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Design Criteria for the 100-K Expansion Pump and Treat

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Richland, Washington

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Fluor Hanford, Inc.

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WMP-30899

DESIGN CRITERIA

FOR THE

100-K EXPANSION PUMP AND TREAT

REVISION 0

ISSUED 9/12/07

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1.0 INTRODUCTION

1.1 BACKGROUND

This project is to expand one of the pump and treat systems at Hanford for removing hexavalent chromium from the groundwater. Low concentrations of hexavalent chromium are toxic to aquatic life in the Columbia River.

During the years of reactor operations at Hanford, hexavalent chromium was used as a corrosion inhibitor in the reactor cooling water systems. Large volumes of reactor coolant water containing hexavalent chromium were directed to retention basins for subsequent discharge to the Columbia River through outfall pipelines. Liquid wastes, containing significant quantities of hexavalent chromium from reactor operations, were also discharged to soil column at cribs, trenches, and French drains.

In numerous reactor operations areas, significant amounts of the hexavalent chromium have been migrating into the groundwater, creating detectable plumes of contamination. Meanwhile, the groundwater is slowly and naturally migrating to the river, carrying the hexavalent chromium with it.

Treatment systems have been in service removing chromium from groundwater at 100-H and 100-K Areas for approximately ten years in response to the 1996 interim action Record of Decision. Each of these 'pump and treat' facilities extracts water from wells along the edge of the plume nearest the river, removes the chromium, and pumps the treated water back into injection wells further upstream in the plume with the objective of reducing the groundwater contamination to <22 ppb hexavalent chromium.

The existing 100-K/KR-4 system operates on a plume east of the 100-K Area reactor site. Shrinkage of this plume is to be accelerated.

Existing KR-4 expansion buildings (1606KA, 1607KA and 1608K) are sized to accommodate the required KR-4 system expansion, therefore are not addressed in this document.

This project shall use design criteria similar to that used at KR-4, but upgraded to address specific improvements Ten years of operating experience have optimized the treatment process and plume shrinkage, and pump and treat systems design has evolved to ease maintenance, improve electrical safety, and eliminate certain operational nuisances.

Two of the more significant design refinements since the KR-4 facility construction have been:

- introduction of acid to control calcite scaling
- effective and simple control of the distribution of treated water among numerous injection wells

1.2 FACILITY TYPE

Type: Non-Radiological
Category: General Service

1.3 SCOPE, MISSION, AND PERFORMANCE SUMMARY

The goal of this expansion project is to accelerate the shrinkage of the KR-4 operable unit in seven years of operation.

This facility will use a standard commercial ion exchange water treatment process using Dowex 21 resin. This resin is in use at three existing facilities

The expansion shall be physically independent of the existing KR-4 facility. Infrastructure (communication links between the two facilities) shall be installed that will allow future operation of the existing KR-4 facility and the K-Expansion facility from the K-Expansion facility control room.

The design treatment flow for the expansion is 300 gallons per minute (gpm) maximum flow using three ion-exchange (IX) trains rated at 100 gpm each, with an expansion capacity of up to six total trains.

Hexavalent chromium is the only constituent requiring removal. Although there is no requirement for the removal of co-contaminants, monitoring and sampling is required for final remedy selection.

A means shall be provided for stream and waste sampling to be done during operation to detect any potential accumulation of unexpected contaminants. Radiological constituents of concern associated with the KR-4 pump and treat systems operation area are in very low concentrations, therefore, no radiological controls are addressed in this functional design. Experience shows that radiological concerns can be addressed using operational controls.

Details of interim and final remedial actions extend beyond the scope of this project, and may be found in the reference documentation, Section 6.

Items not covered in the scope of this project include:

- The K-East hexavalent chromium plume near the KE reactor area,
- Re-alignment of the existing KR-4 facility's extraction and injection wells.

1.4 SITE LOCATION

The existing treatment site is located along the Columbia River between the 100-K and the 100-N reactor sites. Treatment system capability will be expanded upstream, along, and downstream, of the mile long trench. The line of wells will extend for approximately 1.5 miles from end to end, and up to 500 yards inland from the shore.

1.5 PROJECT INTERFACES

Technical planning and control of this project, its functional design requirements, budget appropriation and changes, schedule milestones, and project performance requirements are the responsibility and authority of the Soil and Groundwater Remediation Project (SGRP), 100 Areas Project Manager.

Items used in construction that require longer lead times for procurement than afforded by the construction schedule shall be identified by design engineering for procurement in advance by Fluor Hanford, and identified in the construction package as provided by owner. The three ion exchange (IX) column trains have been procured and are currently located in building 1608KA.

The SGRP design engineers shall provide engineering oversight throughout construction, including approval of submittals and quality assurance inspections, acceptance criteria, resolution of non conformance, interpretations of design media, design clarifications and changes.

Operation and maintenance of the KR-4 expansion are the responsibility and authority of the SGRP, Operations Manager.

Normal interface with the controlling organization is expected.

Electrical Utilities interface include review of the electrical utilities design and possible supply of long lead utility equipment.

