



Production of Chromate Reductase using *Chlorella vulgaris* Microalgae

UBC
CHBE

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Background

Cr(VI)

REDUCTION
AGENT

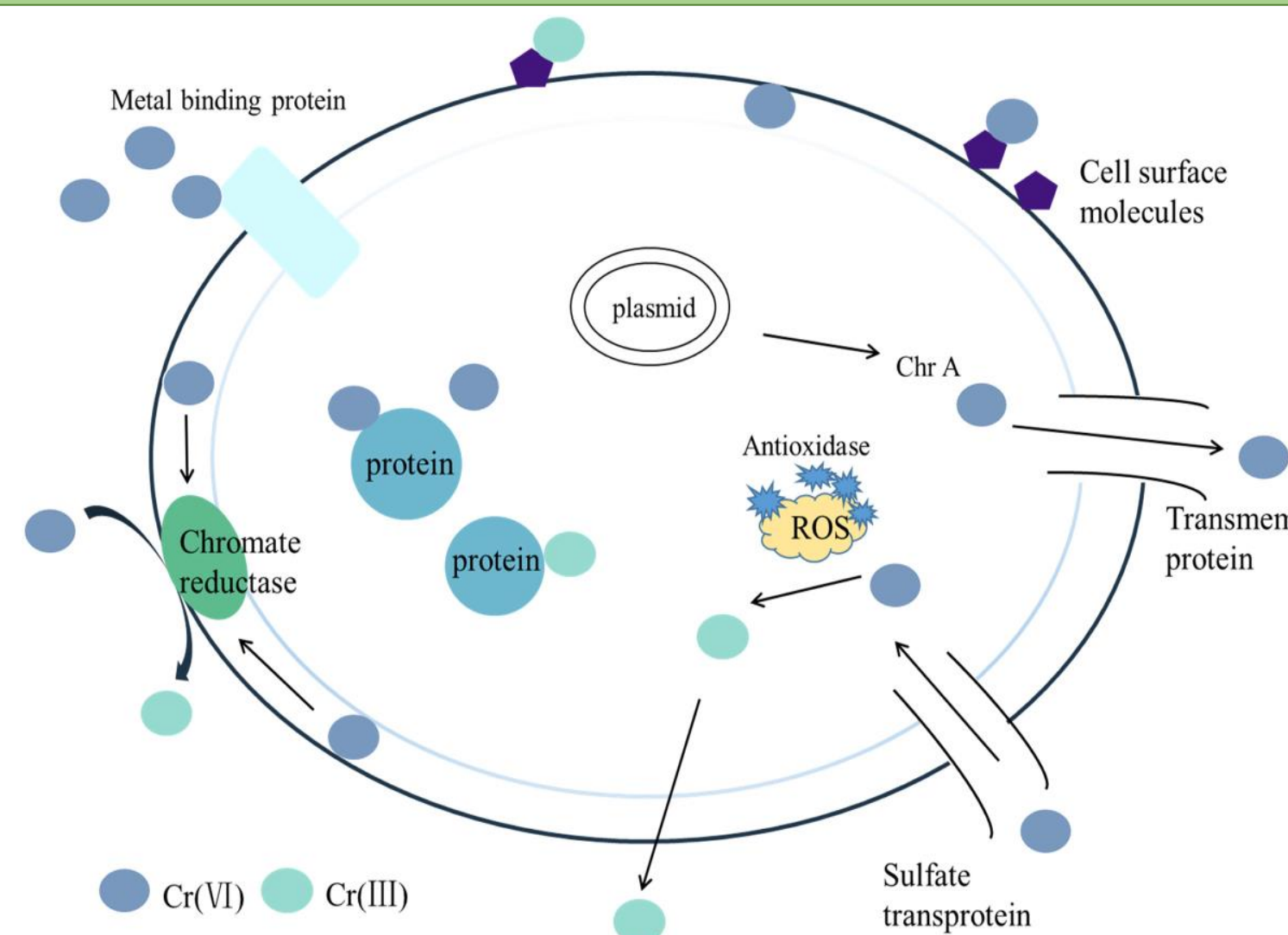
Cr(III)

