MEMORANDUM

TO: Dave Finley

FROM: Dale Anderson

SUBJECT: Estimated Scope of Landfill Impact Problem

DATE: December 14, 2004

The Department (DEQ) was asked to provide additional information about how DEQ has arrived at its projection that 65 of the 130 existing municipal solid waste landfills will ultimately leak and require groundwater remediation, and to more closely evaluate that projected number. The purpose of this memo is to provide that additional information, and explanation of the evaluation process. As will be seen below, after re-evaluation, the number of facilities projected to cause environmental impacts has been revised slightly downward to 58 facilities, approximately a ten percent reduction.

DEQ cited two primary sources for its projection that 65 of Wyoming's landfills will ultimately leak. The first was a study done at the University of Wyoming (Halleman, T.W., 2004) at DEQ's request, to examine the factors contributing to landfill leakage. The second was a multi-year study of 224 landfills located in the State of California (Geosyntec Consultants, Inc., 2003)

DEQ has reexamined both reports, and has collected and evaluated additional data on landfill performance, in an effort to refine its estimate of the scope of the problem likely affecting our state from leaking MSW landfills.

California studied 224 existing and closed MSW landfills. This study included evaluation of several factors that are, or may be related to causing or contributing to groundwater pollution problems. California's average annual precipitation varies across the state from less than ten inches per year to about eighty inches per year, and there are landfills located throughout that range of annual precipitation. In contrast, Wyoming's average annual precipitation varies from less than ten inches per year, to a high of about 70 inches (Natural Resources Conservation Service, 1999). All areas where landfills are located in Wyoming have an average annual precipitation of less than 25 inches per year See maps at end of memo showing average annual precipitation at MSW landfills). The California study reported on the prevalence of leaking landfills in different categories of average annual precipitation. Below we show the incidence of leaking landfills in the dryer areas of California, which correspond to the ranges of annual precipitation we experience in Wyoming:

Average Annual precipitation category, inches per year	Number of California landfills in each precipitation category	Number of landfills undergoing groundwater corrective action	Percentage of landfills undergoing groundwater corrective action
0-9.9	71	14	19.7%
10-19.9	96	37	38.5%
20-29.9	30	13	43.3%

To see how the California leaking landfill data compare with our experience to date in Wyoming, DEQ has also more carefully evaluated the distributions of Wyoming's currently leaking (21) landfills in each of the three average annual precipitation categories. The chart below shows the total number of Wyoming landfills *where groundwater monitoring is occurring* in each of those three precipitation categories; the number of Wyoming landfills leaking, and the percentage of leaking landfills (within the universe of monitored facilities) that currently exist.

Average annual precipitation category, inches per year	Number of Wyoming landfills in each precipitation category with groundwater monitor systems	Number of Wyoming landfills currently showing groundwater impacts	Percentage of monitored Wyoming landfills currently showing groundwater impacts
0-9.9	22	4	18.2%
10-19.9	39	17	43.6%
20-29.9	1	0	0%

Comparison of these two charts indicates that roughly 20 percent of MSW landfills located in areas with average annual precipitation values of 0-9.9 inches per year are currently leaking, in both California and Wyoming. Similarly, the charts show that roughly 40 to 45 percent of MSW landfills in the 10-19.9 inches per year category are currently leaking in both states.

If one assumes that the pattern of leaking landfills that is shown above for the universe of Wyoming landfills with groundwater monitoring systems is consistent with the pattern expected for the universe as a whole, then the following numbers of Wyoming landfills could be expected to ultimately leak:

Average annual precipitation category, inches per year	Total number of Wyoming landfills in each precipitation category	Expected percentage of total that will ultimately leak	Number of Wyoming landfills in each precipitation category expected to leak
0-9.9	51	20%	10
10-19.9	82	45%	37
20-29.9	2	50%**	1

**Based upon DEQ's knowledge of the two landfills located in areas with average annual precipitation of 20-29.9 inches, DEQ predicts a leakage rate of 50% rather than the zero percent rate indicated by the evaluation discussed above.

