Appendix F- Design Criteria and Procedures

F.1 Design Criteria

F.2 Radium In-House Testing Procedures (USEPA)

F.1 Design Criteria

PROJECT NO: 10034 SPEC. NO.: _____

FOR: _____

DESCRIPTION	NAME	DISCIPLINE	SIGNATURE	DATE:
PREPARED BY:	Daniel Trump	PROCESS ENGINEER		
PRIME REVIEW BY:		METALLURGIST		
TECH. REVIEW BY:		METALLURGIST		
TECH. REVIEW BY:				
APPROVED. BY:		PROJECT MANAGER		
CLIENT APPROVAL BY:				

REVISION DESCRIPTION	SECTION OR PAGES	REV NO.	REV. BY	APPROVALS			DATE
				Lyntek	Client	Check	
ISSUED FOR REVIEW		A	DAT	RCS		RCS	8/31/2010
ISSUED FOR CONSTRUCTION							

COMMENTS:

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SECTION Page

SOURCE CODE:

A = CRITERIA PROVIDED BY OWNER
B = PUBLISHED INFORMATION
C = ENGINEER RECOMMENDATION
D = VENDOR ORIGINATED CRITERIA
E = CRITERIA FROM PROCESS CALCULATIONS
F = ENGINEERING HANDBOOK DATA
G = ASSUMED DATA
H = METALLURGICAL LABORATORY TEST RESULT
J = SIMILAR PROJECT INFORMATION

NOMENCLATURE USED IN THIS REPORT:

Universal:

° =	Angular degree
AMSL =	Above mean sea level
atm =	Atmosphere
cP =	Centipoise
d =	Day
D.E. =	Diatomaceous earth
dia =	Diameter
FPR =	Fiberglass
h =	Hour
Hz =	Hertz
µ =	Micron
M =	Million
min =	Minute
N/A =	Not Available
NTU =	Nephelometric Turbidity Unit
P_{80} =	80% Passing
P_{100} =	100% Passing
P.D. =	Positive displacement
ppm =	Parts per million
s =	Second
S.G. =	Specific Gravity
TBD =	To Be Determined
wt% =	Weight Percent
y =	Year

Imperial:

Btu =	British Thermal Unit
cfm =	Cubic Feet per Minute
°F =	Degree Fahrenheit
ft =	feet
ft^2 =	Square feet
ft^3 =	Cubic feet
gal =	Gallons
gpm =	Gallons per minute
gph =	Gallons per hour
lb =	Pounds
HP =	Horsepower
in =	Inch
in/Hg =	Inches of Mercury
MGD =	Million gallons per day
mph =	Miles per hour
oz/y =	Ounces per Year
psia =	Pounds per square inch absolute
td =	Dry tons
tw =	Wet tons

td/h or tw/h = Dry or Wet tons per hour
td/d or tw/d = Dry or Wet tons per day
td/y or tw/y = Dry or Wet tons per year

1.0 GENERAL

1.1 Site Location

The Roca Honda uranium property, McKinley County, New Mexico, totals approximately 1,840 acres and consists of 63 unpatented mining claims totaling approximately 1,200 acres and an adjoining New Mexico State General Mining lease totaling 640 acres. The property is located in the Grants Mineral Belt in northwest New Mexico and the mining claims comprise Sections 9, 10, and the New Mexico State Lease consists of Section 16, all in Township 13 North – Range 8 West (T13N-R8W), New Mexico Principal Meridian in the east part of the Ambrosia Lake District.

