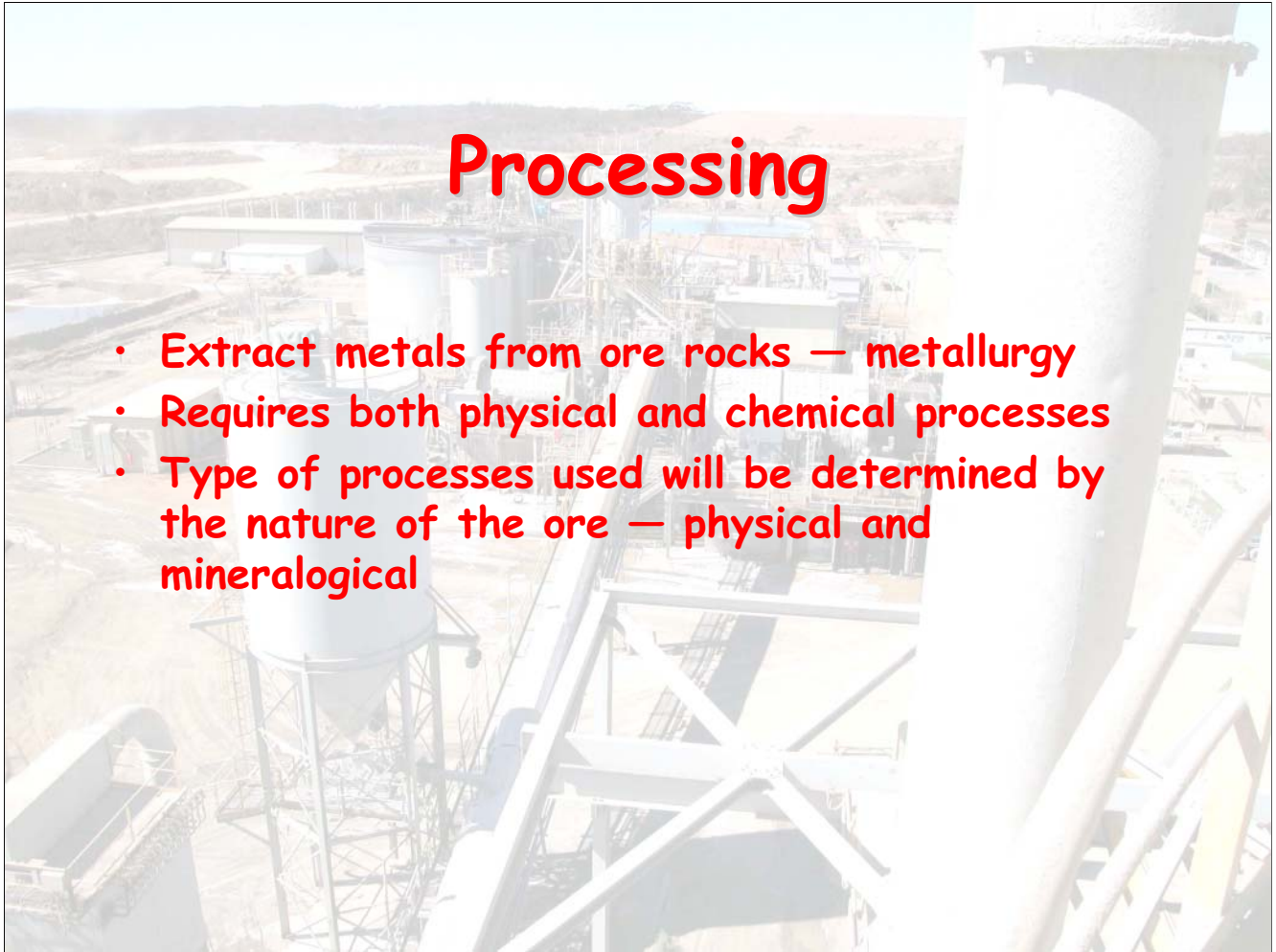






This section presents an overview of the processing techniques used in some operations to extract gold from ore-bearing rocks.

The processing of ore at Coolgardie Mining Company's Three Mile Hill Plant, near Coolgardie, Western Australia, is featured.



