G. Summary of Site Risks:

1. *Summary of Human Health Risk Assessment:*

The baseline risk assessment estimates what risks the site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the Record of Decision summarizes the results of the baseline risk assessment for this site.

For the purposes of this project, a full traditional risk assessment was not performed. Instead because EPA and UDEQ have adopted drinking water standards and the ground waters in the valley are a potential and actual drinking water source, for most cases the concentrations of the chemicals of concern in the ground water were simply compared to the drinking water standards. With the exception of sulfate, which has no primary standard adopted by EPA, any exceedance of primary drinking standards presents an unacceptable risk to anyone drinking this water. Because sulfate concentrations are the most pervasive chemical of concern at the site, the risk assessment focused largely on estimating the concentration of sulfate that produces unacceptable health impacts to sensitive populations. A Risk Assessment Task Force, composed of toxicologists and epidemiologists from EPA, Utah Department of Environmental Quality, Utah Department of Health, Salt Lake City/County Department of Health, City of West Jordan, and Kennecott, aided EPA and its contractor in collecting research papers, evaluating the quality of the research, and recommending the level of concern.

a. *Identification of Chemicals of Concern*: The following table describes the various concentrations found in the acid plume downgradient of the Large Bingham Reservoir:

CONCENTRATIONS OF CHEMICALS OF CONCERN
(From Remedial Investigation Report, Table 4-8; All concentrations are in mg/L unless noted)

Chemical	No. of samples	Minimum value	Maximum value	Mean	Std. Dev.	% not detected
pH*	336	2.6	6.87	4.33	1.22	0
TDS	336	1236	77574	28000	22000	0
bicarbonate	58	<1.0	780	130	150	17
chloride	308	41	539	190	75	0
fluoride	58	<0.1	16.2	2.4	3.8	19

Chemical	No. of samples	Minimum value	Maximum value	Mean	Std. Dev.	% not detected
sulfate	337	**426**	**59,000**	**20,000**	16,000	0
calcium	280	8	1040	420	160	0
magnesium	290	127	8640	2600	2200	0
potassium	279	<0.01	70	7.2	5.9	4
sodium	290	24	910	100	92	0
nitrate	79	<0.01	4.5	0.67	0.95	41
aluminum	124	<0.005	**4690**	**910**	1200	16
arsenic	276	<0.001	**4.1**	0.040	0.27	38
barium	234	<0.005	0.9	0.024	0.065	51
cadmium	277	<0.001	**9.34**	**0.42**	1.1	16
chromium	234	<0.002	0.99	0.078	0.13	39
copper	277	<0.001	**192**	**47**	49	15
iron	148	<0.01	**1222**	**250**	320	5
lead	277	<0.001	**0.85**	**0.034**	0.13	55
manganese	146	0.01	**1100**	**180**	180	0
nickel	129	<0.01	**850**	**18**	75	3
selenium	277	<0.002	**0.9**	0.022	0.081	55
silver	234	<0.001	**0.24**	0.014	0.030	64
zinc	239	<0.01	**544**	**69**	68	2

* negative log of H concentration
bold values exceed either a primary or secondary drinking water standard

As demonstrated in this table, the components with maximum concentrations in the ground water exceeding either a primary or secondary drinking water standard include pH (acidity), total dissolved solids, chloride, fluoride, sulfate, aluminum, arsenic, cadmium, copper, iron, lead, manganese, nickel, selenium, silver and zinc. Even the mean concentrations of several components exceed primary or secondary standards, including pH (acidity), total dissolved solids (TDS), fluoride, sulfate, aluminum, cadmium, copper, lead, manganese, nickel, and zinc. Because the concentration values are widely variable and can migrate, the maximum concentration was used for the exposure point assessment. These concentrations are located in the core of the acid plume.

b. *Exposure Assessment*

Potentially exposed populations in current and future scenarios: Currently, the public is not being exposed to the ground waters of the acid plume. This is because the acid plume is still underneath Kennecott property currently and Kennecott holds the water rights to this water. However, if nothing is done to contain the plume in perpetuity or treat it, the contaminated ground water will continue to move down gradient in the aquifer eventually leaving Kennecott property. Theoretically, at that time, any citizen, municipality, or business that has a water right in the impacted ground water area could access the contaminated water causing their household, customers, and workers to be exposed to unacceptable concentrations of acids, metals, and sulfate in their drinking water. If nothing is done to prevent the continued movement of the plume, more and more wells in the path downgradient of the plumes would degrade in their quality. At least one municipal well field, perhaps two, are also threatened. The situation would only get worse with the passage of time.

The worst case scenario is theoretically possible. There are currently about 800 water rights holders in this area including two municipalities. Absent any institutional controls approved by the Utah State Engineer, additional water rights could be granted and well permits issued to anyone. In addition, several wells were found where the property owner did not possess a water right or a well permit at all. The worst case scenario is unlikely because the State Engineer will probably approve institutional controls to prevent exposure and few citizens would invest the money to drill a well in a known area of contamination.

Any sensitive populations: There are two populations sensitive to excessive levels of sulfate, the most pervasive chemical of concern. Excessive levels of sulfate in drinking water produces diarrhea, a problem which is annoying, but not particularly life threatening, except in infants. Infants with diarrhea can quickly become dehydrated. For this reason, pediatricians warn against making infant formula with waters high in sulfate. Medical evidence shows that adults and older children can build up a tolerance to high sulfate with repeated exposures. Visitors to any area with elevated sulfates in the drinking water would feel the effects to a greater degree than the resident population. Visitors would include household guests, and tourists patronizing local hotels, restaurants, tourist attractions, and commercial establishments.

Route of exposure: The route of exposure is ingestion of contaminated ground water for adults, children, infants, and visitors. Other routes of exposure such as uptake of metals and sulfate from irrigation waters into garden vegetables, dermal exposure, and inhalation were not quantified.

Assumptions: A traditional risk assessment was not conducted for this operable unit because drinking water standards have already been developed by EPA and adopted in regulations by the State of Utah. Therefore, the assumptions used at the site are the assumptions used to derive the national and state drinking water standards. It should be pointed out that some of the drinking water standards are based on more than health concerns; some include recognition of the treatment technologies available at the time of promulgation. As a result, some of the drinking water standards are under review, e.g., for lead and arsenic.

c. *Toxicity assessment*

According to the EPA Office of Ground Water and Drinking Water, the effects of drinking water exceeding the primary standards are given in the following table:

HEALTH EFFECTS OF ELEVATED INORGANIC COMPONENTS IN DRINKING WATER

Drinking water component	Potential Health Effects from ingestion of water exceeding the primary drinking water standard
Arsenic	Skin damage, circulatory system problems, increased risk of cancer
Barium	Increase in blood pressure
Cadmium	Kidney damage
Chromium	Allergic dermatitis
Copper	Gastrointestinal distress, liver or kidney damage
Fluoride	Bone disease, mottled teeth
Lead	Delays in mental development, kidney problems, high blood pressure
Nitrate	blue baby syndrome
Selenium	hair or fingernail loss, numbness, circulatory problems

EPA has not yet adopted a federal primary drinking water standard for sulfate. This is mainly because there is little medical evidence and in some cases the information is contradictory. The State of Utah adopted a primary sulfate drinking water standard of 500 ppm to 1000 ppm, depending on whether the use was principally residential. The risk assessment evaluated the available toxicological information and medical research on sulfate to establish a health based goal for this project. This re-evaluation was conducted because sulfate is the most pervasive chemical of concern in the acid plume.

The risk assessment determined that the main effect of elevated concentrations of sulfate was diarrhea. The effect was short-lived because people appear to develop a tolerance after about a week of exposure. Therefore, residents of an area may not show any symptoms of high sulfate exposure; whereas, visitors to the area could be affected. Although diarrhea is an annoying condition to adults, it can be potentially dangerous to infants. Because of their low body weight, diarrhea can cause dehydration quickly in infants. An examination of the literature determined that few if any effects would occur even to visitors and infants if concentrations of sulfates are kept below 1500 ppm.

d. *Risk Characterization*:

The concentrations of contaminants in the ground water were compared to primary drinking water standards and the health based sulfate level which were used as benchmarks in the following table. In this comparison, the ratio of the acid plume concentrations to the drinking water standard or safe level is analogous to a Hazard Quotient.

RISK OF CHEMICALS OF CONCERN IN ACID PLUME

Chemical of Concern	Primary Drinking Water standard or health based level (mg/l)	Maximum concentration in acid plume (mg/l)	Ratio acid plume/safe level (analogous to a Hazard Quotient)
Arsenic	0.05	4.1	82
Barium	2	0.9	0.45
Cadmium	0.005	9.34	1868
Copper	1.3 (action level)	192	147

Chemical of Concern	Primary Drinking Water standard or health based level (mg/l)	Maximum concentration in acid plume (mg/l)	Ratio acid plume/safe level (analogous to a Hazard Quotient)
Fluoride	4	16.2	4.05
Lead	0.015 (action level)	0.85	56.6
Nitrate	10	4.5	0.45
Selenium	0.05	0.9	18
Nickel	0.1 (Utah standard)	850	8500
Sulfate	1500 ppm health-based level; 500 ppm Utah primary standard	59,000	39.3, based on health based standard; 117.9, based on state primary standard

In this case, the ratios (hazard quotients) are not additive since the contaminants affect different organs and tissues. Most of the metals in the ground waters within the acid plume are in excess of drinking water standards, sometimes by a factor of thousands. The predominant exposure pathway is ingestion of the contaminated ground water.

