



CLOSING IN THE HOLY GRAIL -
BENEFICIAL USE OF HARD ROCK WASTE AS A
SOURCE FOR BIOMINERAL FERTILIZERS

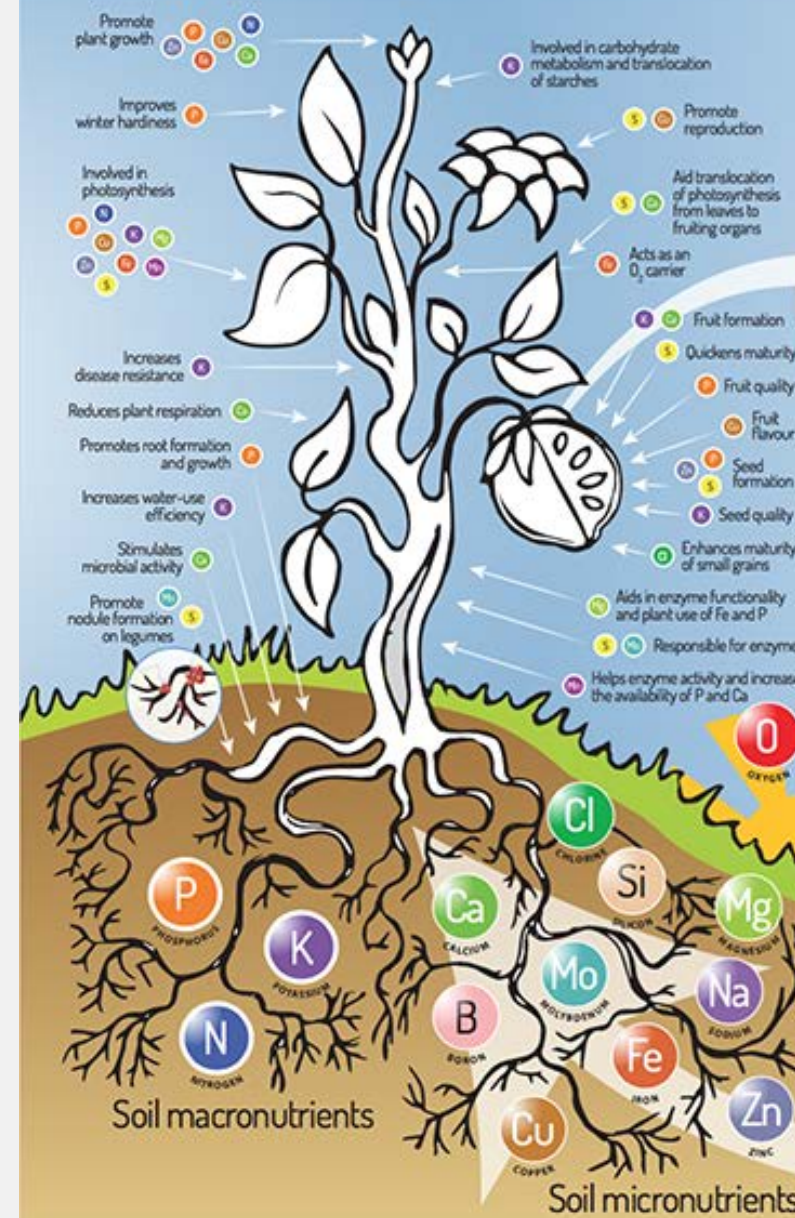
Andrew Harley

Principal Soil Scientist/Geochemist

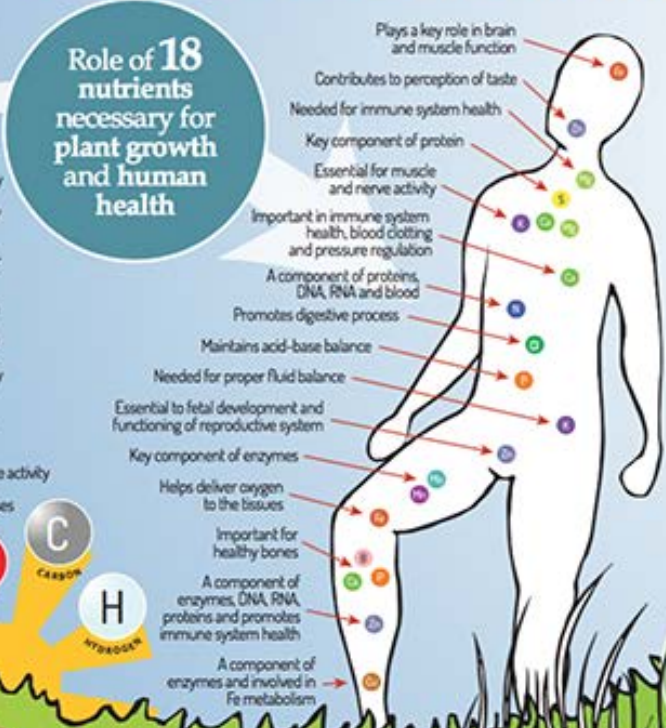
aharley@duraroot.com 720.840.4703



Soil the foundation of nutrition



Role of 18 nutrients necessary for plant growth and human health



Soil degradation leads to the loss of soil micro and macronutrients

Nutrient-poor soils are unable to produce healthy food with all the necessary nutrients for a healthy person

Over 2 billion people suffer from micronutrient deficiencies

Increase soil organic matter content

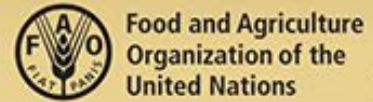
Minimize tillage

Keep soil surface covered

Sustainable soil management for healthy soils, healthy food and healthy people

Reduce erosion

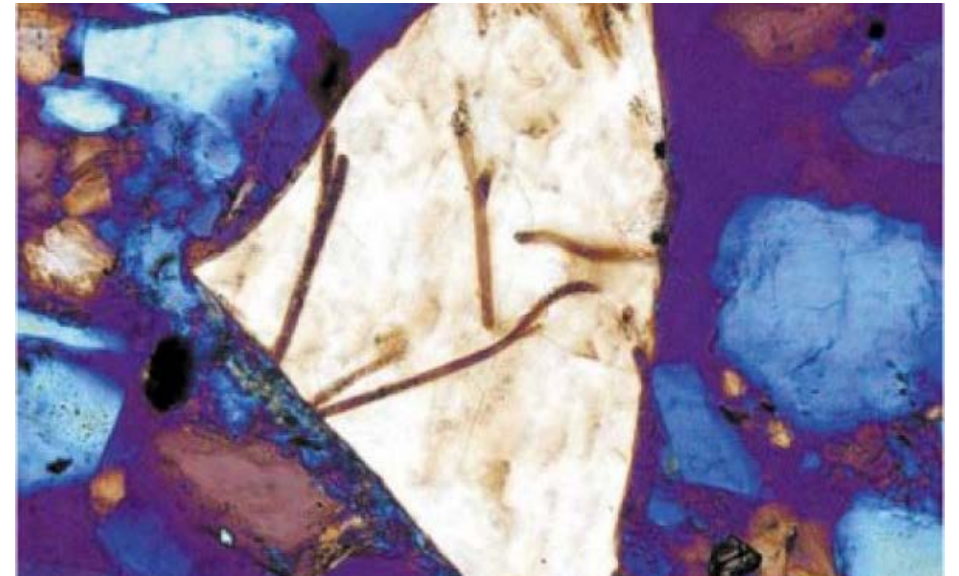
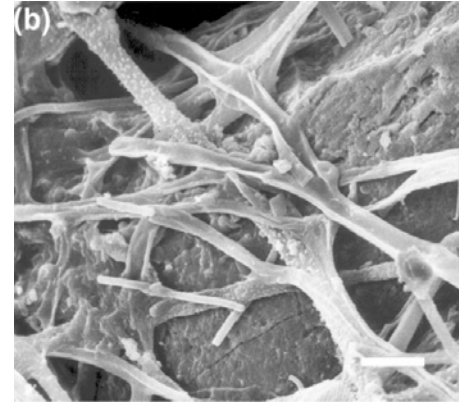
Ensure crop rotation