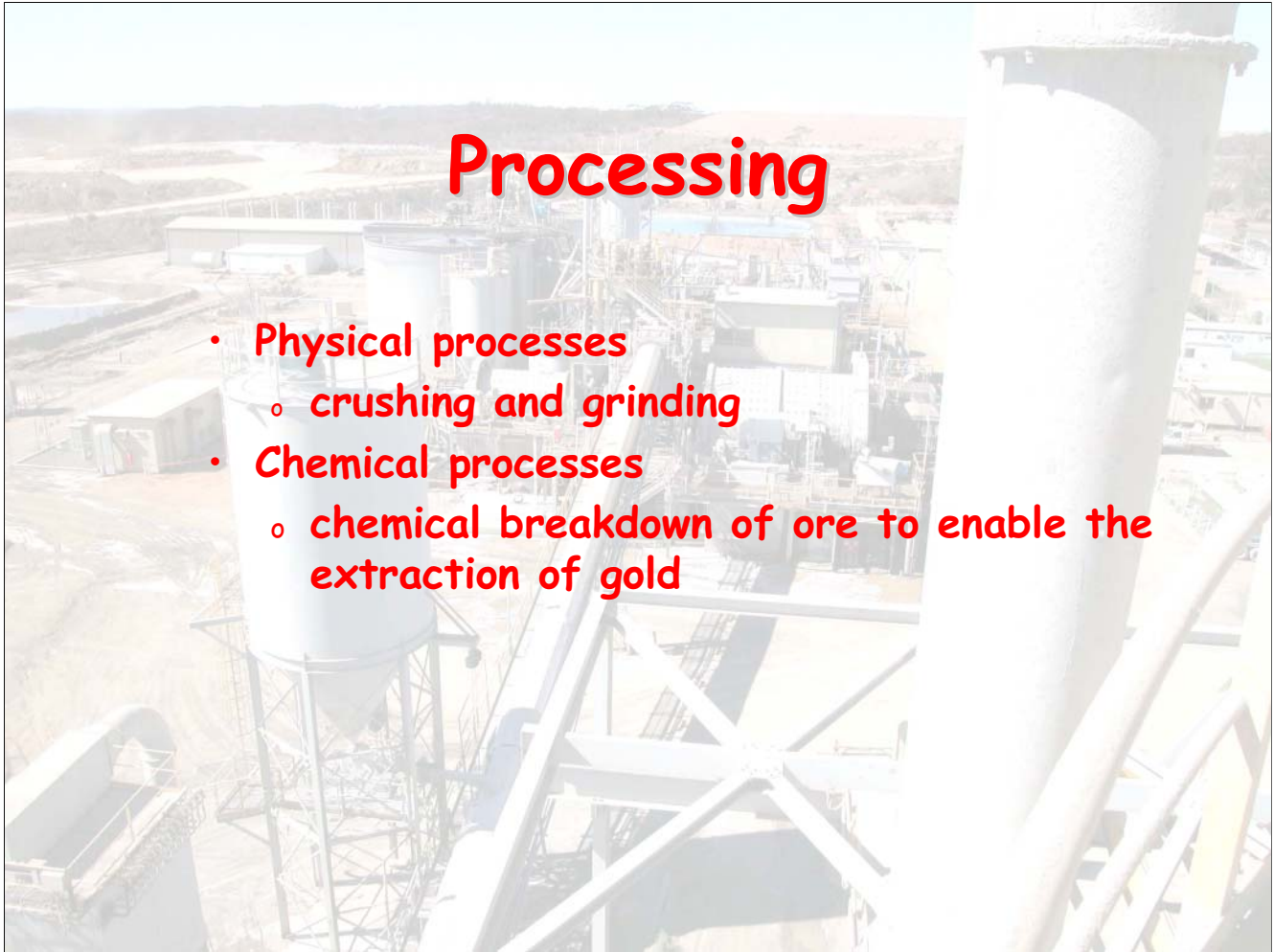
- **Extract metals from ore rocks — metallurgy**
- **Requires both physical and chemical processes**
- **Type of processes used will be determined by the nature of the ore — physical and mineralogical**

The processing of ore rocks to extract metals from them is known as metallurgy.

Processing involves both physical and chemical processes.

The type of processes that are to be used to extract the gold from the ore rocks will be determined by

- the physical nature of the ore rocks;
- the mineralogy (mineral composition) of the ore rocks.



# Processing

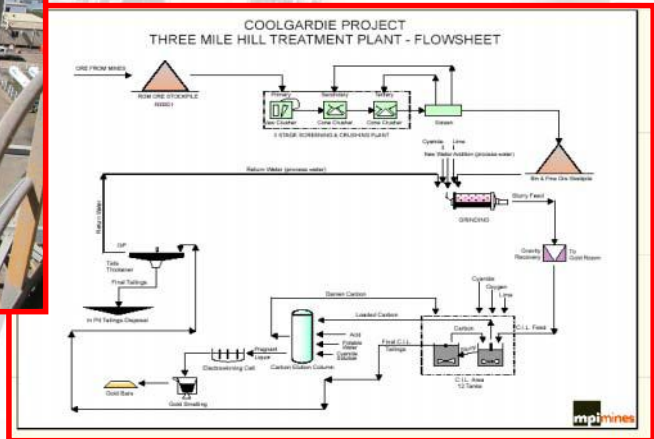
- **Physical processes**
  - **crushing and grinding**
- **Chemical processes**
  - **chemical breakdown of ore to enable the extraction of gold**

The processing of ore rocks includes physical and chemical processes.

Physical processes reduce the size of the ore rocks, and include steps such as crushing and grinding.

Chemical processes are those that separate the metal from the other components within the ore rocks.