1.2 Site Conditions

Site Conditions	Criteria	Source
Site Elevation		
Maximum, ft	7,300	G
Minimum, ft	7,000	G
Mean, ft	7,150	G
Barometric Pressure		
Site Average, mmHg	_	_
Temperature		
Average Daily Max Temperature, °F	100	G
Average Daily Min Temperature, °F	25	G
Precipitation		
Average Yearly Precipitation, in	_	_
Rainy Season	_	_
Maximum, 24 hr, in	2.75	B
Evaporation Rate		
Relative Humidity (Rainy Season), %	_	_
Average Yearly Evaporation rate, in	_	_
Structural Design Criteria		
International Building Code (IBC) 2006		_
Occupancy Category II: All structures except as noted. Occupancy Category III: Structures containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released.		
Minimum Design Loads for Buildings and Other Structures (_)		_

Mine Safety & Health Administration (MSHA)

Seismic Information

Site Class	B	G
IBC/ASCE 7 Seismic Design Category	B	G
IBC/ASCE 7 Design Acceleration Parameter S_{DS} =	0.232	B
IBC/ASCE 7 Design Acceleration Parameter S_{D1} =	0.065	B

Wind Velocity

Prevailing Direction, Annual	NW	B
Maximum 3-second Gust, mi/hr	90	B

Mechanical Design

US System _

Electrical Design

National Electric Code (NEC)
National Fire Protection Association (NPFA)
NFPA 70-2008 National Electric Code (NEC)
NFPA 780-2000 Standard for the Installation of Lightning Protection Systems
National Electrical Manufacturers Association (NEMA)
American National Standards Institute (ANSI)
Illuminating Engineering Society of North America (IESNA)
Institute of Electrical and Electronic Engineers (IEEE)

2.0 PROCESS DESIGN

2.1 General Design

Days Operating per Week	7	G
Shifts per Day	3	G
Hours per Shift	8	G
Plant Flow, gpm	8,000	A
Pond Sizing Capacity, gpm	4,000	A
Process Water Temp, ºF	158	A/J
Process Water pH	6.5-8.0	J
Radium Feed Concentration, pCi/L	63	A
Radium Discharge Limit, pCi/L	15	B
Uranium Feed Concentration, mg/L	_	A/J
Uranium Discharge Limit, mg/L	0.03	B
Water Quality Standards	NMAC 20.3	_

2.2 Plant Design

2.2.1 Ion Exchange Columns

Flow Total, gpm	8,000	A
Flow, gpm/ft^2	10	C
Diameter, ft	12	C
# of Columns	8	C
Column Vessel Material, MOC	Carbon Steel	C
Column Vessel Lining, MOC	NA	C
Column Internals, MOC	Stainless Steel	C

2.3 Barium Chloride Mixing Circuit

2.3.1 Barium Chloride Mix Tanks

Barium Chloride Concentration, wt%	10%	C
Capacity, gal	1,376	C
Barium Chloride Capacity, lb	1,344	C
Slurry Density, SG	1.17	C
Tank Material, MOC	Carbon Steel	C
Agitated (Side Mounted)	Yes	C
Number of Tanks	2	C
Barium Chloride Dosing, mg/L	15	C
Operating Time Per Tank, hr	20.6	C

2.4 Reaction Tanks

Diameter, ft	20	C
Height, ft	25	C
Freeboard, ft	3	C
Working Volume, gal	54,192	C
Retention Time, min total	13.5	C
Retention Time, min per tank	6.8	C
Barium Chloride Dosing, mg/l	15	C
Barium Chloride Feed Rate, gpm	1.5	C
Barium Chloride Feed Concentration, wt%	10	C

2.4.1 Overflow Tank

Diameter, ft	12	C
Height, ft	20	C
Freeboard, ft	3	C
Working Volume, gal	12,700	C
Retention Time, min	1.6	C

2.5 Pressure Leaf Filters

Total Flow capacity, gpm	8,000	C
Number of Filter Vessels, ea	3 (one standby)	C
Filter Area Per Tank, ft^2	2,685	D
Total Filter Area, ft^2	8,055	D
Pressure Leaf Filter Length, ft	37	D
Pressure Leaf Filter Width, ft	12.1	D
Filter Vessel Material, MOC	Carbon Steel	C
Filter Internals Material, MOC	Stainless Steel	D

2.5.1 Pressure Leaf Filter DE Pre-Coat System

Tank Diameter, ft	8	C
Tank Height, ft	10	C
Tank Working Volume, gal	3,007	C
DE Solids % for Pre-Coat	5%	C