Healthy soils for a healthy life

REMINERALIZATION

- Slow release of macro- and micro- minerals
- Increase nutrient uptake
- Improved biological function
- Protects organic matter formation
- Increased resistance to insects and disease
- Enhanced flavor
- Decrease chemical fertilizers, pesticides, herbicides





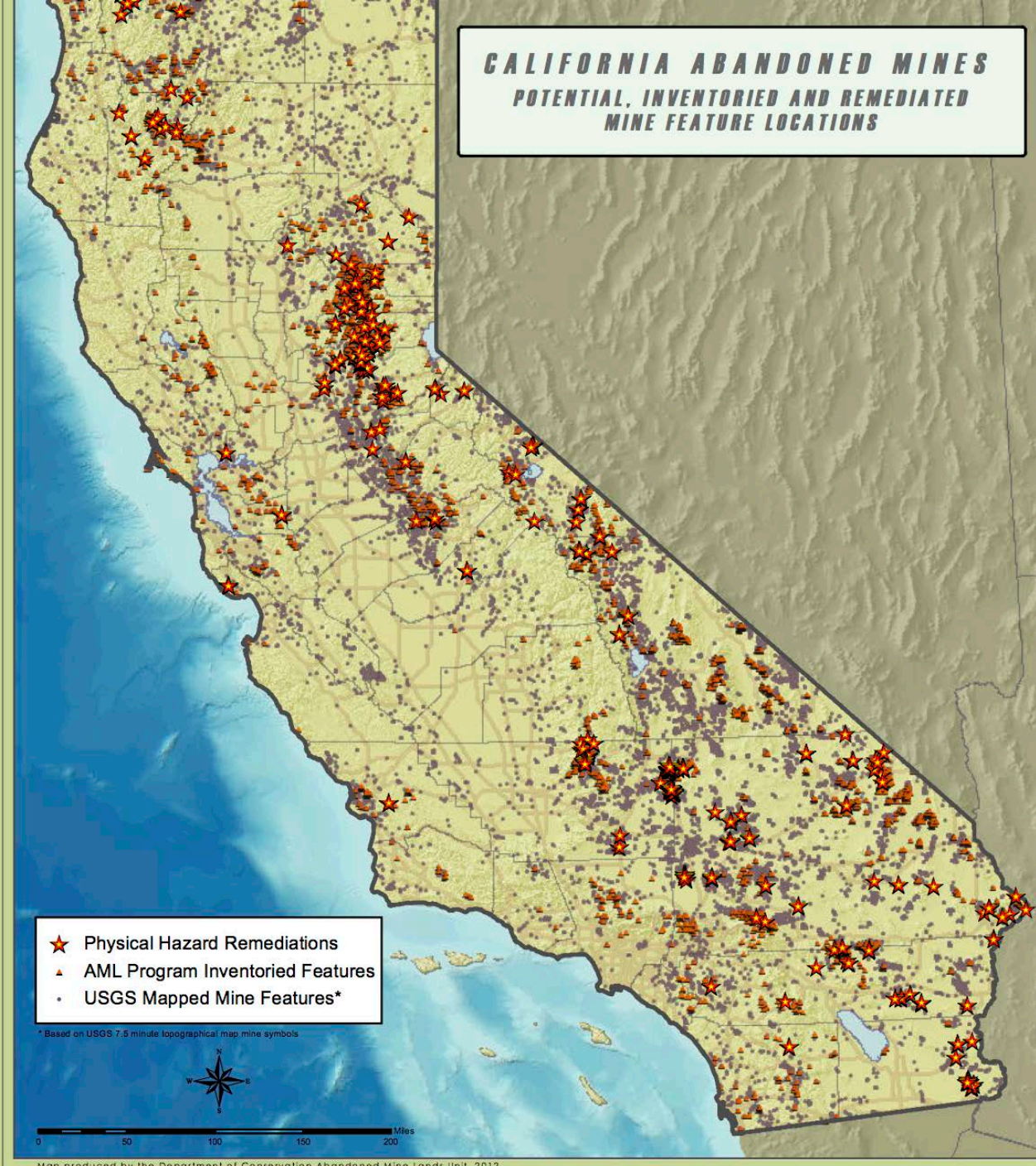


Mineral constituent	Igneous rock	Shale	Sandstone	Nutrient element constituents	
				Major	Minor
	%				
Feldspars	59.5	30.0	11.5	K, Ca, Na	Cu, Mn
Amphiboles & pyroxenes	16.8	–	sm	Mg, Fe, Ca	Ni, Co, Cu, Mn, Zn, Mo
Micas	3.8	–	sm	K, Ca, Na, Mg, Fe	Ni, Mn, Co, Zn, Cu
Titanium minerals	1.5	–	sm	Ti, Fe, Ca	Co, Ni
Apatite	0.6	–	sm	Ca, P	
Clay	–	25.0	6.6	K, Mg, Fe, Ca, Na	
Iron oxides	–	5.6	1.8	Fe	Mn, Zn, Ni, Co
Carbonates	–	5.7	11.1	Ca, Mg, Fe	
Other minerals	–	11.4	2.2	–	–

Table 1: Average mineralogical and nutrient element composition of common rocks on the Earth's land surface (Klein & Hurlbut 1999, based on data of F. W. Clarke).



- The estimated abandoned mines **47,084**.
 - **5,200**, or 11%, present environmental hazards.
 - **39,400**, or 84%, present physical safety hazards.
- approximately **164,795** mining features.
 - Approximately **62,000**, or 38%, of these features are hazardous openings.
- **67%** of the abandoned mine sites in California are on Federal lands.
- **31%** are on private lands.
- **2%** are on state and local lands.



