APPENDIX B

ACTION LEAKAGE RATE

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This appendix (Appendix B-1) presents a calculation of the Action Leakage Rates (ALR) for the evaporation ponds proposed for construction at the Piñon Ridge Project. As per the U.S. EPA (1992), the ALR is defined as "*the maximum design flow rate that the leak detection system (LDS) can remove without the fluid head on the bottom liner exceeding 1 foot.*"

Each evaporation pond cell will be equipped with its own dedicated Leak Collection and Recovery System (LCRS) sump. A mobile pump will be used to pump collected solutions from the LCRS sump back into the evaporation pond cells. The ALR was calculated for each LCRS sump. The ALR was calculated to be 12,000 gallons per acre per day (gpad) for each evaporation pond LCRS sump. If a leakage rate exceeding this value is measured, action must be taken as per Title 40 CFR, Section 264.223.

REFERENCES

40 CFR Part 264 – "*Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*", Subpart K (Surface Impoundments).

U.S. Environmental Protection Agency (U.S. EPA). 1992. "Action leakage rates for detection systems (supplemental background document for the final double liners and leak detection systems rule for hazardous waste landfills, waste piles, and surface impoundments)."

APPENDIX B-1

ACTION LEAKAGE RATE CALCULATION

OBJECTIVE:

The objective is to determine the Action Leakage Rate (ALR) for the Piñon Ridge evaporation pond. The ALR is defined as "*the maximum design flow rate that the leak detection system (LDS) can remove without the fluid head on the bottom liner exceeding 1 foot*" (U.S. EPA 1992; United States Government Printing Office 2002).

GIVEN:

- Leak collection and recovery system (LCRS) configuration.
- Evaporation pond cells configuration (Figure 1).
- Drainage material properties (Attachment 1).

GEOMETRY:

- The evaporation pond cells configuration diagram is shown in Figure 1.
- A typical liner system detail is shown in Figure 2.
- Sump top dimensions of 40 feet by 60 feet for all evaporation pond cells.

MATERIAL PROPERTIES:

Table 1 summarizes the material properties considered in the analysis for the drainage geonet on the evaporation pond cells.

Table 1. Geonet properties

Manufacturer	*Model*	*Transmissivity gal/min ft (m^2/sec)*	*Thickness mil*
GSE	HyperNet	9.66 (2 x 10^{-3})[1]	200

[1] see Attachment 1

METHOD:

- The ALR calculation is based on the U.S. EPA guidelines published in U.S. EPA (1992).

ASSUMPTIONS:

- Darcy's law is valid;
- The gradient of the floor of the evaporation pond cells is approximately 2 percent. The gradient of the side slopes for the cells is approximately 33.3%;
- One foot of water head is developed on the bottom liner.

CALCULATIONS:

The maximum flow rate within the LCRS geonet is calculated using Darcy's equation:

$$Q = K\,i\,A$$

where :

Q = flow through unit width of the LCRS drainage layer [ft^3/sec];
K= hydraulic conductivity of the LCRS drainage layer [ft/sec];
i = hydraulic gradient; and
A= area of the flow per unit width [ft^2/ft].

For a geonet the flow through the layer is calculated by using the following equation:

$$q_{ult} = i\,\theta\,W$$

where:

q_{ult} = flow through the geosynthetic layer [ft^3/sec/ft];
i = hydraulic gradient;
θ = transmissivity [ft/sec]; and
W= width of the drain [ft].

A factor of safety should be applied to consider the reduction in flow capacity of the geonet due to deformations, intrusions, clogging, or precipitation of chemicals (Koerner 1998):

$$q_{allow} = q_{ult}\left[\frac{1}{RF_{IN} + RF_{CR} + RF_{CC} + RF_{BC}}\right]$$

where:

q_{ult} = flow through the geosynthetic layer;
q_{allow} = allowable flow rate;
RF_{IN} = reduction factor for elastic deformation or intrusion;
RF_{CR} = reduction factor for creep deformation;
RF_{CC} = reduction factor for chemical clogging; and
RF_{BC} = reduction factor for biological clogging.

