

2.2. SURFACE MINING--CAPITAL COSTS

2.2.2. MINING EQUIPMENT

2.2.2.2. EXCAVATION, LOAD AND HAUL
BUCKET WHEEL EXCAVATORS

The capital cost for bucket wheel excavation is for the acquisition and erection of bucket wheel excavators. The bucket wheel excavator is a single unit includes an excavating wheel, transporter, and discharge conveyor. The total capital cost is based on a single cost curve having an excavation rate (X), in metric tons of material per day. The curve is valid for operations between 2,200 and 125,000 mtpd, operating three shifts per day.

BASE CURVE

The daily output of an excavator is based on the operating time and output efficiency of the machine. The base case assumes an operating time of 50% and an output efficiency of 46%. The operating time is the percent of 24 h that the machines operate each day. The output efficiency is the percent of theoretical capacity that the machine delivers for a particular overburden.

The total cost includes the costs associated with the acquisition and erection of the bucket wheel excavator. The bucket wheel excavator includes a discharge conveyor (from 8 to 25 m long), but not the in-pit conveying system. The capital cost derived from the curve is a combination of the following costs:

Installation labor cost.....	1.2%
Installation materials cost.....	0.1%
Purchased equipment cost.....	94.7%
Transportation cost.....	4.0%

The installation materials are a small percentage of the overall costs since the bucket wheel excavator is delivered as a complete unit and erected in the field.

The total capital cost is $(Y_C) = 1,660.446(X)^{0.684}$ and is distributed as follows:

- (L) Installation Labor Cost $(Y_L) = 19.925(X)^{0.684}$
- (S) Installation Materials Cost $(Y_S) = 1.660(X)^{0.684}$
- (E) Purchased Equipment Cost $(Y_E) = 1,638.860(X)^{0.684}$

ADJUSTMENT FACTORS

Operating Time Factor The base case assumes a 50% operating time. Bucket wheel excavators do not have high availabilities. The range of expected operating time is 41% to 60%. To adjust for different operating times, multiply the cost obtained from the curve by the following factor:

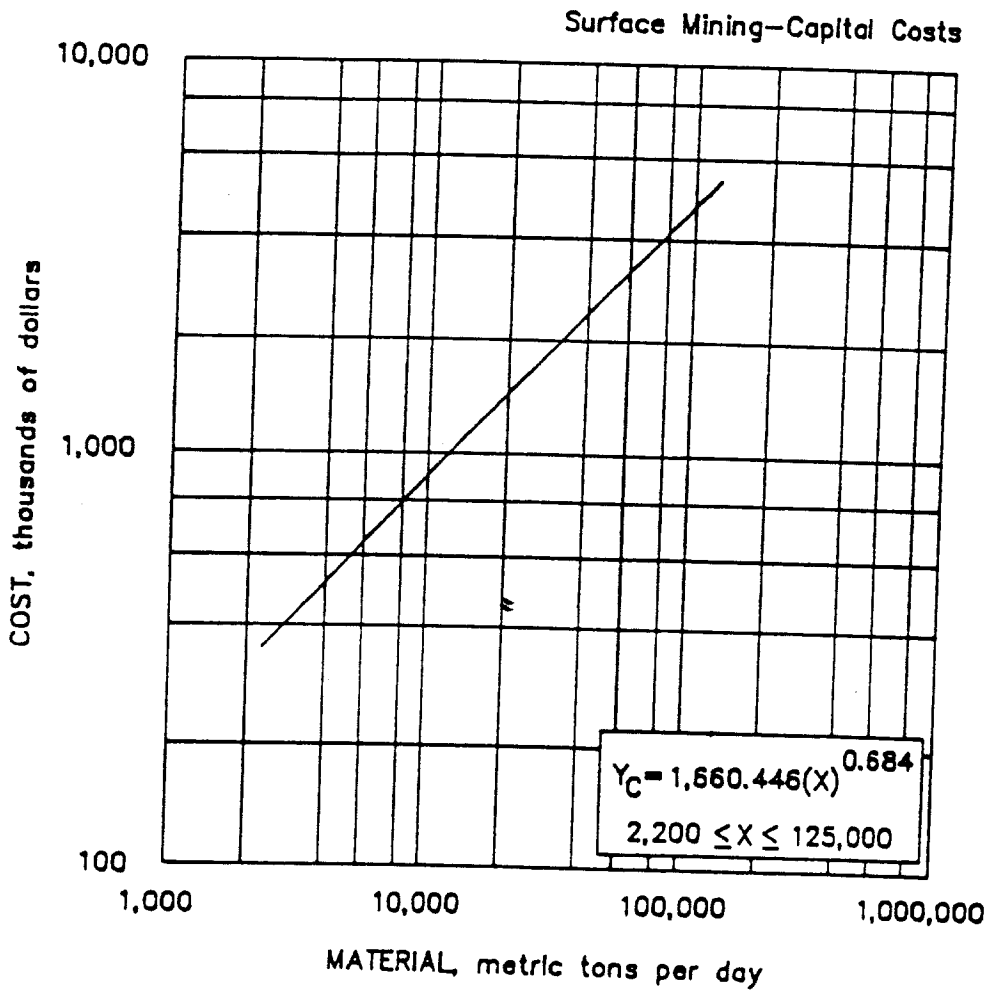
Operating time factor $(F_T) = [50/(T)]^{0.683}$
where T = new percent operating time.