There are several uncertainties associated with estimation of risk from exposure to the contaminated ground water of the acid plume. (1) There are no current exposures to the ground water. Several private well owners have already been hooked up to municipal systems. Kennecott has purchased additional lands to limit access. Therefore, the risk associated with the plume is a future risk assuming that nothing further will be done. Because of the complex chemistry which occurs as the acid plume moves (neutralization, precipitation, redissolution, etc.), the calculations were based on the current concentrations in the plume, not what the plume might contain in the future. This assumption would likely overestimate future risk. (2) Drinking water standards are largely health based, but do contain some consideration for the drinking water treatment technologies routinely available at the time of promulgation. This could mean that the risk could be underestimated. (3) The scientific literature on the health impacts of sulfate is sparse and sometimes contradictory. Because of this uncertainty, EPA has chosen to use a fairly conservative health-based level.

2. *Summary of Ecological Risk Assessment*

The ecological risk assessment estimates what risks the site poses if no action were taken. It provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the Record of Decision summarizes the results of the Ecological Risk Assessment for this site.

In a strategy analogous to the human health risk assessment, the ecological risk assessment was streamlined and focused on the impacts of ground water recharge to the Jordan River and additional loads of contaminants that might be expected in the near and distant future. The concentrations of contaminants in the river with the projected additional loads were then compared to Utah Water Quality Standards for the river. The exposure point was assumed to be that stretch of river that intersects the path of the groundwater flow.

a. *Current and near future water quality impacts from ground water*:

The ecological risk assessment studies compared the concentrations of contaminants in the river with contaminants in nearby monitoring wells to estimate if any ecological impacts might be present or anticipated in the near future. The following table gives the results of this investigation updated with the most recent water quality standards.

COMPARISON OF WATER QUALITY IN WELLS WITH JORDAN RIVER WATER QUALITY STANDARDS (Updated from RI/FS)
Jordan River Narrows to Little Cottonwood Creek segment

Contaminant	Jordan River concentrations	Concentrations in nearby ground water wells	Utah Water Quality Standards for Jordan River segment (4-day, aquatic life 3a class)
TDS	973 mg/l (upstream) 1135 mg/l (downstream)	not given	1200 ppm (agricultural use standard, none for aquatic life)
Cadmium	2.0 ppb or less	<2.0 ppb	1.1 ppb
Copper	20 ppb or less	19 ppb	12 ppb
Selenium	<3 ppb	9 ppb	5 ppb

Contaminant	Jordan River concentrations	Concentrations in nearby ground water wells	Utah Water Quality Standards for Jordan River segment (4-day, aquatic life 3a class)
Zinc	11 ppb	252 ppb	110 ppb
Sulfate	248 mg/l (upstream) 309 mg/l (downstream)	432 mg/l	no standard - calculated from literature 505 mg/l

The concentrations in the ground water of wells near the Jordan River exceed the Utah Water Quality Standards for the Jordan River for copper, selenium, zinc, and perhaps others. After mixing with other waters in the river, the concentrations in the river may eventually exceed the standard in the near term but not excessively so. Kennecott asserts that the contaminants do not come from mining activity but from irrigation and other sources.

b. *Sources of water to the Jordan River segment of interest*:

Although the average flow of the Jordan River during the irrigation season has been estimated near Utah Lake at 204,000 gpm, nearly 100% of the river is diverted by irrigation canals during the irrigation season. The average flow of the river near the site (9000 South) is 40,000 gpm during irrigation season. The ground water model results suggests that 21,400 gpm (53%) of this flow originates from ground water discharge from the western part of the valley (the location of this site), 7,200 gpm (18%) from the eastern side of the valley, and 11,800 gpm (29%) from return flow from the irrigation canals.

c. *Future ecological risk*:

Although the current or near term risk appears to be low for the contaminants associated with the ground water, a different picture altogether emerges if the acid plume is allowed to reach the Jordan River. Ground water modeling suggests that this could occur in 150 years if nothing is done to contain the plume. The following table illustrates what could happen in this circumstance.

POTENTIAL CONCENTRATIONS OF CONTAMINANTS IN JORDAN RIVER IF ACID PLUME IS NOT CONTAINED (updated from the RI Report)

Contaminant	Average Jordan River concentration (average of upsteam and downstream)	Average concentration in acid plume (1997)	Jordan River after mixing with acid plume (assuming a 1:20 mixing ratio, year round)	Water Quality Standard (4-day, aquatic class 3a, Jordan River)	Ratio of future Jordan River to standards
Sulfate	278 mg/l	18,000 mg/l	1039 mg/l	no standard, 505 mg/l calculated from literature	2.06
TDS	1054 mg/l	25,000 mg/l	2195 mg/l	1200 mg/l, agricultural use standard	1.83
Cadmium	< 2 ppb	620 ppb	29.1 ppb	1.1 ppb	26.4
Copper	<20 ppb	41,000 ppb	1818 ppb	12 ppb	151.5
Selenium	<3 ppb	14 ppb	4.3 ppb	5.0 ppb	0.86
Zinc	11 ppb	67,000 ppb	2933 ppb	110 ppb	26.7

This calculation demonstrates that the water quality of the Jordan River would decline seriously should the acid plume be allowed to reach the river. The situation is actually worse during irrigation season when there is essentially no dilution factor available because the flows in the river are less.

d. *Uncertainties*:

The uncertainties inherent in these calculations are numerous. The assumptions are particularly uncertain. (1) This calculation assumes that the acid plume will eventually reach the Jordan River. However, the acid plume is in the principal aquifer rather than the shallow aquifer. It is known that the shallow aquifer discharges to the river. The principal aquifer may go underneath it or discharge to it at a much slower rate. The calculations, therefore, represent a worst case scenario. (2) This calculation assumes that the average concentrations in the acid plume currently would reach the river with its concentrations unmodified by dispersion or reactions with the aquifer solids. This is very unlikely. By the time the acid plume reaches the river, concentrations of contaminants are likely to be much less. Again, the calculations represent a worst case scenario. (3) These calculations assume that the water quality in the river will remain the same in the future as they are today. Although improving water quality in the river will not help much if the acid plume does reach the river, declining water quality in the river could make the situation worse. (4) The mixing ratio varies seasonally. The calculations represent the annual average. During irrigation season the influence of ground water on the Jordan River is much more important than during the rest of the year. (5) The ground water flow rates to the river are based on the ground water model for the site and, therefore, are affected by the uncertainties associated with the use of the model. These uncertainties are just a few examples of the difficulties in estimating risk far into the future.

3. *Basis for action*

Absent limitations on access to the ground water, human health could be at risk to anyone seeking to use the water for culinary purposes. The water quality fails to meet primary standards and health based levels. It is also not suitable for municipal supplies without treatment because it violates a host of secondary standards. In some cases the water is unuseable even for secondary uses such as irrigation due to its acidity.

If nothing is done, the acid plume will continue to move toward the Jordan River where it could impact the Jordan River's aquatic life, perhaps severely.

H. Remedial Action Objectives:

1. Minimize or remove the potential for human risk (by means of ingestion) by limiting exposure to ground water containing chemicals of concern exceeding risk-based concentrations or drinking water Maximum Contaminant Levels.

    a. Human health risk is minimized by either reducing the contaminant levels or cutting off the exposure pathway.

    b. Contaminants, which could be ingested, can be decreased by reducing the concentrations in the aquifer itself to drinking water standards or treating the ground waters to drinking water standards before it is used.

    c. The exposure pathway can be cut by limiting access to the ground water and obtaining water from another source.

2. Minimize or remove the potential for environmental risk (by means of flow of ground water to the Jordan River) to receptors of concern.

    a. Ecological risk is minimized only by reducing the contaminant levels.

    b. Contaminant levels could be decreased only by reducing the concentrations in the aquifer itself.

3. Contain the acid plume and keep it from expanding.

    a. Containment of ground water plumes is the expected minimum for ground water actions in the National Contingency Plan.

    b. Allowing the plume to move farther will contaminate additional ground water, including at least one municipal well field, and damage additional aquifer materials.

    c. Maintain sulfate-laden ground water in excess of 1500 mg/l west of the Kennecott property line in Zone A.

4. Remediate the aquifer over the long term

    a. Ground water in this aquifer is a resource that is needed by the public both now and in the future as communities grow westward toward the Oquirrh Mountains.

b. Remediation is the only long term option which is totally effective in preventing the public from exposure to dangerous levels of contaminants in this ground water.

5. Return ground water to beneficial use.

a. Return of ground water to beneficial use is an expectation of the National Contingency Plan.

b. The site is located in a semi-arid climate. Ground water resources are needed to support additional population and development growth projections for the site.

