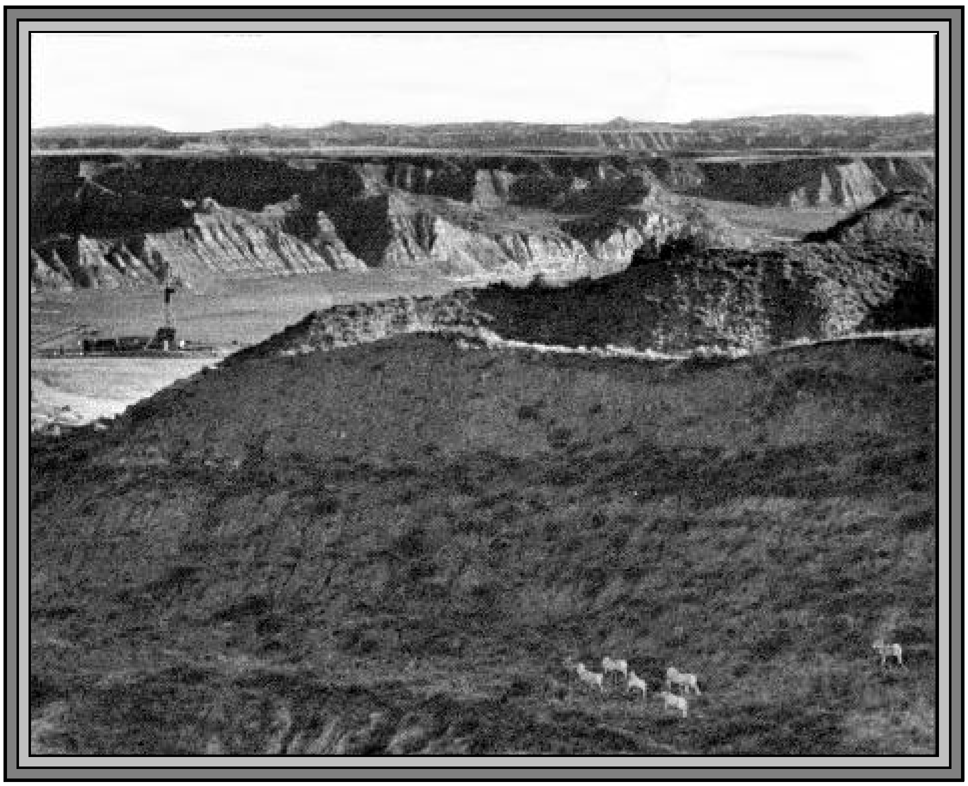
ENVIRONMENTAL HANDBOOK

Environmental Regulations for the

OIL & GAS EXPLORATION & PRODUCTION INDUSTRY



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Utah Division of Oil, Gas & Mining

Department of Natural Resources

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This document is intended for use by companies performing oil and gas exploration and production in the State of Utah. It may also be helpful to service companies and those involved in contracting with producing companies. It is not intended to be a complete treatise on environmental regulations but only as a helpful reference to assist in where to look and provide the basics of the regulatory scheme.

FURTHER INFORMATION CONTACT:

Division of Oil, Gas and Mining
3 Triad Center, Suite 350
355 West North Temple
Salt Lake City, Utah 84180-1203

(801) 538-5340

Note: Cover photo of Big Horn Sheep on hillside with drill rig in background was provided by K.C. “Ken” Cockerham, petroleum consultant.

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AGENCY LISTING

Below is a list of agencies which an oil and gas operator in Utah may need to contact concerning an environmental related issue.

Agency	Actions
Division of Oil, Gas & Mining 3 Triad Center, Suite 350 355 West North Temple Salt Lake City, Utah 84180-1203 (801) 538-5340	Permits to Drill Permits to Inject Disposal Facilities Plugging Approvals Spud & Spill Reporting Pits
Division of Water Rights 1636 West North Temple, Suite 220 Salt Lake City, Utah 84116-3156 (801) 538-7240	Water Appropriation Geothermal Wells Stream Alterations
Division of Water Quality 288 North 1460 West Salt Lake City, Utah 84116 (801) 538-6146	Discharge Permits
Division of Solid & Hazardous Waste 288 North 1460 West Salt Lake City, Utah 84116 (801) 538-6170	Nonexempt Waste (RCRA) Used Oil Recycling
Division of Radiation Control 168 North 1950 West Salt Lake City, Utah 84224 (801) 536-4250	Naturally Occurring Radioactive Material (NORM) Logging tool abandonment Radioactive Material
Division of Air Quality 150 North 1950 West Salt Lake City, Utah 84114 (801) 536-4000	Pollution Source Operating Permits Burn Permits
Bureau of Land Management State Office 324 S. State, Ste. 301 Salt Lake City, Utah 84145 (801) 539-4010 Moab District 82 East Dogwood Moab, Utah 84532 (801) 259-6111 Vernal District 170 S. 500 E. Vernal, Utah 84078 (801) 789-1362	Actions regarding Federal & Indian Leases/Land

SUMMARY OF ENVIRONMENTAL LAWS

National Environmental Policy Act (NEPA)

NEPA is not a regulating law but one that requires federal agencies to take environmental factors into consideration during their decision making processes. It is the implementation of NEPA that requires the preparation of Environmental Impact Statements "EIS" and Environmental Assessment "EA" by federal agencies.

Endangered Species Act (ESA)

The ESA was enacted to protect endangered and threatened species and their habitats. This act is administered by the U.S. Fish and Wildlife Service and may pose a considerable obstacle to development requiring federal action. Its protection is not limited to federal lands. The statute has three basic components: 1) listing of species, 2) anti-taking provisions, and 3) endangered species review.

Clean Air Act (CAA)

This Act has been shaped through a series of statutory enactments spanning nearly 30 years. The Act's basic goals are 1) attainment and maintenance of National Ambient Air Quality Standards, 2) prevention of significant deterioration of air quality in areas of the country where the ambient standards are already being met, 3) preservation of natural visibility in national parks and wilderness areas, 4) avoidance of risk from hazardous air pollutants, 5) protection of stratospheric ozone, and 6) prevention of acid rain.

Utah's comparable law is the Utah Air Conservation Act. It is under this law that Utah regulates pollution sources and administers its federal Clean Air Act delegated program.

Federal Water Pollution Control Act (Clean Water Act)

The Federal Water Pollution Control Act was enacted in 1972, it was significantly amended in 1977 by the Clean Water Act, in 1987 by the Water Quality Act and in 1990 by the Oil Pollution Control Act. It is commonly referred to as the Clean Water Act.

The basic underlying purpose of the Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. This objective is achieved through the regulation of discharges (both point source and dredge and fill) and a variety of other measures. Jurisdiction under this Act extends to "navigable waters". This term is broadly defined to include "the waters of the United States" which includes some dry drainages and wetlands. It is under this law that the Spill Prevention Control and Countermeasure "SPCC" Plans are required.

The comparable Utah law under which delegated federal programs for water are administered is the Utah Water Quality Act.

Safe Drinking Water Act (SDWA)

This law was enacted to establish national standards and requirements for the quality of drinking water. It was substantially amended in 1986. It is under this act that the Wellhead Protection and Underground Injection Control Programs are administered. The comparable Utah law is the Utah Safe Drinking Water Act.

Resource Conservation and Recovery Act (RCRA)

Subtitle C of the Act provides for the cradle-to-grave regulation of hazardous wastes. Certain Exploration and Production (E&P) Wastes are exempt from the requirements of RCRA subtitle C.

Subtitle D of the Act applies to the regulation of solid waste disposal and sanitary landfills.

Subtitle I applies to Underground Storage Tanks.