- Highly toxic form of chromium
- By-product from industries such as chrome plating, dye manufacturing

Current treatment:
No standard, costly, usually stored

- Cr(III) is 500-1000 times less toxic
- Safe to release
- Stable in aquatic environments
- product of natural bioremediation in algae with *Chromate Reductase*

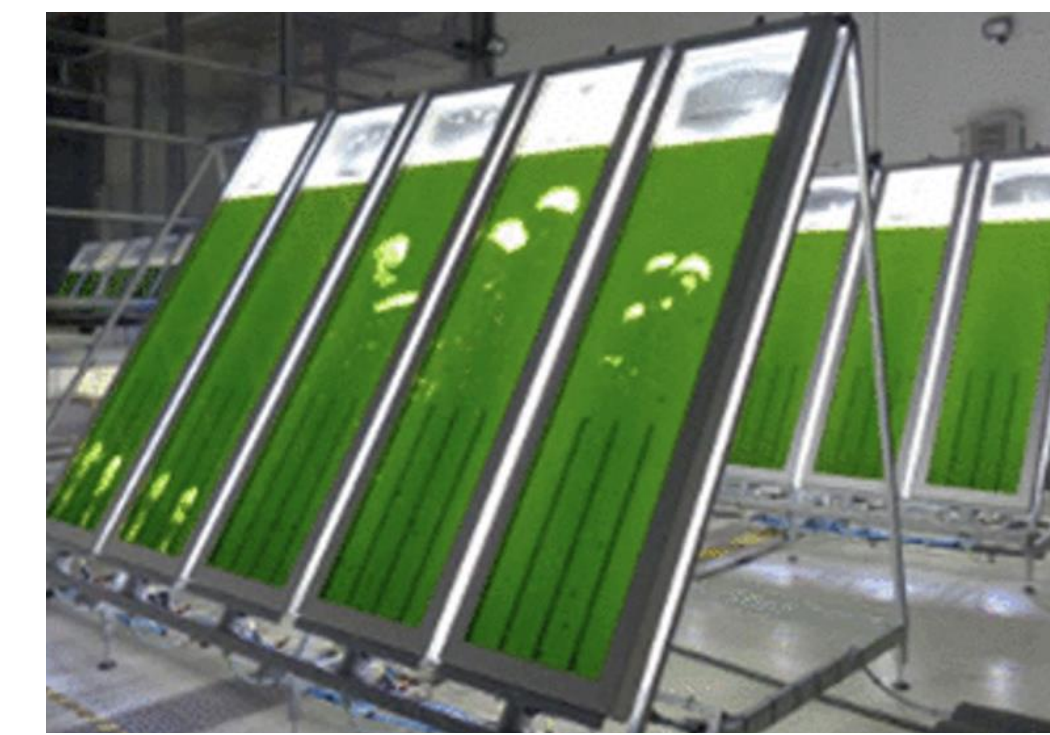
Natural Bioremediation in Microalgae (*Chorella Vulgaris*)



Process Overview

Bioreactor

- Used to grow *Chlorella vulgaris* culture
- 3000 Bioreactors sized at 2.5 m x 0.07 m x 2 m
- Operates in a semi-continuous batch process in 3 day cycles



Disc Stack Centrifuge

- Dewater Bioreactor product stream
- Heavy phase contains *Chlorella Vulgaris* cells and water
- Light phase contains waste water



High Pressure Homogenizer

- Uses high pressure to lyse the cell walls
- Moves intracellular enzyme into fluid
- Operates on a recycle loop



Tangential Flow Ultrafiltration Systems

- 1) Removes cell debris and other large proteins
 - 2) Removes undersized proteins
- Proteins pass through UF unit
 - Operates on recycle loops



