Docket No. 40-6659

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

September 15, 1997

Mr. Michael J. Franko
Texaco Exploration & Production, Inc.
P.O. Box 2100
Denver, Colorado 80201

Mr. Mohammad W. Haque
Nuclear Regulatory Commission
Mail Stop T7J9
Washington, D.C. 20555

Re: Review of the Petrotomics Company's ACL Application
TFN 3 5/134

Dear Mr. Franko:

The Land Quality Division (LQD) and the Water Quality Division (WQD) of the Wyoming Department of Environmental Quality (WDEQ) have reviewed Petrotomic's ACL application, and a copy of the review is attached. WDEQ believes the application should be denied because additional, effective ground water remediation measures are necessary and possible. In particular, WDEQ believes work can be done on the Main Sand Aquifer to prevent off-site ground water contamination, and WDEQ has provided recommendations for measures that the Department believes can be efficient and cost-effective.

If you have any questions or need additional information, please call.

Sincerely,

Richard Chancellor, Administrator
Land Quality Division

Gary Beach, Administrator
Water Quality Division

NL05

cc (w/ attachment):
Georgia A. Cash, LQD
David Hogle, EPA
Rachel Smith, AG
Richard Stockdale, SEO
Jake Strohman, WQD
Joe Virgona, DOE

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WDEQ Technical Review Comments
Application for Alternate Concentrations Limits
Petrotomics Company - TFN 3 5/134
September 1997

REVIEW SUMMARY

The Petrotomics Company (Petrotomics) submitted an application to the Nuclear Regulatory Commission (NRC) to establish Alternate Concentration Limits (ACLs) for ground water, as part of the company's plan for closure of their uranium mill tailings impoundment. A variety of radiological and non-radiological contaminants were introduced into the ground water due to leakage from the tailings impoundment. Of the three aquifers of concern at the site, the Upper Sand has been significantly dewatered as part of Petrotomics' efforts to control contaminant migration. In contrast, the Main and Lower Sands are still capable of producing sufficient quantities of water for reasonably foreseeable uses such as livestock watering. However, the Wyoming Department of Environmental Quality (WDEQ) believes that the amount of contamination remaining in the Main Sand has been underestimated. The contamination migrated from the Upper Sand to the Main Sand through a naturally-occurring 'hole' in the shale between the Upper and Main Sands. In addition, WDEQ believes that man-made 'holes' (i.e., the pits created during mining) between the Main and Lower Sands may not have been appropriately accounted for in the evaluations of future contaminant movement.

Concentrations of non-radiological parameters, in excess of ground water standards set by the WDEQ Water Quality Division (WQD), are already present outside of the NRC's Restricted Area. In the ACL application, Petrotomics proposes to allow migration, off of Petrotomics' property, of radiological and non-radiological contaminants in concentrations that exceed WQD standards. Therefore, WDEQ's review of Petrotomics' ACL application focused on aspects necessary to ensure compliance with the Wyoming Environmental Quality Act (particularly Article 3) and WQD's Rules and Regulations (particularly Chapter VIII). Aspects of the application of specific concern to WDEQ are outlined below, and review sections with more detail are noted in parentheses.

- The geochemical evaluation focuses on the parameters of concern to NRC, without addressing parameters of concern to WDEQ (§§ 4.1 & 4.2);
- Ground water conditions at a given point in time are used as a basis for predictions of future contaminant migration. However, the changes in the conditions prior to that time, which indicate a more complex situation were given limited consideration (§§ 2.2, 2.3, & 4.5.1);
- Impractical scenarios (e.g., continued emphasis on pumping Upper Sand wells), rather than more realistic scenarios (e.g., shifted emphasis to pumping Main Sand wells) were used in evaluating alternatives for continued ground water remediation (§ 4.7);
- Petrotomics relies on obtaining a designation from the Wyoming State Engineer's Office that ground water use in an area around the Petrotomics site will be permanently restricted, but does not indicate that work on obtaining such a designation has proceeded. In addition, such a designation does not meet the requirements of the Wyoming Environmental Quality Act (§ 4.4).

WDEQ believes Petrotomics can design a remediation system to effectively remove a significant portion of the contaminants in the Main Sand, thus protecting future use of the Main and Lower Sands for ground water supply in the Shirley Basin and protecting existing surface water supplies from potential degradation. In addition, this system need not depend on the tailings impoundment remaining open, so closure of the impoundment can proceed.

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1.0 INTRODUCTION

The Petrotomics Company submitted an application to the Nuclear Regulatory Commission (NRC) in September 1996 for Alternate Concentration Limits (ACL's) for ground water, as part of the company's plan for closure of their uranium mill tailings impoundment in the Shirley Basin of Wyoming. ACLs for ground water are designed to be set on a parameter-by-parameter basis to allow variation from specific standards at a Point of Compliance (POC) while still ensuring protection of human health and the environment at a Point of Exposure (POE). The ACL application addressed standards for water quality parameters of concern to the NRC, specifically radionuclides and select toxic metals[1], but it did not address ground water quality standards for non-radiological parameters of concern to the Water Quality Division (WQD) of the Wyoming Department of Environmental Quality (WDEQ), or WDEQ's concerns about radiological and non-radiological parameters in ground water once the water migrates outside the NRC Restricted Area around the tailings impoundment.

A map of the Shirley Basin area is included as Figure 1, and a more detailed map of the Petrotomics site is included as Figure 2. At the Shirley Basin site, the POC is at the boundary of the tailings impoundment, and the current POE is at the boundary of the NRC Restricted Area. Petrotomics' proposes expansion of the NRC Restricted Area so the north and east Restricted Area boundaries would coincide with the north and east boundaries of Petrotomics' Mine Permit 342 with the Land Quality Division (LQD) of the WDEQ (Figure 2).

The three aquifers of concern at the Petrotomics site, in order from shallowest to deepest, are the Upper Sand, the Main Sand, and the Lower Sand, as illustrated on Figure 3. (The Upper and Main Sand are occasionally referred to as the Upper Wind River Aquifer collectively, a term which should not be confused with the Upper Sand.) The Upper and Main Sand are hydraulically connected in the northern portion of the tailings area because of a 'hole' in the shale between them (Figures 3 & 4). They are also connected in the vicinity of several of the pits in the Shirley Basin. Prior to mining, the Lower Sand appears to have been effectively separated from the shallower sands by shale; however, mining may have created hydraulic connections with the shallower sands.

The importance of surface and ground water and the advantages of creating open bodies of water in the Shirley Basin for wildlife, livestock, and even recreational use were recognized in Petrotomic's 1974 permit application with LQD (see, e.g., Appendix F, Page 6). However, under the proposed ACL application, development of surface and ground water resources in

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[1] The radionuclides include Radium-226 and 228 and Thorium-230. The toxic metals include: cadmium; chromium; lead; nickel; selenium; and uranium.

the vicinity of the Petrotomic's site will be severely limited, if not precluded. For example, Petrotomics predicts a ground water contaminant plume, with sulfate concentrations in excess of 3,000 milligrams per liter (mg/l), will extend to the Pathfinder Mines Corporation (Pathfinder's) Pit 33 Reservoir by 2010. This plume will also eventually migrate east to the Medicine Bow River, about 2 miles east of the site. Therefore, the long-term usefulness of the Pathfinder Mines Corporation's Pit 33 Reservoir and of water in the Main Sand for stock and wildlife watering may be jeopardized by contributions of contaminated ground water from the Petrotomics site.

Petrotomics' corrective actions to date have focused on the ground water in the Upper Sand, particularly in the immediate vicinity of the tailings ponds. The actions have included pumping water from a seepage trench, Upper Sand wells, and Main Sand wells and evaporating the contaminated water in ponds on top of the tailings impoundment. Petrotomics contends that treatment of contaminated ground water is no longer feasible because: (a) several of the Upper Sand wells can no longer sustain pumping; and (b) the evaporation ponds will not be available once the tailings impoundment is capped. While the ground water pumping has dewatered the Upper Sand to a large extent, WDEQ believes contaminated Main Sand wells are still capable of producing sufficient quantities for effective withdrawal of contaminants. In addition, treatment of the contaminated water need not occur on top of the tailings impoundment. Therefore, WDEQ believes that additional, effective remediation measures can be implemented to prevent off-site ground water contamination.

This review of Petrotomic's ACL application was prepared jointly by the Land Quality Division (LQD) and the Water Quality Division (WQD) of the WDEQ. The purpose of the joint review was to ensure compliance with WQD's statutes and regulations, while taking advantage of LQD's knowledge of the mining activities in the Shirley Basin and related site conditions. The first part of the review presents some additional evaluation of the available data on ground water levels and quality. This evaluation forms the basis for WDEQ's recommendations for additional remediation measures and provides a framework for WDEQ's comments on specific portions of the ACL application.

2.0 EVALUATION OF CONDITIONS IN THE UPPER & MAIN SAND

The focus of this evaluation is understanding the changes that have occurred in the Main Sand over time, based on information currently available to WDEQ. The evaluation is based on comparing water level and quality data from:

- wells currently designated as background wells and proposed background wells;
- adjacent wells completed in the Upper and Main Sands, respectively; and
- wells along cross-sections of the Main Sand.

Information for this evaluation was obtained from:

- Petrotomics' September 1996 ACL application (the ACL application) prepared by Shepard-Miller, Inc.;
- Petrotomics' December 1996 Addenda 1 & 2 (Addendum 1 or 2) to the ACL application, also prepared by Shepard-Miller, Inc, which addressed NRC's Acceptance Review Issues;
- Petrotomics' September 1996 Background Ground Water Monitoring Assessment (Background Assessment), prepared by Dames & Moore, Inc.;
- Petrotomics' August 1986 Updated Ground Water Hydrology, prepared by Hydro-Engineering;
- Petrotomics' February 1985 report on the Pit 4 Reclamation Reservoir, also prepared by Hydro-Engineering;
- ground water quality and elevation data provided by Petrotomics to LQD on diskette in May and June 1997 and well logs provided to LQD in June 1997; and
- LQD's files (e.g., Annual Reports and the Permit Application) and the Wyoming State Engineer's Office's (SEO's) files (e.g., well permits).

2.1 Wells and Parameters used in the Evaluation

The locations of wells referenced in this evaluation are shown on Figure 4. Prior to the 1996 Background Assessment, Wells 39SC and 41SC were used as background wells. The background wells identified in Petrotomics' September 1996 Assessment include Wells 41SC, 67SC, 69SC, 70SC, 10DC, 11DC, 13DC, 14DC, and 16DC. In general, the suffix 'SC' indicates a well completed in the Upper Sand and the suffix 'DC' is for Main Sand wells. (One exception is Well 52SC which is noted as a Main Sand well in Table 5-1 of the 1986 Hydrology report.) Wells numbered as P4-# were originally installed for evaluation of the impacts of Pit 4 and are generally

completed in the Main Sand, although Wells P4-4 and P4-5 are reportedly completed in the Pit 4 backfill. PT wells were Production Test wells.

Adjacent shallow/deep wells often have the same number with different suffixes (e.g., Wells 8SC/8DC), but not always (e.g., Wells 49SC/5DC). In general, only wells within 100 feet of each other were considered 'adjacent', e.g., Wells 49SC and 5DC; however, in some instances, the only available 'adjacent' wells were on the order of 400 feet apart. The adjacent wells of interest near the 'hole' between the Upper and Main Sands are 49SC/5DC and PT13/12DC. (Water elevation and quality data is available for these four wells except that water level data is not available for Well PT13.) Adjacent wells farther from the 'hole', in general order of increasing distance to the north, include: 58SC/11DC/P4-1; 58SC/18DC; 54SC/P4-6; 55SC/9DC; and 56SC/17DC. Adjacent wells to the east of the 'hole' include 67SC/5WR/13DC and to the west include 8SC/8DC.

The Main Sand cross-section evaluated to the east of the 'hole' includes Wells 5DC, P4-7, P4-4, P4-5, and P4-2. The cross-section to the north includes Wells 5DC, 18DC, P4-1, P4-6, 9DC, and 17DC.

This evaluation focuses on three water quality parameters: sulfate, pH, and radium-226 (Ra-226). The first two parameters are considered representative of the non-radiological parameters of concern to WDEQ, and were relied on by Petrotomics in evaluating the mobility of the radionuclides and select toxic metals. Ra-226 concentrations were evaluated because they provide information on movement of radiological parameters from the tailings area and information on the natural variations in water quality due to uranium mineralization trends that were not removed by mining.

2.2 Background Well

The background wells listed in the ACL application are Wells 39SC and 41SC. The limitations of having only wells completed in the Upper Sand are obvious, and, it is LQD's understanding that the NRC is considering the recommendations in the September 1996 Background Assessment report for selecting background wells. Petrotomics relied on the September 1996 Assessment in preparing the responses to the issues raised by NRC (see, e.g., Addendum 1, Issue 4, Pages 17-20). However, as outlined below, WDEQ has concerns about the findings of the September 1996 Assessment.

The statistical analyses in the September 1996 Assessment indicated that Upper and Main Sand wells could be used collectively to establish background conditions because of the hydrologic connection between the sands, and the wells that should be used to establish background conditions are:

Wells 41SC, 69SC, 67SC, 70SC, 10DC, 11DC, 13DC, 14DC, and 16DC.

However, Well 14DC was "dropped from this list at Petrotomics' request due to the comparatively high Radium-266 [sic] measurements of its water samples." The report also noted that "more detailed hydrogeological or geochemical data" could justify removal of wells from the 'statistical' list. (Assessment, pp. 26-27)

Because of the extent of mine-related activities in the area, including the tailings impoundment, WDEQ believes data from the Petrotomics' wells must be used judiciously because of the influence of the mine-related activities. As an added complication, there is considerable natural variability in the radionuclide concentrations due to the uranium ore trends. The extensive exploration work in the basin; however, allows for some ability to evaluate these variations. Even when the variations due to man-made and natural influences are taken into account, the parameter concentrations in several of the wells selected as background wells are within WQD's Class III standards. Examples of some of WDEQ's concerns about the conclusions of the statistical analyses are outlined in the following paragraphs.

Combining the Upper and Main Sands. The difference in the ground water elevations between the Upper and Main Sand, even in adjacent wells near the 'hole' (Figure 5), illustrate a concern about 'combining' the Upper and Main Sand water quality data to assess background conditions. Factors contributing to the elevation difference could also contribute to water quality differences over time. For this review, WDEQ did not separate the Upper and Main Sands, but the difference in the results of the statistical analyses, if the Upper and Main Sand wells are not combined, should be discussed.

The Pit 4 Wells. All but two of the Pit 4 wells are reportedly completed in the Main Sand, but they were apparently not included in the 1996 Background Assessment or the ACL application. (Two of the Pit 4 wells were completed in the Pit 4 backfill.) Although the Pit 4 wells generally seem to be screened higher in the Main Sand than nearby DC wells, some of the Pit 4 wells would appear to be representative of Main Sand conditions, although not necessarily background conditions. (An exception might be Well P4-1, which shows considerable variation in water levels and quality that may be due to casing problems.) The Pit 4 wells were sealed in 1996; however, the historic data from these wells is of value. (This historic data is discussed in more detail in Section 2.2.3 - the east-west cross-section.) Data from one of the Pit 4 wells, Well P4-2, which is near Well 13DC, was included in the following background discussions to illustrate some of WDEQ's concerns.

Water Level Variations. In the Upper Sand, the water level in Well 69SC is higher than the water level in either Well 67SC or 70SC (Figure 6), which is unusual considering its location relative to

these two wells (Figure 4). (See, e.g., Exhibit 4-1 on Page 10 of the ACL Application Appendix E. The water elevation contours do not encompass Well 69SC.) Therefore, selection of Wells 67SC, 69SC, and 70SC as background wells should depend upon understanding the influence of Pit 4 activities, as well as the statistical evaluation.

In the Main Sand, the influence of both tailings leakage and the Pit 4 activities on some of the selected background wells are apparent. With respect to tailings leakage, it is interesting that Well 15DC, which is between Wells 14DC and 16DC (Figure 4), was not considered suitable as a background well, though Wells 14DC and 16DC were. In fact, the ground water elevation data indicates Wells 10DC and 16DC may have also been impacted by tailings leakage (Figure 7). The leakage through the 'hole' could be considered as a 'slug' of water added to the Main Sand over the time when the tailings impoundment was in use beginning in 1962. The water levels in the Main Sand rose as water was 'pushed' into the Main Sand. Therefore, even if the 'slug' of contaminated water did not reach Well 10DC, it did influence all four of the Main Sand wells in that area (Wells 10DC, 14DC, 15DC, and 16DC). The water levels in these four Main Sand have apparently declined due to the Main Sand pumping and the decrease in the leakage rate.

Sulfate. In the Upper Sand, all of the shallow wells to the west and southwest appear to have been impacted to some degree by the 'mound' of contaminated ground water created due to leakage from the tailings impoundment and the subsequent ground water remediation. As evident on Figure 8, the sulfate concentration in the current background wells has varied by a factor of at least two over time (e.g., the sulfate concentration in Well 41SC varies from 500 to 1500 milligrams per liter (mg/l)). The data record for the three 'new' background wells downgradient of the tailings area is not long enough to determine if variations such as those in wells near the tailings are evident. However, the decline in sulfate concentration in Well 67SC may be due to the Pit 4 reclamation activities, based on variations in the water level and quality data.

Sulfate concentrations versus time in the proposed Main Sand background wells (Figure 9) indicate that Well 14DC has been impacted by tailings leakage, based on the elevated sulfate concentrations relative to the other proposed background wells, as well as the elevated Ra-226 concentrations noted in the 1996 Assessment. The increase in sulfate concentrations in Well P4-2 may reflect the influence of the Pit 4 reclamation activities.

Radium. The radium concentrations show considerable variation from well to well, as shown on Table I. Because of the proximity of several of the wells to the ore trend, Petrotomics should consider evaluating background concentrations within the production zone and outside the production zone, similar to the approach proposed by the in-situ uranium mine operators (see Section 4.2 of this report).

Summary. Even considering the above concerns on background well selection, the predicted concentration distributions in the ACL application exceed the background concentrations, as well as the WQD Class III Standards (Livestock Use), as outlined on Table I. This table includes some of the parameters of concern to the NRC (e.g., uranium and Ra-226) plus some of the other parameters of concern to WQD (e.g, sulfate and Total Dissolved Solids (TDS)). It should be noted that the 1996 Background Assessment includes calculations of tolerance limits only for the parameters of concern to NRC (i.e., radionuclides and select toxic metals). Tolerance limits, which estimate the maximum in the range of background concentrations, were not determined for the other contaminants of concern (i.e., pH, TDS, and sulphates). Therefore, influences of tailings leakage could be overlooked. For example, elevated sulfate concentrations are identified as "generally evidence of tailings water" (ACL Application, p. 38). Given the proximity of some of the background wells to the tailings impoundment (e.g., Well 11DC), it seems at least sulfate should be included in the tolerance limit calculations.

2.3 Adjacent Shallow/Deep Wells

The most important aspect of the water quality in adjacent wells is that, near the 'hole' between the Upper and Main Sands, the water quality of the Main Sand is at least as degraded as, if not worse than, the water quality in the Upper Sand. In addition, this condition existed before pumping of the Main Sand wells began. For example, the sulfate concentrations in Well 5DC are generally at least 2,000 mg/l higher than those in Well 49SC (Figure 10). Therefore, the concern that continued pumping of the Main Sand could 'pull' more contamination from the Upper Sand and subsequently degrade the Main Sand is not a primary concern, although any Main Sand pumping network would need to be carefully designed. In fact, a well-designed remediation system in just the Main Sand could help improve the Upper Sand water quality.

As further justification for continued pumping of the Main Sand, the ground water elevation in the Main Sand is lower than that in the Upper Sand, so the natural gradient would contribute to leakage of ground water from the Upper Sand to the Main Sand. For example, the ground water elevation in Well 5DC is generally 30 feet higher than in Well 49SC (Figure 5). This condition also existed before pumping of the Main Sand wells began.