NON-MINING MINERAL PRODUCTS UTILIZING BIOMINING

- Improved rates of metal recovery
- Reduced capital cost
- Robust technology
- Self managing process
- Environmentally friendly
- Low operator skills
- Applicable over wide feedstock concentration
- Appropriate to recovering wide range of metals and stabilizing toxic elements
- Variety of scales and easy scaling
- Short lead time from design to construction to operation
- Low maintenance requirements



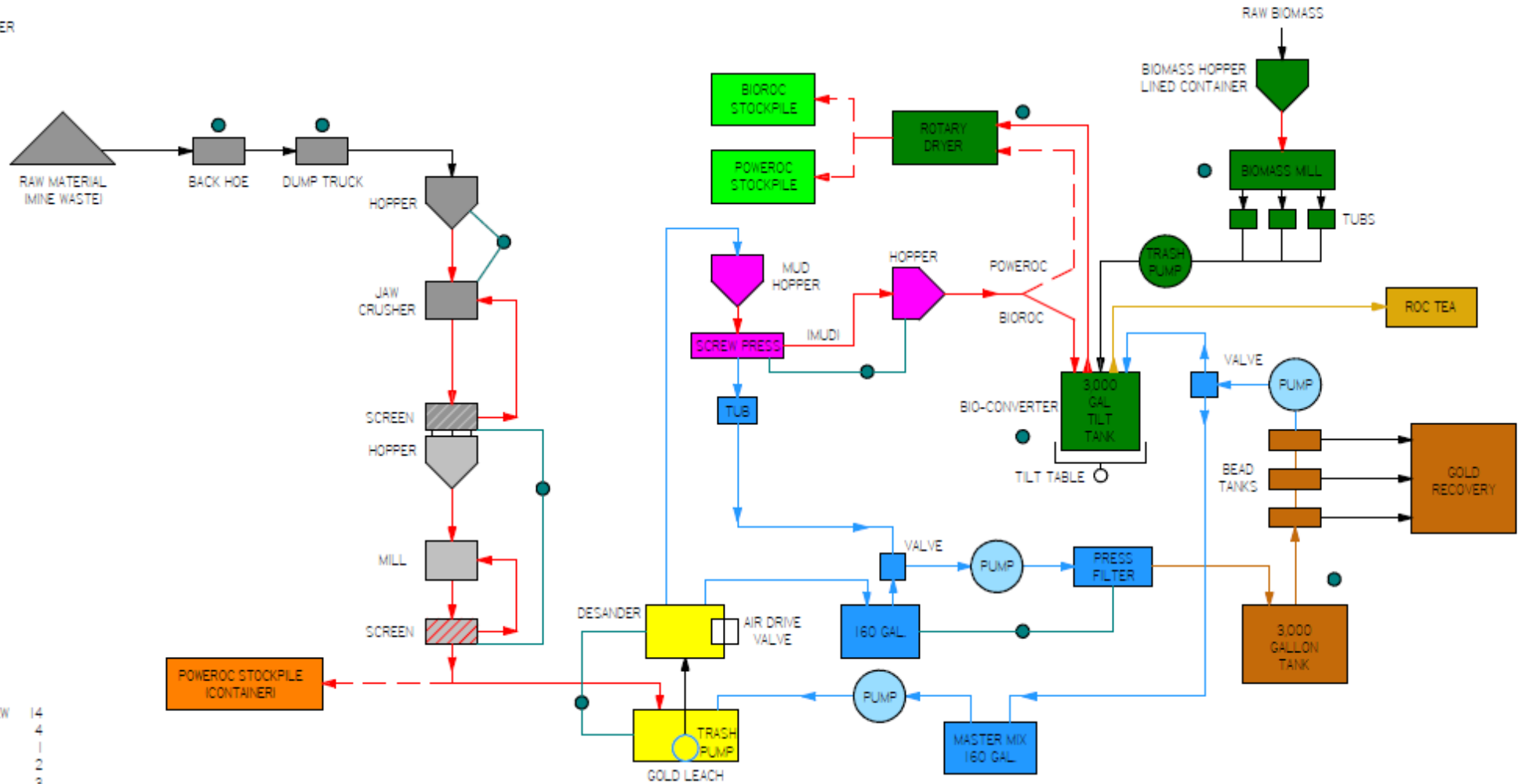
INTERPRET THIS DRAWING FOR HOME Y 11/24/18
 ALL DIMENSIONS ARE IN INCHES (DIM)
 DIMENSIONS FOR BIDDING AND SHOP DRAWING
 DIMENSIONS FOR CONSTRUCTION

NOTES: (UNLESS OTHERWISE SPECIFIED)

KEY

- RED - SCREW CONVEYOR
- BLU - LIQUID
- DOT - CREW MEMBER

REVISIONS				
REV	ECO	DESCRIPTION OF CHANGE	DATE	APPROVAL
2	XXXX	ADD ROC TEA		



EQUIPMENT LIST

CONVEYORS, SCREW	14
HOPPERS	4
JAW CRUSHER	1
SCREENER, 48"	2
CONTAINER	3
PNEUMATIC VALVE	1
WATER PUMPS	3
TRASH PUMPS	2
PRESSURE FILTER	1

PERSONNEL

CREW	12
ADMIN	3

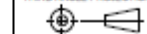


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MATERIAL:

FINISH:

THIRD ANGLE PROJECTION



TOLERANCES:

DECIMALS	± .005
1/16"	± .005
1/8"	± .005
3/16"	± .005
1/2"	± .005
1"	± .005
ANGLES ± 5°	± .005

HOLES:

1/8"	± .005
3/16"	± .005
1/2"	± .005
1"	± .005

EMPIRE GREEN COMMODITIES, INC.

268 ROCKY POINT RD.	
OROVILLE, CA 95966	
DESIGNED BY: H. AMOROSO	DRAWN BY: J. AMOROSO
DATE: 10 FEB 18	

PRODUCTION FLOWCHART
 RAW TO PRE-PACKAGING

EGC-001	2
SHEET 1 OF 1	

SLURRY LEACHING STEP – LIQUID EXTRACTION

AU RECOVERY – WASTE REVENUE

Source	Oz/ton	Recovery
Tailings (CA)	0.237	58%
Waste rock (NV)	0.327	66%
Waste rock (OR)	0.343	62%

HG RECOVERY – WASTE TREATMENT

Tailings (NV)	
Total Hg	783 mg/kg
Leachable Hg	125 mg/L
Resin Leachate Hg	37 mg/L
Resin Recovery	70%