I. Description of Alternatives

The Remedial Investigation/Feasibility Study evaluated six (6) alternatives. A number of others were rejected in the screening process. A summary of each of the six retained alternatives is given below:

1. Alternative 1 - No Further Action.

This alternative relies solely on natural attenuation to achieve long term remediation goals. This could take 800 years or longer. Citizens and municipalities would be responsible for limiting their own exposures.

a. Major elements of Alternative 1:

- Maintenance of source controls already implemented by Kennecott: (Kennecott has constructed a system to collect acid rock drainage which continues to emanate from their waste rock dumps. This must be maintained in order to prevent additional contaminants from entering the ground water.)
- Monitoring effectiveness of source controls as required in a State Groundwater Permit: (The state has issued a Ground Water Permit to Kennecott which requires Kennecott to monitor wells downgradient of their source controls to demonstrate that the controls continue to prevent further contamination.)
- Monitoring migration of the plume: (A monitoring network has been installed. In this alternative, movements of the plume could be determined and water users warned of the arrival of the acid plume.)

b. Key ARARs:

Continued participation in the State Ground Water Protection Program which requires the operations and maintenance of the source control measures is required. After mine closure the operations and maintenance of the source control measures must be maintained, perhaps as an element of the Mine Closure Plan administered by the Utah Division of Oil, Gas and Mining. In addition, chemical specific standards would be ARARs, but they would not be met.

c. *Long term reliability*:

The source control measures are well constructed and are likely to be reliable in the long term.

d. *Quantity of untreated waste and treatment residuals*:

Because there is no treatment, the quantity of untreated water actually grows as the plume gets further dispersed over time. There would be no treatment residuals as a result of this option other than those associated with source control.

e. *Estimated time for design and construction*:

The source control measures are already designed and constructed.

f. *Estimated time to reach remediation goals:*

None of the goals would be achieved for at least 800 years, perhaps longer.

g. *Estimated costs*: (Appendix M, RI/FS)

ESTIMATED COSTS FOR ALTERNATIVE 1

Activity	Capital costs	O+M costs for 30 years	net present value
Source controls (already implemented by Kennecott)	$127M already expended, not included in cost	$19.2M	$19.2M
Monitoring		$7.1M	$7.1M
TOTAL (discount rate = 7%)		$26.3M	$26.3M

h. *Use of presumptive remedies or innovative treatment*:

No presumptive remedies or innovative treatment technologies are used in this alternative.

i. *Expected outcome*:

This alternative relies entirely on natural attenuation leaving the public and municipalities to their own devices to prevent exposure. Eventually when the plume reaches the Jordan River, the aquatic ecosystem might be severely impacted.

2 *Alternative 2 - Institutional Controls*:

This would seek to prevent exposure to the public, but does nothing to contain or treat the plume itself.

a. *Major elements of Alternative 2*

- Restrictions on use of existing wells, as approved by the Utah State Engineer: (Measures include purchase of land and water rights; restrictions on land use to prevent use of wells through codes, covenants; and restrictions by either municipal, county or state government)

- Restrictions on drilling of new wells, as approved by the Utah State Engineer: (Purchases of water rights and land; restrictions on land use to prevent drilling of wells using codes, covenants, and restrictions by either municipal, county or the State Engineer.)

- Modifications of above restrictions as the plume migrates in the future

- Includes the measures in Alternative 1.

b. *Key ARARs*:

In addition to ARARs from Alternative 1, the key ARARs in this case would be the various Utah Water Rights Laws, Utah Well Drilling Regulations, and local building codes.

c. *Long term reliability*:

This relies on the citizens to conform to the letter and spirit of all restrictions that might be placed on them by their local governments and by the State Engineer. This is very unlikely. Circumvention of the water rights regulations and local ordinances is rather common because citizens view these as an infringement on their property rights. Enforcement would be very difficult. Although this might work temporarily, it would not be very reliable in the long term.

d. *Quantity of untreated waste and treatment residuals*:

Since there is no treatment the quantity of untreated water actually grows as the plume gets further dispersed over time. There would be no treatment residuals other than associated with source controls.

e. *Estimated time for design and construction*:

It is estimated that two years would be required to get all of the institutional controls in place.

f. *Estimated time to reach remediation goals*:

Although people might not be exposed to contaminated water, the plume continues to move eventually reaching the Jordan River. It could take 800 years for the contaminated plume to be flushed through the aquifer.

g. *Estimated costs:* (Appendix M, RI/FS)

ESTIMATED COSTS FOR ALTERNATIVE 2

Activity	Capital costs	O+M costs for 30 years	net present value
Activities in Alternative 1		$26.3M	$26.3M
Water rights and land purchase	$16M (2 years)		$16.5M
TOTAL	$16M	$26.3M	$42.3M

h. *Use of presumptive remedies or innovative treatment*:

No presumptive remedies or innovative treatment technologies are used in this alternative.

i. *Expected outcome*:

This alternative relies on natural attenuation but does prevent exposures to the public by limiting access to the water. When the plume reaches the Jordan River the aquatic life could be impacted, perhaps severely. The success depends on the cooperation of municipal, local and state government and all the citizens to cooperate with the regulations. This cannot be guaranteed in perpetuity.

3. *Alternative 3 - Point of Use Management*:

This alternative seeks to prevent exposure to the public but does nothing to contain or treat the plume itself.

a. *Major elements of Alternative 3:*

- Replace impacted private well water by connecting residences to existing municipal water supply systems. (Instead of simply banning further use of wells, private well owners are given replacement water from municipal systems with waters unaffected by the plume. Wells can still be used to provide irrigation water if the values are less than 1500 ppm sulfate.)

- Install household water treatment units (such as reverse osmosis) to treat water supplied to residences by private wells: (When municipal systems are not available, treatment of the private well water can be provide with in-home treatment units. Wells can still be used without treatment to provide irrigation water, if the values are less than 1500 ppm sulfate.)

- If municipal systems are impacted in the future, alternative water supplies would be required or a treatment plant installed: (Modeling suggests that the plume might impact at least one municipal well field. If this occurs, it will be necessary to build a treatment plant for these wells.)

- Includes all the measures in Alternatives 1 and 2.

b. *Key ARARs:*

In addition to the ARARS in Alternative 2, the key ARAR in this alternative would be the Utah Drinking Water regulations which apply to municipal services and drinking water quality at the tap.

c. *Long term reliability:*

Hooking people up to municipal supplies has long term reliability although there could still be exposure to residents with wells since the wells would not be shut off. Limitations on the kinds of uses would work for the current well owner, but may not be passed on to new owners. Because this would be necessary for a long period of time, there could still be occasional exposure. In-home treatment units require some effort on the part of the resident to maintain the units and replace them when necessary. Information about the need for this treatment might not be passed on to any new owners. In-home treatment systems would not work should the acid plume core reach a private well. This alternative does nothing to clean up the aquifer itself.

d. *Quantity of untreated waste and treatment residuals:*

Although there would be some treatment residuals produced within the in-home treatment units, the amount would be minimal and would end up with the trash at a municipal landfill. The quantity of untreated waste actually increases as the plume continues to spread out contaminating more and more water as it moves downgradient.

e. *Estimated time for design and construction:*

It might take two years to locate all the affected parties, design extensions to public water systems, and install in-home systems. Evaluation of the plume movement patterns would continue indefinitely to observe and mitigate future impacts as the plume moves.

f. *Estimated time to reach remediation goals:*

Although exposure to the public would be minimized in the short term, this alternative does nothing to remediate the aquifer. The plume would continue to move unimpeded toward the Jordan River where impacts might occur, perhaps severe impacts. The aquifer would take 800 years or longer to flush through the environment.

g. *Estimated costs:* (Appendix M, RI/FS)

ESTIMATED COSTS FOR ALTERNATIVE 3

Activity	Capital costs	O+M costs for 30 years	net present value
Activities in Alternatives 1 and 2	$16M	$26.3M	$42.3M
Municipal connections	$0.901M	not estimated	$0.901M
Household treatment units (400)	$0.618M	$0.64M	$1.3M
TOTAL (7% discount)	$17.6M	$27.2M	$44.8M

h. *Use of Presumptive remedies or innovative treatment*:

There are no presumptive remedies or innovative treatment technologies used in this alternative.

i. *Expected outcome* :

Private well owners would be protected from exposure to unacceptably high concentrations of contaminants in their well water because an alternative source of culinary water would be provided. The well owners could continue to use their wells for irrigation purposes, but could be exposed if they used the water inappropriately. Institutional controls would have to be in place, essentially in perpetuity to verify that well water is used properly. New owners may not be made aware of the problems. This alternative would do nothing to prevent the plume from eventually reaching the Jordan River perhaps causing severe impacts. Alternative 3 would do nothing to remediate the aquifer. Fresh water recharges would also become contaminated as they encounter the plume and the contaminated alluvium. The plume could take 800 years or longer to course through the system.

4. *Alternative 4 - Hydraulic Containment, Reverse Osmosis (RO) Treatment, Delayed Acid Plume Extraction, Nanofiltration (NF) Treatment and Delivery of treated water*:

Alternative 4 seeks to prevent exposure to the public, contain the contaminated water and eventually treat the contaminated plume.

a. *Major elements of the alternative*:

- Installation of a barrier well containment system at the leading edge of the acid plume: (The barrier well system seeks to prevent further downgradient migration of the plume.)

- Treatment of the water using reverse osmosis (RO) for the first 10 years: (The waters would initially be high in sulfate which could be treated successfully with RO. In 10 years, the core of the acid plume would migrate to the wells and RO would not be able to work, due to high concentrations of sulfate, heavy metals and acid..)

- After the first 10 years, pretreatment of the water will be necessary as the core of the acid plume migrates to the barrier well system: (Membrane technology, such as Nanofiltration (NF) is proposed for pretreatment. As the highly acidic waters encounter the barrier wells, pretreatment of the water to reduce contaminant concentrations will be necessary before it is sent for polishing at the RO plant.)