Utah's Solid and Hazardous Waste Act and the Solid Waste Management Act provide the State authority to regulate solid and hazardous wastes in the state. Utah also has the Waste Oil Management Act for used oil and the Waste Tire Recycling Act to encourage recycling of used tires.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

This law was substantially amended in 1986 by the Superfund Amendments and Reauthorization Act "SARA". This statute provides for the cleanup of contaminated sites by establishing a liability scheme and a governmental administered cleanup fund. CERCLA is not a detailed regulatory statute like the air, water and hazardous waste laws, but is, instead, primarily a liability and remedial act for dealing with hazardous substances which have been released or are about to be released to the environment.

The Utah Hazardous Substances Mitigation Act established a state Superfund program which is administered by the Division of Environmental Response and Remediation. It also established a fund which the state may use for emergency cleanups, investigations and matching funds for CERCLA cleanups.

The Utah Underground Storage Tank Act is the state law which applies to UST's and adopts the federal RCRA standards and financial responsibility requirements. It also established a restricted account in the general fund into which all penalties imposed under the Act are deposited.

Utah Radiation Control Act

Administered by the Division of Radiation Control under authority of the Radiation Control Board. The Board oversees registration and licensing of radiation sources, is authorized to make rules to control exposure to radiation and issues enforcement orders. Radioactive sources used in well logging activities are regulated by this entity. Also, Natural Occurring Radioactive Material "NORM" falls under their jurisdiction.

Utah Oil and Gas Conservation Act (Act)

Although the Act is not specifically an environmental law it establishes jurisdiction over various oil and gas activities and substances which can and do affect the environment.

The Act establishes the Board and Division of Oil, Gas and Mining, outlines the jurisdiction of the Board, prohibits waste of oil or gas, provides for establishment of drilling units, pooling, repressuring, pressure maintenance or cycling, plans for development and operation of pool or field, units, payment of proceeds from sale of production, proceeding on petition to determine cause of nonpayment-remedies and penalties, permitting and bonding of waste crude oil treatment facilities, conservation tax, etc.

Generally, the Board has jurisdication over the discharge, storage, handling, trasportation, reclamation, or disposal of waste materials that result from activities associated with exploration, development, or production of oil and gas resources. Specifically, the Board regulates Class II injection wells, disposal of oilfield wastes, and drilling, completing, operating and plugging of wells to prevent interformational flow and/or pollution of fresh water aquifers or detrimental intrusion of water into hydrocarbon reservoirs.

Under this authority the Board has developed rules for regulating exploration and production activities (R649).The Division implements these rules on behalf of the Board. The activities covered by these rules which have environmental implications are; bonding of wells and disposal facilities, on-site predrill evaluation, casing and cementing of wells, plugging of wells and reclamation of well sites, management of oilfield wastes, construction and use of onsite pits, permitting and regulation of disposal facilities, reporting and cleanup of spills, underground injection, permitting and bonding of waste crude oil treatment facilities, drilling in hydrogen sulfide areas, also gas flaring/venting.

Listing of Utah Oil & Gas Conservation General Rules with Environmental Implications

R649-1	Definitions
R649-2-1	Scope of Rules
2-5	Right to Inspect
2-6	Access to Records
R649-3-1	Bonding
3-7	Well Control
3-8	Casing Program
3-9	Protection of Upper Productive Strata
3-12	Drilling Practices for Hydrogen Sulfide Areas & Fms
3-13	Casing Tests
3-14	Fire Hazards on the Surface
3-15	Pollution and Surface Damage Control
3-16	Reserve Pits and other onsite pits
3-17	Inspection
3-18	On-site Predrill Evaluation
3-20	Gas Flaring or Venting
3-24	Plugging and Abandonment of Wells
3-25	Underground Disposal of Drilling Fluids
3-26	Seismic Exploration
3-32	Reporting of Undesirable Events (spills)
3-33	Drilling Procedures in the Great Salt Lake
3-34	Well Site Restoration
3-36	Shut-in and Temporarily Abandoned Wells
R649-5	Underground Injection Control
R649-6-2	Waste Crude Oil Treatment Facilities
R649-8	Reporting and Report Forms
R649-9	Waste Management and Disposal
9-2	General Waste Management
9-3	Permitting of Disposal Pits

SPILL and UNDESIRABLE EVENT REPORTING

STATE REQUIREMENTS:

Division of Oil, Gas & Mining

Report undesireable events (major & minor), fires, leaks, breaks, spills, flaring, or venting (>10 bbls or >50 Mcf), blowouts and others happening at drilling, producing, transportation, injection or disposal facility.

Major events require verbal notice within 24 hours of discovery. All major and minor events require written report (Sundry Notice) within five days following conclusion of the event.

Department of Environmental Quality (DEQ)

Any spill which enters or has potential to enter "waters of the State". Call 801-536-4100, after hours 536-4123, outside Salt Lake area 1-800-572-6400. These numbers are valid for any environmental emergency reporting to DEQ in Utah.

FEDERAL REQUIREMENTS:

Environmental Protection Agency

Discharge of oil or hazardous substances into or upon navigable waters of the U.S. that meets the sheen test must be reported to EPA National Response Center @ 1-800-424-8802.

Bureau of Land Management

Similar to DOGM reporting of undesireable events major and minor.

* The reporting requirements above do not cover all requirements for hazardous materials which have different and separate requirements not covered by this document.

CLEANUP LEVELS SUMMARY

Recommended abandonment levels:

SALINITY:

Electrical Conductivity <4 mmho/cm which approximates TDS of 2560 mg/l

Exchangable sodium percentage ESP <15%

Sodium adsorption ratio SAR <12

OR

If natural background soil characteristics show poorer quality than that depicted by these limits or if a higher level consistent with intended land use can be demonstrated then these limits can be exceeded.

HYDROCARBON CONTENT:

1% or 10,000 ppm TPH is recommended for sites with low environmental sensitivity

30 ppm to 10,000 ppm TPH is recommended for sites with higher environmental sensitivity depending on Benzene level in waste

Recommended TPH levels are concentrations above background levels.

GUIDANCE: for DETERMINING CLEANUP LEVELS

SUBJECT: Estimating Cleanup Levels for Petroleum Contaminated Soil and other Oily Wastes from Oil and Gas Exploration and Production Operations

This section should be used as guidance for oil and gas operators and the Division staff in evaluating the appropriate cleanup levels for oil and gas exploration and production (E&P) related sites. This guidance also applies to treated oily E&P waste material which is to be applied to soil or buried.

The approach utilized is a ranking system to evaluate the environmental sensitivity of the site. This ranking is then used to determine the cleanup level.

CLEANUP CRITERIA

Salts and hydrocarbons have been identified as the principal limiting constituents of concern relative to onshore exploration and production operations because they may induce a phytotoxicity or, in the case of sodium salts, may deteriorate soil structure interrupting normal soil-plant-water relationships and causing excessive erosion (Miller and Honarvar, 1975; Ferrante, 1981; Freeman and Deuel, 1984; Nelson et al., 1984). Salts and hydrocarbons associated with E&P wastes may also pose a significant threat to surface and groundwater resources if not properly managed (Henderson, 1982; Murphy and Kehew, 1984).

Salinity of waste or treated waste products to be applied to the surface should be limited by the following final disposition criteria: electrical conductivity **EC <4 mmho/cm** which approximates a TDS of 2560 mg/l, exchangeable sodium percentage **ESP <15%**, sodium adsorption ratio **SAR <12**. If natural background soil characteristics show poorer quality than that depicted by these limits or if a higher level consistent with intended land use can be demonstrated then these limits can be exceeded. In very sensitive areas more restrictive limits for salinity may be applied on a case-by-case basis, especially for large volumes of waste to be abandoned.

If significant levels of toxic metals are believed to exist or there is concern due to type or source(s) of wastes, tests will be required and mobility may be evaluated utilizing the Toxicity Characteristic Leaching Procedure (TCLP).