The extraction and injection lines are routed above ground over a large area. Routine interface with Washington Closure Hanford will be required to ensure conflicts with land use are identified and mitigated.

The plume-capture design may place wells, process systems or communications lines inside the 100-K Area, requiring coordination with 100-K Area operations.

1.6 ANTICIPATED DESIGN / CONSTRUCTION SCHEDULE

The treatment facility expansion is to be construction completed by August 8, 2008 and acceptance tested by September 15, 2008. Operational testing (OTP) and facility commissioning will commence after acceptance testing is completed and the facility turned over to Operations.

1.7 METHOD OF PERFORMANCE

Design, procurement, and construction shall be the responsibility of a SGRP dedicated project team, augmented by additional Fluor Hanford design and construction resources as needed to draft the required contract documentation (drawings, specifications, quality assurance plans, test plans, statements of work) and oversee procurement and construction.

The primary contract for procurement and construction will be by bids from pre-qualified general contractors. This method of performance shall be confirmed by a Plant Forces Work Review (PFWR).

2.0 FUNCTIONS

2.1 PROCESS/PRODUCTION RATES, CHEMICAL END STATES, AND NATURAL PHENOMENA SURVIVAL REQUIREMENTS

The production capacity of the expansion will be 300 gpm peak. Actual rates of flow may vary with extraction and injection well capacities, plume capture strategy and hydrological characteristics.

The design will be scalable up to 600 gpm peak capacity, by adding more components of the same initial design and ease of expandability of the system included in the design. Where practicable, future components shall be shown on the drawings in shadow form or labeled as "Future."

When sulfuric acid is being used to moderate scaling, the treated injection stream shall be no lower than a pH of 5.5.

2.2 OPERATIONAL EFFECTIVENESS REQUIREMENTS AND AVAILABILITY

The expected Cr+6 concentration is 200 ppb or less at the extraction wells. The re-injection operating limit will be 10 ppb in order to meet the RDR/RAWP design limit of 20 ppb at the compliance wells. The interim ROD action level (EPA, 1996) for exceeding Cr+6 concentration in the effluent water is 50 ppb.

Plume shrinkage may require a succession of re-alignment of process systems to different physical well locations, imposing design requirements for flexibility, ease of extraction and injection systems relocation.

KR-4 expansion facility will operate twenty-four hours per day, seven days per week, unattended after startup and stabilization, in automatic mode excepting during routine surveillance and operation cycles, effluent sampling, and maintenance.

The expected facility operational availability will be 95 percent, as measured by the amount of time the system is processing ground water through the IX trains, divided by the amount of time the system was neither undergoing planned maintenance nor debilitated by events beyond control of SGRP – utility power outages, range fires, etc.

2.3 PREFERRED TECHNOLOGY AND JUSTIFICATION

The treatment system to be expanded is a standard commercial ion exchange water treatment process using Dowex 21 resin based on experience gained at the KR-4 and HR-3 treatment systems. This was the preferred ion exchange technology identified in the interim action ROD (EPA,1996).

Water will be extracted from the ground near the river, treated to remove hexavalent chromium, then re-injected up-gradient from the extraction sites, as a continuous process.

In compliance with DOE Order 430.1A, which requires efficient use of energy resources, energy efficient lighting and adjustable frequency drives shall be standard equipment.

2.4. SAFETY

The workspace is to be planned for accessibility to equipment for the most safe and economical operation and maintenance of the treatment system.

Process control signal circuits shall be less than 50 volts and separated from higher voltages.

An OSHA compliant eyewash and safety shower are required for acid handling activities.

2.5. UNIQUE ENVIRONMENTAL PROTECTION REQUIREMENTS

Piping and utility routes shall minimize disruption, interference or disturbance of:

1. wildlife and habitat
2. cultural resources
3. waste sites undergoing or planned for remediation

The 100-KR-4 is located in a culturally-resource sensitive area. Therefore, cultural resources shall be addressed in accordance with the cultural resource mitigation plan

All piping shall be visible for routine leak surveillance.

2.6. MATERIALS OF CONSTRUCTION AND PROTECTIVE COATINGS

See Section 4, 'Design Criteria'

2.7. WASTE ACCEPTANCE CRITERIA

Waste material shall be handled, stored, and disposed in accordance with the HR-3/KR-4 Waste Management Plan (Interim Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units-DOE/RL97-01), FH waste management procedures and the waste packaging/ labeling instructions (WP/LIS) to be provided by the assigned Waste Management Specialist.

2.8. IDENTIFICATION OF STUDIES, ANALYSES, AND OTHER REPORTS THAT MUST BE PREPARED AS PART OF THE PROJECT

Any disturbance of the KR-4 grounds requires approval via an Ecological/Cultural Resource Review. This includes all forms of vehicular or pedestrian traffic, parking areas and equipment lay down yards, any other workspaces, all piping and utilities corridors, well drilling pads and access roads, fencing and postings, equipment racks, barricades, and any other installations or disturbances to the grounds.