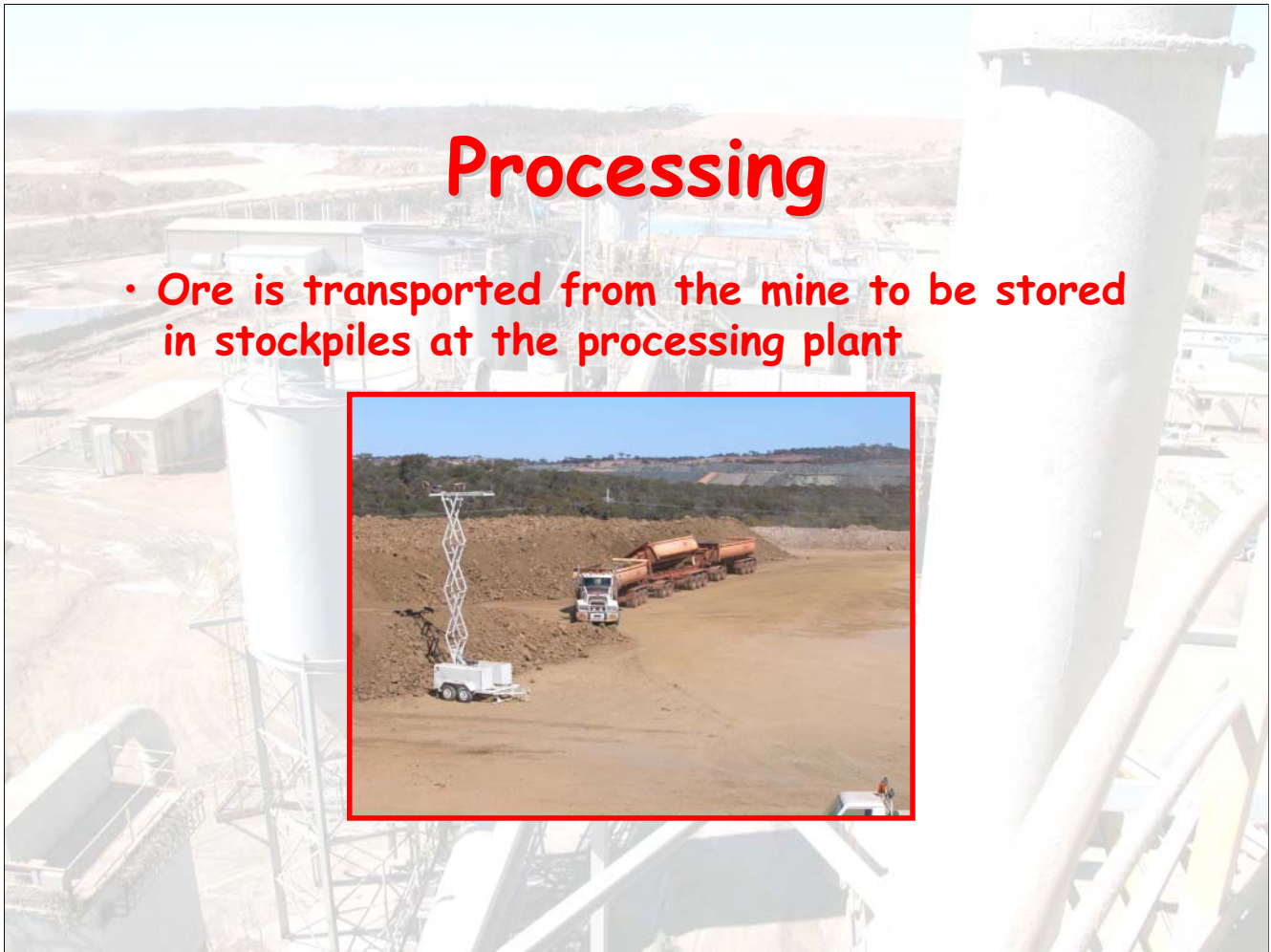
# Processing



[http://www.mpimines.com.au/investorinfo/prospectus/prospectus\\_section3.pdf](http://www.mpimines.com.au/investorinfo/prospectus/prospectus_section3.pdf)

This flowsheet illustrates all the stages involved in the treatment of ore at Coolgardie Mining Company’s Three Mile Hill Plant.

The ore is passed through a three-stage crushing circuit and then through the grinding mill to reduce the size of the ore (physical processing). The gold is recovered from the ore by leaching, elution, and then via the electrowinning cell (chemical processing).



## Processing

- Ore is transported from the mine to be stored in stockpiles at the processing plant

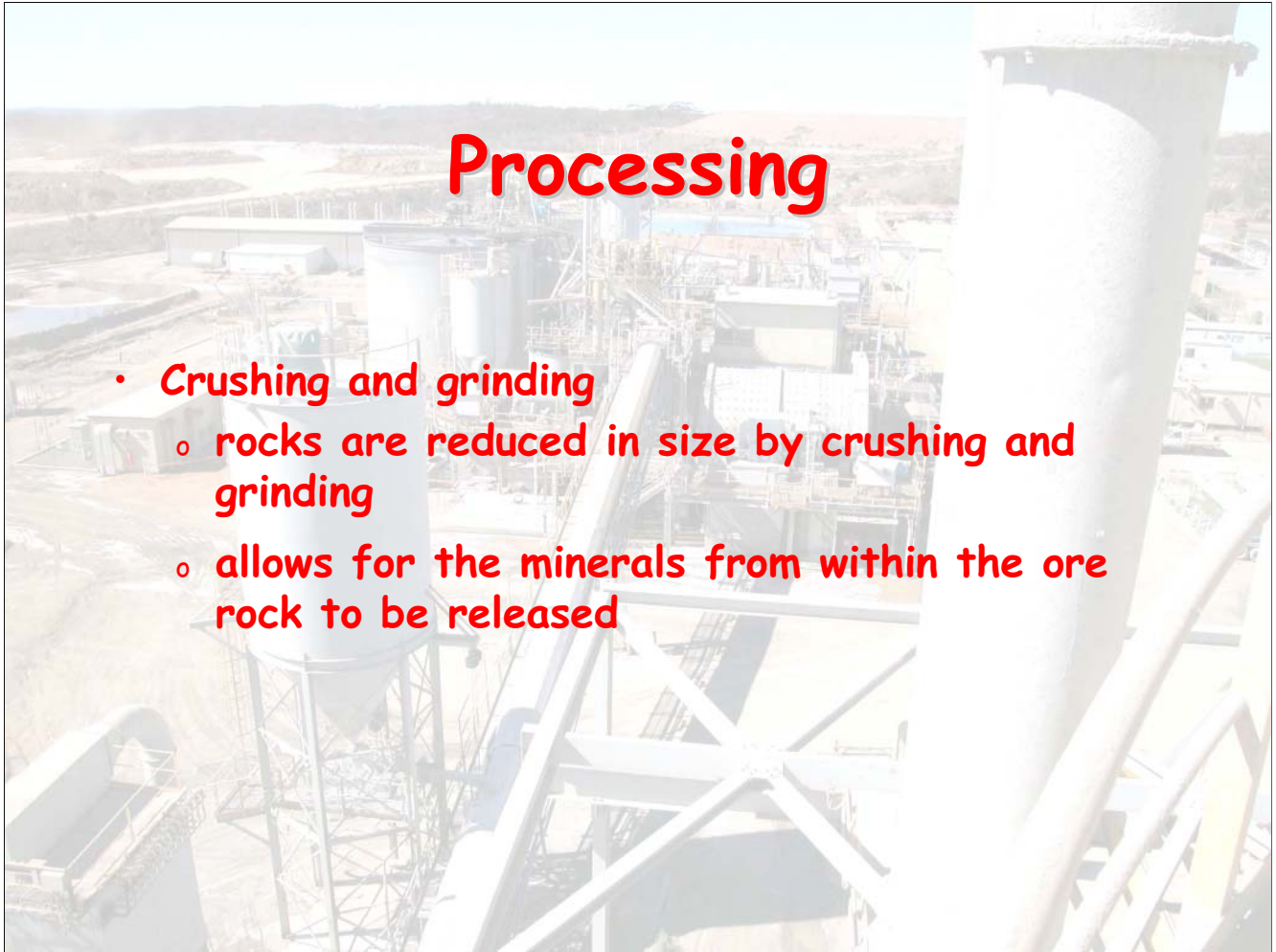
Ore is transported from the mine and stored in stockpiles near the processing plant.

