusted based on the new actual water elevation in the impoundment.

$$(V_t)_{ps} = V_s + (V_w)_{ps} \tag{5.14}$$

where,

$(V_t)_{ps}$	=	total actual volume of solids and water in the impoundment after a spill
V_s	=	volume of solids
$(V_w)_{ps}$	=	volume of water in impoundment after a spill

5.5 Risk Analysis Module Outputs

The risk analysis results can be viewed through the Output Menu Form under the menu option View → Results → Risk Analysis → Tabular or Graphical. A sample of the risk analysis tabular output are provided in Appendix E. The output table generated presents the following Risk Analysis parameters:

- Average Annual Precipitation - mean, standard deviation, and number of years of record,
- Risk Freeboard
- Number of months in a complete operation series (≈No. of Years Operation · 12),
- Number of Series requested simulation (100 or 1,000).
- % Series with at least one month of no reclaim, dry tailings, emergency spill required, or low freeboard.

Table 5.1 displays a truncated version of the risk analysis module tabular output. Typically, the output displays the number of months with a critical event in each series simulated.

Table 5.1 **Sample Risk Analysis Results**

Risk Analysis Parameters

Mean Annual Precipitation	2,006 mm	**Operation Parameters**	
Standard Deviation	200	Number of Years in Operation Series	14
Number of Years of Record	15	Operation Series in Simulation	1,000
Freeboard Required (above EDF)	2 m	Number of Months in Series	167
Risk Freeboard (above EDF)	1.5 m	Number of Months in Simulation	167000
Spillway Invert (below Dam Crest)	1 m		

Risk Analysis Summary Statistics

Spill Results

Year in Series	Avg. # Months with Spill	Avg. Annual Prob. of Spill (%)	Avg. Spill Volume (m^3)	Maximum Spill Volume (m^3)
1	0	0	0	0
2	0.23	16.0	235,498	964,457
3	3.79	54.0	121,429	1,081,157
4	7.17	95.0	185,246	1,139,024

Freeboard Results

Year in Series	Avg. # Months with Low Freeboard	Avg. Annual Prob. of Low Freeboard (%)	Avg. Value of "Low Freeboards" (m)
1	0	0	0
2	4.35	100	-0.23
3	11.82	100	-0.5
4	11.77	100	-0.6

Reclaim Results

Year in Series	Avg. # Months with Reclaim Off	Avg. Annual Prob. of Reclaim Off (%)	Avg. Makeup Volume Requ. (m^3)
1	0.0	0.0	0.0
2	0.0	0.0	0.0
3	0.0	0.0	0.0
4	0.0	0.0	0.0

Tailings Exposure Results

Year in Series	Avg. # Months with Solids Exposed	Avg. Annual Prob. Solids Exposure (%)	Avg. Depth of Water Above Solids (m)
1	0.0	0.0	4.35
2	0.0	0.0	6.47
3	0.0	0.0	5.58
4	0.0	0.0	4.43

For example, the results would be displayed for 1,000 series if the user requested that 1,000 series be run in the total simulation. Only the first 4 years are shown for brevity. A complete version of the risk analysis summary statistic output is provided in Appendix E.

The results of the sample simulation provided on the following page indicate that the impoundment is likely to operate "wetter" than might have been predicted by the average water and material balance. For instance, in Year 4 spill will occur on average 7 months out of the year, with a 95% probability of spill in any given year. The dam will be operating almost continuously with freeboard less than the "risk freeboard" input by the user.

CHAPTER 6.0 CASE STUDIES

A risk analysis approach was incorporated into Visual Balance to assess the expected operating conditions at an impoundment. The statistical methods used in the risk analysis are based on sound statistical principles well suited for small hydrologic data sets.

To test Visual Balance and assess the usefulness of the risk analysis module, five case studies were developed based on past tailings impoundment design or feasibility projects and available data. All case names, meteorological data station names, and identifying details have been omitted or altered in the interest of client privacy. The case studies have been identified as follows:

Case I	North Coast British Columbia, Canada
Case II	North East British Columbia, Canada
Case III	Central Interior British Columbia, Canada
Case IV	Northern Ontario, Canada
Case V	Southern Bolivia

These case studies were selected based on the diversity of site conditions (physical, operational and hydrologic) and regulatory requirements represented. Because Visual Balance does not currently have reservoir linking and routing capabilities, the case studies also needed to be single reservoir systems. The following sections outline each case study's regional characteristics, hydrologic data available for statistical analysis, and general tailings impoundment operating requirements.

The five case studies were run through the average water and material balance module of Visual Balance. Four of the case studies (I, II, III, and V) were run through the risk analysis module of the program. Precipitation data was not available to conduct the risk analysis for Case Study IV, in Northern Ontario. Instead, an average Closure Balance was run for Case Study IV.

The dam crest elevation outcomes from the average Visual Balance run for each case study were compared to the dam crests previously predicted by consultants who used spreadsheet based water balance methods. The results corresponded well to the previous project outcomes, indicating that the average water and material balance model was performing suitably.

For case studies that involved operating mines, risk analysis results were qualitatively compared to the actual operating conditions experienced at the mines. For example, during operation at Case Study II, mine personnel have found that actual operating water volumes in the impoundment were less than volumes predicted by an average spreadsheet-based hydrologic balance. The Visual Balance risk analysis was able to predict the probability of such a scenario. If probable operating conditions can be predicted, undesirable circumstances could be anticipated and accounted for in water management facility design and construction, avoiding the need for costly production shut downs due to permit violations or expensive retrofits.

It should be noted that the rigorous assessment of site details and hydrologic complexities typically involved with a detailed tailings impoundment design was not afforded as part of the Case Study analysis. Site specific details that were not readily available in the project design reports and water balance spreadsheets were not able to be included in the Visual Balance runs. The results of these Case Studies should be viewed in that light.

6.1 Case Study I - North Coast British Columbia, Canada

As part of a mine site feasibility study, a water and material balance was conducted for a proposed tailings impoundment site in the Coast Mountains, North Coast Region, British Columbia, Canada. At the time of this research, the mine was not yet operating.

The site was located near the confluence of two major rivers. Both rivers which were habitat for anadromous fish species. Management of the impoundment as a closed system was an objective of the overall design. The main impoundment area was to be situated in a site with favourable topographical features and with an advantageous ratio of dam volume to storage volume. However, the major challenge with the site was the relatively high inflow volumes from two creeks entering the basin and the difficulty of diverting these flows around the steep slopes of the tailings basin.

Based on the CDSA DSG classification system for the potential Environmental Impact from dam failure, the impoundment at Case Study I was considered to have "High" potential incremental consequence of failure. Water management requirements at the site involved the following:

- containing a 24-hr PMF flood volume
- maintaining an additional 1.5 m of freeboard above this EDF.

In addition to the storage of the tailings and waste rock, the tailings dams were to be constructed to heights that allow for the storage of at least 1,000,000 m^3 of available process recycle water. Surface water diversion works were designed to carry a 24 hour, 200 year AEP flood volume. Available water in the tailings pond would originate from the following main sources:

- slurry water with tailings inflow;
- direct precipitation; and
- surface water runoff not intercepted by the diversion channels.

The hydrologic data available for Case Study 1 consisted of site precipitation, temperature, and stream gauging data for ten years from a private weather station nearby. Regional analysis, using the two nearest Atmospheric Environment Service (AES) stations, was employed to extend the data for a frequency analysis. The data indicated that precipitation falls predominantly as rain in April through October and predominantly as snow in January and February; the rest of the year receives mixed rain and snow.

The mine was planned to be an open pit, with a low estimated waste to ore ratio of about 0.4. Milling 12,000 tonnes per day (tpd) of ore was expected to produce 120 tpd of concentrate. The major portion of the tailings were expected to be non-acid generating tailings constituting 11,400 tpd (95% of 12,000 tpd) or 4,104,000 tonnes per year. Potentially acid generating tailings constituted the remaining 5 percent of the solids (600 tpd). The tailings stream would be approximately 5%wt solids, with about 12,695 m^3/day water in this tailings stream. The tailings in situ dry density in the impoundment was expected to be 1.3 tonnes/m^3 after one year and 1.4 tonnes/m^3 over the long term.

The original water and material balance conducted for Case Study I was performed as part of a mine site feasibility study. Because this mine is not currently operating, direct comparisons to operating scenarios are not possible. The operation scenario simulated include 167 months. During the average Visual Balance water and material balance run, neither emergency spills due to "maximum dam lift per month" nor reclaim shut off due to low pond water depths were required in any of the months simulated. The risk analysis results for Case Study I indicate that the mine is likely to run within the freeboard and reclaim requirements specified by the design (Table 6.1).

The risk analysis results are not surprising as the site was located in a topographically favourable location, and much of the catchment runoff is to be diverted which reduces the fluctuations in water elevations due to randomly generated runoff values. Results of the risk analysis may indicate that less water requires diversion from the impoundment and construction costs for future water management features could be decreased. In addition, such positive risk analysis results could be used to support and speed environmental permit applications.

Table 6.1
Summary Risk Analysis Results - Case Study I

Year in Series	Avg. Ann. Prob. of Spill (%)	Avg. Ann. Prob. of Low Freeboard (%)	Avg. Ann. Prob. of No Reclaim (%)	Avg. Ann. Prob. of Solids Exposed (%)	Avg. Depth of Water Above Solids (m)
1	0	0	0	0	2.77
2	0	0	0	0	2.32
3	0	0	0	0	3.04
4	0	0	0	0	4.03
5	0	0	0	0	5.05
6	0	0	0	0	6.09
7	0	0	0	0	7.1
8	0	0	0	0	8.07
9	0	0	0	0	9.04
10	0	0	0	0	9.95
11	0	0	0	0	11.11
12	0	0	0	0	14.51
13	0	0	0	0	16.17
14	0	0	0	0	16.27

6.2 Case Study II - West-Central British Columbia, Canada

A water and material balance was conducted for Case Study II as part of a detailed tailings impoundment design project. The site is located in west central British Columbia, Canada between the Coast Mountains and the Interior Plateau. The mine is currently operating. The tailings impoundment was designed to provide disposal and permanent submergence of the potentially acid generating (PAG) tailings and waste rock.

Based on the CDSA DSG classification system for the potential Environmental Impact from dam failure, the impoundment at Case Study II was considered to have "low" to "high" potential incremental consequence of failure, or the impacts perceived by the public were expected to be moderate with no expected fatalities. Water management requirements at the site involved the following:

- containing an EDF volume of a 1-in-200 year wet year pond elevation in early operation years, and a PMF after year 3, and
- maintaining at least a 1 m freeboard above the EDF.

Hydrologic data available for Case II consisted of long term data from two AES stations and three years of data from the site itself. Since the site was located in between the Coast Mountains and the Interior Plateau, the average annual precipitation rate for the site was estimated from the average of the nearest Coast AES station and the nearest Interior AES station.

The copper-molybdenum ore deposit is being mined by conventional, open pit operations, with an estimated 90.7 million tonnes of mineable reserves being obtained over the predicted 16 year life of the mine. A tailings pipeline and a reclaim barge and pipeline circuit provide tailings discharge and process water recycling capabilities. The embankment was being raised by the centerline construction method over the life of the mine, with planned annual crest raises in the order of three to ten metres in elevation.

Case Study II involves a mine and impoundment that has been operating for several years. Current operation reports from this active case study indicate that the tailings impoundment is generally running dryer than expected and that reclaim during winter months using a floating barge has been difficult. When conducting the average Visual Balance water and material balance, the reclaim was shut off due to low pond depths in 10 months out of total of 183 months simulated.

A risk analysis was run for Case II using a risk freeboard above the EDF of 0.75 metre, and 1 metre of pond water required for reclaim. The risk analysis generated by Visual Balance predicted the operating conditions presented in Appendix E and a summary of the annual probabilities is presented in Table 6.2.

The results suggest that there is a strong probability that reclaim from the impoundment using a floating barge may be difficult, with a 100% probability that reclaim will need to be shut off in at least 1 month in each of Years 1 through 5 of operation. In addition, the results indicated that the average number of months with freeboard less than the risk freeboard ranged between 1 and 5.5 in the first five years of impoundment operation. It should be noted that some variability in freeboard is expected in the Visual Balance risk analysis due to the "fixed" dam crest elevations used from the average balance run.

Table 6.2
Summary Risk Analysis Results - Case Study II

Year in Series	Avg. Ann. Prob. of Spill (%)	Avg. Ann. Prob. of Low Freeboard (%)	Avg. Ann. Prob. of No Reclaim (%)	Avg. Ann. Prob. of Solids Exposed (%)
1	0	1.0	100	0.0
2	0	100.0	100	0.0
3	0	100.0	100	0.0
4	0	100.0	100	0.0
5	0	80.0	100	0.0
6	0	54.0	100	0.0
7	0	40.0	100	0.0
8	0	35.0	100	0.0
9	0	31.0	98.0	0.0
10	0	29.0	97.0	0.0
11	0	26.0	100.0	0.0
12	0	24.0	92.0	0.0
13	0	31.0	92.0	0.0
14	0	11.0	85.0	0.0
15	0	36.0	83.0	0.0

6.3 Case Study III - North Central British Columbia, Canada

The site used for Case Study III has been in operation for a number of years at the time of the study. The data used for the case study analysis was derived from a project that involved the revision of water and material. The balance revisions were required due to actual operating condition problems and site issues with excess water storage.

The site is located in north-central British Columbia, and involves open pit mining of a total of approximately 220 million tonnes of copper and gold ore. The mine life will continue for at least 13 more years, at a nominal production rate of 45,400 tpd. Tailings from the milling process are pumped in slurry form to the tailings impoundment, where they are discharged. Process water is recycled from the tailings pond via a floating pump barge and reclaim pipelines. Seepage through the dam is intercepted in a downstream seepage recovery pond.

Diversion structures are in place up-gradient of the tailings facility to intercept and divert up-gradient surface runoff water flows around the tailings impoundment. To date, the dam raising has at times only just kept pace with tailings and flood storage and freeboard requirements. Winter construction has been necessitated, which is often not ideal working conditions due to construction with wetter materials and the difficulties associated with working at colder temperatures.

Based on the CDSA DSG classification system for the potential environmental impact from dam failure, the impoundment at Case Study III was considered to have "very high" potential incremental consequence of failure by regulators. Water management at the impoundment site involved the following requirements:

- containing an EDF of 1-in-200 year return period, 24-hour duration storm event;
- design for the passing of an IDF equal to the PMF estimation[1];

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1 Seasonally adjusted storm depths for this event were used in the water balance.

- maintaining equipment and materials for the construction of an emergency spillway at all time, should a longer duration IDF occur; and
- maintaining at least a 2 m freeboard above the IDF.

During the average Visual Balance run, the reclaim was shut off due to low pond depths in 2 out of 149 months simulated. The mine at Case Study III is currently operating. Operation reports indicate that the mine is having difficulty maintaining required freeboard and flood handling capacity, which may result in a temporary production shutdown enforced by regulators if the situation does not improve.

A Visual Balance risk analysis was run using a risk freeboard of 1 metre and a pond depth required for reclaim of 0.5 metre. The results of the risk analysis indicate that the impoundment is likely to run "wet", with the probability of low freeboard (below the "risk freeboard" of 0.8 m) being greater than 80% in operation years 4 through 11. The annual probability of emergency spill being required increases to a maximum of 71% in year 10. The results of the Visual Balance risk analysis are presented in Appendix E and a summary is provided in Table 6.3.

6.4 Case Study IV - Northern Ontario, Canada

Case Study IV represents an active mine in Northern Ontario. The existing tailings disposal facility at the site was designed in the early 1980's to store over 10 million tonnes of tailings solids.

Table 6.3
Summary Risk Analysis Results - Case Study III

Year in Series	Avg. Ann. Prob. of Spill (%)	Avg. Ann. Prob. of Low Freeboard (%)	Avg. Ann. Prob. of No Reclaim (%)	Avg. Ann. Prob. of Solids Exposed (%)
1	0.0	0.0	0.0	1.0
2	0.0	0.0	7.0	1.0
3	0.0	5.0	7.0	0.0
4	1.0	80.0	2.0	0.0
5	56.0	96.0	2.0	0.0
6	46.0	98.0	2.0	1.0
7	20.0	93.0	3.0	0.0
8	23.0	93.0	4.0	1.0
9	39.0	91.0	4.0	0.0
10	71.0	93.0	6.0	0.0
11	40.0	92.0	7.0	0.0

Total tailings production over the life of the mine has been recently re-estimated at approximately 20 million tonnes. In this case study, a water and material balance assessment was conducted as part of the evaluation of options for tailings impoundment expansion. Visual Balance and its average Closure Balance were run on the impoundment expansion scenario ultimately selected by the project consultants.

Based on the CDSA DSG classification system for the potential environmental impact from dam failure, the impoundment at Case Study IV was considered to have “High” potential incremental consequence of failure. The mine operates under a permit which requires, among other provisions, that the water quality in two downstream aquatic habitats be protected.

During operations, and in the event of a design storm, the following water management criteria were to apply to the impoundment:

- storing, without release, the runoff resulting from the PMP event, in addition to the two month spring runoff that would be generated during a 1-in-10 (wet) year return period runoff event.
- maintain minimum freeboard of 1 m above the resulting pond elevation.
- an emergency spillway is to be constructed to provide for emergency release capacity and additional protection against overtopping of the dams.

Upon closure, the spillway is to continue to serve as the emergency spillway and under normal climatic conditions, the following water management design criteria were to apply:

- a minimum water cover of 0.3 m is to be maintained over the tailings surface for the 1 in 100 year return period dry year,
- a minimum water cover of 1 m is to be maintained over the tailings surface, for normal runoff conditions.
- an additional emergency spillway is to be constructed to provide additional release capacity in the event of a blockage of the overflow spillway.
- a minimum freeboard of 1.5 m below the crest of the dams is to be maintained, after closure, under normal runoff conditions.

The mine in Case Study IV involves a number of active tailings impoundments. Visual Balance was used to model an impoundment that is planned to be constructed at the site, but has not yet been built. A risk analysis of this impoundment was not run due to the lack of statistical data regarding precipitation at the project site.

However, some interesting results were provided by the average water and material balance run. During the average water and material balance run, reclaim water was required to be turned off in 32 of the 116 operating months. The depth of free pond water required for reclaim used in the balance was conservatively input as 0.5 metres. If the free pond water depth goes below this value during the Visual Balance average, reclaim is shut off for one month. This result, on only the average run, indicates that Case Study IV may operate much more dry than expected.

The closure plan for this impoundment indicates that tailings are to remain submerged under at least one metre of water. An average Visual Balance closure assessment was run and the results for Years 1 through 10 following closure are presented in Table 6.4. The average closure balance results indicate that the impoundment spills one or two months out of every year. The steady-state pattern which appears to emerge reflects the fact that the spillway and final dam crest elevations are fixed and that inflow and outflow volumes each year are constant in the "average" closure balance. Closure analysis results indicated that the tailings would remain submerged after impoundment abandonment under average hydrologic conditions. The impoundment appeared to reach a somewhat "steady state" after approximately five years of closure, with the solids submerged under approximately an average of 0.85 m of water.

Table 6.4
Summary of Average Closure Balance Results - Case Study IV

Year in Series	Avg. Ann. Prob. of Spill (%)	Avg. Ann. Prob. of Low Freeboard (%)	Avg. Ann. Prob. of Solids Exposure (%)	Avg. Water Depth Above Solids (m)
1	0.0	0.0	0.0	0.05
2	1.0	8.33	0.0	0.79
3	1.0	8.33	0.0	0.87
4	2.0	16.67	0.0	0.96
5	1.0	8.33	0.0	0.88
6	1.0	8.33	0.0	0.92
7	2.0	16.67	0.0	0.97
8	1.0	8.33	0.0	0.89
9	1.0	8.33	0.0	0.89
10	2.0	16.67	0.0	0.95

6.5 Case Study V - Southern Bolivia

A case study from Andean mining region is South America was selected based on the unique characteristics of the projects located in this region. The increased involvement of consultants from British Columbia in mining activities in this region makes Case Study V particularly relevant. Typically, these projects involve limited or unreliable hydrologic data, and a climate that is in sharp contrast with the climate in coastal British Columbia.

A lack of hydrologic data can lead to increased risk in tailings dam design, which in turn leads to increased liability on the part of consultants working in the region. The climate in the western parts of South America is arid and often exhibits evaporation rates exceeding precipitation on an annual basis. However, extreme rainfall conditions can dramatically exceed average arid conditions. These challenging hydrologic design conditions have significant implications for British Columbia consultants working in the region.

The Southern Bolivia case study involved a mine and mineral processing centre in the Potosi mining region and is located in the Altiplano of the Andean Mountains. Its elevation is approximately 4,000 m above sea level. The proposed dam site was located in a broad, shallow sloping valley and the reservoir would be located in a basin with a grade of approximately two percent.

The client wanted to construct a new tailings storage facility for tailings produced by a new concentrator. The concentrator was used for the production of lead and zinc concentrates and was commissioned in 1992. The capacity of the concentrator is 1,400 tpd. Previous tailings storage facilities had been constructed at the site, however, the failure of one of the dams led to a temporary facility being used for tailings storage until a new tailings facility could be built.

Hydrological records have been maintained at the site for temperature and rainfall since 1984. The climate data from the nearby town of Potosi dates back to 1958 and was used to supplement the site data record for the purposes of estimating site hydrologic conditions. Annual average total precipitation at Potosi is approximately 400 mm. Eighty-five percent of the precipitation occurs between November and March. The remaining months of the year, particularly May through August, are very dry. For all months of the year, except January, average evaporation rates exceed precipitation. Annual average evaporation recorded at Potosi is approximately 1,400 mm.

Based on the CDSA DSG classification system for the potential Environmental Impact from dam failure, the impoundment at Case Study V was considered to have "High" potential incremental consequence of failure in that the impacts perceived by the public may be severe. Water management requirements at the site involved the following:

- containing a 1-in-100 year 24 hr storm event, and
- maintaining a 1 m freeboard above the EDF.

In Case Study V, controlled release at varied annual release rates, would be required for water management. A pump barge was to be used to reclaim water to the mill from the tailings pond. The pump barge was also to be used to remove excess water from the impoundment. For the purposes of the water balance, it was assumed that no runoff would occur during the dry season. Due to a lack of streamflow data, this flow estimation was made based on professional judgement.

The mine in Case Study V is currently operating, although the particular tailings impoundment considered in the case study has not yet been constructed. No direct comparison between actual operating conditions and risk analysis results could be made as part of this study.

During the average balance run, the reclaim had to be turned off in 60 out of 155 months of the mine life. A depth of 0.25 m was input as the required free pond depth and none of the catchment area was diverted. In addition, the actual impoundment design was based on an assumed controlled release rate of 20 to 60 m^3/hr depending on the operating year, but was set to zero for the Visual Balance run to increase the possibility of reclaim water availability. In proportion to the tailings slurry water inflow rates, this discharge rate is very low.

A Visual Balance risk analysis was conducted for Case Study V and indicates that the impoundment may require controlled spills from Years 1 through 7. In subsequent years, the tailings may be exposed and additional freshwater make up would likely be required at the mine. A summary of the risk analysis results are presented in Table 6.5. Detailed results are presented in Appendix E.

The closure plan for Case Study V indicated that abandonment of the site included permanent submergence of the tailings material. An average Visual Balance closure analysis indicates that the tailings are likely to be exposed, with the water elevation being up to 10 metres below the surface of the solids. This water elevation is calculated is the same manner as average monthly water elevations: the volume of water at the end of the month is converted to an elevation based on the reservoir geometry. However, for the closure risk analysis the solids elevation in the impoundment is fixed based on the solids elevation in the last month of the average Visual Balance run.

Table 6.5
Summary Risk Analysis Results - Case Study V

Year in Series	Avg. Ann. Prob. of Spill (%)	Avg. Ann. Prob. of Low Freeboard (%)	Avg. Ann. Prob. of No Reclaim (%)	Avg. Ann. Prob. of Solids Exposed (%)
1	17.0	41.0	0.0	0.0
2	21.0	52.0	0.0	0.0
3	19.0	40.0	0.0	0.0
4	18.0	43.0	0.0	0.0
5	25.0	44.0	6.0	1.0
6	23.0	43.0	23.0	9.0
7	19.0	47.0	100.0	71.0
8	0.0	20.0	100.0	100.0
9	0.0	21.0	100.0	100.0
10	7.0	22.0	100.0	100.0
11	9.0	32.0	100.0	100.0

It should be noted that for a site located in an arid area, such as Case Study V, a risk analysis involving randomly generated evaporation values may be more significant than the Visual Balance randomly generated precipitation values.

CHAPTER 7.0 VISUAL BALANCE UTILITY

7.1 Program Applications and Advantages

Visual Balance is a useful planning tool for practitioners of tailings impoundment siting and design. Water and material balance for various impoundment sites or different projects can be run quickly and easily. The program represents an improvement over current methods available for water and material balance in British Columbia, which are limited to simple spreadsheets that are not easily transferable between project sites.

During the impoundment siting process, topography, hydrology and location with respect to the mill are the three main optimization considerations (Vick, 1990). Water and material balance may serve to identify certain unsuitable sites where, even with complete diversion of tributary runoff, precipitation far exceeds outflows. Employing Visual Balance to conduct such water and material balances would be a quick and effective component of impoundment site optimization.

Visual Balance is also a useful tool for impoundment design. The risk analysis module using Monte Carlo statistical simulations of critical hydrologic parameters allows the user to evaluate the probability of the impoundment operating under design conditions and subsequent sensitivity to varied hydrologic parameters. Design conditions that may be affected by varying hydrologic conditions include the impoundment operating as a closed system with no release required, or the need to keep tailings submerged at all times.

The risk analysis component of Visual Balance can assist in the design stage by assessing likely operating scenarios based on a Monte Carlo simulation of expected precipitation and surface runoff values. Results of case study analysis indicate that it is reasonable to expect the risk analysis module to predict probable water management problems in the tailings impoundment.

Water management problems identified by Visual Balance include insufficient free pond water available for reclaim, inadequate freeboard, uncontrolled release requirements, or tailings solids exposure. Knowledge and anticipation of these challenges could influence tailings impoundment site selection, design, or mine operating conditions. Planning for these conditions in impoundment and facility design could save companies considerable cost and aggravation.

Visual Balance also has direct potential application to the assessment of closure scenarios for tailings impoundments. Closure and reclamation planning for mine tailings impoundments is becoming a more significant factor in the approval process of proposed mine site. In addition, failure to incorporate sound reclamation practices in impoundment planning may lead to expensive retrofits later in the operation. In general, the long-term priorities considered for impoundment closure are as follows (Vick, 1990):

- mass stability of the impoundment,
- erosion stability,
- prevention of environmental contamination, and
- eventual return of the disturbed area to productive use.

The concern with water balance estimates for closure scenarios is significant and associated primarily with the mass stability of the impoundment. Hydrologically induced failures due to overtopping or excessive seepage are the major cause of mass instability of abandoned tailings deposits (Vick, 1990). Risk analysis methods may be useful in the estimation of probable performance of the abandoned impoundment.

A risk analysis approach to water balance could be used to predict the probable hydrologic scenarios following closure in the impoundment. Closure scenarios are usually evaluated using average hydrologic conditions and extreme flood events. However, it may be useful to assess closure performance during hydrologic circumstances under other than "average" scenarios. For example, if the method of ARD reduction is to keep tailings wet, the risk analysis module can be used to assess the probability of tailings remaining submerged over the long term.

The results of the Case Studies emphasize the predictive capabilities of Visual Balance. In Case Study II where insufficient free water was available in the pond for mine water reclaim, alternate water reclaim methods other than a floating barge could have been designed, or additional fresh water source requirements would have been anticipated. In Case Study III where excess water was predicted to be a probable issue, engineered methods could have been put in place to manage the excess water. In Case Study V, the need for a water treatment facility may have been eliminated by the anticipation of the lack of a need for regular spills.

Visual Balance includes robust features so that users can tailor the balance to some project specific operating requirements. Examples of these flexible features include:

- varying annual mining production rates in each year of operation;
- varying groundwater seepage rate, tailings beach area, and the volume lost to the dam embankment versus the dam crest elevation; and
- specification of monthly release rates.

Operation parameters can be changed quickly and easily by the program user, and a new water and material balances can be run, in order to evaluate various operation scenarios. Reservoir characteristics, including fraction of runoff diverted, fraction of waste rock submerged, EDF, and hydrologic variables can also be changed in a similar fashion.

7.2 Program Limitations

The objective of this study was to develop a software program which could conduct water and material balance on a monthly basis, similar to water and material balance currently conducted by mining practitioners in British Columbia. These objective were met in the study, however, some additional modules and routines could be added to the program which would increase its utility. These limitations, or potential improvements include:

- Visual Balance was not designed to be used at operating mines. Inflow and outflow volumes of hydrologic and mine production variables at an operating mine sites vary from month to month during operation. Currently, the program is only able to accommodate annual changes in production and is not robust enough to accommodate unique monthly values for inflow and outflow volumes.

- The program was written to handle single reservoir systems, which may be a limitation for sites where flow is routed through treatment ponds or secondary reservoirs. A user could accommodate outflows to a secondary reservoir by incorporating these flows into the "spills and release outflow volume" if the outflow was a constant rate.

- The reservoir geometry inputs for Visual Balance must be expressed as incremental increases in volume for corresponding increases in elevation. Visual Balance can not be adjusted to take into account unusual physical features of an impoundment site or dam layout. One potential case study was rejected based on the complex reservoir geometry and impoundment configuration that could not be accommodated by Visual Balance.

- Visual Balance does not allow any parameters to vary on a daily basis. Monthly parameters are adjusted for the number of mine operation days in a given month, but this in the only "daily" consideration in the program. If daily hydrologic variables are available, the Visual Balance user could manipulate daily hydrologic data to generate monthly mean hydrologic input variables for the program.

- The Visual Balance graphical output shows the required dam crest elevations for each month, which results in an unrealistically smooth line representing dam staging. Dam construction is usually only conducted in summer months and dam lifts are shown as annual steps on the dam staging curve (Figure 1.1). In some cases, the dam crest elevation may be fixed for many years, until dam construction commences for another large dam lift. Visual Balance users would need to manually make these adjustments to the Visual Balance graphical output.

Each of these limitations could be resolved through further development of the program. However, the accommodation of unusual impoundment geometries or layouts would require time and commitment that may be in excess of the value of the outcome. A reasonable solution for these sites would be to continue using spreadsheet-based balances.

7.3 Suggestions for Further Development

The format of Visual Balance is such that additional flexibility features, data input and management means, and calculations modules could be added on a case specific basis. Some additional features and modules might include:

- a mass balance water quality module to model the quality of water in the impoundment and in potential releases;
- a mechanism for reservoir routing and reservoir linkage for the case of multiple tailings impoundments or treatment ponds;
- improved graphical output, including dam staging curve options; and
- data input flexibility to alter production rates and water levels as the mine operates.

The addition of a water quality module to the software program could be readily added as necessary in the future. The concentration of substances in a water body, such as a tailings impoundment, is dependent on the variation of three dominant factors. A mass balance of these dominant factors could be performed by Visual Balance. These dominant factors are:

- net water input,
- mixing over the depth and area of the water body, and
- transformation of the substance via routes such as decomposition, deposition, interaction or consumption by biological organisms.

This research and software development focused on mine tailings impoundment applications. However, tailings are generated by other industries including:

- the chemical industry (potash mining or salt deposits),
- aggregate industry (washing out of sand and fines from crushed rock aggregate),
- agriculture (soil from vegetable cleaning), and
- domestic sewage or industrial effluent solids (ICOLD, 1996).

Visual Balance need not be limited to applications in the mining industry. Landfill design projects in these industry sectors also involve conducting site water and material balances for solid waste impoundment. The model could easily be adapted to conduct water and material balance assessments at industrial tailings storage sites for any industry.

8.0 CONCLUSIONS

Current methods available for water and material balance at tailings impoundments in British Columbia are generally limited to simple spreadsheets. The lack of flexibility and transparency associated with these spreadsheets has been identified as a problem within the industry. In addition, the spreadsheet balances are conducted using average hydrologic values and commonly do not include risk analysis. Methods for risk analysis of spreadsheet-based impoundment balances are limited to statistical distributions provided within spreadsheet packages or developed on a project specific basis.

The Visual Balance software program developed as part of this research is a fast, simple method of modelling the water and material balance in a single impoundment tailings disposal system. It is reasonable to conclude that given the appropriate level of design detail and hydrologic data, Visual Balance is an effective tool for predicting required dam crest elevations over the operating life of a tailings impoundment. Moreover, the risk analysis module is useful in aiding in the anticipation of probable water management problems, and in assessing the likelihood of success for closure scenarios.

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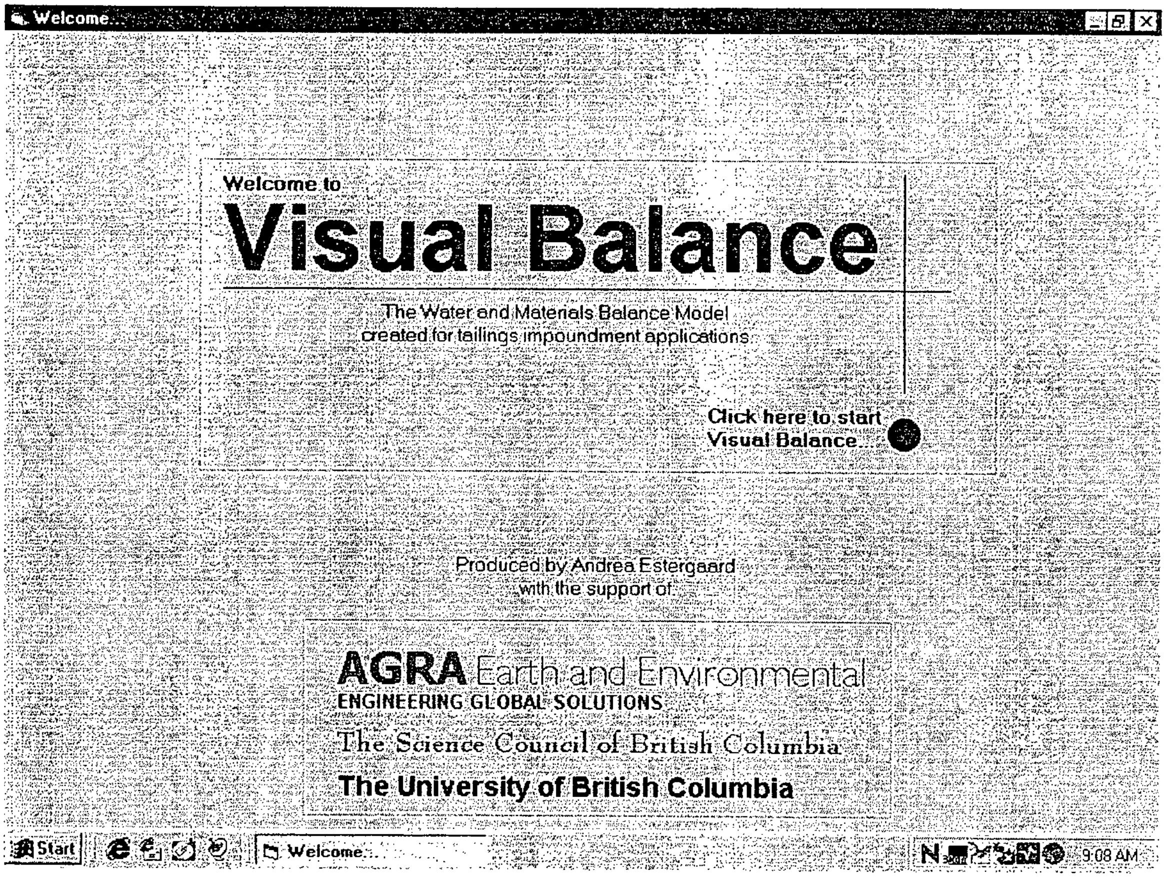
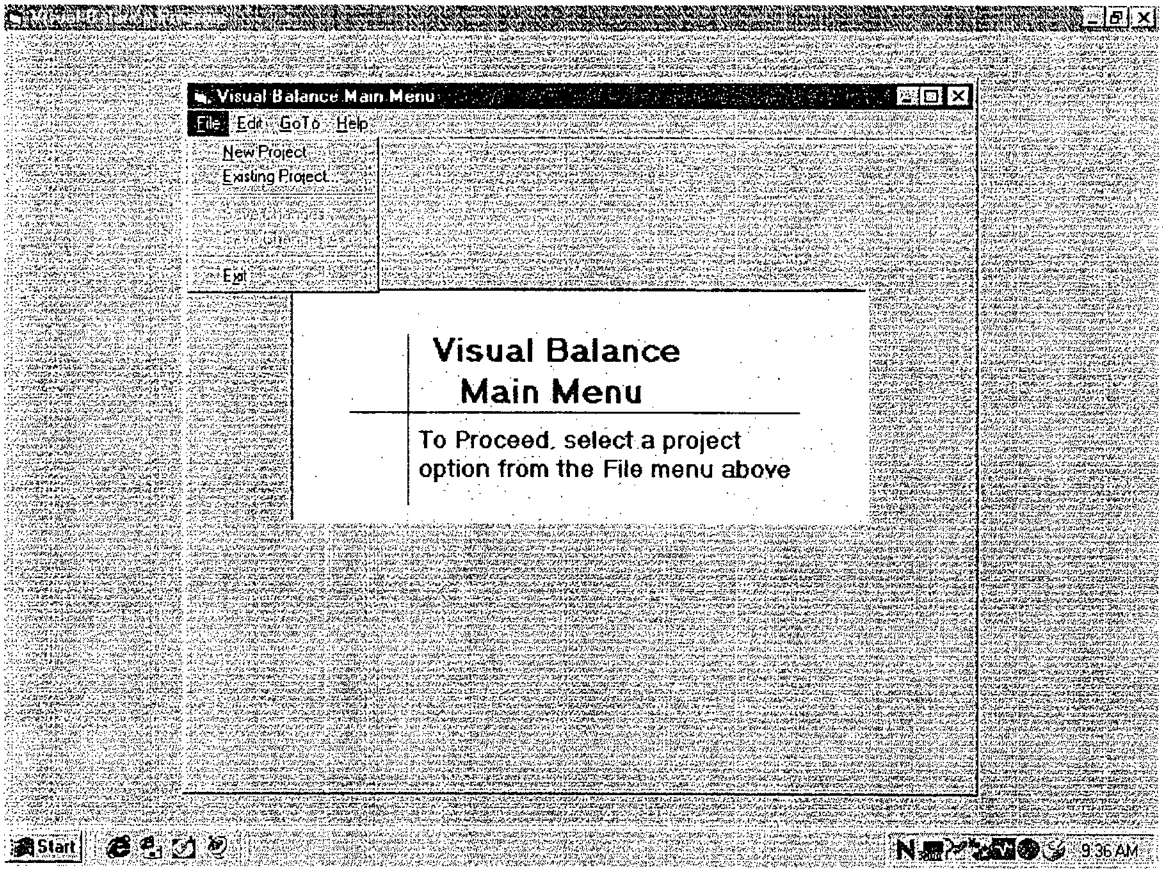
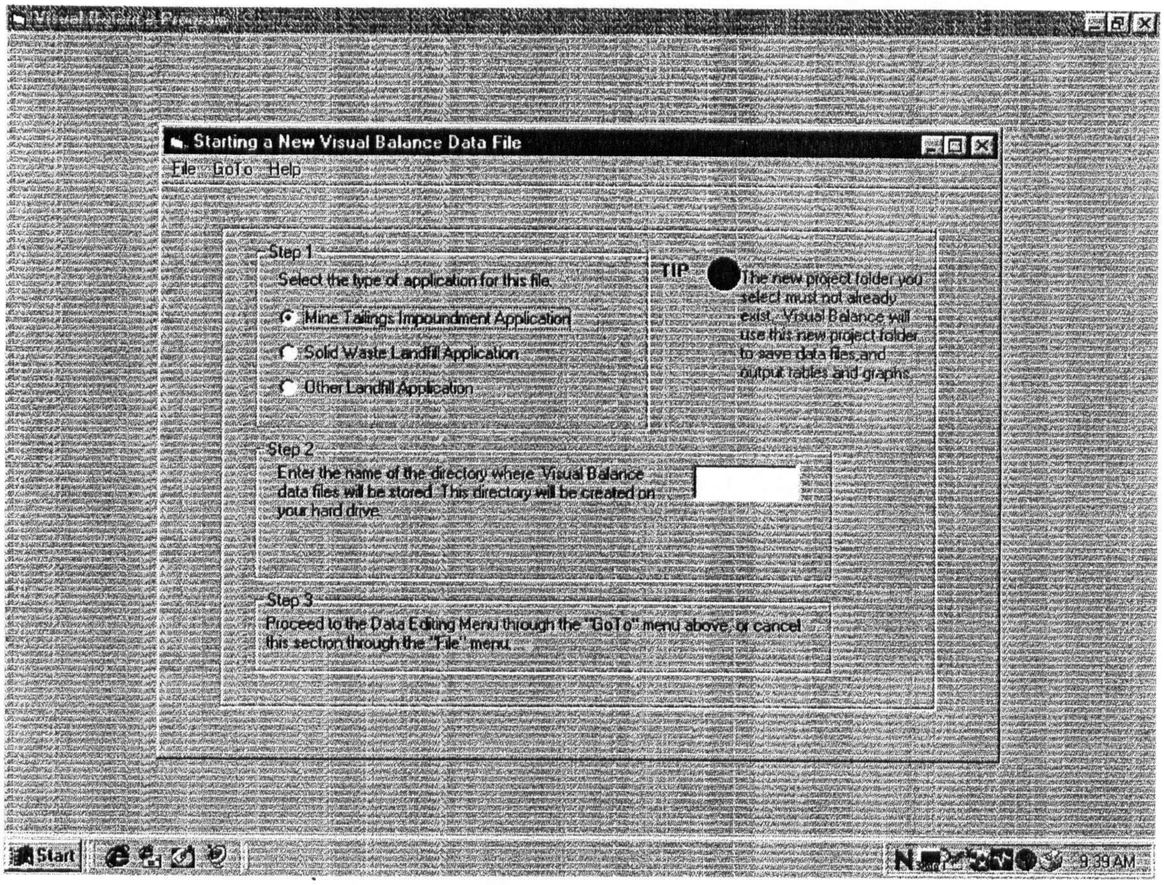
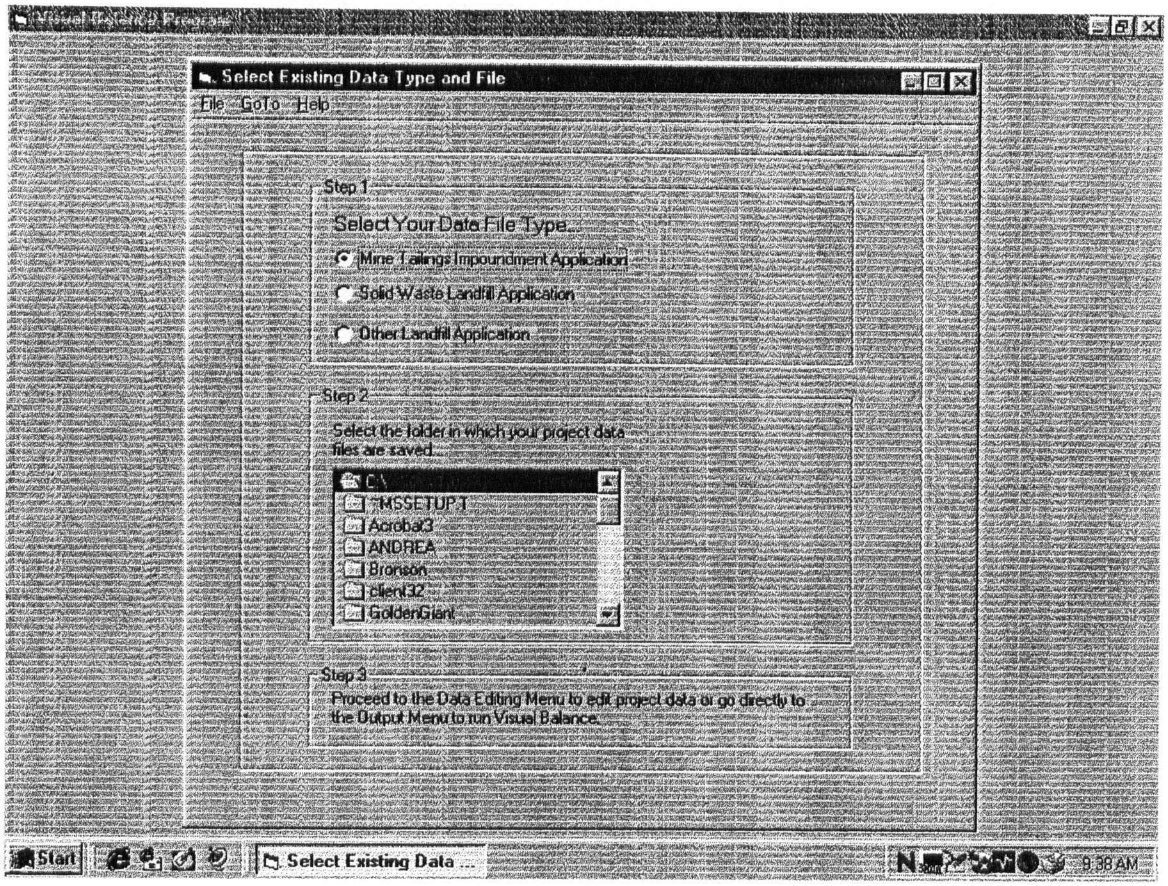
Appendix A

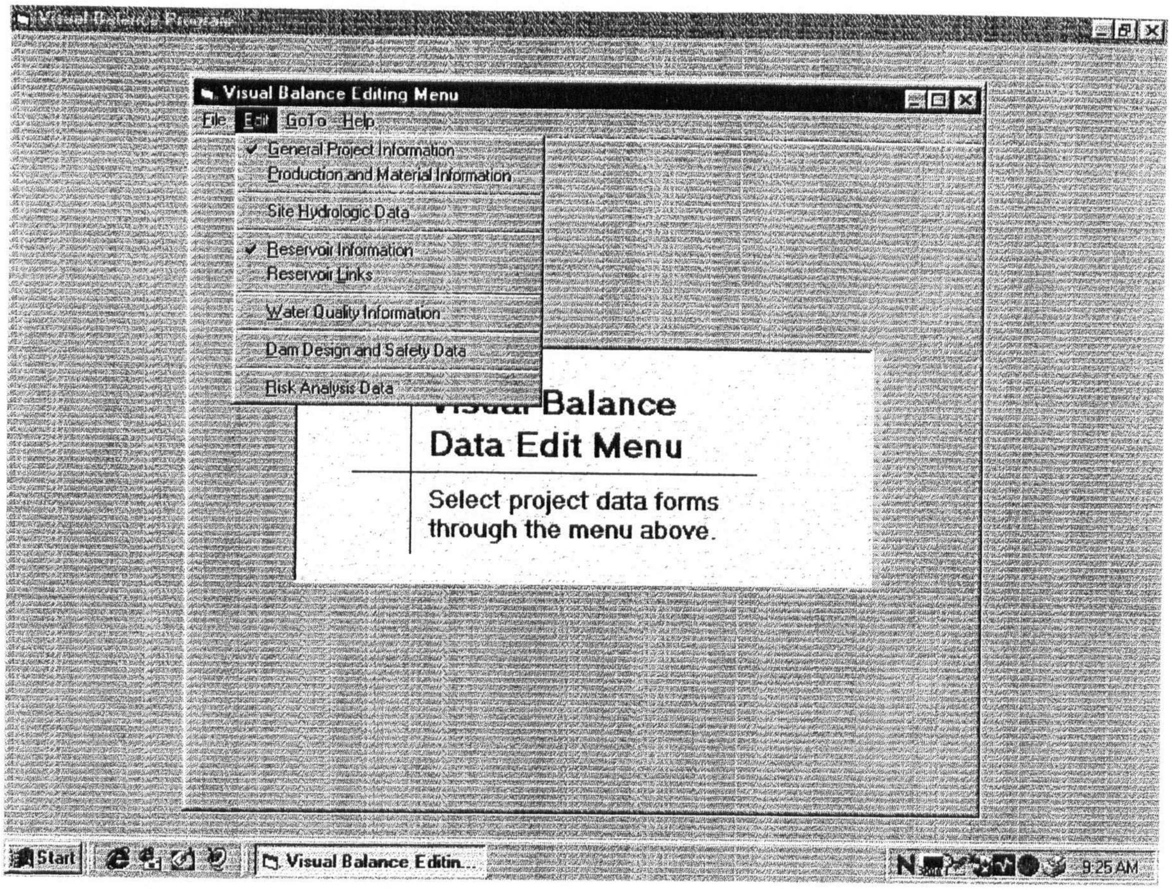
Visual Balance Menu and Data Input Forms

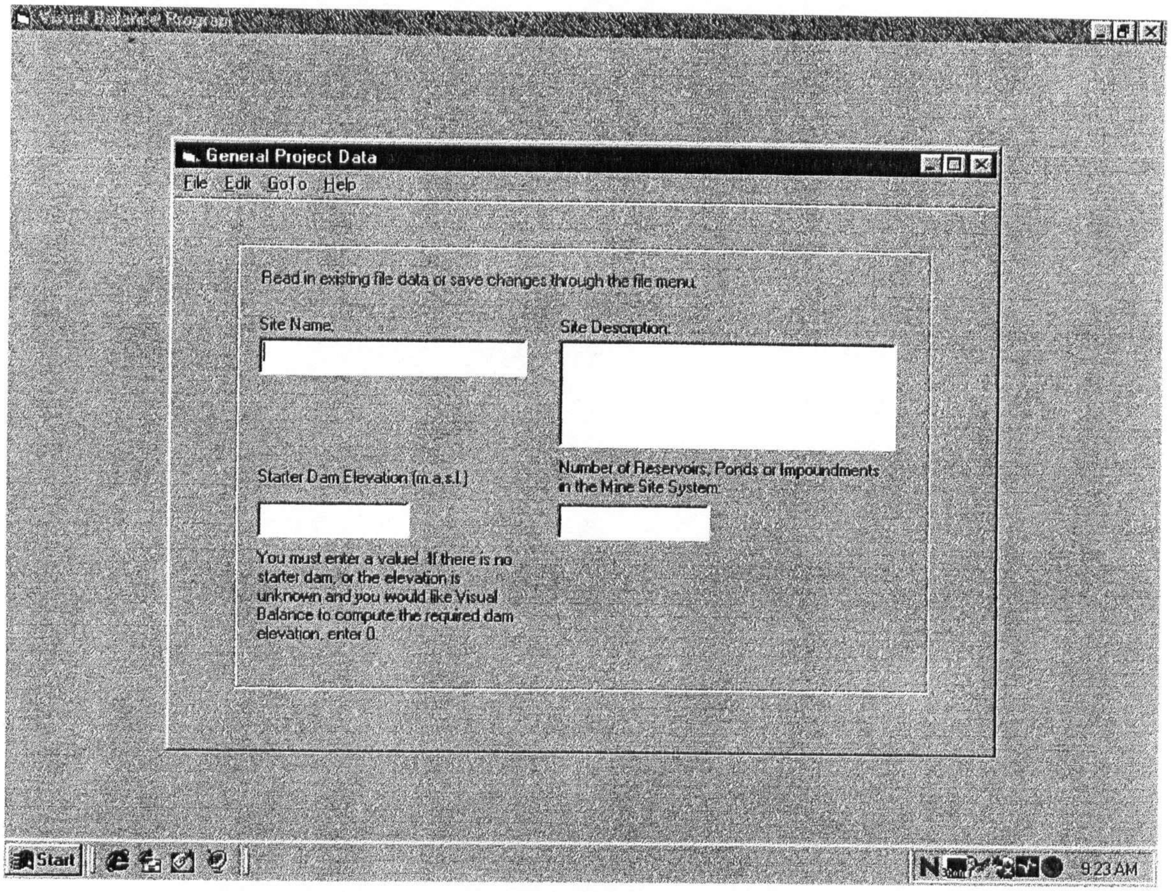

Welcome...
Welcome to
Visual Balance
The Water and Materials Balance Model
created for tailings impoundment applications
Click here to start
Visual Balance...
Produced by Andrea Estergaard
with the support of:
AGRA Earth and Environmental
ENGINEERING GLOBAL SOLUTIONS
The Science Council of British Columbia
The University of British Columbia
Start
Welcome...
9:08 AM

