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OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

December 21, 2000

Office of the Secretary
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001
Attn: Rulemakings and Adjudications Staff

Re: Matter of the Application of Hydro Resources Inc., Docket No. 40-8968-ML, ASLBP No. 95-706-01-ML

Dear Sir or Madam:

Please find an original and two copies of ENDAUM's and SRIC's Intervenors' Response to Hydro Resources Inc.'s Cost Estimates And Restoration Action Plan of November 21, 2000. I have also enclosed one extra copy of the document and a stamped, self-addressed return envelope.

I would appreciate it if you would file the original and the copies of the document. I would also appreciate it if you would date-stamp the extra copy and return it to me in the self-addressed envelope.

If you have any questions regarding this filing, please contact me at your earliest convenience at (505) 989-9022.

Thank you for your assistance in this matter.

Sincerely,

Geoffrey H. Fettus

Geoffrey H. Fettus

cc: Service List

Template = SECY-049

SECY-02

December 21, 2000

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OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judge Thomas S. Moore

In the Matter of)
)
HYDRO RESOURCES, INC.) Docket No. 40-8968-ML
P.O Box 15910)
Rio Rancho, NM 87174) ASLBP No. 95-706-01-ML
)

INTERVENORS' RESPONSE TO HYDRO RESOURCES INC.'S COST ESTIMATES AND RESTORATION ACTION PLAN OF NOVEMBER 21, 2000

Introduction

Pursuant to the Commission's Memorandum and Order, CLI-00-08, 51 NRC 267 (2000) and 10 C.F.R. § 2.1233, Intervenors Eastern Navajo Diné Against Uranium Mining ("ENDAUM") and Southwest Research and Information Center ("SRIC") hereby respond to the Response of Hydro Resources, Inc. to Commission's Order in CLI-00-08 Requiring Submittal of a Financial Assurance Plan, and the attached Church Rock Section 8/Crownpoint Process Plant Restoration Action Plan (November 21, 2000) (hereinafter "RAP" or "HRI's Plan"). This Response is supported by the testimony of Mr. Steven C. Ingle and Dr. Richard J. Abitz.[1]

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[1] Mr. Ingle, a senior analyst and permit coordinator in the Land Quality Division of the Wyoming Department of Environmental Quality ("WDEQ"), is a hydrogeologist with more than 15 years of experience and expertise in the regulation of in situ leach mining, including decommissioning funding. See "Written Testimony of Mr. Steven C. Ingle In Support of Intervenors' Response to Hydro Resources Inc.'s Cost Estimates and Restoration Action Plan of November 21, 2000," attached as **Exhibit 1**. Dr. Abitz, who currently serves as the senior geochemist overseeing remediation of uranium-contaminated groundwater at the U.S. Department of Energy's Fernald, Ohio, facility, has a Ph.D. in geology and extensive

As discussed below, the RAP does not satisfy the Nuclear Regulatory Commission's ("NRC") requirements in 10 C.F.R. § 40, Appendix A, Criterion 9. First, the plan addresses only a third of the licensed project. Although the Commission directed HRI to submit a decommissioning plan for Section 8 only, the NRC has licensed three other sites for which HRI has never submitted a decommissioning plan: Church Rock Section 17, Unit 1, and Crownpoint. Because it fails to provide a decommissioning funding plan for the entire licensed project, the RAP is fundamentally deficient.

Even with respect to Section 8, the RAP does not provide reasonable assurance that Section 8 will be reclaimed adequately after mining activities are completed. HRI substantially underestimates the amount of water that will be processed during groundwater restoration, as well as the time needed to complete the restoration effort. HRI makes unsubstantiated assumptions about plant, labor and equipment operating efficiencies. The RAP contains significant discrepancies from previous descriptions of restoration that were contained in key elements of the HRI license application. Moreover, as demonstrated in the testimony of Mr. Ingle and Dr. Abitz, HRI consistently ignores real-world lessons about the costs and difficulties of restoration at other in-situ uranium mines and uranium contaminated groundwater sites. HRI simply omits many components that are fundamental elements of the approved financial assurance and groundwater restoration plans of current uranium in situ leach ("ISL") operations. HRI's Plan does not include costs for contractor administration and annual inflation adjustments

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professional experience in the remediation of soil and groundwater contaminated by uranium and hazardous metals. See "Written Testimony of Dr. Richard J. Abitz In Support of Intervenors' Response to Hydro Resources Inc.'s Cost Estimates and Restoration Action Plan of November 21, 2000," attached as **Exhibit 2**. (Exhibits will hereinafter be designated as "Ex. __".)

as mandated by the NRC's guidance on financial assurance. HRI further violates the requirements of 10 C.F.R. § 40, Appendix A, Criterion 9 by proposing to fund only a third of its already inadequate surety for Section 8.

As a result of the serious technical inadequacies in the HRI Plan, the surety amount proposed by HRI is profoundly inadequate. HRI's scientifically unsupported Plan is contrary to law, creates a host of potential public health dangers for Church Rock and surrounding communities and, put simply, invites environmental disaster if HRI were to declare bankruptcy or cease to exist. The Presiding Officer should revoke HRI's license as HRI has not submitted an appropriately supported restoration plan and cost estimate as required by the Atomic Energy Act and NRC regulations.

Background

As described in previous filings before the previous Presiding Officer, Judge Peter Bloch, HRI has applied for and obtained a license to build and operate several in situ leach mines and a uranium mill in Church Rock and Crownpoint, New Mexico, a project known as the "Crownpoint Uranium Project." The NRC Staff issued a Final Environmental Impact Statement ("FEIS") for the entire Crownpoint Project in February 1997, and a Safety Evaluation Report ("SER") in December 1997. HRI received an operating license from the Staff on January 5, 1998. License No. SUA-1508. The license allows mining on all four sites for which HRI seeks permission (Church Rock Sections 8 and 17, Unit 1, and Crownpoint), subject to compliance with certain license conditions. Intervenors challenged the validity of HRI's license in an evidentiary proceeding before a Presiding Officer of the ASLBP. See LBP-98-9, 47 NRC 261 (1998), rev'd in part on other grounds, CLI-98-16, 48 NRC 119 (1998).

The issue of decommissioning funding goes back several years. On August 15, 1997, ENDAUM and SRIC filed their Second Amended Request for Hearing, in which they raised, inter alia, concerns regarding the failure of HRI to comply with the decommissioning funding requirements of Criterion 9 of Appendix A to 10 C.F.R. Part 40 and 10 C.F.R. § 40.36. ENDAUM and SRIC's Second Amended Request For Hearing, Petition to Intervene, and Statement of Concerns (August 15, 1997) ("Second Amended Request") at 96-101. These concerns were admitted as germane by the Presiding Officer. LBP-98-9, 47 NRC at 282.

In January 1999, Intervenors submitted a brief and testimony demonstrating that HRI had failed to submit a decommissioning funding plan, in violation of Appendix A to 10 C.F.R. § 40. See Intervenors' Brief in Opposition to Hydro Resources Inc.'s Application for a Materials License with Respect to: Financial Assurance for Decommissioning (January 11, 1999); Testimony of Dr. Michael J. Sheehan (January 11, 1999). Both HRI and the Staff responded in opposition to the Intervenors' assertions. See Hydro Resources Inc.'s Response to Intervenors' Briefs with Respect to Hydro Resources, Inc.'s Technical and Financial Qualifications and Financial Assurance for Decommissioning (February 11, 1999); NRC Staff's Response to Intervenors' Presentations on Technical Qualification, Financial, and Decommissioning Issues (February 18, 1999).[2]

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[2] None of the environmental reports submitted by HRI contained a financial assurance plan. Hydro Resources, Inc. Churchrock Project Environmental Report (April 13, 1988) (Hearing Record ACN 8805200344) ("1988 Churchrock ER"); Churchrock Project Revised Environmental Report (March 16, 1993) (Hearing Record ACN 9304130415) ("1993 Churchrock ER"); Crownpoint Project Technical Report and Analytical Summary (July 31, 1992) (Hearing Record ACN 9509080094) ("Crownpoint ER"); Unit 1 Environmental Assessment (Hearing Record ACN 9509080065) (January 6, 1992) ("Unit 1 ER").

On March 10, 1999, the Presiding Officer issued LBP-99-13, a partial initial decision which resolved decommissioning and financial assurance questions in favor of HRI. LBP-99-13, 49 NRC 233 (1999). In that decision, the Presiding Officer acknowledged that HRI had failed to submit a decommissioning financial assurance plan prior to licensing, but held that the plan need not be submitted or reviewed until just prior to commencement of operation. 49 NRC at 235 On March 30, 1999, ENDAUM and SRIC petitioned for review of LBP-99-13.[3]

On July 23, 1999, in the first of its decisions that dealt in part with the issue of financial assurance and decommissioning, the Commission decided that Criterion 9 of Appendix A to Part 40 is applicable to HRI's license but requires no surety arrangement "until operations begin." CLI-99-22, 50 NRC 3, 18 (1999). Further, the Commission found that "the surety requirement in 10 C.F.R. § 40.36 does not apply to HRI's license." Id. The Commission called for further briefing to clarify whether and when HRI submitted a plan in this case and the extent to which Intervenors may contest that plan. Id. at 19-20.[4]

In response to CLI-99-22, Intervenors asserted that the financial assurance information

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[3] NRC Staff and HRI opposed the Petition for Review. NRC Staff's Response to Petition for Review of LBP-99-13 (April 14, 1999); Hydro Resources, Inc.'s ("HRI's") Opposition to Intervenors' Petition for Review of Presiding Officer's Partial Initial Decision LBP-99-13 (April 13, 1999). The Commission granted Intervernors' subsequent motion for leave to reply on May 3, 1999, and Intervenors promptly submitted that reply. Intervenors' Reply to Responses to Petition for Review (May 10, 1999).

[4] In that Order, the Commission requested briefing from the parties on the following questions: "(1) Was financial assurance information submitted by HRI adequate to meet the requirements for licensing? (2) If HRI is correct in its assertion that an approved financial assurance plan is not a prerequisite to the issuance of a license, what is the meaning of the staff's assertion in its response that "the issue is thus not yet ripe for ... [the Presiding Officer's] ... review?"" Id.

submitted by HRI was not adequate to meet the requirements for licensing. Brief of Intervenors On Review of Partial Initial Decision LBP-99-13, Financial Assurance for Decommissioning (August 13, 1999). HRI and NRC Staff opposed the position of the Intervenors. NRC Staff's Response Brief on Financial Surety Issues (September 3, 1999); Response Brief of Hydro Resources, Inc. (September 3, 1999).

On May 25, 2000, the Commission issued CLI-00-08, which reversed the Presiding Officer's decision in LBP-99-13, 49 NRC 233 (1999), on the ground that HRI failed to submit a financial assurance plan for decommissioning the Crownpoint Project. CLI-00-08, 51 NRC 227, 241 (2000). None of the environmental reports submitted by HRI contained such a plan as that submitted on November 21, 2000. In CLI-00-08, the Commission held that HRI was required to submit its decommissioning funding plan prior to licensing. CLI-00-08, 51 NRC at 240. The Commission also found that the Presiding Officer erred in concluding that questions about HRI's financial assurance plan for decommissioning the Crownpoint Project could be left for post-hearing resolution or a second round of hearings closer to the time of operation. Id. Instead, the Commission ruled that the Intervenors were entitled to a hearing on the adequacy of HRI's decommissioning plan, cost estimates, and financial assurance plan, in the licensing proceeding. Id. at 240-241.

In response to the Commission's Order in CLI-00-08, HRI submitted its Restoration Action Plan on November 21, 2000. Intervenors response to that plan follows.

The filing of HRI's Plan marks the first time that HRI has advanced any detailed or specific plan for restoration of the Crownpoint Project or provided cost estimates. HRI's Plan contains specific details about restoration methods and cost estimates that are not included in previous HRI and NRC staff submissions. For example, HRI explains in a more detailed fashion how it plans to calculate the actual amount of water it will need to flush through the contaminated aquifer. To the extent that restoration plans were addressed in previous HRI or NRC documents, there are substantial and troubling discrepancies. Several crucial elements of the RAP are different from the restoration plans included in the Final Environmental Impact Statement ("FEIS") and HRI's August 1997 Consolidated Operations Plan Revision 2.0 ("COP"). Among the many significant changes highlighted in the RAP from the FEIS and COP are its proposal to install significantly fewer injection and extraction wells in Section 8 and dramatically change the flow rate for the treatment of contaminated water.

Argument

I. Burden of Proof

In NRC proceedings the ultimate burden of persuasion rests with the applicant and with the NRC Staff, to the extent the Staff supports the applicant's position. Philadelphia Electric Co. (Peach Bottom Atomic Power Station, Units 2 & 3), ALAB-566, 10 NRC 527, 529 (1979). For an applicant to prevail on each factual issue, its position must be supported by a preponderance of the evidence. Pacific Gas & Electric Co. (Diablo Canyon Nuclear Power Plant, Units 1 and 2), ALAB-763, 19 NRC 571, 577 (1984), review declined, CLI-84-14, 20 NRC 285 (1984). The burden of persuasion (degree to which a party must convince the Board) should be influenced by the gravity of the matter in controversy. Virginia Electric & Power Co. (North Anna Power Station, Units 1, 2, 3 & 4), ALAB-256, 1 NRC 10, 17 n. 18 (1975). In NEPA proceedings, the applicant has the burden of defending its position, but the Staff retains the ultimate burden of defending its environmental studies. Louisiana Energy Services (Claiborne Enrichment Center), LBP 96-25, 44 NRC 331, 338 (1996), aff'd in relevant part and rev'd on other grounds, CLI-98-03, 47 NRC 77 (1998).

II. Legal Requirements for HRI's Decommissioning Plan

The Atomic Energy Act ("AEA"), NRC regulations and guidance are clear that the RAP must assure that sufficient funds are available to carry out decontamination and decommissioning of a contaminated in situ uranium mine site in a way that will protect public health. The AEA and implementing regulations prohibit issuance of a license to:

> any person to transfer or deliver, receive possession of our title to, or import into or export from the United States, any source material if, in the opinion of the Commission, the issuance of a license to such person for such purpose would be inimical to the common defense and security or the health and safety of the public.

Atomic Energy Act, 42 U.S.C. § 2099 (emphasis added). The NRC's rules and regulations governing the domestic licensing of source material are set forth in 10 C.F.R. Part 40. Section 40.32(d) states that issuance of a specific license to an applicant must "not be inimical to the common defense and security or to the health and safety of the public . . ." 10 C.F.R. §40.32(d) (emphasis added).

The Commission has established specific regulations for the financing of decommissioning, in Appendix A to 10 C.F.R. § 40 and in 10 C.F.R. § 40.36.[5] The language of Criterion 9 creates a two step process for the establishment of an adequate surety for milling operations. First, in conjunction with an environmental report, the applicant must submit "Commission-approved cost estimates in a Commission-approved plan." 10 C.F.R. § 40,

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[5] The Commission has decided that the general financial assurance requirements for source materials licenses, 10 C.F.R. § 40.36, are not applicable to this license. CLI-99-22, 50 NRC 3 (1999)

Appendix A, Criterion 9.[6] Second, surety arrangements that are consistent with the approved plan must be in place prior to the commencement of operations. Id.

Criterion 9 states in pertinent part:

> [E]ach mill operator . . . [must] assure that sufficient funds will be available to carry out the decontamination and decommissioning of the mill and site and for the reclamation of any tailings or waste disposal areas. The amount of funds to be ensured by such surety arrangements must be based on Commission approved cost estimates in a Commission-approved plan for (1) decontamination and decommissioning of mill buildings and the milling site to levels which allow unrestricted use of these areas upon decommissioning, and (2) the reclamation of tailings and/or waste areas . . . . Regardless of whether reclamation is phased through the life of the operation, an appropriate portion of surety liability must be retained until final compliance with the reclamation plan is determined. This will yield a surety that is at least sufficient at all times to cover the costs of decommissioning and reclamation of the areas that are expected to be disturbed before the next license renewal.

Id. (emphasis added). The AEA and the regulations implementing that statute are clear that when a source materials license is granted, adequate financial assurance that fully meets all reclamation and decommissioning needs (such that the property could be released for unrestricted use) is an essential element of ensuring that public health is protected.

In complying with the mandates of the AEA, the Commission has determined that adequate financial assurance for decommissioning is essential to the protection of public health and safety. Final Rule, General Requirements for Decommissioning Nuclear Facilities, 53 Fed. Reg. 24,018, 24,019 (June 27, 1988).

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[6] The use of the term "licensee" in this context is not significant as existing licensees at the time Appendix A was promulgated were also required to comply with its requirements. See Uranium Mill Licensing Requirements, 45 Fed.Reg. 65521, 65530 (October 3, 1980) (Appendix A requires all mill operators to submit programs meeting the financial and technical criteria "in connection with license renewals or within nine months, whichever occurs first"). See also Final Generic Environmental Impact Statement, NUREG-0706 at 12-5. It is clear that the requirement applies to applicants as well as licensees.

In the decision that has elicited this filing, the Commission dismisses NRC staff's and HRI's argument that 10 C.F.R. § 40.31(h) has no relevance to the issue at hand. 51 NRC at 240, n.14. In fact, the Commission noted how 10 C.F.R. § 40.31(h) places a heavy emphasis on the requirement that license applicants show how the requirements and objectives of Appendix A, which include Criterion 9, will be achieved.[7]

In addition, the NRC has issued a guidance document, the "Technical Position on Financial Assurances for Reclamation, Decommissioning, and Long-Term Surveillance and Control of Uranium Recovery Facilities" (October 1988), that provides even more explicit direction on financial assurance for decommissioning to applicants/licensee's. **Ex. 3** (hereinafter "NRC Technical Position on Financial Assurances"). The guidance requires that the licensee provide information that allows the NRC to ensure that the amount of the surety will cover all costs of restoration so that public health is protected. In determining site-specific reclamation and decommissioning cost estimates, the NRC directs the licensee as follows:

> As required under Criteria 9 and 10 of 10 CFR Part 40, Appendix A, the licensee shall supply sufficient information for NRC to verify that the amount of coverage provided by the financial assurance accounts for all necessary activities required under the license to allow the license to be terminated. . . . Cost estimates should be calculated on the basis of completion of all activities by a third party. Unit costs, calculations, references,

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[7] The regulation cited by the Commissioners states:

> An application for a license to receive, possess, and use source material for uranium or thorium milling or byproduct material, as defined in this part, as sites formerly associated with such milling shall contain proposed written specifications relating to milling operations and the disposition of the byproduct material to achieve the requirements and objectives set forth in Appendix A of this part have been addressed. Failure to clearly demonstrate how the requirements and objectives in Appendix A have been addressed shall be grounds for refusing to accept an application.

10 C.F.R. § 40.31(h)

assumptions on equipment and operator efficiencies, etc. should be provided.

NRC Technical Position on Financial Assurances, at 20 (emphasis added). On the specific issue of groundwater restoration, the NRC guidance directs the licensee to describe the method of restoration; the projected length of time to complete the restoration; the volume of the aquifer to be restored; the number of required pumping cycles and cycling time; and the labor and equipment costs associated with the aquifer restoration. NRC Technical Position on Financial Assurances, at 22-23.

The inadequacy of the RAP also raises concerns under the National Environmental Policy Act. 42 U.S.C. §§ 4321 to 4370d. A new Final Environmental Statement ("FES") may be necessary when the current situation departs markedly from the positions espoused or information reflected in the FES. Allied-General Nuclear Services (Barnwell Nuclear Fuel Plant Separations Facility), ALAB-296, 2 NRC 671 (1975); Kerr-McGee Chemical Corp. (West Chicago Rare Earths Facility), LBP-85-3, 21 NRC 244, 256 (1985).

III. HRI's Plan Is Incomplete Because it Addresses Only Section 8

In CLI-00-08, the Commission recognized that "the rulemaking history of Appendix A, Criterion 9, supports our conclusion that Criterion 9 is best interpreted as requiring submission and approval of a financial assurance plan and cost estimates prior to licensing." Id., 51 NRC at 239. While noting that Criterion 9 is "not without ambiguity," the Commission found that:

> *it does clearly require* submission of a financial assurance plan that includes cost estimates, and most significantly, it explicitly provides that this submission must be made 'in conjunction with' an environmental report. Under our regulatory scheme, environmental reports are to be filed prior to issuance of a materials license (and indeed, are to be filed with the license application itself). Beyond the wording of Criterion 9, it makes a good deal of policy sense, in the context of *in situ* mining, for the NRC to consider a license applicant's cost estimate for cleaning up the mining site, and its plan to

pay for cleanup, prior to issuing a license.

Id. (emphasis added, footnotes omitted). Despite the clarity in the wording of Criterion 9, and despite the acknowledged good policy sense of requiring submission of decommissioning funding plans before licensing, the Commission provisionally instructed HRI to submit a decommissioning funding plan *only* for Section 8. Id., 51 NRC at 242. The Commission's rationale for excusing HRI from having to submit a plan for Section 17, Unit 1, or Crownpoint, was that the project involves four separate sites, which "HRI has "no immediate intent to develop other than the Section 8 site." Id. The Commission left open the question of whether it would require HRI to submit a decommissioning funding plan for the entire Crownpoint Uranium Project, noting that it would review that question again in considering whether the bifurcation of the HRI licensing proceeding was lawful. Id., 51 NRC at 243.

Intervenors continue to respectfully assert that the law gives the Commission no flexibility to defer the requirement for submission of a decommissioning funding plan for any part of the Crownpoint Uranium Project for which HRI has sought and obtained a license. The fact that HRI has no immediate plans for developing some portions of the project provides no lawful justification for avoiding these clear requirements. As the Commission implicitly recognized in CLI-00-08, if HRI wishes not to provide a decommissioning funding plan for some portion of its licensed project, it should seek a reduction in the licensed scope of the Crownpoint Uranium Project.

IV. With Respect to Section 8, HRI Fails to Comply with NRC Standards for Decommissioning Plans

Even for Section 8, the RAP fails to comply with NRC regulations because it will not assure that sufficient funds are available to carry out decontamination and decommissioning that will protect the public health. HRI's Plan suffers from technical flaws that would undermine an attempt at restoring a contaminated aquifer if this plan were implemented. As a result, HRI's suggested surety is completely inadequate. Furthermore, HRI compounds the potential problems created by its inadequate surety by suggesting it need only advance one third of the proposed surety amount. RAP Attachment A-1 ("Initial Surety"). Intervenors will demonstrate that HRI's restoration plan and suggested surety would fail to comply with the law even if the entire amount were available.

HRI has provided little or nothing in the way of evidentiary support for its suggested restoration plan. In contrast, with a wealth of scientific support, Intervenors demonstrate that HRI's Restoration Plan would result in a grossly inadequate cleanup, a threat to public health and a hefty bill for the taxpayer.

A. HRI's Plan Underestimates Both the Volume of Water Processed During Restoration and the Time Needed for Adequate Restoration

The quantity of water needed to flush out a mine and restore it, as well as the time span needed to complete the work, are major elements in calculating a decommissioning cost estimate for an ISL mine. As demonstrated in the testimony of Mr. Ingle and Dr. Abitz, HRI seriously underestimates both the volume of water that must be processed during restoration, and the time needed for adequate restoration. As discussed below in Section 1, HRI has made significant technical errors, used unsubstantiated assumptions, and conducted no site-specific analysis to calculate the number of pore volumes that are needed to restore Section 8. Moreover, HRI's estimates are highly unrealistic in light of real-world experience with restoration efforts at other comparable sites.

1. HRI Underestimates the Volume of Water Processed During Restoration

As outlined in the testimony of Mr. Ingle, the RAP significantly underestimates the volume of water necessary for restoration. Ingle Testimony at 8-14. The restoration cost is a significant factor in determining the decommissioning cost estimate. In HRI's Plan, it accounts for 87 percent of the total estimated cost of decommissioning, decontaminating and restoring the Section 8 site, before contingency charges are added. RAP Attachment A-1, Financial Assurance Plan Summary.

In estimating the quantity of water necessary for restoration, there are three important factors: "pore volume," the "flare factor," and "flare water." A "pore volume" describes the quantity of free water in the pores of a given volume of rock.[8] Calculating the size of that pore volume is crucial to making an accurate assessment of the water the must be flushed through the contaminated aquifer for restoration (generally the water is flushed through multiple times). When applied to a uranium ISL mine, a pore volume is the total volume or amount of water in the aquifer that must be treated, or restored during and after mining.

The horizontal "flare factor" describes the portion of the aquifer that contains fluids, such as lixiviant, which have migrated or "flared" laterally from the ore zone during mining, but have

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[8] Intervenors agree with HRI that pore volumes are calculated by determining the three dimensional volume of the rock (that is also the ore zone) and multiplying this number by the percent pore space. This number is then multiplied by the average ore thickness to provide the three dimensional volume of the ore that is to be leached. This volume is converted to pore volume by multiplying the ore volume by the percent porosity and then converting to the units of measurement (gallons). See the RAP, Section E-2, pages 1 and 2. (Note: Licensee did not number the pages of the Plan. The page references given herein are supplied by Intervenors to assist the Presiding Officer.)

remained undetected in the aquifer inside the perimeter monitor well ring. This migration of lixiviant will result in a wider spread of contamination in the aquifer than what the initial calculation of a pore volume might indicate. The "flare water" is an important component of the total amount of fluid that must be flushed from the aquifer during restoration. Mr. Ingle describes in his testimony how a pore volume is calculated in mathematical terms. Ingle Testimony at 9.[9] The basic point is that the horizontal flare factor has a direct effect on the amount of water in each pore volume: the higher the flare factor, the greater the volume of water in each pore volume.

As HRI correctly states, "flare factors," or "pore volume increase factors," are multipliers that are commonly used by the ISL industry to account for leach solution outside of the specific boundaries of the calculated ore pore volume. RAP, Section E-2.

However, HRI gravely underestimates the amount of water necessary for restoration, by arbitrarily using a horizontal flare factor of 1.5, rather than determining an appropriate flare factor based on the characteristics of the CUP site. HRI provides no explanation of its rationale for choosing a horizontal flare factor of 1.5. See RAP, Section E.2.a. The use of this 1.5 horizontal flare factor must be rejected because (a) it is completely unsupported, (b) it does not reflect consideration of site-specific factors, and (c) experience suggests that the factor is likely to be at least twice as high.

As Mr. Ingle testifies, the horizontal flare factor can be modeled, based on the characteristics of a given site. The Wyoming Department of Environmental Quality ("WDEQ")

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[9] Pore volume = (wellfield area) x (ore zone thickness) x (effective porosity) x (horizontal flare factor) x (vertical flare factor)

has its own model for this purpose, which was devised by Mr. Ingle using a publicly available computer program from the U.S. Geological Survey. Ingle Testimony at 9-10. Such modeling is reasonable and feasible for any ISL permit applicant. Id. at 12. Moreover, comparable experience suggests that HRI has grossly underestimated the horizontal flare factor. Id. at 11. As Mr. Ingle explains, in reviewing an ISL permit application for the PRI Highland mine in Wyoming, he used the model to test the accuracy of the applicant's estimated flare factor of 1.4, and found that the appropriate factor was 3, more than twice as high. Id. at 10. Given the significant geological and dimensional similarities between the PRI Highland mine site and the CUP site, the PRI Highland experience shows that a much higher flare factor is appropriate for the CUP. Id. at 11.

HRI's error is significant with respect to the size of the decommissioning cost estimate: for example, to raise the horizontal flare factor by a factor of two would correspondingly increase the volume of water needed for restoration by a factor of two, and double the length of time needed to complete the restoration work. Hence, the cost of groundwater restoration would rise from $7.2 million to more than $14 million. Id. at 13. It is possible, of course, that the size of the horizontal flare factor is greater than three, which would raise the restoration cost estimate even higher.

When HRI's pore volume estimates are compared with real-world experience, they are revealed to be unrealistically and unreasonably low nature. As discussed in Dr. Abitz's testimony, the effort to restore groundwater quality at the Fernald facility in Ohio, under comparable geochemical conditions, has so far demanded a far greater number of pore volumes, at a much higher cost, without yet achieving the restoration goals.[10] Abitz Testimony at 4-10. The present goal of the Fernald restoration project is to reduce contamination levels by one order of magnitude; in comparison, HRI will have to reduce contamination levels by two to five orders of magnitude, depending on the quality of the mining fluids and on the standards to which they are restored. Id. at 5-6. In addition, as Dr. Abitz testifies, the cleanup of the HRI site is likely to be more difficult and complex than at Fernald. Id. at 6. This real-life experience suggests that not only is HRI's restoration cost estimate unreasonable, it is seriously unrealistic.

Dr. Abitz posits a linear correlation between volume treated and cost, concluding that HRI's restoration costs should be in the range of $20 million to $30 million, rather than the seriously underestimated $7.2 million figure it currently provides for in the Restoration Action Plan. RAP, Attachment A-1, Financial Assurance Plan Summary, and Attachment E-2-1. Importantly, Dr. Abitz notes that the assumption of linearity is non-conservative because of the difficulties HRI will face with the complexity of restoring Section 8 and the fact that equipment and labor costs are needed regardless of the volume of water treated. Those associated costs might be more or less, but a conservative estimate demands a rigorous accounting of what all the actual costs might be. HRI has failed to provide such an accounting. Id. at 10-14..

2. HRI Underestimates the Time Needed for Adequate Restoration

As discussed above, HRI has significantly underestimated the number of pore volumes that will be required to restore the aquifer underlying Section 8. To appropriately increase the

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[10] As Dr. Abitz reports, approximately two pore volumes (1.2 billion gallons) are processed each year at an annual cost of $7.8 million. The estimated total cost for reducing uranium contamination by less than two orders of magnitude over a 10-15 year period at Fernald is between $78 and $117 million. Abitz Testimony at 7-8.

volume of pore water would also require a substantial increase in the length of time needed for the restoration effort. HRI has projected that restoration can be completed in 4.4 years, using nine pore volumes. RAP Section E.2.a., Attachment E-2-1. As Mr. Ingle testifies, a reasonable estimate of pore volumes cannot be determined without a site-specific evaluation of the horizontal flare factor; however, it would be reasonable to expect that the volume of water needed to restore Section 8 would be double what HRI has estimated. Ingle Testimony at 13. If the amount of restoration water is doubled, then the time required to process the water must also be doubled. Ingle Testimony at 13.

Dr. Abitz also testifies that the length of time needed to restore the HRI aquifer will be significantly longer than HRI predicts. Abitz Testimony at 13. He bases this conclusion on a thorough comparison of restoration characteristics of the Fernald project against those projected for Section 8. Abitz Testimony at 9-10. And he points to actual ISL operating experience in Wyoming to show that restoration at commercial ISL mines "has taken much longer than originally projected" — 10 years and counting at one operating ISL mine — and has not yet achieved "restoration to premining standards" at any of the commercial sites. Id. at 10.

3. HRI's Restoration Plan Is Contradictory

Under the plan put forth by HRI, if mining were to occur, the uranium contamination in groundwater below Section 8 would reach levels of 50 to 250 mg/L (COP Revision 2.0, Table 3.2-1; FEIS, Table 4.13 at 4-38), which, as noted previously, is up to almost five orders of magnitude above the proposed EPA drinking water standard for uranium (0.03 mg/L) and over two orders of magnitude above HRI's proposed uranium groundwater restoration standard of 0.44 mg/L. HRI plans to extract, treat, and reinject only 9 pore volumes of groundwater —

expected to take 4.4 years and with an inadequate 1.5 horizontal flare factor — to reduce the groundwater contamination by two to three orders of magnitude to 0.44 mg/L, a standard still far over that which EPA asserts will protect human health. While HRI's mining solution will mobilize other heavy metals in the groundwater creating a more complex contaminant mixture, HRI insists in the RAP that it can accomplish restoration in less than half the time that Fernald predicts for a far less chemically complex waste stream. These inherent contradictions demonstrate that HRI's Plan is not realistic, thus not protective of human health and in accordance with the law.

To illustrate the fundamental contradictions and unrealistic assumptions in HRI's Plan, Dr. Abitz summarized his comparison of Fernald's analogous restoration experience with HRI's projected restoration activities at Section 8 in the following table:

Restoration Characteristics	**Fernald**	**Section 8**
Groundwater contaminant(s) of concern	U	TDS, U, Mo, As, Se, Ra-226
Max. initial uranium concentration in groundwater	1.0 mg/L	250 mg/L
Uranium restoration standard	0.02 mg/L	0.44 mg/L
Restoration treatment process(s)	IX	IX, RO, BC
Pore volumes to complete restoration	20-30	9
Monthly volume of water processed	100 million gals	25 million gals
Expected duration of restoration	10-15 years	4.4 years
Annualized cost of groundwater restoration	\$7.8 million	\$1.6 million
Total estimated cost of groundwater restoration	\$78 million - \$117 million	\$7.2 million

From this comparison, it is clear that HRI mistakenly plans to restore much more highly contaminated groundwater with far less flushing (i.e., pore volumes) over a period of about one-third to one-half as long as that at the Fernald site. As Dr. Abitz concluded, "HRI's estimates with respect to pore volumes and the time needed to carry out the restoration plan described in the RAP are unrealistic to a serious degree." Abitz Testimony at 9-10.

B. HRI's Plan Makes Unsubstantiated and Changed Assumptions About Operating Efficiencies, Discrepancies in Flow Rates, and Understated Labor, Equipment and Reclamation Costs

NRC guidance for an adequate surety plan directs HRI to provide the basis for its calculations, references and assumptions on equipment and operator efficiencies. NRC Technical Position on Financial Assurance, at 22-23. Contrary to this guidance, HRI provides little basis for any of its calculations. Moreover, HRI's projections of system efficiencies are so overestimated that this Plan is contrary to law. Further, the significant discrepancies between the RAP and the FEIS and COP suggest that the validity of those earlier documents is in question.

1. HRI Overstates the Efficiency of Brine Concentration and Underestimates the Amount of Brine Concentration Volume

HRI misstates the efficiency of its brine concentration system ("BCS") to great effect on the adequacy of the RAP. In section E.2.c. of the RAP, HRI states, "Typically, for each 100 gallons of waste brine treated, 99 gallons of distilled water and 1 gallon of slurry solids are formed." Mr. Ingle explains that HRI presumes a 99.1 percent rate of efficiency. Ingle Testimony at 14. Yet, the efficiency of the BCS that HRI proposes to use is about 97 percent, according to the manufacturer's own description of the system. While that approximately 2 percent difference seems insignificant at first glance,[11] this lower brine concentrator efficiency has the pronounced effect of nearly tripling the total amount of brine that HRI will need to process every month during restoration. Instead of generating 44,640 gallons of brine per month,[12] HRI's BCS will generate about 130,000 gallons of brine per month.[13] This larger volume of brine generated from the concentrator will necessitate a longer restoration period, additional operational costs (especially for electricity) for the BC and associated rotary drum dryer, and additional costs for disposal of the larger volume of BC solids produced from the dryer. These additional disposal costs could be substantial.

2. The RAP Includes Several Flow Discrepancies

HRI's description of the restoration system is deeply problematic as it involves significant discrepancies between information in the RAP and previous information in HRI's license application documents and the FEIS. As shown in Table 1 below, the 580 gpm flow rate described in the RAP is 2.9 times greater than the 200 gpm flow rate described in HRI's August 1997 Consolidated Operations Plan (Figure 10.4-1 at COP-162) and in the NRC's FEIS (Figure 2.7 at 2-22). In the COP and the FEIS, restoration flow diagrams were provided to showed where the mining solutions were routed and how many gallons per minute of waste water were treated

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[11] That description is contained in a letter to HRI from Resources Conservation Company (RCC) that is included in the RAP in Attachment E-2-4.

[12] This is the value shown by HRI in line 33 of the restoration spreadsheet in Attachment E-2-1 of the RAP. Mr. Ingle believes the number is derived as follows: brine flow (1 gpm) x 60 min/hr x 24 hr/day x 31 days/mo. Further, neither Mr. Ingle nor Intervenors understand why HRI would use a factor of 31 days per month since that would result in a 372-day year.

[13] For calculations, see Ingle Testimony at 15.

at each step of the process. See Ingle Testimony at 17 and Att. E. In these diagrams, the Reverse Osmosis ("RO") unit generates 50 gpm of "reject" water (or 25% of the total flow) that enters the BC. In the RAP (which does not contain a similar flow diagram), 116 gpm of RO reject water (or 20% of the total flow) enters the brine concentrator. HRI does not discuss why the amount of restoration water entering the system has nearly tripled in the 3-plus years that have elapsed since the FEIS and the COP were prepared. This discrepancy must be explained before any confidence can be placed in the RAP. In this context, Intervenors note that the significant discrepancies between the RAP and other licensing documents, including the FEIS, raises concerns that a new Final Environmental Impact Statement ("FEIS") may be necessary in order to address marked differences between the positions espoused or information reflected in the FEIS. Allied-General Nuclear Services (Barnwell Nuclear Fuel Plant Separations Facility), ALAB-296, 2 NRC 671, 680 (1975); Kerr-McGee Chemical Corp. (West Chicago Rare Earths Facility), LBP-85-3, 21 NRC 244, 256 (1985). Upon receiving an explanation of the discrepancies from HRI, Intervenors reserve the right to demand a supplemental EIS if the circumstances warrant it.

Table 1. Comparison of flow rates and Brine Concentrator System efficiencies among various descriptions of the proposed HRI Church Rock groundwater restoration scheme.

	Inflow to RO Unit in gpm	**RO prod'd H20 to reinjection, in gpm (% of inflow)**	**RO reject H2O to BCS, in gpm**	**BC prod'd H2O to reinjection, in gpm**	**BC brine to dryer (or evap pond), in gpm**	**BCS efficiency**
FEIS fig 2.7	200	150 (75%)	50	48	2	96%
COP fig. 10.4-1	200	150 (75%)	50	49	1	98%
RCC Letter (Att. E-2-4)	---	---		121/125 max	3.2	97%
HRI RAP (Sec. E.2.b. and c.)	580	464 (80%)	116	99/100 gals treated (flow rate not given)	1/100 gals treated (flow rate not given)	99%

3. HRI Fails to Account for Costs of the Brine Concentration System

NRC guidance directs that unit costs, calculations, references, assumptions on equipment and operator efficiencies, etc. should be provided. NRC Technical Position on Financial Assurance, at 20. The guidance requires that the licensee provide information that allows the NRC to ensure that the amount of the surety will cover all costs of restoration so that public health is protected. Further, regarding the specific issue of groundwater restoration, the NRC guidance directs the licensee to describe the labor and equipment costs associated with the aquifer restoration. NRC Technical Position on Financial Assurance, at 22-23.