Output Efficiency Factor The output efficiency is the ratio of the actual production to the theoretical capacity of the bucket wheel excavator. The theoretical capacity is based on the number of bucket discharges per minute and the bucket size. The theoretical capacity is normally expressed as loose cubic meters per hour. The factors that determine the output efficiency are the difficulty of digging (required cutting force), the percentage of clay or compact material in the bank, and site-specific details such as climatology. The range of output efficiencies is from 44% to 85%.

To adjust for different output efficiencies, multiply the cost obtained from the curve by the following factor:

$$\text{Output efficiency factor } (F_E) = [46/(E)]^{0.682}$$

where E = new percent output efficiency.



2.2.2.2. Excavation, load and haul
 BUCKET WHEEL EXCAVATORS

2.2. SURFACE MINING--CAPITAL COSTS

2.2.2. MINING EQUIPMENT

2.2.2.3. EXCAVATION, LOAD AND HAUL DRAGLINE

The following cost curve is for the purchase of surface mining equipment. Preproduction development work can be done using the equipment purchased for operating the mine; however, no reduction in the capital cost should be made if a subcontractor brings in his own equipment.

The cost is predicated upon the equipment being delivered and made fully operable at an appropriate site in the Denver, CO, area. It also includes provision for standby equipment and an allowance for miscellaneous items. Escalation for purchased equipment should be factored by the Bureau of Labor Statistics equipment cost index.

The types of equipment covered in the cost curve are all classes of mobile and stationary machinery regularly found in surface mining, including compressors, drills, powder trucks, hydrocranes, wheel loaders, shovels, draglines, crawler dozers and rippers, on-highway and off-highway trucks, and administrative and maintenance equipment not previously included in other sections. The cost for other fixed supporting items, such as power transmission lines and some mobile support items such as fuel trucks, have been included with other capital cost items.

The total capital cost is based on a single cost curve having an production rate (X), in metric tons of material per day. The curve for crawler draglines is valid for a production range of 2,000 to 15,000 mtpd, operating one shift per day; for walking draglines, the curves are valid for a production range of 15,000 to 150,000 mtpd, operating three shifts per day.

BASE CURVE

The curve includes all costs associated with the purchase and installation of all surface mine equipment. The cost for fixed supporting items such as electric power transmission lines has been covered where specifically noted in other items.

The capital cost derived from the dragline curves is a combination of the following costs:

Construction labor cost.....	20%
Construction supply cost.....	1%
Purchased equipment cost.....	77%
Transportation cost.....	2%

A typical breakdown of the major cost components is

	Small (2,000 to 10,000 mtpd)	Large (10,000 to 15,000 mtpd)
<u>Crawler dragline:</u>		
Draglines.....	64%	79%
Auxiliary equipment.....	36%	21%

Walking dragline:

Draglines.....	97% (includes 20% erection cost)
Auxiliary equipment..	3%

The total capital cost for a crawler dragline operation is
 $(Y_C \text{ CRAWLER}) = 1,069.304(X)^{0.803}$ and is distributed as follows:

- (L) Construction Labor Cost $(Y_L \text{ CRAWLER}) = 213.608(X)^{0.803}$
 (S) Construction Supply Cost $(Y_S \text{ CRAWLER}) = 10.693(X)^{0.803}$
 (E) Purchased Equipment Cost $(Y_E \text{ CRAWLER}) = 844.750(X)^{0.803}$

The total capital cost for a walking dragline operation is
 $(Y_C \text{ WALKING}) = 1,054.727(X)^{0.904}$ and is distributed as follows:

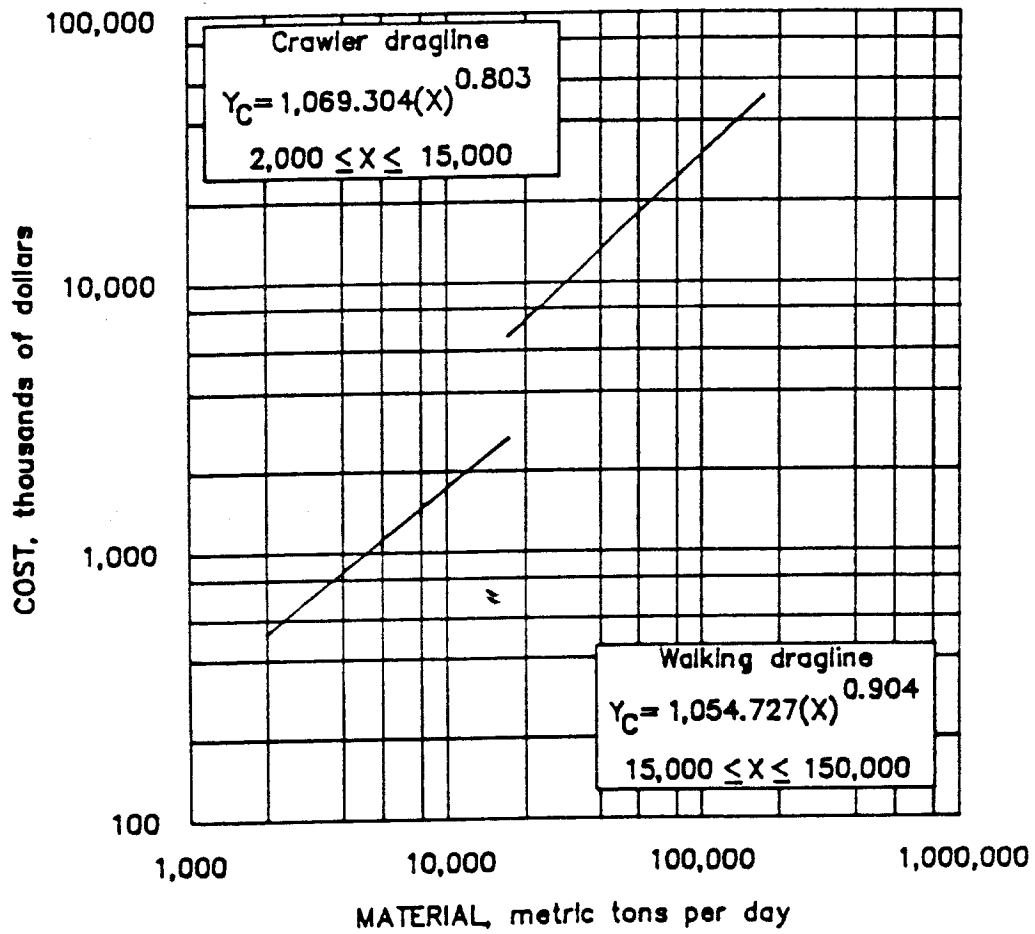
- (L) Construction Labor Cost $(Y_L \text{ WALKING}) = 210.945(X)^{0.904}$
 (S) Construction Supply Cost $(Y_S \text{ WALKING}) = 10.547(X)^{0.904}$
 (E) Purchased Equipment Cost $(Y_E \text{ WALKING}) = 841.567(X)^{0.904}$

ADJUSTMENT FACTOR

Haulage Where trucks are used in combination with crawler draglines, use loader and truck, or shovel and truck, curves and multiply by the appropriate hauling equipment component to obtain the truck haulage capital equipment cost, and add this cost obtained to the crawler dragline curve.

To determine the cost where further handling of material is required from a walking dragline operation, add the cost derived from the electric shovel and truck curve multiplied by a factor of 0.89 (drill and blast equipment, 11% of the total, would not be required).

Surface Mining—Capital Costs



2.2.2.3. Excavation, load and haul
 DRAGLINE

2.2. SURFACE MINING--CAPITAL COSTS

2.2.2. MINING EQUIPMENT

2.2.2.4. EXCAVATION, LOAD AND HAUL
DREDGE

Bucket line dredges are generally designed and configured for a specific mining application. For this reason, a generalized cost model cannot be accurately applied in capital cost estimating. However, for the manual user's guidance, the cost curve below provides a generalized estimate of capital costs, which should be used with caution.

BASE CURVE

The total capital cost is based on a single cost curve having an production rate (X), in bank cubic meters of material per day. The curve is valid for operations between 500 and 20,000 m³/d, operating three shifts per day. The curve is valid for single dredges in the dredging depth range of 10 to 50 m below the water pond level. The cost derived from the curve excludes ore beneficiation.

The capital cost derived from the curve is a combination of the following costs:

Construction labor cost.....	25%
Construction supply cost.....	25%
Purchased equipment cost.....	49%
Transportation cost.....	1%

The total capital cost is $(Y_C) = 34,972.765(X)^{0.627}$ and is distributed as follows:

- (L) Construction Labor Cost $(Y_L) = 8,743.191(X)^{0.627}$
 (S) Construction Supply Cost $(Y_S) = 8,743.191(X)^{0.627}$
 (E) Purchased Equipment Cost $(Y_E) = 17,486.382(X)^{0.627}$

ADJUSTMENT FACTORS

Depth Factor To adjust the capital cost for actual dredging depths and swell factors, multiply the cost obtained from the curve by the following factor:

Depth factor $(F_D) = 0.10 + [6.86(D)(S)^{-1.0}(X)^{-0.615}]$
 where D = actual depth, in meters,
 S = actual swell factor (the reciprocal of one plus the decimal equivalent of percent swell). The base swell factor is 0.80,
 and X = volume to be dredged, in bank cubic meters per day.

Mineral Processing Factor To include the capital cost of a mineral processing plant (i.e., jigging or other gravity separation method) mounted on the dredge, multiply the cost obtained from the curve by one of the following factors:

Minimal mineral processing:

Mineral processing factor $(F_M \text{ MINIMAL}) = 1.25$

Some mineral processing:

Mineral processing factor $(F_M \text{ SOME}) = 1.37$

Complex mineral processing:

Mineral processing factor $(F_M \text{ COMPLEX}) = 1.50$

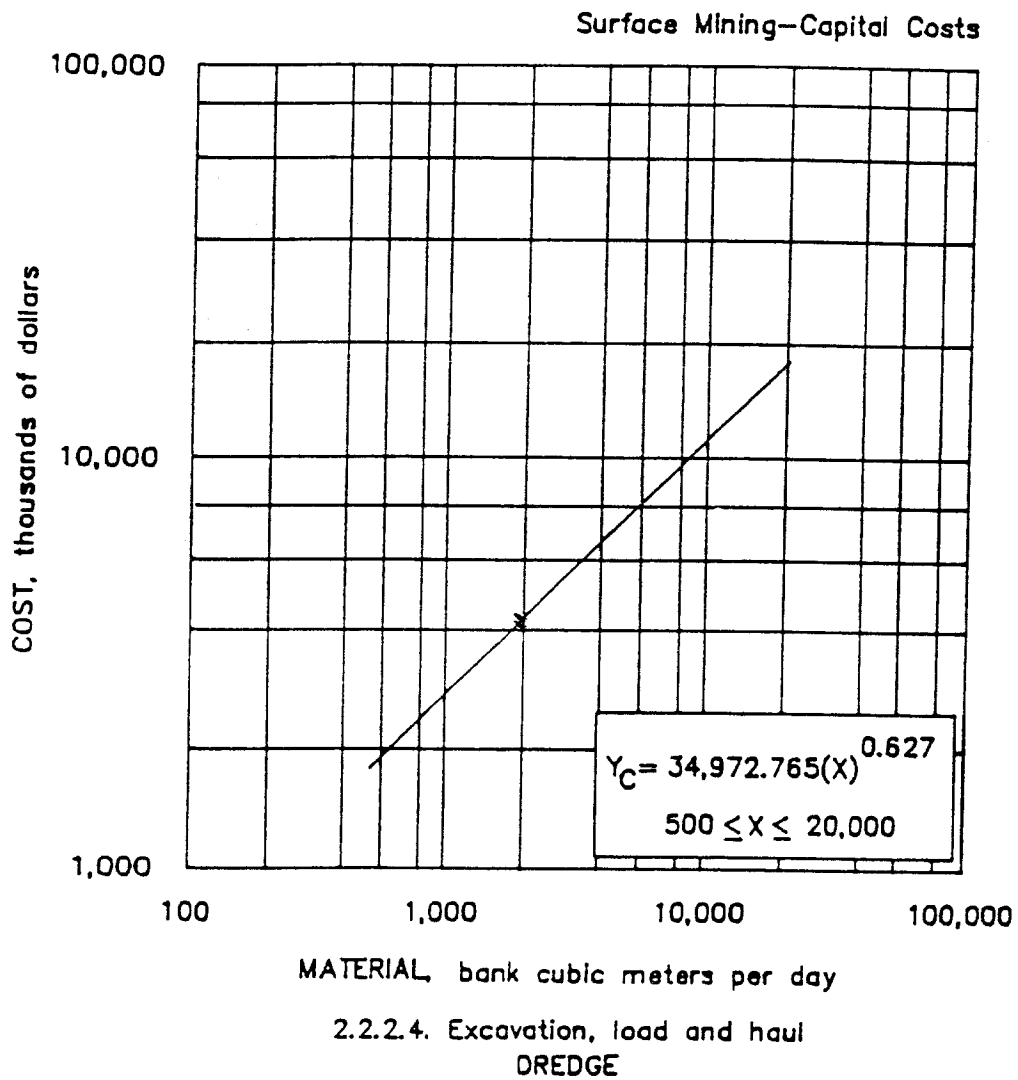
Multiple Dredges If the surface mine operation requires more than one dredge, estimate the capital cost separately for each dredge and apply the applicable factors to each cost.

Refurbishing Factor Dredges built between the late 1930's and the late 1960's can sometimes be refurbished at costs varying respectively from two-thirds to one-third of the costs derived from the curve. Multiply the cost obtained from the curve by its respective factor:

Refurbishing factor $(F_R \text{ 1935-51}) = 0.67$

Refurbishing factor $(F_R \text{ 1952-69}) = 0.33$

Refurbishing factor $(F_R \text{ 1970-84}) = 1.00$



2.2. SURFACE MINING--CAPITAL COSTS

2.2.2. MINING EQUIPMENT

2.2.2.5. EXCAVATION, LOAD AND HAUL
ELECTRIC SHOVEL AND TRUCKS

The following cost curve is for the purchase of surface mining equipment. Preproduction development work can be done using the equipment purchased for operating the mine; however, no reduction in the capital cost should be made if a subcontractor brings in his own equipment.

The total capital cost is based on a single cost curve having an production rate (X), in metric tons of material per day. The curve is valid for a production range of 8,000 to 400,000 mtpd, operating three shifts per day.

BASE CURVE

The cost is predicated upon the equipment being delivered and made fully operable at an appropriate site in the Denver, CO, area. It also includes provision for standby equipment and an allowance for miscellaneous items.

The capital cost derived from the curve is a combination of the following costs:

Construction labor cost.....	4%
Construction supply cost.....	6%
Purchased equipment cost.....	88%
Transportation cost.....	2%

A typical breakdown of the major cost components is

Loading equipment.....	30%
Hauling equipment.....	59%
Drill and blast equipment.....	11%

