SECTION 3.0

DESCRIPTION OF PROPOSED FACILITY

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3.0 DESCRIPTION OF PROPOSED FACILITY

The proposed Crow Butte in situ leach (ISL) facility is designed to process an average of 2500 gallons per minute (gpm) of leach solution. The 2500 gpm does not include the restoration flow. The facility will utilize state-of-the-art unit operations to recover uranium from the recovered leach solutions. These unit operations will consist of ion exchange (IX), uranium elution, uranium precipitation, uranium dewatering, and uranium drying. The Crow Butte process flowsheet is shown in Figure 3.1-1.

3.1 Solution Mining Process and Equipment

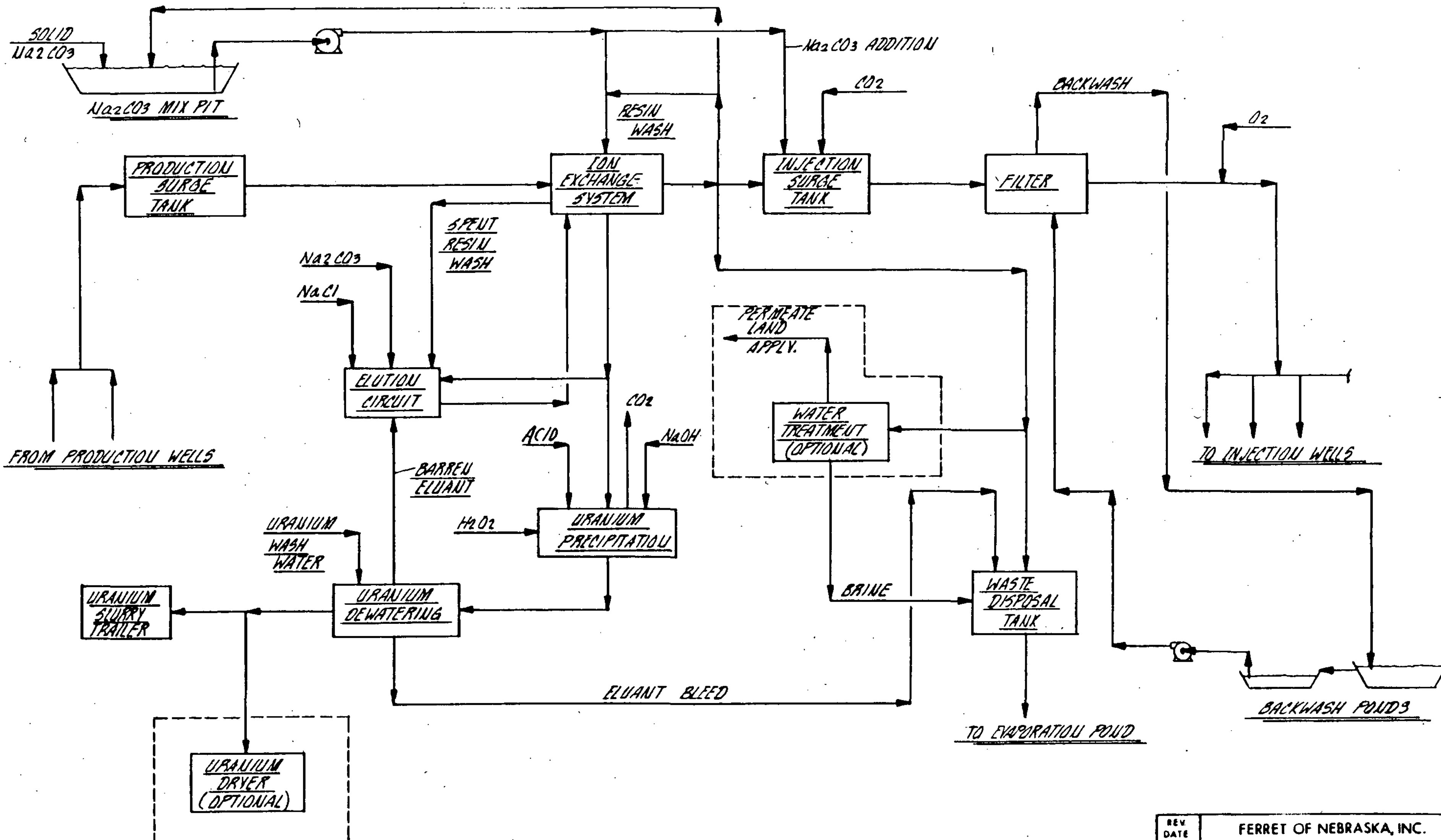
3.1.1 Ore Body

The ore body is in the Basal Chadron Sandstone at a depth which ranges from 400 to 800 feet. The overall width of mineralization in this area ranges from 1000 ft. to 5000 ft. The Basal Chadron Sandstone in the area is approximately 40 ft. A detailed description of the geology is found in Section 2.6, Geology.