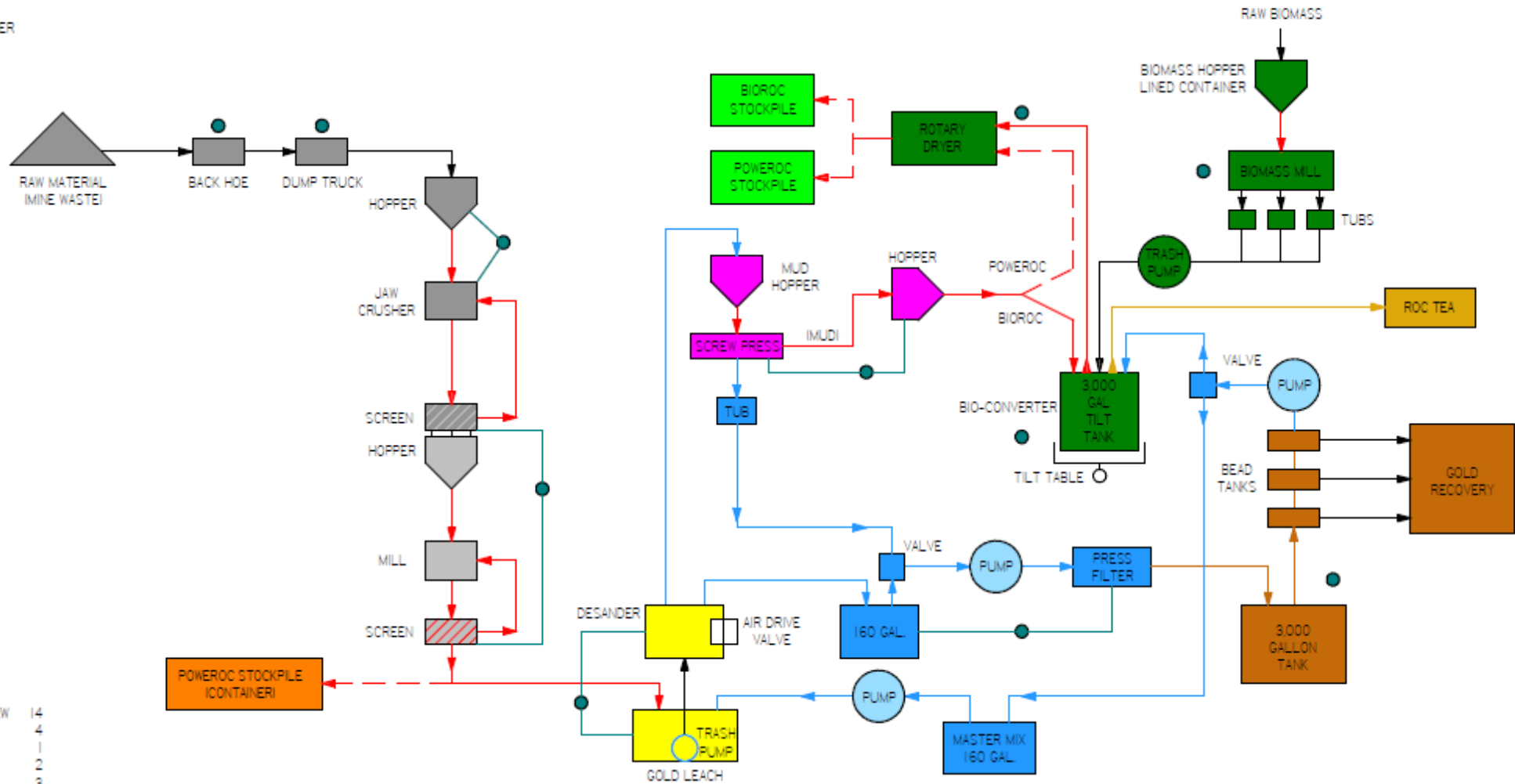
INTERPRET THIS DRAWING FOR HOME Y 11/24/18M
 ALL DIMENSIONS ARE IN INCHES (DIM)
 DIMENSIONS IN BRACKETED GROUPS (DIM)
 DIMENSIONS IN QUOTE (DIM)

NOTES: (UNLESS OTHERWISE SPECIFIED)

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REVISIONS				
REV	ECO	DESCRIPTION OF CHANGE	DATE	APPROVAL
2	XXXX	ADD ROC TEA		



EQUIPMENT LIST

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CREW	12
ADMIN	3



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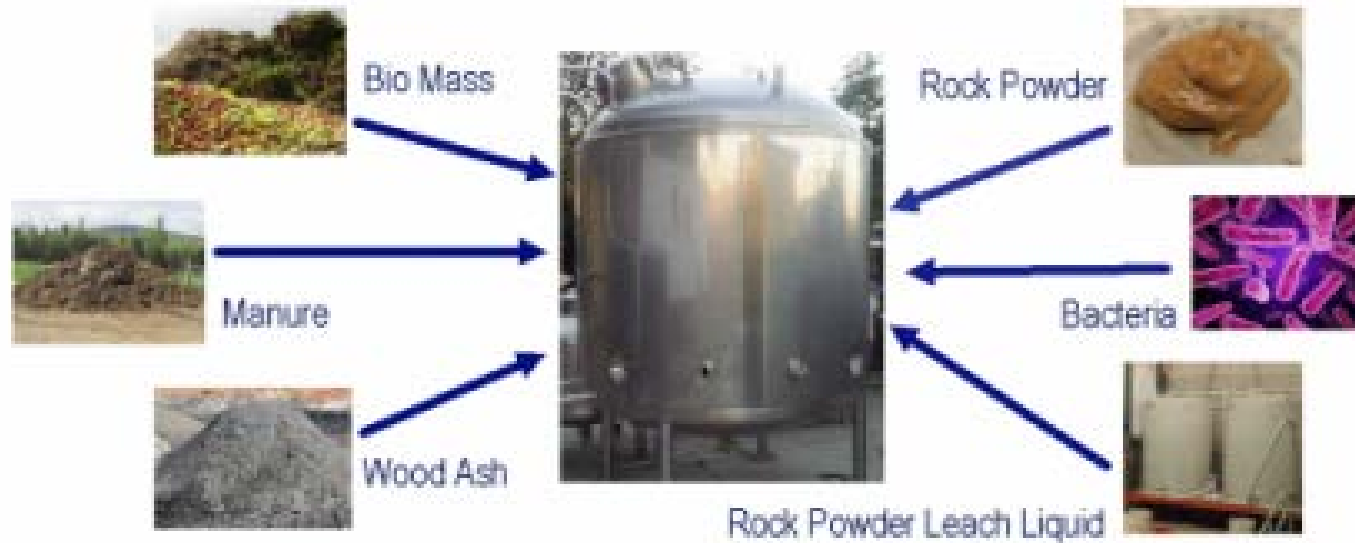
MATERIAL	FINISH	THIRD ANGLE PROJECTION

TOLERANCES	HOLES
DECIMALS X 1.1 XX ± .06 XXX ± .031	1-250 +.017 251-500 +.017 501 & UP -.015

EMPIRE GREEN COMMODITIES, INC. 268 ROCKY POINT RD. OROVILLE, CA 95966	
DESIGNED BY H. AMOROSO	DATE 10 FEB 18

PRODUCTION FLOWCHART RAW TO PRE-PACKAGING	
PROJECT EGC-001	SHEET 2
SHEET 1 OF 1	

Nutrient-Rich Fertilizer



Using readily available waste creates a nutrient rich growing medium without the need for expensive energy-hungry raw materials.