Table 2 shows the adopted reduction factors for a secondary leachate collection system according to Table 4.2 in Koerner (1998):

Table 2. Reduction factors for determining allowable flow rate of geonets

Factor	Recommend value range	Use value for geonet
RF_{IN}	1.5 – 2.0	1.5 (possible elastic deformation)
RF_{CR}	1.4 – 2.0	1.4 (low normal stress)
RF_{CC}	1.5 – 2.0	2.0 (low pH liquids)
RF_{BC}	1.5 -2.0	1.5 (low pH should preclude biological activity)

A water head equal to 1 foot is assumed to be acting over the bottom liner so the hydraulic gradient can be assumed to be equal to the slope of the geonet. For the bottom of the evaporation pond:

$$i = 2\%$$

For the slopes of the evaporation pond (3H:1V):

$$i = 33.3\%$$

The flow in the geonet per unit width for the bottom of the evaporation pond is:

$$\frac{q_{ult}}{W} = 0.02 * 9.66\, gal/\min ft = 0.193\, gal/\min ft$$

And for the sideslopes the flow per unit width is:

$$\frac{q_{ult}}{W} = 0.3333 * 9.66\, gal/\min ft = 3.22\, gal/\min ft$$

The allowable flow rates per unit width for the bottom of the evaporation pond and the sideslopes are:

$$\frac{q_{allow}}{W} = \frac{q_{ult}}{W} * \frac{1}{\prod RF}$$

$$\prod RF = 1.5 + 1.4 + 2.0 + 1.5 = 6.4 \quad \text{for geonet}$$

Flow rate per unit length from the evaporation pond cell bottom:

$$q_{allow\ 2\%} = \frac{0.193\ gal/\min ft}{6.4} = 0.0302\ gal/\min ft$$

Flow rate per unit length from the evaporation pond cell sides slopes:

$$q_{allow\ 33.3\%} = \frac{3.22\ gal/\min ft}{6.4} = 0.503\ gal/\min ft$$

Flow access to the sump is a function of the perimeter length of the crest of the sump. The sump is located at the low point of each cell and adjacent to one of the sideslopes. As shown in Figure 1, the sump will receive leachate from the cell bottom on three sides and from the sideslope on one side. The flow rate to a sump is:

> $q_{allow\ 2\%}$ * perimeter length of sump in that flow direction (3 sides) + $q_{allow\ 33.3\%}$ * perimeter length of sump in that flow direction (1 side)

The ALR expressed in gallons per acre per day (gpad) for each cell is summarized in Table 3:

Table 3. Action leakage rates for different cells expressed in gpad

Sump	Perimeter Length of Sumps		Cell Area (Acres)	ALR (gpd)	ALR (gpad)
	2% slope (ft)	33.3% slope (ft)			
Evap. Pond	140	60	4.1	49,500	12,000

CONCLUSIONS:

Per EPA guidance, the Action Leakage Rate (ALR) was calculated assuming one foot of water head on the bottom geomembrane liner of the evaporation pond liner system. The ALR was calculated to be 12,000 gpad for each evaporation pond cell.

REFERENCES:

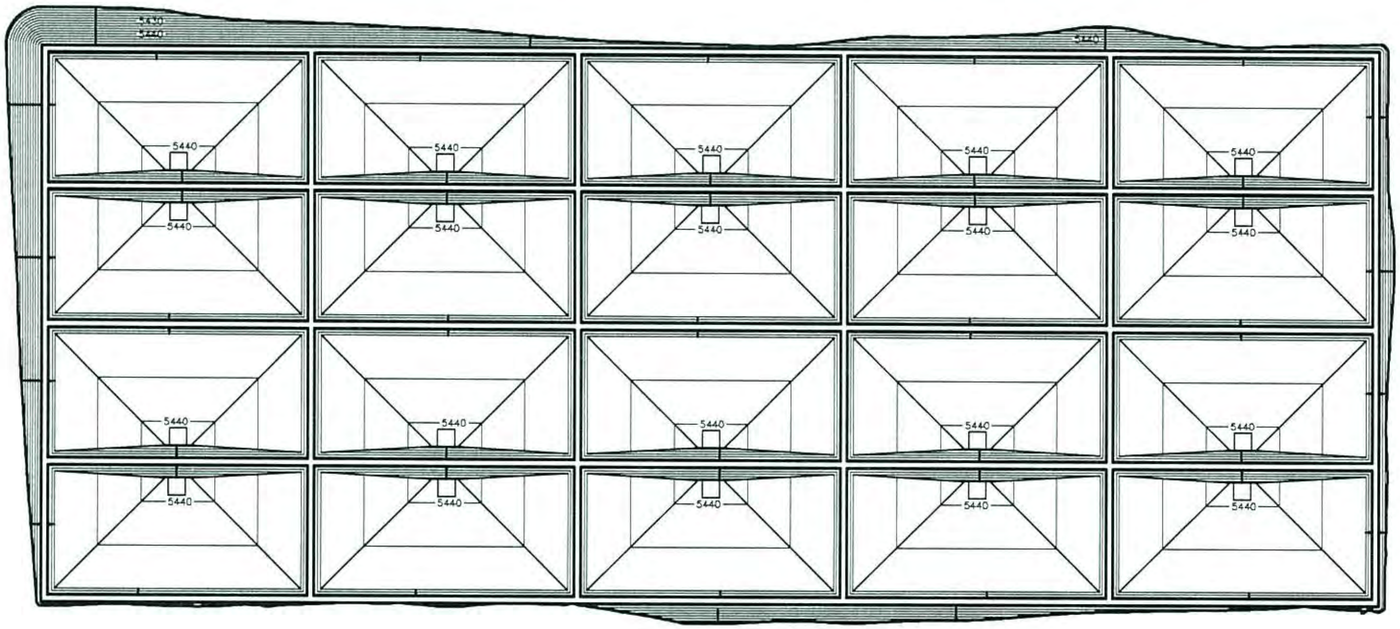
Colorado Department of Public Health and the Environment (CDPHE), Hazardous Waste Regulations 6 CCR 1007-1, Parts 3 and 18.