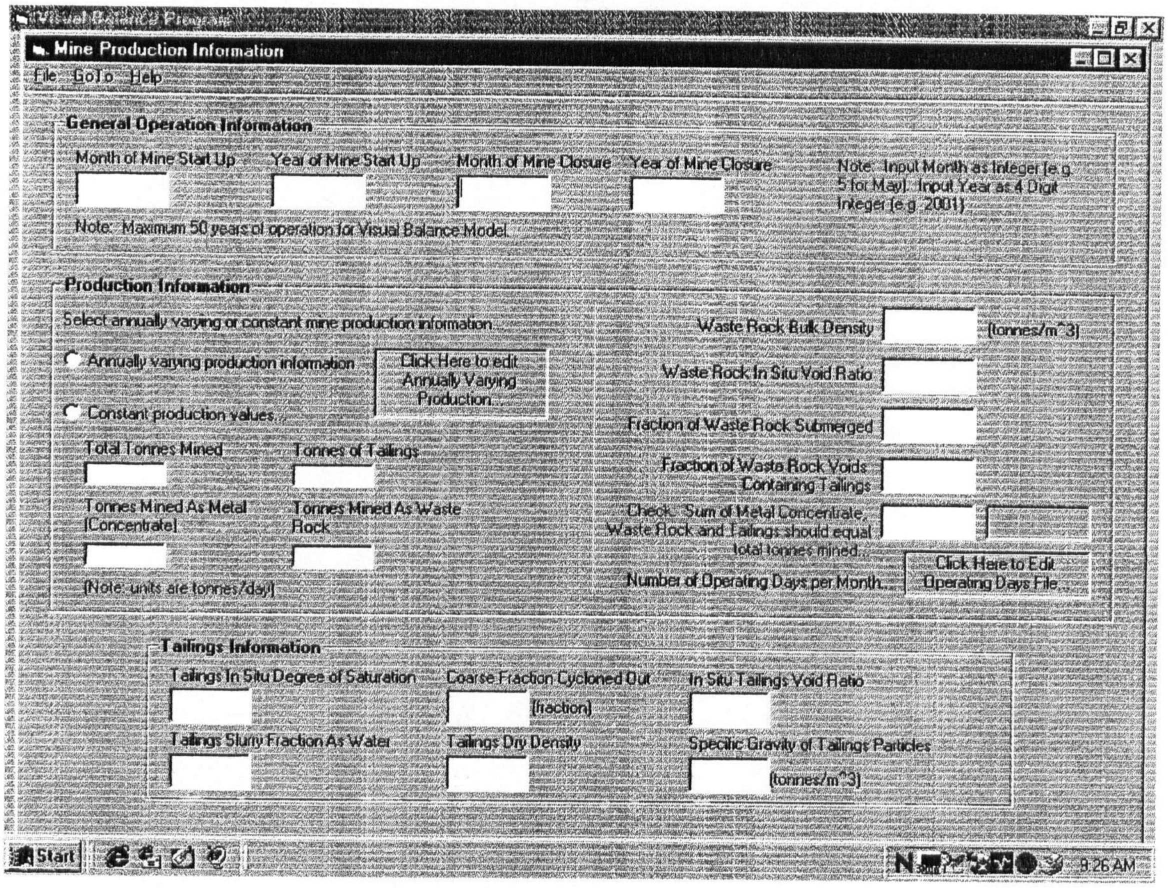

Visual Balance Main Menu
File Edit GoTo Help
New Project
Existing Project...
Exit
Visual Balance
Main Menu
To Proceed, select a project option from the File menu above
Start
9:36 AM

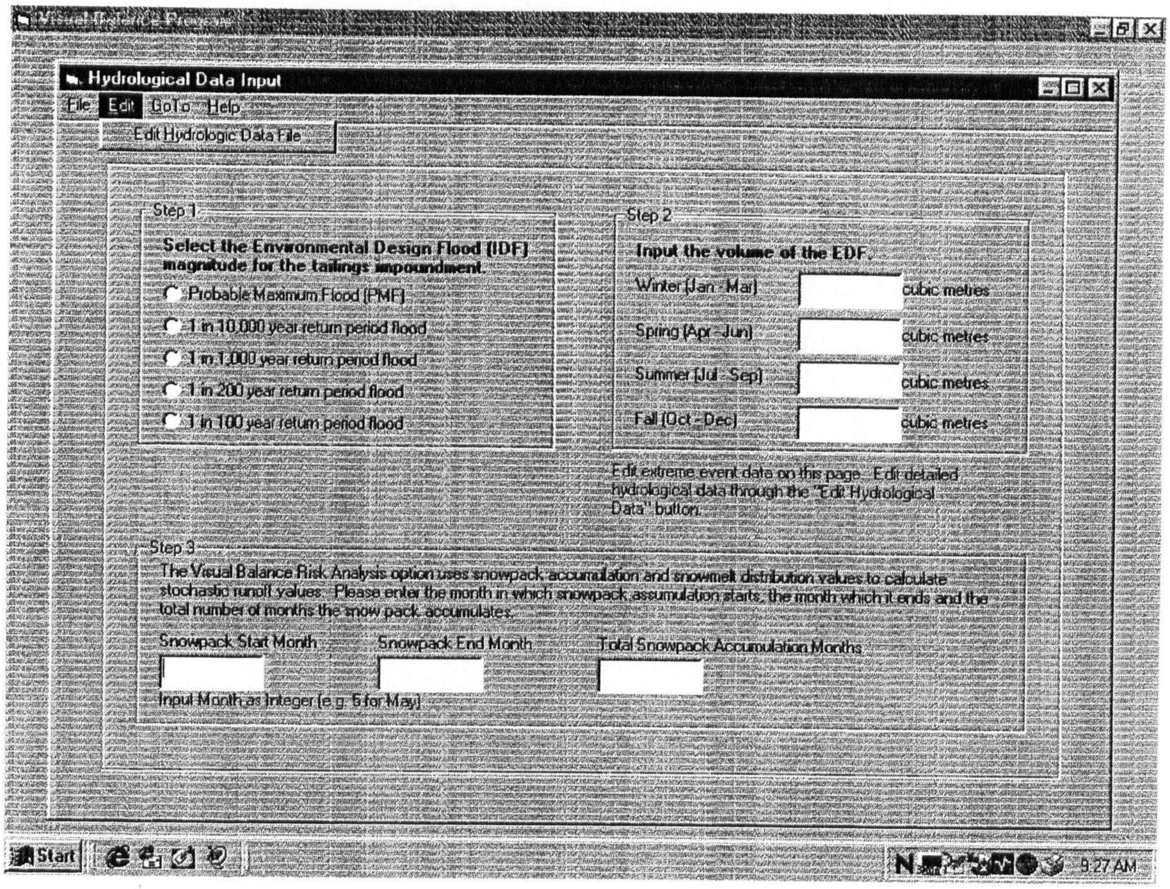

Visual Balance Program
Starting a New Visual Balance Data File
File GoTo Help
Step 1
Select the type of application for this file.
Mine Tailings Impoundment Application
Solid Waste Landfill Application
Other Landfill Application
TIP
The new project folder you select must not already exist. Visual Balance will use this new project folder to save data files and output tables and graphs.
Step 2
Enter the name of the directory where Visual Balance data files will be stored. This directory will be created on your hard drive.
Step 3
Proceed to the Data Editing Menu through the "GoTo" menu above, or cancel this section through the "File" menu.
Start
9:39 AM

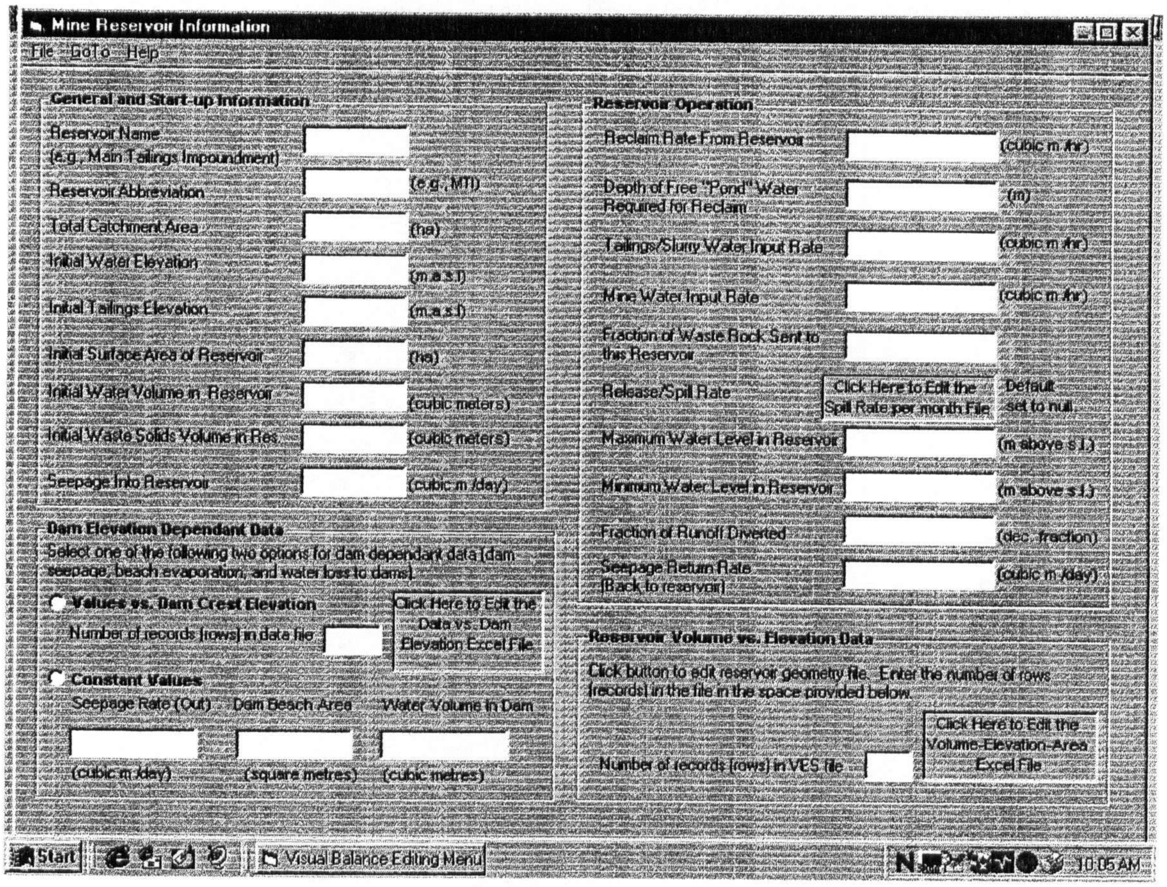

Select Existing Data Type and File
File GoTo Help
Step 1
Select Your Data File Type...
Mine Tailings Impoundment Application
Solid Waste Landfill Application
Other Landfill Application
Step 2
Select the folder in which your project data files are saved...
C:\
~MSSETUP.T
Acrobat3
ANDREA
Bronson
client32
GoldenGiant
Step 3
Proceed to the Data Editing Menu to edit project data or go directly to the Output Menu to run Visual Balance.
Start
Select Existing Data ...
9:38 AM

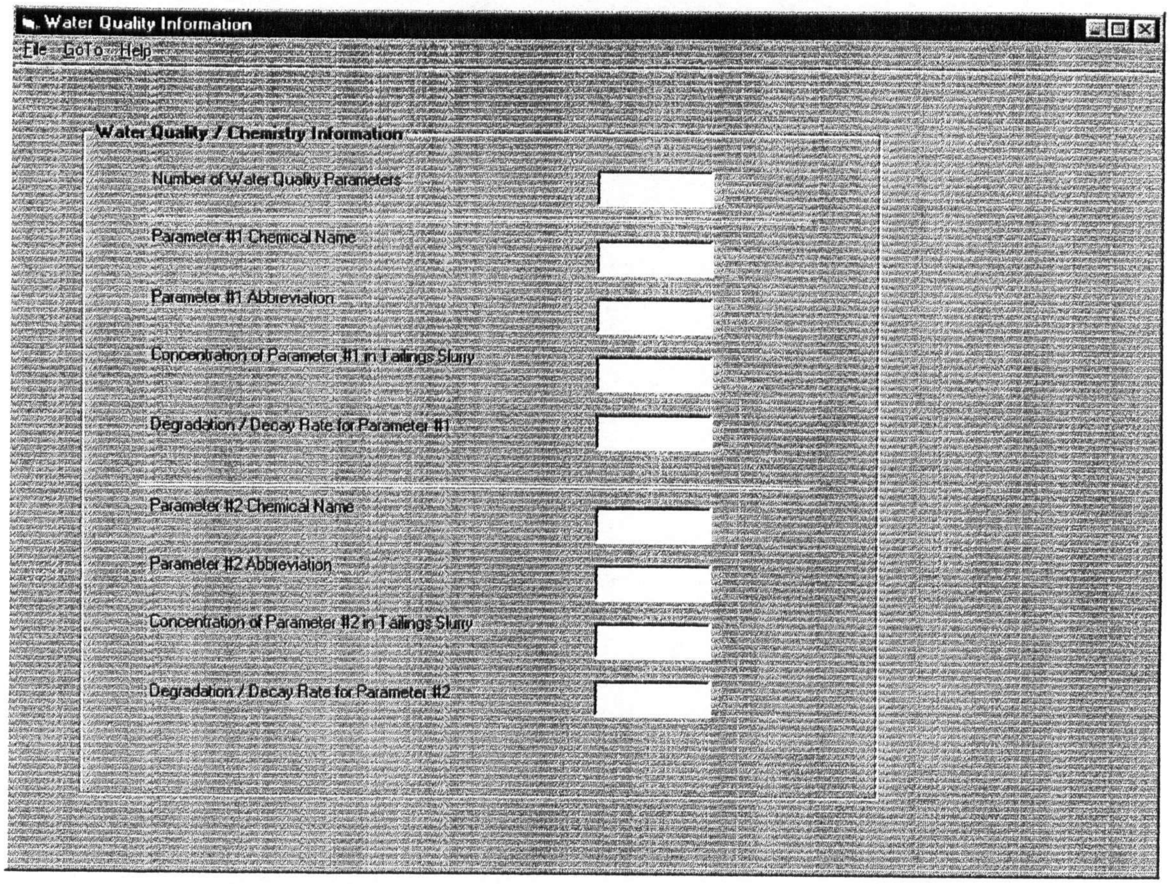

Visual Balance Editing Menu
File
Edit
GoTo
Help
General Project Information
Production and Material Information
Site Hydrologic Data
Reservoir Information
Reservoir Links
Water Quality Information
Dam Design and Safety Data
Risk Analysis Data
Balance
Data Edit Menu
Select project data forms
through the menu above.
Start
Visual Balance Editin...
9:25 AM

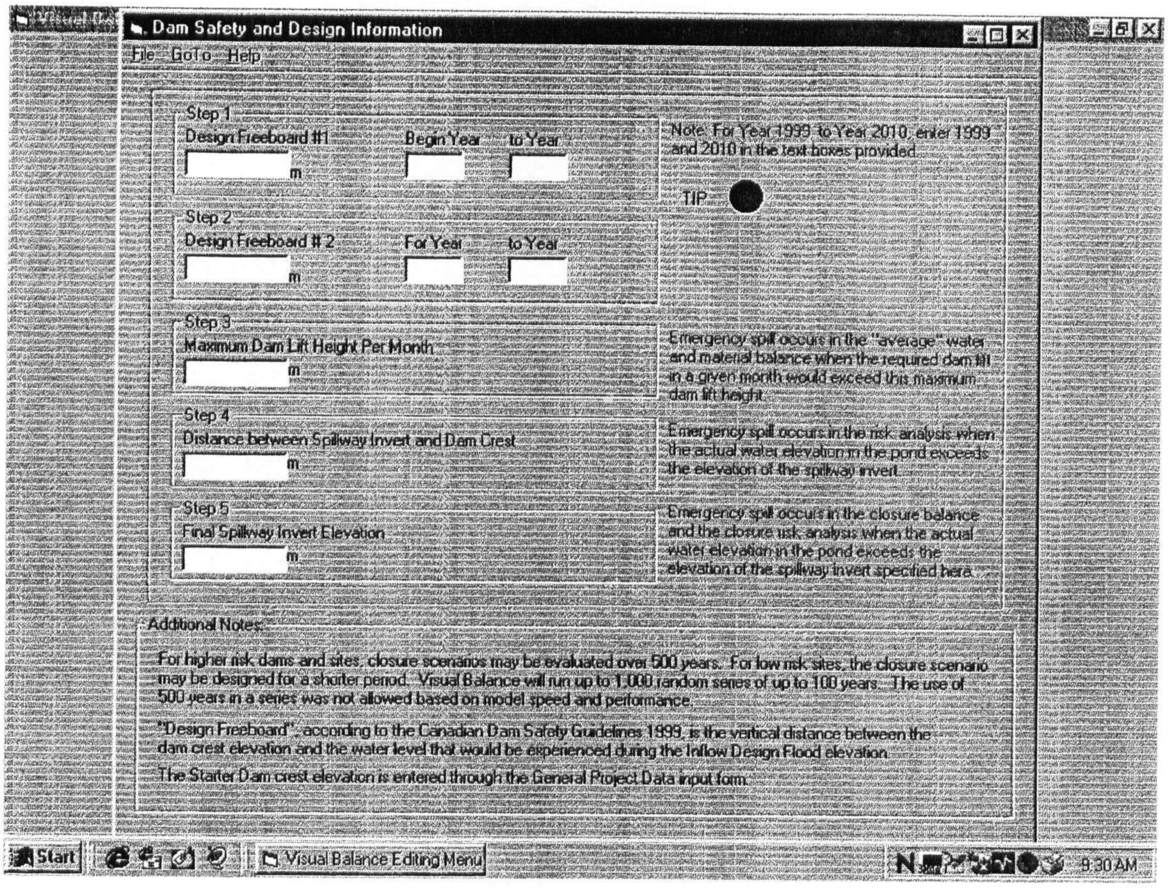

Visual Balance Program
General Project Data
File Edit GoTo Help
Read in existing file data or save changes through the file menu.
Site Name:
Site Description:
Starter Dam Elevation (m.a.s.l.)
Number of Reservoirs, Ponds or Impoundments in the Mine Site System:
You must enter a value! If there is no starter dam, or the elevation is unknown and you would like Visual Balance to compute the required dam elevation, enter 0.
Start
9:23 AM


Mine Production Information
File GoTo Help
General Operation Information
Month of Mine Start Up
Year of Mine Start Up
Month of Mine Closure
Year of Mine Closure
Note: Input Month as Integer (e.g. 5 for May). Input Year as 4 Digit Integer (e.g. 2001)
Note: Maximum 50 years of operation for Visual Balance Model.
Production Information
Select annually varying or constant mine production information.
Annually varying production information
Click Here to edit Annually Varying Production...
Constant production values...
Total Tonnes Mined
Tonnes of Tailings
Tonnes Mined As Metal (Concentrate)
Tonnes Mined As Waste Rock
(Note: units are tonnes/day)
Waste Rock Bulk Density
(tonnes/m^3)
Waste Rock In Situ Void Ratio
Fraction of Waste Rock Submerged
Fraction of Waste Rock Voids Containing Tailings
Check: Sum of Metal Concentrate, Waste Rock and Tailings should equal total tonnes mined...
Number of Operating Days per Month...
Click Here to Edit Operating Days File...
Tailings Information
Tailings In Situ Degree of Saturation
Coarse Fraction Cycloned Out
(fraction)
In Situ Tailings Void Ratio
Tailings Slurry Fraction As Water
Tailings Dry Density
Specific Gravity of Tailings Particles
(tonnes/m^3)
Start
9:26 AM

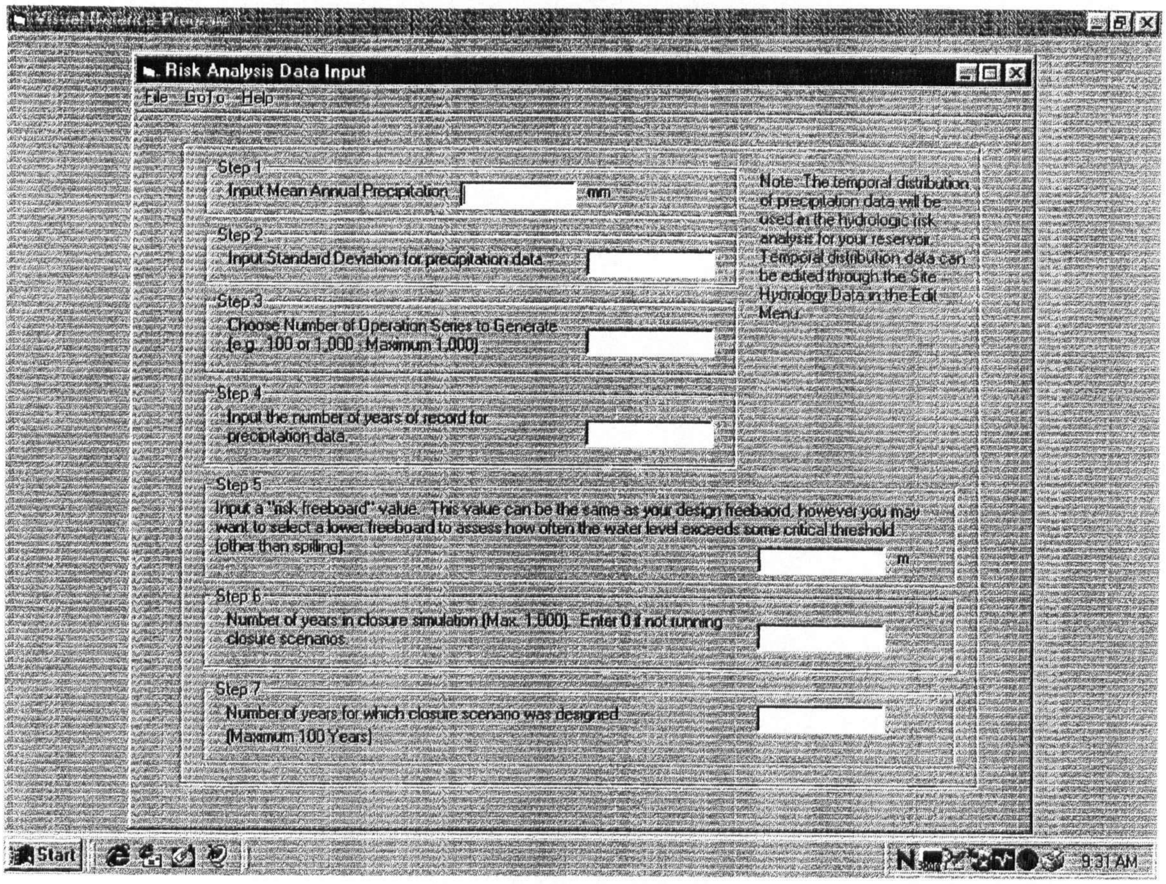

Hydrological Data Input
File Edit GoTo Help
Edit Hydrologic Data File
Step 1
Select the Environmental Design Flood (IDF) magnitude for the tailings impoundment.
Probable Maximum Flood (PMF)
1 in 10,000 year return period flood
1 in 1,000 year return period flood
1 in 200 year return period flood
1 in 100 year return period flood
Step 2
Input the volume of the EDF.
Winter (Jan - Mar)
cubic metres
Spring (Apr - Jun)
cubic metres
Summer (Jul - Sep)
cubic metres
Fall (Oct - Dec)
cubic metres
Edit extreme event data on this page. Edit detailed hydrological data through the "Edit Hydrological Data" button.
Step 3
The Visual Balance Risk Analysis option uses snowpack accumulation and snowmelt distribution values to calculate stochastic runoff values. Please enter the month in which snowpack assumulation starts, the month which it ends and the total number of months the snow pack accumulates.
Snowpack Start Month
Snowpack End Month
Total Snowpack Accumulation Months
Input Month as Integer (e.g. 5 for May)
Start
9:27 AM

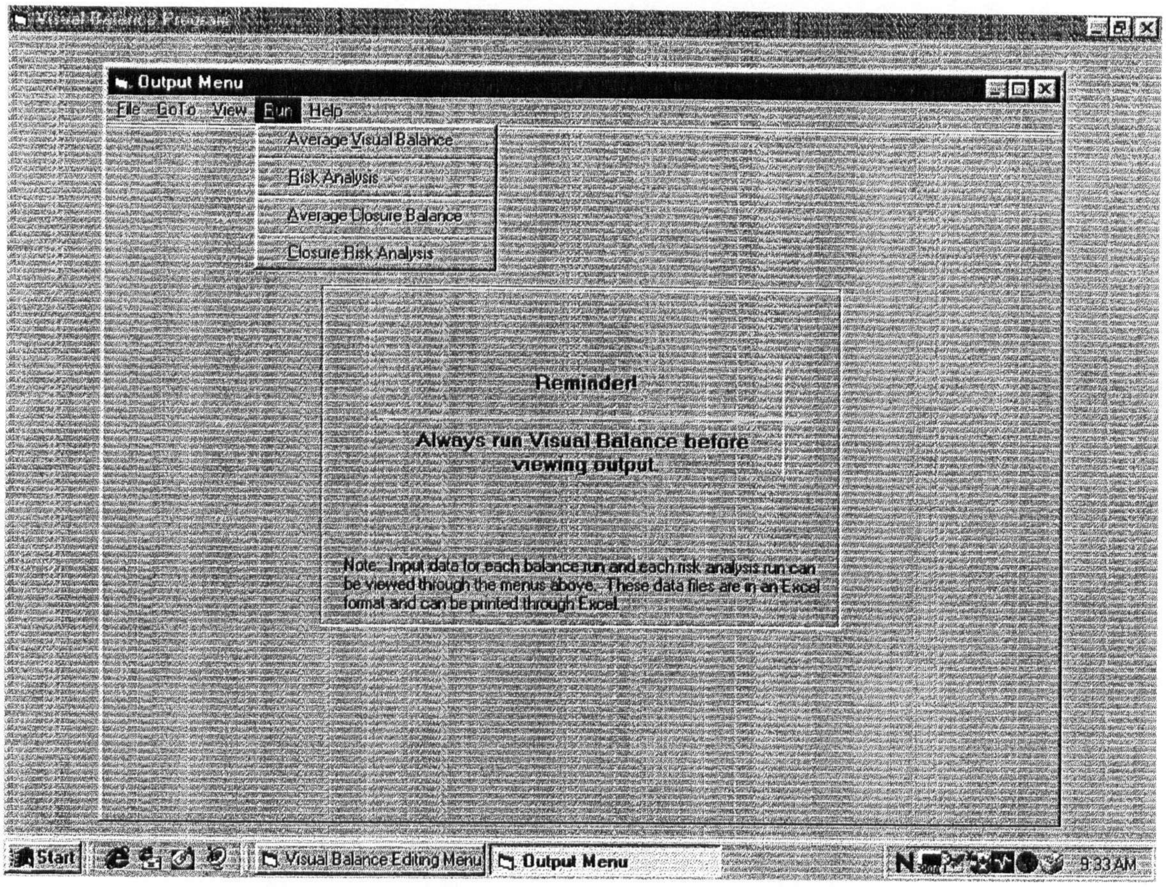

Mine Reservoir Information
File GoTo Help
General and Start-up Information
Reservoir Name
(e.g., Main Tailings Impoundment)
Reservoir Abbreviation
(e.g., MTI)
Total Catchment Area
(ha)
Initial Water Elevation
(m.a.s.l)
Initial Tailings Elevation
(m.a.s.l)
Initial Surface Area of Reservoir
(ha)
Initial Water Volume in Reservoir
(cubic meters)
Initial Waste Solids Volume in Res.
(cubic meters)
Seepage Into Reservoir
(cubic m /day)
Dam Elevation Dependant Data
Select one of the following two options for dam dependant data (dam seepage, beach evaporation, and water loss to dams).
Values vs. Dam Crest Elevation
Number of records (rows) in data file
Click Here to Edit the Data vs. Dam Elevation Excel File
Constant Values
Seepage Rate (Out)
Dam Beach Area
Water Volume in Dam
(cubic m /day)
(square metres)
(cubic metres)
Reservoir Operation
Reclaim Rate From Reservoir
(cubic m /hr)
Depth of Free "Pond" Water Required for Reclaim
(m)
Tailings/Slurry Water Input Rate
(cubic m /hr)
Mine Water Input Rate
(cubic m /hr)
Fraction of Waste Rock Sent to this Reservoir
Release/Spill Rate
Click Here to Edit the Spill Rate per month File
Default set to null.
Maximum Water Level in Reservoir
(m above s.l.)
Minimum Water Level in Reservoir
(m above s.l.)
Fraction of Runoff Diverted
(dec. fraction)
Seepage Return Rate (Back to reservoir)
(cubic m /day)
Reservoir Volume vs. Elevation Data
Click button to edit reservoir geometry file. Enter the number of rows (records) in the file in the space provided below.
Number of records (rows) in VES file
Click Here to Edit the Volume-Elevation-Area Excel File
Start
Visual Balance Editing Menu
10:05 AM


Water Quality Information
File GoTo Help
Water Quality / Chemistry Information
Number of Water Quality Parameters
Parameter #1 Chemical Name
Parameter #1 Abbreviation
Concentration of Parameter #1 in Tailings Slurry
Degradation / Decay Rate for Parameter #1
Parameter #2 Chemical Name
Parameter #2 Abbreviation
Concentration of Parameter #2 in Tailings Slurry
Degradation / Decay Rate for Parameter #2



Dam Safety and Design Information
File GoTo Help
Step 1
Design Freeboard #1
Begin Year
to Year
m
Note: For Year 1999 to Year 2010, enter 1999 and 2010 in the text boxes provided.
TIP
Step 2
Design Freeboard # 2
For Year
to Year
m
Step 3
Maximum Dam Lift Height Per Month
m
Emergency spill occurs in the "average" water and material balance when the required dam lift in a given month would exceed this maximum dam lift height.
Step 4
Distance between Spillway Invert and Dam Crest
m
Emergency spill occurs in the risk analysis when the actual water elevation in the pond exceeds the elevation of the spillway invert.
Step 5
Final Spillway Invert Elevation
m
Emergency spill occurs in the closure balance and the closure risk analysis when the actual water elevation in the pond exceeds the elevation of the spillway invert specified here.
Additional Notes:
For higher risk dams and sites, closure scenarios may be evaluated over 500 years. For low risk sites, the closure scenario may be designed for a shorter period. Visual Balance will run up to 1,000 random series of up to 100 years. The use of 500 years in a series was not allowed based on model speed and performance.
"Design Freeboard", according to the Canadian Dam Safety Guidelines 1999, is the vertical distance between the dam crest elevation and the water level that would be experienced during the Inflow Design Flood elevation.
The Starter Dam crest elevation is entered through the General Project Data input form.
Start
Visual Balance Editing Menu
9:30 AM


Risk Analysis Data Input
File GoTo Help
Step 1
Input Mean Annual Precipitation
mm
Step 2
Input Standard Deviation for precipitation data
Step 3
Choose Number of Operation Series to Generate
(e.g. 100 or 1,000 - Maximum 1,000)
Step 4
Input the number of years of record for
precipitation data.
Note: The temporal distribution of precipitation data will be used in the hydrologic risk analysis for your reservoir. Temporal distribution data can be edited through the Site Hydrology Data in the Edit Menu.
Step 5
Input a "risk freeboard" value. This value can be the same as your design freebaord, however you may want to select a lower freeboard to assess how often the water level exceeds some critical threshold (other than spilling).
m
Step 6
Number of years in closure simulation (Max. 1,000). Enter 0 if not running closure scenarios.
Step 7
Number of years for which closure scenario was designed
(Maximum 100 Years)
Start
9:31 AM


Output Menu
File GoTo View Run Help
Average Visual Balance
Risk Analysis
Average Closure Balance
Closure Risk Analysis
Reminder!
Always run Visual Balance before viewing output.
Note: Input data for each balance run and each risk analysis run can be viewed through the menus above. These data files are in an Excel format and can be printed through Excel.
Start
Visual Balance Editing Menu
Output Menu
9:33 AM

Appendix B

Visual Balance Data Input Excel Tables

Visual Balance
Required Data Input File
Average Annual Hydrologic Data

Month (m)	Avg. Precip (mm)	Temporal Distribution (fraction)	Fraction Snow (fraction)	Snowmelt Distribution (fraction)	Runoff Loss (for Risk Analysis) (mm/month)	Runoff Intensity (for Water Balance) (mm/month)	Pond Evaporation (mm/month)	Beach Evaporation (mm/month)
Jan	9.9	0.02	0.00	0.00	5	4.9	120.1	36.03
Feb	5.7	0.01	0.00	0.00	5	0.7	128.0	38.4
Mar	5.2	0.01	0.00	0.00	5	0.2	171.0	51.3
Apr	2.1	0.00	0.00	0.00	5	0.0	180.6	54.18
May	11.7	0.02	0.00	0.00	5	6.7	199.9	59.97
Jun	61.8	0.13	0.00	0.00	5	56.8	156.7	47.01
Jul	123.3	0.25	0.00	0.00	5	118.3	118.1	35.43
Aug	130.5	0.27	0.00	0.00	5	125.5	110.3	33.09
Sep	93.3	0.19	0.00	0.00	5	88.3	113.8	34.14
Oct	24.6	0.05	0.00	0.00	5	19.6	131.2	39.36
Nov	10.2	0.02	0.00	0.00	5	5.2	123.2	36.96
Dec	11	0.02	0.00	0.00	5	6.0	122.8	36.84
Annual	**489.3**	**1.00**		**0.00**			**1675.7**	**502.71**

Visual Balance
Required Data Input File
Volume Surface Area vs. Elevation Data

Volume-Area-Elevation Data						
Elevation Interval		**Volume**		**Surface Area (At End of Interval)**		
Start	End	Incremental	Cumulative			
(m)	(m)	(m3)	(m3)	(ha)		
4,011.00	4,012.00	0.00	0.00	0.00	base elevation this row	
4,012.00	4,013.00	1,245.00	1,245.00	0.42	start data in this row	
4,013.00	4,014.00	7,220.00	8,465.00	2.09		
4,014.00	4,015.00	34,535.00	43,000.00	4.90		
4,015.00	4,016.00	63,392.00	106,392.00	7.48		
4,016.00	4,017.00	86,297.00	192,689.00	10.00		
4,017.00	4,018.00	113,699.00	306,388.00	12.11		
4,018.00	4,019.00	128,579.00	434,967.00	14.27		
4,019.00	4,020.00	156,828.00	591,795.00	16.70		
4,020.00	4,021.00	177,125.00	768,920.00	19.40		
4,021.00	4,022.00	210,931.00	979,851.00	22.61		
4,022.00	4,023.00	241,229.00	1,221,080.00	26.25		
4,023.00	4,024.00	283,752.00	1,504,832.00	29.62		
4,024.00	4,025.00	308,715.00	1,813,547.00	32.82		
4,025.00	4,026.00	347,710.00	2,161,257.00	36.17		
4,026.00	4,027.00	375,699.00	2,536,956.00	39.44		
4,027.00	4,028.00	413,126.00	2,950,082.00	42.57		
4,028.00	4,029.00	438,224.00	3,388,306.00	45.92		
4,029.00	4,030.00	480,239.00	3,868,545.00	49.37		
4,030.00	4,031.00	507,154.00	4,375,699.00	52.53		
4,031.00	4,032.00	543,540.00	4,919,239.00	55.77		
4,032.00	4,033.00	571,901.00	5,491,140.00	59.18		
4,033.00	4,034.00	611,764.00	6,102,904.00	30.59		

Visual Balance
Required Data Input File
Operating Days per Month

Month	Total Days In Month (Fixed)	Operating Days In Month (User Input)
January	31	30
February	28	27
March	31	30
April	30	29
May	31	30
June	30	29
July	31	30
August	31	30
September	30	29
October	31	30
November	30	29
December	31	30
Operating Days In Year	353	

Visual Balance
Required Data Input File
Spill / Release Volumes

Month	Spill Rate (cubic metres per month)
January	0
February	0
March	0
April	0
May	0
June	0
July	0
August	0
September	0
October	0
November	0
December	0
Annual Spill Volume	**0**

Visual Balance
Optional Data Input File
Annually Varying Waste Production Rates

Year	Total Tonnes Mined (tonnes/day)	Tailings to Reservoir (tonnes/day)	Waste Rock to Reservoir (tonnes/day)
1	16438	16438	2018.63
2	16438	16438	3161.64
3	16438	16438	3287.67
4	16438	16438	7179.18
5	16438	16438	11651.78
6	16438	16438	14794.52
7	16438	16438	13972.60
8	16438	16438	0
9	16438	16438	0
10	16438	16438	0
11	16438	16438	0
12	16438	16438	0
13	16438	16438	0
14	16438	16438	0
15	16438	16438	0
16	1020	1020	0

Visual Balance
Optional Data Entry File
Dam Elevation Dependent Data

Start Elevation (m)	End Elevation (m)	Water Loss (in Dams) (m^3)	Beach Area (m^2)	Seepage Rate from Impoundment (m^3/day)			
105	110	1	1	1			
110	115	1	1	1	Note that values must not equal "0"		
115	120	1	1	1	must be entered if no data is		
120	125	1	1	1	in order for Visual Balance to run.		
125	130	1	1	1			
130	135	1	1	1			
135	140	1	1	1			
140	145	1	1	1			
145	150	1	1	1			
150	155	1	1	1			
155	160	1	1	1			
160	165	1	1	1			
165	170	1	1	1			
170	175	1	1	1			
175	180	1	1	1			
180	185	1	1	1			
185	190	1	1	1			

Appendix C

Visual Balance Computer Code

'Visual Balance - Visual Basic Procedure Code.

'Main Menu' Code

```
Private Sub Form_Load()

'Centre Form on Screen and set up title.'
Top = (Screen.Height - Height) / 2
Left = (Screen.Width - Width) / 2

   'Create Control Array for the Number of Reservoirs Buttons to Create."
   'If Index < intNumReservoirs Then
   'Load CmdReservoir(Index)
   'CmdReservoir(Index).Move 0, 0
   'CmdReservoir(Index).Visible = True
   'Index = Index + 1
   'End If

   FrmMainMenu.mnuSaveChanges.Enabled = False
   FrmMainMenu.mnuSaveChangesAs.Enabled = False
   FrmMainMenu.mnuGeneralData.Enabled = False
   FrmMainMenu.mnuMineProductionInfo.Enabled = False
   FrmMainMenu.mnuSiteHydrology.Enabled = False
   FrmMainMenu.mnuReservoirInfo.Enabled = False
   FrmMainMenu.mnuReservoirLinks.Enabled = False
   FrmMainMenu.mnuWaterQuality.Enabled = False
   FrmMainMenu.mnuDamSafetyStandards.Enabled = False
   FrmMainMenu.mnuRiskAnalysisData.Enabled = False
   FrmMainMenu.mnuGoToEditMenu.Enabled = False
   FrmMainMenu.mnuGoToOutput.Enabled = False
   FrmMainMenu.Show
End Sub

Private Sub mnuExistingProject_Click()
   txtClickExisting.Text = "Yes"
   Load FrmExistingFile
   FrmExistingFile.Show
End Sub

Private Sub mnuGoToOutput_Click()
      Load FrmRunNumber
      FrmRunNumber.Visible = True
```

```
    FrmRunNumber.SetFocus
    FrmRunNumber.Refresh
End Sub

Private Sub mnuNewProject_Click()
  StrMsg = "Would you like to view the 'site map' and general instructions for using the
Visual Balance program?"
  Select Case MsgBox(StrMsg, vbYesNoCancel)
  Case Is = vbYes
    Load FrmInstruct
    FrmInstruct.Show
  Case Is = vbNo
    Load FrmNewFile
    FrmNewFile.Show
  Case Is = vbCancel
    Me.Show
    Exit Sub
  End Select

End Sub

Private Sub mnuReadMe_Click()
  Load FrmReadMe
  FrmReadMe.Show
End Sub


Private Sub mnuSaveProject_Click()
' Clicking the Save command button causes the Save As dialog to appear.

  On Error GoTo Save_Error

  With dlgDialog

    ' Setting CancelError to True causes a trappable error to ocBeg if the user hits Cancel
    .CancelError = True

    ' The Filter is now set to specify those groups of files that our users will be most
    ' interested in using the dialog to locate
    .Filter = "Text Files (*.txt)|*.txt"

    ' FilterIndex is set to 1, meaning that the first part of the filter will be used as the
    ' default, in this case *.txt
```

```
        .FilterIndex = 1

        .DialogTitle = "Select a name to save data as"

        ' An action code of 2 triggers the save as dialog to appear.
        .ShowSave

    End With

    MsgBox "You selected " & dlgDialog.FileName

    Exit Sub

Save_Error:

    ' Cancel the error trapping
    On Error GoTo 0

    MsgBox "You hit cancel, so no file was selected and in an application no data would be
saved"

    Exit Sub

End Sub
```

'Existing File' Code

```
Option Explicit
Dim strProjectDirectory As String * 25
Dim strpath, strWhereSaved As String
Dim blnChecked As Boolean

Private Sub LblTipFile_Click()

End Sub

Private Sub mnuCancelToMain_Click()
   Unload Me
   Load FrmMainMenu
   FrmMainMenu.Refresh
   FrmMainMenu.Show
End Sub

Public Sub mnuGoToEditMenu_Click()

   If DirProject = "C:\" Then
      Beep
      MsgBox "Please select the existing project folder, " & _
      "or return to the Main Menu."
      GoTo ProcNoFile:
   End If

   If DirProject = "C:\VisualBalance" Then
   Beep
   MsgBox "You cannot select the main program directory to save your project files.",
vbExclamation
   GoTo ProcNoFile:
   End If

   strpath = FrmExistingFile.DirProject

   If OptMine Then
      Me.Hide
      Load FrmEditMenu
      FrmEditMenu.Show
   ElseIf OptSolidWaste Then
      Me.Hide
      Load FrmSolidWasteInfo
```

```
      FrmSolidWasteInfo.Show
   ElseIf OptOther Then
      Me.Hide
      Load FrmOtherLandfill
      FrmOtherLandfill.Show
   Else
      MsgBox "You must select a project type to proceed.", vbOKOnly
   End If

ProcNoFile:

End Sub

Public Sub mnuGoToOutput_Click()

   If DirProject = "C:\" Then
      Beep
      MsgBox "Please select the existing project folder, " & _
      "or return to the Main Menu."
      GoTo ProcNoFile:
   End If

   If DirProject = "C:\VisualBalance" Then
      Beep
      MsgBox "You cannot select the main program directory to save your project files.",
vbExclamation
      GoTo ProcNoFile:
   End If

   strpath = FrmExistingFile.DirProject

   If OptMine Then
      Me.Hide
      Load FrmRunNumber
FrmRunNumber.Visible = True
FrmRunNumber.SetFocus
FrmRunNumber.Refresh
   ElseIf OptSolidWaste Then
      Me.Hide
      Load FrmSolidWasteInfo
      FrmSolidWasteInfo.Show
   ElseIf OptOther Then
      Me.Hide
```

```
    Load FrmOtherLandfill
    FrmOtherLandfill.Show
  Else
    MsgBox "You must select a project type to proceed.", vbOKOnly
  End If

ProcNoFile:

End Sub
Private Sub mnuExit_Click(Index As Integer)
  Dim StrMsg As String
  Beep
  StrMsg = "Are you sure you want to close Visual Balance?"
  If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
  End
  Else
  End If
End Sub

Public Sub Form_Load()
  Unload FrmLogo
  Load FrmBlank
  FrmBlank.Show
  'Centre Form on Screen'
  Top = (Screen.Height - Height) / 2
  Left = (Screen.Width - Width) / 2

  DirProject.Path = "C:\"

  blnChecked = False

  FrmEditMenu.mnuGeneralData.Checked = blnChecked
  FrmEditMenu.mnuMineProduction.Checked = blnChecked
  FrmEditMenu.mnuDamSafety.Checked = blnChecked

End Sub

Private Sub ReadMe_Click()
  Load FrmReadMe
  FrmReadMe.Show
End Sub
```

'New File' Code

```
Option Explicit
Dim strpath, strWhereSaved As String
Dim strMsgBox As String

Private Sub mnuEditMenu_Click()

On Error GoTo CheckError:

If OptMine Or OptSolidWaste Or OptOther Then
      If TxtNewDir.Text = "" Then
         GoTo ProcNoFile:
         MsgBox "You must enter a directory in which to save Visual Balance data files for
this project.", vbOKOnly
      ElseIf TxtNewDir.Text = "VisualBalance" Then
         MsgBox "You are not permitted to use the program drive to save project files.",
vbExclamation, vbOKOnly
         GoTo ProcNoFile:
      Else
         strpath = TxtNewDir.Text
         Dim fso, f As Object
         Set fso = CreateObject("Scripting.FileSystemObject")
         Set f = fso.CreateFolder("c:\" & strpath)
      End If
Else
   MsgBox "You must select a project type to proceed.", vbOKOnly
End If

If OptMine Then
   Me.Hide
   FrmEditMenu.mnuGeneralData.Enabled = True
   FrmEditMenu.mnuMineProduction.Enabled = True
   FrmEditMenu.mnuSiteHydrology.Enabled = True
   FrmEditMenu.mnuReservoirInfo.Enabled = True
   FrmEditMenu.mnuReservoirLinks.Enabled = True
   FrmEditMenu.mnuWaterQual.Enabled = True
   FrmEditMenu.mnuDamSafety.Enabled = True
   FrmEditMenu.mnuRiskData.Enabled = True
   FrmEditMenu.mnuGoToOutput.Enabled = True
   FrmEditMenu.Show
ElseIf OptSolidWaste Then
   Me.Hide
```

```
    Load FrmSolidWasteInfo
    FrmSolidWasteInfo.Show
Else
    Me.Hide
    Load FrmOtherLandfill
    FrmOtherLandfill.Show
End If

CheckError:
    Dim intFileExists As Integer
    intFileExists = 58

    If Err = intFileExists Then
        Me.Show
        strMsgBox = "This folder already exists.  Please enter a new folder name, or return to
the main menu and choose 'Existing Project' from the file menu."
        Beep
        MsgBox strMsgBox, vbQuestion
        Unload FrmMainMenu
        GoTo ProcNoFile:
    ElseIf Err = 0 Then
    Exit Sub
Else
    MsgBox "Unexpected Error # " & Err & "!  " & Err.Description, vbExclamation
    Exit Sub
End If

ProcNoFile:
MsgBox "You must enter a new directory name for your new project.", vbExclamation

End Sub

Private Sub Exit_Click()
    Dim StrMsg As String
    Beep
    StrMsg = "Are you sure you want to close Visual Balance?"
    If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
    End
    Else
    End If
End Sub

Private Sub Form_Load()
```

```
    Unload FrmLogo
    Load FrmBlank
    FrmBlank.Show
    'Centre Form on Screen'
    Top = (Screen.Height - Height) / 2
    Left = (Screen.Width - Width) / 2
    mnuGoToOutput.Enabled = False

End Sub

Private Sub Label4_Click()
    LblTipNewFile.Caption = "The new project folder you select must not already exist.
Visual Balance " & _
        "will use this new project folder to save data files," & _
        "and output tables and graphs."
    LblTipNewFile.Refresh
    LblTipNewFile.Visible = True
End Sub

Private Sub ReadMe_Click()
    Load FrmReadMe
    FrmReadMe.Show
End Sub

Private Sub ReturnMainMenu_Click()
    Unload Me
    FrmMainMenu.mnuSaveChanges.Enabled = False
    FrmMainMenu.mnuSaveChangesAs.Enabled = False
    FrmMainMenu.mnuGeneralData.Enabled = False
    FrmMainMenu.mnuMineProductionInfo.Enabled = False
    FrmMainMenu.mnuSiteHydrology.Enabled = False
    FrmMainMenu.mnuReservoirInfo.Enabled = False
    FrmMainMenu.mnuReservoirLinks.Enabled = False
    FrmMainMenu.mnuWaterQuality.Enabled = False
    FrmMainMenu.mnuDamSafetyStandards.Enabled = False
    FrmMainMenu.mnuRiskAnalysisData.Enabled = False
    FrmMainMenu.mnuGoToOutput.Enabled = False
    FrmMainMenu.mnuGoToEditMenu.Enabled = False
    FrmMainMenu.Refresh
    FrmMainMenu.Show
End Sub
```

'Editing Menu Code

```
Option Explicit

Dim strProjectDirectory As String * 25
Dim strpath, StrMsg, strWhereSaved As String
Dim strSiteName As String
Dim blnChecked As Boolean
Private Sub mnuExit_Click()
   Dim StrMsg As String
   Beep
   StrMsg = "Are you sure you want to close Visual Balance?"
   If MsgBox(StrMsg, vbQuestion & vbYesNo) = vbYes Then
   End
   Else
   End If
End Sub

Private Sub Form_Load()

'Centre Form on Screen and set up title.'
Top = (Screen.Height - Height) / 2
Left = (Screen.Width - Width) / 2

mnuExistingProject.Enabled = False
mnuNewProject.Enabled = False



   'Create Control Array for the Number of Reservoirs Buttons to Create."
   'If Index < intNumReservoirs Then
   'Load CmdReservoir(Index)
   'CmdReservoir(Index).Move 0, 0
   'CmdReservoir(Index).Visible = True
   'Index = Index + 1
   'End If
End Sub
Private Sub mnuGeneralData_Click()
   blnChecked = Not blnChecked
   mnuGeneralData.Checked = blnChecked
   Me.Hide
   Load FrmMineProjectData
   FrmMineProjectData.Show
```

```
End Sub

Private Sub mnuReadMe_Click()
  Load FrmReadMe
  FrmReadMe.Show
End Sub

Private Sub mnuMineProduction_Click()

  mnuMineProduction.Checked = True

  Me.Hide

  Load FrmMineProduction
  FrmMineProduction.Show
End Sub

Private Sub mnuDamSafety_Click()
  mnuDamSafety.Checked = True
  Load FrmMineSafetyInfo
  FrmMineSafetyInfo.Show
End Sub

Private Sub mnuGoToOutput_Click()
    Load FrmRunNumber
    FrmRunNumber.Visible = True
    FrmRunNumber.SetFocus
    FrmRunNumber.Refresh
End Sub


Private Sub mnuReservoirInfo_Click()
'Load the Reservoir #1 Information Form.

  Static blnChecked As Boolean
  blnChecked = Not blnChecked
  mnuReservoirInfo.Checked = blnChecked

  Load FrmMineReservoirInfo
  FrmMineReservoirInfo.Show
End Sub

Private Sub mnuReservoirLinks_Click()
```

```
    Static blnChecked As Boolean
    blnChecked = Not blnChecked
    mnuReservoirLinks.Checked = blnChecked

    Load FrmMineResLinks
    FrmMineResLinks.Show
End Sub

Private Sub mnuReturntoMain_Click()
    Unload Me
    Load FrmMainMenu
    FrmMainMenu.Show
End Sub

Private Sub mnuRiskData_Click()

    Me.Hide

    Static blnChecked As Boolean
    blnChecked = Not blnChecked
    mnuRiskData.Checked = blnChecked

    Load FrmRiskData
    FrmRiskData.Show
End Sub


Private Sub mnuSiteHydrology_Click()

    Static blnChecked As Boolean
    blnChecked = Not blnChecked
    mnuSiteHydrology.Checked = blnChecked

    Me.Hide

    Load FrmMineHydro
    FrmMineHydro.Show
End Sub

Private Sub mnuWaterQual_Click()
Static blnChecked As Boolean
    blnChecked = Not blnChecked
```

```
    mnuWaterQual.Checked = blnChecked

    Load FrmMineWaterInfo
    FrmMineWaterInfo.Show
End Sub
```