Highest Quality Micro-Nutrient Rich Products



PowerRock™
BioRock™



RockTea™



Methane Gas to
Produce Electricity

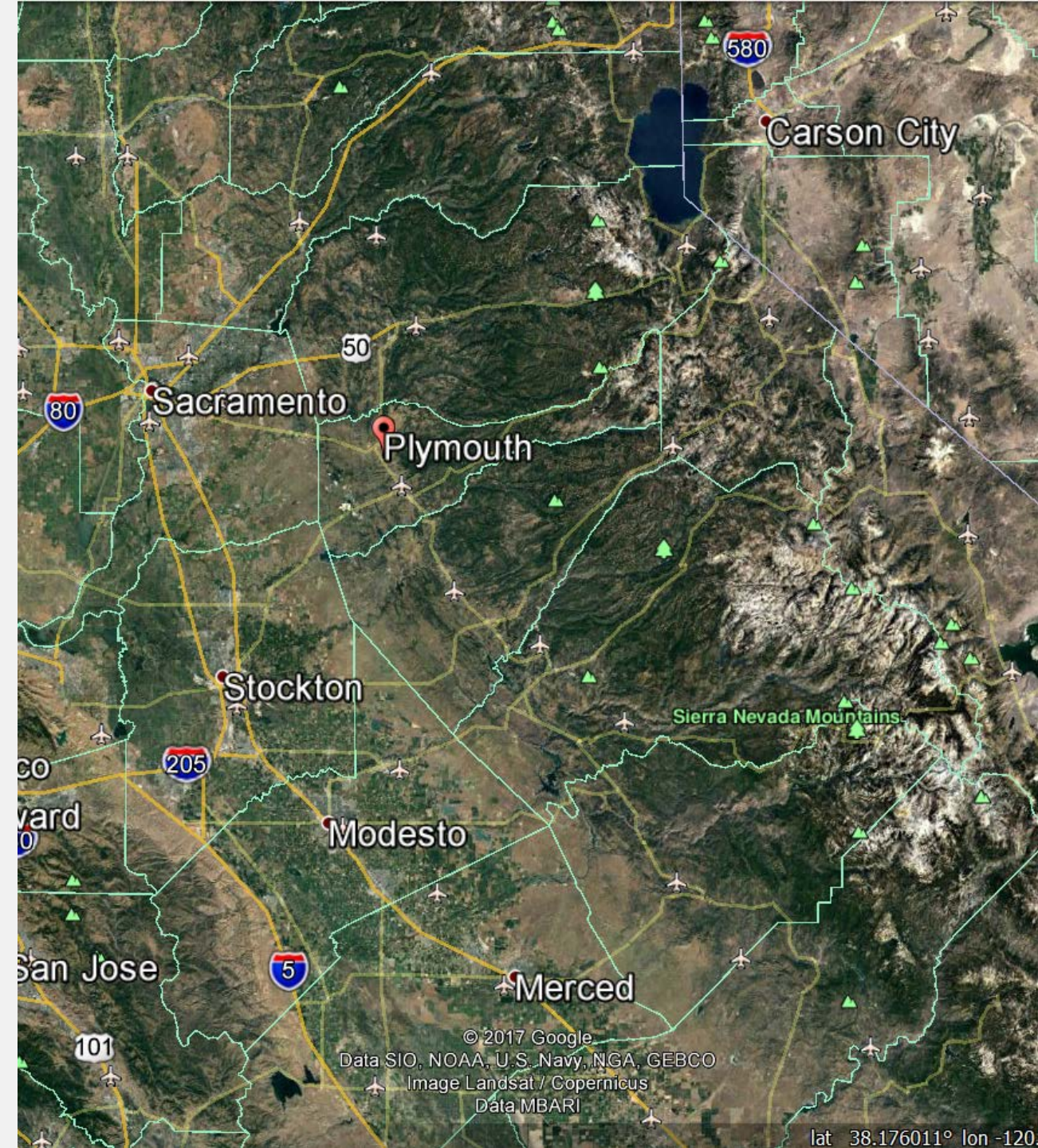
The products of this process carry RECYCLED nutrients to the soil, stimulating healthy plant growth while saving energy and natural resources.



DURAROOT

TAKING BIOMINERAL FERTILIZER TO MARKET

- Centrally located within 50 miles of minimum 10MT of mine waste, preferably 100MT, close to rail and highways.
- Plymouth, CA:
 - California Mother Lode country
 - 100 acres of land centrally located to 20MT gold bearing waste,.
 - Zoned for high density housing with 800 homes to be built at completion.
 - Engineering complete.
 - Permitting stage.



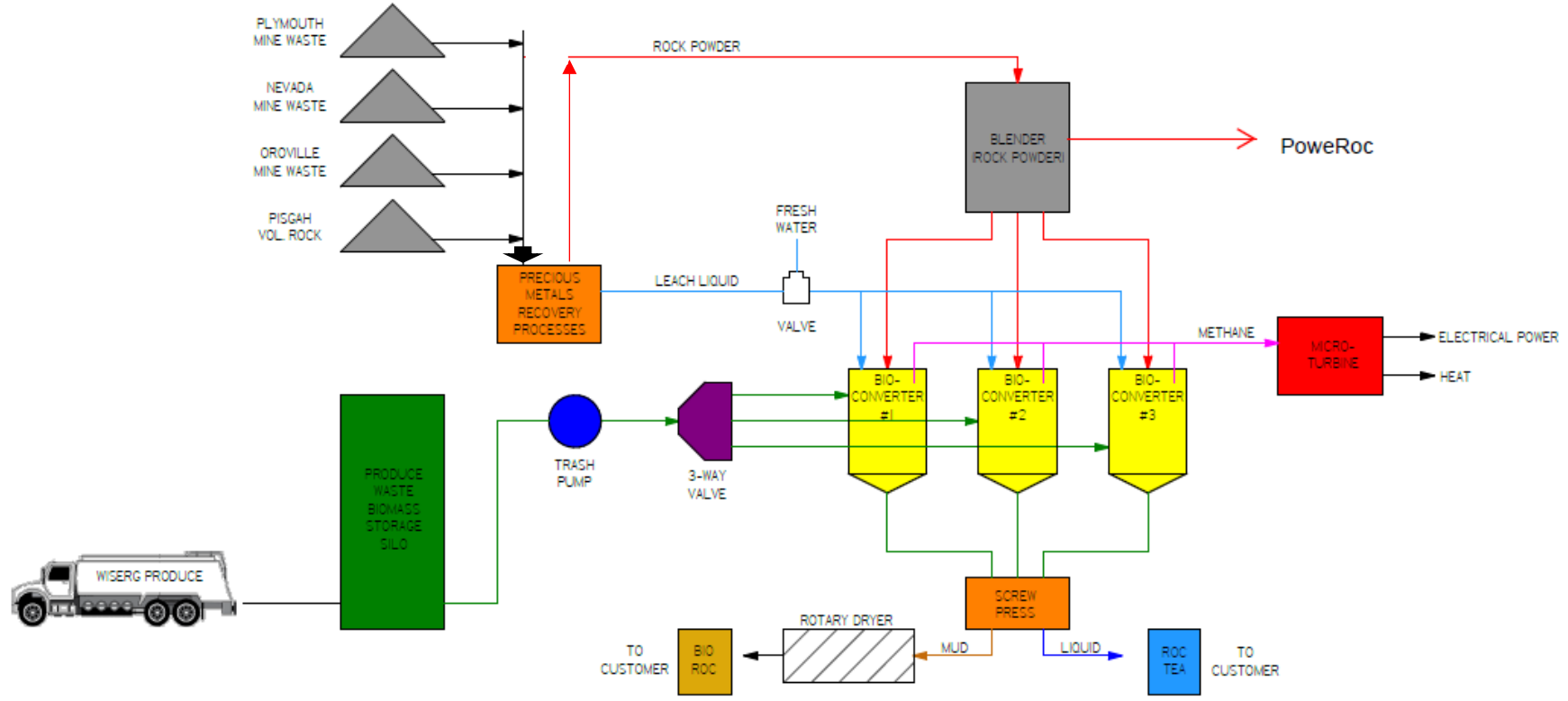
INTERPRET THIS DRAWING PER ASME Y 14.5M-1994
 ALL DIMENSIONS ARE IN INCHES. (REF)
 REMOVE ALL BURRS AND SHARP EDGES
 THREADS: EXT. CL3A, INT. CL2B

NOTES: (UNLESS OTHERWISE SPECIFIED)