This analysis, based solely upon examination of the patterns exhibited by landfills known to be leaking in Wyoming and in similar climatic areas in California, predicts that Wyoming communities will experience leakage and contaminated groundwater at 48 of the state's 130 existing landfills. DEQ's original projection was that 65 landfills would leak.

Modeling of MSW landfill leakage in areas of the country with low average annual precipitation indicates that it takes years, even decades, for leachate to migrate to groundwater and contaminate it. Many of the landfills in the samples noted above have been in existence less than 20 years. For this reason, DEQ believes that using groundwater monitoring data from currently operating landfills as the sole predictor of what percentage of a given state's landfills will ultimately leak is not scientifically supportable.

Generation of leachate at the bottom of a lined landfill is a more direct line of evidence as to a landfill's ultimate performance--whether it will cause groundwater impacts or not. If a landfill generates leachate, that leachate will flow downward through soil pore spaces, or through soil discontinuities, cracks or bedding planes, until it reaches groundwater or until leachate is no longer generated. To evaluate whether landfills in the arid western United States generate leachate, DEQ surveyed surrounding state environmental agencies and contacted owners and operators of all of the lined or partially lined MSW landfills that could be identified. The median leachate generation rate for the facilities contacted was about one inch/acre/year, which is equal to approximately 27,150 gallons/acre/year. The average leachate generation rate was about 1.75 inches/acre/year.

A few important observations can be made from the available leachate generation data reported above include:

(1) Landfills in arid environments can produce significant quantities of leachate each year, as evidenced by the data from three landfills located in areas with average annual precipitation between 0 and 9.9 inches per year;

(2) Leachate production in semi-arid (10-19.9 inches per year) environments is even more significant than in arid ones;

(3) Every lined landfill surveyed, with the single exception of one data point from the Sheridan, Wyoming landfill, reported generation of leachate. (Sheridan reported leachate generation at other data points.)

Leachate volumes generated by these landfills are sufficient to cause adverse impacts on groundwater quality, and they have in the case of the three Wyoming landfills evaluated for leachate generation.

While it may not be reasonable to use the information about leachate generation from the above discussion to reach a conclusion that all of Wyoming's 130 landfills will ultimately require remediation (i.e., that 100 percent of landfills will impact groundwater), the data above suggest that it would be prudent to add a safety factor to any prediction made from the patterns of existing landfill contamination in Wyoming and California. Recall that projections from existing landfill contamination cases yield an expected total of 48 Wyoming landfills requiring remediation. With a 20 percent uncertainty (or safety) factor, DEQ believes that an appropriate estimate of the scope of Wyoming's problems should be set at 58 landfills. The DEQ believes inclusion of an uncertainty factor is appropriate to address other physical factors not considered, and to account for potential impacts caused by landfill gas (see supporting memorandum on the nature of environmental impacts from landfills for information on landfill gas impacts).

Considering the size-dependency documented in the California study, and borne out by Wyoming's experience (that larger landfills are more likely to leak), DEQ now makes the following projections about numbers of landfills, by size category, likely to require corrective actions. DEQ is using size to categorize its projection of the numbers of leaking landfills because our cost analysis, to be discussed later in this paper, uses size categories as a basis for calculating operation, remediation and closure costs:

Size category	Number of Wyoming landfills in each size category	Number of Wyoming landfills predicted to require groundwater remediation, based on DEQ projections	Percentage of Wyoming landfills predicted to require groundwater remediation
Large (>15 acres)	14	13	90%
Medium (5-15 acres)	18	14	80%
Small (1-5 acres)	49	25	50%
Very small (<1 acre)	49	6	12%
Total	**130**	**58**	**45%**

References

Geosyntec Consultants, Inc., 2003, Landfill Facility Compliance Report – Results of Screening Analyses of 224 California MSW Landfills, produced under contract to the California Integrated Waste Management Board.

Halleman, T.W., 2004, A Statistical analysis of Wyoming Landfill Characteristics Contributing to Ground Water Impacts, M.S. Thesis, University of Wyoming, Department of Civil and Architectural Engineering.

Natural Resources Conservation Service, Map of Wyoming Annual Precipitation, March 1999.

END OF MEMORANDUM