An application for a discharge permit from the Division of Water Quality may be required if it is determined that the facility or activity will not have a de minimus actual or potential effect on ground water quality. If the Division determines there is potential for discharge, or if the proposal involves a commercial ongoing disposal operation, the application will be forwarded to the Division of Water Quality for their review.

RANKING CRITERIA for Hydrocarbon Cleanup Level Determination

1. Distance from Contamination to Groundwater The depth to groundwater, in feet below land surface, must consider the highest seasonal average. In some cases, depth to groundwater and subsurface contamination are both relatively deep. The depth to groundwater shown in the ranking below also applies to the distance from the lowest vertical extent of contamination to groundwater. In addition, recharge areas are considered to be as environmentally sensitive as the lowest distance from contamination to groundwater. Sites located in recharge areas may therefore be scored 20 points.

Distance to Groundwater(feet)	Ranking Score
>100	0
100 to 75	4
75 to 50	8
50 to 25	12
25 to 10	16
<10, or recharge area	20

2. Native Soil Type The predominant site lithology and native soil type will be determined by soils classified according to the Unified Soil Classification. The level of environmental sensitivity is determined by the permeability of the soil and the ease with which contaminants migrate through the soil.

Native Soil Type	Ranking Score
a. Low permeability (clay, shale, fat clay, high plasticity clay, elastic silt low plasticity silt, lean clay, silty clay, sandy clay, silty or clayey fine sand, very fine gravelly clay, unfractured igneous and metamorphic rocks, and consolidated, cemented sedimentary rocks; USC=Pt,OH,CH, MH,OL,CL,ML).	0
b. Moderate permeability (clayey sand, poorly graded sand-clay mixtures, silty sand, poorly graded sand-silt mixtures, moderately fractured igneous and metamorphic rocks, moderately permeable limestone; USC=SC,SM).	10
c. High permeability (fine sand, silty sand, sand, gravel, gravelly sand, clayey gravel, gravel-sand-clay-silt mixtures, silty, gravel, highly fractured igneous and metamorphic rocks, vesicular igneous rocks, cavernous or karstic limestone; USC=SM,SP,SW, GC,GM,GP,GW).	20

3. <u>Annual Precipitation</u> The average annual precipitation in a specific area must be identified in order to evaluate the effects of recharge and potential for mobilization of contaminants. The values for average annual precipitation are specific for Utah and represent the annual average precipitation in the desert, mountain, and intermediate geographical regions in the state (Waddell, et.al., 1987). Precipitation information shall be collected from the nearest national meteorological weather station. Onsite ground cover (e.g. concrete or asphalt) that might prevent infiltration of precipitation is not considered due to the potential for irregularities and fractures in the ground cover that could allow infiltration.

Annual Precipitation(inches)	Ranking Score
<10	0
10 to 20	5
>20	10

4. <u>Distance to Nearest Municipal Water Well</u> A municipal water well is assumed to be a well designed to supply groundwater for community consumption. The distances from subsurface contamination to a municipal water well, and the corresponding scores shown below, are based on local and regional knowledge of the properties of the deep confined aquifers that occupy many of the basins in Utah, and those which are tapped by production wells (Clark, et.al., 1990; Herbert, et.al., 1990, Hely, et.al., 1971). Using the Theis equation for a well producing from a confined aquifer (Bouwer, 1978; Freeze and Cherry, 1979; Driscoll, 1986), the effective radii (r) of one-mile (5280 feet), one-quarter of a mile (1320 feet), and 500 feet induced by a high-capacity municipal well are calculated by applying a pumping rate (Q) of 1500 gallons per minute for 183 days (1/2 year) (t), from an aquifer with a hydraulic conductivity (K) of 100 feet per day (ft/day, clean sand), and an aquifer thickness (or perforated interval, b) of 500 feet, transmissivity (T) of 50,000 ft^2/day (Clark, et.al., 1990; Herbert, et.al, 1990, Hely, et.al., 1971), and a storage coefficient (S) of 0.001. The radii of influence demonstrated by the Theis equation are corroborated by the Thiem equation for a pumped or flowing well in a confined aquifer (Bouwer, 1978; Freeze and Cherry, 1979). The Environmental Protection Agency (1980) also suggests a critical minimum distance of 500 feet from a point source of contamination (a landfill, for example) and a down gradient drinking water well.

<u>Theis Equation</u>: $h_2 - h_2 = \frac{Q}{4 ð T} * W(u) \qquad u = \frac{r^2 S}{4 * Tt}$

<u>Thiem Equation</u>: $Q = \frac{2 ð Kb (h_2 - h_1)}{\ln (r_2/r_1)}$

Distance to Nearest <u>Municipal Well</u> (feet)	Ranking Score
>5280	0
5280 to 1320	6
1320 to 500	8
<500	10

5. Distance to Other Water Wells Other wells will be defined as domestic, irrigation, and stockwatering wells that generally have less capacity, and thus smaller radius of influence, than municipal wells. The critical distances of contamination from a low capacity well were also derived using the Theis and Thiem equations, and are based on aquifer properties as described in hydrologic information publications for Utah (Hely, et.al., 1971, Waddell, et.al., 1987, Clark, et.al., and Herbert, et.al., 1990). Those properties include a hydraulic conductivity of 100 ft/day, aquifer thickness (or perforated interval) of 100 feet, transmissivity of 10,000 ft^2/day, pumping rate (Q) of 200 gallons per minute, and a pumping period (t) of 8 hours, which would result in a critical radius of influence of 300 feet (Driscoll, 1986), and maximum radius of influence of one-quarter mile (1320 feet).

Distance to Other Water Well (feet)	Ranking Score
>1320	0
300 to 1320	5
<300	10

6. Distance to Surface Water Surface water bodies include perennial rivers, streams, creeks, irrigation canals and ditches, lakes, and ponds. The critical distance of contamination to a surface water body is based on experimental modeling by Stokman (1987). The model evaluated the changes in benzene concentration in groundwater at varying distances from a release of unleaded gasoline. The model predicted that an initial benzene concentration of approximately three times the MCL was reduced to below the MCL at a distance of 300 feet from the source. Although this distance may not be applicable in all cases, 300 feet is considered to be an appropriate critical distance feet between a source of contamination and surface water. Approximately three times the most sensitive distance is 900 feet, which is rounded up to 1000 feet.

Distance to Surface Water (feet)	Ranking Score
>1000	0
300 to 1000	5
<300	10

7. Potentially Affected Populations The score for affected populations is based on the number of potential receptors within a three-mile radius of a release site, using census plot information. A three-mile radius is based on the ability of contaminants to travel three miles via utility conduits, or by other means. The potentially affected populations include residents, employees, campers, and others who regularly enter the area.

Affected Populations	Ranking Score
<100	0
100 to 3000	5
>3000	10

8. Presence of Onsite or Adjacent Utility Conduits Utility conduits include water distribution lines, sewer lines, septic tanks, buried electrical lines, and any other conduit within 300 feet that may facilitate contaminant migration.