KEY

RED = SCREW CONVEYOR
 BLU = LIQUID

REVISIONS				
REV	ECO	DESCRIPTION OF CHANGE	DATE	APPROVAL
1	XXXX	BASELINE		



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MATERIAL:	THIRD ANGLE PROJECTION
FINISH:	

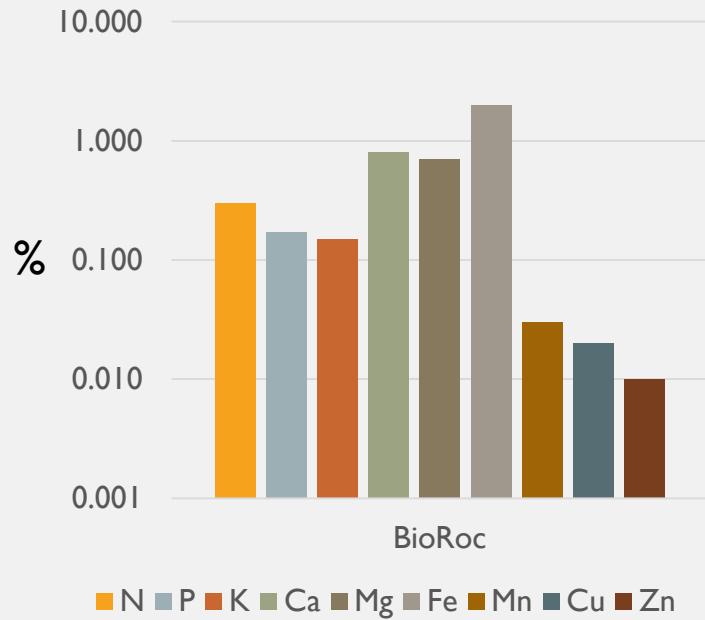
TOLERANCES	HOLES
DECIMALS	0 - .250 +.007 - .003
	.251 - .500 +.010 - .005
	.501 & UP +.015 - .009
ANGLES ± 5°	

AMPI 263 ROCKY POINT RD. OROVILLE, CA 95966	
DRAWN H. AMOROSO	DATE 18 MAR 18
PART NO.	

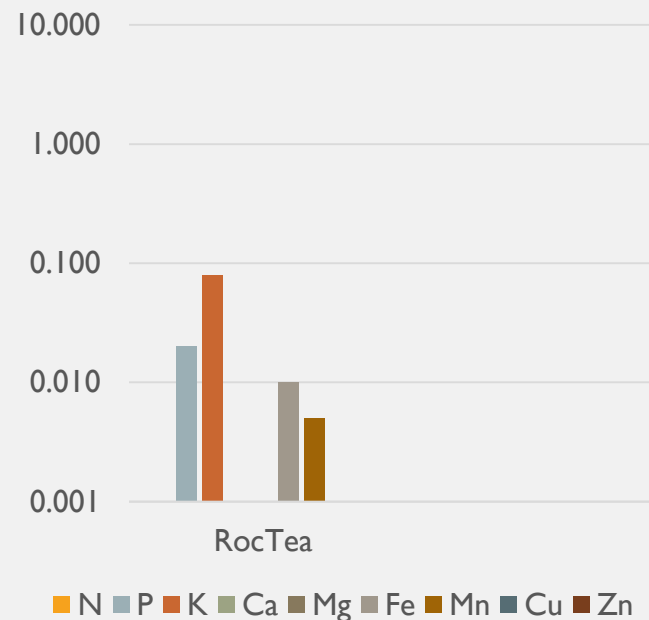
TITLE BIO-CONVERSION FLOWCHART	
DRAWING AMPI-004	REV 1
SHEET 1 OF 1	

NON MINING MINERAL PRODUCTS AGRICULTURAL MINERAL

Biominerall Fertilizer



Biominerall Compost Tea





Firm Name	PLANT NUTRITION TECHNOLOGIES INC
License ID #	446543
Product Name	POWEROC
Type of Fertilizing Material	Specialty Fertilizer
Is this an Organic Input Material (OIM)?	No
Annotation	

Registration ID#	497184
Status	Re-Submitted

Guaranteed Analysis(%)	
Primary Nutrient	
Total Nitrogen (N)	0
Available Phosphoric Acid (P2O5)	0.3
Soluble Potash (K2O)	0.17
Secondary Nutrient	
Calcium (Ca)	1.26
Magnesium (Mg)	0.7
Sulfur (S)	

Guaranteed Analysis(%)	
Micro Nutrient	
Boron (B)	0
Chlorine (Cl)	0
Cobalt (Co)	0
Copper (Cu)	0
Iron (Fe)	2
Manganese (Mn)	0
Molybdenum (Mo)	
Sodium (Na)	
Zinc (Zn)	

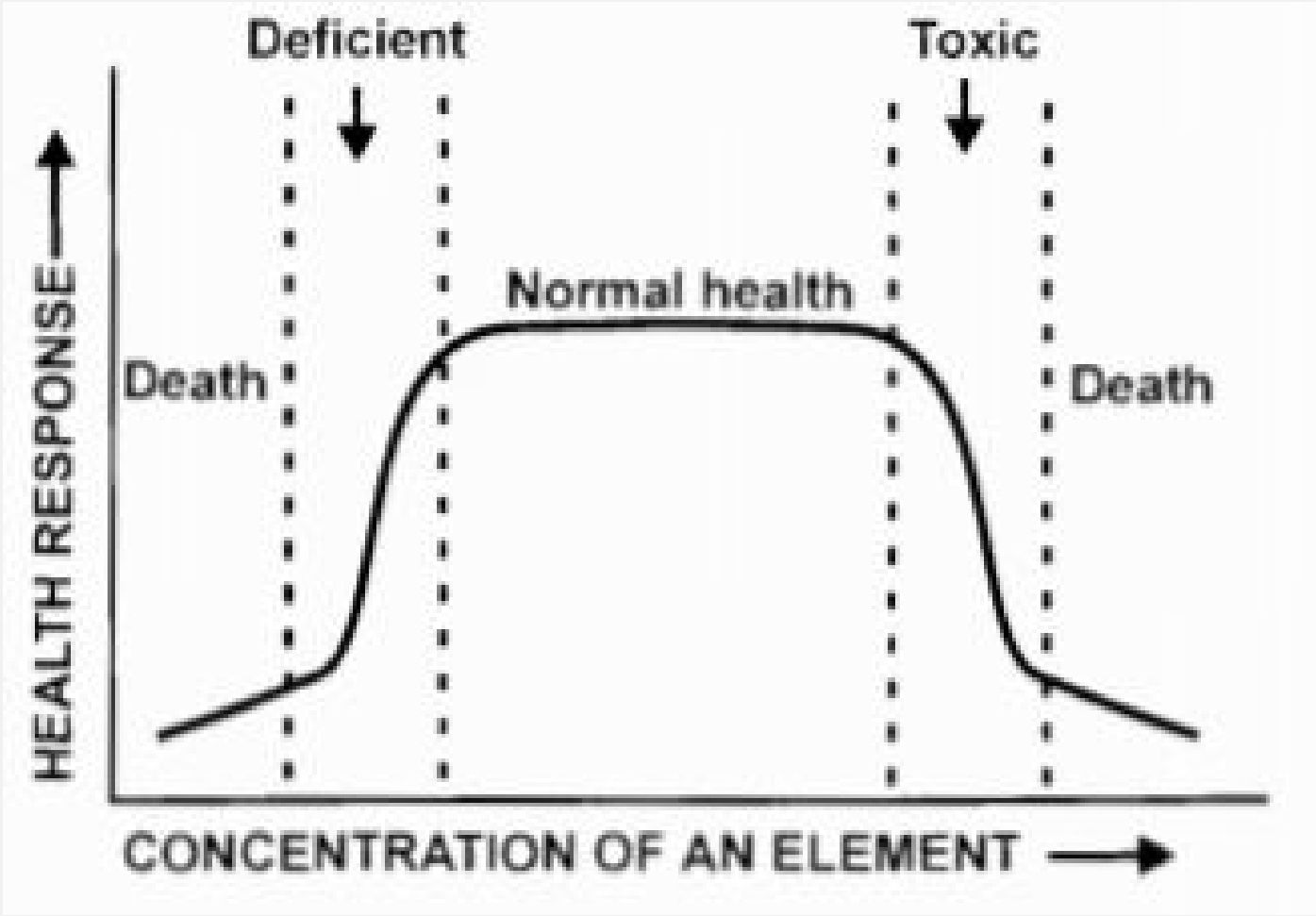
Heavy Metals (ppm)	
Analysis	
Arsenic (As)	= 36.6
Cadmium (Cd)	= 2.9
Cobalt (Co)	ND
Copper (Cu)	= 2,251
Lead (Pb)	= 369.7
Mercury (Hg)	ND
Molybdenum (Mo)	= 4
Nickel (Ni)	= 34.2
Selenium (Se)	= 3.9