'General Project Information Form Code

```
Private Sub Form_Load()

mnuMain.Enabled = False

   Top = (Screen.Height - Height) / 2
   Left = (Screen.Width - Width) / 2

   If FrmMainMenu.txtClickExisting.Text = "No" Then
      blnIsNewProject = True
      strpath = "c:\" & FrmNewFile.TxtNewDir.Text
   Else
      blnIsNewProject = False
      strpath = FrmExistingFile.DirProject
   End If

End Sub

Private Sub mnuGoToEditMenu_Click()
'Return to the Mine Data Editing Menu.'
   StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbYes
      Unload Me
      Load FrmEditMenu
      FrmEditMenu.Show
   Case Is = vbNo
      Exit Sub
   End Select
End Sub

Public Sub mnuReadData_Click()

On Error GoTo CheckError:

   intFileNumber = FreeFile
   Open (strpath & "\mine.txt") For Input As #intFileNumber
   Input #intFileNumber, strSiteName, strSiteDescription, _
      intNumReservoirs, sngStarterDamElev

   TxtSiteName.Text = strSiteName
   TxtSiteDescription.Text = strSiteDescription
```

```
  TxtNumReservoirs.Text = Val(intNumReservoirs)
  TxtStartDam.Text = Val(sngStarterDamElev)

  Close #intFileNumber

CheckError:

  If Err = 53 Then
    MsgBox "This directory does not contain this data file.  Please input appropriate data
and save the file to your project directory.", vbInformation
    Close #intFileNumber
    Exit Sub
  ElseIf Err = 62 Then
  MsgBox "There is an error in your Visual Balance data file.  Either you have not " & _
    "entered required data, or the file does not exist.  " & _
    "Please enter the required data and save the file again.", vbCritical
  Close #intFileNumber
  Exit Sub
  ElseIf Err = 0 Then
    Exit Sub
  Else
    MsgBox "Unexpected Error # " & Err & "!", vbExclamation
    Close #intFileNumber
    Exit Sub
  End If

End Sub


Private Sub mnuExit_Click()

  Dim StrMsg As String
  StrMsg = "Are you sure you want to close Visual Balance?"
  If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
  End
  Else
  End If

End Sub


Private Sub mnuOutput_Click()
```

```
   StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbNo
      GoTo ProcExit
   Case Is = vbYes
      Unload Me
   End Select

   StrMsg = "Have you edited all the necessary Visual Balance Input and Output
information?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
      Load FrmRunNumber
      FrmRunNumber.Visible = True
      FrmRunNumber.SetFocus
      FrmRunNumber.Refresh
   Else
      FrmEditMenu.Show
      Exit Sub
   End If

ProcExit:
End Sub

Private Sub mnuReadMe_Click()

Load FrmReadMe
FrmReadMe.Show

End Sub

Private Sub mnuSaveChanges_Click()

'blnGeneralFile = True

On Error GoTo CheckError:

   'On Error GoTo FileError

   'Open file to write data into.'
      intFileNumber = FreeFile
      Open (strpath & "\mine.txt") For Output As #intFileNumber

   'Write Data into File.'
```

```
        Write #intFileNumber, TxtSiteName.Text, TxtSiteDescription.Text, _
          Val(TxtNumReservoirs.Text), Val(TxtStartDam.Text)
        strWhereSaved = "Your Data Has Been Saved as 'mine.txt' in your project directory  "
        MsgBox (strWhereSaved & strpath)
        Close #intFileNumber
        Exit Sub

CheckError:

If Err = 53 Then
   MsgBox "This directory does not contain this data file.  Please input appropriate data and
save the file to your project directory.", vbInformation
   Exit Sub
ElseIf Err = 0 Then
   Exit Sub
Else
   MsgBox "Unexpected Error # " & Err & "!  " & Err.Description, vbExclamation
   Close #intFileNumber
   Exit Sub
End If

End Sub

Private Sub TxtSiteName_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
   TxtSiteDescription.SetFocus
   End If
End Sub

Private Sub TxtSiteDescription_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
   TxtNumReservoirs.SetFocus
   End If
End Sub
Private Sub TxtNumReservoirs_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
   TxtSiteName.SetFocus
   End If
End Sub
```

'Production and Material Information Form Code

```
Option Explicit

Dim blnIsNewProject, blnAnnVary As Boolean

Dim strProjectDirectory As String * 25
Dim strpath, strWhereSaved, StrMsg As String
Dim strAnnVary As String * 5

Dim intStartMonth, intStartYear, intEndMonth, intEndYear As Integer
Dim sngTonnesTail, sngSumCheck, sngTonnesMetal As Single
Dim sngTonnesMined As Single
Dim sngTonnesRock As Single
Dim sngDegSatTail As Single
Dim sngFracWater As Single
Dim sngBulkDRock, sngVoidRRock, sngFracWRsub, sngFracWRVoidsTail As Single
Dim sngDryDTail, sngVoidRTail, sngSpecGravTail As Single
Dim sngFracCyclone As Single


Private Sub Cancel_Click()
'Return to the Mine Edit Menu.'
   Unload Me
   Load FrmMainMenu
   FrmMainMenu.Show
End Sub

Private Sub Exit_Click(Index As Integer)
   Dim StrMsg As String
   Beep
   StrMsg = "Are you sure you want to close Visual Balance?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
   End
   Else
   End If
End Sub

Private Sub LblEditSeepFile_Click()

On Error GoTo CheckError:

If blnIsNewProject = True Then
```

```
    OLE1.Class = "Excel.Sheet"                    ' Set class name.
    OLE1.OLETypeAllowed = vbOLELinked             ' Specify type of object.
    OLE1.CreateLink ("c:\VisualBalance\Production.xls") ' Create linked object.
Else
    OLE1.Class = "Excel.Sheet"                ' Set class name.
    OLE1.OLETypeAllowed = vbOLELinked         ' Specify type of object.
    OLE1.CreateLink (strpath & "\Production.xls")  ' Specify source file.
End If
OLE1.DoVerb vbOLEOpen

CheckError:
If Err = 31031 Then
    MsgBox "Your project directory does not contain this data file." & vbCrLf & "The generic
Visual Balance file will be displayed where you can edit data and save the file to your project
directory.", vbInformation
    OLE1.CreateLink ("c:\VisualBalance\Production.xls")
    OLE1.DoVerb vbOLEOpen
End If

End Sub

Private Sub mnuGoToEditMenu_Click()
'Return to the Mine Data Editing Menu.'
   StrMsg = "Did you remember to save your changes?"
    Select Case MsgBox(StrMsg, vbYesNo)
    Case Is = vbYes
        Unload Me
        Load FrmEditMenu
        FrmEditMenu.Show
    Case Is = vbNo
        Exit Sub
    End Select
End Sub

Private Sub Form_Load()
'Centre Form on Screen.'
    Left = (Screen.Width - Width) / 2
    Top = (Screen.Height - Height) / 2

If FrmMainMenu.txtClickExisting.Text = "No" Then
    blnIsNewProject = True
    strpath = "c:\" & FrmNewFile.TxtNewDir.Text
```

```
Else
   blnIsNewProject = False
   strpath = FrmExistingFile.DirProject
End If

End Sub


Private Sub Label20_Click()

On Error GoTo CheckError:

If blnIsNewProject = True Then
   OLE1.Class = "Excel.Sheet"                       ' Set class name.
   OLE1.OLETypeAllowed = vbOLELinked                 ' Specify type of object.
   OLE1.CreateLink ("c:\VisualBalance\OperatingDays.xls")  ' Create linked object.
Else
   OLE1.Class = "Excel.Sheet"                       ' Set class name.
   OLE1.OLETypeAllowed = vbOLELinked                 ' Specify type of object.
   OLE1.CreateLink (strpath & "\OperatingDays.xls")   ' Specify source file.
End If
OLE1.DoVerb vbOLEOpen

CheckError:
If Err = 31031 Then
   MsgBox "This directory is missing at least one essential Visual Balance data file.  The
generic Visual Balance file will be displayed where you can edit data and save the file to your
project directory.", vbInformation
   OLE1.CreateLink ("c:\VisualBalance\OperatingDays.xls")
   OLE1.DoVerb vbOLEOpen
End If
End Sub

Private Sub mnuGoToOutput_Click()

If OptAnnuallyVarying Then
   blnAnnVary = True
ElseIf OptProdConstants Then
   blnAnnVary = False
Else
   MsgBox "You must slect a an option for the mine production data in order to proceed.",
vbExclamation
   Exit Sub
```

```
End If

If blnAnnVary = False Then
   If TxtTonnesMined = "" Or TxtTonnesTail = "" Or TxtTonnesRock = "" Or
TxtTonnesMetal = "" Then
      MsgBox "You selected the 'Constant Mine Production Values' option, therefore " & _
      "you must enter constants for the tonnes mined, and the tonnes of tailings, waste rock "
& _
      "concentrate mined.  These values can be zero if not applicable, but can not be left
blank.", vbOKOnly
      Exit Sub
   End If
End If

   StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbNo
      GoTo ProcExit
   Case Is = vbYes
      Unload Me
   End Select

   StrMsg = "Have you edited all the necessary Visual Balance Input and Output
information?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
      Load FrmRunNumber
      FrmRunNumber.Visible = True
      FrmRunNumber.SetFocus
      FrmRunNumber.Refresh
   Else
      FrmEditMenu.Show
      Exit Sub
   End If

ProcExit:
End Sub

Private Sub ReadData_Click()

On Error GoTo CheckError:

Dim intFileNumber As Integer
```

```
    intFileNumber = FreeFile
    Open (strpath & "\production.txt") For Input As #intFileNumber
    Input #intFileNumber, intStartMonth, intStartYear, _
    intEndMonth, intEndYear, sngTonnesMined, _
    sngTonnesMetal, sngTonnesRock, sngTonnesTail, _
    sngBulkDRock, sngVoidRRock, sngFracWRsub, sngFracWRVoidsTail, _
    sngDegSatTail, sngFracWater, sngFracCyclone, _
    sngDryDTail, sngVoidRTail, sngSpecGravTail, strAnnVary

    TxtStartMonth.Text = Val(intStartMonth)
    TxtStartYear.Text = Val(intStartYear)
    TxtEndMonth.Text = Val(intEndMonth)
    TxtEndYear.Text = Val(intEndYear)
    TxtTonnesMined.Text = Val(sngTonnesMined)
    TxtTonnesMetal.Text = Val(sngTonnesMetal)
    TxtTonnesRock.Text = Val(sngTonnesRock)
    TxtTonnesTail.Text = Val(sngTonnesTail)
    TxtBulkDRock.Text = sngBulkDRock
    TxtVoidRRock.Text = Val(sngVoidRRock)
    TxtFracWRSub = Val(sngFracWRsub)
    TxtFracWRVoidsTail = Val(sngFracWRVoidsTail)
    TxtDegSatTail.Text = Val(sngDegSatTail)
    TxtFracWater.Text = Val(sngFracWater)
    TxtFracCyclone = Val(sngFracCyclone)
    TxtDryDTail.Text = sngDryDTail
    TxtVoidRTail.Text = Val(sngVoidRTail)
    TxtSpecGravTail.Text = Val(sngSpecGravTail)

    If strAnnVary = "True " Then
      OptAnnuallyVarying = True
    ElseIf strAnnVary = "False" Then
      OptProdConstants = True
    End If

    Close #intFileNumber

CheckError:

If Err = 53 Then
    MsgBox "This directory does not contain this data file.  Please input appropriate data and
save the file to your project directory.", vbInformation
    Close #intFileNumber
    Exit Sub
```

```
ElseIf Err = 62 Then
   MsgBox "There is an error in your Visual Balance data file.  Either you have not " & _
      "entered required data, or the file does not exist.  " & _
      "Please enter the required data and save the file again.", vbCritical
   Close #intFileNumber
   Exit Sub
Else
      Close #intFileNumber
      Exit Sub
End If

End Sub

Private Sub ReadMe_Click()
   Load FrmReadMe
   FrmReadMe.Show
End Sub

Private Sub ReturntoEdit_Click(Index As Integer)
   sngSumCheck = sngTonnesTail + sngTonnesMetal + sngTonnesRock
   TxtSumCheck = Val(sngSumCheck)
   If sngSumCheck <> sngTonnesMined Then
      MsgBox "The annual tonnage of metal, tailings and waste rock should equal the total
tonnes mined.  There may be an error in your input data!", vbOKOnly
   End If
   'Return to the Mine Edit Menu.'
      StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbYes
      Unload Me
      Load FrmEditMenu
      FrmEditMenu.Show
   Case Is = vbNo
      Exit Sub
   End Select
End Sub

Private Sub SaveChanges_Click(Index As Integer)

If OptAnnuallyVarying = True Then
   strAnnVary = "True"
ElseIf OptProdConstants = True Then
   strAnnVary = "False"
```

```
Else
   MsgBox "You must select an option for mine production data.  Please select an option to
continue.", vbExclamation
   Exit Sub
End If

sngSumCheck = sngTonnesTail + sngTonnesMetal + sngTonnesRock
   TxtSumCheck = Val(sngSumCheck)
   If sngSumCheck <> sngTonnesMined Then
      MsgBox "The annual tonnage of metal, tailings and waste rock should equal the total
tonnes mined.  This is an error! Can not save file!", vbOKOnly
   Else
      Dim intFileNumber As Integer
      On Error GoTo CheckError:

      'Open file to write data into.'
         intFileNumber = FreeFile
         Open strpath & "\production.txt" For Output As #intFileNumber

      'Write Data into File.'
         Write #intFileNumber, Val(TxtStartMonth), _
         Val(TxtStartYear), Val(TxtEndMonth), _
         Val(TxtEndYear), Val(TxtTonnesMined), _
         Val(TxtTonnesMetal), Val(TxtTonnesRock), _
         Val(TxtTonnesTail), _
         Val(TxtBulkDRock), Val(TxtVoidRRock), _
         Val(TxtFracWRSub), Val(TxtFracWRVoidsTail), Val(TxtDegSatTail),
Val(TxtFracWater), _
         Val(TxtFracCyclone), Val(TxtDryDTail), _
         Val(TxtVoidRTail), Val(TxtSpecGravTail), strAnnVary

         strWhereSaved = "Your Data Has Been Saved as 'production.txt' in your project
directory  "
         MsgBox (strWhereSaved & strpath)
         Close #intFileNumber
         Exit Sub

CheckError:
      MsgBox "File error!"

   End If
End Sub
```

```
Private Sub TxtEndMonth_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtStartYear.SetFocus
  End If
End Sub
Private Sub TxtEndYear_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtTonnesMined.SetFocus
  End If
End Sub

Private Sub TxtStartMonth_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtEndMonth.SetFocus
  End If
End Sub
Private Sub TxtStartYear_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtEndYear.SetFocus
  End If
End Sub

Private Sub TxtTonnesMined_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtTonnesMetal.SetFocus
  End If
End Sub
Private Sub TxtTonnesMetal_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtTonnesRock.SetFocus
  End If
End Sub
Private Sub TxtTonnesRock_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtTonnesTail.SetFocus
  End If
End Sub
Private Sub TxtTonnesTail_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtBulkDRock.SetFocus
  End If
End Sub
Private Sub TxtBulkDRock_KeyPress(KeyAscii As Integer)
```

```
    If KeyAscii = 13 Then
        TxtVoidRRock.SetFocus
    End If
End Sub
Private Sub TxtVoidRRock_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
        TxtFracWRSub.SetFocus
    End If
End Sub
Private Sub TxtFracWRsub_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
        TxtDegSatTail.SetFocus
    End If
End Sub
Private Sub TxtDegSatTail_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
        TxtFracWater.SetFocus
    End If
End Sub
Private Sub TxtFracWater_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
        TxtFracCyclone.SetFocus
    End If
End Sub
Private Sub TxtFracCyclone_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
        TxtDryDTail.SetFocus
    End If
End Sub
Private Sub TxtDryDTail_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
        TxtVoidRTail.SetFocus
    End If
End Sub
Private Sub TxtVoidRTail_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
        TxtSpecGravTail.SetFocus
    End If
End Sub
Private Sub TxtSpecGravTail_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
        TxtStartMonth.SetFocus
    End If
```

```
End Sub

Private Sub TxtTonnesMetal_Change()
   sngTonnesMetal = Val(TxtTonnesMetal)
   sngSumCheck = sngTonnesTail + sngTonnesMetal + sngTonnesRock
   TxtSumCheck = Val(sngSumCheck)

End Sub

Private Sub TxtTonnesMined_Change()
   sngTonnesMined = Val(TxtTonnesMined)
   LblTotal.Caption = "Total = " & sngTonnesMined
End Sub

Private Sub TxtTonnesRock_Change()
   sngTonnesRock = Val(TxtTonnesRock)
   sngSumCheck = sngTonnesTail + sngTonnesMetal + sngTonnesRock
   TxtSumCheck = Val(sngSumCheck)

End Sub

Private Sub TxtTonnesTail_Change()
   sngTonnesTail = Val(TxtTonnesTail)
   sngSumCheck = sngTonnesTail + sngTonnesMetal + sngTonnesRock
   TxtSumCheck = Val(sngSumCheck)
End Sub
```

'Site Hydrologic Data Form Code

```
Option Explicit

Dim intFileNumber, intEDFResponse, intStartPackMonth, intEndPackMonth, _
   intTotalPackMonths, strpath As Integer

Public strWhereSaved, StrMsg As String

Public blnHydrofile, blnIsNewProject As Boolean

Dim strProjectDirectory As String * 25

Dim objHydroFile As Object
Dim sngEDFWinter, sngEDFSpring, sngEDFSummer, sngEDFFall As Single

Private Sub mnuEditHydro_Click()

On Error GoTo CheckError

   If blnIsNewProject = True Then
      OLE1.Class = "Excel.Sheet"                    ' Set class name.
      OLE1.OLETypeAllowed = vbOLELinked             ' Specify type of object.
      OLE1.CreateLink ("c:\VisualBalance\hydrodata.xls") ' Create linked object.
   Else
      OLE1.Class = "Excel.Sheet"                    ' Set class name.
      OLE1.OLETypeAllowed = vbOLELinked             ' Specify type of object.
      OLE1.CreateLink (strpath & "\hydrodata.xls")  ' Specify source file.
   End If
      OLE1.DoVerb vbOLEOpen

CheckError:

If Err = 31031 Then
   MsgBox "Your project directory does not contain this data file." & vbCrLf & "The generic
Visual Balance file will be displayed where you can edit data and save the file to your project
directory.", vbInformation
   OLE1.CreateLink ("c:\VisualBalance\hydrodata.xls")
   OLE1.DoVerb vbOLEOpen
End If


End Sub
```

```
Private Sub Exit_Click(Index As Integer)
   Dim StrMsg As String
   Beep
   StrMsg = "Are you sure you want to close Visual Balance?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
   End
   Else
   End If
End Sub

Private Sub Form_Load()
   'Centre Form on Screen.'
   Top = (Screen.Height - Height) / 2
   Left = (Screen.Width - Width) / 2

   mnuReturnToMain.Enabled = False

Dim blnIsNewProject As Boolean
If FrmMainMenu.txtClickExisting.Text = "No" Then
   blnIsNewProject = True
   strpath = "c:\" & FrmNewFile.TxtNewDir.Text

Else
   blnIsNewProject = False
   strpath = FrmExistingFile.DirProject
End If

Label6.Caption = "Note: The EDF is the flood volume which " & _
"the impoundment should contain without spilling.  In some " & _
"cases, this volume may be the same as the Inflow Design Flood " & _
"(IDF).  The IDF is the flood which the dams (including diversions " & _
"and spillways) should be able to safely pass. This volume is " & _
"exclusive of freeboard requirements accounting for wave action."

End Sub

Private Sub mnuGoToOutput_Click()
   StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbNo
      GoTo ProcExit
   Case Is = vbYes
      Unload Me
```

```
    End Select

    StrMsg = "Have you edited all the necessary Visual Balance Input and Output
information?"
    If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
        Load FrmRunNumber
        FrmRunNumber.Visible = True
        FrmRunNumber.SetFocus
        FrmRunNumber.Refresh
    Else
        FrmEditMenu.Show
        Exit Sub
    End If

ProcExit:

End Sub

Private Sub mnuReadMe_Click()
    Load FrmReadMe
    FrmReadMe.Show
End Sub

Private Sub ReadData_Click()

On Error GoTo CheckError

    intFileNumber = FreeFile

    Open (strpath & "\extremes.txt") For Input As #intFileNumber
    Input #intFileNumber, intEDFResponse, sngEDFWinter, sngEDFSpring, _
        sngEDFSummer, sngEDFFall, intStartPackMonth, intEndPackMonth, _
        intTotalPackMonths

    TxtEDFWinter = Val(sngEDFWinter)
    TxtEDFSpring = Val(sngEDFSpring)
    TxtEDFSummer = Val(sngEDFSummer)
    TxtEDFFall = Val(sngEDFFall)
    TxtStartPackMonth = Val(intStartPackMonth)
    TxtEndPackMonth = Val(intEndPackMonth)
    TxtTotalPackMonths = Val(intTotalPackMonths)

    If intEDFResponse = 1 Then
```

```
        OptPMF = True
    ElseIf intEDFResponse = 2 Then
        OptTenThou = True
    ElseIf intEDFResponse = 3 Then
        OptOneThou = True
    ElseIf intEDFResponse = 4 Then
        OptTwoHun = True
    ElseIf intEDFResponse = 5 Then
        OptOneHun = True
    End If

     Close #intFileNumber

CheckError:

    If Err = 53 Then
        MsgBox "This directory does not contain this data file.  Please input appropriate data
and save the file to your project directory.", vbInformation
        Close #intFileNumber
        Exit Sub
    ElseIf Err = 62 Then
        MsgBox "There is an error in one of your data files.  Either you have not " & _
            "entered required data, or the file does not exist.  " & _
            "Please return to the data edit menu and edit your project data input files.", vbCritical
        Close #intFileNumber
        Load FrmEditMenu
        FrmEditMenu.Show
        Exit Sub
    Else
        Close #intFileNumber
        Exit Sub
    End If
End Sub

Private Sub mnuGoToEditMenu_Click()
'Return to the Mine Data Editing Menu.'
    StrMsg = "Did you remember to save your changes?"
    Select Case MsgBox(StrMsg, vbYesNo)
    Case Is = vbYes
        Unload Me
        Load FrmEditMenu
        FrmEditMenu.Show
    Case Is = vbNo
```

```
    Exit Sub
  End Select
End Sub

Private Sub SaveChanges_Click()

On Error GoTo CheckError

blnHydrofile = True

Dim intFileNumber As Integer
  'On Error GoTo FileError

  If OptPMF = True Then
    intEDFResponse = 1
  ElseIf OptTenThou = True Then
    intEDFResponse = 2
  ElseIf OptOneThou = True Then
    intEDFResponse = 3
  ElseIf OptTwoHun = True Then
    intEDFResponse = 4
  ElseIf OptOneHun = True Then
    intEDFResponse = 5
  End If

  'Open file to write data into.'
    intFileNumber = FreeFile
    Open (strpath & "\extremes.txt") For Output As #intFileNumber

  'Write Data into File.'
    Write #intFileNumber, intEDFResponse, Val(TxtEDFWinter.Text), _
      Val(TxtEDFSpring.Text), Val(TxtEDFSummer.Text), _
      Val(TxtEDFFall.Text), Val(TxtStartPackMonth), _
      Val(TxtEndPackMonth), Val(TxtTotalPackMonths)
    strWhereSaved = "Your Data Has Been Saved as 'extremes.txt' in your project directory
"

    MsgBox (strWhereSaved & strpath)
    Close #intFileNumber
    Exit Sub

CheckError:

  If Err = 53 Then
```

```
        MsgBox "This directory does not contain this data file.  Please input appropriate data
and save the file to your project directory.", vbInformation
        Exit Sub
    End If

End Sub
```

‘Reservoir Information Form Code

```
Option Explicit

Dim intDamRows As Integer

Dim blnIsNewProject, blnDamDependFile As Boolean

Dim strProjectDirectory As String * 25
Dim strDependResponse As String * 5
Dim strpath, strWhereSaved, StrMsg As String

Public strResName, strResAbbr, strvolumefile, _
   strSeepOutFile As String
Public sngStartWatElev, sngStartTailElev, sngCatchArea, _
   sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
   sngSeepOutRate, sngSeepReturnRate, sngFracRockIn, _
   sngSlurryWatInRate, sngMineWatInRate, _
   sngSeepInRate, sngMaxWatElev, sngSpillRate, _
   sngMinWatElev, sngFracRunDivert, sngDamLossConstant, _
   sngBeachAreaConstant As Single
Public sngNeededForReclaim, sngReclaimRate As Single

Private Sub Cancel_Click()
'Return to the Mine Edit Menu.'

   Load FrmEditMenu
   FrmEditMenu.Show
End Sub



Private Sub Exit_Click(Index As Integer)
   Dim StrMsg As String
   StrMsg = "Are you sure you want to close Visual Balance?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
   End
   Else
   End If
End Sub

Private Sub Form_Load()
```

```
mnuReturnToMain.Enabled = False

Left = (Screen.Width - Width) / 2
mnuSaveChangesAs.Enabled = False

If FrmMainMenu.txtClickExisting.Text = "No" Then
   blnIsNewProject = True
   strpath = "c:\" & FrmNewFile.TxtNewDir.Text

Else
   blnIsNewProject = False
   strpath = FrmExistingFile.DirProject
End If

End Sub
Private Sub mnuOutput_Click()
   StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbNo
      GoTo ProcExit
   Case Is = vbYes
      Unload Me
   End Select

   StrMsg = "Have you edited all the necessary Visual Balance Input and Output
information?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
      Load FrmRunNumber
      FrmRunNumber.Visible = True
      FrmRunNumber.SetFocus
      FrmRunNumber.Refresh
   Else
      FrmEditMenu.Show
      Exit Sub
   End If

ProcExit:
End Sub


Private Sub LblSpillPerMonthFile_Click()
On Error GoTo CheckError:
```

```
If blnIsNewProject = True Then
   OLE1.Class = "Excel.Sheet"                    ' Set class name.
   OLE1.OLETypeAllowed = vbOLELinked             ' Specify type of object.
   OLE1.CreateLink ("c:\VisualBalance\SpillVolumes.xls") ' Create linked object.
Else
   OLE1.Class = "Excel.Sheet"                 ' Set class name.
   OLE1.OLETypeAllowed = vbOLELinked          ' Specify type of object.
   OLE1.CreateLink (strpath & "\SpillVolumes.xls")  ' Specify source file.
End If

OLE1.DoVerb vbOLEOpen

CheckError:
If Err = 31031 Then
   MsgBox "This directory does not contain this data file.  The generic Visual Balance file
will be displayed where you can edit data and save the file to your project directory.",
vbInformation
   OLE1.CreateLink ("c:\VisualBalance\SpillVolumes.xls")
   OLE1.DoVerb vbOLEOpen
End If


End Sub

Private Sub mnuGoToOutput_Click()

If OptDamDepend Then
   blnDamDependFile = True
ElseIf OptConstants Then
   blnDamDependFile = False
Else
   MsgBox "You must slect a an option for Dam Dependant Variables (seepage, volume
retained in dam, and beach area).  These variables can be fixed or dependant on dam crest
elevation.  Please select an option to continue.", vbExclamation
   Exit Sub
End If

If blnDamDependFile = False Then
   If TxtSeepOutRate = "" Or TxtDamLoss = "" Or TxtBeachArea = "" Then
      MsgBox "You selected the constant 'Dam Dependant Values' option, therefore " & _
      "you must enter constants for the seepage loss, volume " & _
      "loss to the dams, and the tailings beach area.  These values can be zero if not
applicable, but can not be left blank.", vbOKOnly
```

```
      Exit Sub
    End If
  End If

  MsgBox "Did you remember to save your changes?", vbYesNo
    If vbYes Then
      Unload Me
      Load FrmRunNumber
      FrmRunNumber.Visible = True
      FrmRunNumber.SetFocus
      FrmRunNumber.Refresh
    ElseIf vbNo Then
      Exit Sub
    End If
  End Sub

  Private Sub mnuReadMe_Click()
    Load FrmReadMe
    FrmReadMe.Show
  End Sub
  Private Sub mnuGoToEditMenu_Click()

    StrMsg = "Did you remember to save your changes?"
    Select Case MsgBox(StrMsg, vbYesNo)
    Case Is = vbYes
      Unload Me
      Load FrmEditMenu
      FrmEditMenu.Show
    Case Is = vbNo
      Exit Sub
    End Select

  End Sub

  Private Sub LblEditCADFile_Click()

  On Error GoTo CheckError:

  If blnIsNewProject = True Then
    OLE1.Class = "Excel.Sheet"                    ' Set class name.
    OLE1.OLETypeAllowed = vbOLELinked             ' Specify type of object.
    OLE1.CreateLink ("c:\VisualBalance\Volume.xls") ' Create linked object.
  Else
```

```
  OLE1.Class = "Excel.Sheet"              ' Set class name.
  OLE1.OLETypeAllowed = vbOLELinked         ' Specify type of object.
  OLE1.CreateLink (strpath & "\Volume.xls")  ' Specify source file.
End If


OLE1.DoVerb vbOLEOpen

CheckError:
If Err = 31031 Then
  MsgBox "This directory does not contain this data file.  The generic Visual Balance file
will be displayed where you can edit data and save the file to your project directory.",
vbInformation
  OLE1.CreateLink ("c:\VisualBalance\Volume.xls")
  OLE1.DoVerb vbOLEOpen
End If
End Sub

Private Sub LblEditSeepFile_Click()

On Error GoTo CheckError:

If blnIsNewProject = True Then
  OLE1.Class = "Excel.Sheet"                ' Set class name.
  OLE1.OLETypeAllowed = vbOLELinked           ' Specify type of object.
  OLE1.CreateLink ("c:\VisualBalance\DamInfo.xls") ' Create linked object.
Else
  OLE1.Class = "Excel.Sheet"              ' Set class name.
  OLE1.OLETypeAllowed = vbOLELinked         ' Specify type of object.
  OLE1.CreateLink (strpath & "\DamInfo.xls")  ' Specify source file.
End If
OLE1.DoVerb vbOLEOpen

CheckError:
If Err = 31031 Then
  MsgBox "Your project directory does not contain this data file." & vbCrLf & "The generic
Visual Balance file will be displayed where you can edit data and save the file to your project
directory.", vbInformation
  OLE1.CreateLink ("c:\VisualBalance\DamInfo.xls")
  OLE1.DoVerb vbOLEOpen
End If

End Sub
```

```
Private Sub ReadData_Click()
 Dim strResName As String * 20
   Dim intVESRows As Integer
   Dim intFileNumber As Integer

On Error GoTo CheckError:

   intFileNumber = FreeFile
   Open (strpath & "\reservoir.txt") For Input As #intFileNumber
   Input #intFileNumber, strResName, strResAbbr, _
   sngCatchArea, sngStartWatElev, sngStartTailElev, _
   sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
   sngSeepReturnRate, _
   sngFracRockIn, sngNeededForReclaim, sngReclaimRate, _
   sngSlurryWatInRate, sngMineWatInRate, sngSeepInRate, _
   sngMaxWatElev, sngMinWatElev, _
   sngFracRunDivert, intDamRows, sngSeepOutRate, sngBeachAreaConstant, _
   sngDamLossConstant, intVESRows, strDependResponse

   TxtResName.Text = strResName
   TxtResAbbr.Text = strResAbbr
   TxtCatchArea.Text = Val(sngCatchArea)
   TxtStartWatElev.Text = Val(sngStartWatElev)
   TxtStartTailElev = sngStartTailElev
   TxtStartSurfArea.Text = Val(sngStartSurfArea)
   TxtStartWatVol = Val(sngStartWatVol)
   TxtStartSolVol = Val(sngStartSolVol)
   TxtSeepReturnRate = Val(sngSeepReturnRate)
   TxtFracRockIn = Val(sngFracRockIn)
   TxtNeededForReclaim.Text = Val(sngNeededForReclaim)
   TxtReclaimRate.Text = Val(sngReclaimRate)
   TxtSlurryWatInRate = Val(sngSlurryWatInRate)
   TxtMineWatInRate = Val(sngMineWatInRate)
   TxtSeepInRate = Val(sngSeepInRate)
   TxtMaxWatElev = Val(sngMaxWatElev)
   TxtMinWatElev = Val(sngMinWatElev)
   TxtFracRunDivert = Val(sngFracRunDivert)
   TxtDamRows = Val(intDamRows)
   TxtSeepOutRate = Val(sngSeepOutRate)
   TxtBeachArea = Val(sngBeachAreaConstant)
   TxtDamLoss = Val(sngDamLossConstant)
   TxtVESrows = Val(intVESRows)
```

```
    If strDependResponse = "True " Then
        OptDamDepend = True
    ElseIf strDependResponse = "False" Then
        OptConstants = True
    End If

    Close #intFileNumber

CheckError:

If Err = 53 Then
    MsgBox "This directory does not contain this data file.  Please input appropriate data and
save the file to your project directory.", vbInformation
    Close #intFileNumber
    Exit Sub
ElseIf Err = 62 Then
    MsgBox "There is an error in your Visual Balance data file.  Either you have not " & _
        "entered required data, or the file does not exist.  " & _
        "Please enter the required data and save the file again.", vbCritical
    Close #intFileNumber
    Exit Sub
ElseIf Err = 0 Then
    Exit Sub
Else
    MsgBox "Unexpected Error # " & Err & "!  " & Err.Description, vbExclamation
    Close #intFileNumber
    Exit Sub
End If

End Sub

Private Sub SaveChanges_Click(Index As Integer)

If OptDamDepend Then
    strDependResponse = "True"
ElseIf OptConstants Then
    strDependResponse = "False"
Else
    MsgBox "You must slect an option for the 'Dam Dependant Variables' (seepage, volume
retained in dam, and beach area).  These variables can be fixed or dependant on dam crest
elevation.  Please select an option to continue.", vbExclamation
    Exit Sub
End If
```

```
Dim intFileNumber As Integer
   On Error GoTo CheckError

   'Open file to write data into.'
      intFileNumber = FreeFile
      Open (strpath & "\reservoir.txt") For Output As #intFileNumber

   'Write Data into File.'
      Write #intFileNumber, TxtResName, TxtResAbbr, _
      Val(TxtCatchArea.Text), Val(TxtStartWatElev.Text), _
      Val(TxtStartTailElev), Val(TxtStartSurfArea), _
      Val(TxtStartWatVol), Val(TxtStartSolVol), _
      Val(TxtSeepReturnRate), _
      Val(TxtFracRockIn), Val(TxtNeededForReclaim), _
      Val(TxtReclaimRate), _
      Val(TxtSlurryWatInRate), _
      Val(TxtMineWatInRate), Val(TxtSeepInRate), _
      Val(TxtMaxWatElev), _
      Val(TxtMinWatElev.Text), Val(TxtFracRunDivert.Text), _
      Val(TxtDamRows), Val(TxtSeepOutRate), Val(TxtBeachArea), _
      Val(TxtDamLoss), Val(TxtVESrows), strDependResponse

      strWhereSaved = "Your Data Has Been Saved as 'reservoir.txt' in your project directory
"

      MsgBox (strWhereSaved & strpath)
      Close #intFileNumber
      Exit Sub

CheckError:

If Err = 53 Then
   MsgBox "This directory does not contain this data file.  Please input appropriate data and
save the file to your project directory.", vbInformation
   Exit Sub
ElseIf Err = 0 Then
   Exit Sub
Else
   MsgBox "Unexpected Error # " & Err & "!  " & Err.Description, vbExclamation
   Close #intFileNumber
   Exit Sub
End If

End Sub
```

```
Private Sub TxtResName_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtResAbbr.SetFocus
   End If
End Sub
Private Sub TxtResAbbr_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtCatchArea.SetFocus
   End If
End Sub
Private Sub TxtResCatchArea_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtStartWatElev.SetFocus
   End If
End Sub
Private Sub TxtStartWatElev_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtStartTailElev.SetFocus
   End If
End Sub
Private Sub TxtStartTailElev_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtStartSurfArea.SetFocus
   End If
End Sub
Private Sub TxtStartSurfArea_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtStartWatVol.SetFocus
   End If
End Sub
Private Sub TxtStartWatVol_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtStartSolVol.SetFocus
   End If
End Sub
Private Sub TxtStartSolVol_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtFracRockIn.SetFocus
   End If
End Sub
Private Sub TxtFracRockIn_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
```

```
    TxtSeepReturnRate.SetFocus
  End If
End Sub
Private Sub TxtSeepReturnRate_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtReclaimRate.SetFocus
  End If
End Sub
Private Sub TxtReclaimRate_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtNeededForReclaim.SetFocus
  End If
End Sub
Private Sub TxtNeededForReclaim_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtSlurryWatInRate.SetFocus
  End If
End Sub
Private Sub TxtSlurryWatInRate_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtMineWatInRate.SetFocus
  End If
End Sub
Private Sub TxtMineWatInRate_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtSeepInRate.SetFocus
  End If
End Sub
Private Sub TxtSeepInRate_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtMaxWatElev.SetFocus
  End If
End Sub
Private Sub TxtMaxWatElev_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtMinWatElev.SetFocus
  End If
End Sub
Private Sub TxtMinWatElev_KeyPress(KeyAscii As Integer)
  If KeyAscii = 13 Then
    TxtFracRunDivert.SetFocus
  End If
End Sub
```

```
Private Sub TxtFracRunDivert_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtSeepOutRate.SetFocus
   End If
End Sub
Private Sub TxtSeepOutRate_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtVESrows.SetFocus
   End If
End Sub
Private Sub TxtVESRows_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
      TxtResName.SetFocus
   End If
End Sub
```

'Water Quality Information Form Code

```
Private Sub Form_Load()
'Centre Form on Screen.'
   Top = (Screen.Height - Height) / 2
   Left = (Screen.Width - Width) / 2

   mnuReturnToMain.Enabled = False

Dim blnIsNewProject As Boolean
If FrmMainMenu.txtClickExisting.Text = "No" Then
   blnIsNewProject = True
  strpath = "c:\" & FrmNewFile.TxtNewDir.Text

   Else
   blnIsNewProject = False
   strpath = FrmExistingFile.DirProject
End If

End Sub

Private Sub mnuGoToEditMenu_Click()
  StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbYes
      Unload Me
      Load FrmEditMenu
      FrmEditMenu.Show
   Case Is = vbNo
      Exit Sub
   End Select
End Sub

Private Sub mnuGoToOutput_Click()
  StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbNo
      GoTo ProcExit
   Case Is = vbYes
      Unload Me
   End Select

   StrMsg = "Have you edited all the necessary Visual Balance Input and Output
```

```
information?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
      Load FrmRunNumber
      FrmRunNumber.Visible = True
      FrmRunNumber.SetFocus
      FrmRunNumber.Refresh
   Else
      FrmEditMenu.Show
      Exit Sub
   End If

ProcExit:
End Sub

Private Sub mnuReadMe_Click()
   Load FrmReadMe
   FrmReadMe.Show
End Sub

Private Sub mnuReturntoMain_Click()
   Unload Me
   Unload FrmExistingFile
   Unload FrmNewFile
   Load FrmMainMenu
   FrmMainMenu.Show
End Sub

Private Sub ReadData_Click(Index As Integer)
Dim intFileNumber As Integer
On Error GoTo CheckError:
   intFileNumber = FreeFile
   Open (strpath & "\water.txt") For Input As #intFileNumber
   Input #intFileNumber, intNumParameters, strChemName1, strAbbr1, sngConc1,
sngDecay1, strChemName2, strAbbr2, sngConc2, sngDecay2

   TxtNumParameters.Text = Val(intNumParameters)
   TxtChemName1.Text = strChemName1
   TxtAbbr1.Text = strAbbr1
   TxtConc1.Text = Val(sngConc1)
   TxtDecay1.Text = Val(sngDecay1)
   TxtChemName2.Text = strChemName2
   TxtAbbr2.Text = strAbbr2
   TxtConc2 = Val(sngConc2)
```

```
   TxtDecay2 = Val(sngDecay2)

   Close #intFileNumber

CheckError:

If Err = 53 Then
   MsgBox "This directory does not contain this data file.  " & vbCrLf & _
   "Please input appropriate data and save the file to your project directory.", vbInformation
   Close #intFileNumber
   Exit Sub
ElseIf Err = 62 Then
   MsgBox "There is an error in your Visual Balance data file.  Either you have not " & _
      "entered required data, or the file does not exist.  " & _
      "Please enter the required data and save the file again.", vbCritical
   Close #intFileNumber
   Exit Sub
ElseIf Err = 0 Then
   Exit Sub
Else
   MsgBox "Unexpected Error # " & Err & "!" & Err.Description, vbExclamation
   Close #intFileNumber
   Exit Sub
End If

End Sub

Private Sub ReturntoEdit_Click(Index As Integer)
'Return to the Mine Edit Menu.'
   StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbYes
      Unload Me
      Load FrmEditMenu
      FrmEditMenu.Show
   Case Is = vbNo
      Exit Sub
   End Select
End Sub

Private Sub SaveChanges_Click()

Dim intFileNumber As Integer
```

```
   On Error GoTo CheckError:

   'Open file to write data into.'
      intFileNumber = FreeFile
      Open (strpath & "\water.txt") For Output As #intFileNumber

   'Write Data into File.'
      Write #intFileNumber, Val(TxtNumParameters.Text), TxtChemName1.Text,
TxtAbbr1.Text, Val(TxtConc1.Text), Val(TxtDecay1.Text), TxtChemName2.Text,
TxtAbbr2.Text, Val(TxtConc2.Text), Val(TxtDecay2.Text)
      strWhereSaved = "Your Data Has Been Saved as 'water.txt' in your project directory  "
      MsgBox (strWhereSaved & strpath)
      Close #intFileNumber
      Exit Sub

      Close #intFileNumber
CheckError:
If Err = 53 Then
   MsgBox "This directory does not contain this data file.  Please input appropriate data and
save the file to your project directory.", vbInformation
   Exit Sub
End If
End Sub


Private Sub TxtNumParameters_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
   TxtChemName1.SetFocus
   End If
End Sub

Private Sub TxtChemName1_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
   TxtAbbr1.SetFocus
   End If
End Sub
Private Sub TxtAbbr1_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
   TxtConc1.SetFocus
   End If
End Sub
Private Sub TxtConc1_KeyPress(KeyAscii As Integer)
   If KeyAscii = 13 Then
```

```
    TxtDecay1.SetFocus
    End If
End Sub
Private Sub TxtDecay1_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
    TxtChemName2.SetFocus
    End If
End Sub
Private Sub TxtChemName2_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
    TxtAbbr2.SetFocus
    End If
End Sub
Private Sub TxtAbbr2_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
    TxtConc2.SetFocus
    End If
End Sub
Private Sub TxtConc2_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
    TxtDecay2.SetFocus
    End If
End Sub
Private Sub TxtDecay2_KeyPress(KeyAscii As Integer)
    If KeyAscii = 13 Then
    TxtNumParameters.SetFocus
    End If
End Sub
```

'Dam Design and Safety Information Form Code

```
Option Explicit
Dim strProjectDirectory As String * 25
Dim strpath, strWhereSaved, StrMsg As String

Dim sngMaxLift, sngSpillWayInvert, intNumClosYears, _
   sngFinalInvertElev As Single

Dim sngFreeBoard1, sngFreeBoard2 As Single
Dim intFreeBoard1Year1, intFreeBoard1Year2, intFreeBoard2Year1, intFreeBoard2Year2
As Integer
Dim intFileNumber As Integer



Private Sub Cancel_Click()
'Return to the Mine Edit Menu.'

   Load FrmEditMenu
   FrmEditMenu.Show
End Sub


Private Sub Exit_Click(Index As Integer)
   Dim StrMsg As String
   Beep
   StrMsg = "Are you sure you want to close Visual Balance?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
   End
   Else
   End If
End Sub

Private Sub Form_Load()
   'Centre Form on Screen.'
   Top = (Screen.Height - Height) / 2
   Left = (Screen.Width - Width) / 2

mnuReturnToMain.Enabled = False

Dim blnIsNewProject As Boolean
If FrmMainMenu.txtClickExisting.Text = "No" Then
```

```
  blnIsNewProject = True
  strpath = "c:\" & FrmNewFile.TxtNewDir.Text
  Else
  blnIsNewProject = False
  strpath = FrmExistingFile.DirProject
End If

End Sub



Private Sub mnuGoToEditMenu_Click()
  StrMsg = "Did you remember to save your changes?"
  Select Case MsgBox(StrMsg, vbYesNo)
  Case Is = vbYes
    Unload Me
    Load FrmEditMenu
    FrmEditMenu.Show
  Case Is = vbNo
    Exit Sub
  End Select
End Sub

Private Sub mnuGoToOutput_Click()
  StrMsg = "Did you remember to save your changes?"
  Select Case MsgBox(StrMsg, vbYesNo)
  Case Is = vbNo
    GoTo ProcExit
  Case Is = vbYes
    Unload Me
  End Select

  StrMsg = "Have you edited all the necessary Visual Balance Input and Output
information?"
  If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
    Load FrmRunNumber
    FrmRunNumber.Visible = True
    FrmRunNumber.SetFocus
    FrmRunNumber.Refresh
  Else
    FrmEditMenu.Show
    Exit Sub
  End If
```

```
ProcExit:
End Sub

Private Sub mnuReadMe_Click()
   Load FrmReadMe
   FrmReadMe.Show
End Sub

Private Sub Label11_Click()
   FreeboardTip.Visible = True
End Sub

Private Sub ReadData_Click(Index As Integer)

On Error GoTo CheckError:

   intFileNumber = FreeFile
   Open (strpath & "\safety.txt") For Input As #intFileNumber
   Input #intFileNumber, sngFreeBoard1, intFreeBoard1Year1, _
      intFreeBoard1Year2, sngFreeBoard2, _
      intFreeBoard2Year1, intFreeBoard2Year2, _
      sngMaxLift, sngSpillWayInvert, sngFinalInvertElev

   TxtFreeBoard1.Text = Val(sngFreeBoard1)
   TxtFreeBoard1Year1.Text = Val(intFreeBoard1Year1)
   TxtFreeBoard1Year2.Text = Val(intFreeBoard1Year2)
   TxtFreeBoard2.Text = Val(sngFreeBoard2)
   TxtFreeBoard2Year1.Text = Val(intFreeBoard2Year1)
   TxtFreeBoard2Year2.Text = Val(intFreeBoard2Year2)
   TxtMaxLift.Text = Val(sngMaxLift)
   TxtSpillInvert.Text = Val(sngSpillWayInvert)
   TxtFinalInvert.Text = Val(sngFinalInvertElev)

   Close #intFileNumber

CheckError:

If Err = 53 Then
   MsgBox "This directory does not contain this data file.  Please input appropriate data and
save the file to your project directory.", vbInformation
   Close #intFileNumber
   Exit Sub
```

```
ElseIf Err = 62 Then
   MsgBox "There is an error in your Visual Balance data file.  Either you have not " & _
      "entered required data, or the file does not exist.  " & _
      "Please enter the required data and save the file again.", vbCritical
   Close #intFileNumber
   Exit Sub
ElseIf Err = 0 Then
   Exit Sub
Else
   MsgBox "Unexpected Error # " & Err & "!", vbExclamation
   Close #intFileNumber
   Exit Sub
Exit Sub
End If

End Sub

Private Sub ReturntoEdit_Click(Index As Integer)
'Return to the Mine Edit Menu.'
   FreeboardTip.Visible = False
   StrMsg = "Did you remember to save your changes?"
   Select Case MsgBox(StrMsg, vbYesNo)
   Case Is = vbYes
      Unload Me
      Load FrmEditMenu
      FrmEditMenu.Show
   Case Is = vbNo
      Exit Sub
   End Select
End Sub

Private Sub SaveChanges_Click(Index As Integer)

'blnSafetyFile = True

Dim intFileNumber As Integer
   'On Error GoTo CheckError

   'Open file to write data into.'
      intFileNumber = FreeFile
      Open (strpath & "\safety.txt") For Output As #intFileNumber

   'Write Data into File.'
```

```
    Write #intFileNumber, Val(TxtFreeBoard1.Text), Val(TxtFreeBoard1Year1.Text), _
      Val(TxtFreeBoard1Year2.Text), Val(TxtFreeBoard2.Text), _
      Val(TxtFreeBoard2Year1.Text), Val(TxtFreeBoard2Year2.Text), _
      Val(TxtMaxLift.Text), Val(TxtSpillInvert.Text), Val(TxtFinalInvert.Text)
    strWhereSaved = "Your Data Has Been Saved as 'safety.txt' in your project directory  "
    MsgBox (strWhereSaved & strpath)
    Close #intFileNumber
    Exit Sub

CheckError:

If Err = 53 Then
  MsgBox "This directory does not contain this data file.  Please input appropriate data and
save the file to your project directory.", vbInformation
  Exit Sub
ElseIf Err = 0 Then
  Exit Sub
Else: MsgBox "Unexpected Error No. " & Err & "   " & Err.Description
  Exit Sub
End If

End Sub
```

'Risk Analysis Data Form Code

```
Option Explicit

Dim blnRiskFile As Boolean

Dim strpath, strWhereSaved, StrMsg As String

Dim sngMeanAnnual, sngStandardDev, _
   sngNumYearsRecord, intNumClosYears, _
   sngRiskFreeboard As Single

Dim intNumSeries, intNoFile, intNumClosSeries As Integer

Private Sub Form_Load()
   Top = (Screen.Height - Height) / 2
   Left = (Screen.Width - Width) / 2

mnuReturnToMain.Enabled = False

Dim blnIsNewProject As Boolean
If FrmMainMenu.txtClickExisting.Text = "No" Then
   blnIsNewProject = True
   strpath = "c:\" & FrmNewFile.TxtNewDir.Text
Else
   blnIsNewProject = False
   strpath = FrmExistingFile.DirProject
End If

End Sub

Private Sub mnuExit_Click()
   Dim StrMsg As String
   Beep
   StrMsg = "Are you sure you want to close Visual Balance?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
   End
   Else
   End If
End Sub

Private Sub mnuGoToEditMenu_Click()
   StrMsg = "Did you remember to save your changes?"
```

```
  Select Case MsgBox(StrMsg, vbYesNo)
  Case Is = vbYes
    Unload Me
    Load FrmEditMenu
    FrmEditMenu.Show
  Case Is = vbNo
    Exit Sub
  End Select
End Sub

Private Sub mnuGoToOutput_Click()
  StrMsg = "Did you remember to save your changes?"
  Select Case MsgBox(StrMsg, vbYesNo)
  Case Is = vbNo
    GoTo ProcExit
  Case Is = vbYes
    Unload Me
  End Select

  StrMsg = "Have you edited all the necessary Visual Balance Input and Output
information?"
  If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
    Load FrmRunNumber
    FrmRunNumber.Visible = True
    FrmRunNumber.SetFocus
    FrmRunNumber.Refresh
  Else
    FrmEditMenu.Show
    Exit Sub
  End If

ProcExit:
End Sub

Private Sub mnuReadData_Click()
  Dim intFileNumber As Integer

On Error GoTo CheckError

  intFileNumber = FreeFile

  Open (strpath & "\RiskData.txt") For Input As #intFileNumber
  Input #intFileNumber, sngMeanAnnual, _
```

```
        sngStandardDev, intNumSeries, _
        sngNumYearsRecord, sngRiskFreeboard, intNumClosSeries, _
        intNumClosYears

    TxtMeanAnn = Val(sngMeanAnnual)
    TxtStandardDev = Val(sngStandardDev)
    TxtNumSeries = Val(intNumSeries)
    TxtNumYearsRecord = Val(sngNumYearsRecord)
    TxtRiskFreeboard = Val(sngRiskFreeboard)
    TxtNumClosSeries = Val(intNumClosSeries)
    TxtNumClosYears = Val(intNumClosYears)

    Close #intFileNumber

CheckError:

If Err = 53 Then
    MsgBox "This directory does not contain this data file.  Please input appropriate data and
save the file to your project directory.", vbInformation
    Close #intFileNumber
    Exit Sub
ElseIf Err = 0 Then
    Exit Sub
ElseIf Err = 62 Then
    MsgBox "There is an error in your Visual Balance data file.  Either you have not " & _
        "entered required data, or the file does not exist.  " & _
        "Please enter the required data and save the file again.", vbCritical
    Close #intFileNumber
    Exit Sub
Else
    MsgBox "Unexpected Error # " & Err & "!  " & Err.Description, vbExclamation
    Close #intFileNumber
    Exit Sub
End If

End Sub

Private Sub mnuReadMe_Click()
    Load FrmReadMe
    FrmReadMe.Show
End Sub
```

```
Private Sub mnuSaveChanges_Click()

blnRiskFile = True

   Dim intFileNumber As Integer
   On Error GoTo CheckError

   If Val(TxtNumSeries.Text) > 1000 Then
      Beep
      MsgBox "Sorry, the number of series run in the risk analysis simulation can not exceed
1,000." & _
         "Please enter a smaller value to continue.  Your changes have not been saved.",
vbExclamation
      Exit Sub
   End If

   'Open file to write data into.'
      intFileNumber = FreeFile
      Open (strpath & "\RiskData.txt") For Output As #intFileNumber

   'Write Data into File.'
      Write #intFileNumber, Val(TxtMeanAnn.Text), _
         Val(TxtStandardDev.Text), _
         Val(TxtNumSeries.Text), _
         Val(TxtNumYearsRecord.Text), _
         Val(TxtRiskFreeboard.Text), _
         Val(TxtNumClosSeries.Text), _
         Val(TxtNumClosYears.Text)
      strWhereSaved = "Your Data Has Been Saved as 'RiskData.txt' in your project directory
"

      MsgBox (strWhereSaved & strpath)
      Close #intFileNumber
      Exit Sub

CheckError:

If Err = 53 Then
   MsgBox "This directory does not contain this data file.  Please input appropriate data and
save the file to your project directory.", vbInformation
   Exit Sub
ElseIf Err = 0 Then
   Exit Sub
Else
```

```
    MsgBox "Unexpected Error # " & Err & "!  " & Err.Description, vbExclamation
    Close #intFileNumber
    Exit Sub
End If
End Sub
```