HRI states on page 5 of Section E.2.c of the RAP, "BC costs are included within the O & M budget in Attachment E-2-1." Despite closely inspecting HRI's spreadsheet in Attachment E-

2-1 and other sections of the RAP, Mr. Ingle could not find any line item title O&M budget nor could he find any other item that might account for BCS costs. Apparently, HRI fails to account for $2.5 million in capital costs for the BC system, including the rotary drum dryer. Id., at 17-18. This oversight is serious because it ignores a significant cost that is associated with an absolutely critical piece of restoration hardware and that certainly would increase the total surety amount needed for the project.

4. The RAP Underestimates the Cost of the Brine Concentration System

HRI fails to follow NRC guidance on properly accounting for its groundwater restoration costs even with the actual cost of the brine concentration system. HRI was quoted a price of $2.5 million by Resources Conservation Company in its September 13, 2000, letter to HRI. See RAP, Attachment E-2-4 at 4. RCC's letter states, "A chemistry of approximately 4800 mg/l TDS [total dissolved solids] *was provided* as feed to the evaporator/drum dryer system" (emphasis added). Mr. Ingle posits that this wording suggests that HRI provided RCC an estimate of the quality of the waste water from the RO unit ("RO reject"). Id. at 1. Ingle Testimony at 18. In response, RCC quoted a price for a brine concentrator model capable of effectively treating waste water having a maximum total dissolved solid ("TDS") level of nearly 4,800 mg/l. But, as Mr. Ingle explains, this concentration for HRI's RO reject water is almost certainly too low.[14] If HRI had

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[14] According to the FEIS (Table 4.5 at 4-16), the TDS of the lixiviant will range between 1,500 and 5,500 mg/l. If the actual TDS level of the lixiviant (or, mining fluid) that enters the RO is in the middle to upper end of this range, then the TDS levels of the RO reject water could be much higher than 4,800 mg/l as a result of the concentrating effect of the reverse osmosis process. Mr. Ingle's experience at a proposed Wyoming ISL mine confirms this scenario. The RO unit at the proposed PRI Gas Hills mine is anticipated to produce a brine having a TDS concentration of 40,000 to 60,000 mg/l, or 8.3 to 12.5 times higher than HRI's estimate.

given RCC a more realistic assumption about the quality of the RO reject water, RCC would likely have quoted a price for a brine concentrator that has the capacity to treat a much more concentrated and contaminated waste stream.[15] Understandably, such a machine would cost more than the equipment quoted to HRI by RCC. By understating the quality of its RO waste water, HRI received an understated price quote for an undersized piece of hardware.

5. The RAP Underestimates the Number of Wells Needing Plugging and Abandonment During Restoration

In complete disregard of the direction to account for all activities necessary in order to terminate its license (NRC Technical Position on Financial Assurance, at 20) HRI is also significantly underestimating the costs of well plugging and abandonment ("P&A") by underestimating the number of injection and production wells that must be P&A'd during restoration. In the RAP, HRI clearly anticipates installing 215 injection wells and 226 extraction wells (see, "Well Plugging and Abandonment" table in Attachment E-4-1). Yet, in its license application, HRI estimated that the entire Church Rock site (Section 8 and Section 17 combined) would have more than 1,700 injection and production wells. Staub January 1999 Testimony, Table 7 at 37.[16] If that total were divided evenly between the two sites, then HRI would have around 845 wells (injectors plus extractors) for Section 8 — or, a little less than twice as many as

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[15] Indeed, a check of RCC's website (www.thomasregister.com/olc/rccionics/home.htm) shows that the company sells a wide range of machines capable of treating a variety of industrial waste waters having TDS concentrations approaching 100,000 mg/l.

[16] See Written Testimony of Dr. William P. Staub, attached at Exhibit 2 to ENDAUM's and SRIC's Amended Written Presentation on Groundwater Protection, January 18, 1999. In his testimony, Dr. Staub listed 868 production wells and 834 injection wells for the entire Church Rock site (Sections 8 and 17), based on a table contained in HRI's April 1996 answer to NRC Request for Additional Information Question #92.

anticipated in the RAP. Two times as many wells would nearly double the estimated cost of well plugging and abandonment from $401,345 to more than $800,000. That is a significant increase that is not accounted for or explained in the RAP.

6. HRI's Method to Plug and Abandon Wells Is Improper

HRI creates another problem for itself by failing to provide an adequate method to plug and abandon its wells. Dr. Abitz testifies that the plugging and abandonment of production wells, as proposed by HRI in Attachment E-4-2, relies on a simple and inadequate approach that minimizes HRI's commitment of technical, mechanical and cost resources at the expense of protecting the aquifer from the spread of contaminants. Abitz Testimony at 14-16. Dr. Abitz testifies that plugging and abandonment operations need to be carried out in a rigorous fashion to ensure that the well does not serve as a preferential flow path between groundwater zones of varying quality. Id. at 15. This becomes increasingly important as the depth of the well increases. Below Section 8, groundwater quality in the proposed mined ore zones will be of very poor quality and under greater hydrostatic pressure, relative to overlying groundwater in non-ore zones of the Westwater Canyon Member and Dakota Formation.[17] This requires that the cement plug be placed in a manner that avoids bridging (which is the formation of air gaps in the cement plug) to achieve a high degree of integrity with respect to minimizing the migration of contaminated groundwater from regions of high hydrostatic pressure to overlying regions of less

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[17] Groundwater horizons with higher hydrostatic pressure will flow to groundwater horizons with lower pressure. Therefore, groundwater horizons overlying the contaminated water in the ore zone are under less pressure and they will be impacted by the migration of the contaminated water from lower zones if a preferential path is formed by the improper abandonment of the well

pressure. Id. The well-plugging method proposed by HRI delivers grout from the top of the well casing, which greatly increases the potential of bridging and the formation of an ineffective seal.

Both Dr. Abitz and Mr. Ingle suggest setting up a drill rig with a tremie pipe and slurrying in cement from the bottom to the top of the hole. Abitz Testimony at 15; Ingle Testimony at 20. When executed properly, the tremie-line method eliminates bridging in the grout plug, which leads to decreased porosity and permeability and a greater probability that preferential flow paths have been minimized. Abitz Testimony at 15. This procedure is recommended by the Ohio EPA and the U.S. EPA and is required by WDEQ. Abitz Testimony at 15-16; Ingle Testimony at 20, n. 19. HRI does not propose to use this EPA-recommended and WDEQ-required method, which is could easily double the $847.98 average cost per hole estimated by HRI in the RAP. (See "Well Plugging and Abandonment Table," Attachment E-4-1, page 1.). Neither Mr. Ingle or Dr. Abitz expressed any confidence in the integrity of well plugging unless the cement is slurried from the bottom to the top of the well. Id. at 20; Abitz Testimony at 16.

7. HRI Underestimates Labor Costs

Disregarding NRC guidance to account for its costs, HRI underestimates the personnel requirements needed for wellfield and plant operators during the restoration period. There are numerous significant defects in HRI's assessment of labor costs. First, HRI's RAP does not clearly establish that restoration will be conducted on a 24 hour basis. As Mr. Ingle testifies, however, it is important to run a restoration operation on a 24 hour basis, otherwise, the cone of depression created by pumping out the contaminated water cannot be sustained. Ingle Testimony at 20. Mr. Ingle asserts that it is crucial that personnel be at the site to monitor and operate the treatment systems the entire 24 hours. Id. HRI seems to be planning its personnel needs around only one 8 hour shift and not around continuous (i.e., 24 hour) operation of the system.[18] Mr. Ingle concludes that HRI's labor cost estimates are low by a factor of three,[19] or HRI really does not intend to conduct continuous restoration, 24 hours per day, 7 days per week. Id. Either way, the RAP is seriously deficient in these critical areas.[20]

Second, the RAP is unclear regarding the positions needed to run the operation, the cost, and the number of shifts contemplated. HRI states in Section E.2.d "every employee will be wearing multiple hats" during the restoration phase. Yet, Mr. Ingle deduces that the labor cost summaries contained in Attachment E-2-3 contemplate only one employee for each of the five or six positions critical for proper operation of the restoration system. Id., at 21, n. 20. In providing financial assurance that will protect public health, the NRC cannot, nor should it, assume multiple responsibilities for individual employees. Neither should the NRC be confident in a financial assurance plan that bases its labor costs on a single eight-hour shift per day without consideration of multiple daily shifts and weekend and holiday operations.

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[18] This fact was deduced by both Dr. Abitz and Mr. Ingle by dividing the "Annual" wage figures in the "Labor Summaries" table in Attachment E-2-3 by 2,080 work hours in a 40-hour-per-week work year. Indeed, the hourly wages for non-salaried employees were calculated by HRI on an eight-hour per day/40 hour per week basis. This clearly indicates that HRI's cost estimates are based only on one eight-hour shift per day, not three eight-hour shifts that would be needed for continuous operation.

[19] Total salary and wage costs over the 53 months covered in the restoration are about $2.3 million. The additional labor costs for continuous operations over that 53-month period would be about $6.8 million.

[20] See also, Mr. Ingle's testimony that HRI makes a significant oversight when it fails to provide for a RO/BC operator, crucial for monitoring those processes each shift. Ingle Testimony at 22-23.

C. Lack of Fundamental Components of Acceptable Financial Assurance Plan

Both Mr. Ingle and Dr. Abitz state that HRI's RAP fails to provide cost estimates for several crucial elements of restoring an in situ leach uranium mine. Failure to provide such elements violates NRC regulation and guidance that directs licensees to account for all activities necessary in order to terminate its license (NRC Technical Position on Financial Assurance, at 20).

1. HRI Must Provide Reverse Osmosis Unit Operation and Maintenance and Disposal Costs

Mr. Ingle testifies that to ensure optimum operation of the Reverse Osmosis unit, solutions from a depleted mine area should be treated with anti-scalent, pH-balanced and run through sand filters and then cartridge filters. Ingle Testimony at 24-25.[21] HRI appears to agree; it states in the RAP (Section E.2.b., fourth page) that it intends to use anti-scalents and regularly clean out or replace the filters. But, as Mr. Ingle notes, HRI does not account for the significant down time that comes from backwashing the sand filter and replacing the cartridge filters. Id. The spent filters and trapped solids must be collected and transported to an offsite disposal facility licensed to receive 11(e)(2) byproduct material. These are disposal costs that are separate and therefore additional to estimated costs of disposing of the brine concentrator/dryer solids (see Attachment E-2-3). These costs are not reflected in HRI's RAP. HRI should have disclosed the volume and characteristics of its RO unit waste streams, and estimated the costs of properly and legally disposing of those wastes.

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[21] This is a necessity, because the RO membranes are sensitive to being clogged with scale and trapped solids.

2. HRI Must Account for the Costs of an Appropriate Reducing Agent

The RAP is deficient because it does not discuss or present costs to account for addition of a reducing agent (e.g., hydrogen sulfide) to the RO water injected into the aquifer. Addition of a reducing agent is an increasingly used restoration practice carried out at in situ leach uranium mines in Wyoming. Ingle Testimony at 24-25. Abitz Testimony at 10-11. As Dr. Abitz notes in his testimony, HRI's RAP fails to provide information or data that demonstrate the present aquifer reduction potential is capable of immobilizing uranium, arsenic, molybdenum and selenium once these constituents have been oxidized. Id. at 11. Specifically, HRI's Plan fails to provide any information on reaction kinetics to back up their speculation that uranium, arsenic, molybdenum and selenium will be reduced and immobilized in a timely fashion without the aid of a reducing agent. As Dr. Abitz testifies, HRI should add a reducing agent to the RO water to serve as a catalyst for the reduction reactions and that the addition of these chemicals to the RO injectate must be considered in the cost proposal. Id.

3. HRI Fails to Account for Several Other Important Issues

HRI's Plan omits or ignores several other crucial issues and costs that are significant in proper restoration of a contaminated aquifer. These missing costs, which, although not of the cost magnitude of the areas discussed above, are important because they represent costs that haven't been considered, and because their inclusion in a financial assurance plan increases the confidence of all the concerned parties in the completeness of the plan and competency of the operator. Ingle Testimony at 22.

Mr. Ingle testifies to several of these issues. (1) HRI's well plugging and abandonment cost estimate clearly ignores the costs associated with properly abandoning ore delineation holes.

Id. at 25-26. Abandoning 250 such holes, which is a conservative estimate, would add another $150,000 to the total cost. (2) HRI fails to account for cleanup of leakage from evaporation ponds that HRI proposes to construct at the Church Rock Section 8 satellite plant and operate at the Crownpoint Processing Plant.[22] Id. at 26. (3) HRI makes no provision in the bond proposal for backup equipment. Without backup equipment, there is no way to account for downtime, due to normal maintenance or equipment failure. Id. (4) HRI does not include NRC-mandated costs for contract administration contingency and inflation. Id. at 27-28. These costs alone would add more than $1 million to HRI's already underestimated total cost estimate of $9.4 million. RAP Attachment A-1. (5) HRI's estimate for analytical costs associated with post-restoration groundwater quality stability testing is low by at least 25%. Ingle Testimony at 27-28. (6) HRI does not include costs for mechanical integrity testing personnel and equipment and for computers and software. Federal and state underground injection control regulations, including those of the WDEQ, require mechanical integrity tests ("MIT") of all injection wells before they are placed in service and MITs every five years during the wells' operation. (7) Mr. Ingle believes it is crucial for HRI to determine baseline water quality early in the licensing or permitting process so that restoration standards can be established. Id. at 28-29. The simple fact is that the baseline water quality will determine the amount of restoration that will be needed. For example, if the baseline water quality contains 800 mg/l TDS and the lixiviant contains 1,000 mg/l TDS, then restoration will require less time and expense to return the groundwater to

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[22] Mr. Ingle testifies that in his experience all lined ponds eventually leak (even without a breach in the liner or berm integrity), and some of the underlying contaminated material will need to be disposed of as byproduct material. Ingle Testimony at 26.

baseline. However, if the mining solution is 1,500 mg/l to 5,500 mg/l TDS, then restoring to a baseline value of 360 mg/l TDS will cost considerably more and take much longer. This is precisely the situation at Church Rock. (See, FEIS, Table 4.6 at 4-16.) Hence, the HRI restoration cost estimate is not, at this time, based on attainment of baseline water quality after mining is done, but on the NRC's determination that the groundwater will have to be flushed nine times before the standards — whatever they will be — are attained.[23]

D. HRI's Overall Cost Estimate is Indefensibly Low

Mr. Ingle and Dr. Abitz present convincing evidence that HRI's overall cost estimate of $9.4 million is indefensibly low. Mr. Ingle compiled all of the cost inaccuracies, discrepancies, underestimations and omissions that he identified in his testimony in to show that HRI's cost estimate is likely to be closer to $23.9 million than $9.4 million — or 2.5 times higher than HRI projects in the RAP. Ingle Testimony, Table 2 at 32. Dr. Abitz finds, in his extensive comparison of HRI's Plan with actual and anticipated restoration experience at the Fernald site, that HRI's cost estimate is low by a factor of at least two, and perhaps as high as a factor of three, if HRI's restoration period extends outward to a more realistic 10 years. Abitz Testimony at 7-8. It should be clear from the Intervenors' experts separate but complimentary analyses that the cost estimate contained in HRI's RAP is indefensibly low by at least two times.

Conclusion

Put very simply, HRI's RAP is seriously flawed. By failing to demonstrate that it can comply with requirements of 10 CFR Part 40, Appendix A Criterion 9 and its corresponding

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[23] For a rough comparison of HRI's suggested surety amount with Intervenors' cost suggestions, see Table 2 in Mr. Ingle's Testimony at 32.

guidelines in the NRC's 1988 guidelines, "Technical Position on Financial Assurances for Reclamation, Decommissioning, and Long-Term Surveillance and Control of Uranium Recovery Facilities," HRI has not met its burden of demonstrating that its restoration plan will not threaten the public health nor endanger the groundwater supplies of Church Rock and surrounding Navajo communities in northwestern New Mexico.

In sum, HRI's Plan is inadequate to describe how the company will decommission, decontaminate and restore the Church Rock 8 mining site and the Crownpoint uranium processing plant site. Nor is HRI even remotely close to suggesting a conservative, protective surety amount, especially in light of its proposal to fund only one third of the suggested amount. See Table 2, Ingle Testimony at 33. The plan woefully underestimates the volume of water that will be processed during restoration, makes unsubstantiated assumptions about plant and equipment operating efficiencies, contains significant discrepancies from previous descriptions of restoration that were contained in key elements of the HRI license application, and simply omits a number of important components that are necessary to ensure that HRI's financial assurance and groundwater restoration plans are adequate.

For the foregoing reasons, the Presiding Officer should find that the RAP fails to meet the requirements of the AEA and NRC regulations in providing adequate financial assurance for decommissioning, decontamination and restoration of the Crownpoint Uranium Project.

Respectfully submitted,

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December 21, 2000

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
BEFORE THE COMMISSION

In the Matter of HYDRO RESOURCES, INC. P.O. Box 15910 Rio Rancho, NM 87174	Docket No. 40-8968-ML ASLBP No. 95-706-01-ML

CERTIFICATE OF SERVICE

I hereby certify that on December 21, 2000, I caused to be served copies of the foregoing:

INTERVENORS' RESPONSE TO HYDRO RESOURCES INC.'S COST ESTIMATES AND RESTORATION PLAN OF NOVEMBER 21, 2000

upon the following persons by U.S. mail, first class, and in accordance with the requirements of 10 C.F.R. § 2.712. Service was also made via e-mail to the parties marked below by an asterisk. The envelopes were addressed as follows:

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Dated at Santa Fe, New Mexico,
December 21, 2000

Geoffrey H. Fettus

December 19, 2000

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judge Thomas S. Moore

In the Matter of	)	
	)	
HYDRO RESOURCES, INC.	)	Docket No. 40-8968-ML
P.O Box 15910	)	
Rio Rancho, NM 87174	)	ASLBP No. 95-706-01-ML
	)	

WRITTEN TESTIMONY OF MR. STEVEN C. INGLE IN SUPPORT OF INTERVENORS' RESPONSE TO HYDRO RESOURCES INC.'S COST ESTIMATES AND RESTORATION ACTION PLAN OF NOVEMBER 21, 2000

On behalf of Eastern Navajo Diné Against Uranium Mining ("ENDAUM") and Southwest Research and Information Center ("SRIC"), Steven C. Ingle submits the following testimony regarding Hydro Resources Inc.'s ("HRI's") cost estimates and Restoration Action Plan ("RAP") for a source and byproduct materials license.

1. I am competent to give this testimony, and the factual statements herein are true and correct to the best of my knowledge, information and belief. The opinions expressed herein are based on my best professional judgment and extensive experience in treatment of uranium and other heavy metal contaminated groundwater as a result of in-situ leach ("ISL") uranium mining.

2. I am providing this testimony on behalf of ENDAUM and SRIC, in response to HRI's decontamination, decommissioning and reclamation ("DDR") plan for the Church Rock Section 8 site of the proposed Crownpoint Uranium Project ("CUP").

3. I am an expert in groundwater protection and restoration aspects of uranium in situ

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leach mining. My qualifications to give this testimony are contained in my resume, which is attached as **Attachment A** to this written testimony.[1] My relevant education, training and experience are summarized in my resume. As stated therein, I hold a Masters Degree in Geological Engineering from the South Dakota School of Mines and Technology and a Bachelors Degree in Geology from the University of Minnesota at Duluth. After receiving my masters degree, I spent 12 years in private industry performing uranium and precious metals exploration, primarily in the central and western U.S. I returned to school and did non-degreed post-graduate studies at the Colorado School of Mines in groundwater hydrology. For the past 15 years, I have worked as a groundwater hydrogeologist at the Wyoming Department of Environmental Quality ("WDEQ"), Land Quality Division ("LQD"), involved primarily in uranium and coal mining regulation. I am currently a senior analyst. In this position, I also serve as the State of Wyoming's principal contact with the U.S. Environmental Protection Agency ("USEPA") for Class III Underground Injection Control ("UIC") operations in Wyoming.[2] While at WDEQ, I have served as the permit coordinator for groundwater restoration at several commercial-scale ISL uranium mines. My work at the WDEQ has encompassed virtually all facets of environmental regulation of ISL uranium mines, including review of permit applications, site investigations, remedial investigations, groundwater monitoring, analysis of environmental chemical data, computer modeling of soil and groundwater systems, and soil and groundwater restoration. As one of WDEQ's technical experts who evaluate and resolve

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[1] Attachments will hereinafter be designated as "Ex. __."

[2] Class III UIC wells often are called solution mining wells and include injection wells for the purpose of producing uranium.

groundwater restoration at uranium mines, I am intimately familiar with the variety of solid and liquid uranium species that occur in the environment and the chemical and physical properties that affect the mobilization of uranium and its radioactive progeny. I am intimately familiar with all aspects of uranium ISL mining techniques including lixiviant formulation, geometry of injection and extraction wells, geochemical reactions that occur between the lixiviant and ore-zone minerals, ion-exchange processes used to recover uranium from the pregnant lixiviant, and groundwater sweep, reverse osmosis and reductant treatment processes used to restore the mined groundwater zones. I am also intimately familiar with the content and breadth of uranium ISL financial assurance plans, having evaluated most of the plans submitted to WDEQ by commercial ISL operators in the state. I am knowledgeable in restoration and financial assurance requirements of the State of Wyoming and of the NRC, including NRC's financial assurance regulations, codified at 10 CFR 40, Appendix A, Criterion 9, and its corresponding 1988 staff guidance document.

4. In preparing this affidavit, I have reviewed the following documents and materials:

Hydro Resources, Inc. Church Rock Section 8/Crownpoint Process Plant Restoration Action Plan ("RAP", or "the Plan"). License No. SUA-1580, November 17, 2000.

Power Resources, Inc. WDEQ Annual Report for Permit 603, Highland Uranium Project ("PRI 2000 Annual Report"), July 2000.

U.S. Nuclear Regulatory Commission, Memorandum and Order, CLI-00-08, May 25, 2000.

ENDAUM's and SRIC's Brief on Review of Partial Initial Decision LBP-99-13, Financial Assurance for Decommissioning, August 13, 1999.

Written Testimony of Dr. Richard J. Abitz ("Abitz Testimony"), January 8, 1999, and Written Testimony of Dr. William P. Staub ("Staub Testimony"), January 9, 1999, attached as Attachments 1 and 2, respectively, to ENDAUM's and SRIC's Amended Written Presentation on Groundwater Protection, January 18, 1999.

Written Testimony of Michael F. Sheehan ("Sheehan Testimony"), Ph.D., January 7, 1999, attached at Attachment 1 to ENDAUM's and SRIC's Written Presentation on Financial Assurance for Decommissioning, January 11, 1999.

Source Materials License SUA-1508, Hydro Resources, Inc., Crownpoint Uranium Project ("HRI License"), January 5, 1998. Hearing Record ACN 980116066.

Safety Evaluation Report, Hydro Resources, Inc. License Application for Crownpoint Uranium Solution Mining Project, McKinley County, New Mexico. U.S. Nuclear Regulatory Commission, Washington, D.C., December 5, 1997.

Draft Standard Review Plan for In Situ Leach Uranium Extraction License Applications. NUREG-1569 Division of Waste Mangement, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C., October 1997.

Crownpoint Uranium Project Consolidated Operations Plan ("COP"), Revision 2.0. Hydro Resources, Inc., Albuquerque, New Mexico, August 15, 1997. Hearing Record ACN 9708210179.

Final Environmental Impact Statement to Construct and Operate the Crownpoint Uranium Solution Mining Project, Crownpoint, New Mexico, NUREG-1508, BLM NM-010-93-02, BIA EIS-92-001 ("FEIS"). Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, in cooperation with U.S. Bureau of Land Management and U.S. Bureau of Indian Affairs, February, 1997. Hearing Record ACN 9703200270.

G. A. Cash, WDEQ, Land Quality Department. Letter to S. Morzenti, Power Resources, Inc., concerning "Correction to Table IV, Pore Volume Esimate-Power Resources, Inc. Highland Uranium Project, June 1996," Wyoming Department of Environmental Quality, August 13, 1996 (with attached Table IV).

A. Lafferty, S. Ingle, R. Hoy, WDEQ Land Quality Department. Memorandum to G. A. Cash, transmitting "Technical Review, PRI Pore Volume Estimte — Permit 603, June 1996," June 17, 1996.

Power Resources, Inc. Gas Hills In Situ Leach Permit Application. Wyoming Department of Environmental Quality, Temporary Filing No. 3 5/93 (updated material submitted in 2000).

Technical Position on Financial Assurances for Reclamation, Decommissioning, and Long-Term Surveillance and Control of Uranium Recovery Facilities, U.S. Nuclear Regulatory Commission, Division of Low-Level Waste Management and Decommissioning, October 1988.

M. G. McDonald and A. W. Harbaugh. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, in *Techniques of Water-Resources Investigations of the United States Geological Survey*, Book 6, Ch.A1, U.S. Government Printing Office (Washington, DC), 1988.

M. G. McDonald and A. W. Harbaugh. A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, U.S. Geological Survey ("USGS") Open-File Report 83-875, 1983.

Finally, I have participated in numerous telephone calls and conference calls with other members of ENDAUM's and SRIC's team of experts to discuss issues regarding HRI's project in general and the company's November 17 financial assurance plan specifically.

5. The purpose of this testimony is to set forth my professional opinion on the adequacy of HRI's Restoration Action Plan ("RAP" or "the Plan"), which was submitted by HRI to the NRC on November 21, 2000. The RAP describes HRI's proposal for restoring groundwater and drinking water supplies at the Church Rock Section 8 site after mining ceases. In my professional opinion, the Plan does not meet the standards set forth in the NRC's financial assurance requirements for source and byproduct materials licenses — Criterion 9 of 10 CFR Part 40 Appendix A, and the NRC's 1988 "Technical Position on Financial Assurances for Reclamation, Decommissioning, and Long-Term Surveillance and Control of Uranium Recovery Facilities" ("Technical Position on Financial Assurances"). HRI's Plan is inadequate to describe and define the techniques to be used and the costs associated with decommissioning, decontaminating and restoration ("DDR") of the Church Rock 8 mining site and the Crownpoint uranium processing plant site. The plan woefully underestimates the volume of water that will be processed during restoration, makes unsubstantiated assumptions about equipment operating efficiencies, contains significant discrepancies from previous descriptions of restoration that were

contained in key elements of the HRI license application, fails to provide for 24-hour continuous operation to ensure restoration effectiveness, and simply omits a number of critical components, including more than $1 million in NRC-mandated costs for contract administration and inflation. On the cost side, my analysis shows that the Plan's overall cost estimate of $9.48 million is *low* by *at least* 2.5 times. And on the technical side, my analysis demonstrates that HRI's Restoration Action Plan will not protect the public health or the groundwater supplies of Church Rock and surrounding Navajo communities in northwestern New Mexico. As such, I believe the RAP should not be approved by the NRC.

A. HRI's Restoration Action Plan Does Not Satisfy Requirements of Criterion 9 or the NRC Technical Position on Financial Assurances

6. Criterion 9 of Appendix A of 10 CFR Part 40 requires licensees to establish and maintain financial surety for uranium mill and tailings operations. The amount of the surety should be based on a "Commission-approved plan for decommissioning, . . .decontamination,. . . and reclamation. . ." The plan itself should be submitted "in conjunction with an environmental report that addresses the expected environmental impacts of the milling operation, decommissioning and tailings reclamation. . ."

7. These broad objectives are discussed in more detail, and with specific references to uranium ISL mining, in the NRC Technical Position on Financial Assurances. The Commission "views" the Technical Position "as a regulatory tool, for applicants, licenses, and NRC staff, for implementing . . .Criteria 9." Technical Position on Financial Assurances at i. This means that the NRC Staff uses provisions of the Technical Position to evaluate an applicant's financial assurance plan and DDR cost estimates.

8. In my view, HRI's Restoration Action Plan does not satisfy the provisions of the Technical Position. For example, the Technical Position states (at 23) that costs associated with groundwater restoration should be based in part on the "volume of aquifer required to be restored, area and thickness of aquifer, [and] number of pumping cycles. . ." Based on my examination of HRI's pore volume calculation, and its use of a horizontal flare factor that is low by at least a factor of two (see Paragraphs 10-19 below), I believe that HRI has not adequately established the volume of restoration water that will need treatment, and therefore has not adequately estimated the cost of groundwater restoration.

B. Overview of Technical Deficiencies of the HRI Restoration Action Plan

9. There are three main areas of technical deficiencies in the HRI Plan. First, the RAP woefully underestimates the volume of water that will be processed during restoration, and in turn renders the Plan's cost estimates low by at least a factor of two. Second, it makes unsubstantiated assumptions and outright errors about plant and equipment operating efficiencies and about restoration through-flow, thus reducing still further cost estimates that are already unreasonably low. In this context, I also identify several significant discrepancies between information in the RAP and previous descriptions of restoration that were contained in key elements of the HRI license application. These discrepancies raise questions in my mind about the accuracy and credibility of the RAP. And third, the Plan is simply void of many components that are fundamental elements of the financial plans of current uranium ISL operators in Wyoming. These omissions also work to lessen the cost estimates attendant to the plan.

C. Underestimation of Volume of Water Processed During Restoration

10. I believe that HRI's Restoration Plan significantly underestimates the volume of water necessary for restoration, principally by undersizing each "pore volume" of water that must be restored.[3] I believe that the primary source of this underestimation is the 1.5 horizontal "flare" factor that HRI chose to calculate the amount of water in every pore volume at the Church Rock Section 8 site. In this part of my testimony, I will explain how I reached these conclusions and why an accurate estimatation of the horizontal flare factor is critical to the determination of the volume of water that must be treated during restoration.

11. First, I should define the terms "pore volume," "flare factor," and "flare water" and how they are related mathematically. In a general sense, a pore volume is the total volume or amount of water that occupies the spaces between the grains of sand in an aquifer. When applied to a uranium ISL mine, a pore volume is the total volume or amount of water that in the aquifer that must be treated, or restored, during and after mining. The horizontal flare factor describes the portion of the aquifer that contains fluids, such as lixiviant, which have migrated or "flared" laterally from the pattern area during mining, but have remained undetected in the aquifer inside the perimeter monitor well ring. The "flare water" is an important component of the total amount of fluid must be "flushed" from the aquifer during restoration. In general, then, a pore volume at an ISL mine is defined in mathematical terms as:

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[3] Intervenors and I agree with HRI that the general definition of a pore volume is the amount of water needed to leach an ore body or the amount of water that must be flushed through the depleted ore to restore the groundwater to its pre-mining, baseline water quality. However, we disagree with HRI's calculation of an appropriate pore volume for restoration of Section 8 once contaminated by mining.

Pore volume = (wellfield area) x (ore zone thickness) x (effective porosity[4]) x (horizontal flare factor) x (vertical flare factor)[5]

As can be seen from this equation, the horizontal flare factor has a direct effect on the amount of water in each pore volume: the higher the flare factor, the greater the volume of water in each pore volume.

12. To test the accuracy of pore volume estimates at Wyoming ISL mines, I developed a model to estimate the horizontal flare factor. The model was based on and used the U.S. Geological Survey's MODFLOW[6] computer program to simulate groundwater flow using actual aquifer characteristics. My colleagues and I applied the model to the Power Resources, Inc. ("PRI"), Highland Uranium Project A and B wellfields, using the ore zone dimensions and aquifer parameters of a portion one of those wellfields. The model itself and the results of its application to the PRI Highland mine are described in a June 1996 WDEQ technical report that I coauthored. The report, titled "Technical Review, PRI Pore Volume Estimate, Permit 603," is appended to my testimony at **Attachment B**. An August 13, 1996, WDEQ letter to PRI explaining minor corrections to the model output and attaching a revised table comparing PRI's

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[4] Effective porosity is the portion, or percentage, of the void spaces between the grains of sand in an aquifer that are filled with water that can be removed.

[5] This mathematical relationship can be, and often is, manipulated to account for site-specific geologic conditions, mining techniques, and conversion factors for differing units of volume.

[6] MODFLOW is a commonly used computer program that allows groundwater hydrologists to simulate the flow of groundwater, and any contaminants, or "particles," contained in it, using actual aquifer data. It was developed by the U.S. Geological Survey (McDonald and Harbaugh, 1983 and 1988), has been court-justified, and is accepted for use in regulatory compliance by USEPA and most state environmental agencies.

and WDEQ's estimated pore volumes is appended to my testimony as **Attachment C**. The MODFLOW simulation was performed using an existing "ideal" wellfield pattern used by PRI at the Highland Project. **Ex. B, Figure 1**. The pattern was optimally balanced and the simulation run to steady state conditions. The portion of MODFLOW that calculates groundwater flow velocity was then run and the extent of horizontal flare calculated.[7]

13. The results of the modeling of groundwater flow at PRI's Highland mine confirmed our suspicion: The horizontal flare factor was not 1.4 as PRI had claimed, but actually 3.0. **Ex. B, Table IV and Ex. C, Table IV**. Power Resources later reran the model, using a particle tracking program in MODFLOW. The horizontal flare factor obtained by PRI using the modified model was 2.94, or only slightly lower than the value obtained earlier by the WDEQ staff.[8]

14. The effect of using a horizontal flare factor of 2.94 for PRI's Highland Project was to increase the volume of restoration water by factors ranging from 2.7 times to 5.2 times for each of the six ore zones at PRI operation. These effects can be seen in the pore-volume calculations in revised Table IV (**Ex. C**). These increased volumes in turn led to an increase in the amount of PRI's financial surety for the Highland Project.[9]

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[7] MODFLOW uses the hydraulic charateristics to determine the velocity, or speed, of the water moving through the aquifer. Velocity multiplied by time gives the distance a particle, such as chloride, has moved. The computer program will make these calculations very rapidly.

[8] The WDEQ flare factor was slightly larger than that of the agreed upon factor of 2.94 because of slight differences in aquifer parameters and the actual wellfield bleed rate.

[9] The resulting increase in the PRI-Highland surety amount is documented in the record of the HRI-CUP proceeding. See, Sheehan Testimony, Attachment E (letter from P. R. Hildenbrand, PRI, to G. Cash, WDEQ/LQD, September 12, 1997).

15. Although the WDEQ model was applied to the specific conditions at the PRI Highland site, there is no reason that it cannot be applied to virtually any uranium ISL mine because it incorporates site-specific geologic and hydrologic conditions and uses wellfield geometries that are specific to each site. I suspect that when the model is applied to two other ISL operations[10] that are mining the same formation as that at the PRI site, we will find higher horizontal flare factors — and therefore, larger pore volumes — at those mines, too.

16. I believe that the conditions at the PRI Highland Project are sufficiently analogous to those at the HRI Section 8 site to conclude that HRI should have used a much larger horizontal flare factor to estimate the volume of water that will be processed during restoration at Section 8. I base this opinion on several factors. First, the ore zones at both sites are set in interbedded sandstones of fluvial deposition. **Ex. B at 1**; Abitz Testimony at 9-10; FEIS at 3-18. Second, baseline water quality, expressed as total dissolved solids, at the PRI site is similar to that at the Church Rock site. Staub Testimony, Table 6 at 23. And third, the dimensions of the wellfields and orebodies and the porosity of the aquifers are remarkably similar between the Highland Project and the Section 8 project. These similarities can readily be seen by comparing the data in Table 1 of the HRI RAP (section E.2, page 2) with those in revised Table IV of **Ex. C.** For ease of comparison, I have placed both of these tables on a single sheet and incorporated them into **Attachment D** attached hereto. At PRI, the wellfield areas range from about 107,000 square feet

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[10] These are the Rio Algom Smith Ranch Mine and Cogema's Irigaray/Christensen Ranch Project.

("ft^2") (Wellfield A) to 1.6 million ft^2 (Wellfield F)[11]; at Section 8, the wellfield areas range from 124,600 ft^2 (Zone UD) to 658,700 ft^2 (Zone UC). The ore zone thickness at PRI is about 15 ft.; the ore zone thicknesses at Section 8 vary from 8.6 to 14.9 ft. And the porosites are 0.27 and 0.25, respectively. Because of these similarities. I believe that PRI's conditions are directly compared to those at HRI's Section 8 site, and that HRI should have used a higher horizontal flare factor.[12]

17. After reviewing HRI's Restoration Action Plan, I can find no site-specific or technical basis for HRI's selection of a horizontal flare factor of 1.5. HRI states, on the third page of Section E.2 ("Groundwater Restoration Budget") of the RAP, that flare factors "are commonly used by the ISL industry to account for leach solution outside the specific boundaries" of the ore zones and "are generally accepted increases that should be recognized in cost estimates." HRI goes on to say that it uses horizontal and vertical "pore volume increase factors" of 1.5 and 1.3, respectively. The company does not indicate how it determined either number. I believe that it is reasonable and feasible to for any ISL permit applicant to perform a site-specific analysis to obtain an appropriate flare factor. Using a generic horizontal flare factor — especially a factor as low as 1.5 — is not acceptable in this case.

18. The practical effect of using a horizontal flare factor that is nearly twice that

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[11] These areas are calculated by multiplying the "Ideal" Pattern Area in Column 3 of Table IV by the "Number of Patterns" in Column 4.