Legend:

BDL - Below Detection Level

ND - None Detected





BUT DOES IT WORK? ALMOND GROWERS CALIFORNIA

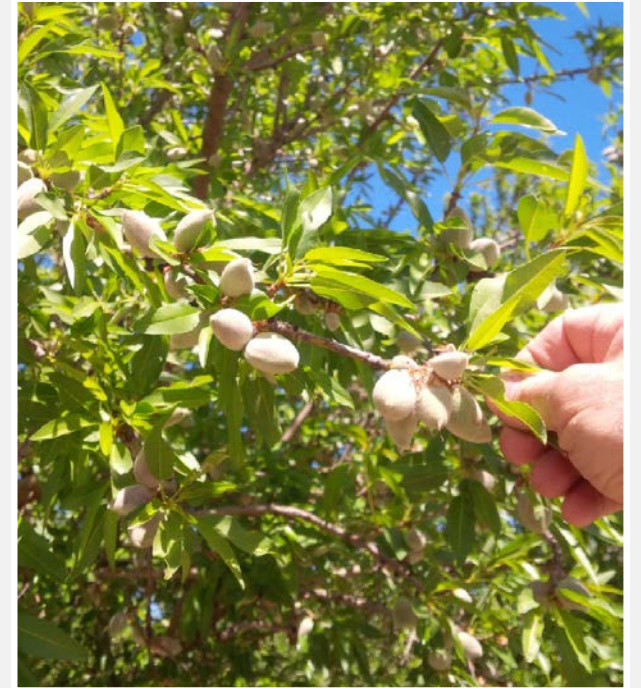
Low production due to:

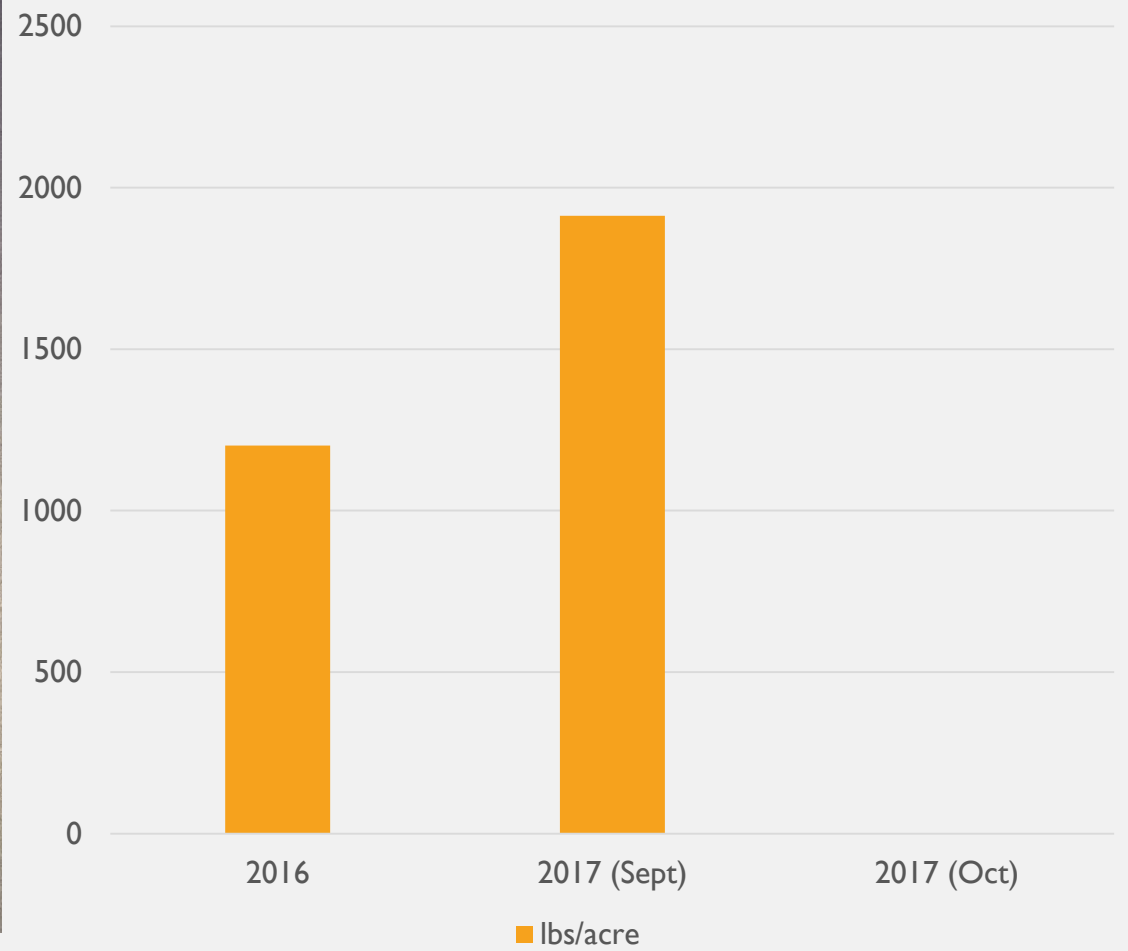
End of lifespan (2016)

Drought conditions.

2 tons/acre applied 2016 and 2017

YES IT DOES
ALMOND GROWERS CALIFORNIA





PERMACULTURE IN PRACTICE

The best way to look at permaculture in practice is to look at an example, and there is no better example than the permacultural way of keeping chickens.



THE CHICKEN-GREENHOUSE - As far as possible, made out of locally produced materials. Orientated facing south to catch passive solar gain. The need for continuous input of energy is designed out of the permaculture system by making **useful connections** between its different parts. For example, the heat, CO₂ and manure produced by the chickens are considered useful outputs of the system, rather than as pollutants.