2.6 Settling Ponds

Number of Ponds, ea	2	C
Flow, gpm	4,000	A
Retention Time, hr	2	C
Capacity per pond, gal	480,000	C
Capacity per pond, acre feet	1.47	C
Pond Depth, ft	7	C

2.7 Discharge Holding Ponds

Number of Ponds, ea	2	C
Flow, gpm	4,000	A
Retention Time per pond, hr	1.2	C
Capacity per pond, gal	288,000	C
Capacity per pond, acre feet	0.88	C
Pond Depth, ft	7	C

2.8 Sludge Ponds

Capacity per pond, gal	275,000	C
Capacity per pond, acre feet	0.84	C
Pond Depth, ft	7	C

3.0 CONTROL PHILOSOPHY

Plant will be a combination of manual controls with automatic integrated controls where appropriate to prevent leaks or spills, and determine proper Reagent usage where applicable.

3.1 Plant Feed Area (100 Area)

	Function
Level Element	Prevent Settling Pond Overflow

3.2 Plant IX Columns Area (200 Area)

	Function
Level Element	Determine resin levels in columns

3.3 Reaction Tank Area (300 Area)

	Function
Level Element	Prevent Overflow Tank Overflow
Flow Meter	Determine Barium addition
	Determine pumping rate
	Determine DE body feed rate

3.4 Leaf Filter Area (400 Area)

	Function
Level Element	Indicate level in DE mix tank
Pressure Indicate	Determines leaf filter cleaning

3.5 Sludge and Discharge Pond Area (500 Area)

	Function
Level Element	Prevent Overflow Tank Overflow

F.2 Radium In-House Testing Procedures (USEPA)

7500- RA D Sequential Precipitation Method for Radium 226 and Radium 228 in Drinking Water

Scope and Application

This technique is devised so that the beta activity from actinium-228, the daughter product of radium-228 which is produced by decay of radium-228, can be determined and related to the radium-228 that is present in the sample. To quantify actinium-228 the efficiency of the beta counter for measuring actinium-228 is to be calibrated with a beta source of comparable average beta energy. Radium-226 can be determined by alpha counting the $BaSO_4$ final precipitate.

Principle of Method

The radium in the drinking water sample is collected by coprecipitation with barium and lead sulfate, and purified by reprecipitation from EDTA solution. Both radium-226 and radium-228 are collected in this manner. After a 6 to 36-hour ingrowth period, actinium-228 is carried on yttrium oxalate, purified and beta counted. The radium-226 is precipitated as a sulfate and then alpha counted.

Sample Handling and Preservation

It is recommended that samples be preserved at the time of collection by adding enough 1N HNO_3 to the sample to bring it to pH 2. If samples are to be collected without preservation, they should be brought to the laboratory within 5 days, then preserved and held in the original container for a minimum of 16 hours before analysis or transfer of the sample.

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Reagents

Acetic Acid, $HC_2H_3O_2$: 17.4 N (glacial)

Ammonium hydroxide, NH_4OH: 15 N (conc.)