Spray Freeze Dryer

- Dries concentrated purified Chromate Reductase
- Uses -50 °C nitrogen gas to dry and freeze moisture
- Ferrous chloride mixed in with final solid product at 3:1 ratio



Environmental Considerations

Plant Location

- Preferable *Temperature, Sunlight:* 21.3 °C, 2582 hr/year
- Convenient *Product/Waste Transportation:* Near Port of Houston
- Lower *Industrial Land Cost:* US\$172/sqft



- Solid Waste: *Collected* → bio-fertilizer and bio-fuel
- Liquid Waste: *Discharged* → Gulf of Mexico under regulations
- NO* harmful chemicals are used in this process except for *trace* amount of Potassium dichromate

Waste Treatment

- Texas power grid offers *40% renewable power*
- Gate-to-gate emission CO2 equivalent: *1258 tonnes/year*

GHG Emissions

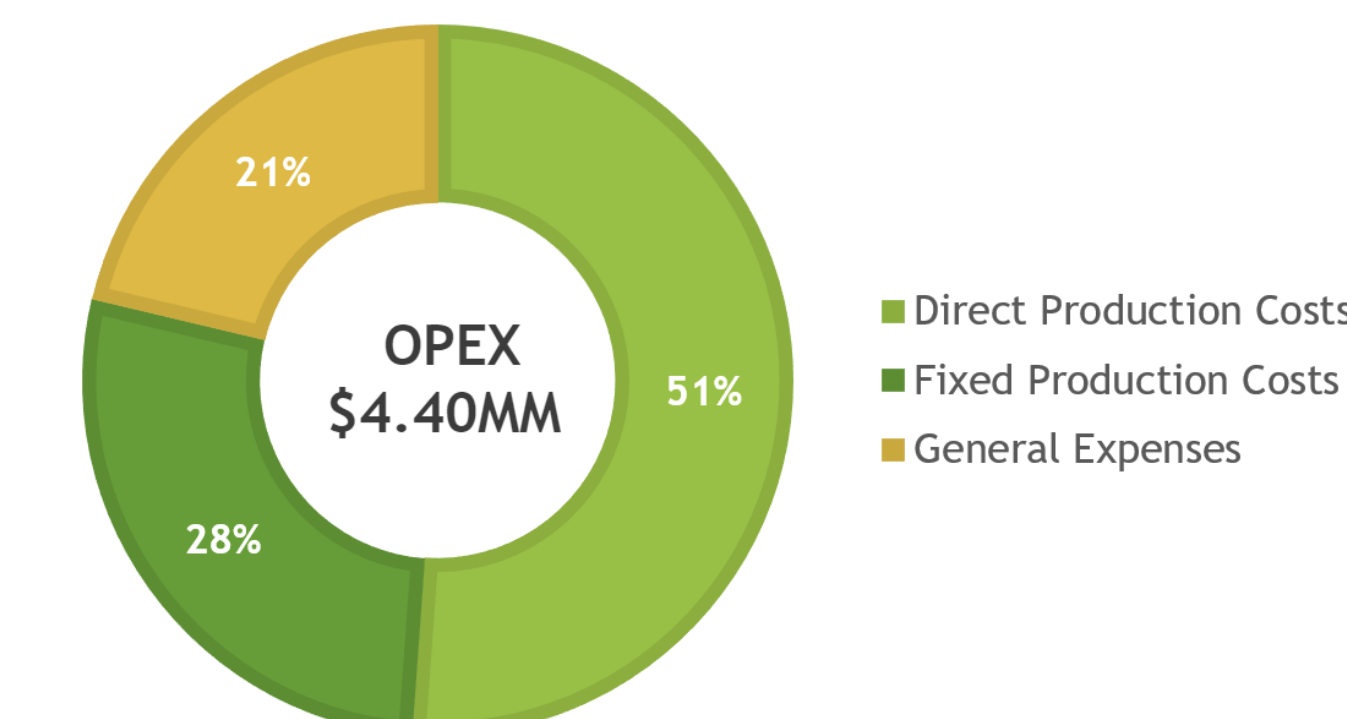
Acknowledgements

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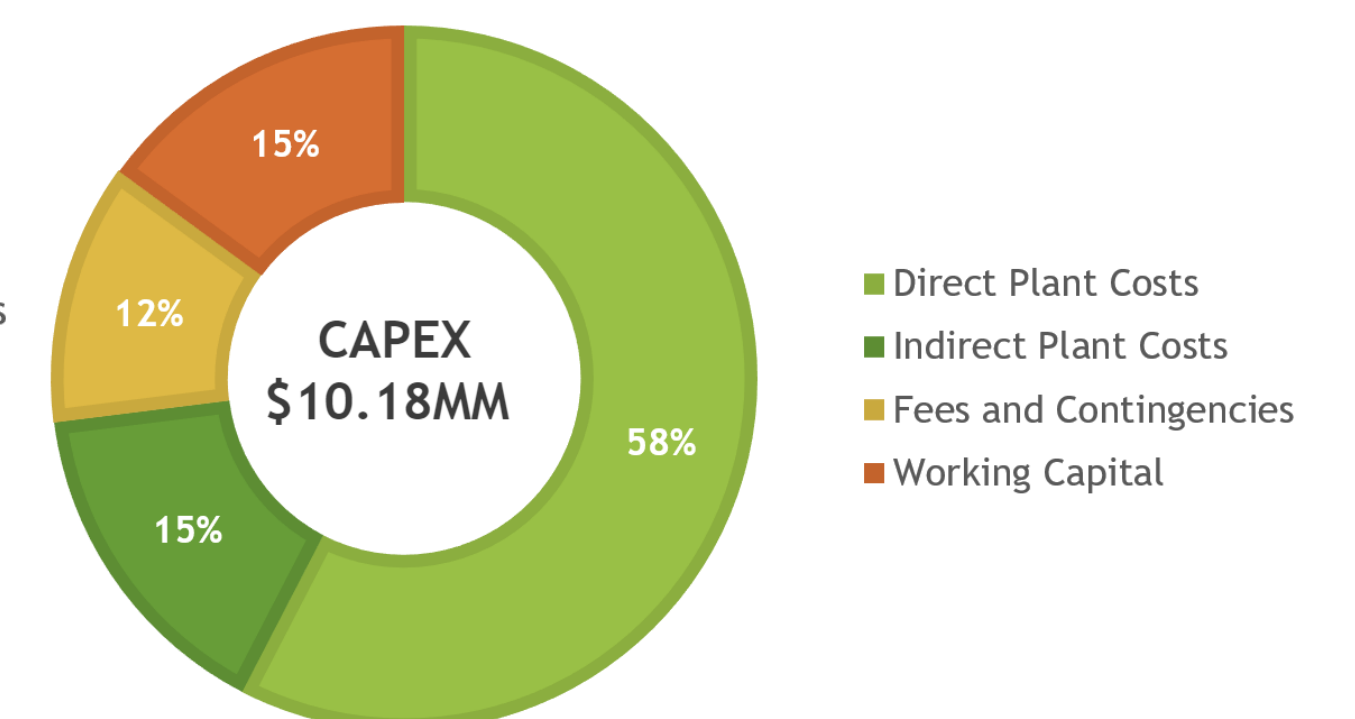
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Economic Analysis