3.1.2 Well Construction and Integrity Testing

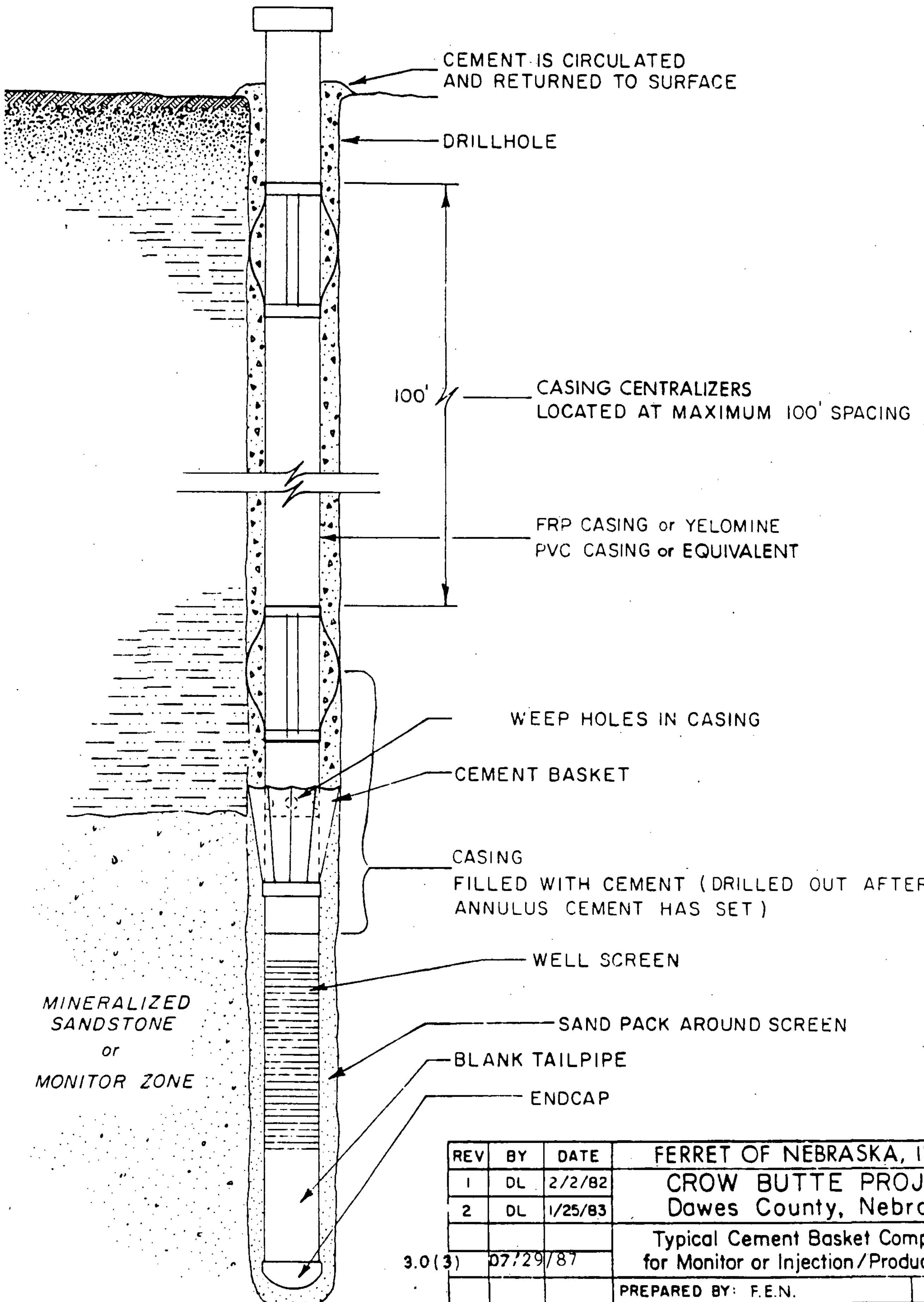
Two well construction methods and appropriate casing materials will be used for the well construction and installation of production and injection wells. The well construction methods are not necessarily described in the order of their preferred use. Either of these methods could be used for monitor wells.

Method No. 1, Figure 3.1-2 involves the setting of an integral casing/ screen string. The method consists of drilling a hole, geophysically logging the hole to define the desired screen interval, and reaming the hole if necessary to the desired depth and diameter. Next, a string of casing with the desired length of screen attached to the lower end is



REV. DATE	FERRET OF NEBRASKA, INC.	
	CROW BUTTE PROJECT Dawes County, Nebraska	
	PROCESS FLOWSHEET	
	PREPARED BY: F.E.N.	
	DWN. BY: R. S. DATE: 7/31/87	FIGURE 3.1-1

WELL COMPLETION METHOD No. I



REV	BY	DATE	FERRET OF NEBRASKA, INC.
1	DL	2/2/82	CROW BUTTE PROJECT
2	DL	1/25/83	Dawes County, Nebraska
3.0(3)	07/29/87		Typical Cement Basket Completion for Monitor or Injection/Production Wells
			PREPARED BY: F.E.N.
			DWN BY: JC — DATE: 8/87

FIG. 3.1-2

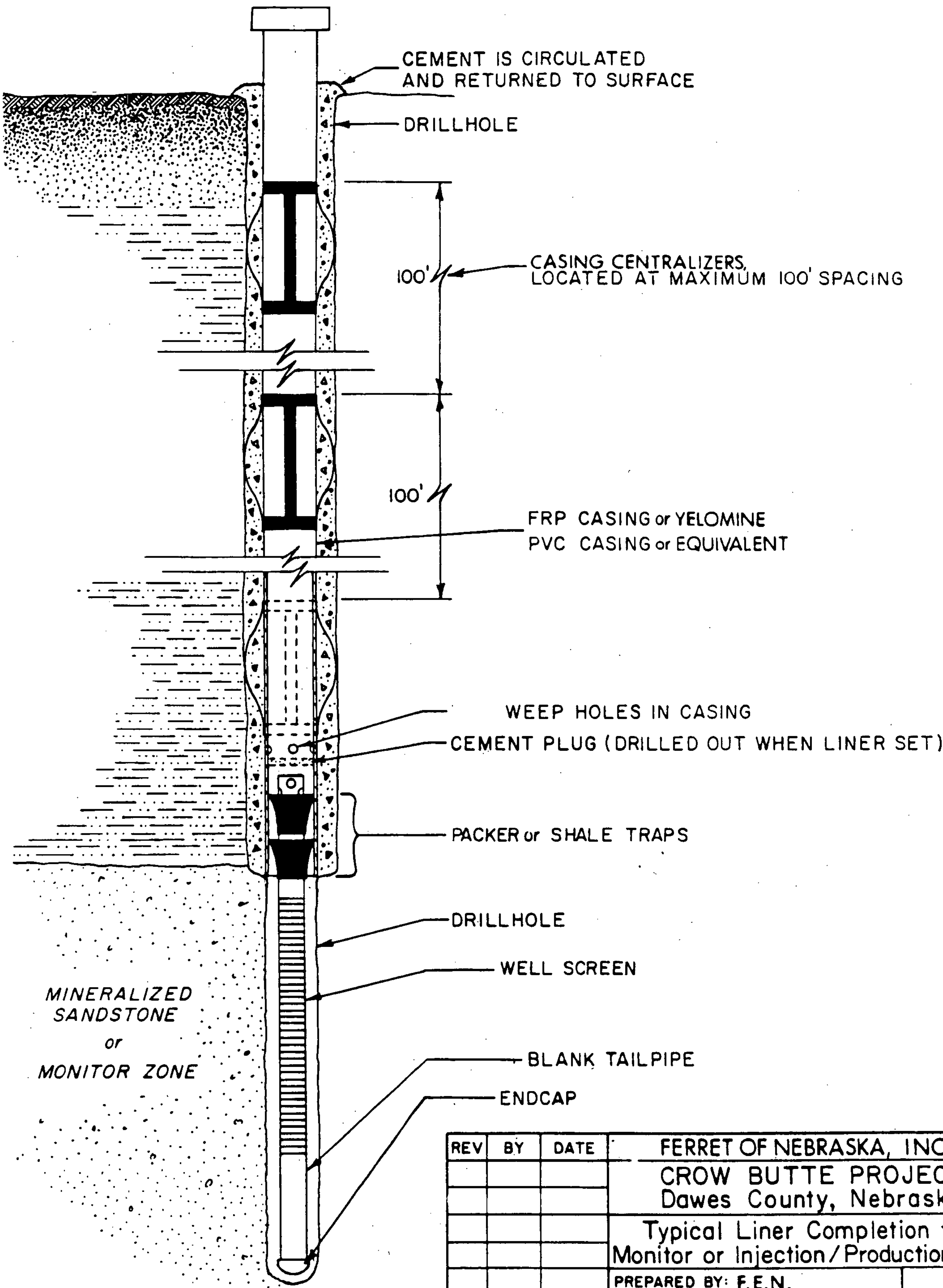
placed in the hole. A cement basket is attached to the blank casing just above the screen to prevent blinding of the screen interval during cementing. The cement is then pumped down the inside of the casing to a plug set just below the cement basket. The cement passes out through weep holes in the casing and is directed by the cement basket back to the surface through the annulus between the casing and the drill hole. After the cement has cured sufficiently, the residual cement and plug are drilled out, and the well is developed by air lifting or pumping.