Koerner, R. M. (1998). *Designing with geosynthetics*, Prentice Hall, Upper Saddle River, N.J.

U.S. EPA. (1992). "Action leakage rates for detection systems (supplemental background document for the final double liners and leak detection systems rule for hazardous waste landfills, waste piles, and surface impoundments)." U.S. Enviromental Protection Agency.

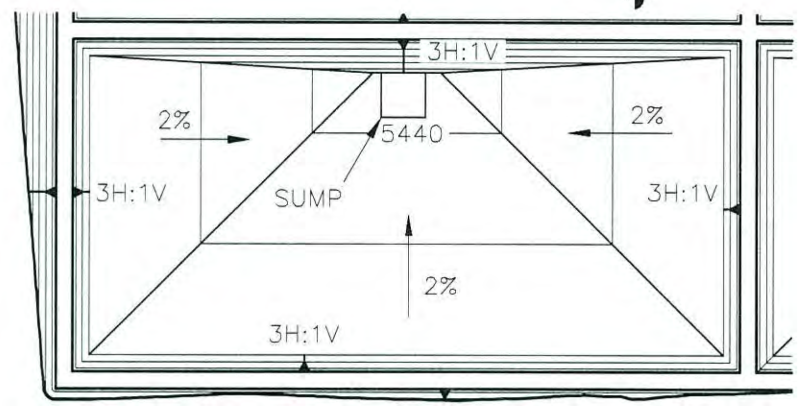
United States Government Printing Office. (2002). *Title 40, CFR*, U.S. G.P.O., Washington, D.C.