- Treated water would be delivered to a municipal water purveyor.
- Concentrates would be discharged into Kennecott's tailings line or into Kennecott's mineral processing water circuit.
- Includes all the measures in Alternatives 1, 2, and 3.

b. *Key ARARs*:

In addition to ARARs in Alternative 3, key ARARs include the Utah Drinking Water Regulations, Utah Public Water Supply requirements, the Utah Ground Water Protection Corrective Action program, RCRA, the Utah Pollutant Discharge Elimination Program permit regulations, and Utah Water Rights Laws.

c. *Long term reliability*:

While preventing exposures to water users downgradient, this alternative incorporates a barrier well system which would seek to prevent further downgradient migration of the plume. The long term reliability of the barrier system is questionable because the highly acidic waters eventually encounter the barrier wells and any leakage past these wells would cause significant amounts of contaminants to escape downgradient. However, the technology, reverse osmosis with nanofiltration pretreatment, has been shown in pilot tests to work on the plume and could be reliable with proper maintenance.

d. *Quantity of untreated waste and treatment residuals*:

At the end of the remedial action, there should be no untreated wastes. If a pumping rate of 3500 gpm is assumed, treatment residuals could be as high as 2100 gpm over the life of the project. Existing infrastructure for management of treatment residuals would be available so long as the mining operations continue. Other methods of disposal for treatment residuals would be necessary following mine closure.

e. *Estimated time for design and construction*:

The entire remedy would not be in place for 10 years. A monitoring system would also be needed to ensure that leakage past the barrier wells is not occurring.

f. *Estimated time to reach remediation goals*:

Containment of the plume might be achieved quickly and prevention of exposure to humans and the aquatic species in the Jordan River would also be achieved quickly. The time required to remediate the aquifer could be 150 years or longer.

g. *Estimated costs* (Appendix M, RI/FS)

ESTIMATED COSTS FOR ALTERNATIVE 4

Activity	Capital costs	O+M costs for 30 years	net present value
Monitoring, Institutional Controls, Point of Use Management (Alternatives 1 - 3)	$17.6M	$27.2M	$44.8M
Installation of barrier wells, pump stations and infrastructure	$20.8M	$65.4M	$86.2M
Reverse Osmosis facility	$23.3M	Part of infrastructure O+M	$23.3M
Nanofiltration pretreatment plant after first 10 years	$30.M	$38.4M	$68.4M
Additional barrier wells and upgrades after first 10 years	$21.8M	Part of infrastructure O+M	$21.8M
TOTAL (7% discount)	$86.2M	$103.8M	$217.2M

h. *Use of presumptive remedies or innovative treatment*:

This alternative does not use presumptive remedies. Membrane technology such as nanofiltration is still considered innovative because a number of the operational details and O+M requirements have not yet been fully worked out.

i. *Expected outcome*:

Citizens are protected from exposure to contaminants and the acid plume never reaches the Jordan River. The ground water is cleaned up over time and is returned to beneficial use. Continued monitoring would be necessary to verify barrier well effectiveness.

5 *Alternative 5 - Hydraulic Containment, NF Pretreatment, RO Treatment, Active Pumping of the Core of the Acid Plume and Delivery of the treated water*:

Alternative 5 has two well systems, one for containment of the plume at the plume boundary and another for withdrawal of acidic waters from the core of the plume to begin the remediation of the aquifer. People are prevented from being exposed during the project by point of use management and treated water is provided to communities.

a. *Major elements of Alternative 5*:

- Installation of a barrier well containment system: (The barrier well system collects contaminated waters (primarily sulfate laden) at the leading edge of the plume preventing further migration of the plume. Traditional RO treatment can be used.)

- Installation of a well or wells in the core of the acid plume so that highly acidic waters do not migrate to the barrier wells and remediation of the acid plume can begin quickly: (Modeling suggest that pumping from the core would prevent the acid plume from approaching the barrier well system. Any migration of the acid water beyond the barrier wells could cause severe degradation of ground water quality. With these upgradient core plume wells, the barrier wells become a safety net rather than the primary containment system.)

- Pretreatment of acid waters using nanofiltration: (Waters from the core of the plume are too high in dissolved solids to be treated efficiently with reverse osmosis. Membranes would clog too quickly. Nanofiltration has been shown to work on a pilot scale using acid leachate waters from the site. Operational details need some refinement.)

- Treatment of pretreated core waters and barrier well sulfate waters by reverse osmosis: (Treatment and polishing of waters would be accomplished using traditional RO technology.)

- Treated water is delivered to a municipal water purveyor, as a requirement under the NRD action.

- Pre-mine closure, treatment concentrates are disposed by insertion into Kennecott's tailings line or into Kennecott's mineral processing water circuit.

- Includes all the measures in Alternatives 1, 2, and 3.

b. *Key ARARs*:

In addition to ARARs in Alternative 3, key ARARs include the Utah Drinking Water Regulations, Utah Public Water Supply requirements, the Utah Ground Water Protection Corrective Action program, RCRA, the Utah Pollutant Discharge Elimination Program permit regulations, and Utah Water Rights Laws.

c. *Long term reliability*:

While preventing exposures to the public downgradient, this alternative provides a dual containment system. The acid wells would withdraw waters from the core of the plume. Drawdowns within the aquifer caused by this pumping should theoretically stop all eastward movement of the plume. The barrier wells along the front of Zone A would provide a safety net to stop less concentrated materials from escaping downgradient. The technology has been shown in preliminary pilot tests to work on the plume and, with proper maintenance, the technology will be reliable.

d. *Quantity of untreated waste and treatment residuals*:

At the end of the remedial action, there should be no untreated wastes. If a combined barrier well/acid well pumping rate of 3500 gpm is assumed, treatment residuals could be as high as 1300 gpm over the life of the project. Existing infrastructure for management of treatment residuals would be available so long as the mining operations continue. Other methods of disposal for treatment residuals would be necessary following mine closure. A plan will be developed using current technology as a part of the Remedial Design which can be implemented immediately, with the understanding that a different strategy can be used upon approval by EPA and UDEQ using technology available at the time of mine closure.

e. *Estimated time for design and construction*:

Construction completion is estimated to take 5 years. Design and experimentation with treatment parameters could take 1.5 years of this.

f. *Estimated time to reach remediation goals*:

Containment of the plume could be achieved quickly and prevention of exposure to people in the affected area and the aquatic species in the Jordan River could also be achieved quickly. The time required to remediate the aquifer could be 150 years or longer. Modeling suggests that the original core of the acid plume would be largely removed in the first 30 years. However, withdrawals and treatment would have to continue for a long time as components in the solid phase of the impacted aquifer materials begin to re-dissolve back into the water as the fresh water flows through the contaminated aquifer material. The time it would take to achieve a total cleanup is unknown. Further modeling and monitoring may give insights on progress as the project continues.

g. *Estimated costs*: (Appendix M, RI/FS)

ESTIMATED COSTS FOR ALTERNATIVE 5

Activity	Capital costs	O+M costs for 30 years	net present value
All the measures in Alternatives 1, 2, and 3	$18M	$27M	$45M
Installation of a barrier well containment	$8.98M	$19.23M	$28.11M
Withdrawal from the core of acid plume and Pretreatment of this acid water using NF	$23.1M	$33.9M	$47.0M
Treatment of pretreated acid waters by reverse osmosis	$2.9M	Included in RO costs	$2.9M
Treatment of sulfate waters from barrier sulfate wells by reverse osmosis	$17.5M	$21.3M	$38.8M
Treated water is delivered to a municipal water purveyor	included in treatment	included in treatment	included in treatment

Activity	Capital costs	O+M costs for 30 years	net present value
Concentrates are disposed in Kennecott's tailings line	$4.4M	$21.0M	$25.4M
TOTAL	$74.5M	$122.7M	$197.2M

h. *Use of presumptive remedies or innovative treatment*:

This alternative does not use presumptive remedies. Membrane technology such as nanofiltration is still considered innovative because a number of the operational details and O+M requirements have not yet been fully worked out. Disposal of the treatment residuals into the existing tailings pipeline is also innovative. It takes advantage of the neutralization capacity of the tailings in a 13-mile long pipeline to neutralize the treatment concentrate and precipitate out the metals. Because it takes advantage of existing infrastructure of the mill, it is also very cost effective.

i. *Expected outcome*:

Citizens are protected from exposure to contaminants and the acid plume never reaches the Jordan River. The aquifer is cleaned up over time. Based on modeling predictions, most of the cleanup occurs while the mining operations continue so existing infrastructure can be used. The ground water is returned to beneficial use.

6 *Alternative 6 - Hydraulic Containment, NF Pretreatment,RO Treatment, Active Pumping of the Acid Plume and Lime Treatment of Treatment Residuals*

a. *Major elements of Alternative 6:*

- Same as Alternative 5, except acidic waters are withdrawn from the aquifer, treated with NF and the treatment concentrate is treated with lime. Two waste streams are generated: solid residuals from lime treatment and the water which is not delivered to the public but is used as process waters by Kennecott. The RO plant treats only the waters from the barrier wells, not waters from the core of the plume.

- Standard technology for lime treatment of acid rock drainage used by the mining industry is used instead of more innovative technology such as treatment in the tailings pipeline.