Since this system is based on successful experience gained from similar Hanford facilities, the only additional technical analysis required is site specific evaluation of hydrogeologic conditions that will allow cleanup of the plume within seven years. This activity shall be performed by SGRP Geosciences and will result in definition of well locations and measured well production rates. However, this data will not be available to the design team during the design activity. The well locations and expected production rates have been provided to engineering by the SGRP 100 Areas Project Manager as follows:

EXTRACTION WELLS	COORDINATES		GPM
199-K-161	148202.13	570004.43	30
199-K-147	148558.14	570411.58	50
199-K-130 (EXISTING)	148661.20	570479.00	60
199-K-148	148768.00	570585.00	50
199-K-131	148903.90	570662.00	30
199-K-149 (EXISTING)	148970.30	570778.60	20
INJECTION WELLS			
199-K-159	149160.00	570912.00	75
199-K-160	149120.00	570930.00	75
199-K-154	148027.64	570320.67	75
199-K-155	147950.01	570230.01	75

This data may change when the actual well data is developed.

2.9. UNIQUE TESTING AND INSPECTION REQUIREMENTS

No unique testing will be required.

During acceptance testing:

- Ion exchange vessels shall be loaded with Dowex 21 resin,
- All pumps shall be energized,

- All flows including injection shall be activated during the ATP using actual groundwater,
- The treatment system leak tested by an "in-service leak test" inspection per ASME B31.3
- The control system shall be stabilized during construction and prior to operational commissioning (OTP).
- Leak testing of the extraction and injection transport piping systems shall be an in-service inspection per ASME B31.3.

2.10. CHEMICAL STORAGE

Space shall be planned for chemical storage cabinets.

The process system shall use sulfuric acid. Maximum quantity in the facility at any time must not exceed fifty gallons. An eye wash station and safety shower shall be provided located adjacent to the sulfuric acid work station.

2.11. DESIGN LIFE.

The nominal design life is ten years.

The pump and treat portion of the interim remedial action shall continue until the selection of a final remedy or until EPA and Ecology are satisfied that termination (or intermittent operation) is appropriate.

2.12. SPECIAL OPERATION AND MAINTENANCE REQUIREMENTS, E.G., REMOTE

The system design shall be limited to commercial standard equipment and systems.

Off-normal process conditions shall be annunciated using an auto-dialer.

Process controls shall include remote monitoring using a generic browser with dial-up, and with High-speed Digital Subscriber Line (HDSL) circuits to MO234 and to the existing KR4 facility.

3.0 PROJECT INPUTS

3.1 EXISTING SSC'S AND DESIGN BASELINES TO BE MODIFIED

Electrical utilities and communications shall be required. Design standards and service loads for these utilities shall be coordinated with their respective utility organizations.

Communications for remote monitoring of the new treatment system shall be connected into the existing communications network linking 200E/MO-234, 100K/KWest, 100H/HR-3 and 100N/NR-2. Remote monitoring communications network shall be extended to the existing KR-4 facility system thus allowing for remote monitoring at MO-234. This will also allow for future operational control of the KR-4 facility from the K Expansion control room.

3.2 EXISTING FEASIBILITY STUDIES, REPORTS, AND CONCEPTUAL DESIGN

The RDR/RAWP shall be updated (2007 Supplement) as part of this project to address the treatment system expansion.

A detailed white paper on acid injection affects on calcification and flows thru the IX trains was completed in early 2000 that has significant information in reducing train differential pressures.

The system design descriptions for 100-KR-4, 100-HR-3 and K-West may be beneficial to understanding the continued use of the Dowex-21 resin treatment system.

3.3 DESIGN ASSUMPTIONS AND RISKS

3.3.1 Outdoor Ambient Temperature

Assumed range of outdoor temperatures is -23 (February 1950) to +113 (August 1961) degrees Fahrenheit, as reported by Hanford Meteorological Station.

3.3.2 Contaminant Concentrations

The expected Cr+6 concentration is 200 ppb or less at the extraction wells. Note: Chromium concentrations greater than 200 ppb may require a treatment system using a resin different than Dowex 21.

3.3.3 Well Productivity

The RDR/RAWP 2007 Supplement (pending) is in development. Some wells are not yet drilled and well locations and production capacities are not fully tested. Initial design is proceeding with specific locations of wells and capacities as provided by the SGRP 100 Areas Project Manager, and an average well capacity of 42 gallons per minute with a maximum of 60 gpm and a minimum of 20 gpm.

The injection distribution design assumes a 62 gpm average injection well capacity.

The risk of not meeting the capacity requirements is introduced by the lack of quantitative data on the ability of the aquifer to yield sufficient quantity of groundwater to the extraction wells. This information shall not be available until the wells are drilled and tested after the completion of the design. The wells design shall be in accordance with standard well completion practices, as well as meeting state requirements for well construction. Well field modifications may include but not necessarily be limited to pump motor size, well locations, number of wells needed to satisfy the operational objectives.

3.3.4 Plume Shrinkage

Effectiveness of plume treatment is initially estimated based on modeling of the hydrological conditions and local groundwater chemistry. The performance of the expansion shall be documented in the annual pump and treat performance report based on groundwater monitoring requirements defined in the RDR/RAWP 2007 Supplement (pending). A succession of well re-alignments may be required to shrink the plume.