[12] The factor identified as "Barren Zone Sweep Efficiency" in Table IV is virtually the same at "V-PIF", or vertical flare factor, in HRI Table 1. Indeed, the cover memorandum for the WDEQ Technical Report states clearly that the "vertical component is expressed in terms of the 'barren zone sweep efficiency'. . . (Ex. B).

proposed by HRI (i.e., 2.94 v. 1.5) is to nearly double the amount of water needed for restoration of the contaminated aquifer. This effect can readily be observed by examining Table 1 of HRI's RAP. By substituting the value of 2.94 for the number 1.5 in the column headed "H-PIF", and multiplying the factors given in the table, the total volume of water processed during restoration of the nine listed ore zones increases from 1.33 billion gallons to approximately 2.5 billion gallons. This near doubling of the volume of water needed for restoration dramatically increases the cost of restoration. I base this conclusion on an examination of the groundwater restoration spreadsheet contained in the HRI Plan as Attachment E-2-1. On line 35 of the spreadsheet, the beginning volume of restoration water planned for treatment is 1.33 billion gallons. HRI projects that it will take four years and five months to treat this initially planned, beginning volume. Assuming that HRI's other input factors to Table 1 are accurate, the effect of having to treat 2.5 billion gallons would nearly double the restoration time period to approximately nine years, and thereby nearly double the estimated costs from $7.2 million to more than $14 million.[13]

19. In summary, our modeling of groundwater flow at a Wyoming ISL mine having analogous characteristics to those of HRI's Section 8 demonstrated that the horizontal flare factor was more than twice that estimated by the mine operator. While we applied the MODFLOW-based model to a particular site, it can be applied to any uranium ISL site. HRI chose not to conduct a site-specific analysis, such as the one conducted by WDEQ and PRI, but instead to use a generic horizontal flare factor that is not conservative. The effect of HRI's choice is to

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[13] HRI's estimated cost of groundwater restoration of $7.2 million is reflected on the last column of the spreadsheet on the fifth page of Attachment E-2-1 and also in the first line of the RAP "Summary" table contained in Attachment A-1.

underestimate restoration fluid volume by nearly two times and in turn underestimate restoration costs by nearly twice.

D. Unsubstantiated Assumptions About Operating Efficiencies, Discrepancies in Flow Rates, and Understated Equipment and Reclamation Costs

20. The NRC's Technical Position on Financial Assurances advises (at 20) that a licensee's or applicant's financial assurance plan should include "assumptions on equipment and operator efficiencies." As I discuss in the paragraphs that follow, HRI has overstated the efficiency of the brine concentrator it proposes to use while omitting the costs of the unit from the plan's overall cost estimate. The HRI RAP also underestimates costs associated with well plugging and abandonment (Technical Position at 23) and contains no provisions for contract administration contingency costs or cost adjustments for inflation (*Id.* at 26).

21. In examining HRI's groundwater restoration plan, especially the descriptions of the reverse osmosis ("RO") treatment of wellfield restoration solutions and brine concentration of RO "reject" water, I found several problems:

- overstated efficiencies of the proposed brine concentrator ("BC")
- discrepancies in restoration flow rates between the RAP and earlier HRI and NRC documents
- failure to account for $2.5 million in capital costs for the BC system, including the rotary drum dryer
- understated brine concentrations that result in undersized equipment

I will discuss these problems in detail in the paragraphs that follow.

22. **Overstated Efficiencies of the Brine Concentrator.** As shown in Table 1 below, HRI misstates the efficiency of its brine concentration system ("BCS"). In section E.2.c. of the RAP, HRI states, "Typically, for each 100 gallons of waste brine treated, 99 gallons of distilled water and 1 gallon of slurry solids are formed." The water-to-brine ratio (in gpm) envisioned by

HRI in the groundwater restoration spreadsheet in Attachment E-2-1 is 115:1, or 99.1% (i.e., 115 gpm/116 gpm) efficiency. Yet, the efficiency of the BCS that HRI proposes to use is about 97 percent, according to the manufacturer's own description of the system. That description is contained in a letter to HRI from Resources Conservation Company (RCC) that is included in the RAP in Attachment E-2-4. RCC states that its system generates 3.2 gpm of brine out of a maximum capacity of 125 gpm entering the BC. That ratio represents a water-to-brine efficiency of about 97.4% (or, 121.8 gpm/125 gpm), which is 1.7% *less efficient* than represented by HRI in the text of the RAP.

Table 1. Comparison of flow rates and Brine Concentrator System efficiencies among various descriptions of the proposed HRI Church Rock groundwater restoration scheme.

	Inflow to RO Unit in gpm	**RO prod'd H20 to reinjection, in gpm (% of inflow)**	**RO reject H2O to BCS, in gpm**	**BC prod'd H2O to reinjection, in gpm**	**BC brine to dryer (or evap pond), in gpm**	**BCS efficiency**
FEIS fig 2.7	200	150 (75%)	50	48	2	96%
COP fig. 10.4-1	200	150 (75%)	50	49	1	98%
RCC Letter (Att. E-2-4)	---	---		121/125 max	3.2	97%
HRI RAP (Sec. E.2.b. and c.)	580	464 (80%)	116	99/100 gals treated (flow rate not given)	1/100 gals treated (flow rate not given)	99%

23. **Increased Brine Volumes.** This lower brine concentrator efficiency has the pronounced effect of nearly tripling the total amount of brine that HRI will need to process every

month during restoration. Instead of generating 44,640 gallons of brine per month,[14] HRI's BCS will generate about 130,000 gallons of brine per month. I derived this number using the manufacturer's BC maximum and brine outflow rates, instead of HRI's. The result is shown in the following calculations:

i. Manufacturer's brine flow rate = 3.2 gpm out of 125 gpm maximum inflow

ii. HRI's projected brine outflow rate = 1 gpm out of 116 gpm maximum inflow

iii. HRI's manufacturer's-equivalent brine flow rate = 3.2 gpm x 116 max. gpm/125 gpm = 2.97 gpm brine output from the RCC brine concentrator

iv. HRI's revised monthly brine output = 2.97 gpm x 60 min/hr x 24 hr/day x 30.4 days/mo = 130,015 gallons of brine per month

This larger volume of brine generated from the concentrator will necessitate a longer restoration period, additional operational costs (especially for electricity) for the BC and associated rotary drum dryer, and additional costs for disposal of the larger volume of BC solids produced from the dryer. The additional disposal costs could be substantial.

24. **Flow Discrepancies**. The second problem involving HRI's description of the restoration system involves discrepancies between information in the RAP and previous information in HRI's license application documents and the FEIS. As shown in Table 1 above, the 580 gpm flow rate described in the RAP is 2.9 times greater than the 200 gpm flow rate

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[14] This is the value shown by HRI in line 33 of the restoration spreadsheet in Attachment E-2-1 of the RAP. I believe the number is derived as follows: brine flow (1 gpm) x 60 min/hr x 24 hr/day x 31 days/mo. I do not understand why HRI would use a factor of 31 days per month since that would result in a 372-day year.

described in HRI's August 1997 Consolidated Operations Plan (Figure 10.4-1 at COP-162) and in the NRC's FEIS (Figure 2.7 at 2-22). In the COP and the FEIS, restoration flow diagrams were provided to showed where the mining solutions were routed and how many gallons per minute of waste water were treated at each step of the process. I have copied this diagrams and included them in **Attachment E** attached hereto. In these diagrams, the RO unit generates 50 gpm of "reject" water (or 25% of the total flow) that enters the BC. In the RAP (which does not contain a similar flow diagram), 116 gpm of RO reject water (or 20% of the total flow) enters the brine concentrator. HRI does not discuss why the amount of restoration water entering the system has nearly tripled in the 3-plus years that have elapsed since the FEIS and the COP were prepared.

25. **Unaccounted for Costs of the BCS**. The third problem involves HRI's apparent failure to account for $2.5 million in capital costs for the BC system, including the rotary drum dryer. HRI states on page 5 of Section E.2.c of the RAP, "BC costs are included within the O & M budget in Attachment E-2-1." I closely inspected the spreadsheet in Attachment E-2-1 and I cannot find any line item titled "O&M Budget," nor can I decipher any line item that would account for $2.5 million in BCS costs. The cost estimates in the restoration spreadsheet are strictly for operations of the wellfield and RO during restoration. Neither could I find any other reference or text in the RAP to verify that HRI has accounted for the costs of the brine concentrator. This oversight is serious because it ignores a significant cost that is associated with an absolutely critical piece of restoration hardware and that certainly would increase the total surety amount needed for the project.

26. **Underestimated Cost of the Brine Concentrator**. Not only is the cost of the brine

concentrator system unaccounted for, but its actual cost is likely to be much higher than the $2.5 million quoted by Resources Conservation Company in its September 13, 2000, letter to HRI. See RAP, Attachment E-2-4 at 4. RCC's letter states, "A chemistry of approximately 4800 mg/l TDS [total dissolved solids] *was provided* as feed to the evaporator/drum dryer system" (emphasis added). This wording suggests that HRI provided RCC an estimate of the quality of the waste water from the RO unit ("RO reject"). Id. at 1. In response, RCC quoted a price for a brine concentrator model capable of effectively treating waste water having a maximum TDS level of nearly 4,800 mg/l. But this concentration for HRI's RO reject water is almost certainly too low. According to the FEIS (Table 4.5 at 4-16), the TDS of the lixiviant will range between 1,500 and 5,500 mg/l. If the actual TDS level of the lixiviant (or, mining fluid) that enters the RO is in the middle to upper end of this range, then the TDS levels of the RO reject water could be much higher than 4,800 mg/l as a result of the concentrating effect of the reverse osmosis process.[15] Projected RO reject water quality at a proposed Wyoming ISL mine confirms this. The RO unit at the proposed PRI Gas Hills mine is anticipated to produce a brine having a TDS concentration of 40,000 to 60,000 mg/l, or 8.3 to 12.5 times higher than HRI's estimate.[16] If HRI had given RCC a more realistic assumption about the quality of the RO reject water, RCC would likely have quoted a price for a brine concentrator that has the capacity to treat a much more

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[15] Indeed, the purpose of the RO unit is to concentrate the dissolved solids in the mine water. "Clean" water, or mining effluent that has been treated to remove contaminants, comes out one side of the RO. Highly concentrated dirty water, or "RO reject" water, comes out the "back end" of the unit. This is illustrated in the diagrams in **Attachment E**.

[16] Data from the PRI Gas Hills permit application are shown in **Attachment F** attached to this affidavit.

concentrated and contaminated waste stream.[17] Understandably, such a machine would cost more than the equipment quoted to HRI by RCC. By understating the quality of its RO waste water, HRI received an understated price quote for an undersized piece of hardware.

27. **Wells Needing Plugging and Abandonment**. I am concerned that HRI is also significantly underestimating the costs of well plugging and abandonment ("P&A") by underestimating the number of injection and production wells that must be P&A'd during restoration. In the RAP, HRI clearly anticipates installing 215 injection wells and 226 extraction wells (see, "Well Plugging and Abandonment" table in Attachment E-4-1). Yet, in its license application, HRI estimated that the entire Church Rock site (Section 8 and Section 17 combined) would have more than 1,700 injection and production wells. Staub Testimony, Table 7 at 37.[18] If that total were divided evenly between the two sites, then HRI would have around 845 wells (injectors plus extractors) for Section 8 — or, a little less than twice as many as anticipated in the RAP. Two times as many wells would nearly double the estimated cost of well plugging and abandonment from $401,345 to more than $800,000. That is a significant increase that is not accounted for or explained in the RAP.

28. **Proper Well Plugging and Abandonment**. The method that HRI proposes to use to plug and abandon its wells is improper. Proper abandonment techniques will protect

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[17] Indeed, a check of RCC's website (www.thomasregister.com/olc/rccionics/home.htm) shows that the company sells a wide range of machines capable of treating a variety of industrial waste waters having TDS concentrations approaching 100,000 mg/l.

[18] Dr. Staub listed 868 production wells and 834 injection wells for the entire Church Rock site (Sections 8 and 17), based on a table contained in HRI's April 1996 answer to NRC Request for Additional Information Question #92.

groundwater resources, but will cost more than HRI has estimated. HRI states in its parent company's Standard Operating Procedures document (see Attachment E-4-2 of RAP) that it will plug and abandon mining wells by slurrying in cement from the top of the hole. This procedure is not consistent with the procedure recommended by EPA and required by WDEQ. According to an EPA manual on design and installation of groundwater monitoring wells, wells must be abandoned by slurrying in cement from the *bottom to the top* of the hole "to prevent segregation, dilution and bridging" of the cement.[19] This requires setting up a drill rig with a tremie pipe to fill the hole with cement. HRI does not propose to use this EPA-recommended and WDEQ-required method, which is more costly than HRI's proposed method. Proper plugging and abandonment pursuant to the EPA method could easily *double* the $847.98 average cost per hole estimated by HRI in the RAP. (See "Well Plugging and Abandonment Table," Attachment E-4-1, page 1.) I would not have confidence in the integrity of well plugging unless the cement is slurried from the bottom to the top of the well.

29. **Underestimated Personnel Requirements**. I believe that HRI has underestimated personnel requirements needed for wellfield and plant operators during the restoration period. In order to restore an ISL mine safely, the restoration operation must be run on a 24-hour basis; otherwise, the cone of depression created by pumping out contaminated water cannot be sustained. HRI's RAP does not clearly establish that restoration will in fact be conducted on a 24-hour basis. HRI states in Section E.2.d. that "every employee will be wearing multiple hats"

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[19] L. Aller, et al. Handbook of Suggested Practices for the Design and Installation of Ground-water Monitoring wells. U.S. Environmental Protection Agency (EPA 600/4-89/034), 1989, p. 260.

during the restoration phase. HRI states that several salaried and hourly employees will work in a variety of restoration-related positions and have overlapping duties during restoration. The cost estimates contained in the restoration spreadsheet in Attachment E-2-1 and the labor cost summaries contained in Attachment E-2-3 contemplate only one employee for each of the five or six positions critical for proper operation of the restoration system.[20] It looks to me like HRI is planning its personnel needs around only one eight-hour shift, and not around continuous (i.e., 24-hour) operation of the restoration system.[21] For bonding purposes, neither the State nor NRC can or should assume multiple responsibilities for individual employees. Neither should the NRC be confident in a financial assurance plan that bases its labor costs on a single eight-hour shift per day without consideration of multiple daily shifts and weekend and holiday operations. For these reasons, I must conclude that either HRI's labor cost estimates are low by a factor of three,[22] or HRI really does not intend to conduct continuous restoration, 24 hours per day, 7 days per week. Either way, the RAP is seriously deficient in these critical areas.

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[20] Indeed, the restoration cost spreadsheet includes $10,487 in monthly costs for hourly wage workers, totaling $125,844 a year. From the "Labor Summaries" table in Attachment E-2-3, I find that amount buys only a plant operator, foreman, wellfield operator, environmental sampler and pump hoist operator (wages totaling $123,763).

[21] I deduced this fact by dividing the "Annual" wage figures in the "Labor Summaries" table in Attachment E-2-3 by 2,080 work hours in a 40-hour-per-week work year. Indeed, the hourly wages for non-salaried employees were calculated by HRI on an eight-hour per day/40 hour per week basis. This clearly indicates that HRI's cost estimates are on based only on one eight-hour shift per day, not three eight-hour shifts that would be needed for continuous operation.

[22] Total salary and wage costs over the 53 months covered in the restoration are about $2.3 million. If, as I suspect, these costs reflect only one eight-hour shift per day, then the additional labor costs for continuous operations over that 53-month period would be about $6.8 million.

30. **Lack of RO/BC Operator.** No provision is made for an operator of the RO unit and brine concentrator. Based on my knowledge of uranium ISL restoration operations, I believe that at least one person is needed to monitor the RO and BC operations in each shift. Assuming that at least three workers are needed if the RO and BC units are operated 24 hours a day, seven days a week, and each worker is paid about $25,000 annually, then RO/BC-associated labor costs alone would be about $331,250 over 53 months,[23] or higher if restoration takes longer, which I believe it will.

31. **Brine Disposal Costs.** I believe that HRI's estimate of $6,541 per month in costs for disposal of brine concentrator solids (which amounts to $346,673 over the 53-month restoration period) is unreasonably low. The byproduct material disposal cost estimated by HRI does not include the receiving fee ($55/cubic yard) charged by International Uranium (USA) Corporation ("IUSA") at the Blanding site or the $10/cubic foot ($270/cubic yard) charge for items specified under Part 10, item (ii) of the IUSA disposal agreement, which is included in the HRI RAP in Attachment E-5-3. Neither does HRI account for the $35/hour unloading time charge contained in the agreement. HRI must include the IUSA charges in its disposal cost estimate.

32. **Miscellaneous Items**. I also have concerns about several other items for which cost estimates are either absent from or appear to be presented inaccurately in the RAP. While none of these items individually may appear to be significant against the total cost of DDR, together they may add a few hundreds of thousands of dollars to the total cost estimate. More important, the fact that these items are missing or inaccurate again makes me question the completeness,

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[23] This amount is calculated as follows: $25,000/yr x 3 employees = $75,000/12 mos/yr = $6,250/mo x 53 mos = $331,250.

accuracy, and credibility of the either plan. Those items include:

i. The RAP includes a pay category for a geophysical well logger (see Attachment E-2-3, page 1), but does not include a cost estimate for well logging equipment or well logging contractors. These costs will be significant for the 400 to 800 wells that eventually will be installed in Section 8. HRI must include a contract cost for geophysical logging.

ii . The estimated electrical pump cost is $0.0875/kw, but the estimated wellfield and plant electrical cost is $0.075/kw. HRI needs to use the $0.0875 for all electrical costs. WDEQ staff considers accurate electrical costs an important matter for determining the overall DDR cost estimate.

iii HRI did not provide a basis for or breakdown of costs used to derive the $2,000 monthly charge for "Environmental analysis" in the restoration spreadsheet. This cost is apparently different from, and additional to, the $80,000 cost of "groundwater stability analysis" (see Attachment A-1 and Section E.3). Additional details about this amount are needed to assess the accuracy of HRI's estimates of the monthly costs of "environmental analysis."

E. Lack of Fundamental Components of Acceptable Financial Assurance Plan

33. HRI's RAP fails to provide cost estimates for several crucial elements of restoration of an in situ leach uranium mine. The most significant of these missing elements, in terms of their potential additional DDR costs, are certain RO operation and maintenance and separate disposal costs, the absence of costs associated with the groundwater sweep restoration phase,

costs associated with the likely use of chemical reductants to achieve pre-mining, baseline standards, and costs for proper plugging and abandonment of ore delineation holes.

34. **RO Unit O&M and Disposal Costs**. To ensure optimum operation of the Reverse Osmosis unit, solutions from a depleted mine area should be treated with anti-scalent, pH-balanced and run through sand filters and then cartridge filters. This is a necessity, because the RO membranes are sensitive to being clogged with scale and trapped solids. HRI appears to agree; it states in the RAP (Section E.2.b., fourth page) that it intends to use anti-scalents and regularly clean out or replace the filters. But HRI does not account for the significant down time that comes from backwashing the sand filter and replacing the cartridge filters. Balancing the pH of the fluids also has not been accounted for in the HRI bond estimate. The spent filters and trapped solids must be collected and transported to an offsite disposal facility licensed to receive 11(e)(2) byproduct material. These are disposal costs that are *separate* and therefore *additional* to estimated costs of disposing of the brine concentrator/dryer solids (see Attachment E-2-3). These costs are not reflected in HRI's RAP. HRI should have disclosed the volume and characteristics of its RO unit waste streams, and estimated the costs of properly and legally disposing of those wastes.

35. **Groundwater sweep costs**. Groundwater sweep is the first stage in restoration for all current operations in Wyoming. Groundwater sweep is 100% groundwater removal, with no reinjection, and accounts for several pore volumes. This is not accounted for in the HRI restoration plan.

36. **Need for and Cost of Chemical Reductants**. Restoration operations in Wyoming have had limited success in removing heavy metals, such as selenium and uranium, and in one

case, arsenic, from groundwater using RO units. In recent years, some operators have begun using chemical reductants to improve restoration success. In previous research and development projects in Wyoming, the use of a reductant, specifically hydrogen sulfide, proved successful in achieving restoration standards for troublesome contaminants, including trace metals. PRI has experimented using a chemical reductant (a sodium sulfide solution) in restoration efforts at its Highland Project B Wellfield, and anticipates spending more than $300,000 in the current fiscal year on chemical reductants.[24] HRI, on the other hand, has made no provision for the use of a reductant at the Section 8 site. As Dr. Abitz states in his testimony, HRI has not yet demonstrated that certain metals, including uranium, arsenic, molybdenum and selenium, will be reduced and immobilized in a timely fashion without the aid of a reducing agent added to the RO reinjection water. Abitz Testimony, ¶14. I fully agree with Dr. Abitz's assessment. Where reductants are being used, the objective is to facilitate and speed up restoration generally, and the attainment of standards for certain geochemically troublesome constituents. Using chemical reductants will *increase* restoration costs over the long haul, as they are done at sites in Wyoming.

37. **Plugging and Abandonment of Ore Delineation Holes.** HRI's well plugging and abandonment cost estimate clearly ignores the costs associated with properly abandoning ore delineation holes. Hundreds of ore zone delineation holes are drilled during the life of the mining, which in the case of Church Rock is about seven years. The Well Plugging and Abandonment Table in Attachment E-4-1 includes cost estimates only for injectors, extractors

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[24] PRI 2000 Annual Report, Section 3.2 at 9 and Appendix 4 ("2000-2001 Surety Estimate Revision") at 5. Relevant excerpts are appended hereto as **Attachment G**.

and four different monitor wells. Using HIR's per-hole cost estimates as a guide, the average cost of abandoning a delineation drill hole that's drilled in the Westwater Canyon Formation is somewhere between $600 and $650, depending on the depth of the hole. Abandoning, 250 such holes, which is a conservative estimate, would add another $150,000 to the total cost of DDR.

38. **Other Missing Costs.** I identified several other missing costs, which, although not of the cost magnitude of the areas discussed above, are important because they represent *real* costs that haven't been considered, and because their inclusion in a financial assurance plan increases the confidence of the regulator, like me, in the completeness of the plan and competency of the operator.

39. **Pond Leakage, Contaminated Soils and Groundwater.** The first of these additional unaccounted-for costs are the costs associated with cleanup of leakage from evaporation ponds that HRI proposes to construct at the Church Rock Section 8 satellite plant and operate at the Crownpoint Processing Plant. All lined ponds eventually leak (even without a breach in the liner or berm integrity), and some of the underlying contaminated material will need to be disposed of as byproduct material. If near-surface groundwater is contaminated by pond leakage, additional groundwater remediation may be required.

40. **Backup Equipment.** Another unaccounted-for cost is backup equipment expense. HRI makes no provision in the bond proposal for backup equipment. Without backup equipment, there is no way to account for downtime, due to normal maintenance or equipment failure. All operations would need to cease until the initial equipment is put back online. These costs should be estimated by HRI and included in its RAP.

41. **Contract Administration and Inflation.** Contract administration and inflation

costs are not, but should be, included in the RAP. NRC's Technical Position on Financial Assurances (at 26) states clearly that a licensee "should include a 10 percent minimum contingency for contract administration in the event the licensee defaults", and furthermore, "should submit . . . cost estimates for inflation ninety (90) days before. . .the effective date of the surety instrument or as specified in the license." In the event of bond forfeiture, the bond inflation factor should cover the entire length of time needed for restoration. HRI's RAP accounts for neither a contract administration contingency nor an annual inflation cost.[25] A contract administration contingency of 10% would add $824,853 to the total cost estimate in Attachment A-1 of the RAP.[26] The inflation cost during the estimated duration of restoration of 4.4 years would approach $200,000,[27] and will likely be even higher because restoration will almost certainly take more time than the 4.4 years estimated by HRI. This amount could be reduced annually if the company demonstrates it is making adequate progress on restoration. Nonetheless, contract-administration contingency and inflation-related costs are not trivial — indeed, they exceed $1 million combined. If these NRC-mandated costs, and only these costs,

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[25] The 15% "Contingency/Profit" included in the Summary Table in Attachment A-1 and discussed (minimally) in Section E-9 of the RAP is a separate cost from those associated with contract administration and inflation. Inclusion of a contigency cost in the overall cost estimate is consistent with Section 4.1.9 of the Technical Position on Financial Assurances (at 26).

[26] This figure is obtained by multiplying the "Project total" of $8,248,533 by 0.1.

[27] This figure is estimated by dividing the total surety cost of $8.249 million by 4.4 years to obtain an annualized surety value. The annualized value is multiplied by 0.035 to obtain an annual inflation cost. This formula is repeated for the next three years, except that the annualized surety is subtracted from the total surety in each successive year. For the fifth year, the total surety is multiplied by .4. The inflation costs for each of the five years is then summed to obtain a total inflation cost.

were added to HRI's cost estimate of $9.4 million, the revised "total surety" would approach $10.6 million.[28]

42. **Analytical Costs.** HRI's estimate for analytical costs associated with post-restoration groundwater quality stability testing is low by at least 25%. HRI states that three sample sets will be taken over a single 6-month period following restoration. However, there should be four samples for a 6-month period: an initial sample set, a sample set at two months, a sample set at four months, and a sample set at six months. HRI must add the cost of the additional stability sample set, or $20,000, to the cost of stability analysis. My professional opinion, however, is that six months is insufficient time to determine compliance with restoration standards.

43. **Mechanical Integrity Testing.** Other costs not included in the bond calculation include costs for mechanical integrity testing personnel and equipment and for computers and software. Federal and state underground injection control regulations, including those of the WDEQ, require mechanical integrity testing ("MIT") of all injection wells before they are placed in service and MITs every five years during the wells' operation. Each of these tests typically costs about $100 and would be needed at least twice for all 215 injection wells proposed by HRI. This represents at least $21,500 in additional DDR costs. Computer hardware and software is not required, but is essential for wellfield control, hydrologic modeling, management of site geologic and chemical data, and countless other uses. Computer costs may be minor in the overall surety scheme, but they reflect a desire on the part of the operator to strive for full

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[28] This revised total surety, based solely on HRI's cost estimate contained in the RAP, are reflected in Table 2, which appears at the end of my testimony.

compliance with regulatory requirements.

44. **Determination of Baseline Water Quality**. HRI has reported baseline water quality data for the Church Rock Section 8 site, based on sampling of several on-site monitor wells. (See, e.g., the FEIS at 3-36, 3-38, 3-39 and 4-16.) I am aware that HRI is required, by license condition, to determine final baseline values for the aquifers at the Section 8 site before lixiviant injection. HRI-CUP License Condition 10.21. However, I believe that baseline water quality should be determined early in the licensing or permitting process so that restoration standards can be established. The simple fact is that the baseline water quality will determine the amount of restoration that will be needed. For example, if the baseline water quality contains 800 mg/l TDS and the lixiviant contains 1,000 mg/l TDS, then restoration will require less time and expense to return the groundwater to baseline. However, if the mining solution is 1,500 mg/l to 5,500 mg/l TDS, then restoring to a baseline value of 360 mg/l TDS will cost considerably more and take much longer. This is precisely the situation at Church Rock. (See, FEIS, Table 4.6 at 4-16.) Hence, the HRI restoration cost estimate is not, at this time, based on attainment of baseline water quality after mining is done, but on the NRC's determination that the groundwater will have to be flushed nine times before the standards — whatever they will be — are attained.

G. Conclusions

45. An adequate financial assurance plan is a fundamental health and safety issue for any uranium ISL mining operation. This is particularly important because, as Dr. Staub noted in his written testimony in this proceeding nearly two years ago, no commercial-scale uranium ISL mining operation in Wyoming has successfully restored groundwater to premining, baseline

conditions.[29] Staub Testimony at 21. In fact, restoration is ongoing at all of the commercial operations in Wyoming, and has been since the early 1990s. Hence, it is absolutely critical, in my view, that HRI's Restoration Action Plan accurately, completely and honestly address all elements of DDR at the Section 8 site *now*, before lixiviant is injected and restoration commences. Unfortunately, HRI's RAP does not represent an adequate or approvable framework for establishing the very cost estimates upon which a surety amount eventually will be based. As set forth in this affidavit, my major reasons for this view include:

- restoration water volume for the Section 8 site is underestimated by at least a factor of 2 because of HRI's unjustified use of a low horizontal flare factor;
- costs associated with treatment of mining solutions during restoration are underestimated because of reliance on overstated operating efficiencies of treatment equipment, discrepancies in flow rates, failure to include the cost of a brine concentrator system, inaccurate estimates of brine concentrations, underestimated costs of proper well plugging and abandonment, underestimated personnel costs, and low estimates of the volumes of brine that must be disposed offsite; and
- omissions of entire cost categories, including O&M costs for treatment equipment, costs of groundwater sweep, costs of plugging and abandonment of ore-delineation holes, costs of using chemical reductants to achieve premining, baseline water quality, and costs associated with contractor administration and annual inflation.

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[29] I know Dr. Staub professionally from his valuable evaluations of Wyoming ISL operations as a consultant to the NRC in the 1980s and early-90s, and I think highly of work, including his previous testimony for the Intervenors.

The overall effect of these myriad deficiencies in the HRI cost estimate is considerable. As I show in Table 2 below, HRI's cost estimate of $9.4 million is about 2.5 times *lower* than the $23.9 million cost estimate that I calculated for the Church Rock site, using realistic assumptions and accounting for millions of dollars in costs that HRI ignored. HRI's cost estimate is low by several million dollars solely simply because the company has so severely underestimated the volume of restoration water that it will be treated and disposed of, and the length of time that restoration will take.

46. By its own admission, HRI's RAP suffers from an "absence of real information." RAP, Section A, page 1. But, as I have demonstrated in this testimony, there is considerable relevant and analogous uranium ISL restoration experience in Wyoming to draw from to develop a credible cost estimate. HRI chose not to take such a rigorous approach, and its Plan suffered accordingly. Ultimately, HRI shoulders the burden of demonstrating that its financial assurance plan contains "sufficient information for NRC to verify that the amount of coverage provided. . .accounts for all necessary activities required under the license to allow the license to be terminated." Technical Position on Financial Assurances at 20. Because of its many technical difficiencies, unsubstantiated assumptions, and omissions of important information, I do not believe that HRI's RAP meets this standard and therefore should not be approved by the NRC.

47. This concludes my testimony.

Table 2. Comparison of HRI's Estimated DDR Costs with Likely or Possible Costs of DDR

Decommissioning, Decontamination, Restoration ("DDR") Cost Item	**HRI's Estimated Cost in the RAP (Attachment A-1, "Project Total")**	**Likely or Possible Actual Additional DDR Cost**
Groundwater Restoration ● + Brine concentrator system ● + Use of chemical reductant ● + Additional brine disposal costs ● + RO/BC labor costs ● + Mechanical integrity testing ● + O&M costs	\$ 7.2 million \$ 0 \$ 0 not expected \$ 0 \$ 0 \$ 0	\$ 14 million at least \$2.5 million \$ 300,000 (unestimated) \$ 331,250 \$ 21,500 (unestimated)
Groundwater Stability Analysis	\$ 80,000	\$ 100,000
Well Plugging and Abandonment ● + Use of proper cementing techniques ● + P&A ore delineation holes	\$ 401,345 \$ 0 \$ 0	≥ \$ 800,000 (unestimated) \$ 150,000 or more
Equipment Removal	\$ 67,626	\$ 67,626
Wellfield Decommissioning and Decon	\$ 105,228	\$ 105,228
Building Decommissioning and Decon	\$249,874	\$ 249,874
Surface Reclamation	\$ 139,600	\$ 139,600
Subtotals	**\$ 8,248,533**	**≥ \$ 18,765,078**
Contingency/Profit (15%)	\$ 1,237,280	≥ \$ 2,814,762
Contractor Administration Contingency (10%)	\$ 0	≥ \$1,876,508
Inflation $\sum_{n=4.4yrs}[(\text{surety}_{yr1}/4.4\text{ yr})(0.035) - (\text{surety}_{yr\,k-}/4.4\text{ yr})(0.035)]$	\$ 0	≥ \$ 440,000
Total Surety	**\$ 9,485,812**	**≥ \$23,896,348**
NRC-Mandated Contractor Contingency + Inflation for added to RAP "Total Surety"	\$ 1,051,665	n/a
Revised HRI Cost Estimate	**\$ 10,537,477**	**n/a**

AFFIRMATION

I declare on this 19 day of December, 2000, at Laramie, Wyoming, under penalty of perjury that the foregoing is true and correct to the best of my knowledge, and the opinions expressed herein are based on my best professional judgment.

Steven C. Ingle
Steven Ingle

Sworn and subscribed before me, the undersigned, a Notary Public in and for the State of Wyoming, on this 19 day of December, 2000, at Laramie, Wyoming.

My Commission expires on 5-11-2003.

Debora M Miller
Notary Public

DEBORA M MILLER
Notary Public
Albany County, WY
My commission expires
May 11 2003

RESUME

STEVEN C. INGLE

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PERSONAL DATA

Birth date: November 15, 1949, Single (widowed) with 3 children

EDUCATION

M.S. - Geological Engineering, December, 1977, South Dakota School of Mines and Technology, Rapid City, South Dakota. Thesis Topic: Paleodrainage and Basin Analysis, Dana Basin, Wyoming

B.A. - Geology, June, 1972, University of Minnesota, Duluth

Continuing Education: Outreach student at Colorado School of Mines in groundwater hydrology.

Memberships: American Water Well Research Association, National Groundwater Association, Licensed Professional Geologist (Wyoming, #3359)

EMPLOYMENT

STATE OF WYOMING, DEPARTMENT OF ENVIRONMENTAL QUALITY/LAND QUALITY DIVISION: December, 1985 to present

Senior Analyst: August 1, 1989 to present

Duties include. Reviewing and analyzing hydrology portions of mine permit applications for compliance with the Environmental Quality Act. Acts as a consultant in analyzing and evaluation of specific hydrologic problems, has included groundwater modeling and evaluation of modeling efforts. Am involved in evaluation and design of groundwater systems. Oversee's the states Class III UIC program. Currently rewriting the rules and regulations for compliance with Federal requirements. The change in job classification was a requested by me for personal reasons.

Chief Hydrologist: November, 1988 to August 1989

Duties included supervising a staff of groundwater and surface water hydrologists in the review of mine permit applications for compliance with the Environmental Quality Act. Performed hydrologic reviews of mine permit applications. Coordinated reviews with other state and federal agencies. Revised and prepared guidelines for industry guidance. Acted as a consultant on special projects.

Senior Analyst: December, 1985 to November, 1988

Duties include. Reviewing and analyzing hydrology portions of mine permit applications for compliance with the Environmental Quality Act. Acts as a consultant in analyzing and evaluation of specific hydrologic problems, has included groundwater modeling and evaluation of modeling efforts. Am involved in evaluation and design of groundwater related mining projects.

SELF EMPLOYED: January 1983 to January 1985

Duties included precious metal and uranium claim staking, sampling, field mapping, report writing, and ore tonnage and grade calculations from borehole data in California, Nevada, and Wyoming.

PHILLIPS PETROLEUM COMPANY: January, 1978 to January, 1983

Associate Minerals Geologist- September 1981 to January 1983, Reno Nevada.

Exploration for disseminated precious-metals in northwestern Nevada, Idaho and California. Duties included regional reconnaissance field mapping and geochemical sampling for Carlin and Borealis-type deposits. Responsibility to oversee Phillips interests in a joint-venture drilling and sampling project with Amax. Also participated in the exploration of, and responsible for the geochemical and geophysical evaluation of the Thunder Mountain precious metal deposit in Idaho.

Associate Minerals Geologist- March 1979 to July, 1981, Burnsville, Minnesota. Responsible for Phillips uranium exploration operations in eastern South and North Dakota and southern and western Minnesota. Duties included regional sampling and mapping programs, project development, field evaluations, and budgeting. Planned, conducted, and evaluated a 2500 square mile trace element groundwater geochemical exploration survey. Also included extensive interaction with federal and state agencies, exploration, permitting, speaking to the press, student groups, landowners and anti-nuclear groups.

Staff Geologist- January 1978 to March, 1979 Casper, Wyoming

Responsible for development and evaluation of sedimentary basin uranium prospects in the Platte River Valley, Powder River, Wind River, Red Desert, and Washikie Basin areas of Wyoming, northwestern Colorado, and Montana.

GROTH MINERALS CORPORATION- January, 1974 to November, 1977

Project Geologist- May, 1976 to November, 1977, Rawlins, Wyoming.

Management of field and office operations for Wyoming. Responsible for joint-venture sedimentary basin uranium projects in Wyoming and other western states, including evaluation of exploration results, recommendations, and budgeting.

Project Geologist- May, 1975 to January, 1976, Steamboat Springs, Colorado.

Field geologist on various uranium prospects in Wyoming. Duties included project generation, field mapping, radiometric surveying, clam and drillhole staking, prospect evaluation and recommendations, and budgeting.

Geologist- January 1974 to January, 1975, Lakewood, Colorado.

Field geologist on various projects and prospects in Montana, North Dakota, and Wyoming. Promoted to Project geologist July, 1974. Duties included supervision of a team of drillers and support personnel in siting drill holes, analyzing chip samples and geophysical log interpretation.

MINNESOTA DEPARTMENT OF NATURAL RESOURCES: June, 1972 to November, 1972

Geologist- (temporary position). Hired as a mining aide, promoted to field geologist in geochemical research program to determine applicability of various geochemical methods of reconnaissance in base and precious metal exploration in the Birchdale Greenstone Belt, Minnesota. Duties included surveying, geologic mapping, soil and vegetation sampling, geophysical surveying, and assisted in laboratory analysis.

MEMORANDUM

TO: Georgia A. Cash, District I Supervisor

FROM: April Lafferty, Steve Ingle, Roberta Hoy

DATE: June 17, 1996

RE: Pore Volume Estimate
Permit 603 - Power Resources, Inc. (PRI)

The attached review includes LQD's estimate, for PRI's bond calculation, of the quantity of ground water impacted by mining in each wellfield at PRI's Highland Uranium Project. This quantity is expressed as a 'pore volume' associated with an 'ideal' pattern area.

LQD's total estimate for all the wellfields is about three times PRI's total estimate. To date, PRI has used a 'flare factor' of 1.4 in their calculation of the pore volume. As discussed in the attached review, the factor PRI uses is based on information from one of Cogma's research and development projects and includes both vertical and horizontal flare. LQD believes sufficient information is available for the PRI site so a site-specific assessment can be made. In addition, differences in the lithology between the PRI and Cogema sites, particularly the thickness of the sandstone layers containing the ore zone(s), indicate that evaluation of the horizontal and vertical components of the flare, separately, is necessary.