- Treatment residuals from lime treatment of the nanofiltration concentrations are stored in a lined repository located close to the treatment plant.

b. *Key ARARs*:

In addition to ARARs in Alternative 5, key ARARs include the Utah Drinking Water Regulations, the Utah Ground Water Protection Corrective Action program, Utah Water Rights Laws and the Utah Pollutant Discharge Elimination Program permit regulations. Depending on the composition of the lime wastes, RCRA Hazardous Waste regulations are relevant and therefore influence the design of the repository. It would also need to meet the substantive requirements of the Utah Ground Water Protection Program.

c. *Long term reliability*:

While preventing exposures to the public downgradient, this alternative provides a dual containment system. The wells in the core of the acid plume would withdraw highly contaminated ground water. Drawdowns within the aquifer caused by this pumping should theoretically stop all eastward movement of the plume. The barrier wells of the acid plume would provide a safety net to stop less concentrated materials from escaping downgradient. The lime treatment technology is not innovative and has been used with reliability in the mining industry for years. However, it does present a disposal problem for the solid wastes produced by the lime treatment.

d. *Quantity of untreated waste and treatment residuals:*

At the end of the remedial action, there should be no untreated wastes. If a combined barrier well/core well pumping rate of 3500 gpm is assumed, treatment residuals could be as high as 240,000 tons/year.

e. *Estimated time for design and construction*:

Construction completion is estimated to take 5 years. Design and experimentation with treatment parameters could take 1.5 years of this.

f. *Estimated time to reach remediation goals*:

Containment of the plume could be achieved quickly and prevention of exposure to people in the affected area and the aquatic species in the

Jordan River would also be achieved quickly. The time required to remediate the aquifer could be 150 years or longer. Modeling suggests that the original core of the acid plume would be largely removed in the first 30 years. However, withdrawals and treatment would have to continue for a long time as components in the solid phase of the impacted aquifer materials begin to re-dissolve back into the water as clean water flows through the contaminated aquifer material. The time it would take to totally cleanup the ground water and the aquifer materials is unknown.

g. *Estimated costs*

ESTIMATED COSTS FOR ALTERNATIVE 6

Activity	Capital Costs	O+M/30 years	net present value
Alternative 5 (except method for disposal of treatment residuals)	$74.5M	$122.7M	$197.2M
Treatment residuals treated with lime and sludge removal	$13.2M	$149.8M	$163.2M
TOTAL	$87.7M	$272.5M	$360.4M

h. *Use of presumptive remedies and innovative treatment*:

This alternative does not use presumptive remedies. It uses an innovative membrane technology (nanofiltration) treatment for the acid waters.

i. *Expected outcome*:

Citizens are protected from exposure to contaminants and the acid plume never reaches the Jordan River. The aquifer is cleaned up over time. The ground water is returned to beneficial use. The volume of lime required using this approach would be large leading to a great increase of traffic in the area. A regulated retention structure for the sludge would be needed.

7 *Ancillary alternatives for special situations*

a. *Alternatives for NF concentrate disposal following cessation of mining and milling operations in 30 years* (tailings pipeline would no longer have tailings flows). These apply to Alternatives 4 and 5.

- Pump the concentrate to a lined facility on the waste rock dumps for evaporation, disposal of the sludges in the dump or in a lined storage facility.

- Use the former tailings pipeline or another dedicated pipeline to convey concentrate to shallow ponds on the top of the new tailings pond for evaporation. Lining depends on the characteristics of the residuals.

- Same as above, but create solar ponds to create electricity. Electricity could be used to help evaporate water during the winter months. Sludge storage is also necessary.

- Lime treatment and disposal of residuals in an on-site RCRA-like repository.

b. *Alternative for RO concentrate disposal following mine closure in 30 years* (this applies to Alternatives 4, 5 and 6):

- Direct disposal in the Great Salt Lake via a new pipeline and outfall. This depends on the nature of the concentrate and impacts on the Great Salt Lake

- Evaporation ponds

c. *Alternatives for well-head protection*

Because there is a possibility that water level drops might affect municipal and private wells throughout the area, additional alternatives for Well Head Protection were developed. In the case of Alternatives 1, 2, and 3, these might be needed to protect wells from being impacted by contaminated water as the plume moves through. In the case of Alternatives 4, 5, and 6, this is needed to prevent wells from going dry as the acid plume in Zone A is aggressively pumped out of the aquifer. These measures might also be needed if the barrier well system is ineffective in totally containing the plume.

- For the West Jordan municipal well field:
  - Install injection wells between the acid plume and the West Jordan municipal well field. (This requires permission from UDEQ.)
  - Inject sufficient water into aquifer to prevent excessive water level drops near West Jordan well field and prevent acid plume migration in that direction. (This requires permission from UDEQ.)
  - Water would come from uncontaminated sources of water in the nearby mountains.

- If draw downs are the main problem, storage of water in the winter months in above ground tanks instead of reinjection.

- For private wells:
  - Hook up to municipal water.
  - Installation and maintenance of a residential reverse osmosis treatment system if municipal water hook up is impractical.
  - Deepening of the affected well if it is thought that a deeper well would yield sufficient replacement water.
  - Replacement of water using other sources.
  - Underground injection up gradient of affected wells to counterbalance the drops. (This requires permission from UDEQ.)

J. Summary of Comparative Analysis of Alternatives:

The National Contingency Plan (NCP) requires that the various remedial action alternatives be evaluated individually and then compared relative to each other using nine criteria. The nine criteria in the National Contingency Plan and how the alternatives compare are described below:

1. Overall protection of human health and the environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

Alternatives 2, 3, 4, 5, and 6 all protect human health. Alternatives 4, 5, and 6 use institutional controls to limit exposure of humans to the contaminated ground water while the aquifer itself is being restored. In Alternatives 2 and 3, human health is also protected by limiting exposure of the public to the contaminated waters through the use of institutional controls. For these alternatives, institutional controls are the sole mechanism of prevention both short term and long term. Alternative 1 does not protect human health.

Alternatives 4, 5, and 6 protect the environment by preventing migration of the plume. The plume never reaches the Jordan River where exposure to aquatic life could occur.

Alternatives 1, 2, and 3 do nothing to contain the plume or prevent it from reaching the Jordan River. They would not protect the environment.

2. Compliance with Applicable or Relevant and Appropriate Requirements

CERCLA and the NCP require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as ARARs, unless such ARARs are waived under conditions outlined by CERCLA.

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations that are promulgated under Federal environmental or State environmental or facility siting laws. These regulations specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations that are promulgated under Federal environmental or State environmental or facility siting laws. These requirements, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site do address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner and are more stringent than Federal requirements may be relevant and appropriate.

The NCP Criterion of compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for invoking a waiver.

Alternatives 4, 5, and 6 would comply with ARARs through appropriate designs. Alternatives 1 - 3 would not comply with chemical specific ARARs

3. *Long Term Effectiveness and Permanence*

Long term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

All alternatives, except the no action Alternative 1, provide some degree of long term protection. Alternatives 4, 5, and 6 offer a permanent cleanup of the aquifer allowing eventually the full use of the ground water resource. The Jordan River would be protected by the remedial action preventing the migration of the plume.

Alternatives 2 and 3 can be effective but access to the contaminated ground water by use of water rights and the circumvention of the institutional controls is possible. The Jordan River would not be protected by these two alternatives. Alternative 1 provides no protection at all to either the public or the Jordan River. The plume would continue to migrate, contaminating the aquifer further and causing the cleanup time to increase.

Alternatives 4, 5, and 6 would produce some form of treatment residuals which would require proper handling and maintenance to maintain effectiveness.

4. *Reduction of Toxicity, Mobility, or Volume through Treatment*

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

Alternatives 4, 5, and 6 all use treatment technologies that would reduce toxicity, mobility and volume of the contaminated ground water. Although Alternative 3 uses in home treatment technology, the purpose is not treatment of the aquifer itself and does not reduce toxicity, mobility or volume. Alternatives 1 and 2 do not involve any treatment at all and would not reduce toxicity, mobility and volume of the contaminated plume. In fact it is likely that the volume of contaminated ground water would actually increase under Alternatives, 1, 2, and 3.

5. *Short term effectiveness*

Short term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

Alternatives 2, 3, 4, 5 and 6 would be effective in the short term because all of these alternatives depend, in the short term, on limiting exposures to humans via institutional controls. Alternatives 3, 4, 5, and 6 are enhanced by providing alternative sources of water to those whose wells are limited by the controls. Alternative 1 is not effective, short term or long term.

6. *Implementability*

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental agencies are considered.

Implementability at this site is a function of the complexity of the remedy. Alternative 1, the no action alternative is most implementable because no one has to do anything extra. Well owners would have to protect themselves. Alternatives 2 and 3 requires the cooperation of the State Engineer and the local governments in restricting the use of the ground water and/or restricting land use. Alternatives 4, 5, and 6 in addition to the above cooperation, also require cooperation of the State Engineer to give permission to pump at rates effective to contain the contamination even though water levels throughout the area might drop thus affecting other water rights owners. A cooperative municipal water purveyor would also be needed to accept the treated water which is also a requirement of the NRD settlement. Alternative 6, in addition to all the cooperation required above would also require large volumes of lime and produce large volumes of residual wastes. Traffic problems and wear and tear on roads could be the result.

7. *Cost*

The types of costs that are assessed include capital costs, annual operation and maintenance costs and net present value of capital and O+M costs.