'Output Menu Code

```
Option Explicit

'General counters and response variables.
Dim blnRiskClosureRan As Boolean
Dim intVESRows, intYear, intSeries, intNumClosSeries, intNumClosYears, _
   intClearSeries, intSeriesCounter, intClosureMonths, _
   intDamRows, intCounter, intClearCounter, _
   intCol, intEDFResponse, intNoFile, _
   intColumn, intPackCounter, intTotalMonths, intMonthCounter, _
   intFileNumber, intRow, sglTotalYears, intYearCounter, _
   intRowCounter, intCurMonth, intPrevMonth, intWrongFormat, _
   intNumReservoirs, intM, intDaysinMonth, intTotalClosMonths, _
   intClosSerCounter As Integer

Dim strProjectDirectory, StrMsg, strpath, strMsgBox, _
   strWhereSaved, strStartMonthLabel, strMonthLabel, _
   strSiteName, strFile As String
Dim strDependResponse, strAnnVary As String * 5

'Design variables.

Dim intFreeBoard1Year1, intFreeBoard1Year2, _
   intFreeBoard2Year1, intFreeBoard2Year2, _
   intYearAsDateCount, intRunNumber, intTotalYears As Integer
Dim sngDamLossConstant, sngSeepOutRateConstant, sngEDFWinter, _
   sngEDFSpring, sngEDFSummer, sngEDFFall, sngMaxLift, sngTempWatElev, _
   sngTempElevDiff(1 To 600), sngDesignSpillVol(1 To 601), _
   sngFracSnow(1 To 12), sngSpillWayInvertElev(1 To 601), _
   sngSpillWayInvert, sngFinalCrestElev As Single

'Production Varibles

   Public intStartMonth, intStartYear, intEndMonth, intEndYear As Integer
   Dim sngTonnesMined, sngTonnesMetal, sngTonnesRock, _
      sngTonnesTail, sngDegSatTail, sngFracWater, _
      sngFracCyclone, sngBulkDRock, sngVoidRRock, _
      sngDryDTail, sngVoidRTail, sngSpecGravTail, _
      sngFracWRsub, sngSpillPerMonth(1 To 12) As Single
   Dim intOperDaysinMonth(1 To 12), intOperDaysPerYear As Integer
   Dim sngAnnMined(1 To 50), sngAnnRock(1 To 50), sngAnnTail(1 To 50), _
      sngFracWRVoidsTail As Single
```

```
'Reservoir Variables

    Dim strResName, strResAbbr, strvolumefile, _
      strSeepOutFile As String * 50
    Public sngStartWatElev, sngStartTailElev, sngCatchArea, _
      sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
      sngSeepReturnRate, sngSeepOutRate, sngFracWRIn, _
      sngSlurryWatInRate, _
      sngMineWatInRate, sngSeepInRate, sngBeachArea, _
      sngMaxWatElev, sngMinWatElev, sngFracRunDivert As Single
    Public sngNeededForReclaim, sngReclaimRate As Single

'General hydrologic Variables (some as arrays representing months
'of the year).

    Dim sngAvgPrecip(1 To 12), sngPercentRain(1 To 12), _
      sngPondEvap(1 To 12), sngBeachEvap(1 To 12), _
      sngIntensity(1 To 12), sngAvgTemp(1 To 12), _
      sngEDFVolume As Single

'Calculation Variables (Arrays of values representing each month
'or each production year).

    Dim sngAnnDirPrecip(1 To 50), sngAnnRunoff(1 To 50), _
      sngAnnMineWater(1 To 50) As Single, sngAnnTailingsWater(1 To 50), _
      sngAnnSeepIn(1 To 50), sngAnnEvap(1 To 50), _
      sngAnnReclaim(1 To 50), sngMonthPondEvap(1 To 600), _
      sngMonthWatLoss(1 To 600), sngMonthSolLoss(1 To 600), _
      sngMonthBeachEvap(1 To 600), sngMonthSeepOut(1 To 600), _
      sngMonthVoidLoss(1 To 600), sngMonthSpill(1 To 600), _
      sngMonthReclaim(1 To 600), sngSpillPerYear, _
      sngDesignFreeboard, sngBeachAreaConstant, _
      sngActualFreeboard(1 To 600), sngMonthDamLoss(1 To 600), _
      sngStarterDamElev, sngMonthTailLossToWR(1 To 600), _
      sngBegWatElev(1 To 600), sngEndWatElev(1 To 600), _
      sngBegWatVol(1 To 600), sngEndWatVol(1 To 600), _
      sngBegTotVol(1 To 600), sngEndTotVol(1 To 600), _
      sngBegSolVol(1 To 600), sngEndSolVol(1 To 600), _
      sngBegPondArea(1 To 600), sngEndPondArea(1 To 600), _
      sngEndSolElev(1 To 600), sngEndDamCrestElev(1 To 600), _
      sngEndEDFElev(1 To 600), sngFreeBoard1, sngFreeBoard2, _
      sngMonthTailVolIn(1 To 600), _
      sngMonthWRVolIn(1 To 600), sngMonthSolIn(1 To 600), _
```

```
    sngMonthTailLoss(1 To 600), sngMonthTailInWRVoids(1 To 600), _
    sngMonthWatLossToWR(1 To 600), sngMonthWatLossToTail(1 To 600), _
    sngDamLoss, sngEndPondDepth(1 To 600), sngMonthDirPre(1 To 600), _
    sngMonthMineWater(1 To 600), sngMonthSlurryWater(1 To 600), _
    sngMonthSeepIn(1 To 600) As Single

'CAD File Variables

Dim sngStartElev(1 To 14), sngEndElev(1 To 14), _
  sngIncVolume(1 To 14), sngCumVolume(1 To 14), _
  sngSurfaceArea(1 To 14) As Single


'Risk Analysis Variables.

Dim lngAnnSpillMonths(1 To 1001, 1 To 50), lngAnnDryTailMonths(1 To 1001, 1 To 50), _
  lngAnnLowFreeMonths(1 To 1001, 1 To 50), lngAnnLowPondMonths(1 To 1001, 1 To
50) As Long

Dim lngTotAnnSpillMonths(1 To 50), lngTotAnnLowFreeMonths(1 To 50), _
  lngTotAnnLowPondMonths(1 To 50), lngTotAnnDryTailMonths(1 To 50) As Long

Dim intYearsWithSpill(1 To 50), intYearsWithLowFree(1 To 50), _
  intYearsWithLowPond(1 To 50), intYearsWithDryTail(1 To 50) As Integer

Dim sngAvgSpillMonths(1 To 50), sngAvgLowFreeMonths(1 To 50), _
  sngAvgLowPondMonths(1 To 50), sngAvgDryTailMonths(1 To 50), _
  sngAnnSpillProb(1 To 50), sngTempSpillVol, sngSpillVol, _
  sngAnnSpillVol(1 To 1001, 1 To 50), sngMaxSpillVol(1 To 50), _
  sngAnnFreshVol(1 To 1001, 1 To 50), sngMaxFreshVol(1 To 50), _
  sngTotSpillVol(1 To 50), sngTotPondDepth(1 To 50), sngTotFreshVol(1 To 50), _
  sngAnnFreeboard(1 To 1001, 1 To 50), sngTotFreeboard(1 To 50), _
  sngAnnLowFreeProb(1 To 50), sngAvgLowFreeHeight(1 To 50), _
  sngAnnLowPondProb(1 To 50), sngAnnDryTailProb(1 To 50), sngAvgSpillVol(1 To 50),
_
  sngAvgPondDepth(1 To 50), sngAnnPondDepth(1 To 1001, 1 To 50), _
  sngAvgFreshVol(1 To 50), sngTempFreshVol, sngFreshVol, _
  sngTempFreeboard As Single

Dim sngBegRiskTotVol(1 To 600), sngEndRiskTotVol(1 To 600), _
  sngBegRiskWatElev(1 To 600), sngEndRiskWatElev(1 To 600), _
  sngBegRiskPondArea(1 To 600), sngEndRiskPondArea(1 To 600), _
  sngEndRiskPondDepth(1 To 600), sngEndRiskEDFElev(1 To 600), _
```

```
   sngRiskDirPre(1 To 600), sngRiskReclaim(1 To 600), sngRiskRunoff(1 To 600), _
   sngRiskPondEvap(1 To 600), sngRiskWatIn(1 To 600), _
   sngRiskWatLoss(1 To 600), sngRiskPondVol(1 To 600), sngMeanAnnual, _
   sngStandardDev, sngSpillTo, sngSpillVolume(1 To 600), sngTempVol, sngRiskPrecip(1
To 600), _
   sngRiskAnnPrecip(1 To 50), sngSimSpillVolume, _
   sngRiskRunoffLoss(1 To 12), sngRiskPondLevel(1 To 600), _
   sngRiskFreeboard, sngMonthPercent(1 To 12), _
   sngRunoffLoss(1 To 12), sngTotalRunoffLoss, _
   sngNumYearsRecord, sngTotalTemporal, _
   sngMonthSeepReturn(1 To 600), sngMonthWatIn(1 To 600), _
   sngMonthRunoff(1 To 600), sngSeriesSpillVolume(1 To 1001) As Single

Dim intStartPackMonth, intEndPackMonth, intTotalPackMonths, _
   intPackMonthCounter, intSpillCount, _
   intReclaimOffCount(1 To 600), intNU, intNoFileMade, _
   intNumSeries As Integer
Dim sngSnowPackDepth, sngFracMelt(1 To 12), sngTotalPackDepth(1 To 1001) As Single
Dim blnIsNewProject, blnRiskRan, blnVbRan, _
   blnCalcDamDependersOnce, blnDamDependFile As Boolean

'Closure Analysis Variables

Dim sngBegClosTotVol(1 To 1200), sngEndClosTotVol(1 To 1200), _
   sngBegClosWatElev(1 To 1200), sngEndClosWatElev(1 To 1200), _
   sngBegClosPondArea(1 To 1200), sngEndClosPondArea(1 To 1200), _
   sngEndClosPondDepth(1 To 1200), sngEndClosEDFElev(1 To 1200), _
   sngClosDirPre(1 To 1200), sngClosRunoff(1 To 1200), _
   sngClosPondEvap(1 To 1200), sngClosWatIn(1 To 1200), _
   sngClosWatLoss(1 To 1200), sngClosPondVol(1 To 1200), _
   sngClosPrecip(1 To 1200), sngClosAnnPrecip(1 To 100), _
   sngClosRunoffLoss(1 To 12), sngClosPondLevel(1 To 1200) As Single

Dim lngClosSpillMonths(1 To 1001, 1 To 100), lngClosDryTailMonths(1 To 1001, 1 To
100), _
   lngClosLowFreeMonths(1 To 1001, 1 To 100) As Long

Dim lngTotClosSpillMonths(1 To 100), lngTotClosLowFreeMonths(1 To 100), _
   lngTotClosDryTailMonths(1 To 100) As Long

Dim intClosYearsWithSpill(1 To 100), intClosYearsWithLowFree(1 To 100), _
   intClosYearsWithDryTail(1 To 100) As Integer
```

```
Dim sngAvgClosSpillMonths(1 To 100), sngAvgClosLowFreeMonths(1 To 100), _
   sngAvgClosDryTailMonths(1 To 100), sngClosSpillProb(1 To 100), _
   sngClosSpillVol(1 To 1001, 1 To 100), sngMaxClosSpillVol(1 To 100), _
   sngTotClosSpillVol(1 To 100), sngClosFreeboard(1 To 1001, 1 To 100), _
   sngTotClosFreeboard(1 To 100), sngTempClosSpillVol, _
   sngClosLowFreeProb(1 To 100), sngAvgClosLowFreeHeight(1 To 100), _
   sngClosDryTailProb(1 To 100), sngAvgClosSpillVol(1 To 100), _
   sngClosureCrest, sngClosSolElev, sngClosSolVol, sngClosInvertElev, _
   sngFinalInvertElev As Single

Dim sngClosMonthSeepOut(1 To 1200), sngClosMonthBeachEvap(1 To 1200), _
   sngClosMonthSeepIn(1 To 1200), sngClosActualFreeboard(1 To 1200), _
   sngAvgClosPondDepth(1 To 100), sngClosPondDepth(1 To 1001, 1 To 100), _
   sngPondDepth, sngTotClosPondDepth(1 To 100), sngTempPondDepth As Single

Dim blnClosureRan As Boolean

'Average Closure Run Variables

Dim sngACBegWatElev(1 To 1200), sngACBegWatVol(1 To 1200), _
   sngACBegTotVol(1 To 1200), sngACBegPondArea(1 To 1200), _
   sngACEndTotVol(1 To 1200), sngACEndWatElev(1 To 1200), _
   sngACEndPondArea(1 To 1200), sngACEndWatVol(1 To 1200), _
   sngACMonthBeachEvap(1 To 1200), sngACPondDepth(1 To 1200), _
   sngACMonthSeepOut(1 To 1200), sngACMonthPondEvap(1 To 1200), _
   sngACMonthSeepIn(1 To 1200), sngACMonthDirPre(1 To 1200), _
   sngACMonthRunoff(1 To 1200), sngACMonthWatIn(1 To 1200), _
   sngACMonthWatLoss(1 To 1200), sngACEndEDFElev(1 To 1200), _
   sngACActualFreeboard(1 To 1200) As Single

Dim lngACDryTailMonths(1 To 1200), lngACLowFreeMonths(1 To 1200), _
   lngACSpillMonths(1 To 1200) As Long

Dim sngACAnnFreeboard(1 To 100), sngACSpillVol, sngACTempSpillVol, _
   sngACMaxSpillVol(1 To 100), sngAvgACSpillMonths(1 To 100), _
   sngAvgACLowFreeMonths(1 To 100), sngACAnnSpillVol(1 To 100), _
   sngAvgACDryTailMonths(1 To 100), sngAvgACSpillVol(1 To 100), _
   sngAvgACLowFreeHeight(1 To 100), _
   sngAvgACPondDepth(1 To 100), sngACAnnPondDepth(1 To 100) As Single

'Output Variables

Dim objExcelOutFile, ObjWatElevFile, objWatQualFile As Object
```

```
Private Sub Exit_Click(Index As Integer)
   Beep
   StrMsg = "Are you sure you want to close Visual Balance?"
   If MsgBox(StrMsg, vbQuestion + vbYesNo) = vbYes Then
   End
   Else
   End If
End Sub

Private Sub Form_Load()

On Error GoTo CheckError:

'Centre Form on the Screen
Top = (Screen.Height - Height) / 2
Left = (Screen.Width - Width) / 2

blnVbRan = False
blnRiskRan = False
blnCalcDamDependersOnce = False
blnCalcElevOnce = False
blnCalcPondOnce = False
blnCalcVolumeOnce = False
blnClosureRan = False
blnRiskClosureRan = False
WaterQual(2).Enabled = False

intRunNumber = FrmRunNumber.TxtRunNum

If FrmMainMenu.txtClickExisting.Text = "No" Then
   blnIsNewProject = True
   strpath = "c:\" & FrmNewFile.TxtNewDir.Text
Else
   blnIsNewProject = False
   strpath = FrmExistingFile.DirProject
End If

'Open the general mine information file. Read the
   'data to the appropriate variables.

   intFileNumber = FreeFile

      Open (strpath & "\mine.txt") For Input As #intFileNumber
```

```
    Input #intFileNumber, strSiteName, strSiteDescription, _
      intNumReservoirs, sngStarterDamElev
    Close #intFileNumber

'Open the reservoir data file and read values into variables.

  Open (strpath & "\reservoir.txt") For Input As #intFileNumber
  Input #intFileNumber, strResName, strResAbbr, _
    sngCatchArea, sngStartWatElev, sngStartTailElev, _
    sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
    sngSeepReturnRate, sngFracWRIn, _
    sngNeededForReclaim, sngReclaimRate, _
    sngSlurryWatInRate, sngMineWatInRate, _
    sngSeepInRate, sngMaxWatElev, sngMinWatElev, _
    sngFracRunDivert, intDamRows, _
    sngSeepOutRate, sngBeachAreaConstant, sngDamLossConstant, _
    intVESRows, strDependResponse
  Close #intFileNumber

'Read the Dam design data etcetera...

  intFileNumber = FreeFile
  Open (strpath & "\safety.txt") For Input As #intFileNumber
  Input #intFileNumber, sngFreeBoard1, intFreeBoard1Year1, _
    intFreeBoard1Year2, sngFreeBoard2, intFreeBoard2Year1, _
    intFreeBoard2Year2, sngMaxLift, sngSpillWayInvert, _
    sngFinalInvertElev
  Close #intFileNumber

'Open the hydrological extreme data file.

  Open (strpath & "\extremes.txt") For Input As #intFileNumber
  Input #intFileNumber, intEDFResponse, sngEDFWinter, sngEDFSpring, _
    sngEDFSummer, sngEDFFall, intStartPackMonth, intEndPackMonth, _
    intTotalPackMonths
  Close #intFileNumber

'Open the mine production information file.  Read the
'data to the appropriate variables.

intFileNumber = FreeFile
```

```
   Open (strpath & "\production.txt") For Input As #intFileNumber
   Input #intFileNumber, intStartMonth, intStartYear, _
      intEndMonth, intEndYear, sngTonnesMined, _
      sngTonnesMetal, sngTonnesRock, sngTonnesTail, _
      sngBulkDRock, sngVoidRRock, sngFracWRsub, sngFracWRVoidsTail, _
      sngDegSatTail, sngFracWater, sngFracCyclone, _
      sngDryDTail, sngVoidRTail, sngSpecGravTail, strAnnVary
   Close #intFileNumber

'Read in risk variables from text file.

   intFileNumber = FreeFile

   Open (strpath & "\RiskData.txt") For Input As #intFileNumber
   Input #intFileNumber, sngMeanAnnual, _
      sngStandardDev, intNumSeries, _
      sngNumYearsRecord, sngRiskFreeboard, intNumClosSeries, intNumClosYears
   Close #intFileNumber


'Determine the total number of months for which inflow
'water must be calculated.

If intStartMonth < intEndMonth Then
   intTotalMonths = (intEndMonth - intStartMonth) _
   + (intEndYear - intStartYear) * 12
Else
   intTotalMonths = (intEndYear - intStartYear - 1) * 12 _
      + (12 - intEndMonth)
End If

sglTotalYears = (intStartMonth / 12) + _
   (intEndYear - intStartYear) - 1


'________________________________________________________________________
'Error Handling

CheckError:
   intNoFile = 31031
   intNoFileMade = 53

   If Err = intNoFile Then
```

```
    OLE1.CreateLink ("c:\VisualBalance\RiskData.xls")

  ElseIf Err = 0 Then
    Me.Show
  ElseIf Err = 6 Then
    MsgBox "There is an error in the data in one of your " & _
      "data files.  Visual Balance has detected an overflow " & _
      "error in a standard data file (not an Excel file).  Please " & _
      "return to the data edit menu and ensure that all the appropriate " & _
      "data has been entered prior to running Visual Balance.", vbCritical
    Close #intFileNumber
    GoTo ShowEditMenu
  ElseIf Err = 53 Then
    MsgBox "There are required data files missing from your directory.  " & vbCrLf & _
      "Please return to the data edit menu to add data files or use " & _
      "Windows Explorer to ensure that all required data has been entered.", vbExclamation
    GoTo ShowEditMenu
    Exit Sub
  ElseIf Err = 62 Then
    MsgBox "There is an error in one of your data files.  Either you have not " & _
      "entered required data, or the file does not exist.  " & _
      "Please return to the data edit menu and edit your project data input files.", vbCritical
    Close #intFileNumber
    GoTo ShowEditMenu
  Else
    MsgBox "Unexpected Error # " & Err & "!", vbExclamation
    Close #intFileNumber
    GoTo ShowEditMenu
    Exit Sub
  End If

ShowEditMenu:
  Load FrmEditMenu
  FrmEditMenu.mnuGeneralData.Enabled = True
  FrmEditMenu.mnuMineProduction.Enabled = True
  FrmEditMenu.mnuSiteHydrology.Enabled = True
  FrmEditMenu.mnuReservoirInfo.Enabled = True
  FrmEditMenu.mnuReservoirLinks.Enabled = True
  FrmEditMenu.mnuWaterQual.Enabled = True
  FrmEditMenu.mnuDamSafety.Enabled = True
  FrmEditMenu.mnuRiskData.Enabled = True
  FrmEditMenu.mnuGoToOutput.Enabled = True
  FrmEditMenu.Refresh
```

```
   FrmEditMenu.Show
   Close #intFileNumber
   Exit Sub

ProcExit:
   Close #intFileNumber
   Exit Sub

ProcError:
   Close #intFileNumber
   MsgBox Err.Description
   Resume ProcExit

OverflowError:
   Close #intFileNumber
   Unload FrmWaitingSign
   FrmOutputMenu.MousePointer = 1
   MsgBox "Due to the overflow error in your reservoir, Visual Balance was unable to
complete the water balance.  Please edit your input files in order to proceed.", vbOKOnly
   Exit Sub

Me.Refresh
Me.Show

End Sub

Private Sub mnuMain_Click(Index As Integer)
   Unload Me
   FrmMainMenu.Show
End Sub

Private Sub mnuAvgClosureTables_Click()

If blnClosureRan = False Then
   MsgBox "You need to run a Visual Balance Closure Analysis " & _
   "for this data prior to viewing output.", vbExclamation
   GoTo ProcExit:
End If

   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is creating " & _
      "an Excel output file for your Closure Analysis..."
   FrmWaitingSign.Visible = True
```

```
   FrmWaitingSign.Show
   FrmWaitingSign.Refresh
   MousePointer = vbHourglass

Dim appClosResults As New Excel.Application
Dim wkbClosResults As New Excel.Workbook
Dim wksClosResults As New Excel.Worksheet

   appClosResults.Workbooks.Add
   appClosResults.Worksheets.Add

   With appClosResults.Range("A1:F30").Font
      .Size = 10
      .Name = "Arial"
      .ColorIndex = 1
   End With

   appClosResults.Range("A1:F1").ColumnWidth = 20
   appClosResults.Range("A4:E12").NumberFormat = "#,##0"
   appClosResults.Range("B7:G300").NumberFormat = "###,###,##0.0#"
'______________________________________________________________________

With appClosResults
   .Cells(1, 1).Value = "Closure Analysis Summary Statistics for " & strSiteName
   .Cells(1, 1).Font.Bold = True

   .Cells(3, 1).Value = "Closure Analysis Input Parameters"
   .Cells(3, 1).Font.Bold = True

   .Cells(4, 1).Value = "Minimum Design Freeboard (above EDF)"
   .Cells(5, 1).Value = "Risk Freeboard (above EDF)"
   .Cells(6, 1).Value = "Final Spillway Invert Elevation"
   .Cells(7, 1).Value = "Final Dam Crest Elevation"
   .Cells(8, 1).Value = "Number of Years in Closure Series"
   .Cells(9, 1).Value = "Number of Series in Simulation"

   .Cells(4, 3).Value = sngFreeBoard1
   .Cells(5, 3).Value = sngRiskFreeboard
   .Cells(6, 3).Value = sngClosInvertElev
   .Cells(7, 3).Value = sngClosureCrest
   .Cells(8, 3).Value = intNumClosYears
   .Cells(9, 3).Value = intNumClosSeries
```

```
.Range("A11:F15").Font.Bold = True
.Cells(11, 1).Value = "Closure Analysis Annual Summary Statistics"
.Cells(12, 1).Value = "Spill Results"
.Cells(13, 1).Value = "Year In Series "
.Cells(13, 2).Value = "Avg. # Months"
.Cells(14, 2).Value = "With Spill"
.Cells(13, 3).Value = "Average Annual"
.Cells(14, 3).Value = "Prob. of Spill (%)"
.Cells(13, 4).Value = "Avg. Spill Volume"
.Cells(14, 5).Value = "Maximum Spill Volume"

intRowCounter = 15
intCounter = 0
While intCounter < intNumClosYears
   intRowCounter = intRowCounter + 1
   intCounter = intCounter + 1
   'Spill Statistics
   .Cells(intRowCounter, 1).Value = intCounter
   .Cells(intRowCounter, 2).Value = lngACSpillMonths(intCounter)
   .Cells(intRowCounter, 3).Value = (lngACSpillMonths(intCounter) / 12) * 100
   .Cells(intRowCounter, 4).Value = sngAvgACSpillVol(intCounter)
   .Cells(intRowCounter, 5).Value = sngACMaxSpillVol(intCounter)
Wend

   .Cells(intRowCounter + 1, 1).Font.Bold = True
   .Cells(intRowCounter + 2, 1).Font.Bold = True
   .Cells(intRowCounter + 2, 2).Font.Bold = True
   .Cells(intRowCounter + 3, 2).Font.Bold = True
   .Cells(intRowCounter + 2, 3).Font.Bold = True
   .Cells(intRowCounter + 3, 3).Font.Bold = True
   .Cells(intRowCounter + 2, 4).Font.Bold = True
   .Cells(intRowCounter + 3, 4).Font.Bold = True
   .Cells(intRowCounter + 1, 1).Value = "Freeboard Results"
   .Cells(intRowCounter + 2, 1).Value = "Year in Series"
   .Cells(intRowCounter + 2, 2).Value = "Avg. # Months with"
   .Cells(intRowCounter + 3, 2).Value = "Low Freeboard"
   .Cells(intRowCounter + 2, 3).Value = "Avg. Annual Prob."
   .Cells(intRowCounter + 3, 3).Value = "of Low Freeboard (%)"
   .Cells(intRowCounter + 2, 4).Value = "Avg. Height of"
   .Cells(intRowCounter + 3, 4).Value = "'Low Freeboards' "

intCounter = 0
intRowCounter = intRowCounter + 4
```

```
    While intCounter < intNumClosYears
        intCounter = intCounter + 1
        'Freeboard Statistics
        .Cells(intRowCounter, 1).Value = intCounter
        .Cells(intRowCounter, 2).Value = sngAvgACLowFreeMonths(intCounter)
        .Cells(intRowCounter, 3).Value = sngAvgACLowFreeMonths(intCounter) / 12 * 100
        .Cells(intRowCounter, 4).Value = sngAvgACLowFreeHeight(intCounter)
        intRowCounter = intRowCounter + 1
    Wend

    .Cells(intRowCounter + 1, 1).Font.Bold = True
    .Cells(intRowCounter + 2, 1).Font.Bold = True
    .Cells(intRowCounter + 2, 2).Font.Bold = True
    .Cells(intRowCounter + 3, 2).Font.Bold = True
    .Cells(intRowCounter + 2, 3).Font.Bold = True
    .Cells(intRowCounter + 3, 3).Font.Bold = True
    .Cells(intRowCounter + 2, 4).Font.Bold = True
    .Cells(intRowCounter + 3, 4).Font.Bold = True
    .Cells(intRowCounter + 1, 1).Value = "Tailings Exposure Results"
    .Cells(intRowCounter + 2, 1).Value = "Year in Series"
    .Cells(intRowCounter + 2, 2).Value = "Avg. # Months with"
    .Cells(intRowCounter + 3, 2).Value = "Solids Exposed"
    .Cells(intRowCounter + 2, 3).Value = "Avg. Annual Prob."
    .Cells(intRowCounter + 3, 3).Value = "of Solids Exposure"
    .Cells(intRowCounter + 2, 4).Value = "Avg. Depth of Water"
    .Cells(intRowCounter + 3, 4).Value = "above solids (m)"

    intCounter = 0
    intRowCounter = intRowCounter + 5
    While intCounter < intNumClosYears
        intCounter = intCounter + 1
        'Tailings Statistics
        .Cells(intRowCounter, 1).Value = intCounter
        .Cells(intRowCounter, 2).Value = sngAvgACDryTailMonths(intCounter)
        .Cells(intRowCounter, 3).Value = sngAvgACDryTailMonths(intCounter) / 12 * 100
        .Cells(intRowCounter, 4).Value = sngAvgACPondDepth(intCounter)
        intRowCounter = intRowCounter + 1
    Wend

End With
'___________________________________

Unload FrmWaitingSign
```

```
appClosResults.Visible = True

MousePointer = 1

ProcExit:
   Exit Sub
End Sub

Private Sub mnuRiskClosureTables_Click()

If blnClosureRan = False Then
   MsgBox "You need to run a Visual Balance Closure Risk Analysis " & _
   "for this data prior to viewing output.", vbExclamation
   GoTo ProcExit:
End If

   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is creating " & _
      "an Excel output file for your VB Closure Risk Analysis..."
   FrmWaitingSign.Visible = True
   FrmWaitingSign.Show
   FrmWaitingSign.Refresh
   MousePointer = vbHourglass

Dim appClosRiskResults As New Excel.Application
Dim wkbClosRiskResults As New Excel.Workbook
Dim wksClosRiskResults As New Excel.Worksheet

   appClosRiskResults.Workbooks.Add
   appClosRiskResults.Worksheets.Add

   With appClosRiskResults.Range("A1:F30").Font
      .Size = 10
      .Name = "Arial"
      .ColorIndex = 1
   End With

   appClosRiskResults.Range("A1:F1").ColumnWidth = 20
   appClosRiskResults.Range("A4:E12").NumberFormat = "#,##0"
   appClosRiskResults.Range("B7:G300").NumberFormat = "###,###,##0.0#"
'_______________________________________________________________

With appClosRiskResults
```

```
.Cells(1, 1).Value = "Closure Analysis Summary Statistics for " & strSiteName
.Cells(1, 1).Font.Bold = True

.Cells(3, 1).Value = "Closure Analysis Input Parameters"
.Cells(3, 1).Font.Bold = True

.Cells(4, 1).Value = "Mean Annual Precipitation"
.Cells(5, 1).Value = "Standard Deviation"
.Cells(6, 1).Value = "Number of Years of record"
.Cells(7, 1).Value = "Minimum Design Freeboard (above EDF)"
.Cells(8, 1).Value = "Risk Freeboard (above EDF)"
.Cells(9, 1).Value = "Final Spillway Invert Elevation"
.Cells(10, 1).Value = "Final Dam Crest Elevation"

.Cells(4, 3).Value = sngMeanAnnual
.Cells(5, 3).Value = sngStandardDev
.Cells(6, 3).Value = sngNumYearsRecord
.Cells(7, 3).Value = sngFreeBoard1
.Cells(8, 3).Value = sngRiskFreeboard
.Cells(9, 3).Value = sngClosInvertElev
.Cells(10, 3).Value = sngClosureCrest

.Cells(11, 1).Font.Bold = True
.Cells(11, 1).Value = "Operation Input Parameters"
.Cells(12, 1).Value = "Number of Years in Closure Series"
.Cells(13, 1).Value = "Number of Series in Simulation"
.Cells(12, 3).Value = intNumClosYears
.Cells(13, 3).Value = intNumClosSeries

.Range("A15:F18").Font.Bold = True
.Cells(15, 1).Value = "Closure Analysis Summary Statistics"

.Cells(16, 1).Value = "Spill Results"
.Cells(17, 1).Value = "Year In Series "
.Cells(17, 2).Value = "Avg. # Months"
.Cells(18, 2).Value = "With Spill"
.Cells(17, 3).Value = "Average Annual"
.Cells(18, 3).Value = "Prob. of Spill (%)"
.Cells(17, 4).Value = "Avg. Spill Volume"
.Cells(17, 5).Value = "Maximum Spill Volume"

intRowCounter = 18
intCounter = 0
```

```
While intCounter < intNumClosYears
   intRowCounter = intRowCounter + 1
   intCounter = intCounter + 1
   'Spill Statistics
   .Cells(intRowCounter, 1).Value = intCounter
   .Cells(intRowCounter, 2).Value = sngAvgClosSpillMonths(intCounter)
   .Cells(intRowCounter, 3).Value = sngClosSpillProb(intCounter)
   .Cells(intRowCounter, 4).Value = sngAvgClosSpillVol(intCounter)
   .Cells(intRowCounter, 5).Value = sngMaxClosSpillVol(intCounter)
Wend

   .Cells(intRowCounter + 1, 1).Font.Bold = True
   .Cells(intRowCounter + 2, 1).Font.Bold = True
   .Cells(intRowCounter + 2, 2).Font.Bold = True
   .Cells(intRowCounter + 3, 2).Font.Bold = True
   .Cells(intRowCounter + 2, 3).Font.Bold = True
   .Cells(intRowCounter + 3, 3).Font.Bold = True
   .Cells(intRowCounter + 2, 4).Font.Bold = True
   .Cells(intRowCounter + 3, 4).Font.Bold = True
   .Cells(intRowCounter + 1, 1).Value = "Freeboard Results"
   .Cells(intRowCounter + 2, 1).Value = "Year in Series"
   .Cells(intRowCounter + 2, 2).Value = "Avg. # Months with"
   .Cells(intRowCounter + 3, 2).Value = "Low Freeboard"
   .Cells(intRowCounter + 2, 3).Value = "Avg. Annual Prob."
   .Cells(intRowCounter + 3, 3).Value = "of Low Freeboard (%)"
   .Cells(intRowCounter + 2, 4).Value = "Avg. Height of"
   .Cells(intRowCounter + 3, 4).Value = " 'Low Freeboards'"

intCounter = 0
intRowCounter = intRowCounter + 4
While intCounter < intNumClosYears
   intCounter = intCounter + 1
   'Freeboard Statistics
   .Cells(intRowCounter, 1).Value = intCounter
   .Cells(intRowCounter, 2).Value = sngAvgClosLowFreeMonths(intCounter)
   .Cells(intRowCounter, 3).Value = sngClosLowFreeProb(intCounter)
   .Cells(intRowCounter, 4).Value = sngAvgClosLowFreeHeight(intCounter)
   intRowCounter = intRowCounter + 1
Wend

.Cells(intRowCounter + 1, 1).Font.Bold = True
.Cells(intRowCounter + 2, 1).Font.Bold = True
.Cells(intRowCounter + 2, 2).Font.Bold = True
```

```
    .Cells(intRowCounter + 3, 2).Font.Bold = True
    .Cells(intRowCounter + 2, 3).Font.Bold = True
    .Cells(intRowCounter + 3, 3).Font.Bold = True
    .Cells(intRowCounter + 2, 4).Font.Bold = True
    .Cells(intRowCounter + 3, 4).Font.Bold = True
    .Cells(intRowCounter + 1, 1).Value = "Tailings Exposure Results"
    .Cells(intRowCounter + 2, 1).Value = "Year in Series"
    .Cells(intRowCounter + 2, 2).Value = "Avg. # Months with"
    .Cells(intRowCounter + 3, 2).Value = "Solids Exposed"
    .Cells(intRowCounter + 2, 3).Value = "Avg. Annual Prob."
    .Cells(intRowCounter + 3, 3).Value = "of Solids Exposure"
    .Cells(intRowCounter + 2, 4).Value = "Avg. Depth of Water"
    .Cells(intRowCounter + 3, 4).Value = "above solids (m)"

    intCounter = 0
    intRowCounter = intRowCounter + 5
    While intCounter < intNumClosYears
      intCounter = intCounter + 1
      'Tailings Statistics
      .Cells(intRowCounter, 1).Value = intCounter
      .Cells(intRowCounter, 2).Value = sngAvgClosDryTailMonths(intCounter)
      .Cells(intRowCounter, 3).Value = sngClosDryTailProb(intCounter)
      .Cells(intRowCounter, 4).Value = sngAvgClosPondDepth(intCounter)
      intRowCounter = intRowCounter + 1
    Wend

End With
'_____________________________________

Unload FrmWaitingSign

appClosRiskResults.Visible = True

MousePointer = 1

ProcExit:
  Exit Sub

End Sub


Private Sub mnuReturntoEdit_Click(Index As Integer)
  Unload Me
```

```
   Load FrmEditMenu
   FrmEditMenu.mnuGeneralData.Enabled = True
   FrmEditMenu.mnuMineProduction.Enabled = True
   FrmEditMenu.mnuSiteHydrology.Enabled = True
   FrmEditMenu.mnuReservoirInfo.Enabled = True
   FrmEditMenu.mnuReservoirLinks.Enabled = True
   FrmEditMenu.mnuWaterQual.Enabled = True
   FrmEditMenu.mnuDamSafety.Enabled = True
   FrmEditMenu.mnuRiskData.Enabled = True
   FrmEditMenu.mnuGoToOutput.Enabled = True
   FrmEditMenu.Show
End Sub

Private Sub mnuReturntoMain_Click()
   Unload Me
   Load FrmMainMenu
   FrmMainMenu.Refresh
   FrmMainMenu.Show
End Sub

Private Sub mnuRiskGraph_Click()
Dim intColumn As Integer

If blnRiskRan = False Then
   MsgBox "You need to run a risk analysis for this data prior to viewing output.",
vbExclamation
   GoTo ProcExit:
End If

   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is creating " & _
      "an Excel output graph file..."
   FrmWaitingSign.Visible = True
   FrmWaitingSign.Show
   FrmWaitingSign.Refresh
   MousePointer = vbHourglass

Exit Sub

Dim blnIsNewProject As Boolean
If FrmMainMenu.txtClickExisting.Text = "No" Then
   blnIsNewProject = True
   strpath = "c:\" & FrmNewFile.TxtNewDir.Text
```

```
Else
   blnIsNewProject = False
   strpath = FrmExistingFile.DirProject
End If

Dim appRisk As Object
Dim wksRiskData As Object
Dim wkbRisk As Excel.Workbook
   Set wkbRisk = GetObject("c:\VisualBalance\RiskCurve.xls")
   Set appRisk = wkbRisk.Application
   Set wksRiskData = wkbRisk.Worksheets("RiskData")

'Label the the month record/Columns.'
   strStartMonthLabel = FindMonthLabel(intStartMonth)
   wksRiskData.Cells(2, 3).Value = strStartMonthLabel

   intColumn = 2
   intMonthCounter = 1
   intYearCounter = 1
   Do Until intMonthCounter > intTotalMonths
      intColumn = intColumn + 1
      intMonthCounter = intMonthCounter + 1
      intCurMonth = (intMonthCounter + (intStartMonth - 1)) _
      - ((intYearCounter - 1) * 12)
         If intCurMonth = 12 Then
            intYearCounter = intYearCounter + 1
         End If
      strMonthLabel = FindMonthLabel(intCurMonth)
      wksRiskData.Cells(3, intColumn).Value = strMonthLabel
   Loop


'Fill the time in years into the second row.
   intColumn = 2
   intMonthCounter = 0
   intYearCounter = 0
   Do Until intMonthCounter > intTotalMonths
      intMonthCounter = intMonthCounter + 1
      intYearCounter = intMonthCounter / 12
      wksRiskData.Cells(2, intColumn).Value = _
      intYearCounter
      intColumn = intColumn + 1
   Loop
```

```
'Put the End of the month water volume in the 13th row.
   intColumn = 2
   intMonthCounter = 0
   Do Until intMonthCounter > intTotalMonths
      intMonthCounter = intMonthCounter + 1
      wksRiskData.Cells(13, intColumn).Value = _
         sngEndRiskTotVol(intMonthCounter)
      intColumn = intColumn + 1
   Loop

'Put the End of the month solids elevation in the fourth column.
'Put the End of the month water elevation in the fifth column.
'Put the End of the month dam crest elevation in the sixth column.
   intColumn = 2
   intMonthCounter = 0
   Do Until intMonthCounter > intTotalMonths
      intMonthCounter = intMonthCounter + 1
      wksRiskData.Cells(4, intColumn).Value = _
         sngEndSolElev(intMonthCounter)
      wksRiskData.Cells(5, intColumn).Value = _
         sngEndRiskWatElev(intMonthCounter)
      wksRiskData.Cells(6, intColumn).Value = _
         sngEndRiskEDFElev(intMonthCounter)
      wksRiskData.Cells(10, intColumn).Value = _
         sngEndDamCrestElev(intMonthCounter)
      intColumn = intColumn + 1
   Loop

Unload FrmWaitingSign
MousePointer = 1

wkbRisk.SaveAs (strpath & "\RiskCurve.xls")

   OLE1.Class = "Excel.Sheet"                    ' Set class name.
   OLE1.OLETypeAllowed = vbOLELinked
   OLE1.CreateLink (strpath & "\RiskCurve.xls")
   OLE1.DoVerb vbOLEOpen

ProcExit:
   Exit Sub
```

```
End Sub

Private Sub mnuRiskTables_Click()

If blnRiskRan = False Then
   MsgBox "You need to run a risk analysis for this data prior to viewing output.",
vbExclamation
   GoTo ProcExit:
End If

   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is creating an " & _
      " Excel output file for your VB Risk Analysis..."
   FrmWaitingSign.Visible = True
   FrmWaitingSign.Show
   FrmWaitingSign.Refresh
   MousePointer = vbHourglass

Dim appRiskResults As New Excel.Application
Dim wkbRiskResults As New Excel.Workbook
Dim wksRiskResults As New Excel.Worksheet

   appRiskResults.Workbooks.Add
   appRiskResults.Worksheets.Add

   With appRiskResults.Range("A1:F30").Font
      .Size = 10
      .Name = "Arial"
      .ColorIndex = 1
   End With

   appRiskResults.Range("A1:F1").ColumnWidth = 20
   appRiskResults.Range("A4:E12").NumberFormat = "#,##0"
   appRiskResults.Range("B7:G300").NumberFormat = "###,###,##0.0#"
'________________________________________________________________

With appRiskResults
   .Cells(1, 1).Value = "Risk Analysis Summary Statistics for " & strSiteName
   .Cells(1, 1).Font.Bold = True

   .Cells(3, 1).Value = "Risk Analysis Input Parameters"
   .Cells(3, 1).Font.Bold = True
```

```
.Cells(4, 1).Value = "Mean Annual Precipitation"
.Cells(5, 1).Value = "Standard Deviation"
.Cells(6, 1).Value = "Number of Years of record"
.Cells(7, 1).Value = "Minimum Design Freeboard (above EDF)"
.Cells(8, 1).Value = "Risk Freeboard (above EDF)"
.Cells(9, 1).Value = "SpillWay Invert, Height Above EDF"
.Cells(10, 1).Value = "Pond Depth Required for Reclaim"

.Cells(4, 3).Value = sngMeanAnnual
.Cells(5, 3).Value = sngStandardDev
.Cells(6, 3).Value = sngNumYearsRecord
.Cells(7, 3).Value = sngFreeBoard1
.Cells(8, 3).Value = sngRiskFreeboard
.Cells(9, 3).Value = sngSpillWayInvert
.Cells(10, 3).Value = sngNeededForReclaim

.Cells(11, 1).Font.Bold = True
.Cells(11, 1).Value = "Operation Input Parameters"
.Cells(12, 1).Value = "Number of Years in Operation Series"
.Cells(13, 1).Value = "Number of Series in Simulation"
.Cells(12, 3).Value = intTotalYears
.Cells(13, 3).Value = intNumSeries

.Range("A15:F18").Font.Bold = True
.Cells(15, 1).Value = "Risk Analysis Summary Statistics"

.Cells(16, 1).Value = "Spill Results"
.Cells(17, 1).Value = "Year In Series "
.Cells(17, 2).Value = "Avg. # Months"
.Cells(18, 2).Value = "With Spill"
.Cells(17, 3).Value = "Average Annual"
.Cells(18, 3).Value = "Prob. of Spill (%)"
.Cells(17, 4).Value = "Avg. Spill Volume"
.Cells(17, 5).Value = "Maximum Spill Volume"

intRowCounter = 18
intCounter = 0
While intCounter < intTotalYears
   intRowCounter = intRowCounter + 1
   intCounter = intCounter + 1
   'Spill Statistics
   .Cells(intRowCounter, 1).Value = intCounter
   .Cells(intRowCounter, 2).Value = sngAvgSpillMonths(intCounter)
```

```
   .Cells(intRowCounter, 3).Value = sngAnnSpillProb(intCounter)
   .Cells(intRowCounter, 4).Value = sngAvgSpillVol(intCounter)
   .Cells(intRowCounter, 5).Value = sngMaxSpillVol(intCounter)
Wend

   .Cells(intRowCounter + 1, 1).Font.Bold = True
   .Cells(intRowCounter + 2, 1).Font.Bold = True
   .Cells(intRowCounter + 2, 2).Font.Bold = True
   .Cells(intRowCounter + 3, 2).Font.Bold = True
   .Cells(intRowCounter + 2, 3).Font.Bold = True
   .Cells(intRowCounter + 3, 3).Font.Bold = True
   .Cells(intRowCounter + 2, 4).Font.Bold = True
   .Cells(intRowCounter + 3, 4).Font.Bold = True
   .Cells(intRowCounter + 1, 1).Value = "Freeboard Results"
   .Cells(intRowCounter + 2, 1).Value = "Year in Series"
   .Cells(intRowCounter + 2, 2).Value = "Avg. # Months with"
   .Cells(intRowCounter + 3, 2).Value = "Low Freeboard"
   .Cells(intRowCounter + 2, 3).Value = "Avg. Annual Prob."
   .Cells(intRowCounter + 3, 3).Value = "of Low Freeboard (%)"
   .Cells(intRowCounter + 2, 4).Value = "Avg. Height of"
   .Cells(intRowCounter + 3, 4).Value = " 'Low Freeboards'"

intCounter = 0
intRowCounter = intRowCounter + 4
While intCounter < intTotalYears
   intCounter = intCounter + 1
   'Freeboard Statistics
   .Cells(intRowCounter, 1).Value = intCounter
   .Cells(intRowCounter, 2).Value = sngAvgLowFreeMonths(intCounter)
   .Cells(intRowCounter, 3).Value = sngAnnLowFreeProb(intCounter)
   .Cells(intRowCounter, 4).Value = sngAvgLowFreeHeight(intCounter)
   intRowCounter = intRowCounter + 1
Wend

.Cells(intRowCounter + 1, 1).Font.Bold = True
.Cells(intRowCounter + 2, 1).Font.Bold = True
.Cells(intRowCounter + 2, 2).Font.Bold = True
.Cells(intRowCounter + 3, 2).Font.Bold = True
.Cells(intRowCounter + 2, 3).Font.Bold = True
.Cells(intRowCounter + 3, 3).Font.Bold = True
.Cells(intRowCounter + 2, 4).Font.Bold = True
.Cells(intRowCounter + 3, 4).Font.Bold = True
.Cells(intRowCounter + 2, 5).Font.Bold = True
```

```
.Cells(intRowCounter + 3, 5).Font.Bold = True
.Cells(intRowCounter + 1, 1).Value = "Reclaim Results"
.Cells(intRowCounter + 2, 1).Value = "Year in Series"
.Cells(intRowCounter + 2, 2).Value = "Avg. # Months with"
.Cells(intRowCounter + 3, 2).Value = "Reclaim Off"
.Cells(intRowCounter + 2, 3).Value = "Avg. Annual Prob."
.Cells(intRowCounter + 3, 3).Value = "Month Reclaim Off (%)"
.Cells(intRowCounter + 2, 4).Value = "Avg. Freshwater"
.Cells(intRowCounter + 3, 4).Value = "Makeup Vol. Required"
.Cells(intRowCounter + 2, 5).Value = "Max. Freshwater"
.Cells(intRowCounter + 3, 5).Value = "Makeup Vol. Required"

intCounter = 0
intRowCounter = intRowCounter + 4
While intCounter < intTotalYears
  intCounter = intCounter + 1
  'Reclaim Statistics
  .Cells(intRowCounter, 1).Value = intCounter
  .Cells(intRowCounter, 2).Value = sngAvgLowPondMonths(intCounter)
  .Cells(intRowCounter, 3).Value = sngAnnLowPondProb(intCounter)
  .Cells(intRowCounter, 4).Value = sngAvgFreshVol(intCounter)
  .Cells(intRowCounter, 5).Value = sngMaxFreshVol(intCounter)
  intRowCounter = intRowCounter + 1
Wend

.Cells(intRowCounter + 1, 1).Font.Bold = True
.Cells(intRowCounter + 2, 1).Font.Bold = True
.Cells(intRowCounter + 2, 2).Font.Bold = True
.Cells(intRowCounter + 3, 2).Font.Bold = True
.Cells(intRowCounter + 2, 3).Font.Bold = True
.Cells(intRowCounter + 3, 3).Font.Bold = True
.Cells(intRowCounter + 2, 4).Font.Bold = True
.Cells(intRowCounter + 3, 4).Font.Bold = True
.Cells(intRowCounter + 1, 1).Value = "Tailings Exposure Results"
.Cells(intRowCounter + 2, 1).Value = "Year in Series"
.Cells(intRowCounter + 2, 2).Value = "Avg. # Months with"
.Cells(intRowCounter + 3, 2).Value = "Solids Exposed"
.Cells(intRowCounter + 2, 3).Value = "Avg. Annual Prob."