From the stockpile the ore is transported to the first stage of processing — the crusher.

In some mines ore is stockpiled in separate piles that represent ore of different grades.

To obtain the optimum grade for which gold recovery is best for each particular plant, it may be necessary to mix high-grade ore with low-grade ore.

The grade of the ore may affect the amount of chemical agents required to obtain the best recovery, therefore if the grade is relatively constant there should be little variation required in the treatment process and the chemical conditions required. This would allow metallurgists and plant operators to concentrate on optimizing those conditions to recover the gold from the ore.



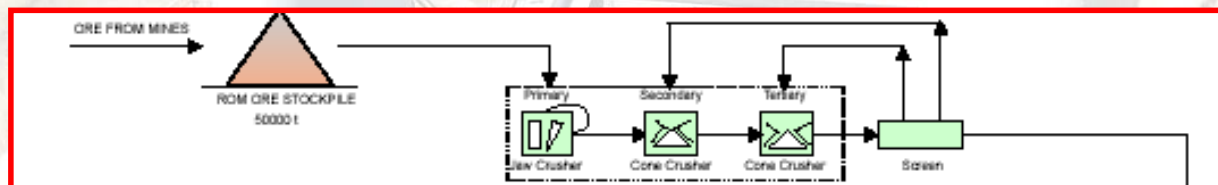
## Processing

- **Crushing and grinding**
  - rocks are reduced in size by crushing and grinding
  - allows for the minerals from within the ore rock to be released

The purpose of crushing and grinding the ore rocks is to reduce the size and to allow the valuable minerals to be separated from those that are of no value. Small-sized particles of ore provide a greater surface area on which the chemical processes can act to extract gold.

# Processing

- **Crushing and grinding**
  - **3-stage crushing process — primary, secondary and tertiary crushers (jaw and cone crushers)**
  - **end product must be very fine**
  - **oversized ore rocks are screened out**



[http://www.mpimines.com.au/investorinfo/prospectus/prospectus\\_section3.pdf](http://www.mpimines.com.au/investorinfo/prospectus/prospectus_section3.pdf)

At the Three Mile Hill Plant CMC use a 3-stage crushing process:

This involves a primary crusher — in this case a jaw crusher

A secondary crusher — cone crusher

And a tertiary crusher — cone crusher

The end product must be very fine to allow the greatest surface area of the rock to be covered by the solution that will assist in the recovery of gold. Any oversized rocks are screened out and will not pass on to the next stage of treatment of the ore. They pass back either to the secondary or tertiary crusher to be put through the crushing process again.

# Processing

## Jaw crusher

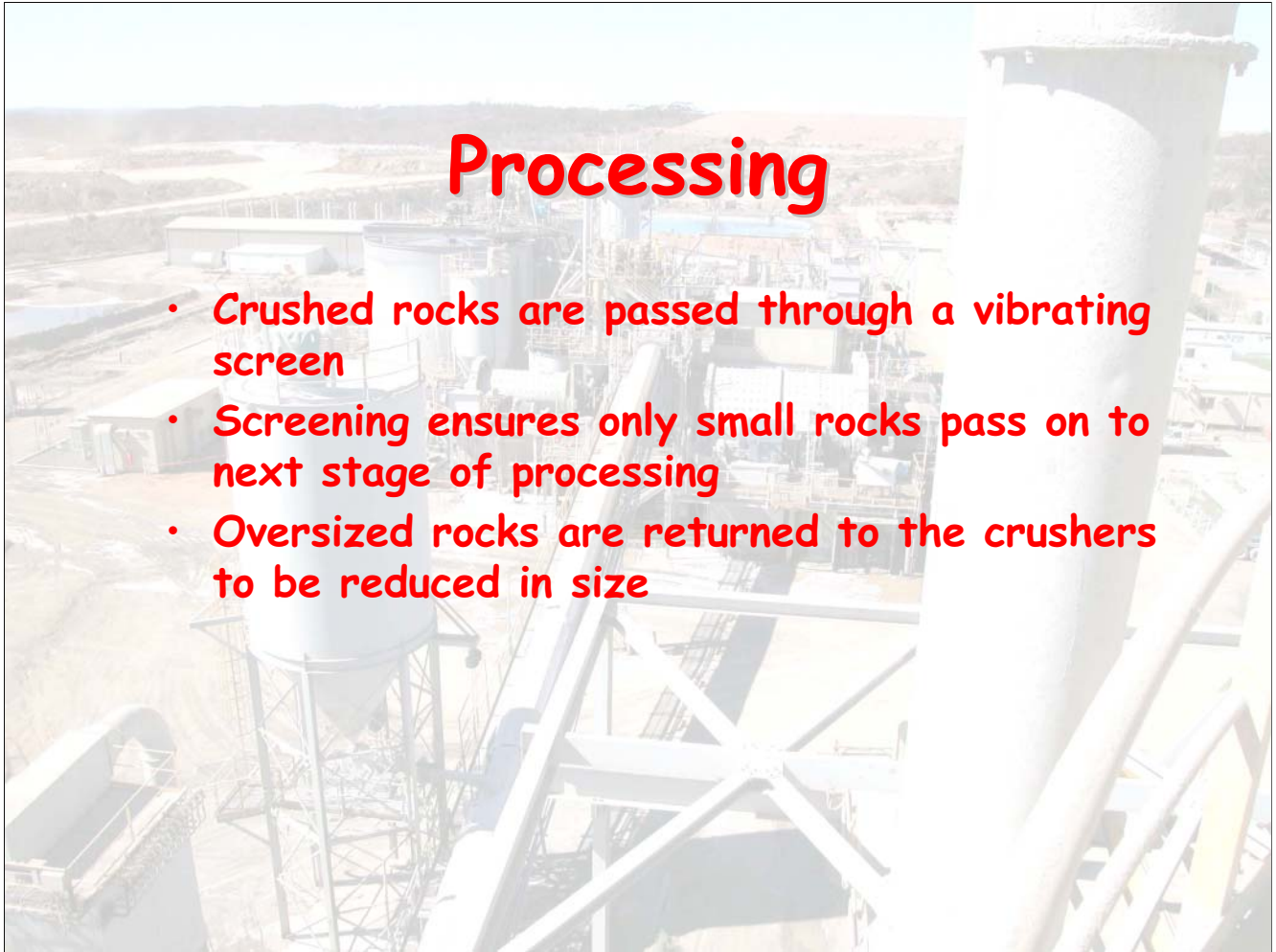
- rocks are crushed between a fixed jaw and a moving jaw within the jaw crusher
- rocks are crushed to a size generally less than 20 cm