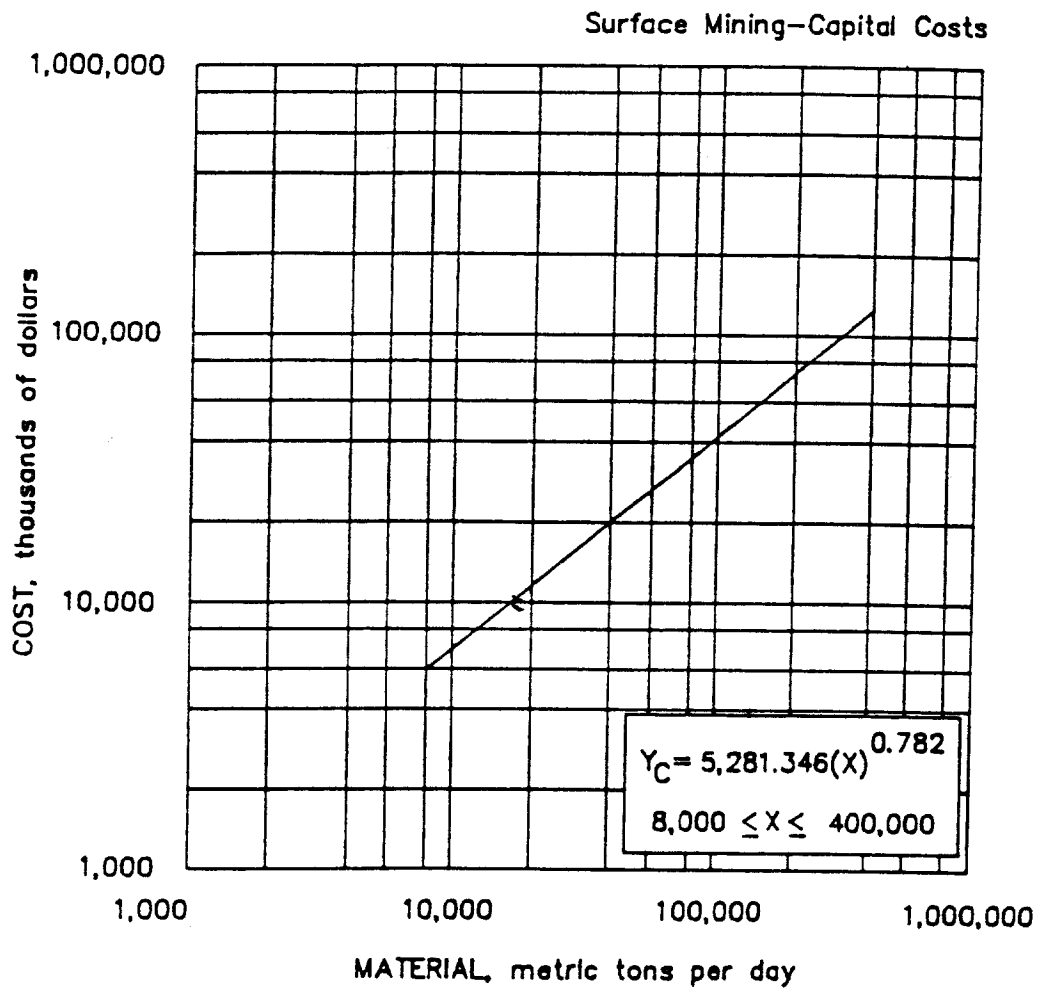
The total equipment capital cost for electric shovel and truck operation is $(Y_C) = 5,281.346(X)^{0.782}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u>	$(Y_L) = 211.254(X)^{0.782}$
(S) <u>Construction Supply Cost</u>	$(Y_S) = 316.881(X)^{0.782}$
(E) <u>Purchased Equipment Cost</u>	$(Y_E) = 4,753.211(X)^{0.782}$

ADJUSTMENT FACTOR

Haulage Factor To determine costs for hauls of varying length or depth of pit, multiply the cost obtained from the base curve by the following factor:

Haulage factor $(F_H) = 0.0546(R)^{0.047}(L)^{0.353}$
 where R = depth of pit, in meters (R = 1.0 for negative or 0% grade from loading point),
 and L = length of haul, in meters



2.2.2.5. Excavation, load and haul
ELECTRIC SHOVEL AND TRUCKS

2.2. SURFACE MINING--CAPITAL COSTS

2.2.2. MINING EQUIPMENT

2.2.2.6. EXCAVATION, LOAD AND HAUL
FRONT-END LOADER OR DIESEL SHOVEL AND TRUCKS

The following cost curves are for the purchase of surface mining equipment and are based on mines operating three shifts per day. Preproduction development work can be done using the equipment purchased for operating the mine; however, no reduction in the capital cost should be made if a subcontractor brings in his own equipment.

The total capital cost is based on a single cost curve having an production rate (X), in metric tons of material per day. The curve is valid for a production range of 1,000 to 10,000 mtpd, operating three shifts per day.

BASE CURVE

The cost is predicated upon the equipment being delivered and made fully operable at an appropriate site in the Denver, CO, area. It also includes provision for standby equipment and an allowance for miscellaneous items.