2.4 Cross-Sections

Evaluation of conditions along the cross-sections indicates the importance of 'sorting out' the various influences on the ground water conditions, including the tailings leakage, the Upper and Main Sand remediation pumping, and the Pit 4 activities.

North-South. The ground water elevations and sulfate concentrations in Well 9DC, about 2000 feet north of the 'hole', increased even as Main Sand wells closer to the 'hole' were being pumped (Figure 11). These increases coincide with a pH decrease, indicating the influence of tailings leakage (Figure 12). The ground water elevation in Well 17DC also appears to be increasing; however, not enough water quality data is available to determine whether this is a trend. The leakage through the 'hole' could be considered as a 'slug' of water added to the Main Sand over the time when the tailings impoundment was in use beginning in 1962. It is WDEQ's interpretation that pumping of the Main Sand reduced the quantity of water in the 'slug', but did not catch the initial 'front' of contaminated water passing through the Main Sand because the Main Sand pumping did not start until 1989.

Evaluation of other data along the north-south cross-section illustrates the concerns about a 'front' of contaminated water passing through the Main Sand. The sulfate concentration in Well 18DC was higher than the concentration in Well 5DC (Figure 13), even though Well 18DC is north of the 'hole' (Figure 4). Once pumping of Well 18DC started in 1995 (Table II), the sulfate concentration decreased rapidly although it was still higher than that in Well 5DC. The pumping of Well 5DC is not thought to have created the slug, based on the concentrations in Wells P4-6 and P4-1. Well P4-1 is northwest of Well 18DC and Well P4-6 is north of Well P4-1, and both Wells P4-1 and P4-6 are between Wells 18DC and 9DC. The sulfate concentrations in Well P4-1 (closest to Well 5DC) initially declined, and then varied, after pumping of Well 5DC began. The concentrations in Well P4-6 (farther from Well 5DC) declined. In contrast, the sulfate concentrations in Well 9DC have been increasing significantly. Therefore, the sulfate source for Well 9DC was apparently 'between' Well 9DC and the 'hole' prior to the pumping of Well 5DC.

The ground water elevations also indicate something unusual. The elevations in Well 18DC have been higher than those in Well 5DC (Figure 14) despite the fact that Well 5DC should be upgradient of this well (see Figure 2-8 in the ACL application).

East-West. Evaluation of data along the east-west cross-section illustrates the importance of understanding Pit 4 history. This pit was reportedly pumped from May 1978 to March 1980 at an average rate of 900 gpm. The lower portion of it was subsequently backfilled, and the upper portion of it was supposed to remain as a reservoir for stock and wildlife watering.

However, slumping of the northeast pit wall required repair. Discussion with Petrotomics, including slope analysis, indicated that more 'lay-back' of the pit walls was necessary, and the material from the 'lay-back' could be placed in the pit. Therefore, the water in the reservoir was pumped out in 1997, and the repairs completed. However, considering the impact of

tailings leakage on the Upper and Main Sand, which would have contributed to the reservoir, it is doubtful the reservoir water quality could have been maintained to meet the proposed use.

Sulfate concentrations along the east-west cross-section indicate the initial influence of tailings leakage through the 'hole' was initially limited to Wells 5DC and P4-7 (Figure 15). Other wells along the eastern extension of this cross-section (e.g., Well P4-2) have shown gradual increases in sulfate concentrations over time. However, it is not clear whether these increases are due to tailings leakage or activities at Pit 4.

The water level measurements in the wells along the east-west cross-section (Figure 16), which began about four years after dewatering of Pit 4 ceased, apparently respond to a variety of influences. The increase in the initial measurements may be attributable to the ground water recovery after dewatering. The subsequent decline in some of the wells could be due to pumping of Well 5DC, but in the eastern wells, it could also be due to evaporation from Pit 4. (The variation in Well P4-2 could be due to a change in the measuring point too.) Of significant interest is the fact that the elevations indicate the potentiometric surface, and subsequent contaminant migration paths, have changed over time.

(Note: Water level data, reportedly collected in 1979-80 from some of the Pit 4 wells, was submitted to LQD in Petrotomics' Permit 342 1990-91 Annual Report; however, this data would have been collected before the wells were installed. This data was not included in any of the evaluations discussed above, and both WDEQ and Petrotomics believe the data is not from the Pit 4 wells. Efforts to locate the source of this data (such as multiple measuring points of the water level in Pit 4) should continue though.)

3.0 REQUIRED ACTIONS

Based on WDEQ's evaluation, Petrotomics needs to reassess the best approach to ground water remediation at this site. Two issues are critical to long-term protection of the ground and surface waters. The first topic is continued pumping of the Main Sand, and the second is the evaluating the Pit 4 impacts.

3.1 Continued Pumping of the Main Sand

In the ACL application, Petrotomics emphasizes the reduced yields of the ground water extraction wells. They also mention the concern about 'pulling' ground water contamination from the Upper Sand to the Main Sand resulting in additional contamination of Main Sand. While WDEQ agrees that production from Upper Sand wells is severely limited (requiring

unusual pumping methods, such as vacuum extraction of the wells), WDEQ does not agree, based on available information, that pumping of the Main Sand wells is no longer possible due to reduced yields. WDEQ also does not agree that continued pumping of Main Sand wells would 'worsen' the contamination of the Main Sand by 'pulling' down additional contamination.

In the ACL application, the claims that continued pumping of the Main Sand is no longer feasible are not well supported. For example, the pumping rate from Well 5DC apparently declined from 1989 to 1994 (Table II), but it is not clear why pumping of this well stopped or whether it could be pumped at a lower rate (e.g., 2 gpm). It is also not clear why none of the other Main Sand wells cannot be pumped at lower rates. Based on the specific capacity tests reported on the SEO well permit forms, information in the 1986 Hydrology Report, and comparison of water levels with screened intervals, it seems continued pumping of the Main Sand is feasible. Also, in terms of pounds of contaminants removed, pumping of the Main Sand has proven almost as effective as pumping of the Upper Sand (Table III), for the contaminants of concern to both the NRC and WDEQ.

The most important aspect would be selection of strategic pumping locations (from existing or new wells) to avoid 'spreading' the contamination and to control how contamination is 'pulled' from the Upper Sand. A variety of methods could be used to evaluate pumping patterns, from a relatively straightforward zone of capture analysis to application of the ground water model constructed for the site. In addition, even if a continuous pumping rate could not be used in the Main Sand, a cyclic pumping schedule (such as that used for the Upper Sand) could be implemented.

3.2 Evaluation of Pit 4 Impacts

Pit 4 created an artificial 'hole' between the Upper and Main Sands. It may also have created a 'hole' between the Main and Lower Sands. The elevation of the bottom of Pit 4 (6800 feet above mean sea level (msl) per the 1985 Pit 4 Report) should be compared with the top of the Lower Sand elevation using the available lithologic data - based on the elevations in Figure 3, the bottom of Pit 4 would have been in the Lower Sand In addition, WDEQ is concerned that the influence of the Pit 4 dewatering and subsequent recharge on the tailings contaminant distribution is not well understood, particularly based on the water levels and contaminant concentrations in the wells to the west and southwest of Pit 4. Therefore, WDEQ requests that Petrotomics perform a comparative analysis of the Pit 4 activities with the ground water remediation activities and water level and water quality data.

4.0 SPECIFIC TEXT COMMENTS

The following comments are grouped by topic. For each topic, WDEQ has provided a brief explanation of why the topic is of concern, and then specific comments on that topic are presented in the order found in the ACL application.

4.1 Parameters of Concern

The ACL application only addresses those parameters of concern to NRC, i.e., radionuclides and select toxic metals. However, the contaminant plume includes parameters of concern to WDEQ, such as elevated sulfate concentrations and low pH, which render the water unsuitable for current and reasonably foreseeable future uses, such as stock and wildlife watering. Sulfate and low pH are considered in the ACL application, but only in relation to the mobility of radionuclides and the select metals, not in relation to their own impacts on water use.

1) Page 3 (last ¶ in §1.1.2): This paragraph lists standards for parameters of concern to NRC, but no reference is made to standards for parameters of concern to WDEQ. Before this ACL application could be considered by WDEQ, the parameters of concern to WDEQ would need to be addressed.

2) Page 39, Page 46 (2nd ¶): This paragraph illustrates how sulfate and pH were used in the ACL application, i.e., for evaluating the mobility of other constituents.

3) Page 51 (1st ¶ in §2.2.4.2.1) & Page 62 (4th bullet): Reference is made to risks associated with "site-derived constituents". However, because the constituents of concern in the ACL application are limited to those of concern to the NRC, no reference is made to risks associated with constituents of concern to WDEQ. In other words, sulfate concentrations which were high enough to preclude use of the water would not be considered a risk even though sulfate is a site-derived constituent.

4) Pages 69-70 (§2.3.7), Appendix A, Pages 27-28 (carryover ¶), 36-37 (carryover ¶) & 31-32 (carryover ¶): WDEQ does not accept Petrotomics' redefinition of the State's standards for protection of livestock. In particular, it is not clear that the standards used by Petrotomics, the Health Effect Levels (HELs), are 'sounder' than the State's standards considering the values are extrapolated primarily from data on "chicken, mallard duck, mouse, rat, and mink." Petrotomics does acknowledge potential adverse effects when the WQD standards are used.

5) Page 71 (Table 2-17), Page 73 (§2.3.12.1), & Page 43 (Table A.4): Comparison of the ACL list of constituents of concern with the constituents listed in Table I in Chapter VIII of the WQD's Rules and Regulations indicates a limitation of the ACL approach. Table I includes a much more extensive list of parameters of concern with respect to stock watering. A copy of Table I is included in Appendix A of this review.

6) Appendix A, Page 8 (§2.1.4, 2nd sentence): Two separate ground water classifications are noted in this sentence. The Class V designation is from the U.S. Environmental Protection Agency (EPA) and is a temporary reclassification to allow for mining. The Class IV designation is from the WQD, but the classification is done on a well-by-well basis. Therefore, water from a well in a uranium ore zone may be classified as Class IV (Industrial Use), while an adjacent well outside the ore zone may be classified as Class I (Domestic Use). (See Section 4.2 - Remediation Goals for additional discussion of ground water classification.)

The ground water beneath the property that lies downgradient of the Petrotomics Property must be protected to applicable ground water quality standards. The shallow ground water aquifers beneath Petrotomic's property (Upper and Main Sands) are not presently being used in the vicinity of the Petrotomics' mine, but future uses are feasible. The ground water aquifers in the Shirley Basin have not been classified by WQD. Due to naturally occurring radiological constituents along uranium ore bodies, it would be difficult to classify the aquifers over a broad area. In Wyoming, ground water is classified by use and by background conditions; whichever is the most pristine condition or highest classified use. The ground water in the immediate area is not presently being used for livestock uses, but it does need to be protected for potential uses.

4.2 Remediation Goals

WDEQ does not have regulations that accept a risked-based approach to corrective actions at sites where ground water is contaminated; therefore, Petrotomic's ACL application was reviewed based upon compliance with WQD's Chapter VIII Rules and Regulations, Quality Standards for Wyoming's Groundwaters. The Chapter VIII Standards are applicable to non-radiological ground water contamination beneath Petrotomic's property and ground water on adjacent properties that may be impacted from the contamination (i.e., radiological and non-radiological) plumes emanating from Petrotomic's contamination sources.

According to WQD's Chapter VIII Rules & Regulation's Section 4(d)(6), a facility having discharges to ground water resulting in concentrations in excess of standards can be allowed and permitted. The facility owner is required to return the water quality to applicable water quality standards or better, "excepting that the uranium concentrations in any Class I Groundwater of the

State shall not exceed the pre-discharge background concentration." Petrotomic's ACL application does not propose to return the ground water to applicable quality standards. In addition, Petrotomics' responses to questions raised by the NRC do not accurately reflect WQD's ground water classification process, so the appropriate standards are not recognized.

7) Page 1 (2nd ¶, 1st sentence): WDEQ believes that additional ground water remediation is necessary and can be done effectively to prevent contamination of ground water resources outside of Petrotomic's LQD permit boundary and NRC restricted area.

8) Page 2 (Item 5): As noted above, WDEQ does not accept risk-based corrective action analyses. In addition, WDEQ does not believe risk analyses are sufficiently protective of potential future uses.

9) Addendum 1, Page 18 (1st full ¶): Classification of the ground waters of the State of Wyoming is done on a *well-by-well* basis *by WQD* (unless an entire aquifer is being classified). If a well is in use, the classification is based on that use, e.g., domestic. If a well is not in use, the classification is based on the average of the available analyses for each sampling parameter and comparing the average value with the class-of-use standards in Table I of Chapter VIII of the Water Quality Rules and Regulations. The average concentration of each parameter cannot exceed the standard for a given class-of-use in order for the water from that well to receive that classification. The classification scenario outlined in Addendum 1 is not accurate; therefore, the conclusions about the applicable remediation goals are not accurate. Even in recent discussions with in-situ uranium producers about the classification process, a distinction is made between the ground water in the ore zone and ground water outside the ore zone.

   In addition, as outlined in Section 2.0 of this review, WDEQ believes there are serious concerns in the September 1996 Background Assessment which is relied upon in the Addenda. The radiological constituents (i.e., uranium and radium) are naturally occurring along the uranium ore bodies present in the Shirley Basin. Previous research has documented the areas where the ore bodies are present. Potential water users could review the existing research to determine the appropriate locations for drilling new wells to avoid areas with documented ore bodies.

10) Addendum 1, Page 20: The statement is made that WDEQ established a production water criteria for Ra-226 of 60 picoCuries per liter (pCi/l) for discharges to waters being "put to beneficial use for stock and wildlife watering and occasional irrigation." However, that regulation also states that "radioactive materials shall not be present in the water or in the sediments in amounts which could cause harmful accumulation of radioactivity in plant, wildlife, stock, or aquatic life." (WQD R&R, Ch. 1, §22(b)&(c)). Therefore, Petrotomics

must address not only the discharge concentrations, but the potential accumulated concentrations.

4.3 Expansion of the NRC Restricted Area

In order to encompass the areal extent of the ground water contamination in which the sulfate concentration exceeds 6,000 mg/l and the pH is less than 4.0, Petrotomics proposes expansion of the NRC restricted area. The expanded area would extend the boundaries of the NRC restricted area to the north and east to coincide with the current LQD permit boundaries (Figure 2). In addition to the concerns outlined below, the regulatory 'mechanics' of such an extension have not been discussed by NRC and LQD yet.

The U.S. Nuclear Regulatory Commission's (NRC) Alternate Concentration Limits for Title II Uranium Mills (January 1996) Staff Technical Position Guide and Review Plan provides guidelines for locating the POC and POE monitoring points. The attenuation processes acting on the contaminants between the POC and POE need to reduce the contamination to acceptable concentrations to the potential receptors at the POE. However, the predicted concentrations at the POE are unsuitable for Wyoming's Class III Standard. Therefore, even though the attenuation processes may reduce the concentrations to levels acceptable to the NRC, the concentrations are not reduced to levels acceptable to WDEQ based on reasonably foreseeable uses.

11) Page 5 (carryover ¶ from Page 4): Petrotomics states that the "buffer land", which would be inside the expanded NRC restricted area, would allow for attenuation of the "listed ground water constituents to acceptable levels". However, because the listed constituents do not include the contaminants of concern to WDEQ, attenuation of these contaminants is not taken into consideration.

12) Page 125 (1st full ¶), Page 128 (1st ¶ in §4.3), & Addendum 1, Page 16 (2nd ¶, last sentence): Other than the cursory discussions on these pages, WDEQ has not received any information that would indicate the U.S. Department of Energy (DOE) would be willing to take responsibility for the expanded area, particularly considering ground water contamination will extend beyond the expanded area.

4.4 SEO Designation of a Restricted Use Area

In off-site areas of ground water contamination, Petrotomics seems to rely heavily on institutional controls, including appropriation restrictions by the Wyoming State Engineer's Office (SEO), to limit ground water development. WDEQ believes this reliance is misplaced.

13) Page 66 (last sentence), Page 124 (5th bullet) & Appendix A, Page 10 (§2.2.1, 5th sentence): It is WDEQ's understanding that the State Engineer's Office (SEO) is reluctant to designate areas where ground water withdrawal is curtailed due to ground water contamination. Petrotomics must contact the SEO to determine whether such restrictions are a viable option or not; *however*, such a designation would still not meet the requirements of the Wyoming Environmental Quality Act. Based on information in the Petrotomics file, the Main Sand can easily produce sufficient water to maintain a stock or industrial well. There are numerous permitted wells throughout the state that tap perched aquifers or similar features that are of limited areal extent but have sufficient capacity to provide valuable water resources.

14) Page 68 (4th bullet), Page 69 (2nd bullet), & Appendix A, Page 2 (carryover ¶ from Page 1, last sentence), Addendum 1, Pages 11, 13, 16, & 19: Petrotomics cites the option for alternate water sources from the Lower Sand as a factor in reducing the risk associated with the proposed ACLs. However, if the Lower Sand in connected to the shallower sands due to the mine pits, then development of the Lower Sand is jeopardized. In addition, well completions would also be limited in the Lower Sand to areas outside the contaminant plumes to avoid well completions through the plumes. A well completion through a plume would cost more, due to the need for double casing to protect from cross-contamination during drilling, and would be of long-term concern because of potential problems due to improper completion and deterioration of the well over time.

4.5 Site Characterization

Petrotomics has emphasized the harsh surface conditions in the Shirley Basin in an apparent effort to justify statements about the limited potential for future development of water resources in the basin. However, WDEQ believes several of the statements are excessive, particularly considering the wide range of climatic conditions humans inhabit just within the United States, the dependence on the surface water sources in the Shirley Basin, and historically poor foresight in predicting where growth will occur (e.g., Las Vegas and the High Plains).

4.5.1 Ground Water Conditions

15) Page 5 (1st ¶ in §1.3, 2nd sentence): Although steady declines in contaminant concentrations have been noted in some wells, such declines have not been noted in all wells or for all parameters, as discussed in Section 2.0 of this review. Petrotomics should avoid broad generalizations that are overly optimistic.

16) Page 5 (§1.3): WDEQ believes this summary section should mention that ground water contamination has migrated to (& is migrating in) the Main Sand. Only conditions in the Upper Sand are now discussed in this section.

17) Page 6 (§1.4): It is WDEQ's understanding that the September 1996 Assessment of background conditions, which relies wells other than 39SC and 41SC, includes the background criteria Petrotomics intends to use.

18) Page 21 (§2.1.2.1, 1st ¶): The statement that the rate of leakage from the tailings peaked in 1980 should be clarified, particularly as the reported amount of "tailings and liquid effluent produced" was over 1,000,000 tons in 1970, 1979, and 1981-1985, based on the estimates in Table 2-1.

19) Page 21 (§2.1.2.1): LQD has had some success in evaluating historic leakage rates from tailings pond using the original pond designs. If Petrotomics's has not already done so, the initial pond designs should be reviewed.

20) Page 26 (3rd ¶ in §2.2.2, 4th sentence): Please note that the referenced isohyetal maps include the mountains to the east, and LQD has previously expressed concern about the higher precipitation value. The impact of using a higher precipitation value on the model results should be discussed.

21) Pages 29-39 (§2.2.3.2): The parameter-by-parameter discussion of geochemical considerations is helpful.