FIGURES



EVAPORATION PONDS
GENERAL LAYOUT

EVAPORATION POND
DETAIL

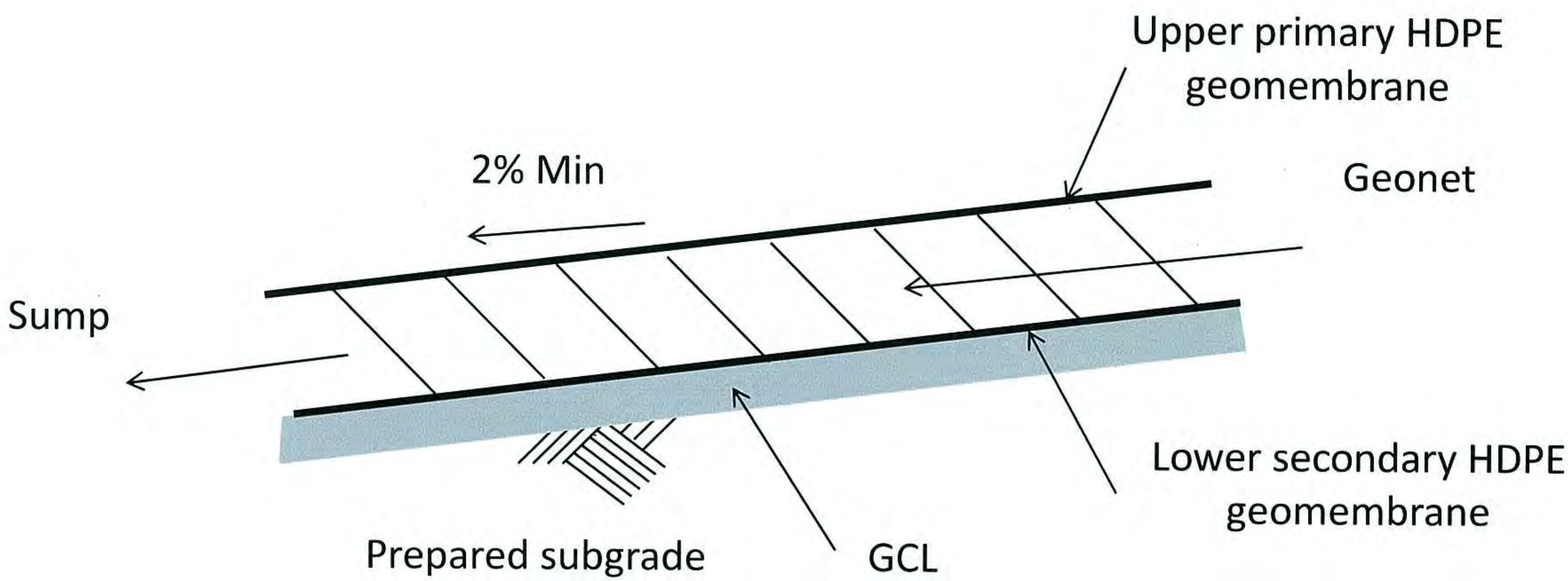


Golder Associates Denver, Colorado

TITLE

EVAPORATION POND CONFIGUR ATION

CLIENT/PROJECT ENERGY FUELS RESOURCES CORPORATION PIÑON RIDGE PROJECT – EVAPORATION POND DESIGN MONTROSE COUNTY, COLORADO	DRAWN EF	DATE APRIL 7, 2008	JOB NO. 073-81694
	CHECKED [signature]	SCALE N.T.S.	DWG. NO.
	REVIEWED [signature]	FILE NO.	FIGURE NO. 1



Golder Associates
Denver, Colorado

TITLE

LINER SYSTEM TYPICAL DETAIL

CLIENT/PROJECT			
ENERGY FUELS RESOURCES CORPORATION PIÑON RIDGE PROJECT – EVAPORATION POND DESIGN MONTROSE COUNTY, COLORADO	DRAWN EF	DATE APRIL 7 2008	JOB NO. 073-81694
	CHECKED	SCALE N.T.S.	DWG. NO.
	REVIEWED	FILE NO.	FIGURE NO. 2

ATTACHMENT 1
GEONET PROPERTIES

GSE

GSE STANDARD PRODUCTS

Product Data Sheet

GSE HyperNet Geonets

GSE HyperNet geonets are synthetic drainage materials manufactured from a premium grade high density polyethylene (HDPE) resin. The structure of the HyperNet geonet is formed specifically to transmit fluids uniformly under a variety of field conditions. HDPE resins are inert to chemicals encountered in most of the civil and environmental applications where these materials are used. GSE geonets are formulated to be resistant to ultraviolet light for time periods necessary to complete installation. GSE HyperNet geonets are available in standard, HF, HS, and UF varieties.

The table below provides index physical, mechanical and hydraulic characteristics of GSE geonets. Contact GSE for information regarding performance of these products under site-specific load, gradient, and boundary conditions.

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE ROLL VALUE[c]			
			HyperNet	HyperNet HF	HyperNet HS	HyperNet UF
Product Code			XL4000N004	XL5000N004	XL7000N004	XL8000N004
Transmissivity[a], gal/min/ft (m^2/sec)	ASTM D 4716-00	1/540,000 ft^2	9.66 (2×10^{-3})	14.49 (3×10^{-3})	28.98 (6×10^{-3})	38.64 (8×10^{-3})
Thickness, mil (mm)	ASTM D 5199	1/50,000 ft^2	200 (5)	250 (6.3)	275 (7)	300 (7.6)
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	1/50,000 ft^2	45 (7.9)	55 (9.6)	65 (11.5)	75 (13.3)
Carbon Black Content, %	ASTM D 1603, modified	1/50,000 ft^2	2.0	2.0	2.0	2.0
Roll Width, ft (m)			15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)
Roll Length, ft (m)[b]			300 (91)	250 (76)	220 (67)	200 (60)
Roll Area, ft^2 (m^2)			4,500 (418)	3,750 (348)	3,300 (305)	3,000 (278)

NOTES:

- [a]Gradient of 0.1, normal load of 10,000 psf, water at 70° F (20° C), between steel plates for 15 minutes.
- [b]Please check with GSE for other available roll lengths.
- [c]These are MARV values that are based on the cumulative results of specimens tested by GSE.

DS017 R07/07/03

Americas	GSE Lining Technology, Inc.	Houston, Texas	800-435-2008	281-443-8564	Fax: 281-230-8650
Europe/Middle East/Africa	GSE Lining Technology GmbH	Hamburg, Germany		49-40-767420	Fax: 49-40-7674233
Asia/Pacific	GSE Lining Technology Company Ltd.	Bangkok, Thailand		66-2-937-0091	Fax: 66-2-937-0097

This product data sheet is also available on our website at:

www.gseworld.com