PASSIVE SOLAR GAIN - Although strictly speaking, it is impossible to 'produce' energy, to all practical extents and purposes the Sun's energy is unlimited and converting some of it to a useable form is a gain in real terms, whereas burning fossil fuels is a loss.

RAINWATER COLLECTION - There is a waterbutt to collect rainwater from the roof, which will supply a large portion of the chickens' drinking water with little expenditure of energy. Collecting it at height requires no pumping in distribution. Where mains water is metered, the system (waterbutts, guttering, etc.) will soon pay for itself in cash terms.

ALDER TREE - Certain trees, such as the Alder tree, planted near the pond can provide additional food sources for chickens and fish in the form of caterpillars that rain down from its boughs at certain times of year.

EDGE - The most productive ecosystems on earth are those on the edges of water. Plants here have the advantages of both mediums: the water means that they never suffer from drought stress and the soil gives them a place to root and grow that is close to the air. In order to maximise the edge effect, ponds should have wavy shorelines of bays and promontories, and a shalving shore rather than a quick drop from dry land to deep water.

BULRUSHES - and similar plants, such as reeds, reedmace and water lilies all have edible parts (usually starchy roots or tubers that can complement the protein from fish) and can outyield land-based plants. Reedbeds, in the UK climate produce more biomass than any other ecosystem.

PIGS - Pigs can also make use of edible water plants and love 'edges' to wallow in.

USEFUL CONNECTION (WHEATFIELD) - If left into the field after harvest, chickens will eat up the ears of grain missed during harvesting. The chickens are making use of a resource that would otherwise go to waste.

SUPPLEMENTARY FEEDING - may be needed at some times of the year, but a well-designed system will keep this to a minimum.

THE CHICKEN FORAGE SYSTEM - makes use of perennial plants (which require little or no maintenance once established) such as trees and shrubs, to grow food for the chickens where they live. Chickens can eat things that humans cannot, thus converting a diverse number of things to useful food. No transport is involved and the food simply falls down to the chickens. No harvesting is necessary. The chickens do it for you. The chicken forage system exhibits the permaculture principle of good **relative placement** for **useful connections**.

HEAT TRANSFER - During cold winter mornings, heat from the south-facing greenhouse helps to keep the chicken house warm. Conversely, during the night, body heat from the chickens helps to keep the greenhouse warm, supporting plant growth without avoiding the need for paraffin or gas heaters.

CO₂ / O₂ TRANSFER - Carbon dioxide exhaled by the chickens can be used in photosynthesis by the plants in the greenhouse. Oxygen produced during photosynthesis can be breathed by the chickens.

FALSE ACACIA TREE - As well as being highly decorative, the false acacia tree yields seeds for chicken forage, flowers for bee forage, leaves for pig forage, timber that is durable without the need for preservatives and increased soil fertility through nitrogen fixing.

MANURE TO FOOD - By positioning the chicken house above the pond, productivity of the pond can be increased. It's really just the same as manuring a field, but there is less work involved and the potential return is greater than if it was spread on land.

USING WATER - A body of water can produce ten times the amount of protein, in the form of fish, as the same area of grazing land in the form of sheep or cattle. A carefully chosen selection of different kinds of fish, each making use of a different kind of food, can make full use of the diverse natural food supplies available in the pond: plant and animal plankton, vegetation, small animals (such as snails) and even the rich detritus at the bottom of the pond.

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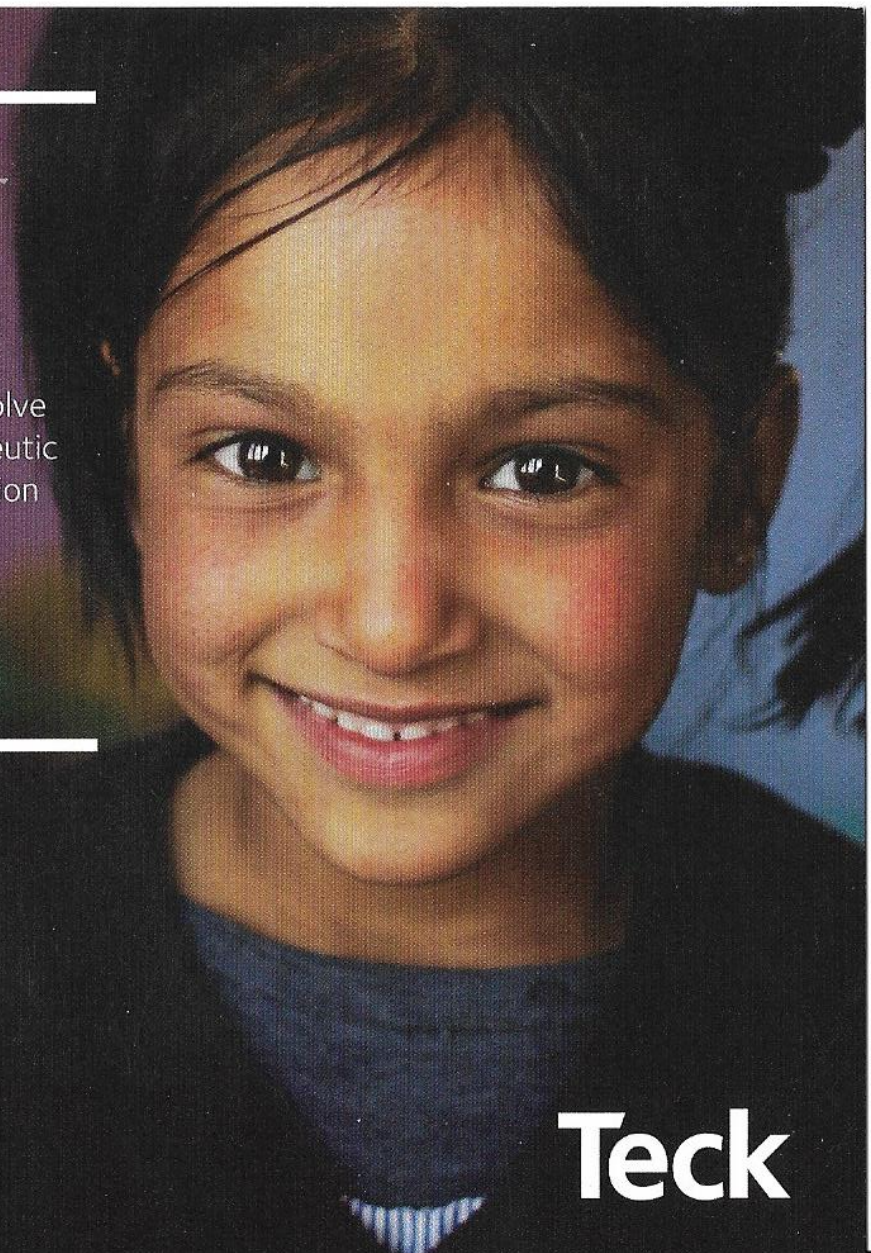
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As a major zinc producer, Teck is committed to helping solve the global health issue of zinc deficiency through therapeutic zinc, zinc supplementation, food fortification, crop nutrition and awareness and advocacy. To date, our program has reached more than 140 million people worldwide.

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NM EPSCOR OPPORTUNITIES

- Strategic metals, Cu,V, Co
- Uranium transport and site remediation
- Social and natural science network
- Sustainability