22) Page 50 (2nd bullet), Page 67 (carryover ¶ from Page 66), Appendix A, Page 8 (7th sentence) & Addendum 1, Pages 3 & 4: The rate of future ground water contribution from the tailings leakage to Petrotomics' Pit 33 Reservoir is calculated as 2% in the ACL application, and the analysis of the contribution of mass of constituents to the reservoir was in the December 1996 Addenda (Issue 1, Factor 7, Pages 6 & 7, Figure 1). However, this 'contribution' analysis only discusses the *incremental* contribution to the Pathfinder Reservoir. Depending upon the ratio of constituent concentrations in the reservoir to the influent concentrations, the tailings leakage could impact usage of the reservoir for stock and wildlife watering, the approved post-mine reservoir use. For example, if the sulfate concentration in the reservoir is 2,800 mg/l, and an additional 500 mg/l are 'added' by the tailings leakage, the resulting reservoir concentration would exceed the WDEQ class-of-use standard of 3,000 mg/l. The incremental contribution should be compared to the concentrations in the reservoir (such as those reported in Table 1 of Addendum 1) to affirm the assertions that impacts to the

reservoir will be minimal. This analysis should include both the constituents of concern in the ACL application and other constituents, such as sulfate and pH, which could impact reservoir usage.

In addition, in the Addenda, the implication is that stocking of Pit 33 with fish will not be permitted by WDEQ. However, if Pathfinder wishes to change the post-mining use of the reservoir in the future to include a fishery, it could be considered by WDEQ.

23) Page 57 & Figures 2-3 & 2-4: WDEQ is concerned that representing the source loading as decreasing exponentially from a single area is not realistic, particularly for the Main Sand. Based on the dynamics of the sulfate distribution discussed in Section 2.0 of this review, the initial sulfate concentration around the area of Well 18DC is was significantly higher than 10,000 mg/l until pumping began and behavior of Well 9DC shows there may still be an unrecovered 'slug' of contaminated ground water.

24) Figures 2-7, 2-8, 2-32 & 2-33: The 'data points', i.e., the well locations and corresponding ground water elevations or sulfate concentrations, should be shown on the figures (see, e.g., Exhibits 4-1 Upper & Main in Appendix E). In particular, the date of the water level measurements should also be shown. In order to avoid 'over-crowding' the figure, but keeping the 8½x11 format, even showing 'strategic' wells, if not all the wells, and their respective elevations or concentrations would be helpful. This is of particular concern because the date of the water level measurements is crucial considering the changes that have occurred in the last few years and some of the unusual water levels (e.g., in Wells 69SC and 18DC discussed in Section 2.0 of this review).

The present fate and transport modeling results predicted that by 2100, the sulphate plume in the Main Sand will reach Petrotomic's east property boundary. The modeling predicts that sulphate concentrations up to 5800 mg/l will migrate north from Petrotomics and onto the Pathfinder property and concentrations up to 3700 mg/l will migrate to the main east property. Since Figures 2-41, 2-49, and 2-51 in the ACL Application of the predicted parameter concentrations did not extend beyond the east boundary, the offsite extent of the sulphate plumes is not illustrated. Petrotomics must provide contaminant iso-concentration maps for the years' 2200, 2500, and 3000 that include the entire sulphate and TDS plumes that have emanated from the Petrotomic's property.

25) Appendix A, Pages 6-7 (§2.1.2): In the second sentence in this section, the statement is made that "constituent concentrations decreased in wells that were completed at increasing distances from the tailings impoundment." However, as discussed in

Section 2.0 of this review, the sulfate concentration in at least one of the wells is increasing while the pH is decreasing, indicating increased impact of leakage from the tailings. In the last full sentence on Page 6, the statement is made that "concentrations have also begun to decrease slightly due to attenuation and dispersion." Again, based on the existing data, this statement is too broad. Although concentrations have declined in some wells, they have increased in others, indicating that the "buffering and attenuation capacity" of the subsurface materials are not sufficient to impact concentrations "within a short distance of the tailings impoundment". The interpretation in this section also depends upon the 'constituent list'. Because some of the parameters of concern to WDEQ are more mobile than those on Petrotomics' 'constituent list', this section does not address all the parameters of concern.

26) Addendum 1, Page 15 (2nd ¶): Please discuss the selection of Wells 5DC and 12DC as POC wells in light of the facts that the sulfate concentrations in Well 18DC are higher than those in Well 5DC and that Well 12DC did not fit with either the 'impacted' or 'non-impacted' wells according to the 1996 Background Assessment.

27) Addendum 1, Page 16 (last ¶): It should be clarified whether or not the mine pits, in particular Pit 4 and Pit 33, penetrated the shale between the Main and Lower Sand.

4.5.2 Future Development

28) Appendix A, Page 5 (1st ¶): It is LQD's understanding that there are other minerals and other uranium mining methods (e.g., in-situ mining) of interest in the Shirley Basin.

29) Appendix A, Page 13 (§2.2.2): LQD has received inquiries about the potential for development of the Jenkins Pit for recreation, which would impact water usage.

4.5.3 Wildlife

30) Page 26 (2nd ¶ in §2.2.2, last sentence) & Appendix A, Page 4 (2nd full ¶): The implication seems to be that wildlife are present in Shirley Basin for only 2 or 3 months of the year and winter in a limited locality, such as Bates Hole. These statements do not give an accurate picture of the extent of migration, the wintering areas along the Medicine Bow River, or similar aspects of the extent of wildlife usage of the Basin.

31) Appendix A -Page 7 (§2.1.3): The phrase "limited hunting" is not clear. Like most states, Wyoming has restrictions on hunting to help sustain healthy game populations.

4.6 Continued Effectiveness of the Existing Remediation System

Petrotomics emphasizes the difficulties of continued remediation of the Upper Sand at the expense of a thorough discussion of the potential for continued remediation of the Main Sand.

32) Page 2 (1st ¶ in §1.1.2, last sentence), Page 64 (carryover ¶ from Page 63), Page 74 (§2.3.14, 3rd sentence), Page 78 (last ¶), & Page 82 (1st sentence): WDEQ is not convinced that the Main Sand has been dewatered to the point of "inefficient and ineffective pumping levels", as discussed in Section 2.0 of this review. Although some of the wells may no longer be able to produce 20 gpm (Table II), WDEQ believes a lower pumping rate, or a cyclic pumping scenario, would be effective in removing additional contaminants and controlling off-site migration of contaminated ground water.

33) Page 3 ('bullets'): The pumping of three Main Sand wells (Wells 5DC, 12DC, & 18DC) is not listed as one of the compliance actions in the Corrective Action Plan (CAP). It should be clear whether the Main Sand pumping was part of the CAP or not, and it should also be clear that three wells in the Main Sand were pumped, whether that was a part of the CAP or not.

34) Page 6 (1st sentence) & Table 1-1: The discussion of the water level declines in the Upper Sand illustrates the emphasis on the shallower sand and the lack of discussion of the Main Sand.

35) Pages 9-20 (§2.1.1): The information in this section, and its presentation, were valuable to WDEQ's review.

36) Page 19 (Table 2-8): This table would be more useful if it differentiated between the mass of material removed from Upper Sand and the mass removed from the Main Sand or cross-referenced the tables in Section 3.

37) Page 80-81: Petrotomics emphasizes their efforts to date to control the tailings leakage and contaminant migration. Given the level of effort to date, WDEQ is surprised that the company would not be willing to consider continued pumping of the Main Sand, particularly as such pumping would be of more limited scope than the efforts to date and would help prevent potential liability for off-site impacts.

38) Page 82 (§3.2.2, 1st ¶, last sentence): 'Pulling' contaminants from the Upper Sand is not necessarily detrimental, and if the Main Sand remediation system were carefully

designed, could actually speed site closure. Also, as noted in Section 2.0 of this review, contaminant concentrations in the Main Sand already exceed or are equal to the concentrations in the Upper Sand (Figure 10). Also, the natural gradient is downward, so the contaminants will migrate from the Upper to the Main Sand near the 'hole' even if no additional remediation of the Main Sand occurs.

39) Page 120 (last ¶): If 158 million gallons were removed in 7.25 years, this value converts to 2.2 million gallons per year or 4 gallons per minute. There appears to be considerable variation in the production rate of the three Main Sand wells that have been pumped and some decline in the pumping rate over time in the most productive well (Table II). Even so, WDEQ believes that the Main Sand can still produce sufficient water to effectively impact contaminant migration.

40) Table 3-7: Reference to this table was not found in the text, although it may have been overlooked.

41) Appendix E (Title): The title of this Appendix is confusing. Although data from both the Upper and Main Sands is included in this appendix, all of the text appears to focus on the Upper Sand. For example, only one water elevation map is presented and that one is for the Upper Sand. However, the term Upper Wind River Sand, which could mean the Upper Sand and Main Sands or just the Upper Sand, is used extensively. The impacts of the corrective action on the conditions in the Upper Sand should be discussed separately from the impacts to the Main Sand.

4.7 Problems in Petrotomic's Alternate Remediation Scenarios

Petrotomics should differentiate their need to close the tailings area from overall site closure and tailings closure. Closure of the tailings area does not preclude continued ground water treatment, although it does require use of an alternate area and/or method for treatment. WDEQ believes Petrotomics' has been overly 'pessimistic' and unrealistic in their evaluations of alternate remediation scenarios and has not targeted these scenarios to the most critical water quality problems.

42) Page i (2nd ¶, 3rd sentence), Page 82 (§3.2.2, 1st ¶, last sentence), Page 101 (§3.2.8.3): Pumping of just the Main Sand is not identified as an alternate remediation scenario, even though it is implicitly criticized because of the fact that water from the Upper Sand will be 'pulled' into the Main Sand near the 'hole'. As discussed in Sections 2.0 and 4.5 of this review, WDEQ believes pumping of the Main Sand should be evaluated as an alternate remediation scenario.

Since the sulphate plume lying beneath the tailings area is still present in the years 2500 and 3000, it appears to be from a continuous source that does not decrease significantly with time. Petrotomics can feasibly implement additional corrective actions to prevent the predicted ground water contamination concentrations at the property boundary and at locations outside the Restricted Area. Neither the ACL application nor the Addenda describe how the constituent concentrations and the movement of the ground water contamination plumes would be affected by additional pumping. Petrotomics needs to evaluate the effects of implementing this remedial action. The difference in the contaminant concentrations for the following scenarios: 1) pumping the Main Sand Aquifer for a reasonable amount of time, versus 2) not implementing any active remedial actions, needs to be determined. Petrotomics has removed a considerable amount of contaminant mass through their remedial actions to date, but a significant amount of contamination remains in the Main Sand Aquifer. If no actions are taken to actively remediate the aquifer, the fate and transport modeling predicted that unacceptable concentrations of non-radiological contaminants would reach the north and east property boundary moving off-site in both directions.

43) Page 69 (1st & 3rd bullets): WDEQ believes it is optimistic to assume an institutional control or notification monument will remain in place for 1,000 years.

44) Page 79 (carryover ¶ to Page 80) & Page 93 (§3.2.4.6, 2nd ¶): Variations in water quality among the wells could be taken care of by mixing the water pumped from the different wells prior to treatment, rather than installing a separate treatment system for each well.

45) Page 85 (§3.2.3.1): No mention is made of the possibility of pumping Main Sand wells, either existing or new. WDEQ believes an effective pumping network could be designed to allow for continued remediation of the Main Sand, which could also improve the Upper Sand water quality near the tailings.

46) Page 88 (3rd ¶, last sentence) & Pages 89 through 91 (§3.2.4.3): The only deep well disposal alternative seems to be construction of an on-site well. However, there are existing disposal wells in the state, including wells at in-situ uranium facilities and commercial disposal wells, which might or might not be capable of disposing of Petrotomics' waste stream. In addition, rehabilitation of an old oil and gas well, if available, could be an option rather than construction of a new well.

47) Page 91 (§3.2.4.4): Electrodialysis could be considered to be in the "experimental & development stages" because of the project scale, otherwise, the technique has been used at a laboratory scale for some time.

48) Page 94 (§3.2.5): WDEQ is curious whether it would possible to design a 'plug' for the 'hole' between the Upper and Main Sands, rather than a slurry wall. However, such a 'plug' even if possible, would not allow pumping of the Main Sand to 'pull' contamination out of areas of the Upper Sand, which no longer sustain pumping.

49) Page 97 (2nd ¶), Page 98 (§3.2.7.2) & Page 111 (§3.3.5.2): No basis is provided for the assumption that a 120 gpm pumping rate is necessary - pumping of ten wells at five gpm each could be more effective. If a lower pumping rate proved effective, evaporation ponds covering much less than 75 acres could be used. In turn, costs for this option could reduced proportionately.

50) Page 112 (3rd bullet): A 3% evaporation rate seems low. A reference for this rate must be provided.

51) Appendix A, Page 1 (1st ¶, next to last sentence): As discussed throughout this review, WDEQ does not believe "Petrotomics has determined....", in an appropriate manner, that "further ground water restoration" is neither practical nor cost effective.

4.8 Ground Water Model

A substantial portion of Petrotomic's ACL application is based on the model results. Although WDEQ believes the model 'construction' appears reasonable, the complete input parameters have not been provided. In the evaluation of the calibration process, the emphasis appears to have been on the Upper Sand, so the calibration 'success' of the model for the Main Sand is not clear.

52) Page 49 (1st ¶) & Appendix F, Page 6 (2nd ¶): Please discuss whether changes were made to the way in which the pits were simulated after the calibration period. For example, Pit 33 was dewatered over the calibration period so it was treated as a constant head node with the head set equal to the elevation of the bottom of the pit. However, the pit is now recovering, but it is not clear how it is currently simulated. There is some discussion on Page 49 of the main text, but it is very general.

53) Page 51 (bullet) & Addendum 1 (Page 9): Please discuss the reasons the base flow to the river increases and for what length of time the concentrations to the river increase.

54) Figures 2-28 through 2-30: A better explanation of the relationship between the Model Zero Saturation Limit and the site hydrogeology would be helpful.

55) Appendix F, Page 4 (last ¶), Page 5 (1st ¶), Page 8 (§5.1): The input arrays for the aquifer top and bottom elevations, conductivities, head distributions, and other parameters should be provided.

56) Appendix F (Page 5): Please discuss how the 'hole' between the Upper and Main Sands was simulated. Also, a vertical hydraulic conductivity of 1% for the aquifer materials seems low - please discuss the basis for this value (e.g., stratification within the sands or similar factors).

57) Appendix F (Page 8): Please discuss why water levels from Main Sand wells were used not used as calibration targets.

58) Appendix F (Figures 24-26): Without a copy of the potentiometric contours based on the measured water levels, evaluation of the Calibrated 1985 Potentiometric Surface is difficult.

59) Please discuss the sensitivity analyses that were performed.

4.9 Typographical & Editorial Comments

These comments should be self-explanatory.

60) Throughout Application: It would be easier to reference specific portions of the application if each section had a unique pagination scheme (e.g. A-# for Appendix A).

61) Page 38 (last sentence): The sulfate concentrations are shown on Figure 2-23, and the chloride concentrations are shown on Figure 2-22, rather than vice versa.

62) Page 61 (Table 2-16, last column): The title of this column should be 'POE (Main *East*)'.

63) Page 74 (§2.3.14, 2nd sentence): The word "futurewell" should be corrected.

64) Page 127 (3rd & 4th bullets): These two bullets are the same.

65) Appendix A, Page 14 (§2.3.1, 1st sentence): The phrase "shallow and aquifer" should be corrected.

Table I
Comparison of Proposed Background Concentrations with Predicted ACL Concentrations
WDEQ Review of Petrotomics ACL Application - TFN 3 5/134
September 1997

	pH	Uranium (mg/l)	Radium-226 (pCi/l)	Sulphate (mg/l)	TDS (mg/l)
Background Wells[1]					
Averages (10/17/81 - 2/29/96)	7.04	0.055 *0.050 (w/o Well 16DC)*	40 *16 (w/o Well 16DC)* *0.77 (just Well 41SC)*	1230	1718
Ranges (10/17/81 - 2/29/96)	5.76 - 8.25	<0.001 - 3.24	0.13 - 216 *0.13 - 61 (w/o Well 16DC)* *0.19 - 1.9 (Well 41SC only)*	1760	730 - 7260 *730 - 3606* *(w/o Well 41SC's 1st value)*
Predicted Maximum Future Concentrations[2]					
Upper Sand North POE (Year) & East POE (Year)	 -- --	 0.09 (3000) <0.01 (2000)	 272 (--) 272 (--)	 5800 (2050) 2500 (2050)	 -- --
Main Sand North POE (Year) & East POE (Year)	 -- --	 <0.01 (2000) <0.01 (2000)	 272 (--) 272 (--)	 5500 (2000) 3700 (2200)	 -- --
WDEQ Class III Standards					
	6.5 - 8.5	5	5[3]	3000	5000

[1] The proposed background wells include: 41SC, 67SC, 69SC, 70SC, 10DC, 11DC, and 16DC.
[2] The uranium and sulphate concentrations are from Table 2-15 and the Ra-226 concentrations are from Table A.3 of the ACL application.
[3] The Radium Standard includes both Ra-226 and Ra-228.

Table II
Pumping Rates from Main Sand Remediation Wells
WDEQ Review of Petrotomics ACL Application - TFN 3 5/134
September 1997

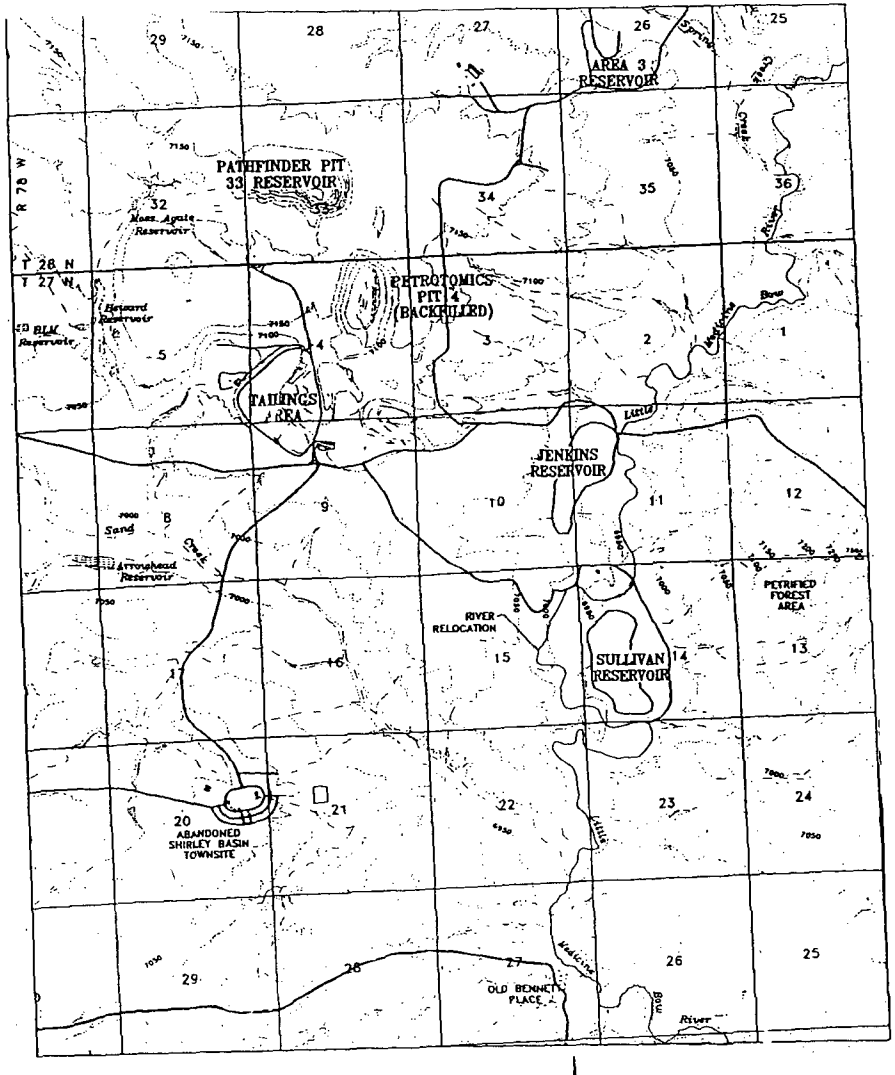
	Well 5DC		Well 12DC		Well 18DC	
	gallons/year[1]	gpm[2]	gallons/year[1]	gpm[2]	gallons/year[1]	gpm[2]
1989	20,886,163	40	--		--	
1990	27,450,864	52	--		--	
1991	34,757,856	66	--		--	
1992	26,669,261	51	6,926,573	13	--	
1993	9,951,883	19	7,624,008	14	--	
1994	10,560,312	20	--		--	
1995	--	--	9,437,803	18	630,907	1
1stQ 1996	--	--	2,646,101	5	657,518	1

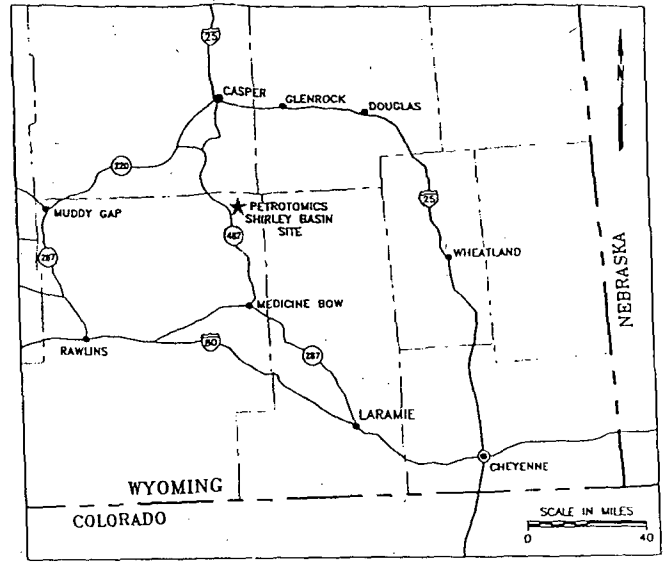
[1] From Table 3-7 in the ACL application.
[2] Assuming the well was pumped every day, all day.