The capital cost derived from the curve is a combination of the following costs:

Construction labor cost.....	4%
Construction supply cost.....	6%
Purchased equipment cost.....	88%
Transportation cost.....	2%

A typical breakdown of the major cost components is

	Small (1,000 to 3,000 mtpd)	Large (3,000 to 10,000 mtpd)
Loading equipment.....	41%	22%
Hauling equipment.....	40%	51%
Drill and blast equipment	19%	27%

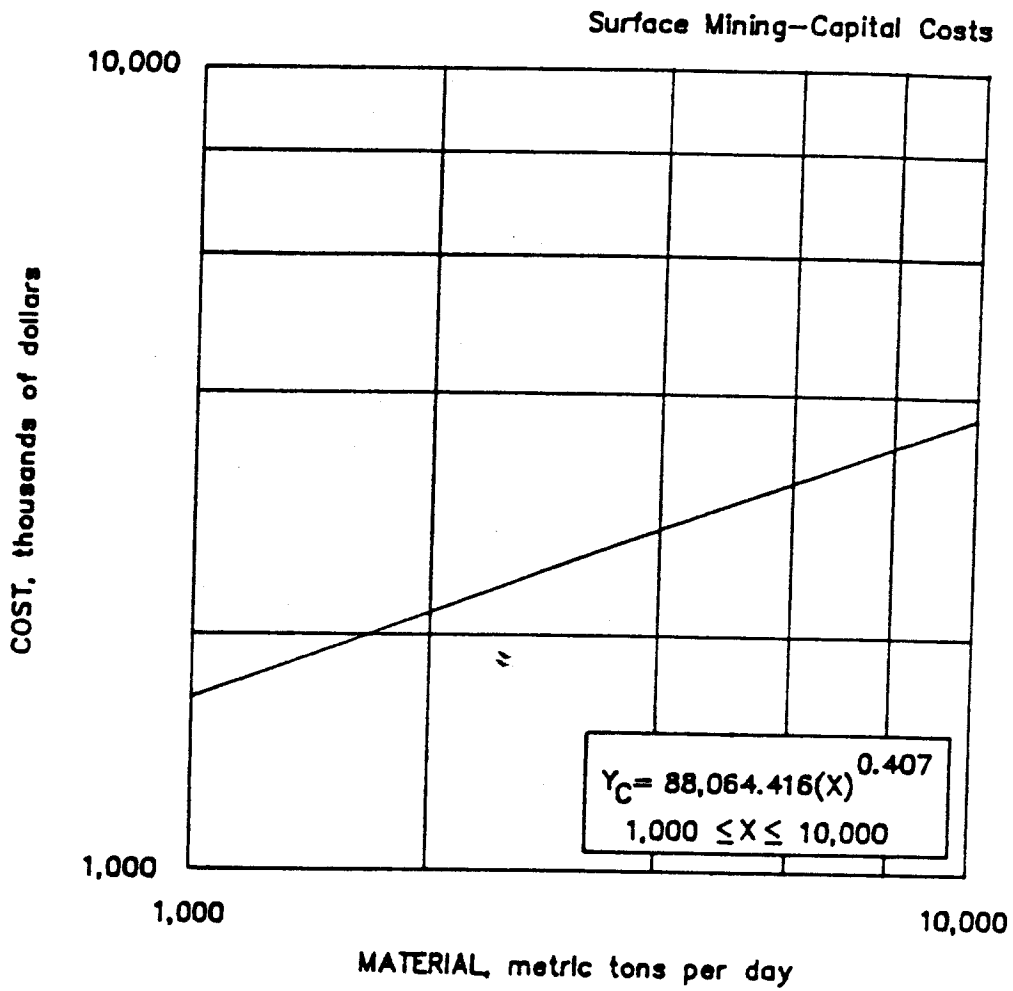
The total equipment capital cost for front-end loader or diesel shovel and truck operation is $(Y_C) = 88,064.416(X)^{0.407}$ and is distributed as follows:

- (L) Construction Labor Cost $(Y_L) = 3,522.577(X)^{0.407}$
- (S) Construction Supply Cost $(Y_S) = 5,283.865(X)^{0.407}$
- (E) Purchased Equipment Cost $(Y_E) = 79,257.974(X)^{0.407}$

ADJUSTMENT FACTOR

Haulage Factor To determine costs for hauls of varying length or depth of pit, multiply the cost obtained from the base curve by the following factor:

Haulage factor $(F_H) = 0.080(R)^{0.047}(L)^{0.353}$
where R = depth of pit, in meters (R = 1.0 for negative or 0% grade from
loading point),
and L = length of haul, in meters.



2.2.2.6. Excavation, load and haul
 FRONT-END LOADER OR DIESEL SHOVEL AND TRUCKS

2.2. SURFACE MINING--CAPITAL COSTS

2.2.2. MINING EQUIPMENT

2.2.2.7. EXCAVATION, LOAD AND HAUL
HYDRAULIC MINING

The capital cost for hydraulic mining is for the acquisition and installation of equipment needed to excavate or fluidize an ore. The hydraulic mining unit operation includes the monitor, hydraulic controls and pumps for the monitors, control cab, and high-pressure water pumps.

The total capital cost is based on a single cost curve having an production rate (X), in metric tons of ore slurried per day. The curve is valid for a production range of 9,500 to 58,000 mtpd, operating three shifts per day.

BASE CURVE

The base curve is for the hydraulic mining of phosphate matrix. The matrix is excavated by draglines and deposited in "pits" where hydraulic mining occurs. The hydraulic monitors (also called guns, giants, or water cannons) break down the matrix for pumping to the processing plant. The monitors are mounted on a pit gun car which advances with the draglines. The base case assumes an 85% operating time and a water ratio of 0.67 mt of slurried ore per metric ton of water.

The total cost includes the cost associated with the acquisition and installation of the monitors, hydraulic control units for the monitors, gun car, high-pressure water pumps, and piping around the gun car. Not included in the cost is the mine water system.