Method No. 2, shown in Figure 3.1-3 uses a screen telescoped down inside the cemented casing. As in the first method, a hole is drilled and geophysically logged to locate the desired screen interval. The hole is then reamed if necessary only to the top of the desired screen interval. Next a string of casing with a plug at the lower end and weep holes just above the plug is set in the hole. Cement is then pumped down the casing and out the weep holes and goes back to the surface through the annulus. After the cement has cured, the residual cement in the casing and the plug are drilled out and the drilling continues through the desired zone. The screen with a packer and/or shale traps is then telescoped through the casing and set in the desired interval. The packer and/or shale traps serve to hold the screen in the desired position while acting as a fluid seal. Well development is again accomplished by air lifting or pumping. Minor variations from these procedures may be used as conditions require.

A well completion report will be filled out for each well. The completion report form as provided by NDEC is shown in Figure 3.1-4. These data will be kept available on site for review.

Prior to leach solution injection, field testing of injection and recovery wells will be performed to demonstrate the mechanical integrity of the well casing. This testing will be performed using pressure-packer tests. The mechanical integrity tests will use the following procedure:

WELL COMPLETION METHOD No. 2



REV	BY	DATE	
			FERRET OF NEBRASKA, INC.
			CROW BUTTE PROJECT Dawes County, Nebraska
			Typical Liner Completion for Monitor or Injection/Production Wells
			PREPARED BY: F.E.N.
			DWN BY: J.C. — DATE: 8/87 — FIG. 3.1-3

NEBRASKA DEPARTMENT OF ENVIRONMENTAL CONTROL

FOR AGENCY USE

APPLICATION NUMBER

WELL COMPLETION REPORT

Company: ______ Project: ______

Type of Well: Production/Injection ____ Monitor ____ Well No.: ______

Ground Elevation: ______ Well Head Elevation: ______

Drilling Contractor: ______

Driller: ______

Mud Products: ______

Amount: ______

Bit Size: ______ Date Drilling Began: ______

Date Drilling Completed: ______ Depth Drilled: ______

Completed Formation: ______

Casing Diameter: ______ Casing Type: ______

Casing Depth: ______ Basket Depth: ______

Packer Type: ______ Packer Depth: ______

Centralizer Depth(s): ______

Screen Size: ______ Gravel Size: ______

Screened Interval(s): ______

Upper boundary of Completed Formation: ______

Lower boundary of Completed Formation: ______

Cement Contractor: ______ Operator: ______

Estimated Cement Volume: ______ Cement Volume, used: ______

Cement Weight: ______ Water Amount: ______

Cement Type or Class: ______ Additives: ______

Cement Circulated to Surface: Yes ____ No ____ Density of Fluid: ______

Logging Contractor: ______

Operator: ______

Unit No.: ______ Probe No.: ______

Log Type: ______

Well Deviation: ______

White-Yellow: DEC Pink: Your records

1. The well will be tested after the cement plug at the bottom of the of the casing has been drilled out. The test consists of placement of one or two packers within the casing. The bottom packer will be set just above the well screen and the upper packer if used will be set at the wellhead. Alternatively a well cap can be used at the wellhead. The bottom packer will be inflated and the casing will be pressurized to a value which simulates the maximum anticipated operating pressure plus an engineering safety factor.

2. The well will then be "closed in" and the pressure observed for a minimum of 20 minutes.

3. If more than 10% of the pressure is lost during this period, the well will be deemed unacceptable for use as an injection well.

An alternate method of integrity testing an operational well may be used. The alternate method would involve installing a well cap and pressurizing the well with air to force the water column down the casing to a level where air pressure will be at a minimum equal to the maximum operating pressure plus an engineering safety factor. After the well is presurized the well will be sealed and the pressure monitored for 10 minutes. If more than 10% of the pressure is lost during this period the well will be deemed unacceptable for use as an injection well.

When possible, the well will be repaired and the integrity tests will be repeated. If the well casing leakage cannot be repaired or corrected, the well will be plugged and reclaimed as described in Section 6.0, Groundwater Quality Restoration, Surface Reclamation and Plant Decommissioning of this application.

FEN will have available on site the results of all mechanical integrity tests for regulatory review. An example form is included as Figure 3.1-5. FEN will test all injection and recovery wells for mechanical integrity.

3.1.3 Wellfield Operation

The proposed mine schedule for the Crow Butte Project is shown in Table 3.1-1. This mine schedule covers the first ten years of the project. Mine schedules for later years will be submitted one year prior to the proposed mining. A map showing the proposed mine plan is found as Figure 3.1-6. A typical wellfield layout is shown in Figure 3.1-7. The wellfield is a repeated 5 spot design, the spacing between injection wells will range from 40 to 100 ft.