Based on LQD's evaluation of horizontal flare, using the Visual MODFLOW program, a horizontal flare factor of 3.0 is appropriate for the Highland project. The vertical component is expressed in terms of the "barren zone sweep efficiency" from a 1987 paper by Lake and Zapata, and this value ranges from 0.2 to 1.0, i.e., from 20% to 100% of the barren zone is impacted, depending upon individual wellfield characteristics.

Attachment
cc: Mark Moxley, District II Supervisor
Glenn Mooney, District III Sr. Geologist

Ingle Attachment B

TECHNICAL REVIEW
PRI PORE VOLUME ESTIMATE - PERMIT 603
June 1996

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1.0 INTRODUCTION

Power Resources, Inc. (PRI) operates the Highland Uranium Project, an in-situ uranium mine in Converse County, Wyoming, as described in Permit 603 of the Land Quality Division (LQD) of the Wyoming Department of Environmental Quality and Source Material License SUA-1511 of the United States Nuclear Regulatory Commission (NRC). (This mine was formerly operated by the Everest Minerals Corp.) LQD believes that PRI's current estimate of the volume of ground water impacted by mining (the 'pore volume'), for their bond calculation, is inadequate and should be increased. This increase is based on: LQD's analysis and interpretation of data collected at the site, including excursion histories; water level and water quality data; production/injection information; experience with other in-situ operations; and experience with ground water remediation.

The purpose of this memorandum is to outline the analyses conducted by LQD and explain the necessary increases in PRI's pore volume estimate. A key portion of LQD's analysis has involved the use of a ground water flow model. Because of the importance of the operational sequence in in-situ uranium mining and the relatively unique terminology used to describe the operations, a brief discussion of in-situ uranium operations in general is provided as a basis for the interpretations in this memorandum.

1.1 General Physical Setting of In-Situ Uranium Operations

The in-situ uranium mines in Wyoming, such as PRI, generally consist of a series of wellfields. Each wellfield produces from an ore zone(s) which is part of a sandstone layer in a sequence of interlayered sandstones and shales. The sandstones are generally considered as aquifers and the shales as aquitards.

Each wellfield consists of several groups of production and injection wells. The smallest 'ideal' group is usually a 5-spot pattern, which includes a production well centered within a square of four injection wells, as shown on Figure 1. The 'pattern area' is the area within the square outlined by the four injection wells, and is generally on the order of a few thousand square feet (ft^2). However, because of the ore distribution, each 5-spot pattern may not form a square, and the patterns are usually combined, as shown on Figure 2. In some cases, lines of production and injection wells are used instead of groups of wells.

The production and injection wells are screened across the ore zones within the sandstones. To ensure the efficiency of the mining operation and evaluate impacts on ground water, three 'types' of monitoring wells are also generally installed. One type includes the monitoring wells installed prior to mining to establish baseline conditions. Many of these wells are screened over only the ore zone and are later converted to production or injection wells. Once mining and ground water restoration are complete, they are again used as monitoring wells to evaluate the success of restoration. A second type of monitoring well includes wells installed in 'monitor rings' around each wellfield. The wells in the monitor ring are completed in the same lithologic unit as the production and injection wells. However, these monitoring wells are usually completed over the total sandstone thickness, unless the sandstone is exceptionally thick, to ensure any adverse ground water impacts are detected. The third type of monitoring well includes wells which have been installed in the sandstones above and below the sandstone containing the ore zone to ensure any vertical movement of ground water is detected.

1.2 Overview of Mining and Restoration Progression

At each wellfield, the operations are conducted in a series of steps. Proper completion of each step is necessary to ensure mining and restoration are conducted efficiently and to ensure 'excursions' do not occur (i.e., to ensure substances mobilized by the in-situ mining process do not migrate outside the monitor ring or to overlying or underlying aquifers).

Establishing Baseline. This preliminary step involves: delineating lithologic units and ore zones; determining baseline water quality, quantity, and flow direction; evaluating aquifer characteristics; and assessing impacts of any previous mining operations. An important aspect of this step is to determine aquifer parameters to design appropriate injection and production rates. Another aspect is to determine whether or not there are any improperly abandoned wells or drill holes in the mine area, or any gaps in overlying or underlying aquitards, which could result in vertical excursions.

Ore Extraction. The ore extraction process involves introducing a leaching solution (lixiviant) into the ore zone, through the injection wells, to mobilize the uranium and pumping the resultant fluid (the pregnant liquor) from the production wells. Balancing the production and injection rates in the wellfields during ore extraction is critical to ensure efficient mining and to avoid excursions. Flare is needed beyond the pattern area for efficient ore extraction, but excessive flare will result in water flow beyond the influence of the production wells, resulting in an excursion. (If an excursion is detected, that portion of a wellfield closest to the monitoring well on excursion is usually over-pumped to try to 'pull' the impacted fluids back to the pattern area.) After the uranium-laden fluid from the production wells is processed, most of the waste water is disposed of by methods such as evaporation and deep well injection (i.e., injection into a formation below the sandstones of interest).

Ground Water Sweep. In addition to uranium, the leaching solution mobilizes other parameters, such as arsenic and selenium (Deutsch, p.13). Therefore, once the ore extraction process is completed, pumping continues for a specified time to ensure all mobilized parameters are 'pulled' back toward the pattern areas. Pumping is usually from the production wells, although the injection wells may also be pumped on occasion.

Reverse Osmosis (RO). Once the ground water containing the mobilized parameters has been 'pulled' back into the pattern areas, the water is pumped out, generally through the production wells, and treated at the surface by reverse osmosis. The treated water is then injected back into the sandstone, generally through the injection wells. If the ground water sweep was not thorough and/or RO is not conducted adequately, then during RO, ground water containing parameters mobilized during ore extraction can be 'pushed' away from the pattern areas by the injected water.

Addition of Reductant. An operator may, if necessary, inject a reductant (usually hydrogen sulfide) into the ore zone to precipitate trace metals from the ground water. This is usually done in small areas which need additional treatment after RO is complete.

Stability. After RO and reductant injection are completed, the wellfield is left idle for a six-month period to ensure the restoration steps have been effective in returning the ground water in the wellfield to baseline water quality conditions and that parameters of concern are not remobilized.

Reclamation. This is a broad category which includes activities that can take place throughout the life of the mine. However, most of the reclamation occurs after stability of the ground water quality is assured and primarily involves: removal of all surface facilities which the landowner does not want; plugging and abandonment of wells; and replacing topsoil and vegetation.

1.3 Terminology

Many of the terms used to describe in-situ mining operations are quite broad, combining several specific aspects of the operations into a single word or phrase. However, because much of LQD's evaluation has focused on specific aspects of the operations, it is important to differentiate these aspects.

1.3.1 Wellfield Balance. In evaluation of the wellfield balance, three aspects must be taken into account. The first is the "bleed" or "overproduction" rate, during ore extraction. This rate is the amount, if any, by which the production rate exceeds the injection rate. It is typically expressed as a percentage and is usually less than 10%. (A 'bleed' rate is also maintained during RO, and the rate is typically 20% greater than the injection rate. However, the RO bleed rate does not impact this review.)

The second aspect of wellfield balance is over what area the balance is calculated. For example, each 5-spot pattern can be balanced. The balance can also be calculated over a group of patterns or over the wellfield as a whole. However, the larger the area, the less sensitive the balance is to localized variations in production and injection rates. The third aspect is how often the wellfield is balanced. The less frequently the balance is calculated, the longer a pattern could remain out of balance, hence the larger the quantity of overinjection or overproduction.

1.3.2 Flare Extent and Pore Volume. The basic equation used to calculate the ground water pore volume impacted by mining is the simple volumetric calculation:

Pore Volume = (Flare Area)(Flare Thickness)(Effective Porosity)

The term 'flare area' includes the 'pattern area' plus the area through which the lixiviant extends due to the influence of injection before it is 'pulled back' into the pattern area by the influence of production (Figure 1). Similarly, the flare thickness is the ore zone thickness plus the vertical extent of lixiviant above and below the ore zone. The extent of horizontal flare is generally greater than vertical flare because horizontal permeability is generally higher than vertical permeability.

The term 'pore volume' refers to the volume of ground water impacted by mining and requiring restoration. However, it is *not* the total volume of water that will be pumped during restoration. In general, several pore volumes must be pumped, depending upon the ion exchange rate between the ground water and aquifer material and similar factors.

2.0 HIGHLAND URANIUM PROJECT

Aspects of PRI's operations helpful to understanding the interpretations in this memorandum are discussed in this section. In addition, LQD's 1987 ground water model, which was used to help select appropriate spacing of the monitor ring at PRI, is introduced.

2.1 Well Placement and Construction

PRI's six existing wellfields are designated as the A- through F-Wellfields, the locations of which are shown on Plate I. The sandstones and shales underlying the PRI site are collectively known as the Highland Group, and are sequentially named, from deeper to shallower, the 20 Sand, the 25 Shale, the 30 Sand, the 35 Shale, the 40 Sand, the 45 Shale, and the 50 Sand, as illustrated on Plate II. Table I lists which wellfield produces from which sandstone.

At PRI, the ore zones (and therefore the screened thicknesses of the production and injection wells) are generally on the order of 15 feet thick, while the sandstones are twice as thick (i.e., about 30 feet thick) except in the C- and F-Wellfields (Table I). In the C-Wellfield, the sandstone is about 60 feet thick. The F-Wellfield has been simplified as a 15-foot thick ore zone within a 150-foot thick sandstone. In reality, the F-Wellfield produces from three separate ore zones at different depths within the 150-foot thick sandstone. To avoid vertical overlap within the wellfield, at a given location, only one of the three ore zones is mined. Therefore, the F-Wellfield could also be simplified as three separate 50-foot thick sandstones. However, for comparison of LQD's vertical flare estimates with those from a mining operation from which empirical data is available, the simplification of the F-Wellfield as a 15-foot thick ore zone in a 150-foot thick sandstone is more logical.

The approximate locations of the monitor rings for each of PRI's wellfields are shown on Plate I, and the locations of the 'M' wells which form the B-Wellfield monitor ring are shown on Plate III. The basic pattern areas for each of PRI's wellfields are listed in Table I. The distribution of the groups of production and injection wells within one of PRI's wellfields, the B-Wellfield, is shown on Plate III.

2.2 Mining and Restoration Operations

A brief discussion of specific facets of PRI's operations which impact the pore volume estimate is included in this section.

Wellfield Status. Ground water sweep has been completed in the A-Wellfield, and RO is currently underway. In the B-Wellfield, sweep is in progress, and it is LQD's understanding that RO is scheduled to begin in late 1996/early 1997. The C- through F-Wellfields are currently in, or near the end of, ore extraction, which generally requires about two years. It is also LQD's understanding that PRI will be submitting an application for a sixth wellfield, the G-Wellfield, in the future.

Mining and Restoration Specifics. At PRI, the lixiviant is composed of native ground water, carbon dioxide, and oxygen. Most of PRI's mining and restoration operations are similar to the general operations described in Section 1.2, with one exception. During RO, PRI uses 'mega-patterns' for the injection/pumping distribution. Treated water is injected through injection wells around a group of 5-spot patterns, rather than the injection wells in each 5-spot pattern, and pumped from a production and/or injection well(s) near the center of the group.

PRI's Wellfield Balance. PRI has indicated that they try to maintain a bleed rate of 1.5 to 2.0 % (personal communication from W.F. Kearney, PRI, to A. Lafferty, LQD, spring 1996). LQD has had difficulties assessing PRI's wellfield balance, which they reportedly evaluate every third day (PRI Amendment, p.OP-13). One difficulty is that PRI's permit requires that PRI maintain production and injection records on-site, but PRI has had difficulty compiling the records for the operations prior to 1990, when PRI switched to a computerized system. Another difficulty is that the reported rates vary considerably from an 'ideal' wellfield balance.

LQD originally requested production and injection data from November 1988 because it was thought that operations on this date would be representative in that portion of the wellfield selected for modelling. In other words, all the production and injection wells in that portion of the wellfield would have been in full operation, and there were no excursions in that area at that time. Production data for November 1988 was received from PRI; however, the production and injection data subsequently submitted was from November and December 1989. The 1989 data indicated a consistent *overinjection* rate of 1 to 7%. The November 1988 production data and November/December 1989 production and injection data provided by PRI is summarized on Table II.

Ground Water Treatment and Restoration Progress. In PRI's current bond estimate, PRI has assumed that four pore volumes will need to be pumped during ground water sweep to accomplish restoration. LQD is not presently requesting an increase in the bond of the number of pore volumes required for restoration, although LQD believes that number may be low based on work at other sites (Staub, pp. A-60 & A-171). Once PRI completes restoration of one of their wellfields, the number of pore volumes may need to be increased in the bond.

The number of pore volumes is not only critical to the bond estimate, but it also impacts the production and restoration capacity of the operation. Ground water pumped for restoration is processed through many of the same steps as for production. After removal of uranium, part of the waste stream is treated through reverse osmosis units, and recombined with the remainder of the waste stream to allow for partial dilution of the contaminants of concern. (Brine from the reverse osmosis units is disposed of in an on-site deep disposal well.). The waste stream is then treated for radium removal through press filters and Radium Settling Ponds. The waste stream is then pumped to Purge Storage Reservoirs for evaporation. As the weather allows (generally during late spring, summer, and early fall), water is pumped from the Purge Storage Reservoirs to irrigation circles for disposal. Because the volume of water in the ponds can only be reduced by evaporation and pumping to the irrigation circles, the capacities of the ponds are a limiting factor in the rate of mining and restoration. The rate at which waste water can be disposed of in the deep disposal well is also a limitation.

2.3 PRI's Flare Factor

The equation used by PRI in their bond calculations (AR, p.22) is a variation of the equation discussed in Section 1.3.2:

Pore Volume for a single pattern =
(Pattern Area)(Ore Zone Thickness)(Flare Factor)(Effective Porosity)

The parameter of concern in this review is the flare factor, which LQD believes to be underestimated and believes should be separated into horizontal and vertical components. The effective porosity is based on laboratory testing of core samples, and LQD believes the reported porosity values are representative.

PRI does not differentiate between horizontal and vertical flare in their bond calculation, but uses a 'total' flare factor of 1.4 (AR, p.22). Visualization of the flare factor is easier if it is converted to a 'flare volume'. Assuming the area of a 5-spot pattern in the B-Wellfield is 70 by 70 feet, the ore zone thickness is 15 feet, and the effective porosity is 0.27, then the 'pattern volume' would be 19,845 ft^3 and the 'flare volume' would be 27,783 ft^3. If the ratio of the horizontal and vertical proportions in the 'flare volume' is the same as in the 'pattern volume', then, for a flare factor of 1.4, the for the horizontal flare would only extend about 4 feet beyond each side of the pattern and about 1 foot above and 1 foot below the ore zone.

Based on communication between PRI and LQD during a meeting on May 13, 1996, PRI's flare factor of 1.4 is based on coring results from a research and development (R&D) project at another in-situ uranium mine in Wyoming, the Irigaray Mine, operated by Cogema Mining Company as described in LQD Permit 478-A1. Although the Cogema R&D project and PRI's Highland Uranium Project are both in the Powder River Basin in Wyoming, there are two significant hydrogeologic differences between the sites. First, the horizontal permeability at the Cogema site is lower than at the Highland site. (Cogema reports a horizontal permeability range of 2.1 to 6.9 gallons per day per square foot (gpd/ft^2) for their Units 6 and 7 (Cogema Baseline, p.8; Cogema 1977 Report, p.71), and, for the 30-Sand, PRI reports a range of 21.3 to 28.8 gpd/ft^2 (PRI Pump Test, Table 2).) The higher permeability would result in a more extensive flare, depending on the similarity of other factors. Second, the ore zone targeted by Cogema at the Irigaray site is part of a much thicker sandstone than most of the sandstones at PRI, i.e., the lithology of the F-Wellfield is much more similar to the conditions at Irigaray than at the Highland A- through E-Wellfields. As will be discussed in Section 4.2, variations in the ratio of the ore zone thickness to the sandstone thickness result in significant variations in the vertical flare factor.

2.4 1987 LQD Model

In 1987, LQD modelled ground water flow conditions at the Highland Uranium Project to provide a better technical basis of the proposed well spacings in the monitor rings at the mine (LQD 1987 Memo). The same basic USGS model was used in 1987 as was used for this review, specifically the USGS MODFLOW model (McDonald & Harbaugh, 1984 and 1988). The differences between the model set-up and simulations in 1987 and 1996 are discussed in brackets '{}' in Section 3.0 Horizontal Flare; however, the results from both the 1987 and 1996 modelling efforts indicate that a flare factor of 1.4 is too low. In addition, it should be noted that the operator at the time, Everest Minerals Corp., "consistently stated that the normal [horizontal] flare was approximately 75 feet" (LQD 1987 Memo, p. 4).

3.0 HORIZONTAL FLARE

For the 1996 analysis of the extent of the horizontal flare at PRI, LQD initially used the USGS MODFLOW model, which is a public domain, court verified, quasi 3-dimensional ground water flow model. During the week of April 29, 1996, LQD received Visual MODFLOW, which is an enhanced version of MODFLOW that incorporates improved graphical input and output capabilities and several of the programs developed for modelling specialized conditions in conjunction with MODFLOW. For example, Visual MODFLOW incorporates the USGS MODPATH program which allows for 'tracking' of contaminant 'particles' in a ground water flow field. However, because MODPATH is limited to steady-state conditions (Pollock, 1989, and Lu, 1994), it did not prove as useful for this review as the ground water flow simulation.

3.1 Model Set-Up

Because of the scale of the mine, estimates of impacted areas for the bond calculations are based on 'ideal' pattern areas. Therefore, LQD did not model all of the PRI operation or an entire wellfield, but selected a representative portion of one wellfield sufficient to be indicative of general conditions in the PRI permit area.

3.1.1 Model Area. The model was set up to simulate ground water flow in a portion of the B7 pattern group in the B-Wellfield, Section 21, Township 36 North, Range 72 West, as shown on Plate III. This portion of the B-Wellfield was selected because no operational excursions have been reported in the area, and LQD did not want to model conditions that may have led to an excursion. The model was set up on a uniform 100 x 100 grid, using 25-foot node sizes (625 ft^2 per node), and the wellfield was placed in the approximate center of the grid and oriented such that there would be a single well per node. (The model was originally set up on a uniform 50 x 50 grid, using 50-foot node sizes. However, in response to concerns about the well location sensitivity voiced by PRI during the meeting on May 13, 1996, the node size was reduced and the number of nodes increased.) As shown on Plate IV, the model area was significantly larger than the portion of the wellfield modelled to avoid boundary ('edge') effects.

{The 1987 model was based on a 21 x 21 grid with node sizes varying from 50-foot upwards, again to avoid boundary effects.}

3.1.2 <u>Model Parameters</u>. The B-Wellfield is completed in the 30-Sand; therefore, a single, 30-foot thick layer was modelled, i.e., no flow was assumed to occur through either the overlying or underlying aquitards (the 35- and 25-Shales, respectively). To be conservative, no baseline groundwater gradient was used in the simulation, although the baseline potentiometric surface for this area indicates a gradient toward the south. Aquifer parameters used in the simulation were taken from PRI's baseline aquifer test results. The horizontal permeability of the modelled area was set at 17 feet/day, and the vertical permeability was assumed to be 1.7 feet/day (one-tenth the horizontal permeability). The storativity was set at 0.0002, and as part of the overall conservative approach, it was not changed if the aquifer changed from confined to unconfined conditions due to a water level drop. The boundaries were set to a constant head of 30 feet, and the initial heads in the interior nodes were also set at 30 feet. This is a simplification of the average baseline potentiometric surface elevation of 5030 feet above mean sea level.

{The 1987 model included three layers: an overlying aquifer; a confining layer; and the 25-foot thick aquifer containing the ore zone. However, no vertical leakage was allowed from the confining layer, so the setting was similar to that in the 1996 model. The 1987 model did include a regional gradient of 0.006, which reduced the extent of the flare upgradient of and perpendicular to the pattern area, but substantially increased the flare extent downgradient of the pattern area. Therefore, not modelling a regional gradient, as in the 1996 model, should be the more conservative approach and allows for generalization of the results. The 1987 hydraulic conductivity estimate, 4.5 feet/day, was less than that obtained from subsequent aquifer tests. The storage coefficient was about the same, 0.0001.}

3.2 Design of Model Simulations (or 'Runs')

LQD performed numerous runs, primarily because of difficulties in obtaining information about the wellfield balance and actual production and injection rates. The results from four runs are discussed in detail and presented graphically in this review. Three of the runs simulated long-term, 'balanced' conditions based on November 1988 production data supplied by PRI and injection rates calculated by LQD to coincide with various bleed rates. The fourth run simulated conditions during November/December 1989 using production and injection data supplied by PRI. Results from runs to evaluate sensitivity to transmissivity, storativity, and anisotropy are available in LQD files.

3.2.1 Production and Injection Wells. A total of twenty-seven wells, including eight production wells and nineteen injection wells, were used in the 1996 simulations. The locations of the wells with respect to the model grid are shown on Figure 3.

{The 1987 model used one and two 5-spot patterns located near the center of the grid.}

Long-Term 'Balanced' Runs. The production and injection rates used for these three runs are shown on Table III. In each case, the production rates were set equal to the November 1988 production rates provided by PRI. The injection rates were calculated by LQD to coincide with bleed rates of 0.88%, 1.6%, and 2.0%, respectively. LQD tried to balance each 5-spot pattern. However, calculating the per-pattern balance was difficult because the actual well locations do not correspond to 'ideal' 5-spot configurations. Therefore, increasing or decreasing the bleed rate was not just a matter of uniformly increasing or decreasing injection rates. In general, to avoid 'injection highs' in injection wells on the corners of the modelled wellfield, such as around Wells I-194 and Well I-201, changes in production and injection rates were usually greater in wells near the center of the modelled area than in wells on the corners.

{The 1987 model used a 3% bleed rate for 'balanced' runs, and excursions were also purposely simulated in other runs.}

For the 'balanced' runs, a stress period of 720 days in length was used, and the stress period was divided into 10 time steps, the default number of time steps in the program. The stress period length of 720 days (i.e., two years) was used because this is approximately the length of time a wellfield would be in production. The results of the runs indicated that steady state conditions were achieved rapidly (i.e., within the first few months of wellfield operation).

November/December 1989 Data. The production and injection rates used for this run are shown on Table III, along with the range of the actual production and injection rates reported for this time period by PRI. In the northwest corner, the injection rates in Well I-194 and I-195 were less than or equal to the lowest reported rate because the reported rates include additional patterns to the west.

For the modelling of actual production and injection data, one stress period of 21 days was used, and the stress period divided into 10 time steps, each 2.1 days in length. The use of a 21-day stress period was justified based on a review of the actual production and injection data which indicated that the conditions in this portion of the wellfield did not change significantly over the 21-day period (Table II).

3.3 Model Results

To avoid numerous oversized figures because of the size of the model area, the model results for the simulation of a 1.6% bleed rate are shown over the entire model area on Plate IV, and a 'window' of the model area in the immediate vicinity of the modelled production and injection wells for the same run is shown on Plate V and Figure 4. Only the 'window' is shown for the other three runs (Figures 5 through 7). For each figure, the window extends from Row 42, Column 42 to Row 72, Column 72. (The actual origins are a few feet different in each window because, while it is relatively easily to specify row and column numbers in outlining a window, it is much more difficult to specify actual points.)

Ground water velocity vectors have been used to illustrate flow directions in the vicinity of the modelled wellfield. The vectors are represented as arrows on the plates and figures. (The arrow size is proportional to the ground water velocity and the arrow direction coincides with the flow direction. To illustrate the flow directions on the plates, an output option of 200 vectors at a scale factor of 2 was selected. To avoid crowding of vectors on the smaller figures, an output option of 100 vectors at scale factor of 2 was used. Ground water elevation contours are also shown on the plates and figures. Contour intervals were 1.0 foot.

3.3.1 'Balanced' Wellfield. The results, over the entire modelled area, of the simulation using a 1.6% bleed rate over a 720-day period are shown on Plate IV. The results, in the 'window' in the vicinity of the production and injection wells, of the same simulation are shown on Plate V and Figure 4. The same window for the simulations of 0.88% and 2.0% bleed rates over 720 days are shown on Figures 5 and 6, respectively.

In comparing Figures 4 through 6, there are both similarities and differences in the ground water flow fields among these runs. All three runs indicate that most of the flow from the injection wells is 'recaptured' by the production wells. As would be expected, the areas of most concern for lack of recapture are on the wellfield corners. Flow velocities are greatest in the 0.88% run, and this run indicates a water level rise within the bend of the 'L' shape of the modelled wellfield, which is not as apparent on the 1.6% or 2% runs. The flare in the northeastern and southeastern portion of the wellfield is pronounced in the 0.88% run, while there is little, if any, flare in the northeastern portion in the 2.0% run.

3.3.2 November/December 1989. Predictably, the 4.0% overinjection during November/December 1989, when modelled over a 21-day period, resulted in flow away from the wellfield, particularly to the south, which was not 'recaptured' (Figure 7). Several of the 5-spots were apparently out of balance. The most obvious example was in the southernmost 5-spot, in which the injection rate for Well I-211A was reported as 10 gallons per minute (gpm). The reported production rate from Well P-110A, the production well for that 5-spot, was also 10 gpm. Therefore, because Well I-211A is one of three injection wells in that pattern, that southernmost pattern was consistently (and considerably) out-of-balance.

3.3.3 Model Sensitivity. 'Classic' sensitivity analyses for horizontal conductivity and storativity were performed by varying the values of these parameters by an order of magnitude upwards and downwards. As is usually the case, the model results were more sensitive to variations in transmissivity than storativity; however, order-of-magnitude changes had a minimal impact on the model. The results of these sensitivity runs are available in LQD's files. PRI's baseline aquifer test results provided good coverage of the modelled area for transmissivity and storativity data, which lessens questions about the influence of variations in these parameters. An anisotropy of 1.3 was imposed on a run with the 1.6% bleed rate and no significant differences were noted in the results. The results of this run are also available in LQD files.

Of greater concern was the sensitivity of the model to variations in the bleed rate. As stated above, three of the runs presented illustrate the sensitivity of the model results to variations in the bleed rate from 0.88 to 2.0% (Figures 4 through 6). PRI has stated that the wellfield instrumentation is accurate to plus or minus 0.5 gpm. The modelling results show the sensitivity of the wellfield is such that instrument variation may cause problems in maintaining a good balance and control of the mining fluids. Fluctuations of less than 0.5 gpm in the amount of fluid injected or produced could result in variations in bleed rate within the 0.88 to 2.0% modelled. As listed in Table III, the difference in the total injection rate between the 0.88% and 2.0% runs is only about 1 gpm.

3.3.4 Comparison with Measured Water Levels. The model water level elevations were compared to the water levels in Monitor Wells M-27 through M-31, the locations of which are shown on Plate III. Water levels in the monitor wells fluctuate considerably from 1988 through 1996. The water levels during the last half of 1989 are shown on Figure 8, along with the water levels based on the model results over a six-month period. The magnitudes of the actual variations are considerably larger than the model variation. 'Natural' changes in the water levels should be minimal, whereas changes in excess of 5 feet, such as those shown on Figure 8, are probably the result of significant production and injection variations. Therefore, the elevation variations in the monitor wells indicate a consistent balance has apparently not been maintained over the life of the B-Wellfield.

3.3.5 Mass Balance Calculations. For each run, the model calculates the mass balance, i.e. the quantity of water inflow and outflow. For each of the four runs discussed in this review, the balance was within 0.1%.

3.4 Calculation of the Horizontal Flare Factor

The results of the 1.6% model simulation were used to analyze the horizontal flare factor, appropriate for conditions at the Highland Uranium Project, using two separate methods. The first method took into account the variation of the modelled wellfield from an 'ideal' configuration of uniform 5-spot patterns. The second method focused on the flare in that portion of the wellfield most like a uniform 5-spot pattern, specifically the northwest portion of the modelled wellfield.

For the first method, a line was traced around the outermost lateral extent of the influence of the injection wells, based on interpretation of the output option of 200 vectors at a scale factor of 2. This line is shown on Plate VI, and the area enclosed is the 'flare area'. A line was also traced around the patterns, as shown on Plate VI, and the area enclosed is the 'pattern area'. A digitizer was used to determine the area within each of these two lines. The ratio of the 'flare area' (measured as 131,032 ft^2) to the 'pattern area' (measured as 40,403 ft^2) yields a horizontal flare factor of 3.24.

For the second method, the 'flare area' is the area within the square outlined by the stagnation points associated with the injection wells in a 5-spot pattern. (The stagnation point is the outermost extent of flow from an injection well away from a production well, as illustrated on Figure 1.) The layout of injection Wells I-194 through I-197 in relation to production Well P-102, in the northwest portion of the modelled wellfield, was considered the most similar to an 'ideal' 5-spot pattern. Only Wells I-194 and I-195 were used in the analysis because of the influence of Well P-103 on Wells I-196 and I-197. One line was traced between Well I-194 and I-195 and another line was traced between the stagnation points associated with Wells I-194 and I-195, as shown on Plate VI. The length of the line between the injection wells (74 ft) was used as the length of each side of the 'pattern area', resulting in a 'pattern area' of 5476 ft^2. Similarly, the length of the line between the stagnation points (125 ft) was used as the length of each side of the 'flare area', resulting in a 'flare area' of 15,625 ft^2. The ratio of this 'flare area' to the 'pattern area' yields a horizontal flare factor of 2.85.

Based on the results of these two methods, a horizontal flare factor of 3.0 has been used in the calculations of the per-wellfield pore volume, as summarized in Table IV.

{The horizontal flare factor was not analyzed as part of LQD's 1987 model; however, a simplistic calculation can be used to assess the factor based on the reported flare distance. Assuming each pattern was 50 feet x 50 feet, the 'pattern area' would be 2500 ft^2. If the flare extended *only* downgradient of the pattern a distance of 240 feet (LQD 1987 memo, p.3), then the 'flare area' would be the pattern area plus an area of 50 feet x 240 feet, resulting in a 'flare area' of 14,500 ft^2. The ration of the 'flare area' to the 'pattern area' results in a flare factor of 5.8.}

4.0 VERTICAL FLARE

Excursions to aquifers overlying and underlying the sandstone units in which ore zones are deposited are evidence that vertical flare does occur, and such excursions have received attention in research articles (e.g., Staub, et al., 1986). The impacts of these vertical excursions are often, but not exclusively, compounded by the presence of an improperly abandoned well or an opening in the underlying or overlying aquitard, and aquifer testing prior to mining is designed, in part, to locate and mitigate such problems.

The impact of vertical flare within a sandstone unit containing an ore zone has received some attention, with respect to mining efficiency (i.e., to minimize injecting lixiviant into, or pumping water from, the 'barren' sandstone outside of the ore zone). LQD believes detailed evaluation of the impact of vertical flare on the estimates of pore volume for ground water sweep and reverse osmosis is necessary to ensure thorough remediation and adequate bonding. Although the sandstone outside of the zone may be 'barren' with respect to economic concentrations of uranium ore, it may contain other minerals, associated with the roll-front deposition, such as selenium and radium, as well as quantities of uranium too small to mine economically. All of these minerals can be mobilized during mining and restoration and have an adverse impact on ground water quality.

Vertical flare within the sandstone surrounding the ore zone is dependent upon well construction (i.e., partially penetrating wells), hydrogeologic factors, and the wellfield balance. The influence of each of these items on the extent of vertical flare within the sandstone is discussed in the following sections.

4.1 Effects of Partial Penetrating Wells

PRI's injection and production wells are screened across an ore zone within a sandstone unit. At most, the ore zones are only about half as thick as the sandstone units in which the ore was deposited (Table I). Therefore, the injection and production wells are partially penetrating wells, i.e. the wells are screened (or open) over only a portion of the total sandstone aquifer thickness. Although the ore zone is chemically different than the associated sandstone, differences in the hydrologic characteristics of the ore zone and associated sandstone are relatively small. Therefore, even though the production and injection wells are completed in the ore zone, they are in communication with the 'barren' sandstone.

Within confined aquifers, such as the sandstone units at PRI, flow to (or from) an individual, fully penetrating, pumping (or injection) well is horizontal, as illustrated on Figures 9a&b. (For simplicity, it has been assumed that the aquifer is flat-lying and of infinite areal extent.) However, if a well penetrates only part of a confined aquifer, vertical flow to, or from, the well must also be taken into consideration, as illustrated on Figures 10a & b. The impact of partial penetration on drawdown in partially penetrating pumping wells has been studied extensively (e.g., Kruseman and De Ridder, 1970, and McWhorter and Sunada, 1977).

Two factors can limit the impacts of vertical flow around partially penetrating wells. First, the balance of injection and production, can reduce, but not eliminate, such impacts, as discussed in the next section. Second, the effects of partial penetration are generally negligible at a lateral distance, from the well, greater than about 1.5 to 2 times the overall aquifer thickness. However, as discussed in the next sections, the distance between the production and injection wells is often close to this lateral distance, and the cumulative impact of vertical flow can negate this limitation.

4.2 Hydrogeologic Factors and Calculation of the Vertical Flare Volume

One method for assessing the vertical flare volume was developed by L.W. Lake and V.J. Zapata (1987). The parameters and equations used in this method are shown on Table V. Although this method simplifies the conditions at PRI, by simulating only one injection and one production well, it can be used to illustrate the major factors affecting the extent of vertical flare. (LQD is also working on modelling the vertical flare from an 'ideal' 5-spot pattern, using Visual MODFLOW, as modelling vertical flow is significantly easier with this version of MODFLOW than with earlier versions.)

Two values of interest are derived from this method. The first value is the percent of injected fluid which migrates vertically out of the ore zone, between an injection and production well, even when the injection and production rates are balanced. Although this fluid migrates out of the ore zone near the injection well, it is 'pulled' back into the ore zone due to the influence of the pumping well (Figures 11a & b). The second value is the 'barren zone sweep efficiency', which represents the percent of the barren zone impacted by the injected fluid which migrates from the ore zone. This value increases with time as the ratio of the volume of injected fluid to the volume of the ore zone increases.

The first value, the percent of injected fluid which migrates out of the ore zone (F_{xz}), is dependent upon three major factors: (1) the distance between the injection and production well; (2) the ratio of the ore zone thickness to the overall sandstone thickness; (3) the ratio of the vertical and horizontal permeabilities of the sandstone. The equations relating these factors, and the curve needed to solve the equations graphically, are included in Table V and Figure 12. The first two factors can be determined from the data in Table I. A ratio of vertical to horizontal permeabilities was set at 0.07, based on information from another Cogema site in Wyoming, the Christensen Ranch site (Cogema, App. D-6, p.D6-2). During the May 13, 1996 meeting between LQD and PRI, PRI expressed concern about the impact of thin shale 'stringers', associated with the ore deposition, on the vertical permeabilities. However, such 'stringers' would be expected at the Cogema Christensen Ranch site (Cogema, App. D-5, p. D5-17). Also, such 'stringers' are not generally continuous laterally.

Using the Lake and Zapata equations, the percent of fluid which migrates out of the ore zones (F_{xz}) in the PRI wellfields ranges between 50 and 70% (Table V), which is a substantial portion of the injected fluid. Therefore, the potential for mobilization of parameters of concern in the 'barren' zone is high. (Note: There is apparently a typographical error in the "application" of this graphical method on p.55 of the 1987 Lake and Zapata paper. The ratio of vertical to horizontal permeabilities is given as 0.01; however, a value of 0.1 is more realistic. Using 0.1 in the calculation of R_L, the result is 0.018, rather than 0.18, which graphically relates to the reported F_{xz} value of 0.12.)

The second value, the barren zone sweep efficiency (E_{xz}), is dependent upon the same factors as the first value (F_{xz}). In addition, the difference, if any, in the horizontal permeabilities of the ore zone and the associated sandstone can also be incorporated. However, such differences are generally minimal, and small differences do not significantly affect the value of E_{xz} . When E_{xz} equals 1.0, then the entire barren zone has been impacted by fluid from the injection well. Figures 13a&b illustrate the rate at which an E_{xz} of 1.0 is approached as the ratio of the injected volume to the ore zone volume (t_D) increases. Although there are several factors which influence E_{xz}, some generalizations are possible for conditions similar to those at PRI. For example, as shown on Figure 13a, when the distance between the production and injection wells is greater than the thickness of the sandstone, E_{xz} rapidly approaches 1.0. Similarly, as shown on Figure 13b, when the ore zone is almost as thick as the sandstone, E_{xz} rapidly approaches 1.0.

At PRI, the injection rates are such that the ratio of the injected volume to the ore zone volume (t_D) increases quickly. For example, using an area similar to that modelled for the horizontal flare, the ore zone volume is about 178,605 cubic feet (ft^3) (9 patterns x 15 feet ore zone thickness x 4900 ft^2 per pattern x 0.27 effective porosity). If the injected volume is about 128 gpm (Table III), which is about 17 ft^3 per minute or 24,640 ft^3 per day. Therefore, t_D equals 1 in about a week. For each wellfield, E_{xz} was calculated at $t_D=1$ and $t_D=2$ to determine if the responses at PRI would be similar to the responses reported by Lake and Zapata.

Comparison of the calculated E_{xz} values with those on Figure 13a indicates the same factors are important at PRI. In the A-, B-, D-, and E-Wellfields, the distance between the injection and production wells is greater than the sandstone thickness, and the ore zone thickness is half the sandstone thickness. Therefore, based on the above discussion, the entire sandstone thickness within the pattern area is affected by vertical flow from the injection wells within a few months after the wellfield is put into production, i.e., the barren zone sweep efficiency is 1.0. In the C- and F-Wellfields, the sandstone thickness is greater, and as a result, less of the barren zone is impacted. Barren zone efficiencies of 0.5 and 0.2, respectively, are appropriate for these two wellfields. It should be noted that this approach simplifies delineation of the vertical flare by assuming the vertical flare only impacts sandstone above and below the pattern area, i.e., not any of the sandstone above or below the horizontal flare area outside the pattern area.