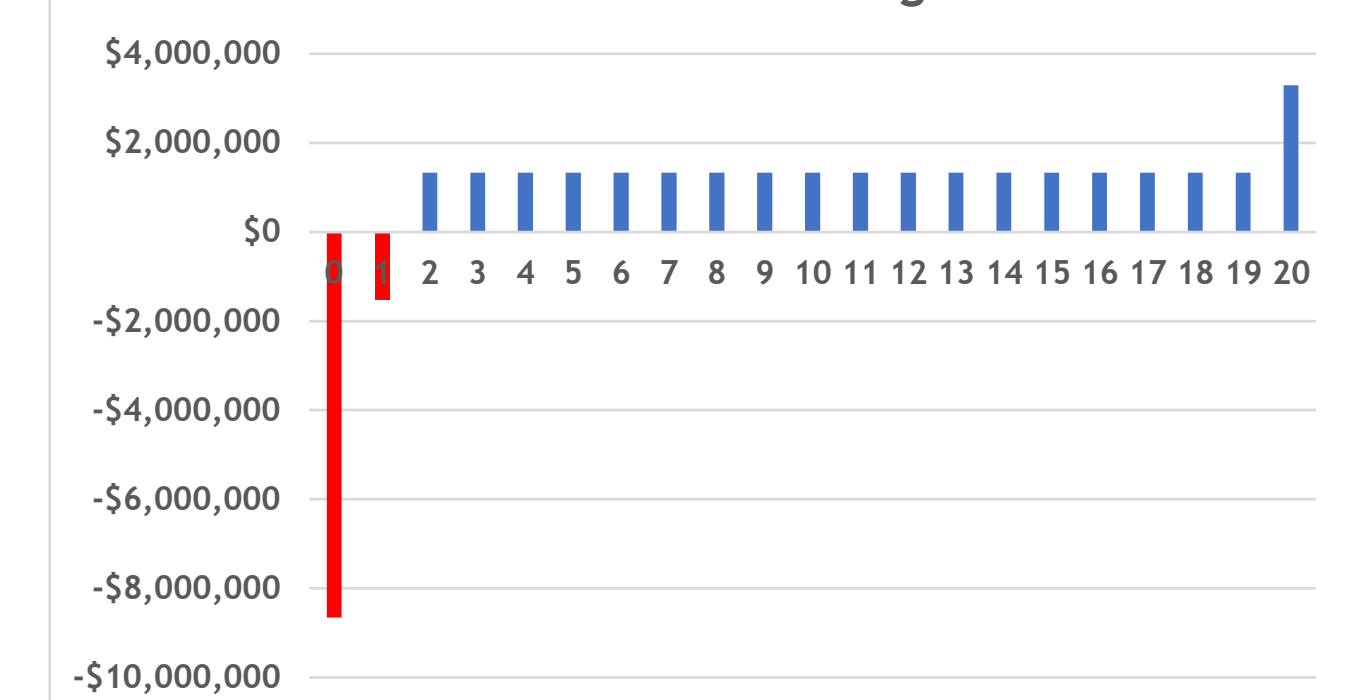
OPERATIONAL EXPENDITURE



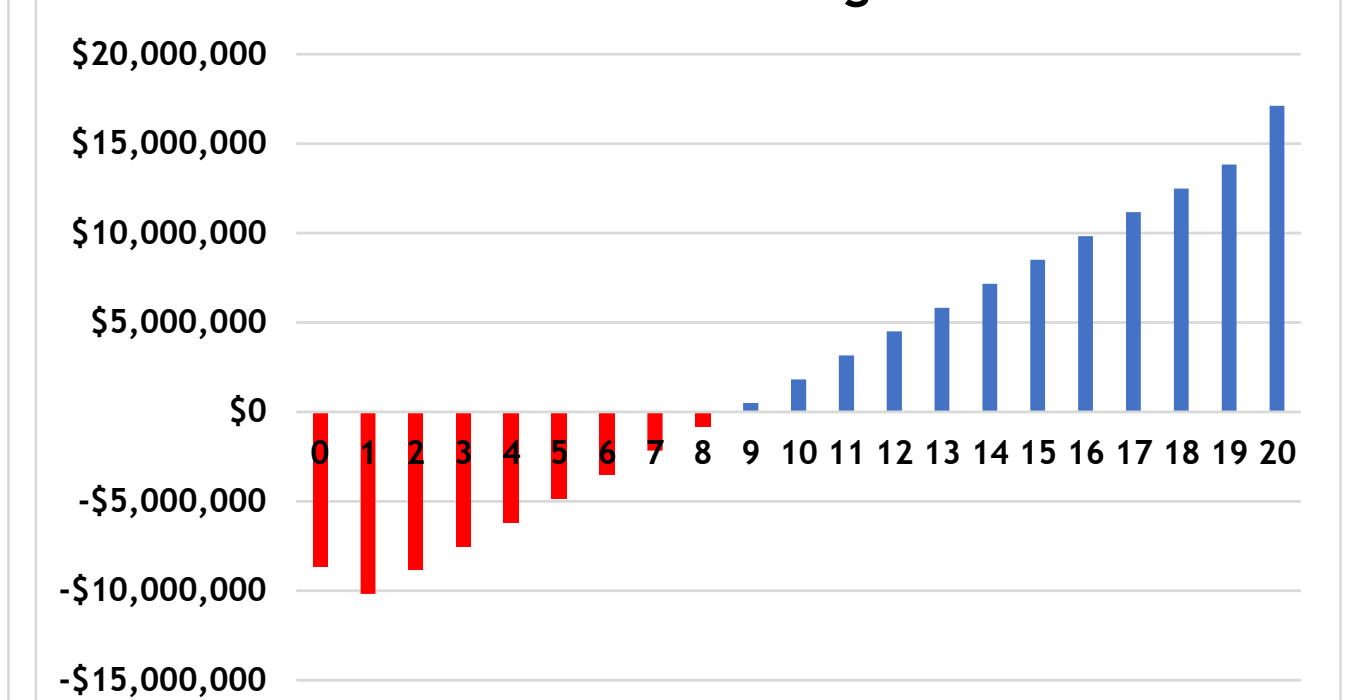
CAPITAL EXPENDITURE



Annual Cash Flow Diagram



Net Cash Flow Diagram



Key Criteria

Annual Profit = \$1.33 Million