3.3.5 Process Controls

Certain elements of the Distributed Control System (DCS) hardware, all of the software, and certain components of the process control network comprise single points of operational failure as follows:

- Remote operation of the KX facility requires that the DCS system is working satisfactorily, both hardware and software, including the HMI. Risk is mitigated by fallback to local operation at increased operations cost.
- No redundancy of HMI or the DCS systems shall be provided.
- Fallback to local operation of transfer pumps or extraction pumps shall require a working process control network, an input from the respective tank level switch to the Process Logic Controller (PLC), correct logic to output an enabling signal from the PLC to the pump Adjustable Frequency Drive (AFD), and functional output hardware to output the enabling electrical signal to the AFD. Some workable redundancy shall be inherent in multiple extraction systems, less so in multiple transfer pumps, and entirely vacant from the central PLC processor unit, logic configuration, and the intra-station process control network linkage.
- Redundant PLC's or networks shall not be provided.
- Spare optical fibers shall be installed with each optical network link.

3.3.6 Electrical Systems

- Some of the electrical service and power distribution components are single points of failure, but with sufficient reliability to justify the risk against performance requirements.
- Electrical design is not based on assumptions with respect to fire safety. Electrical system protections shall typically be redundant in compliance with NEC.

3.3.7 Mechanical Systems

For mechanical systems, some workable redundancy shall be inherent in multiple extraction and injection systems. Feed pump and injection pump stations, shall be fully redundant, having on-line spares. The influent and effluent tanks and associated instruments and piping shall be a single point of failure. The risk is reasonable within the annual average performance requirements. This strategy has been shown in existing systems to provide greater than 95 percent facility availability.

For assumptions and risks involving pressure vessels, see below 'Structural Systems'

3.3.8 Structural Systems

The buildings are existing (1606KA, 1607KA, and 1608KA) and are not included in this document. The existing buildings were designed for 20 lb snow load, 85mph wind gusts, and UBC Seismic Zone 2B.

Equipment supports shall be designed with sufficient load capacity and strength to effect insignificant risk of failure from normal defects. Risks include material and workmanship defects in manufacturing and construction, as well as counterfeit components. Additional equipment and accessories shall comply with HNF-PRO-97, Natural Phenomenon Hazard.

Engineering inspection reports shall be required for all structural systems and components.

3.3.9 Emergency Systems

The eye wash and shower maintenance shall be administratively controlled by Operations to assure the equipment is available when an emergency wash is needed.

The eye-wash station and safety shower are parts of an emergency system, not a single point of failure. Preventative maintenance and test routines shall be provided. Engineering inspection shall be required in addition to acceptance testing.

3.4 REPORTING

Data from the pump-and-treat operation is used by DOE, regulators, and internal geoscientists. Sufficient data must be provided to calculate for the plant as a whole the daily volume treated, operating or "up" time, and the net amount of Cr+6 removed. Flow volume and "in-service" time will also need to be calculated for each extraction and injection well and IX train. Water levels are required for each extraction and injection well.

3.5 CONSTRAINTS

As an economic constraint, existing monitoring wells shall be used to the extent practicable, together with new wells drilled where necessary to achieve acceptable plume-capture and injection distribution.

The extraction system shall utilize two existing and empty 30 ft x 30 ft KR-4 (1607KA, Transfer Building X1; 1606KA, Transfer Building X2) buildings located in the east and west areas of the plume, to consolidate extraction flow streams to reduce the change of temperature during weather extremes. These buildings shall be designated 'Transfer Buildings X1 & X2.'

The treatment and injection systems shall utilize an empty 60 ft x 150 ft (1608KA, Process Building) building, to protect the process systems from weather extremes. This building shall be designated 'KX Process Building.'

4.0 DESIGN CRITERIA

4.1 GENERAL CRITERIA

4.1.1. Design-Specific Quality Assurance Requirements.

There are no Safety Class or Safety Significant structures, systems or components (SSC) involved in this project. The entire scope is General Service. The graded approach as described in HNF-PRO-259 shall be implemented. The project is predominantly Quality Assurance (QA) Level 0, commercial standard. Some SSCs will be GS Quality level 3 as described in HNF-PRO-259 such as ASME Code items (requiring independent verification), procurement of items shown to be vulnerable to counterfeiting (requiring receipt inspection). Items shall be in accordance with the codes and standards defined in Section 5.0.

Additional QA requirements for this project:

- Any materials or components that, due to economic constraints must be tolerated by design as a single point of failure with respect to safety of life, health and property, must appear in a suitable inspection plan, or in a submittal of analysis and inspection:
  - A. QA inspection plan (e.g., pressure vessels, ASME piping)
  - B. Engineer's analysis and inspection report (e.g., structures and load)
- Other material and components are not single points of failure, yet may have some consequence with respect to safety of life, health and property. These shall require

individual engineering assessment of any risks remaining with partially redundant systems, throughout the course of design. Appropriate specifications, submittals, inspection plans and reports, are to be included as appropriate (e.g. eye-wash station, safety shower).