Table III
Quantity of Contaminants Removed per Quantity of Ground Water Pumped
WDEQ Review of Petrotomics ACL Application - TFN 3 5/134
TFN 3 5/134 - September 1997

Parameter	Pounds Removed per 1,000 Gallons Pumped	
	Upper Sand[1]	Main Sand[2]
TDS	222.44	403.52
Chloride	2.85	2.11
Sulfate	147.31	95.81
Arsenic	4.34e-05	2.79e-05
Barium	2.60e-04	3.35e-04
Cadmium	1.06e-03	2.93e-04
Chromium	0.01	7.39e-04
Lead	3.23e-03	1.06e-03
Nickel	0.03	0.02
Selenium	1.09e-04	5.58e-05
Uranium	0.07	0.01
Radium-226	1.36	0.72
Radium-228	0.08	0.36
Thorium-230	7.04	0.42

[1] The values for the Upper Sand were calculated using the information in Tables 3-6a&b of the ACL application.
[2] The values for the Main Sand were calculated using the information in Table 3-8 of the ACL application.

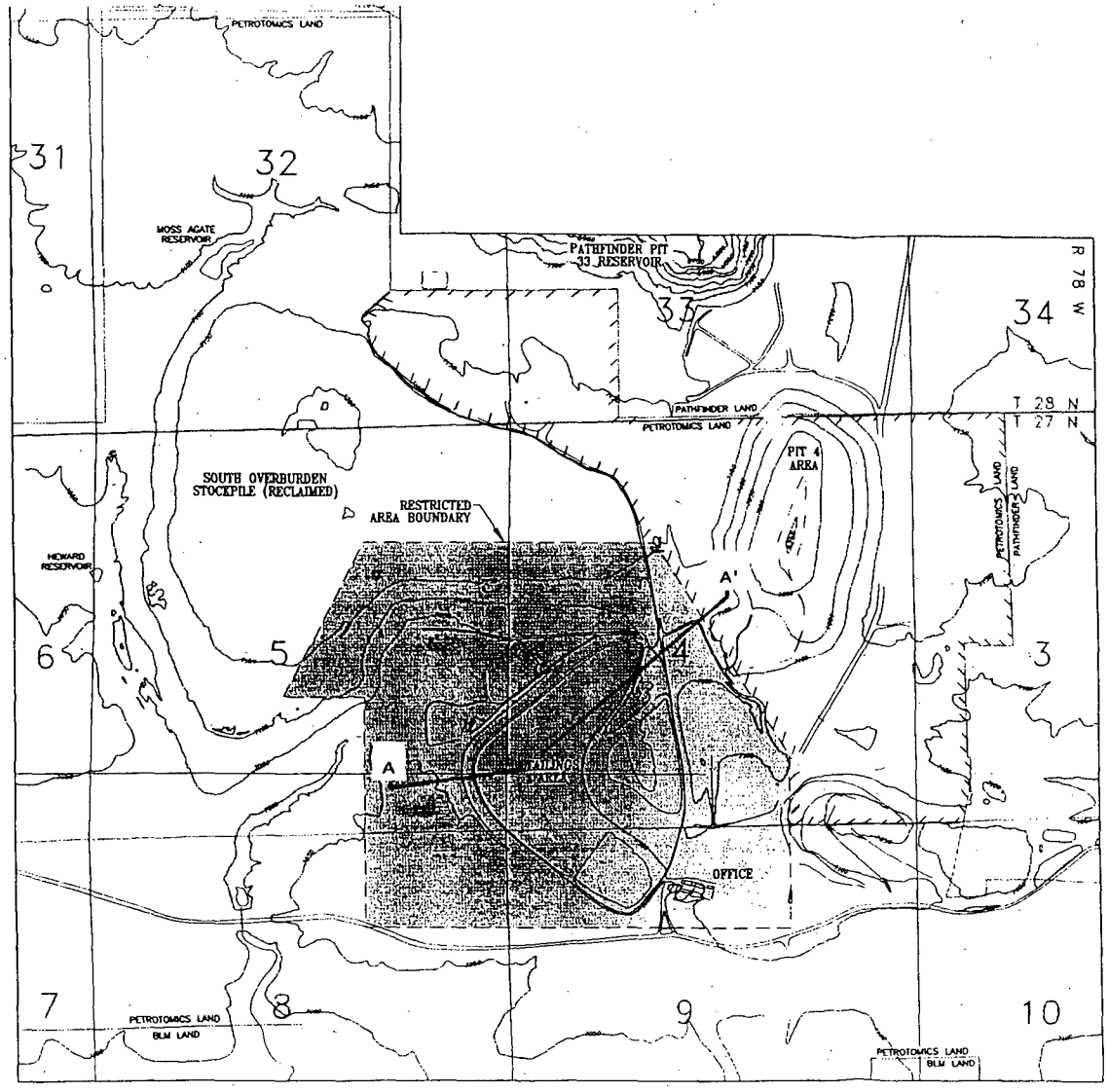




BASE MAPS: FIGURES 1-1 & 2-5 OF PETROTOMICS' ACL APPLICATION

FIGURE 1
LOCATION MAP
SHIRLEY BASIN AREA

PREPARED BY WDEQ - TFN 3 5/134
AUGUST 1997



BASE MAP: FIGURE 1-1 OF THE ACL APPLICATION

LEGEND:

PETROTOMICS PROPERTY

CURRENT NRC RESTRICTED AREA

A — A' APPROXIMATE CROSS-SECTION LOCATION (SEE FIGURE 3)

LQD PERMIT BOUNDARY

N

SCALE IN FEET

1500 0 3000

FIGURE 2
LOCATION MAP
THE PETROTOMICS COMPANY
SHIRLEY BASIN SITE

PREPARED BY WDEQ - TFN 3 5/134
AUGUST 1997

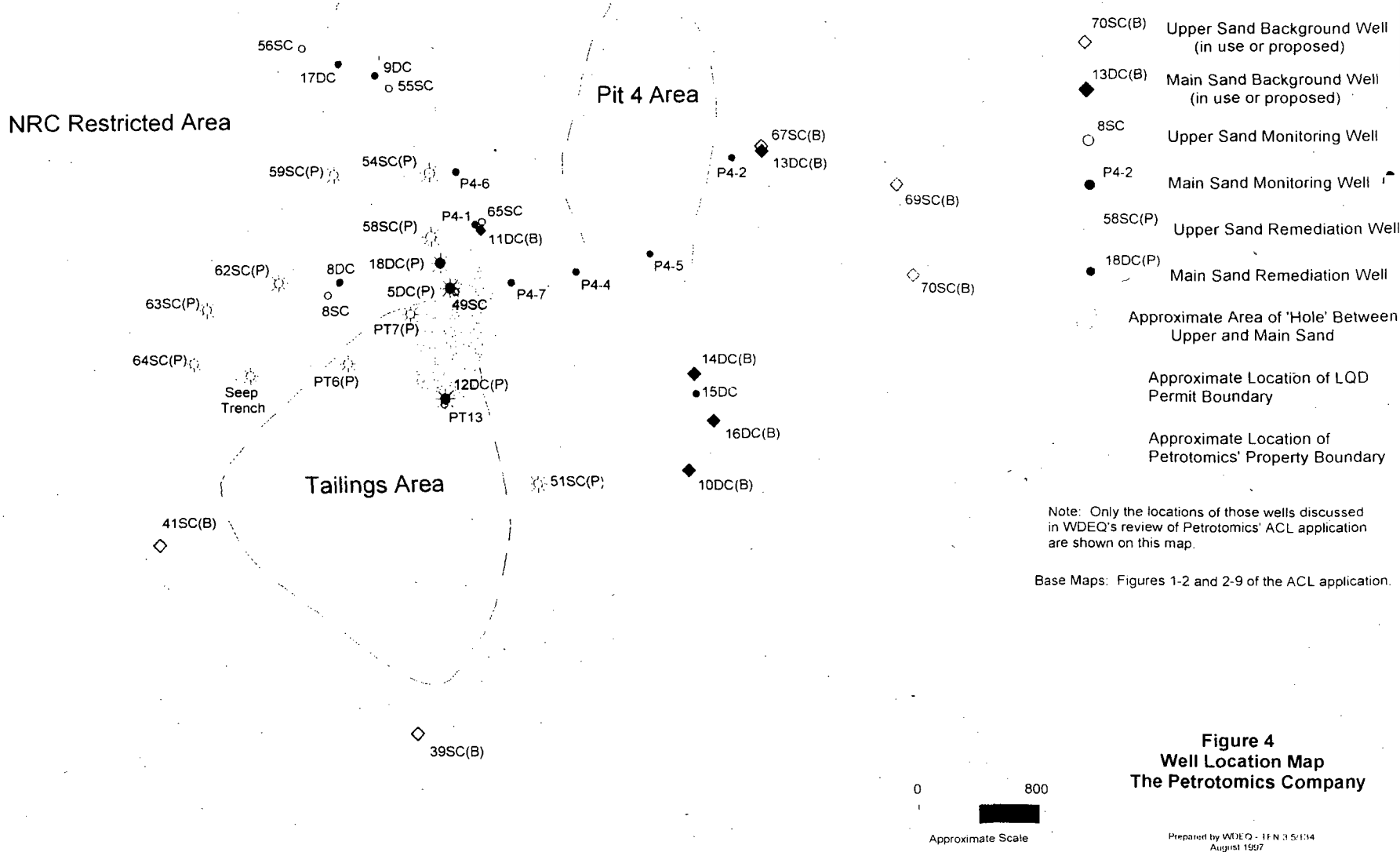
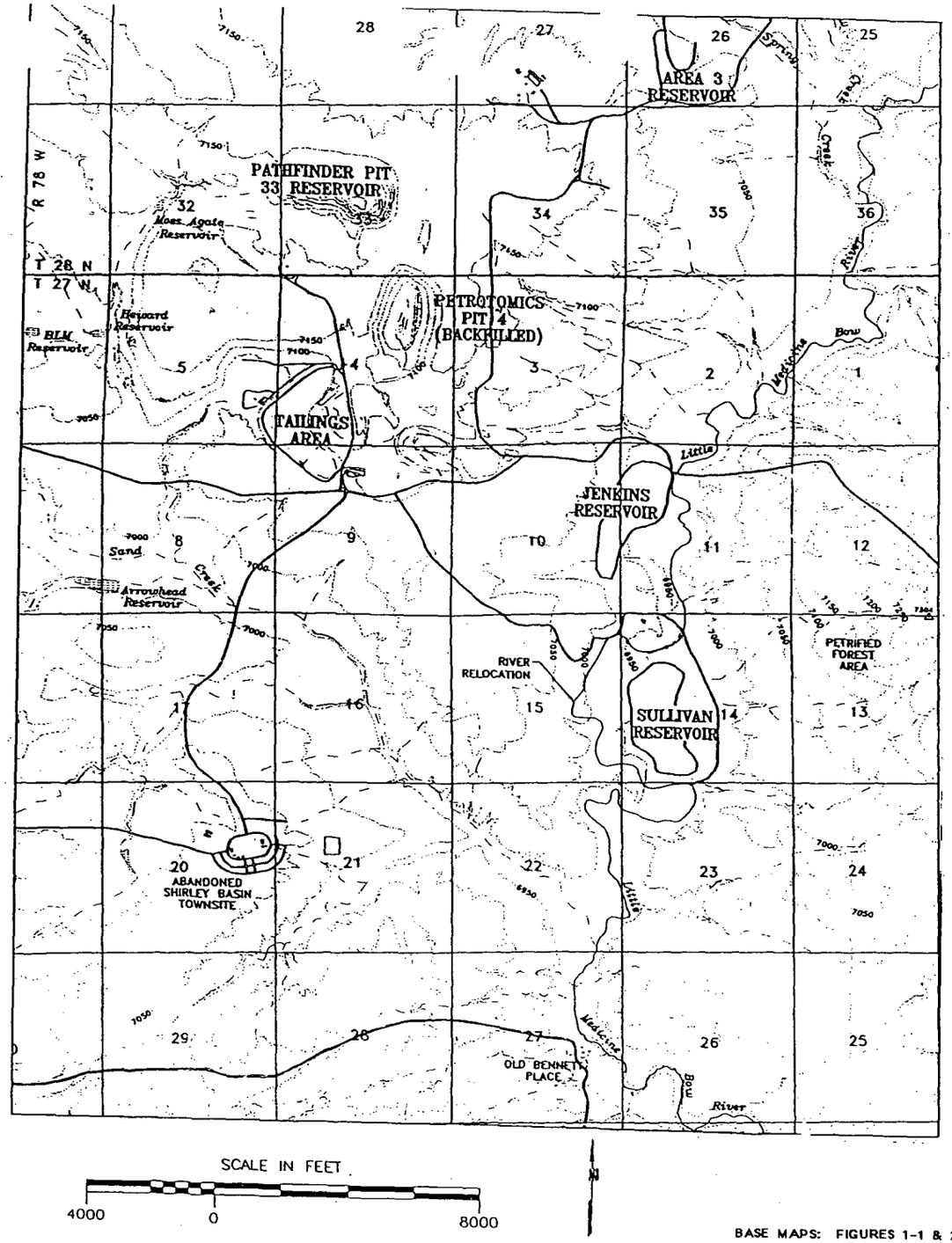
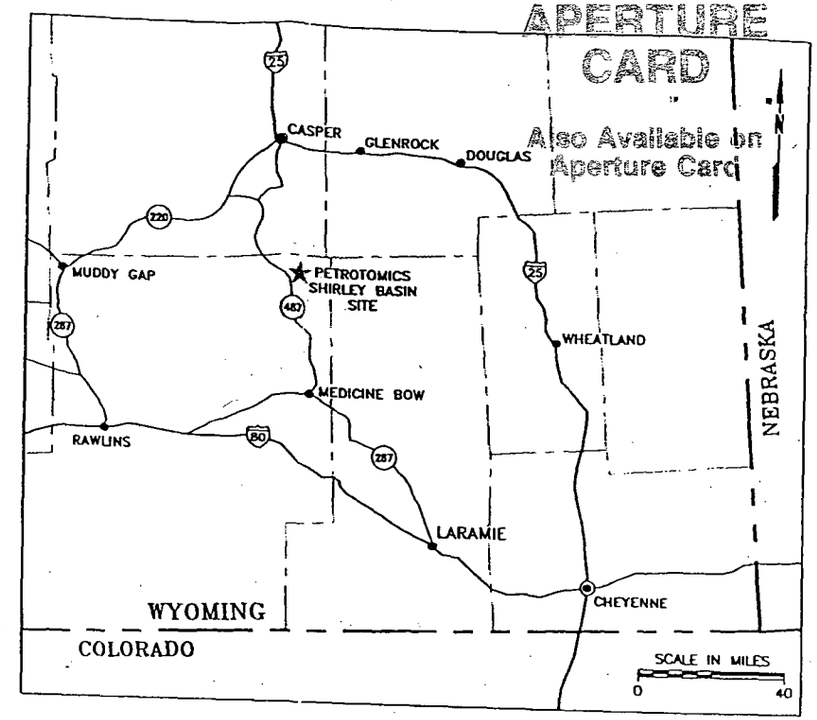


Figure 4
Well Location Map
The Petrotomics Company

3 fold-out MAPS follow





APERTURE CARD
Also Available on Aperture Card

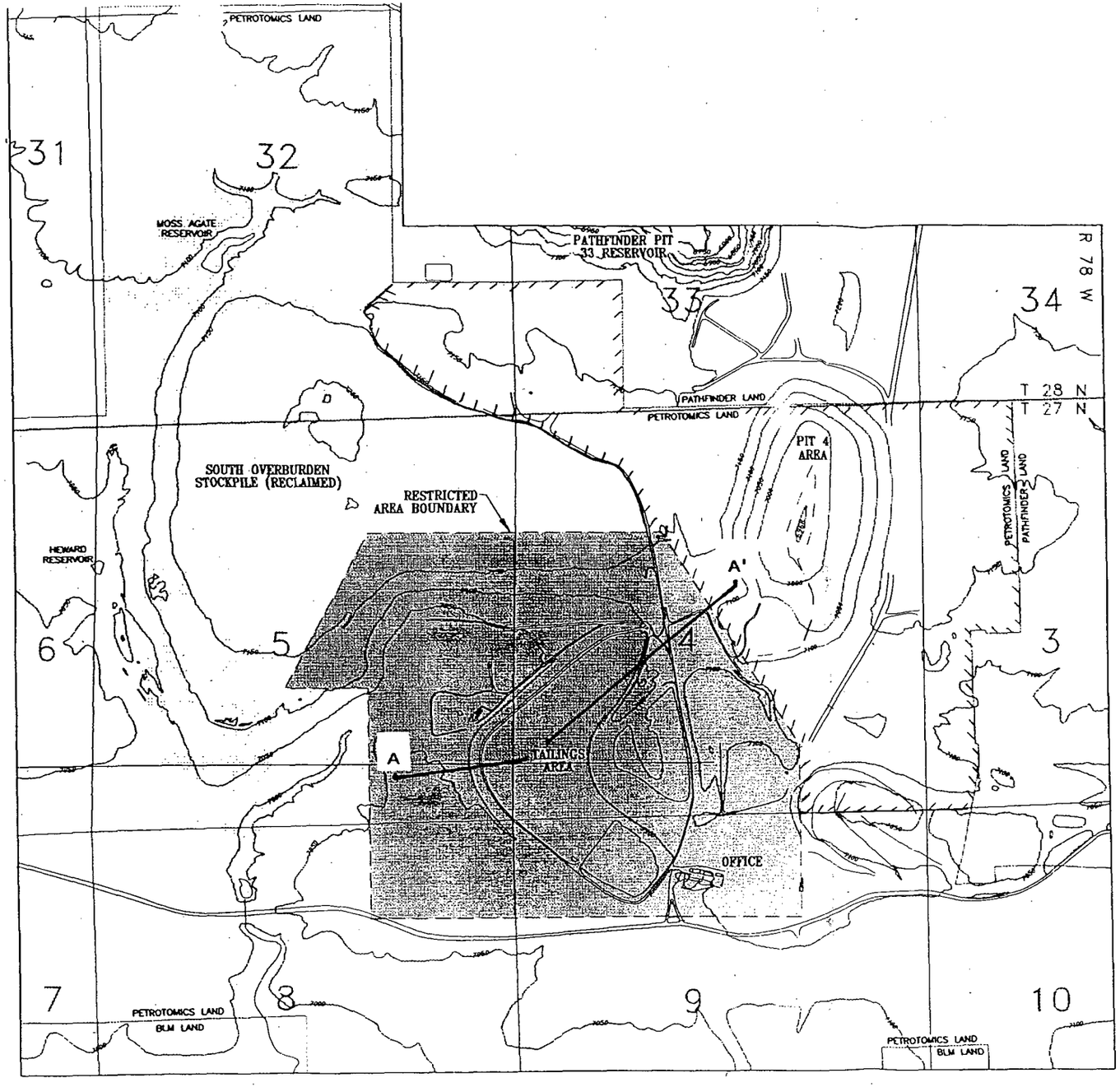
9710030151-01

FIGURE 1
LOCATION MAP
SHIRLEY BASIN AREA

BASE MAPS: FIGURES 1-1 & 2-5 OF PETROTOMICS' ACL APPLICATION

PREPARED BY WDEQ - TFN 3 5/134
AUGUST 1997

MICROFILMED
APERTURE
CARD



BASE MAP: FIGURE 1-1 OF THE ACL APPLICATION

LEGEND:

Also Available on Aperture Card

PETROTOMICS PROPERTY

CURRENT NRC RESTRICTED AREA

A — A' APPROXIMATE CROSS-SECTION LOCATION (SEE FIGURE 3)

LQD PERMIT BOUNDARY

N

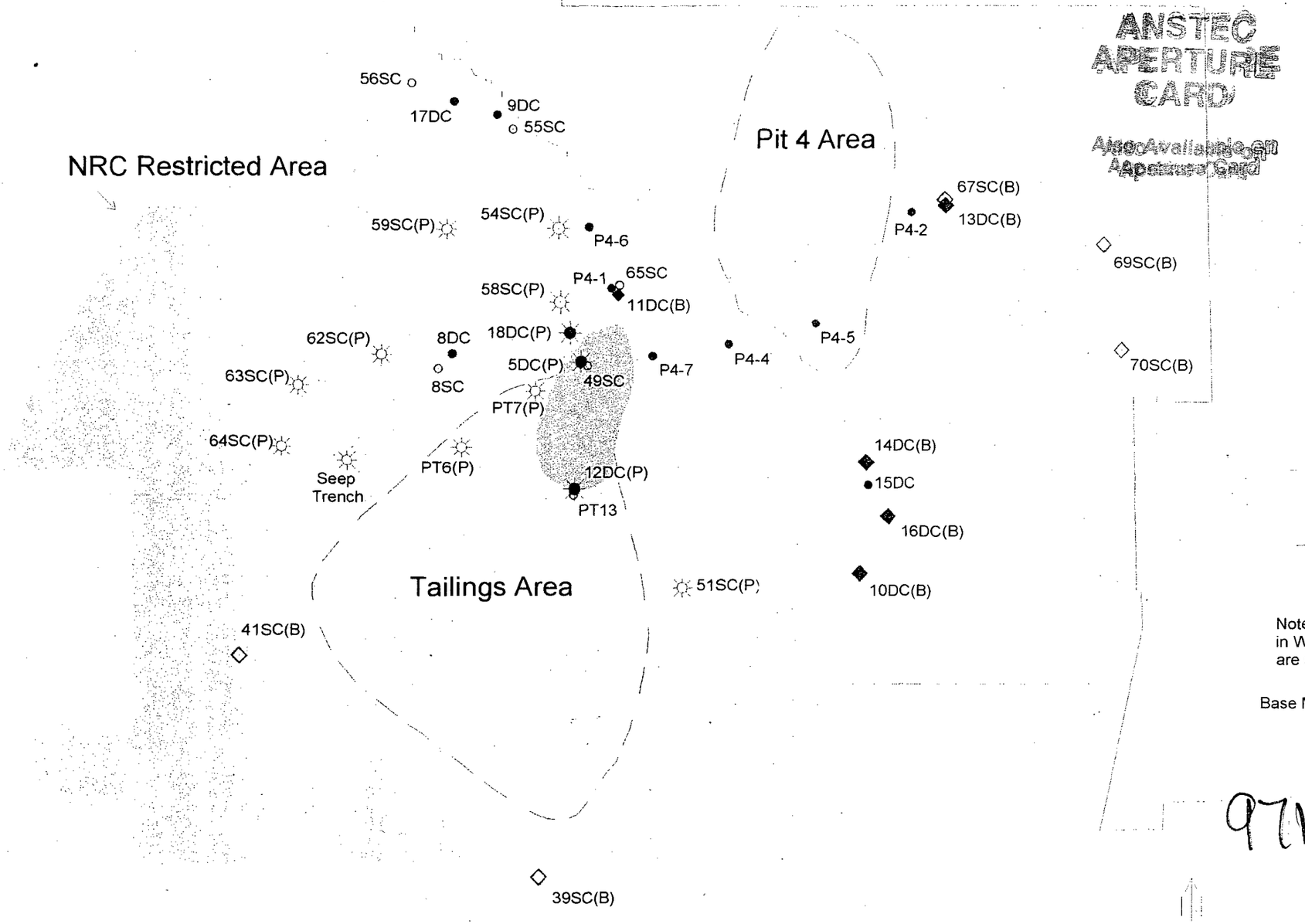
SCALE IN FEET

1500 0 3000

9710030151-02

FIGURE 2
LOCATION MAP
THE PETROTOMICS COMPANY
SHIRLEY BASIN SITE

PREPARED BY WDEQ - TFN 3 5/134
AUGUST 1997



ANSTEC APERTURE CARD
AnsecAvailable on Aperture Card

70SC(B) Upper Sand Background Well (in use or proposed)

13DC(B) Main Sand Background Well (in use or proposed)

8SC Upper Sand Monitoring Well

P4-2 Main Sand Monitoring Well

58SC(P) Upper Sand Remediation Well

18DC(P) Main Sand Remediation Well

Approximate Area of 'Hole' Between Upper and Main Sand

Approximate Location of LQD Permit Boundary

Approximate Location of Petrotomics' Property Boundary

Note: Only the locations of those wells discussed in WDEQ's review of Petrotomics' ACL application are shown on this map.

Base Maps: Figures 1-2 and 2-9 of the ACL application.

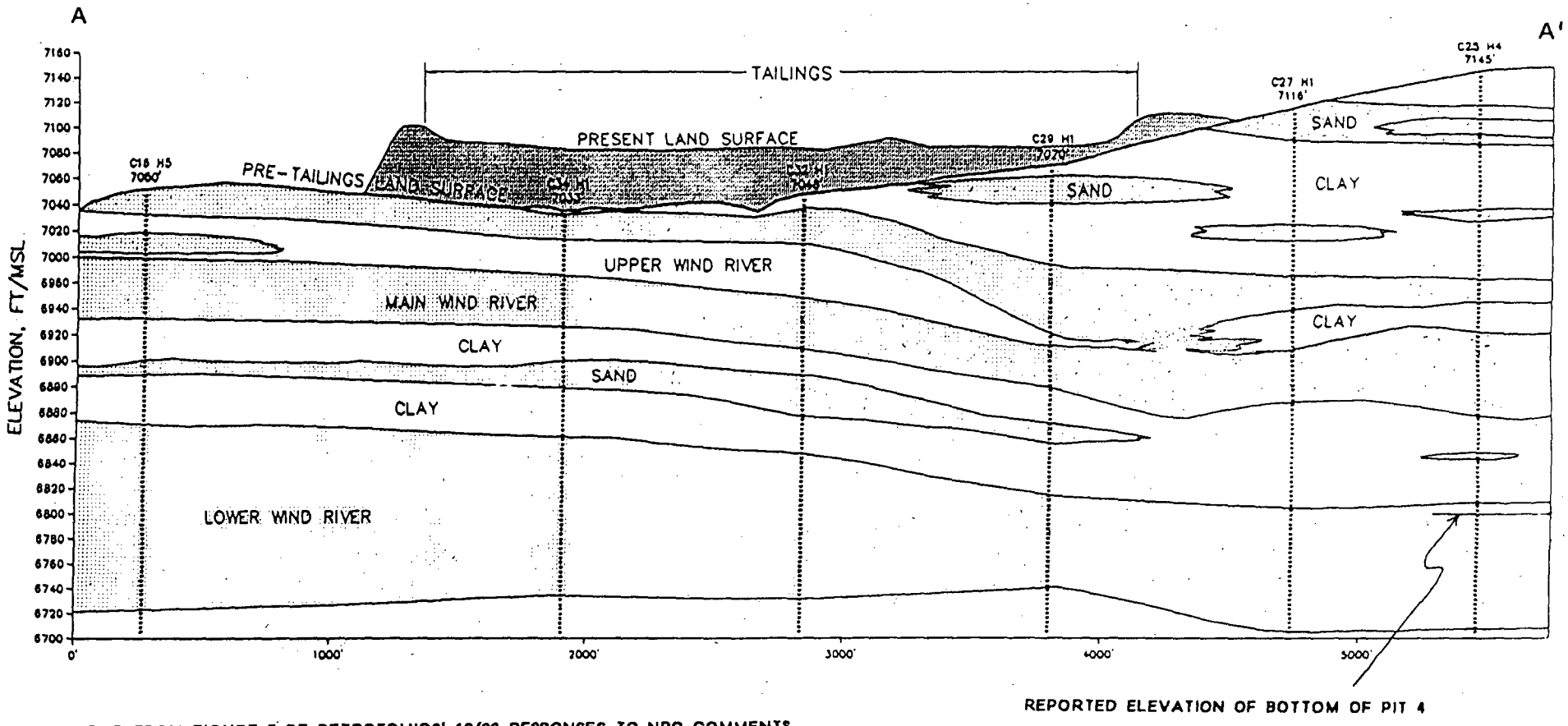
9710030151-03

0 800

Approximate Scale

Figure 4
Well Location Map
The Petrotomics Company

Prepared by WDEQ - TFN 3 5/134
August 1997



MODIFIED FROM FIGURE 5 OF PETROTOMICS' 12/98 RESPONSES TO NRC COMMENTS.

SEE FIGURE 2 FOR APPROXIMATE CROSS-SECTION LOCATION.