## Cone crusher

- rocks are crushed between a large solid steel cone shape that moves back and forth and around within a steel casing
- rocks generally crushed to around 2 cm

A jaw crusher operates with one fixed jaw and one moveable jaw. The rocks fall within the two jaws and are crushed as the moveable jaw is pressed towards the fixed jaw of the crusher. Rocks are generally crushed to a size less than 20 cm.

A cone crusher has a central solid steel cone shape within a steel casing. The solid cone shape moves back and forth and around within the steel casing. In the cone crusher rocks are crushed to around 2 cm.



As the rocks pass from one crusher to the next, they pass through a screening process that allows smaller rocks to pass on to the next stage of crushing. Oversized rocks are returned to the crusher to be reduced in size.

# Processing

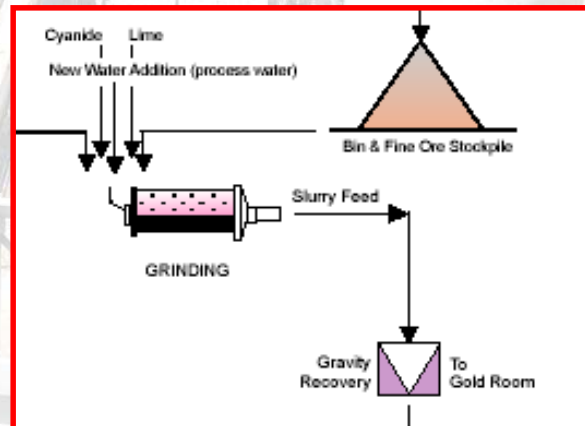


- Fine crushed ore is transported to the fine ore bin
- Conveyor belts transport the ore to the grinding mill

Once the ore has been crushed, it is transported to the grinding mill to be further reduced in size.

# Processing

- Fine ore rock enters the grinding mill
- Mixed with water to make the slurry feed



[http://www.mpimines.com.au/investorinfo/prospectus/prospectus\\_section3.pdf](http://www.mpimines.com.au/investorinfo/prospectus/prospectus_section3.pdf)

The grinding mill is where the ore is ground down until it is very fine.

Grinding of the ore occurs by tumbling the material within the grinding mill. The ore is ground between balls or rods within the mill as it rotates. Water is added to the feed material to make a slurry.

Grinding mills are named by the implements used within the mill to carry out the grinding. Ball mills are those using steel balls between which the ore is ground. Rod mills use long steel rods between which the ore is ground. Autogenous mills are those that do not contain rods or balls. SAG mills (semi-autogenous mills) have only a few balls or rods within the mill.

# Processing

- Slurry passes through cyclone to separate finer and heavier, coarser material
- Coarse material is returned to the mill to be ground to a smaller size
- Finer material is passed on to the next stage of the processing plant
- Screening of the fine material ensures only ground ore rock material is passed on to the next stage

The slurry passes through a cyclone where any heavy coarse material is separated from the finer material and returned to the grinding mill.

Screening of the fine material ensures that no debris is passed on to the next stage of the processing of the ore.

A gravity recovery process captures any free coarse gold that has been released from the ore rocks during the crushing and grinding processes. This works on the principle that the free coarse gold will be heavier than the other minerals within the rock. The movement of the material through the gravity recovery circuit will separate the heavier material from the lighter material. The heavier free gold is then sent to the gold room for smelting and to be poured into gold bars.

# Processing

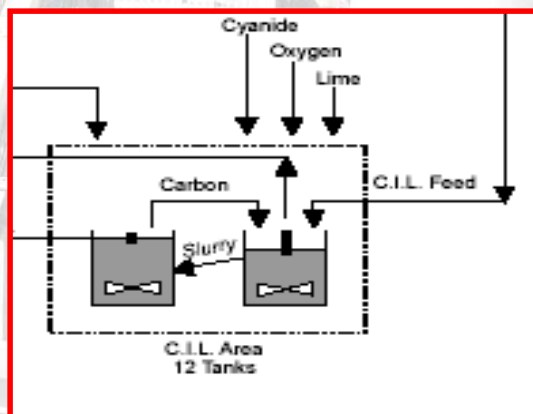
- Cyanide is added to dissolve gold within the slurry
- The pH must remain high to enable the dissolution of the gold
- Lime is added to raise the pH
- Cyanide is consumed, therefore little wastage into the environment as a gas

## Chemical processing

Cyanide is added to the slurry to dissolve gold particles from the crushed ore rocks. Lime is also added to maintain a high pH of the solution to ensure that the gold dissolves. Cyanide is consumed in the dissolution process and there is little wastage into the environment as a gas.

# Processing

- The remaining solution is passed through the Carbon in Leach plant
- Carbon granules are added to absorb the gold from the solution



[http://www.mpimines.com.au/investorinfo/prospectus/prospectus\\_section3.pdf](http://www.mpimines.com.au/investorinfo/prospectus/prospectus_section3.pdf)

The remaining solution is then passed through the Carbon in Leach (CIL) tanks.

Here the solution is oxygenated, with oxygen bubbled through the solutions in each of the tanks. Lime and cyanide are added to assist in the recovery process. The solution is constantly agitated whilst in the tanks to allow the added carbon granules to be exposed to as much of the solution as possible. The carbon granules are porous and provide maximum surface area for exposure to the gold-bearing solution.

The dissolved gold is attracted and adheres to the surface of the carbon granules.