Alternatives 1, 2, and 3 are the least costly, with costs ranging from \$26M to \$45M, but none of these do anything to cleanup the aquifer. The active remediation remedies, Alternatives 4, 5, and 6 are more costly (\$197M to \$360M) but will eventually clean up the aquifer. Alternatives 4 and 5 take advantage of existing mining infrastructure resulting in savings in disposal costs of treatment residues pre-mine closure. Alternative 6 is the most expensive but does not have any apparent advantages over Alternative 5. Note that since the RI/FS was completed, the total costs for Alternative 5 have been reduced.

8. *State acceptance*

This includes the state's position and key concerns related to the alternatives and comments on ARARs and proposed use of waivers:

In 1995, the state and Kennecott negotiated a Consent Decree to settle a Natural Resources Damage Claim for damages to the ground water in the Southwest Jordan Valley. The terms of the Consent Decree established a cash payment and a letter of credit based on the estimated cost to contain, remove, and treat the contaminated ground water from the plume (Zones A and B). Kennecott could apply for a rebate against the letter of credit by extracting the contaminated water, treating it to drinking water quality standards and providing it to a purveyor of municipal water for use in the affected area. In December, 1999, Kennecott submitted to the State Trustee a plan for use of the Natural Resources Damage settlement dollars. The plan is a combination of Alternative 5, as defined in this ROD, and an additional treatment of sulfate contaminated ground waters downgradient of the Zone A acid plume. Therefore, the state supports Alternative 5, because this alternative is most consistent with the requirements of the NRD action. The state opposes Alternatives 1, 2, and 3 because they essentially sacrifice the aquifer's future use forever. In a semi-arid climate, sacrificing any future water resource has economic development impacts and presents a continuing threat which will have to be managed in perpetuity. Alternative 4 takes longer than Alternative 5, active cleanup of the Zone A acid plume does not take place in the beginning, the potential for this plume not to be captured by the barrier wells is too risky, and costs more. Alternative 6 costs more than Alternative 5 without any apparent benefit to the aquifer or the citizens of Utah.

9. *Community Acceptance*

This determines which components of the alternatives the community support, have concerns about, or oppose.

The primary vehicle of community participation was the Technical Review Committee composed of technical staff from the local governments in addition to state and federal experts. In these discussions, the Committee favored Alternative 5 over Alternative 4 because pumping of the acid plume was slated to begin right away and the core waters would be removed before they could migrate to the downgradient barrier wells. They also favored use of the mining infrastructure as a way to minimize waste handling problems. They liked the concept of attempting to remove most of the acid plume before mine closure. Alternative 6 was not discussed much because it was more costly without any apparent benefit. Alternatives 1, 2, and 3 were unacceptable to the committee because those alternatives sacrificed any use of the aquifer for generations to come.

Alternative 5 in conjunction with a companion NRD settlement plan was supported by the city councils in West Jordan, South Jordan, Herriman, and Riverton. There was some disagreement on the portion of the NRD settlement plan dealing with which cities were to receive the treated water to the four communities in the affected area. All of the cities wanted more water than the proposal allotted, and a few of the private well owners wanted direct supply of the water at wholesale rates.

During the official public comment period and public hearing, very few citizens commented on the relative merits of the alternatives. Instead, most of the comments were on the potential consequences of the implementation of EPA's and UDEQ's preferred remedy. Alternative 5 would result in drawdowns significant enough to influence a wide area in the western part of the valley. This means that water levels in existing wells could drop to the extent that they would be rendered useless, even if the waters in that well were unaffected by the plume. Few opposed the plan because of this, suggesting instead that a plan to deal with these water level impacts on well owners be formulated as a part of the remedial strategy.

10 Summary Table of Alternatives

Criteria	Alternative 1 No action	Alternative 2 Institutional Controls	Alternative 3 Point of Use Mgt	Alternative 4 Hydraulic Containment	Alternative 5 Active Pumping	Alternative 6 Active Pumping - lime treatment
Threshold criteria - protection of human health and the environment	Would not protect human health or the environment	Would protect human health, but potentially not the environment	Would protect human health, but potentially not the environment.	Would protect human health and the environment	Would protect human health and the environment	Would protect human health and the environment
Threshold criteria - meet ARARs	Would not meet Utah groundwater cleanup standards in a reasonable time frame (800 + yrs)	Would not meet Utah groundwater cleanup standards in a reasonable time frame (800+ yrs), same as Alt 1.	Would not meet Utah groundwater cleanup standards in reasonable time frame (800+ yrs), same as Alt 1	Would achieve ARARs, but might take 50 -150 years or longer	Would achieve ARARs, but might take greater than 50-150 years, but shorter than Alt 4.	Would achieve ARARs, but might take greater than 50 - 150 years, same as Alt 5, shorter than Alt 4.
Long term effectiveness and permanance	Is not effective at all. - Relies entirely on natural attenuation	Relies heavily on institutional controls for long term protectiveness, essentially in perpetuity, and natural attenuation	Relies heavily on institutional controls for long term protectiveness, essentially in perpetuity and natural attenuation	While relying heavily on institutional controls for long term protection, the plume does not move into new areas and eventually shrinks. Concern that acid plume might get by the barrier.	While relying on institutional controls for long term protection, the plume does not move into new areas and is cleaned up in 50-150 yrs. Acid plume never reaches barrier.	Same as 5
Reduction of TMV through treatment	no treatment, no reduction of TMV, volume actually increases as plume moves	no treatment, no reduction of TMV, volume actually increases as plume moves	no treatment, no reduction of TMV, volume actually increases as plume moves	treatment reduces toxicity, mobility, and volume	treatment reduces toxicity, mobility and volume over a shorter time frame	Same as 5
Short term effectiveness	no action, no problems (but no progress either)	no action, no problems (but no progress either)	no action, no problems (but no progress)	no serious problems during construction -pumping rates and well distances need to be determined to ensure effectiveness	no serious problems during construction-pumping rates and well distances need to be determined to ensure effectiveness	Same as 5

Criteria	Alternative 1 No action	Alternative 2 Institutional Controls	Alternative 3 Point of Use Mgt	Alternative 4 Hydraulic Containment	Alternative 5 Active Pumping	Alternative 6 Active Pumping - lime treatment
Implement-ability	no action, no problems (but no protection and no progress)	no engineering action but requires the cooperation of the State Engineer and local governments to control well use	no action, no problems with implementation. Does require aid of state engineer, and local water suppliers	technology available, few problems encountered	technology available, few problems encountered	technology available, few problems encountered, except disposal of sludges produced by lime treatment would require lots of land (and lime supplies could get scarce).
Cost	Low	Low	Low	High	High, but 15% less than Alternative 4	Very High
State acceptance	unacceptable	unacceptable	unacceptable	slower than other active remediation plans, therefore unacceptable	state preference	waste disposal problems
Community acceptance	unacceptable	unacceptable	unacceptable	no comment	communities support this plan, coupled with companion NRD plan	no comment

K. **Principal Threat Waste:**

The principal threat waste is the source of the acid plume containing high metal and sulfate concentrations. In this case, the sources of the acid plume have been addressed in previous actions. However, the acid plume itself is not much different in composition as the original sources. Alternatives 1, 2, and 3 do not address the remnants of the principal threats in the aquifer itself. Human exposure to the waste is prevented by institutional controls essentially in perpetuity. Alternatives 4, 5, and 6 address the remnants of the principal threats in the aquifer by pumping the acid plume from the aquifer, treating the water, and providing the water to municipalities for beneficial use.

L. **Selected Remedy**

EPA and UDEQ have selected Alternative 5 as the remedy for addressing the acid plume at Operable Unit 2 of the Kennecott South Zone site.

1. Summary of the Rationale for the Selected Remedy

EPA and UDEQ selected Alternative 5 for the following reasons.

a. EPA and UDEQ preferred active remediation of the plume in Zone A. It was unacceptable to allow the plume to continue to move downgradient polluting more and more ground water as it did so. Containment was a minimum requirement to prevent a major municipal well field from being impacted and to prevent a potential impact on the Jordan River. The active remediation alternatives were Alternatives 4, 5, and 6. All others were eliminated from further consideration as not protective and failing to meet remedial goals.

b. Of the active remediation alternatives, Alternatives 4, 5, and 6, Alternatives 5 and 6 were preferred relative to Alternative 4 because withdrawals of the acid plume were slated to begin right away, 10 years ahead of Alternative 4. This would mean that the aquifer has the potential to be remediated faster in Alternatives 5 and 6. Pilot testing would be required for Alternatives 4, 5, and 6 to prove operation status and sustainability. Alternative 4 also relies on a single barrier well system to contain the plume. The consequences of the acid plume escaping capture of the barrier wells and migrating farther could be extreme.

c. Of the fastest active remediation alternatives, Alternatives 5 and 6, Alternative 5 was preferred because its costs were less with the same benefits to the aquifer. Alternative 5 had the added benefit of using existing waste handling infrastructure of the mining company so long as the mining operations continued. The waste handling problems associated with Alternative 6, although traditional, would have implementability problems requiring transportation of large quantities of lime and treatment sludges. Finally, Alternative 5 fits best with a plan to settle the NRD issues at the site. Similar treatment technologies are proposed for use in both the CERCLA and NRD plans and the systems can be integrated at key spots.

2. Description of the selected remedy

- Operations and maintenance of surface source controls (already implemented under provisions of a state Ground Water Protection Permit).