FIGURE 3
GENERALIZED CROSS-SECTION
PETROTOMICS' SHIRLEY BASIN SITE

PREPARED BY WDEQ - TFN 3 5/134

AUGUST 1997

3 MAPS

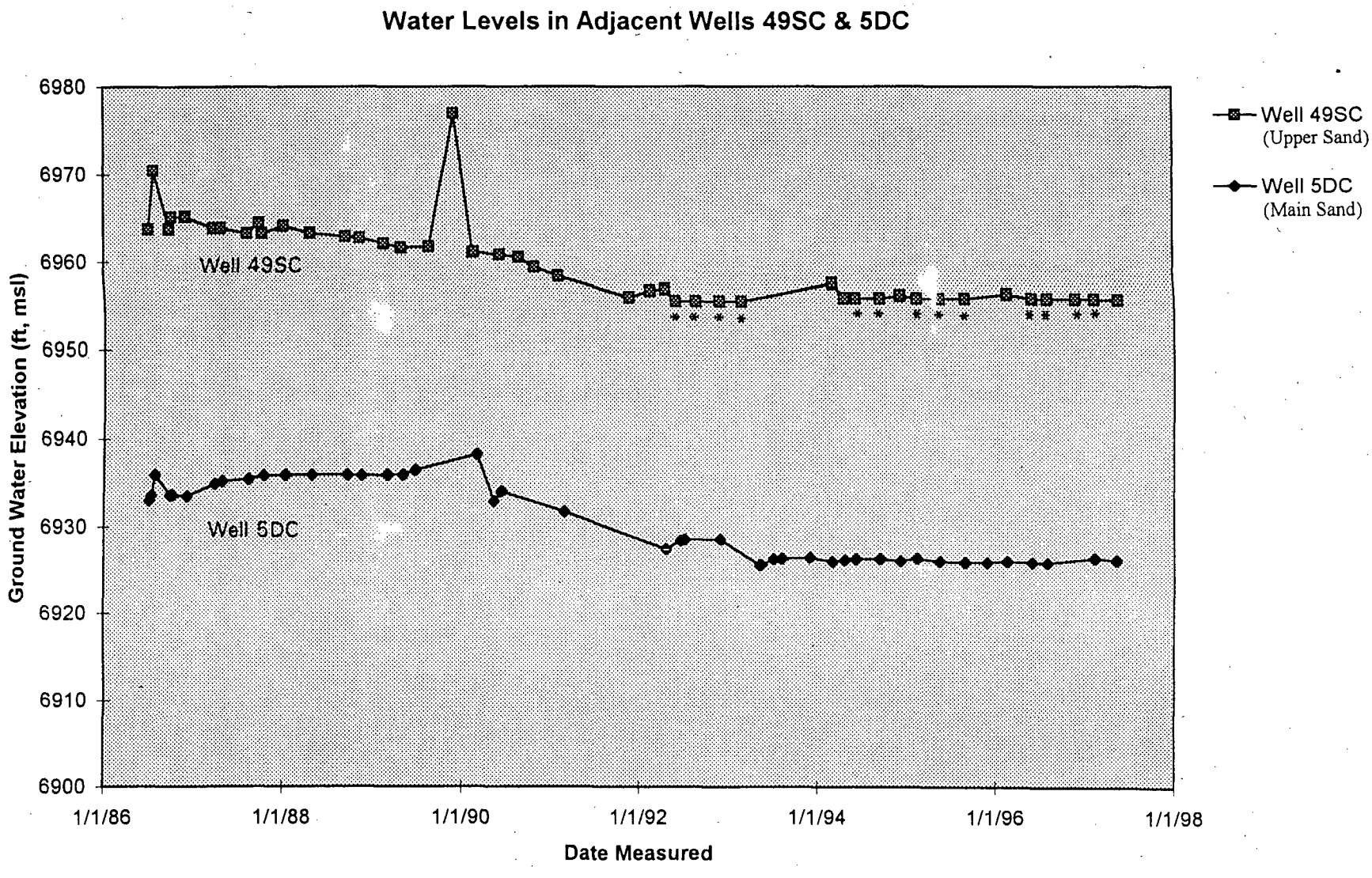


Figure 5
Water Levels vs. Time
Well 49SC & 5DC

Prepared by WDEQ - TFN 3 5/134
June 1997

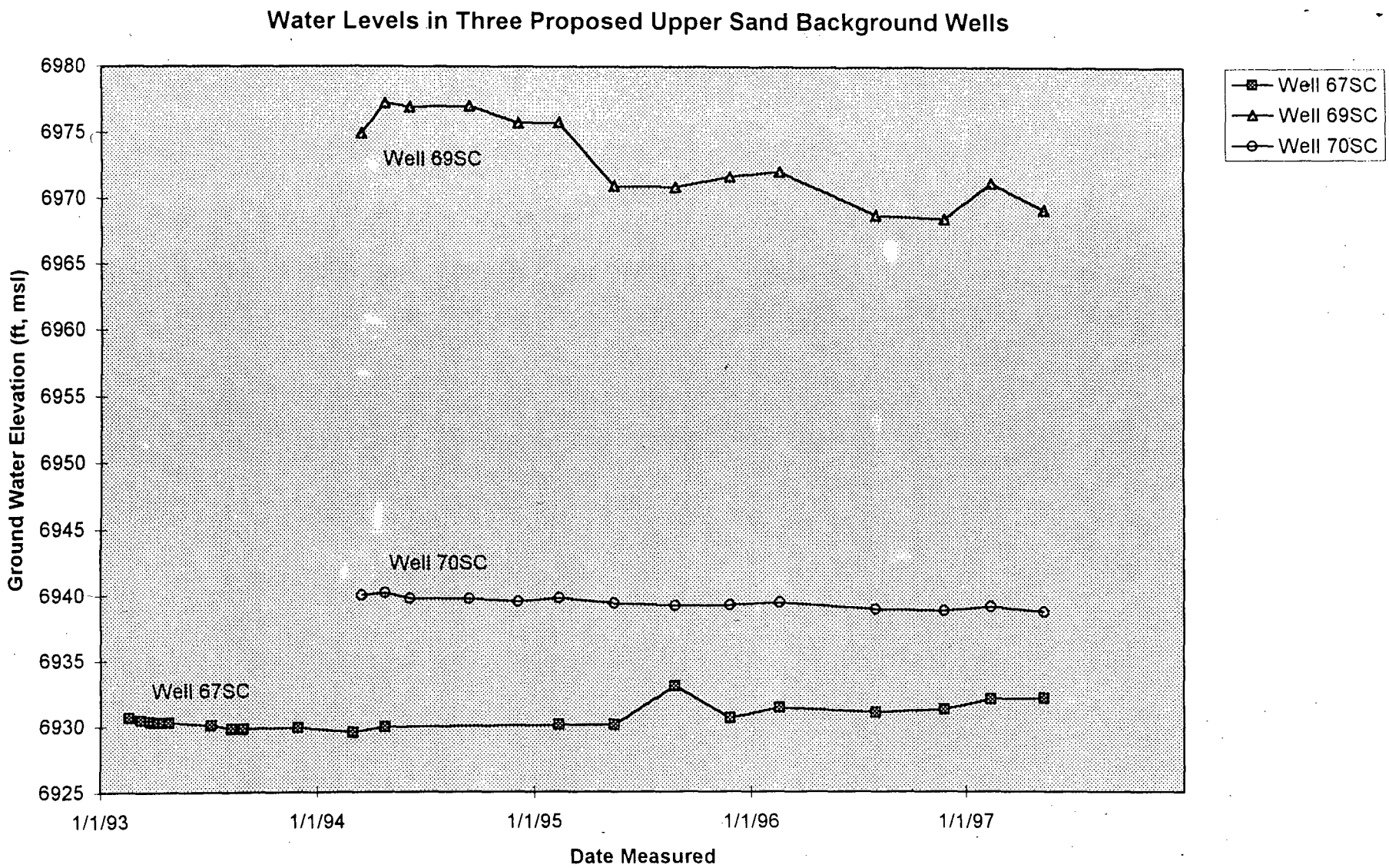


Figure 6
Water Levels vs. Time
Three Proposed Upper Sand Background Wells

Prepared by WDEQ - TFN 3 5/134
July 1997

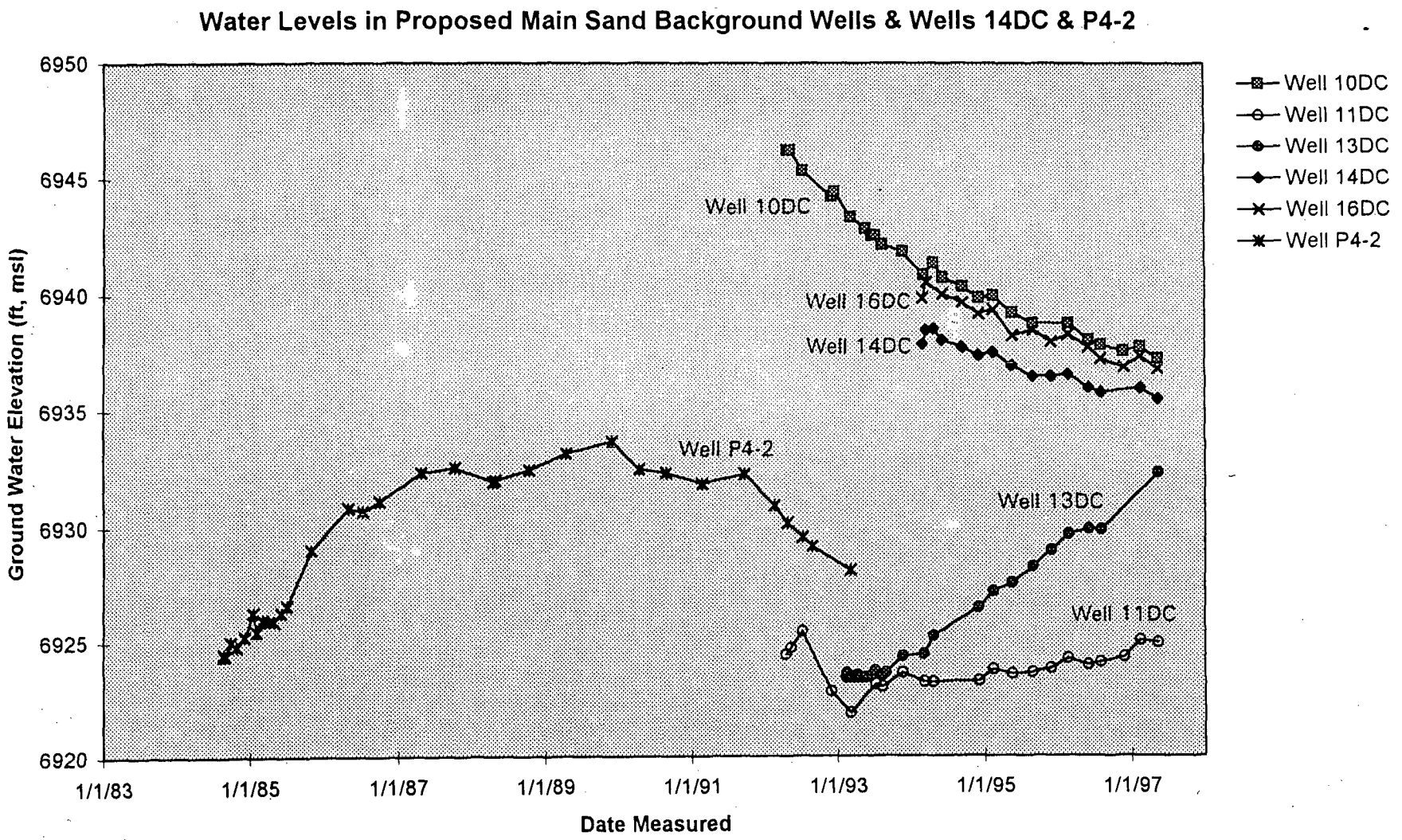


Figure 7
Water Levels vs. Time
Proposed Main Sand Background Wells & 14DC & P4-2

Prepared by WDEQ - TFN 3 5/134
July 1997

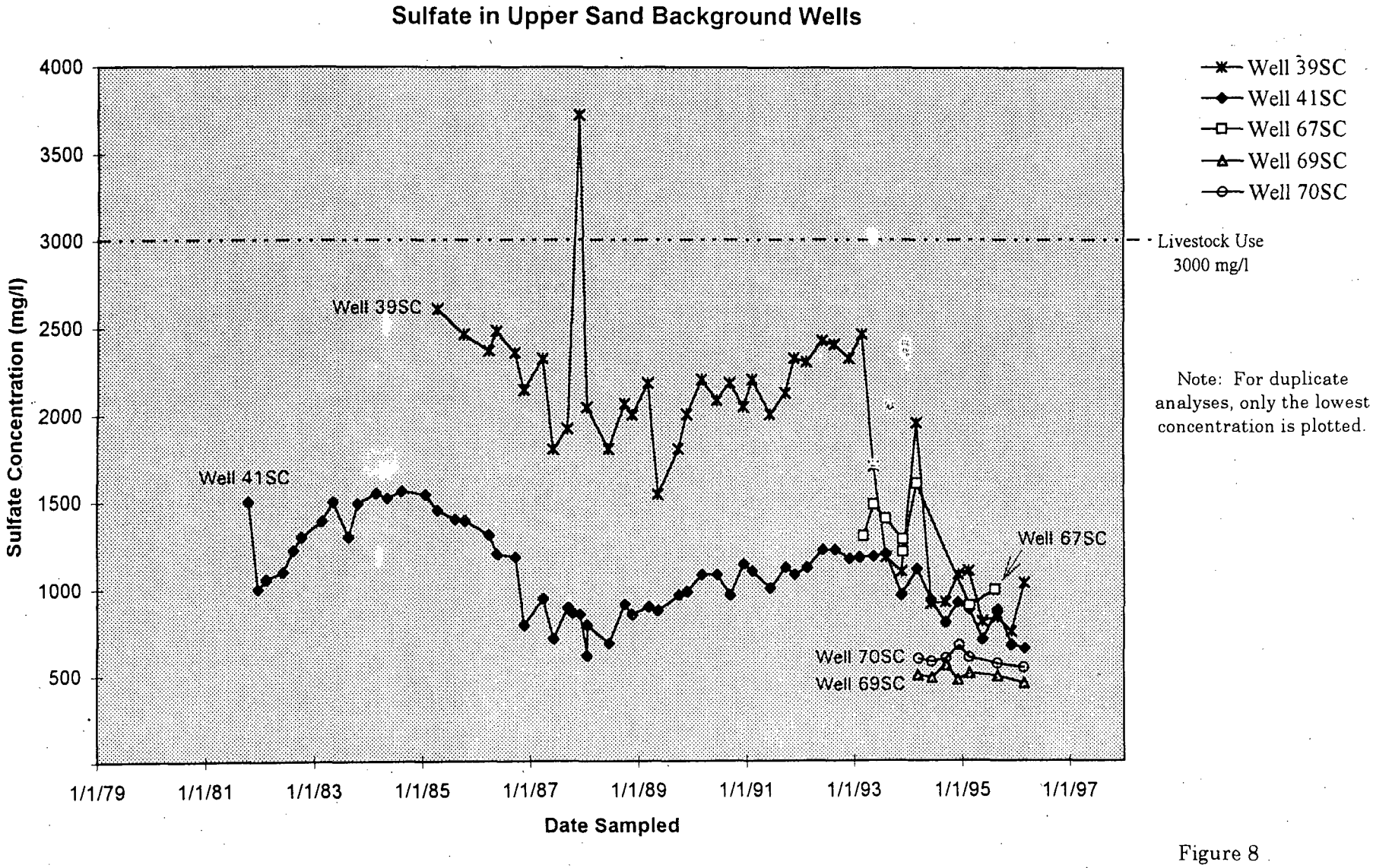


Figure 8
Sulfate Concentrations vs. Time
Upper Sand Background Wells

Prepared by WDEQ - TFN 3 5/134
June 1997

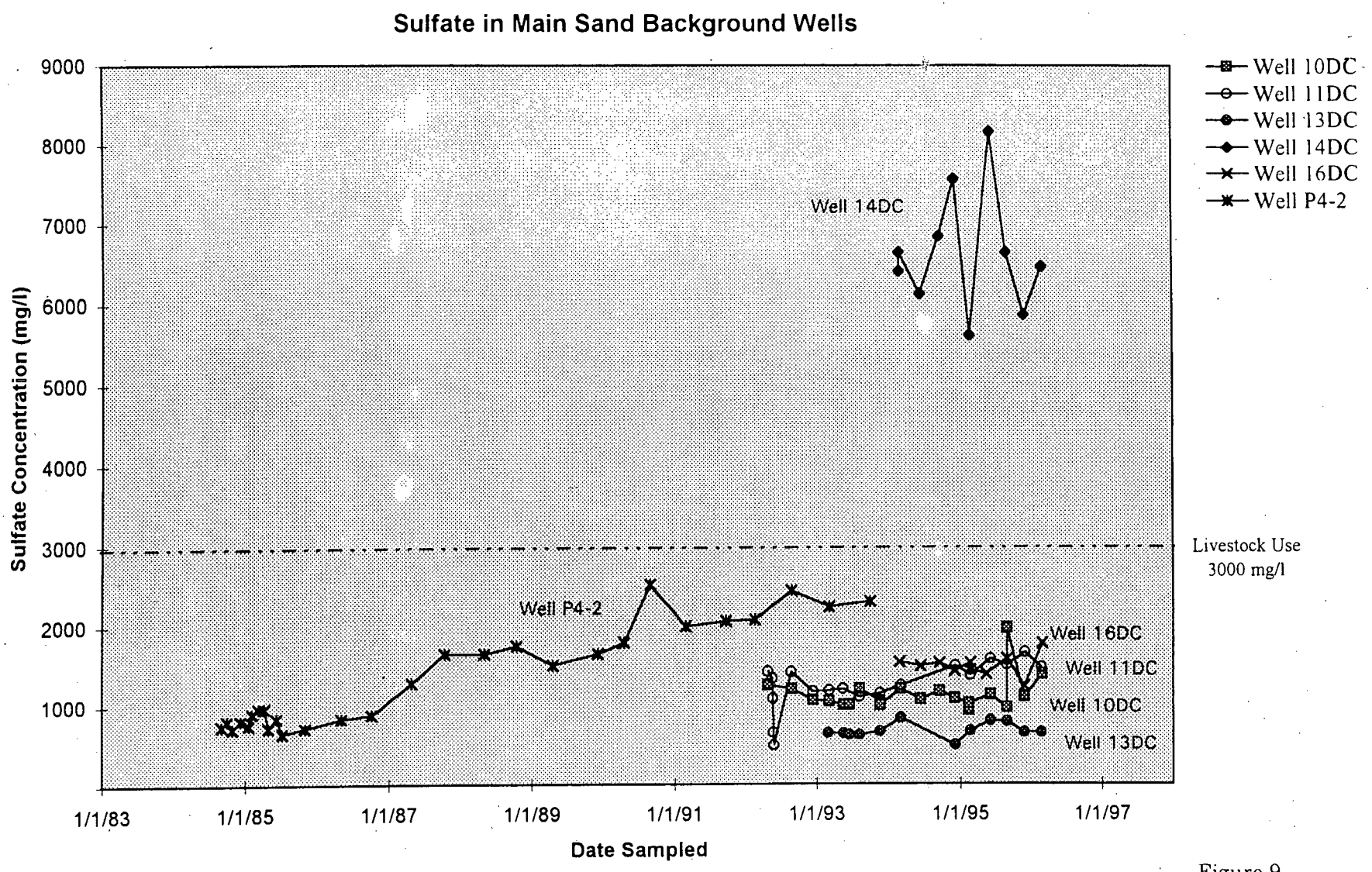


Figure 9
Sulfate Concentrations vs. Time
Main Sand Background Wells

Prepared by WDEQ/LQD - TFN 3 5/134
June 1997

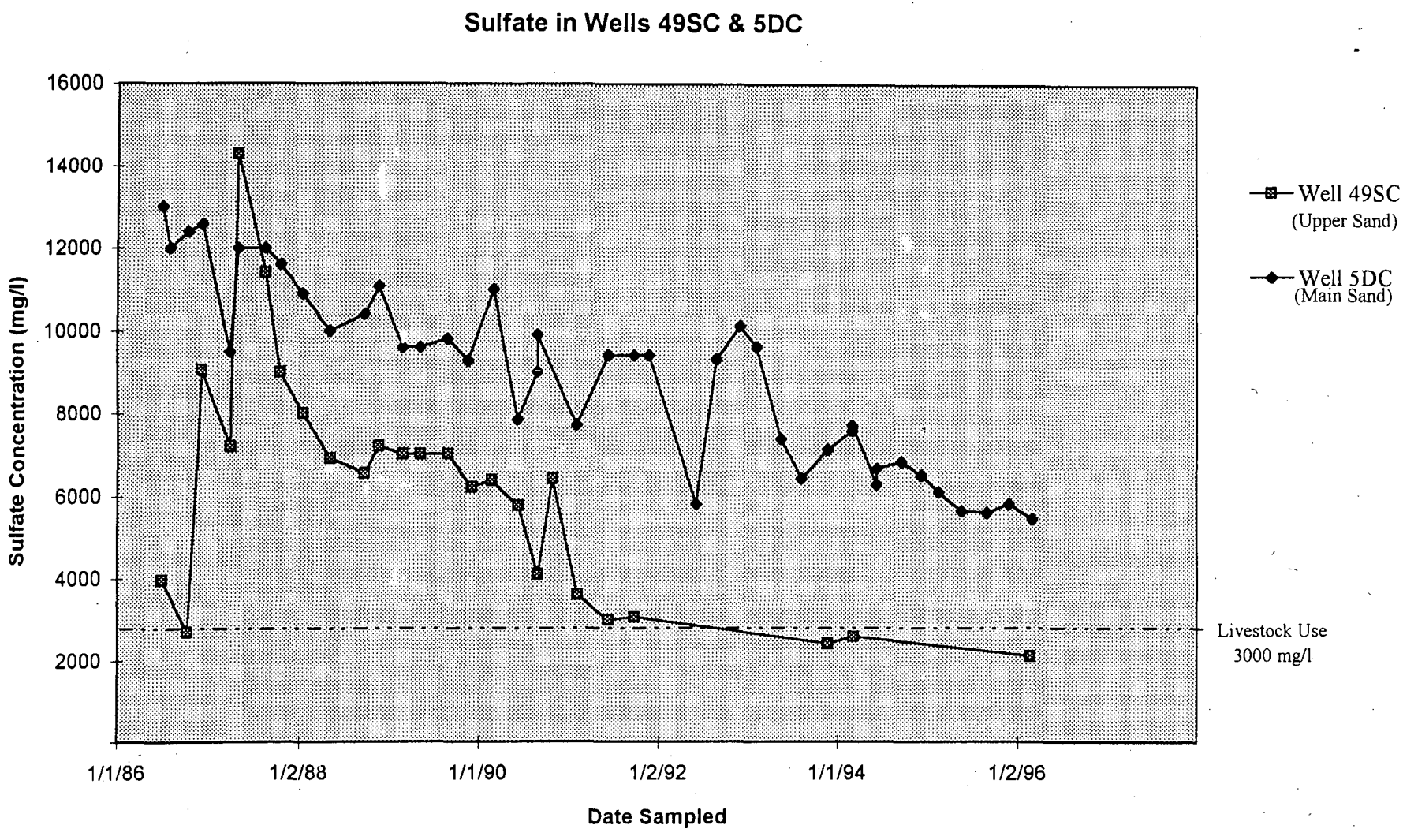


Figure 10
Sulfate Concentrations vs. Time
Wells 49SC & 5DC

Prepared by WDEQ/LQD
June 1997

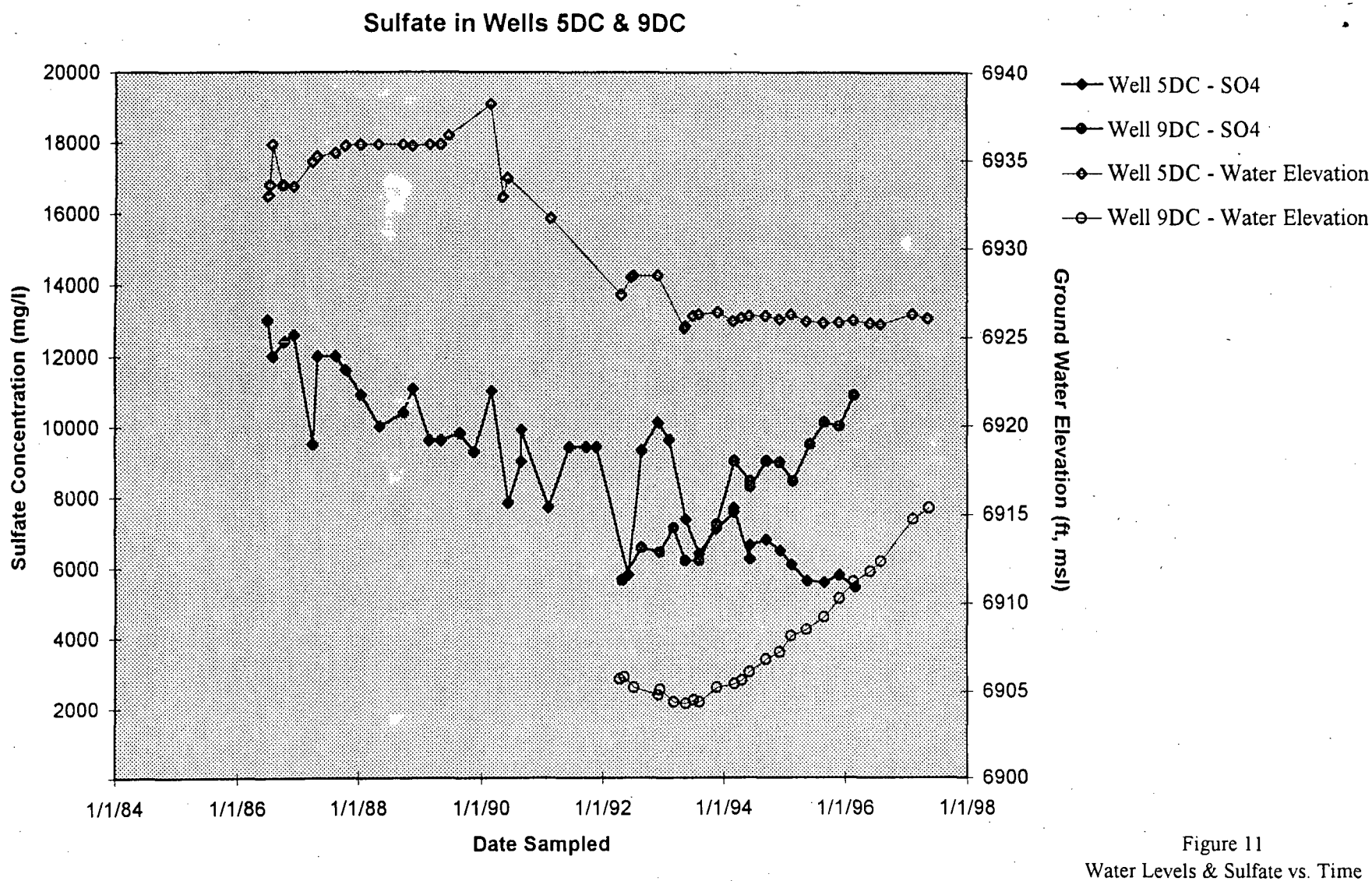


Figure 11
Water Levels & Sulfate vs. Time
Wells 5DC & 9DC

Prepared by WDEQ/LQD
June 1997

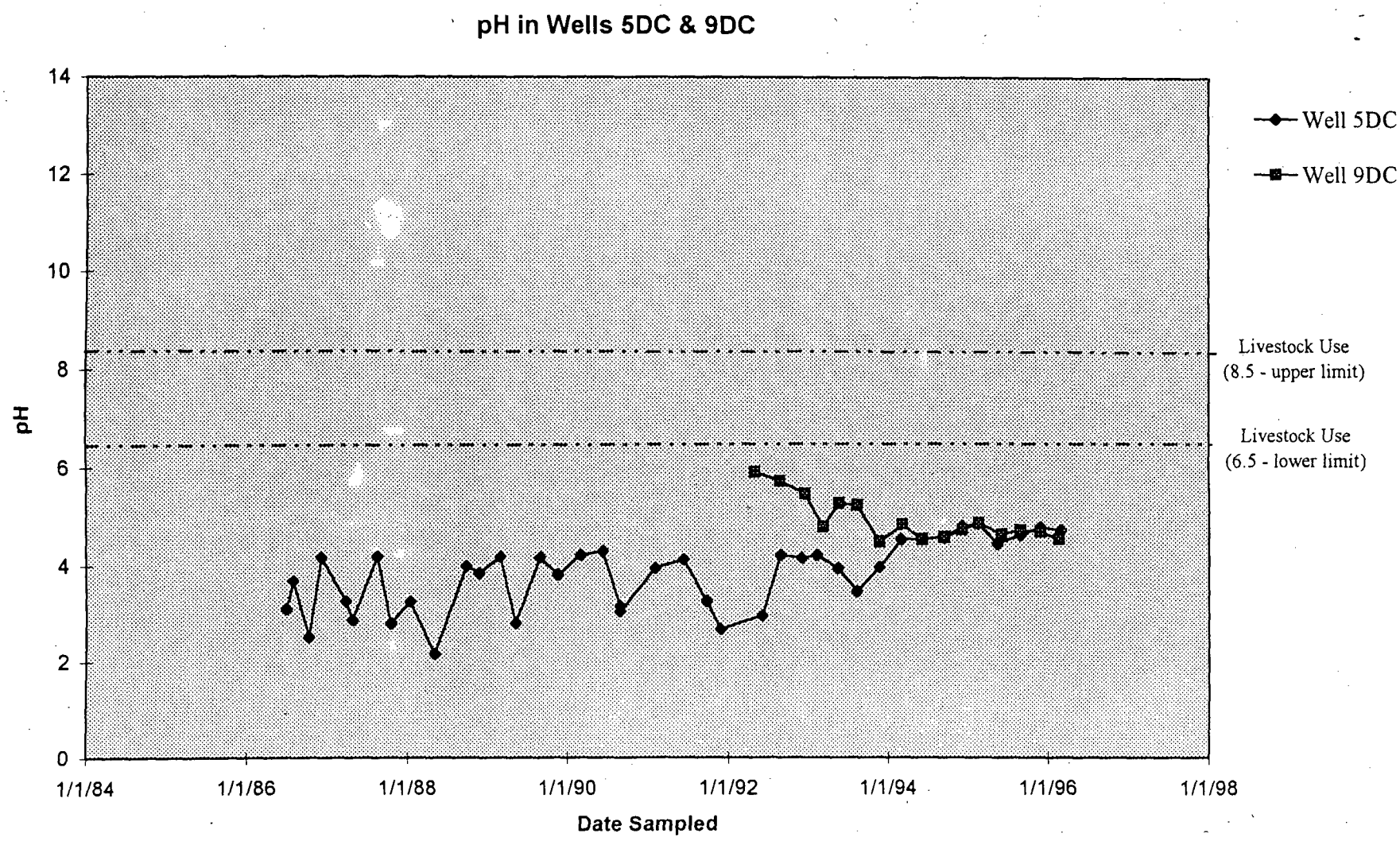


Figure 12
pH vs. Time
Wells 5DC & 9DC

Prepared by WDEQ/LQD
June 1997

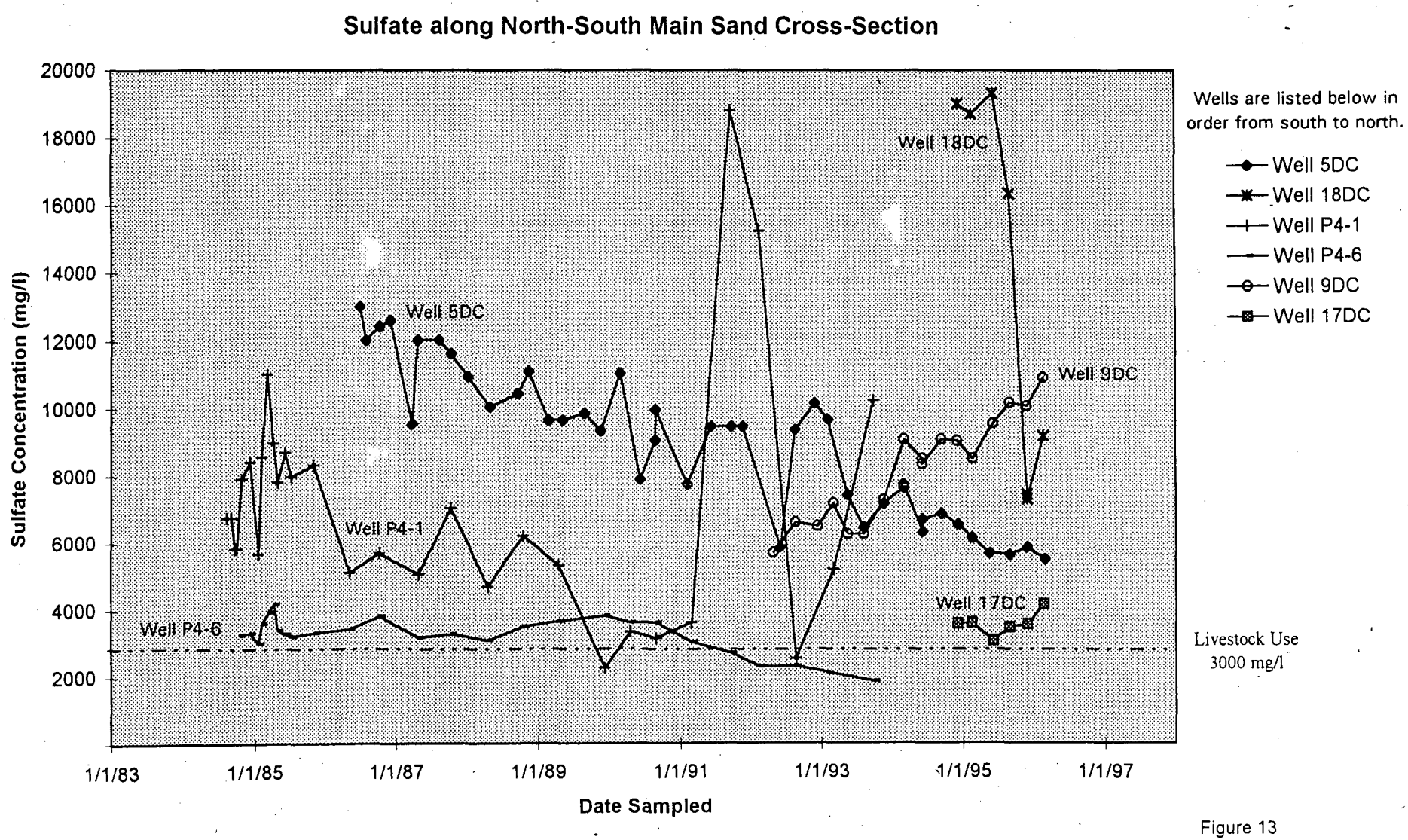


Figure 13
Sulfate Concentrations vs. Time
North-South Main Sand Cross-Section

Prepared by WDEQ - TFN 3 5/134
June 1997

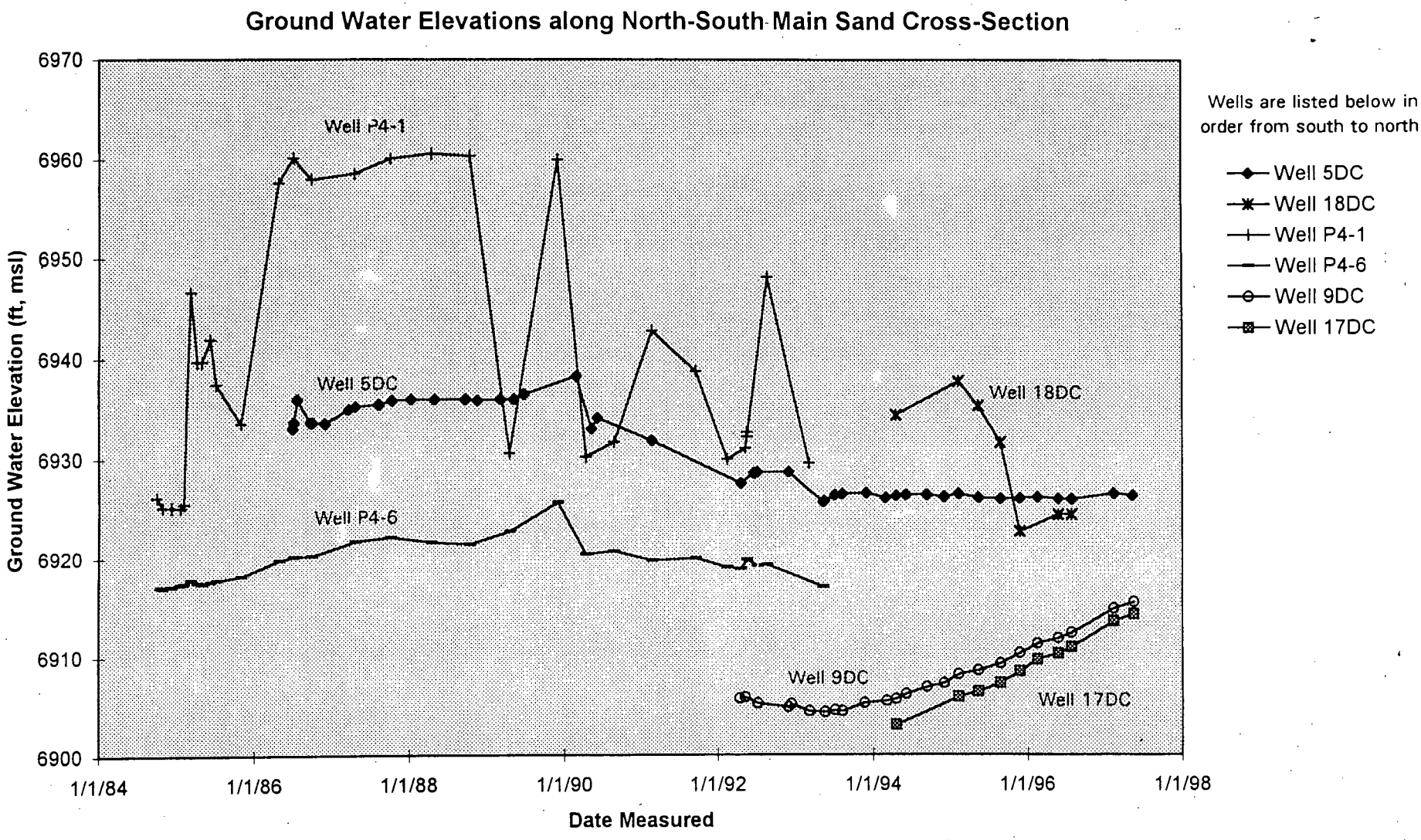


Figure 14
Water Levels vs. Time
North-South Main Sand Cross-Section

Prepared by WDEQ/LQD - TFN 3 5/134
August 1997

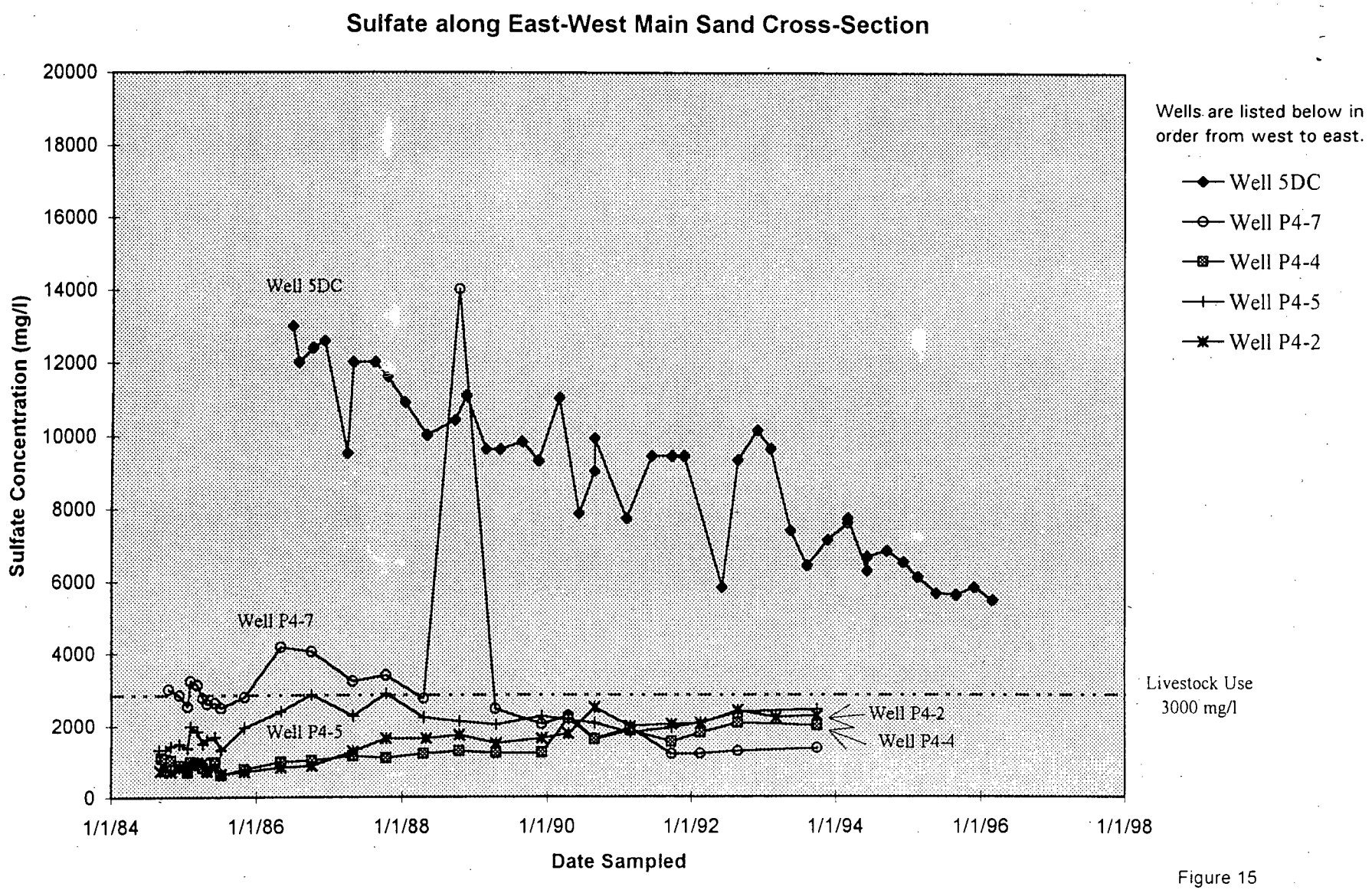


Figure 15
Sulfate Concentrations vs. Time
East-West Main Sand Cross-Section

Prepared by WDEQ/LQD
June 1997

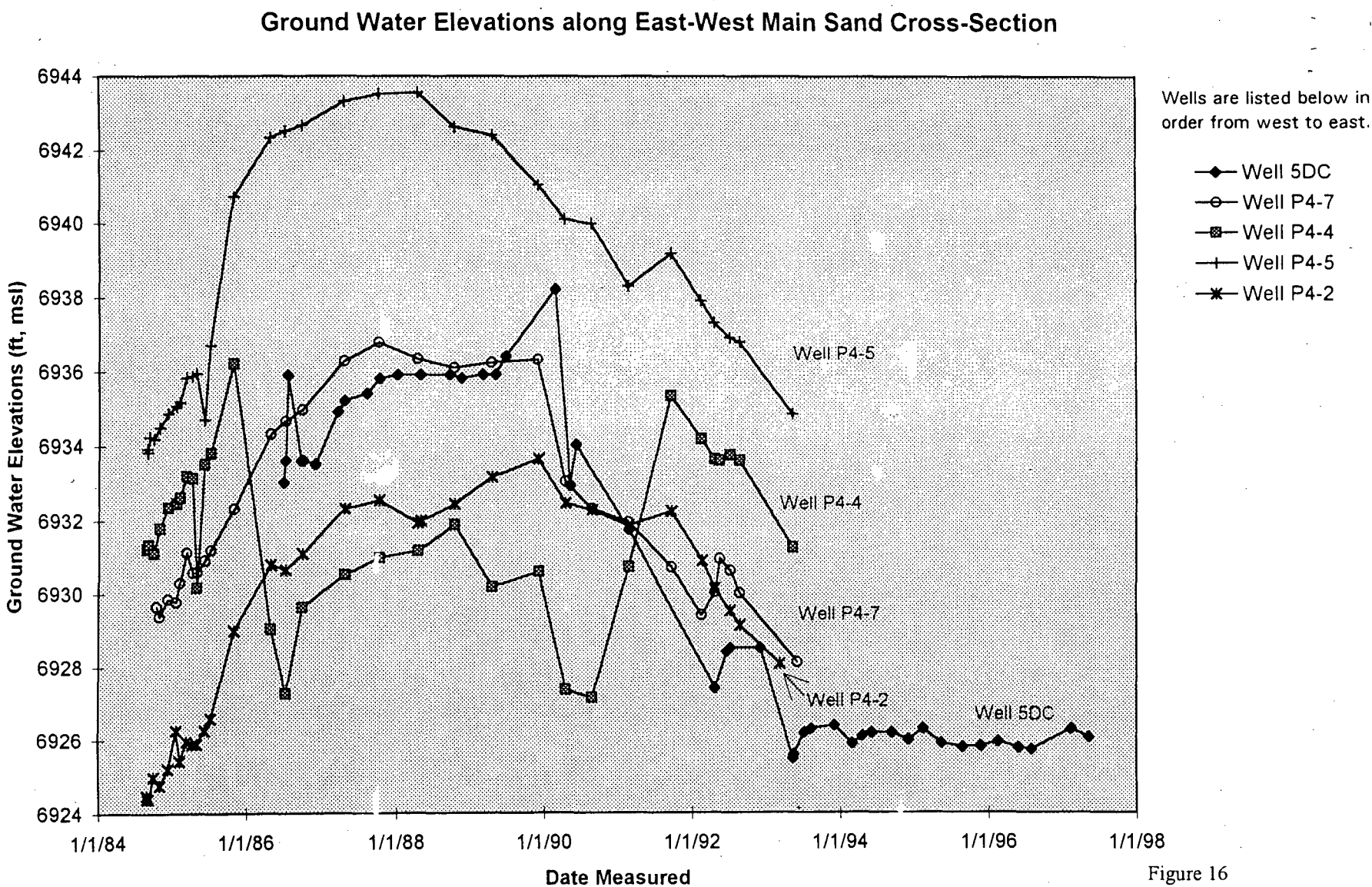


Figure 16
Water Levels vs. Time
East-West Main Sand Cross-Section

Prepared by WDEQ - TFN 3 5/134
August 1997

CHAPTER VIII

QUALITY STANDARDS FOR WYOMING GROUNDWATERS

Section 1. Authority. These regulations are promulgated pursuant to Sections 35-11-101 through 1104 of the Wyoming Statutes, specifically Section 35-11-302, and no person shall cause, threaten or allow violation of any water quality standard or provision contained herein.