Piping from the plant building to the wellfield building and from the wellfield building to the individual wells will be buried below the frost line. Either high density polyethylene or PVC pipe will be used for the underground service. At the wells, pitless adapters will be used to eliminate any above ground piping. All underground piping will be leak tested prior to use. Figure 3.1-8 shows details of the piping connections between the wells and the main manifolds.

Monitor wells will be placed in the Chadron sand. In addition to the Chadron sand, monitor wells will also be placed in the first significant water bearing Brule sand above the Chadron sand. All monitor wells will be completed and developed prior to leach solution injection.

Computations have indicated the minimum pressure that could initiate hydraulic fraction will be 0.63 psi/ft of well depth. The injection pressure will be limited to less than 0.63 psi/ft of well depth to prevent fracturing the formation. The 0.63 psi/ft. of well depth limit provides a factor of safety to avoid fracturing the formation at the depths and peizometric surfaces encountered in the vicinity of the wellfield. Injection pressures will not exceed the pressure at which the well was integrity tested, less safety factor.

CASING INTEGRITY TEST REPORT FORM

WELL NO ________ DATE ____________

WELLFIELD ________________________

CASING TYPE ______________________ DIAMETER ____________

TOTAL DEPTH __________________ TOP OF SCREEN ____________

TEST PACKER(S) DEPTH ________________ TEST DURATION ________

COMMENTS ____

TIME	ELAPSED TIME (MIN)	PRESSURE (psig)		TIME	ELAPSED TIME (MIN)	PRESSURE (psig)	

TEST PERFORMED BY: ____________

3.0(9) 07/29/87 DATE: ________

FIGURE 3.1-5

TABLE 3.1-1

CROW BUTTE PROJECT

MINE SCHEDULE

Years No.	Mining Flow (GPM)	Restoration Flow (GPM)	Average Area Being Mined (Acres)	Average Area Being Restored (Acres)	Average Area Being Reclaimed (Acres)
1	1250	0	11.25	0	0
2	1250	0	11.25	0	0
3	2500	0	22.5	0	0
4	2500	400	22.5	22.5	0
5	2500	400	22.5	22.5	22.5
6	2500	400	22.5	22.5	22.5
7	2500	400	22.5	22.5	22.5
8	2500	400	22.5	22.5	22.5
9	2500	400	22.5	22.5	22.5
10	2500	400	22.5	22.5	22.5
11-20+	2500	400	22.5	22.5	22.5
+1 yr.	0	400	0	22.5	22.5
+2 yrs.	0	400	0	22.5	22.5
+3 yrs.	0	0	0	0	22.5 Site Decommissioning

THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:
FIGURE NO.: 3.1-6, "PROPOSED MINE SCHEDULE YEARS 1-10"