The capital cost derived from the curve is a combination of the following costs:

Construction labor cost.....	9%
Construction supply cost.....	15%
Purchased equipment cost.....	75%
Transportation cost.....	1%

A typical breakdown of the major cost components is

Water pumps.....	71%
Monitors and control units....	29%

The total capital cost is $(Y_C) = 232.640(X)^{0.702}$ and is distributed as follows:

- (L) Construction Labor Cost $(Y_L) = 20.938(X)^{0.702}$
 (S) Construction Supply Cost $(Y_S) = 34.896(X)^{0.702}$
 (E) Purchased Equipment Cost $(Y_E) = 176.806(X)^{0.702}$

ADJUSTMENT FACTORS

Water Ratio Factor Each deposit to be hydraulically mined will require different

quantities of water and therefore different sizes or numbers of monitors. The more competent the deposit, the more water that will be used. The measure of difficulty in slurring the deposit is the mass ratio of ore excavated to water used. To adjust for different water requirements, multiply the cost obtained from the base curve by the following factor:

$$\text{Water ratio factor } (F_R) = [0.670/(R)]^{0.548}$$

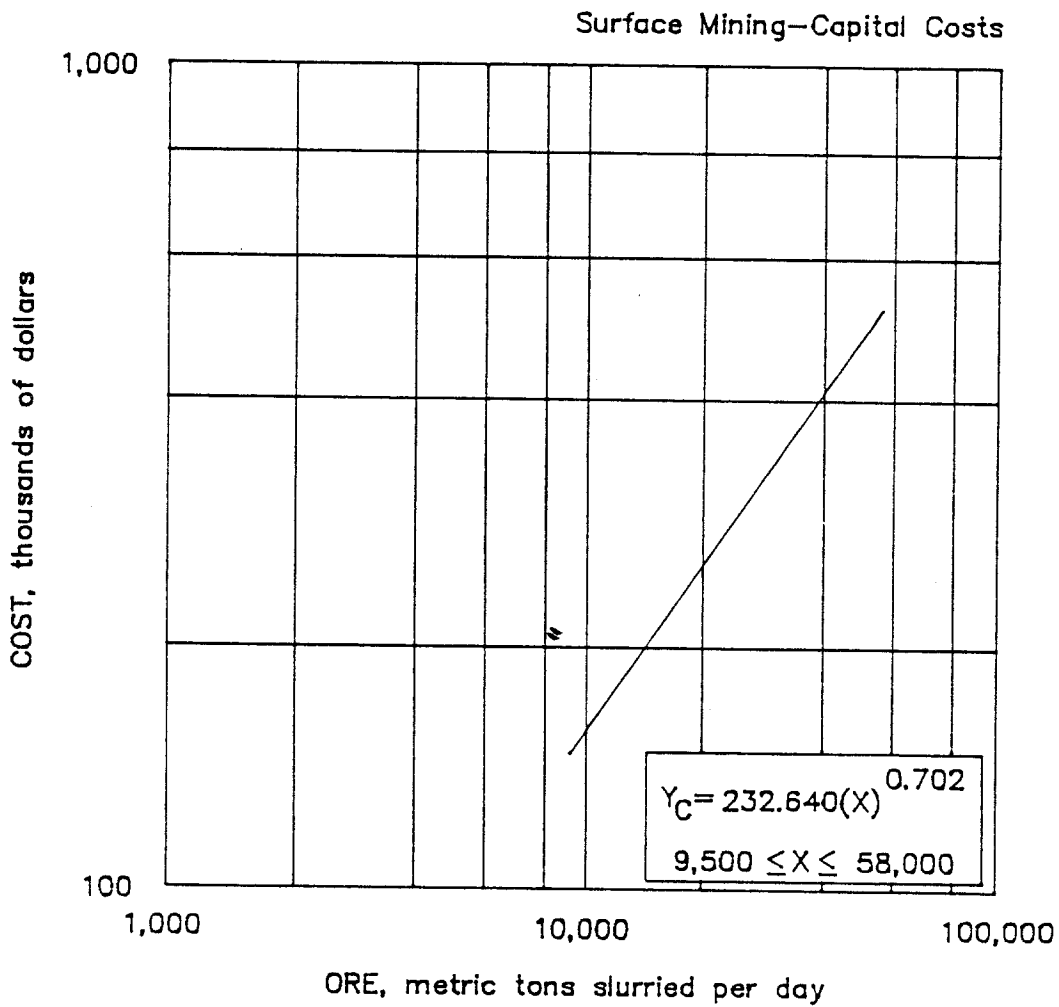
where R = new water ratio (mt ore slurried)/(mt water used).

For phosphate, the water ratio can vary from 0.3 to 0.7. For other applications it can vary from 0.2 to 1.5.

Tailings Factor Hydraulic mining can be used to excavate tailings ponds for the re-processing of the tailings. This application normally requires higher water pressure and larger monitors. To adjust for hydraulic mining of tailings, multiply the cost obtained from the base curve by the following factor:

$$\text{Tailings factor } (F_T) = 1.07$$

The tailings adjustment is based on a water ratio of 1.22 mt of tailings slurried per metric ton of water applied.