- Integration and use of Institutional Controls, upon approval by the State Engineer while restoration is ongoing:

  Institutional controls include, but are not limited to, well drilling moratorium by the Utah State Engineer, pumping limits placed on existing wells by the Utah State Engineer, purchase (or exchange) of land, purchase (or exchange) of water rights, municipal zoning and land use regulations. Other options are available to the State Engineer. The State Engineer reviews impacts to the water rights owners and public comments.

- Point of Use Management for private well owners while restoration is ongoing:

  Point of Use Management includes, but is not limited to, providing replacement water to private well owners by hooking them up to municipal culinary systems, the provision of in-home treatment units (e. g., reverse osmosis units) when the household is beyond the municipal service area, the provision of bottled water, extension of wells into uncontaminated portions of the aquifer, replacement of wells.

- Development of a plan to deal with consequences of water level drops caused by pumping of the acid plume:

  The agencies will request that, as a part of RD/RA, the PRP devise a method to mitigate the impact of drawdowns on private and municipal wells located in and near the affected area. This plan could include the following actions, performed on a case-by-case basis: Drilling of new and deeper wells, installing well completions at deeper depths, alternate water sources, purchase or exchange of water rights, well abandonment and compensation.

- Installation of a barrier well containment system at the leading edge of the acid plume (where sulfate concentrations are less than 1500 ppm in the projected migration pathway of the plume movement)

  The performance standard for this system requires that no waters exceeding state and federal drinking water standards for metals or exceeding 1500 ppm sulfate shall migrate off Kennecott property (as of December 13, 2000) past the barrier wells.

- Installation of a well or wells in the core of the acid plume. (There are already two wells which have been installed in core area for pilot testing purposes.)
- Pretreatment of acid water using nanofiltration.
- Treatment of pretreated acid waters by a reverse osmosis plant.
- Treatment of the waters from the barrier wells by a reverse osmosis plant.
- Treated water is delivered to a municipal water purveyor (as required for a rebate as stated in the Natural Resources Damage Settlement plan and approved by the State Trustee).
- Installation and maintenance of a monitoring system to track the movement of the plume, the progress of active remediation, and measure the progress of natural attenuation for the sulfate contamination within the Zone A plume and downgradient of the barrier wells. The goal of the natural attenuation is to achieve the State's primary drinking water standard of 500 ppm.
- Prior to mine closure, the concentrates from NF plant and RO plant are disposed in Kennecott's tailings pipeline. The tailings pipeline serves as a 13 mile linear treatment system. Acids would be neutralized and metals would precipitate into the tailings slurry. Metals are stored along with tailings in the Magna Tailings Impoundment, newly expanded and renovated.
- Following cessation of nearby mining and milling operations, the NF and RO concentrates shall be disposed in a facility appropriate to the types of wastes then remaining in the concentrate. None of the specific requirements mentioned in the description of alternatives will be chosen at this time. A disposal method which could be implemented quickly following mine closure must be included as a part of RD/RA. In 30 years, it is anticipated that other technologies may be available to handle residuals from the treatment plants. Closure of the mine may require infrastructure and O+M which could be used also for the concentrates, the chemistry of the ground water could be significantly less concentrated than today, and more will be known about the nature of any proposed discharge to the Great Salt Lake and the potential effects thereof. The Agencies also acknowledge the possibility of a completely different option for addressing the concentrates upon mine closure. EPA and UDEQ would then encourage the submittal of a new

proposal that takes into consideration changed circumstances and new technology to more effectively address the concentrates.

- Should the plume begin to impact the West Jordan Municipal Well Field (either through increased loadings or water level drops), a reinjection program may be considered.

3. Summary of the Estimated Remedy Costs

The information in this cost estimate summary table is based on the best available information regarding the anticipated scope of the remedial action. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering and design of the remedy. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences, or a Record of Decision Amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50% to -30% of the actual project cost. Since the RI/FS was submitted, there have been additional cost estimates which are lower than those presented here. This version is verbatim from the RI/FS.

PROJECT COST ESTIMATE
CAPITAL COSTS
(From Appendix M, RI/FS Report, 1998①)

ACTIVITY	Quantity Unit	Unit Cost	Total Cost
Source controls			already constructed
Institutional controls			
Water rights and land use restrictions	1 lot	$16,000,000	$16,000,000
Point of use management			
Municipal Connections	35,000 Linear ft	$25	$875,000
Household Treatment Units	400	$1,500	$600,000
Draw down impacts (potential)			
Private well owners	25 wells with 20-40 ft drops, 15 wells with 40-100 ft drops, 4 wells with >100 ft drops	case by case basis	not estimated

ACTIVITY	Quantity Unit	Unit Cost	Total Cost
Municipal wells	2 wells with 20-40 ft drops, 4 wells with >100 ft drops	case by case basis	not estimated
Reinjection program	unknown	case by case basis	not estimated
Barrier Well extraction and RO treatment			
Wells (C' steel)	10,000 Linear ft	$260	$2,600,000
Well Pump Stations	6	$425,000	$2,550,000
Booster Pump Stations	1	$550,000	$ 550,000
Power substations	3	$150,000	$ 450,000
Reverse Osmosis Facility	2,000 gpm	$3.20/gal per day	$9,216,000
6" - 12" dia. C' steel pipelines	20,000 Linear ft	$85	$1,700,000
8" concentrate C' steel pipeline	500 Linear ft	$70	$ 35,000
Power transmission lines	20,000 Linear ft	$45	$ 900,000
Acid plume (core waters) extraction to Nanofiltration pretreatment and Reverse Osmosis Treatment			
Wells (stainless steel)	5000 Linear ft	$350	$1,750,000
Well Pump Station	5	$500,000	$2,500,000
Booster Pump Station	1	$600,000	$ 600,000
Power substations	2	$150,000	$ 300,000
6" - 12" dia pipelines (stainless steel)	10,000 Linear ft	$140	$1,400,000
Power transmission lines	10,000 Linear ft	$45	$ 450,000
Nanofiltration facility	1,500 gpm (this flow depends on remedial design)	$4.10/gal.day	$ 8,856,000

ACTIVITY	Quantity Unit	Unit Cost	Total Cost
Modify Reverse Osmosis Plant above to increase the flow to 2,750 gpm	1 lot	$2,000,000	$2,000,000
Upgrade existing lime treatment plant at concentrator and head of tailings line (750 gpm)	1 lot	$3,000,000	$3,000,000
New disposal infrastructure for use following mine closure			not estimated
Sub Total			$56,302,000
EPCM	20% construct, 1% IC, POU		$ 8,106,000
Contingency	25% construct, 2% IC, POU		$12,327,000
TOTAL			$76,735,000

① costs were estimated in 1998 and were not adjusted for inflation

ESTIMATED ANNUAL PROJECT COSTS
OPERATIONS AND MAINTENANCE
(From Appendix M, RI/FS Report, 1998)

Activity	Quantity unit	Unit Cost	total
Monitoring			
Personnel and equipment	2 technicians	$50,000	$100,000
Analytical services	700 analyses	$500	$350,000
Annual report preparation	1 lot	$20,000	$20,000
Source Control Operations and Maintenance	1% of construction cost	$127,000,000	$1,270,000
Institutional Controls	none	none	none
Point of Use Management			
Maintenance of household RO units	10% of capital cost	$600,000	$60,000

Activity	Quantity unit	Unit Cost	total
Barrier Well extraction plus RO treatment			
Power for pumping	3,609,000 kWh	$0.035	$126,000
Maintenance	5% of construction cost	$18,001,000	$900,000
RO System	2000 gpm (product flow rate)	$0.84	$883,000
Operations Labor	5 persons	$50,000	$250,000
Acid extraction to Nanofiltration and RO treatment			
Power for pumping	3,003,000 kWh	$0.035	$105,000
Maintenance	5% of construction cost	$20,856,000	$1,043,000
Operations Labor	5 persons	$50,000	$250,000
NF system	1,500 gpm (product flow rate, depends on design)	$1.26	$993,000
Lime	750 gpm at 0.1 lb per gal = 19,710 tons	$75	$1,478,000
Subtotal			$7,828,000
EPCM	1% Source Cont, POU, 5% treatment		$ 318,600
Contingency	5% Source Cont, POU, 25% treatment		$1,673,000
TOTAL			$9,819,600

SUMMARY OF TOTAL COSTS
CAPITAL AND NET PRESENT VALUE
(From Appendix M, RI/FS)

Activity	Assumptions	Years	total
Capital - Institutional Controls	7% discount	2	16,049,000
Capital - Point of Use Management	7% discount	2	17,528,000
Capital - Wells and Treatment	7% discount		40,715,000
O+M Source Control @ 1,844,000/yr	7% discount	1,844,000/yr for perpetuity	26,343,000
O+M Institutional Controls	none		
O+M Point of Use @64,000/yr	7% discount	64,000/yr for perpetuity	914,000
O+M Wells and Treatment			
Sulfate extraction and RO	7% discount	2,826,000/yr for perpetuity	40,372,000
Acid extraction, NF, RO	7% discount	5,079,000/yr for 21 years	$55,031,000
TOTAL NET PRESENT VALUE			$197M

4. Expected Outcomes of the Selected Remedy:

The overall objective of the selected remedy in conjunction with the NRD settlement action is to remediate the aquifer so that full unrestricted use of the ground water by public and municipal well owners is achieved. Because this will take a long time, perhaps 50 - 150 years or longer, it is also necessary to contain the plume from further migration so that the situation does not become worse and private well owners are not exposed to unacceptable concentrations of contaminants. Containment will also prevent contamination of the Jordan River and exposure of aquatic organisms to the plume contaminants. Until the aquifer meets drinking water standards, water treated as a part of this program can be used by the public.