Presence of Adjacent or Onsite Utility Conduits or Wells	Ranking Score
Not present	0
Unknown	8
Present	10

9. Summation of Ranking Criteria to Determine Environmental Sensitivity and Cleanup Levels

The summation of all of the above ranking scores will yield one value which shall be used to determine the appropriate soil cleanup levels on a case-by-case basis. The sensitivity levels are as follows:

Level I Sensitivity: For scores totaling <50

Level II Sensitivity: For scores totaling ≥ 50

Evaluation Ranking Criteria and Ranking Score
For Oily Waste Cleanup Levels

Site-Specific Factors	Ranking Score	Site Ranking Score
Distance to Groundwater (feet)		
>100	0	
100 to 75	4	
75 to 50	8	
50 to 25	12	
25 to 10	16	
<10, or recharge area	20	
Native Soil Type		
Low permeability	0	
Mod. permeability	10	
High permeability	20	
Annual Precipitation (inches)		
<10	0	
10 to 20	5	
>20	10	
Distance to Nearest Municipal Water Well (feet)		
>5280	0	
1320 to 5280	6	
500 to 1320	8	
<500	10	
Distance to Other Water Well (feet)		
>1320	0	
300 to 1320	5	
<300	10	
Distance to Surf. Water (feet)		
>1000	0	
300 to 1000	5	
<300	10	
Affected Populations		
<100	0	
100 to 300	5	
>3000	10	
Presence of Nearby Utility Conduits		
Not Present	0	
Unknown	8	
Present	10	
Final Score		

Levels of Environmental Sensitivity and
Recommended Cleanup Levels for Soils and Oily Wastes
Total Petroleum Hydrocarbon (TPH in mg/kg or ppm)

	Level I
Total Points	<50
TPH*,**	10,000

	Level II
Total Points	≥50
TPH*	

For all scores totaling ≥50 the cleanup level will be calculated using the formula below. 10,000 ppm and 30 ppm TPH are the upper and lower limits of cleanup required.

.005 x 100 = .5 ÷ fraction benzene in soil = cleanup level in ppm

Where: .005 = maximum contaminant level for benzene in ppm

100 = attenuation factor (EPA,1980)

Example: .005 x 100 = .5 ÷ .0001 = 5,000 ppm TPH
for .01% benzene level in waste or soil to be abandoned
% TPH which is benzene is an indication of aqueous solubility of the waste

It is believed that most of the sites located in oil fields in the State of Utah will fall in the Level I category and would only require cleanup to the 1% TPH level. Sites which fall in Level II, are in more sensitive areas and probably should not receive or retain very large volumes of waste material but if they must, then it should meet more stringent requirements. Since crude oil typically contains about 15% by weight total aromatics, oily wastes may contain similar compositions. However, the heavier compounds are much less soluble than light ones and justify less consideration for mobility in the environment. Fresh crude oils generally contain less than 3% significantly soluble aromatics. Aromatics are of greater concern than aliphatic hydrocarbons because they are in general less degradable. Since in sensitive areas it is likely that some aromatics will make their way into ground or surface waters more stringent cleanup levels seem appropriate.

Salinity of waste or treated waste products to be applied to the surface should be limited by the following final disposition criteria: electrical conductivity EC < 4 mmho/cm; exchangeable sodium percentage ESP <15%; sodium adsorption ratio SAR <12. If natural background soil characteristics show poorer quality than that depicted by these limits or if a higher level consistent with intended land use can be demonstrated, then these limits can be exceeded. These restrictions are not intended to limit the salinity of wastes but apply to the mixture after application which is intended for permanent abandonment. In very sensitive areas more restrictive limits for salinity may be applied on a case-by-case basis, especially for large volumes of waste to be abandoned.

Testing Methods

* ASTM Method D3328-90, or SW846-8015
** EPA 418.1, If this method shows a TPH loading less than required then it is not necessary to re-analyze using a gas chromatographic method.
TPH concentration levels are the concentrations above background levels

REFERENCES
(for cleanup levels)

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Murphy, H.F., 1929, Some Effects of Crude Petroleum on Nitrate Production, Seed Germination and Growth. Soil Sci. 27:117-120.

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Stokman, S.K., 1987, Estimation of Concentration of Soluble Petroleum Hydrocarbons Migrating into Groundwater from Contaminated Soil Sources, in the Proceedings of the NWWA/API Petroleum Hydrocarbons and Organic Chemical in Groundwater:Prevention, Detection and Restoration, Houston, Texas, November 1987.

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Waddell, K.M., Seiler, R.L., Santini, M., Solomon, D.K., 1987, Ground-Water Conditions in the Salt Lake Valley, Utah, 1969-83, and Predicted Effects of Increased Withdrawals from Wells. State of Utah, Department of Natural Resources Technical Publication No. 87, prepared by the United States Geological Survey in cooperation with the Department of Natural Resources, Division of Water Rights.

GUIDANCE: for DETERMINING PIT LINING REQUIREMENTS

SUBJECT: Determination of Liner Requirements for Reserve Pits Used in Oil and Gas Drilling Operations and Onsite Pits Used in Production Operations

This section should be used as guidance by oil and gas operators and Division staff in evaluating the appropriate containment requirements for fluids and drill cuttings which are used and produced as a byproduct of oil and gas drilling and production operations.

The approach utilized is a ranking system to evaluate the environmental sensitivity of the site. This ranking is then used to determine the appropriate method or type of containment needed to protect the surface and near surface environment.

RANKING CRITERIA

1. Distance from Surface to Groundwater The depth to groundwater, in feet below land surface, must consider the highest seasonal average. In addition, recharge areas are considered to be as environmentally sensitive as the distance to groundwater. Sites located in recharge areas may therefore be scored 20 points.

Distance to Groundwater(feet)	Ranking Score
>200	0
100 to 200	5
75 to 100	10
25 to 75	15
<25 or recharge area	20

2. Distance to Surface Water Surface water bodies include perennial rivers, streams, creeks, irrigation canals and ditches, lakes, and ponds. Large drainages which lead to surface waters should be considered as if they contained surface waters.

Distance to Surface Water(feet)	Ranking Score
>1000	0
300 to 1000	2
200 to 300	10
100 to 200	15
<100	20

3. Distance to Nearest Municipal Water Well A municipal water well is assumed to be a well designed to supply groundwater for community consumption.

Distance to Nearest Municipal Well(feet)	Ranking Score
>5280	0
1320 to 5280	5
500 to 1320	10
<500	20

4. Distance to Other Water Wells Other wells will be defined as domestic, irrigation, and stockwatering wells that generally have less capacity, and thus smaller radius of influence, than municipal wells.

Distance to Other Water Wells(feet)	Ranking Score
>1320	0
300 to 1320	10
<300	20

5. Native Soil Type The predominant site lithology and native soil type will be determined by soils classified according to the Unified Soil Classification. The level of environmental sensitivity is determined by the permeability of the soil and the ease with which potential contaminants could migrate through the soil.

Native Soil Type	Ranking Score
a. Low permeability (clay, shale, fat clay, high plasticity clay, elastic silt low plasticity silt, lean clay, silty clay, sandy clay, silty or clayey fine sand, very fine gravelly clay; USC=Pt,OH,CH, MH,OL,CL,ML).	0
b. Moderate permeability (clayey sand, poorly graded sand-clay mixtures, silty sand, poorly graded sand-silt mixtures, unfractured igneous and metamorphic rocks, consolidated and cemented sedimentary rock; USC=SC,SM).	10
c. High permeability (fine sand, silty sand, sand, gravel, gravelly sand, clayey gravel, gravel-sand-clay-silt mixtures, silty, gravel, fractured igneous and metamorphic rocks, vesicular igneous rocks, porous sedimentary rocks; USC=SM,SP,SW, GC,GM,GP,GW).	20

6. Fluid Type The type of liner to be used should be compatible with the fluids it will contain.

Fluid Type	Ranking Score
Air/Mist	0

Fresh Water	5
TDS >5000 and <10000	10
TDS >10000, or Oil Base Drilling Fluid	15
Fluid containing significant levels of hazardous constituents	20

7. Drill Cuttings Most cuttings are not considered as detrimental to the environment. Large volumes of salt cuttings or other soluble materials which could degrade soils or water should be given special consideration.

Drill Cuttings Type	Ranking Score
Shale, Sandstone, Limestone, Dolomite	0
Salt or other potentially detrimental cuttings.	10

8. Annual Precipitation The average annual precipitation in a specific area must be identified in order to evaluate the effects of recharge and potential for mobilization of contaminants.