Section 2. Definitions. The following definitions supplement those definitions contained in Section 35-11-103 of the Wyoming Environmental Quality Act.

(a) "Aquifer" means a zone, stratum or group of strata that can store and transmit water in sufficient quantities for a specific use.

(b) "Background" means the constituents or parameters and the concentrations or measurements which describe water quality and water quality variability prior to a subsurface discharge.

(c) "Below-Surface Receiver (Receiver)" means any zone, interval, formation or unit in the subsurface which can accept water or fluid from other sources.

(d) "Domestic Water" means a water which is suitable for uses, including but not limited to, drinking, gardening and other household uses, municipal uses and farmstead uses, including water used in the washing or hydro-cooling of farm products destined for human consumption on the farm, for sale on the fresh food market or for delivery to a processing plant for canning, freezing or other type of preparation prior to marketing.

(e) "Fluid" means any material which flows or moves whether semisolid liquid, sludge, gas or any other form or state.

(f) "Groundwater" means subsurface water that fills available openings in rock or soil materials such that they may be considered water saturated under hydrostatic pressure.

(g) "Groundwaters of the State" are all bodies of underground water which are wholly or partially within the boundaries of the State; Groundwaters of the State is synonymous with Groundwaters of Wyoming.

(h) "Hazardous Material (Substance)" means any matter of any description including petroleum related products and radioactive material (substance) which, when discharged into any waters of the State presents an imminent and substantial hazard to public health or welfare and shall include all materials (substances) so designated by the U.S. Environmental Protection Agency in the Federal Register for March 13, 1978 (Part III), Water Programs, Hazardous Substances.