The final cleanup levels for the remedy are given in the following table:

FINAL CLEANUP LEVELS FOR THE SELECTED REMEDY

Contaminant	Remediation Level throughout acid plume	Containment Level at Kennecott property line downgradient of Zone A (as of 12-13-2000)	Treatment Level for RO treatment plant
Basis	health based levels from site specific risk assessment	health based levels from site specific risk assessment	ARAR, state primary and secondary drinking water standards.
acidity	pH = 6.5 - 8.5	pH = 6.5 - 8.5	pH = 6.5 - 8.5
Arsenic	0.05 mg/l	0.05 mg/l	0.05 mg/l
Barium	2 mg/l	2 mg/l	2 mg/l
Cadmium	0.005 mg/l	0.005 mg/l	0.005 mg/l
Copper	1.3 mg/l	1.3 mg/l	1.0 mg/l
Fluoride	4 mg/l	4 mg/l	2 mg/l
Lead	0.015 mg/l	0.015 mg/l	0.015 mg/l
Nitrate	10 mg/l	10 mg/l	10 mg/l
Selenium	0.05 mg/l	0.05 mg/l	0.05 mg/l
Nickel	0.1 mg/l	0.1 mg/l	0.1 mg/l
Aluminum	-	-	0.05 - 2 mg/l
Chloride	-	-	250 mg/l
Manganese	-	-	0.05 mg/l
Silver	-	-	0.10 mg/l
Sulfate	1500 mg/l, active CERCLA remediation 500 mg/l, passive CERCLA action via natural attenuation	1500 mg/l	250 mg/l

Contaminant	Remediation Level throughout acid plume	Containment Level at Kennecott property line downgradient of Zone A (as of 12-13-2000)	Treatment Level for RO treatment plant
TDS	-	-	500 mg/l
Zinc	-	-	5 mg/l

M. Statutory Determinations

The following describes how the selected remedy will satisfy the statutory requirement of the nine selection criteria specified in the National Contingency Plan

1. Protection of Human Health and the Environment: Human health is protected by the selected remedy both short term and long term. Short term protection is achieved by limiting exposure of residents to contaminated ground water through use of institutional controls, point-of-use management and by containment of the plume from further migration. Environmental protection is achieved by containment of the plume such that the contaminants do not reach the exposure point at the Jordan River. Long term protection of both human health and the environment is achieved by active remediation of the plume so that the waters can be returned to beneficial use without restrictions.

2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs): Section 121(d) of CERCLA, 42 U.S.C. § 9621(d), the National Oil and Hazardous Substances Pollution Contingency Plan (the "NCP"), 40 CFR Part 300 (1990), and guidance and policy issued by EPA require that remedial actions under CERCLA comply with substantive provisions of applicable or relevant and appropriate standards, requirements, criteria, or limitations ("ARARs") from State of Utah and federal environmental laws and State facility siting laws during and at the completion of the remedial action. These requirements are threshold standards that any selected remedy must meet.

   This document identifies ARARs that apply to the activities to be conducted under the Southwestern Jordan River Valley Ground Water Plumes Operable Unit 2 remedial action. The ARARs or groups of related ARARs contained in Appendix A are each identified by a statutory or regulatory citation, followed by a brief explanation of the ARAR and how and to what extent the ARAR is expected to apply to the activities to be conducted under this remedial action.

   Substantive provisions of the requirements listed in Appendix A are identified as ARARs pursuant to 40 CFR § 300.400. ARARs that are within the scope of this remedial action must be attained during and at the completion of the remedial action.

   Types of ARARs: ARARs are either "applicable" or "relevant and appropriate." Both types of requirements are mandatory under Superfund guidance. Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under federal environmental or state environmental facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not "applicable" to hazardous substances, pollutants, contaminants, remedial actions, locations, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

The determination that a requirement is relevant and appropriate is a two-step process: (1) determination if a requirement is relevant and (2) determination if a requirement is appropriate. In general, this involves a comparison of a number of site-specific factors, including an examination of the purpose of the requirement and the purpose of the proposed CERCLA action; the medium and substances regulated by the requirement and the proposed requirement; the actions or activities regulated by the requirement and the remedial action; and the potential use of resources addressed in the requirement and the remedial action. When the analysis results in a determination that a requirement is both relevant and appropriate, such a requirement must be complied with to the same degree as if it were applicable.

ARARs are contaminant, location, or action specific. Contaminant specific requirements address chemical or physical characteristics of compounds or substances on sites. These values establish acceptable amounts or concentrations of chemicals which may be found in or discharged to the ambient environment.

Location specific requirements are restrictions placed upon the concentrations of hazardous substances or the conduct of cleanup activities because they are in specific locations. Location specific ARARs relate to the geographical or physical positions of sites, rather than to the nature of contaminants at sites.

Action specific requirements are usually technology based or activity based requirements or limitations on actions taken with respect to hazardous substances, pollutants or contaminants. A given cleanup activity will trigger an action specific requirement. Such requirements do not themselves determine the cleanup alternative, but define how chosen cleanup methods should be performed.

Many requirements listed as ARARs are promulgated as identical or near identical requirements in both federal and state law, usually pursuant to delegated environmental programs administered by EPA and the state. The Preamble to the

NCP provides that such a situation results in citation to the state provision and treatment of the provision as a federal requirement.

Also contained in this list are policies, guidance or other sources of information which are "to be considered" in the selection of the remedy and implementation of the ROD. Although not enforceable requirements, these documents are important sources of information which EPA and the UDEQ may consider during selection of the remedy, especially in regard to the evaluation of public health and environmental risks; or which will be referred to, as appropriate, in selecting and developing cleanup actions.

This list in Appendix A constitutes EPA's and UDEQ's formal identification and detailed description of ARARs for the remedial action at the Kennecott South Zone Site, Southwestern Jordan River Valley Ground Water Plumes Operable Unit 2.

3. Cost Effectiveness: A Cost Effective remedy in the Superfund program is one whose costs are proportional to its overall effectiveness. This includes long term and short term effectiveness and reduction of toxicity, mobility, and volume through treatment.

At this site, the remedial alternatives fall into two groups:

(1) Alternatives 1, 2, and 3 contain no active remediation component, but rely on personal controls, institutional controls or replacement waters to prevent exposure to the citizenry. The plume continues to move downgradient until it discharges to the Jordan River contaminating more and more of the aquifer as it moves. These alternatives are relatively low in cost, but do not protect the environment long term. In addition, the ground waters are not returned to beneficial use.

(2) Alternatives 4, 5, and 6 contain an active remediation component and achieve containment of the plume and eventual remediation of the aquifer. In addition, Alternative 4 might not be effective in containing the plume in long term. Although Alternative 4 could be slower than the Alternatives 5 and 6, the results are roughly equivalent in terms of effectiveness, permanence, and reduction of toxicity, mobility, and volume through treatment in the short term. Alternative 5 is the most cost effective of the active remediation alternatives. It has an added advantage over Alternative 6 producing no sludges requiring disposal prior to mine closure. All alternatives would have to deal with treatment residuals post mine closure, but because Alternatives 5 and 6 would be faster, the amount of residuals would probably be less.

4. Utilization of Permanent solutions and alternative Treatment to the Maximum Extent Practicable: Alternative 5 takes advantage of an emerging technology using membrane technology, such as nanofiltration. Since it achieved the same goals as

the more traditional treatment technologies at a lower cost, it was selected. The selected remedy fulfills the requirement for use of innovative technologies to the maximum extent practicable. It also provides a permanent solution to the ground water problem although this could take 50 years or longer.

5. Preference for Treatment as a Principal Element: The selected remedy uses treatment as a principal element in remediation of the aquifer and meets the statutory requirement. Monitored Natural Attenuation (MNA) is used as a supplement to the active restoration only after the contaminants in the plume have been reduced to levels that are protective of human health and the environment. The extended time frame for MNA is reasonable in light of the uncertainties as to whether additional active restoration of the remaining sulfate would decrease the time required to meet MCLs as compared to MNA.

6. Five-year Review Requirements: Since hazardous substance, pollutants, and contaminants will remain on-site in the aquifer while the long-term remedial action is on-going, five year reviews are required at this site to determine if the remedy continues to remain effective, protect human health and the environment, and comply with ARARs.

N. DOCUMENTATION OF SIGNIFICANT CHANGES

The Selected Remedy is essentially the same as Alternative 5 which was the preferred alternative of EPA and UDEQ as presented to the public. As a result of the public comment, an additional element was added to Alternative 5 in the Selected Remedy. The additional element was EPA's and UDEQ's response to a potential problem of water level drawdowns in the aquifer as a result of aggressive pumping from the acid plume. The change requires private or municipal well owners who discover their wells have been rendered useless because of water level declines as a result of this project should be consulted and provided with options to solve their problem by the PRP. This would be done on a case-by-case basis. Solutions would be dependent on the nature of the well, its uses, and the cost of alternatives. The plan will be included as a work element in the RD/RA Consent Decree.