WITHIN THIS PACKAGE... OR, BY SEARCHING USING THE DOCUMENT/REPORT FIGURE NO.: 3.1-6

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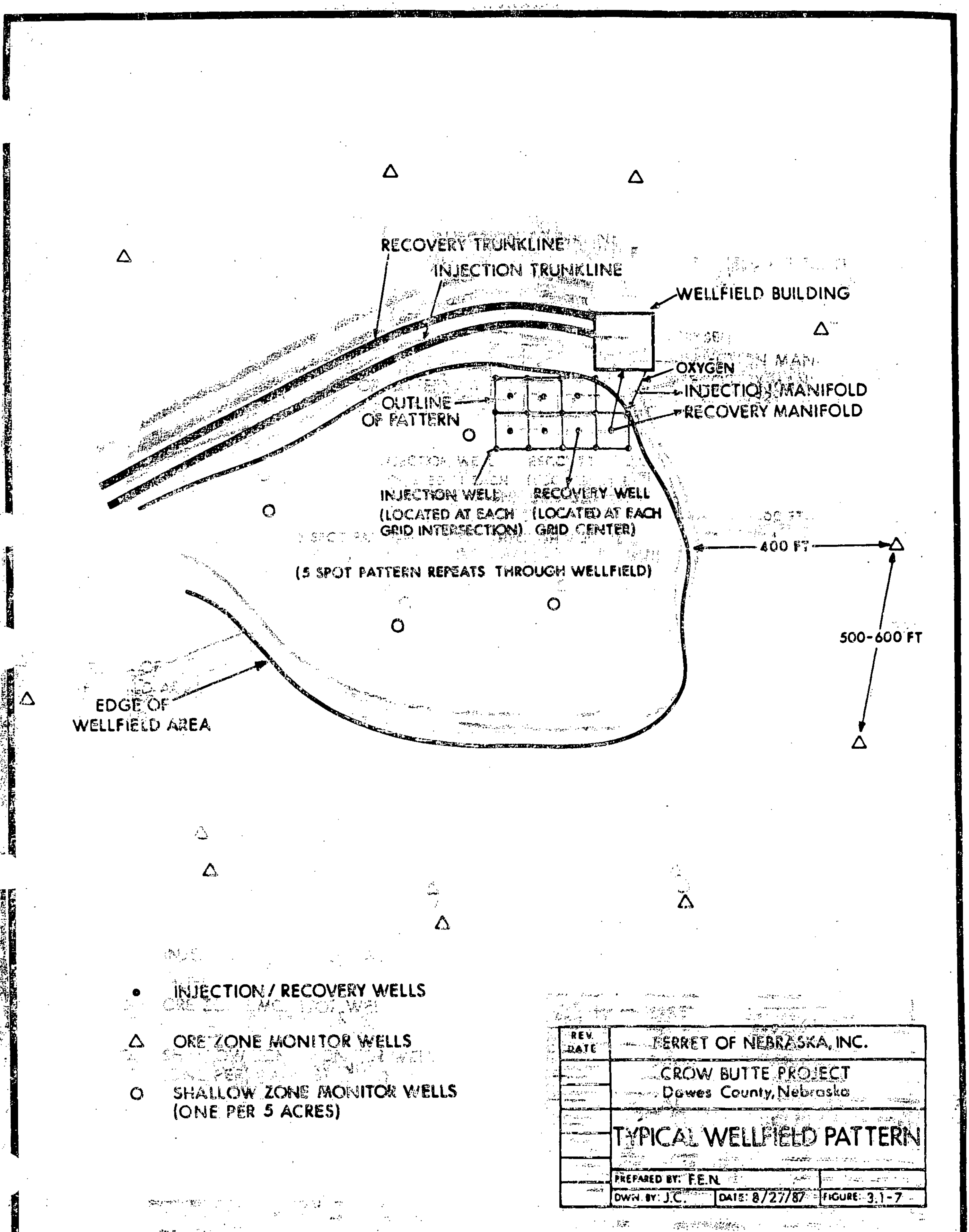
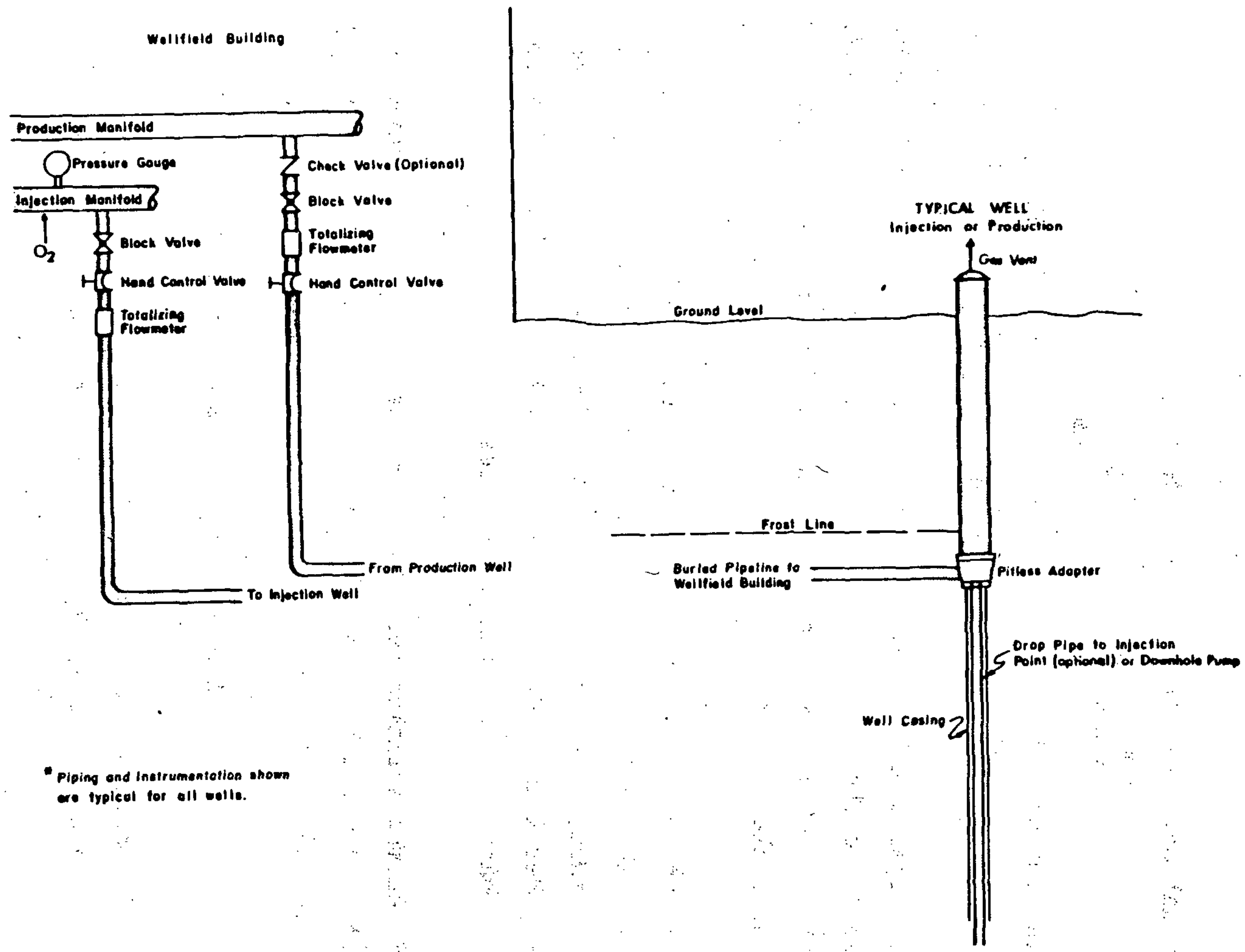

RECOVERY TRUNKLINE
INJECTION TRUNKLINE
WELLFIELD BUILDING
OXYGEN
INJECTION MANIFOLD
RECOVERY MANIFOLD
OUTLINE OF PATTERN
INJECTION WELL (LOCATED AT EACH GRID INTERSECTION)
RECOVERY WELL (LOCATED AT EACH GRID CENTER)
(5 SPOT PATTERN REPEATS THROUGH WELLFIELD)
400 FT
500-600 FT
EDGE OF WELLFIELD AREA
INJECTION / RECOVERY WELLS
ORE ZONE MONITOR WELLS
SHALLOW ZONE MONITOR WELLS (ONE PER 5 ACRES)
REV. DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
TYPICAL WELLFIELD PATTERN
PREPARED BY: F.E.N.
DWN. BY: J.C.
DATE: 8/27/87
FIGURE: 3.1-7



* Piping and instrumentation shown are typical for all wells.

REV. DATE	
	FERRET OF NEBRASKA, INC.
	CROW BUTTE PROJECT Dawes County, Nebraska
	SURFACE AND SUBSURFACE SYSTEM DETAILS
	PREPARED BY: F.E.N.
	DWN. BY: JC — DATE: 7/31/87 — FIGURE: 3.1-8

3.0(13) 07/29/87

3.1.4 Uranium Recovery Process

Sodium and carbonate species along with an oxidizer (oxygen or hydrogen peroxide) will be added to the formation water for dissolution of uranium.

Uranium dissolution is a process involving an oxidation step and a dissolution step. The reactions representing these steps at a neutral pH are:

Oxidation: $UO_2 + H_2O_2 \text{ ---> } UO_3 + H_2O$

$UO_2 + 1/2O_2 \text{ ---> } UO_3$
(solid) (in solution) (at solid surface)

Dissolution: $UO_3 + 2\ HCO_3^{-1} \text{ ---> } UO_2(CO_3)_2^{-2} + H_2O$

$UO_3 + CO_3^{=} + 2HCO_3^{-1} \text{ ---> } UO_2(CO_3)_3^{-4} + H_2O$

The principal uranyl carbonate complex ions formed as illustrated above, are uranyl dicarbonate, $(UO_2)(CO_3)_2^{-2}$ (UDC), and uranyl tricarbonate $(UO_2)(CO_3)_3^{-4}$, (UTC). The relative abundance of each is a function of pH and total carbonate strength.