Annual Precipitation (inches)	Ranking Score
<10	0
10 to 20	5
>20	10

9. Potentially Affected Populations The score for affected populations is based on the number of potential receptors within a one-mile radius of a site. The potentially affected populations include residents, employees, campers, and others who regularly enter the area.

Affected Populations	Ranking Score
<10	0
10 to 30	6
30 to 50	8
>50	10

10. Presence of Onsite or Adjacent Utility Conduits Utility conduits include water distribution lines, sewer lines, septic tanks, buried electrical lines, and any other conduit that may facilitate contaminant migration.

Presence of Adjacent or Onsite Utility Conduits	Ranking Score
Not present	0
Unknown	10
Present	15

11. Summation of Ranking Criteria to Determine Type of Containment Required

The summation of all of the above ranking scores will yield one value which shall be used to determine the appropriate type of containment, on a case-by-case basis. The sensitivity levels are as follows:

Level I Sensitivity: For scores totaling ≥20
Level II Sensitivity: For scores totaling 15 to 19
Level III Sensitivity: For scores totaling <15

12. Containment Requirements According to Sensitivity Level

Level I: Requires total containment by synthetic liner, concrete structure or other type of total containment structure or material.

Level II: Bentonite or other compatible lining is discretionary depending on the fluid to be contained and environmental sensitivity.

Level III: No specific lining requirements.

Evaluation Ranking Criteria and Ranking Score
For Reserve and Onsite Pit Liner Requirements

Site-Specific Factors	Ranking	Site Ranking
Distance to Groundwater (feet)		
>200	0	
100 to 200	5	
75 to 100	10	
25 to 75	15	
<25 or recharge area	20	
Distance to Surf. Water (feet)		
>1000	0	
300 to 1000	2	
200 to 300	10	
100 to 200	15	
< 100	20	
Distance to Nearest Municipal Well (feet)		
>5280	0	
1320 to 5280	5	
500 to 1320	10	
<500	20	
Distance to Other Wells (feet)		
>1320	0	
300 to 1320	10	
<300	20	
Native Soil Type		
Low permeability	0	
Mod. permeability	10	
High permeability	20	
Fluid Type		
Air/mist	0	
Fresh Water	5	
TDS >5000 and <10000	10	
TDS >10000 or Oil Base Mud	15	
Fluid containing significant levels of hazardous constituents	20	
Drill Cuttings		
Normal Rock	0	
Salt or detrimental	10	
Annual Precipitation (inches)		
<10	0	
10 to 20	5	
>20	10	
Affected Populations		
<10	0	
10 to 30	6	
30 to 50	8	
>50	10	
Presence of Nearby Utility Conduits		
Not Present	0	
Unknown	10	
Present	15	

Final Score	

OTHER GUIDELINES FOR PITS

1. Unlined pits shall **not** be constructed on areas of fill materials.

2. A pit shall **not** be constructed in a drainage or floodplain of flowing or intermittent streams.

3. Synthetic liners used for reserve pits, shall be of no less than 12 mil thickness and shall be compatible with the fluid to be contained. Synthetic liners used for onsite pits with a longer expected life shall be a minimum of 30 mil thickness or as approved by the Division.

4. Synthetic liners shall be installed over smooth fill material which is free of pockets, loose rocks or other materials which could damage the liner.

5. Monitoring systems for pits or closed mud systems may be required for drilling in sensitive areas.

GUIDANCE: for RESERVE PIT CLOSURE

Subject: Recommended procedures to be followed when closing reserve pits used during the drilling of oil and/or gas wells and other exploratory test holes

Procedures:

A reserve pit should be closed within one year following drilling and completion of a well (R649-16.3). A pit is considered cleaned up when it meets the following recommended levels. Operators should avoid putting wastes other than drill cuttings, mud and completion fluids into a reserve pit as such a practice could complicate pit closure requirements.

Liquid in a pit should be allowed to either evaporate or be removed. If removed, it must be disposed of properly, some options are injection (in this well or another), hauled to a permitted disposal facility, or re-used at another well.

Pit liners can be cut off above the cuttings/mud level and hauled to a landfill, or folded in and processed along with other pit contents and covered. No remnants of liner material should be exposed at the surface when pit closure is complete. Pit area should be mounded so as not to allow ponding of water and drainage diverted around as not to allow erosion of the old pit site.

Backfill Closure:

If well was drilled with fresh mud, a liner was not required, and pit does not contain much oil (TPH $\leq$3%). The pit can simply be backfilled after the fluids are removed, evaporated and/or percolated.

Dilution Burial:

This method should not be used in general if the water table is less than 10 feet below the pit bottom, especially if intervening material is permeable such as sandy or gravelly soils. The pit contents are mixed with adjacent soil to reduce constituents levels below recommended levels (EC $\leq$12 mmhos/cm, TPH $\leq$3%), or higher if background levels are higher or with Division approval. After mixing the pit contents should contain no more than about 50% moisture by weight prior to burial of a waste/soil mix. Mixed contents should be covered with at least two feet of soil including top soil if possible.

Solidification:

This method commonly uses cementitious/pozzolanic processes that envelope the waste solids in a materials matrix. The mixed pit contents should be covered with at least two feet of soil including top soil if possible.

Spreading:

Pit contents (after fluid removal) can be spread over a location and mixed in if cleanup levels are met as determined using the Division's guidance for estimating cleanup levels for petroleum contaminated soils. A pit can then be backfilled.

GUIDANCE: for E&P WASTE DISPOSAL METHODS

SUBJECT: Disposal methods and recommendations for Oil and Gas Exploration and Production (E & P) Wastes. This section is to serve as a guide to oil and gas producers and prospective producers, concerning the proper and

accepted methods of disposal of oil-field wastes in Utah

Regulatory Authority:

The regulatory authority for oil and gas related activities in Utah is divided among several state, local and federal agencies. The Division (DOGM) and Board of Oil, Gas and Mining are the primary authority for regulation of oil and gas activities on all land and lease hold interests within the state. This authority is found in the Oil and Gas Conservation Act 40-6-1 et seq. U.C.A. (1953 as amended). Depending on land and lease type, various federal (BLM, Forest Service, EPA, BIA) agencies take a lead role in many regulatory functions. The Division is the only agency with authority over oil and gas related activities on all lands within the state.

Waste Types:

The wastes addressed by this document are of two types exempt and nonexempt, hazardous and nonhazardous wastes generated during oil and gas drilling, and production. Exempt wastes are those that EPA has determined are exempt from RCRA hazardous waste management requirements. Wastes which are listed as nonexempt are not necessarily hazardous. However, because of regulations under the Department of Environmental Quality, Division of Solid and Hazardous Waste.

Operations should be aware of EPA's "mixture rule" which requires that the commingling of listed hazardous wastes with nonhazardous wastes renders the entire mixture a hazardous waste. The intent is to prevent avoidance of hazardous waste regulations by dilution. Operators should avoid mixing of exempt oil-field wastes with other waste types. For example a half empty container of solvent should not be discarded into a reserve pit. This would result in the expensive closing of the pit under RCRA regulations.

An abbreviated listing of oil-field wastes follows:

Exempt Wastes

These are wastes generated during "primary field operations", they generally enter the waste stream via either the well or the flow line.

- drilling muds
- cuttings
- produced water
- oily wastes - tank bottoms, separator sludge, pig trap solids
- oily debris, filter media, and contaminated soils
- untreated emulsions
- produced sand
- spent iron sponge
- dehydration and sweetening wastes (including glycol amine wastes)
- filter backwash and water softener regeneration brine
- pit sludge and bottoms from storage or disposal of exempt wastes
- others not specifically listed (for a more complete list see federal register, 53 FR 25446, July 6, 1988)

Nonexempt Wastes

These are wastes which are not necessarily unique to the oil and gas industry, and which are usually generated during maintenance activities. Wastes generated by transporting and/or refining companies are also nonexempt. This means that all wastes generated or separated after custody of the oil or gas has changed to the transporter or refiner is nonexempt.