## Processing



- **Carbon in Leach circuits comprise numerous tanks through which the solution is passed**
- **Oxygen is pumped into the tanks to ensure that the slurry is well mixed and that the carbon granules can become well-coated with gold from solution**

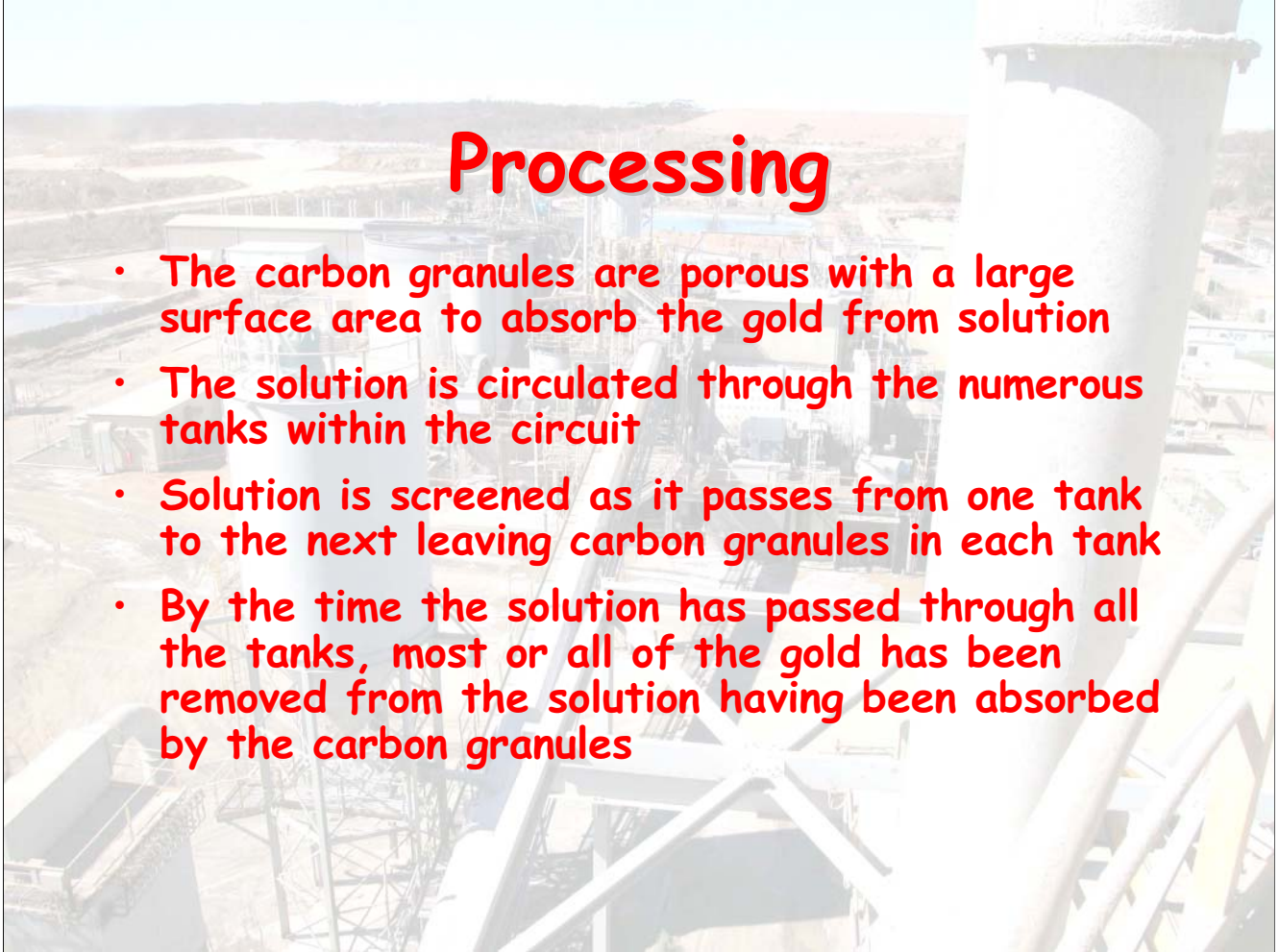
At the Three Mile Hill Plant there are 2 CIL circuits operating concurrently, that is 2 circuits of 6 tanks, with 12 tanks altogether.

There is flow of the solution through the series of 6 tanks within the circuit, so that by the time the solution has reached the sixth tank there is negligible gold remaining in solution — it has all been absorbed onto the carbon granules.

The carbon that is covered with gold from solution is known as loaded carbon and it is then passed through to the next stage of the treatment where the gold will be recovered from the carbon.

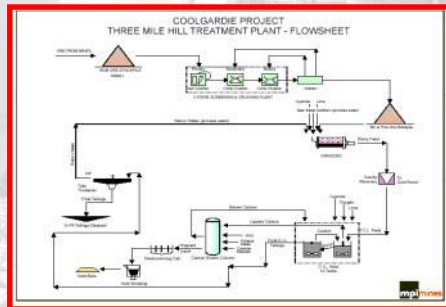
# Processing

- The carbon granules are porous with a large surface area to absorb the gold from solution
- The solution is circulated through the numerous tanks within the circuit
- Solution is screened as it passes from one tank to the next leaving carbon granules in each tank
- By the time the solution has passed through all the tanks, most or all of the gold has been removed from the solution having been absorbed by the carbon granules