In addition to the complexing agent, sodium bicarbonate, an oxidant is added to the injection solution to carry out the oxidation reaction shown above. Although several oxidants could be used, the common choices are hydrogen peroxide (H_2O_2) or gaseous oxygen (O_2). Both of these oxidants revert to naturally occurring substances.

Uranium bearing solution resulting from the leaching of uranium underground will be recovered and the uranium will be extracted in the processing plant. The plant process will utilize the following steps:

a. Loading of uranium complexes onto an ion exchange resin;

b. Reconstitution of the leach solution by addition of sodium bicarbonate, pH adjustment with CO_2, and addition of oxygen;

c. Elution of uranium complexes from the resin using a sodium chloride/sodium bicarbonate eluant;

d. Precipitation of uranium using H_2O_2 and necessary pH adjustment.

The process flow sheet for the above steps is shown in Figure 3.1-1. The anticipated process plant layout is shown in Figure 3.1-9. The plant will be designed to operate at an average capacity of 2500 gallons per minute. Because of operational considerations at times, the flow will be in excess of 2500 gpm and at times below 2500 gpm but the nominal annual average is 2500 gpm.

The process flow sheet and plant layout as shown are based upon preliminary engineering data. If during detail design and equipment selection more suitable equipment is identified and purchased, the details of the layout may change; however, the general process will remain the same. The effluents will remain approximately the same and the space requirements will be approximately as shown.

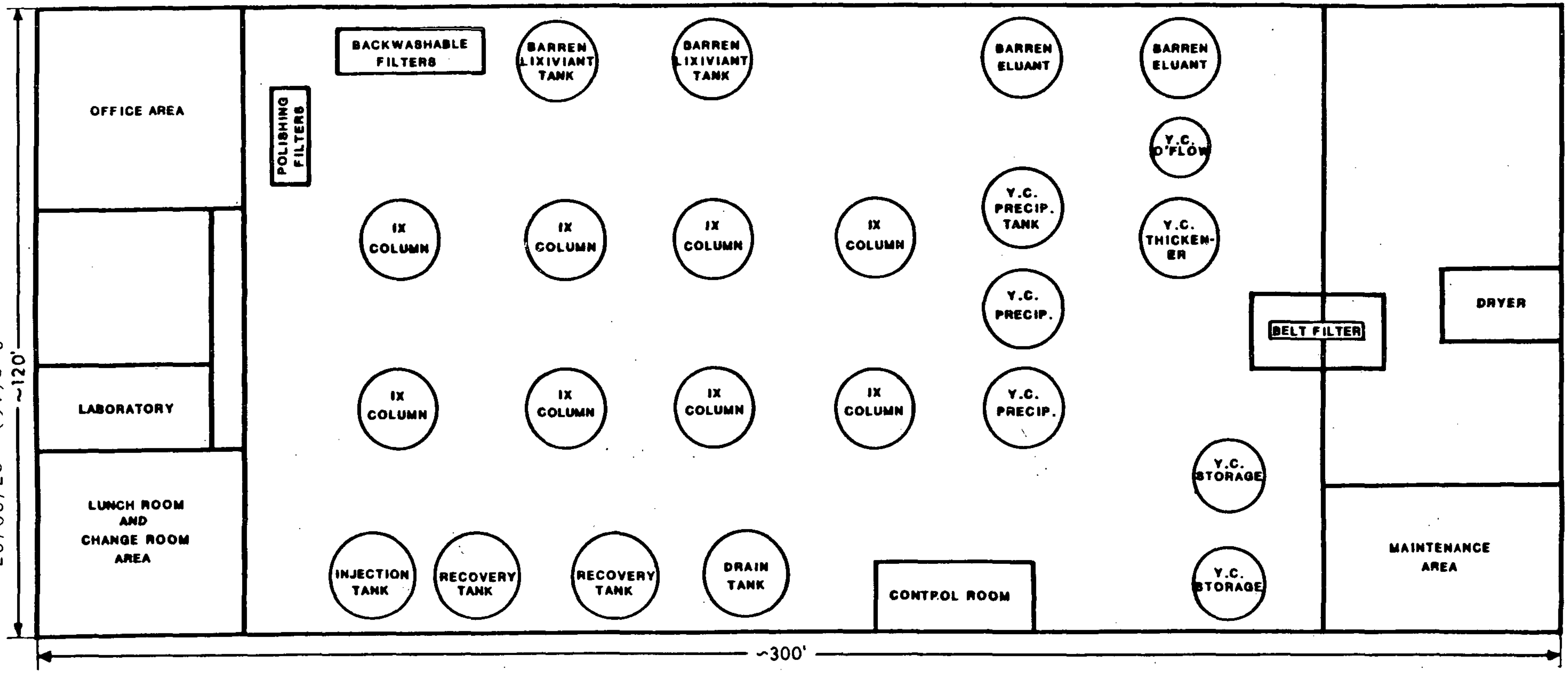
Recovery of uranium will take place in the ion exchange columns. The uranium bearing leach solution will enter the column and as it passes through, the uranium complexes in solution will be loaded onto the IX resin in the column. The loading process is represented by the following chemical reaction.

$$2\ R\,HCO_3 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$

$$2\ RCl + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2Cl^-$$

$$R_2SO_4 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$$

As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride, bicarbonate or sulfate ions.



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REV. DATE	FERRET OF NEBRASKA, INC.		
	CROW BUTTE PROJECT Dawes County, Nebraska		
	PLANT LAYOUT		
	PREPARED BY: C. SCHICK		
	DWN. BY: JC	DATE: 7/31/87	FIGURE: 3.1-9

The now-barren leach solution passes to a barren lixiviant surge tank. At this point the solution is refortified with sodium and carbonate chemicals as required and pumped to the wellfield for reinjection into the formation. The expected lixiviant concentration and composition is shown in Table 3.1-2.