.Cells(intRowCounter + 3, 3).Value = "of Solids Exposure"
.Cells(intRowCounter + 2, 4).Value = "Avg. Depth of Water"
.Cells(intRowCounter + 3, 4).Value = "above solids (m)"

intCounter = 0
```

```
    intRowCounter = intRowCounter + 4
    While intCounter < intTotalYears
      intCounter = intCounter + 1
      'Tailings Statistics
      .Cells(intRowCounter, 1).Value = intCounter
      .Cells(intRowCounter, 2).Value = sngAvgDryTailMonths(intCounter)
      .Cells(intRowCounter, 3).Value = sngAnnDryTailProb(intCounter)
      .Cells(intRowCounter, 4).Value = sngAvgPondDepth(intCounter)
      intRowCounter = intRowCounter + 1
    Wend

End With
'_____________________________________________

Unload FrmWaitingSign

appRiskResults.Visible = True

MousePointer = 1

ProcExit:
    Exit Sub

End Sub

Private Sub mnuRunAvgClosure_Click()

If blnVbRan = False Then
    MsgBox "You must run an Visual Balance Average Balance for these input" & _
      "variables prior to running a VB Closure Balance.  The average run will set" & _
      " the final solids volumes and elevations to be used in VB Closure Balance." & _
      vbExclamation
    GoTo ProcExit:
End If

intSpillCount = 0

If blnVbRan = True Then
    intRunNumber = intRunNumber + 1
End If

'On Error GoTo CheckError:
```

```
   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "An average Visual Balance is being run."
   FrmWaitingSign.LblProgress.Caption = "This is balance run number..."
   FrmWaitingSign.LblRunCounter = intRunNumber
   FrmWaitingSign.Visible = True
   FrmWaitingSign.Show
   FrmWaitingSign.Refresh
   FrmOutputMenu.MousePointer = vbHourglass

intClearCounter = 1
While intClearCounter < 1200
   sngACBegWatElev(intClearCounter) = 0
   sngACBegWatVol(intClearCounter) = 0
   sngACBegTotVol(intClearCounter) = 0
   sngACBegPondArea(intClearCounter) = 0
   sngACEndTotVol(intClearCounter) = 0
   sngACEndWatElev(intClearCounter) = 0
   sngACEndPondArea(intClearCounter) = 0
   sngACEndWatVol(intClearCounter) = 0
   sngACMonthBeachEvap(intClearCounter) = 0
   sngACMonthSeepOut(intClearCounter) = 0
   sngACMonthPondEvap(intClearCounter) = 0
   sngACMonthSeepIn(intClearCounter) = 0
   sngACMonthDirPre(intClearCounter) = 0
   sngACMonthRunoff(intClearCounter) = 0
   sngACMonthWatIn(intClearCounter) = 0
   sngACMonthWatLoss(intClearCounter) = 0
   sngACEndEDFElev(intClearCounter) = 0
   sngACActualFreeboard(intClearCounter) = 0
   sngACPondDepth(intClearCounter) = 0
   intClearCounter = intClearCounter + 1
Wend

   sngACSpillVol = 0
   sngACTempSpillVol = 0

   intClearCounter = 1
While intClearCounter < 100
   lngACDryTailMonths(intClearCounter) = 0
   lngACLowFreeMonths(intClearCounter) = 0
   lngACSpillMonths(intClearCounter) = 0
   sngACAnnPondDepth(intClearCounter) = 0
   sngACAnnFreeboard(intClearCounter) = 0
```

```
   sngACMaxSpillVol(intClearCounter) = 0
   sngAvgACSpillMonths(intClearCounter) = 0
   sngAvgACLowFreeMonths(intClearCounter) = 0
   sngACAnnSpillVol(intClearCounter) = 0
   sngAvgACDryTailMonths(intClearCounter) = 0
   sngAvgACSpillVol(intClearCounter) = 0
   sngAvgACLowFreeHeight(intClearCounter) = 0
   sngAvgACPondDepth(intClearCounter) = 0
   intClearCounter = intClearCounter + 1
Wend
'
'_______________________________________________________________________
'.            CLOSURE BALANCE CODE

'Calculate the water and mass balance for each month
'up to the total number of years of closure analysis.  VB Closure runs
' from January to December.

   If strDependResponse = "True " Then
      sngSeepOutRate = CalcSeepR(sngClosureCrest)
      sngBeachArea = CalcBeachA(sngClosureCrest)
   Else
      sngSeepOutRate = sngSeepOutRateConstant
      sngBeachArea = sngBeachAreaConstant
   End If

   intTotalClosMonths = 12 * intNumClosYears
   sngClosureCrest = sngEndDamCrestElev(intTotalMonths)
   sngClosSolElev = sngEndSolElev(intTotalMonths)
   sngClosSolVol = sngEndSolVol(intTotalMonths)
   sngClosInvertElev = sngClosureCrest - sngSpillWayInvert

   intMonthCounter = 0
   intCurMonth = 0
   intYearCounter = 1

   Do Until intMonthCounter = intTotalClosMonths

      intMonthCounter = intMonthCounter + 1
      intCurMonth = intCurMonth + 1
         If intCurMonth = 13 Then
            intCurMonth = 1
            intYearCounter = intYearCounter + 1
         End If
```

```
    intPrevMonth = intMonthCounter - 1
    intDaysinMonth = CalcNumDaysInMon(intCurMonth)

    If intMonthCounter = 1 Then
       sngACBegWatElev(intMonthCounter) = sngEndWatElev(intTotalMonths)
       sngACBegWatVol(intMonthCounter) = sngEndWatVol(intTotalMonths)
       sngACBegTotVol(intMonthCounter) = sngEndTotVol(intTotalMonths)
       sngACBegPondArea(intMonthCounter) = sngEndPondArea(intTotalMonths)
    Else
       sngACBegTotVol(intMonthCounter) = sngACEndTotVol(intPrevMonth)
       sngACBegWatElev(intMonthCounter) = sngACEndWatElev(intPrevMonth)
       sngACBegPondArea(intMonthCounter) = sngACEndPondArea(intPrevMonth)
    End If

 'Calculate the water inflows to the reservoir for each month.

 sngACMonthDirPre(intMonthCounter) = sngAvgPrecip(intCurMonth) _
    / 1000 * sngACBegPondArea(intMonthCounter) * 10000

 sngACMonthRunoff(intMonthCounter) = (sngIntensity(intCurMonth) / 1000) _
    * ((sngCatchArea - sngACBegPondArea(intMonthCounter)) * 10000) * (1 -
sngFracRunDivert)

 sngACMonthSeepIn(intMonthCounter) = sngSeepInRate * intDaysinMonth

 'Calculate the water loss for each month...

 sngACMonthPondEvap(intMonthCounter) = _
    (sngPondEvap(intCurMonth) / 1000) _
    * (sngACBegPondArea(intMonthCounter) * 10000)

 sngACMonthSeepOut(intMonthCounter) = sngSeepOutRate * intDaysinMonth

 sngACMonthBeachEvap(intMonthCounter) = (sngBeachEvap(intCurMonth) / 1000) _
    * sngBeachArea

 '*****************************************************************

 'Sum up the water inflows for the month...

 sngACMonthWatIn(intMonthCounter) = _
    sngACMonthDirPre(intMonthCounter) _
    + sngACMonthRunoff(intMonthCounter) _
```

```
    + sngACMonthSeepIn(intMonthCounter)

 'Sum up the water losses for the months...

 sngACMonthWatLoss(intMonthCounter) = _
    sngACMonthPondEvap(intMonthCounter) _
    + sngACMonthBeachEvap(intMonthCounter) _
    + sngACMonthSeepOut(intMonthCounter)

 'Based on a new volume of water in the pond,
 'find the new surface area and water elevation at the
 'end of the month.

    sngACEndTotVol(intMonthCounter) = _
       sngACBegTotVol(intMonthCounter) _
       + sngACMonthWatIn(intMonthCounter) _
       - sngACMonthWatLoss(intMonthCounter)

    sngACEndWatVol(intMonthCounter) = sngACBegWatVol(intMonthCounter) _
       + sngACMonthWatIn(intMonthCounter) _
       - sngACMonthWatLoss(intMonthCounter)

    sngACEndWatElev(intMonthCounter) = _
       CalcElevation(sngACEndTotVol(intMonthCounter))
       If sngACEndWatElev(intMonthCounter) = 0 Then
          GoTo OverflowError:
       End If

    sngACPondDepth(intMonthCounter) = sngACEndWatElev(intMonthCounter) _
       - sngClosSolElev
    sngTempPondDepth = sngACAnnPondDepth(intYearCounter)
    sngACAnnPondDepth(intYearCounter) = sngACPondDepth(intMonthCounter) _
       + sngTempPondDepth

    If sngACEndWatElev(intMonthCounter) > sngClosSolElev Then
       sngACEndPondArea(intMonthCounter) =
CalcArea(sngACEndWatElev(intMonthCounter))
       Else: sngACEndPondArea(intMonthCounter) = CalcArea(sngClosSolElev)
    End If

    'Add on the EDF elevation...

    If intCurMonth = 1 Or 2 Or 3 Then
```

```
        sngEDFVolume = sngEDFWinter
    ElseIf intCurMonth = 4 Or 5 Or 6 Then
        sngEDFVolume = sngEDFSpring
    ElseIf intCurMonth = 7 Or 8 Or 9 Then
        sngEDFVolume = sngEDFSummer
    ElseIf intCurMonth = 10 Or 11 Or 12 Then
        sngEDFVolume = sngEDFFall
    End If

    sngACEndEDFElev(intMonthCounter) = _
        CalcElevation(sngACEndTotVol(intMonthCounter) + sngEDFVolume)
        If sngACEndEDFElev(intMonthCounter) = 0 Then
            GoTo OverflowError:
        End If

    If sngACEndWatElev(intMonthCounter) < sngClosSolElev _
        And intMonthCounter > 1 Then
        lngACDryTailMonths(intYearCounter) = _
            lngACDryTailMonths(intYearCounter) + 1
    End If

    sngACActualFreeboard(intMonthCounter) = sngClosureCrest _
            - sngACEndEDFElev(intMonthCounter)

    If sngACActualFreeboard(intMonthCounter) <= sngRiskFreeboard _
        And sngACEndWatElev(intMonthCounter) > sngClosInvertElev And
intMonthCounter > 1 Then
            lngACLowFreeMonths(intYearCounter) = _
                lngACLowFreeMonths(intYearCounter) + 1
            lngACSpillMonths(intYearCounter) = _
                lngACSpillMonths(intYearCounter) + 1

            sngTempFreeboard = sngACAnnFreeboard(intYearCounter)
            sngACAnnFreeboard(intYearCounter) = sngTempFreeboard _
                + sngACActualFreeboard(intMonthCounter)

            sngACEndWatElev(intMonthCounter) = sngClosInvertElev

            sngTempVol = sngACEndTotVol(intMonthCounter)
            sngACEndTotVol(intMonthCounter) =
CalcVolume(sngACEndWatElev(intMonthCounter))
            sngACSpillVol = sngTempVol - sngACEndTotVol(intMonthCounter)
            sngACTempSpillVol = sngACAnnSpillVol(intYearCounter)
```

```
            sngACAnnSpillVol(intYearCounter) = sngACTempSpillVol + sngACSpillVol
            If sngACSpillVol > sngACMaxSpillVol(intYearCounter) Then
               sngACMaxSpillVol(intYearCounter) = sngACSpillVol
            End If

            sngACEndEDFElev(intMonthCounter) =
CalcElevation(sngACEndTotVol(intMonthCounter) + sngEDFVolume)
            If sngACEndWatElev(intMonthCounter) > sngClosSolElev Then
               sngACEndPondArea(intMonthCounter) =
CalcArea(sngACEndWatElev(intMonthCounter))
               Else: sngACEndPondArea(intMonthCounter) = CalcArea(sngClosSolElev)
            End If

      ElseIf sngACActualFreeboard(intMonthCounter) <= sngRiskFreeboard _
         And sngACEndWatElev(intMonthCounter) < sngClosInvertElev _
         And intMonthCounter > 1 Then
            lngACLowFreeMonths(intYearCounter) = _
               lngACLowFreeMonths(intYearCounter) + 1
            sngTempFreeboard = sngACAnnFreeboard(intYearCounter)
            sngACAnnFreeboard(intYearCounter) = sngTempFreeboard _
               + sngACActualFreeboard(intMonthCounter)
      End If
   Loop
'
_______________________________________________________________________
'Balance is complete.

   'Sum up the risk output indicators.
   'This section refers to freeboard and pond level prior to any emergency spill
   'over and above the regular design spill input by the user.

      intYear = 1

         Do Until intYear = intNumClosYears

            sngAvgACSpillMonths(intYear) = lngACSpillMonths(intYear) / 12
            sngAvgACLowFreeMonths(intYear) = lngACLowFreeMonths(intYear) / 12
            sngAvgACDryTailMonths(intYear) = lngACDryTailMonths(intYear) / 12

            If sngAvgACSpillMonths(intYear) > 0 Then
               sngAvgACSpillVol(intYear) = sngACAnnSpillVol(intYear) _
               / lngACSpillMonths(intYear)
            Else: sngAvgACSpillVol(intYear) = 0
            End If
```

```
        If sngAvgACLowFreeMonths(intYear) > 0 Then
           sngAvgACLowFreeHeight(intYear) = sngACAnnFreeboard(intYear) _
           / lngACLowFreeMonths(intYear)
        Else: sngAvgACLowFreeHeight(intYear) = 0
        End If

        sngAvgACPondDepth(intYear) = sngACAnnPondDepth(intYear) / 12

        intYear = intYear + 1
     Loop
'___________________________________________________________
'Closure Analysis Complete.  Error handling and exit code below.


blnClosureRan = True

Beep
FrmWaitingSign.Visible = False
Unload FrmWaitingSign
FrmOutputMenu.MousePointer = 1
StrMsg = "Visual Balance has finished computing the water balance " & _
   "for these closure input variables."
MsgBox StrMsg, vbOKOnly
FrmOutputMenu.Visible = True


'************************************************
'************************************************


'_____________________________________________
' Error Handling.


CheckError:
   intNoFile = 31031

   If Err = intNoFile Or Err = 3011 Then
      MsgBox "There is an error in one of your Visual Balance Excel" & _
      "data input files.  Please check to see that the" & _
      " table of data has been 'defined' appropriately within Excel.  Please return to the data
```

```
edit menu.  " & _
        " The table definition can be found in Excel under Menu: " & _
        "Insert, Name, Define).", vbCritical
        GoTo ProcExit
    ElseIf Err = 0 Then
        GoTo ProcExit
    Else
        strMsgBox = "Unexpected error #" & Str(Err) & " occurred: " & Error
        MsgBox strMsgBox, vbExclamation, vbOKOnly
        GoTo ProcExit
    End If

ProcExit:
    Beep
    FrmWaitingSign.Visible = False
    Unload FrmWaitingSign
    Exit Sub

ProcError:
    MsgBox Err.Description
    Resume ProcExit

OverflowError:
    Unload FrmWaitingSign
    FrmOutputMenu.MousePointer = 1
    MsgBox "Due to the overflow error in your reservoir in month # " _
        & intMonthCounter & " Visual Balance was unable to complete the " & _
        "water balance.  Please edit your input files in order to " & _
        "proceed.", vbOKOnly
    Exit Sub

End Sub

Private Sub mnuRunRiskClosure_Click()

If blnVbRan = False Then
    MsgBox "You should run an average Water & Materials Balance for" & _
    "this data prior to running a Closure Risk Analysis, in order to" & _
    "set the final solids and dam crest elevations for your impoundment.", vbExclamation
    GoTo ProcExit:
End If

'On Error GoTo CheckError:
```

```
   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "Visual " & _
      "Balance Closure Risk Analysis is running..."
   FrmWaitingSign.Show
   StrMsg = "The number of random closure series simulations completed is:  "
   FrmWaitingSign.LblProgress.Caption = StrMsg
   FrmWaitingSign.Refresh
   FrmOutputMenu.MousePointer = vbHourglass

'Counter variables are intialized to zero in case multiple Closure
'Analyses are performed.

sngSpillVol = 0

   intClearCounter = 1
   Do Until intClearCounter = intNumClosYears + 1
      lngTotClosSpillMonths(intClearCounter) = 0
      sngAvgClosLowFreeMonths(intClearCounter) = 0
      lngTotClosLowFreeMonths(intClearCounter) = 0
      sngAvgClosDryTailMonths(intClearCounter) = 0
      lngTotClosDryTailMonths(intClearCounter) = 0
      sngAvgClosSpillMonths(intClearCounter) = 0
      sngTotClosSpillVol(intClearCounter) = 0
      sngClosSpillProb(intClearCounter) = 0
      intClosYearsWithSpill(intClearCounter) = 0
      sngClosLowFreeProb(intClearCounter) = 0
      intClosYearsWithLowFree(intClearCounter) = 0
      sngClosDryTailProb(intClearCounter) = 0
      intClosYearsWithDryTail(intClearCounter) = 0
      sngTotClosFreeboard(intClearCounter) = 0
      sngMaxClosSpillVol(intClearCounter) = 0
      sngAvgClosLowFreeHeight(intClearCounter) = 0
      sngAvgClosSpillVol(intClearCounter) = 0
      sngTempClosSpillVol = 0
      intClearSeries = 1
      Do Until intClearSeries = intNumClosSeries + 1
         lngClosSpillMonths(intClearSeries, intClearCounter) = 0
         lngClosDryTailMonths(intClearSeries, intClearCounter) = 0
         lngClosLowFreeMonths(intClearSeries, intClearCounter) = 0
         sngClosFreeboard(intClearSeries, intClearCounter) = 0
         sngClosSpillVol(intClearSeries, intClearCounter) = 0
         sngClosPondDepth(intClearSeries, intClearCounter) = 0
```

```
      intClearSeries = intClearSeries + 1
    Loop

    intClearCounter = intClearCounter + 1
  Loop

intClosureMonths = 12 * intNumClosYears
sngClosureCrest = sngEndDamCrestElev(intTotalMonths)
sngClosSolElev = sngEndSolElev(intTotalMonths)
sngClosSolVol = sngEndSolVol(intTotalMonths)
sngClosInvertElev = sngSpillWayInvertElev(intTotalMonths)
intClosSerCounter = 1

  If strDependResponse = "True " Then
    sngSeepOutRate = CalcSeepR(sngClosureCrest)
    sngBeachArea = CalcBeachA(sngClosureCrest)
  Else
    sngSeepOutRate = sngSeepOutRateConstant
    sngBeachArea = sngBeachAreaConstant
  End If

  sngClosMonthSeepOut(intMonthCounter) = sngSeepOutRate * intDaysinMonth

'
'_____________________________________________________________________
' START CLOSURE RISK ANALYSIS SIMULATION.

While intClosSerCounter < intNumClosSeries + 1

  'Re-run water balance with new precip. values.
  'Incorporate recognition of low freeboard values,
  'spill events, and dry tailings months.

  intMonthCounter = 0
  intCurMonth = 1
  intYearCounter = 1
  intPackCounter = 0
  intPackMonthCounter = 0

While intMonthCounter < intClosureMonths

    intMonthCounter = intMonthCounter + 1
    intPrevMonth = intMonthCounter - 1
```

```
    intCurMonth = intCurMonth + 1
      If intCurMonth = 13 Then
        intYearCounter = intYearCounter + 1
        intCurMonth = 1
      End If
    intDaysinMonth = CalcNumDaysInMon(intCurMonth)

    If intCurMonth = 1 Then
      sngClosAnnPrecip(intYearCounter) = _
        CalcRandomAnnPrecip(sngMeanAnnual, sngStandardDev, _
        sngNumYearsRecord)
    End If

  'Generate random precip for each month, based on the
  ' new random annual values.

    sngClosPrecip(intMonthCounter) = sngClosAnnPrecip(intYearCounter) _
      * sngMonthPercent(intCurMonth)

  'Initialize volumes based on previous end-of-month totals.

  If intMonthCounter = 1 Then
    sngBegClosTotVol(intMonthCounter) = sngEndTotVol(intTotalMonths)
    sngBegClosWatElev(intMonthCounter) = sngEndWatElev(intTotalMonths)
    sngBegClosPondArea(intMonthCounter) =
CalcArea(sngBegClosWatElev(intMonthCounter))
  Else
    sngBegClosTotVol(intMonthCounter) = sngEndClosTotVol(intPrevMonth)
    sngBegClosWatElev(intMonthCounter) = sngEndClosWatElev(intPrevMonth)
    sngBegClosPondArea(intMonthCounter) = sngEndClosPondArea(intPrevMonth)
  End If

  'Calculate the new random water inflows to the reservoir for each month.

  sngClosDirPre(intMonthCounter) = (sngClosPrecip(intMonthCounter) _
    / 1000) * sngBegClosPondArea(intMonthCounter) * 10000

  'Runoff calculations are based on the random precip values.  The user enters a value
  'for "fraction of precip as snow".  Snow begins to accumulate
  'according to the "Start snow accumulation month" entered by the user.
  'The only runoff during these snow accumulation months would be the direct
  'precip that is rain.
```

```
    'The user also enters a "end snow accumulation month", and at this point the snowpack is
    '"runoff" in subsequent months according to the temporal runoff distribution provided by
    'the user.
    'One complicating factor is that in the start up year, the Closure risk analysis has no
accumulated
    'snow pack to runoff, so the only runoff will come from direct precip that is not snow.

    If intCurMonth = intStartPackMonth Then
       intPackMonthCounter = 1
       intPackCounter = intPackCounter + 1
       sngSnowPackDepth = sngClosPrecip(intMonthCounter) * sngFracSnow(intCurMonth)
       If sngFracSnow(intCurMonth) = 1 Then
            sngClosRunoff(intMonthCounter) = 0
       Else:   sngClosRunoff(intMonthCounter) = ((sngClosPrecip(intMonthCounter) _
            * (1 - sngFracSnow(intCurMonth)) _
            - sngRunoffLoss(intCurMonth)) / 1000) _
            * (1 - sngFracRunDivert) _
            * ((sngCatchArea - sngBegClosPondArea(intMonthCounter)) * 10000)
       End If
       intPackMonthCounter = intPackMonthCounter + 1

    ElseIf intPackMonthCounter = 0 Then
       If sngFracSnow(intCurMonth) = 1 Then
            sngClosRunoff(intMonthCounter) = 0
       Else:   sngClosRunoff(intMonthCounter) = ((sngClosPrecip(intMonthCounter) _
            * (1 - sngFracSnow(intCurMonth)) _
            - sngRunoffLoss(intCurMonth)) / 1000) _
            * (1 - sngFracRunDivert) _
            * ((sngCatchArea - sngBegClosPondArea(intMonthCounter)) * 10000)
       End If

    ElseIf intPackMonthCounter > 1 And intPackMonthCounter < intTotalPackMonths Then
       sngSnowPackDepth = sngSnowPackDepth + (sngClosPrecip(intMonthCounter) _
          * sngFracSnow(intCurMonth))
       If sngFracSnow(intCurMonth) = 1 Then
            sngClosRunoff(intMonthCounter) = 0
       Else:   sngClosRunoff(intMonthCounter) = ((sngClosPrecip(intMonthCounter) _
            * (1 - sngFracSnow(intCurMonth)) _
            - sngRunoffLoss(intCurMonth)) / 1000) _
            * (1 - sngFracRunDivert) _
            * ((sngCatchArea - sngBegClosPondArea(intMonthCounter)) * 10000)
       End If
       intPackMonthCounter = intPackMonthCounter + 1
```

```
ElseIf intPackMonthCounter = intTotalPackMonths Then
   sngTotalPackDepth(intClosSerCounter) = sngSnowPackDepth
   sngClosRunoff(intMonthCounter) = (1 - sngFracRunDivert) _
      * ((sngClosPrecip(intMonthCounter) * (1 - sngFracSnow(intCurMonth)) _
      + (sngFracMelt(intCurMonth) * sngTotalPackDepth(intPackCounter)) _
      - sngRunoffLoss(intCurMonth)) / 1000) _
      * ((sngCatchArea - sngBegClosPondArea(intMonthCounter)) * 10000)
   intPackMonthCounter = intPackMonthCounter + 1

ElseIf intPackMonthCounter > intTotalPackMonths Then
   sngClosRunoff(intMonthCounter) = (1 - sngFracRunDivert) _
      * ((sngClosPrecip(intMonthCounter) * (1 - sngFracSnow(intCurMonth)) _
      + (sngFracMelt(intCurMonth) * sngTotalPackDepth(intPackCounter)) _
      - sngRunoffLoss(intCurMonth)) / 1000) _
      * ((sngCatchArea - sngBegClosPondArea(intMonthCounter)) * 10000)
   intPackMonthCounter = intPackMonthCounter + 1
End If

'Seepage Into Impoundment...

sngClosMonthSeepIn(intMonthCounter) = sngSeepInRate * intDaysinMonth

'Calculate the new water loss for each month based on
' the new reservoir surface area.  Note that beach area does not change
'because either the beach area is a fixed user-entered constant,
'or is dependant on dam crest elevation which does not change in a
'given month during the risk analysis.

sngClosPondEvap(intMonthCounter) = _
   (sngPondEvap(intCurMonth) / 1000) _
   * (sngBegClosPondArea(intMonthCounter) * 10000)

sngClosMonthBeachEvap(intMonthCounter) = (sngBeachEvap(intCurMonth) / 1000) _
   * sngBeachArea

'Sum up the water inflows for the months...

sngClosWatIn(intMonthCounter) = _
      sngClosDirPre(intMonthCounter) _
      + sngClosRunoff(intMonthCounter) _
      + sngClosMonthSeepIn(intMonthCounter)
```

```
'Sum up the water losses for the months...

sngClosWatLoss(intMonthCounter) = _
    sngClosPondEvap(intMonthCounter) _
    + sngClosMonthBeachEvap(intMonthCounter) _
    + sngClosMonthSeepOut(intMonthCounter)

'Based on a new volume of water volumes in closure months,
'find the new surface area and elevations at the
'end of the Month.

  sngEndClosTotVol(intMonthCounter) = _
    sngBegClosTotVol(intMonthCounter) _
    + sngClosWatIn(intMonthCounter) _
    - sngClosWatLoss(intMonthCounter)

  sngEndClosWatElev(intMonthCounter) = _
    CalcElevation(sngEndClosTotVol(intMonthCounter))
    If sngEndClosWatElev(intMonthCounter) = 0 Then
      GoTo OverflowError:
    End If

  sngEndClosPondArea(intMonthCounter) = _
    CalcArea(sngEndClosWatElev(intMonthCounter))

  'Add on the EDF elevation...

  If intCurMonth = 1 Or 2 Or 3 Then
    sngEDFVolume = sngEDFWinter
  ElseIf intCurMonth = 4 Or 5 Or 6 Then
    sngEDFVolume = sngEDFSpring
  ElseIf intCurMonth = 7 Or 8 Or 9 Then
    sngEDFVolume = sngEDFSummer
  ElseIf intCurMonth = 10 Or 11 Or 12 Then
    sngEDFVolume = sngEDFFall
  End If

  sngEndClosEDFElev(intMonthCounter) = _
    CalcElevation(sngEndClosTotVol(intMonthCounter) + sngEDFVolume)
    If sngEndClosEDFElev(intMonthCounter) = 0 Then
      GoTo OverflowError:
    End If
```

```
sngPondDepth = sngEndClosWatElev(intMonthCounter) _
    - sngClosSolElev
sngTempPondDepth = sngClosPondDepth(intClosSerCounter, intYearCounter)
sngClosPondDepth(intClosSerCounter, intYearCounter) = sngPondDepth _
    + sngTempPondDepth

'Sum up the risk output indicators.
'This section refers to freeboard and pond level prior to any emergency spill
'over and above the regular design spill input by the user.

If sngEndClosWatElev(intMonthCounter) < sngClosSolElev _
    And intMonthCounter > 1 Then
    lngClosDryTailMonths(intClosSerCounter, intYearCounter) = _
        lngClosDryTailMonths(intClosSerCounter, intYearCounter) + 1
End If

sngClosActualFreeboard(intMonthCounter) = sngClosureCrest _
        - sngEndClosEDFElev(intMonthCounter)

If sngClosActualFreeboard(intMonthCounter) <= sngRiskFreeboard _
    And sngEndClosWatElev(intMonthCounter) > sngClosInvertElev And
intMonthCounter > 1 Then
        lngClosLowFreeMonths(intClosSerCounter, intYearCounter) = _
            lngClosLowFreeMonths(intClosSerCounter, intYearCounter) + 1
        lngClosSpillMonths(intClosSerCounter, intYearCounter) = _
            lngClosSpillMonths(intClosSerCounter, intYearCounter) + 1

        sngTempFreeboard = sngClosFreeboard(intClosSerCounter, intYearCounter)
        sngClosFreeboard(intClosSerCounter, intYearCounter) = sngTempFreeboard _
            + sngClosActualFreeboard(intMonthCounter)

        sngEndClosWatElev(intMonthCounter) = sngClosInvertElev

        sngTempVol = sngEndClosTotVol(intMonthCounter)
        sngEndClosTotVol(intMonthCounter) =
CalcVolume(sngEndClosWatElev(intMonthCounter))
        sngSpillVol = sngTempVol - sngEndClosTotVol(intMonthCounter)
        sngTempClosSpillVol = sngClosSpillVol(intClosSerCounter, intYearCounter)
        sngClosSpillVol(intClosSerCounter, intYearCounter) = sngTempClosSpillVol +
sngSpillVol
        If sngSpillVol > sngMaxClosSpillVol(intYearCounter) Then
            sngMaxClosSpillVol(intYearCounter) = sngSpillVol
        End If
```

```
            sngEndClosEDFElev(intMonthCounter) =
CalcElevation(sngEndClosTotVol(intMonthCounter) + sngEDFVolume)
            sngEndClosPondArea(intMonthCounter) =
CalcArea(sngEndClosWatElev(intMonthCounter))

      ElseIf sngClosActualFreeboard(intMonthCounter) <= sngRiskFreeboard _
         And sngEndClosWatElev(intMonthCounter) < sngClosInvertElev _
         And intMonthCounter > 1 Then
            lngClosLowFreeMonths(intClosSerCounter, intYearCounter) = _
               lngClosLowFreeMonths(intClosSerCounter, intYearCounter) + 1
            sngTempFreeboard = sngClosFreeboard(intClosSerCounter, intYearCounter)
            sngClosFreeboard(intClosSerCounter, intYearCounter) = sngTempFreeboard _
               + sngClosActualFreeboard(intMonthCounter)
      End If

      Wend

         'One Closure Series has been completed.  Annual stats for the simulation will be
         'totaled.  Check to see if the years had spills, low freeboard or whatever,
         'in this series.

         intYear = 1
         Do Until intYear = intNumClosYears

            If lngClosSpillMonths(intClosSerCounter, intYear) > 0 Then
               intClosYearsWithSpill(intYear) = intClosYearsWithSpill(intYear) + 1
            End If

            If lngClosLowFreeMonths(intClosSerCounter, intYear) > 0 Then
               intClosYearsWithLowFree(intYear) = intClosYearsWithLowFree(intYear) + 1
            End If

            If lngClosDryTailMonths(intClosSerCounter, intYear) > 0 Then
               intClosYearsWithDryTail(intYear) = intClosYearsWithDryTail(intYear) + 1
            End If
            intYear = intYear + 1
         Loop

      FrmWaitingSign.LblRunCounter.Caption = intClosSerCounter
      FrmWaitingSign.Refresh
      intClosSerCounter = intClosSerCounter + 1
   Wend
```

```
'Simulation is complete.
'Total up the series stats for all the entire simulation.

intYear = 0
intSeries = 1
Do Until intYear = intNumClosYears
   intYear = intYear + 1
   intSeries = 1
   Do Until intSeries = intNumClosSeries
      If intSeries = 1 Then
         lngTotClosSpillMonths(intYear) = lngClosSpillMonths(1, intYear)
         lngTotClosLowFreeMonths(intYear) = lngClosLowFreeMonths(1, intYear)
         lngTotClosDryTailMonths(intYear) = lngClosDryTailMonths(1, intYear)

         sngTotClosSpillVol(intYear) = sngClosSpillVol(1, intYear)
         sngTotClosFreeboard(intYear) = sngClosFreeboard(1, intYear)
         sngTotClosPondDepth(intYear) = sngClosPondDepth(1, intYear)
      Else
         lngTotClosSpillMonths(intYear) = _
            lngTotClosSpillMonths(intYear) + lngClosSpillMonths(intSeries, intYear)
         lngTotClosLowFreeMonths(intYear) = _
            lngTotClosLowFreeMonths(intYear) + lngClosLowFreeMonths(intSeries,
intYear)
         lngTotClosDryTailMonths(intYear) = _
            lngTotClosDryTailMonths(intYear) + lngClosDryTailMonths(intSeries,
intYear)

         sngTotClosSpillVol(intYear) = sngTotClosSpillVol(intYear) +
sngClosSpillVol(intSeries, intYear)
         sngTotClosFreeboard(intYear) = sngTotClosFreeboard(intYear) +
sngClosFreeboard(intSeries, intYear)
         sngTotClosPondDepth(intYear) = sngTotClosPondDepth(intYear) +
sngClosPondDepth(intSeries, intYear)
      End If
      intSeries = intSeries + 1
   Loop
   Loop

   intYear = 1
   Do Until intYear = intNumClosYears
      sngAvgClosSpillMonths(intYear) = lngTotClosSpillMonths(intYear) /
intNumClosSeries
```

```
            sngAvgClosLowFreeMonths(intYear) = lngTotClosLowFreeMonths(intYear) /
intNumClosSeries
            sngAvgClosDryTailMonths(intYear) = lngTotClosDryTailMonths(intYear) /
intNumClosSeries

            If sngAvgClosSpillMonths(intYear) > 0 Then
               sngAvgClosSpillVol(intYear) = sngTotClosSpillVol(intYear) /
lngTotClosSpillMonths(intYear)
            Else: sngAvgClosSpillVol(intYear) = 0
            End If

            If sngAvgClosLowFreeMonths(intYear) > 0 Then
               sngAvgClosLowFreeHeight(intYear) = sngTotClosFreeboard(intYear) /
lngTotClosLowFreeMonths(intYear)
            Else: sngAvgClosLowFreeHeight(intYear) = 0
            End If

            sngAvgClosPondDepth(intYear) = sngTotClosPondDepth(intYear) /
(intNumClosSeries * 12)

            sngClosSpillProb(intYear) = (intClosYearsWithSpill(intYear) / intNumClosSeries)
* 100
            sngClosLowFreeProb(intYear) = (intClosYearsWithLowFree(intYear) /
intNumClosSeries) * 100
            sngClosDryTailProb(intYear) = (intClosYearsWithDryTail(intYear) /
intNumClosSeries) * 100

            intYear = intYear + 1
         Loop
'
________________________________________________________________
'Closure Analysis Complete.  Error handling and exit code below.

blnRiskClosureRan = True
   Beep
   FrmWaitingSign.Visible = False
   Unload FrmWaitingSign
   FrmOutputMenu.MousePointer = 1
   MsgBox "Visual Balance has finished computing the risk analysis for these closure " & _
      "scenario variables.", vbOKOnly
   FrmOutputMenu.Visible = True

'
________________________________________________________________
'Error Handling
```

```
'MathHandler:
  ' Dim sngSimSpillMonthsInv As Single
  ' sngSimSpillMonthsInv = 1 / lngSimSpillMonths
  ' sngAvgSpillVolume = sngSimSpillVolume * sngSimSpillMonthsInv
  ' Resume Next

CheckError:
   intNoFile = 31031
   'intWrongFormat = 3161

   If Err = intNoFile Then
      MsgBox "Your project directory is missing this file.  The generic Visual Balance Excel
file will be loaded for you to edit and save in your project directory.", vbOKOnly
      OLE1.CreateLink ("c:\VisualBalance\RiskData.xls")
      OLE1.DoVerb vbOLEOpen
   'ElseIf Err = intWrongFormat Then
   '  Beep
   '  StrMsg = "An error has occurred reading the Excel file with your temporal " & _
   '  "precipitation data.  You must edit your Excel file before " & _
   '  "running the risk analysis. Click 'Yes' " & _
   '  "if you would you like to load the standard " & _
   '  "Visual Balance Excel file for temporal data " & _
   '  "and begin again?  " & _
   '  "Click 'No' to return to the Output Menu."
   '  If MsgBox(StrMsg, vbExclamation + vbYesNo) = vbYes Then
   '     FrmRiskData.OLE1.CreateLink ("c:\VisualBalance\RiskData.xls")
   '     FrmRiskData.OLE1.DoVerb vbOLEOpen
   '  Else
   '     GoTo ProcExit:
   '  End If
   ElseIf Err = 0 Then
      GoTo ProcExit
   Else
      strMsgBox = "Unexpected error #" & Str(Err) & " occurred: " & Error
      MsgBox strMsgBox, vbExclamation, vbOKOnly
   End If

ProcExit:
   FrmWaitingSign.Visible = False
   Unload FrmWaitingSign
   FrmOutputMenu.MousePointer = 1
   FrmOutputMenu.Visible = True
   Exit Sub
```

```
ProcError:
   MsgBox Err.Description
   Resume ProcExit

OverflowError:
   Unload FrmWaitingSign
   FrmOutputMenu.MousePointer = 1
   MsgBox "Due to the overflow error in your reservoir, Visual Balance was unable to
complete the water balance.  Please edit your input files in order to proceed.", vbOKOnly
   Exit Sub
End Sub

Private Sub mnuRunRisk_Click()

If blnVbRan = False Then
   MsgBox "An Average Visual Balance run must be conducted for " & _
   "this data prior to running a risk analysis.  The Average VB run will set " & _
   "the monthly dam crest elevations from which the performance of the reservoir will " & _
   "will be assessed.", vbExclamation
   GoTo ProcExit:
End If

'On Error GoTo CheckError:

   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "Visual " & _
      "Balance Risk Analysis is running..."
   FrmWaitingSign.Show
   StrMsg = "The number of random series simulations completed is:  "
   FrmWaitingSign.LblProgress.Caption = StrMsg
   FrmWaitingSign.Refresh
   FrmOutputMenu.MousePointer = vbHourglass

'Read in risk variables from text file.

   intFileNumber = FreeFile

   Open (strpath & "\RiskData.txt") For Input As #intFileNumber
   Input #intFileNumber, sngMeanAnnual, _
      sngStandardDev, intNumSeries, _
      sngNumYearsRecord, sngRiskFreeboard, intNumClosSeries, intNumClosYears
   Close #intFileNumber
```

```
'Read design dam crest elevations saved from average Balance Run.

   intMonthCounter = 1
   intFileNumber = FreeFile
   Open (strpath & "\damcrests.txt") For Input As #intFileNumber
   While intMonthCounter < intTotalMonths
      Input #intFileNumber, sngEndDamCrestElev(intMonthCounter)
      intMonthCounter = intMonthCounter + 1
   Wend
   Close #intFileNumber

'Counter variables are intialized to zero in case multiple Risk
'Analyses are performed.

intSeriesCounter = 1
sngSpillVol = 0

   intClearCounter = 1
   Do Until intClearCounter = intTotalYears + 1
      lngTotAnnSpillMonths(intClearCounter) = 0
      sngAvgLowFreeMonths(intClearCounter) = 0
      lngTotAnnLowFreeMonths(intClearCounter) = 0
      sngAvgLowPondMonths(intClearCounter) = 0
      lngTotAnnLowPondMonths(intClearCounter) = 0
      sngAvgDryTailMonths(intClearCounter) = 0
      sngAvgPondDepth(intClearCounter) = 0
      lngTotAnnDryTailMonths(intClearCounter) = 0
      sngAvgSpillMonths(intClearCounter) = 0
      sngTotSpillVol(intClearCounter) = 0
      sngTotFreshVol(intClearCounter) = 0
      sngAnnSpillProb(intClearCounter) = 0
      intYearsWithSpill(intClearCounter) = 0
      sngAnnLowFreeProb(intClearCounter) = 0
      intYearsWithLowFree(intClearCounter) = 0
      sngAnnLowPondProb(intClearCounter) = 0
      intYearsWithLowPond(intClearCounter) = 0
      sngAnnDryTailProb(intClearCounter) = 0
      intYearsWithDryTail(intClearCounter) = 0
      sngMaxFreshVol(intClearCounter) = 0
      sngMaxSpillVol(intClearCounter) = 0
      sngTotFreeboard(intClearCounter) = 0
      sngAvgLowFreeHeight(intClearCounter) = 0
      sngAvgFreshVol(intClearCounter) = 0
```

```
    sngAvgSpillVol(intClearCounter) = 0
    sngTempFreshVol = 0
    sngFreshVol = 0
    sngTempSpillVol = 0
    intClearSeries = 1
    Do Until intClearSeries = intNumSeries + 1
      lngAnnSpillMonths(intClearSeries, intClearCounter) = 0
      lngAnnDryTailMonths(intClearSeries, intClearCounter) = 0
      lngAnnLowFreeMonths(intClearSeries, intClearCounter) = 0
      lngAnnLowPondMonths(intClearSeries, intClearCounter) = 0
      sngAnnFreeboard(intClearSeries, intClearCounter) = 0
      sngAnnSpillVol(intClearSeries, intClearCounter) = 0
      sngAnnFreshVol(intClearSeries, intClearCounter) = 0
      sngAnnPondDepth(intClearSeries, intClearCounter) = 0
      intClearSeries = intClearSeries + 1
    Loop

    intClearCounter = intClearCounter + 1
  Loop

'
'______________________________________________________________________
' START RISK ANALYSIS SIMULATION.


While intSeriesCounter < intNumSeries + 1

  'Re-run water balance with new precip. values.
  'Incorporate 'if' statements for recognizing low freeboard values,
  'spill events, dry tailings, not enough free pond water for reclaim.

  intMonthCounter = 0
  intCurMonth = intStartMonth - 1
  intYearAsDateCount = intStartYear
  intYearCounter = 1

  intPackCounter = 0
  intPackMonthCounter = 0

While intMonthCounter < intTotalMonths

    intMonthCounter = intMonthCounter + 1
    intPrevMonth = intMonthCounter - 1
```

```
  intCurMonth = intCurMonth + 1
    If intCurMonth = 13 Then
    intYearAsDateCount = intYearAsDateCount + 1
    intCurMonth = 1
    End If
  intDaysinMonth = CalcNumDaysInMon(intCurMonth)

  If intMonthCounter = 1 Or intCurMonth = intStartMonth Then
    sngRiskAnnPrecip(intYearCounter) = _
      CalcRandomAnnPrecip(sngMeanAnnual, sngStandardDev, _
      sngNumYearsRecord)
  End If

  If intCurMonth = intEndMonth Then
    intYearCounter = intYearCounter + 1
  End If

'Generate random precip for each month, based on the
' new random annual values.

  sngRiskPrecip(intMonthCounter) = sngRiskAnnPrecip(intYearCounter) _
    * sngMonthPercent(intCurMonth)

'Initialize volumes based on previous end-of-month totals.

If intYearAsDateCount = intStartYear And intMonthCounter = 1 Then
  sngBegSolVol(intMonthCounter) = sngStartSolVol
  sngBegRiskTotVol(intMonthCounter) = sngStartSolVol + sngStartWatVol
  sngBegRiskWatElev(intMonthCounter) = sngStartWatElev
  sngBegRiskPondArea(intMonthCounter) = CalcArea(sngStartWatElev)
Else
  sngBegSolVol(intMonthCounter) = sngBegSolVol(intPrevMonth)
  sngBegRiskTotVol(intMonthCounter) = sngEndRiskTotVol(intPrevMonth)
  sngBegRiskWatElev(intMonthCounter) = sngEndRiskWatElev(intPrevMonth)
  sngBegRiskPondArea(intMonthCounter) = sngEndRiskPondArea(intPrevMonth)
End If

'Calculate the new random water inflows to the reservoir for each month.

sngRiskDirPre(intMonthCounter) = (sngRiskPrecip(intMonthCounter) _
  / 1000) * sngBegRiskPondArea(intMonthCounter) * 10000

'Runoff calculations are based on the random precip values.  The user enters a value
```