These values of the barren zone sweep efficiency, and their impact on the pore volume estimate, are summarized in Table IV. By using the barren zone sweep efficiency, the volume of sandstone above and below the pattern area can be calculated. This is then added to the flare volume, which includes the pattern volume, to determine the total pore volume impacted by mining.

4.3 <u>Wellfield Balance</u>

If a partially penetrating injection well in a pattern or operating unit is out of balance and overinjecting, then the injected fluid can migrate vertically and laterally farther than if the injection well were in balance. Then the pattern must be 'over-pumped' to try to 'pull' the fluid back toward the area of influence of the pattern. If the pattern is not 'over-pumped' or not 'over-pumped' enough, the excess fluid may not be recaptured in the vertical flow around a partially penetrating production well. Therefore, the impact of overinjection may be cumulative over time.

5.0 SUMMARY

PRI operates the Highland Uranium Project, an in-situ uranium mine which has been in operation since the late 1980s. LQD has been concerned that PRI's estimate, for their bond calculations, of the volume of ground water impacted by mining is too low. PRI uses a flare factor of 1.4 times the 5-spot 'pattern volume' as the 'pore volume' and assumes that four pore volumes must be removed during ground water restoration. This flare factor is based on core data from a research and development project at another Wyoming in-situ mine.

LQD has evaluated the horizontal and vertical flares separately using data from the Highland Uranium Project. The horizontal flare was evaluated using the USGS MODFLOW model (and the newer Visual MODFLOW). Conditions in a portion of the B-Wellfield were simulated. For three of the model runs, it was assumed the wellfield was balanced, with the bleed rates of 0.88%, 1.6% and 2.0%, respectively. Data submitted by PRI for November/December 1989, which indicated a consistent overinjection rate of 2% to 5% during that time, was used in a fourth run. (LQD's review of water level changes over time indicates the wellfield may not have been consistently balanced.) The results of the 'balanced' runs indicate that most of the injected water is 'recaptured' by the production wells, and the horizontal flare factor is 3.0. The results of the November/December 1989 run indicate that at least one 5-spot pattern is significantly out-of-balance and water injected in the southern portion of the modelled wellfield is not 'recaptured' by the production wells.

The vertical flare was evaluated using a 'graphical' method developed by Lake and Zapata (1987). The most important factors are the ore zone thickness in relation to the sandstone thickness and the distance between the production and injection wells, and the horizontal and vertical permeabilities. Therefore, the vertical flare should be calculated on a wellfield by wellfield basis because of the lithologic control. The Lake and Zapata method results in a "barren zone sweep efficiency". The vertical flare in the A-, B-, D-, and E-Wellfields extends throughout the sandstone, so the sweep efficiency is 1.0. The sweep efficiency in the C-Wellfield is about 0.5, as the sandstone is slightly thicker. The sweep efficiency in the F-Wellfield is 0.2.

The horizontal and vertical flare factors developed in this technical review have been used by LQD to calculate the pore volume for each of the wellfields at the Highland Uranium Project. The calculations are summarized on Table IV. The pore volumes currently used in PRI's bond are also summarized on Table IV. The number of pore volumes impacted by mining, based on LQD's calculations, is generally three times the PRI's pore volume estimates. LQD's concerns that the current pore volume estimate is too low, based on evaluation of available data and experience with contaminant migration, are confirmed by the results of this review. It is LQD's belief that the pore volumes developed in this review must be used in PRI's future bond estimates so adequate resources are available to the State of Wyoming for ground water restoration should the company forfeit the bond.

6.0 REFERENCES

Abbreviations used in the text are shown in parentheses at the end of each reference.

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Table I
Wellfield Proportions
PRI Permit 603
June 1996

Wellfield	Sandstone Unit	Average Sandstone Thickness w/i Wellfield (feet)	Average Ore Zone Thickness (feet)	Average Pattern Area $(ft^2)^{(1)}$
A	20 Sand	$30^{(2)}$	15.4	4900
B	30 Sand	$30^{(2)}$	15.4	4900
C	50 Sand	$60^{(3)}$	15	6500
D	40 Sand	$40^{(4)}$	15	6500
E	50 Sand	$35^{(5)}$	15	6500
F	50 Sand	$150^{(6)}$	15	6500

Sources: (1) Pattern areas used in PRI's bond calculation (AR, p.22).

(2) Based on interpretation by PRI of WDEQ/LQD of geophysical logs supplied by PRI.

(3) Based on Figure ? - Isopach of 50 Sandstone, Section 14/24 Amendment, in Appendix 6 of Application for Amendment No. 1, Change No. 3, approved 6/27/89.

(4) Based on Plates 2-1 & 2-2, 40 Sand Cross-Sections B-B' & E-E', Pump Test Volume 2 of 3 (Start 1991), Section 22/23 Sand Mine Unit Hydrology Test, submitted 1/7/91.

(5) Based on Plate 11 - 50 Sand Isopach, Area E - 50 Sand Mine Unit, Volume #3 - Pump Test Data, submitted 11/8/91; and p. 1-5, Change No. 8, Vol. 1 of 2, approved 11/8/91.

(6) The F Wellfield actually consists of a series of three ore zones and is simplified as a single ore zone within a 150-foot sandstone for the purposes of this review.

Table II
Production and Injection Data Provided by PRI
PRI Permit 603 - June 1996

	Well	11/30/88	11/22/89	11/28/89	11/30/89	12/2/89	12/8/89	12/12/89
Production Wells (gpm)	P-102	13	7	7	8	7	7	7
	P-103	11	9	9	9	9	9	9
	P-104A	20	11	11	11	11	11	11
	P-105	13	11	11	11	11	11	11
	P-106	22	10	10	10	9	13	13
	P-107A	23	8	8	8	8	7	7
	P-108A	13	10	10	10	10	10	10
	P-110A	13	10	10	10	10	10	10
Total		128	76	76	77	75	78	78
Injection Wells (gpm)	I-194	–	4/2[1]	3/1.5	2/1	3/1.5	2/1	1/0.5
	I-195	–	3/1.5	3/1.5	2/1	2/1	2/1	3/1.5
	I-196	–	5	5	5	5	5	4
	I-197	–	7	7	7	7	7	7
	I-198	–	5	5	5	5	5	5
	I-199	–	4	5	5	5	4	4
	I-200	–	5	5	3	5	5	5
	I-201	–	2	2	2	2	2	2
	I-202	–	5	6	5	5	5	5
	I-203	–	3	3	3	3	3	3
	I-204A	–	3	3	3	3	3	3
	I-205	–	3	3	3	3	3	3
	I-206A	–	6	6	6	6	6	6
	I-207	–	4	4	4	4	8	8
	I-208A	–	4	4	4	4	4	4
	I-209A	–	3	3	3	3	3	3
	I-210	–	3	3	3	3	3	3
	I-211A	–	10	10	10	10	10	10
	I-212A	–	5	5	5	4	5	5
Total		–	84/81.5	85/82	80/78	82/79.5	85/83	84/82
% OverInjection		–	6.7%	7.3%	1.3%	5.7%	6.0%	4.9%

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[1] Full Injection Rate/'Half-Injection' Rate. In evaluation of the area modelled by LQD, the injection rates in Wells I-194 and I-195 must be divided by 2 because these wells are influenced by production Well P-102 and a production well to the west. The % OverInjection was calculated using the 'half-injection' rates for Wells I-195 and I-195.

Table III
Production & Injection Rates in the Model Runs
PRI Permit 603 - June 1996

Balanced 1.6% Bleed

Production				Injection			
Well	Row, Column	Rate		Well	Row, Column	Rate	
		cfs	gpm			cfs	gpm
P-102	53,49	2503.0	13.0	I-194	51,48	762.3	4.0
P-103	53,53	2118.0	11.0	I-195	54,48	762.3	4.0
P-104A	54,56	3850.0	20.0	I-196	52,51	1147.0	6.0
P-105	55,59	2503.0	13.0	I-197	54,51	1097.5	5.7
P-106	57,59	4235.0	22.0	I-198	53,55	2136.3	11.1
P-107A	58,62	4428.0	23.0	I-199	55,54	2126.2	11.0
P-108A	60,58	2503.0	13.0	I-200	53,58	1813.5	9.4
P-110A	63,61	2503.0	13.0	I-201	53,61	1185.3	6.2
Total		24,643.0	128.0	I-202	56,58	2129.5	11.1
				I-203	56,60	1243.3	6.5
				I-204A	57,63	2076.5	10.8
				I-205	59,57	2013.3	10.5
				I-206A	59,60	720.9	3.7
				I-207	60,62	1405.3	7.3
				I-208A	60,56	633.5	3.3
				I-209A	62,58	683.3	3.6
				I-210	62,62	682.5	3.5
				I-211A	64,59	818.2	4.2
				I-212A	64,61	818.2	4.2
				Total		24254.9	126.1

Table III (cont'd)
Production & Injection Rates in the Model Runs
PRI Permit 603 - June 1996

Balanced 0.88% Bleed

Production				Injection			
Well	Row, Column	Rate		Well	Row, Column	Rate	
		cfs	gpm			cfs	gpm
P-102	53,49	2503.0	13.0	I-194	51,48	674.0	3.5
P-103	53,53	2118.0	11.0	I-195	54,48	674.0	3.5
P-104A	54,56	3850.0	20.0	I-196	52,51	989.2	5.1
P-105	55,59	2503.0	13.0	I-197	54,51	989.2	5.1
P-106	57,59	4235.0	22.0	I-198	53,55	2126.2	11.0
P-107A	58,62	4428.0	23.0	I-199	55,54	2126.2	11.0
P-108A	60,58	2503.0	13.0	I-200	53,58	1278.2	6.6
P-110A	63,61	2503.0	13.0	I-201	53,61	913.2	4.7
Total		24,643.0	128.0	I-202	56,58	2626.2	13.6
				I-203	56,60	2607.2	13.5
				I-204A	57,63	1028.2	5.3
				I-205	59,57	1202.2	6.2
				I-206A	59,60	1644.2	8.5
				I-207	60,62	1163.2	6.0
				I-208A	60,56	701.2	3.6
				I-209A	62,58	1182.2	6.1
				I-210	62,62	963.0	5.0
				I-211A	64,59	770.0	4.0
				I-212A	64,61	770.0	4.0
				Total		24,427.8	126.3

Table III (cont'd)
Production & Injection Rates in the Model Runs
PRI Permit 603 - June 1996

Balanced 2.0% Bleed

Production				Injection			
Well	Row, Column	Rate		Well	Row, Column	Rate	
		cfs	gpm			cfs	gpm
P-102	53,49	2503.0	13.0	I-194	51,48	671.5	3.5
P-103	53,53	2118.0	11.0	I-195	54,48	712.5	3.7
P-104A	54,56	3850.0	20.0	I-196	52,51	1097.5	5.7
P-105	55,59	2503.0	13.0	I-197	54,51	1097.5	5.7
P-106	57,59	4235.0	22.0	I-198	53,55	2085.5	10.8
P-107A	58,62	4428.0	23.0	I-199	55,54	2086.5	10.8
P-108A	60,58	2503.0	13.0	I-200	53,58	1771.5	9.2
P-110A	63,61	2503.0	13.0	I-201	53,61	404.5	2.1
Total		24,643.0	128.0	I-202	56,58	1769.5	9.2
				I-203	56,60	1135.5	5.9
				I-204A	57,63	2079.5	10.8
				I-205	59,57	1193.5	6.2
				I-206A	59,60	1963.5	10.2
				I-207	60,62	2925.5	15.2
				I-208A	60,56	633.5	3.3
				I-209A	62,58	633.5	3.3
				I-210	62,62	632.0	3.3
				I-211A	64,59	633.5	3.3
				I-212A	64,61	633.5	3.3
				Total		24,160.0	125.5

Table III (cont'd)
Production & Injection Rates in the Model Runs
PRI Permit 603 - June 1996

November/December 1989 - 4.0% OverInjection

Production					Injection				
Well	Row, Column	Model Input Rate		Range of Reported Rates (gpm)	Well	Row, Column	Model Input Rate		Range of Reported Rates (gpm)
		cfs	gpm				cfs	gpm	
P-102	53,49	1347.0	7.0	7.0-8.0	I-194	51,48	194.0	1.0	1.0-4.0
P-103	53,53	1733.0	9.0	9.0	I-195	54,48	194.0	1.0	2.0-3.0
P-104A	54,56	2118.0	11.0	11.0	I-196	52,51	770.0	4.0	4.0-5.0
P-105	55,59	2118.0	11.0	11.0	I-197	54,51	1347.0	7.0	7.0
P-106	57,59	1925.0	10.0	9.0-13.0	I-198	53,55	963.0	5.0	5.0
P-107A	58,62	1347.0	7.0	7.0-8.0	I-199	55,54	770.0	4.0	4.0-5.0
P-108A	60,58	1925.0	10.0	10.0	I-200	53,58	963.0	5.0	3.0-5.0
P-110A	63,61	1925.0	10.0	10.0	I-201	53,61	385.0	2.0	2.0
Total		14438.0	75.0	75.0-78.0	I-202	56,58	963.0	5.0	5.0-6.0
					I-203	56,60	577.5	3.0	3.0
					I-204A	57,63	577.5	3.0	3.0
					I-205	59,57	577.5	3.0	3.0
					I-206A	59,60	1155.0	6.0	6.0
					I-207	60,62	963.0	5.0	4.0-8.0
					I-208A	60,56	770.0	4.0	4.0
					I-209A	62,58	577.5	3.0	3.0
					I-210	62,62	577.5	3.0	3.0
					I-211A	64,59	1925.0	10.0	10.0
					I-212A	64,61	770.0	4.0	4.0-5.0
					Total		15019.5	78.0	78.0-83.0

Table IV
PRI and LQD Pore Volume Estimates - PRI Permit 603
June 1996

Wellfield	'Ideal' Pattern Dimensions (feet)	'Ideal' Pattern Area (feet)	Number of Patterns	Thickness (feet)		Effective Porosity	PRI Flare Factor	LQD Flare Components		Pore Volume(1) (acre-feet)	
				Ore Zone	Barren Zone			Horizontal Flare Factor	Barren Zone Sweep Efficiency	PRI	LQD
A	70x70	4900	22	15	30	0.27	1.4	3.0	1.0	14.3	40.2
B	70x70	4900	150	15	30	0.27	1.4	3.0	1.0	98.3	273.9
C	80x80	6500	197(2)	15	35	0.27	1.4	3.0	0.5	162.4	497.0
D	80x80	6500	43	15	30	0.27	1.4	3.0	1.0	36.4	104.1
E	80x80	6500	157	15	30	0.27	1.4	3.0	1.0	132.8	380.3
F	80x80	6500	250	15	135	0.27	1.4	3.0	0.2	140.4	726.6

(1) PRI's Pore Volume Estimate =
(Pattern Area)(# of Patterns)(Ore Zone Thickness)(Effective Porosity)(Flare Factor)
LQD's Pore Volume Estimate =
(Pattern Area)(# of Patterns)(Ore Zone Thickness)(Effective Porosity)(Horizontal Flare Factor)+
(Pattern Area)(# of Patterns)(Barren Zone Volume)(Effective Porosity)(Barren Zone Sweep Efficiency)
1 cubic foot = 2.3 x 10^{-5} acre-feet

(2) The number of patterns includes those in the C-Wellfield and the C-19N pattern area associated with the underground workings.

See 8/13/96 Correction Letter
@ front of volume.

Table V
Vertical Flare Parameters - PRI Permit 603
June 1996

Wellfield	'L' Half-Distance between Injection & Production Wells (feet)	'H' Average Sandstone Thickness w/i Wellfield (feet)	L/H	'Z' Average Ore Zone Thickness (feet)	'h_D' (Z/H)	'R_L' Effective Length-Thickness Ratio	'F_{xz}' Fraction of Fluid Leaving Ore Zone	'E_{xz}' Barren Zone Sweep Efficiency	
								$t_D=1$	$t_D=2$
A	99	30	3.3	15	0.50	0.86	0.5	0.36	0.78
B	99	30	3.3	15	0.50	0.86	0.5	0.36	0.78
C	114	60	1.9	15	0.25	0.49	0.7	0.13	0.29
D	114	40	2.8	15	0.38	0.74	0.6	0.25	0.56
E	114	35	3.3	15	0.43	0.85	0.6	0.32	0.69
F	114	150	0.8	15	0.10	0.20	0.6	0.03	0.07

For a complete description of the equations and assumptions used in this method, see Lake & Zapata, 1987.

$R_L \approx L/H*(k_z/k_x)^{1/2}$
F_{xz} was calculated by multiplying the 'normalized' value of F_{xz} from Figure 12 by $(1-h_D)$.
E_{xz} was determined using the graphical method discussed in Lake & Zapata, 1987.

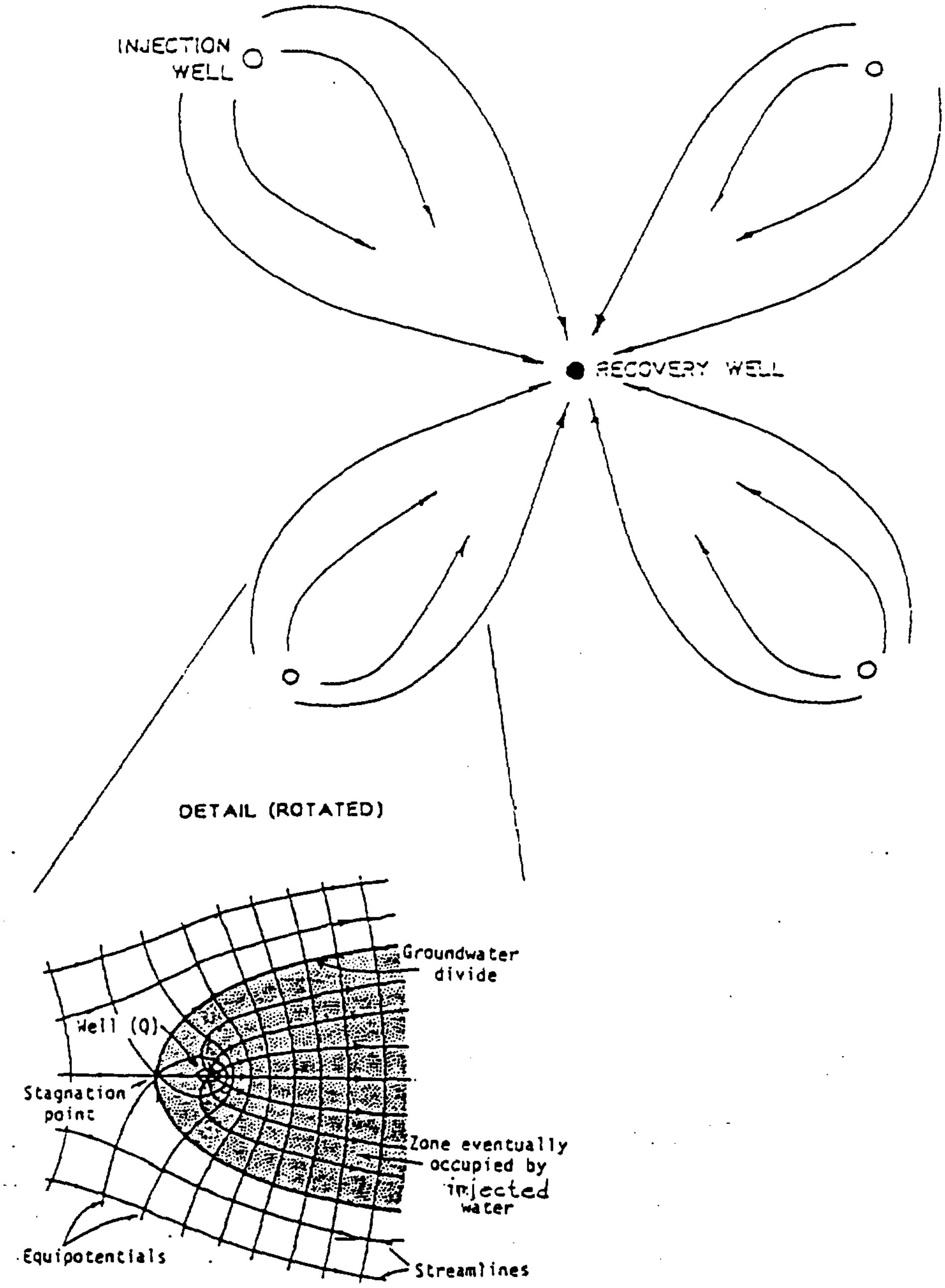
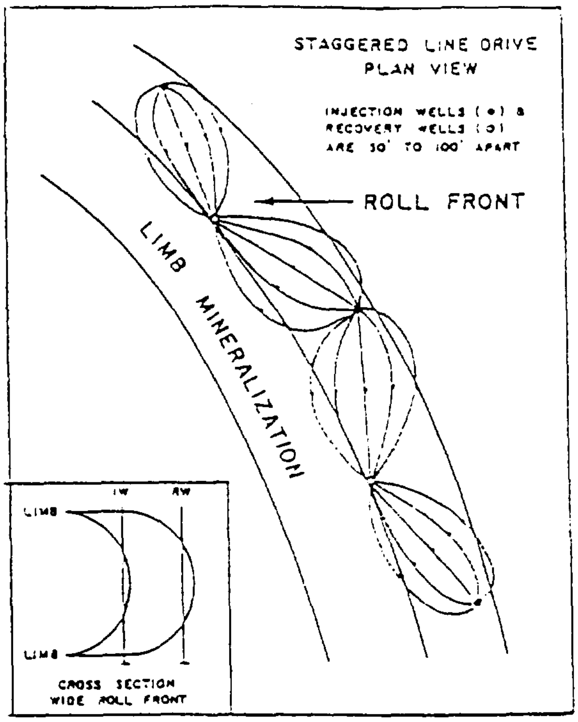
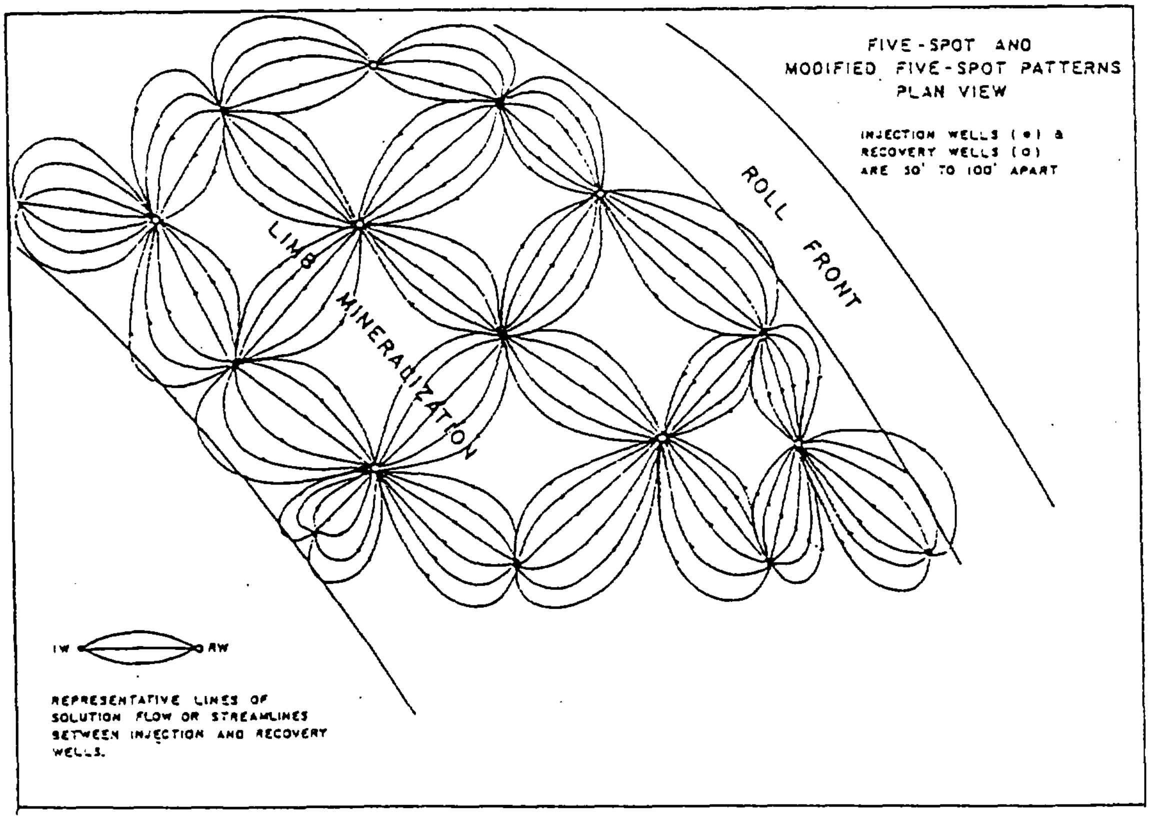


FIGURE 1
'IDEAL' 5-SPOT PATTERN

SOURCES:
FULL-SCALE, COGEMA 1977 REPORT, FIG. 2-4
DETAIL, WALTON, 1984, P.287

POWER RESOURCES, INC.
HIGHLAND URANIUM PROJECT
WDEQ/LQD PERMIT 603
JUNE 1996
PREPARED BY: WDEQ/LQD

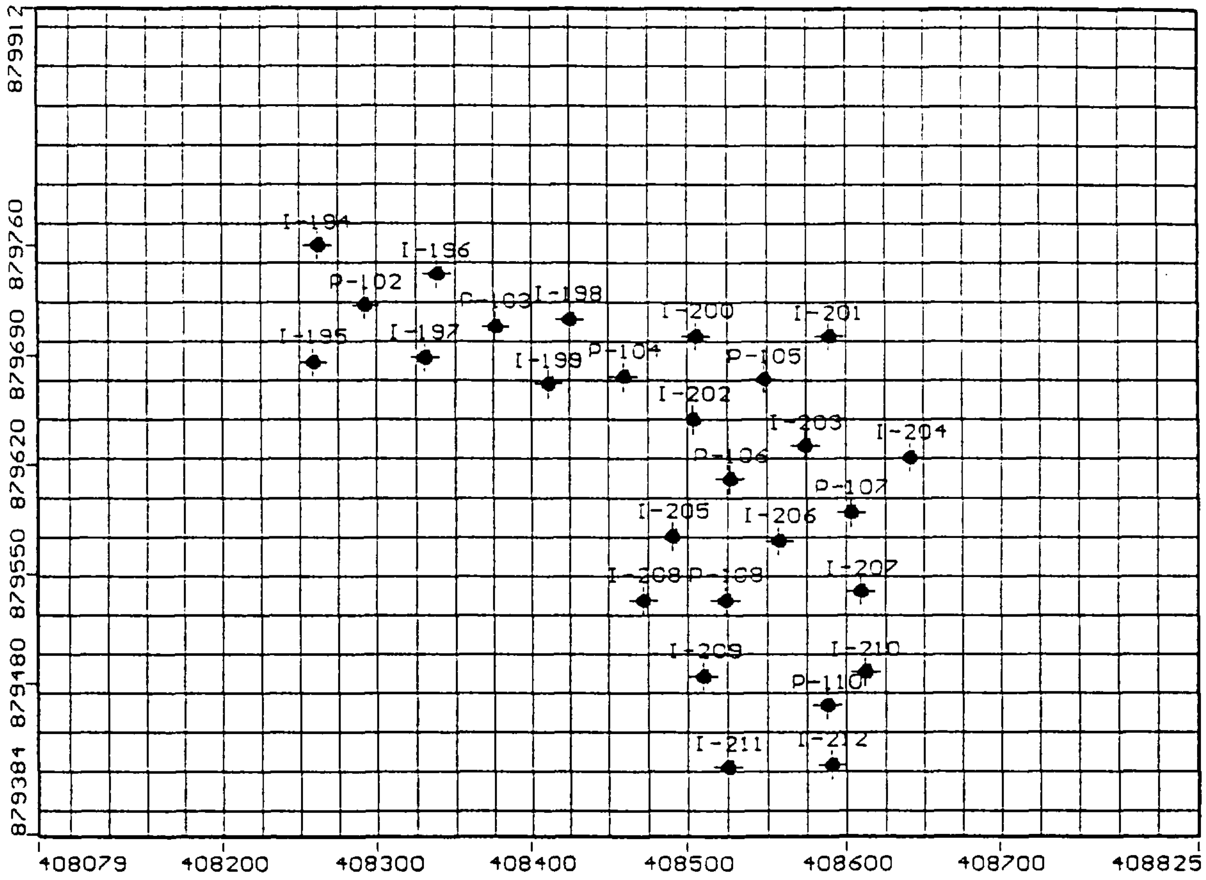




SOURCE:
COGEMA AMENDMENT, FIG. 3.4

FIGURE 2
'TYPICAL' PATTERN COMBINATIONS

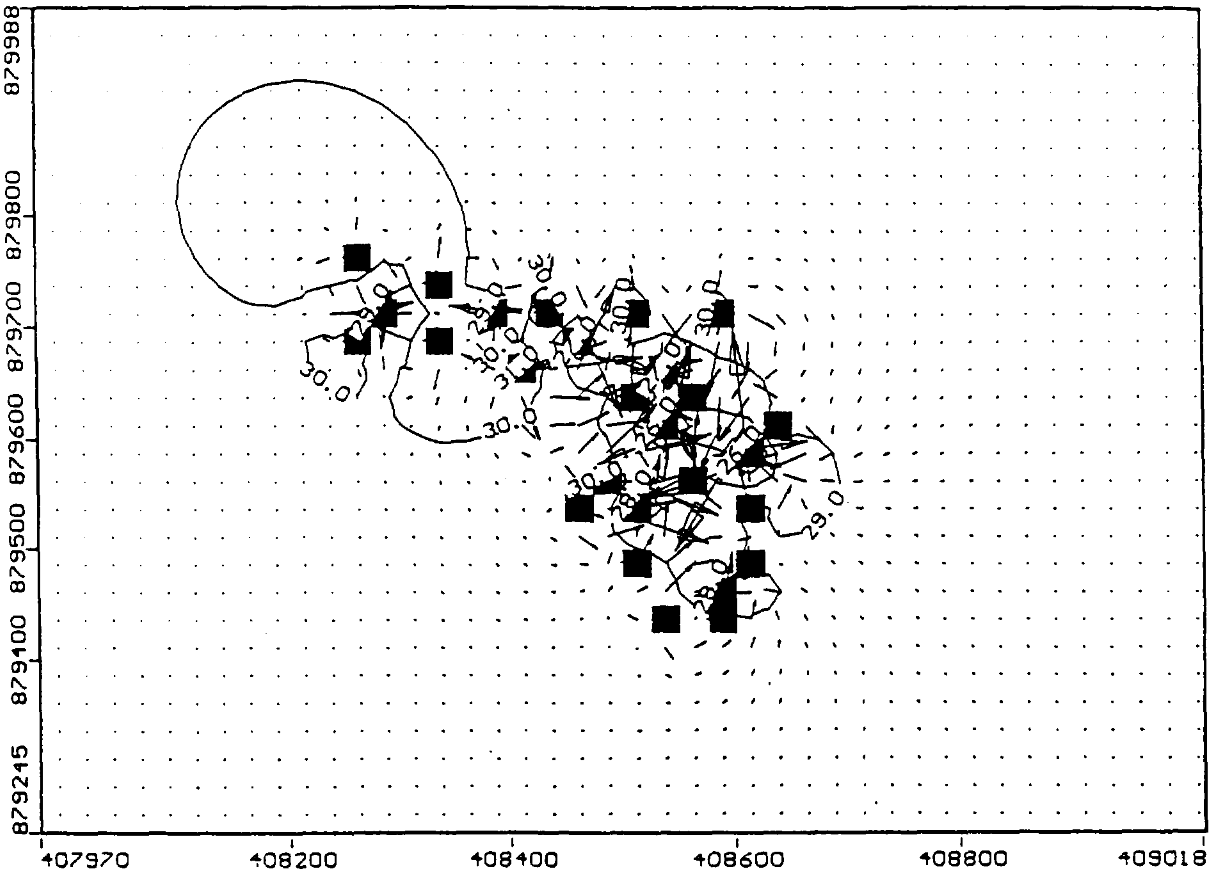
PRI HIGHLAND URANIUM PROJECT
WDEQ/LQD PERMIT 603 - JUNE 1996



State of Wyoming – DEQ – Cheyenne, W
Project: PRI
Description: Well Locations in Grid
Modeller: LQD
11 Jun 96

Visual MODFLOW v.1.50. (c) 1995
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 1
Current Layer: 1

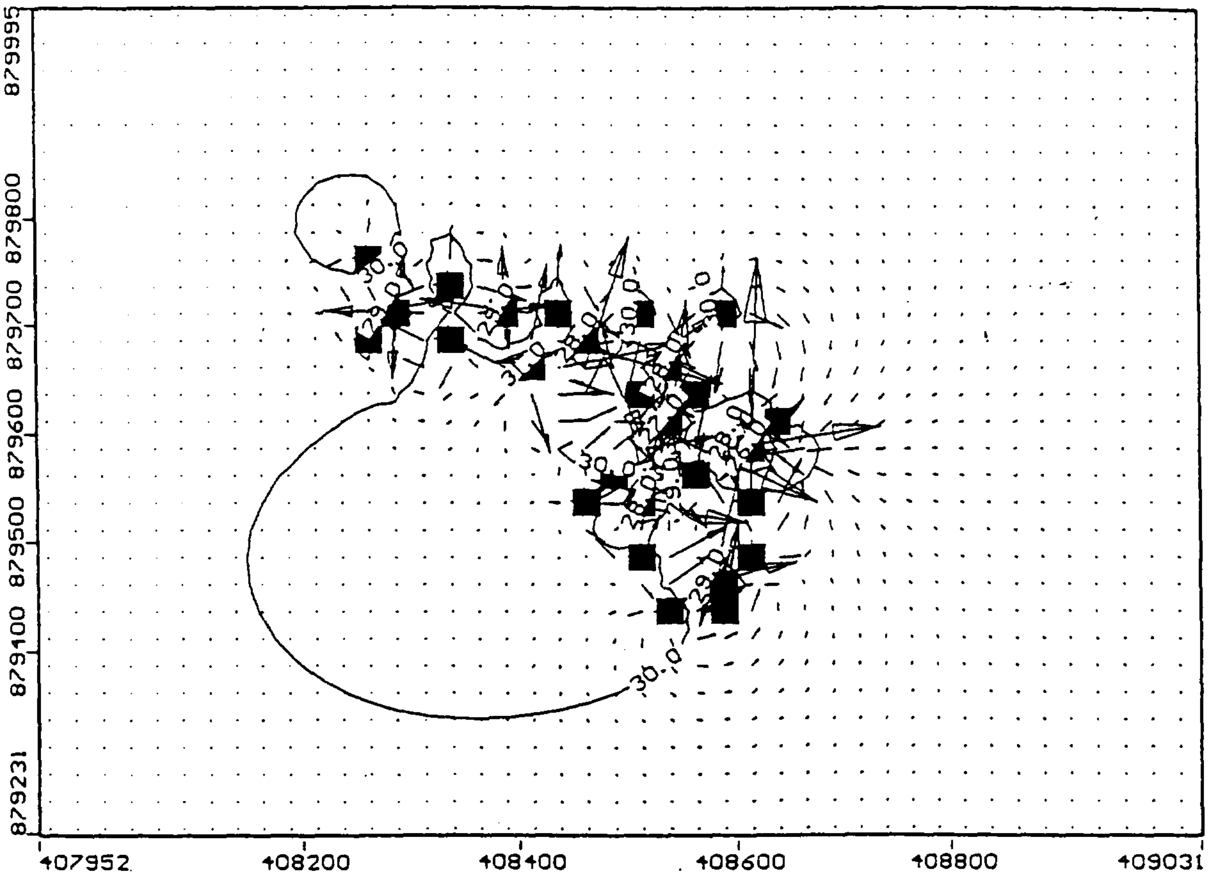
FIGURE 3



State of Wyoming – DEQ – Cheyenne, W
Project: PRI
Description: 1.6% AT 2YEARS OPERATION
Modeller: LQD
6 Jun 96

Visual MODFLOW v.1.50, (c) 1995
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 1
Current Layer: 1

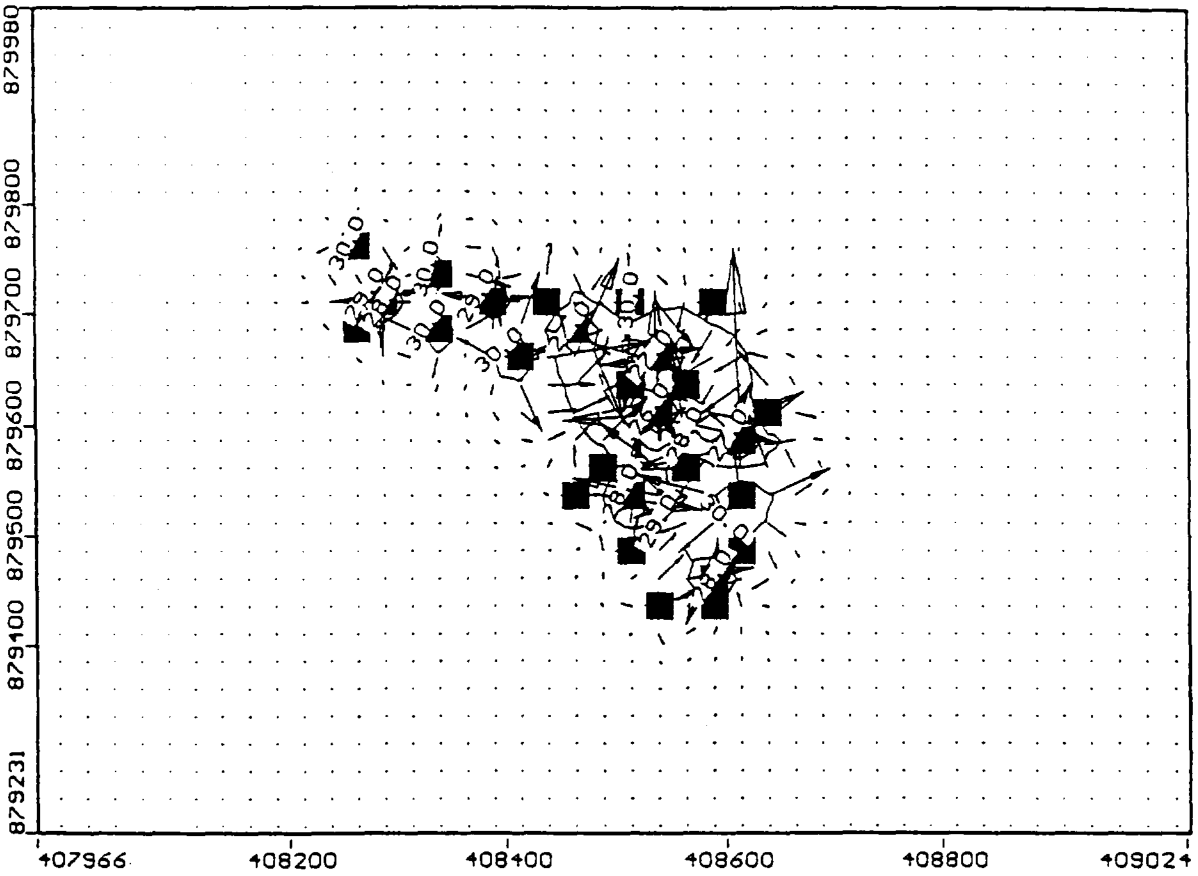
FIGURE 4



State of Wyoming – DEQ – Cheyenne, W
Project: PRI
Description: 0.88% AT 2 YRS OPERATION
Modeller: LQD
4 Jun 96