Once the majority of ion exchange sites on the resin in an IX column are filled with uranium, that column is taken off stream. The loaded resin is then stripped of uranium in place through an elution process based on the following chemical reaction:

$$R_2UO_2(CO_3)_2 + 2Cl^- + CO_3^{=} \text{ ---> } 2\ RCl + UO_2(CO_3)_2^{-2}$$

During the elution process, the first half of the pregnant eluate will be transferred to the precipitation tank. The second half of the eluant volume, which is lower in uranium content, will be stored in the intermediate eluant storage tank to be used on the first half of the next elution cycle.

After the uranium has been stripped from the resin, the resin will be rinsed with a solution containing sodium bicarbonate. This rinse removes the high chloride eluant physically entrained in the resin and partially converts the resin to bicarbonate form. In this way, chloride ion buildup in the leach solution can be controlled.

When a sufficient volume of pregnant eluant is held in storage it is acidified to destroy the uranyl carbonate complex ion. The solution is agitated to assist in removal of the resulting CO_2. The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \text{ ---> } UO_2^{++} + 3\ CO_2\uparrow + 3H_2O$$

Hydrogen peroxide is then added to the solution to precipitate the uranium according to the following reaction:

TABLE 3.1-2

TYPICAL LIXIVIANT CONCENTRATION AND COMPOSITION

SPECIES	RANGE	
	LOW	HIGH
Na	$\leq$ 400	6000
Ca	$\leq$ 20	500
Mg	$\leq$ 3	100
K	$\leq$ 15	300
CO_3	$\leq$ 0.5	2500
HCO_3	$\leq$ 400	5000
Cl	$\leq$ 200	5000
SO_4	$\leq$ 400	5000
U_3O_8	$\leq$ 0.01	500
V_2O_5	$\leq$ 0.01	100
TDS	$\leq$1650	12000
pH	6.5	10.5

* All values in mg/l except pH.

$$UO_2^{++} + H_2O_2 + 2H_2O \longrightarrow UO_4 \cdot 2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry is pH adjusted, allowed to settle, and the clear solution decanted. The decant solution is either recirculated back to the barren eluant storage tank or sent to waste. The thickened uranyl peroxide is further dewatered and washed using a vacuum belt filter or equivalent. The solids discharge is either sent to the dryer for drying before shipping or is sent to storage for shipment as a slurry to a licensed milling or converting facility.

3.1.5 Process Wastes

The operation of the process plant results in two primary sources of liquid waste. They are (1) eluant bleed, and (2) production bleed.

All these waste streams are routed to water treatment or the evaporation ponds. The anticipated composition and flowrates of the liquid waste streams are shown in Table 3.1-3. A water and material balance diagram for the process plant including the waste streams are shown in Figure 3.1-10.

3.2 Recovery Plant Equipment

The proposed plant facilities and process equipment will be housed in a building approximately 300 feet long by 120 feet wide. This will include office and laboratory space. The proposed facility layout is shown in Figure 3.1-9.

The recovery plant equipment can be placed in one of the following unit operations: lixiviant recovery, ion exchange, filtration, lixiviant injection, elution/precipitation and dewatering/drying. All these unit operations are tied together to comprise the recovery plant.

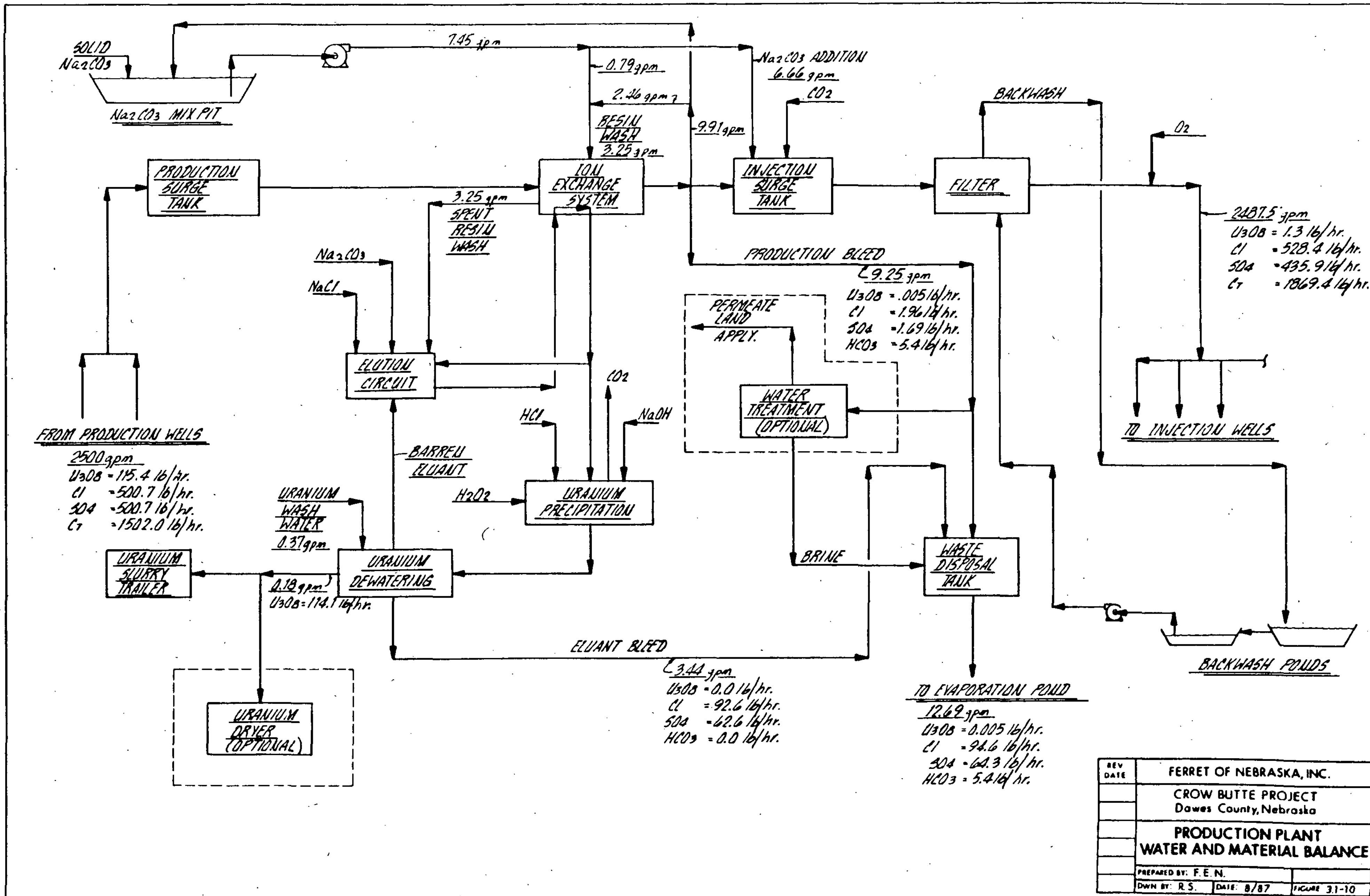
The lixiviant recovery system consists of recovery surge tanks and ion exchange feed pumps. The surge tanks are fiberglass reinforced plastic (FRP) construction and the pumps are centrifugal type.