'for "fraction of precip as snow". Snow begins to accumulate
'according to the "Start snow accumulation month" entered by the user.
'The only runoff during these snow accumulation months would be the direct
'precip that is rain.

'The user also enters a "end snow accumulation month", and at this point the snowpack is
'"runoff" in subsequent months according to the temporal runoff distribution provided by
'the user.
'One complicating factor is that in the start up year, the risk analysis has no accumulated
'snow pack to runoff, so the only runoff will come from direct precip that is not snow.

```
If intCurMonth = intStartPackMonth Then
   'START PACKING SNOW, IF IT SNOWS IN THIS MONTH'
   intPackMonthCounter = 1
   intPackCounter = intPackCounter + 1
   sngSnowPackDepth = sngRiskPrecip(intMonthCounter) * sngFracSnow(intCurMonth)
   If sngFracSnow(intCurMonth) = 1 Then
         sngRiskRunoff(intMonthCounter) = 0
   Else:   sngRiskRunoff(intMonthCounter) = ((sngRiskPrecip(intMonthCounter) _
         * (1 - sngFracSnow(intCurMonth)) _
         - sngRunoffLoss(intCurMonth)) / 1000) _
         * (1 - sngFracRunDivert) _
         * ((sngCatchArea - sngBegRiskPondArea(intMonthCounter)) * 10000)
   End If
   intPackMonthCounter = intPackMonthCounter + 1

ElseIf intPackMonthCounter = 0 Then

   'This condition of intPackMonthCounter = 0 only occurs during the first year,
   'when the first snowpack has not been built up.

   If sngFracSnow(intCurMonth) = 1 Then
         sngRiskRunoff(intMonthCounter) = 0
   Else:   sngRiskRunoff(intMonthCounter) = ((sngRiskPrecip(intMonthCounter) _
         * (1 - sngFracSnow(intCurMonth)) _
         - sngRunoffLoss(intCurMonth)) / 1000) _
         * (1 - sngFracRunDivert) _
         * ((sngCatchArea - sngBegRiskPondArea(intMonthCounter)) * 10000)
   End If

ElseIf intPackMonthCounter > 1 And intPackMonthCounter < intTotalPackMonths Then
   'SNOW IS PACKING HERE.
```

```
   sngSnowPackDepth = sngSnowPackDepth + (sngRiskPrecip(intMonthCounter) _
      * sngFracSnow(intCurMonth))
   If sngFracSnow(intCurMonth) = 1 Then
         sngRiskRunoff(intMonthCounter) = 0
   Else:  sngRiskRunoff(intMonthCounter) = ((sngRiskPrecip(intMonthCounter) _
         * (1 - sngFracSnow(intCurMonth)) _
         - sngRunoffLoss(intCurMonth)) / 1000) _
         * (1 - sngFracRunDivert) _
         * ((sngCatchArea - sngBegRiskPondArea(intMonthCounter)) * 10000)
   End If
   intPackMonthCounter = intPackMonthCounter + 1

ElseIf intPackMonthCounter = intTotalPackMonths Then
   'THIS IS THE LAST PACK MONTH.
   sngTotalPackDepth(intSeriesCounter) = sngSnowPackDepth
   sngRiskRunoff(intMonthCounter) = (1 - sngFracRunDivert) _
      * ((sngRiskPrecip(intMonthCounter) * (1 - sngFracSnow(intCurMonth)) _
      + (sngFracMelt(intCurMonth) * sngTotalPackDepth(intPackCounter)) _
      - sngRunoffLoss(intCurMonth)) / 1000) _
      * ((sngCatchArea - sngBegRiskPondArea(intMonthCounter)) * 10000)
   intPackMonthCounter = intPackMonthCounter + 1

ElseIf intPackMonthCounter > intTotalPackMonths Then
   'SNOWPACK IS RUNNING OFF IN THESE MONTHS
   sngRiskRunoff(intMonthCounter) = (1 - sngFracRunDivert) _
      * ((sngRiskPrecip(intMonthCounter) * (1 - sngFracSnow(intCurMonth)) _
      + (sngFracMelt(intCurMonth) * sngTotalPackDepth(intPackCounter)) _
      - sngRunoffLoss(intCurMonth)) / 1000) _
      * ((sngCatchArea - sngBegRiskPondArea(intMonthCounter)) * 10000)
   intPackMonthCounter = intPackMonthCounter + 1
End If

'Calculate the new pond evaporation for each month based on
' the new reservoir surface area...

' Note that beach evaporation does not change in any given month
'because either the beach area is a fixed user-entered constant,
'or is dependent on dam crest elevation
' which does not change in a given month during the risk analysis.

sngRiskPondEvap(intMonthCounter) = _
   (sngPondEvap(intCurMonth) / 1000) _
   * (sngBegRiskPondArea(intMonthCounter) * 10000)
```

```
If intMonthCounter = 1 Then
   sngRiskReclaim(intMonthCounter) = _
      sngReclaimRate * 24 * intDaysinMonth
ElseIf intMonthCounter > 1 And sngEndRiskPondDepth(intPrevMonth) _
   < sngNeededForReclaim Then
   sngRiskReclaim(intMonthCounter) = 0
   lngAnnLowPondMonths(intSeriesCounter, intYearCounter) = _
      lngAnnLowPondMonths(intSeriesCounter, intYearCounter) + 1
   sngTempFreshVol = sngAnnFreshVol(intSeriesCounter, intYearCounter)
   sngFreshVol = sngReclaimRate * 24 * intDaysinMonth
   sngAnnFreshVol(intSeriesCounter, intYearCounter) = sngTempFreshVol _
      + sngFreshVol
   If sngFreshVol > sngMaxFreshVol(intYearCounter) Then
      sngMaxFreshVol(intYearCounter) = sngFreshVol
   End If
Else
   sngRiskReclaim(intMonthCounter) = _
      sngReclaimRate * 24 * intDaysinMonth
End If

'Sum up the water inflows for the months...

   sngRiskWatIn(intMonthCounter) = _
      sngRiskDirPre(intMonthCounter) _
      + sngRiskRunoff(intMonthCounter) _
      + sngMonthMineWater(intMonthCounter) _
      + sngMonthSlurryWater(intMonthCounter) _
      + sngMonthSeepIn(intMonthCounter) _
      + sngMonthSeepReturn(intMonthCounter)

'Sum up the water losses for the months...

   sngRiskWatLoss(intMonthCounter) = _
      sngRiskPondEvap(intMonthCounter) _
      + sngMonthBeachEvap(intMonthCounter) _
      + sngMonthSeepOut(intMonthCounter) _
      + sngMonthVoidLoss(intMonthCounter) _
      + sngRiskReclaim(intMonthCounter) _
      + sngMonthSpill(intMonthCounter) _
      + sngMonthWatLossToTail(intMonthCounter) _
      + sngMonthWatLossToWR(intMonthCounter)
```

```
'**Notice that solids inflow and losses do not change from the average
'Visual Balance run.  The variables of solids in and tailings loss to
'waste rock voids are persistant from the Visual Balance run.

'Based on a new volume of water and average volume of
'solids in the pond, find the new surface area and elevations at the
'end of the Month.

  sngEndRiskTotVol(intMonthCounter) = _
    sngBegRiskTotVol(intMonthCounter) _
    + sngRiskWatIn(intMonthCounter) _
    + sngMonthSolIn(intMonthCounter) _
    - sngRiskWatLoss(intMonthCounter) _
    - sngMonthSolLoss(intMonthCounter)

  sngEndRiskWatElev(intMonthCounter) = _
    CalcElevation(sngEndRiskTotVol(intMonthCounter))
    If sngEndRiskWatElev(intMonthCounter) = 0 Then
      GoTo OverflowError:
    End If

  sngEndRiskPondArea(intMonthCounter) = _
    CalcArea(sngEndRiskWatElev(intMonthCounter))

  'Add on the EDF elevation...

  If intCurMonth = 1 Or 2 Or 3 Then
    sngEDFVolume = sngEDFWinter
  ElseIf intCurMonth = 4 Or 5 Or 6 Then
    sngEDFVolume = sngEDFSpring
  ElseIf intCurMonth = 7 Or 8 Or 9 Then
    sngEDFVolume = sngEDFSummer
  ElseIf intCurMonth = 10 Or 11 Or 12 Then
    sngEDFVolume = sngEDFFall
  End If

  sngEndRiskEDFElev(intMonthCounter) = _
    CalcElevation(sngEndRiskTotVol(intMonthCounter) + sngEDFVolume)
    If sngEndRiskEDFElev(intMonthCounter) = 0 Then
      GoTo OverflowError:
    End If

  sngEndRiskPondDepth(intMonthCounter) = sngEndRiskWatElev(intMonthCounter) _
```

```
    - sngEndSolElev(intMonthCounter)
  sngTempPondDepth = sngAnnPondDepth(intSeriesCounter, intYearCounter)
  sngAnnPondDepth(intSeriesCounter, intYearCounter) = _
    sngEndRiskPondDepth(intMonthCounter) + sngTempPondDepth

'Sum up the risk output indicators.
'This section refers to freeboard and pond level prior to any emergency spill
'over and above the regular design spill input by the user.

  If sngEndRiskWatElev(intMonthCounter) < sngEndSolElev(intMonthCounter) _
    And intMonthCounter > 1 Then
    lngAnnDryTailMonths(intSeriesCounter, intYearCounter) = _
      lngAnnDryTailMonths(intSeriesCounter, intYearCounter) + 1
  End If

  sngActualFreeboard(intMonthCounter) = sngEndDamCrestElev(intMonthCounter) _
      - sngEndRiskEDFElev(intMonthCounter)

  If sngActualFreeboard(intMonthCounter) <= sngRiskFreeboard _
    And sngEndRiskWatElev(intMonthCounter) >
sngSpillWayInvertElev(intMonthCounter) _
    And intMonthCounter > 1 Then
      lngAnnLowFreeMonths(intSeriesCounter, intYearCounter) = _
        lngAnnLowFreeMonths(intSeriesCounter, intYearCounter) + 1
      sngTempFreeboard = sngAnnFreeboard(intSeriesCounter, intYearCounter)
      sngAnnFreeboard(intSeriesCounter, intYearCounter) = sngTempFreeboard _
        + sngActualFreeboard(intMonthCounter)

      lngAnnSpillMonths(intSeriesCounter, intYearCounter) = _
        lngAnnSpillMonths(intSeriesCounter, intYearCounter) + 1

      sngEndRiskWatElev(intMonthCounter) =
sngSpillWayInvertElev(intMonthCounter)

      sngTempVol = sngEndRiskTotVol(intMonthCounter)
      sngEndRiskTotVol(intMonthCounter) =
CalcVolume(sngEndRiskWatElev(intMonthCounter))
      sngSpillVol = sngTempVol - sngEndRiskTotVol(intMonthCounter)

      sngEndRiskEDFElev(intMonthCounter) =
CalcElevation(sngEndRiskTotVol(intMonthCounter) + sngEDFVolume)
      sngEndRiskPondArea(intMonthCounter) =
CalcArea(sngEndRiskWatElev(intMonthCounter))
```

```
            sngTempSpillVol = sngAnnSpillVol(intSeriesCounter, intYearCounter)
            sngAnnSpillVol(intSeriesCounter, intYearCounter) = sngTempSpillVol +
sngSpillVol

            If sngSpillVol > sngMaxSpillVol(intYearCounter) Then
               sngMaxSpillVol(intYearCounter) = sngSpillVol
            End If

      ElseIf sngActualFreeboard(intMonthCounter) <= sngRiskFreeboard _
         And sngEndRiskWatElev(intMonthCounter) < _
            sngSpillWayInvertElev(intMonthCounter) _
         And intMonthCounter > 1 Then
            lngAnnLowFreeMonths(intSeriesCounter, intYearCounter) = _
               lngAnnLowFreeMonths(intSeriesCounter, intYearCounter) + 1
            sngTempFreeboard = sngAnnFreeboard(intSeriesCounter, intYearCounter)
            sngAnnFreeboard(intSeriesCounter, intYearCounter) = sngTempFreeboard _
               + sngActualFreeboard(intMonthCounter)
      End If

   'Total up the #-of-month stats for the series (1 to 100 or 1 to 1,000)generated.
      Wend

         'One series has been completed

         FrmWaitingSign.LblRunCounter.Caption = intSeriesCounter
         FrmWaitingSign.Refresh

         'Check to see if the years had spills, low freeboard or whatever,
         'in this series.

         intYear = 1
         Do Until intYear = intTotalYears

            If lngAnnSpillMonths(intSeriesCounter, intYear) > 0 Then
               intYearsWithSpill(intYear) = intYearsWithSpill(intYear) + 1
            End If

            If lngAnnLowFreeMonths(intSeriesCounter, intYear) > 0 Then
               intYearsWithLowFree(intYear) = intYearsWithLowFree(intYear) + 1
            End If

            If lngAnnLowPondMonths(intSeriesCounter, intYear) > 0 Then
```

```
            intYearsWithLowPond(intYear) = intYearsWithLowPond(intYear) + 1
         End If

         If lngAnnDryTailMonths(intSeriesCounter, intYear) > 0 Then
            intYearsWithDryTail(intYear) = intYearsWithDryTail(intYear) + 1
         End If
         intYear = intYear + 1
      Loop
   intSeriesCounter = intSeriesCounter + 1
Wend

    'Now the simulation is done.
    'Total up the series stats for all the series generated.

    intYear = 0
    intSeries = 1
    Do Until intYear = intTotalYears + 1
       intYear = intYear + 1
       intSeries = 1
       Do Until intSeries = intNumSeries
          If intSeries = 1 Then
             lngTotAnnSpillMonths(intYear) = lngAnnSpillMonths(1, intYear)
             lngTotAnnLowFreeMonths(intYear) = lngAnnLowFreeMonths(1, intYear)
             lngTotAnnLowPondMonths(intYear) = lngAnnLowPondMonths(1, intYear)
             lngTotAnnDryTailMonths(intYear) = lngAnnDryTailMonths(1, intYear)

             sngTotPondDepth(intYear) = sngAnnPondDepth(1, intYear)
             sngTotSpillVol(intYear) = sngAnnSpillVol(1, intYear)
             sngTotFreeboard(intYear) = sngAnnFreeboard(1, intYear)
             sngTotFreshVol(intYear) = sngAnnFreshVol(1, intYear)

          Else
             lngTotAnnSpillMonths(intYear) = _
                lngTotAnnSpillMonths(intYear) + lngAnnSpillMonths(intSeries, intYear)
             lngTotAnnLowFreeMonths(intYear) = _
                lngTotAnnLowFreeMonths(intYear) + lngAnnLowFreeMonths(intSeries,
intYear)
             lngTotAnnLowPondMonths(intYear) = _
                lngTotAnnLowPondMonths(intYear) + lngAnnLowPondMonths(intSeries,
intYear)
             lngTotAnnDryTailMonths(intYear) = _
                lngTotAnnDryTailMonths(intYear) + lngAnnDryTailMonths(intSeries,
intYear)
```

```
            sngTotPondDepth(intYear) = sngTotPondDepth(intYear) _
              + sngAnnPondDepth(intSeries, intYear)
            sngTotSpillVol(intYear) = sngTotSpillVol(intYear) _
              + sngAnnSpillVol(intSeries, intYear)
            sngTotFreeboard(intYear) = sngTotFreeboard(intYear) _
              + sngAnnFreeboard(intSeries, intYear)
            sngTotFreshVol(intYear) = sngTotFreshVol(intYear) _
              + sngAnnFreshVol(intSeries, intYear)
          End If
          intSeries = intSeries + 1
        Loop
        Loop

        intYear = 1
        Do Until intYear = intTotalYears

          sngAvgPondDepth(intYear) = sngTotPondDepth(intYear) / (intNumSeries * 12)
          sngAvgSpillMonths(intYear) = lngTotAnnSpillMonths(intYear) / intNumSeries
          sngAvgLowFreeMonths(intYear) = lngTotAnnLowFreeMonths(intYear) /
intNumSeries
          sngAvgLowPondMonths(intYear) = lngTotAnnLowPondMonths(intYear) /
intNumSeries
          sngAvgDryTailMonths(intYear) = lngTotAnnDryTailMonths(intYear) /
intNumSeries

          If sngAvgSpillMonths(intYear) > 0 Then
            sngAvgSpillVol(intYear) = sngTotSpillVol(intYear) /
lngTotAnnSpillMonths(intYear)
          Else: sngAvgSpillVol(intYear) = 0
          End If

          If sngAvgLowFreeMonths(intYear) > 0 Then
            sngAvgLowFreeHeight(intYear) = sngTotFreeboard(intYear) /
lngTotAnnLowFreeMonths(intYear)
          Else: sngAvgLowFreeHeight(intYear) = 0
          End If

          If sngAvgLowPondMonths(intYear) > 0 Then
            sngAvgFreshVol(intYear) = sngTotFreshVol(intYear) /
lngTotAnnLowPondMonths(intYear)
          Else: sngAvgFreshVol(intYear) = 0
          End If
```

```
        sngAnnSpillProb(intYear) = (intYearsWithSpill(intYear) / intNumSeries) * 100
        sngAnnLowFreeProb(intYear) = (intYearsWithLowFree(intYear) / intNumSeries)
* 100
        sngAnnLowPondProb(intYear) = (intYearsWithLowPond(intYear) / intNumSeries)
* 100
        sngAnnDryTailProb(intYear) = (intYearsWithDryTail(intYear) / intNumSeries) *
100

        intYear = intYear + 1
      Loop
'______________________________________________________________________
'Risk Analysis Complete.  Error handling and exit code below.

blnRiskRan = True

  Beep
  FrmWaitingSign.Visible = False
  Unload FrmWaitingSign
  FrmOutputMenu.MousePointer = 1
  MsgBox "Visual Balance has finished computing the risk analysis for these input " & _
    "variables.", vbOKOnly
  FrmOutputMenu.Visible = True

'______________________________________________________________________
'Error Handling

'MathHandler:
  ' Dim sngSimSpillMonthsInv As Single
  ' sngSimSpillMonthsInv = 1 / lngSimSpillMonths
  ' sngAvgSpillVolume = sngSimSpillVolume * sngSimSpillMonthsInv
  ' Resume Next

CheckError:
  intNoFile = 31031
  'intWrongFormat = 3161

  If Err = intNoFile Then
    MsgBox "Your project directory is missing this file.  The generic Visual Balance Excel
file will be loaded for you to edit and save in your project directory.", vbOKOnly
    OLE1.CreateLink ("c:\VisualBalance\RiskData.xls")
    OLE1.DoVerb vbOLEOpen
  'ElseIf Err = intWrongFormat Then
```

```
    '  Beep
    '  StrMsg = "An error has occurred reading the Excel file with your temporal " & _
    '  "precipitation data.  You must edit your Excel file before " & _
    '  "running the risk analysis. Click 'Yes' " & _
    '  "if you would you like to load the standard " & _
    '  "Visual Balance Excel file for temporal data " & _
    '  "and begin again?  " & _
    '  "Click 'No' to return to the Output Menu."
    '  If MsgBox(StrMsg, vbExclamation + vbYesNo) = vbYes Then
    '     FrmRiskData.OLE1.CreateLink ("c:\VisualBalance\RiskData.xls")
    '     FrmRiskData.OLE1.DoVerb vbOLEOpen
    '  Else
    '     GoTo ProcExit:
    '  End If
  ElseIf Err = 0 Then
     GoTo ProcExit
  Else
     strMsgBox = "Unexpected error #" & Str(Err) & " occurred: " & Error
     MsgBox strMsgBox, vbExclamation, vbOKOnly
  End If

ProcExit:
  FrmWaitingSign.Visible = False
  Unload FrmWaitingSign
  FrmOutputMenu.MousePointer = 1
  FrmOutputMenu.Visible = True
  Exit Sub

ProcError:
  MsgBox Err.Description
  Resume ProcExit

OverflowError:
  Unload FrmWaitingSign
  FrmOutputMenu.MousePointer = 1
  MsgBox "Due to the overflow error in your reservoir, Visual Balance was unable to
complete the water balance.  Please edit your input files in order to proceed.", vbOKOnly
  Exit Sub

End Sub

Private Sub mnuTableElevExtended_Click()
```

```
If blnVbRan = False Then
   MsgBox "You have not run a water & materials balance for this data.", vbExclamation
   GoTo ProcExit:
End If

MsgBox "Remember, this was balance run # " & intRunNumber & ".  You should save the
data in your project directory under that run number.", vbInformation

   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is creating an Excel output
file..."
   FrmWaitingSign.Visible = True
   MousePointer = vbHourglass
   FrmWaitingSign.Refresh
   FrmWaitingSign.Show

Dim appWatElev As New Excel.Application
Dim wkbWatElev As New Excel.Workbook
Dim wksWatElev As New Excel.Worksheet

   appWatElev.Workbooks.Add
   appWatElev.Worksheets.Add

   With appWatElev.Range("A1:FM1").Font
      .Size = 10
      .Name = "Arial"
      .ColorIndex = 1
   End With

   With appWatElev.Range("A1")
      .ColumnWidth = 29
      .Font.Bold = True
   End With

   appWatElev.Range("B1:FM1").ColumnWidth = 12

   appWatElev.Rows(3).NumberFormat = "#,##0.0"

   intRow = 4
   While intRow < 26
      With appWatElev
         .Rows(intRow).NumberFormat = "###,###,##0"
      End With
```

```
        intRow = intRow + 1
    Wend

    intRow = 27
    While intRow < 32
        With appWatElev
            .Rows(intRow).NumberFormat = "##,##0.0"
        End With
        intRow = intRow + 1
    Wend

    appWatElev.Range("A1").Value = "Site Name: " & strSiteName

'Add Titles to the Columns of the Excel Worksheet
    appWatElev.Range("A2").Value = "Month"
    appWatElev.Range("A3").Value = "Time In Years"

    With appWatElev.Range("A4")
        .Value = "Water Inflow per Month"
        .Font.Bold = True
    End With
    appWatElev.Range("A5").Value = "Direct Precipitation"
    appWatElev.Range("A6").Value = "Runoff"
    appWatElev.Range("A7").Value = "Slurry Water Input"
    appWatElev.Range("A8").Value = "Mine Water"
    appWatElev.Range("A9").Value = "Groundwater Seepage"
    appWatElev.Range("A10").Value = "Seepage or Treated Water Return"
    appWatElev.Range("A11").Value = "Monthly Water Inflow"

    With appWatElev.Range("A12")
        .Value = "Water Losses per Month"
        .Font.Bold = True
    End With
    appWatElev.Range("A13").Value = "Total Evaporation (Pond & Beach)"
    appWatElev.Range("A14").Value = "Reclaim Water Out"
    appWatElev.Range("A15").Value = "Total Months Reclaim Off"
    appWatElev.Range("A16").Value = "Seepage Out"
    appWatElev.Range("A17").Value = "Release Volume"
    appWatElev.Range("A18").Value = "Water Lost to Voids"
    appWatElev.Range("A19").Value = "Loss to Embankment"
    appWatElev.Range("A20").Value = "Monthly Water Losses"
    With appWatElev.Range("A21")
        .Value = "End of Month Water Volume"
```

```
    End With

    With appWatElev.Range("A22")
      .Value = "Solids Inflow and Losses"
      .Font.Bold = True
    End With
    appWatElev.Range("A23").Value = "Monthly Solids & Voids Inflow"
    appWatElev.Range("A24").Value = "Monthly Tailings Lost to Voids"
    appWatElev.Range("A25").Value = "Total Sol & Voids Vol."

    With appWatElev.Range("A26")
      .Value = "Balance Summary"
      .Font.Bold = True
    End With
    appWatElev.Range("A27").Value = "Solids Elev."
    appWatElev.Range("A28").Value = "Water Elev."
    appWatElev.Range("A29").Value = "Free Water Depth"
    appWatElev.Range("A30").Value = "EDF Elev."
    appWatElev.Range("A31").Value = "Dam Crest Elev."

'Label the second row with units for each field.'
    appWatElev.Range("B5").Value = "(years)"
    appWatElev.Range("B6").Value = "(m3)"
    appWatElev.Range("B7").Value = "(m3)"
    appWatElev.Range("B8").Value = "(m3)"
    appWatElev.Range("B9").Value = "(m3)"
    appWatElev.Range("B10").Value = "(m3)"
    appWatElev.Range("B11").Value = "(m3)"

    appWatElev.Range("B13").Value = "(m3)"
    appWatElev.Range("B14").Value = "(m3)"
    appWatElev.Range("B15").Value = ""
    appWatElev.Range("B16").Value = "(m3)"
    appWatElev.Range("B17").Value = "(m3)"
    appWatElev.Range("B18").Value = "(m3)"
    appWatElev.Range("B19").Value = "(m3)"
    appWatElev.Range("B20").Value = "(m3)"
    appWatElev.Range("B21").Value = "(m3)"

    appWatElev.Range("B23").Value = "(m3)"
    appWatElev.Range("B24").Value = "(m3)"
    appWatElev.Range("B25").Value = "(m3)"
```

```
    appWatElev.Range("B27").Value = "(m.a.s.l.)"
    appWatElev.Range("B28").Value = "(m.a.s.l.)"
    appWatElev.Range("B29").Value = "(m)"
    appWatElev.Range("B30").Value = "(m.a.s.l.)"
    appWatElev.Range("B31").Value = "(m.a.s.l.)"

'Label the the month record/rows.'
    strStartMonthLabel = FindMonthLabel(intStartMonth)
    appWatElev.Range("C2").Value = strStartMonthLabel

    intCol = 2
    intMonthCounter = 1
    intYearCounter = 1
    Do Until intMonthCounter > intTotalMonths
        intCol = intCol + 1
        intMonthCounter = intMonthCounter + 1
        intCurMonth = (intMonthCounter + (intStartMonth - 1)) _
        - ((intYearCounter - 1) * 12)
            If intCurMonth = 12 Then
                intYearCounter = intYearCounter + 1
            End If
        strMonthLabel = FindMonthLabel(intCurMonth)
        appWatElev.Cells(2, intCol).Value = strMonthLabel
    Loop

'Put the elevations in the appropriate columns.

    intCol = 2
    intMonthCounter = 0
    intYearCounter = 1
    Do Until intMonthCounter > intTotalMonths

        intCol = intCol + 1
        intMonthCounter = intMonthCounter + 1
        intYearCounter = intMonthCounter / 12

        appWatElev.Cells(3, intCol).Value = _
            intYearCounter

        appWatElev.Cells(5, intCol).Value = _
            sngMonthDirPre(intMonthCounter)
        appWatElev.Cells(6, intCol).Value = _
            sngMonthRunoff(intMonthCounter)
```

```
appWatElev.Cells(7, intCol).Value = _
    sngMonthSlurryWater(intMonthCounter)
appWatElev.Cells(8, intCol).Value = _
    sngMonthMineWater(intMonthCounter)
appWatElev.Cells(9, intCol).Value = _
    sngMonthSeepIn(intMonthCounter)
appWatElev.Cells(10, intCol).Value = _
    sngMonthSeepReturn(intMonthCounter)
appWatElev.Cells(11, intCol).Value = _
    sngMonthWatIn(intMonthCounter)

appWatElev.Cells(13, intCol).Value = _
    sngMonthPondEvap(intMonthCounter) _
    + sngMonthBeachEvap(intMonthCounter)
appWatElev.Cells(14, intCol).Value = _
    sngMonthReclaim(intMonthCounter)
appWatElev.Cells(15, intCol).Value = _
    intReclaimOffCount(intMonthCounter)
appWatElev.Cells(16, intCol).Value = _
    sngMonthSeepOut(intMonthCounter)
appWatElev.Cells(17, intCol).Value = _
    sngMonthSpill(intMonthCounter)
appWatElev.Cells(18, intCol).Value = _
    sngMonthWatLossToTail(intMonthCounter) _
    + sngMonthWatLossToWR(intMonthCounter)
appWatElev.Cells(19, intCol).Value = _
    sngMonthDamLoss(intMonthCounter)
appWatElev.Cells(20, intCol).Value = _
    sngMonthWatLoss(intMonthCounter)
appWatElev.Cells(21, intCol).Value = _
    sngEndWatVol(intMonthCounter)

appWatElev.Cells(23, intCol).Value = _
    sngMonthSolIn(intMonthCounter) _
    + sngMonthVoidLoss(intMonthCounter)
appWatElev.Cells(24, intCol).Value = _
    sngMonthTailLossToWR(intMonthCounter)
appWatElev.Cells(25, intCol).Value = _
    sngEndSolVol(intMonthCounter)

appWatElev.Cells(27, intCol).Value = _
    sngEndSolElev(intMonthCounter)
appWatElev.Cells(28, intCol).Value = _
```

```
        sngEndWatElev(intMonthCounter)
      appWatElev.Cells(29, intCol).Value = _
        sngEndPondDepth(intMonthCounter)
      appWatElev.Cells(30, intCol).Value = _
        sngEndEDFElev(intMonthCounter)
      appWatElev.Cells(31, intCol).Value = _
        sngEndDamCrestElev(intMonthCounter)
  Loop

Unload FrmWaitingSign

appWatElev.Visible = True

MousePointer = 1

ProcExit:
  Exit Sub
End Sub

Private Sub mnuViewInputs_Click()

Load FrmWaitingSign
  FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is creating an Excel data
file..."
  FrmWaitingSign.Visible = True
  MousePointer = vbHourglass
  FrmWaitingSign.Refresh
  FrmWaitingSign.Show

Dim appInputs As New Excel.Application
Dim wkbInputs As New Excel.Workbook
Dim wksInputs As New Excel.Worksheet

  appInputs.Workbooks.Add
  appInputs.Worksheets.Add

  With appInputs.Range("A1:G1").Font
    .Size = 11
    .Name = "Arial"
    .ColorIndex = 1
  End With

  appInputs.Range("A1").Font.Bold = True
```

```
    With appInputs.Range("A1")
      .ColumnWidth = 32
    End With

    With appInputs.Range("B1:G1")
      .ColumnWidth = 15
    End With
    appInputs.Range("B1:B4").NumberFormat = "###,###"
    appInputs.Range("B5:B6").NumberFormat = "####"
    appInputs.Range("B7:B48").NumberFormat = "###,##0.0#"
    appInputs.Range("B49").NumberFormat = "###,###,##0"

'Add Titles to the Columns of the Excel Worksheet
    appInputs.Range("A1").Value = "Balance Input Data "
    appInputs.Range("B1").Value = "Run Number " & intRunNumber

    appInputs.Range("A2").Value = "Project Name:  " & strSiteName

    appInputs.Range("A3").Value = "Start Up Month"
    appInputs.Range("B3").Value = intStartMonth

    appInputs.Range("A4").Value = "Month of Closure"
    appInputs.Range("B4").Value = intEndMonth

    appInputs.Range("A5").Value = "Start Up Year"
    appInputs.Range("B5").Value = intStartYear

    appInputs.Range("A6").Value = "Year of Closure"
    appInputs.Range("B6").Value = intEndYear

    With appInputs.Range("A7")
      .Value = "Production Information"
      .Font.Bold = True
    End With

    appInputs.Range("A8").Value = "Tonnes Mined Per Day"
    appInputs.Range("B8").Value = sngTonnesMined

    appInputs.Range("A9").Value = "Tonnes Concentrate Per Day"
    appInputs.Range("B9").Value = sngTonnesMetal

    appInputs.Range("A10").Value = "Tonnes Waste Rock"
```

```
applnputs.Range("B10").Value = sngTonnesRock

applnputs.Range("A11").Value = "Tonnes Tailings Per Day"
applnputs.Range("B11").Value = sngTonnesTail

With applnputs.Range("A12")
   .Value = "Waste Rock Information"
   .Font.Bold = True
End With

applnputs.Range("A13").Value = "Bulk Density"
applnputs.Range("B13").Value = sngBulkDRock

applnputs.Range("A14").Value = "Void Ratio"
applnputs.Range("B14").Value = sngVoidRRock

With applnputs.Range("A15")
   .Value = "Tailings Information"
   .Font.Bold = True
End With

applnputs.Range("A16").Value = "Degree of Saturation"
applnputs.Range("B16").Value = sngDegSatTail

applnputs.Range("A17").Value = "Slurry Fraction as Water"
applnputs.Range("B17").Value = sngFracWater

applnputs.Range("A18").Value = "Coarse Fraction Cycloned Out"
applnputs.Range("B18").Value = sngFracCyclone

applnputs.Range("A19").Value = "Dry Density"
applnputs.Range("B19").Value = sngDryDTail

applnputs.Range("A20").Value = "In Situ Void Ratio"
applnputs.Range("B20").Value = sngVoidRTail

With applnputs.Range("A22")
.Value = "Reservoir Information"
.Font.Bold = True
End With

applnputs.Range("A23").Value = "Reservoir Name"
applnputs.Range("B23").Value = strResName
```

```
appInputs.Range("A24").Value = "Reservoir Catchment Area"
appInputs.Range("B24").Value = sngCatchArea

appInputs.Range("A25").Value = "Start Up Water Elevation"
appInputs.Range("B25").Value = sngStartWatElev

appInputs.Range("A26").Value = "Start Up Solids Elevation"
appInputs.Range("B26").Value = sngStartTailElev

appInputs.Range("A27").Value = "Start Up Reservoir Surface Area"
appInputs.Range("B27").Value = sngStartSurfArea

appInputs.Range("A28").Value = "Start Up Water Volume"
appInputs.Range("B28").Value = sngStartWatVol

appInputs.Range("A29").Value = "Start Up Solids Volume"
appInputs.Range("B29").Value = sngStartSolVol

appInputs.Range("A30").Value = "Seepage Rate In (m3/day)"
appInputs.Range("B30").Value = sngSeepInRate

With appInputs.Range("A31")
   .Value = "Operation Data"
   .Font.Bold = True
End With

appInputs.Range("A32").Value = "Reclaim Rate (m3/hr)"
appInputs.Range("B32").Value = sngReclaimRate

appInputs.Range("A33").Value = "Pond Depth Required for Reclaim (m)"
appInputs.Range("B33").Value = sngNeededForReclaim

appInputs.Range("A34").Value = "Slurry Input Rate (m3/hr)"
appInputs.Range("B34").Value = sngSlurryWatInRate

appInputs.Range("A35").Value = "Mine Water Input Rate (m3/hr)"
appInputs.Range("B35").Value = sngMineWatInRate

appInputs.Range("A36").Value = "Fraction of Waste Rock to Res."
appInputs.Range("B36").Value = sngFracWRIn

appInputs.Range("A37").Value = "Fraction Runoff Diverted"
```

```
applnputs.Range("B37").Value = sngFracRunDivert

applnputs.Range("A38").Value = "Seepage Return Rate (m3/day)"
applnputs.Range("B38").Value = sngSeepReturnRate

With applnputs.Range("A39")
   .Value = "Dam Design Information"
   .Font.Bold = True
End With

applnputs.Range("A40").Value = "Maximum Dam Lift Height (m)"
applnputs.Range("B40").Value = sngMaxLift

applnputs.Range("A41").Value = "# Rows in Volume-Elevation"
applnputs.Range("B41").Value = intVESRows

applnputs.Range("A42").Value = "Freeboard Period One (m)"
applnputs.Range("B42").Value = sngFreeBoard1

applnputs.Range("A43").Value = "Freeboard Period Two (m)"
applnputs.Range("B43").Value = sngFreeBoard2

applnputs.Range("A44").Value = "EDF Volume (m3)"
applnputs.Range("B44").Value = sngEDFVolume

applnputs.Range("A45").Value = "Dam Elevation Dependant Data File?"
With applnputs.Range("B45")
   .Value = strDependResponse
End With

applnputs.Range("A46").Value = "Number of Rows in Data File"
If strDependResponse = "True " Then
      applnputs.Range("B46").Value = intDamRows
Else:  applnputs.Range("B46").Value = "Not Appl."
End If

applnputs.Range("A47").Value = "Constant Seepage Out (m3/hr)"
applnputs.Range("B47").Value = sngSeepOutRateConstant

applnputs.Range("A48").Value = "Constant Beach Area (m2)"
applnputs.Range("B48").Value = sngBeachAreaConstant

applnputs.Range("A49").Value = "Constant Volume Loss to Dam (m3)"
```

```
   appInputs.Range("B49").Value = sngDamLossConstant

Unload FrmWaitingSign

appInputs.Visible = True

MousePointer = 1

ProcExit:
   Exit Sub

End Sub

Private Sub mnuViewRiskInputs_Click()

If blnRiskRan = False Then
   MsgBox "You have not run a risk analysis for this data.  Please do so prior to viewing
input data or results.", vbExclamation
   GoTo ProcExit:
End If

   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is creating an Excel data
file..."
   FrmWaitingSign.Visible = True
   MousePointer = vbHourglass
   FrmWaitingSign.Refresh
   FrmWaitingSign.Show

Dim appRiskInputs As New Excel.Application
Dim wkbRiskInputs As New Excel.Workbook
Dim wksRiskInputs As New Excel.Worksheet

   appRiskInputs.Workbooks.Add
   appRiskInputs.Worksheets.Add

   With appRiskInputs.Range("A1").Font
      .Size = 11
      .Name = "Arial"
      .ColorIndex = 1
      .Bold = True
   End With
```

```
    appRiskInputs.Range("A1").Font.Bold = True

    With appRiskInputs.Range("A1")
       .ColumnWidth = 35
    End With

    With appRiskInputs.Range("B1:G1")
       .ColumnWidth = 15
    End With

    appRiskInputs.Range("B1:B500").NumberFormat = "###,##0.00"

'Add Titles to the Columns of the Excel Worksheet

    appRiskInputs.Range("A1").Value = "Risk Analysis Parameters"
    appRiskInputs.Range("B1").Value = "Run Number: " & intRunNumber
    appRiskInputs.Range("A2").Value = "Site Name: " & strSiteName

    appRiskInputs.Range("A3").Value = "Mean Annual Precipitation"
    appRiskInputs.Range("A4").Value = "Standard Deviation"
    appRiskInputs.Range("A5").Value = "Number of Years of record"
    appRiskInputs.Range("A6").Value = "Freeboard Required above EDF"
    appRiskInputs.Range("B3").Value = sngMeanAnnual
    appRiskInputs.Range("B4").Value = sngStandardDev
    appRiskInputs.Range("B5").Value = sngNumYearsRecord
    appRiskInputs.Range("B6").Value = sngRiskFreeboard

    appRiskInputs.Range("A8").Value = "Operation Parameters"
    appRiskInputs.Range("A9").Value = "Number of Years in Operation Series"
    appRiskInputs.Range("A10").Value = "Operation Series in Simulation"
    appRiskInputs.Range("A11").Value = "Number of Months in Simulation"
    appRiskInputs.Range("B9").Value = sglTotalYears
    appRiskInputs.Range("B10").Value = intNumSeries
    appRiskInputs.Range("B11").Value = intNumSeries * intTotalMonths

Unload FrmWaitingSign

appRiskInputs.Visible = True

MousePointer = 1

ProcExit:
    Exit Sub
```

```
End Sub


Private Sub ReadMe_Click()
   Load FrmReadMe
   FrmReadMe.Show
End Sub

Private Sub StagingCurve_Click(Index As Integer)

On Error GoTo CheckError

   If blnVbRan = False Then
      MsgBox "You should run a water & materials balance for this data prior to running a
risk analysis.", vbExclamation
      GoTo ProcExit:
   End If

Load FrmWaitingSign
FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is creating output graph file..."
FrmWaitingSign.Visible = True
FrmWaitingSign.Show
FrmWaitingSign.Refresh
MousePointer = vbHourglass

'If FrmMainMenu.txtClickExisting.Text = "No" Then
   'blnIsNewProject = True
   'strpath = "c:\" & FrmNewFile.TxtNewDir.Text
'Else
   'blnIsNewProject = False
   'strpath = FrmExistingFile.DirProject
'End If

Dim appStaging As Object
Dim wksStagingData As Object
Dim wkbStaging As Excel.Workbook
   Set wkbStaging = GetObject("c:\VisualBalance\StagingCurve.xls")
   Set appStaging = wkbStaging.Application
   Set wksStagingData = wkbStaging.Worksheets("StagingData")

'Label the the month record/Columns.'
   strStartMonthLabel = FindMonthLabel(intStartMonth)
   wksStagingData.Cells(2, 3).Value = strStartMonthLabel
```

```
    intColumn = 2
    intMonthCounter = 1
    intYearCounter = 1
    Do Until intMonthCounter > intTotalMonths
        intColumn = intColumn + 1
        intMonthCounter = intMonthCounter + 1
        intCurMonth = (intMonthCounter + (intStartMonth - 1)) _
        - ((intYearCounter - 1) * 12)
            If intCurMonth = 12 Then
                intYearCounter = intYearCounter + 1
            End If
        strMonthLabel = FindMonthLabel(intCurMonth)
        wksStagingData.Cells(3, intColumn).Value = strMonthLabel
    Loop


'Fill the time in years into the second row.
    intColumn = 2
    intMonthCounter = 0
    Do Until intMonthCounter > intTotalMonths
        intMonthCounter = intMonthCounter + 1
        intYearCounter = intMonthCounter / 12
        wksStagingData.Cells(2, intColumn).Value = _
        intYearCounter
        intColumn = intColumn + 1
    Loop


'Put the End of the month water volume in the 13th row.
    intColumn = 2
    intMonthCounter = 0
    Do Until intMonthCounter > intTotalMonths
        intMonthCounter = intMonthCounter + 1
        wksStagingData.Cells(13, intColumn).Value = _
            sngEndTotVol(intMonthCounter)
        intColumn = intColumn + 1
    Loop

'Put the End of the month solids elevation in the fourth column.
'Put the End of the month water elevation in the fifth column.
'Put the End of the month dam crest elevation in the sixth column.
    intColumn = 2
```

```
    intMonthCounter = 0
    Do Until intMonthCounter > intTotalMonths
      intMonthCounter = intMonthCounter + 1
      wksStagingData.Cells(4, intColumn).Value = _
        sngEndSolElev(intMonthCounter)
      wksStagingData.Cells(5, intColumn).Value = _
        sngEndWatElev(intMonthCounter)
      wksStagingData.Cells(6, intColumn).Value = _
        sngEndEDFElev(intMonthCounter)
      wksStagingData.Cells(10, intColumn).Value = _
        sngEndDamCrestElev(intMonthCounter)
      intColumn = intColumn + 1
    Loop

    Unload FrmWaitingSign
    MousePointer = 1

    strFile = "StagingCurve" & intRunNumber & ".xls"
    wkbStaging.SaveAs (strpath & strFile)

    OLE1.Class = "Excel.Sheet"          ' Set class name.
    OLE1.OLETypeAllowed = vbOLELinked
    OLE1.CreateLink (strpath & strFile)
    OLE1.DoVerb vbOLEOpen

CheckError:


ProcExit:
    Exit Sub

End Sub

Private Sub GraphWater_Click(Index As Integer)

MsgBox "This option is not available." & vbOKOnly

End Sub

Private Sub ReturntoMain_Click(Index As Integer)
    Unload Me
    Unload FrmExistingFile
    Unload FrmNewFile
```

```
   Load FrmMainMenu
   FrmMainMenu.Show
End Sub

Private Sub mnuRunVisualBalance_Click()

intSpillCount = 0

If blnVbRan = True Then
   intRunNumber = intRunNumber + 1
End If

'On Error GoTo CheckError:

   Load FrmWaitingSign
   FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is running."
   FrmWaitingSign.LblProgress.Caption = "This is balance run number..."
   FrmWaitingSign.LblRunCounter = intRunNumber
   FrmWaitingSign.Visible = True
   FrmWaitingSign.Show
   FrmWaitingSign.Refresh
   FrmOutputMenu.MousePointer = vbHourglass

'First, the program should check that a file exists with
'all the basic data else an error appears saying invalid
'filename or insufficient data.

'Starting with the initial water elevation for a given
'start month and start year, the sum_total accumulation
'for that month would be calculated and the resulting
'water elevation estimated.

'Open the hydrological Excel data file as an ADO
'recordset and save the data to specific variables to
'use in computation.

      Dim mydb As Object
      Dim myTable As Recordset

      Set mydb = DBEngine.OpenDatabase(strpath & "\HydroData.xls", _
      dbDriverNoPrompt, False, "Excel 8.0")
      Set myTable = mydb.OpenRecordset("Hydro")
      myTable.MoveFirst
```

```
    intRowCounter = 1
    While intRowCounter < 13
      sngAvgPrecip(intRowCounter) = myTable.Fields(0)
      sngMonthPercent(intRowCounter) = myTable.Fields(1)
      sngFracSnow(intRowCounter) = myTable.Fields(2)
      sngFracMelt(intRowCounter) = myTable.Fields(3)
      sngRunoffLoss(intRowCounter) = myTable.Fields(4)
      sngIntensity(intRowCounter) = myTable.Fields(5)
      sngPondEvap(intRowCounter) = myTable.Fields(6)
      sngBeachEvap(intRowCounter) = myTable.Fields(7)
      myTable.MoveNext
      intRowCounter = intRowCounter + 1
    Wend

'Open the Operating Days Excel data file as an ADO
'recordset and save the data to specific variables to
'use in computation.

    Dim Daysdb As Object
    Dim DaysTable As Recordset

    Set Daysdb = DBEngine.OpenDatabase(strpath & "\OperatingDays.xls", _
    dbDriverNoPrompt, False, "Excel 8.0")
    Set DaysTable = Daysdb.OpenRecordset("Days")
    DaysTable.MoveFirst

    intRowCounter = 1
    While intRowCounter < 13
      intOperDaysinMonth(intRowCounter) = DaysTable.Fields(2)
      DaysTable.MoveNext
      intRowCounter = intRowCounter + 1
    Wend
    intOperDaysPerYear = DaysTable.Fields(1)

'Open the Spill rate per month excel file.

    Dim Spilldb As Object
    Dim SpillTable As Recordset

    Set Spilldb = DBEngine.OpenDatabase(strpath & "\SpillVolumes.xls", _
    dbDriverNoPrompt, False, "Excel 8.0")
    Set SpillTable = Spilldb.OpenRecordset("Spill")
    SpillTable.MoveFirst
```

```
    intRowCounter = 1
    While intRowCounter < 13
      sngSpillPerMonth(intRowCounter) = SpillTable.Fields(1)
      SpillTable.MoveNext
      intRowCounter = intRowCounter + 1
    Wend
    sngSpillPerYear = SpillTable.Fields(1)

  intTotalYears = intEndYear - intStartYear

  'Open the Annually Varying production and material depostion rates file if
  'necessary values.

  If strAnnVary = "True " Then

    Dim Proddb As Object
    Dim ProdTable As Recordset

    Set Proddb = DBEngine.OpenDatabase(strpath & "\Production.xls", _
    dbDriverNoPrompt, False, "Excel 8.0")
    Set ProdTable = Proddb.OpenRecordset("Production")
    ProdTable.MoveFirst

    intRowCounter = 1
    While intRowCounter < intTotalYears
      sngAnnMined(intRowCounter) = ProdTable.Fields(1)
      sngAnnTail(intRowCounter) = ProdTable.Fields(2)
      sngAnnRock(intRowCounter) = ProdTable.Fields(3)
      ProdTable.MoveNext
      intRowCounter = intRowCounter + 1
    Wend
  End If

'
'____________________________________________________________________
'           WATER AND MATERIAL BALANCE CODE

'Calculate the water and mass balance for each month
'up to the total number of months of operation.

  intMonthCounter = 0
  intCurMonth = intStartMonth - 1
  intYearCounter = 0
```

```
Do Until intMonthCounter = intTotalMonths

   intMonthCounter = intMonthCounter + 1
   intCurMonth = intCurMonth + 1
      If intCurMonth = 13 Then
         intCurMonth = 1
      End If
      If intCurMonth = intStartMonth Then
         intYearCounter = intYearCounter + 1
      End If
   intPrevMonth = intMonthCounter - 1
   intDaysinMonth = CalcNumDaysInMon(intCurMonth)

   If intMonthCounter = 1 Then
      sngBegWatElev(intMonthCounter) = sngStartWatElev
      sngBegWatVol(intMonthCounter) = sngStartWatVol
      sngBegSolVol(intMonthCounter) = sngStartSolVol
      sngBegTotVol(intMonthCounter) = sngStartWatVol + sngStartSolVol
      sngBegPondArea(intMonthCounter) = sngStartSurfArea
   Else
      sngBegTotVol(intMonthCounter) = sngEndTotVol(intPrevMonth)
      sngBegWatElev(intMonthCounter) = sngEndWatElev(intPrevMonth)
      sngBegSolVol(intMonthCounter) = sngEndSolVol(intPrevMonth)
      sngBegPondArea(intMonthCounter) = sngEndPondArea(intPrevMonth)
   End If

'Calculate the water inflows to the reservoir for each month.

sngMonthDirPre(intMonthCounter) = sngAvgPrecip(intCurMonth) _
   / 1000 * sngBegPondArea(intMonthCounter) * 10000

sngMonthRunoff(intMonthCounter) = (sngIntensity(intCurMonth) / 1000) _
   * ((sngCatchArea - sngBegPondArea(intMonthCounter)) * 10000) * (1 -
sngFracRunDivert)

sngMonthMineWater(intMonthCounter) = sngMineWatInRate * 24 * intDaysinMonth

sngMonthSlurryWater(intMonthCounter) = sngSlurryWatInRate * 24 * intDaysinMonth

sngMonthSeepIn(intMonthCounter) = sngSeepInRate * intDaysinMonth

sngMonthSeepReturn(intMonthCounter) = sngSeepReturnRate * intDaysinMonth
```

```
'Calculate the water loss for each month...

'1. Evaporation
sngMonthPondEvap(intMonthCounter) = _
   (sngPondEvap(intCurMonth) / 1000) _
   * (sngBegPondArea(intMonthCounter) * 10000)

'2. Reclaim Water

If intMonthCounter = 1 Then
   sngMonthReclaim(intMonthCounter) = _
      sngReclaimRate * 24 * intDaysinMonth
   intReclaimOffCount(intMonthCounter) = 0
ElseIf intMonthCounter > 1 And sngEndPondDepth(intPrevMonth) <
sngNeededForReclaim Then
   sngMonthReclaim(intMonthCounter) = 0
   intReclaimOffCount(intMonthCounter) = intReclaimOffCount(intPrevMonth) + 1
ElseIf intMonthCounter > 1 And sngEndPondDepth(intPrevMonth) >
sngNeededForReclaim Then
   sngMonthReclaim(intMonthCounter) = _
      sngReclaimRate * 24 * intDaysinMonth
   intReclaimOffCount(intMonthCounter) = intReclaimOffCount(intPrevMonth)
End If

'3. Release Volume

sngMonthSpill(intMonthCounter) = sngSpillPerMonth(intCurMonth)

'4. Volume loss to the dam, beach evaporation and dam seepage
   'from either the constant, user-entered values or the dam elevation dependant
   'values entered in an Excel spreadsheet.

If strDependResponse = "True " Then
   If intMonthCounter = 1 Then
      sngDamLoss = 0
      sngSeepOutRate = 0
      sngBeachArea = 0
   Else
      sngDamLoss = CalcDamL(sngEndDamCrestElev(intPrevMonth))
      sngSeepOutRate = CalcSeepR(sngEndDamCrestElev(intPrevMonth))
      sngBeachArea = CalcBeachA(sngEndDamCrestElev(intPrevMonth))
   End If
```

```
Else
   sngDamLoss = sngDamLossConstant
   sngSeepOutRate = sngSeepOutRateConstant
   sngBeachArea = sngBeachAreaConstant
End If

sngMonthSeepOut(intMonthCounter) = sngSeepOutRate * intDaysinMonth
sngMonthBeachEvap(intMonthCounter) = (sngBeachEvap(intCurMonth) / 1000) _
   * sngBeachArea

If intMonthCounter = 1 Then
   sngMonthDamLoss(intMonthCounter) = sngDamLoss
Else
   If sngMonthDamLoss(intMonthCounter) = sngMonthDamLoss(intPrevMonth) Then
      sngMonthDamLoss(intMonthCounter) = sngMonthDamLoss(intPrevMonth)
   Else
      sngMonthDamLoss(intMonthCounter) = sngDamLoss -
sngMonthDamLoss(intPrevMonth)
   End If
End If

'5. Water loss due to retention in Waste rock and tailings voids.
   'First need to calculate the solids inflow volume for each month,
   'the volume of water lost to solids voids...

If strAnnVary = "True " Then

   sngMonthTailVolIn(intMonthCounter) = (sngAnnTail(intYearCounter) / sngDryDTail)
_
      * intOperDaysinMonth(intCurMonth) * (1 - sngFracCyclone)

   sngMonthWRVolIn(intMonthCounter) = (sngFracWRIn * sngFracWRsub _
      * sngAnnRock(intYearCounter) * intOperDaysinMonth(intCurMonth)) _
      / sngBulkDRock

   sngMonthWatLossToTail(intMonthCounter) = sngMonthTailVolIn(intMonthCounter) _
      * (sngVoidRTail / (1 + sngVoidRTail)) * sngDegSatTail

   sngMonthWatLossToWR(intMonthCounter) = (1 - sngFracWRVoidsTail) _
      * (sngMonthWRVolIn(intMonthCounter) * (sngVoidRRock / (1 + sngVoidRRock)))

ElseIf strAnnVary = "False" Then
```

```
    sngMonthTailVolIn(intMonthCounter) = ((sngTonnesTail _
        * intOperDaysinMonth(intCurMonth)) / sngDryDTail) * (1 - sngFracCyclone)
    If sngFracWRIn > 0 Then
        sngMonthWRVolIn(intMonthCounter) = (sngFracWRIn * sngFracWRsub _
            * sngTonnesRock * intOperDaysinMonth(intCurMonth)) _
            / sngBulkDRock
    Else
        sngMonthWRVolIn(intMonthCounter) = 0
    End If

    sngMonthWatLossToTail(intMonthCounter) = (sngTonnesTail _
        * intOperDaysinMonth(intCurMonth) * sngVoidRTail _
        * (1 - sngFracCyclone) * sngDegSatTail) / (sngSpecGravTail)

    sngMonthWatLossToWR(intMonthCounter) = (1 - sngFracWRVoidsTail) _
        * sngMonthWRVolIn(intMonthCounter) * (sngVoidRRock / (1 + sngVoidRRock))
End If

'Calculate Losses of Solids Volume..
'1. Calculate the loss of tailings solids to the WR voids.

    sngMonthTailLossToWR(intMonthCounter) = sngFracWRVoidsTail _
        * (sngMonthWRVolIn(intMonthCounter) * (sngVoidRRock / (1 + sngVoidRRock)))

'**************************************************************

'Sum up the water inflows for the month...

sngMonthWatIn(intMonthCounter) = _
    sngMonthDirPre(intMonthCounter) _
    + sngMonthRunoff(intMonthCounter) _
    + sngMonthMineWater(intMonthCounter) _
    + sngMonthSlurryWater(intMonthCounter) _
    + sngMonthSeepIn(intMonthCounter) _
    + sngMonthSeepReturn(intMonthCounter)

'Sum up the solids inflow for the months...

sngMonthSolIn(intMonthCounter) = sngMonthTailVolIn(intMonthCounter) _
    + sngMonthWRVolIn(intMonthCounter)

'Sum up the water and solids losses for the months...
```

```
sngMonthWatLoss(intMonthCounter) = _
   sngMonthPondEvap(intMonthCounter) _
   + sngMonthBeachEvap(intMonthCounter) _
   + sngMonthSeepOut(intMonthCounter) _
   + sngMonthWatLossToTail(intMonthCounter) _
   + sngMonthWatLossToWR(intMonthCounter) _
   + sngMonthReclaim(intMonthCounter) _
   + sngMonthSpill(intMonthCounter) _
   + sngMonthDamLoss(intMonthCounter)

'Sum the loss of solids for the month...

sngMonthSolLoss(intMonthCounter) = sngMonthTailLossToWR(intMonthCounter)

'Based on a new volume of solids and water in the pond,
'find the new surface area and water elevation at the
'end of the Start Up Month.

   sngEndTotVol(intMonthCounter) = _
      sngBegTotVol(intMonthCounter) _
      + sngMonthWatIn(intMonthCounter) _
      + sngMonthSolIn(intMonthCounter) _
      - sngMonthWatLoss(intMonthCounter) _
      - sngMonthSolLoss(intMonthCounter)

   If intMonthCounter > 1 Then
      sngEndSolVol(intMonthCounter) = _
      sngEndSolVol(intPrevMonth) + sngMonthSolIn(intMonthCounter) - _
         sngMonthSolLoss(intMonthCounter)
   Else
      sngEndSolVol(intMonthCounter) = sngMonthSolIn(intMonthCounter) - _
         sngMonthSolLoss(intMonthCounter) + sngStartSolVol
   End If

   sngEndSolElev(intMonthCounter) = CalcElevation(sngEndSolVol(intMonthCounter))
      If sngEndSolElev(intMonthCounter) = 0 Then
         GoTo OverflowError:
      End If

   If intMonthCounter > 1 Then
      sngEndWatVol(intMonthCounter) = _
      sngEndWatVol(intPrevMonth) + sngMonthWatIn(intMonthCounter) - _
         sngMonthWatLoss(intMonthCounter)
```

```
Else
   sngEndWatVol(intMonthCounter) = sngMonthWatIn(intMonthCounter) - _
      sngMonthWatLoss(intMonthCounter) + sngStartWatVol
End If

sngEndWatElev(intMonthCounter) = _
   CalcElevation(sngEndTotVol(intMonthCounter))
   If sngEndWatElev(intMonthCounter) = 0 Then
      GoTo OverflowError:
   End If

sngEndPondDepth(intMonthCounter) = sngEndWatElev(intMonthCounter) _
   - sngEndSolElev(intMonthCounter)

sngEndPondArea(intMonthCounter) = CalcArea(sngEndWatElev(intMonthCounter))

'Add on the EDF elevation...

If intCurMonth = 1 Or 2 Or 3 Then
   sngEDFVolume = sngEDFWinter
ElseIf intCurMonth = 4 Or 5 Or 6 Then
   sngEDFVolume = sngEDFSpring
ElseIf intCurMonth = 7 Or 8 Or 9 Then
   sngEDFVolume = sngEDFSummer
ElseIf intCurMonth = 10 Or 11 Or 12 Then
   sngEDFVolume = sngEDFFall
End If

sngEndEDFElev(intMonthCounter) = _
   CalcElevation(sngEndTotVol(intMonthCounter) + sngEDFVolume)
   If sngEndEDFElev(intMonthCounter) = 0 Then
      GoTo OverflowError:
   End If

'Add on the minimum design freeboard to the EDF elevation...

If intYearCounter > intFreeBoard1Year2 Then
   sngDesignFreeboard = sngFreeBoard2
Else
   sngDesignFreeboard = sngFreeBoard1
End If

sngEndDamCrestElev(intMonthCounter) = _
```

```
        sngEndEDFElev(intMonthCounter) + sngDesignFreeboard

    'Check to see if the monthly dam raise exceeds the specified maximum dam raise.
    'If the raise exceeds the max. raise, then the new dam crest elevation is set
    'equal to the previous months elevation + max. dam lift.  A spill is triggered
    'to lower the EDF elevation to the required level to provide adequate freeboard.

    If sngEndDamCrestElev(intMonthCounter) < sngStarterDamElev Then
        sngEndDamCrestElev(intMonthCounter) = sngStarterDamElev
    End If

    If intMonthCounter > 1 Then
        If ((sngEndDamCrestElev(intMonthCounter) - sngEndDamCrestElev(intPrevMonth))
_
            > sngMaxLift) Then
            intSpillCount = intSpillCount + 1
            sngEndDamCrestElev(intMonthCounter) = sngEndDamCrestElev(intPrevMonth) _
                + sngMaxLift
            sngTempWatElev = sngEndWatElev(intMonthCounter)
            sngEndWatElev(intMonthCounter) = sngEndDamCrestElev(intMonthCounter) _
                - sngDesignFreeboard
            sngDesignSpillVol(intMonthCounter) = sngEndTotVol(intMonthCounter) _
                - sngEndWatVol(intMonthCounter)
            sngEndWatVol(intMonthCounter) =
CalcVolume(sngEndWatElev(intMonthCounter))
        End If
    End If

    sngSpillWayInvertElev(intMonthCounter) = _
        sngEndDamCrestElev(intMonthCounter) - sngSpillWayInvert
  Loop

'______________________________________________________________________

'LASTLY, ANNUAL TOTALS FOR EACH YEAR OF OPERATION CAN BE
'CALCULATED BASED ON THE MONTHLY TOTALS ABOVE.  THE FIRST AND
'LAST YEARS OF OPERATION MAY CONTAIN LESS THAN 12 MONTHS AND
'MUST BE COMPUTED SEPARATELY.

  'Sum up the inflows over the total number of years of operation.
  Dim sngTotalYears As Single

  intYearCounter = 1
```

```
sngTotalYears = intTotalMonths / 12
While intYearCounter < sngTotalYears

   sngAnnDirPrecip(intYearCounter) = sngMonthDirPre(1) + _
   sngMonthDirPre(2) + sngMonthDirPre(3) + _
   sngMonthDirPre(4) + sngMonthDirPre(5) + _
   sngMonthDirPre(6) + sngMonthDirPre(7) + _
   sngMonthDirPre(8) + sngMonthDirPre(9) + _
   sngMonthDirPre(10) + sngMonthDirPre(11) + _
   sngMonthDirPre(12)

   sngAnnRunoff(intYearCounter) = sngMonthRunoff(1) + _
   sngMonthRunoff(2) + sngMonthRunoff(3) + sngMonthRunoff(4) + _
   sngMonthRunoff(5) + sngMonthRunoff(6) + sngMonthRunoff(7) + _
   sngMonthRunoff(8) + sngMonthRunoff(9) + sngMonthRunoff(10) + _
   sngMonthRunoff(11) + sngMonthRunoff(12)

   sngAnnMineWater(intYearCounter) = sngMonthMineWater(1) + _
   sngMonthMineWater(2) + sngMonthMineWater(3) + _
   sngMonthMineWater(4) + sngMonthMineWater(5) + _
   sngMonthMineWater(6) + sngMonthMineWater(7) + _
   sngMonthMineWater(8) + sngMonthMineWater(9) + _
   sngMonthMineWater(10) + sngMonthMineWater(11) + _
   sngMonthMineWater(12)

   sngAnnTailingsWater(intYearCounter) = sngMonthSlurryWater(1) + _
   sngMonthSlurryWater(2) + sngMonthSlurryWater(2) + _
   sngMonthSlurryWater(2) + sngMonthSlurryWater(3) + _
   sngMonthSlurryWater(4) + sngMonthSlurryWater(5) + _
   sngMonthSlurryWater(6) + sngMonthSlurryWater(7) + _
   sngMonthSlurryWater(8) + sngMonthSlurryWater(9) + _
   sngMonthSlurryWater(10) + sngMonthSlurryWater(11) + _
   sngMonthSlurryWater(12)

   sngAnnSeepIn(intYearCounter) = sngMonthSeepIn(1) + _
   sngMonthSeepIn(2) + sngMonthSeepIn(3) + sngMonthSeepIn(4) + _
   sngMonthSeepIn(5) + sngMonthSeepIn(6) + sngMonthSeepIn(7) + _
   sngMonthSeepIn(8) + sngMonthSeepIn(9) + sngMonthSeepIn(10) + _
   sngMonthSeepIn(11) + sngMonthSeepIn(12)

   intYearCounter = intYearCounter + 1
Wend
```

```
'***************************************

'Sum up the Annual outflows

intYearCounter = 1
While intYearCounter < 2
   sngAnnEvap(intYearCounter) = sngPondEvap(1) + _
   sngPondEvap(2) + sngPondEvap(3) + sngPondEvap(4) + sngPondEvap(5) + _
   sngPondEvap(6) + sngPondEvap(7) + sngPondEvap(8) + sngPondEvap(9) + _
   sngPondEvap(10) + sngPondEvap(11) + sngPondEvap(12)
   '(Add Beach Evap).

   sngAnnReclaim(intYearCounter) = sngMonthReclaim(1) + _
   sngMonthReclaim(2) + sngMonthReclaim(3) + sngMonthReclaim(4) +
sngMonthReclaim(5) + _
   sngMonthReclaim(6) + sngMonthReclaim(7) + sngMonthReclaim(8) +
sngMonthReclaim(9) + _
   sngMonthReclaim(10) + sngMonthReclaim(11) + sngMonthReclaim(12)

intYearCounter = intYearCounter + 1
Wend

'Losses = sngAnnPondEvap(1) + sngAnnBeachEvap(1) sngAnnReclaim(1)

'Save design dam crest elevations for future risk analysis.

   intFileNumber = FreeFile
   Open (strpath & "\damcrests.txt") For Output As #intFileNumber
   intMonthCounter = 1
   While intMonthCounter < intTotalMonths
      Write #intFileNumber, sngEndDamCrestElev(intMonthCounter)
      intMonthCounter = intMonthCounter + 1
   Wend

   Close #intFileNumber

'Balance is complete.

blnVbRan = True

Beep
FrmWaitingSign.Visible = False
Unload FrmWaitingSign
```

```
FrmOutputMenu.MousePointer = 1
StrMsg = "Visual Balance has finished computing the water balance " & _
   "for these input variables.  Please note that the mine reclaim was turned off in " & _
   intReclaimOffCount(intTotalMonths) & " months out of the entire water balance, which
inclued " & _
   intTotalMonths & " months total.  Due to the maximum dam crest lift height per month of
" & _
   sngMaxLift & " metres, spill was required in " & intSpillCount & " months."
MsgBox StrMsg, vbOKOnly
FrmOutputMenu.Visible = True


'***********************************************
'***********************************************


'________________________________________________
' Error Handling.


CheckError:
   intNoFile = 31031

   If Err = intNoFile Or Err = 3011 Then
      MsgBox "There is an error in one of your Visual Balance Excel" & _
      "data input files.  Please check to see that the" & _
      " table of data has been 'defined' appropriately within Excel.  Please return to the data
edit menu.  " & _
      " The table definition can be found in Excel under Menu: " & _
      "Insert, Name, Define).", vbCritical
      GoTo ProcExit
   ElseIf Err = 0 Then
      GoTo ProcExit
   Else
      strMsgBox = "Unexpected error #" & Str(Err) & " occurred: " & Error
      MsgBox strMsgBox, vbExclamation, vbOKOnly
      GoTo ProcExit
   End If

ProcExit:
   Beep
   FrmWaitingSign.Visible = False
   Unload FrmWaitingSign
```

```
    Exit Sub

ProcError:
    MsgBox Err.Description
    Resume ProcExit

OverflowError:
    Unload FrmWaitingSign
    FrmOutputMenu.MousePointer = 1
    MsgBox "Due to the overflow error in your reservoir in month # " _
        & intMonthCounter & " Visual Balance was unable to complete the " & _
        "water balance.  Please edit your input files in order to " & _
        "proceed.", vbOKOnly
    Exit Sub

End Sub

Private Sub mnuTableElevConcise_Click(Index As Integer)

If blnVbRan = False Then
    MsgBox "You have not run a water & materials balance for this" & _
        "data.", vbExclamation
    GoTo ProcExit:
End If

MsgBox "Remember, this was balance run # " & intRunNumber & "." & _
    "You should save the data in your project directory under that " & _
    "run number.", vbInformation

    Load FrmWaitingSign
    FrmWaitingSign.LblRunMessage.Caption = "Visual Balance is " & _
        "creating an Excel output file..."
    FrmWaitingSign.Visible = True
    MousePointer = vbHourglass
    FrmWaitingSign.Refresh
    FrmWaitingSign.Show

Dim appElevConcise As New Excel.Application
Dim wkbElevConcise As New Excel.Workbook
Dim wksElevConcise As New Excel.Worksheet

    appElevConcise.Workbooks.Add
    appElevConcise.Worksheets.Add
```

```
With appElevConcise.Range("A1:G1").Font
    .Bold = True
    .Size = 11
    .Name = "Arial"
    .ColorIndex = 1
End With

With appElevConcise.Range("A1:B1")
    .ColumnWidth = 15
End With

appElevConcise.Range("C1").ColumnWidth = 20

With appElevConcise.Range("D1:G1")
    .ColumnWidth = 15
End With

appElevConcise.Range("B1:B500").NumberFormat = "0.00"
appElevConcise.Range("C1:C500").NumberFormat = "###,###,###"
appElevConcise.Range("D1:G500").NumberFormat = "###,##0.0#"

appElevConcise.Range("A1").Value = "Site Name: " & strSiteName
appElevConcise.Range("A2").Value = "Run Number: " & intRunNumber

'Add Titles to the Columns of the Excel Worksheet
appElevConcise.Range("A3").Value = "Month"
appElevConcise.Range("B3").Value = "Time In Years"
appElevConcise.Range("C3").Value = "Total Solids, Water "
appElevConcise.Range("C4").Value = "and Voids Volume"
appElevConcise.Range("D3").Value = "Solids"
appElevConcise.Range("D4").Value = "Elevation"
appElevConcise.Range("E3").Value = "Water"
appElevConcise.Range("E4").Value = "Elevation"
appElevConcise.Range("F3").Value = "EDF Elev."
appElevConcise.Range("G3").Value = "Dam Crest"
appElevConcise.Range("G4").Value = "Elevation"

'Label the second row with units for each field.'
appElevConcise.Range("B5").Value = "(years)"
appElevConcise.Range("C5").Value = "(m3)"
appElevConcise.Range("D5").Value = "(m.a.s.l.)"
appElevConcise.Range("E5").Value = "(m.a.s.l.)"
```

```
    appElevConcise.Range("F5").Value = "(m.a.s.l.)"
    appElevConcise.Range("G5").Value = "(m.a.s.l.)"


'Label the the month record/rows.'
    strStartMonthLabel = FindMonthLabel(intStartMonth)
    appElevConcise.Range("A5").Value = strStartMonthLabel

    intRow = 5
    intMonthCounter = 0
    intYearCounter = 1
    Do Until intMonthCounter > intTotalMonths
        intRow = intRow + 1
        intMonthCounter = intMonthCounter + 1
        intCurMonth = (intMonthCounter + (intStartMonth - 1)) _
        - ((intYearCounter - 1) * 12)
            If intCurMonth = 12 Then
                intYearCounter = intYearCounter + 1
            End If
        strMonthLabel = FindMonthLabel(intCurMonth)
        appElevConcise.Cells(intRow, 1).Value = strMonthLabel
    Loop

'Put the elevations in the appropriate columns.

    intRow = 5
    intMonthCounter = 0
    intYearCounter = 1
    Do Until intMonthCounter > intTotalMonths
        intRow = intRow + 1
        intMonthCounter = intMonthCounter + 1
        intYearCounter = intMonthCounter / 12

        appElevConcise.Cells(intRow, 2).Value = _
            intYearCounter
        appElevConcise.Cells(intRow, 3).Value = _
            sngEndTotVol(intMonthCounter)
        appElevConcise.Cells(intRow, 4).Value = _
            sngEndSolElev(intMonthCounter)
        appElevConcise.Cells(intRow, 5).Value = _
            sngEndWatElev(intMonthCounter)
        appElevConcise.Cells(intRow, 6).Value = _
            sngEndEDFElev(intMonthCounter)
```

```
        appElevConcise.Cells(intRow, 7).Value = _
            sngEndDamCrestElev(intMonthCounter)
    Loop

Unload FrmWaitingSign

appElevConcise.Visible = True

MousePointer = 1

ProcExit:
    Exit Sub

End Sub

Private Sub TableWaterQuality_Click(Index As Integer)
Set objWatQualFile = CreateObject("Excel.Application")
    objWatQualFile.Visible = True
    objWatQualFile.Workbooks.Add

'Format the header cells and column width.

    With objWatQualFile.Range("A1:D1").Font
        .Bold = True
        .Size = 11
        .Name = "Arial"
        .ColorIndex = 1
    End With

'Add Titles to the Columns of the Excel Worksheet
    objWatQualFile.Range("A1").Value = "Month"
    objWatQualFile.Range("B1").Value = "Concentration in Pond"

'Label the second row with units for each field.'
    objWatQualFile.Range("B2").Value = "(mg/L)"

'Label the the month record/rows.'

    strStartMonthLabel = FindMonthLabel(intStartMonth)
    objWatQualFile.Range("A3").Value = strStartMonthLabel

    intRow = 3
    intMonthCounter = 1
```

```
    intCurMonth = intStartMonth
    intYearCounter = 1
    Do Until intMonthCounter = intTotalMonths
      intRow = intRow + 1
      intMonthCounter = intMonthCounter + 1
      intCurMonth = (intMonthCounter + (intStartMonth - 1)) _
      - ((intYearCounter - 1) * 12)
        If intCurMonth = 12 Then
          intYearCounter = intYearCounter + 1
        End If
      strMonthLabel = FindMonthLabel(intCurMonth)
      objWatQualFile.Cells(intRow, 1).Value = strMonthLabel
    Loop

    'ObjElevConciseFile.Range("A1:F1").Number.Number.Decimal = 2
    objWatQualFile.Range("A1:F1").ColumnWidth = 15

End Sub
```