- used lubrication/hydraulic oils
- used solvents and cleaners, including caustics
- laboratory wastes
- sanitary wastes
- radioactive tracer wastes
- service company wastes such as empty drums, rinsate, spilled chemicals, sandblast media, etc.
- unused fracturing fluids or acids
- refinery wastes
- waste in transportation pipeline-related pits
- pigging waste from pipeline pumping stations
- miscellaneous solid wastes (trash)
- others not specifically listed (for a more complete list see federal register, 53 FR 25446, July 6, 1988)

Disposal Methods:

The method of disposal used should be compatible with the waste being disposed of. Nonexempt hazardous wastes should be handled and disposed of in accordance with RCRA requirements. The methods listed in this document for disposal of exempt and nonexempt-nonhazardous oil field wastes, are the most common methods but are by no means the only alternatives.

Underground Injection - Class II well:

- Fluids brought to the surface with conventional oil or natural gas production and commingled with waste water produced from the operation of a gas plant which is an integral part of production operations.

Surface Produced Water Disposal Pits (lined):

- Exempt nonhazardous waste fluids, primarily produced water.

UPDES - Permitted Discharges:

- Point source discharges which comply with requirements of the Utah Pollutant Discharge Elimination System, this program is administered by the Utah Department of Environmental Quality, Division of Water Quality. This method is only applicable to relatively fresh produced water.

Unlined Surface Disposal Pits:

- Produced water meeting the volume and/or quality restrictions of R649-9-3.4, Oil and Gas Conservation General Rules.

- Oily waste material (soil) resulting from spills or other emergency discharges of crude. Some pits are approved specifically for this purpose.

Reserve Pit Backfilling:

- Drilling mud, cuttings etc. from the drilling operations in many cases can be allowed to dry then be covered over. This will depend on the environmental sensitivity of the site, the contamination potential of the pit contents, and the time limit set for closing of the pit. The contents may require liquid removal and treatment to reduce mobility and/or toxicity such as solidification prior to burial. Requirements for pit location, construction, and lining will be determined at the pre-drilling site inspection. The Division's Guidance Document for determining pit liner requirements will be used.

- In general, reserve pit contents that are covered and/or abandoned should meet the following criteria: 1) contain no halogenated solvents, 2) have free liquids removed, and 3) the residual solids are nonhazardous, 4) meet cleanup levels as outlined in the Division's Guidance Document for estimating cleanup levels for oily wastes. Also, refer to the section of this document concerning Reserve Pit Closure.

Underground Disposal of Drilling Fluids:

- Drilling fluids may be injected downhole in accordance with R649-3-25, Oil and Gas Conservation General Rules. This is approved on a case-by-case basis.

Landfills:

- Associated exempt wastes and nonexempt nonhazardous wastes which are acceptable to the facility operator. This may include wastes such as: spent filters, filter media, scale, and trash. Local health and county officials or other facility owner should be contacted prior to any disposal.

Incineration:

- Oily wastes may be incinerated with approval from the DOGM and the Department of Environmental Quality, Division of Air Quality.

Methods of disposal or treatment such as Road Spreading, Landspreading, Bioremediation, Composting and others will be discussed and permitted on a case-by-case basis. Permitting these types of activities would involve the land management agency or owner and possibly the Department of Environmental Quality as well as Division of Oil, Gas and Mining, depending on the waste to be disposed of and method proposed.

Recommendations:

Reduction of the amount of material generated which must be disposed of is the best practice. Recycling should also be used whenever possible. In general, good housekeeping practices should be used. Catch leaks and drips, contain spills, and cleanup promptly. Waste reduction and recycling should be used at least in part before resorting to the listed disposal options.

Before using a disposal facility the DOGM should be contacted to verify the status of the permitted facility to accept oil-field wastes.

GUIDANCE: for DETERMINING SURFACE CASING SETTING DEPTHS

Subject: Assistance to operators in determining the proper depth to set surface casing when drilling for oil and gas in Utah

Table Of Contents

Introduction

This section is intended to be an aid to companies planning or considering the drilling of an oil and/or gas well in the State of Utah. Utah has a complex variety of terrain, plant and animal communities, mineral resources, geology, and land types. This necessitates good planning before applying for a permit to drill.

Functions of Surface Casing:

The surface casing is a very important part of a well and serves many functions. The surface casing protects fresh water aquifers from contamination during drilling, throughout the production phase, and even after the well is plugged. It acts as an anchor to which blow out prevention equipment is attached, it holds back unconsolidated or unstable shallow formations while the lower portion of the hole is being drilled, and it prevents loss of drilling fluid to permeable shallow formations. Some of the things that should be considered when determining the surface casing settings are: depth of fresh water aquifers, characteristics of shallow formations, zones which have been used for injection, and the possibility of encountering high pressure and/or sour gas in the producing zones.

It is not the intent of this document to instruct anyone in setting depths of surface casing, but only to point out some important things to consider as they relate to various areas in Utah.

Overview of Utah Geology and Producing Areas:

Utah's geology is well known for its variety and exposures. Much of the rock record can be seen first hand and many structures are exposed in "textbook form". This variety is one fact that makes casing setting depths difficult and important. Utah can be divided into four major physiographic provinces. These are the Colorado Plateau, the Middle Rocky Mountains, the Great Basin-Colorado Plateau Transition Province, and the Great Basin. Almost all of the oil and gas production in Utah is located in the eastern half of the state, but wells can be found in all four provinces. The major producing areas are the Paradox Basin, the Uinta Basin and the Overthrust Belt area.

Since the geology and thus the ground water and mineral resources vary with each area, the surface casing setting depth must be suitable for that particular area. Even within major producing areas or basins there is variation in what needs to be protected. In some producing fields disposal zones which are above producing formations must be sealed off to prevent future problems. Some areas of the state have other resources such as oil shale and mining operations which must be protected for multiple mineral development.

UINTA BASIN AREA

Northern Uinta Basin:

Generally the area bounded by the Uinta Mountains on the north, highway 40 on the south and extent of the basin on the east (Utah part) and west.

Geology:

The Uinta Basin is an asymmetric Tertiary basin. It is both a structural and topographic basin. Strata on the northern flank of the basin dip steeply toward the axis, but beds toward the southern flank dip gently. Most of the exposed strata in this area is of Tertiary or younger age. The composite geologic section exposed in the area is thousands of feet thick. However, nowhere in the area does the residual section reach total thickness. Rocks that crop out in this area range in age from upper Precambrian to the Holocene.

Ground Water:

Ground water in the area is contained primarily in consolidated rocks with low permeability, except where fractured. The most permeable aquifer in the area consists of unconsolidated glacial outwash and alluvial deposits which are relatively thin and exist mostly as discontinuous terrace coverings. There are seven water-bearing formations which are considered most important in the area for either recharge to the ground-water system or potential water well yields. Those seven are listed below:

- Glacial outwash, alluvium, of Pleistocene age, and related course-grained deposits.
- Duchesne River Formation
- Uinta Formation
- Currant Creek Formation
- Glen Canyon (Navajo SS)
- Weber Quartzite
- Mississippian Limestone

Southern Uinta Basin:

Generally the area bounded by highway 40 on the north, the Book Cliffs area on the south and the extent of the basin to the east and west.

Geology:

The general geology of the area was discussed in the previous section on the Northern Uinta Basin. Surface geology in the area consists of rocks ranging in age from Cretaceous to Holocene and in general dip gently to the north. Most of the formations except for younger alluvium are important sources for oil and gas production. Extensive deposits of oil shales are present in the Green River Formation, and gilsonite veins cut the Uinta Formation in various locations throughout the southern portion of the Basin.