Ammonium oxalate, $(NH_4)_2C_2O_4$-H_2O: 5 %

Ammonium sulfate, $(NH_4)_2SO_4$: 200 mg/ml

Ammonium sulfide, $(NH_4)_2S$: 2 %

Barium carrier: 16 mg/ml

Citric acid, $C_6H_8O_7$-H_2O: 1 M

EDTA reagent: 0.25 M

Indicator, methyl orange: 0.1 %

Lead carriers: 1.5 mg/ml

Nitric acid, HNO_3: 16 N (conc.), 6 N, 1 N

Sodium hydroxide, NaOH: 18 N, 10 N, 1 N

Strontium carrier: 20 mg/ml

Strontium-yttrium mixed carrier: 0.9 mg/ml Sr^{+2}-0.9 mg/ml Y^{+3}

Sulfuric acid, H_2SO_4: 18 N

Yttrium carrier: 18 mg/ml, 9 mg/ml

Procedure

1. For each liter of drinking water, add 5 ml 1 M $C_6H_8O_7$-H_2O and a few drops methyl orange indicator The solution should be red (Note 1).
2. Add 2.0 ml barium carrier (16 mg/ml), stir well. Heat to incipient boiling and maintain at this temperature for 30 minutes.
3. Add 15 N NH_4OH until a definite yellow color (pH 7) is obtained, then add a few drops excess. Precipitate lead and barium sulfates by adding 18 N H_2SO_4 until the red color (pH 1-1.5) reappears, then add 0.25 ml excess. Add 5 ml $(NH_4)_2SO_4$ (200 mg/ml) for each liter of sample. Stir frequently and keep at a temperature of about 90C for 30 minutes. Alternatively, cool and let settle overnight; aspirate supernatant and transfer precipitate to a 40 ml centrifuge tube; wash twice with 10 ml di-water; continue with step 6.
4. Cool slightly, then filter with suction through a 47-mm metricel membrane filter (GA-6, 0.45 um-pore size). Make a quantitative transfer of precipitate to the filter by rinsing last particles out of beaker with a strong jet of water. Alternatively,
5. Carefully place filter with precipitate in the bottom of a 250 ml beaker. Add about 10 ml 16 N HNO_3 and heat gently until the filter completely dissolves. Transfer the precipitate with the aid of more 16 N HNO_3 into a polypropylene centrifuge tube. Centrifuge and discard supernatant.
6. Wash the precipitate with 15 ml 16 N HNO_3, centrifuge, and discard supernatant.
7. Repeat step 6.
8. Add 25 ml basic EDTA reagent, heat in a hot water bath, and stir well. Add a few drops 10 N NaOH if the precipitate does not readily dissolve.

9. Add 1 ml strontium-yttrium mixed carrier and stir thoroughly. Add a few drops 10 N NaOH if any precipitate forms.
10. Add 1 ml $(NH_4)_2SO_4$ (200 mg/ml) and stir thoroughly. Add 17.4 N CH_3COOH until barium sulfate precipitates, then add 2 ml excess. Digest in a hot water bath until precipitate settles. Centrifuge and discard supernatant.
11. Add 20 ml basic EDTA reagent, heat in a hot water bath, and stir until precipitate dissolves. Repeat steps 9 and 10. Note time of last barium sulfate precipitation; this is the beginning of the actinium-228 ingrowth time. ***May be eliminated if water is evaluated for Y-90 interference and potential excess calcium.***
12. Dissolve the precipitate in 20 ml basic EDTA reagent as before, then add 1 ml yttrium carrier (9 mg/ml) and 1 ml lead carrier (1.5 mg/ml). If any precipitate forms, dissolve by adding a few drops 10 N NaOH. Cap the polypropylene tube and age at **6 to 36** hours.
13. Add 0.3 ml $(NH_4)_2S$ and stir well. Add 10 N NaOH dropwise with vigorous stirring until lead sulfide precipitates, then add 10 drops excess. Stir intermittently for about 10 minutes. Centrifuge and decant supernatant into a clean tube.
14. Add 1 ml lead carrier (1.5 mg/ml), 0.1 ml $(NH_4)_2S$, and a few drops 10 N NaOH. Repeat precipitation of lead sulfide as before. Centrifuge and filter supernatant through Whatman #42 filter paper into a clean tube. Wash filter with a few ml water. Discard residue.
15. Add 5 ml 18 N NaOH (make at least 2 normal in OH^-). Stir well and digest in a hot water bath until yttrium hydroxide coagulates. Centrifuge and decant supernatant into a beaker. Cover beaker and save supernatant for $BaSO_4$ recovery steps 20-22. Note time of yttrium hydroxide precipitation: this is the end of the actinium-228 ingrowth time and beginning of actinium-228 decay time.
16. Dissolve the precipitate in 2 ml 6 N HNO_3. Heat and stir in a hot water bath about 5 minutes. Add 5 ml water and reprecipitate yttrium hydroxide with 3 ml 10 N NaOH. Heat and stir in a hot water bath until precipitate coagulates. Centrifuge and discard supernatant.
17. Dissolve precipitate with 1-3 ml 1 N HNO_3 plus 2 or 3 drops 6 N HNO_3 and heat in hot water bath a few minutes. Dilute to 5 ml and add 2 ml 5 % $(NH_4)_2C_2O_4$-H_2O.