- The design shall include cleaning/cleanliness criteria to define cleaning processes, cleanliness inspections foreign material exclusion devices and, if applicable, maximum levels of harmful ingredients.

4.1.2. Additional Evaluations

Radiological impacts on personnel and the environment will be evaluated by monitoring co-contaminants. The Record of Decision (ROD EPA et al. 1996) identified the 100-KR-4 OU co-contaminants as tritium and Sr-90. Carbon-14 is a contaminant of interest. Monitoring for co-contaminates shall be required in extraction wells and the pump & treat influent and effluent streams. Analysis for co-contaminants will be performed by a certified laboratory. Monitoring by sampling extraction flow streams and surveying the ion exchange media will also be performed.

4.1.3. Requirements for Flexibility and Future Expansion (e.g., turndown ratios, over-design factors for equipment and piping)

Design shall be scaleable to 600 gpm peak capacity by adding similar equipment and systems used in the initial 300 gpm design.

Design shall provide flexibility following startup to accommodate changes in plume characteristics, or different understandings of actual or perceived responses of the aquifer/plume to the pump and treat activity.

4.1.4. Verification and Validation

Design verification shall be by peer review.

An acceptance testing plan (ATP) shall be prepared and performed by the installation contractor with SGRP Engineering and Construction Services acceptance when all testing required to demonstrate facility installation per design, including design changes, are complete. The ATP procedure shall be approved by FH prior to contractor execution of the activity.

4.1.4.1. Qualitative Acceptance Testing

The ATP shall not test individual components or sub-systems, wiring continuity testing and such that can be more safely and economically demonstrated as a completely functional system behavior.

Operable range of instrumentation and equipment, including pump rotation, shall require only a basic qualitative check against the designed operating range. No quantitative test results shall be required for flows, pressures, levels, temperatures, or pH. (Required calibrations shall be performed after turnover of the system to Operations and prior to the Operational Test Procedure (OTP).

In-service leak testing per ASME B31.3 shall be performed for all piping and vessels

4.1.4.2. Quantitative Acceptance Testing

Resistance testing acceptance criteria shall be specified for electrical power distribution wiring insulation, based on length of individual circuits.

Signal to noise ratio acceptance criteria shall be specified for DCS network wiring and optical circuits, based on length of individual circuits.

HVAC air flows and discharge temperatures shall be specified based on air handler specifications and duct/diffuser design.

There are no other quantitative mechanical tests required to demonstrate quality of construction.

Facility operation processing groundwater as part of acceptance testing shall be sufficient to demonstrate acceptable construction.

Submittal of test reports shall be specified for quantitative acceptance testing.

4.1.4.3. Operational Testing Plan (OTP) and Commissioning

Remaining design validation after acceptance testing shall then be combined with an OTP.

4.1.5. Fire Protection, Fire Detection, and Fire Suppression Requirements

The treatment system shall not be designed for human habitation. The facility has requested an exemption from the fire suppression system requirements.

4.2 PROCESS DESIGN CRITERIA

Well casings shall be minimum 6" to accommodate extraction pumps and instruments. Well internals shall be stainless steel below static water level, at a minimum. Above static water level the internals may be galvanized pipe. Well level sensing and pump discharge pressure shall be available at the remote monitoring location.

Extraction well heads are to be insulated and heat traced for freeze protection. Pipe connections, wiring and insulation shall be arranged to allow removal of the extraction well pump without 100% removal of all heat trace etc. and allow sufficient room to accommodate removal equipment. There will be no backup protection in the form of an automatic line drain back into the well upon pump shutdown other than removal of the extraction well pump foot valve to allow drain back into the well (backup was provided in the original pump and treat designs, which was then later excluded).

Individual extraction flow streams shall be controlled by adjustable frequency drive on the extraction pump. Extraction flow settings shall be manually controlled as the master set point for overall system flows.

Outdoor conveyance piping shall be HDPE.

Each extraction well flow, IX feed flow, and injection well flow stream shall be independently adjustable and stable, and not appreciably change the flow at any other extraction well, IX train, or injection well. Pressure-distribution controls shall be utilized to that effect, as follows:

- Extraction flow streams shall not be combined except at a designated static pressure discharge point, typically a tank at atmospheric pressure,
- Injection flow streams shall not be combined except at a designated static source point, typically a pressure-controlled pump-discharge manifold,
- IX feed flow streams shall not be combined except at a pressurized source manifold, and/or a designated static pressure discharge tank.

To accomplish the above pressure-distribution control as a matter of design precedent, extraction flows shall individually discharge into a transfer tank at the nearest transfer building, or directly into a process building influent tank. Transfer lines shall individually discharge into a process building influent tank. Treated streams from individual IX trains shall discharge into a process effluent tank. Discharge pressure indicating transmitters shall be provided for transfer, feed and injection booster pumps to enable pressure stabilized distribution to multiple transfer lines, IX trains, and injection wells.