'Calculation Modules - Code

```
Option Explicit

Dim strResName, strResAbbr, strDependResponse As String
Dim sngCatchArea, sngStartWatElev, sngStartTailElev, _
   sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
   sngSeepReturnRate, sngFracWRIn, _
   sngNeededForReclaim, sngReclaimRate, _
   sngSlurryWatInRate, sngMineWatInRate, _
   sngSeepInRate, sngMaxWatElev, sngMinWatElev, _
   sngFracRunDivert, sngSeepOutRate, sngDamLossConstant, _
   sngBeachAreaConstant As Single

Dim intDamRows, intVESRows, intFileNumber As Integer

Public cstA_0, cstA_1, cstB_0, cstB_1, sngP, _
   sngZ, sngXp, fncG1, fncG2, fncG3, _
   fncG4, sngTp As Single

Public blnRiskRun, blnCalcElevOnce, blnCalcPondOnce, _
blnCalcVolumeOnce, blnCalcDamDependersOnce As Boolean

Dim strProjectDirectory As String * 25
Dim strpath, strWhereSaved As String

Dim sngDL(1 To 26), sngBA(1 To 26), sngSR(1 To 26) As Single

'Global Variables
Global strSiteName, strSiteDescription As String
Global intNU, intNumReservoirs, intTrialCalc As Integer


'Volume-Elevation-Area Calculation variables.
Dim sngVol, sngElev, sngIncrement, sngA3, sngA1 As Single

'CAD File Variables
Dim sngStartElev(1 To 40), sngEndElev(1 To 40), _
sngIncVolume(1 To 40), sngCumVolume(1 To 40), _
sngSurfaceArea(1 To 40) As Single


Public Function CalcNumDaysInMon(intM) As Integer
```

```
Dim intDInM As Integer
'Decide how many days are in each month.
  If intM = 4 Or 6 Or 9 Or 11 Then
    intDInM = 30
  ElseIf intM = 2 Then
    intDInM = 28
  Else
    intDInM = 31
  End If
  CalcNumDaysInMon = intDInM
End Function
Public Function CalcDamL(sngElev)

On Error GoTo CheckError

If blnCalcDamDependersOnce = False Then

  Dim Damdb As Object
  Dim DamTable As Recordset
  Dim intRowCounter, intCounter As Integer
  Dim strpath, strWhereSaved, blnIsNewProject As String

  If FrmMainMenu.txtClickExisting.Text = "No" Then
    blnIsNewProject = True
    strpath = "c:\" & FrmNewFile.TxtNewDir.Text
  Else
    blnIsNewProject = False
    strpath = FrmExistingFile.DirProject
  End If

  'Open the reservoir data file and read to variables.

  intFileNumber = FreeFile

  Open (strpath & "\reservoir.txt") For Input As #intFileNumber
  Input #intFileNumber, strResName, strResAbbr, _
    sngCatchArea, sngStartWatElev, sngStartTailElev, _
    sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
    sngSeepReturnRate, sngFracWRIn, _
    sngNeededForReclaim, sngReclaimRate, _
    sngSlurryWatInRate, sngMineWatInRate, _
    sngSeepInRate, sngMaxWatElev, sngMinWatElev, _
    sngFracRunDivert, intDamRows, _
```

```
    sngSeepOutRate, sngDamLossConstant, sngBeachAreaConstant, _
    intVESRows, strDependResponse
  Close #intFileNumber

  Set Damdb = DBEngine.OpenDatabase(strpath & "\DamInfo.xls", dbDriverNoPrompt,
False, "Excel 8.0")
  Set DamTable = Damdb.OpenRecordset("DamInfo")
  DamTable.MoveFirst
  intRowCounter = 0
  While intRowCounter < intDamRows
    intRowCounter = intRowCounter + 1
    sngStartElev(intRowCounter) = DamTable.Fields(0)
    sngEndElev(intRowCounter) = DamTable.Fields(1)
    sngDL(intRowCounter) = DamTable.Fields(2)
    sngBA(intRowCounter) = DamTable.Fields(3)
    sngSR(intRowCounter) = DamTable.Fields(4)
    DamTable.MoveNext
  Wend

End If
  blnCalcDamDependersOnce = True
'StopReadingExcel:

  intCounter = 1

If sngElev > sngEndElev(intVESRows) Then
  Beep
  MsgBox "Total reservoir capacity has been exceeded!  Volume of solids and/or water is
greater than the largest volume entered for your reservoir geometry data.  Please edit
necessary volume-elevation data files.", vbExclamation
  GoTo ExitFunc:
Else
  Do Until sngElev < sngEndElev(intCounter)
  intCounter = intCounter + 1
  Loop

  If intCounter = 1 Then
   sngA3 = 0
   CalcDamL = sngDL(intCounter)
  Else
    sngA3 = sngEndElev(intCounter) - sngEndElev(intCounter - 1)

    If sngDL(intCounter) = sngDL(intCounter - 1) Then
```

```
        CalcDamL = sngDL(intCounter)
      Else
        CalcDamL = (sngEndElev(intCounter) - _
        ((sngDL(intCounter) - sngElev) / _
        (sngDL(intCounter) - sngDL(intCounter - 1))) * sngA3)
      End If
    End If
End If

CheckError:

If Err.Number = 11 Or Err = 9 Then
   CalcDamL = sngDL(intCounter)
   Resume Next
ElseIf Err = 94 Then
    'GoTo StopReadingExcel:
ElseIf Err = 0 Then
    GoTo ExitFunc
Else
    MsgBox "Unexpected Error # " & Err & Err.Description
End If

ExitFunc:

End Function

Public Function CalcSeepR(sngElev)

On Error GoTo CheckError:

If blnCalcDamDependersOnce = False Then

    Dim Damdb As Object
    Dim DamTable As Recordset
    Dim intRowCounter, intCounter As Integer

    Dim strpath, strWhereSaved, blnIsNewProject As String

    If FrmMainMenu.txtClickExisting.Text = "No" Then
      blnIsNewProject = True
      strpath = "c:\" & FrmNewFile.TxtNewDir.Text
    Else
      blnIsNewProject = False
```

```
        strpath = FrmExistingFile.DirProject
    End If

    'Open the reservoir data file and read to variables.

    intFileNumber = FreeFile

    Open (strpath & "\reservoir.txt") For Input As #intFileNumber
    Input #intFileNumber, strResName, strResAbbr, _
        sngCatchArea, sngStartWatElev, sngStartTailElev, _
        sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
        sngSeepReturnRate, sngFracWRIn, _
        sngNeededForReclaim, sngReclaimRate, _
        sngSlurryWatInRate, sngMineWatInRate, _
        sngSeepInRate, sngMaxWatElev, sngMinWatElev, _
        sngFracRunDivert, intDamRows, _
        sngSeepOutRate, sngDamLossConstant, sngBeachAreaConstant, _
        intVESRows, strDependResponse
    Close #intFileNumber

    Set Damdb = DBEngine.OpenDatabase(strpath & "\DamInfo.xls", dbDriverNoPrompt,
False, "Excel 8.0")
    Set DamTable = Damdb.OpenRecordset("DamInfo")
    DamTable.MoveFirst
    intRowCounter = 0
    While intRowCounter < intDamRows
      intRowCounter = intRowCounter + 1
      sngStartElev(intRowCounter) = DamTable.Fields(0)
      sngEndElev(intRowCounter) = DamTable.Fields(1)
      sngDL(intRowCounter) = DamTable.Fields(2)
      sngBA(intRowCounter) = DamTable.Fields(3)
      sngSR(intRowCounter) = DamTable.Fields(4)
      DamTable.MoveNext
    Wend

End If
StopReadingExcel:
     blnCalcDamDependersOnce = True
    intCounter = 1

If sngElev > sngEndElev(intDamRows) Then
    Beep
    MsgBox "Total reservoir capacity has been exceeded!  Volume of solids and/or water is
```

```
greater than the largest volume entered for your reservoir geometry data.  Please edit
necessary volume-elevation data files.", vbExclamation
    GoTo ExitFunc:
Else
    Do Until sngElev < sngEndElev(intCounter)
    intCounter = intCounter + 1
    Loop

    If intCounter = 1 Then
      sngA3 = 0
      CalcSeepR = sngSR(intCounter)
    Else
       sngA3 = sngEndElev(intCounter) - sngEndElev(intCounter - 1)

        If sngSR(intCounter) = sngSR(intCounter - 1) Then
            CalcSeepR = sngSR(intCounter)
            Exit Function
        Else
            CalcSeepR = (sngEndElev(intCounter) - ((sngSR(intCounter) - sngElev) /
(sngSR(intCounter) - sngSR(intCounter - 1))) * sngA3)
        End If
    End If
End If

CheckError:

If Err.Number = 11 Then
   CalcSeepR = sngSR(intCounter)
   Resume Next
ElseIf Err = 94 Then
    GoTo StopReadingExcel
ElseIf Err = 0 Then
    GoTo ExitFunc
Else
    MsgBox "Unexpected Error # " & Err & Err.Description
End If

ExitFunc:

End Function

Public Function CalcBeachA(sngElev)
```

```
On Error GoTo CheckError

If blnCalcDamDependersOnce = False Then

   Dim Damdb As Object
   Dim DamTable As Recordset
   Dim intRowCounter, intCounter As Integer

   Dim strpath, strWhereSaved, blnIsNewProject As String

   If FrmMainMenu.txtClickExisting.Text = "No" Then
      blnIsNewProject = True
      strpath = "c:\" & FrmNewFile.TxtNewDir.Text
   Else
      blnIsNewProject = False
      strpath = FrmExistingFile.DirProject
   End If

   'Open the reservoir data file and read to variables.

   intFileNumber = FreeFile

   Open (strpath & "\reservoir.txt") For Input As #intFileNumber
   Input #intFileNumber, strResName, strResAbbr, _
      sngCatchArea, sngStartWatElev, sngStartTailElev, _
      sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
      sngSeepReturnRate, sngFracWRIn, _
      sngNeededForReclaim, sngReclaimRate, _
      sngSlurryWatInRate, sngMineWatInRate, _
      sngSeepInRate, sngMaxWatElev, sngMinWatElev, _
      sngFracRunDivert, intDamRows, _
      sngSeepOutRate, sngDamLossConstant, sngBeachAreaConstant, _
      intVESRows, strDependResponse
   Close #intFileNumber

   Set Damdb = DBEngine.OpenDatabase(strpath & "\DamInfo.xls", dbDriverNoPrompt,
False, "Excel 8.0")
   Set DamTable = Damdb.OpenRecordset("DamInfo")
   DamTable.MoveFirst
   intRowCounter = 0
   While intRowCounter < intDamRows
     intRowCounter = intRowCounter + 1
     sngStartElev(intRowCounter) = DamTable.Fields(0)
```

```
      sngEndElev(intRowCounter) = DamTable.Fields(1)
      sngDL(intRowCounter) = DamTable.Fields(2)
      sngBA(intRowCounter) = DamTable.Fields(3)
      sngSR(intRowCounter) = DamTable.Fields(4)
      DamTable.MoveNext
    Wend

End If
StopReadingExcel:
  blnCalcDamDependersOnce = True

  intCounter = 1

If sngElev > sngEndElev(intDamRows) Then
      Beep
      MsgBox "Total reservoir capacity has been exceeded!  Volume of solids and/or water is
greater than the largest volume entered for your reservoir geometry data.  Please edit
necessary volume-elevation data files.", vbExclamation
      GoTo ExitFunc:
Else
  Do Until sngElev < sngEndElev(intCounter)
  intCounter = intCounter + 1
  Loop

  If intCounter = 1 Then
    sngA3 = 0
    CalcBeachA = sngBA(intCounter)
  Else
      sngA3 = sngEndElev(intCounter) - sngEndElev(intCounter - 1)
      If sngDL(intCounter) = sngDL(intCounter - 1) Then
          CalcBeachA = sngBA(intCounter)
          Exit Function
       Else
          CalcBeachA = (sngEndElev(intCounter) - ((sngBA(intCounter) - sngElev) /
(sngBA(intCounter) - sngBA(intCounter - 1))) * sngA3)
          Exit Function
       End If
  End If
End If

CheckError:

If Err.Number = 11 Then
```

```
  CalcBeachA = sngBA(intCounter)
  Resume Next
ElseIf Err = 94 Then
   GoTo StopReadingExcel
ElseIf Err = 0 Then
   GoTo ExitFunc
Else
   MsgBox "Unexpected Error # " & Err & Err.Description
End If

ExitFunc:

End Function


Public Function CalcElevation(sngVol)

'On Error GoTo FuncError

If blnCalcElevOnce = False Then

'Open the Volume-Elevation-Surface Area CAD Excel data
'file as an ADO recordset and save the data to specific
'variables to use in computation.

   Dim CADdb As Object
   Dim CADTable As Recordset
   Dim intRowCounter, intCounter As Integer

   Dim strpath, strWhereSaved, blnIsNewProject As String

   If FrmMainMenu.txtClickExisting.Text = "No" Then
      blnIsNewProject = True
      strpath = "c:\" & FrmNewFile.TxtNewDir.Text
   Else
      blnIsNewProject = False
      strpath = FrmExistingFile.DirProject
   End If

   'Open the reservoir data file and read to variables.

   intFileNumber = FreeFile
```

```
    Open (strpath & "\reservoir.txt") For Input As #intFileNumber
    Input #intFileNumber, strResName, strResAbbr, _
      sngCatchArea, sngStartWatElev, sngStartTailElev, _
      sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
      sngSeepReturnRate, sngFracWRIn, _
      sngNeededForReclaim, sngReclaimRate, _
      sngSlurryWatInRate, sngMineWatInRate, _
      sngSeepInRate, sngMaxWatElev, sngMinWatElev, _
      sngFracRunDivert, intDamRows, _
      sngSeepOutRate, sngDamLossConstant, sngBeachAreaConstant, _
      intVESRows, strDependResponse
    Close #intFileNumber

    Set CADdb = DBEngine.OpenDatabase(strpath & "\Volume.xls", dbDriverNoPrompt,
False, "Excel 8.0")
    Set CADTable = CADdb.OpenRecordset("ResVolume")
    CADTable.MoveFirst
    intRowCounter = 1
    sngStartElev(intRowCounter) = CADTable.Fields(0)
    sngEndElev(intRowCounter) = CADTable.Fields(1)
    sngIncVolume(intRowCounter) = CADTable.Fields(2)
    sngCumVolume(intRowCounter) = CADTable.Fields(3)
    sngSurfaceArea(intRowCounter) = CADTable.Fields(4)

    While intRowCounter < intVESRows
      CADTable.MoveNext
      intRowCounter = intRowCounter + 1
      sngStartElev(intRowCounter) = CADTable.Fields(0)
      sngEndElev(intRowCounter) = CADTable.Fields(1)
      sngIncVolume(intRowCounter) = CADTable.Fields(2)
      sngCumVolume(intRowCounter) = CADTable.Fields(3)
      sngSurfaceArea(intRowCounter) = CADTable.Fields(4)
    Wend
    blnCalcElevOnce = True
End If

    intCounter = 1

    If sngVol > sngCumVolume(intVESRows) Then
      If blnRiskRun = True Then
      Else
        Beep
        MsgBox "Total reservoir capacity has been exceeded!  Volume of solids and/or water
```

```
is greater than the largest volume entered for your reservoir geometry data.  Please edit
necessary volume-elevation data files.", vbExclamation
        GoTo OverflowError:
      End If
    Else
      Do Until sngVol < sngCumVolume(intCounter)
        intCounter = intCounter + 1
      Loop

      If intCounter = 1 Then
        sngIncrement = 0
        CalcElevation = sngStartElev(intCounter)
      Else
        sngIncrement = sngEndElev(intCounter) - sngEndElev(intCounter - 1)

        CalcElevation = Round((sngEndElev(intCounter) _
        - ((sngCumVolume(intCounter) - sngVol) _
        / (sngCumVolume(intCounter) - sngCumVolume(intCounter - 1))) _
        * sngIncrement), 3)
      End If
    End If

FuncExit:
    Exit Function
FuncError:
    Beep
    MsgBox Err.Description
Resume FuncExit

OverflowError:
    CalcElevation = 0

End Function

Public Function CalcArea(sngElev)

'Open the Volume-Elevation-Surface Area CAD Excel data
'file as an ADO recordset and save the data to specific
'variables to use in computation.

If blnCalcPondOnce = False Then

    Dim CADdb As Object
```

```
  Dim CADTable As Recordset
  Dim intRowCounter, intCounter As Integer
  Dim strpath, strWhereSaved As String

  If FrmMainMenu.txtClickExisting.Text = "No" Then
    strpath = "c:\" & FrmNewFile.TxtNewDir.Text
  Else
    strpath = FrmExistingFile.DirProject
  End If

  'Open the reservoir data file and read to variables.

  intFileNumber = FreeFile

  Open (strpath & "\reservoir.txt") For Input As #intFileNumber
  Input #intFileNumber, strResName, strResAbbr, _
    sngCatchArea, sngStartWatElev, sngStartTailElev, _
    sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
    sngSeepReturnRate, sngFracWRIn, _
    sngNeededForReclaim, sngReclaimRate, _
    sngSlurryWatInRate, sngMineWatInRate, _
    sngSeepInRate, sngMaxWatElev, sngMinWatElev, _
    sngFracRunDivert, intDamRows, _
    sngSeepOutRate, sngDamLossConstant, sngBeachAreaConstant, _
    intVESRows, strDependResponse
  Close #intFileNumber

  Set CADdb = DBEngine.OpenDatabase((strpath & "\Volume.xls"), dbDriverNoPrompt,
False, "Excel 8.0")
  Set CADTable = CADdb.OpenRecordset("ResVolume")
  CADTable.MoveFirst
  intRowCounter = 0
  While intRowCounter < intVESRows
    intRowCounter = intRowCounter + 1
    sngStartElev(intRowCounter) = CADTable.Fields(0)
    sngEndElev(intRowCounter) = CADTable.Fields(1)
    sngIncVolume(intRowCounter) = CADTable.Fields(2)
    sngCumVolume(intRowCounter) = CADTable.Fields(3)
    sngSurfaceArea(intRowCounter) = CADTable.Fields(4)
    CADTable.MoveNext
  Wend
  blnCalcPondOnce = True
 End If
```

```
 intCounter = 1
 Do Until sngElev < sngEndElev(intCounter)
  intCounter = intCounter + 1
 Loop

 If intCounter = 1 Then
   sngA1 = 0
   CalcArea = sngSurfaceArea(intCounter)
 Else

 sngA1 = sngSurfaceArea(intCounter) - sngSurfaceArea(intCounter - 1)

 CalcArea = ((sngSurfaceArea(intCounter) _
  - ((sngEndElev(intCounter) - sngElev) _
  / (sngEndElev(intCounter) - sngEndElev(intCounter - 1))) _
  * sngA1))
 End If

End Function

Public Function CalcVolume(sngElev)

If blnCalcVolumeOnce = False Then

'Open the Volume-Elevation-SurfaceArea CAD Excel data
'file as an ADO recordset and save the data to specific
'variables to use in computation.

  Dim CADdb As Object
  Dim CADTable As Recordset
  Dim intRowCounter, intCounter As Integer

  Dim strpath, strWhereSaved, blnIsNewProject As String

  If FrmMainMenu.txtClickExisting.Text = "No" Then
    blnIsNewProject = True
    strpath = "c:\" & FrmNewFile.TxtNewDir.Text
  Else
    blnIsNewProject = False
    strpath = FrmExistingFile.DirProject
  End If
```

```
  'Open the reservoir data file and read to variables.

  intFileNumber = FreeFile

  Open (strpath & "\reservoir.txt") For Input As #intFileNumber
  Input #intFileNumber, strResName, strResAbbr, _
     sngCatchArea, sngStartWatElev, sngStartTailElev, _
     sngStartSurfArea, sngStartWatVol, sngStartSolVol, _
     sngSeepReturnRate, sngFracWRIn, _
     sngNeededForReclaim, sngReclaimRate, _
     sngSlurryWatInRate, sngMineWatInRate, _
     sngSeepInRate, sngMaxWatElev, sngMinWatElev, _
     sngFracRunDivert, intDamRows, _
     sngSeepOutRate, sngDamLossConstant, sngBeachAreaConstant, _
     intVESRows, strDependResponse
  Close #intFileNumber

  Set CADdb = DBEngine.OpenDatabase(strpath & "\Volume.xls", dbDriverNoPrompt,
False, "Excel 8.0")
  Set CADTable = CADdb.OpenRecordset("ResVolume")
  CADTable.MoveFirst
  intRowCounter = 0
  While intRowCounter < intVESRows
    intRowCounter = intRowCounter + 1
    sngStartElev(intRowCounter) = CADTable.Fields(0)
    sngEndElev(intRowCounter) = CADTable.Fields(1)
    sngIncVolume(intRowCounter) = CADTable.Fields(2)
    sngCumVolume(intRowCounter) = CADTable.Fields(3)
    sngSurfaceArea(intRowCounter) = CADTable.Fields(4)
    CADTable.MoveNext
  Wend
  blnCalcVolumeOnce = True
End If

  intCounter = 1
  Do Until sngElev < sngEndElev(intCounter)
     intCounter = intCounter + 1
  Loop

  If intCounter = 1 Then
  CalcVolume = sngCumVolume(intCounter)
  Else
  sngA3 = sngCumVolume(intCounter) - sngCumVolume(intCounter - 1)
```

```
  CalcVolume = ((sngCumVolume(intCounter) _
     - ((sngEndElev(intCounter) - sngElev) _
     / (sngEndElev(intCounter) - sngEndElev(intCounter - 1))) _
     * sngA3))
  End If


End Function

Public Function FindMonthLabel(intM)

Dim strMLabel As String

   If intM = 1 Then
      strMLabel = "January"
   ElseIf intM = 2 Then
      strMLabel = "February"
   ElseIf intM = 3 Then
      strMLabel = "March"
   ElseIf intM = 4 Then
      strMLabel = "April"
   ElseIf intM = 5 Then
      strMLabel = "May"
   ElseIf intM = 6 Then
      strMLabel = "June"
   ElseIf intM = 7 Then
      strMLabel = "July"
   ElseIf intM = 8 Then
      strMLabel = "August"
   ElseIf intM = 9 Then
      strMLabel = "September"
   ElseIf intM = 10 Then
      strMLabel = "October"
   ElseIf intM = 11 Then
      strMLabel = "November"
   Else: strMLabel = "December"
End If

FindMonthLabel = strMLabel

End Function

Public Function CalcRandomAnnPrecip(sngMean, sngSD, sngDF)
```

```
'Generate an array of random precipitation and
'run-off values using the Student t-distribution
' as expanded by Abramowitz and Stegen.

cstA_0 = 2.30753
cstA_1 = 0.27061
cstB_0 = 0.99229
cstB_1 = 0.04481

    Randomize
    sngP = Rnd(2)
    If sngP > 0.5 Then
        sngP = 1 - sngP
        sngZ = Sqr(Log(1 / sngP ^ 3))
        'Note that "Log" here is the natural log.
        'Log base N would be LogN(x) = log(x)/log(n)
        sngXp = sngZ - (cstA_0 + cstA_1 * sngZ / (1 + cstB_0 * sngZ _
            + cstB_1 * (sngZ ^ 2)))
    Else
        sngZ = Sqr(Log(1 / sngP ^ 3))
        'Note that "Log" here is the natural log.
        'Log base N would be LogN(x) = log(x)/log(n)
        sngXp = -(sngZ - (cstA_0 + cstA_1 * sngZ / (1 + cstB_0 * sngZ _
            + cstB_1 * (sngZ ^ 2))))
    End If

    intNU = sngDF  'degrees of freedom for t-distribution

    fncG1 = 0.25 * ((sngXp ^ 3) + sngXp)

    fncG2 = (1 / 96) * ((5 * sngXp ^ 5) _
        + (16 * sngXp ^ 3) + (3 * sngXp))

    fncG3 = (1 / 384) * ((3 * sngXp ^ 7) _
        + (19 * sngXp ^ 5) + (17 * sngXp ^ 3) _
        - (15 * sngXp))

    fncG4 = (1 / 92160) * ((79 * sngXp ^ 9) _
        + (776 * sngXp ^ 7) + (1482 * sngXp ^ 5) _
        - (1920 * sngXp ^ 3) - (945 * sngXp))


    sngTp = sngXp + ((fncG1 / intNU) _
```

```
    + (fncG2 / intNU ^ 2) + (fncG3 / _
    intNU ^ 3) + (fncG4 / intNU ^ 4))

  CalcRandomAnnPrecip = sngMean + (sngTp * sngSD)


End Function
```

Appendix D

Visual Balance Case Studies
Data Input Summary Tables

Balance Input Data	Run Number 1
Project Name: Case Study I	
Start Up Month	1
Month of Closure	12
Start Up Year	1997
Year of Closure	2012
Production Information	
Tonnes Mined Per Day	11,760.0
Tonnes Concentrate Per Day	100.0
Tonnes Waste Rock	4,704.0
Tonnes Tailings Per Day	6,956.0
Waste Rock Information	
Bulk Density	2.0
Void Ratio	0.66
Tailings Information	
Degree of Saturation	0.9
Slurry Fraction as Water	1.1
Coarse Fraction Cycloned Out	0.1
Dry Density	1.32
In Situ Void Ratio	1.05
Specific Gravity	2.7
Reservoir Information	
Reservoir Name	Main Pond
Reservoir Catchment Area	169.0
Start Up Water Elevation	122.5
Start Up Solids Elevation	122.5
Start Up Reservoir Surface Area	27.4
Start Up Water Volume	1,000,000.0
Start Up Solids Volume	0.0
Seepage Rate In (m3/day)	25.0
Operation Data	
Reclaim Rate (m3/hr)	1,300.0
Pond Depth Required for Reclaim (m)	0.5
Slurry Input Rate (m3/hr)	1,330.0
Mine Water Input Rate (m3/hr)	0.0
Fraction of Waste Rock to Res.	0.9
Fraction Runoff Diverted	0.6
Seepage Return Rate (m3/day)	0.0
Dam Design Information	
Maximum Dam Lift Height (m)	3.0
# Rows in Volume-Elevation	18.0
Freeboard Period One (m)	2.0
Freeboard Period Two (m)	2.0
EDF Volume (m3)	1,000,000.0
Dam Elevation Dependant Data File?	FALSE
Number of Rows in Data File	Not Appl.
Constant Seepage Out (m3/hr)	0.0
Constant Beach Area (m2)	10,000.0
Constant Volume Loss to Dam (m3)	100,000

Balance Input Data	Run Number 1
Project Name: Case Study II	
Start Up Month	11
Month of Closure	9
Start Up Year	1997
Year of Closure	2013
Production Information	
Tonnes Mined Per Day	0.0
Tonnes Concentrate Per Day	0.0
Tonnes Waste Rock	0.0
Tonnes Tailings Per Day	0.0
Waste Rock Information	
Bulk Density	2.0
Void Ratio	0.35
Tailings Information	
Degree of Saturation	1.0
Slurry Fraction as Water	1.35
Coarse Fraction Cycloned Out	0.1
Dry Density	1.35
In Situ Void Ratio	1.32
Specific Gravity	2.7
Reservoir Information	
Reservoir Name	TMF-1
Reservoir Catchment Area	142.3
Start Up Water Elevation	1,000.0
Start Up Solids Elevation	980.0
Start Up Reservoir Surface Area	14.94
Start Up Water Volume	1,125,083.0
Start Up Solids Volume	43,009.0
Seepage Rate In (m3/day)	0.0
Operation Data	
Reclaim Rate (m3/hr)	1,400.0
Pond Depth Required for Reclaim (m)	1.0
Slurry Input Rate (m3/hr)	1,452.0
Mine Water Input Rate (m3/hr)	0.0
Fraction of Waste Rock to Res.	1.0
Fraction Runoff Diverted	0.7
Seepage Return Rate (m3/day)	0.0
Dam Design Information	
Maximum Dam Lift Height (m)	4.0
# Rows in Volume-Elevation	23.0
Freeboard Period One (m)	1.5
Freeboard Period Two (m)	1.5
EDF Volume (m3)	1,000,000.0
Dam Elevation Dependant Data File?	FALSE
Number of Rows in Data File	Not Appl.
Constant Seepage Out (m3/hr)	
Constant Beach Area (m2)	10,000.0
Constant Volume Loss to Dam (m3)	100,000

Balance Input Data	Run Number 1
Project Name: Case Study III	
Start Up Month	5
Month of Closure	10
Start Up Year	1998
Year of Closure	2010
Production Information	
Tonnes Mined Per Day	48,000.0
Tonnes Concentrate Per Day	336.0
Tonnes Waste Rock	0.0
Tonnes Tailings Per Day	47,664.0
Waste Rock Information	
Bulk Density	0.0
Void Ratio	0.0
Tailings Information	
Degree of Saturation	1.0
Slurry Fraction as Water	1.33
Coarse Fraction Cycloned Out	0.0
Dry Density	1.2
In Situ Void Ratio	1.32
Specific Gravity	2.78
Reservoir Information	
Reservoir Name	TSF
Reservoir Catchment Area	1,125.0
Start Up Water Elevation	1,425.0
Start Up Solids Elevation	1,415.4
Start Up Reservoir Surface Area	66.47
Start Up Water Volume	5,572,903.0
Start Up Solids Volume	0.0
Seepage Rate In (m3/day)	1,080.0
Operation Data	
Reclaim Rate (m3/hr)	4,167.0
Pond Depth Required for Reclaim (m)	0.25
Slurry Input Rate (m3/hr)	4,061.0
Mine Water Input Rate (m3/hr)	0.0
Fraction of Waste Rock to Res.	0.0
Fraction Runoff Diverted	0.0
Seepage Return Rate (m3/day)	1,333.0
Dam Design Information	
Maximum Dam Lift Height (m)	5.0
# Rows in Volume-Elevation	19.0
Freeboard Period One (m)	1.0
Freeboard Period Two (m)	2.0
EDF Volume (m3)	2,530,000.0
Dam Elevation Dependant Data File?	FALSE
Number of Rows in Data File	Not Appl.
Constant Seepage Out (m3/hr)	
Constant Beach Area (m2)	10,000.0
Constant Volume Loss to Dam (m3)	10,000

Balance Input Data	Run Number 1
Project Name: Case Study IV	
Start Up Month	5
Month of Closure	4
Start Up Year	1998
Year of Closure	2008
Production Information	
Tonnes Mined Per Day	1,600.0
Tonnes Concentrate Per Day	0.0
Tonnes Waste Rock	0.0
Tonnes Tailings Per Day	1,600.0
Waste Rock Information	
Bulk Density	0.0
Void Ratio	0.0
Tailings Information	
Degree of Saturation	0.9
Slurry Fraction as Water	1.3
Coarse Fraction Cycloned Out	0.0
Dry Density	1.32
In Situ Void Ratio	1.05
Specific Gravity	2.7
Reservoir Information	
Reservoir Name	Main
Reservoir Catchment Area	76.0
Start Up Water Elevation	342.6
Start Up Solids Elevation	339.0
Start Up Reservoir Surface Area	0.0
Start Up Water Volume	1,068,880.0
Start Up Solids Volume	330,000.0
Seepage Rate In (m3/day)	0.0
Operation Data	
Reclaim Rate (m3/hr)	260.0
Pond Depth Required for Reclaim (m)	0.5
Slurry Input Rate (m3/hr)	350.0
Mine Water Input Rate (m3/hr)	0.0
Fraction of Waste Rock to Res.	0.0
Fraction Runoff Diverted	0.0
Seepage Return Rate (m3/day)	734.4
Dam Design Information	
Maximum Dam Lift Height (m)	3.0
# Rows in Volume-Elevation	14.0
Freeboard Period One (m)	1.0
Freeboard Period Two (m)	1.0
EDF Volume (m3)	0.0
Dam Elevation Dependant Data File?	FALSE
Number of Rows in Data File	Not Appl.
Constant Seepage Out (m3/hr)	0.0
Constant Beach Area (m2)	0.0
Constant Volume Loss to Dam (m3)	0

Balance Input Data	Run Number 1
Project Name: Case Study V	
Start Up Month	1
Month of Closure	12
Start Up Year	1997
Year of Closure	2009
Production Information	
Tonnes Mined Per Day	1,400.0
Tonnes Concentrate Per Day	252.0
Tonnes Waste Rock	0.0
Tonnes Tailings Per Day	1,148.0
Waste Rock Information	
Bulk Density	0.0
Void Ratio	0.0
Tailings Information	
Degree of Saturation	0.95
Slurry Fraction as Water	0.71
Coarse Fraction Cycloned Out	0.25
Dry Density	1.8
In Situ Void Ratio	0.9
Specific Gravity	3.4
Reservoir Information	
Reservoir Name	Dam D
Reservoir Catchment Area	200.0
Start Up Water Elevation	4,015.8
Start Up Solids Elevation	4,012.0
Start Up Reservoir Surface Area	0.0
Start Up Water Volume	79,809.0
Start Up Solids Volume	5,740.0
Seepage Rate In (m3/day)	200.0
Operation Data	
Reclaim Rate (m3/hr)	110.0
Pond Depth Required for Reclaim (m)	0.2
Slurry Input Rate (m3/hr)	117.0
Mine Water Input Rate (m3/hr)	57.6
Fraction of Waste Rock to Res.	0.0
Fraction Runoff Diverted	0.0
Seepage Return Rate (m3/day)	0.0
Dam Design Information	
Maximum Dam Lift Height (m)	3.0
# Rows in Volume-Elevation	23.0
Freeboard Period One (m)	1.0
Freeboard Period Two (m)	1.0
EDF Volume (m3)	25,000.0
Dam Elevation Dependant Data File?	True
Number of Rows in Data File	23.0
Constant Seepage Out (m3/hr)	0.0
Constant Beach Area (m2)	0.0
Constant Volume Loss to Dam (m3)	0

Appendix E

Visual Balance Sample
Risk Analysis Results Summary Tables

Risk Analysis Summary Statistics for Case Study I

Risk Analysis Input Parameters	
Mean Annual Precipitation	2,006
Standard Deviation	200
Number of Years of record	15
Minimum Design Freeboard (above EDF)	2.0
Risk Freeboard (above EDF)	2.0
SpillWay Invert, Height Above EDF	1.0
Pond Depth Required for Reclaim	0.5
Operation Input Parameters	
Number of Years in Operation Series	15.0
Number of Series in Simulation	1,000.0

Risk Analysis Summary Statistics

Spill Results

Year In Series	Avg. # Months With Spill	Average Annual Prob. of Spill (%)	Avg. Spill Volume	Maximum Spill Volume
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0

Freeboard Results

Year in Series	Avg. # Months with Low Freeboard	Avg. Annual Prob. of Low Freeboard (%)	Avg. Height of 'Low Freeboards'
1	0.0	0.0	0.0
2	0.0	0.0	0.0
3	0.0	0.0	0.0
4	0.0	0.0	0.0
5	0.0	0.0	0.0
6	0.0	0.0	0.0
7	0.0	0.0	0.0
8	0.0	0.0	0.0
9	0.0	0.0	0.0

10	0.0	0.0	0.0
11	0.0	0.0	0.0
12	0.0	0.0	0.0
13	0.0	0.0	0.0
14	0.0	0.0	0.0
15	0.0	0.0	0.0

Reclaim Results

Year in Series	Avg. # Months with Reclaim Off	Avg. Annual Prob. Month Reclaim Off (%)	Avg. Freshwater Makeup Vol. Required	Max. Freshwater Makeup Vol. Required
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0

Tailings Exposure Results

Year in Series	Avg. # Months with Solids Exposed	Avg. Annual Prob. of Solids Exposure	Avg. Depth of Water above solids (m)
1	0.0	0.0	2.77
2	0.0	0.0	2.32
3	0.0	0.0	3.04
4	0.0	0.0	4.03
5	0.0	0.0	5.05
6	0.0	0.0	6.09
7	0.0	0.0	7.1
8	0.0	0.0	8.07
9	0.0	0.0	9.04
10	0.0	0.0	9.95
11	0.0	0.0	11.11
12	0.0	0.0	14.51
13	0.0	0.0	16.17
14	0.0	0.0	16.27
15	0.0	0.0	0.0

Case Study II
Visual Balance Risk Analysis Results

Risk Analysis Summary Statistics for Case Study II

Risk Analysis Input Parameters	
Mean Annual Precipitation	1,462
Standard Deviation	200
Number of Years of record	26
Minimum Design Freeboard (above EDF)	1.5
Risk Freeboard (above EDF)	0.75
SpillWay Invert, Height Above EDF	1.0
Pond Depth Required for Reclaim	1.0
Operation Input Parameters	
Number of Years in Operation Series	16.0
Number of Series in Simulation	100.0

Risk Analysis Summary Statistics
Spill Results

Year In Series	Avg. # Months With Spill	Average Annual Prob. of Spill (%)	Avg. Spill Volume	Maximum Spill Volume
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0

Case Study II

Visual Balance Risk Analysis Results

Freeboard Results

Year in Series	Avg. # Months with Low Freeboard	Avg. Annual Prob. of Low Freeboard (%)	Avg. Height of 'Low Freeboards'
1	0.0	0.0	0.0
2	3.71	100.0	-0.15
3	5.38	100.0	0.29
4	3.75	82.0	0.58
5	0.9	29.0	0.66
6	0.45	17.0	0.66
7	0.19	12.0	0.61
8	0.86	18.0	0.65
9	0.0	0.0	0.0
10	0.33	10.0	0.71
11	0.0	0.0	0.0
12	0.0	0.0	0.0
13	0.08	8.0	0.73
14	0.0	0.0	0.0
15	0.0	0.0	0.0
16	0.0	0.0	0.0

Reclaim Results

Year in Series	Avg. # Months with Reclaim Off	Avg. Annual Prob. Month Reclaim Off (%)	Avg. Freshwater Makeup Vol. Required	Max. Freshwater Makeup Vol. Required
1	0.99	100.0	1,008,000.0	1,008,000.0
2	0.99	100.0	1,008,000.0	1,008,000.0
3	1.0	100.0	1,008,000.0	1,008,000.0
4	1.1	100.0	1,008,000.0	1,008,000.0
5	1.21	100.0	1,008,000.0	1,008,000.0
6	1.37	99.0	1,008,000.0	1,008,000.0
7	0.81	80.0	1,008,000.0	1,008,000.0
8	0.74	74.0	1,008,000.0	1,008,000.0
9	0.56	57.0	1,008,000.0	1,008,000.0
10	0.44	44.0	1,008,000.0	1,008,000.0
11	0.59	60.0	1,008,000.0	1,008,000.0
12	0.42	42.0	1,008,000.0	1,008,000.0

13	0.3	30.0	1,008,000.0	1,008,000.0
14	0.25	25.0	1,008,000.0	1,008,000.0
15	0.27	27.0	1,008,000.0	1,008,000.0
16	0.0	0.0	0.0	1,008,000.0

Tailings Exposure Results

Year in Series	**Avg. # Months with Solids Exposed**	**Avg. Annual Prob. of Solids Exposure**	**Avg. Depth of Water above solids (m)**
1	0.0	0.0	2.84
2	0.0	0.0	2.08
3	0.0	0.0	1.85
4	0.0	0.0	1.58
5	0.0	0.0	1.53
6	0.0	0.0	1.49
7	0.0	0.0	1.41
8	0.0	0.0	1.42
9	0.0	0.0	1.51
10	0.0	0.0	1.46
11	0.0	0.0	1.44
12	0.0	0.0	1.5
13	0.0	0.0	1.48
14	0.0	0.0	1.49
15	0.0	0.0	1.51
16	0.0	0.0	0.0

Risk Analysis Summary Statistics for Case Study III

Risk Analysis Input Parameters	
Mean Annual Precipitation	951
Standard Deviation	160
Number of Years of record	6
Minimum Design Freeboard (above EDF)	1.0
Risk Freeboard (above EDF)	0.8
SpillWay Invert, Height Above EDF	0.75
Pond Depth Required for Reclaim	0.25
Operation Input Parameters	
Number of Years in Operation Series	12.0
Number of Series in Simulation	100.0

Risk Analysis Summary Statistics

Spill Results

Year In Series	Avg. # Months With Spill	Average Annual Prob. of Spill (%)	Avg. Spill Volume	Maximum Spill Volume
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0
4	0.01	1.0	90,602.07	90,602.07
5	2.17	56.0	242,169.74	872,975.46
6	3.02	46.0	56,296.54	368,878.73
7	0.46	20.0	165,942.13	387,778.39
8	1.09	23.0	68,470.18	286,594.94
9	1.23	39.0	206,230.4	686,014.46
10	5.22	71.0	134,000.41	548,757.84
11	2.17	40.0	74,448.29	309,297.81
12	0.0	0.0	0.0	678,482.66

Freeboard Results

Year in Series	Avg. # Months with Low Freeboard	Avg. Annual Prob. of Low Freeboard (%)	Avg. Height of 'Low Freeboards'
1	0.0	0.0	0.0
2	0.0	0.0	0.0
3	0.05	5.0	0.72
4	4.34	80.0	0.35
5	10.08	96.0	-0.08
6	10.56	98.0	0.0

7	9.99	93.0	0.3
8	8.02	93.0	0.22
9	9.26	91.0	0.29
10	10.9	93.0	0.04
11	9.58	92.0	0.31
12	0.0	0.0	0.0

Reclaim Results

Year in Series	Avg. # Months with Reclaim Off	Avg. Annual Prob. Month Reclaim Off (%)	Avg. Freshwater Makeup Vol. Required	Max. Freshwater Makeup Vol. Required
1	0.0	0.0	0.0	0.0
2	0.07	7.0	3,000,240.0	3,000,240.0
3	0.79	79.0	3,000,240.0	3,000,240.0
4	0.02	2.0	3,000,240.0	3,000,240.0
5	0.03	2.0	3,000,240.0	3,000,240.0
6	0.05	3.0	3,000,240.0	3,000,240.0
7	0.05	4.0	3,000,240.0	3,000,240.0
8	0.05	4.0	3,000,240.0	3,000,240.0
9	0.08	6.0	3,000,240.0	3,000,240.0
10	0.08	7.0	3,000,240.0	3,000,240.0
11	0.07	6.0	3,000,240.0	3,000,240.0
12	0.0	0.0	0.0	3,000,240.0