Using pH paper verify that the solution is slightly acid. Heat to coagulate, centrifuge and discard supernatant.

18. Add 10 ml water, 6 drops 1 N HNO_3 and 6 drops 5 % $(NH_4)_2C_2O_4$-H_2O. Heat and stir in a hot water bath a few minutes. Using pH paper verify that the solution is slightly acid. Centrifuge and discard supernatant.
19. Transfer quantitatively to a tared stainless-steel planchet with a minimum amount of water. Dry under an infra-red lamp to a constant weight and count in a low-background beta counter. (Note 2).
20. To the supernatant from step 15, add 4 ml 16 N HNO_3 and 2 ml $(NH_4)_2SO_4$ (200 mg/ml), stirring well after each addition. Add 17.4 N CH_3COOH until barium sulfate precipitates, then add 2 ml excess. Digest on a hot plate until precipitate settles. Centrifuge and discard supernatant.
21. Wash precipitate twice with 10 ml water. Centrifuge and discard supernatant.
22. Collect the precipitate on a tared membrane filter (Gelman Suport-450, 47mm diameter, 0.45 μm pore size). Dry and mount on a 2 in. stainless steel planchet. Count in low background alpha/beta proportional counter.

Reagent Preparation

1. Acetic acid. CH_3COOH, 17.4 N: This is the concentrated (glacial) reagent: sp.gr. 1.06, 99.5 %
2. Ammonium hydroxide, NH_4OH, 15 N: This is the concentrated reagent; sp. gr. 0.9, 50 %
3. Ammonium oxalate, $(NH_4)_2C_2O_4$-H_20, 5 %: Dissolve 25 grams $(NH_4)_2C_2O_4$ in water and dilute to 500 ml.
4. Ammonium sulfate, $(NH_4)_2SO_4$, 200 mg/ml: Dissolve 20 grams $(NH_4)_2SO_4$ in a minimum of water and dilute to 100 ml.
5. Ammonium sulfide. $(NH_4)_2S$ 2 %: Dilute 10 ml $(NH_4)_2S$, (20-24 %). to 100 ml with water.
6. Citric acid 1 M: Dissolve 19.2 grams $C_6H_8O_7$ in water and dilute to 100 ml.
7. EDTA reagent. 0.25 M: Dissolve 20 grams NaOH in about 750 ml water, heat, and slowly add 93 grams $Na_2C_{10}H_{14}O_8N_2$-$2H_2O$ (disodium ethylenedinitriloacetate dehydrate) while stirring. After the salt is in solution, filter through coarse filter paper and dilute to 1 liter.
8. Indicator, methyl orange, 0.1 %: Dissolve 0.1 grams methyl orange indicator in 100 ml water.
9. Nitric acid, HNO_3. 16 N: This is the concentrated reagent, sp.gr. 1.42, 70 %. 6 N: cautiously add 395 ml 16 N HNO_3 to 600 ml water and dilute to 1 liter. 1 N: Add 62 ml 16 N HNO_3 to 900 ml water and dilute to 1 liter.
10. Sodium hydroxide, NaOH, 18 N: Dissolve 720 grams NaOH in 500 ml water and dilute to 1 liter. 10 N: Dissolve 400 grams NaOH in 500 ml water and dilute to 1 liter. 1 N: Dilute 100 ml 10 N NaOH to 1 liter with water.
11. Sulfuric acid, H_2SO_4, 18 N: cautiously add with stirring, 500 ml 36 N H_2SO_4 (this is concentrated H_2SO_4) to 400 ml water and dilute to 1 liter.