Visual MODFLOW v.1.50, (c) 1995
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 1
Current Layer: 1

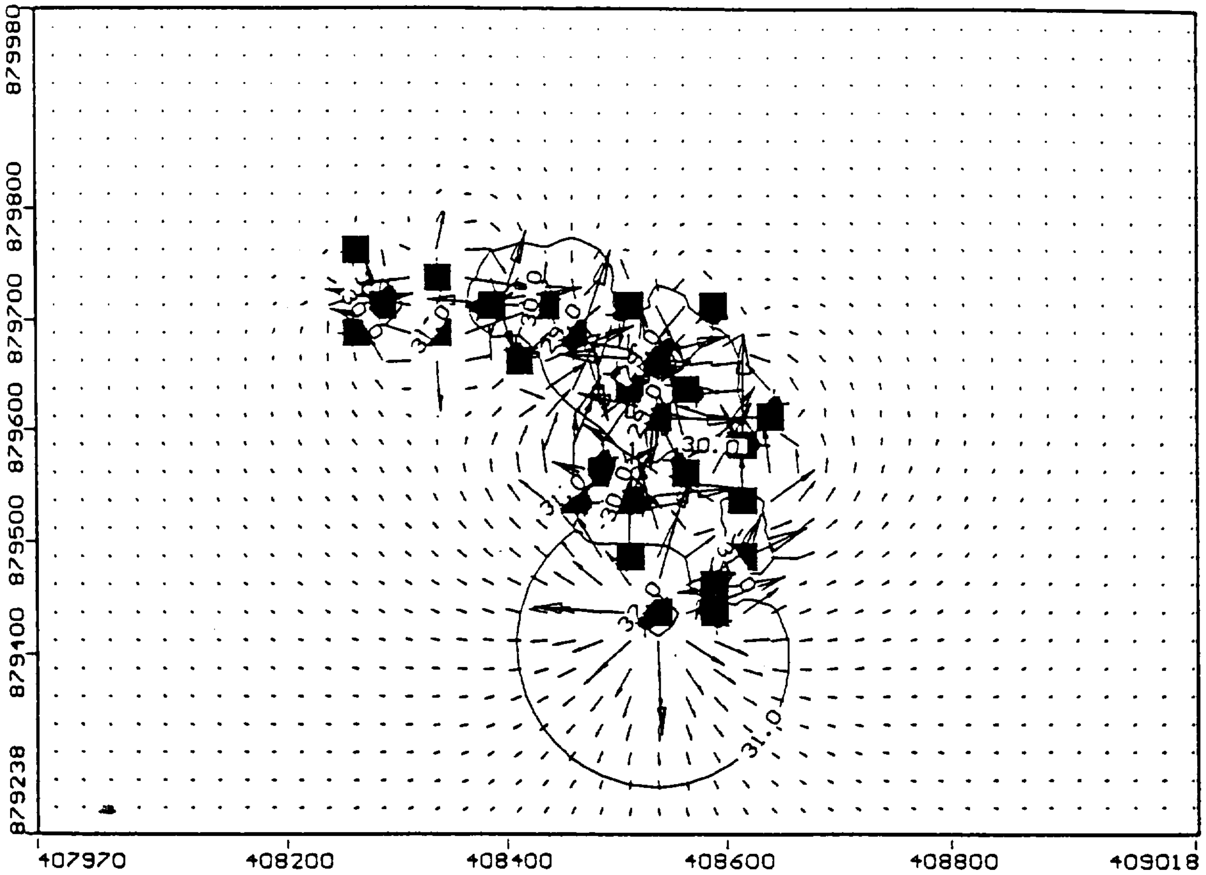
FIGURE 5



State of Wyoming – DEQ – Cheyenne, W
Project: PRI
Description: 2.0% AT 2 YEARS OPERATION
Modeller: LQD
4 Jun 96

Visual MODFLOW v.1.50, (c) 1995
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 1
Current Layer: 1

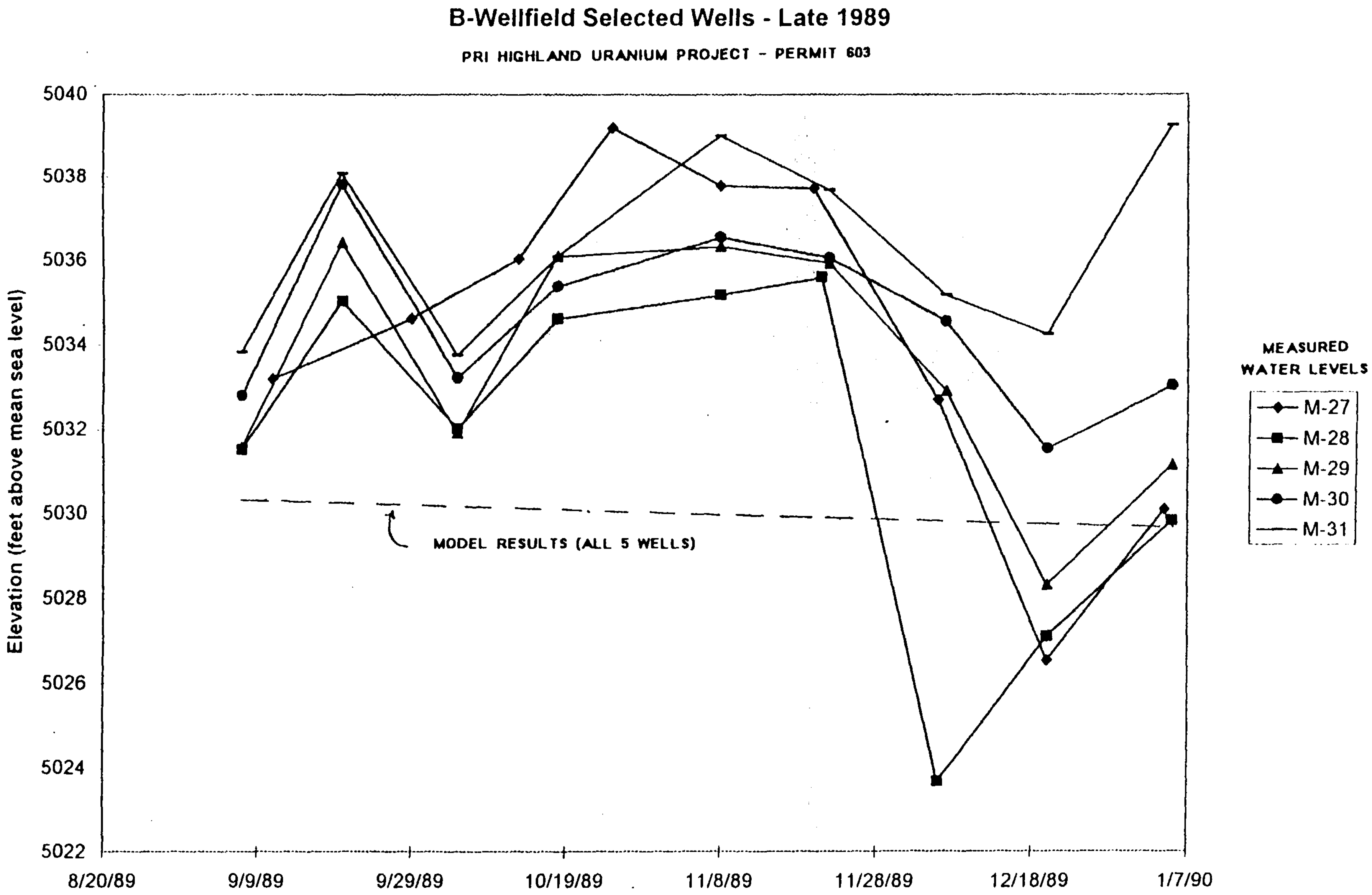
FIGURE 6



State of Wyoming – DEQ – Cheyenne, W
Project: PRI
Description: November/December 1989
Modeller: LQD
11 Jun 96

Visual MODFLOW v.1.50, (c) 1995
Waterloo Hydrogeologic Software
NC: 100 NR: 100 NL: 1
Current Layer: 1

FIGURE 7



PREPARED BY WDEQ/LQD
JUNE 1996

FIGURE 8

COMPARISON OF MEASURED WATER LEVEL CHANGES
WITH MODEL RESULTS

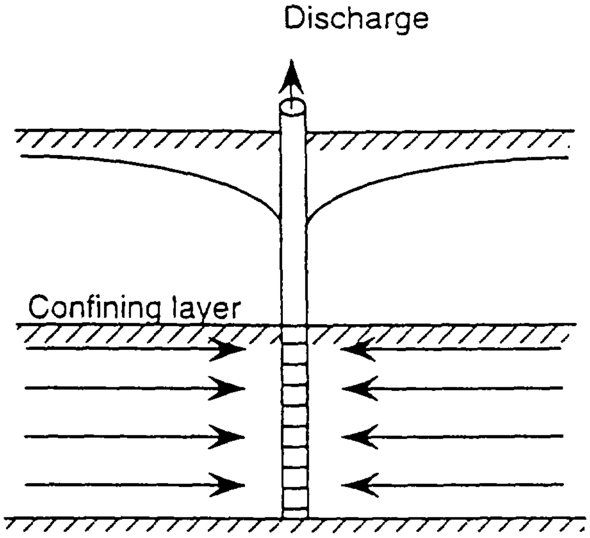


FIGURE 9A

FLOW TOWARD
FULLY PENETRATING
PRODUCTION WELL

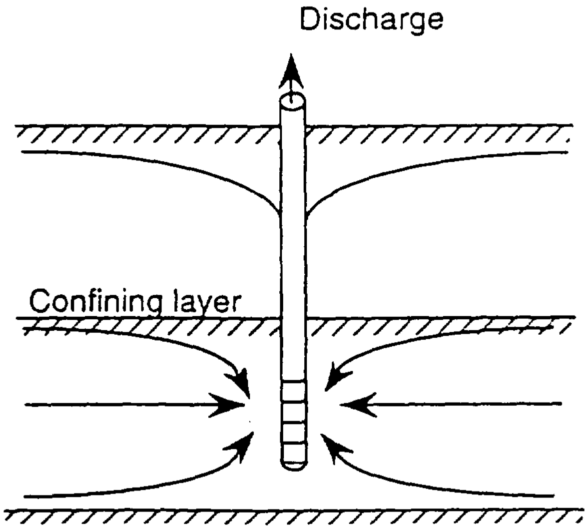


FIGURE 9B

FLOW TOWARD
PARTIALLY PENETRATING
PRODUCTION WELL

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JUNE 1996

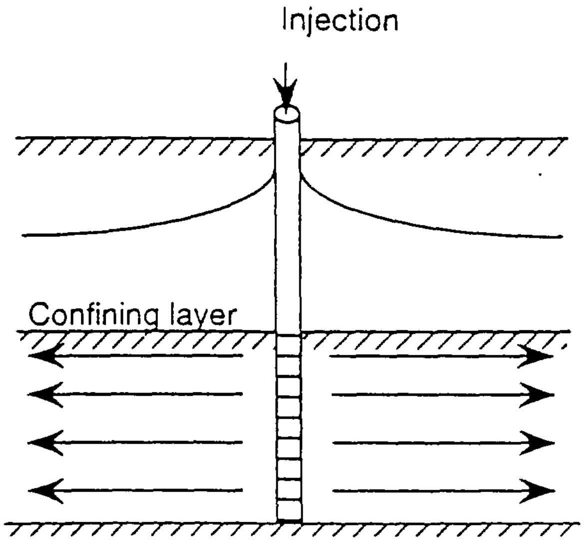


FIGURE 10A

**FLOW AWAY FROM
FULLY PENETRATING
INJECTION WELL**

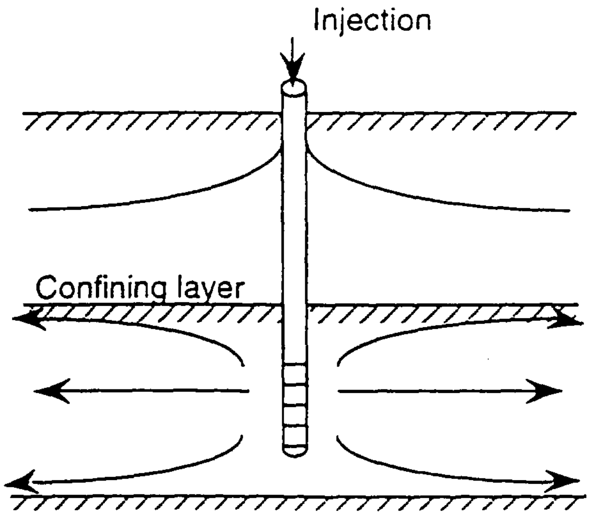


FIGURE 10B

**FLOW AWAY FROM
PARTIALLY PENETRATING
INJECTION WELL**

**PRI HIGHLAND URANIUM PROJECT - PERMIT 603
PREPARED BY WDEQ/LQD
JUNE 1996**

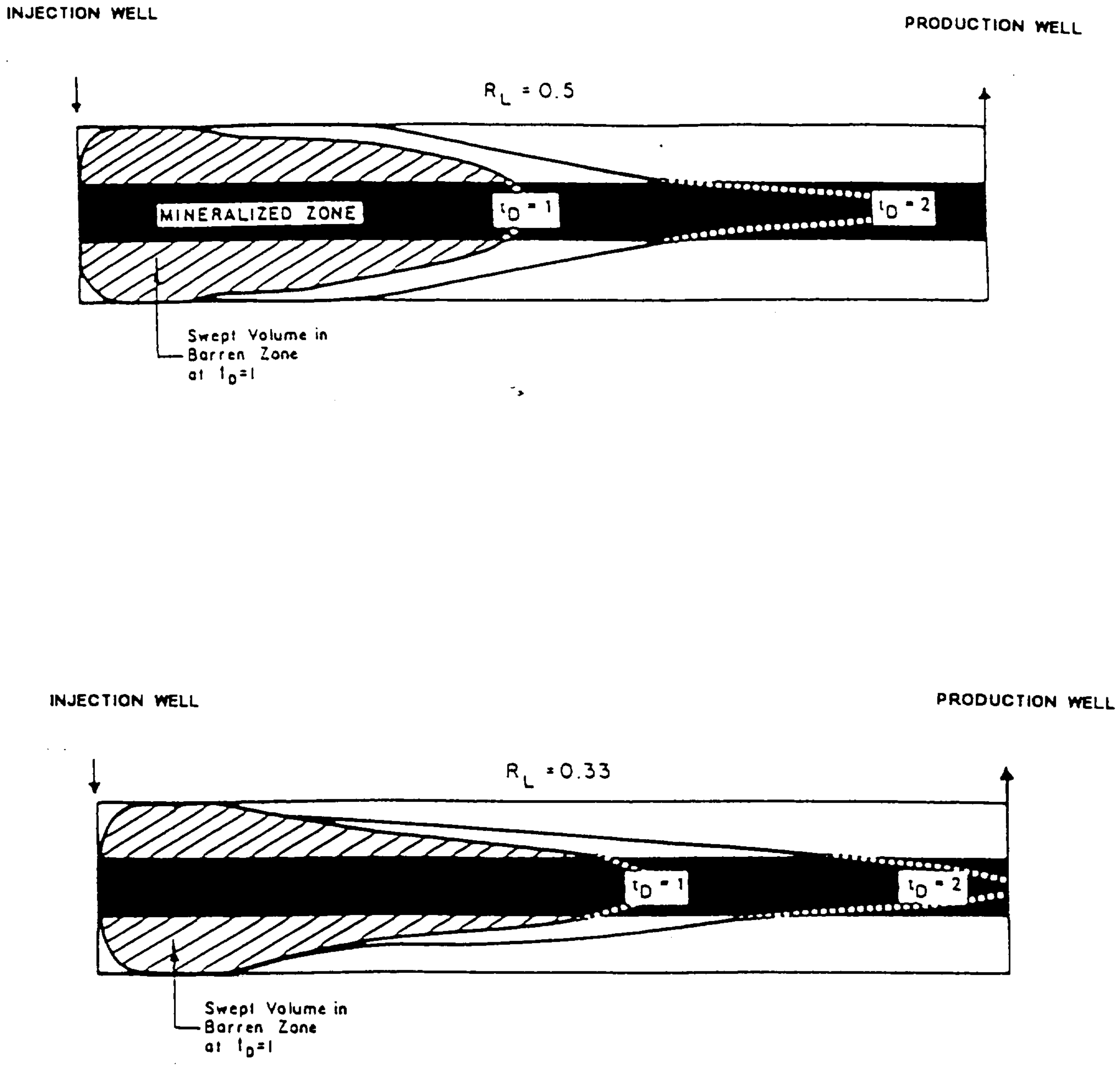


FIGURE 11

Flare shapes for various R_L and t_D.

PRI HIGHLAND URANIUM PROJECT
PERMIT 603
JUNE 1996
SOURCE: LAKE & ZAPATA, 1987

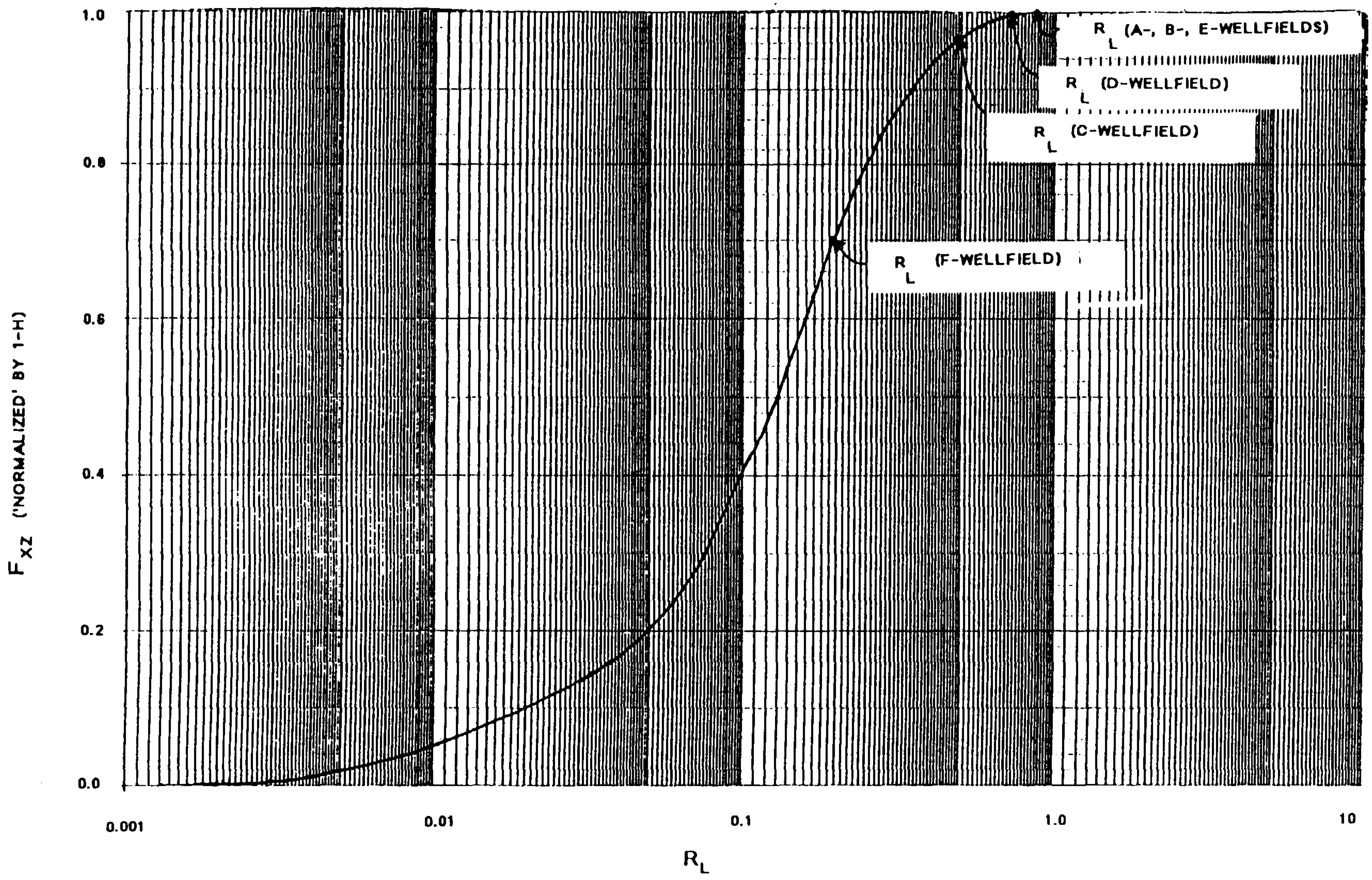
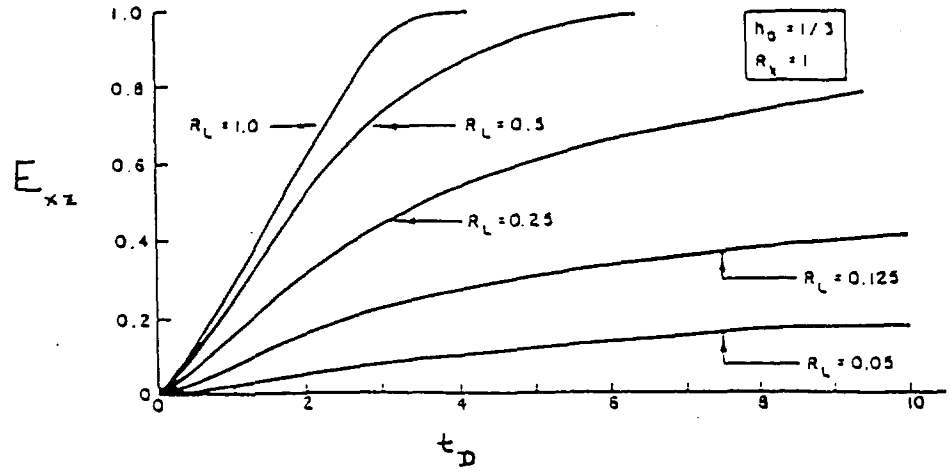


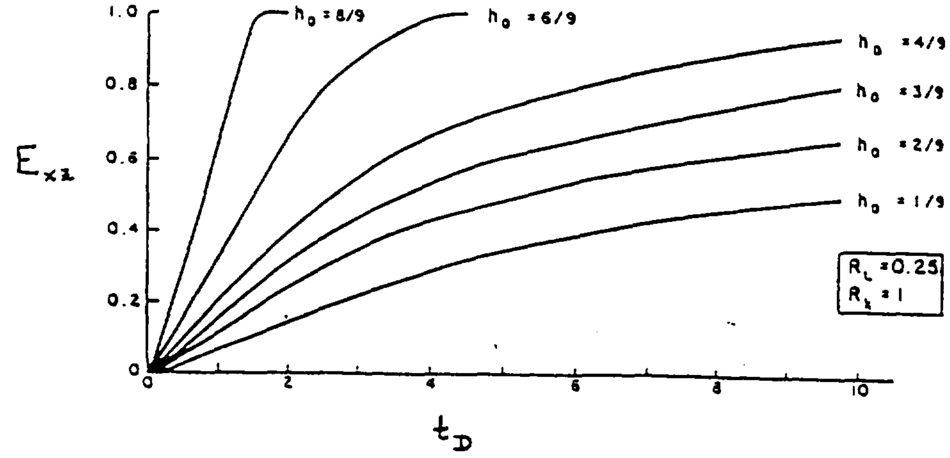
FIGURE 12

PRI HIGHLAND URANIUM PROJECT
PERMIT 603
JUNE 1996
SOURCE: LAKE & ZAPATA, 1987



E_{xz} as a function of t_D and R_L.

FIGURE 13A



E_{xz} as a function of t_D and h_D.

FIGURE 13B

PRI HIGHLAND URANIUM PROJECT
PERMIT 603 JUNE 1986
SOURCE: LAKE & ZAPATA, 1987

HE STATE OF WYOMING

JIM GERINGER
GOVERNOR

Department of Environmental Quality

Herschler Building ● 122 West 25th Street ● Cheyenne, Wyoming 82002

ADMINISTRATION	ABANDONED MINES	AIR QUALITY	INDUSTRIAL SITING	LAND QUALITY	SOLID & HAZARDOUS WASTE	WATER QUALITY
(307) 777-7758	(307) 777-6145	(307) 777-7391	(307) 777-7368	(307) 777-7756	(307) 777-7752	(307) 777-7781
FAX 777-7682	FAX 634-0799	FAX 777-5616	FAX 777-6937	FAX 634-0799	FAX 777-5973	FAX 777-5973

August 13, 1996

Mr. Stephen Morzenti
Vice-President of Operations and Development
Power Resources, Inc.
800 Werner Court, Suite 230
Casper, Wyoming 82601

Subject : Correction to Table IV, Pore Volume Estimate-Power Resources, Inc.
Highland Uranium Project, June 1996

Dear Mr. Morzenti:

In June 1996, the Land Quality Division (LQD) provided Power Resources, Inc. (PRI) a copy of LQD's technical assessment of pore volume at the Highland Uranium Project (Pore Volume Estimate - Power Resources, Inc. Highland Uranium Project). The LQD has recently identified some arithmetic mistakes and some items that need clarification on Table IV of that document. A copy of the corrected Table IV is enclosed. Please replace Table IV in PRI's volume with the corrected table. The LQD hopes that these errors did not cause PRI any inconvenience.

Five values presented in the Barren Zone Thickness Column were incorrect. Correcting these values resulted in three changes to values in the LQD Pore Volume Column. Additionally, in the equation for calculation of the LQD's Pore Volume Estimate, "Barren Zone Volume" was changed to "Barren Zone Thickness."

To clarify, the data, presented in the columns labelled 'Ideal' Pattern Area, Number of Patterns, PRI Flare Factor, Effective Porosity, and PRI Volume, were copied from the PRI 1995-1996 Annual Report. The LQD did not calculate any of these values. The pattern dimensions presented in the 'Ideal' Pattern Dimensions Column are generalized values calculated from the 'Ideal" Pattern Area. The LQD has added notes to Table IV to help clarify these issues.

An extension of the surety estimate submittal date until August 30, 1996 has been approved. It is the understanding of the LQD that this extension, requested by PRI, will provide PRI adequate time to complete the 1996 Surety Estimate including the interim compromise pore volume value. If you have any questions, please contact me.

Sincerely,

Georgia A. Cash
District I Supervisor

enclosure

GAC/al
xc: G. Mooney
M. Moxley
M. Layton, NRC

Table IV
PRI and LQD Pore Volume Estimates - PRI Permit 603
June 1996

Wellfield	'Ideal' Pattern Dimensions, Approximate (feet)(1)	'Ideal' Pattern Area (feet^2)(1)	Number of Patterns(2)	Thickness (feet)		Effective Porosity(2)	PRI Flare Factor(2)	LQD Flare Components		Pore Volume (acre-feet)	
				Ore Zone(2)	Barren Zone			Horizontal Flare Factor	Barren Zone Sweep Efficiency	PRI(2)	LQD(3)
A	70x70	4900	22	15	15	0.27	1.4	3.0	1.0	14.3	40.2
B	70x70	4900	150	15	15	0.27	1.4	3.0	1.0	98.3	273.9
C	80x80	6500	197(4)	15	45	0.27	1.4	3.0	0.5	162.4	536.8
D	80x80	6500	43	15	25	0.27	1.4	3.0	1.0	36.4	121.5
E	80x80	6500	157	15	20	0.27	1.4	3.0	1.0	132.8	411.9
F	80x80	6500	250	15	135	0.27	1.4	3.0	0.2	140.4	726.6

(1) These dimensions are provided to help visualize the sizes of the various wellfield patterns and should not be used to calculate the 'ideal' pattern areas. The 'ideal' pattern areas were obtained from PRI's 1995-96 Annual Report.

(2) Values in these columns were obtained from PRI's 1995-96 Annual Report. The equation used by PRI to estimate the impacted ground water pore volume was also obtained from the 1995-96 Annual Report. LQD did not 'check' the reported numbers using the equation in the Annual Report.

PRI's Pore Volume Estimate =
(Pattern Area)(# of Patterns)(Ore Zone Thickness)(Effective Porosity)(Flare Factor)

(3) LQD's Pore Volume Estimate =
(Pattern Area)(# of Patterns)(Ore Zone Thickness)(Effective Porosity)(Horizontal Flare Factor)+
(Pattern Area)(# of Patterns)(Barren Zone Thickness)(Effective Porosity)(Barren Zone Sweep Efficiency)
1 cubic foot = 2.3 x 10^{-5} acre-feet

(4) The number of patterns includes those in the C-Wellfield and the C-19N pattern area associated with the underground workings.

Table 1 – Churchrock Section 8 Pore Volume Calculation

ZONE	Area (ft2)	Tk (ft)	Vol (ft3)	Por	gal/ft3	PV (gal)	H-PIF	V-PIF	CPV (gal)	9 X CPV
UA	318,700	8.6	2,740,820	0.25	7.48	5,125,333	1.5	1.3	9,994,400	89,949,601
LA	404,500	12.2	4,934,900	0.25	7.48	9,228,263	1.5	1.3	17,995,113	161,956,016
UB	329,500	10.5	3,459,750	0.25	7.48	6,469,733	1.5	1.3	12,615,978	113,543,805
LB	555,300	11.6	6,441,480	0.25	7.48	12,045,568	1.5	1.3	23,488,857	211,399,711
UC	658,700	14.9	9,814,630	0.25	7.48	18,353,358	1.5	1.3	35,789,048	322,101,435
ULC	378,200	10.5	3,971,100	0.25	7.48	7,425,957	1.5	1.3	14,480,616	130,325,545
LLC	321,900	12.3	3,959,370	0.25	7.48	7,404,022	1.5	1.3	14,437,843	129,940,584
UD	124,600	10.4	1,295,840	0.25	7.48	2,423,221	1.5	1.3	4,725,281	42,527,525
MD+LD	326,500	12	3,918,000	0.25	7.48	7,326,660	1.5	1.3	14,286,987	128,582,883
TOTALS	3,417,900		40,535,890			75,802,114			147,814,123	1,330,327,106

Table IV
PRI and LQD Pore Volume Estimates - PRI Permit 603
June 1996

Wellfield	'Ideal' Pattern Dimensions, Approximate (feet)(1)	'Ideal' Pattern Area (feet²)(1)	Number of Patterns(2)	Thickness (feet)		Effective Porosity(2)	PRI Flare Factor(2)	LQD Flare Components		Pore Volume (acre-feet)	
				Ore Zone(2)	Barren Zone			Horizontal Flare Factor	Barren Zone Sweep Efficiency	PRI(2)	LQD(3)
A	70x70	4900	22	15	15	0.27	1.4	3.0	1.0	14.3	40.2
B	70x70	4900	150	15	15	0.27	1.4	3.0	1.0	98.3	273.9
C	80x80	6500	197(4)	15	45	0.27	1.4	3.0	0.5	162.4	536.8
D	80x80	6500	43	15	25	0.27	1.4	3.0	1.0	36.4	121.5
E	80x80	6500	157	15	20	0.27	1.4	3.0	1.0	132.8	411.9
F	80x80	6500	250	15	135	0.27	1.4	3.0	0.2	140.4	726.6

(1) These dimensions are provided to help visualize the sizes of the various wellfield patterns and should not be used to calculate the 'ideal' pattern areas. The 'ideal' pattern areas were obtained from PRI's 1995-96 Annual Report.

(2) Values in these columns were obtained from PRI's 1995-96 Annual Report. The equation used by PRI to estimate the impacted ground water pore volume was also obtained from the 1995-96 Annual Report. LQD did not 'check' the reported numbers using the equation in the Annual Report.
PRI's Pore Volume Estimate =
(Pattern Area)(# of Patterns)(Ore Zone Thickness)(Effective Porosity)(Flare Factor)

(3) LQD's Pore Volume Estimate =
(Pattern Area)(# of Patterns)(Ore Zone Thickness)(Effective Porosity)(Horizontal Flare Factor)+
(Pattern Area)(# of Patterns)(Barren Zone Thickness)(Effective Porosity)(Barren Zone Sweep Efficiency)
1 cubic foot = 2.3×10^{-5} acre-feet

(4) The number of patterns includes those in the C-Wellfield and the C-19N pattern area associated with the underground workings.

Ingle Attachment D

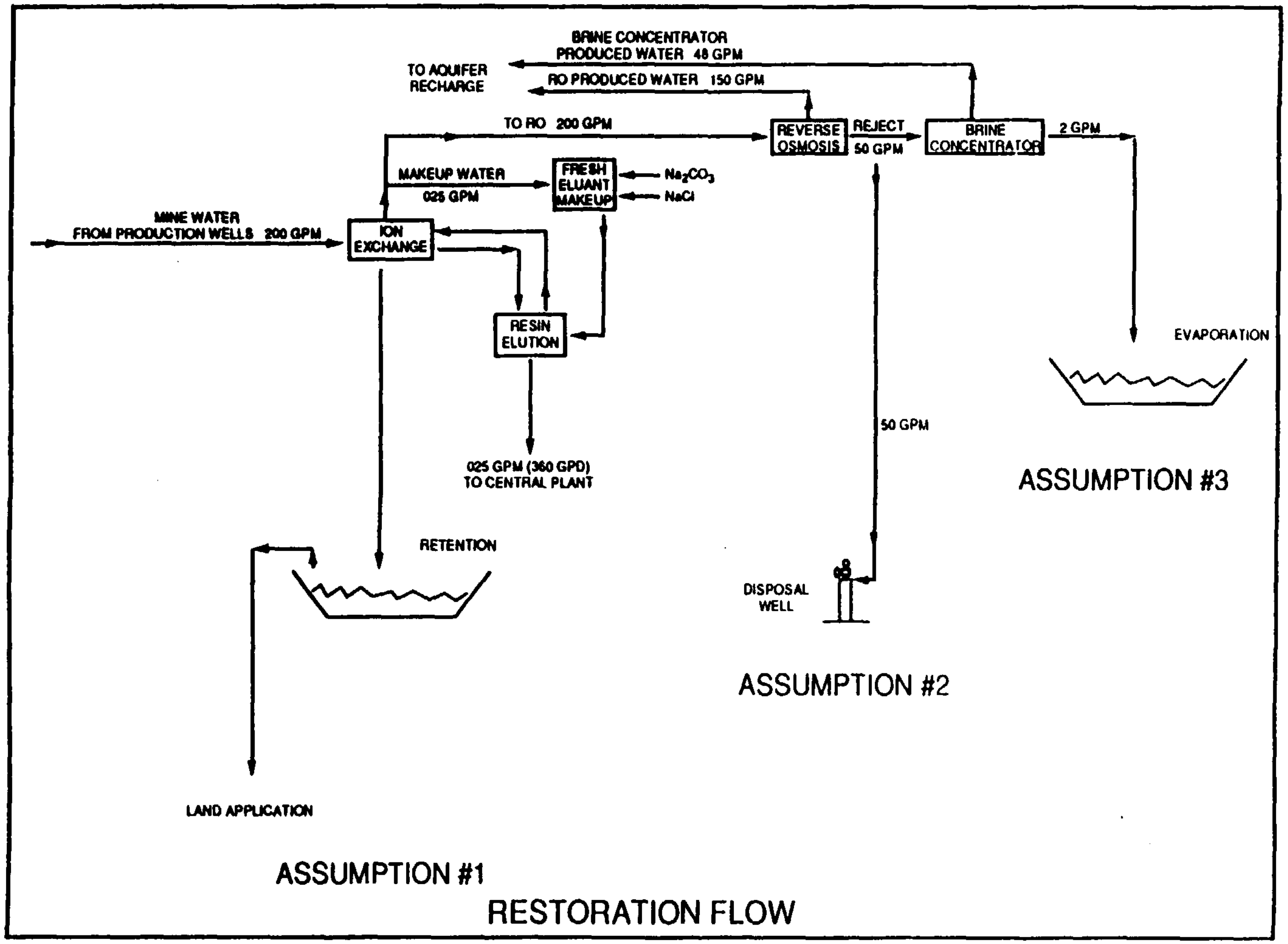
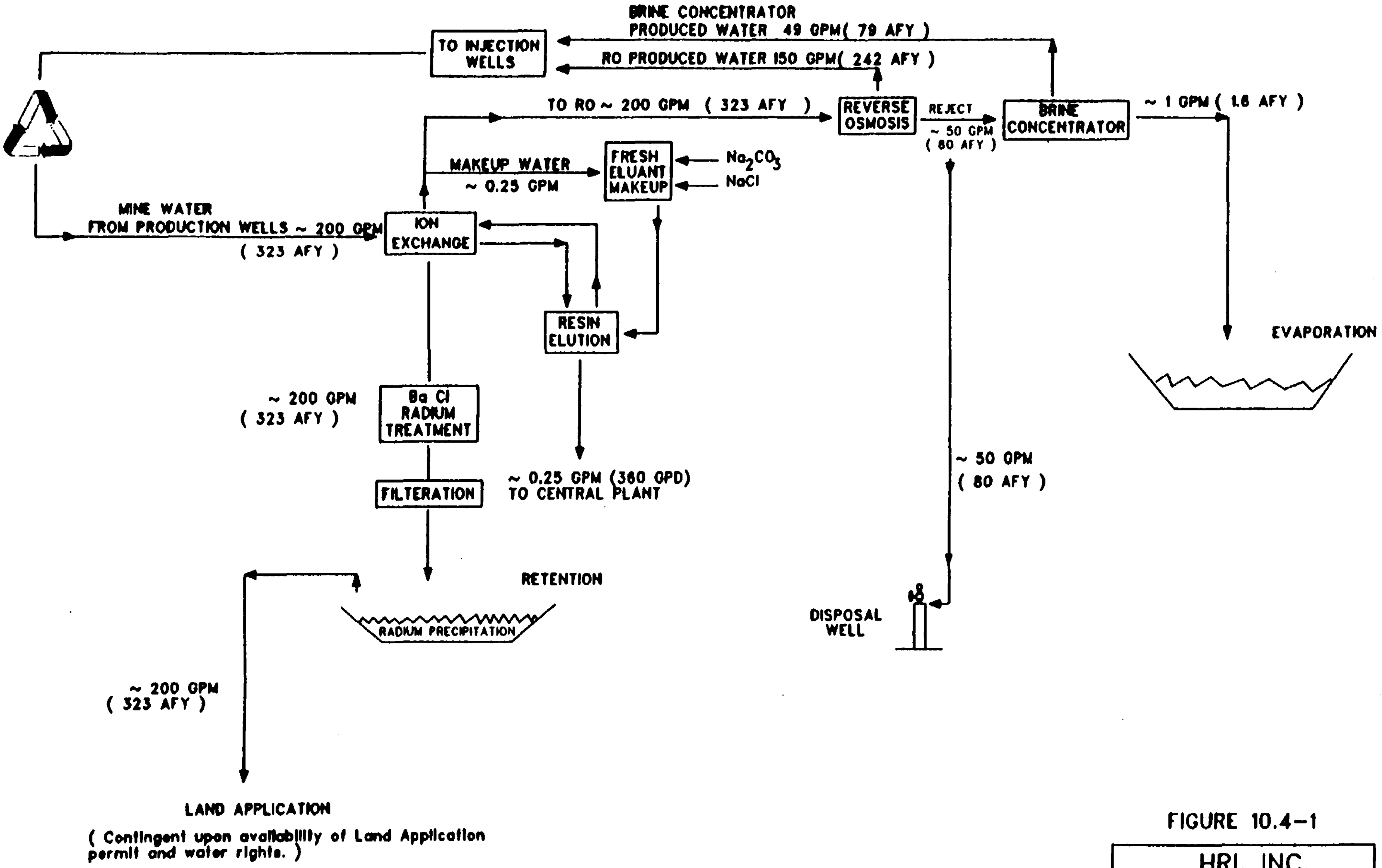


Figure 2.7. Schematic flow diagram and approximate flow rates of restoration wastewater treatment systems.