Individual transfer flow streams shall be controlled by manual block/throttle valves. Individual IX feed flow streams shall be controlled by manual block/throttle valves for up to three IX trains with space in the IX feed piping layout for future addition of motor operated throttles, if necessary, to control as many as six IX train flow streams. Injection flow streams shall be controlled by motor operated valve with position feedback indication to the remote monitoring location (HMI).

System flow balance shall be accomplished by tank level regulators controlling their respective tank discharge pump AFDs.

Indoor piping shall default to PVC by established precedent.

Provisions shall be made for sampling individual extraction well influent flows, and treated water effluent.

Sulfuric acid shall be added to the flow upstream of the Ion Exchange process to control calcite scaling and prevent equipment damage. The acid injection system shall not be required to control pH to a set point, but shall be required to control injection rate as a set point ratio to process water flow. The injection system capacity shall be capable of maintaining a nominal 7.0pH in continuous operation, and capable of lowering the pH to 6.0 for batch treatment.

Overland conveyance piping shall not be fitted with any leak detection or containment system. Leak detection shall be by routine surveillance of the pipeline, and supplemented with low flow detection and/or flow balance monitoring systems.

4.2.1. Process design and operating limits

Pressure, Extraction Systems	100psig	100psig
Pressure, Transfer Systems	100psig	100psig
Pressure, IX System	150psig	75psig
Temperature, IX System	122°F	<110°F
Pressure, Injection Systems	100psig	100psig
pH, Injection Systems	N/A	5.5 > < 8.5
Building roof load	5 psf	5 psf

4.2.2. Mechanical

All pumps are to be controlled by AFD's. Impellers shall not be trimmed except to limit deadhead pressure at maximum rated speed. All pumps that operate as a group in parallel shall be of the same size and capacity.

All electric driven pumps and motorized equipment shall accommodate three phase motors to minimize motor maintenance.

The transfer pump stations, feed pump stations and injection booster pump stations shall each be a scalable set of pumps sized so that the process may continue at peak capacity upon loss of one individual pump out of the set.

Outdoor piping velocity is critical to prevent over heating and freezing. Optimum line sizing shall be calculated to minimize freezing potential and to minimize solar heating of the water.

Pump station intake and discharge manifolds and tanks shall be sized for 600 gpm peak capacity, and six IX trains. Transfer station intake and discharge manifolds and tanks shall be sized for 300 gpm peak capacity per each transfer station.

Minimum transfer and process influent tank capacities are also constrained by:

- The need to restart after an unexpected shutdown on a hot day:
    1. For the transfer tanks, the capacity may be based on the smallest extraction line volume, the temperatures of the tank dilution water, and the heated extraction line water.
    2. For the process influent tank, the capacity is based on the transfer line volume.
- The ability to store approximately five minutes of flow during a process upset event.

Effluent tank design shall consider controlling tank turbulence to minimize noise in tank level sensing and injection valve position control. This noise may cause excessive cycling of the valves leading to premature valve failure.

4.2.3. Electrical

All custom built electrical panels must be NEC compliant and shall require a fully detailed fire safety inspection report by either the electrical design engineer, or the site certified NEC electrical inspector.

Power Distribution:

- Electrical enclosures shall be coated steel.
- Electrical enclosures shall be dust tight.
- Wherever feasible, materials and components specified by design shall be listed by a nationally recognized independent testing laboratory.
- Circuit overload protection shall be coordinated – device nearest fault shall clear first.

4.2.4. Process Control

Software based controls shall not be used to assure safety of life, health or property.

Hard wired interlocks design to 'fail safe' shall shutdown related pumps on:

- Excessive influent water temperature,
- Leaks detected by floor cavity moisture sensors,
- Excessive feed pump pressure,
- Excessively high or low tank level,
- Effluent/injection water pH ≤ 5.5 0r ≥ 8.5.

Extraction pumps and transfer pumps are remote from the tanks into which they discharge, respectively the transfer tank and the process influent tank, and shall not be hardwired to shutdown on high tank level.

Hardwired interlock shall enable the acid injection at a minimum process water flow rate, adjustable by the operations/process design authority.

The above interlocks shall disable pumps in both local and remote control modes.

Additional process control limits and regulators shall be built into PLC software to maintain flow balance and to restrict flows and levels within respective working capacities of pumps, tanks, IX trains, and wells. Restrictive limits shall produce alarms and shutdown related pump controllers. The System Design Description shall document where alarm acknowledgement is prerequisite to restart.

All alarms shall be latched flashing for operator acknowledgement, then non-flashing until the alarm dead-band is cleared. All alarms shall be at a process limit resulting in a forced shutdown. All quantitative alarms shall be preceded by a warning indication with the same latch and acknowledgement behavior as an alarm, but established at more conservative set points and no shutdown of systems.

As a default, no system shall restart automatically after clearing an alarm condition. One exception is that pumps interlocked with tank level software switches shall be in suspended operation until the warning level condition clears, then resume pumping, irrespective of annunciation acknowledgements. However, hardware tank level switches installed at more extreme tank levels shall trip the software pump master control latch, requiring a manual restart by the operator.