Ground Water:

Ground water in the area is contained primarily in consolidated rocks with low to very low permeabilities except where fractured. Alluvium and terrace deposits can be very permeable but may be saturated only during part of the year. Additionally, in some areas, upper zones of Tertiary formations may not be water bearing due to being drained by deeply incised streams and rivers. The most important water bearing formations are as follows:

- Alluvium and terrace deposits
- Duchesne River Formation
- Uinta Formation
- Green River Formation

Ground Water Quality:

The ground-water quality in the Uinta Basin varies with depth and location. In general, if it exists, shallow ground water is of better quality and becomes poorer with depth. Department of Natural Resources, Technical Publication #92 (available upon request at the Division) contains information on the Base of Moderately Saline Water (BMSW) in the Uinta Basin. The BMSW shows a mound of saline water underlying part of the basin with very saline to briny ground water present at depths of less than 1,000 feet in some places. In general, those water zones above the BMSW depth should be isolated from lower saline and producing zones.

Multiple Mineral Development:

Operators should be aware that some parts of the Uinta Basin are designated by the Board for multiple mineral development. Special requirements are spelled out in regulations (R649-3-27, 28, 29, 30) for those areas to protect the resource and/or mining operations. Oil shale, tar sands, gilsonite, coal, and trona are some of the non-petroleum resources found in the basin. Throughout some of the basin, most of these minerals would be at such a depth that would make them un-minable and thus not a problem. If there is question about whether or not you are drilling in a designated area, the Division should be contacted for more information.

Disposal Zones:

Some areas, particularly the greater Altamont/Bluebell area contains formations above producing formations which have historically and are presently being used for disposal of produced water. These zones can be pressured up and must be isolated, casing strings must be cemented through them to protect them from corrosion and leakage problems.

Area Summary:

The following items should be considered when designing casing programs for wells in the Uinta Basin Area:

- fresh water aquifers
- base of moderately saline water (<10,000 mg/1 TDS)
- other mineral resources
- disposal zones
- other potential oil and gas zones, Green River and Wasatch Formations in some areas the Uinta Formation

CANE CREEK ANTICLINE AREA

The general area surrounding the Cane Creek anticline in Grand County, Utah.

Geology:

The Cane Creek anticline lies within the Paradox basin which accumulated a thick sequence of salt deposits during Pennsylvanian time. The anticline is one of a series of northwest trending features which developed from salt diapirism and regional warping. Rocks exposed at the surface are primarily Mesozoic deposits of the Glen Canyon Group except near the Colorado River where rocks as old as Permian Elephant Canyon Formation are exposed.

The main target formation for oil and gas development has been the Pennsylvanian Paradox Formation. Some oil has also been produced from the Mississippian carbonates in the area. More recent horizontal drilling efforts have targeted the Cane Creek zone within the Paradox Formation. This zone is at an approximate depth of 7200 feet in the area. The Paradox Formation also contains potassium-salts and halite, which are mined in the area.

Ground Water:

Formations down to the level of the Colorado River (4000'asl) are basically unsaturated. Studies indicate that ground water flow in the area is controlled primarily by extensional faulting. These faults appear to be limited to the crest area of the Cane Creek anticline near the Moab Salt Inc. potash mine. Wells and mine shafts, in areas void of extensional faulting, encountered little ground water. While those located near faults (Texasgulf Cane Creek No. 7 Well) encountered prolific water zones. These zones are charged with hydrogen sulfide brines. More recent drilling encountered mostly unsaturated rocks which were drilled with air down to the Cutler Group (Elephant Canyon or Rico Fm.) around 2100 feet depth where salty water was encountered. Drilling also encountered several lost return intervals in the upper Hermosa.

Multiple Mineral Development:

The Paradox Formation contains evaporite units deposited in sequence, some of which are mined for potash and halite. Solution mining is currently taking place utilizing the fifth salt unit down in the sequence. Potash also occurs in the ninth unit down in the sequence.

Some areas have been designated as Potash Areas. Regulations (R649-3-28) specify special requirements applicable to drilling in Designated Potash Areas. If there is a question about whether or not you are planning to drill in a designated potash area the Division should be contacted for more information.

Area Summary:

The following items should be considered when determining surface casing setting depths for wells in the Cane Creek Area:

- prolific salt water zones near extensional faulting
- lost return zones in the lower Cutler and upper Hermosa Groups, especially upper clastic zones in the Paradox Formation
- hydrogen sulfide and hydrocarbon gases found in the Honaker Trail and Paradox Formations
- potash zones and designated potash areas

Cisco Area

The Mancos Shale lowland area including the Greater Cisco area.

Geology:

The Mancos Shale Formation is the predominant surface formation in this area. Due to the preponderance of fine-grained sediments and water soluble minerals found in this formation it does not usually contain any fresh water.

Ground Water:

Ground water that comes in contact with the Mancos Shale Formation almost always contains high levels of dissolved solids. Ground water is usually limited to alluvial deposits along streams and drainages or to sandstone units some of which are very localized with low recharge rates. Wells in the area are usually drilled with air with little or no water encountered until the Dakota Formation is penetrated.

Multiple Mineral Development:

Multiple mineral development is not a problem in this area. The Dakota Formation does contain a few thin coal seams but they are not protected by any special designation.

Area Summary:

The following items should be considered when determining surface casing setting depths for wells in the Cisco Area:

- any alluvial deposits which may contain water
- proposed depth of the well

BASIN AND RANGE AREA

Most of western Utah is included in this physiographic province. It is comprised of the area west of the Wasatch, Pavant, and Canyon mountain ranges and north of the Tonoquints Volcanic Province to the state boundaries west and north.

Geology:

The area consists of a series of mountain ranges and valleys created by alternating horst and graben structures. The fault blocks which make up most of the mountains are composed of consolidated sediments mainly limestones and dolomites with some quartzites, sandstones, and shales. Some volcanic rocks are also found in this area. Valley fill material consists of alluvium, colluvium, with some basalt flows, pyroclastics and eolian material.

Ground Water:

The most important and most used aquifers are in the valley fill material. Fractured sedimentary rocks contribute to the movement of water from mountain recharge areas to the valleys, but are not used as a major water source. Ground water generally flows from mountain areas through the valley fill to central playa areas. The water quality generally gets worse (higher in dissolved solids) as it moves from the mountains to the valley centers. Artesian, confined and perched water table conditions are found in the valley fill. Water wells utilizing these water sources vary in depth, generally less that 1,000 feet deep.

Multiple Mineral Development:

Multiple mineral development should not be a problem in this area.

Area Summary:

The following should be considered when determining surface casing setting depths for wells in the Basin and Range area of western Utah:

- alluvial valley fill material containing fresh water especially near mountains
- volcanic rocks and sedimentary rocks containing fractures and/or solution voids which can contain fresh water and/or be a loss circulation problem

OVERTHRUST BELT AREA

The overthrust belt area of Utah lies mostly in Summit County the area from Coalville trending northeast toward the Lodgepole, Elkhorn, and Pineview oil fields. Continuing northeast to Anschutz Ranch and Cave Creek Gas fields to the Wyoming-Utah border.

Geology:

The Overthrust Belt is a very complicated geologic area, resulting from extensive lateral movement of the Pacific and North American plates. Large scale thrusting and faulting has created a complex structural pattern. Rocks from late Cretaceous through Quaternary age are exposed on the surface. Tertiary sediments unconformably overlie the Cretaceous sediments and mask most of the structure in the area. Important productive zones for oil and gas have been discovered in the Nugget and Twin Creek Formations and additional productive zones of less importance have been discovered in the Stump and Frontier Formations.

Ground Water:

In general, very little work has been done on the ground water resources of this area. The following information is from a study by Gates, Steiger and Green (1984).