U.S. NRC, FEIS for Crownpoint Uranium Project (February 1997), p. 2-22.



AFY = Acre-Feet/Year

REVISED AUG. 29, 1996
REVISED MAY 8, 1997

FIGURE 10.4-1

HRI, INC.

CHURCHROCK PROJECT
RESTORATION FLOW SHEET

RESTOR3

HRI, Consolidated Operations Plan (August 1997), p. COP-162.

These materials are stored in labeled, readily identifiable and covered commercial waste dumpsters.

Under agreements with the NRC and American Nuclear Corporation (ANC) these wastes are periodically transported to the American Nuclear Corporation (ANC) tailings facility located in the Gas Hills of Wyoming, for disposal.

4.4.2 Wellfield Purge

The wellfield purge assists in providing a cone of depression around the operating wellfield, thereby preventing excursions. The purge is removed from the process stream after passing through the ion exchange system. Fluids pumped during well workovers (modifications) are also contributed to the purge via the wellfield cleanout pipeline which carries these fluids to the Satellite facility. The purge is treated with barium chloride to remove radium-226 to less than 30 pCi/l. Details of the radium treatment system are included in the WDEQ-WQD Permit No. 87-042RR. The treated purge is stored in the purge storage reservoir where it is periodically used to irrigate native grasslands. The treated purge typically consists of the following:

Sulfate	100-400 mg/l
Sodium	100-400 mg/l
Chloride	10-600 mg/l
Uranium	0.1-3.0 mg/l
Ra-226	5-30 pCi/l
Selenium	0.002-1 mg/l

4.4.3 Salt Water Waste Stream

The salt water waste stream is produced at the CPF and results from laboratory liquid wastes, elution agents decanted from the precipitation circuit, yellowcake wash water, reject make-up solutions, and CPF washdown water. Because of their high TDS, these wastes are considered non-treatable and are disposed of by deep well injection, via an abandoned and modified oil well, into a formation which does not contain fresh water. The waste disposal well is located approximately one mile north of the CPF/office area and is shown on Plate 1. The waste disposal well is permitted by the WDEQ-WQD through the UIC (Underground Injection Control) program - Permit No. UIC89-030.

This waste stream is accumulated at the CPF in two 20,000 gallon fiberglass tanks and periodically pumped to the waste disposal well for injection. The waste disposal well is permitted for, and has the capability of injecting 185 gpm, although currently the average injection rate is 47 gpm. To date (January 1991), approximately 800,000 gallons per month are disposed of in the waste disposal well. The salt water waste stream varies in composition, but typically contains the following concentrations.

HCO_3 - 150-500 mg/l
NH_4 (as N) - 1000-1700 mg/l
TDS - 40,000 - 60,000 mg/l
pH - 7-8
Uranium (as U_3O_8) - 10-30 mg/l
Radium-226 - 50-100 pCi/l

5. DELINEATION AND ASSESSMENT DRILLING

5.1 General

Drilling, in combination with geophysical logging, is necessary to delineate uranium ore bodies in adequate detail to allow mine planning and wellfield development. Delineation drilling occurs periodically throughout the year, depending on production and development needs. Typically, 200 to 500 delineation drillholes are drilled each year.

Assessment drilling is also periodically done for lease holding purposes on unpatented mining claims. Approximately 40 to 50 drillholes are drilled each year for assessment purposes.

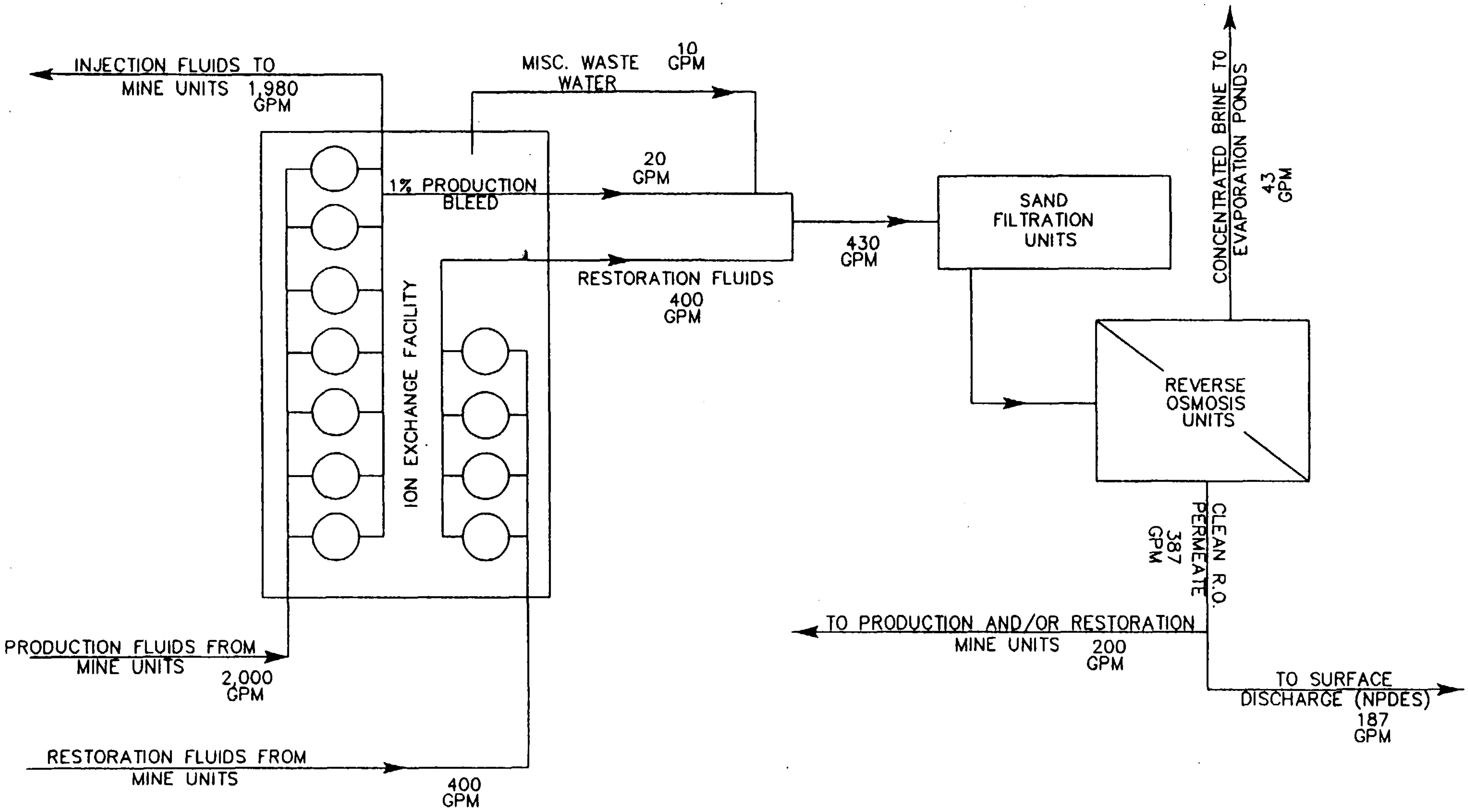
5.2 Drillhole Abandonment Procedures

All drillholes and wells are abandoned in accordance with WS-35-11-404 and Chapter XV of the WDEQ-LQD Rules and Regulations to prevent adverse impacts to ground water quality or quantity.

6. WELL INSTALLATION AND COMPLETION

6.1 General

Several types of wells are installed at the project site to facilitate the in situ mining process. Injection wells are installed to allow the injection of the lixiviant. Production wells are installed to allow the recovery (pumping) of the pregnant lixiviant (production fluid). Monitor wells are installed within the production zone to determine baseline water quality conditions, as well as around the outside of the production zone (monitor well ring), to document the



LQD RECD
SEP 5 2000
TFN 3 5/93
PERMIT

*NOTE: FLOWRATES ARE FOR EXAMPLE ONLY

REVISION DATE: 8/00
LAST PLOT DATE: 8/00
CAD FILENAME: F00P315

POWER RESOURCES, INC.

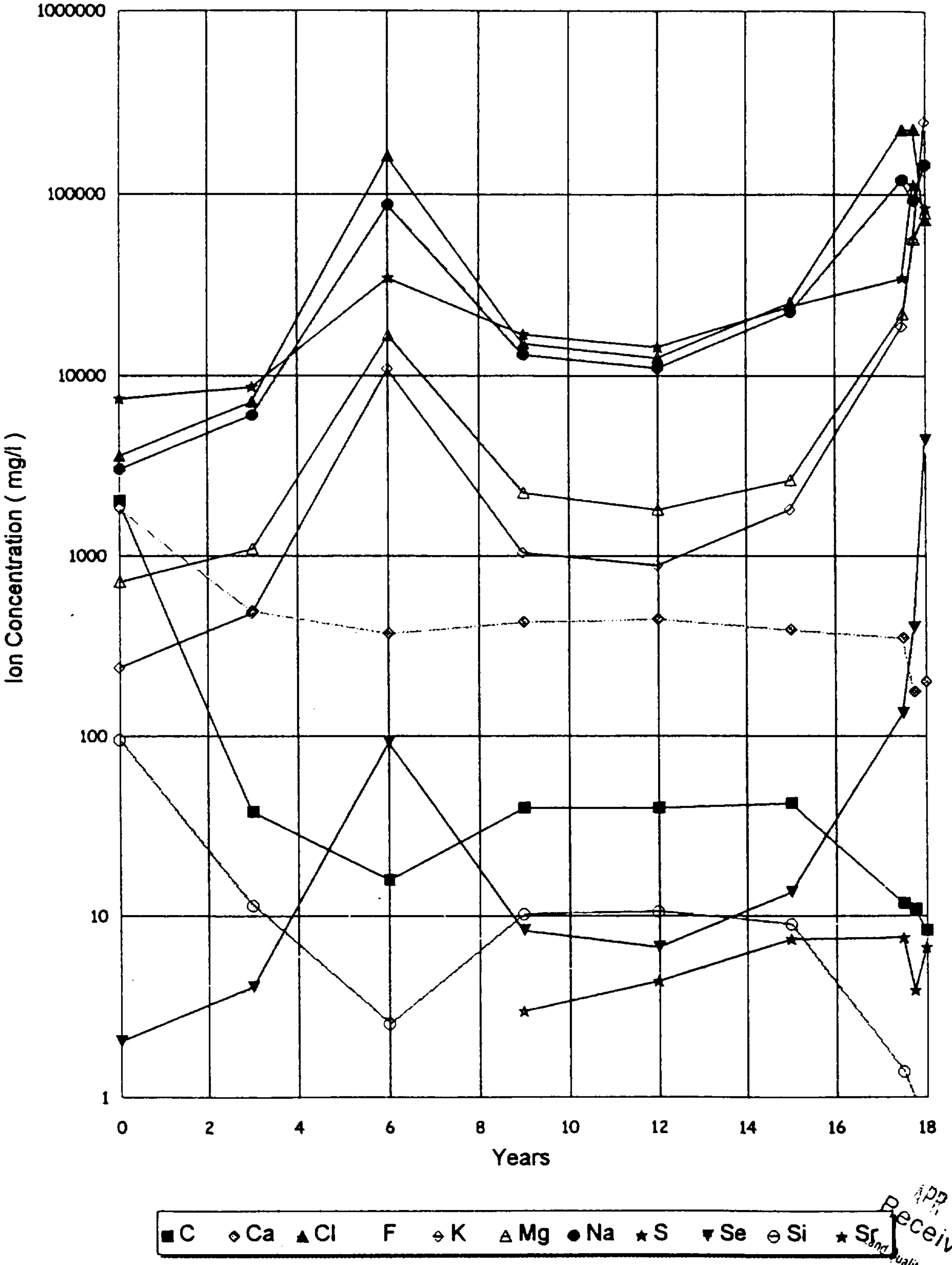
FIG. OP3-15

GAS HILLS PROJECT
WASTE WATER TREATMENT SCHEMATIC
FREMONT & NATRONA COUNTIES, WY

FIGURE OP 3-17

Evaporation Pond Aqueous Concentrations

(Solutions)



A

WDEQ ANNUAL REPORT

FOR

PERMIT 603

HIGHLAND URANIUM PROJECT

JULY 2000

Ingle Attachment G

On March 31, 2000, PRI submitted to the LQD the A-Wellfield Ground Water Quality Stabilization Report. This report included ground water data obtained during the stability period as well as water level data from the production, the overlying and the underlying zones. Also, attached to the report were the responses to Ms. Cutillo's memorandum. The LQD responded to this report in a letter dated June 12, 2000. Attached to this letter was another memorandum from Ms. Cutillo with additional comments. PRI's response is forthcoming. Currently, the A-Wellfield is inactive and continues to be monitored on a bi-monthly basis.

Since the details of the A-Wellfield stability period were presented in the A-Wellfield Ground Water Quality Stabilization Report, this information will not be re-submitted in this report. However, the bi-monthly water quality data collected during this reporting period from the A-Wellfield MP-Wells is presented in Appendix 2A. The water samples for the annual Guideline-8 analyses of the MP-Wells were collected on April 26, 2000, and the results are included with this report as Appendix 2B. Table 3-1 summarizes the mean water quality characteristics for selected Guideline-8 parameters from the A-Wellfield MP-Wells for data collected annually from 1991 to 2000. Baseline and "Class of Use" concentrations for each of these parameters are also shown in the table. The data shows the ground water quality of the A-Wellfield remains stable.

3.1.2 Ground Water Restoration Plans for 2000-2001

Following a successful resolution of the concerns outlined in Ms. Cutillo's most recent memorandum, and with concurrence from the WDEQ that the A-Wellfield is restored, PRI plans on beginning the decommissioning process.

3.2 B-Wellfield Restoration Activities

<u>Ground Water Sweep</u>

Ground water restoration activities commenced in the B-Wellfield on July 16, 1991 when injection of lixiviant was discontinued and ground water sweep pumping was started in several selected groups of mining patterns, in accordance with Section RP 4.3.2 of the approved permit application. Ground water has been pumped continuously from the B-Wellfield since that time. Additional ground water was withdrawn via the bleed stream from both of the RO Units. The combined ground water sweep fluids from the B-Wellfield flow through Satellite No. 1 to remove dissolved residual uranium and radium. The treated water is pumped through the radium settling basin to the Satellite No. 1 Purge Storage Reservoir where it is stored for periodic disposal at the Satellite No.1 Wastewater Land Application Area (Irrigator No. 1).

During this reporting period, the A-Wellfield was inactive. Therefore, the cumulative total of fluid withdrawn came exclusively from the B-Wellfield. During this reporting period, a volume of approximately 90 AF of ground water sweep fluid was pumped from the B-Wellfield, bringing the cumulative total through May 31, 2000 to 604 AF. This is equivalent to 6.1 PV displacements using the revised B-Wellfield pore volume estimate of 98.3 AF. The greater proportion of the fluids removed from the B-Wellfield during this reporting period was pumped from the B1, B6, B9, B10 and B11 pattern groups.

Reverse Osmosis

During the current reporting period, RO Unit #1, which is located inside Satellite 1, was used to supply permeate for injection in the B1, B2, B4, B17, and B18 pattern groups. RO Unit #2, which is mounted in trailers, supplied permeate for injection in the B6, B10, and B11 pattern groups. The progressive improvement in water quality by RO treatment is monitored by routine sampling of the pumping wells that feed the RO Units, and by occasional sampling of other wells. The rate of improvement in water quality at the pumping wells varies, depending upon the flow lengths and the number of adjacent injection wells. Thus, the relocation of the injection and pumping capacity, as wells respond to treatment, is a continuous activity conducted on a pattern by pattern basis. The results of RO treatment in the B-Wellfield are best described with the aid of isoconcentration maps, which are discussed below in the section on well sampling.

Addition of Chemical Reductant

During the early months of 1999, a mixing and storage station for sodium sulfide was designed and constructed in Satellite No.1 to supply an alternative chemical reductant for use in the B-Wellfield. This reagent has a similar effect to H_2S gas, is consistent with permit requirements and is safer to use. The system was designed to supply sodium sulfide solution to the permeate streams of both RO units and also to a closed-loop recirculation circuit which has been installed in the B13-B14 pattern group. Experimental addition of this reagent to permeate from RO Unit #1 began on June 8, 1999. The addition of sodium sulfide was halted shortly thereafter due to plugging problems caused by the formation of an iron precipitate. By late August 1999, filtration was in place in the appropriate header houses and the addition of sodium sulfide was restarted. The plugging problems persisted, however, so by the middle of September 1999, the use of sodium sulfide was again halted. The formation of the iron precipitate appears to be related to the CO_2 gas that remains in the ground water after mining and the increase in pH that results from the addition of sodium sulfide. A solution to this problem is to degas the RO permeate prior to sodium sulfide addition. With such a short operating history for this reagent in the B-Wellfield permeate injection areas there are no results to include with this Annual Report.

POWER RESOURCES INC HIGHLAND URANIUM PROJECT
2000-2001 SURETY ESTIMATE REVISION
(REVISED JUNE 2000)

	Ground Water Restoration	A-Wellfield	B-Wellfield	C-Wellfield	C-19N Pattern	C-Haul. Drifts	D-Wellfield	E-Wellfield	F-Wellfield	H-Wellfield	D-EXT-WF	I-Wellfield
	Ground Water Sweep Unit Cost ($/Kgal)	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	$0.77	
	Subtotal Ground Water Sweep Costs per Wellfield	$10,358	$47,114	$86,877	$2,216	$7,789	$19,060	$67,817	$228,387	$78,557	$15,711	
	Total Ground Water Sweep Costs	$563,886										
III.	Reverse Osmosis Costs											
	PV's Required	5	5	5	5	5	5	5	5	5	5	
	Total Kgals for Treatment	67644	307673	567340	14473	50864	124467	442873	1490937	513011	102602	
	Reverse Osmosis Unit Cost ($/Kgal)	$1.33	$1.33	$1.33	$1.33	$1.33	$1.33	$1.33	$1.33	$1.33	$1.33	
	Subtotal Reverse Osmosis Costs per Wellfield	$89,669	$407,851	$752,066	$19,185	$67,425	$164,994	$587,072	$1,976,387	$680,047	$136,009	
	Total Reverse Osmosis Costs	$4,880,706										
IV.	Chemical Reductant Costs											
	Number of Patterns	31	141	196	5		43	153	465	160	32	
	Chemical Reductant Unit Cost ($/pattern)	$245	$245	$245	$245		$245	$245	$245	$245	$245	
	Subtotal Chemical Reductant Costs per Wellfield	$7,595	$34,545	$48,020	$1,225	$0	$10,535	$37,485	$113,925	$39,200	$7,840	
	Total Chemical Reductant Costs	$300,370										
IV.	Elution Costs											
	A. Elution Processing Costs											
	Kgals/Elution Required	35000	35000	35000	35000	35000	35000	35000	35000	35000	35000	
	Number of Elutions	2	11	19	1	2	4	15	51	18	4	
	Processing Unit Cost ($/Elution)	$525	$525	$525	$525	$525	$525	$525	$525	$525	$525	
	Subtotal Processing Costs	$1,050	$5,775	$9,975	$525	$1,050	$2,100	$7,875	$26,775	$9,450	$2,100	
	B. Deep Well Injection Costs											
	Deep Well Injection Volume (Kgals/Elution)	12	12	12	12	12	12	12	12	12	12	
	Total Kgals for Injection	24	132	228	12	24	48	180	612	216	48	
	Deep Well Injection Unit Cost ($/Kgals)	$4.60	$4.60	$4.60	$4.60	$4.60	$4.60	$4.60	$4.60	$4.60	$4.60	
	Subtotal Deep Well Injection Costs	$110	$607	$1,049	$55	$110	$221	$828	$2,816	$994	$221	
	Subtotal Elution Costs per Wellfield	$1,160	$6,382	$11,024	$580	$1,160	$2,321	$8,703	$29,591	$10,444	$2,321	
	Total Elution Costs	$73,686										
V.	Monitoring and Sampling Costs											
	A. Restoration Well Sampling											
	Estimated Restoration Period (Years)	5	5	5	5	2	5	5	5	5	5	
	1. Well Sampling prior to restoration start											
	# of Wells	5	20	31	5	7	9	31	21	12	4	
	$/sample	$150	$150	$150	$150	$150	$150	$150	$150	$150	$150	
	2. Restoration Program Sampling											
	# of Wells	5	20	31	5	7	9	31	21	12	4	
	$/sample	$150	$150	$150	$150	$150	$150	$150	$150	$150	$150	
	Samples/Year	1	1	1	1	1	1	1	1	1	1	
	# of Wells	5	20	31	5	7	9	31	21	12	4	
	$/sample	$34	$34	$34	$34	$34	$34	$34	$34	$34	$34	
	Samples/Year	6	6	6	6	6	6	6	6	6	6	
	3. UCL Sampling											
	# of Wells	18	70	78	5	20	29	55	89	69	16	

December 19, 2000

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION
ATOMIC SAFETY AND LICENSING BOARD PANEL

Before Administrative Judge Thomas S. Moore

In the Matter of)
)
HYDRO RESOURCES, INC.) Docket No. 40-8968-ML
P.O Box 15910)
Rio Rancho, NM 87174) ASLBP No. 95-706-01-ML
)

WRITTEN TESTIMONY OF DR. RICHARD J. ABITZ IN SUPPORT OF INTERVENORS' RESPONSE TO HYDRO RESOURCES INC.'S COST ESTIMATES AND RESTORATION ACTION PLAN OF NOVEMBER 21, 2000

On behalf of Eastern Navajo Diné Against Uranium Mining ("ENDAUM") and Southwest Research and Information Center ("SRIC"), Dr. Richard J. Abitz submits the following testimony regarding Hydro Resources Inc.'s ("HRI's") Cost Estimates and Restoration Action Plan for a source and byproduct materials license.

1. I am competent to give this testimony, and the factual statements herein are true and correct to the best of my knowledge, information and belief. The opinions expressed herein are based on my best professional judgment and extensive expertise and experience in groundwater treatment and restoration, with particular emphasis on the treatment of groundwater contaminated with uranium and other heavy metals.

2. I am giving this testimony on behalf of ENDAUM and SRIC to respond to HRI's decontamination, decommissioning and reclamation plan for the Church Rock Section 8 site of the proposed Crownpoint Uranium Project (CUP).

EXHIBIT
2

3. My qualifications to give this testimony are contained in my resume, which is appended hereto as **Attachment A.**[1] I previously submitted testimony in this proceeding with respect to groundwater protection issues.[2] My relevant education, training and experience are summarized on pages 1-3 of my January 1999 Testimony. As stated therein, I have a Ph.D. in geology and extensive professional experience in the remediation of soil and groundwater contaminated by uranium and hazardous metals (e.g., arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver). Currently, I am the senior geochemist overseeing restoration of uranium contaminated groundwater at the U.S. Department of Energy ("DOE") Fernald, Ohio, uranium plant, where approximately 100 million gallons of groundwater are extracted and treated each month. I have also reviewed and evaluated clean-up plans for groundwater contamination at the United Nuclear Corporation uranium mill tailings site located 2.5 miles from the proposed HRI Section 8 in situ mining operation.

4. In preparing this testimony, I reviewed the following documents: (1) HRI's "Church Rock Section 8/Crownpoint Process Plant Restoration Action Plan" ("RAP"), dated November 17, 2000, and submitted to the NRC on November 21, 2000; (2) briefs and attachments with respect to financial assurance for decommissioning;[3] (3) orders of either the Presiding Officer or

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[1] Attachments to the testimony will hereinafter be designated as ("Att. __").

[2] See Exhibit 1 of Intervenors' Brief With Respect to Groundwater Protection, Written Testimony Dr. Richard J. Abitz (January 11, 1999) ("Abitz January 1999 Testimony"); Affidavit of Dr. Richard J. Abitz, In Response to the Presiding Officer's Questions In the Memorandum and Order of April 21, 1999 (May 21, 1999) ("Abitz May 1999 Affidavit").

[3] Including: ENDAUM's and SRIC's Written Presentation, January 11, 1999, with Exhibit 1, Written Testimony of Dr. Michael Sheehan; NRC Staff's Response, February 18, 1999; HRI's Response, February 23, 1999; ENDAUM's and SRIC's on Partial Initial Decision LBP-99-13,

the Commission (Presiding Officer, March 9, 1999), (Commission, July 23, 1999), (Commission, May 25, 2000); (4) the NRC's Final Environmental Impact Statement (NUREG-1508) (February 1997) for the Crownpoint Uranium Solution Mining Project, HRI's Consolidated Operations Plan, Revision 2.0 ("COP") (August 15, 1997), the NRC's Safety Evaluation Report for the CUP (December 5, 1997); (5) the January 9, 1999, written testimony of Dr. William P. Staub ("Staub Testimony"), given on behalf of ENDAUM and SRIC, which summarizes the failure of mining companies to restore groundwater quality at Wyoming in situ leach ("ISL") uranium mines; and (6) the December 19, 2000, written testimony of Mr. Steven Ingle ("Ingle Testimony"), given on behalf of ENDAUM and SRIC in response to HRI's RAP.[4]

5. In the paragraphs that follow, I address HRI's cost estimates and certain elements of its restoration plan, as presented in the RAP, in the following areas: (1) HRI's significant underestimation of restoration costs when compared with the reality of costs of groundwater restoration at the Fernald site in Ohio; (2) the omission of discussion and costs associated with adding a reducing agent to the reinjected Reverse Osmosis ("RO") water; (3) the unattainable schedule and underestimated labor force presented in Attachment E-2-1 of the RAP; and (4) the

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August 13, 1999; HRI's Response, September 3, 1999; NRC Staff's Response, September 3, 1999; ENDAUM and SRIC, Motion for Partial Reconsideration, June 5, 2000.

[4] In preparing this testimony, I also re-reviewed relevant portions of several other documents that I had previously reviewed and used to preparate my January 1999 testimony, including (1) Crownpoint Uranium Project Consolidated Operations Plan, Revision 0.0, Hydro Resources, Inc., Albuquerque, New Mexico, September 1996, Hearing Record ACN 9701160106; (2) Draft Standard Review Plan for In Situ Leach Uranium Extraction License Applications, NUREG-1569, Division of Waste Mangement, Office of Nuclear Material Safety and Safeguards, U.S. Nuclear Regulatory Commission, Washington, D.C., October 1997; and (3) HRI's Source Materials License SUA-1508, January 5, 1998, Hearing Record ACN 980116066.

improper procedure HRI proposes to use to plug and abandon wells.

A. Experience Demonstrates That HRI Cannot Possibly Clean the Contaminated Groundwater at Section 8 in the Time It Has Allotted for Restoration.

6. For purposes of assessing HRI's restoration action plan, the Fernald groundwater restoration project that I oversee provides a useful basis of comparison. In this paragraph, I describe the Fernald restoration effort. Groundwater contamination at the Fernald site involves one, and *only* one, contaminant — uranium. Otherwise, the quality of the Great Miami Aquifer ("GMA") that underlies the Fernald site is very good, having a total dissolved solids ("TDS") concentration of less than 400 milligrams per liter ("mg/L"); indeed, if not for the uranium levels in the GMA, the aquifer would still be a source of drinking water in the Cincinnati area. Groundwater restoration at Fernald began in 1993 and is expected to continue through 2008, a period of 15 years. Restoration of the groundwater uses the conventional "pump and treat" technology in which contaminated groundwater is pumped from the aquifer, treated and then reinjected to reduce contaminant levels. The sole *treatment* technique for uranium removal is anion exchange by barium-chloride resin beads, which is commonly referred to as ion exchange ("IX") — the same basic technology that HRI would use to extract uranium from groundwater at the Church Rock site. Dozens of extraction wells on average pump about 100 million gallons of groundwater from the GMA each month. About a quarter of this volume, or 25 million gallons, that meets the uranium restoration standard of 0.02 mg/L is reinjected each month. The excess water is discharged to surface water pursuant to a federal Clean Water Act permit. In seven years, the maximum initial uranium concentration of 1.0 mg/L in the aquifer has been reduced to the current concentration of less than 0.2 mg/L. At the current rate, another eight years of

pumping and treating the groundwater will be needed to achieve the restoration goal of 0.02 mg/L,.[5] which, when adopted by DOE in 1993 was based on EPA's 1991 proposed drinking water standard for uranium.[6]

7. From a water quality and geochemical perspective, the Church Rock site and the Fernald site are very similar, and therefore directly comparable. The groundwater in the two aquifers (GMA at Fernald and the Westwater Canyon Aquifer at Church Rock) has similar characteristics with respect to water quality and uranium mobility. Both aquifers provide very high quality drinking water (i.e., total dissolved solids are less than 400 mg/L, pH is neutral to slightly alkaline, and uranium is less than 0.005 mg/L in uncontaminated areas of the aquifers), and bicarbonate is the dominant anion in the groundwater.[7] The bicarbonate ions are particularly important because they complex and transport the uranyl ion, which increases the mobility of uranium in an oxidized aquifer. Moreover, the lixiviant proposed to be injected into the ore body at Section 8 is fortified with a strong oxidizer (dissolved oxygen) and additional bicarbonate ions (in the form of sodium bicarbonate) to maximize the mobility of uranium in the aquifer. If mining occurs at the CUP, the aqueous form of the uranium contamination in the Westwater

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[5] On December 7, 2000, EPA promulgated a final national primary drinking water standard for uranium of 0.03 mg/L. <u>See</u> 65 Fed. Reg. 76708.

[6] National Primary Drinking Water Regulations; Radionuclides; Proposed Rule. 56 Fed. Reg. 33050-33127, July 18, 1991.

[7] The sediments of the Westwater aquifer differ slightly from those at the Fernald site. The Westwater sediments are composed primarily of feldspar and quartz sand grains, whereas the sedimentation at Fernald consists primarily of carbonate gravel and sand. These differences do not, however, detract from the validity of this comparison because bicarbonate is the dominant anion in both groundwater systems.

Canyon Aquifer will be identical to that in the aquifer below the Fernald site (i.e., $UO_2(CO_3)_2^{-2}$ and $UO_2(CO_3)_3^{-4}$).

8. While the water quality and geochemisty of the two sites are similar, groundwater contamination at the Fernald site is of a much smaller magnitude than that expected by HRI at Section 8 after solution mining begins. As a result, the scope and techniques of restoration being used at Fernald are far less complex and technically challenging than the scope and techniques proposed by HRI at Section 8. Because of these key differences in scope and magnitude, the restoration schedule and costs at Fernald provide a useful "reality check" against which to evaluate HRI's restoration plan and cost estimates. As I will show in the paragraphs that follow, our experience at Fernald demonstrates quite clearly that HRI's projected duration and costs of restoration are wildly unrealistic and will almost certainly be substantially greater than represented in the RAP.

9. As I discussed in Paragraph 6 above, groundwater that had an initial, maximum uranium contamination of 1.0 mg/L is being restored at Fernald to the proposed EPA uranium drinking water standard of 0.02 mg/L. Before restoration is completed at the Fernald site, an estimated 20 to 30 pore volumes of groundwater will have been extracted, treated and reinjected to reduce uranium contamination from its current level of about 0.2 mg/L to a level, 0.02 mg/L, that ensures protection of human health. I want to emphasize that restoration at Fernald is still *ongoing*, and that after seven years, we are only about half way toward our cleanup goal.

10. If mining were to occur at Section 8, the uranium contamination in the groundwater below Section 8 would reach levels of 50 mg/L to 250 mg/L (COP, Table 3.2-1; FEIS, Table 2.1), which are up to nearly <u>five</u> orders of magnitude above the final EPA drinking water

standard for uranium (0.03 mg/L) and two to three orders of magnitude above NRC's uranium groundwater restoration standard for the CUP of 0.44 mg/L. HRI License Condition 10.21(A). Additionally, other toxic and radioactive elements, including arsenic, molybdenum, selenium and radium, will be mobilized in the Section 8 groundwater, making the mix of contaminants far more complex than at Fernald. The overall water quality in the Westwater Canyon Aquifer will deteriorate dramatically: TDS concentrations will increase from about 360 mg/L to between 1,500 to 5,500 mg/L. FEIS, Table 2.1 at 2-6 and Table 4.13 at 4-38. As a consequence of this gross increase in contaminant levels, groundwater in the mine zones will have to undergo different and successive treatments to reduce contaminant levels. HRI plans to use ion exchange, reverse osmosis, and brine concentration to generate "clean" water for rejection. COP Revision 2.0 at 161-163; RAP Section E.2 and Attachment E-2-1. By comparison, Fernald is using only ion exchange. HRI plans to extract, treat, and reinject only 9 pore volumes of groundwater, over the course of only 4.4 years (see RAP, Section E.2.a. and Attachment E-2-1), in order to reduce the groundwater contamination by two to three orders of magnitude to 0.44 mg/L.

11. Maximum treatment capacity (i.e., the amount of water the decontamination system can process) was not achieved at Fernald until in 1998, about five years after restoration began. Approximately 2 pore volumes, or about 1.2 *billion* gallons, have been processed in each year of the last two years, at a cost of about $7.8 million annually.[8] Since the 2-pore volume production

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[8] This amount is the sum of three different restoration components incurred at the Fernald site during the 2000 fiscal year: $6.9 million for uranium removal from water, $709,809 for operation and maintenance costs for the Fernald pumping wells, and $179,619 for maintenance of the reinjection wellfield. These costs are shown in three spreadsheets that are appended to my testimony as **Attachment B**.

level is expected remain constant for the remaining duration of restoration, which is six to eight years, the cost to complete restoration will range somewhere between about $47 million and $62 million. Therefore, Fernald's estimated total cost for reducing the uranium contamination by less than two orders of magnitude over the expected 10- to 15-year restoration period ran is in the range of $78 million to $117 million.

12. HRI's projected restoration costs are displayed in the restoration spreadsheet of Attachment E-2-1 of the RAP. HRI projects that it will process about 25.9 million gallons of restoration water each month, or about 311 million gallons a year. These rates are roughly one-fourth of the volume of restoration water being processed at Fernald (which is about 100 million gallons per month or 1.2 billion gallons per year). Using Fernald's average annual restoration cost of $7.8 million as a guide and assuming that there is a linear correlation between volume of water treated and cost, then HRI's annual restoration cost should be about $1.95 million. HRI projects a total restoration cost of $7.2 million over a period of 4.4 years, or about $1.64 million per year. Accordingly, when HRI's restoration volume and cost estimates are normalized against Fernald's production and costs, HRI's restoration costs are underestimated by about 16%.[9]

13. But what happens to HRI's cost estimates if they are projected out over a longer restoration period of, say, 10 years, which is the minimum length of time projected to achieve the restoration goal at Fernald? If HRI's Fernald-normalized costs of $1.95 million annually are extended out 10 years, then HRI's total restoration cost — not including any other cost category

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[9] I should note here that the assumption of linearity of volume and cost is non-conservative because costs for equipment and labor are accrued regardless of the volume of water treated. Those associated costs might be more or less, but a conservative estimate demands a rigorous accounting of what <u>all</u> the actual costs might be. HRI has failed to provide such an accounting.

such as well plugging and abandonment or NRC-mandated contingency and inflation costs — would approach $20 million. If restoration takes 15 years, then HRI's total restoration costs would approach $30 million.