(i) "Milliequivalents Per Liter", abbreviated meq/l, used to report the Residual Sodium Carbonate concentration in water used for irrigation, is defined as 0.001 of the equivalent weight of the ion per liter volume.

(j) "Milligrams Per Liter", abbreviated mg/l, means milligrams of solute per liter of solution -- equivalent to parts per million assuming unit density of water.

(k) "Parameter" means one of a set of physical or chemical properties whose measured values determine the characteristics of a fluid.

(l) "pH" is a term to express the intensity of the acid or basic condition. A pH value of 7.0 at 25 degrees C is neutral, with pH's of less than 7.0 progressively more acid and pH's of greater than 7.0 progressively more basic.

(m) "Picocuries Per Liter", abbreviated pCi/l, is a measure of radioactivity of waters or fluids. A picocurie is equal to 10^{-12} curie; a curie is defined as 3.7×10^{10} disintegrations per second.

(n) "Residual Sodium Carbonate", abbreviated RSC, is defined as twice the concentration of carbonate or bicarbonate a water would contain after subtracting an amount equivalent to the calcium plus the magnesium, and is a measure of potential hazard which exists when waters high in carbonate and bicarbonate and relatively low in calcium and magnesium are used for irrigation.

(o) "Sodium Adsorption Ratio", abbreviated SAR, of a water is defined by the U.S. Department of Agriculture Laboratory (1954) as:

$$SAR = \sqrt{\frac{(Na^{+})}{\frac{(Ca^{\pm 2}) + (Mg^{\pm 2})}{2}}}$$

where ion concentrations are expressed in milliequivalents per liter. The SAR predicts reasonably well the degree to which irrigation water tends to enter into cation-exchange reactions in soil.

(p) "Standard Unit", abbreviated s.u., is the unit of measurement used to describe the numerical pH of a solution, fluid or pollutant.

(q) "Subsurface Discharge" means a discharge to a below-surface receiver.

(r) "Total Dissolved Solids", abbreviated TDS, is the sum of the dissolved mineral constituents in water, expressed as mg/l.

(s) "Toxic Materials (Substances)" are those materials (substances) or combinations of materials (substances), including disease causing agents, which, after discharge and upon exposure, ingestion, inhalation or assimilation into any environmentally significant organism, either directly from the environment or indirectly by ingestion through food chains, may cause death, disease, behavioral abnormalities, cancer, genetic malfunctions, physiological malfunctions (including malfunctions in reproduction of offspring) or physical deformations in such organisms or their offspring; and includes all materials (substances) so designated as toxic by the U.S. Environmental Protection Agency in the Federal Register for December 24, 1975 (Part IV), Water Programs, National Interim Primary Drinking Water Regulations.

(t) "Underground Water" means subsurface water, which is any body of water under the surface of the earth, including water in the vadose zone and groundwater.

(u) "Vadose Zone" means the unsaturated zone in the earth, between the land surface and the top of the first saturated aquifer which is not a perched water aquifer. The vadose zone characteristically contains liquid water under less than atmospheric pressure, and water vapor and air or other gases at atmospheric pressure. Perched water bodies exist within the vadose zone.

(v) "Virtually Free" means a concentration less than the concentration which is the lower limit of detection.

Section 3. Underground Water Protected.

(a) All waters, including groundwaters of the State, within the boundaries of the State of Wyoming are the property

of the State; and control of the beneficial use of waters of the State resides with the Wyoming State Engineer.

(b) Nothing herein contained shall be construed so as to interfere with the right of any person to use water from any underground water source for any purpose identified in W.S. 35-11-102 and 35-11-103(c)(i); or to limit or interfere with the jurisdiction, duties or authorities of other Wyoming State agencies or officials.

(c) Protection shall be afforded all underground water bodies (including water in the vadose zone). Water being used for a purpose identified in W.S. 35-11-102 and 103(c)(i) shall be protected for its intended use and uses for which it is suitable. Water not being put to use shall be protected for all uses for which it is suitable.

Section ". <u>Quality Standards Prescribed; Groundwaters of the State Classified</u>.

(a) Standards are prescribed to protect the natural quality of underground water:

(i) Receiving pollution or wastes directly from a subsurface discharge or by migrating water or fluid of a discharge;

(ii) Invaded by underground water of inferior quality as a result of well or exploration hole drilling or completion practices;

(iii) From pollution which may result from above-ground facilities capable of causing or contributing to pollution;

(iv) From pollution which may result from surface mining operations.

(b) Groundwaters of the State are classified in order to apply standards to protect water quality. Groundwaters of the State are classified by use, and by ambient water quality.

(c) Waters which are known sources of supply and appropriated for uses identified in W.S. 35-11-102 and 103(c)(i) are classified herein as: Domestic water; Water for fish and aquatic life; Water for agriculture; Water for livestock; and, Water for industry.

A discharge or activity that impacts an underground source of water for existing uses identified in W.S. 35-11-102 and 103(c)(i) shall not make the affected water unsuitable for

its intended use or uses, at any place or places of withdrawal or natural flow to the surface.

(d) Unappropriated waters are classified by ambient water quality.

(i) Class I Groundwater of the State - This water is suitable for domestic use. The ambient quality of underground water of this suitability does not have a concentration in excess of any of the standards for Class I Groundwater of the State (see Table I, page 9).

(ii) Class II Groundwater of the State - This water is suitable for agricultural use where soil conditions and other factors are adequate. The ambient quality of underground water of this suitability does not have a concentration in excess of any of the standards for Class II Groundwater of the State (see Table I, page 9).

(iii) Class III Groundwater of the State - This water is suitable for livestock. The ambient quality of underground water of this suitability does not have a concentration in excess of any of the standards for Class III Groundwater of the State (see Table I, page 9).

(iv) Class Special (A) Groundwater of the State - This water is suitable for fish and aquatic life. The ambient quality of underground water of this suitability does not have a concentration in excess of any of the standards for Class Special (A) Groundwater of the State (see Table I, page 10).

(v) Underground water of Class I, II, III or Special (A) shall not contain biological, hazardous, toxic or potentially toxic materials or substances in concentrations or amounts which exceed maximum allowable concentrations based upon information of the EPA in the Federal Register for December 24, 1975 (Part IV), Water Programs, National Interim Primary Drinking Water Regulations; and in the Federal Register for March 13, 1978 (Part II), Water Programs, Hazardous Substances.

In addition, underground water of Class I, II, III or Special (A) shall not contain any biological, hazardous, toxic or potentially toxic materials or substances in concentrations or amounts which, based upon the latest available scientific information and as determined by the Administrator, will impair this water for its use suitability or which may contribute to a condition in contravention of groundwater quality standards or to any toxic or hazardous effect on natural biota.

(vi) A discharge into an aquifer containing Class I, II, III or Special (A) Groundwater of the State shall not result in variations in the range of any parameter, or concentrations of constituents in excess of the standards of these regulations at any place or places of withdrawal or natural flow to the surface. A discharge which results in concentrations in excess of standards shall be permitted if post-discharge water quality can be returned to water quality standards or better quality; excepting that the uranium concentration in any Class I Groundwater of the State shall not exceed the pre-discharge background concentration.

(vii) Class IV Groundwater of the State - This water is suitable for industry. The quality requirements for industrial water supplies range widely and almost every industrial application has its own standards.

(A) Class IV (A) Groundwater of the State has a total dissolved solids concentration not in excess of 10,000 mg/l.

(B) Class IV (B) Groundwater of the State has a total dissolved solids concentration in excess of 10,000 mg/l.

(C) A discharge into an aquifer containing Class IV (A) or IV (B) Groundwater of the State shall not result in the water being unfit for its intended use.

(D) A discharge into an aquifer with Class IV (A) or IV (B) Groundwater of the State shall not result in oil and grease concentrations in excess of 10 mg/l or a lesser amount if a concentration in excess of the lesser amount is determined to be toxic; or oil and grease in excess of background concentrations of the underground water, whichever is greater, at any place or places of withdrawal or natural flow to the surface.

(E) A discharge into an aquifer with Class IV (A) or IV (B) Groundwater of the State shall not result in radioactivity concentrations or amounts which exceed the standards for Class I through III and Special (A) Groundwaters of the State; or in concentrations or amounts which exceed background concentrations of the underground water, whichever is greater, at any place or places of withdrawal or natural flow to the surface.

(F) A discharge into an aquifer with Class IV (A) or IV (B) Groundwater of the State shall not result in biological, hazardous, toxic or potentially toxic materials or substances including pesticides, insecticides or herbicides in

concentrations or amounts which exceed maximum allowable concentrations, based upon information of the EPA in the Federal Register for December 24, 1975 (Part IV), Water Programs, National Interim Primary Drinking Water Regulations, and in the Federal Register for March 13, 1978 (Part II), Water Programs, Hazardous Substances; or which exceed background concentrations of the underground water, whichever is greater, at any place or places of withdrawal or natural flow to the surface.

In addition, a discharge shall not result in any biological, hazardous, toxic or potentially toxic materials or substances, in concentrations or amounts which, based on the latest available scientific information and as determined by the Administrator, will impair the quality of ambient groundwaters of the State of this Class; or which may contribute to a condition in contravention of groundwater quality standards or cause, allow or permit any deleterious effect on natural biota.

(viii) Groundwater of the State found closely associated with commercial deposits of hydrocarbons and/or other minerals, or which is considered a geothermal resource, is Class V (Hydrocarbon Commercial), Class V (Mineral Commercial) or Class V (Geothermal) Groundwater of the State.

(A) A discharge into a Class V (Hydrocarbon Commercial) Groundwater of the State shall be for the purpose of the production of oil and gas and shall not result in the degradation or pollution or waste of other water resources.

(B) A discharge into a Class V (Mineral Commercial) Groundwater of the State shall be for the purpose of mineral production and shall not result in the degradation or pollution of the associated or other groundwater unless the affected groundwater quality can be returned to background or better quality after mining ceases, by a reduction or elimination of pollution; or in the waste of other water resources. If it has been determined by the Administrator that a return to background quality cannot be achieved, the affected groundwater will, at a minimum, be returned to a condition and quality consistent with the pre-discharge use suitability of the water.

(C) A discharge into a Class V (Geothermal) Groundwater of the State shall be for the purpose of the production of geothermal resources and shall not result in the degradation or pollution or waste of other water resources.

(ix) Class VI Groundwater of the State may be unusable or unsuitable for use:

(A) Due to excessive concentration of total dissolved solids or specific constituents; or

(B) Is so contaminated that it would be economically or technologically impractical to make the water useable; or

(C) Is located in such a way, including depth below the surface, so as to make use economically and technologically impractical.

Section 5. Classification for Groundwater of the State Affected by a Discharge; Classification by Aquifer and Area.

(a) Classification of groundwaters of the State shall be based on the water quality standards of this chapter; excepting, a Class I Groundwater of the State shall be classified by ambient water quality and the technical practicability and economic reasonableness of treating ambient water quality to meet use suitability standards.

(b) Underground water quality shall be classified for an aquifer which is or may be affected by a subsurface discharge or other activity identified in Section 4.a. of these regulations.

(c) Classification shall be made:

(i) Whenever there is pollution or the threat of pollution to a groundwater of the State; or

(ii) The physical, chemical, radiological or biological properties of any groundwater of the State are or may be altered by man's action.

(d) Classification shall be for a water in a specified locally defined area by named and described aquifer or receiver. Any aquifer or receiver in its regional setting may have one or more classifications by defined area or areas.

(i) The name shall be a recognized geologic name whenever possible;

(ii) The description shall include a lithologic description.

(e) The lateral and vertical limits of an aquifer or receiver, for purposes of classification, shall be based on existing water use, ambient water quality and geologic and hydrologic characteristics of the aquifer or of the receiver.

TABLE I

UNDERGROUND WATER CLASS Use Suitability Constituent or Parameter	I Domestic Concentration*	II Agriculture Concent.*	III Livestock Concent.*
Aluminum (Al)	---	5.0	5.0
Ammonia (NH_3-N)	0.5[8]	---	---
Arsenic (AS)	0.05	0.1	0.2
Barium (Ba)	1.0	---	---
Beryllium (Be)	---	0.1	---
Boron (B)	0.75	0.75	5.0
Cadmium (Cd)	0.01	0.01	0.05
Chloride (Cl)	250.0	100.0	2000.0
Chromium (Cr)	0.05	0.1	0.05
Cobalt (Co)	---	0.05	1.0
Copper (Cu)	1.0	0.2	0.5
Cyanide (CN)	0.2	---	---
Fluoride (F)	1.4-2.4[7]	---	---
Hydrogen Sulfide (H_2S)	0.05	---	---
Iron (Fe)	0.3	5.0	---
Lead (Pb)	0.05	5.0	0.1
Lithium (Li)	---	2.5	---
Manganese (Mn)	0.05	0.2	---
Mercury (Hg)	0.002	---	0.00005
Nickel (Ni)	---	0.2	---
Nitrate (NO_3-N)	10.0	---	---
Nitrite (NO_2-N)	1.0	---	10.0
(NO_3+NO_2)-N	---	---	100.0
Oil & Grease	Virtually Free	10.0	10.0
Phenol	0.001	---	---
Selenium (Se)	0.01	0.02	0.05
Silver (Ag)	0.05	---	---
Sulfate (SO_4)	250.0	200.0	3000.0
Total Dissolved Solids (TDS)	500.0	2000.0	5000.0
Uranium (U)	5.0	5.0	5.0
Vanadium (V)	---	0.1	0.1
Zinc (Zn)	[illegible].0	2.0	25.0
pH	6.5-9.0s.u.	4.5-9.0s.u.	6.5-8.5s.u
SAR	---	8	---
RSC	---	1.25 meq/1	---
Combined Total Radium 226 and Radium 228[9]	5pCi/1	5pCi/1	5pCi/1
Total Strontium 90	8pCi/1	8pCi/1	8pCi/1
Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium)[9]	15pCi/1	15pCi/1	15pCi/1

*mg/l, unless other wise indicated

TABLE I

UNDERGROUND WATER CLASS Use Suitability Constituent of Parameter	Special (A) Fish/Aquatic Life Concentration*
Aluminum (Al)	0.1
Ammonia (NH_3)	0.02[1]
Arsenic (As)	0.05
Barium (Ba)	5.0
Beryllium (Be)	0.011-1.3[3]
Boron (B)	---
Cadmium (Cd)	0.0004-0.015[3]
Chloride (Cl)	---
Chromium (Cr)	0.05
Cobalt (Co)	---
Copper (Cu)	0.01-0.04[3]
Cyanide (CN)	0.005
Fluoride (F)	---
Hydrogen Sulfide (H_2S)	0.002[2]
Iron (Fe)	0.5
Lead (Pb)	0.004-0.15[3]
Lithium (Li)	---
Manganese (Mn)	1.0
Mercury (Hg)	0.00005
Nickel (Ni)	0.05-0.4[3]
Nitrate (NO_3-N)	---
Nitrite (NO_2-N)	---
(NO_3+NO_2-N	---
Oil & Grease	Virtually free
Phenol	0.001
Selenium (Se)	0.05
Silver (Ag)	0.0001-0.00025[3]
Sulfate (SO_4)	---
Total Dissolved Solids (TDS)	500.0[4]-1000.0[5]-2000.0[6]
Uranium (U)	0.03-1.4[3]
Vanadium (V)	---
Zinc (Zn)	0.05-0.6[3]
Ph	6.5s.u.-9.0s.u.
Combined Total Radium 226 and Radium 228[9]	5pCi/1
Total Strontium 90	8pCi/1
Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium)[9]	15pCi/1

*mg/l, unless other wise indicated

TABLE I

Explanation for Superscript Used in Table I

[1]Unionized ammonia: When ammonia dissolves in water, some of the ammonia reacts with water to form ammonium ions. A chemical equilibrium is established which contains unionized ammonia (NH_3), ionized ammonia (NH_4+) and hydroxide ions (OH^-). The toxicity of aqueous solutions of ammonia is attributed to NH_3; therefore, the standard is for unionized ammonia. (Note: 0.02 mg/l NH_3 is equivalent to 0.016 NH_3 as N.)

[2]Undissociated H_2S: The toxicity of sulfides derives primarily from H_2S, rather than from the dissociated (HS) or (S) ions; therefore, the standard is for the toxic undissociated H_2S.

[3]Dependent on hardness: The toxicity of metals in natural waters varies with the hardness of the water; generally, the limiting concentration is greater in hard water than in soft water.

[4]Egg hatching

[5]Fish rearing

[6]Fish and aquatic life

[7]Dependent on the annual average of the maximum daily air temperature: 1.4 mg/l corresponds with a temperature range of 26.3 to 32.5 degrees C and 2.4 mg/l corresponds with a temperature of 12.0 degrees C (53.7 degrees F) and below.

[8]Total ammonianitrogen

[9]Requirements and procedures for the measurement and analysis of gross alpha particle activity, Radium 226 and Radium 228 shall be the same as requirements and procedures of the U.S. Environmental Protection Agency, National Interim Primary Drinking Water Regulations, EPA-570/9-76-003, effective June 24, 1977.

(f) An underground water may be reclassified if new or additional data warrant reclassification.

Section 6. Standards for the Underground Management of Hazardous or Toxic Wastes. The underground management of wastes includes the temporary storage and the ultimate disposal of all hazardous or toxic wastes in below-surface

receivers. The following standards apply to any underground storage or disposal of hazardous or toxic wastes.

(a) The below-surface receiver:

(i) Is an extensive sedimentary rock stratum or strata free of complex faulting and folding and distant from any underground water recharge area;

(ii) Is adequately separated from aquifers both above and below;

(iii) Has normal or low formation pressure and is capable of accepting the discharge without necessitating excessive discharge or injection pressure;

(iv) Has slow movement of ambient formation fluid under the natural horizontal gradient and is not in an area of underground water discharge for the receiver;

(v) Is located areally and stratigraphically so that an escape of waste to useable water resources would not be anticipated due to:

(A) Seismic risk;

(B) Abandoned holes; or

(C) Mineral exploration or other drilling, or mineral development.

(b) The underground water in the receiver;

(i) Is not an economically available source of water or is unusable;

(ii) Is confined by strata overlying and underlying the receiver; and

(iii) Is classified as class IV groundwater by this chapter.

(c) The discharge or waste:

(i) Will not create or result in a hazard to health or impair existing rights, and is not prohibited from subsurface disposal by Federal or State law or regulation;

(ii) Will not degrade or decrease the availability of mineral resources, including oil and gas;

(iii) Is compatible with the receiver and ambient water; and

(iv) Can be controlled at all times.

Section 7. Testing Procedures.

(a) For determination of the parameters involved in the standards, analysis will be in accord with test procedures as defined pursuant to: Title 40, Code of Federal Regulations, Part 136, or any modifications thereto. For test procedures not listed in the Code of Federal Regulations, test procedures outlined in EPA Methods for Chemical Analysis of Water and Wastes (March, 1979); or Standard Methods for the Examination of Water and Wastewaters (1975); or, A.S.T.M. Standards, Part 31 (1979), Water shall be used.

(b) The analytical technique for total uranium (as U) shall be the fluorometric method as referenced in Methods for Determination of Radioactive Substances in Water and Fluvial Sediments, Techniques of Water - Resource Investigations of the U.S. Geological Survey, Book 5, Chapter A-5 (1977).

(c) Where standard methods of testing have not been established, the suitability of testing procedures shall be determined by the Department.

Section 8. Limit of Detection. Where the standard is below the lower limit of detection given in EPA Methods for Chemical Analysis of Water and Wastes (March, 1979), or Standard Methods for the Examination of Water and Wastewaters (1975), or, A.S.T.M. Standards, Part 31 (1979), Water, the standard shall be the lower limit of detection, unless otherwise provided by the Council.

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