Ground water in the area occurs in unconsolidated alluvium and in older semi-consolidated and consolidated rocks. Ground water in the alluvium and shallow older units is generally under water table conditions. Ground water in some aquifers, closer to the town of Coalville, is sometimes under artesian conditions. The alluvium is the most important hydrogeologic unit in the area because of its high permeability and freshness of water.

There are six important water bearing aquifers in the overthrust area and these are listed below.

- Quaternary Alluvium
- Wasatch Formation
- Evanston Formation
- Echo Canyon Conglomerate
- Wanship Formation
- Frontier Formation

Ground water quality in the area varies with depth and location. Most fresh water is contained in the Quaternary alluvium or Tertiary sandstones and siltstones. Water analysis reports from the area indicate a gradual increase in salinity with depth in the Cretaceous Units, with some aquifers of fresher water underlying zones of higher salinity waters.

Disposal Zones:

In the Pineview Field, the Stump Formation has been historically and presently, on a limited basis, utilized for disposal of produced water. Oil Company information indicates that the Stump Formation has become overpressured from disposal operations, and adequate casing programs and cement operations should be planned to isolate this zone to protect from corrosion and leakage problems.

Multiple Mineral Development:

Multiple mineral development should not be a problem in this area. There are however, some coal resources and limited mining activity in parts of the area.

Area Summary:

The following items should be considered when designing casing programs in the Overthrust Area.

- fresh water Aquifers
- base of moderately saline water (<10,000 mg/1 TDS, commonly found in the Kelvin Formation)
- disposal zones (Stump Formation)
- other potential oil and gas, producing zones (Stump and Frontier Formations)
- coal seams if applicable

Paradox and Blanding Basin Area

This area is bounded by the Monument Upwarp on the west which expresses itself as the Comb Ridge monocline. The LaSal Mountains to the north and the Utah state line to the south and east.

Geology:

As the Uncompahgre Uplift rose during the Middle Pennsylvanian, the Paradox Basin developed as a series of northwest - southeast trending anticlines and synclines. Most of the exposed strata in the area are composed of Lower Cretaceous and Upper Jurassic rocks, the highest percentage being various members of the Morrison Formation. Northward toward the LaSal Mountains, rocks of middle to lower Jurassic age crop out and a series of faults in the Lisbon Valley area have exposed a belt of rocks which are Pennsylvanian and Permian in age. Quaternary alluvial deposits are present in valleys and washes. Quaternary eolian deposits are present on mesas and in many upland areas.

Strata underlying the area consists of rocks ranging in age from Precambrian to Triassic. Hydrocarbons are found primarily in the Pennsylvanian Paradox Formation.

Ground Water:

Ground water in the area is contained primarily in consolidated rocks with permeabilities which range from very low to low. Fractures and faults increase permeability locally and occur in most water bearing strata. Recharge to most of the aquifers occurs in the form of precipitation in the Abajo Mountains and the LaSal Mountains. Minor recharge may occur along Comb Ridge and areas west of Comb Ridge, and additional recharge may come from streams, rivers and leaking aquifers.

For the purpose of this document, there are three aquifers comprised of groups of formations which yield water and are considered important in the area. These aquifers grouped by Avery 1986 are designated as N, M, and D. These aquifers are listed below.

N aquifer: Wingate, Kayenta, Navajo, Carmel and the Entrada Formations.

M aquifer: Morrison Formation.

D aquifer: Burro Canyon and Dakota Formations.

Each of the above aquifers have very low to low permeabilities and contain waters which are fresh to briny. Throughout the entire area these aquifers provide potable water for human and livestock consumption and additionally for irrigation. Additionally, the Quaternary alluvium deposits may contain waters on a seasonal basis and may be an important unconsolidated aquifer.

Area Summary:

All of the above listed aquifers should be adequately protected during the drilling and completion process. It is recommended that all wells drilled within this area should set surface casing through the lower most fresh water aquifer encountered, and circulate cement from total depth of the surface casing back to surface.

High Plateaus Area

The central and south-central part of the state which includes the Wasatch, Kolab, Sevier, and Aquarius plateaus.

Geology:

The High Plateau region of Utah is the transition zone between the Colorado Plateau and the Basin and Range area. The High Plateaus Area is divided into three longitudinal strips, each consisting of two to four plateaus generally separated by escarpments or valleys. The relief variations are usually controlled by faults, but a few escarpments were formed solely by erosion. Except for local distortion along faults, the rocks generally are horizontal or gently dipping. Rocks exposed in this area of the state range from Permian to Tertiary in age. They consist of both sedimentary and igneous types.

Ground Water:

Wells and springs show fresh water to exist in limestones of Paleozoic age, Wingate and Navajo Sandstones, Carmel Formation Tropic Shale, Wahweap and Straight Cliffs Sandstones, Emery Sandstone Member of the Mancos Shale, Blackhawk, Price River, Kaiparowits and North Horn Formations, Flagstaff Limestone, Wasatch, Brian Head, Green River and Crazy Hollow Formations, and igneous rocks of Tertiary age.

Many communities in the High Plateaus Area obtain their water supplies from springs that issue from bedrock. Sedimentary rocks of Tertiary age yield water to most of these springs in the northern part of the plateaus, and igneous rocks of Tertiary age are the source of most springs in the central part of the High Plateaus. In the southern part of the High Plateaus, limestones of Tertiary age yield water to springs atop the plateaus, but along the escarpments sandstones of Mesozoic age are the principal aquifers. The numerous springs that yield large quantities of fresh water in the High Plateaus are a reflection of the great amount of precipitation on this area.

In general the fresh water lies above the Bluegate Shale Member of the Mancos Shale Formation in this area.

Multiple Mineral Development:

There are significant coal resources located throughout much of the High Plateaus Area. Drilling in areas of mine workings should comply with R649-3-29,30.

Area Summary:

The following should be considered when determining surface casing setting depths for wells in the High Plateaus Area:

- Fresh water aquifers located usually stratigraphically above the Bluegate Shale Member of the Mancos Shale Formation

- Coal seams and coal mining areas

North Slope Uinta Mountains Area

The area between the Uinta Mountains northward to the state line.

Geology:

This area covers from the Uinta Mountain uplift to the state line and includes part of the Green River Basin. Rocks range in age from Pre-Cambrian in the high mountain area to Quaternary alluvium stream deposits. Subsurface structural features which influence exploration and probably also affect ground water flow are the North Flank Fault, and Moxa Arch.

Ground Water:

Glacial valleys perpendicular to the strike of the Uinta Mountains and separated by bedrock ridges act as groundwater basins. Water infiltrates the glacial deposits in the basins and travels and discharges to streams and springs near mouths of valleys at lower elevations. Local, intermediate and regional flow systems are present in the area. Precipitation which falls on exposed bedrock at higher elevations becomes part of the regional systems which discharge in the Green River Basin. Precipitation which recharges alluvium and glacial material becomes part of local and intermediate flow systems. The discharge points for these systems are in the Bishop conglomerate and glacial deposits as shown by numerous springs in these formations at lower elevations. Most of the water wells in the area are completed in the Tertiary Bishop conglomerate or glacial deposits.

Since this area is on or near the Uinta Mountains, which is a recharge area, the water quality is generally good even to great depths. Some water produced with oil and gas at depths exceeding 10,000 feet has a total dissolved solids content less than 10,000 mg/l.

Multiple Mineral Development:

Multiple mineral development should not be a problem in this area.

Area Summary:

The following items should be considered when determining surface casing setting depths for wells in the North Slope Area:

- prolific unconfined fresh water aquifers in the alluvium, glacial and conglomerate deposits
- confined fresh water aquifers in the pre-Tertiary and early Tertiary strata, which is permeable, with recharge areas exposed in higher elevations, if not properly isolated could leak into lower pressure zones