14. In my professional opinion, normalizing HRI's costs against Fernald's experience is appropriate. In theory, restoration at Fernald should be *technically easier* than restoration at Section 8. At Fernald, uranium contamination is reduced only by less than two orders of magnitude; at Section 8, it is reduced from more than two orders of magnitude to as many as five, and to a restoration standard, 0.44 mg/L, that is nearly 15 times higher than the federal uranium drinking water standard. At Fernald, treatment is accomplished by only one method, ion exchange; at Section 8, three treatments will be used — IX, RO and brine concentration. The larger magnitude of the contamination and the greater complexity of the treatment regime are certain to increase HRI's restoration costs over the amount proposed in the RAP.

15. In summary, I believe that HRI's estimated restoration costs are unrealistically low when compared with actual restoration experience at a technically analogous site, the Fernald facility. The key restoration characteristics of the two sites illustrate my point:

Restoration Characteristics	**Fernald**	**Section 8**
Groundwater contaminant(s) of concern	U	TDS, U, Mo, As, Se, Ra-226
Max. initial uranium concentration in groundwater	1.0 mg/L	250 mg/L
Uranium restoration standard	0.02 mg/L	0.44 mg/L
Restoration treatment process(s)	IX	IX, RO, BC
Pore volumes to complete restoration	20-30	9
Monthly volume of water processed	100 million gals	25 million gals
Expected duration of restoration	10-15 years	4.4 years
Annualized cost of groundwater restoration	$7.8 million	$1.6 million
Total estimated cost of groundwater restoration	$78 million - $117 million	$7.2 million

From this comparison, it is clear that HRI's plan is to restore much more highly contaminated groundwater with far less flushing (i.e., pore volumes) over a period of about one-third to one-half as long as that at the Fernald site. Simply put, HRI's estimates with respect to pore volumes and the time needed to carry out the restoration plan described in the RAP are unrealistic to a serious degree.

16. HRI's restoration cost estimates are even more unrealistic when they are examined against actual restoration experience at operating uranium ISL mines. Restoration has taken much longer than originally projected at commercial ISL mines in Wyoming, and no commercial-scale ISL mine has yet to achieve restoration to premining standards. See Ingle Testimony, ¶ 45; and Staub Testimony at 17-21, attached as Exhibit 2 to ENDAUM's and SRIC's Amended Written Presentation on Groundwater Protection, January 18, 1999. Indeed,

restoration at Power Resources, Inc.'s Highland Project A and B wellfields is now entering its tenth year, and restoration at Cogema's Christensen Ranch and Irigaray mines began in 1996 and 1995, respectively. Staub Testimony at 18. Hence, the projected restoration period contained in HRI's restoration action plan — 4.4 years — is widely optimistic, and in my view totally unrealistic, when compared with actual restoration time at operating ISL mines.

B. HRI Omits Any Discussion of Costs Associated with the Use of a Reducing Agent, a Step Crucial to Any Realistic Plan to Restore the Contaminated Groundwater.

17. The HRI restoration plan does not discuss or present costs to account for the addition of a reducing agent (e.g., hydrogen sulfide) to the RO water injected into the aquifer during restoration. Addition of a reducing agent has been needed at uranium ISL research and development facilities in Wyoming, and is now being used at at least one commercial ISL operation there. See Ingle Testimony, ¶ 36. HRI's RAP fails to provide information or data that demonstrate the reduction potential of the Westwater Canyon Aquifer is capable of immobilizing uranium, arsenic, molybdenum and selenium once those constituents have been oxidized. Specifically, the RAP fails to provide any information on reaction kinetics to back up its assumption that no reducing agent will be needed to immobilize uranium and other trace elements in a timely fashion following cessation of mining. Given the lack of a technical basis for this assumption, and the increasing use of chemical reductants at Wyoming mines, I believe that HRI's plan should include costs associated with buying and adding a reducing agent to the RO water to serve as a catalyst for reduction reactions.

C. HRI Makes Several Unsupportable Operational Assumptions.

18. Operational statistics and costs, as summarized in HRI's Plan in Attachment E-2-1,

assume treatment equipment efficiencies that simply cannot be achieved. These *overstated* efficiencies profoundly *underestimate* the costs associated with proper restoration of contaminated groundwater. A thorough review of HRI's omissions and gross underestimation of costs was undertaken by Mr. Ingle in his testimony (at 13-29), but I am compelled to remark on several items.

19. A review of the math used in the restoration cost spreadsheet (Attachment E-2-1 of the HRI Plan) for the RO and brine concentration ("BC") treatment processes reveals that HRI bases its estimations of what the restoration plan can accomplish on a <u>372</u> day year. HRI's estimate that the RO unit will process nearly 25.9 million gallons per month is derived by multiplying the RO inflow capacity of 580 gallons (RAP Attachment E-2-1, Line 21) per minute by 60 minutes in an hour by 24 hours in a day and by 31 days in a month. As HRI should know, there are, on average, only 30.4 days in a 365-day year, and most professionals assume a 30-day month when making monthly or annualized calculations.

20. HRI assumes in Attachment E-2-1 that its water treatment system will achieve 100 percent efficiency, mean that it will work properly and continuously for the duration of the restoration period. I do not believe that this efficiency is technologically achievable, based on my knowledge of the efficiencies of treatment equipment being used at Fernald. The Advanced Waste Water Treatment facility at the Fernald site has an 80 percent efficiency rate, which is considered excellent by industry standards. Hence, if HRI's reverse osmosis and brine concentrator system work 80 percent of the time instead of 100 percent, the absolute minimum time HRI would have to complete restoration of 1.37 billion gallons (RAP Attachment E-2-1, Line 39, column 5/5) is about 5 years and 4 months, not 4 years and 5 months are now estimated

in the RAP.[10]

21. Mr. Ingle argues convincingly in his testimony (at 8-13) that HRI should have used a higher horizontal flare factor to calculate the total volume of its restoration water. If HRI had used a factor of 2.94, as suggested by Mr. Ingle, its total restoration flow volume, and therefore its restoration cost estimate, would have been substantially higher. By substituting a value of 2.94 in the column head "H-PIF" in Table 1 of Section E.2.a. of the RAP, the total treatment volume would be 2,607,441,120 gallons, or roughly 2.6 billion gallons.[11] Using values of 833,760 gallons/day (i.e., (25,846,560 gallons/month)/(31 days/month)), an 80 percent efficiency factor and 365 days/year, the time required to treat 2.6 billion gallons of groundwater is approximately 11 years. The cost attributable to 6.6 additional years of restoration time would add roughly $10.8 million to the $7.2 million HRI now calculates as its restoration costs.[12]

22. HRI also appears to have underestimated its labor costs against comparable costs incurred at Fernald. HRI's projected costs for salaries and wages total $42,737 per month, or about $513,000 per year. RAP Attachment E-2-1, Lines 47 and 48. This entire amount can be considered the total labor costs for groundwater restoration at Section 8. By comparison, labor costs associated with operational of the groundwater restoration system at Fernald total

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[10] I derived this value from the following calculation: 1.37 billion gallons x (1-0.8) = 274 million gallons + 1.37 billion gallons =1.644 billion gallons/25.9 million gallons/mo = 63.47 mos./12 mos./yr = 5.3 years = 5 years, 4 months.

[11] From Table 1 of RAP Section E.2.a.: 75,802,114 gallons per pore volume x 2.94 H-PIF x 1.3 V-PIF x 9 pore volumes = 2,607,441,120 gallons.

[12] $7.2 million total restoration cost/4.4 years = $1.64 million/yr x 6.6 years = $10.8 million.

approximately $2.96 million.[13] Thus, Fernald's costs for groundwater-restoration personnel that are comparable to the personnel needed by HRI at Section 8 are about 5.8 times greater than those estimated by HRI in the RAP. If the Fernald costs associated with treating 1.2 billion gallons of restoration water per year are scaled to the HRI estimate of 311 million gallons per year, then Fernald's HRI-adjusted groundwater restoration labor costs would be about $767,000 annually.[14] This labor cost, which revolves around Fernald's less complicated water treatment system and technology, is still $254,000 per year *greater* than HRI's estimate of $513,000 per year for the more technically challenging RO/BC operation.

23. A similar case can be made that HRI underestimated its maintenance costs. HRI's estimate for maintenance associated with the treatment plant operations is $63,600 per year, which includes plant piping and valves, brine concentrator instruments, pumps, plant electrical, filters, RO unit, lab supplies, and RO membranes. RAP, Attachment E-2-1, Lines 80-84, 89-91. Comparable maintenance costs at the Fernald site are $334,000 per year, or about 5.3 times the HRI's estimated costs. Att. C, Line 310. Again, by normalizing the Fernald maintenance cost to the volume of groundwater treated, as done in Paragraph 22, HRI's Fernald-adjusted maintenance costs would be about $86,300 per year, or an additional $22,700 per year in maintenance costs over that estimated in the RAP.

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[13] I obtained this amount from a Fernald spreadsheet titled, "12 Month Spread by Object Class with Accruals for Fiscal Year 2000 for Charge Number: 5BWPA - Uranium Removal from Water (LOE)," a copy of which is appended to this testimony as **Attachment C**. I added the total Fiscal Year 2000 costs for the following labor cost categories that appear in Att. C: engineering (002), environmental scientist (003), waste disposition engineering (004), maintenance/operations (013), crafts (020), MEO/HEO (021), and utility workers (022).

[14] Assuming that labor costs are linearly related to gallons processed, then ($2.96 billion)/ ((1,200,000,000 / 311,000,000)) = $767,133.

24. By combining the adjustments developed in Paragraphs 22 and 23, HRI appears to have underestimated its labor and maintenance costs by approximately $276,700 per year, or an additional $1.22 million over the RAP's unrealistic restoration schedule of 4.4 years, or an additional $2.76 million to $4.15 million over a more reasonable restoration period of 10 to 15 years.

D. HRI's Plan Fails to Provide a Method for Abandoning Production Wells That Protects the Aquifer from Future Contamination.

25. The plugging and abandonment of production wells, as proposed by HRI in Attachment E-4-2, relies on a simple and inadequate approach that minimizes HRI's commitment of technical, mechanical and cost resources at the expense of protecting the aquifer from the spread of contaminants. Well plugging and abandonment must be carried out in a rigorous fashion to ensure that the well does not serve as a preferential flow path between groundwater zones of varying quality. This becomes increasingly important as the depth of the well increases. Below Section 8, groundwater quality in the proposed mined ore zones will be of very poor quality and under greater hydrostatic pressure relative to overlying groundwater in non-ore zones of the Westwater Canyon Member and Dakota Formation.[15] This requires that the cement plug be placed in a manner that avoids bridging, which is the formation of air gaps in the cement that may jeopardize the continuity and integrity of the cement plug, potentially leading to migration of contaminated groundwater from regions of high hydrostatic pressure to regions of

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[15] As background, groundwater horizons with higher hydrostatic pressure will flow to groundwater horizons with lower pressure. Therefore, groundwater horizons overlying the contaminated water in the ore zone are under less pressure and they will be impacted by the migration of the contaminated water from lower zones if a preferential path is formed by the improper abandonment of the well.

less pressure.

26. The common well-plugging practice of industry is to introduce grout to the bottom of the well with a tremie line, which is slowly pulled up the well as backfilling commences. The well-plugging method proposed by HRI delivers grout from the top of the well casing, which greatly increases the potential for bridging and the formation of an ineffective seal. When executed properly, the tremie-line method eliminates bridging in the grout plug, which leads to decreased porosity and permeability and a greater probability that preferential flow paths will have been minimized if not eliminated. Use of the tremie-line method for plugging monitoring, extraction, and injection wells at the Fernald site (maximum well depth equals 150 feet) is recommended by the Ohio Environmental Protection Agency. As Mr. Ingle notes, the tremie line-bottom up method is also recommended by the U.S. EPA as standard practice for plugging and abandoning groundwater monitoring wells. Ingle Testimony, ¶ 28 at 19-20. HRI's proposed method of plugging wells that range in depth from 600 feet to 800 feet is clearly inconsistent with industry practices and government recommendations, and is not adequate to protect public health and the environment.

27. This concludes my testimony.

AFFIRMATION

I declare on this 19 day of December, 2000, at Ross, Ohio, under penalty of perjury that the foregoing is true and correct to the best of my knowledge, and the opinions expressed herein are based on my best professional judgment.

Richard J. Abitz

Sworn and subscribed before me, the undersigned, a Notary Public in and for the State of Ohio, on this 19 day of December, 2000, at Ross, Ohio.

My Commission expires on ____________.

CARL F FAUVER, NOTARY PUBLIC
IN AND FOR THE STATE OF OHIO
MY COMMISSION EXPIRES MAY 22 2005

Carl F Fauver

Notary Public

Richard J. Abitz

Professional Qualifications

Dr. Abitz is a geochemist with over twelve years of experience in the analysis of chemical and radiological data, modeling of soil/water systems and radioactive waste streams with experimental methods and geochemical computer codes, and development of work plans for CERCLA and RCRA sites. His expertise includes the application of geochemical principles, experimental methods, and computer models to problems involving the solubility and mobility of hazardous and radioactive elements in the environment, the remediation of waters and soil contaminated by hazardous and radioactive wastes, and the design and treatment of mixed and radioactive waste streams. Dr. Abitz has published over twenty-five technical papers in his area of expertise.

In his twelve years of environmental consulting, Dr. Abitz has developed a thorough understanding of geochemical processes responsible for the mobilization of radioactive and hazardous wastes associated with a number of environmental programs administered by the U.S. Department of Energy (DOE). At Los Alamos National Laboratory (LANL), Dr. Abitz developed waste analysis and radioactive material management plans for transuranic and low-level mixed wastes generated, treated, and stored on site. For the Idaho National Engineering Laboratory (INEL), he evaluated the waste characterization program for high-level radioactive and hazardous waste processed at the Idaho Chemical Processing Plant (ICPP). Dr. Abitz also directed geochemical studies at the Waste Isolation Pilot Plant (WIPP) that evaluated the composition and origin of saline groundwater and brine in the vicinity of and within this underground repository for transuranic waste.

Presently, Dr. Abitz serves with Fluor Fernald, Inc on the Fernald Environmental Restoration Management Contract (FERMCO). Dr. Abitz serves FERMCO and DOE as the project manager responsible for remediation of the former production area, where uranium metal was produced for over 30 years, and as the senior geochemist for groundwater restoration activities associated with removal of uranium from the Great Miami aquifer. He is also a senior consultant to the DOE Technology Development Program and oversees active research projects at several universities. These projects include laboratory studies on the mobilization and removal of uranium from soil/water systems, including the passive removal of uranium from groundwater using inorganic and organic systems.

Education and Training

Ph.D., Geology, University of New Mexico, Albuquerque; 1989
M.S., Geology, University of New Mexico, Albuquerque; 1984
B.A., Geology, Humboldt State University, Arcata, California; 1981
Environmental Risk Assessment Communication and Application Workshop, INEL Oversight Program, Boise, Idaho; 1992
OSHA Hazardous Waste Operations Training, 29 CFR 1910.120 (40 hours, IT Corporation, 1994)

Experience and Background

1998 - present **Project Manager/Senior Consultant, Fluor Fernald, Inc., Cincinnati, Ohio.**

- As a project manager, Dr. Abitz oversees a remediation design budget of six million dollars and is responsible for Title I/II/III design work that will lead to removal of all contaminated soil and subgrade structures within the former Production Area. Dr. Abitz leads a team of engineers and scientists who integrate the remedial design with regulatory issues, sampling and analysis plans, waste management operations, demolition and construction activities, health and safety issues, radiological controls, and quality assurance protocols.

- Dr. Abitz serves as a senior consultant to the DOE Technology Development Program, where he is tasked with technical oversight of several university studies dealing with the mobilization of uranium and its removal from groundwater. Laboratory investigations examine the leaching behavior of uranium from contaminated soil, contaminated soil treated with phosphate, and aggregate materials used to construct liners in the Fernald On-Site Disposal Facility (OSDF). This research established baseline levels for uranium in OSDF construction materials and evaluated the effectiveness of phosphate in reducing the solubility and mobility of uranium in the disposal cell.

  Dr. Abitz also participates in research that evaluates the natural attenuation of uranium by the using a combination of passive inorganic and organic systems. The inorganic systems include rip-rap channels constructed with rock containing iron oxyhydroxide phases (e.g., goethite and hematite) or phosphate minerals (e.g., apatite) and flow-through cells using zero-valent iron. Organic systems that show potential promise include sulfate-reducing bacteria, microbial mats, lichen, and phytoextraction. A combination of these systems may prove to be practical and cost effective in the treatment of low leachate volumes generated by the OSDF after its closure.

President/Owner, Geochemical Consulting Services, Albuquerque, New Mexico.

1997 - 1998 Dr. Abitz served as a geochemical consultant to FERMCO and the WIPP Project.

- At FERMCO, he evaluated the efficiency of selected alternatives for soil and groundwater remediation, including *in situ* uranium leaching methods. This effort involved supervising the technical team, assisting in the negotiation of clean-up levels with DOE and EPA, developing soil-treatment protocols, and interacting with public-interest groups as needed.

- At the WIPP site, Dr. Abitz provided the operating contractor with expertise in the area of brine geochemistry. He was responsible for oversight of laboratory analyses and QA/QC, data analysis, and geochemical interpretation of the composition and origin of fluids in the vicinity of underground operations. Dr. Abitz also provided knowledge on the solubility of transuranic elements in sodium-chloride brine and in brine containing organic-complexing agents such as citric acid, oxalic acid, and EDTA.

Project Manager/Senior Staff Consultant, IT Corporation, Albuquerque, New Mexico.

1994 - 1997 Dr. Abitz served as project scientist/manager on geochemical tasks associated with the WIPP Project, Norton AFB Groundwater Study, FERMCO Operable Units 5 and 3 RI/FS, and Wright-Patterson AFB RI/FS. Specific activities include:

- Conducted a rerun of the chemical compatibility analysis of TRU waste forms and container materials for Appendix C1 of the WIPP RCRA Part B permit. The chemical compatibility analysis was carried out with all defense generated, contact-handled (CH) and remote-handled (RH) transuranic-mixed waste streams reported in the 1995 WIPP Transuranic Waste Baseline Inventory Report (WTWBIR). Chemicals reported by the generator sites were classified into reaction groups as defined by the U.S. Environmental Protection Agency (EPA) document "A Method for Determining the Compatibility of Hazardous Wastes." The list of potential chemical incompatibilities reported by the program was hand checked using the EPA document as a reference to assure proper functioning of the program. All potential chemical incompatibilities were then evaluated on a case-by-case basis to identify which of the reactions could occur, given the nature of the waste, its chemical constituents, and final waste form.

- Assisted in evaluating the geochemical performance of backfill configurations proposed in the WIPP Compliance Certification Application. Modeled the interaction of Salado Formation brine with MgO placed in the backfill to estimate the quantity of MgO required to buffer the pH of the indigenous brine between 8 and 9. This pH range is desirable for minimizing the solubility of plutonium and neptunium contained within the waste forms, and lowers the solubility of uranium and americium relative to lower pH values found in Salado Formation brine.

- Project scientist responsible for developing the background groundwater report for Norton AFB This report established background radionuclide concentrations in local and regional groundwater and provided a robust scientific model to explain the presence of elevated levels of naturally-occurring uranium. The task required coordination of scientific and support staff to produce a principal milestone document that was delivered to the client one week ahead of schedule.

- Project manager and scientist on FERMCO OU5 FS task to evaluate aqueous reactions of metal and radionuclide complexes in proposed injection zones of the Great Miami Aquifer. Responsible for oversight of technical tasks, budget, schedule, and final technical report.

- Senior staff consultant responsible for oversight on geochemical issues related to the mobility of 15 metals in the soil/groundwater environment at Wright-Patterson AFB. Provided guidance on evaluating the control of pH, Eh, groundwater chemistry, and adsorption on contaminant mobility.

- Project scientist tasked with overseeing archive activities and development of sampling and analysis plans for two RFI Work Plans at SNL/NM. The work plans deal with historical and active SNL/NM test ranges were a variety of DoD and DOE weapons testing was/is conducted. Archive activities include record searches, personnel interviews, and abstracting classified documents. Sampling and analysis plans cover sites that include detonation and burn tests with mock nuclear weapons containing HE and DU, anti-armor munitions, calibration of target sensing equipment for naval gun fire, impact testing of containers and weapons accelerated with rocket pulldown techniques, and hazardous and mixed-waste disposal mounds.

- Project manager and scientist on FERMCO OU3 RI/FS task to evaluate the release of radionuclides and metals from the proposed on-site disposal facility. Responsible for oversight of technical tasks, budget, schedule, and final technical report.

1991 - 1994 ***Senior Geochemist, IT Corporation, Albuquerque, New Mexico*** Dr. Abitz evaluated the radiochemistry of transuranic elements in sodium-chloride brine for the WIPP Project and served as the project geochemist for four operable units on the FERMCO RI/FS. He was also active setting up the LANL RMMA concept and provided radiochemistry support to INEL in developing a No Migration Variance Petition (NMVP) for the INEL calcine facility.

- Developed solubility database for the WIPP EATF. Evaluated the solubility of thorium, uranium, neptunium, plutonium, and americium in sodium-chloride brine and in the presence of organic complexing agents, such as EDTA and citric acid. Prepared charts that plotted the solubility curves of the radionuclides over the pH range of 2 to 12.

- Authored white paper on geochemistry of FERMCO site for OU 5 RI/FS. This paper discusses leaching, dissolution, and desorption processes that release uranium and its progeny from surface sources, adsorption and aqueous complexation of the solubilized uranium and progeny with subsurface soils and groundwater, and predicts secondary uranium phases that may form in the soils.

- Conducted site-surveys and interviewed LANL personnel on radiation practices associated with the handling, packaging, labeling, storage, transport, and disposal of transuranic materials. Information was used to develop LANL RMMA concept, where each RMMA is held accountable for all radiaoactive materials that enter and exit the area.

- Developed waste analysis plans for transuranic and low-level mixed wastes present at LANL. This activity was conducted to complete RCRA Part B permits and ensure regulatory compliance to DOE orders for all LANL facilities that generate, store, or dispose of mixed waste.

- Managed and had technical oversight on $250,000 geochemical program associated with FEMP RI/FS. Program tasks include the characterization of soil mineralogy by polarized light microscopy and x-ray diffraction studies, design and implementation of laboratory tests to characterize the composition of leachate derived from cemented and vitrified waste samples, evaluation of contaminant adsorption ratios, data validation, and tracking of labor and material costs.

- Designed laboratory experiments for FEMP RI/FS to measure adsorption ratios of radionuclides and metals and implemented ANSI/ANS-16.1 leach tests to evaluate the performance of cemented waste forms. Results were used to evaluate the most effective alternative for immobilizing radionuclides and metals from a near surface disposal cell.
- Led INEL waste characterization program on calcined solid waste. Responsible for evaluating radiochemistry data on uranium fission products and transuranic elements in aqueous and calcined waste forms. Provided assistance in the development of EPA approved sampling and analytical plans to support a NMVP for the radioactive calcined waste stored at the ICPP.

1988 - 1991 ***Geochemist, IT Corporation, Albuquerque, New Mexico*** Dr. Abitz played the principal role in providing geochemical support to the Fernald Environmental Management Project (FEMP). He also established his expertise in geochemical modeling by applying geochemical models to the study of the fate and transport of radionuclides and metals at the FEMP, investigating cement seals and backfill at Yucca Mountain, and elucidating the origin and evolution of brines present at the WIPP repository horizon.

- Modeled geochemistry of leachate, groundwater, and surface waters to support FEMP RI/FS Program. Remedial investigation work includes solubility, speciation and reaction-path modeling with the EQ3/6 code to assess the mobility of buried and stored mixed-waste forms. This activity includes the development of conceptual models, the simulation of geochemical scenarios, and the evaluation and analysis of migration pathways. In support of the feasibility study, modeling was conducted to estimate the optimum pH for removal of uranium from groundwater by anion exchange or precipitation. This information was used in laboratory bench-scale experiments to minimize schedule delays and costs and to achieve full-scale capabilities in the shortest period of time.

- Authored sampling and analytical plans and reports issued as part of the FEMP RI/FS Programs, and coordinated review and resolution of all technical comments.

- Assessed the performance of cement seals and backfill in volcanic rock for the Yucca Mountain high-level nuclear waste repository program. This assessment consisted of computer simulations to evaluate the chemical integrity and longevity of cement seals in the presence of site groundwater and to rank a variety of ash-flow tuff/clay mixtures for their ability to seal drifts and prevent the migration of radionuclides.

- Managed project on interlaboratory comparison of synthetic brine samples to assess precision and accuracy of analytical techniques used to characterize WIPP brine samples.

- Evaluated analytical data obtained on brine samples recovered from the WIPP repository horizon. Task responsibilities include the monitoring of laboratory QA/QC procedures to ensure database integrity, supervision of the statistical and geochemical modeling conducted on the database, and development of hypotheses and conceptual models to investigate the origin of the brine.

- Conducted geochemical modeling with the EQ3/6 code to calculate solubility limits of toxic metals in Salado Formation brine and Culebra groundwater. This data was used to support work carried out for the WIPP Supplemental Environmental of the Pretest Waste Characterization Plan, SEIS, and NMVP documents.

- Participated in the SW-846 Sampling and Monitoring Working Group assisting the EPA in the development of mixed-waste protocols for DOE sites that generate and store transuranic waste, and ensuring that the developed protocols are integrated with the WIPP Pretest Waste Characterization Plan.

1987 - 1988 ***Geology Instructor, University of New Mexico, Albuquerque, New Mexico.*** Developed lectures for Physical Geology and Historical Geology, supervised 30-40 students in class and field projects, organized and conducted field-trips, and evaluated student performance.

1985 - 1987 ***Research Technician, Department of Geology, University of New Mexico, Albuquerque, New Mexico.*** Instructed and supervised students in the proper and safe use of analytical instruments (x-ray fluorescence and solid-source mass spectrometer). Maintained ultra-clean rock digestion laboratory and prepared a variety of solutions and distilled acids used in ion-exchange columns. Developed computer programs for analytical equipment and data base analysis.

1981 - 1985 ***Teaching Assistant, Department of Geology, University of New Mexico, Albuquerque, New Mexico.*** Supervised 10-20 students in mineralogy and petrology laboratories, developed laboratory exercises, evaluated student performance, and maintained mineral and rock collections.

1981 ***Field Geologist, California Department of Water Resources, Red Bluff, California.*** Conducted field investigations and developed slope stability maps of the drainage basins for the South Fork Trinity and Middle Fork Eel Rivers, California.

Professional Affiliations

American Geophysical Union
Geological Society of America
International Association of Geochemistry and Cosmochemistry

Publications

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12 MONTH SPREAD BY CHARGE NUMBER WITH ACCRUALS FOR FISCAL YEAR 2000
FOR CONTROL ACCOUNT: 5BWM - O _M WELLFIELD

CHARGE	DESCRIPTION	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL
5BWM1	O & M OF WELLFIELD	26,859.15	50,184.95	105,789.91	78,517.59	55,711.53	67,325.58	50,283.52	68,635.34	23,768.56	44,441.42	67,921.50	70,370.21	709,809.26
5BWM2	MAINTENANCE OF THE RE-INJECTION WELLFIELD	(732.55)	1,051.78	403.72	5,285.56	30,745.06	16,911.86	12,803.65	3,010.13	17,847.32	8,975.07	56,087.82	27,229.22	179,618.64
		26,126.60	51,236.73	106,193.63	83,803.15	86,456.59	84,237.44	63,087.17	71,645.47	41,615.88	53,416.49	124,009.32	97,599.43	889,427.90

Abitz Attachment B

12 MONTH SPREAD BY CHARGE NUMBER WITH ACCRUALS FOR FISCAL YEAR 2000
FOR CONTROL ACCOUNT: 5BWP - WATER TREATMENT OPERATIONS

CHARGE	DESCRIPTION	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL
5BWPA	URANIUM REMOVAL FROM WATER (LOE)	270,113.98	608,811.94	690,736.65	530,347.39	649,123.97	564,153.62	598,032.38	755,893.20	476,201.36	430,200.48	644,940.07	685,238.62	6,903,793.66
5BWPT	SEWAGE TREATMENT PLANT OPERATIONS	18,034.68	43,097.91	54,465.14	48,892.89	44,641.95	40,976.11	42,503.30	62,800.56	48,529.14	44,051.86	49,692.22	51,296.55	548,982.31
		288,148.66	651,909.85	745,201.79	579,240.28	693,765.92	605,129.73	640,535.68	818,693.76	524,730.50	474,252.34	694,632.29	736,535.17	7,452,775.97

12 MONTH SPREAD BY OBJECT CLASS WITH ACCRUALS FOR FISCAL YEAR 2000
FOR CHARGE NUMBER: 5BWPA - URANIUM REMOVAL FROM WATER (LOE)

OC	DESCRIPTION	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	TOTAL
002	ENGINEERING	8,370.93	22,428.22	21,081.46	16,113.46	21,684.19	15,141.14	21,590.86	28,380.88	17,409.47	14,104.68	15,691.91	25,512.20	227,509.40
003	ENV. SCIENTIST	2,959.90	2,330.38	1,771.86	752.02	4,535.12	2,688.49	2,134.59	4,635.04	2,249.06	2,069.32	1,478.69	1,237.11	28,841.58
004	WASTE DISPOSITION ENGINEERING	829.33	829.32	320.41	206.55	569.78	478.36	483.40	(71.33)	74.02	115.45	184.36	1,087.35	5,107.00
005	PROJECT CONTROLS	22.26	0.00	0.00	0.00	0.00	286.20	(31.80)	182.85	0.00	0.00	0.00	230.55	690.06
006	CONSTRUCTION ENGINEER	1,097.14	1,420.99	2,098.45	2,660.21	2,772.42	669.59	370.16	218.74	162.18	0.00	0.00	0.00	11,469.88
007	CONSTRUCTION MGR/SUPPORT	941.82	2,244.87	1,298.42	881.48	1,680.73	826.90	870.56	610.06	0.00	157.29	0.00	0.00	9,512.13
008	CONSTRUCTION COORDINATOR	1,041.17	655.53	403.35	559.14	529.35	161.73	333.55	(20.21)	0.00	0.00	120.04	(60.02)	3,723.63
009	ACQUISITIONS / CONTRACTS	0.00	0.00	0.00	0.00	0.00	19.78	0.00	464.95	0.00	0.00	0.00	0.00	484.73
010	QA / AUDIT	2,468.58	1,474.21	1,673.55	1,239.48	1,984.52	2,457.12	621.33	1,721.08	1,020.11	358.20	836.32	3,148.25	19,002.75
011	SAFETY / HEALTH PROFESSIONAL	1,257.97	1,397.47	616.75	247.55	908.07	505.43	1,406.97	(3.66)	264.31	78.78	144.92	(57.97)	6,766.59
012	LAB	5,743.73	14,247.79	13,873.54	10,178.31	17,414.19	13,272.27	14,770.79	12,144.74	9,652.65	11,361.87	14,772.16	13,933.78	151,365.82
013	MAINTENANCE / OPERATIONS	30,134.11	72,115.67	68,835.77	48,675.44	85,511.61	58,448.57	57,633.54	68,951.86	43,263.75	45,585.45	69,229.07	63,601.12	711,985.96
014	DRAFTER	0.00	0.00	733.53	2,263.43	2,483.87	1,558.98	529.10	0.00	1,114.22	(11.01)	1,483.77	(185.47)	9,970.42
015	CLERICAL SUPPORT	1,433.57	2,520.31	2,085.03	1,971.19	2,805.45	1,804.36	1,703.20	2,887.54	2,719.48	1,978.05	3,334.96	2,690.16	27,933.30
016	SAFETY/HEALTH TECHS	592.82	1,316.98	1,632.27	632.71	457.35	538.10	(17.85)	(16.69)	679.85	652.08	490.42	618.58	7,576.62
017	LAB TECHS	2,109.21	5,390.71	3,885.38	5,805.10	4,653.07	4,891.53	4,019.53	4,085.68	3,242.50	2,498.58	3,389.47	3,973.85	47,944.61
018	RAD TECHS	4,113.64	8,666.81	8,303.04	5,426.80	9,142.56	7,301.86	8,916.11	11,028.93	6,876.39	5,086.70	4,154.78	4,280.92	83,298.54
019	SECURITY	4.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.47
020	CRAFTS (HASMAD)	13,819.46	31,349.42	49,720.36	15,224.77	36,606.81	31,420.78	33,241.24	33,790.47	27,850.36	29,205.70	45,492.97	40,723.91	388,446.25
021	MVO/HEO (HAXWAT)	4,445.43	10,034.84	7,973.18	4,602.91	9,465.43	7,102.12	10,220.24	18,854.48	7,356.82	6,346.00	8,937.88	8,503.92	103,843.25
022	UTILITIES WORKERS	61,807.56	152,101.92	156,104.47	104,345.00	136,575.70	115,683.46	120,207.66	152,164.57	112,963.50	104,934.50	143,675.02	136,483.65	1,497,047.01
023	ADMIN1-T MEMBERS, TECH SPEC.	838.88	2,586.13	(38.20)	593.34	993.75	2,604.95	3,267.64	4,229.39	3,598.13	2,671.71	4,157.16	3,518.36	29,021.24
024	ADMIN2-TECH EXP/LEADERS/COACH	745.96	655.12	1,760.77	57.37	3,259.60	2,035.19	1,579.31	2,779.99	3,275.10	460.40	220.84	1,442.86	18,272.51
025	ADMIN3-PROG/PROJ COACHES	3,629.92	9,238.23	7,169.54	4,335.06	8,149.74	7,162.87	6,265.24	12,355.39	11,722.82	8,371.56	14,609.37	15,115.33	108,125.07
097	VACATION ACCRUAL	1,027.14	(13,895.63)	(17,454.33)	8,872.05	(2,471.72)	9,553.39	7,707.93	11,663.34	(5,377.57)	4,793.52	5,552.32	(4,886.43)	5,084.01
098	DISTRIBUTION OF TIME OFF	11,070.88	36,546.48	53,286.75	74,365.23	29,357.39	42,254.20	27,527.32	49,997.56	43,325.37	51,769.25	38,322.49	35,281.15	493,104.07
099	DISTRIBUTION BURDENS & BENEFIT	51,411.87	127,065.64	135,426.35	101,164.92	125,266.52	106,899.63	111,314.55	142,459.56	109,667.78	104,729.91	134,335.03	130,837.01	1,380,578.77
261	BLDG & ROAD MATERIALS & SUPPLI	(37.56)	(12.52)	0.00	(19.21)	0.00	0.00	(25.04)	0.00	0.00	(66.74)	(40.74)	(17.97)	(219.78)
262	HARDWARE & SMALL TOOLS*	0.00	(51.78)	(75.32)	0.00	(200.18)	(20.06)	(22.72)	(105.90)	(43.42)	(274.31)	(26.39)	0.00	(820.08)
263	CHEMICALS & COMPOUNDS*	0.00	(962.55)	(962.55)	(1,925.10)	(1,925.10)	(962.55)	(5,775.30)	0.00	(962.55)	(1,925.10)	0.00	(962.55)	(16,363.35)
264	METALS & METAL ALLOYS*	0.00	0.00	0.00	0.00	(3.41)	0.00	0.00	0.00	0.00	(0.96)	0.00	0.00	(4.37)
265	ELECTRICAL MATERIALS & SUPPLIE	(186.29)	(1,904.20)	(1,253.97)	(246.04)	(344.86)	(1,051.99)	(783.78)	(1,610.21)	(291.28)	(1,675.67)	(1,809.29)	(2,500.65)	(13,658.23)
266	ELECTRONIC SUPPLIES*	2,033.17	(649.34)	1,590.12	(39.76)	(77.24)	(26.86)	(877.90)	(3,733.69)	(26.36)	(101.28)	(16.27)	(56.41)	(1,981.82)
267	MECHANICAL MATERIALS/SUPPLIES*	(3,595.43)	(12,434.32)	(4,256.72)	(9,987.00)	(3,270.21)	(8,182.87)	(5,153.43)	(10,964.92)	(8,928.20)	(4,343.28)	(10,106.41)	(5,440.95)	(86,663.74)
268	CUSTODIAL MATERIALS/SUPPLIES*	0.00	(30.18)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	(30.18)
269	OFFICE MATERIALS/SUPPLIES*	(5.32)	0.00	0.00	0.00	0.00	(7.98)	0.00	0.00	0.00	(3.99)	(7.98)	0.00	(25.27)
270	FUELS & LUBRICANTS*	0.00	(35.96)	(9.99)	(9.99)	(19.98)	0.00	(19.98)	(19.98)	(9.99)	0.00	(30.97)	0.00	(156.84)
271	CLOTHING*	(26.25)	(331.25)	(254.15)	(39.44)	(84.39)	(123.98)	(20.02)	(3.84)	(35.91)	(151.80)	(89.74)	(38.93)	(1,199.70)
275	MISC MATERIALS & SUPPLIES*	0.00	(38.00)	(79.20)	(345.98)	0.00	(95.60)	(38.00)	(75.62)	(57.60)	134.80	0.00	(114.00)	(709.20)
310	MAINTENANCE MATL AND SUP.	57,556.10	27,221.09	23,986.28	14,491.66	17,980.42	15,432.05	26,941.70	33,776.54	15,728.32	10,341.89	62,713.34	27,958.36	334,127.75
315	GARAGE MATERIALS AND EXP.	7.10	0.00	9.54	0.00	0.00	0.00	0.00	56.75	0.00	0.00	13.36	0.00	86.75

Abitz Attachment C