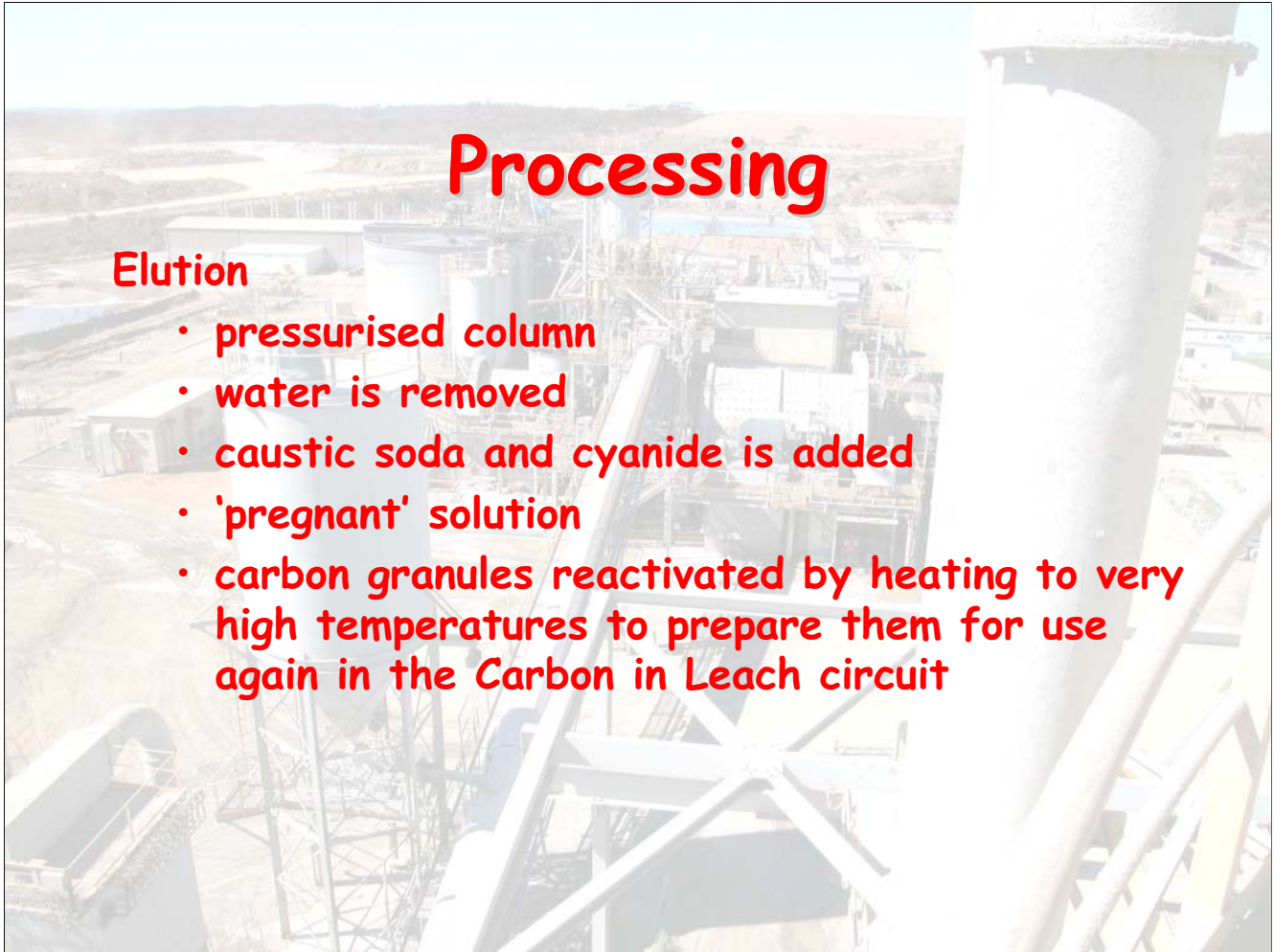
# Processing

- Carbon granules within the tanks become loaded with gold and are collected
- They are placed in the Carbon Elution Chamber to strip the gold from the surfaces of the carbon granules



[http://www.mpimines.com.au/investorinfo/prospectus/prospectus\\_section3.pdf](http://www.mpimines.com.au/investorinfo/prospectus/prospectus_section3.pdf)

The loaded carbon, which is carbon that has attracted the gold from the solution, is moved on to the Carbon Elution Chamber.



The gold is removed from the carbon in a pressurized column.

Water is removed.

Cyanide and acid are passed through the column. This removes the gold from the carbon and is concentrated in the resultant solution.

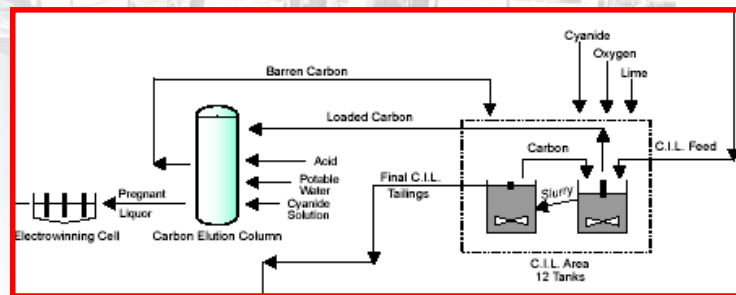
This pregnant solution contains a high concentration of gold.

The pregnant solution is transported to electrowinning cells in the gold room.

The carbon granules are collected and reactivated by heating to high temperatures. They are then returned to the CIL circuit to be reused.