TABLE 3.1-3

ESTIMATED WASTE VOLUMES AND COMPOSITIONS

(Mg/l except as noted)

Parameter	Production Bleed	Eluant Bleed
Flowrate (GPM)	9.25	3.44
U_3O_8	0.2 to 50	0.2 to 100
Cl^-	200 to 3000	20,000 to 75,000
$SO_4^=$	500 to 5000	1,000 to 40,000
$CO_{3(T)}$	350 to 5000	10 to 1,000
Na	50 to 6000	20,000 to 75,000
Ca	20 to 1000	10 to 500


SOLID Na_2CO_3
Na_2CO_3 MIX PIT
7.45 gpm
0.79 gpm
2.26 gpm
9.91 gpm
Na_2CO_3 ADDITION 6.66 gpm
CO_2
RESIN WASH 3.25 gpm
PRODUCTION SURGE TANK
ION EXCHANGE SYSTEM
3.25 gpm SPENT RESIN WASH
INJECTION SURGE TANK
BACKWASH
FILTER
O_2
2487.5 gpm
U_3O_8 = 1.3 lb/hr.
Cl = 528.4 lb/hr.
SO_4 = 435.9 lb/hr.
C_T = 1869.4 lb/hr.
PRODUCTION BLEED
9.25 gpm
U_3O_8 = .005 lb/hr.
Cl = 1.96 lb/hr.
SO_4 = 1.69 lb/hr.
HCO_3 = 5.4 lb/hr.
Na_2CO_3
NaCl
ELUTION CIRCUIT
PERMEATE LAND APPLY.
WATER TREATMENT (OPTIONAL)
TO INJECTION WELLS
CO_2
HCl
NaOH
FROM PRODUCTION WELLS
2500 gpm
U_3O_8 = 115.4 lb/hr.
Cl = 500.7 lb/hr.
SO_4 = 500.7 lb/hr.
C_T = 1502.0 lb/hr.
BARREN ELUANT
URANIUM WASH WATER 0.37 gpm
H_2O_2
URANIUM PRECIPITATION
BRINE
WASTE DISPOSAL TANK
URANIUM SLURRY TRAILER
URANIUM DEWATERING
0.18 gpm
U_3O_8 = 114.1 lb/hr.
ELUANT BLEED
3.44 gpm
U_3O_8 = 0.0 lb/hr.
Cl = 92.6 lb/hr.
SO_4 = 62.6 lb/hr.
HCO_3 = 0.0 lb/hr.
URANIUM DRYER (OPTIONAL)
TO EVAPORATION POND
12.69 gpm
U_3O_8 = 0.005 lb/hr.
Cl = 94.6 lb/hr.
SO_4 = 64.3 lb/hr.
HCO_3 = 5.4 lb/hr.
BACKWASH PONDS
REV DATE
FERRET OF NEBRASKA, INC.
CROW BUTTE PROJECT
Dawes County, Nebraska
PRODUCTION PLANT
WATER AND MATERIAL BALANCE
PREPARED BY: F.E.N.
DWN BY: R.S.
DATE: 8/87
FIGURE 3.1-10

The ion exchange system consists of two sets of four (4) columns. These four columns are operated in a carousel configuration. The columns are constructed out of FRP and operate in an upflow, fluidized bed manner. The resin will be eluted and rinsed in place. The uranium loading process is continuous but the elution process is operated on a batch basis.

The injection filtration system will consist of backwashable filters with the option of installing polishing filters downstream of the backwashable filters. The backwash system will be operated on a closed loop circuit - meaning the backwash water would be collected and reused for backwashing.

The lixiviant injection system will consist of the injection surge tanks and the injection pumps. The tanks will be fabricated out of FRP and the injection pumps will be centrifugal type.

The elution/precipitation circuit will consist of the barren eluant tanks and the acidizer/precipitator tanks. The barren eluant tanks and the precipitator tanks are fabricated out of FRP. The eluant is pumped from the barren eluant tanks to the ion exchange column which is in the elution mode. After the resin is eluted the pregnant eluant is transferred to the acidizer/precipitator where the uranium is precipitated.

The precipitated uranium (yellowcake) is dewatered and washed using a vacuum belt filter or equivalent. The yellowcake can then be either shipped as a slurry for drying or converting at a licensed facility, or it will be dried on site by a vacuum dryer. A vacuum dryer vent is sealed by passing the resultant water vapors and particulates through a liquid filled chamber and the environmental impacts are minimized.

A discussion of the areas in the proposed plant layout where fumes or gases could be generated can be found in Section 7.3. The production solution surge tank is a possible source of radon and CO_2 gases and vents to the atmosphere by a turbine ventilator or fan. Other process tanks are similarly vented for radon and CO_2 removal. Building ventilation in the process equipment area is accomplished by the use of an exhaust system. This exhaust system draws fresh air in from ventilators and help to sweep radon, which accumulates near the floor of the building, out to the atmosphere.

3.3 Instrumentation

Wellfield instrumentation is provided to measure total production and injection flow. In addition, instrumentation is provided to indicate the maximum pressure which is being applied to the injection wells. Instrumentation is calibrated on a schedule that is consistent with good operating practice.

In the plant, instrumentation is provided to monitor the total flow into the plant, the total injection flow leaving the plant and the total waste flow leaving the plant. Instrumentation is provided on the injection manifold to record an alarm in the event of any pressure loss that might indicate a leak or rupture in the injection system. The injection pumps are sized or equipped so that they are incapable of producing pressures high enough to exceed the design pressure of the injection lines or the maximum pressure to be applied to the injection wells.

Other instrumentation such as pressure gauges, pH indicators, and flow indicators are provided at various places in the process where required.