Carriers

1. Ba^{+2} - 16 mg/ml. Dissolve 2.846 grams $BaCl_2$-$2H_2O$ in water, add 0.5 ml 16 N HNO_3, and dilute to 1000 ml with water.
2. Pb^{+2}- 15 mg/ml. Dissolve 2.397 grams $Pb(NO_3)_2$ in water, add 0.5 ml 16 N HNO_3, and dilute to 100 ml with water. Pb^{+2} - 1.5 mg/ml. Dilute 10.0 ml $Pb(NO_3)_2$ (15 mg/ml) to 100 ml with water.
2. Y^{+3} 18 mg/ml. Add 22.85 grams Y_2O_3 to an Erlenmeyer flask containing 20 ml water. Heat to boiling and continue stirring with a magnetic stirring hoe plate while adding 16 N HNO_3 in small amount. Usually about 30 ml 16 N HNO_3 is necessary to dissolve the Y_2O_3. Small additions of water may be required to replace that lost by evaporation. After total dissolution add 70 ml 16 N HNO_3 and dilute to 1 liter with water. Y^{+3} 9 mg/ml. Dilute quantitatively 50 ml Y^{+3} carrier 18 mg/ml with 50 ml water.
4. Sr^{+2} - Y^{+3} (mixed carrier) - (0.9 mg/ml Sr+2 and - 0.9 mg/ml Y^{+3}).

   Solution A - Dilute 10.0 ml yttrium carrier Y^{+3} (18 mg/ml) to 100 ml.

   Solution B - Dissolve 0.4348 grams $Sr(NO_3)_2$ in water and dilute to 100 ml.

   Combine Solutions A and B, and label.
5. Sr^{+2} - 20 mg/ml: Dissolve 48.3 gm $Sr(NO_3)_2$ in 900 ml water. Add 1 ml 16 N HNO_3.

Calculation

Calculate Ac-228 ingrowth = $1- e^{-\lambda t}$

Calculate the concentration, D of Ra-228 in picocuries per liter as follows:

$$D = \frac{C}{2.22 \times EVR} \times \frac{\lambda t_2}{\left(1 - e^{-\lambda t_2}\right)} \times \frac{1}{\left(1 - e^{\lambda t_3}\right)} \times \frac{1}{e^{-\lambda t_1}}$$

where:

C = average net count rate, count/minute,

E = counter efficiency, for Ac-228

V = liters of sample used,

R = fractional chemical yield of yttrium carrier (step 19) multiplied by fractional chemical yield of barium carrier (step 25),

2.22 = conversion factor from disintegrations/minute to picocuries,

l = the decay constant for Ac-228 (0.001884/min)

t_1 = the time interval (in minutes) between the first yttrium hydroxide precipitation in step 15 and the start of the counting time,

t_2 = the time interval of counting in minutes, and

t_3 = the ingrowth time of Ac-228 in minutes measured from the last barium sulfate precipitation in step 11 to first yttrium hydroxide precipitation in step 15.

$\left(1 - e^{-\lambda t_2}\right)$ is a factor to correct the average count rate to count rate at beginning of counting time.

$$\text{radium 226, pCi/L} = \frac{\text{Net CPM}}{2.22 \times \text{abcde}}$$

A = ingrowth factor from table below

Ingrowth hours	Alpha Activity from 226Ra
0	1.000
1	1.016
2	1.036
3	1.058
4	1.080
5	1.102
6	1.124
24	1.489
48	1.905
72	2.253

b = efficiency factor for alpha counting.

c = self-absorption factor.
d = chemical yield, and
e = sample volume, L.

Notes:

At the time of sample collection add 4 ml 16 N HNO_3 for each gallon of water.

References

Krieger H.L.; Whittaker E.L. Prescribed Procedures for the Measurement of Radioactivity in Drinking Water: EPA-600/4-80-032, pp. 49-57, Aug. 1980.

Standard Methods for the Examination of Water and Wastewater 20th Edition 1998