2.2.2.7. Excavation, load and haul
HYDRAULIC MINING

2.2. SURFACE MINING--CAPITAL COSTS

2.2.2. MINING EQUIPMENT

2.2.2.8. EXCAVATION, LOAD AND HAUL
SCRAPERS

The following cost curve is for the purchase of surface mining equipment and is based on mines operating three shifts per day. Preproduction development work can be done using the equipment purchased for operating the mine; however, no reduction in the capital cost should be made if a subcontractor brings in his own equipment.

The total capital cost is based on a single cost curve having an production rate (X), in metric tons of material per day. The curve is valid for a production range of 2,000 to 250,000 mtpd, operating three shifts per day.

BASE CURVE

The cost is predicated upon the equipment being delivered and made fully operable at an appropriate site in the Denver, CO, area. It also includes provision for standby equipment and an allowance for miscellaneous items.

The capital cost derived from the curve is a combination of the following costs:

Construction labor cost.....	4%
Construction supply cost.....	6%
Purchased equipment cost.....	88%
Transportation cost.....	2%

A typical breakdown of the major cost components is:

Scrapers.....	66%
Pit equipment (crawler dozers).	26%
Road equipment (graders, water trucks, pickup trucks).....	8%

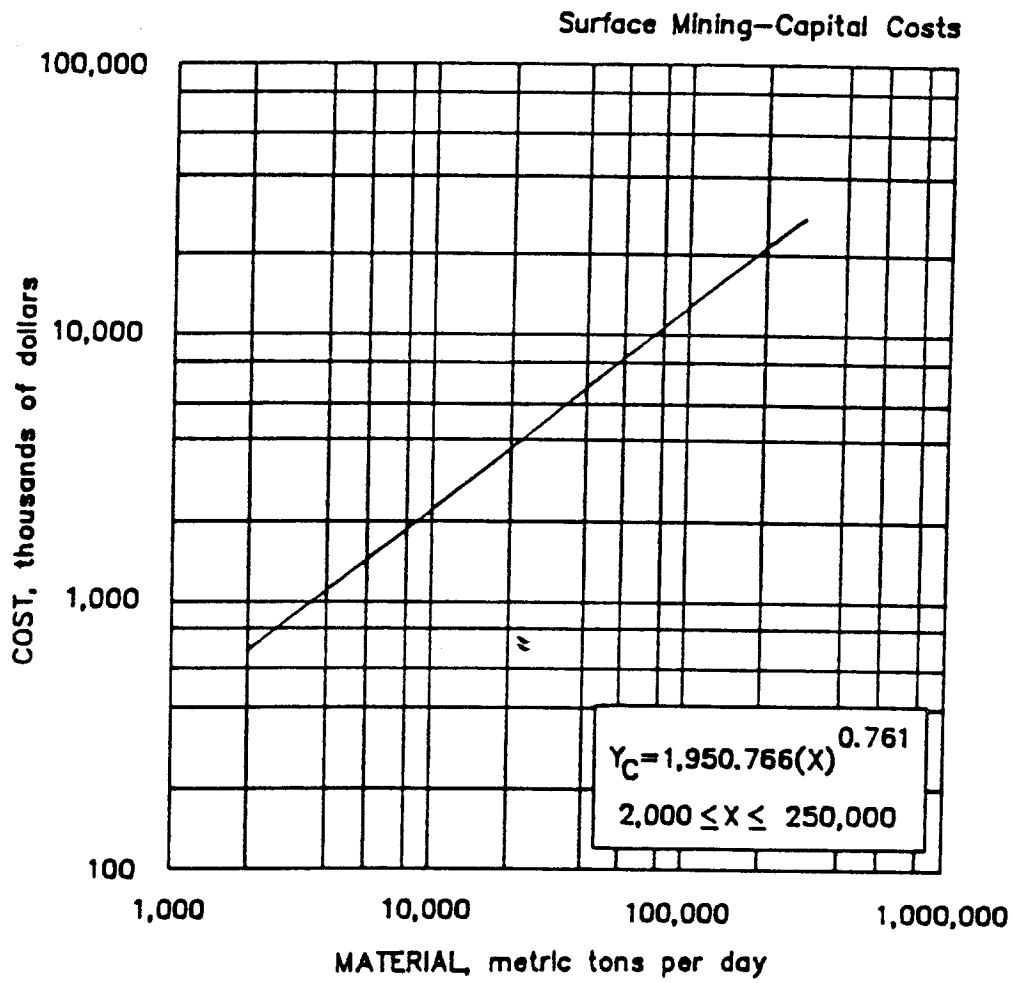
The total equipment capital cost for scraper operation is $(Y_C) = 1,950.766(X)^{0.761}$ and is distributed as follows:

(L) <u>Construction Labor Cost</u>	$(Y_L) = 78.031(X)^{0.761}$
(S) <u>Construction Supply Cost</u>	$(Y_S) = 117.046(X)^{0.761}$
(E) <u>Purchased Equipment Cost</u>	$(Y_E) = 1,755.689(X)^{0.761}$

ADJUSTMENT FACTOR

Haulage Factor To determine costs for hauls of varying length or depth of pit, multiply the cost obtained from the base curve by the following factor:

Haulage factor $(F_H) = 0.064(L)^{0.403}(G)^{1.620}$
 where L = length of haul, in meters,
 and G = grade (defined as 1.0 plus or minus percent grade/100).



**2.2.2.8. Excavation, load and haul
SCRAPERS**