Instrumentation and controls shall be 24 VDC throughout, and using non-inverter 24VDC bypass-battery backup/charging sufficient for ten minutes minimum data acquisition. 24VDC power supplies shall be NEC class II, electrically safe from shock hazards, and separated into different enclosures from the control cabinets.

A dedicated ten minute minimum 120 VAC inverter UPS shall be specified for the human-machine-interface (HMI), of residential or commercial quality.

All AFDs shall 'fault' upon loss of communication with the PLC. Consequently, the plant shall shutdown on failure of UPS power for process control, except for the backwash and sluice pumps which shall be under exclusive local manual control.

Where low voltage distance limitations or wiring economics require distributed controls, all communication networks will conform to standards of ProFiBus or ProFiNet.

The HMI shall be used for data acquisition, alarm and event logging, remote process monitoring and manual input, and not for any process control logic. Loss of the HMI, such as rebooting, shall have no effect on the facility in operation.

The facility shall be entirely operable without the HMI, using local control mode, notwithstanding two conditions:

- Enablement of extraction and transfer pumps on tank level requires a good control network
- Local override of injection valve position requires switching off its power circuit breaker.

4.2.5. Data Gathering

Instrumentation shall be installed sufficient to implement the reporting requirements of Section 3.4.

4.2.6. Structural

ARCO Building Systems Design Certification shows that the existing pre-engineered buildings were designed for a 5 psf collateral roof load. Independent building components, as applicable, shall be verified and inspected during design of electrical and mechanical equipment supports. All major equipment loads shall be supported at ground floor level. Major equipment supports and anchorage shall be designed in accordance with HNF-PRO-097.

Field crafted supports and hardware shall be subject to engineering inspection and approval.

Tanks inside the process and transfer buildings shall meet seismic loading per UBC.

4.2.7. General Criteria

Process control set points, interlocks and behavior of process regulators shall be documented in a System Design Description as the definitive configuration control document for the process control system, in addition to the information on the P&ID.

Measurements shall be in English units. Any exceptions shall reflect the most common industry practices for:

- The subject materials and equipment,
- The involved construction organizations,
- The responsible operations and maintenance organization.

All equipment shall be tagged using ISA standard scheme for instrumentation, "function-system-unique instance." All system designations shall begin with the letter 'X' to identify this expansion.

For portability, systems shall not use physical well numbers. Well numbers shall appear only on site plans and on the physical well symbol of the P&ID.

Systems:

• Extraction for Transfer Building X1	XE01 through XE09.
• Extraction for Transfer Building X2	XE11 through XE19.
• Extraction for Process Building	XE21 through XE29.
• Transfer X1	X1
• Transfer X2	X2
• Process Influent	X3
• IX	X4
• Effluent	X5
• Injection	XJ01 through XJ09.
• Sluice	X6
• Backwash	X7
• Acid Injection	X8

4.3 FACILITY CRITERIA

4.3.1 Architectural and civil/structural

None of the buildings shall be suitable for continuous human occupancy. Sanitary and operations support facilities exists on the KR-4 site near the new process building for the purpose of general paperwork, planning, meals and refreshments, rest periods, protection from thermal exposure and land line communications.

4.3.2 Heating, Ventilation, and Air Conditioning

DOE Order 430.1A requires energy efficient HVAC where practicable.

The new buildings are insulated. When the facility is in operation, the ground water and floor shall provide considerable temperature moderation.

Auxiliary heat shall be provided for each building, to protect the process tanks and lines when the facility is shut down in winter.

Auxiliary cooling shall be provided for each building or room containing electronic or other temperature sensitive components, limiting the ambient to ≤100 deg. F.

Venting is required from the buildings to the outdoors.

4.3.3 Utilities

Electrical power distribution and process power shall be 480 VAC.

13.8 kV Distribution shall be extended across a roadway to the KX process building. 13.8kV distribution shall be extended approximately two thousand feet to Transfer Building X2. Both locations shall be provided new transformers, lightning protection and fused disconnects to comply with utility operations standards in addition to National Electrical Safety Code (NESC.)

Lighting shall be DOE recognized energy efficient, (DOE Order 430.1A).

Indoor lighting shall be nominal 75 foot candles throughout, with a minimum 75 foot candles in areas of sampling, analysis, acid handling, eye-wash, and 480 V electrical enclosures and utilization equipment.

Outdoor lighting shall meet standards for pedestrian walkways in parking lots at each entrance to the building, and at each exterior point of service (influent and effluent piping and electrical service disconnect). No yard lighting shall be provided – material handling shall require daylight conditions.

An HDSL circuit shall be extended to the KX process building by LMSI for offsite monitoring. No voice lines will be required.

There will be no potable water or sanitary facilities provided at the expansion buildings.

4.3.4 Fire protection

No active fire protection systems are required as neither this project nor any of the structures in which it is to reside are suitable for human occupancy. Electrical installation shall comply with National Fire Protection Association (NFPA), National Electrical Code (NEC).

The existing steel buildings are surrounded by and attached to grounding rings. All conduits shall be grounded. Extraction well structures shall be grounded to well casings. No other lightning protection shall be provided.

A graveled or asphalt thirty foot zone free of vegetation shall be maintained around all facility buildings and structures as a fire buffer zone.