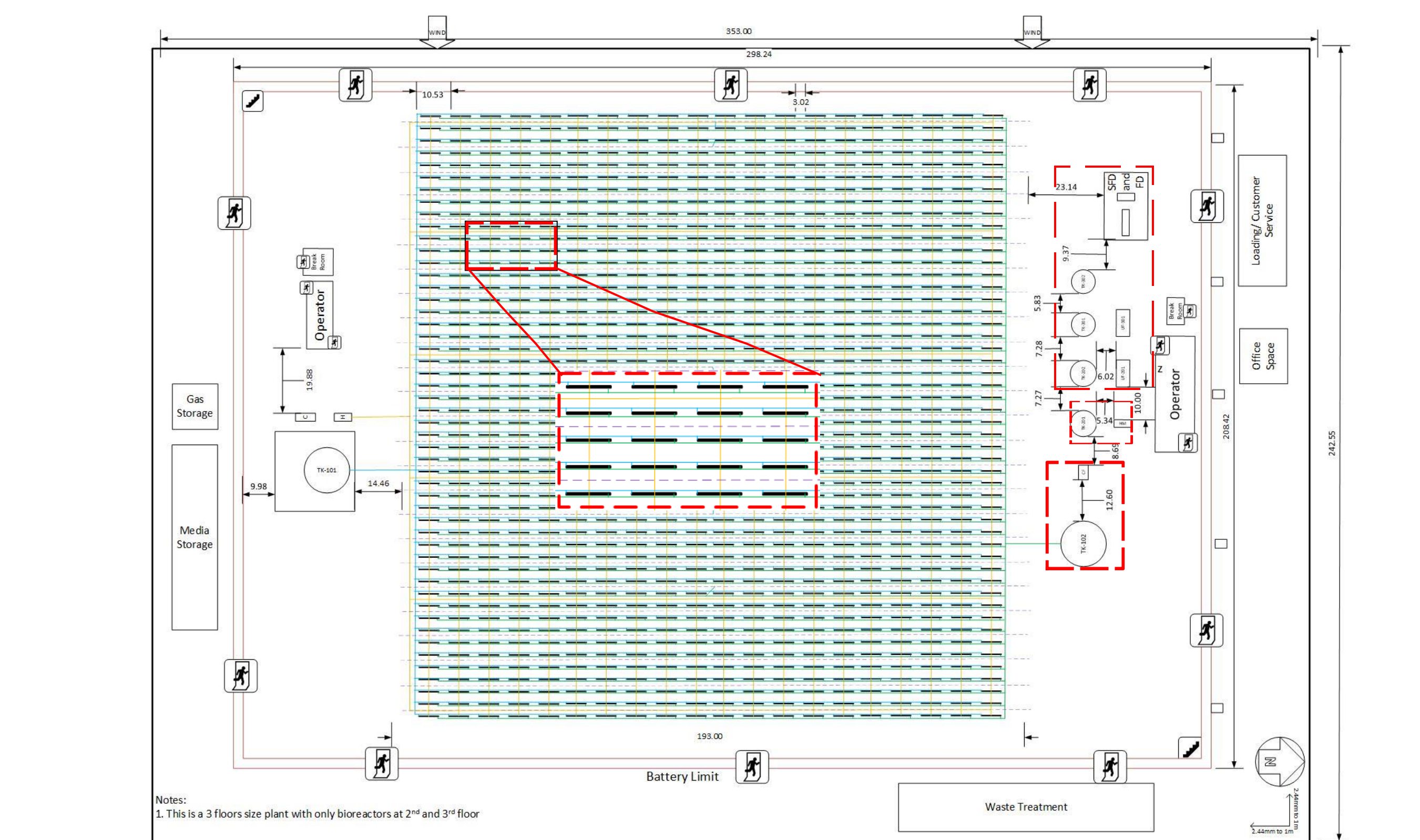
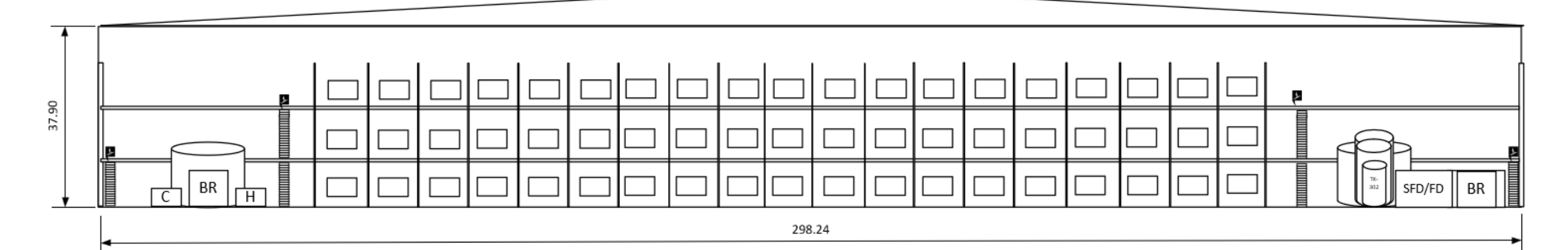
Payback Period = 8.6 years

Cash Criterion (CCR) = 1.18

Rate of Return on Investment (ROROI) = 0.15

Plant Layout

Side View



Legend:	Revision	Description	Date	Worked By	Approved By	UBC Engineering Ltd.
Media Storage	A	First Detailed Draft	2023-03-23	KSC		UBC Engineering Ltd.
C: Compressor						
Un: Unloader						
UF: Ultrafiltration						
TS: Storage Tank						
SD: Spray Freeze Dryer						
TD: Freeze Dryer						
CF: Centrifuge						