# Processing

- Electrowinning cell



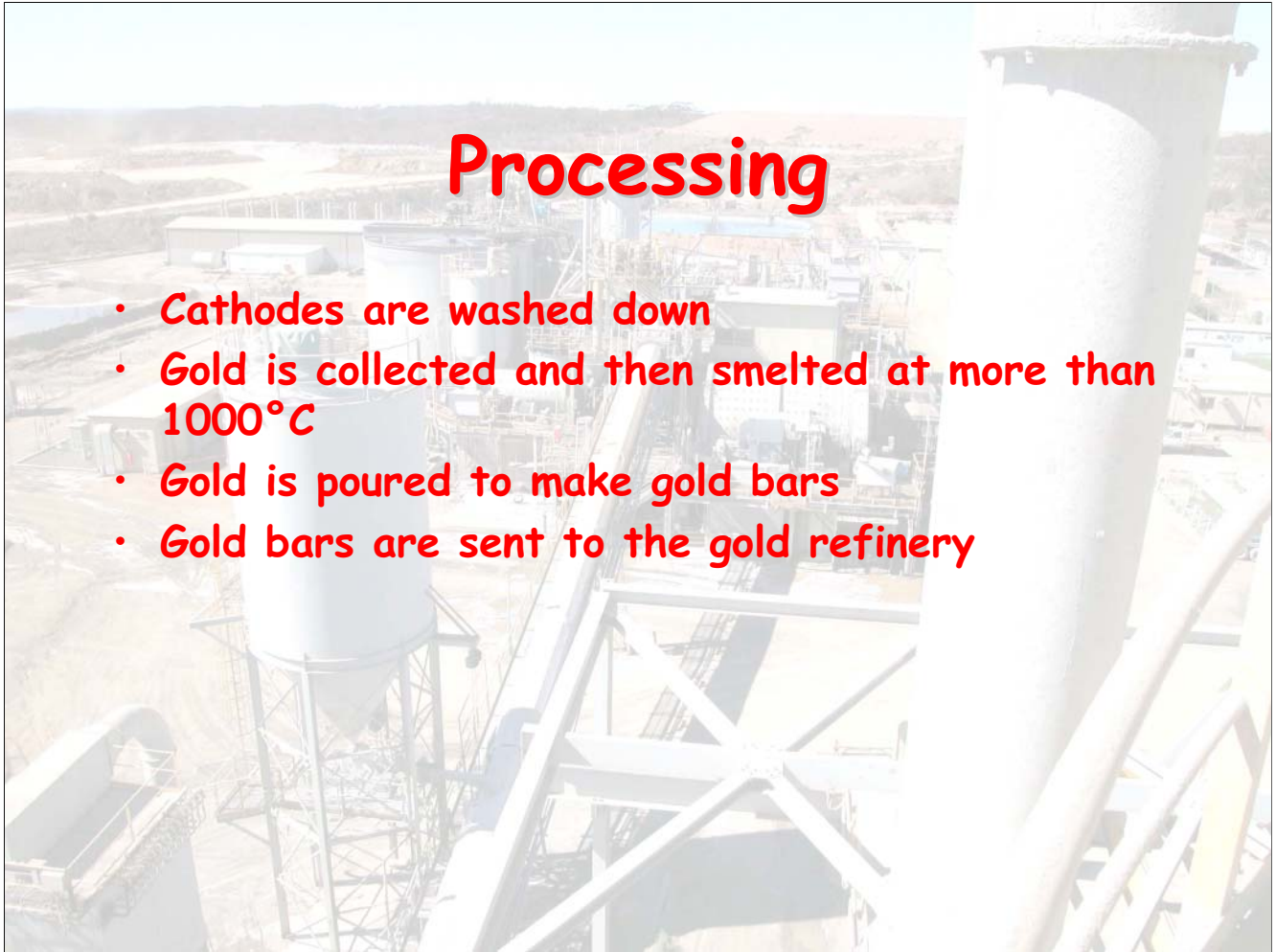
[http://www.mpimines.com.au/investorinfo/prospectus/prospectus\\_section3.pdf](http://www.mpimines.com.au/investorinfo/prospectus/prospectus_section3.pdf)

- Electrolysis
- Gold plated onto cathode

The solution containing the gold is known as the pregnant liquor. It is moved to the electrowinning cells to remove the gold from the solution.

An electric current is passed through the electrowinning cell to plate the gold onto steel cathodes.

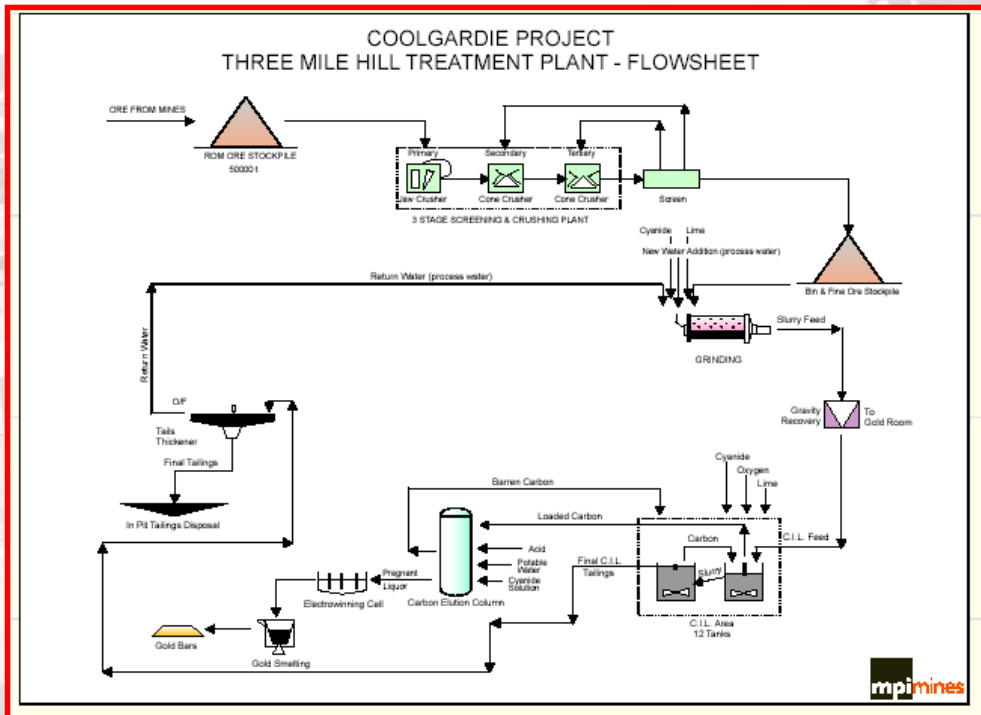
The carbon is collected and heated to reactivate it, making it ready to absorb more gold when returned to the CIL tanks.



The cathodes are washed down and the gold is collected and then smelted at more than 1000°C.

The molten material is poured to make gold bars.

The gold is collected and taken to the gold refinery and then on-sold for use in a wide range of products.



The final solution from the CIL tanks, once the gold has been absorbed onto the carbon, is sent to the tailings dams. Tailings go through a multistage process to recover water that can be reused in the treatment of new ore. CMC use Three Mile Hill openpit to contain the final tailings.

Environmental considerations are a major influence on the way any plant is operated.

Recovery and recycling of process water decreases the demand on potable water supplies required for the plant.

The storage of tailing in an old openpit means there is less land used by the plant and less impact on the surrounding flora and fauna.