4.4 GENERAL REQUIREMENTS

In addition to industrial safety codes and standards, equipment layout shall provide for most safe and economical maintenance of equipment.

Routing of piping into and out of buildings shall allow clearances for access by emergency equipment and a minimum 30 foot fire buffer zone free of weeds.

In addition to NESC clearance requirements, layout of 13.8 kV distribution and structural guying shall be arranged to be conspicuous, avoiding blind spots, and out of the way of any interference with safe pedestrian or vehicular traffic, parking and access for loading and unloading.

All aspects of the outdoor design shall compliment the special requirements to protect cultural resources, wildlife activities and habitat, and environment and any special requirements as identified in the Ecological/Cultural Resource Review.

Outdoor wiring and signal circuits shall be protected by markers where off road, and by barriers within five feet of vehicular traffic. Barriers shall not be designed as vehicular crash barriers.

The construction package shall include detailed procurement and construction specifications and installation drawings.

Design format shall compliment the innate tendency for construction crafts to work primarily from drawings, while procurement agents and supervision are more likely to review specifications. Design that requires craft compliance shall appear on drawings. In case an installation method must be inextricably combined with a procurement or construction specification, that section of the specification shall be clearly referenced on the drawing detail.

In some cases, an independent quality assurance inspection plan may be substituted for design engineering inspection. In either case, an inspection report *for approval by design engineering* shall be required.

5.0 CODES AND STANDARDS

Depending on the definitive design development, codes and standards shall be applied which meet the criteria of assuring safety of life, health and property.

When more than one standard is suitable, only that which is favored by life-cycle cost-benefit shall apply.

5.1 ELECTRICAL:

- NFPA 70, National Electrical Code
- IEEE C2-2005 National Electrical Safety Code
- LPI-175, Standard of Practice
- UL-96A, Installation requirements for lightning protection systems.
- NFPA 780; IES Lighting handbook

- UL-508 Industrial Control Equipment
- TIA/EIA-485, Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems
- IEEE 802.3 Ethernet
- IEC 61158 Fieldbus
- IEC 61784 Type 3, Profibus
- IEC 60793 Optical Fiber
- IEC 61131/NEMA IA2.7 2005 Part 7, Fuzzy Control Program

5.2 MECHANICAL:

- International Conference of Building Officials - Uniform Building Code (UBC), 1997
- International Association of Plumbing and Mechanical Officials – Uniform Plumbing Code
- ASME B31.1, Power Piping,
- ASME B31.3, Process Piping
- ASME Boiler and Pressure Vessel Code, Section III and Section VIII.
- ASME B16.5, Pipe Flanges and Flanged Fittings NPS ½ through NPS 24
- ASME B16.3 Malleable iron threaded fittings class 150
- ASTM A 53 or A106
- ASTM A 312 stainless steel
- ASTM A 182 – Stainless Steel Pipe Flanges
- ASTM A 193 – Alloy Steel & Stainless Steel Bolting Material
- ASTM A 194 – Alloy Nuts for Bolts
- ASTM A 197 – Malleable Iron
- ASTM A 47 – Malleable Iron Castings
- ASTM D 2467 – PVC Pipe
- ASTM A 105 – Carbon Steel Forging
- ASTM B 16.34 – Valves, Flanged, Threaded & Welding Ends
- ASTM D3350, D3261 HDPE pipe
- AWWA M55 HDPE pipe

5.3 CIVIL/STRUCTURAL:

- HNF-PRO-097, Revision 4, *Engineering Design and Evaluation (Natural Phenomenon Hazard),* Fluor, Richland, Washington,
- ASCE 7-98, (ANSI) – Minimum Design Loads for Buildings and Other Structures
- American Institute of Steel Construction - ASD Manual of Steel Construction (MO21)
- ACI 318-99- American Concrete Institute - Building Code Requirements for Structural Concrete
- International Conference of Building Officials - Uniform Building Code (UBC), 1997
- American Institute of Timber Construction - Timber Construction Manual and current publications of the American plywood Association.
- Road Design - American Association of State Highway and Transportation Officials.
- WAC 173-160, Minimum Standards for Construction and Maintenance of Wells

5.4 FIRE PROTECTION:

- (SCRD) DOE O 420.1A, *Facility Safety*
- International Conference of Building Officials - Uniform Building Code (UBC), 1997
- National Fire Protection Association (NFPA) standards (e.g., NFPA 101, Code for safety to life from fire in buildings and structures)

5.5 QUALITY ASSURANCE:

- HNF-PRO-33415, *Structures, Systems, Components Cleaning/Cleanliness And Foreign Material Exclusion,* Fluor, Richland, Washington.
- HNF-PRO-259, *Graded Approach,* Fluor, Richland, Washington.

6.0 REFERENCE

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DOE/RL-2006-75, RDR/RAWP, *Supplement to the Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action*, U.S. Department of Energy, Richland, Washington, Published (pending).

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WMP-29491, Rev. 0, *Design Criteria for the K-West Pump and Treat*, Fluor, Richland, Washington, Published April 2006

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