Tailings Exposure Results

Year in Series	Avg. # Months with Solids Exposed	Avg. Annual Prob. of Solids Exposure	Avg. Depth of Water above solids (m)
1	0.0	0.0	4.34
2	0.01	1.0	3.59
3	0.1	11.0	1.98
4	0.0	0.0	2.71
5	0.02	2.0	2.98
6	0.01	1.0	2.82
7	0.0	0.0	2.4
8	0.01	1.0	2.49
9	0.0	0.0	2.58
10	0.0	0.0	2.64
11	0.0	0.0	2.25
12	0.0	0.0	0.0

Average Closure Analysis Summary Statistics for Case Study IV

Closure Analysis Input Parameters	
Minimum Design Freeboard (above EDF)	1
Risk Freeboard (above EDF)	1
Final Spillway Invert Elevation	347
Final Dam Crest Elevation	348.1
Number of Years in Closure Series	50.0
Number of Series in Simulation	1,000.0

Closure Analysis Annual Summary Statistics
Spill Results

Year In Series	**Avg. # Months With Spill**	**Average Annual Prob. of Spill (%)**	**Avg. Spill Volume**	**Maximum Spill Volume**
1	0.0	0.0	0.0	0.0
2	1.0	8.33	442,719.55	442,719.55
3	1.0	8.33	479,100.0	479,100.0
4	2.0	16.67	478,350.0	498,700.0
5	1.0	8.33	452,300.0	452,300.0
6	1.0	8.33	521,500.0	521,500.0
7	2.0	16.67	478,350.0	498,700.0
8	1.0	8.33	452,300.0	452,300.0
9	1.0	8.33	521,500.0	521,500.0
10	2.0	16.67	478,350.0	498,700.0
11	1.0	8.33	452,300.0	452,300.0
12	1.0	8.33	521,500.0	521,500.0
13	2.0	16.67	478,350.0	498,700.0
14	1.0	8.33	452,300.0	452,300.0
15	1.0	8.33	521,500.0	521,500.0
16	2.0	16.67	478,350.0	498,700.0
17	1.0	8.33	452,300.0	452,300.0
18	1.0	8.33	521,500.0	521,500.0
19	2.0	16.67	478,350.0	498,700.0
20	1.0	8.33	452,300.0	452,300.0
21	1.0	8.33	521,500.0	521,500.0

Visual Balance
Average Closure Balance Results - Case Study IV

22	2.0	16.67	478,350.0	498,700.0
23	1.0	8.33	452,300.0	452,300.0
24	1.0	8.33	521,500.0	521,500.0
25	2.0	16.67	478,350.0	498,700.0
26	1.0	8.33	452,300.0	452,300.0
27	1.0	8.33	521,500.0	521,500.0
28	2.0	16.67	478,350.0	498,700.0
29	1.0	8.33	452,300.0	452,300.0
30	1.0	8.33	521,500.0	521,500.0
31	2.0	16.67	478,350.0	498,700.0
32	1.0	8.33	452,300.0	452,300.0
33	1.0	8.33	521,500.0	521,500.0
34	2.0	16.67	478,350.0	498,700.0
35	1.0	8.33	452,300.0	452,300.0
36	1.0	8.33	521,500.0	521,500.0
37	2.0	16.67	478,350.0	498,700.0
38	1.0	8.33	452,300.0	452,300.0
39	1.0	8.33	521,500.0	521,500.0
40	2.0	16.67	478,350.0	498,700.0
41	1.0	8.33	452,300.0	452,300.0
42	1.0	8.33	521,500.0	521,500.0
43	2.0	16.67	478,350.0	498,700.0
44	1.0	8.33	452,300.0	452,300.0
45	1.0	8.33	521,500.0	521,500.0
46	2.0	16.67	478,350.0	498,700.0
47	1.0	8.33	452,300.0	452,300.0
48	1.0	8.33	521,500.0	521,500.0
49	2.0	16.67	478,350.0	498,700.0
50	1.0	8.33	0.0	452,300.0

Visual Balance

Average Closure Balance Results - Case Study IV

Freeboard Results

Year in Series	**Avg. # Months with Low Freeboard**	**Avg. Annual Prob. of Low Freeboard (%)**	**Avg. Height of Low Freeboards'**
1	0.0	0.0	0.0
2	0.08	8.33	0.49
3	0.08	8.33	0.45
4	0.17	16.67	0.45
5	0.08	8.33	0.48
6	0.08	8.33	0.4
7	0.17	16.67	0.45
8	0.08	8.33	0.48
9	0.08	8.33	0.4
10	0.17	16.67	0.45
11	0.08	8.33	0.48
12	0.08	8.33	0.4
13	0.17	16.67	0.45
14	0.08	8.33	0.48
15	0.08	8.33	0.4
16	0.17	16.67	0.45
17	0.08	8.33	0.48
18	0.08	8.33	0.4
19	0.17	16.67	0.45
20	0.08	8.33	0.48
21	0.08	8.33	0.4
22	0.17	16.67	0.45
23	0.08	8.33	0.48
24	0.08	8.33	0.4
25	0.17	16.67	0.45
26	0.08	8.33	0.48
27	0.08	8.33	0.4
28	0.17	16.67	0.45
29	0.08	8.33	0.48
30	0.08	8.33	0.4
31	0.17	16.67	0.45
32	0.08	8.33	0.48
33	0.08	8.33	0.4

34	0.17	16.67	0.45
35	0.08	8.33	0.48
36	0.08	8.33	0.4
37	0.17	16.67	0.45
38	0.08	8.33	0.48
39	0.08	8.33	0.4
40	0.17	16.67	0.45
41	0.08	8.33	0.48
42	0.08	8.33	0.4
43	0.17	16.67	0.45
44	0.08	8.33	0.48
45	0.08	8.33	0.4
46	0.17	16.67	0.45
47	0.08	8.33	0.48
48	0.08	8.33	0.4
49	0.17	16.67	0.45
50	0.0	0.0	0.0

Tailings Exposure Results

Year in Series	**Avg. # Months with Solids Exposed**	**Avg. Annual Prob. of Solids Exposure**	**Avg. Depth of Water above solids (m)**
1	0.0	0.0	0.05
2	0.0	0.0	0.79
3	0.0	0.0	0.87
4	0.0	0.0	0.96
5	0.0	0.0	0.88
6	0.0	0.0	0.92
7	0.0	0.0	0.97
8	0.0	0.0	0.89
9	0.0	0.0	0.89
10	0.0	0.0	0.95
11	0.0	0.0	0.86
12	0.0	0.0	0.9
13	0.0	0.0	0.95
14	0.0	0.0	0.87

Visual Balance
Average Closure Balance Results - Case Study IV

15	0.0	0.0	0.91
16	0.0	0.0	0.98
17	0.0	0.0	0.85
18	0.0	0.0	0.89
19	0.0	0.0	0.94
20	0.0	0.0	0.86
21	0.0	0.0	0.9
22	0.0	0.0	0.96
23	0.0	0.0	0.88
24	0.0	0.0	0.92
25	0.0	0.0	0.97
26	0.0	0.0	0.88
27	0.0	0.0	0.93
28	0.0	0.0	0.95
29	0.0	0.0	0.87
30	0.0	0.0	0.91
31	0.0	0.0	0.96
32	0.0	0.0	0.88
33	0.0	0.0	0.92
34	0.0	0.0	0.98
35	0.0	0.0	0.85
36	0.0	0.0	0.89
37	0.0	0.0	0.94
38	0.0	0.0	0.85
39	0.0	0.0	0.9
40	0.0	0.0	0.96
41	0.0	0.0	0.88
42	0.0	0.0	0.92
43	0.0	0.0	0.97
44	0.0	0.0	0.85
45	0.0	0.0	0.89
46	0.0	0.0	0.95
47	0.0	0.0	0.87
48	0.0	0.0	0.9
49	0.0	0.0	0.95
50	0.0	0.0	0.0

Visual Balance Risk Analysis Summary Results
Case Study V

Risk Analysis Summary Statistics for Case Study V

Risk Analysis Input Parameters

Mean Annual Precipitation	450 mm
Standard Deviation	100
Number of Years of record	14
Minimum Design Freeboard (above EDF)	1.0 m
Risk Freeboard (above EDF)	0.75 m
SpillWay Invert, Height Above EDF	0.5 m
Pond Depth Required for Reclaim	0.25 m
Operation Input Parameters	
Number of Years in Operation Series	12.0
Number of Series in Simulation	100.0

Risk Analysis Summary Statistics

Spill Results

Year In Series	Avg. # Months With Spill	Average Annual Prob. of Spill (%)	Avg. Spill Volume	Maximum Spill Volume
1	0.19	5.0	15,988.17	46,876.74
2	0.07	4.0	10,068.14	27,695.6
3	0.16	2.0	37,189.9	130,936.66
4	0.06	1.0	21,319.5	53,084.41
5	0.0	0.0	0.0	0.0
6	0.01	1.0	26,769.1	26,769.1
7	0.06	2.0	37,601.67	108,019.09
8	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0
10	0.12	3.0	19,727.05	58,678.36
11	0.12	3.0	11,904.03	39,947.69
12	0.0	0.0	0.0	0.0

Freeboard Results

Year in Series	Avg. # Months with Low Freeboard	Avg. Annual Prob. of Low Freeboard (%)	Avg. Height of 'Low Freeboards'
1	1.2	12.0	0.48
2	0.75	13.0	0.55
3	0.41	7.0	0.47
4	0.42	6.0	0.56
5	0.25	3.0	0.52
6	0.26	4.0	0.55

7	0.38	11.0	0.57
8	0.21	12.0	0.67
9	0.13	7.0	0.65
10	0.52	8.0	0.51
11	0.69	8.0	0.56
12	0.0	0.0	0.0

Reclaim Results

Year in Series	Avg. # Months with Reclaim Off	Avg. Annual Prob. Month Reclaim Off (%)	Avg. Freshwater Makeup Vol. Required	Max. Freshwater Makeup Vol. Required
1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0
4	0.04	1.0	79,200.0	79,200.0
5	0.79	44.0	79,200.0	79,200.0
6	1.86	85.0	79,200.0	79,200.0
7	4.31	100.0	79,200.0	79,200.0
8	10.32	100.0	79,200.0	79,200.0
9	11.78	100.0	79,200.0	79,200.0
10	11.87	100.0	79,200.0	79,200.0
11	11.88	100.0	79,200.0	79,200.0
12	0.0	0.0	0.0	0.0

Tailings Exposure Results

Year in Series	Avg. # Months with Solids Exposed	Avg. Annual Prob. of Solids Exposure	Avg. Depth of Water above solids (m)
1	0.0	0.0	2.67
2	0.0	0.0	4.1
3	0.0	0.0	3.28
4	0.02	1.0	2.09
5	0.13	8.0	1.05
6	0.49	29.0	0.58
7	1.71	79.0	0.33
8	8.17	100.0	-0.14
9	11.1	100.0	-0.54
10	11.79	100.0	-1.22
11	11.88	100.0	-1.87
12	0.0	0.0	0.0

Appendix F

Visual Balance Sample
Concise Volume and Elevation Output File

Site Name: Case Study I

Run Number: 1

Month	Time In Years (years)	Total Solids, Water and Voids Volume (m^3)	Solids Elevation (m.a.s.l.)	Water Elevation (m.a.s.l.)	EDF Elev. (m.a.s.l.)	Dam Crest Elevation (m.a.s.l.)
January	0.08	1,093,518	112.76	117.88	121.16	125.0
February	0.17	1,245,038	115.07	118.46	121.55	125.0
March	0.25	1,404,414	115.81	119.08	121.96	125.0
April	0.33	1,585,748	116.52	119.77	122.43	125.0
May	0.42	1,879,173	117.26	120.61	123.18	125.18
June	0.50	2,223,618	117.97	121.49	124.07	126.07
July	0.58	2,518,416	118.71	122.25	124.83	126.83
August	0.67	2,775,525	119.45	122.91	125.37	127.37
September	0.75	3,110,029	120.11	123.78	126.01	128.01
October	0.83	3,508,307	120.6	124.8	126.78	128.78
November	0.92	3,771,477	121.08	125.36	127.28	129.28
December	1.00	4,005,788	121.57	125.81	127.73	129.73
January	1.08	4,217,692	122.06	126.22	128.14	130.14
February	1.17	4,412,174	122.51	126.59	128.52	130.52
March	1.25	4,602,091	123.0	126.96	128.88	130.88
April	1.33	4,792,957	123.48	127.33	129.25	131.25
May	1.42	5,067,043	123.97	127.85	129.78	131.78
June	1.50	5,372,268	124.45	128.44	130.31	132.31
July	1.58	5,632,702	124.94	128.94	130.73	132.73
August	1.67	5,869,154	125.33	129.4	131.11	133.11
September	1.75	6,218,647	125.68	130.06	131.67	133.67
October	1.83	6,636,370	126.05	130.73	132.35	134.35
November	1.92	6,929,073	126.41	131.21	132.82	134.82
December	2.00	7,199,500	126.78	131.64	133.26	135.26
January	2.08	7,440,016	127.15	132.03	133.65	135.65
February	2.17	7,659,411	127.48	132.39	134.0	136.0
March	2.25	7,867,302	127.85	132.72	134.34	136.34
April	2.33	8,063,893	128.2	133.04	134.65	136.65
May	2.42	8,326,007	128.57	133.46	135.07	137.07

Month	Time In Years (years)	Total Solids, Water and Voids Volume (m^3)	Solids Elevation (m.a.s.l.)	Water Elevation (m.a.s.l.)	EDF Elev. (m.a.s.l.)	Dam Crest Elevation (m.a.s.l.)
June	2.50	8,606,751	128.93	133.92	135.48	137.48
July	2.58	8,845,781	129.3	134.3	135.82	137.82
August	2.67	9,069,393	129.66	134.66	136.14	138.14
September	2.75	9,428,162	130.02	135.22	136.66	138.66
October	2.83	9,857,736	130.33	135.84	137.28	139.28
November	2.92	10,169,974	130.63	136.29	137.73	139.73
December	3.00	10,464,993	130.94	136.72	138.16	140.16
January	3.08	10,725,283	131.25	137.09	138.54	140.54
February	3.17	10,962,138	131.52	137.43	138.88	140.88
March	3.25	11,182,804	131.83	137.75	139.2	141.2
April	3.33	11,383,522	132.13	138.04	139.49	141.49
May	3.42	11,636,866	132.44	138.41	139.85	141.85
June	3.50	11,899,198	132.74	138.79	140.22	142.22
July	3.58	12,121,606	133.05	139.11	140.51	142.51
August	3.67	12,334,945	133.36	139.42	140.8	142.8
September	3.75	12,701,343	133.66	139.95	141.29	143.29
October	3.83	13,141,163	133.97	140.54	141.89	143.89
November	3.92	13,469,792	134.27	140.98	142.33	144.33
December	4.00	13,784,847	134.58	141.41	142.75	144.75
January	4.08	14,060,778	134.89	141.78	143.12	145.12
February	4.17	14,311,074	135.15	142.12	143.46	145.46
March	4.25	14,541,326	135.43	142.42	143.77	145.77
April	4.33	14,745,066	135.69	142.7	144.04	146.04
May	4.42	14,992,124	135.97	143.03	144.38	146.38
June	4.50	15,241,608	136.24	143.37	144.71	146.71
July	4.58	15,452,731	136.51	143.65	145.0	147.0
August	4.67	15,659,271	136.79	143.93	145.26	147.26
September	4.75	16,030,587	137.06	144.43	145.73	147.73
October	4.83	16,476,620	137.33	145.03	146.29	148.29
November	4.92	16,815,594	137.6	145.46	146.72	148.72
December	5.00	17,143,485	137.88	145.87	147.13	149.13

Month	Time In Years (years)	Total Solids, Water and Voids Volume (m^3)	Solids Elevation (m.a.s.l.)	Water Elevation (m.a.s.l.)	EDF Elev. (m.a.s.l.)	Dam Crest Elevation (m.a.s.l.)
January	5.08	17,429,579	138.15	146.23	147.5	149.5
February	5.17	17,688,727	138.4	146.56	147.82	149.82
March	5.25	17,925,375	138.68	146.86	148.12	150.12
April	5.33	18,131,158	138.95	147.12	148.38	150.38
May	5.42	18,373,907	139.23	147.43	148.69	150.69
June	5.50	18,614,411	139.49	147.73	148.99	150.99
July	5.58	18,817,465	139.77	147.99	149.25	151.25
August	5.67	19,019,039	140.04	148.24	149.51	151.51
September	5.75	19,394,023	140.29	148.72	149.98	151.98
October	5.83	19,844,854	140.55	149.29	150.52	152.52
November	5.92	20,191,545	140.8	149.72	150.94	152.94
December	6.00	20,529,267	141.06	150.14	151.34	153.34
January	6.08	20,823,310	141.31	150.5	151.69	153.69
February	6.17	21,089,472	141.55	150.81	152.01	154.01
March	6.25	21,331,244	141.8	151.1	152.3	154.3
April	6.33	21,538,683	142.05	151.35	152.55	154.55
May	6.42	21,777,906	142.31	151.64	152.83	154.83
June	6.50	22,010,958	142.56	151.92	153.11	155.11
July	6.58	22,207,220	142.82	152.15	153.35	155.35
August	6.67	22,404,560	143.08	152.39	153.58	155.58
September	6.75	22,782,710	143.32	152.84	154.04	156.04
October	6.83	23,237,775	143.58	153.38	154.58	156.58
November	6.92	23,591,456	143.83	153.81	155.0	157.0
December	7.00	23,937,953	144.09	154.22	155.39	157.39
January	7.08	24,239,060	144.35	154.58	155.73	157.73
February	7.17	24,511,516	144.58	154.91	156.04	158.04
March	7.25	24,757,933	144.84	155.19	156.32	158.32
April	7.33	24,966,888	145.08	155.43	156.56	158.56
May	7.42	25,202,850	145.32	155.69	156.82	158.82
June	7.50	25,428,931	145.56	155.95	157.08	159.08
July	7.58	25,618,766	145.8	156.16	157.29	159.29

Month	Time In Years (years)	Total Solids, Water and Voids Volume (m^3)	Solids Elevation (m.a.s.l.)	Water Elevation (m.a.s.l.)	EDF Elev. (m.a.s.l.)	Dam Crest Elevation (m.a.s.l.)
August	7.67	25,812,060	146.04	156.38	157.51	159.51
September	7.75	26,193,265	146.28	156.81	157.94	159.94
October	7.83	26,652,492	146.52	157.33	158.46	160.46
November	7.92	27,013,203	146.75	157.74	158.87	160.87
December	8.00	27,368,686	146.99	158.14	159.27	161.27
January	8.08	27,677,115	147.24	158.49	159.62	161.62
February	8.17	27,956,118	147.45	158.8	159.93	161.93
March	8.25	28,207,379	147.7	159.09	160.2	162.2
April	8.33	28,417,914	147.93	159.32	160.42	162.42
May	8.42	28,650,485	148.17	159.59	160.67	162.67
June	8.50	28,869,335	148.41	159.83	160.9	162.9
July	8.58	29,052,520	148.65	160.04	161.1	163.1
August	8.67	29,241,639	148.89	160.24	161.3	163.3
September	8.75	29,625,993	149.13	160.65	161.71	163.71
October	8.83	30,089,505	149.37	161.14	162.2	164.2
November	8.92	30,457,431	149.6	161.53	162.59	164.59
December	9.00	30,822,121	149.84	161.92	162.98	164.98
January	9.08	31,138,040	150.08	162.25	163.31	165.31
February	9.17	31,423,729	150.29	162.56	163.62	165.62
March	9.25	31,679,929	150.52	162.83	163.89	165.89
April	9.33	31,892,077	150.74	163.05	164.12	166.12
May	9.42	32,121,183	150.97	163.3	164.36	166.36
June	9.50	32,332,642	151.19	163.52	164.58	166.58
July	9.58	32,509,021	151.42	163.71	164.77	166.77
August	9.67	32,693,862	151.65	163.91	164.97	166.97
September	9.75	33,081,439	151.87	164.32	165.78	167.78
October	9.83	33,549,327	152.1	164.81	166.81	168.81
November	9.92	33,924,603	152.32	165.44	167.64	169.64
December	10.00	34,299,390	152.55	166.26	168.46	170.46
January	10.08	34,624,627	152.78	166.98	169.18	171.18
February	10.17	34,919,482	152.99	167.63	169.82	171.82

Month	Time In Years (years)	Total Solids, Water and Voids Volume (m^3)	Solids Elevation (m.a.s.l.)	Water Elevation (m.a.s.l.)	EDF Elev. (m.a.s.l.)	Dam Crest Elevation (m.a.s.l.)
March	10.25	35,183,023	153.21	168.2	170.24	172.24
April	10.33	35,397,730	153.44	168.68	170.52	172.52
May	10.42	35,621,050	153.67	169.17	170.82	172.82
June	10.50	35,819,521	153.89	169.6	171.08	173.08
July	10.58	35,983,424	154.12	169.96	171.29	173.29
August	10.67	36,160,152	154.35	170.21	171.53	173.53
September	10.75	36,553,712	154.57	170.73	172.04	174.04
October	10.83	37,029,225	154.8	171.35	172.67	174.67
November	10.92	37,416,303	155.02	171.86	173.18	175.18
December	11.00	37,804,338	155.23	172.37	173.69	175.69
January	11.08	38,138,367	155.45	172.81	174.13	176.13
February	11.17	38,439,547	155.64	173.21	174.53	176.53
March	11.25	38,706,747	155.86	173.56	174.88	176.88
April	11.33	38,922,355	156.07	173.85	175.09	177.09
May	11.42	39,144,250	156.29	174.14	175.24	177.24
June	11.50	39,340,809	156.49	174.4	175.38	177.38
July	11.58	39,503,872	156.71	174.61	175.5	177.5
August	11.67	39,680,552	156.93	174.84	175.62	177.62
September	11.75	40,074,113	157.14	175.19	175.9	177.9
October	11.83	40,549,625	157.35	175.53	176.23	178.23
November	11.92	40,936,704	157.56	175.8	176.51	178.51
December	12.00	41,324,738	157.78	176.07	176.78	178.78
January	12.08	41,658,768	157.99	176.31	177.01	179.01
February	12.17	41,959,947	158.19	176.52	177.23	179.23
March	12.25	42,227,147	158.4	176.71	177.41	179.41
April	12.33	42,442,755	158.61	176.86	177.57	179.57
May	12.42	42,664,651	158.83	177.02	177.72	179.72
June	12.50	42,861,210	159.04	177.16	177.86	179.86
July	12.58	43,024,272	159.25	177.27	177.98	179.98
August	12.67	43,200,952	159.47	177.4	178.1	180.1
September	12.75	43,594,513	159.68	177.67	178.38	180.38

Month	Time In Years (years)	Total Solids, Water and Voids Volume (m^3)	Solids Elevation (m.a.s.l.)	Water Elevation (m.a.s.l.)	EDF Elev. (m.a.s.l.)	Dam Crest Elevation (m.a.s.l.)
October	12.83	44,070,025	159.9	178.01	178.71	180.71
November	12.92	44,457,104	160.1	178.28	178.98	180.98
December	13.00	44,845,139	160.3	178.55	179.26	181.26
January	13.08	45,179,168	160.51	178.79	179.49	181.49
February	13.17	45,480,348	160.69	179.0	179.7	181.7
March	13.25	45,747,547	160.89	179.19	179.89	181.89
April	13.33	45,963,155	161.09	179.34	180.09	182.09
May	13.42	46,185,051	161.29	179.5	180.42	182.42
June	13.50	46,381,610	161.49	179.64	180.71	182.71
July	13.58	46,544,673	161.69	179.75	180.95	182.95
August	13.67	46,721,352	161.9	179.87	181.21	183.21
September	13.75	47,114,913	162.09	180.32	181.79	183.79
October	13.83	47,590,426	162.3	181.02	182.49	184.49
November	13.92	47,977,504	162.49	181.59	183.06	185.06
December	14.00					

Appendix G

Visual Balance Sample
Extended Volume and Elevation Output File

Visual Balance
Extended Volume and Elevation Results - Case Study I

Month		**January**	**February**	**March**	**April**	**May**	**June**
Time In Years	(years)	0.1	0.2	0.3	0.3	0.4	0.5
Direct Precipitation	(m3)	57,814	26,305	24,358	18,845	18,121	13,684
Runoff	(m3)	47,804	46,897	37,203	25,106	21,707	15,387
Total Evaporation (Pond & Beach)	(m3)	274	292	1,763	5,309	14,278	21,684
Slurry Water Input	(m3)	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	(m3)	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off		0	0	0	0	0	0
Spill Volume	(m3)	0	0	0	0	0	0
Month Water Inflow	(m3)	1,063,968	1,031,552	1,019,912	1,002,301	998,178	987,421
Month Solids & Voids Inflow	(m3)	294,827	265,344	294,827	285,000	294,827	265,344
Month Water Lost to Voids	(m3)	85,933	77,340	85,933	83,069	85,933	77,340
Solids Elev.	(m.a.s.l.)	113.0	115.2	116.0	116.8	117.6	118.3
Water Elev.	(m.a.s.l.)	118.0	118.7	119.3	119.9	120.3	120.6
Free Water Depth	(m)	5.0	3.5	3.3	3.1	2.7	2.3
EDF Elev.	(m.a.s.l.)	125.7	126.1	126.4	126.7	127.0	127.2
Dam Crest Elev.	(m.a.s.l.)	127.2	127.6	127.9	128.2	128.5	128.7

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**July**	**August**	**September**	**October**	**November**	**December**	**January**
Time In Years	0.6	0.7	0.8	0.8	0.9	1.0	1.1
Direct Precipitation	14,211	17,733	61,352	72,151	65,959	75,277	64,167
Runoff	15,302	18,254	60,217	65,790	55,424	58,801	46,788
Total Evaporation (Pond & Beach)	25,843	21,530	14,379	7,114	838	0	304
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	987,863	994,337	1,079,919	1,096,292	1,079,733	1,092,427	1,069,304
Month Solids & Voids Inflow	294,827	294,827	265,344	294,827	285,000	245,689	294,827
Month Water Lost to Voids	85,933	85,933	77,340	85,933	83,069	71,611	85,933
Solids Elev.	119.1	119.9	120.4	121.0	121.5	121.9	122.5
Water Elev.	120.9	121.2	121.8	122.4	123.0	123.6	124.2
Free Water Depth	1.8	1.3	1.3	1.4	1.5	1.7	1.7
EDF Elev.	127.4	127.7	128.1	128.5	129.0	129.4	129.9
Dam Crest Elev.	128.9	129.2	129.6	130.1	130.5	130.9	131.4

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**February**	**March**	**April**	**May**	**June**	**July**	**August**
Time In Years	1.2	1.3	1.3	1.4	1.5	1.6	1.7
Direct Precipitation	60,607	51,018	36,212	32,417	23,618	23,956	32,860
Runoff	41,408	32,938	22,328	19,420	13,797	13,743	15,834
Total Evaporation (Pond & Beach)	673	3,692	10,202	25,542	37,427	43,563	39,896
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	0	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,060,366	1,042,306	1,016,890	1,010,187	995,765	996,049	1,007,044
Month Solids & Voids Inflow	265,344	294,827	285,000	294,827	265,344	294,827	294,827
Month Water Lost to Voids	77,340	85,933	83,069	85,933	77,340	85,933	85,933
Solids Elev.	123.0	123.5	124.0	124.6	125.0	125.4	125.8
Water Elev.	124.7	125.2	125.5	125.7	125.9	127.9	128.2
Free Water Depth	1.7	1.7	1.4	1.2	0.9	2.5	2.3
EDF Elev.	130.2	130.5	130.8	131.0	131.2	132.9	133.1
Dam Crest Elev.	131.7	132.0	132.3	132.5	132.7	134.4	134.6

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**September**	**October**	**November**	**December**	**January**	**February**	**March**
Time In Years	1.8	1.8	1.9	2.0	2.1	2.2	2.3
Direct Precipitation	110,728	125,740	110,791	122,513	101,059	92,073	75,169
Runoff	52,317	57,216	48,251	51,243	40,885	36,374	29,074
Total Evaporation (Pond & Beach)	25,951	12,398	1,408	0	479	1,023	5,440
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,121,395	1,141,306	1,117,392	1,132,105	1,100,294	1,086,797	1,062,593
Month Solids & Voids Inflow	265,344	294,827	285,000	245,689	294,827	265,344	294,827
Month Water Lost to Voids	77,340	85,933	83,069	71,611	85,933	77,340	85,933
Solids Elev.	126.2	126.6	127.0	127.3	127.7	128.1	128.5
Water Elev.	128.6	129.2	129.7	130.2	130.6	131.0	131.3
Free Water Depth	2.5	2.6	2.7	2.9	2.9	2.9	2.8
EDF Elev.	133.5	133.9	134.4	134.8	135.2	135.5	135.8
Dam Crest Elev.	135.0	135.4	135.9	136.3	136.7	137.0	137.3

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**April**	**May**	**June**	**July**	**August**	**September**	**October**
Time In Years	2.3	2.4	2.5	2.6	2.7	2.8	2.8
Direct Precipitation	52,141	46,114	33,234	33,432	40,368	135,047	151,455
Runoff	19,779	17,228	12,259	12,227	14,632	48,426	53,102
Total Evaporation (Pond & Beach)	14,690	36,334	52,664	60,795	49,012	31,650	14,934
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,030,270	1,021,692	1,003,843	1,004,009	1,013,351	1,141,823	1,162,906
Month Solids & Voids Inflow	285,000	294,827	265,344	294,827	294,827	265,344	294,827
Month Water Lost to Voids	83,069	85,933	77,340	85,933	85,933	77,340	85,933
Solids Elev.	128.9	129.3	129.6	130.0	130.4	130.7	131.0
Water Elev.	131.6	131.8	132.0	132.1	132.3	132.8	133.2
Free Water Depth	2.7	2.6	2.3	2.1	2.0	2.1	2.2
EDF Elev.	136.1	136.3	136.4	136.6	136.7	137.1	137.5
Dam Crest Elev.	137.6	137.8	137.9	138.1	138.2	138.6	139.1

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Time In Years	2.9	3.0	3.1	3.2	3.3	3.3	3.4
Direct Precipitation	131,591	143,692	117,648	107,018	87,245	60,320	53,203
Runoff	44,923	47,854	38,231	33,983	27,142	18,470	16,094
Total Evaporation (Pond & Beach)	1,672	0	558	1,189	6,314	16,994	41,920
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,134,864	1,149,896	1,114,229	1,099,351	1,072,737	1,037,140	1,027,647
Month Solids & Voids Inflow	285,000	245,689	294,827	265,344	294,827	285,000	294,827
Month Water Lost to Voids	83,069	71,611	85,933	77,340	85,933	83,069	85,933
Solids Elev.	131.3	131.6	132.0	132.3	132.6	132.9	133.3
Water Elev.	133.7	134.2	134.6	135.0	135.3	135.6	135.8
Free Water Depth	2.4	2.5	2.6	2.7	2.7	2.6	2.5
EDF Elev.	138.0	138.4	138.8	139.1	139.4	139.7	139.9
Dam Crest Elev.	139.5	139.9	140.3	140.6	140.9	141.2	141.4

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	June	July	August	September	October	November	December
Time In Years	3.5	3.6	3.7	3.8	3.8	3.9	4.0
Direct Precipitation	38,251	38,412	46,293	154,547	172,712	149,451	162,592
Runoff	11,456	11,430	13,684	45,306	49,700	42,065	44,830
Total Evaporation (Pond & Beach)	60,614	69,852	56,205	36,220	17,030	1,899	0
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,008,057	1,008,192	1,018,328	1,158,203	1,180,763	1,149,867	1,165,772
Month Solids & Voids Inflow	265,344	294,827	294,827	265,344	294,827	285,000	245,689
Month Water Lost to Voids	77,340	85,933	85,933	77,340	85,933	83,069	71,611
Solids Elev.	133.6	133.9	134.2	134.5	134.9	135.2	135.4
Water Elev.	135.9	136.0	136.2	136.6	137.1	137.5	137.9
Free Water Depth	2.3	2.1	2.0	2.1	2.2	2.3	2.5
EDF Elev.	140.0	140.2	140.3	140.7	141.1	141.5	141.9
Dam Crest Elev.	141.5	141.7	141.8	142.2	142.6	143.0	143.4

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	January	February	March	April	May	June	July
Time In Years	4.1	4.2	4.3	4.3	4.4	4.5	4.6
Direct Precipitation	132,658	120,265	97,759	67,534	59,526	42,768	42,924
Runoff	35,829	31,863	25,459	17,316	15,082	10,733	10,708
Total Evaporation (Pond & Beach)	629	1,336	7,075	19,027	46,902	67,771	78,056
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,126,837	1,110,478	1,081,569	1,043,200	1,032,958	1,011,851	1,011,982
Month Solids & Voids Inflow	294,827	265,344	294,827	285,000	294,827	265,344	294,827
Month Water Lost to Voids	85,933	77,340	85,933	83,069	85,933	77,340	85,933
Solids Elev.	135.7	136.0	136.3	136.6	136.9	137.2	137.5
Water Elev.	138.3	138.7	139.0	139.3	139.5	139.6	139.8
Free Water Depth	2.6	2.7	2.7	2.7	2.6	2.5	2.3
EDF Elev.	142.3	142.6	142.9	143.2	143.4	143.5	143.6
Dam Crest Elev.	143.8	144.1	144.5	144.7	144.9	145.0	145.1

Visual Balance
Extended Volume and Elevation Results - Case Study I

Month	**August**	**September**	**October**	**November**	**December**	**January**	**February**
Time In Years	4.7	4.8	4.8	4.9	5.0	5.1	5.2
Direct Precipitation	51,699	172,480	191,852	164,978	178,455	144,777	130,562
Runoff	12,819	42,437	46,638	39,581	42,292	33,890	30,216
Total Evaporation (Pond & Beach)	62,768	40,423	18,917	2,096	0	686	1,451
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,022,868	1,173,267	1,196,840	1,162,909	1,179,097	1,137,017	1,119,127
Month Solids & Voids Inflow	294,827	265,344	294,827	285,000	245,689	294,827	265,344
Month Water Lost to Voids	85,933	77,340	85,933	83,069	71,611	85,933	77,340
Solids Elev.	137.8	138.1	138.4	138.6	138.9	139.2	139.5
Water Elev.	139.9	140.3	140.8	141.2	141.6	142.0	142.4
Free Water Depth	2.2	2.3	2.4	2.5	2.7	2.8	2.9
EDF Elev.	143.8	144.2	144.6	145.0	145.4	145.8	146.1
Dam Crest Elev.	145.3	145.7	146.1	146.5	146.9	147.3	147.6

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**March**	**April**	**May**	**June**	**July**	**August**	**September**
Time In Years	5.3	5.3	5.4	5.5	5.6	5.7	5.8
Direct Precipitation	105,636	72,670	63,847	45,752	45,842	55,119	183,502
Runoff	24,199	16,494	14,391	10,256	10,241	12,272	40,673
Total Evaporation (Pond & Beach)	7,645	20,474	50,306	72,500	83,363	66,921	43,006
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,088,185	1,047,515	1,036,588	1,014,358	1,014,433	1,025,741	1,182,525
Month Solids & Voids Inflow	294,827	285,000	294,827	265,344	294,827	294,827	265,344
Month Water Lost to Voids	85,933	83,069	85,933	77,340	85,933	85,933	77,340
Solids Elev.	139.8	140.1	140.3	140.6	140.9	141.2	141.4
Water Elev.	142.7	142.9	143.1	143.2	143.4	143.5	143.9
Free Water Depth	2.9	2.9	2.8	2.6	2.5	2.3	2.5
EDF Elev.	146.4	146.7	146.8	146.9	147.1	147.2	147.6
Dam Crest Elev.	147.9	148.2	148.3	148.4	148.6	148.7	149.1

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**October**	**November**	**December**	**January**	**February**	**March**	**April**
Time In Years	5.8	5.9	6.0	6.1	6.2	6.3	6.3
Direct Precipitation	203,922	175,311	189,584	153,625	138,273	111,683	76,710
Runoff	44,707	37,928	40,511	32,474	28,982	23,232	15,848
Total Evaporation (Pond & Beach)	20,107	2,227	0	728	1,536	8,082	21,612
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,206,979	1,171,589	1,188,445	1,144,449	1,125,605	1,093,264	1,050,908
Month Solids & Voids Inflow	294,827	285,000	245,689	294,827	265,344	294,827	285,000
Month Water Lost to Voids	85,933	83,069	71,611	85,933	77,340	85,933	83,069
Solids Elev.	141.7	142.0	142.2	142.5	142.7	143.0	143.3
Water Elev.	144.4	144.8	145.2	145.6	145.9	146.2	146.5
Free Water Depth	2.7	2.8	3.0	3.1	3.2	3.2	3.2
EDF Elev.	148.0	148.4	148.8	149.2	149.5	149.8	150.1
Dam Crest Elev.	149.5	149.9	150.3	150.7	151.0	151.3	151.6

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**May**	**June**	**July**	**August**	**September**	**October**	**November**
Time In Years	6.4	6.5	6.6	6.7	6.8	6.8	6.9
Direct Precipitation	67,316	48,192	48,256	57,986	192,893	213,971	183,553
Runoff	13,836	9,865	9,855	11,813	39,171	43,099	36,609
Total Evaporation (Pond & Beach)	53,039	76,366	87,753	70,402	45,207	21,098	2,332
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,039,502	1,016,407	1,016,461	1,028,150	1,190,413	1,215,420	1,178,512
Month Solids & Voids Inflow	294,827	265,344	294,827	294,827	265,344	294,827	285,000
Month Water Lost to Voids	85,933	77,340	85,933	85,933	77,340	85,933	83,069
Solids Elev.	143.6	143.8	144.1	144.4	144.6	144.9	145.2
Water Elev.	146.6	146.8	146.9	147.0	147.4	147.8	148.2
Free Water Depth	3.1	2.9	2.8	2.6	2.7	2.9	3.1
EDF Elev.	150.2	150.3	150.4	150.6	150.9	151.3	151.7
Dam Crest Elev.	151.7	151.8	151.9	152.1	152.4	152.9	153.2

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**December**	**January**	**February**	**March**	**April**	**May**	**June**
Time In Years	7.0	7.1	7.2	7.3	7.3	7.4	7.5
Direct Precipitation	198,105	160,364	144,323	116,557	80,049	70,239	50,272
Runoff	39,148	31,396	28,014	22,452	15,314	13,368	9,532
Total Evaporation (Pond & Beach)	0	760	1,604	8,435	22,553	55,342	79,663
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,195,603	1,150,110	1,130,687	1,097,359	1,053,713	1,041,957	1,018,155
Month Solids & Voids Inflow	245,689	294,827	265,344	294,827	285,000	294,827	265,344
Month Water Lost to Voids	71,611	85,933	77,340	85,933	83,069	85,933	77,340
Solids Elev.	145.4	145.7	145.9	146.2	146.4	146.7	146.9
Water Elev.	148.7	149.0	149.4	149.7	149.9	150.1	150.2
Free Water Depth	3.3	3.4	3.5	3.5	3.5	3.4	3.3
EDF Elev.	152.1	152.5	152.8	153.1	153.3	153.5	153.6
Dam Crest Elev.	153.6	154.0	154.3	154.6	154.9	155.0	155.1

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**July**	**August**	**September**	**October**	**November**	**December**	**January**
Time In Years	7.6	7.7	7.8	7.8	7.9	8.0	8.1
Direct Precipitation	50,328	60,460	201,065	222,892	191,060	206,059	166,684
Runoff	9,524	11,418	37,863	41,672	35,408	37,875	30,385
Total Evaporation (Pond & Beach)	91,519	73,405	47,122	21,978	2,427	0	790
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,018,201	1,030,228	1,197,278	1,222,913	1,184,818	1,202,285	1,155,419
Month Solids & Voids Inflow	294,827	294,827	265,344	294,827	285,000	245,689	294,827
Month Water Lost to Voids	85,933	85,933	77,340	85,933	83,069	71,611	85,933
Solids Elev.	147.2	147.4	147.7	147.9	148.2	148.4	148.7
Water Elev.	150.3	150.4	150.8	151.2	151.6	152.0	152.4
Free Water Depth	3.1	3.0	3.1	3.3	3.4	3.6	3.7
EDF Elev.	153.7	153.9	154.2	154.6	155.0	155.4	155.8
Dam Crest Elev.	155.2	155.4	155.7	156.1	156.5	156.9	157.3

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**February**	**March**	**April**	**May**	**June**	**July**	**August**
Time In Years	8.2	8.3	8.3	8.4	8.5	8.6	8.7
Direct Precipitation	149,912	121,000	83,056	72,849	52,131	52,185	62,688
Runoff	27,120	21,741	14,833	12,951	9,235	9,226	11,061
Total Evaporation (Pond & Beach)	1,666	8,757	23,400	57,399	82,608	94,898	76,110
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,135,382	1,101,091	1,056,239	1,044,149	1,019,716	1,019,762	1,032,099
Month Solids & Voids Inflow	265,344	294,827	285,000	294,827	265,344	294,827	294,827
Month Water Lost to Voids	77,340	85,933	83,069	85,933	77,340	85,933	85,933
Solids Elev.	148.9	149.2	149.4	149.7	149.9	150.2	150.4
Water Elev.	152.7	153.0	153.3	153.4	153.5	153.6	153.8
Free Water Depth	3.8	3.8	3.8	3.7	3.6	3.4	3.3
EDF Elev.	156.1	156.4	156.6	156.7	156.8	156.9	157.0
Dam Crest Elev.	157.6	157.9	158.1	158.2	158.3	158.4	158.6

Visual Balance
Extended Volume and Elevation Results - Case Study I

Month	**September**	**October**	**November**	**December**	**January**	**February**	**March**
Time In Years	8.8	8.8	8.9	9.0	9.1	9.2	9.3
Direct Precipitation	208,458	231,073	198,053	213,584	172,784	155,408	125,444
Runoff	36,680	40,363	34,289	36,671	29,409	26,240	21,030
Total Evaporation (Pond & Beach)	48,855	22,784	2,516	0	819	1,727	9,078
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,203,489	1,229,786	1,190,692	1,208,605	1,160,543	1,139,998	1,104,824
Month Solids & Voids Inflow	265,344	294,827	285,000	245,689	294,827	265,344	294,827
Month Water Lost to Voids	77,340	85,933	83,069	71,611	85,933	77,340	85,933
Solids Elev.	150.7	150.9	151.2	151.4	151.6	151.8	152.1
Water Elev.	154.1	154.6	155.0	155.4	155.7	156.0	156.3
Free Water Depth	3.4	3.6	3.8	4.0	4.1	4.2	4.2
EDF Elev.	157.4	157.8	158.2	158.6	158.9	159.2	159.5
Dam Crest Elev.	158.9	159.3	159.7	160.1	160.4	160.8	161.0

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Month	April	May	June	July	August	September	October
Time In Years	9.3	9.4	9.5	9.6	9.7	9.8	9.8
Direct Precipitation	86,111	75,529	54,049	54,105	64,993	216,119	239,577
Runoff	14,344	12,522	8,928	8,919	10,692	35,455	39,002
Total Evaporation (Pond & Beach)	24,260	59,510	85,648	98,388	78,908	50,650	23,623
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,058,805	1,046,401	1,021,327	1,021,374	1,034,035	1,209,923	1,236,929
Month Solids & Voids Inflow	285,000	294,827	265,344	294,827	294,827	265,344	294,827
Month Water Lost to Voids	83,069	85,933	77,340	85,933	85,933	77,340	85,933
Solids Elev.	152.3	152.6	152.8	153.1	153.3	153.5	153.8
Water Elev.	156.5	156.7	156.8	156.9	157.0	157.3	157.8
Free Water Depth	4.2	4.1	4.0	3.8	3.7	3.8	4.0
EDF Elev.	159.7	159.9	160.0	160.1	160.2	160.5	160.9
Dam Crest Elev.	161.2	161.4	161.5	161.6	161.7	162.0	162.4

Visual Balance

Extended Volume and Elevation Results - Case Study I

Month	**November**	**December**	**January**	**February**	**March**	**April**	**May**
Time In Years	9.9	10.0	10.1	10.2	10.3	10.3	10.4
Direct Precipitation	205,360	221,481	179,161	161,130	130,054	89,269	78,295
Runoff	33,120	35,408	28,389	25,325	20,292	13,839	12,079
Total Evaporation (Pond & Beach)	2,609	0	849	1,790	9,412	25,150	61,690
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,196,830	1,215,239	1,165,900	1,144,805	1,108,696	1,061,457	1,048,724
Month Solids & Voids Inflow	285,000	245,689	294,827	265,344	294,827	285,000	294,827
Month Water Lost to Voids	83,069	71,611	85,933	77,340	85,933	83,069	85,933
Solids Elev.	154.0	154.2	154.5	154.7	155.0	155.2	155.4
Water Elev.	158.1	158.5	158.9	159.2	159.5	159.7	159.9
Free Water Depth	4.1	4.3	4.4	4.5	4.6	4.5	4.5
EDF Elev.	161.3	161.7	162.0	162.3	162.6	162.8	162.9
Dam Crest Elev.	162.8	163.2	163.5	163.8	164.1	164.3	164.4

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Extended Volume and Elevation Results - Case Study I

Month	**June**	**July**	**August**	**September**	**October**	**November**	**December**
Time In Years	10.5	10.6	10.7	10.8	10.8	10.9	11.0
Direct Precipitation	56,024	56,079	67,361	223,987	248,297	212,832	229,538
Runoff	8,612	8,603	10,313	34,196	37,607	31,924	34,119
Total Evaporation (Pond & Beach)	88,777	101,978	81,784	52,494	24,483	2,704	0
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,022,986	1,023,032	1,036,025	1,216,532	1,244,254	1,203,107	1,222,007
Month Solids & Voids Inflow	265,344	294,827	294,827	265,344	294,827	285,000	245,689
Month Water Lost to Voids	77,340	85,933	85,933	77,340	85,933	83,069	71,611
Solids Elev.	155.6	155.9	156.1	156.3	156.6	156.8	157.0
Water Elev.	160.0	160.1	160.2	160.5	160.9	161.3	161.7
Free Water Depth	4.3	4.2	4.1	4.2	4.4	4.5	4.7
EDF Elev.	163.0	163.1	163.2	163.5	163.9	164.3	164.7
Dam Crest Elev.	164.5	164.6	164.7	165.1	165.5	165.8	166.2

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Month	January	February	March	April	May	June	July
Time In Years	11.1	11.2	11.3	11.3	11.4	11.5	11.6
Direct Precipitation	185,680	166,993	134,785	92,515	81,140	58,059	58,113
Runoff	27,346	24,387	19,535	13,319	11,624	8,287	8,278
Total Evaporation (Pond & Beach)	880	1,855	9,754	26,064	63,931	92,001	105,677
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,171,376	1,149,730	1,112,670	1,064,184	1,051,114	1,024,695	1,024,741
Month Solids & Voids Inflow	294,827	265,344	294,827	285,000	294,827	265,344	294,827
Month Water Lost to Voids	85,933	77,340	85,933	83,069	85,933	77,340	85,933
Solids Elev.	157.2	157.4	157.7	157.9	158.1	158.3	158.6
Water Elev.	162.0	162.3	162.6	162.8	163.0	163.0	163.1
Free Water Depth	4.8	4.9	4.9	4.9	4.8	4.7	4.5
EDF Elev.	165.1	165.7	166.3	166.7	167.1	167.2	167.4
Dam Crest Elev.	166.6	167.3	167.8	168.2	168.6	168.7	168.9

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Month	August	September	October	November	December	January	February
Time In Years	11.7	11.8	11.8	11.9	12.0	12.1	12.2
Direct Precipitation	69,801	232,084	257,252	220,493	237,783	192,335	173,255
Runoff	9,923	32,900	36,174	30,699	32,800	26,281	23,385
Total Evaporation (Pond & Beach)	84,745	54,392	25,366	2,801	0	912	1,925
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,038,074	1,223,334	1,251,776	1,209,542	1,228,932	1,176,966	1,154,989
Month Solids & Voids Inflow	294,827	265,344	294,827	285,000	245,689	294,827	265,344
Month Water Lost to Voids	85,933	77,340	85,933	83,069	71,611	85,933	77,340
Solids Elev.	158.8	159.0	159.3	159.5	159.7	159.9	160.1
Water Elev.	163.2	163.6	164.0	164.4	164.8	165.2	165.9
Free Water Depth	4.4	4.5	4.7	4.9	5.1	5.3	5.8
EDF Elev.	167.6	168.3	169.2	170.0	170.5	170.9	171.3
Dam Crest Elev.	169.1	169.8	170.7	171.5	172.0	172.4	172.8

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Extended Volume and Elevation Results - Case Study I

Month	**March**	**April**	**May**	**June**	**July**	**August**	**September**
Time In Years	12.3	12.3	12.4	12.5	12.6	12.7	12.8
Direct Precipitation	140,499	96,838	85,185	61,088	61,213	73,603	245,122
Runoff	18,621	12,628	10,977	7,802	7,782	9,315	30,814
Total Evaporation (Pond & Beach)	10,168	27,282	67,119	96,801	111,314	89,361	57,448
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,117,470	1,067,815	1,054,512	1,027,240	1,027,345	1,041,267	1,234,286
Month Solids & Voids Inflow	294,827	285,000	294,827	265,344	294,827	294,827	265,344
Month Water Lost to Voids	85,933	83,069	85,933	77,340	85,933	85,933	77,340
Solids Elev.	160.4	160.6	160.8	161.0	161.2	161.4	161.6
Water Elev.	166.5	166.9	167.2	167.4	167.5	167.8	168.5
Free Water Depth	6.1	6.3	6.4	6.4	6.3	6.3	6.8
EDF Elev.	171.6	171.9	172.1	172.2	172.3	172.4	172.8
Dam Crest Elev.	173.1	173.4	173.6	173.7	173.8	173.9	174.3

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Month	October	November	December	January	February	March	April
Time In Years	12.8	12.9	13.0	13.1	13.2	13.3	13.3
Direct Precipitation	273,036	235,420	254,797	205,199	183,804	147,821	101,141
Runoff	33,649	28,310	30,077	24,223	21,697	17,449	11,939
Total Evaporation (Pond & Beach)	26,922	2,991	0	973	2,042	10,698	28,495
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,265,035	1,222,080	1,243,224	1,187,771	1,163,851	1,123,620	1,071,430
Month Solids & Voids Inflow	294,827	285,000	245,689	294,827	265,344	294,827	285,000
Month Water Lost to Voids	85,933	83,069	71,611	85,933	77,340	85,933	83,069
Solids Elev.	161.9	162.1	162.3	162.5	162.7	162.9	163.1
Water Elev.	169.3	170.1	170.6	171.0	171.5	171.8	172.1
Free Water Depth	7.5	8.0	8.3	8.6	8.8	8.9	9.0
EDF Elev.	173.4	173.8	174.3	174.8	175.1	175.3	175.4
Dam Crest Elev.	174.9	175.4	175.9	176.3	176.6	176.8	176.9

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Extended Volume and Elevation Results - Case Study I

Month	**May**	**June**	**July**	**August**	**September**	**October**	**November**
Time In Years	13.4	13.5	13.6	13.7	13.8	13.8	13.9
Direct Precipitation	88,498	63,213	63,213	75,855	251,879	278,137	237,291
Runoff	10,447	7,462	7,462	8,954	29,733	32,833	28,011
Total Evaporation (Pond & Beach)	69,729	100,169	114,951	92,097	59,031	27,425	3,015
Slurry Water Input	957,600	957,600	957,600	957,600	957,600	957,600	957,600
Reclaim Water Out	936,000	936,000	936,000	936,000	936,000	936,000	936,000
Total Months Reclaim Off	0	0	0	0	0	0	0
Spill Volume	0	0	0	0	0	0	0
Month Water Inflow	1,057,295	1,029,025	1,029,025	1,043,160	1,239,962	1,269,319	1,223,652
Month Solids & Voids Inflow	294,827	265,344	294,827	294,827	265,344	294,827	285,000
Month Water Lost to Voids	85,933	77,340	85,933	85,933	77,340	85,933	83,069
Solids Elev.	163.3	163.5	163.8	164.0	164.2	164.4	164.6
Water Elev.	172.3	172.4	172.4	172.6	173.0	173.5	174.0
Free Water Depth	8.9	8.8	8.7	8.6	8.8	9.1	9.4
EDF Elev.	175.5	175.6	175.6	175.7	175.9	176.2	176.5
Dam Crest Elev.	177.0	177.1	177.1	177.2	177.5	177.7	178.0